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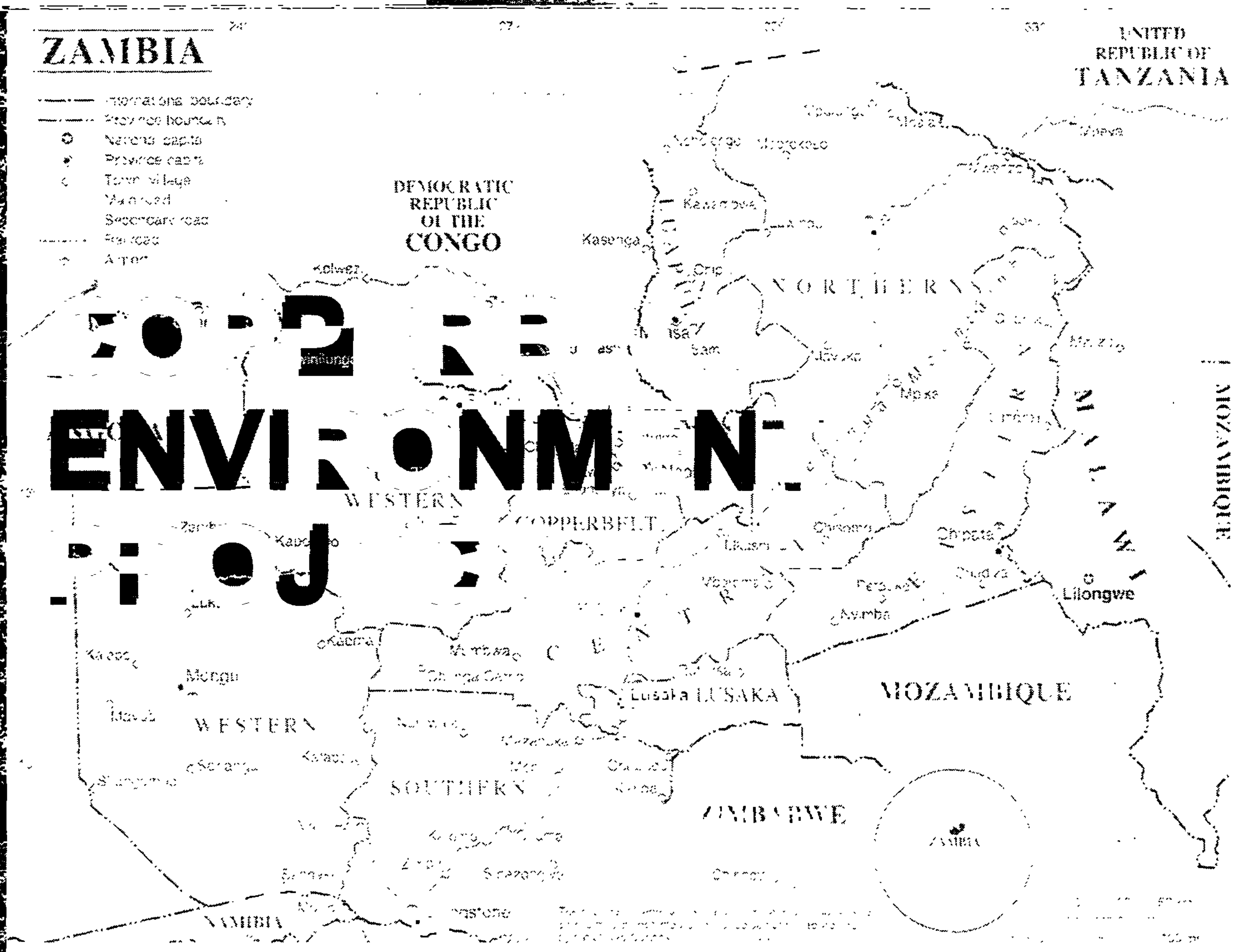

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ENVIRONMENT • ENGINEERING • WATER RESOU

EXECUTIVE SUMMARY

1. EXECUTIVE SUMMARY

I INTRODUCTION

This document constitutes an Environmental Assessment (EA) of the World Bank Copperbelt Environment Project (CEP), to be implemented in the Republic of Zambia over a five year period. The CEP has been categorised as an "A" project under World Bank guidelines and thus requires a full environmental assessment (EA) to be completed and disclosed prior to project appraisal. The overall objectives of the EA are to ensure that actions proposed under the project do not cause negative environmental or social effects, that the proposed measures to mitigate identified environmental and social impacts are appropriate, and that the level of public consultation and disclosure complies with national environmental legislation and World Bank Safeguard policies. The EA was executed in direct accordance with World Bank Operational Policy (OP) 4.01- Environmental Assessment.

The proposed CEP will support GRZ to address environmental liabilities that it has accepted as a consequence of mining sector reform and will comprise the following three components:

Component 1 - Consolidated long-term Environmental Management Plan (CEMP). This component will focus on the preparation of an EMP consolidating the EMPs prepared by investors and by ZCCM-IH for each privatized facility. The CEMP will determine the cumulative impact of mining activities outside of current mine license areas, including impacts on the Kafue River watershed, on critical ecological processes and on neighboring populations. It will establish the overall environmental management priorities within the broader context of environmental and social sustainability and indicate how these liabilities are to be addressed.

Component 2 - Establishment of an Environmental Mitigation Fund (EMF). The EMF will serve as a mechanism to fund environmental and social mitigation measures to mitigate the historical legacy of mining-related environmental degradation, based on the priorities set within the CEMP. Those measures that have high human health and safety implications will be given the highest priority. Time-bound environmental and contractual obligations to investors of an environmental nature will also be given priority consideration.

Component 3 - Strengthening the regulatory framework for environmental management in the mining sector. The CEP will help ensure full compliance of the mining sector with national environmental regulations. For this purpose, the CEP will fund appropriate capacity building within ECZ, MSD and delegated agencies under the Environmental Protection and Pollution Control Act (EPPCA), as well as universities and recognized training and research institutions.

As a consequence of the process of privatisation, Zambia Consolidated Copper Mines (ZCCM) was transformed from a state mining corporation to an Investments Holding Company, ZCCM-IH, almost entirely owned by GRZ. ZCCM-IH retained liability for a wide range of environmental concerns which were not passed on to the private investment consortia and is charged with, amongst other tasks, managing the remediation of defunct sites and lands, as well as implementing and/or financing the obligations agreed with investors as part of specific privatization deals (largely decommissioning of defunct sites within the new Mine License Areas, and some resettlement at the Konkola Mine). ZCCM-IH also continues to own those mines, or portions of mines, that have not been sold (as in Ndola, and the smelter at Kitwe), and to own between 10% to 20% of most privatised mines[1]. As a defunct mine site, the Kabwe mine is still controlled in many areas by ZCCM-IH, but 14 small-scale investors are also using the site.

With at least 12 different mine sites active in the Copperbelt, most with different management and ownership structures, the sector, and the treatment of environmental management is complex. The Mines Safety Department (MSD) within the Ministry of Mines and Minerals Development (MMMD) is mandated to ensure that the mines operate within mine sector regulations regarding occupational health and mine safety, and in past practice, served as the primary regulator of the mining sector. The MSD holds among other statutory functions, a responsibility to protect the environment and to control pollution in the areas where prospecting, exploration and mining operations are being carried out. The Environmental Council of Zambia (ECZ), as the overall national environmental protection agency, is the lead agency in enforcing the Environmental Protection and Pollution Control Act (EPPCA), which focuses on environmental protection in general. The ECZ carries out this role by working in cooperation with, and in cases delegating sectoral institutions of government, such as the MSD, to act on its behalf. The evolving roles of MSD and ECZ will need to be carefully articulated in order to facilitate effective implementation of the CEP.

The complexity of the mining sector poses challenges for effective regulation, as ECZ must now negotiate with a large number of stakeholders. At the same time, because of agreements with investors, the GRZ will be liable for the cost of any lawsuit against a private mine company, as long as that company operates within the framework of its agreed Environmental Management Plan (EMP). Therefore, over the next 15 to 20 years, the EMPs, as much as existing legislation, will guide environmental performance within the mining sector. The CEP will thus play a crucial role in ensuring that the negotiations of the EMPs benefit from outside independent expertise, and that the EMPs provide an opportunity to both share information

[1] The overall sector – including mines outside of the Copperbelt - is comprised of 14 mine sites owned by eight companies including ZCCM, which owns between 10% to 20% of Chambishi, Mufulira, Nkana, RAMCOZ, Kansanshi, Konkola, Nchanga, and Nampundwe mines, and 100% of Ndola Lime and the Nkana Smelter.

with stakeholders at the local level, and to integrate their concerns. At present investor specific EMPs are at various stages of completion and will be integrated into the CEMP process.

II SYNOPSIS OF MAJOR ENVIRONMENTAL AND SOCIAL ISSUES IN COPPERBELT AND KABWE

This EA presents an evaluation of mining hazards in the Copperbelt and Kabwe from a risk-based perspective, focusing on the impacts on human health, animals and plants. The primary environmental health issue in the Copperbelt mining sector is exposure to sulphur dioxide and particulate emissions in the towns of Mufulira, Kitwe and Chambishi.

Aside from sulphur dioxide, copper is the key element that is found in excessive quantities immediately downstream from mine sites and downwind of smelters in the Copperbelt. Because of the geology of the Kafue River basin, there is little acid rock drainage (ARD), which limits the availability of other elements, such as lead and arsenic, to pose a significant health threat. Kafue River water is generally within World Health Organisation (WHO) water quality guidelines for copper. However, water sources closer to mine sites can, in certain instances, exceed WHO limits for copper.

In Kabwe, lead contamination in soil presents an immediate health concern due to high lead contamination within residential areas. Based on the review of existing information by a medical toxicologist, other health issues related to mine pollution are not likely to be significant, and specific recommendations have been provided on those items that require further testing to rule out health effects during the CEMP process.

Analysis and stakeholder consultations carried out as part of this EA raised a number of environmental and social issues affecting the Copperbelt province and the Kabwe region. These issues have been categorised as those directly related to past and present mining activities, and those that may affect the context in which the CEP will be implemented, but that are not directly related to mining. These issues are summarised below and in Table 1:

Mining Related Issues

Environmental:

- Kabwe health effects of lead contamination, primarily in soil and possibly food.
- Sulphur dioxide emissions from Mufulira, Nkana, Chambishi and Luanshya smelters.
- Siltation into streams
- Localized accidents as a result of access to unsecured mine sites

Social:

- Possible resettlement of people currently occupying potentially unsafe areas on ZCCM-IH land.
- Loss of income generating opportunities based on using the sites (scavenging or fishing) versus remedial measures to ensure long-term stability of these sites and to protect users from potential hazards.
- Increases in deforestation, vandalism of mine sites and mine site accidents, with decline in mine security.

<u>Non-Mining Related Issues</u>

Environmental:

- Rapid increase in deforestation and settlement in national forest reserves and watershed areas in the Kafue basin.
- Outdated, poorly maintained sewage treatment plants and direct discharge of sewage into the Kafue River.
- Increased levels of solid waste being disposed within neighbourhoods and on ZCCM-IH lands, causing increased air pollution from burning waste and breeding grounds for rats and malaria.
- Theft of PCB-based oil from electricity transformers for use as cooking oil.

Social:

- Increasing tariffs for water, electricity, education, health care and other services felt acutely by groups that have not benefited directly from recent growth in the mining sector, e.g., municipal employees (many of whom have not been paid for many months), public sector and university employees on fixed salaries, residents of Luanshya who are dependent on the now non-functioning mining sector, residents of Kabwe, retrenched miners with few skills, retired miners, and other already vulnerable groups such as widows and those affected by AIDS.
- Overtaxed public health facilities, increased fees and more restricted access to mine hospitals, compounded by a drain of medical personnel reported to have left the country for more lucrative positions within the past year.
- Weak municipal governments unable to effectively collect tax revenues from mining sector, yet needing to augment services.

Table 1: Overview of Mine Facility and Potential Impact

MINE FACILITY	ZCCM-IH RESPONSIBILITIES[2]	POTENTIAL HUMAN HEALTH IMPACT / PEOPLE AFFECTED	POTENTIAL ECOLOGICAL IMPACT
UNDERGROUND WORKINGS	• Private mine owners are responsible for underground workings in the Copperbelt • ZCCM-IH retains responsibility for Kabwe workings	• At least 3,000 squatters currently live on mine land that needs to be assessed for risk from subsidence. Degree of potential risk unknown and actual number affected likely to be much less than this. (ZCCM liability) • Small number likely affected	• Subsidence and erosion can result in vegetation loss.
OPEN PIT	• ZCCM-IH has responsibility for several open pits at Nchanga, Nkana • ZCCM-IH retains responsibility for Kabwe pit remediation	• Only Nchanga open pit is active and thus level of risk to employees is higher than for the remaining closed pits that generally do not have many people illegally accessing them. Several open pits are not near population centers and thus this risk may be relatively small. • However, collapsing pit walls could incur into adjacent roadways as at Chingola. • Small number likely affected	• Mine de-watering provides major water input to Kafue River, with significant positive impact during periods of low flow. • In Kabwe negative impacts on aquatic ecosystems because water is contaminated by lead and zinc. • In Chambishi pumping water out of pit has lowered groundwater table, in Konkola, the wettest mine no such effect has been documented.
WASTE DUMPS **(GENERIC EVALUATION)**	• All defunct dumps (approximately 70% total) may fall to ZCCM-IH's responsibility • Defunct OB dumps at Nchanga, Nkana and most other mines. Some remain undecided. • Waste Rock Dumps: Many are undecided in Ndola, Mufulira and elsewhere. New mine companies may want to re-mine these dumps. • Slag Stockpiles: ZCCM-IH retains liability only at Kabwe	• Some dumps used for scavenging or agriculture but in the Copperbelt, because copper is not highly toxic, and other potentially toxic substances such as lead and arsenic are present in the ore in small quantities, likely risk from consumption of food grown on dumps is low. • Secondary risks from use of site for illegal trash dumping, causes rats, mosquito breeding vectors which residents around TD25 in Kitwe complained of. Uncontrolled trash dumping at TD25 contributed to substantial contamination of stream emerging from site (likely greater contributor of contaminants than the tailings themselves)	• Eroded materials may interfere with drainage facilities and lead to off-site sedimentation • Serious impact to aquatic life due to reduced oxygenation of sediment impacted rivers, suffocation of benthic fauna, and potentially increased metal loads in riverine sediments. • Natural revegetation and/or planting programmes can be impeded by physical instability of slopes, lack of soil organic matter and, occasionally, phytotoxicity factors. • Nkana slag dump effluents are mixed with process plant effluents. Variably low pH, metalliferous waters with little life-sustaining potential. Wider fates and contaminant impacts

[2] Subject to change.

MINE FACILITY	ZCCM-IH RESPONSIBILITIES[2]	POTENTIAL HUMAN HEALTH IMPACT / PEOPLE AFFECTED	POTENTIAL ECOLOGICAL IMPACT
	• Ore Stockpiles: ZCCM-IH has claimed responsibility for several ore stockpiles in Nchanga	• Most significant dust exposure problems occur around Kabwe dump, where high atmospheric lead, zinc, and cadmium concentrations are recorded. • In Mufulira, several people were killed because they were scavenging in the slag stockpile and part of the dump collapsed.	require investigation • Impacts primarily a function of surface drainage control. Leachates from sulphide ore stockpiles may be metalliferous and acidic.
CONCENTRATOR	ZCCM-IH retains responsibility for defunct concentrator at Kabwe. None in the Copperbelt.	Little or no health impact.	• Impacts are primarily a function of effluent management and efficiency of sedimentation in tailings facilities.

MINE FACILITY	ZCCM-IH RESPONSIBILITIES[2]	POTENTIAL HUMAN HEALTH IMPACT / PEOPLE AFFECTED	POTENTIAL ECOLOGICAL IMPACT
SMELTER (PYROMETALLURGICAL PLANT)	Current operation of smelters falls under new mine owners' responsibilities, though ZCCM-IH may be liable for historical environmental damage	• In Copperbelt atmospheric emissions of SO_2 and possibly other volatiles exert a high impact on populations in smelter plume paths. From SO_2, respiratory symptoms, increased morbidity from respiratory disease, increased mortality esp. from cardiopulmonary disease. Populations affected include: • Kitwe (Nkana west, Wusakile - up to 53,000 people potentially affected) • Mufulira (Kankoyo, Kantanshi - up to 75,000 people potentially affected), and • Chambishi (data on wind dispersion not available so unknown number of people affected) • At Kabwe, populations in Kasanda township are likely to have been in smelter path in the past. Historical impact from lead may be significant. • Acid corrosion of infrastructure. • Significant number of people affected.	• Documented impacts include vegetation 'die-back' from high SO_2 loads. In Copperbelt, during SA complaints of inability to garden in back yard registered in immediate vicinity of smelter in Wusakile (Kitwe) and Kankoyo (Mufulira). • Possible soil acidification from SO_2 wash-out and dry deposition (despite bedrock buffering, many laterite soils are leached of bases and thus inherently acidic). Acid intolerant plants become eliminated from vegetation.
TAILINGS LEACH PLANT	None.	• Limited human impact	• Sedimentation of surface watercourses, including the Kafue River (Hippo Pool). • Impacts on benthic fauna, fish hatchery areas and possibly larger fauna (hippo, crocodile) though other sources of pollution may also be major contributing factors. Reduced feeding and breeding success for benthic fauna and fish. Reduced aquatic diversity. Possible mortality of aquatic organisms caused by reduced biological oxygen demand.
ACID PLANT	ZCCM continues to own SmelterCo. though it is managed by KCM.	• Limited human impact • Inhalation of Sulphur dioxide	• Acidification and increased metal loads to surface drainage receiving effluents resulting in changes in species composition and loss of sensitive species. • Open liming of drainage waters at Chambishi produces severe, localized gypsum precipitation over riverine sediments and aquatic flora.

MINE FACILITY	ZCCM-IH RESPONSIBILITIES[2]	POTENTIAL HUMAN HEALTH IMPACT / PEOPLE AFFECTED	POTENTIAL ECOLOGICAL IMPACT
TAILINGS FACILITIES - Paddock Dumps - Cross Valley Dumps	Several defunct tailings sites have fallen under ZCCM-IH responsibility. Some have failed causing siltation in streams (e.g., Luanshya, 33C in Nkana). In Luanshya, dams are used for municipal water supply.	• Health impact from drinking contaminated water likely to be low because contaminated drainage systems are not known to be used for drinking (requires more thorough confirmation for broader number downstream users in EMP) and because high levels of copper tend to create bad taste in water which discourages consumption. SA site visits confirmed knowledge that streams were either contaminated (not suitable for drinking) or tasted bad so were not used. High reliance on wells or on piped water systems for drinking water. Bioavailability and solubility of metals in tailings is low. • Impact on water utilities treatment costs downstream reportedly high because siltation increases cost to treat water, and can reportedly clog water reservoirs and pipes for domestic water users (particularly for Chingola, Mufulira). If mine siltation is found to be the cause, this may impede water access or increase cost to several thousand water consumers. • Extent of fish consumption from contaminated tailings lagoons unknown, but KCM EMP noted that there was some health impact from consumption of fish from Lubengele Tailings, but that the nutritional impact of restricting all fishing would outweigh the impact of eating the fish in moderate quantities. Should be assessed further. • In some cases there may be physical risk to adjacent houses if area is not stable (possibly with TD25) • Tailings dams with water in Konkola have been documented as hosting bilharzias. • Informal settlements exist on the margins of dumps (TD26, TD27) in Kitwe, and may be subject to significant dusting exposure. • Older Nkana paddocks are used for cultivation. Heavy metal exposure through crop contamination warrants investigation, though likely risk to health in Copperbelt is low because of ore composition. In Kabwe no known cultivation on tailings, though EMP should assess if there is any	• Siltation of dambos and watercourses arises due to erosion of poorly consolidated or unvegetated paddocks or collapse of tailings because of poor maintenance – this can reduce water available downstream • High levels of silt can smother fish eggs and other aquatic life, thus reducing variety and number of fish in streams. However other compounding non-mining factors may be more significant influences (sewage) • Reduced aquatic life in tributary streams to the Kafue affects an unknown number of people dependent on fishing • Possible minor decrease in fertility of soil in adjacent area to tailings dam • At Chambishi, ferruginous tailings effluents have caused precipitation of iron on streambeds, and suffocation of benthic fauna.

MINE FACILITY	ZCCM-IH RESPONSIBILITIES[2]	POTENTIAL HUMAN HEALTH IMPACT / PEOPLE AFFECTED	POTENTIAL ECOLOGICAL IMPACT
		cultivation adjacent to tailings as composition of ore does pose higher health risk from plants absorbing metals.	
MINE & PROCESS WASTE WATER	• Dewatering responsibilities have been transferred largely to the private sector, except at Kabwe.	• Mine water serves as source for municipal water supply in several towns providing potentially very significant health benefit to thousands of water consumers through increased access to piped water. However, high suspended solids increase cost of treatment. • Better co-ordination between mine companies and utilities can lead to more precise treatment, thus reducing costs. Currently occurring with AHS-MMS.	• Occasional ochre (iron oxide) precipitation and suffocation of aquatic flora and benthic fauna where minewaters discharge to surface water bodies. • Increased turbidity (suspended solids) resulting in alterations to composition of aquatic flora and fauna and usually decreased diversity • Effects on riverine ecology and fisheries • Effects of subsidence on surface resources • Effects on surface water resources • Effects on groundwater resources

III STAKEHOLDERS PERSPECTIVES

A series of consultations were held with residents, local officials and community groups in the Copperbelt area. The majority of residents and community workers consulted had limited understanding of mine pollution, and generally did not rank this as a priority concern. This perspective may be due in part to lack of public information disseminated on mine pollution. There is no legal requirement for mining companies to share environmental data with local government or the public, and apparently no system for warning residents when there are excessive emissions, or overflows from tailings dams. The dissemination of environmental information to communities, and the establishment of information and warning networks to downstream and downwind communities in a format that local population can understand should be encouraged in the EMPs.

IV. ISSUES TO BE ADDRESSED THROUGH THE CEP

The EMP/CEMP

The CEP's design assumes that the model of an investor EMP and a counterpart EMP by ZCCM-IH will be applied to all investment groups. The EMPs prepared by ZCCM-IH are to be matched to the investor EMPs for each site, to ensure that all environmental issues are included and that there is concurrence between the two EMPs on who is responsible for what issues. The project's design assumes that the respective EMPs will reflect the results of consultations between investors and ZCCM-IH. It also assumes that the investor and counterpart EMPs will be reviewed and approved concurrently by ECZ and by the Mines Safety Department (MSD), the latter as the delegated authorizing agency for handling environmental issues related to mining licenses, under the Environmental Protection and Pollution Control Act (EPPCA) and the Mines and Mineral Act of 1995.

The CEMP itself will need to devote adequate attention to the issues posing the greatest threat to people and to ecosystems, and should also address emergency response plans, procedures for safe handling of toxic substances, and public communication and outreach by mine companies to downstream and downwind residents. The CEMP process should be used as a vehicle to communicate findings to a broad spectrum of stakeholders in each town and for residents and others to voice their concerns with regard to specific rehabilitation

Rehabilitation of Mine Sites

An overview of the issues in rehabilitation of mine sites that could be considered for financing under the EMF is presented in Table 2.

The criteria for the selection of sites to be rehabilitated will be finalized during project appraisal. Some potential considerations include selecting sites that offer the maximum economic benefit if rehabilitated, or focusing on sites posing the greatest threat to human health, the stability of the site and potential for subsidence, and to the ecosystem in general. Several factors characterizing mining in the Copperbelt and Kabwe (relatively similar ores from site to site, large number of sites to be assessed, focus on copper and lead mining) suggest that a simplified qualitative ranking model for site selection would offer benefits in terms of increased transparency to a wide stakeholder audience and reduced delays before rehabilitation starts.

The challenges needing to be addressed in the process that will govern rehabilitation of sites under the CEP are:

- The long-term sustainability of tailings facilities that are frequently used for agriculture, scavenging, vandalism and deforestation, and all other activities that can jeopardise long-term stability and have the potential to reverse efforts to stabilize sites through planting vegetation/tree cover.
- The low capacity for ongoing maintenance by the municipal institutions to whom management will likely fall in the long-term.
- The lack of security personnel at sites, a situation that will likely continue.

Rehabilitation solutions need to be as low maintenance as possible in light of the limited capacity and resources of those institutions (municipal governments) which will likely take over the sites once they have been rehabilitated. .

Safeguard Compliance and Participatory Planning Process

Rehabilitation of mine sites in the Copperbelt, particularly those near population centers, will require close coordination with those using the site and with stakeholders who would eventually be expected to take over the site. This EA has made recommendations on the composition of a proposed project steering committee, which could include both local government and NGOs as well as relevant government agencies.

As an environmental rehabilitation program, the CEP is intended to improve environmental conditions, not exacerbate them. However, because the specific investments to be funded under the EMF cannot be specified in detail at this stage, the project will need to define standard procedures for:

- Evaluating the social and environmental impact of specific sub-project proposals to ensure compliance with World Bank safeguard policies and to ensure that the proposed rehabilitation does not cause negative environmental effects either within the site or downstream/downwind of the site.
- Consulting with the affected public and stakeholders.
- Estimating the cost-benefit of different rehabilitation options proposed for specific sites.
- Ensuring that the type of rehabilitation proposed is cost-effective, technically sound, and sustainable in terms of the level of long-term maintenance required.

This EA has already identified some of the types of activities that could be considered for funding under the EMF and the areas where rehabilitation may require more careful scrutiny, prior World Bank review and additional expertise (for example, with the expansion of the medical and physical lead rehabilitation program in Kabwe, with some select sites where resettlement may arise, in the event of archeological sites being affected, or where sites such as dams that may be unstable and are near population centers). Other types of projects (replanting, vegetative cover of sites remote from human populations for example) pose comparatively lower social or environmental risks, and may require a more streamlined evaluation and approval process. However, because the rehabilitation and decommissioning of sites is a relatively new activity for ZCCM-IH and ECZ, requiring skills in new areas, the Bank may want to consider prior approval of the first set of remediation plans to ensure that the process is working smoothly. The World Bank would also need to establish mechanisms for evaluation of how well the process was working. A manual of procedures, to be agreed on by the World Bank, ZCCM-IH, and ECZ, could be developed which would outline the process, content, and review procedures for the site management plans, including specific trigger questions regarding Bank safeguards.

ZCCM-IH will need assistance under the CEP to develop a land policy governing the management and allocation of the large tracts of land it has retained. Other issues to be addressed carefully include health problems in Kabwe, and resettlement of squatters on ZCCM-IH or private mine lands that are not considered safe for habitation (over 3,000 residents are estimated to live on land that requires a safety assessment). This situation could represent a substantial, though currently unquantified cost to the CEP.

Kabwe Site

Given the sensitivity of the lead rehabilitation program in Kabwe, external review is proposed for any changes to the existing program. Expertise should be retained in mine site rehabilitation, medical toxicology and risk communications. In addition, more extensive testing is required to understand the extent and distribution of contamination. It would be prudent to opt for census testing of blood, at least in areas with evidence of contamination at levels that could warrant medical intervention. This recommendation could have significant implications for the program cost. Given the magnitude of the lead contamination in Kabwe, the project team should consider forming a Kabwe task force for ongoing rehabilitation, which would include health authorities, NGOs, education representatives, local government and mines.

No physicians trained in toxicology or occupational health reside in Zambia. Since one component of Kabwe's rehabilitation program is likely to be increased medical treatment, it is crucial that counsel be sought from an outside professional toxicologist, preferably experienced with remediation and in public health in a developing country setting.

Several technical options exist for lead protection, but a more complete analysis of the viability and effectiveness of these options in light of the current context needs to be explored with residents. Actions to improve hygiene and reduce lead dust in homes are likely to produce the most immediate benefits.

Risks

The physical risks associated with rehabilitation of mine sites in the Copperbelt are modest because the materials at the sites, with the exception of limited stocks of radioactive substances, are not highly toxic. Where engineered works are adopted, they should be applied in a pragmatic fashion to manage discharges at a reasonable cost, without the need for more than passive care maintenance and infrequent monitoring. The engineered works described in Part II (Section 7) of the EA are in common use at mines throughout the world and hence, the risk of failure, aside from inappropriate engineering and applications is minimal. Large-scale removal or transport of contaminated materials that could pose risks to the public or ecosystems is not envisaged.

Effectively controlling exposure to lead in Kabwe requires behavioural change on the part of residents. Thus, at Kabwe the project should adequately appraise support needed by health care authorities, develop a careful risk communication strategy and co-ordinate, possibly through a task force, with health care, municipal, mines, NGOs and other key stakeholders.

V. ALTERNATIVES TO THE CEP

An analysis of alternatives to the design and implementation plan for the CEP was undertaken as a component of the EA process. The non-intervention option is not considered viable. From a World Bank perspective, the institution has provided financial support for minerals sector reform in Zambia for a decade.

The proposed CEP structure draws upon experience from a number of ongoing, or previously executed World Bank programs in the minerals sector, for example in Ecuador, Bolivia and Argentina. The concurrent process of task identification and institutional capacity building has proved effective in all such instances.

Finally, the only other alternative to the current CEP structure would be for GRZ to seek grant funding sources (the CEP is a concessional long-term credit which must be repaid in hard currency) from other donors. Given the magnitude of the clean-up required in Kabwe and in the Copperbelt, it is recommended that the GRZ seek such funding sources to complement the CEP and to minimise the future debt burden on the country. The funding mechanism within the project may facilitate such supplemental financing.

VI. SUMMARY RECOMMENDATIONS

1) *Definition of responsibilities* – Clear definition of responsibilities among ECZ, MSD and ZCCM-IH with regard to regulation and roles in CEP implementation is required for successful CEP implementation. Responsibility for the implementation of rehabilitation measures relating to historical environmental liabilities lies with ZCCM-IH. Measures relating to active plant and facilities are the responsibility of private sector mine operators. Monitoring and enforcement of all such actions is the responsibility of the ECZ, the MSD and other regulatory bodies, as prescribed under Zambia's mining and environmental legislation.

2) *Prioritisation of issues* – ZCCM-IH, private sector mine operators, and regulatory authorities will need to form a consensus regarding priority environmental issues to be addressed by their respective site-specific EMPs, and under the CEMP. Major areas of expenditure will likely include the monitoring and control of atmospheric emissions, control of sediment loads, improved water quality and the lead rehabilitation program at Kabwe.

3) *Environmental Mitigation Fund* – The Environmental Mitigation Fund (EMF) of the CEP is the project's major component. ZCCM-IH liabilities may, on the basis of existing rehabilitation cost estimates, potentially exceed the EMF budget. Expenditure should therefore be focused towards priority impacts, as identified in this EA, and subsequently under the CEMP. A risk assessment approach should also be considered.

4) *Institutional Capacity* – The regulatory agencies, ECZ and MSD, have basic mandates and technical competency, but require an organisational focus and training to enable them to adequately discharge their functions in CEP implementation. ZCCM-IH will need to bolster its capacity in community liaison functions, legal expertise, and toxicology/risk assessment communication in order to carry out its post-privatization obligations effectively. Training for all of the above institutions in risk assessment and site rehabilitation would be important. The issue of incentives to retain qualified staff will also need to be further evaluated in an effort to decrease the staff turnover at ECZ and MSD.

5) *World Bank Safeguard Policies* – Because activities to be funded under the EMF cannot be specified in detail prior to the establishment of the fund, the setting of priorities and the fuller investigation and selection of remedial measures, the EMF will need to put in place a process for environmental and social safeguards review in order to ensure compliance with WB Safeguard Policies[3]. The screening and review process will include the participation and consultation of

[3] With OP 4.01, Environmental Assessment; in some cases OP 4.12, Involuntary Resettlement, OP 4.37, Dam Safety, OP 4.09, Pest Management, or OP 11.03, Management of Cultural Property, may be triggered. The triggering of other safeguard policies, e.g. Natural Habitats, cannot be ruled out, but seems less likely, based on the information gathered for he CEP EA.

stakeholders through various vehicles like a project steering committee with wide stakeholder representation (including NGOs and local government) to ensure adequate screening and consensus among stakeholders.

Remedial activities undertaken by the EMF will be screened for safeguards compliance, in addition to the environmental assessment requirements of GRZ. Those projects that trigger Bank safeguard policies would necessitate a more detailed environmental and social evaluation, careful third-party review and assistance, as well as prior approval by the World Bank. A manual of procedures could detail the specific triggers for such review.

Thus, the EMF will be required to establish procedures for 1) screening each proposed activity to determine which safeguard policies are triggered; 2) carrying out environmental assessments, including effects on cultural property; 3) preparing resettlement action plans, dam safety plans, pest management plans; and 4) consulting with the affected publics and NGOs and disclosing safeguard documents. The Bank will need to assist the EMF in developing the capacity to make these determinations and carrying out the work in coordination with the ECZ and the Bank. In addition, the Bank will need to develop a mechanism for monitoring the process.

Table 2: Mine Facilities and Environmental Rehabilitation

MINE FACILITY	POTENTIAL IMPACT ON HEALTH AND ECOLOGY	POTENTIAL ENVIRONMENTAL CHANGES TO SITE OVER TIME	OPTIONS FOR REHABILITATION / LAND USES	COMMUNITY MANAGEMENT ISSUES
UNDERGROUND WORKINGS	• Localized hazard to squatters on subsidence area (possibly AMCO in Kitwe) • Health: low to none • Ecology: low to none	• Subsidence and collapse of workings • Discharge of mine drainage water • Loss or partial loss of land use	• Removal of chemicals and other hazardous materials • Seal off from surface entry workings • Delineate areas unsafe for human habitation and usage • Monitoring subsidence effects on ponding and stream flows; maintain stream flows and alignments, if necessary.	• Signs to keep people from settling on unsafe areas • Locate buildings out side of subsidence zone • Manage agriculture activities • Discussion with key stakeholders with regard to land allocation to ensure they do not allocate land that is not safe
OPEN PITS	• Health: localized hazard for those illegally accessing area if pit is unstable • Ecology: limited environment for flora and fauna. • Visual Environment: pit may be unsightly, consumes land that could be used for other purposes	• Stability of the pit walls • Collapsing pits may affect adjacent roadways, though impact on population not likely to be high because of distance from population centers. • Potential break back (cracking and settlement around rim of pit), raveling and instability of pit walls, and hydrogeological problems associated with the development of pit lakes.	• Evaluation of the zone of settlement or potential instability behind rim of pit (unstable areas closed to public) • Not practical to reprofile unstable pit slopes • Hydrologic forecast of long term water levels and water quality; prepare plan for utilization of pit lake for recreation and possible aquaculture. • Where feasible, develop a beach area for recreational access; prepare access trails and vegetate flatter areas.	• Signs to keep people from settling on unsafe areas. • Community involved in management of in pit lake as a reserve and recreational site. • Discussion with key stakeholders with regard to land allocation to ensure they do not allocate land that is not safe

MINE FACILITY	POTENTIAL IMPACT ON HEALTH AND ECOLOGY	POTENTIAL ENVIRONMENTAL CHANGES TO SITE OVER TIME	OPTIONS FOR REHABILITATION / LAND USES	COMMUNITY MANAGEMENT ISSUES
WASTE ROCK DUMPS	• Health: low to none • Visual Environment: cannot establish more than sparse vegetation and consumes land that could be used for other purposes.	• Possible increased metals (copper) in runoff to streams though type of metals are relatively benign. Can reduce number of fish. Minor siltation to streams • Because they tend to consist of harder, less erodible materials most waste rock dumps are comparatively stable, limited exposure to slope raveling and erosion.	• May vegetate slopes where feasible; i.e., where sufficient soil is present in rock interstices • Assessment of long-term mineralogical and geochemical evolution of sulphide assemblages may be required	• Signs to keep people from settling on unsafe areas. • In some cases there may be physical risk if area is not stable. • Limited for land use; unproductive for agriculture. • Community education to ensure that new vegetation/trees are not cut down. • Employment of community members to carry out plantings. • Planting species not used for charcoal or firewood. • Explore with community sustainable ways of using the site.
OVERBURDEN DUMPS	• Health: low to none • Ecology: minor siltation to streams • Visual Environment: should support vegetation	• Change in original land use (productivity) • Disruption of surface drainage.	• Implementation of siltation reduction measures • Drainage improvements to minimize slope gulleying and down-catchment siltation • Should naturally revegetate, or can be planted or seeded with local species.	• Community education to ensure that new vegetation/trees are not cut down. • Employment of community members to carry out plantings. • Planting species not used for charcoal or firewood. • Explore with community whether there are sustainable ways of using the site.

MINE FACILITY	POTENTIAL IMPACT ON HEALTH AND ECOLOGY	POTENTIAL ENVIRONMENTAL CHANGES TO SITE OVER TIME	OPTIONS FOR REHABILITATION / LAND USES	COMMUNITY MANAGEMENT ISSUES
SLAG STOCKPILES	• Health: low to none – localized issue for those living near stockpile and illegally accessing site. • Ecology: some increased metals runoff to streams • Visual Environment: sparse to no vegetation. • Air – minor dust to adjacent communities • Water – siltation and heavy metals contamination during rainy season	• Stockpiles are stable and resistant to erosion. • Limited changes over time.	• Reprocess and eliminate stockpile where economically justified. • Perimeter collection ditches and sediment basins. • Vegetate lower slopes.	• Community education to ensure that new vegetation/trees are not cut down • Employment of community members to carry out plantings • Planting species not used for charcoal or firewood • Explore with community whether there are sustainable ways of using the site
ORE STOCKPILES	• Increased heavy metals, acidity, or pollution. In Copperbelt heavy metals not likely to be highly toxic. • Health: Low to None – localized issue for those living near stockpile and illegally accessing site. • Ecology: runoff water may affect water quality • Visual Environment: consumes land that could be used for other purposes	• Long term impact only if ore is not processed.	• Temporary stockpiles awaiting processing.	• Minor if ore is processed.
CONCENTRATOR	• High suspended solids loads • Effects of high metal discharges on surface water quality	• Temporary impact during mine operations.	• Decommissioning of all infrastructure • Closure plans to include restitution of drainage ways and revegetation.	• Monitor water quality and limit any agriculture and water extraction adjacent to site as appropriate.

MINE FACILITY	POTENTIAL IMPACT ON HEALTH AND ECOLOGY	POTENTIAL ENVIRONMENTAL CHANGES TO SITE OVER TIME	OPTIONS FOR REHABILITATION / LAND USES	COMMUNITY MANAGEMENT ISSUES
SMELTER (PYROMETALLURGICAL PLANT)	• Health: High – exposure to air-borne SO_2, and potentially to accumulated metals deposited on plants and soil in downwind areas. SO_2 produces impact while smelter is operational, but deposits of metals in soils can last after smelter is closed. • Ecology: In immediate vicinity residents report that plants do not grow well	• Increased quantities of production may lead to increases in SO_2 unless sufficient improvements are undertaken at smelters	• Decommissioning of all infrastructure • Closure plans to include restitution of drainage ways and revegetation. • Represents a priority issue to be addressed under the EMP/CEMP with private mine companies	• Through EMPs, mine companies should be encouraged to warn residents to take positive measures when there are times of very high SO2 levels. • Communities need an accessible avenue for complaint when emissions levels are high.
TAILINGS LEACH & ACID PLANT	• Potential for release of acidic water. • Sediment discharge to watershed; siltation and metals contamination during rainy season.	• Temporary impacts during plant operations.	• Decommissioning of all infrastructure • Closure plans to include restitution of drainage ways and revegetation.	• Through EMPs, mine companies should be encouraged to implement warning system for downstream users not to drink water when effluent levels surge above normal, to develop networks of downstream users who they could notify

MINE FACILITY	POTENTIAL IMPACT ON HEALTH AND ECOLOGY	POTENTIAL ENVIRONMENTAL CHANGES TO SITE OVER TIME	OPTIONS FOR REHABILITATION / LAND USES	COMMUNITY MANAGEMENT ISSUES
TAILINGS FACILITIES: **CROSS VALLEY DUMPS**[4]	• Health: generally low impact (to be confirmed through further testing in EMP/CEMP) • Ecology: impact on aquatic life and water available downstream likely high but other compounding non-mining factors may be more significant (e.g. sewage). • Possible minor impact on fertility of soil in adjacent area to tailings dam. • Visual Environment: large tracts of land may remain unvegetated, dusty and unused.	• Long-term stability of the embankments • Discharge water quality and loading to receiving environment	• Analysis of capacity of spillway to convey major flood events (e.g. 1 in 1000 years) • Dam break analysis in event of failure • Upgrade spillway as appropriate for closure; seal off decant • Restrict habitation in floodway area below dam. • Establish vegetative cover	• Slope failures at several tailings dams linked directly to vandalism and community use of the site • Community education to ensure that new vegetation/trees are not cut down and to gain agreement on site use plan that does not affect stability of site • Employment of community members to carry out plantings • Planting species not used for charcoal or firewood • Explore with community whether there are sustainable ways of using the site • Through EMPs, mine companies should be encouraged to implement warning system for downstream users not to drink water when effluent levels surge above normal.

[4] Engineered dams utilized to retain tailings; are located in valleys containing natural water courses.

MINE FACILITY	POTENTIAL IMPACT ON HEALTH AND ECOLOGY	POTENTIAL ENVIRONMENTAL CHANGES TO SITE OVER TIME	OPTIONS FOR REHABILITATION / LAND USES	COMMUNITY MANAGEMENT ISSUES
TAILINGS FACILITIES: PADDOCK DUMPS[5]	• Health: impact low • Ecology: minor impact on aquatic life and water available downstream. Possible minor impact on fertility of soil in adjacent area to tailing dump. • Visual Environment: large tracts of land may remain unvegetated, dusty and unused	• Erosion and sedimentation on perimeter slopes • Seepage control and off-site contamination of water courses by silt and chemicals • Wind blown dust	• Drainage collection ditches or swales on dump surface; discharge down slope in a rock -lined spillway and into sediment basin; seal decants • Establish perimeter collection ditches and silt traps. • Route drainage ways through natural or constructed wetlands where feasible. • Establish vegetative cover (may require soil capping to assist with vegetative growth)	• Amenable to establishment of vegetation including trees; community involved in tree planting and protection. • May be suitable for limited agriculture crop production and grazing (to be tested in EMP/CEMP)
MINE AND PROCESS WASTE WATER	• Increased turbidity (suspended solids) makes treatment of municipal water more difficult and expensive • At areas where metals content is high (Chingola) reduces fish and plant life in riverine ecology and fisheries • But may also have positive impact in terms of diluting other metals in streams and providing drinking water source for municipal water supplies. • Effects on surface water and groundwater	• In several towns water pumped from mine provides source of potable water. In Chililabombwe and Nchanga, provides significant amount of water to Kafue. • Sediment load (may be high in suspended solids). • Impact on water quality as a result of underground mining activities, sewage, fuel and diesel spills in the sumps.	• Temporary impacts during mine operations. • Hydrology and water quality in long term will tend to revert to pre-existing conditions	• Better coordination between mine companies and utilities can lead to improved municipal water treatment, reduced costs. Currently occurring with AHC-MMS and KCM.

[5] Tend to be older, less engineered impoundments that consist of ring dykes formed by depositing the coarser sand fraction of the tailings, separated by the action of spigots and cyclones.

MINE FACILITY	POTENTIAL IMPACT ON HEALTH AND ECOLOGY	POTENTIAL ENVIRONMENTAL CHANGES TO SITE OVER TIME	OPTIONS FOR REHABILITATION / LAND USES	COMMUNITY MANAGEMENT ISSUES
HAZARDOUS WASTES: PCBS	Health: Low impact as long as precautions to secure PCBs from theft are taken and to ensure they are not accidentally released during transport or disposal. Ecology: low and limited to immediate area if leaking into soil and groundwater	• If security of site is not maintained, there is risk of theft or leakage	• Dispose of PCB and radioactive wastes in secure sites and eventually eliminate in accordance with POP convention • Limit occupational exposure to radionuclides	• Appropriate safeguards to protect disposal sites from unauthorized entry and vandalism
HAZARDOUS WASTES: RADIONUCLIDES	Health: Low to general population, unknown risk to underground mine workers Ecology: Low	• Excessive exposure of workers to radionuclides can lead to respiratory disease and lung cancer		

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ENVIRONMENTAL ASSESSMENT
OF
COPPERBELT ENVIRONMENT PROJECT

PREPARED FOR:

ZCCM INVESTMENT HOLDINGS PLC

C53670000

FEBRUARY 2002

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ACRONYMS

AHC	Assets Holding Company
ARD	Acid Rock Drainage
BA	Basal Area
BOD	Biological Oxygen Demand
CANMET	Canada Centre For Mineral and Energy Technology
CBE	Citizens for a Better Environment
CBO	Community Based Organisation
CEC	Copperbelt Energy Corporation
CEMP	Consolidated Environmental Management Plan
CEP	Copperbelt Environment Project
CETZAM	Christian Enterprise Trust in Zambia
CIDA	Canadian International Development Agency
CINDI	Children in Distress
COMET	Copper Mines Enterprises Trust
CU	Commercial Utilities
DBH	Diameter and Breast Height
DWA	Digby Wells and Associates
EA	Environmental Assessment
ECZ	Environmental Council of Zambia
EEPA	Environmental Education
EINMS	Environmental Information Networks and Monitoring Systems
EIS	Environmental Impact Statement
EMF	Environmental Mitigation Fund
EMP	Environmental Management Plan
EPPCA	Environmental Protection and Pollution Control Act
ERIPTA	Economic Recovery Initiative Program Technical Assistance
ESF	Environmental Support Fund
ESP	Environmental Support Project
FEMP	Final Environmental Management Plan
GB	Great Britain
GC-ECD	Gas Chromatography Electronic Capture Detector
GCMS	Gas Chromatography Mass Spectrometry
GDP	Gross Domestic Product
GIS	Geographic Information System
GP	Good Practice
GRZ	Government of the Republic of Zambia
HGLP	High Grade Leach Plant
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
IFC	International Finance Corporation

INR	Institute of Natural Resources
ISO	International Organization for Standardization
IUCN	International Union for the Conservation of Nature
JICA	Japanese International Cooperation Agency
KCM	Konkola Copper Mines
KDMP	Konkola Deep Mining Project
LML	Large Scale Mining Licenses
MCM	Mopani Copper Mines
MDA	Mine Development Agreement
MENR	Ministry of Environment and Natural Resources
ML	Mining License
MMA	Mines and Minerals Act
MMMD	Ministry of Mines and Minerals Development
MMS	Mine township Municipal Services
MOU	Memorandum of Understanding
MSD	Mines Safety Department
MTSP	Mines Township Services Project
MWSC	Mulonga Water and Sewer
MWUZ	Mine Workers' Union of Zambia
NEAP	National Environmental Action Plan
NFM	Non-Ferrous Metals
NGO	Non-Governmental Organisation
NRR	Neutral-Red Retention
OB	Overburden
OP	Operational Policy
PAD	Project Appraisal Document
PCB	Polychlorinated Biphenyls
PDC	Project Development Committee
PFAP	Provincial Forestry Action Program
PMF	Probable Maximum Flood
PMU	Project Management Unit
POP	Persistent Organic Pollutants
PPP	Participatory Planning Process
PPZ	Poor People of Zambia
PRA	Participatory Rural Appraisal
PSC	Project Steering Committee
QA/QC	Quality Assurance/Quality Control
RAMCOZ	Roan Antelope Mining Corporation of Zambia
RAP	Resettlement Action Plan
RLE	Roasting, Leaching and Electrowinning
RPS	Radian Protection Service

SA	Social Assessment
SADC	Southern African Development Community
SI	Statutory Instruments
SLOS	Sub-level Open Stopping
SMP	Social Management Program
SRK	Steffen, Robertson and Kirsten
SSMA	Small Scale Mining Agreement
TD	Tailings Dump
TE-NORM	Technically Enhanced Naturally Occurring Radioactive Materials
TLP	Tailings Leach Plant
TOR	Terms of Reference
TSS	Total Suspended Solids
UN	United Nations
UNEP	United Nations Environment Program
UNIP	United National Independence Party
UPND	United Party for National Development
US-EPA	United States Environmental Protection Act
VMS	Volcanogenic Massive Sulphides
WHO	World Health Organization
WRAP	Water Resources Action Programme
ZACCI	Zambian Association of Chambers of Commerce and Industry
SAMSIF	Zambia Social Investment Fund Project
ZAWA	Zambian Wildlife Authority
ZCCM-IH	ZCCM Investments Holdings Plc
ZESCO	Zambia Electricity Supply Corporation
ZRP	Zambia Republican Party

PART I:
HISTORY AND CONTEXT OF THE COPPERBELT ENVIRONMENT PROJECT (CEP)

1. INTRODUCTION

1.1 ORIGINS AND OBJECTIVES OF THE CEP

In 1995, the Government of the Republic of Zambia (GRZ) began the process of privatizing the assets of Zambia Consolidated Copper Mines Limited (ZCCM) with the objective of restructuring the Zambian economy, developing the private sector and encouraging investment in Zambia. Privatization of all ZCCM units composed of Kansanshi, Konkola, Nchanga, Mufulira, Nkana, Chambishi, Chibuluma, Luanshya and Nampundwe was completed in March 2000. As a result, ZCCM was transformed into an investment holding company, ZCCM-IH Plc, with a 10-20% minority shareholding in the newly privatized mining companies including processing plants and electrical power supply companies.

A cornerstone of the privatisation process was the provision of assurances by the Government of the Republic of Zambia (GRZ) to prospective investors that responsibility for the historical legacy of mining-related environmental degradation will, where appropriate, remain with the GRZ. These liabilities are to be administered through ZCCM-IH.

The Copperbelt Environment Project (CEP) proposes to help the GRZ address environmental liabilities and obligations associated with the privatization of mining assets that are incumbent on GRZ, in particular the liabilities related to public health and safety. It will be funded through a loan from the International Development Agency (IDA) branch of the World Bank to the Government of Zambia. The CEP forms one of a series of measures funded by the World Bank, to facilitate the successful and sustainable privatisation of Zambia's mining assets.

1.2 BASIC CEP COMPONENTS

The proposed CEP will comprise the following three components:

Component 1 - Consolidated long-term Environmental Management Plan (CEMP). This component will focus on the preparation of a single EMP consolidating the individual EMPs prepared by investors and by ZCCM-IH for each privatized facility. The CEMP will determine the cumulative impact of mining activities outside of current mine license areas, including impacts on the Kafue River watershed, on critical ecological processes and on neighboring populations. It will establish the overall environmental management priorities within the broader context of environmental and social sustainability and indicate how these liabilities are to be addressed.

Component 2 - Establishment of an Environmental Mitigation Fund (EMF). The EMF will serve as a mechanism to fund environmental and social mitigation measures to mitigate the historical legacy of mining-related environmental degradation, based on the priorities set within the CEMP. Those measures that have high human health and safety implications will be given the highest priority.

Time-bound environmental and contractual obligations to investors of an environmental nature will also be given priority consideration.

Component 3 - Strengthening the regulatory framework for environmental management in the mining sector. The CEP will help ensure full compliance of the mining sector with national environmental regulations. For this purpose, the CEP will fund appropriate capacity building within ECZ, MSD and delegated agencies under the Environmental Protection and Pollution Control Act (EPPCA), as well as universities and recognized training and research institutions.

The CEP proposes that project activities be overseen by a steering committee to be chaired by the Ministry of Finance. The Committee would include the Ministry of Mines and Mineral Development, the Ministry of Environment, ZCCM-IH, the Environmental Council of Zambia, the Mine Workers Union of Zambia (MUZ), the Chamber of Commerce and Industry, the Chamber of Mines, local governments, and representation from nongovernmental organizations and academia. It will: i) ensure coordination between the different project stakeholders, ii) provide a forum for resolving issues related to the management of the environmental liabilities falling on GRZ, iii) ensure the necessary linkages with other related activities.

The decisions of the EMF will have to take into account the views and interests of all the stakeholders. For these purposes, the Government and ZCCM-IH will set up an entity that will be semi-autonomous of ZCCM-IH. This entity will have objectives, policies and procedures that are approved by GRZ and ZCCM-IH. The EMF as an organization will consist of an EMF Board and a Project Management Unit (PMU). The composition of the EMF Board would by and large be the same as the composition of the steering committee. The EMF Board would: i) ensure that the program of activities that will be carried out under EMF is consistent with EMF objectives and the policies approved by GRZ and ZCCM-IH, and agreed with the donors; ii) approve the specific proposals for all remedial activities to be financed by the EMF, and iii) oversee the activities of the PMU.

The PMU will consist of a small number of staff, headed by a Director, including environmental specialists, an engineer, an accountant, a procurement specialist, a communications specialist and a lawyer. The PMU and its staff would be accountable to the Steering Committee in its capacity as the EMF Board.

The detailed principles guiding the three components of the CEP were not fully defined at the outset of the EA. As a consequence, the document includes recommendations concerning the structure of the project based on consultations and observations during the field missions.

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[1] Other agencies may, however, participate; the ECZ has the power to delegate to other agencies such as the Mine Safety Department in the Ministry of Mines and Minerals Development.
[2] As stated in, World Bank (March 23, 2001) *Copperbelt Environment Project*.

1.3 OTHER RELATED WORLD BANK AND NON-WORLD BANK PROJECTS

The CEP fits within a broader World Bank strategy for assisting Zambia in the mine privatisation process. The privatisation of mines had implications beyond the environment sector (see Section 3.2). Some projects which address other areas of privatisation include:

- *Mines Township Services Project* (MTSP) (World Bank) – the purpose of the MTSP is to support the smooth transition of management of water, sewage and solid waste services from the former ZCCM to a private specialised manager and to improve the efficiency and sustainability of these services. The project covers a five year transition period following the privatisation. One focus of the project is to improve management of these utilities and this should include improved management of existing wastewater treatment facilities which discharge into the Kafue.

- *Economic Recovery and Investment Promotion Technical Assistance Credit Project* (ZM-ERIPTA) (World Bank – this project commenced in 1996 and is scheduled to close at the end of 2001. It supports the implementation of the Economic Recovery and Investment Promotion Reform Program and continues the implementation of reforms that were the focus of previous adjustment operations, namely the privatisation of parastatals and the reform of the legal framework governing business activity. The component of this project which is relevant for the CEP is the support to the Zambia Privatisation Agency and the technical assistance and training to strengthen the Ministry of Mines and Minerals Development (MMMD). Technical assistance to the MMMD should help the institution to oversee implementation of the new Mining Act by improving its geological database, its ability to promote the sector to private investors and its capability to administer and supervise the mining sector, including the small-scale miners.

- *The Public Service Capacity Building Program Project* (World Bank) – this project seeks to provide efficient, public service delivery processes, to facilitate economic growth and to reduce poverty. The component most relevant to privatisation are activities related to redundant staff and social safety net programs for civil servants who have been made redundant.

Within the environment sector, the CEP will complement and require careful and possibly formalised co-ordination with two other projects that share at least one of two common objectives: institutional strengthening of agencies implicated in the CEP (the Mine Safety Department and the Environmental Council of Zambia) and improved community involvement in environmental management and improved environmental education;

- *Environmental Management in the Mining Sector* (CANMET) (Canadian International Development Agency), – the project seeks to strengthen Zambian capacity to regulate, monitor and enforce environmental management of mining companies.[3] The main focus of the CANMET project is capacity building of the Mine Safety Department of the Ministry of Mines and Minerals Development. Secondary partners will include the Environmental Council of Zambia (ECZ), ZCCM Investment Holdings Plc and the Universities of Zambia and the Copperbelt.[4] The ECZ and ZCCM-IH are members of the technical committee which has been set up under CANMET the Zambian and Canadian governments. The technical committee will decide on utilisation of funds for some training needs.

- *Environmental Support Project* (ESP) (World Bank.) – The ESP supports national and community level improvements in environmental management, regulation and public awareness of environmental issues. The ESP will strengthen institutions and the legal framework for environmental planning and management, improve environmental education and public awareness (EEPA), enhance environmental information networks and monitoring systems (EINMS), provide a Pilot Environment Fund, promote community-based microprojects, finance studies and develop Community Environmental Management Plans in two pilot communities at the district level (including Mufulira in the Copperbelt). The ESP also serves as a tool for implementing the National Environmental Action Plan and the five main areas of concern (air pollution, water pollution and inadequate sanitation, wildlife depletion, deforestation and land degradation);

- *Zambia Social Investment Fund Project* (ZAMSIF) (World Bank Credit #3350) – this project supports two main strategic objectives of the Government of Zambia: 1) decentralisation and empowering local authorities to improve governance and efficiency in service delivery; and 2) increasing access to basic social services through direct poverty interventions. The Community Investment Fund component of the project, could potentially play a key complementary role with regard to the CEP (see Section 3 of Part III on Recommendations and Section 7 of Part II on rehabilitation options). The Community Investment Fund component consists of community-based small projects including social mobilisation, infrastructure, improved natural resources management, service delivery activities and capacity building for communities. The second component establishes a Direct Investment Fund, comprising larger projects benefiting more than one community to be managed and executed by district authorities and builds capacity and training for local governments and administrations. The third component, Poverty Monitoring and Analysis, funds data collection, training and capacity building on financial, technical and institutional issues and sponsors workshops and information dissemination. The fourth component finances institutional support for ZAMSIF, supplying administration and operating costs, assessments, poverty maps, training and capacity building.

[3] World Bank, PAD, November 16, 2000

[4] CANMET "Background for Komex," email attachment September 4, 2001

Other related projects include:

- *Water Resources Action Programme (WRAP)* (support provided by Norad, Ireland Aid, GTZ, The World Bank and the Government of Zambia) – the WRAP was formulated by the Ministry of Energy and Water Development to implement Zambia's National Water Policy (establishing a comprehensive framework to promote the use, development and management of water resources in a sustainable manner). The Programme's objective is to manage and utilise Zambia's water resources for maximum economic benefit in an equitable and sustainable manner with strong stakeholder participation. (MENR, WRAP pamphlet, c. 2001). The Programme includes a pilot analysis of the Kafue River Basin (including sources of pollution), with the eventual creation of a Kafue River Basin Working Group in one or two years' time which would include key stakeholders such as the mines, water and utility providers, Environmental Council of Zambia, river users and so forth.

- *IFC Konkola Copper Mines Plc (KCM) Investment* – the purchase and two-year rehabilitation program of the mining and processing facilities of the Konkola, Nchanga and Nampundwe divisions of ZCCM-IH.

- *Nkana Metallurgical Complex* (British Department for International Development, DFID) – this project finances upgrades to the SmelterCo smelter in Kitwe that should reduce atmospheric emissions from the smelter.

1.4 OBJECTIVES OF THE EA

The CEP has been categorised as an "A" project under World Bank guidelines and thus requires a full environmental assessment (EA) to be completed and disclosed prior to project appraisal. The overall objective of an EA is typically to ensure that actions proposed under a project do not cause negative environmental or social effects or that the proposed measures to mitigate any identified environmental and social impacts are appropriate and to ensure a level of public consultations and disclosure that complies with national environmental legislation and World Bank Safeguard Policies.

Unlike a traditional EA, this EA is not an evaluation of a specific set of investments since no specific set of investments has yet been proposed. It also does not represent a comprehensive environmental baseline. The EA is thus evaluating the extent to which the proposed CEP framework will ensure that all relevant and significant environmental and social impacts are taken into account when specific remediation actions are defined during project implementation. The approach of this EA is therefore to assess and make recommendations on, the process proposed under the CEP to ensure that it will support actions that are environmentally and socially sustainable. The EA will also place the project in its broader social and environmental context and will explore, in a generic way, the potential impact of different types of rehabilitation that might eventually be implemented under the CEP.

1.5 DOCUMENT LAYOUT

The EA is presented in three parts, each organised into chapters:

- *Part I: History and Context of the Copperbelt Environmental Project* – introduces the CEP; summarises the methodology used to carry out the EA; provides a project context, including information on the privatisation process; outlines ZCCM-IH environmental and social obligations; identifies institutional actors; and summarises relevant national environmental regulations and international agreements.
- *Part II: Current Overview of the Environmental Hazards* – outlines principles of risk-based approach; summarises mining processes, facilities and potential hazards; analyses risk from these hazards to people, animals and plants; identifies priority mine environment issues; suggests monitoring requirements and data gaps needing to be addressed; and outlines general environmental rehabilitation options.
- *Part III: Assessment of the Copperbelt Environment Project* – details regarding proposed actions, project alternatives, impacts and risks of proposed actions and participatory processes are provided. A summary of key findings and recommendations are offered.

Figures and photos are found at the end of Part III and in Annex D.

2. METHODOLOGY AND OVERALL APPROACH

2.1 STUDY APPROACH

Initially, the EA was prepared as a stand-alone document by Komex International Ltd. (Komex)[5]. A separate Social Assessment (SA) covering both social and health issues was contracted with a different team of consultants (S. Keener team leader, Dr. Guidotti George Washington University, J. Meagher of Intercet, Ltd. and Dr. Silengo of Copperbelt University). ZCCM-IH and the World Bank conducted an initial review of the draft EA. This review, combined with an initial scoping mission and consultations for the SA, highlighted the utility of combining the perspective of beneficiaries of the SA with the analysis of environmental issues in the EA; thus, it was determined that the two reports should be merged. Respective terms of references and addenda that address the combined approach are included in Annex A.

2.2 METHODOLOGY

Komex adhered closely to OP 4.01 protocols in the execution of the initial draft EA for the CEP. Particular attention was paid to the following specified aims and conditions:

- The EA must elucidate environmental risks and impacts in the project's area of influence. It must include an evaluation of project alternatives and recommendations for the improvement of design and environmental management planning.

- The EA must take into account the natural environment (air, water and land), human health and safety and social aspects (including resettlement). It must be consistent with national legislation, environmental action strategies and the country's overall policy framework.

The first draft of the EA of the CEP was completed in a period of 30 days with effect from 31st March 2001. Given the limited time period, the focus of Komex's initial draft EA was based largely on review of existing documentation, supplemented by site visits and interviews carried out between March 22 and April 5, 2001.

[5] Komex has exercised reasonable skill, care and diligence to assess the information acquired during the preparation of this report, but makes no guarantees or warranties as to the accuracy or completeness of this information. Komex does not accept any responsibility for the use of this report for any purpose other than that stated in Section 1.1 and bears no responsibility to any third party for the use, in whole or in part, of the contents herein.

The EA exercise described in this volume has involved the analysis of approximately 7000 pages of information previously compiled by ZCCM-IH, private minerals sector investors and their contracted consultants. All citations of pre-existing information are included in this report following due evaluation by Komex International Ltd of the credibility and validity of the source. Komex International Ltd cannot, however, bear ultimate responsibility for technical or scientific inaccuracies, which may have arisen from the correct citation of such material. Any questions concerning the information or its interpretation should be directed to Mr. Frederic Claridge, Komex International Ltd.

Both the EA and the SA teams reviewed the substantive written information made available by ZCCM-IH and other, including Environmental Management Plans (EMPs) for each of the eleven former ZCCM operations in the Copperbelt. As part of the preparation for mine privatisation, these EMPs were commissioned by ZCCM between 1996-1998, were prepared by SRK Consulting and were part of a component of wider Environmental Impact Statements (EISs) for these sites. In addition, the respective teams reviewed EMPs and Social Management Plans (SMPs) that were prepared by KCM and a baseline environmental document on Mufulira prepared by MCM. Audits of dump facilities completed between 1998-2001 by Knight Piesold were also reviewed. This was supplemented by review of the relatively limited number of available independent studies that have been completed to date (a full list of references is provided at the end of the report).

During Komex's two missions to Zambia (March 22-April 5 and October 9-October 30, 2001), a representative sample of Copperbelt sites and the town of Kabwe were visited to gain a perspective of the information presented in the EMPs from 1996-1998. Field observations were noted and incorporated into the EA; however, systematic audits (environmental or compliance) of the sites were beyond the scope of this EA. Site visits focused on those areas with a potential to be eligible for funding under the CEP (likely to fall under ZCCM-IH responsibilities); thus, sites where private investors took on all the liabilities, such as at Bwana Makubwa, were not visited.

The SA took place during two missions, a scoping mission (May 3 to May15, 2001) and a field mission (June 29 to July 21, 2001). In addition to an extensive review of documentation as noted above, the SA team held discussions with a wide number of stakeholders and NGOs at the national, provincial and district levels. Based on the scoping mission, the SA identified key stakeholders likely to be directly affected by the project and then key informant interviews and focus group discussions were held with the groups identified:

- residents downwind of smelters
- residents in neighbourhoods which may have high levels of contaminants in Kabwe
- fishermen, residents and farmers along streams receiving mine effluent
- scavengers on mine sites
- squatters on mine sites
- farmers on mine sites
- fishermen on tailings dams
- residents adjacent to mine sites

Given the large number of potential sites (over 150), the SA focused on identifying case studies of the types of situations likely to be encountered at mine sites under the CEP. These case studies used the discussions noted above, supplemented by sites visits, discussion with persons encountered at sites and then gathered available data (often not complete) on the actual level of contamination at the selected site. The SA focused on: (i) sites which were likely to have the most proximity/potential impact on people; (ii) sites which had been identified as causing the most potential environmental harm; and (iii) sites that were more likely to be eligible for funding under the EMF component of the CEP (possibly falling under ZCCM-IH's list of responsibilities) The SA team visited about 20 mine sites and held numerous discussions with individuals or groups in the categories outlined above. The SA team's toxicologists also compiled a preliminary review of available data (and gaps) that would indicate the potential for health risk from different mine pollution sources.

2.2.1 CONSULTATIONS

World Bank Operational Policy 4.01 requires the borrower to consult project-affected groups and local non-governmental organisations (NGOs) about the project's environmental aspects and take their views into account during the EA process. For Category A projects such as the CEP, the borrower is required to consult these groups at least twice: (a) shortly after environmental screening and before the terms of reference for the EA are finalised; and (b) once a draft EA report is prepared.

As noted above, numerous consultations with individuals and communities were carried out as part of the SA, which was initiated following the first phase of the Komex EA. These consultations and feedback resulted in the amendment to the EA and additional work to focus on those issues that were of most concern to the population. A complete list of consultations and sites visited for both the EA and SA is included in Annex B.

More formalised group meetings of stakeholders to discuss the design of the CEP, however, were postponed until after the issuance of this EA. Effective consultations require that stakeholders have access to background information on the health and environmental impacts of the different sources of past pollution; however, based on the results of the first scoping mission, there was insufficient test data to determine the full human impact of some of these sources of pollution and even less public awareness of the impact. It would therefore be misleading to initiate a series of public discussions about the project priorities until better data was available to stakeholders and until they have had adequate time to review this information. This EA cannot replace a complete baseline, but it will provide the state of current information and information gaps upon which the project design will be based and therefore will serve in some measure to provide the necessary background information to stakeholders.

This EA also includes recommendations on the consultative process which will be key in the formulation of effective CEMPs and, as noted above, on the involvement of communities in the EMF component of the CEP. Zambian regulations on disclosure and consultation in Environmental Impact Statements for specific investments would need to be carefully followed and have been summarised in Annex C.

2.2.2 WORLD BANK SAFEGUARDS COMPLIANCE

Because activities to be funded under the EMF cannot be specified in detail prior to the establishment of the fund, the setting of priorities and the fuller investigation and selection of remedial measures, the EMF will need to set in place a process for environmental and social review of any activities selected for funding under the CEP credit in order to ensure compliance with WB Safeguard Policies. Remedial activities undertaken by the EMF will typically need an environmental assessment in compliance with OP 4.01, Environmental Assessment; in some cases OP 4.12, Involuntary Resettlement, OP 4.37, Dam Safety, OP 4.09, Pest Management, or OPN 11.03, Management of Cultural Property, may be triggered. The triggering of other safeguard policies, e.g., Natural Habitats, cannot be ruled out, but seems less likely, based on the information gathered for the CEP EA.

2.3 EA TEAM COMPOSITION

The EA team comprised of permanent staff of Komex International Ltd, supplemented by contracted personnel from the Kitwe-based NGO, Citizens for a Better Environment (CBE). The principal consultants included:

- A project leader/EA expert.
- A hazardous waste specialist.
- A hydrologist/water quality specialist.
- A social scientist.
- A remediation specialist.
- A risk assessment specialist.

Technical support was provided by a local team of EA, metallurgical and mining engineering specialists with an extensive knowledge of the Zambian Copperbelt.

The SA team included the following:

- A team leader/Social Assessment Specialist
- A local sociologist with expertise in social issues in the mining sector (Copperbelt University) [6]
- International Health/Toxicology Specialists (George Washington University, Intercet Ltd.)

Secretarial and research support was also contracted locally.

[6] The local team leader was Dr. Mitulo Silengo, Copperbelt University. He supervised Roy Chileshe, Copperbelt University and Rhoda Chambatu.

Team leaders of each team were:

Environmental Assessment: Fred Claridge Komex International Ltd. Calgary, Canada	Social Assessment: Sarah Keener Washington, D.C.

3. PROJECT CONTEXT

3.1 NATIONAL CONTEXT

Zambia has a population estimated to approach 10 million, living in an area half the size of Europe. It is considered a low income country, with a GDP per capita (1998) of US$330, below the Sub-Saharan average of US$480 per capita. Average economic growth rates during the 1990s were very low – about 1%, the lowest in the SADC region.

Some 85% of Zambians work as subsistence farmers. Throughout the post-colonial period copper mining has formed the backbone of the Zambian economy, accounting during the 1970s and 1980s for over 80% of the foreign exchange earnings and 15% of GDP. In the past decade, however, employment in this sector has declined with reduced ore production. Low macroeconomic growth stems primarily from low production and low prices in the copper mining sector. It is now expected that the recent privatisation of the mines will lead to increased copper production, contributing to macroeconomic growth and employment creation (and thus potentially to increased emission of pollutants).

Although the majority of mines in Zambia are copper mines located in the Copperbelt, there are also small scale gem mines, a lead mine in Kabwe and a few copper mines outside of the Copperbelt region including the future Lumwana copper project in North-western province and Nampundwe near Lusaka. In addition to industries serving miners, other sources of employment include agriculture and tourism, which have been identified as potential future growth sectors if the country manages to diversify its economy away from mining.

The most recent income/expenditure surveys (1998) reveal that 73% of the population fell below the poverty line and about 58% fell below an extreme poverty line. Zambia is the most urbanised country in Southern Africa outside of South Africa. A large percentage of the poor are concentrated in urban areas with the largest proportion (18% of the total poor) located in the most populated region, the Copperbelt. In urban areas, about 56% of the overall population falls below the poverty line.

3.1.1 OVERVIEW OF THE COPPER INDUSTRY IN ZAMBIA

Prior to Zambia's political independence, the Anglo American Corporation owned the mines. A few years after independence (1967), the mines were nationalised and the parastatal, Zambia Consolidated Copper Mines (ZCCM) was created.

The Copperbelt's mines have a theoretical capacity for the production of at least 750,000 t/y of copper, a figure reached in 1970 immediately following the industry's nationalisation. Subsequently, production has declined progressively due to under-investment, the use of inefficient and outdated technology and the exhaustion of low cost ore reserves. In 1999, production fell to below 300,000 t/y for the first time since the 1960s.

The impact of declining production on the Zambian economy was compounded during this period by falling copper prices and the country's diminishing influence within the global commodity market. In 1969, Zambia was the largest copper producer in the developing world and the third largest globally (after the United States and the former U.S.S.R), controlling 12.2% of world supply. Technological advances which facilitate the exploitation of high tonnage/low grade ores, have since radically altered global patterns of copper exploration and production. Over 60% of world supply is now derived from systems of north and Latin America and the eastern Pacific Rim.

The poor economic performance of Zambia's copper mines during the period 1970-1999 undoubtedly exacerbated their environmental impact. Against a background of marginal viability, further losses of competitiveness through pollution abatement expenditure were resisted by ZCCM.

Under public ownership, the mining industry was often used to pursue non-commercial objectives of government, including employment maximisation, the provision of a broad array of social and municipal services to mine communities and uneconomic investment choices. When the world price of copper fell, the government was unable to adjust the social services provided by the mines to reflect this drop in income and thus the capital available to update mining technology (including environmental technology) declined and production deteriorated. In response, the industry began to consider the option of privatisation starting in early 1990s. In 1991, privatisation of the copper industry formed a central issue in Zambia's first post-colonial multi-party elections. It was argued that private ownership would scale down the government's direct initiative in economic activities and correspondingly its administrative load. It would also reduce government's budgetary costs (and eventually its mounting debt) arising from subsidies and capital expenditure. One of the major anxieties resulting from privatisation has been the concern with loss of employment by workers and loss of a wide range of free or subsidised social services both by employers but also by other residents who indirectly benefited.

In 1995, a tender process for the purchase of mining and ore processing facilities was initiated, with all installations offered on an individual basis. Important ownership transfers occurred in 1999 and 2000. Anglo American (via the corporation's Zambian investment arm, Zambia Copper Investments Ltd) acquired the Nchanga, Nampundwe and Konkola mines, now operating under the umbrella of Konkola Copper Mines (KCM). This transfer involved an immediate cash payment to the GRZ of US$ 30 million, plus a deferred consideration of US$ 60 million. Anglo American have additionally pledged to invest US$ 208 million in facility modernisation by 2003, plus the independent investment of US$ 523 million to develop the 55 million ton Konkola Deep copper deposit. KCM now manages the Nkana smelter, trading as SmelterCo, with an option to purchase in 2005. The Nkana and Mufulira mines were purchased by Mopani Copper Mines (MCM), with First Quantum and Glencore providing the major investment.

ZCCM-IH remains a minority shareholder in the privatised mines with the shareholding ranging from 10 to 20%. The main objective of ZCCM-IH is monitoring investment in accordance with prior agreements and meeting environmental obligations resulting from pre-privatisation activities.

A summary of the principal state to private sector transfers effected prior to December 2000 is provided in Table 3.1.

Table 3.1: Zambian Mining & Mineral Processing Facilities: Status of Holdings (December 2000)

MINE/FACILITY NEW LICENSE (OLD)	ACTIVITY	OWNERSHIP	OPERATING NAME	NEAREST MUNICIPALITY
Bwana Mkubwa LML 19	Tailings feedstock	First Quantum	Bwana Mkubwa Mine	Ndola
Chambishi 1 LML 30 (ML 19)	Cobalt Plant (plus Nkana slag feed)	Avmin, ZCCM-IH 10%	Chambishi Metals plc	Chambishi
Chambishi 2 LML 30 (ML 19)	Underground mine (under modernisation)	China Non-Ferrous Metal Corp. ZCCM-IH 15%	NFC Africa plc	Chambishi
Mufulira LML 32 (ML 15)	Underground mine and smelter	First Quantum/Glencore ZCCM-IH 10%	Mopani Copper Mines (MCM)	Mufulira
Nkana 1 LML 37 (ML 3)	Underground mine	First Quantum / Glencore ZCCM-IH 10%	Mopani Copper Mines (MCM)	Kitwe
Nkana 2 LML 37 (ML 3)	Copper smelter & process plant	ZCCM-IH (with KCM management and 5 year purchase option)	SmelterCo.	Kitwe
Ndola Lime (ML 8)	Lime quarrying	ZCCM-IH 100%	Ndola Lime Company Limited	Ndola
Chibuluma LML 24 (ML 18)	Underground mine	Metorex	Chibuluma Mines	Kalulushi
Roan Antelope LML 08 (ML 16)	Underground mine	Binani Industries* ZCCM-IH 15%	RAMCOZ	Luanshya
Baluba LML 09 (ML 17)	Underground mining	Binani Industries* ZCCM-IH 15%	RAMCOZ	Luanshya
Kansanshi (ML 11)	Open mine pit	Phelps Dodge**, ZCCM-IH 20%	Kansanshi Copper – Gold Deposit	Kansanshi and Solwezi
Konkola LML 03 (ML 7)	Underground mine	Anglo-American (ZCI) IFC 7.5%, ZCCM-IH 20% Com. Dev. Corp 7.5%	Konkola Copper Mines (KCM)	Chililabombwe
Nchanga LML 05 (ML 10)	Open pit mine	Anglo-American (ZCI) IFC 7.5%, ZCCM-IH 20% Com. Dev. Corp 7.5%	Konkola Copper Mines (KCM)	Chingola
Nampundwe (ML 2)	Underground mine	Anglo-American (ZCI) IFC 7.5%, ZCCM-IH 20% Com. Dev. Corp 7.5%	Konkola Copper Mines (KCM)	80 km from Lusaka

* *Is currently in Receivership*

** *First Quantum Minerals Ltd. is working toward a timely execution of Definitive Agreement in regard to the acquisition of Phelps Dodge's interest.*

3.1.2 PROJECT AREA

Sites within the Copperbelt and Kabwe regions will be eligible for funding under the EMF component of the CEP and thus represent the project area for this component (Figure 1). The process for ranking which sites receive funding is discussed further in Section 5.1 of Part II, though the final definition will be developed under the project.

3.1.3 OVERVIEW OF THE COPPERBELT

The Copperbelt covers an area 150 km by 50 km close to Zambia's northern border with the Democratic Republic of the Congo (Figure 1).

3.1.3.1 Local Population

The current population of the Copperbelt is estimated to be 1.6 million (CSO, 2001) or about 15% of the total Zambian population (Table 3.2). A majority of the population on the Copperbelt is still dependent on mining and its related activities.

Table 3.2: Population in the Copperbelt

Town	Population (2000)
Kalulushi, Chambishi	72 765
Lufwanyama	65 804
Chililabombwe	84 866
Masaiti	97 712
Mufulira	152 664
Luanshya	155 979
Chingola	177 445
Kitwe	388 646
Ndola	393 793
Copperbelt	**1 589 674**

Source: CSO, 2001

In the last year the Copperbelt has witnessed revitalisation in economic activities focused on mining. Copper production has increased and industries supplying goods and services to the mines have been enjoying timely payments whereas in the last few years under ZCCM-IH they were often caught up in liquidity problems of ZCCM-IH. This is also true in the hotel and allied hospitality business which has benefited from an influx of both Zambian and foreign investors wishing to do business on the Copperbelt.

The distribution of the benefits from increased economic activity, however, is very uneven among Copperbelt towns and between different institutions. Towns such as Kitwe and Chingola have benefited by serving as headquarters for some of the new companies and other towns such as Chililabombwe are expected to benefit substantially in the event of mine expansion. In Luanshya, in contrast, the company that purchased the mine has gone into receivership; this poses major economic hardships for the town and has resulted in a marked decline in environmental management at the mine. Municipalities and public employees have not benefited directly from the increased income from copper mining.

3.1.3.2 Physical Environment

The Zambian Copperbelt has three distinct seasons: winter months of May to July are generally cool and dry, with mean daily temperatures of around 20°C and gross rainfall of below 150 mm; August to October is characterised by hot, dry conditions, with maximum temperatures around 36°C; and the wet season typically occurs from November to April, when over 90% of the region's mean annual precipitation of 1350 mm falls. The predominant wind direction is from the north-east (thus producing a net atmospheric contaminant plume to the south-west), with maximum speeds of about 30 m/sec in the summer months and 22 m/sec in the winter.

Several vegetation types can be found in the Copperbelt, including closed forest, open forest with grassland, termitaria and grasslands. The baseline reports for the former ZCCM mining license areas refer to the presence of Miombo and Acacia woodland and grasslands, but habitats are not described clearly in the form of vegetation associations or communities. Comprehensive faunal inventories are lacking for the Copperbelt; however, an evaluation of wildlife suitability on the mine license areas indicates that game ranching has potential at many of the mine sites.

Approximately 90% of the region is drained by the Kafue River and its tributary network (*e.g.*, Kakosa stream at Konkola, the Mushishima stream at Nchanga, Mufulira stream at Mufulira) (Figure 2). The Kafue River bisects the Copperbelt in a south-southeasterly orientation, rising from headwaters close to the Congo border, approximately 100 km upstream of the Konkola Division. Discharges affected by mining occur along an 80 km length of channel extending from Konkola to Luanshya stream.

See Annex D for detailed information regarding the physical environmental setting and Section 2 of Part II for information on Copperbelt geology. Archaeological information is detailed in Annex E.

3.1.4 OVERVIEW OF KABWE

Kabwe, a town 180,556 persons (2000), is strategically located at the centre of the country at the crossing of the road leading to the Copperbelt and just north of the road connecting Eastern and Western Zambia. As the major town in Central Province, Kabwe continues to attract in-migration. This has resulted in some of the largest unplanned settlements in the country (Makululu for example). These townships consist of both new residents and established residents, including retired and redundant miners, who have rented out their homes in the planned settlements in order to generate income.

The economy of Kabwe, although much reduced, is somewhat diversified. Other than the remaining small-scale mining activities, the main economic activities include agriculture (cotton and food crops), a textile company that is a Zambian-Chinese joint-venture, Zambian Railways, breweries, Kabwe Industrial Fabrics and various retail establishments.

Government services have been deeply scaled back, especially in the first six months of 2001, because of budget constraints leading to suspension of pay for provincial and municipal employees and a resulting strike. When the lead mine closed in Kabwe, the Kabwe Municipal Council (KMC) responsibilities expanded to cover the provision of water supply, sanitation, solid waste, malaria control and other services to former mine townships with no institutional support to change cost recovery, rate collection for new house owners or tariffs to match the changed role of the KMC. KMC has not received its allocation from central government (in 1998 for example it was supposed to receive about K54 million but only received K29 million). KMC has had difficulty providing adequate services. It is thus not surprising that in discussions with various stakeholders, the absence of adequate water, sanitation and sewage treatment emerged as a top priority.

Environmental health problems related to poor water supply and sanitation are particularly severe in Kabwe as was evident in the cholera epidemic during February and March of 2001; during this period, there were 744 cases in the area, compared to 1474 cases in Zambia overall. The cause of the epidemic was multifactoral: a blocked sewer system overflowing into the water supply source (which was not monitored due to a strike resulting from suspension of payment of municipal employee wages, combined with excess rainfall, a dam spill and disabled pumps, overwhelmed the drinking water disinfection system). This was not an isolated event. An investigation of a cholera outbreak in January 2000 determined that some water sources tested in Kabwe, including reservoir water intake, wells and water works, were positive for fecal coliforms, except for the actual site of chlorination (according to the Kabwe Provincial and District Health Management Teams). The root cause of this problem, underlying the infrastructure failure, is reduced income, which reduced revenues for municipal rates needed to support public health services and the water and sewer services.

The sewage treatment plant previously operated by ZCCM is no longer functional. Raw sewage is currently discharged directly into the drainage canal. The smell of sewage is periodically prevalent downstream of the dambo, according to local residents and is persistently noticeable in communities close to the site (*e.g.*, Chowa).

This impoverished infrastructure for environmental health is reflected in the following indicators: Only 50% of the population has access to safe water; 65% are using flush toilets, 30% use pit latrines and 5% defecate on the ground. Consistent with this, analysis for coliforms in three samples of tap water from Kabwe in 9 January 2001, just before the circumstances that led to the cholera outbreak, showed positive fecal coliforms.

Following closure of the mine, the KMC did not take over adequate malaria control. As in the Copperbelt towns, malaria remains a leading cause of death.

Lead mining in Kabwe has left a host of environmental problems which pose a significant threat to health. Since closure ZCCM-IH has had a program of environmental mitigation in place which has included some testing and treatment for individuals affected by lead poisoning. However, this program has not received adequate funding. ZCCM-IH is trying to identify walk-away solutions for environmental hazards on the site because security on site cannot be maintained and attempts to restrict access have been compromised by theft of signage and fencing materials. Rehabilitation issues are further discussed in Section 7 of Part II.

3.1.4.1 Physical Environment

Kabwe is situated about 130 km north of Lusaka and provides a strategic linkage between Lusaka and the northern region, including the Copperbelt, Northern and Luapula Provinces. The terrain of the Kabwe area is generally a gentle relief and is approximately 1180 m above sea level.[7] Streams to the west and southwest drain to the Kafue catchment while those to the north and east drain to the Lunsemfwa.[8] Surface drainage from the Kabwe Mine is mainly into the Mine Canal, which flows eastwards towards the Muswishi River into the Lunsemfwa drainage.[9]

The mean annual rainfall for Kabwe is about 900 mm and occurs mainly during October to May. Temperature averages range from 14 to 27C. The prevailing winds in the Kabwe area are from the south east to the northwest, with an average windspeed of 52 m/s.[10] (See Annex D for additional baseline information.)

Information was not available regarding archaeological sites within the Kabwe Mine area.

3.1.5 OVERVIEW OF LEAD AND ZINC MINING AND MINERAL FACILITIES (KABWE)

The Kabwe mine complex is located in the town of Kabwe, 130 km north of Lusaka. The Kabwe Mine commenced operation in 1904 and ZCCM mining operations ceased in 1994, prior to the wave of other privatisation in the mining industry. Over the years, the complex expanded to include open cast and underground mine workings, mineral processing, smelting and refining, hydroelectric power generating plants, townships and associated facilities.

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[7] ZCCM-IH, 1995.
[8] ZCCM-IH, 1995.
[9] ZCCM-IH, 1995.
[10] ZCCM-IH, 1995.

Since ZCCM operations ceased, most of the mine complex and facilities have been sold to private investors. The mine complex facilities were sold in pieces to a total of 13 businesses and individuals. One of the larger investors, Sable Zinc, has taken over waste dumps, leach residue and tailing materials to reprocess for zinc recovery. Most others are apparently using the mine to sell scrap metal. Some new investors have misused their assets because conditions were not stipulated in the sales agreements specifying the types of allowable land use on the premise (*i.e.*, residential or industrial). One investor has turned the former mining department offices and shift boss' offices into residential plots (Kabwe Mine Site Rehabilitation and Decommissioning Plan Progress to June 2001, ZCCM-IH). (see Sections 4 and 7 of Part II for more detail on Kabwe).

3.2 CHANGES IN THE COPPERBELT SINCE PRIVATISATION

Within the past two years, social, economic and environmental conditions in the project region have changed substantially. Many of these changes have affected overall environmental conditions, as well as the nature of challenges that will face those trying to remediate past mine pollution.

3.2.1 ZCCM-IH'S REDUCED ROLE

Prior to privatisation, ZCCM provided services within designated "mine" townships that might elsewhere fall under the rubric of municipalities (water supply and sewage, solid waste collection, road maintenance, subsidised medical care and medical facilities, fire departments, schools, free housing, malaria control, social services, scholarships, sports and recreation clubs, playgrounds, community clubs, maintenance and cutting of grass in public areas, mealie meal to miners' families). With the exception of Ndola, a dual administrative and service structure developed in each town: mine townships and their related infrastructure services and administrations and Council townships. Although statistics are not available for all towns, between a third and a half of the population in all towns except Ndola lived in mine townships (though a far greater percentage of the population is dependent, directly or indirectly on the mining sector). The ZCCM welfare system spilled over into non-mine areas as well; local authorities and their constituents benefited from property rates from the mines, from road maintenance that ZCCM would not restrict to mine areas, from assistance with solid waste collection, from malaria spraying in both mine and non-mine areas and from referrals to better-quality ZCCM run medical facilities. The central government also had access to cash revenue from copper sales (though it was accumulating debt) to subsidise other parts of the economy when the industry was performing well.

With privatisation of the mines has come a significant economic and social adjustment both for miners, for municipalities and for the role of ZCCM-IH. ZCCM-IH shrank from a total employment level of 62,222 in 1977, to 24,252 in 1999. ZCCM-IH no longer exists in its previous structure and purpose. It has been re-organised into ZCCM-IH (employs 30) and the Asset Holding Company for Mine township Municipal Services (AHC-MMS) (employs 300). Miners are now employed directly by the private mines.

Services ZCCM-IH used to provide have now been either:

(1) transferred to municipalities;
(2) transferred to central government ministries;
(3) privatised or taken over by the new mine companies; or,
(4) closed or simply no longer provided.

New mine owners want to focus again on revitalising the core business, mining and avoid becoming a social services provider.

3.2.2 REDUCED SOCIAL CAPITAL IN EX-MINE TOWNSHIPS

Solutions to remediation of mine sites that involve community participation will need to be designed around the characteristics of communities in the area of the sites.

Prior to privatisation, ZCCM's community service departments, located in each mine township, dealt with service and social problems that would arise, thus obviating the need for most community based organisations or local government councillors. In formal housing mine townships, households had little need to co-operate with one another to improve services and thus there is very little experience with co-operative initiatives. During community consultations on water in 1999, it was clear that in the mine townships residents in all but the lowest income areas did not want to participate in any water billing system which required them to depend on or co-operate with neighbours, even if it meant that they could pay a lower bill. The local churches were one of the only other community organisations in these areas. Since privatisation and the disengagement of ZCCM community services, there have been a few efforts in some areas to create neighbourhood associations, known as Resident Development Committees (RDCs). However, the "social capital" or social networks of co-operation and support, that exists in many informal housing areas in the Copperbelt is significantly lower in formal housing areas of the region.

3.2.3 FROM UNIFORMITY TO INCREASED SUB-REGIONAL VARIATIONS

Under ZCCM all the mines located in different towns worked as parts of one interdependent corporation. Copper from Chililabombwe or Nchanga would be sent to a smelter in another town such as Mufulira. Similarly, Kalulushi served as a residential community for many of the former ZCCM managers working in Kitwe. Ndola, though not as dependent on ZCCM because of a lack of separate mine residential areas, has numerous businesses, consulting firms and engineering firms that service the mining sector throughout the region. Corporate policies regarding health, education, housing and services historically were also uniform from one mine town to the next when the mines were owned by one corporation, whether private or parastatal. Now each community and local government must respond to the policies of the current owners and thus variations among towns are likely to increase.

Since privatisation, the interdependence of the private sector has continued. However, policies towards water supply, malaria spraying, security, mine involvement in services, employee compensation and even environmental management have all been decentralised down to the level of the municipality or to the level of the mine company. Therefore, the types of services to be found in specific towns, the economic health of the mine and thus of the town, the approach to environmental management and to corporate responsibility is becoming increasingly varied and diverse within the region.

3.2.4 COST RECOVERY

Prior to privatisation, rent, utilities, education, health care and some food were largely provided by ZCCM rather than billed to or paid for by miners at the point of service. During the transition to privatisation and separation of services, many mine owners agreed to deduct rates and utility payments directly from miners' salaries, in order to provide a steady revenue flow to the municipalities and utilities. However, the trend is away from such deductions, as mine companies are wary of bearing the workers' ire when rates or tariffs increase. According to the District Administrator in Chingola, KCM will no longer deduct municipal rates after July 1, 2001). Thus, municipalities and utilities will quickly need to develop systems and personnel to collect property rates and utility tariffs and promote a change in the culture under which these services were provided in kind as part of the fringe benefits of their salaries.

3.2.5 HOUSING

Prior to privatisation all housing in mine townships, services and maintenance were the responsibility of the mine. Upon retirement at age 55, miners would typically move back to their rural place of origin to make room for new miners to live. Housing represented a major benefit of employment, with higher ranking miners being placed in larger better equipped houses.

With the privatisation of the mines, most sitting tenants in mine housing were offered the purchase of their housing out of the accounts they had built up for retirement. Most purchased their houses, as it had become much more difficult than in earlier generations to move back to their villages of origin. Some tenants became owners, only to discover that they could not afford the services such as water and sewerage, which had been "free" before. As a result, some ex-miners are moving out of their purchased houses to less expensive quarters, renting out their houses to anyone who can afford the rates. As a result, it is likely that miners will no longer have an incentive to settle only in ex-mine townships. Similarly, many miners who were retrenched have rented out their houses and moved to less expensive houses to maintain. Thus, over time, it is likely that the Council area will have miners and that ex-mining areas will have non-mining residents. According to a social assessment survey carried out in 1999 as part of the Mine Township Services Project, the ex-mine townships were still largely composed of miners as shown in below:

Table 3.3: Composition of Mine Townships in Selected Towns

	% Miner	% Ex-Miner	% Non-Miner	Total Housing

	Occupied	Occupied	Occupied	Units
Nchanga	80%	18%	2%	5,786
Konkola	72%	23%	5%	4,767
Mufulira	46%	19%	35%	9,596
Nkana	83%	13%	4%	6,768
Luanshya	62%	3%	35%	9,519
TOTAL	66%	14%	20%	36,436

Source: AHC/ZCCM/Roan Antelope Mining Corp.

In some cases (as in Kankoyo in Mufulira and Wusakile in Kitwe), miners have become more aware of health problems related to mine pollution from smelters and have moved and rented their homes out to non-miners. Thus, the majority of residents in Kankoyo township are said to be unemployed non-miners.

3.2.6 WATER AND SEWERAGE SUPPLY

The provision of clean reliable water and sanitation services has consistently emerged as a top priority among Copperbelt residents in household surveys and even in discussions with residents during the field work for the social assessment.[11] Prior to privatisation a dual system of water and sewerage provision existed for mine townships and for council townships. In mine townships, ZCCM ran the utility as well as solid waste collection and disposal services and in council townships the local authorities managed water and sewer services directly. In a few selected cases there was overlap between the two systems where the council authorities purchased bulk water from ZCCM (in Kitwe) or where mine areas were serviced by the councils; however, for the most part these exist as two distinct systems, each with its own water sources and sewage treatment plants.

New mine owners did not want to take over water and sewer provision. With the assistance of MTSP, water and sewer assets were transferred to the AHC (Asset Holding Company) and management was contracted to an experienced private water and sewer operator on a performance basis. In parallel, in non-mine townships local councils created Commercial Utilities (CUs) in an effort to improve the poor management and maintenance of recently rehabilitated water and sewer systems.[12] Previously water and sewer revenues went directly to the local Councils and were not completely reinvested in the management and maintenance of the systems; as a result management and maintenance of the systems deteriorated, leading to poor environmental management and numerous non-functioning sewage treatment plants contributing to pollution in the Kafue.

[11] See Structure Plans for Ndola, Luanshya by Scott Wilson in 1999 and Consumer Assessment for Water and Sewer Services in the Copperbelt, 2001 and Social Assessment Survey, MTSP.

[12] Under the Urban Restructuring and Water Supply Project water and sewer infrastructure in many Copperbelt towns was rehabilitated (URWSP). The World Bank supported MTSP supports an assessment of options on how to integrate these dual CU-AHC systems at the end of the private manager's contract, in order to diminish the fragmentation and duplication inherent in having dual systems in many towns.

The best available estimates show that, on aggregate, about half of all Copperbelt domestic consumers rely on CUs and half rely on AHC-MMS for water and sewer services, although reliable data on customer numbers is difficult to obtain, particularly in CU areas (for specifics see Annex Q on Additional Social Assessment Data). [13] Thus, a total of four utilities provide service in the Copperbelt, complicating the task of reducing non-mining sources of water pollution to the Kafue.

- AHC-MMS (ex-mine townships in the Copperbelt)
- Mulonga Water and Sewerage (covering Council townships of Mufulira, Chingola and Chililabombwe)
- Nkana Water and Sewerage (covering Council townships of Kitwe and Kalulushi)
- Kafubu Water and Sewerage Company (covering Council townships of Ndola, Luanshya and Masaiti).

Water and sewer utilities in the Copperbelt will continue to face financial (and therefore operational) constraints even with the planned management reforms. These constraints stem from the mismatch between income levels in the region and level of service provided to consumers; unmetered flat tariff rates also exacerbate this problem by failing to provide any incentive for water conservation. Levels of consumption among high cost households in the Copperbelt exceed the design standard by a factor of two, at over 593 litres/capita/day whereas an affordable level were all costs to be charged would be 134 l/c/d for a high cost household. These levels of consumption also exceed design standards (though by a much lesser degree) for low cost households and are well in excess of other African averages. In comparison, internationally recognised recommended levels of water consumption per capita range from 20 to 30 litres.

Because water and sewer services were heavily subsidised both by ZCCM and by local authorities (through the indirect non-payment of ZESCO electricity bills), both utilities have or will be increasing tariffs. Within the framework of the MTSP, low income consumers will face only a minimal tariff increase while in council areas some providers have been sharply increasing tariffs even to low income consumers. Unless demand management is introduced, it is likely the sector will continue to encounter constraints to expanding service to new areas such as peri-urban or informal settlements or to properly maintain or expand sewage treatment plants, thereby limiting their pollution of the Kafue.

3.2.7 SOLID WASTE DISPOSAL

Insufficient solid waste disposal in the region may contribute to disease and to localised air pollution. Solid waste disposal services for mine townships were taken over by the AHC-IHMMS and had been under contract to several private operators. There have been reports of problems with some of the

[13] Information on the number of standposts was not available for all CUs so this data has been excluded from the calculation of customers served. Were this included, there would likely be a greater number of customers served by the CUs than by AHC-MMS. In addition, there may be more customers in CU areas than these calculations show as the CU areas tend to have more standposts which serve a larger number of people

contractors and as a result there are several areas (Kankoyo in Mufulira is one) where solid waste has accumulated in residential areas. Some high cost residents have hired private contractors to haul waste though some of these contractors dump illegally on uncertified sites, such as TD25 in central Kitwe. In Council areas, the municipalities have always had responsibility for solid waste collection. Due to financial problems within the last year, many municipalities have had a difficult time keeping pace with solid waste collection. . According to a survey in 1999 (Scott Wilson), a majority of residents dump their refuse into the yard or a nearby ditch. In low income areas, a significant percentage (over 40%) burn their refuse, contributing to local air pollution that was evident during many SA site visits. In high income areas people have started to contract with private firms to collect refuse. The SA team witnessed some refuse collectors illegally dumping on ZCCM tailings sites which were adjacent to residential areas; this creates a local environmental nuisance.

3.2.8 HEALTH CARE

Populations in poor health may be more susceptible to the effects of a given exposure to environmental toxins. The spread of HIV/AIDS over the last decade and the resulting morbidity and mortality is placing a substantial burden on the health sector in the Copperbelt as elsewhere in Zambia, as well as having a far reaching impact on all sectors of the economy. The epidemic has been associated with an increase in TB prevalence in Zambia. In 1997, adult HIV prevalence was estimated at 19.07 per cent of the population aged 15-49, with a total number of 770,000 people estimated to be infected regardless of age. This is roughly in the same range that was found by KCM in an employee testing program.

Prior to privatisation, ZCCM ran some health care facilities in each of the towns. These were provided at low or no cost to miners and served an important function as a referral hospitals to the public sector with some of the best quality and best equipped health facilities in the region. This function was particularly important in towns such as Chililabombwe/Konkola mine and Chingola/Nchanga mine where there was no government hospital. Although the government was often supposed to pay for these referrals, many times they did not and this thus served as an implicit subsidy to the non-mining sector. After privatisation, most new mines took over some though not all of the existing mine facilities and typically changed the fee structure so that the free referrals of the past were no longer continued. In some cases, the size of the existing hospital was also reduced. The remaining clinics and hospitals were either privatised or handed over to government. In a minority of towns, there have been some closures. Thus, the net impact is likely to be an increase in the cost of services for non-mine employees, less access to the superior quality services and a greater number of people resorting to the public sector. In Chililabombwe, for example, retrenchees and retirees no longer have free access to the mine hospital and are unlikely to be able to pay the fees. They and others like them, will thus increasingly rely on the already overburdened public hospital which is ill equipped (no X-ray machine, operating theatre or mortuary, patients must purchase medicines).

During key informant interviews numerous former mine employees noted that the quality of health services had declined (less money for medicines) and that as a result many qualified doctors and medical personnel were leaving the Copperbelt and going abroad.

3.2.9 EDUCATION

In most mine towns ZCCM ran competitive "trust" schools that served both miners and better off non-mining families. In almost all cases the mines have taken over the schools, but have almost doubled the fee structure for non-miners (which includes former ZCCM employees). Typically, the pre-privatisation term rate of K400,000 (US$125) per pupil per term has jumped to K700,000 (about US$218) per pupil per term. In some areas as in Chingola and Chililabombwe, there may be competition among the top mine schools for spaces as a large number of expatriates will be moving to the area. With increased fees, some people have reported that there is keen competition for spaces in the existing government run schools. While this change may have the greatest effect on those elite who could pay for such education in the first place, it explains some of the frustration often voiced by Copperbelt residents and former ZCCM employees, about access to education. It will also increase the number of students in the public school system.

3.2.10 MUNICIPALITIES

Following restoration of mine sites under the EMF, sites will eventually be turned over to other institutions such as local authorities. The limited capacity of these authorities to manage such sites should therefore be taken into account in the CEP design.

Municipalities are currently undergoing a severe financial crisis. This also applies to towns that have benefited from the privatisation. No municipalities have had the mechanisms in place to capture the potential increase in tax revenues from growth. Revenues have gone uncollected and municipal expenditures have drastically declined. As of July 2001, Council staff in many places had not been paid for seven months. According to several town clerks and district administrators consulted, this was partially attributable to a decrease in revenues from property tax from the mines (as in Luanshya) or from the miners and partially attributed to a lack of transfers from central government. In addition, some municipalities may have used revenues from the water sector to finance other activities (which then meant there was not enough revenue to properly treat or maintain the water). When these accounts were hived off into CUs, this source of cash was also taken away from municipalities.

A Draft Decentralisation Policy, which should clarify the operational responsibilities of the local governments and the central government ministry, has been under formulation for the past several years by GRZ, but has not yet been finalised.

3.2.11 SECURITY, ROADS

Prior to privatisation ZCCM had numerous security personnel who served to ensure safety within mine residential areas, to guard the vast tracts of land (thousands of hectares), tailings, dumps sites and facilities of the mine areas against deforestation and vandalism. Following privatisation and the reduction in ZCCM staff, this function was largely eliminated. At the same time, new mine owners such as KCM and MCM redefined mine boundaries to exclude defunct sites and tracts of land they would not need (others such as Binani took over all sites, but do not have the staff to adequately police the sites). As a consequence, deforestation, illegal dumping and scavenging in large tracts of land and on mine sites, has increased dramatically. In many cases this has been a primary factor in causing instability and in some cases failure of defunct mine sites. In addition, in many towns the lack of mine police presence in the neighbourhoods has contributed to the perception that crime has increased significantly.

Roads within municipal areas were also handed over to municipalities to maintain. These roads bear a heavy burden of commercial traffic because of the interdependent nature of mining in between Copperbelt towns noted above. KCM has noted that it occasionally will help repair roads as a stopgap measure, but has no intention of doing so on a regular basis. In the midst of their financial crisis, municipalities have not been able to adequately carry out this new function. According to the town clerk in Luanshya:

> *"The roads are orphans and bridges are being degraded."*

3.2.12 EMPLOYMENT

Without a formal study, it is difficult to assess whether employment and incomes are increasing since privatisation or not. Macroeconomic statistics suggest that there has been a healthy recovery in GDP growth since privatisation. However, discussion with many residents tends to reflect the sense of distress over rising costs as the former ZCCM welfare system, unsustainable as it might have been, is dismantled. Based on data from 5 towns (Luanshya, Kitwe, Kalulushi, Chililabombwe, Chingola) there was a decrease in formal full time mine employment of over 20,000 workers from 1996 compared to today. However, only limited data is available on the number of contractors. Based on the towns where data on contractors exists, there has been an increase in the number of contractors though there still has been a net decline, albeit smaller, in formal employment in the mines.

Representatives of the Mine Workers' Union (MUZ) of Zambia noted that there has been an improvement in economic activity and increased opportunities for contractors, including those who have been retrenched from mines. During the period of transition to privatisation there were only short-term contracts, payment for work was consistently delayed and the Kwacha was constantly losing value. Since privatisation, there have been longer term contracts with timely payment and people have been able to plan their budgets. The MUZ representatives also noted that "although there have been increases of 74% in miners' salaries, the miners are not receiving the same services they used to as part of their employment package." It is not clear how many of the contractors are from South Africa or the degree to which this may negate the benefits to the local population of increased contracting opportunities.

Although temporarily on hold because of low copper prices, another potential source of future employment creation is the Konkola Deep Mining Project (KDMP) which was expected to generate 3,000 to 4,000 local jobs in Chililabombwe. Some of these people may be redeployed from Nchanga open pit, which is scheduled to close in 2011 with a loss of about 800 jobs.

Table 3.4: Employment Changes in Mining for Selected Copperbelt Towns

Site	1996	2001	Change	1996 - Contractors	2001 - Contractors	Change (Contractors)	Total Change Including Contractors
Luanshya	9,817	4,310	-5,507	114	NA	NA	-5,507
Kitwe	*14,772	4,601	-10,171	NA	1,135	NA	NA
Kalulushi	1,074	572	-502	NA	NA	NA	-502
Chililabombwe	4,637	3,157	-1,480	285	1,799	1,514	34
Chingola	8,606	5,949	-2,657	973	1,648	1,585	-1,072
Total	38,906	18,589	-20,317				

*The pre-privatisation figure for Nkana may have included SmelterCo employees and ZCCM headquarter employees.

It is clear that there are certain groups – the retired and some of the retrenched – that are facing difficult challenges. It is also clear that others in towns such as Kitwe, Chingola and Chililabombwe there has been a resurgence in economic activity which has created opportunities for others.

BOX: Downhousing

A phenomenon reported by many people in the Copperbelt – though not yet confirmed by any quantitative study - is what is perceived of as downsizing. As was explained by several Copperbelt residents:

"when a miner receives his retrenchment or retirement package, he typically lives in the house he lived in when working for the mines. Since he had never had to budget much as a miner – with free housing, services, mealie meal and vegetables often grown in the garden by his wife – he may spend his package faster than anticipated. As his package diminishes, he progressively moves into smaller and smaller houses until he ends up in a squatter or informal housing settlement or on a piece of land that he is farming somewhere. If he owned the house, he uses this for rental income."

However, some other residents reported that many retrenchees are better off because they have been able to find work with private contractors.

In Kitwe, many of the scavengers on former mine sites encountered during the social assessment work were dependents of miners who were in their late teens or their twenties and who had not found work. Even without retrenchment, it appears that if your father was a miner, you can no longer assume that you will be a miner too. As a result, more of these people are seeking income in the informal sector, including scavenging.

3.2.13 RETRENCHMENT

It is difficult to forecast what the longer-term income of retrenched miners will be, but those involved in focus group discussions held in 1999 were most often involved in marketing (informal trading), seasonal fish mongering, had mini-bus businesses or carpentry and were earning less than they had earned as miners. Only 5% had found another job with regular income. There have been no systematic studies to examine how many of these retrenchees have since found work with the large number of contractors now working for MCM and KCM (the MUZ representative was optimistic that many were better off). During field work for the social assessment, many of those who were practising agriculture along river banks were either women or retired or retrenched miners. At one time, resettlement areas were created for retired miners in various areas. There have also been reports that retired and retrenched miners are settling in protected forest areas because they can't find land elsewhere.

Table 3.5: Changes in Copperbelt Since Privatisation

Town	Mine	Notes	Dependence on Mine	Population in Mine Township	Mine Employment	Payment of Miners/ Contractors	Health	Education	Water Supply & Sanitation	Solid Waste	Malaria Spraying	Roads in town	Security	Street Lighting	AIDS Awareness
Luanshya	RAMCOz		High	The mine community (miners & family) represent ~ 25% of local population	Direct Employees 1996: 9817 Direct Employees 2001: 4310	Miners on recess for past 3 months; Binani declared bankruptcy.	4 clinics closed, 2 taken over by Binani, 1 privatised. Not running well (no medicine) because of Binani's financial problems.	Numerous government schools. Only one school under ZCCM-IH, taken over by Binani	AHC - 70% of domestic connections, CU - 30%. AHC supposed to receive remittances from Binani from miners' salaries but not receiving.	Municipality in some areas No capacity since workers are on strike. Hospital does not have incinerator. AHC contracted in other areas but problems with contractor.	Previously ZCCM, unknown but unlikely that Binani has taken over.	Maintenance to local government within town. No capacity to undertake this due to non-payment municipal salaries past 7 months.	Used to be ZCCM around mine. Now mine security has dropped from 15 to 2. Deforestation, vandalism rampant. In other areas local police.	Used to be ZCCM in mine areas, now municipality	Unknown
Kitwe	Mopani Copper Mines & SmelterCo	Third largest town in Zambia Also serves as centre for those living in Kalulushi and as the headquarters for MCM.	Relatively High	Just over 100,000 persons (about 36%) are estimated to live in former mine areas and 179,332 to live in Council areas. In addition about 44,000 persons are estimated to live in informal settlements in peri-urban or outlying areas.	Direct Employees 1998: 14772 (but includes SmelterCo and possibly ZCCM HQ staff). Direct Employees 2001: 4601 Contractors 2001: 1135.	On time	Wusakile Mine Hospital now operated by Mopani Nkana Hospital acquired by NFC Africa Mining, fee for service for non-miners 3 clinics taken over by Mopani, 4 privatised, one to Ministry of Health	Mopani took over Nkana Trust School. Mpelembe Secondary School was Donated to the Jesuits	AHC - 28% domestic connections + Bulk to Council areas CU - 72% domestic connections but purchases bulk water from AHC. Water source includes what is pumped from mine.	Municipality though Town Clerk states that this is up to communities In ex-mine areas AHC has contracted solid waste. Much illegal dumping.	Mopani has taken over in both ex-mine and Council areas in co-ordination with District Health Management Team.	Municipality.	Mopani security on mine. For defunct sites supposed to be ZCCM-IH but no capacity/ security personnel.	Municipality but capacity constrained.	
Kalulushi	Chibuluma Mine/Metorex	Small town with numerous "high cost" former ZCCM employees who work in Kitwe and Council areas Economy linked to Kitwe.	High	NA	Direct employees 1996:1074 Direct employees 2001: 572. Currently 16 contractors but change in number contractors before not known.	On time	Metorex took over Chibuluma Mine Hospital. A fee of $65 per month is required for non-mine employees and five dependants.	Kalulushi Trust School taken over by PTA. Fees used to be K20,000 for miners, K400,000 non-miners. Today fees for all are K900,000.	Source of water from mine. AHC and CU active.	Municipality & AHC contracts in former mine areas.	Chambishi Metals Plc undertakes malaria spraying in Chambishi township	Maintenance to local government within town.	NA	Used to be ZCCM in mine townships now municipality.	
Chililabombwe	Konkola Mine/KCM	Likely to benefit from mine expansion.	High	(1996) About half population lives in mine area; half in Council area	Direct employment down but total employment up. Direct Employees 1996: 4,637 Direct Employees 2000: 3,157 + 587 contractors & 1,212 casual labourers	On time	KCM took over Konkola Hospital, 6 clinics. Medical care free for miners, but paid for by non-miners including retrenched and retired miners. Govt. run hospital at Kakoso run down and weighed down by new clients who cannot afford fees at mine hospital.	Of 29 schools only 1, the Konkola Trust School was run by ZCCM. This was taken over by KCM. Previously mine employees paid K20,000 and non-mine employees paid K400,000 per term. Now mine employees still pay K20,000 but non-mine employees pay K 700,000.	AHC provides potable water. Source from mines	Municipality & AHC contracts in former mine areas.	KCM has taken over in ex-mine and non-mine areas.	Responsibility with municipality but on an emergency basis KCM may help repair some areas.	KCM security at mine site, local police elsewhere (formerly ZCCM in ex-mine townships)	Used to be ZCCM in mine townships now municipality.	KCM has free treatment for those who are tested, AIDS awareness program
Chingola	Nchanga Mine/KCM	Serves as KCM headquarters and likely to benefit from increased economic activity.	High	(1996) About half population lives in mine area; half in Council area	Direct employment 5949 and 973 contractors	On time increase in number of contractors.	Nchanga North Hospital to Government, one clinic to government KCM took over Nchanga South hospital. No more free government referrals to mine hospitals but non-miners can pay for service.	KCM runs Chingola Trust School Mine employees' children pay a nominal fee of K20000 per term. Children of Non-mine employees have seen fees revised from K400000 before privatisation to K700000 per term.	AHC - 38%, CU - 62%	Municipality & AHC contracts in former mine areas. Due to problems with contractors and municipality, increased solid waste burning in neighbourhood.	KCM has taken over in ex-mine and non-mine areas.	Responsibility with municipality but on an emergency basis KCM may help repair some areas.	KCM security at mine site, local police elsewhere (formerly ZCCM in ex-mine townships)	Used to be ZCCM in mine areas, now municipality	KCM has free treatment for those who are tested, AIDS awareness program

Town	Mine	Notes	Dependence on Mine	Population in Mine Township	Mine Employment	Payment of Miners/ Contractors	Health	Education	Water Supply & Sanitation	Solid Waste	Malaria Spraying	Roads in town	Security	Street Lighting	AIDS Awareness
Mufulira	Mopani Copper Mines		High	10,086 (33%) former mine houses; 5,089 Council houses	3631 Direct employees and 1078 contract labour	On time		Numerous non-mine schools. Only one school owned by ZCCM, Mufulira Trust and taken over by MCM. Previously mine employees paid K20,000 and non-mine employees paid K400,000 per term. Now mine employees still pay K20,000 but non-mine employees pay K 700,000.	AHC - 60% domestic connections CU - 40% domestic connections	Municipality & AHC contracts in former mine areas Due to problems with contractors and municipality, increased solid waste burning in neighbourhood.	Mopani has taken over in both ex-mine and Council areas in co-ordination with District Health Management Team.	Maintenance to local government within town. No capacity to undertake this due to non-payment municipal salaries past 7 months.	Mopani security on mine. For defunct sites supposed to be ZCCM-IH but no capacity/ security personnel.	Used to be ZCCM in mine areas, now municipality	
Ndola	Ndola Lime/ZCCM-IH	Provincial capital, administrative centre Unlike other areas, no distinct mine townships or separate services.	Medium/Low: Provides services to mining industry in the overall region but not dependent on any one mine.	No specific mine residential areas	Previous Direct employees547 in 1997: Direct employees 2001: 428 + 100 temporary workers No major retrenchment planned.	NA	ZCCM had 2 clinics in Ndola Central. Otherwise mine employees used public health system in Ndola (2 hospitals)	ZCCM supports Ndola Primary School, a trust school serving mine and non-mine people (less than half were mine dependents) Otherwise numerous public schools.	CU predominantly - AHC does not have any role here since there were not traditionally separate mine townships.	No change - municipality	None undertaken	Always responsibility of municipality.	No change.	No change.	Unknown whether mining companies are involved in this.
Ndola	Bwana Makubwa Mine/First Quantum Minerals of Canada	Mine closed in 1985, but company is reworking tailings	Medium/Low: Provides services to mining industry in the overall region but not dependent on any one mine.	No specific mine residential areas	The company currently employs 110 people, while additional employment on a contract basis varies between 10 and 100 people at any one time.						Participated in malaria spraying in one area - Itawa Dambos				

3.3 OVERVIEW OF COPPERBELT TOWNS AND MINE ENVIRONMENT ISSUES

Kitwe: Third largest town in Zambia. Headquarters for ZCCM-IH, for MCM and for numerous mining and engineering services for the region and thus experiencing some economic growth. Situated about 20 minutes from Kalulushi. Kitwe has a smelter (owned by ZCCM-IH but operated under a management contract by KCM) which contributes to sulphur dioxide emissions. Kitwe has numerous defunct mine sites in the centre of town, as well as a number of sites outside of the town, including TD33C which has already failed, contributing to siltation in the Chibuluma Stream. Negotiation of ZCCM-IH versus MCM liabilities is still underway. MCM EMP is pending and company is supposed to propose which sites it will take over by March 2002.

Chingola: Headquarters for KCM and for numerous companies providing services to the mining industry. Discussion of opening hotels to accommodate the influx of foreign mine workers. The sites around Nchanga mine produce a large proportion of the sediment going into the Kafue. Several defunct sites are outside the main town. KCM EMP has been in draft stage under discussion since June, 2001 and includes proposals for the allocation of responsibility for mine clean-up between ZCCM-IH and KCM.

Kalulushi: Kalulushi has long served as a small "bedroom" community for Kitwe and as a centre for the Chibuluma mine owned by Metorex. It does not have many other economic activities outside of mining. PCB and radioactive storage sites are located within the compound of Alfred Knight (Z) Ltd., which purchased the Kalulushi-based laboratory and materials testing facilities from ZCCM-IH. EMP was to be concluded in 1998 but is now anticipated by the end of 2001.

Chililabombwe: A small town almost entirely dependent on the KCM owned Konkola mine for its economic activity. Expected to benefit substantially from expansion plans for the Konkola Deep Mining Project with an estimated 3,000 to 4,000 local jobs to be generated (KDMP has been postponed indefinitely). Relatively few defunct sites are located here. KCM EMP in draft form for comment since June 2001. EMP proposes allocation of responsibilities between KCM and ZCCM-IH.

Mufulira: Mufulira's economic health is highly dependent on the MCM owned smelter (the mine itself has not been very productive). The smelter has no acid plant and there are numerous points releasing fugitive emissions. Public concern over SO_2 emissions are high given past community environmental discussions as one of the pilot towns for the Environmental Support Project. Several defunct mine sites are also located in Mufulira. There are few supporting industries other than mining. If the smelter were to close this would have a drastic impact on the town's economy. MCM has completed a draft environmental baseline, but EMP and proposal of the allocation of responsibilities is still under negotiation.

Luanshya: Luanshya has been highly dependent on mining and has thus experienced drastic economic hardship because of the bankruptcy of its owners, the Binani group. Binani's mine, RAMCOZ, took responsibility for all environmental obligations – past and present – by adopting ZCCM's 1996 Environmental Impact Statement. Even so, they have not been able to maintain the current sites and the mine itself has flooded and the smelter is no longer working. Further degradation in mine sites may lead to erosion on the steep slopes of the Chonga tailings dam, thus adding to already high siltation loading in the Luanshya river. In addition, the Luanshya River was severely impacted by the failure of the mine's tailings pumping system earlier in 2001. This failure caused extensive flooding and led to slumps in adjacent tailings dumps, including portions of the Makoma Dam which stores the water supply for the town of Luanshya and adjacent communities. Allocation of responsibility for mine sites may eventually fall back to ZCCM-IH/GRZ if potential new owner refuses to take on responsibility for these sites. The stability of many sites has changed substantially since the original EIS in 1996.

Ndola: Ndola serves as the first town one reaches in the Copperbelt coming from Lusaka and as the provincial capital. Unlike other towns, Ndola never had the distinct and separately managed mining communities that were typical in other Copperbelt towns. Thus, the impact of privatisation has been less dramatic. The town has perhaps the most diversified economy. Because of this, Ndola is not very dependent for its economic base on the production of the two nearby mines – Ndola Lime and Bwana Makubwa Mine, even though a large number of businesses in the city do cater to the mining sector in general. Because the Ndola Lime has not yet been sold, its liabilities remain with its current owner, ZCCM-IH. Environmental issues associated with the lime operations are not severe, but there are resident complaints arising from deposition of nuisance dust in neighbourhoods downwind of the smelter. The ZCCM EIS from 1996 is the most recent environmental analysis of the mines in Ndola.

Chambishi: Chambishi is a relatively small town, dependent on mining, with two separate mining operations – NFC Africa and Chambishi Metals. The town includes a smelter and thus it is likely that the most pressing mine environment issue in Chambishi relates to SO2 emissions. Both companies accepted responsibilities for all environmental obligations, past and present. The one exception is that Chambishi Metals PLC has been indemnified by GRZ against any environmental liabilities arising from ZCCM-IH activities prior to September 11, 1998. Both companies were to have completed EMPs but have not met their deadlines.

3.4 ENVIRONMENTAL ISSUES IN THE COPPERBELT AND KABWE

3.4.1 POLLUTION OF WATER BY RAW SEWAGE

Lack of cost recovery and financial viability in the water and sewage sector has contributed to a lack of proper maintenance of existing sewage systems and thus to raw sewage dumping into water sources such as the Kafue. This is very common in most of the Copperbelt towns and in Kabwe. During the site visits it was observed that sewage water is used for irrigating vegetable gardens in Mufulira (Kawama West), Kitwe (Ndeke township) and Luanshya (Mpatamatu). In most cases sewer lines are either blocked or vandalised and sewer water is diverted from channels leading into primary settling ponds into vegetable gardens. Residents gardening using raw sewer water in Kawama West in Mufulira and Ndeke township in Kitwe maintained that it was safe to use the raw sewer water as they had been practising this for a long period of time. However, this view is not universal as the city council had cut down gardens irrigated in this manner during a cholera outbreak and other residents had a name for vegetables grown in this manner – "Pasoda" – which they sold to markets in town but did not eat themselves. Information regarding use of sewer discharge to irrigate food crops is provided in Annex F.

In towns such as Ndola, which has some of the highest incidences of cholera in the country, the water quality problem is particularly severe as the intake for potable water supply is downstream of the sewage discharge point. In Kabwe widespread contamination of piped water supply also presented a problem.

Past financial and managerial problems with water and sewer utilities also meant that the problem was not always adequately addressed through water treatment as many utilities do very little testing of organics in drinking water and thus have very rough measures for whether existing treatment is working or is sufficient. AHC-MMS plans to set up a laboratory to conduct a wide variety of tests on water intake at various points in the Kafue. Mulonga Water and Sewer also recently (November, 2000) started using KCM's laboratory to obtain better testing data on water quality. To date, there is no regional organisation for systematically sharing or co-ordinating this analysis.

Unless the financial condition of many of these utilities, which are now trying to shift to direct cost recovery post-privatisation, improves, the problem of raw sewage will likely continue or get worse.

3.4.2 SOLID WASTE COLLECTION AND DETERIORATING SANITARY CONDITIONS

As noted above, deterioration in solid waste collection has led to increased burning in low cost areas and high levels of refuse sitting in neighbourhoods and proving breeding grounds for mosquitoes or for disease (See Annex Q on Additional Social Assessment Data). This together with a lapse in mosquito spraying during the transition to privatisation had led to increases in malaria cases in the past year according to one District Health Management Team (Kitwe). Residents reported that there were now cases of cholera whereas this was previously unheard of in the past.

In some towns such as Chingola, Chililabombwe and Kitwe there is anecdotal evidence that an increase in mining activity is having an impact on the volume of waste water and solid waste that needs to be treated and disposed. The KDMP project, for example, expects 1000 new contract workers (likely expatriate) to locate to Chililabombwe[14]. KCM was considering building a new sewage treatment plant to deal with this issue or providing assistance to MWSC to fund an upgrading of service. However, such proposals need to be integrated into sectoral analysis of the long-term sustainability and willingness to pay for such services; if they are not, there may be more raw sewage going into the Kafue in the long-term when such

[14] KCM Social Management Plan, page B-3-5

new systems break down because of lack of maintenance (the case with existing systems). Increased density in areas such as Chililabombwe may also have environmental implications because of inadequate water and sewer services.

3.4.3 LAND USE, CHARCOAL AND DEFORESTATION

Deforestation and encroachment is a major environmental issue in all the Copperbelt towns (Table 3.6). The main causes are clearing for subsistence agriculture, land clearing for settlement and tree cutting to supply fuel wood for domestic and industrial use. With frequent discussion of retrenchment during the latter half of the 1990s and the increasing trend towards private sector rules of job security, many Copperbelt (and Kabwe) residents started to feel less secure about their economic future. Anecdotal evidence from discussions with several local authorities in the Copperbelt, points to the marked increase in requests for land allocation as an insurance policy in case of retrenchment. According to one NGO in Kabwe, local Councillors may have a financial incentive to allocate land as well. An additional factor in the increase is that with privatisation, retirees are no longer obligated to leave "mine housing" (housing originally built by the mines and supplied to their workforce) and sought access to land closer to town for growing food crops to supplement their income. In many cases, people would secure access to relatively large amounts of land and would end up selling access rights to the land to charcoal burners.

Table 3.6: Estimated Annual Land Clearing on Copperbelt

Purpose	Hectares/ household/ year	Number of Households	Land Clearing (hectares)		Total Hectares
			Medium Density Forest	Low Density Forest	
Shifting cultivation	1.50	62,000	18,000	74,400	93,000
Permanent agriculture	2.00	1,800	1,080	2,520	3,600
Charcoal production	0.07	428,000	29,960	0	29,960
Firewood	0.05	62,000	620	2,480	3,100
Total			**50,260**	**79,400**	**129,660**

Source: Copperbelt Provincial Forest Action Programme, 1998

Charcoal burning has become a major source of supplemental income and source of fuel among low-income groups. According to numerous informants, the demand for charcoal has increased in tandem with increases in the cost of electricity. In certain instances retrenchees are settling in National Forest Reserve areas (*e.g.* Nsato in Mufulira, Luano forest reserve) and cutting down trees in order to cultivate or simply selling the access to charcoal burners. These areas are important catchment areas for the river system in the region and continued infringement could affect the water available in these river systems. It is estimated that up to 50,000 hectares of well-stocked forests are cleared annually for charcoal production (PFAP, 1998).

Numerous mine companies complained of the infringement of charcoal burners onto their land, contributing to deforestation and erosion in some mine sites. Deforestation is also occurring on defunct sites which have few if any guards. This results in erosion and eventually gullying, contributing to the siltation of local streams. KCM's EMP states that in the Copperbelt "runoff is 50% higher than normal due to deforestation." Charcoal production in the Copperbelt is usually carried out by youths who travel long distances to the forests. They pack the charcoal in bags and then transport it to the markets in Chingola or sell it along the roadside.

ZCCM-IH owned significant portions of viable land – often in and around population centres - which new mine owners have not taken over (see also Section 4 on ZCCM-IH liabilities). As of July 2001, ZCCM-IH was in the process of working out a policy for what to do with this land. A key issue for the CEP is whether some of the ZCCM-IH land and sites can be used to ease land pressure around communities.

4. COPPERBELT PRIVATISATION AND ENSUING ENVIRONMENTAL OBLIGATIONS

4.1 OVERVIEW OF ZCCM-IH ENVIRONMENTAL OBLIGATIONS

Following the privatisation of ZCCM and its transformation from a state mining corporation to an Investments Holding Company, ZCCM-IH retained liability for a wide range of environmental concerns which were not passed on to the private investment consortia. The outstanding responsibilities of ZCCM-IH are specified in the mines Transaction Documents, Development Agreements and, where applicable, Environmental Liability Agreements and the Environmental Deed Agreements.

The Mines and Minerals Act (MMA) of 1995 and the Mines and Minerals (Environmental) Regulation of 1997 specify the requirement for all mine operators to develop environmental management plans (EMPs), including costed remediation plans. The MMA designates the Minister of Mines and Mineral Resources as ultimately responsible for EMP enforcement, with the Director of Mine Safety (an officer in the Ministry of Mines and Minerals Resources), holding supervisory powers over mine licensees. The ECZ evaluates environmental impact assessments (including EMPs), monitors impacts of natural resource use and works with MSD on issuing certificates of mine closure (ECZ responsibilities as outlined under the EPPCA, are listed in greater detail in Section 5.4.1). ECZ is also responsible for monitoring and enforcing environmental issues that fall beyond the scope of the Mines and Minerals Environmental Regulations, including the discharge of effluents, the maintenance of tailings dams, sulfur dioxide emissions, as well as cumulative impacts downstream from mining sites.

The MMA was amended in 2000 to apportion responsibility for environmental liabilities between the privatised mines and GRZ. Legal liabilities relating to defunct facilities (*e.g.*, closed tailings paddocks, waste dumps and unused plant or infrastructure) remain with the latter. The GRZ must additionally assume responsibility for environmental liabilities arising from the future operation of purchased assets, provided that the operations comply with the applicable environmental management plans, including specified actions and timetables to bring the such assets into compliance.

4.2 THE EMP PROCESS

With at least 11 different mines active in the Copperbelt, most with different management and ownership structures, the treatment of environmental management is complex. As noted above, as preparation for the privatisation process, in 1996-1998, ZCCM commissioned a comprehensive series of EMPs for each of its MLAs as a component of wider Environmental Impact Statements (EISs) for these sites. In addition, for Nkana, Nampundwe (outside the Copperbelt), Nchanga and Konkola mines a series of environmental audits and interim environmental management plans were completed in 1999. In these environmental audits and in negotiations with KCM, ZCCM states:

"ZCCM has undertaken, in terms of the Development Agreement, to fund the cost of the repair of historical environmental damage and certain outstanding rehabilitation."

The document continued on to state that ZCCM/GRZ will seek donor funding to finance the cost of such repair (thus the origins of the CEP). However, while the statement above has governed the allocation of responsibility between ZCCM and KCM, other mines that were sold prior to this time appear to have assumed responsibility for cleaning up even historical (*i.e.* defunct) sites. However, they are not liable for lawsuits arising from past environmental practices (such as past damage from SO_2).

Since privatisation, several managing consortia have opted to formulate their own EMPs (Table 4.1), rather than inheriting EMP strategies from ZCCM-IH. KCM is the first private investor to complete its own EMP for lands and facilities acquired from ZCCM-IH. Zambian regulations (SI 28) specify that during the process of completing an EMP the private mine company is responsible for publicising the proposed project, meeting with affected parties and considering views of these affected parties. However, once the draft EIS/EMP is available, ECZ is responsible for distributing the EIS/EMP to stakeholders, for dissemination to the general public through placement of the document in a public facility in the vicinity of the site, for inviting public comment and for holding hearings on the comments if necessary (see Annex C) within a specified period of time.[15] The initial period for public display of KCM's EMP was apparently less than the mandated time required and this period was thus extended.

KCM recently presented the EMP in public at a series of fora, which were previously announced in the media and facilitated by a local NGO (Citizens for a Better Environment). It is anticipated that public comments regarding the EMP will be reflected in the final KCM EMP. Mopani Copper Mines (MCM), Chambishi Metals and NFC Africa are also currently preparing EMPs, the precise content of which cannot be predicted.

Because Kabwe was privatised early on and sold in parts to many different investors, ZCCM-IH did not complete a formal EMP. For defunct sites in Kabwe, ZCCM-IH completed a mine closure and decommissioning plan, but encountered financing constraints to fully implement these plans. Aside from Sable Zinc, current Kabwe investors do not appear to have plans to complete EMPs.

[15] The Statute is specific: ECZ must place a notification in at least two national newspapers three times a week for two consecutive weeks and broadcast a notification on national radio, detailing the place and time where copies of an environmental impact statement are available for inspection and the procedures for submitting comments. Twenty days is allowed for receipt of comments or 35 days if there are logistical problems or particularly sensitive issues that arise.

Table 4.1: Environmental Management Plan (EMP) Provision for Privatised Mines

Company	Nearest Municipality	EMP Completion
Konkola Copper Mines	Chililabombwe, Chingola	March 2002
Mopani Copper Mines	Kitwe, Mufulira	September 2001**
Chibuluma Mines	Kalulushi	1998**
Roan Antelope	Luanshya	Adopted ZCCM-IH EMP
SmelterCo	Kitwe	March 2002
Chambishi Metals	Chambishi/Kalulushi	March 2000**
NFC Africa	Chambishi/Kalulushi	December 1998**
Cyprus Amax (Kansanshi)	Kansanshi (not in Copperbelt)	At the time of application to develop the project
Various small scale companies, largest is Sable Zinc	Kabwe (not in Copperbelt)	No stated plans.

*** Target not achieved*

The private investor EMPs for the remaining mines are due by March 31, 2002 (see above table). The investors have the option of adopting the ZCCM-IH EMP for the site. In one case, the investor (Binani Industries of Luanshya) adopted the ZCCM-IH EMP but then did not have the capacity to implement it and subsequently underwent bankruptcy. This has resulted in major degradation in environmental management at Luanshya. Yet others have promised to complete an EMP, but are well behind schedule, possibly because they did not allocate sufficient resources to this task. While there have been delays in the preparation and approval of EMPs, they will be integrated in the CEMP process.

The next step in the EMP process will be for ZCCM-IH to prepare its own counterpart EMPs for the numerous lands and facilities not acquired by the private investors. ZCCM-IH is to present the draft Terms of Reference of the EMPs for review by ECZ and public commentary, as required under the provisions of the EPCCA (Environmental Impact Assessment Regulations, Statutory Instrument No. 28 of 1997).

After the counterpart EMPs have been completed by ZCCM-IH, they will be put together with individual investor EMPs to form a comprehensive Consolidated Environmental Management Plan (CEMP) which will provide an overview of all sites and planned remediation, regardless of ownership. This CEMP will allow for a more integrated view of environmental management and mitigation; for example, understanding the impact of environmental mitigation downstream requires assessing actions planned in both an EMP governing the private mine site as well as an EMP for the surrounding ZCCM-IH areas. This CEMP will also account for cumulative environmental impacts associated with ongoing operations and historic liabilities at all of the mines. A critical underlying assumption is that the CEMP will draw substantially on mitigation actions developed within the EMPs for individual mining and mineral processing operations by ZCCM-IH and, in several instances, by the new management of privatised mines. Hence, the adequacy of actions contained in these documents has been subject to particular scrutiny.

Adequate public input and comment in the EMP process is particularly important, because the EMP, rather than Zambian environmental laws, will guide environmental activities in mining at the local level for the next 15 to 20 years (see Section 4.2.1 below on stability period and Part III on recommendations for public review of EMPs). Zambian regulations require public discussion and disclosure of EMPs (see Annex C, Zambian Regulation on Public Consultation in Environmental Impact Statement).

4.2.1 STABILITY PERIOD

In order to catch up with years of under-investment in environmental management of the mines, the privatization process included major concessions made to investors, greatly limiting their environmental obligations and liabilities. These concessions include granting of stability periods during which changes made to Zambia's mining and environmental legislation will not apply. GRZ has granted a stability period of 20 years to KCM and SmetlerCo. All other privatized mines were granted a 15-year stability period.

Table 4.2: Stability Periods for the Privatised Mines

Company	End Stability Period
Konkola Copper Mines	2020
Mopani Copper Mines	March 2015
Chibuluma Mines	2012
Roan Antelope	2012
SmelterCo	2020
Chambishi Metals	2013
NFC Africa	2013
Cyprus Amax (Kansanshi)	15 years following project commencement

During these stability periods, each investor must conduct operational activities in accordance to the EMP they negotiate with ECZ. Pollution sources must still be covered by a permit, but investors cannot be fined or penalized for pollution levels under what is specified in the EMP, even if in excess of national regulations. They also do not need to pay fees for pollution levels within national regulations. It is not presently clear whether GRZ or ZCCM-IH is responsible for pollution levels from which investors are excused therefore, responsible for environmental legacies and other environmental liabilities arising from the operations of the mines so long as they operate within its agreed environmental management plan.[18]

[16] Pers. Comm. Paulman Chunga, Legal Specialist, Zambia.
[17] An additional nuance is that MCM and KCM have 5 years before they have to pay a license fee for emitting SO_2. The level of that fee and whether it covers all SO_2 being emitted or only some portion of it, is a matter of debate.
[18] ZCCM-IH, 3 January 2001. ZCCM-IH Overview of Environmental Obligations.

There has been criticism from some international NGOs with regard to the negotiations on privatisation and the stability period accorded to mining companies on pollution. While there is little that can be done to alter existing agreements, it will be important that the CEP reinforce Zambia's relatively weak capacity to negotiate subsequent EMPs with large, well funded international corporations. The ECZ is responsible for approving EMPs and plays a key role in gathering public opinion on the EMPs. However, without its own specialists in the mining sector, the ECZ is ill equipped to provide technical oversight of these massive documents. ZCCM-IH has strong technical background in mining, but may not be perceived as an independent reviewer. As a shareholder and former miner, the ZCCM-IH may share the perspective of the new mine owner rather than that of a critical reviewer of a proposed plan. Some stakeholders outside of government have been vocal, particularly on certain issues (such as the advocacy NGO Citizens for a Better Environment or residents in Mufulira about smelter emissions) but either are not adequately heard during the EMP process or do not have the technical background to argue for specific changes to the EMPs. It is therefore crucial that the CEP reinforce Zambian capacity to invite public participation in the EMP process and to technically review the EMPs proposed.

4.3 POST PRIVATISATION OBLIGATIONS

When mines were privatised, new owners did not purchase all assets nor take on all obligations of existing assets; in most cases new Mine License Areas (MLA) were created which were smaller than the ZCCM-MLAs, leaving considerable tracts of land and facilities that remain the responsibility of ZCCM-IH. In addition, in the Development Agreements some private mine companies specified that they would not take over defunct sites within their new MLAs. The obligations that remain with the GRZ can be grouped into three categories: 1) contractual obligations, essentially commitments it has made to private mine companies in the legal documents (Development Agreements) governing the sale of the mines; 2) statutory obligations which stem from Zambian regulations with regard to the maintenance and closure of defunct or closed mines; and 3) legal obligations or potential legal obligations, arising either from commitments to past workers of ZCCM or from any future law suits against the GRZ or the private mines.

4.3.1 CONTRACTUAL OBLIGATIONS

In its specific agreements with investors, the GRZ/ZCCM-IH has in some cases agreed to undertake or finance certain actions. In the case of KCM, for example, KCM is managing the rehabilitation of some sites within its mine area and some resettlement, which ZCCM-IH/GRZ is financing. These sites may not correspond to those which have highest priority from an environmental point of view. They typically fall within the new mine license area. Mine companies such as KCM are eager to have these sites remediated. In some cases, a mine company's EMP may specify other actions but if these have not been laid out in the Development Agreements, there is no contractual obligation of ZCCM-IH or GRZ to undertake these actions. The Development Agreement is a legal document and thus there has been substantial discussion of how to interpret various clauses of the document. ZCCM-IH is in the process of retaining an environmental legal advisor to assist with interpreting the agreements.

The current status of contractual obligations is grouped into three situations: companies such as KCM to which GRZ has made commitments as a condition of sale; companies such as MCM which is defining its EMP and which may request GRZ to take over rehabilitation of certain sites; and companies, largely privatised prior to KCM, which have nominally taken over responsibility for defunct facilities.

A) **KCM** (Chingola, Chililabombwe): According to the Development Agreement with KCM, the GRZ has agreed to finance the following activities:

i) Resettlement Action Plan at Konkola Mine [19]

An increased catchment area will be flooded by the year 2010 due to the expansion of the Lubengele Tailings Dam (which will cater for increased mine production from the Konkola Deep Mining Project), three communities will be affected by the predicted 1:100 yr. flood event. Only the portion of the communities (parts of Kawama and all of Mingoma, about 750 people) that fall directly in the path of the flood will be resettled based on the RAP. The RAP was written on the basis of wide consultation with affected parties, and was approved as meeting World Bank standards by the International Finance Corporation (IFC), the private sector arm of the World Bank. It was publicly disclosed under IFC rules both in Zambia and in the World Bank InfoShop. Consultation with affected communities continues through a Steering Committee. While KCM funded the preparation of the RAP and is managing its implementation, ZCCM-IH is responsible for its funding. Expected completion of the resettlement work is during 2002.

ii) Select Defunct Facilities in KCM mine areas

ZCCM-IH has agreed to allow KCM to plan and manage the decommissioning of defunct facilities, which remain the legal responsibility of ZCCM-IH within KCM license areas. These include:

a) Structures[20]

A number of structures including High Grade Leach Plant (HGLP), Power Plant, Lime Plant, *etc.* have not been taken on by the new investors as they were not in use at the time of take over and will need to be cleaned up by ZCCM-IH. The anticipated expenditure for demolition of defunct facilities structures is US $3.7 M. Contractors have been pre-qualified and ZCCM-IH is currently reviewing the tender documents received to allow KCM to award the contracts for work to commence.

[19] ZCCM-IH obligations and costs associated with the RAP are summarised based on the information stated in: ZCCM-IH, 3 January 2001. ZCCM-IH Overview of Environmental Obligations.

[20] ZCCM-IH obligations and costs associated with defunct facilities at KCM are summarised based on the information stated in: ZCCM-IH, 3 January 2001. ZCCM-IH Overview of Environmental Obligations.

b) Scrap Materials[21]

Scrap materials have accumulated at 27 sites, totalling approximately 5,800 tonnes. . Following sale of most of the scrap heaps to scrap metal dealers, a small net gain (US$20,000) is forecast.

c) Spillage[22]

General plant spillage (oil, chemicals, concentrates, *etc.*), tailings pipeline leakage, soil contamination and leachate pollution from the heap leach pad at Nchanga must also be remediated..

iii) Select Activities for SmelterCo. (Managed by KCM with an option to purchase but still owned by ZCCM-IH)

- Demolition of Torco Plant
- Demolition of Converter Boiler
- Demolition of No. 2 Acid Plant

B) MOPANI COPPER MINES (MCM) (Mufulira, Kitwe)

MCM has adopted the ZCCM-IH Environmental Impact Statement (EIS) pending the preparation of its own EMP. The company is currently finalising a baseline study to define conditions at the time of ownership transfer and to identify any areas of land or water polluted prior to sale. Such areas will be the responsibility of the ZCCM-IH and will be titled to the GRZ for re-use following remediation.

Under the terms of the Transaction Documents, MCM may request that ZCCM-IH reclaim certain areas not required for future operations which contain materials which must be removed to make the sites compliant with environmental legislation. ZCCM-IH will remove pollutants.

C) CHIBULUMA MINES PLC (Kalulushi)
NFC AFRICAN MINING (Chambishi Mine)
CHAMBISHI METALS PLC (Chambishi Smelter and Mine)
ROAN ANTELOPE MINING CORPORATION OF ZAMBIA (RAMCOZ) (Luanshya)

Chibuluma Mines Plc adopted ZCCM's pre-existing Environmental Impact Statement on purchase of the property. NFC African Mining Plc adopted the plan set out in Schedule 2 of the Development Agreement for Chambishi mine. ZCCM-IH has no remaining environmental obligations for either mine.

[21] ZCCM-IH obligations and costs associated with scrap materials at KCM are summarised based on the information stated in: ZCCM-IH, 3 January 2001. ZCCM-IH Overview of Environmental Obligations.

[22] ZCCM-IH obligations and costs associated with spillage at KCM are summarised based on the information stated in: ZCCM-IH, 3 January 2001. ZCCM-IH Overview of Environmental Obligations.

Chambishi Metals Plc adopted the plan set out in Schedule 5 of the Development Agreement for the site. Though ZCCM-IH has no environmental obligations associated with Chambishi Metals Plc, the company has been indemnified by GRZ against any environmental liabilities arising out of activities conducted by ZCCM prior to September 11, 1998 and environmental claims during the period envisaged by the final environmental plan.[23]

RAMCOZ adopted ZCCM's Environmental Imact Statement on purchase, therefore assuming all environmental liabilities associated with pre/existing facilities. RAMCOZ is, however, now in receivership and the assets have been tendered for sale.

4.3.2 STATUTORY OBLIGATIONS

According to Zambian regulations, upon mine closure, mine owners are required to inspect and maintain sites and eventually remediate them so that they are no longer causing environmental damage. This would apply to all mine sites that are considered defunct (no longer being used by current mine owners). Some sites require interim maintenance before final rehabilitation. This means that routine maintenance of tailings impoundments and overburden dumps at Konkola, Nchanga and Nkana must continue under ZCCM-IH funding until final rehabilitation and decommissioning of the sites. Activities to be undertaken include statutory inspection, maintenance of drainage channels, reinstatement of decant facilities, general maintenance of access roads, formation of a vegetative cover and prevention of human intrusion.

In cases where mine owners took over all obligations (as with NFC Africa in Chambishi), the current mine owner is responsible for rehabilitating and maintaining the site. In more recent cases (KCM, MCM), ZCCM-IH has often been identified as responsible for rehabilitation of specific defunct sites as noted above.

With regard to the CEP, most of ZCCM-IH's statutory obligations (unlike the contractual obligations) have not yet been placed within a time frame for completion and can be selected or prioritised according to an agreed upon criteria outlined in the CEP (see Part II). A large number of ZCCM-IH's statutory obligations lie outside of the new MLAs on ZCCM-IH land.

Detailed information regarding the identification of hazards associated with past and ongoing mining and mineral processing activities in the Copperbelt is provided in Section 3 of Part II and Annex G. Based on information reviewed by the EA team and feedback received from ZCCM-IH, sites for which ZCCM-IH holds responsibility or are yet to be decided include[24]:

[23] ZCCM-IH obligations and costs associated with Chambishi Metals Plc are summarised based on the information stated in: ZCCM-IH, 3 January 2001. ZCCM-IH Overview of Environmental Obligations.
[24] This list is subject to change.

- 4 Open Pits (Nchanga) and 1 still to be decided (Ndola Lime);
- 16 Overburden Dumps (Nchanga, Nkana) and 2 still to be decided (Ndola Lime);
- 2 Waste Rock Dumps yet to be decided (Ndola Lime);
- 6 Ore Stockpiles (Nkana, Nchanga);
- 13 Paddock Tailings Dumps (Nkana, Konkola) and 3 still to be decided (Mufulira);
- 2 Cross Valley Tailings Dumps (Nkana);
- 3 Water Impoundments (Nchanga, Chambishi); and
- 1 Solid Waste Tip (Nkana).

Table 4.3: Mine Facilities Indicating ZCCM-IH Responsibilities and Facilities Still Undecided

Mine Facility	Mufulira ML 15 MCM	Nkana 1 ML 3 MCM	Ndola Lime ML 8 Ndola Lime Company	Konkola ML 7 KCM	Nchanga ML 10 KCM	Roan Antelope ML 16 RAMCOZ	Baluba ML 17 RAMCOZ	Chambishi 1 ML 19 Chambishi Metals	Chambishi 2 ML 19 NFC Africa plc	Nkana 2 ML 3 SmelterCo	Chibuluma ML 18 Chibuluma Mines
Open Pit			1 pit (und)		Luano Chingola C Chingola E Mimbula 1 & 2 Fitula	Mine Company took over all sites (defunct and active) but new investors may not be willing to take over all sites in which case responsibility could revert to ZCCM-IH	Mine Company took over all sites (defunct and active) but new investors may not be willing to take over all sites in which case responsibility could revert to ZCCM-IH	Private Mine Company took over all sites (defunct and active) upon purchase	Private Mine Company took over most sites (defunct and active) upon purchase	Still Owned by ZCCM-IH	Private Mine Company took over all sites (defunct and active) upon purchase
Overburden Dumps		OB 53 OB 54 OB 63	Old dump (und) NW and SW Dump (und)		OB 4 - OB 11 OB 13 - OB 15 OB 18 OB 19						
Waste Rock Dumps			R4 (und) R5 (und)								
Ore Stockpiles		SP 3 SP 10 SP 51			SP 11 SP 13 SP 14						
Paddock Tailings Dumps	TD 4 (und) TD 5 (und) TD 8 (und)	TD 19 TD 25 TD 31 TD 33C TD 35, 36, 37,38,39, 40, 41		D L (Kakosa)							
Cross Valley Tailings Dumps		TD 26 TD 27									
Water Impoundments					Fitula Dam				Werners Dam New Dam		

und = undecided

All underground workings, slag stockpiles and concentrators are now the responsibility of the private mine investors.

4.3.3 STATUS OF ENVIRONMENTAL OBLIGATIONS (KABWE)

As with the other closed mines, ZCCM-IH retains a statutory responsibility to decommission and rehabilitate Kabwe's defunct mine sites and to maintain those sites until final rehabilitation. ZCCM-IH has been implementing Kabwe's 1996 Rehabilitation and Decommissioning Plan, but as explored in Section 7.5.4 of Part II, the program historically suffered from lack of adequate resources to fully implement the plan.

4.3.4 URGENT STATUTORY RESPONSIBILITIES

ZCCM-IH has identified the following sites as requiring urgent attention, prior to implementation of the CEP. These include:

a) Nkana Tailings Paddock No. 33c

Tailings paddock TD 33C has had several breaches breached between 1997 and 2000, causing extensive deposition of tailings mainly in the surrounding environment, with minor impacts on in the Chibuluma stream. ZCCM-IH has continued management of the paddock and will ensure full restoration prior to final closure and decommissioning. An estimated US$600,000 was originally estimated to complete this work, although this may now increase in the light of the most recent failure (see Photo 8).

b) Polychlorinated Biphenyls (PCBs)

Stocks of PCBs have accumulated over several decades and now require disposal. An estimated 100 tonnes of PCB oil, PCB capacitors and contaminated materials are located at three sites, Nkana Old Cobalt Plant and in Kalulushi and Kabwe. PCBs may be kept in interim storage and eventually disposed of in accordance with a national strategy (see Part II section 3.6.7 and Annex G). Interim storage and disposal costs are estimated at US$1 million. Zambia is a signatory to international conventions on Persistent Organic Pollutants (POPs), notably the Basel Convention.

c) Demolition of defunct facilities at Kansanshi Mine. (US$210,000)

d) Pollution Control Measures on dumps at Nchanga, Konkola, Nampundwe, Nkana and Chambishi. (US$2,731,870).

4.3.5 FINANCIAL IMPACT OF URGENT ZCCM-IH OBLIGATIONS WITH REGARD TO THE CEP

The World Bank and GRZ have agreed that US$6 million of the US$7 million surplus funds from the ZCCM Retrenchment Program Credit Agreement will be utilised for urgent remedial measures. [25] The CEP is expected to cover the statutory and contractual obligations not covered under the LRP. The following urgent measures have been identified by ZCCM-IH:

Contractual obligations contained in Development Agreements for Nchanga, Nkana, Konkola (Total estimated cost: US$4,384,020)

- Resettlement Action Plan (RAP)
- Defunct Facilities Rehabilitation at Konkola, Nchanga, Nampundwe, Nkana

Urgent Statutory obligations (Total estimated cost: US$4,541,870)

- Polychlorinated Biphenyls (PCBs) Disposal
- Kansanshi Mine Rehabilitation
- Repair of Breach on Tailings Dam No. 33C at Nkana.
- Pollution Control Measures on dumps at Nchanga, Konkola, Nampundwe, Nkana, Luanshya and Chambishi

4.3.6 LEGAL / GOVERNMENT LIABILITY

As noted above, many of the private mine companies indemnified themselves against the legal liability of law suits arising from their operations during the stability period as long as they operate within the agreed actions of their EMPs. This means that the GRZ must pay the cost of any law suits resulting from mine pollution, unless the mine company violated the terms of the EMP they negotiate with ECZ. In addition, ZCCM-IH (ultimately GRZ) is responsible for the impact of any "historical" pollution, though with many issues (such as SO_2 emissions) it may be difficult to apportion the cause of the impact between current and historical pollution sources. The CEP is not intended to pay for the cost of these law suits, but to focus on rehabilitation efforts to mitigate the sources of pollution.

In addition, a number of legal responsibilities of mine operators exist under the Workers Compensation Act 1999, which replaced the Pneumoconiosis Act of 1950. Any person being employed as a miner must have a medical certificate or undergo a medical examination to determine the status of fitness with regard to tuberculosis and pneumoconiosis. Once employed or following cessation of employment, a medical exam must be carried out every year. If tuberculosis or pneumoconiosis is identified, the employee or ex-employee may be liable to compensation. ZCCM is understood to have met its health obligations to its

[25] Ministry of Finance and Economic Development, Nov. 9, 2001, Third Addendum to Subsidiary Loan Agreement.

previous employees through annual payments to the Workers Compensation Control Board (Government of Zambia).

ZCCM-IH is not responsible for transport of dangerous goods used by private mines in production (*e.g.*, sulphuric acid). This responsibility lies with the private mine owner and the transportation company (*e.g.*, Zambia Railways). Thus, when accidents occur during transport by current mine owners, the incident should be reported to the ECZ and measures should be implemented to mitigate adverse effects. Inter-town mine transport is substantial and in early 2001, a truckload of acid was being transported from the Bwana Mkubwa mine site to Chingola when it spilled. Some citizens when to collect the acid in buckets, assuming it was valuable and injuries resulted.

4.3.7 SOCIAL OBLIGATIONS

4.3.7.1 Informal Settlements on ZCCM-IH Land

Informal squatter settlements have existed for many years on ZCCM-IH land since vast tracts of land were not actually used for mining. Squatters range from very low income groups that make a marginal living off of scavenging around the mine site and who actually live on the mine area (as is the case with Kandabwe – see box) to users who do not live on the land but who use it for cultivation or scavenging.

The stance of different mine companies has varied with regard to taking over land with squatters on it and for some mines such as KCM and MCM, this stance has softened over time. Specific reference is not made to squatters in the development agreements with investors. Other than KCM and MCM, there has been no clear agreement on a policy or allocation of financial responsibility for resettlement of squatters and whether they represent "historical" liabilities. In 1996, the privatisation team of ZCCM commissioned a study of illegal settlements on mine land because they anticipated that private investors would not want to buy a mine with such settlements. Initially KCM was adamant about not taking over land with squatters and it went as far as excising most of the existing squatter settlements when it redrew the mine license boundary. The areas where squatters remained on KCM land were areas that KCM needed for the KDMP (all of Mingoma and part of Kawama), as noted. ZCCM-IH agreed with KCM to pay the costs of a Resettlement Action Plan for about 750 people that would need to be moved because these households would otherwise be inundated when the level of the tailings dam was raised. News of the compensation (housing, facilities, *etc.*) associated with the plan has spread to other squatter settlements. Seasonal settlements continue on KCM land where people practice agriculture or other scavenging activities. Although KCM was initially not going to allow any of these activities, it appears to have adopted a "management" approach where it would allow some activity (other than deforestation). However, its Social Management Plan (SMP) states that in practice mine police may have been discouraging access by groups that used to cultivate/scavenge in the mine area.

Kandabwe – Profile of a Squatter Community on Mine Land

The Kandabwe squatter settlement is named after an area of Zambia where coal is abundant. In front of each house sits a pile of black pebbles, coal that has been scavenged from the Nkana mine site on which the settlement sits. The coal is sold to the nearby breweries and social problems such as alcoholism are evident. Most residents depend on some form of scavenging from the mine area. Residents obtain water from a hose at the edge of the settlement that has been attached illegally to an AHC water pipe. There is little or no vegetation in the settlement and residents appeared to be at the very low end of the income scale. According to one resident, politicians promised they would bring piped water two years ago, but nothing has changed. Refuse and some sewage for those without latrines goes into the Kitwe stream which runs behind the settlement, contributing substantially to water pollution downstream. During the site visit, politicians from an opposing party were actively campaigning in the neighbourhood while other residents adamantly directed the SA team to the governing party's branch chairman. Upon purchase of the mine, MCM excised Kandabwe from their purchase and the community is therefore technically under the jurisdiction of ZCCM-IH/GRZ even though it lies within the MCM mine area.

The negotiations with Mopani included a provision that would allow Mopani to propose what it did not want to take responsibility for (environmentally or socially) after 12 months, a period, which expired in March, 2001. Mopani had 6 months to negotiate with Government and ZCCM-IH and the agreement is pending. As of the writing of this assessment, a final decision on responsibilities had not been made. At one point MCM's public relations department told squatters that they would be evicted from MCM land, but then later retracted this stance when they met substantial political opposition. At present MCM appears to be focusing on a more restrictive view of resettlement and is currently discussing the situation of the AMCO community in Kitwe on the Nkana mine site (whether they would have to be moved, who would be responsible for resettlement if this is deemed necessary, what the risk is if people stay). The settlement is composed of residents who moved into what were initially meant as temporary quarters for those who constructed the mines; the land under the settlement may have become unstable and be potentially at risk for caving or subsidence (to be investigated).

At Kansanshi mine, large scale mining had ceased in 1986, and a small-scale scheme ceased in 1998. A report submitted to the United Nations Committee on Economic, Social and Cultural Rights that is critical of privatisation of the mines in general *(Zambia: Deregulation and the Denial of Human Rights, by "Rights and Accountability in Development, Queen Elizabeth House, Oxford University, March 2000)*claims that some 200 homes were demolished by the then-current mine owner, Cyprus Amax, that were either part of the established mine township or were then being built. Whatever the details, it seems clear that Kansanshi has residual settlement or resettlement issues.

ZCCM-IH is currently reviewing the squatter settlements that remain on ZCCM-IH land. It is concurrently developing a land policy on what to do with its vast tracts of land and this will invariably touch on the future of these squatter settlements. ZCCM-IH may need to distinguish between sites that are dangerous to their inhabitants and sites that can be handed over to local authorities without any further discussion. A preliminary review of Chambishi, Mufulira, Konkola, Nkana and Nchanga mines showed a minimum of about 25,000 people illegally living on mine land (ZCCM-IH or new owners' land) in these areas and about 3,112 of these people living in areas where safety should be assessed, presumably in the context of the EMP process. Towns where a formal assessment does not appear to have taken place include those where the new owners took over most liabilities (Bwana Mkubwa mine) or which are closed (Luanshya).

Table 4.4: Squatter Settlements Where Safety Needs to be Assessed
(Partial List)

Company/Mine/Town	Settlement	Population	Issue
MCM/Nkana/Kitwe	Kasengu	119	Risks may be associated with quality of water at Mindolo dam but likelihood of risk is low
MCM/Nkana/Kitwe	Lima	2408	Dam is currently low, but if dam collapsed, this settlement would be inundated
MCM/Nkana/Kitwe	AMCO	443	Residents on mine site. May be subject to subsidence/caving.
MCM/Mufulira/Mufulira	Valley Dam	32	If dam becomes unstable this would affect squatters
KCM/Konkola/Chililabombwe	Fitwaola	80	Will be affected by KDMP as ore body would need to be exploited. Not clear if included under RAP and will be KCM responsibility.
KCM/Konkola/Chililabombwe	Momba	30	19 residents may be affected by KDMP (flooded). Included under RAP

IFC financing has meant that KCM properties are subject to IFC/World Bank policy on involuntary resettlement. Other mines among those privatized are not subject to this policy. Because any sites that are identified for resettlement (during the CEMP process) that are also ZCCM-IH liabilities may fall under the scope of the CEP, and therefore would be subject to the World Bank policy. Dialogue should begin with ZCCM-IH to agree on the policies under which resettlement and other housing or land acquisition activities would be implemented. National regulations do not appear to provide clear rights to illegal residents whose plots have not been regularised by the municipal council, regardless of the amount of time they have lived there. In the event that people need to be moved for remediation or for another reason, ZCCM-IH should include in its CEMP a note regarding the fair treatment of people forcibly moved, regardless of whether they are present legally or illegally.

Past experience with resettlement initiatives in Zambia suggests that it is a complex, highly politicised process, subject to substantial delay. Resettlement should only be undertaken if absolutely necessary given the disruption to the population. For example, the decision to move an entire community needs to be weighed against the potential risk of remaining in an area; if the risk of subsidence is low or if the impact of subsidence is minor, then communities could be informed of what they could do to avoid exposure to the risk rather than moving an entire community.

ZCCM-IH appears to have been in a long-term battle against illegal settlers on mine land (dating back before 1991) that has apparently been stalled during various election periods. In the past, ZCCM had unsuccessfully tried to relocate the inhabitants to Kawama township (in Chililabombwe/Konkola) and according to the KCM SMP, to evict residents of Poor People of Zambia settlement (PPZ, in Chililabombwe/Konkola). There was political sensitivity to mine privatisation in PPZ because of ZCCM's previous attempts to evict the community. Resettlement of informal areas has also encountered substantial political opposition in implementation since many of these settlements are high density (such as Kawama) and thus provide substantial constituencies for some members of parliament. The CEP should support the development of ZCCM-IH's land policy and resettlement policy to be fully consistent with Zambian law, the Bank's Operational Policy on Involuntary Resettlement, and good practice on privatization and land administration.

5. INSTITUTIONAL ACTORS AND LEGAL FRAMEWORK IN THE ENVIRONMENT SECTOR

5.1 BACKGROUND

Modern environmental legislation and an adequate institutional capacity for enforcement, will underpin the successful implementation of the CEP, its CEMP and EMF. Zambia's environmental legislation has been refined considerably under the current GRZ administration (1991-2000). Statutes have been reoriented to facilitate economic liberalisation, while safeguarding against the potentially negative environmental consequences of this process. A full legislative review has, to date, encompassed mining and most other economic sectors.

5.2 INSTITUTIONAL CAPACITY

Zambia's environmental statutes give adequate empowerment to its regulatory agencies to monitor and control the full spectrum of mining-related environmental hazards identified in subsequent sections of this EA (see Sections 3 and 4 of Part II). With few exceptions (*e.g.* SO_2) permissible discharges and emissions are consistent with those of European and North American regulatory agencies and a comprehensive parameter range is encompassed. Licensing procedures are equally comprehensive. With a robust legal framework thus in place, successful implementation of the CEP (and in particular the CEMP) will hinge on the development of the necessary institutional capacity for enforcement. Institutional under-resourcing and/or structural deficiencies have undermined the impact of modern environmental legislation introduced for the minerals sector in several developing countries including the Philippines, Bolivia, Ecuador and Tanzania. Based on this experience, Component 3 of the CEP (Environmental Capacity Building) must address a number of key issues. These requirements are incorporated in the project design recommendations in Section 3 of Part III.

Co-ordination: Environmental management is ultimately a multi-sectoral responsibility. Inter-ministerial co-ordination of the utilisation of minerals, water, productive land and other resources is complex. In several countries, multi-disciplinary agencies (*e.g.*, the US-EPA and UK Environment Agency) provide the holistic perspective necessary for effective environmental management. In Zambia, this role is assumed by ECZ.

Under the CEP, responsibility for CEMP and wider project implementation lies with ZCCM-IH. Enforcement and monitoring of compliance with obligatory actions assigned to both ZCCM-IH and private investors will, however, remain with the GRZ's numerous regulatory agencies, including ECZ, the Mines Safety Department (MSD) of the Ministry of Mines and Minerals Development (MMMD), the Water Board, the Ministry of Environment, the Radiation Protection Board, the Ministry of Health and the Ministry of Lands.

The World Bank's Project Appraisal Document (PAD) for the CEP identifies ECZ as lead regulatory agency. Component 3 of the CEP (Environmental Capacity Building) must focus on developing ECZ's capacity both to fulfil its own remit (under the 1990 EPPCA) and to effectively co-ordinate the activities of other regulatory bodies. Critical links include those between (i) ECZ and the Ministry of Environment, (ii) ECZ and the MSD, (iii) ECZ and bodies responsible for specific hazards (*e.g.* radioactive waste sources) or impact receptors (*e.g.*, water resources). A logical bridge between ECZ and MSD is provided under a CIDA funded CANMET capacity building program, initiated in 2001. Co-ordination of CEP capacity-building activities with those of CANMET must be a specified responsibility of ZCCM-IH.

Responsibility definition: Several areas of Zambia's environmental legislation are duplicatory, potentially resulting in ambiguity over institutional enforcement responsibilities. ECZ's inspectorate holds, for example, responsibilities for pollution control under the EPPCA (1990), which are clearly replicated by the Water Board's inspectorate under the Water Act (1948). Sources of radiation including waste are the responsibility of the Radiation Protection Service as provided by the Ionising Radiation Act (1975) under the Ministry of Health. ECZ holds powers and responsibilities which are closely analogous (the new Hazardous Waste Regulations).

Under the CEMP, the formulation of environmental actions and the designation of corporate liabilities must be accompanied by clear guidelines regarding the responsible enforcement body and relevant binding legislation. This could be established through a consultative process chaired by ECZ and ZCCM-IH, to occur in tandem with CEMP design.

Technical capacity and operational resources: Technical capacity and operational resources are important determinants of the ability of environmental regulatory authorities to fulfil their official remit. Interviews undertaken by Komex International with senior technical personnel of the Ministry of Environment, ECZ, MSD, the Radiation Protection Board, the Water Board and ZCCM-IH during the execution of this EA highlighted a generally impressive level of technical expertise and professional motivation. All institutions have benefited from bi- and multi-lateral technology transfer programs. However, retention staff rates and operational resources are critical constraints to the effectiveness of Zambia's environmental regulatory authorities.

Examples of non-compliance with emission and discharge regulations were identified by Komex International during cursory field visits of Copperbelt mining and beneficiation operations (detailed in Annex G). This signifies, in part, the limited capacity of authorities such as ECZ to inspect and monitor activities on a systematic basis. Prior to privatisation, ECZ focused on national environmental regulation, with much of the regulation of mines emanating from the Mine Safety Department. This historical legacy is reflected in the staff concentration of MSD in the Copperbelt and ECZ's staff concentration in Lusaka (ECZ's one office in the Copperbelt is in Ndola which is not a major mining town). Significant work remains to be done to develop ECZ's mining-specific expertise. However, staff retention at ECZ has reportedly posed a greater problem than in some other agencies. Given the limited human and financial resources, ECZ may need to move towards a strategy of prioritising environmental hazards and ensuring adequate enforcement first for those hazards that may cause the greatest harm to human or ecological health (see Part II on risk-based approach).

Critical enforcing bodies such as ECZ and the MSD may warrant evaluation as candidates for institutional restructuring programs under Component 3 of the CEP, as included in World Bank-funded minerals sector projects in numerous other countries (*e.g.*, Ecuador, Bolivia, Argentina, Mauritania, Ghana, Burkina Faso and Mozambiquė). These aim to improve efficiency and self-sustainability by redressing the balance between capital/staff costs and operational resources.

Capacity to manage social issues related to mine sites: As noted in Section 3, prior to privatisation ZCCM had a large security and community affairs staff to monitor active and defunct mine sites and to deal with social issues. Many of the challenges for the sustainable rehabilitation of mine sites stem from human interactions with these sites in the context of relatively unrestricted access. The CEP will need to address community involvement in rehabilitation; at the same time the CEP project design will need to account for ZCCM-IH's, inability, as a technical institution, to extend beyond its current capacity to manage complex social projects (see Part III, recommendations). This may also require strengthening or support through the project of ZCCM-IH's supervisory skills in this area.

5.3 NATIONAL ENVIRONMENT ACTION PLAN

The overarching policy for Zambia's new environmental legislation is provided by the 1994 National Environmental Action Plan (NEAP), implemented by the Ministry of Environment and Natural Resources. This has effectively replaced the original legal blue-print, the 1985 National Conservation Strategy. The NEAP outlines the framework for all aspects of national environmental policy, embodying three central principles: (i) the right of citizens to a clean and healthy environment, (ii) integrated local community and private sector participation in natural resources management, (iii) obligatory environmental impact assessment (EIA) for major projects in all sectors. The NEAP additionally aims to facilitate wider involvement of the private sector in environmental management, while recognising that government must develop a greater capacity for monitoring, regulation and enforcement.

The NEAP encompasses five priority areas for environmental control (all of which are applicable to the Copperbelt and Kabwe): (i) water pollution and inadequate sanitation, (ii) soil/land degradation, (iii) air pollution (in the Copperbelt towns), (iv) wildlife depletion (fish and game), (v) deforestation. In each case, it specifies requirements for the review of laws and regulations, as appropriate, to ensure consistency with the nation's wider environmental policy framework. Since the implementation of the NEAP in 1994, this legislative review has been undertaken with respect to mining, forestry, water and sanitation, wildlife and fisheries.

5.4 ENVIRONMENTAL LEGISLATION

A wide variety of acts related to environmental protection bear upon the issues covered in the project. . These are complemented by and closely integrated with, a range of Statutory Instruments and international conventions and agreements to which Zambia is a signatory. Areas of legislation and associated Statutory Instruments (SI) of particular relevance to the minerals sector, the CEP, the assignment of environmental liabilities in the Copperbelt and the implementation of the CEMP are outlined below.

5.4.1 ENVIRONMENTAL PROTECTION AND POLLUTION CONTROL ACT NO. 12 (1990). CAP 204

The 1990 Environmental Protection and Pollution Control Act (EPPCA) established a new national regulatory body, Environmental Council of Zambia (ECZ). The ECZ serves to:

- Advise government on all environmental issues;
- Recommend measures to control pollution and enforce permissible standards;
- Co-ordinate inter-ministerial activities relating to the environment;
- Co-ordinate national and international environmental affairs;
- Request and evaluate environmental impact assessment (EIAs) for new industrial developments as appropriate; and,
- Monitor impacts of natural resource use.

The EPPCA focuses heavily on waste management, including specific procedures for collection, storage, transportation, treatment, reduction, re-use, recycling and disposal. All areas are of relevance to the mining sector. Section 49 sets out the duties of ECZ in this context. These include:

(i) classification of waste and disposal advice;

(ii) regulation of the handling, storage, transportation, segregation and destruction of hazardous waste; and,

(iii) provision for the monitoring and regulations of sites.

Section 51 specifies the following offences: (i) discharging waste so as to cause pollution in the environment, (ii) transportation waste to any site without a license, (iii) transport of waste to a site which has not been established by a license, (iv) operating a waste disposal site or plant generating hazardous waste.

The EPPCA was amended in 1999, empowering (ECZ) inspectors to arrest, detain without warrant and prosecute offenders under the Act and to impound and dispose of the means for waste conveyance.

5.4.2 STATUTORY INSTRUMENTS RELEVANT TO THE ENVIRONMENTAL PROTECTION AND POLLUTION CONTROL ACT NO. 12 (1990)

5.4.2.1 SI No. 28 (1997): Environmental Protection and Pollution Control (Environmental Impact Assessment) Regulations

Statutory Instrument SI No. 28 outlines the mechanisms by which ECZ may invoke and evaluate EIAs, including those for mining and mineral processing activities. It specifies that TOR for EIAs to be prepared by the developer in consultation with ECZ and outlines the public consultation responsibilities of the developer. Schedule 4 specifies the structure of EIAs, to include (i) preliminary actions (project description), (ii) identification of potential impacts, (iii) a baseline study, (iv) impact evaluation (qualitative and quantitative), (v) public participation, (vi) identification of mitigation measures, (vii) assessment of alternatives, (viii) decisions of the developer, (ix) submission by the developer, (x) decision of the ECZ, (xi) implementation and post-implementation audits.

Under SI No. 28, EIAs are subject to a 45 day evaluation period, during which they must be made available for the scrutiny of government agencies, NGOs and the public. The ECZ is empowered to convene public meetings as appropriate. The ECZ must subsequently either make a unilateral judgement or obtain a decision via a public hearing. Once an EIA is approved, development of the project must commence within three years of authorisation. The ECZ charges a fee for operational costs related to the EIA review and approval process, as specified in the Fifth Schedule of SI No. 28.

5.4.2.2 Statutory Instrument SI No. 72 (1993): Water Pollution Control (Effluent and Wastewater) Regulations

Statutory Instrument SI No. 72 defines permissible effluent limits for industry, including the minerals sector. Under SI No. 72, licenses must be obtained for the discharge of any industrial or sewage effluent or for the abstraction of water to dilute effluents. License holders are obliged to keep a record of licensed activities and to report this to the Inspectorate at six-monthly intervals. Non-compliant discharges of effluent must be reported to the Inspectorate.

5.4.2.3 Statutory Instrument SI No. 141 (1996): Air Pollution Control (Licensing and Emission Standards) Regulations

Analogous in structure to SI No. 72, the Air Pollution Control Regulations, SI No. 141, specify permissible air quality guidelines (Schedule 1) with which mineral processing plant and other industrial activities must comply. A licensing procedure for atmospheric emissions is established (Schedule 2) and monitoring requirements outlined. Excess emission events must be reported to the Inspectorate.

5.4.2.4 Statutory Instrument SI No. of 2001: The Hazardous Waste Management Regulations

A new statutory instrument implemented on October 1, 2001 under the EPCCA. These regulations apply to the control and monitoring of the generation, collection, storage, transportation, treatment and disposal of hazardous wastes – defined as wastes which are poisonous, corrosive, explosive, inflammable, toxic or harmful to man, animal, plant or the environment.

5.4.3 THE MINES AND MINERALS ACT

5.4.3.1 SI No. 31, 1995

The EPPCA and its associated statutory instruments are overprinted by legislation specific to the minerals industry, most significantly the 1995 Mines and Minerals Act. Part I, Clauses 75 – 82 of the act relate to environmental protection. The Director of Mines is uniquely empowered to issue Large Scale Mining Licenses (LML), the acquisition of which is subject to a valid EIA. The Director of Mine Safety within the Ministry of Mines and Minerals Development (MMMD) is charged with responsibility for matters concerning the safety of prospecting, exploration and mining operations and also acts as the lead agent (in liaison with ECZ) for EIA assessment. The Director or authorised persons, is permitted to enter mine areas at any time for inspections.

Part II of the Mines and Minerals Act (1995) outlines specific EIA requirements for mining projects. Authorisation for mine development, notwithstanding the role of ECZ, must be obtained from the MMMD Director of Mines Safety. The Director grants authorisation in consultation with the Environmental Council of Zambia (ECZ).

5.4.3.2 Amendment, 2000

The Mines and Minerals Act was amended in 2000, such that any environmental liabilities that have arisen or arise in the future as a result of the operations of the Assets by ZCCM prior to their sale will be assumed and vest in GRZ. Furthermore, GRZ is responsible for environmental liabilities arising from the operations of the Assets after their acquisition, provided that the operations are in compliance with the applicable environmental management plan, including the actions and timetables required to bring the Assets into compliance. ZCCM-IH is therefore responsible for environmental liabilities arising from the operations of the mines, so long as each mine operator operates within this agreed environmental management plan.

The Act was amended in 2000 to provide for among other things Investment Incentives such as relief from tax, customs duty and mineral royalty tax to the new mine owners as contained in the Development Agreements entered into between Government and the mining investors.

5.4.4 STATUTORY INSTRUMENTS RELEVANT TO THE MINES AND MINERALS ACT NO. 31 (1995)

5.4.4.1 Statutory Instrument SI No. 29 (1997): The Mines and Minerals (Environmental) Regulations

Statutory Instrument SI No. 29 regulates the execution of EIAs in the minerals sector, although the structural and evaluation procedures remain as prescribed under SI No. 28 (section 5.4.2.1 above). Guidelines for the siting and management of Mine Dumps (mine residual deposits) are provided, along with air and water quality standards, procedures for storage and handling of hazardous materials and the inspection of mining facilities.

5.4.4.2 Statutory Instrument SI No. 119 (1994): Mining (Mineral Resource Extraction) Regulations Controlling Emissions of Sulphur to the Atmosphere from Pyrometallurgical Processes

Statutory Instrument SI No. 119 prescribes that monthly emission reports must be submitted by pyrometallurgical plant operators to the Chief Mining Engineer and Chief Inspector of Mines. Emission limitations are provided in the regulations and a fine levied for excess discharge of SO_2. However, in the case of MCM's Mufulira and KCM-managed SmelterCo. smelters, a grace period from penalties has been granted for the first five years of operations.

5.4.4.3 Statutory Instrument SI No. 102 (1998): The Mines and Minerals Environmental Protection Fund Regulations

An Environmental Protection Fund is established under SI No. 102 to provide insurance against corporate failure to execute EIS commitments and to finance rehabilitation should the operator fail to undertake such responsibilities.

5.4.5 PNEUMOCONIOSIS ACT (CAP. 217)

The Pneumoconiosis Act specifies the requirement for certificates of fitness for all employees operating in restricted mine areas (scheduled areas). A mine scheduled area is a place where free silica in the respirable dust with particle size less than 5 microns is harmful to humans if inhaled over a period. The Act also classifies communities living in the "immediate area" (within a 100-meter radius from a mining area) as a scheduled area and must be subject to the provisions of the Act (SI No. 97 of 1997).

5.4.6 THE WATER ACT NO. 198 (1948)

The Water Act, enacted in 1948 is the primary legislative basis for water resources management. It provides for control, ownership and use of water excluding the Zambezi, Luapula and Luangwa rivers which border with other countries. It specifies conditions for the use of water resources by the mining and transport industries and for all urban activities, to be supervised under the auspices of the Water

Board. The act stipulates procedures for the acquisition of water rights and outlines the mitigation responsibilities of polluters. Notification procedures for intended abstraction are provided, plus emergency contingency plans for implementation by abstractors during periods of drought or flood. The Water Act is currently under amendment by the ministries of Energy and Water Resources and Legal Affairs. Notification procedures for intended abstraction, emergency contingency plans are not in the Act but in the upcoming amendment.

5.4.7 STATUTORY INSTRUMENTS RELEVANT TO THE WATER ACT NO. 198 (1948)

5.4.7.1 Statutory Instrument SI No. 20 (1993): Water Board (Charges) Regulations

Statutory Instrument SI No. 20 provides a framework of charges for water abstractors.

5.4.7.2 Statutory Instrument SI No. 53 (1994): Water Board (Water Measurement) Regulations

Statutory Instrument SI No. 53 empowers the Water Board to emplace abstraction measurement and hydrographic monitoring stations at sites considered necessary and beneficial to water-right holders.

5.4.7.3 Statutory Instrument No. SI No. 119 (1994): Water Board (Works) Regulations

Statutory Instrument SI No. 119 outlines restrictions and controls on the construction of hydraulic structures (including mine tailings facilities).

5.4.7.4 Statutory Instrument SI No. 1 (2000): Water Board (Protection of Public Streams) Regulations

Statutory Instrument SI No. 1 outlines controls of riparian land use. Cultivation and felling are restricted within 50 metres of riverbanks.

5.4.8 THE WATER SUPPLY AND SANITATION ACT NO. 28 (1997)

To provide for an efficient sustainable supply of water and sanitation services under the regulation of the National Water supply and Sanitation Council. The Act also facilitates the formation of commercialised urban water supply and sanitation utilities, regulates the licensing of water utility providers and sanitation services.

5.4.9 IONISING RADIATION ACT (19751991)

The Ionising Radiation Act provides for protection against occupational and environmental exposure to radiation sources. It establishes the Radiation Protection Board, with responsibility for the licensing of radioactive materials and monitoring of exposure levels.

5.4.9.1 Statutory Instrument No. 171 (1992)

Establishes limits of exposure to radiation, dose limits, limits of radionuclides and planned exposure time. It also addresses the structural requirement and inspection of buildings, licensing, transport and storage of radioactive material, reporting procedures of releases to environment at decommissioning and abandonment of facilities.

5.5 REGIONAL ENVIRONMENTAL STEERING COMMITTEES

As part of the CEP, a Steering Committee has been proposed to assist with implementation of the CEP.[26] The Ministry of Finance is to chair it with representation from the Ministry of Mines, the Ministry of Environment and Natural Resources, ZCCM-IH, ECZ, the Chamber of Mines, academia and other key stakeholders such as local government administrators, NGOs and other suitable persons. This Committee's responsibilities will include:

i) monitoring project preparation and project implementation;
ii) ensuring co-ordination between the different project stakeholders;
iii) providing a forum for resolving issues related to the management of the environmental liabilities falling on GRZ; and,
iv) ensuring necessary linkages with other ongoing activities, such as the Mines Municipal Services Project, the CIDA-funded Environmental Management in the Mining Sector Project and the Environmental Support Program in MENR.

Another project that has a mandate related to the goals and objectives of the CEP is the Water Resources Action Programme (WRAP). The WRAP, a multi-donor initiative to implement Zambia's National Water Policy, seeks to improve watershed management and to promote the sustainable use of water resources. Several steering committees will or have been formed under the WRAP that may be important to include in discussions of CEP implementation. For example, copper mining activities occur within the Kafue River Basin. Processing and effluent related to mining activities are discharged to the Kafue River system (either to the Kafue River directly or indirectly through tributaries). Thus, water sector committees focusing on the Kafue River Basin could complement or offer value to the CEP (where appropriate). The WRAP includes a pilot initiative to create a Kafue River Basin Authority, though this would likely commence one year from now. Funding is currently being negotiated for this pilot under the WRAP from the World Bank-Netherlands Water Partnership. When this goes forward, the pilot will seek to co-ordinate with key stakeholders in the basin, including mine companies, ZCCM-IH, ECZ among others. The specific committees under the WRAP are:

[26] Information regarding the Steering Committee is from: CEP: Preparation Mission, 1-14 August 2001, Draft.

- **Task Team under the Water Resources Action Programme (WRAP)** (to be formalised): an autonomous body consisting of the Programme Manager and eight specialists (areas of expertise: international waters; institutional and legal framework; water resources information; institutional and human resources development; water resources, demand, supply and infrastructure; economics and financing; water and environment; and public relations and advocacy). Responsibilities will focus on developing the strategies to implement Zambia's National Water Policy. The Task Team will fall under the supervision of an inter-ministerial body, the Steering Team and will collaborate with the National Co-ordinator. To begin with, efforts will be focussed on the Kafue River Basin to formulate a water resources management at a basin, catchment and community level;

- **The Kafue River Basin Environmental Management Steering Committee under the Integrated Kafue River Basin EIA** (to be formalised): the Permanent Secretary of the MENR would serve as chair and membership would include major stakeholders in the Kafue catchment. Responsibilities would include:
  i) Co-ordination of the study;
  ii) Management and approval of use of project funds;
  iii) Co-ordination of appointments of Consultants;
  iv) Co-ordination of workshop organisation;
  v) Review of reports from consultant; and,
  vi) Appointment and co-ordination of work of the Study Co-ordinator (Terms of Reference, Integrated Kafue River Basin Environmental Impact Assessment, June 1999).

5.6 NATIONAL REGULATIONS ON PUBLIC CONSULTATION, ACCESS TO INFORMATION AND DISCLOSURE

As summarised in Annex C, for projects requiring an EIS, Statutory Instrument No. 28 contains specific clauses on type and duration of public disclosure and consultation of the EIS. This includes consultation with a wide spectrum of stakeholders on the terms of reference for the EIS, as well as the public disclosure and period for comment for the EIS once drafted. The ECZ plays a key role in managing the disclosure and comment process.

At present there is no legislation requiring mine companies to publish or disclose information on pollution levels. They are required only to report these to ECZ. This represents an issue in the case where a mine company exceeds normal emissions levels or has a plant accident that may affect the health or welfare of downstream or downwind residents. Evaluation of mine EMPs should look carefully at the need for such a warning system to communities. Reportedly Zambian "Right to Know" legislation is in draft form, but has not yet been approved.

5.7 NGOS

NGOs may play an important role in forming links to communities either during the EMP process or during remediation of specific sites. Annex R on NGOs provides a list of NGOs active in each town according to local government sources. NGOs active in the Copperbelt and Kabwe tend to fall into one of three categories:

- International NGOs with extensive community based projects who also work to develop local community-based organisations. These NGOs tend to focus on community-based projects in informal housing or rural areas and to respond to those priorities that are defined by the communities (often water supply, schools, health care, sanitation). They can offer a useful link to local communities, though the number of communities they cover tends to be small overall with many neighbourhoods with no NGOs active.

- Local NGOs focused on a specific issue such as the care of orphans or AIDS. These are more frequently encountered in each town but may not be involved in issues outside of their focus.

- Advocacy NGOs who have few community-based projects or staff, but who are dedicated to specific issues. The number such NGOs active in the mining environment is limited to about three NGOs, with one having its base outside of the region.

5.8 INTERNATIONAL PROTOCOLS

Zambia is signatory to the following international environmental protocols and agreements. Integration of the terms of these protocols with national legislation is the responsibility of the Legal and Enforcement Component of the Environmental Support Program under the ministry of Environment and Natural Resources in conjunction with the ministry of Legal Affairs and the ECZ.

- The Rio Declaration on Environment and Development;
- Convention Concerning the Protection of Workers Against Occupational Hazards in the Working Environment due to Air Pollution and Noise Vibrations;
- Vienna Convention for the Protection of the Ozone Layer;
- Montreal Protocol on Substances that Deplete the Ozone layer;
- UN Framework Convention on Climate Change;
- Convention on Biological Diversity;
- Convention on Wetlands of International Importance;
- Convention for the Protection of the World Cultural and Natural Heritage;
- African Convention on the Conservation of Nature and Natural Resources;
- Statutes of the International Atomic Energy;
- International Plant Protection Convention; and,
- Basel Convention on the Control of Transboundary Movement of Hazardous Waste.

PART II:
OVERVIEW OF CURRENT ENVIRONMENTAL HAZARDS

1. INTRODUCTION

1.1 STRUCTURE OF Part II

Part II introduces the concept of a risk assessment or hazard-ranking approach to determine which mining environmental issues should be prioritised for attention. Chapter 2 provides a background to the geology and mining processes in the Copperbelt and Kabwe and the potential environmental effects that could be associated with these mining practices (Annex G provides more detail on the technical processes and range of effects often associated with these processes). Chapter 3 subsequently presents the data available on the known effects of mining on health and on ecology in the Copperbelt and Kabwe. An understanding of range of toxins introduced to the environment as a result of mining or associated mineral processing activities is critical to the evaluation of potential ecological or human health impact. The health assessment presented in Chapter 3 provides such information within the specific context of the Copperbelt and Kabwe, as a first step in the process of ranking hazards for attention under the CEP. Subsequent sections explore the current level of knowledge on the impact on animals, plants and one of the key ecosystems in the region, the Kafue River. Chapter 5 uses information established in previous chapters to outline those issues having the greatest impact on people, animals and plants according to a qualitative risk assessment methodology. Chapter 6 outlines the data gaps that will need to be filled through EMPs and the CEMP and the monitoring systems that should be put in place. Chapter 7 presents some technical options for rehabilitation of sites.

1.2 RISK-BASED APPROACH AND METHODOLOGY

Environmental management is commonly based on the establishment of "acceptable" standards for specific pollutants from different sources. Standards vary from country to country, with some, such as China, setting standards based on a level considered realistically achievable and others setting them at or below the lowest level at which health or ecological impacts will occur (a common approach of the WHO). In Zambia most standards other than those for SO_2 are roughly in line with those used in more developed countries such as the USA and Europe.

Compliance with these standards can be monitored, exceedances triggering action by regulators to ensure future compliance (*e.g.*, by imposing penalties on polluters). Frequently, financial and physical resources for environmental protection are inadequate to address all situations where contaminants are released at concentrations exceeding threshold levels. In such cases, a risk-based approach may be appropriate to prioritise remedial action and to determine how limited resources for environmental rehabilitation or regulation should be allocated.

In situations where resources are limited, a risk-based approach may be advisable to focus resources on problems most likely to result in significant damage to people, animals, plants and sensitive ecosystems. This does not imply that standards are ignored, only that the most serious issues will receive priority attention from regulators and from those remediating sites until such time as adequate resources become available to address other cases of non-compliance with environmental standards.

In the case of Zambia, as discussed in Part I, ECZ/MSD are currently unable to fully enforce existing environmental regulation in the mining sector. Therefore, the sector could consider the utility of a risk-based strategy towards regulation and towards environmental restoration under the CEP. Such a strategy was used in a similar situation in Bolivia in the context of the World Bank Environment, Industry and Mining Project, underway since 1996. In the Bolivian case, the government needed to determine how best to allocate remediation resources in a context of numerous different mines and limited information.[1] The Bolivian approach involved four stages of analysis:

1) Conduct a preliminary screening (qualitative or based on available quantitative data) of sites and issues according to their impacts on:

    1. human health;
    2. ecosystems;
    3. future use of the site or land (potential income from); and,
    4. aesthetic factors.

2) Identify priority sites for remedial action based on data obtained during short visits to the sites (and their surroundings) identified in stage 1 as most likely to be hazardous. Define data needs for more complete assessments of the impacts of the hazards and sources of damage.

3) Carry out audits on high priority properties to ascertain the nature and extent of the hazards.

4) Determine appropriate actions at each of the priority sites, based on estimates of the benefits of reducing environmental contamination and on the costs of alternative actions for reducing contamination.

Monitoring effort can then be invested in priority issues and additional, more detailed investigations carried out accordingly.

Undertaking of a rapid initial assessment can be done by; first, identifying the likelihood that a given contaminant exists; second, establishing the likelihood of people, animals or plants becoming exposed to that contaminant; third, factoring in the toxicity of the contaminant; and finally, if the necessary information is available, estimating the degree to which people, animals and plants are exposed and the likely consequences of that level of exposure. Under such a system, isolated tailings or waste dumps

[1] This approach is well documented in World Bank Technical Paper No. 398, *Setting Environmental Priorities for Environmental Management, An Application to the Mining Sector in Bolivia,* W. Ayres, K. Anderson and D. Hanrahan, 1998.

which are removed from any impact on watercourses or people would rank lower than those sites which are next to population centres or sensitive ecological environments. The simple presence of a contaminant in the ore, tailings or waste rock does not necessarily mean it will pose a threat since the right conditions must be present for it to be mobilised and taken up by animals, plants or ecology. For example, many of the materials found in tailings in the Copperbelt pose no threat from direct skin contact. Others are not readily soluble in water and are thus less likely to be absorbed.

2. OVERVIEW OF MINING PROCESSES AND POTENTIAL CONTAMINANT SOURCES (COPPERBELT AND KABWE)

2.1 INTRODUCTION

In the Copperbelt and Kabwe, some appreciation of the regional geology (see Section 2.2) and the methods currently and historically used in the extraction and processing of base-metal ores is needed. Sources of contaminants come either from the material that is being mined or from the processes used to extract the metals. This chapter provides an overview of the geology of the Copperbelt and Kabwe, mining processes, mine site components and mining-related environmental impacts (with details presented in Annex G). Location maps for the Copperbelt mine sites and Kabwe are provided in Figures 1-4. Area plans of the mine sites and adjacent communities are provided in the Figures in Annex D.

2.2 GEOLOGICAL SETTINGS AND THEIR RELATIONSHIP WITH MINING ENVIRONMENTAL IMPACTS (COPPERBELT AND KABWE DISTRICTS)

The style of mineralisation of a region and its geological setting influences the range of contaminants likely to be found and plays a key role in determining whether those contaminants are likely to pose a hazard. Globally, a common by-product of mining is acid waters which are more likely to dissolve metals, causing them to be available to be absorbed by people drinking the water, by fish or by plants. This situation is called acid rock drainage (ARD) and typically causes significant negative environmental impacts.

Fortunately, in both the Copperbelt and Kabwe, the host rocks for the mineral deposits tend to buffer the acidity; thus, for the majority of sites, waters are not highly acidic.

While minewater hazards within the Copperbelt and Kabwe are subject to a strong geological control, a range of other toxin mobilisation mechanisms may remain; including dusting, suspended sediment mobilisation and atmospheric volatile discharges.

More detailed geological settings are provided in Annex G.

2.3 MINING PROCESSES

The following general overview of mining and mineral processing activities identifies a broad range of possible effects mining has on the environment as well as possible sources of hazards. Some effects are aesthetic, some have an impact on human health, some may cut off sources of income and some may actually create sources of income. Additional mineral processing information is provided in Annex G. A preliminary assessment of the actual known impact of these effects/contaminants is presented in subsequent sections on health and ecology.

2.3.1 ORE EXPLOITATION

A range of ore exploitation methods has historically been used in the Copperbelt and Kabwe mining districts. These can be classified into (a) open pit and (b) underground operations. Some mines have applied both methods.

2.3.1.1 Open Pits

Open pits of up to 1 km diameter and >437 m depth are or have been, worked at Kabwe (seven pits), Nchanga, Nkana and Chambishi. Only the Nchanga pit remains active, with closure scheduled for 2004. With open pit mining, a large quantity of soil, rock and bedrock must be excavated to produce a relatively small amount of ore. This type of mining therefore generates a high tonnage of waste rock and overburden (the soil and material found above the ore) which is disposed of in waste dumps, overburden dumps and waste rock dumps. This waste is a potentially important source of sediment and is a possible source of metalliferous seepage, as discussed in a following section.

The localised hazards of open pit mining in the Copperbelt and Kabwe have, in most respects been considerably greater than underground mining. Pit management is complex. Excavation methods exist that minimise the tonnage of barren rock removed to produce a given amount of ore and that provide for more stable pit walls. In the case of the Copperbelt and Kabwe, historically inadequate geotechnical characterisation of the host geology (lithologies), site hydrogeology and structure has made slope optimisation difficult, resulting in several instances of slope failure.

The hydrogeology of permeable strata surrounding open pits is also frequently complex. Flow gradients towards the mine workings may be produced, resulting in high pore-water pressure behind the pit walls and, hence, geotechnical instability. Continuous monitoring and dewatering via a curtain of piezometers and extraction wells encircling the pit is often fundamental. At Nchanga, inadequate pit wall depressurisation was implicated in the fatal pit wall collapse at the site in April 2001.

Open pit depths invariably penetrate permanently saturated strata. De-watering is thus essential to avoid flooding of the pit during the excavation phase. With respect to the Copperbelt's pits, depths range from 50 – 437 m, with depths to water in the range of 30 – 100 m. Rate requirements for de-watering vary markedly, but are commonly of the order of 100 l/s. Because of their interaction with exposed ores, pit waters can be of poor chemical quality, with high dissolved copper and cobalt concentrations (in the Copperbelt). Their disposal thus poses a potential localised hazard to groundwater and surface drainage if not buffered by other elements.

Following closure, water levels in open pits will be allowed to recover to a static point, as is happening at Kabwe. Submergence of sulphide rich pit walls may also be favoured as a mechanism for controlling sulphide oxidation by removing exposure to the atmosphere. Pit lakes, while an accepted component of many modern mine closure plans, do however carry accompanying risks, particularly in instances where pits discharge to the groundwater regime. This would need to be assessed during the EMPs to rule it out as a source of ongoing pollution.

Pit wall collapse poses a very localised risk to workers at the only functioning open pit, Nchanga. For the remaining closed pits in the Copperbelt or Kabwe (several of these are under ZCCM-IH responsibility) the degree of risk will depend on the number of people illegally accessing the pit. Unlike tailings dams, defunct pits visited during the SA field work did not appear to be used for agriculture, fishing or scavenging and thus the number of people accessing them is likely to be small (usage should be confirmed through the EMPs). Although few people may have access to these pits, the hazards are tangible. In Kabwe, several boys drowned because they went swimming in an open pit that had filled with water and the walls to the pit are quite steep. This occurred in spite of the presence of a fence surrounding the open pit. Warnings, community education and other measures to impede access should be put in place.

BOX: CASE STUDY NCHANGA OPEN PITS

Several of the ZCCM-managed open pits and overburden dumps in Nchanga Mine lie some 12 to 15 km from the centre of Chingola town. Others lie within 2 to 5 km of downtown Chingola. With the dismantling of ZCCM security forces, access to most of the ZCCM-managed sites is not controlled. The SA team conducted discussions with residents and scavengers at a number of open pits in the area.

At one such site, open pit C (within 5 km of Chingola), fissures are present prior to the edge of the pit and one wall is likely to fail this rainy season, causing a hazard to anyone happening to be in or around the pit at that time. If the pit walls continue to crumble, the road that crosses near the pit and that allows access to other defunct mine sites could eventually be compromised. Large pieces of malachite and copper lay scattered around the pit rim, but did not appear to be of any interest to scavengers. Population density in the immediate area (within 1 km) is low and no people were present around the pit during the site visit, save for one man sitting under a tree at one end. The pit and its surrounding area were barren of any vegetation.

In a second grouping of sites, approximately 12 to 15 km from downtown Chingola, are located numerous overburden dumps and open pits which are likely to fall under ZCCM responsibility. A dumpsite for demolition debris and contaminated soils from Nchanga mine had been created at one of these sites, Chingola open pit. Approximately 30 men were already scavenging the dumpsite for wires from the pieces of rock and concrete that had been deposited within the past two weeks. Demolition debris is of particular interest to the scavengers as it typically has wire and metals that can be sold to scrap metal dealers. The group interviewed reported earnings from 10,000 K to 30,000 K per day for this work. They all came from the closest neighbourhood, low cost Chiwempala. Many of the men were relatively young and reported that their parents were farmers or charcoal burners. The active Muntipa tailings dam which is under KCM control, lies relatively near the Chingola open pit, but fences and warning signs appear to have discouraged access.

The Mimbula open pits are situated still farther from town, down the same road as the Chingola open pit. The Mimbula pits are filled with water, forming a small reservoir and lie near a number of overburden dumps. Cattle use the pits for drinking water and others had used the pit for recreational boating. The closest residents, a farmer and his wife, live about 1 km from the pit, adjacent to the stream coming from the pit. They used this stream for washing clothes and for irrigating maize, but relied on a spring for drinking water. They therefore had little knowledge or concern about the quality of the water in the open pit. A fishing net hung in their yard, which they reported was used by their son to fish downstream of the pit. However, they noted that this is not a frequent occurrence and the fish they typically eat comes from the market. The farmer was not a member of any association, but did attend a church to which about 60 other neighbours belong. When he has a problem or wants news he goes to the local "chairman" (he was not sure of which party). He has been on this farm since 1983. He reported his key concerns as lack of seeds and fertiliser for his two hectare farm.

2.3.1.2 Underground Exploitation

The location of ore reserves of the Copperbelt has favoured underground exploitation at Konkola, Nkana, Nchanga, Mufulira, Chambishi, Luanshya, Baluba and Kabwe.[2] In the Copperbelt, some underground tunnels have subsequently been back-filled to reduce both subsidence and the requirement to hoist waste rock to surface. At Kabwe, no back-filling has been attempted and workings have been abandoned with support pillars in place.

Subsidence, changes in the stability of the ground because of tunnels underneath, has affected both the Copperbelt and Kabwe to some degree. At Kabwe, subsidence has been limited due to the exploitation of ore from massive dolomites. In the Copperbelt, there are cracks propagating upward, while ore exploitation from the flatter, deeper sectors of such structures has resulted in more uniform but broader depression features. Common risks associated with subsidence include, (a) open fissures and sinkholes and (b) chimney collapses (vertical columns of rock which collapse due to jointing). At least 4,000 ha has been affected to the extent that access and grazing restrictions are required.

Detailed data on specific areas subject to subsidence have been presented in KCM's EMP for Konkola and Nchanga mines which stated that the potential for future chimney collapse was slim. Such updated information is needed at other mines that have not conducted environmental reviews since 1996. In particular, future assessment should characterise the level of risk (likelihood of collapse and impact) to people and animals for subsidence and chimney collapse.

Most underground mining in the Copperbelt and Kabwe has occurred in or is connected to, high yield aquifer rocks. Thus, de-watering (pumping water out) of the excavations is necessary to gain access to extract ore. The rates of pumping range from 1,000 m^3/day to as much as 330,000 m^3/day at Konkola. The latter is, in global mining terms, exceptional as it is one of the wettest mines in the world and equates to the removal of 70 tons of water for each ton of ore extracted. As noted above, in contrast to many of the world's stratabound copper sulphide provinces, Copperbelt minewaters present no ARD hazard and total suspended and dissolved solids loads are low. The volumes of water pumped into the Kafue and its tributaries substantially increases the volume of water flowing through this river basin to downstream users. During the dry season, water from mines forms the largest single contributor to total flows. During 1995, up to 40% of the water in the upper Kafue River was estimated to originate from Konkola (Pettersson and Ingri, 1999). Augmentation of low flows, while contrary to natural conditions, can have some positive effects: 1) it can improve the survival rate of aquatic life during periods of low-flow; 2) its contribution to the Kafue provides a major source of drinking water for the largest Zambian cities in the Copperbelt and downstream (Lusaka); and, 3) because most Copperbelt minewater is of high quality both

[2] At Kabwe, underground mining commenced in 1940, with all excavations connected to the earlier open pit workings. Sub-Level Open Stoping (SLOS) has been utilised to extract ore from depths exceeding 400 m. Vertical shafts provide access to the mineralised strata, within which a series of lateral drives is then emplaced.

chemically and microbiologically, it generally serves as a net dilutant of more contaminated discharges to the system. A contrast exists however, at Kabwe, where minewater is carried by a surface canal, the sediments of which are highly contaminated with lead and zinc.

Pumping water from the upper levels of certain Copperbelt mines, notably Chambishi, has induced significant drops in groundwater levels (drawdown), reduction of flows from natural springs and losses of yield from some pre-existing abstraction wells (for irrigation and potable supply). However, pumping water from the mine abstracting the largest volume of water from underground aquifers, Konkola mine, apparently has not resulted in any significant drawdown in the region.[3] Detailed information is not available for other mines.

2.3.2 WASTE ROCK AND OVERBURDEN DISPOSAL

Overburden and waste rock dumps are formed from the soil or rock excavated to get to the ore which is processed in mining. These dumps are generally less toxic than some other mining by-products as they mimic the ground (soil, rock, bedrock) composition in a given area rather than being the by-products of refining ore.[4] These dumps cover a considerable surface area in the Copperbelt and Kabwe, accounting for more than 1,700 ha, with a total volume of at least 900 million m^3. Aesthetically, the surface storage of this material constitutes the most conspicuous mining impact in both regions. These dumps are, in practical terms, permanent features as the cost of re-transportation (for example, to permit infilling of open pits) is prohibitive.

Surface storage of sub-ore grade and barren waste in the above tonnages can be unstable, contribute to erosion and potentially contain runoff which has some metal/metalloid content depending on the nature of the material. The establishment of a vegetative cover (either by natural recolonization or by planting) is used on waste rock and overburden dumps to control erosion, but is problematic. The relative success of revegetation may be influenced by the toxicity of soil, as well as physical factors such as the steep gradients of peripheral slopes and lack of topsoil. Dumps are thus highly prone to erosion by wind and water. Sediment yields from Copperbelt waste dumps have not been quantified, but indisputably magnify the suspended load to the Kafue and tributary rivers.

While waste rock and overburden is, by definition, sub-ore grade material (not concentrated in heavy metals), potentially toxic metals and metalloids can, in relatively rare cases, occur if these substances happen to be present in the soil or rock that has been excavated. The oxidation of sulphides may potentially result in mobilisation of such elements at a rate controlled by several factors including the

[3] One reason for this stems from the high rates of recharge over a large basin area. Another is the high amount of water in storage (*i.e.*, that which can be pumped from fractures and pores before any fall in water level occurs).
[4] Natural ground and rock can have some isolated veins of metallic ore, but not to the degree or concentration found in other mining waste.

interaction of water with the materials, the solubility of the material and the degree to which buffering rocks such as those prevalent in the Copperbelt and Kabwe were present (see Annex G for more detail).

Data reviewed by the SA team for selected overburden dumps did not show that they presented major health hazards, with relatively good buffering capacity in the leachate coming from the dumps. A more thorough assessment of site specific characteristics would be warranted in the EMP. In addition, relatively little information has been gathered on how these dumps are being used by the population. ZCCM-IH currently holds responsibility for several overburden dumps at Nchanga and Nkana.

2.3.3 ORE PROCESSING

The processing technologies applied to extract base metals from the Copperbelt and Kabwe ores share some similarities. However, significant differences exist at the pyrometallurgical stage (though the Kabwe smelter is no longer operational). At all mines, the initial process of metal concentration has taken place using froth flotation. Ore is crushed mechanically to a fine powder and conveyed to a concentrator, where metals are separated from non-metallic minerals in the crushed feed by flotation. The ore is mixed with a solution of water, xanthate, sodium hydrosulphide and frothing agents in a cell or cylindrical tank. Air is injected, causing the formation of bubbles to which sulphides and other metallic particles adhere. The waste material settles and is discharged as a tailings slurry. The froth is skimmed, the water and reagents distilled and the clean metallic concentrate recovered following a thickening process. In comparison to other technologies flotation is a relatively benign procedure as there are no toxic substances deployed, leachates are alkaline and metal solubilities are low.

Generally, the fundamental consideration is the volume of slurried tailings discharged. Freely releasing the aqueous component of this slurry can cause eutrophication (overloading of nutrients) of natural watercourses. Re-circulating this fluid is generally not considered cost-effective in the Copperbelt.

After flotation in the concentrator, further processing is required to purify the ore metals. In the Copperbelt and Kabwe, this has been undertaken at several pyrometallurgical plants (smelters). Three copper smelting plants are located at Mufulira, Nkana and Luanshya (though Luanshya has not operated since 1998). One cobalt plant is located at Chambishi. One lead smelter was located at Kabwe, which ceased to operate in 1994.

The metallurgical procedures at each plant vary. However, several common stages, generally referred to as RLE (roasting, leaching and electrowinning) are utilised (see Annex G for further details on the process). The roasting of sulphide ores releases volatiles which, unless captured, are released into the atmosphere via the stack or via leaks in the stack (fugitive emissions). These emissions can potentially affect people who breath contaminated air and cause deposition over time on plants and soil downwind of the smelter. Emissions of SO_2 from the Copperbelt's smelters range from between 300,000 and 700,000 tons per year. Substantial quantities of dust are also emitted which are composed of the other elements in the base ore (such as lead). See discussion of smelters under the health section.

Once the process has removed the majority of the valuable metals, the depleted calcine residue (a mixture of residual sulphates and Fe oxyhydroxides) is slurried and is generally discharged to a tailings facility (see discussion of tailings below). Effluents from copper refining typically require neutralisation with lime before being discharged into tailings facilities.[5] Copper is then recovered by electrowinning and exported as copper cathode. Metalliferous effluents of both acidic and alkaline composition are produced by the acid leaching and electrowinning phases of the copper beneficiation process and the leaching of lead-zinc oxides.

At Kabwe, a range of secondary leaching, electrolytic and pyrometallurgical technologies have been used for lead and zinc recovery from sulphide and oxide ores. Slag, leach residues and slimes from all of these metallurgical processes have been stored at Kabwe's waste/tailings dump.

From stacks and fugitive emission sources the dust and SO_2 from smelters is dispersed along a plume path which may vary with wind and weather. The level of concentration of metals and thus the number of people affected, should decrease the further the distance from the smelter. As discussed in detail below on health impact, various studies have modeled the path of the smelter plumes and the concentration at ground level (the indicator of importance to assessing the impact on people) which provides an indication of the <u>potential</u> number of people affected which is significant in towns with smelters. These community monitoring stations have not been sensitive enough to measure low doses of lead or arsenic. Less complete information is available for Chambishi or Kabwe.

2.3.4 ACID PLANTS

Technology for the removal of SO_2 from stack emissions has been implemented at the Nkana and Chambishi smelters. These serve to reduce acidic gases and to recover sulphuric acid which may subsequently be sold or utilised in the leach cycles of copper and cobalt beneficiation. Nkana has three operating acid plants with a combined production capacity of 920 tonnes of acid per day. In spite of some acid plant technology, sulphur dioxide emissions remain a major hazard (see Part II, Section 3.6.9).

Acid plants generate low pH discharges, which require liming prior to their release into tailings facilities or surface watercourses. These waters are also prone to enrichment with non-sulphur volatiles, which are not typically measured in the standard water quality tests performed in the region (see Section 6 on data

[5] An issue of environmental significance specific to Nchanga involves the operation of a tailings leach plant (TLP) for the re-processing of some 600,000 tons per month of formerly worked tailings from Nchanga tailings pile TD2. The process consists of leaching of the stockpile with sulphuric acid, followed by solvent extraction of copper from the pregnant solution and finally electrowinning. After leaching, the residual solids are neutralised through the addition of quick-lime and sent as slurry to a tailings impoundment.

gaps and monitoring). These elements are mobile across a wide pH/Eh range, thus they may not be effectively precipitated by the liming process and should be tested for during the EMP process.

Emissions reduction technologies are lacking at the Mufulira smelter, which has the emissions of most concern in the region. Once the SmelterCo smelter at Nkana is refurbished, it may process much of the ore currently being processed at Mufulira (which comes from KCM). The financial justification for investing in improvements at Mufulira may therefore be slim as the Mufulira mine produces too low a volume of ore on its own to keep the smelter operational.

2.3.5 TAILINGS

Tailings disposal sites in the Copperbelt and Kabwe districts can broadly be classified into either cross-valley or paddock dump types. Paddock dumps consist of ring dykes with solid and liquid tailings contained within the perimeter dykes. Paddock dumps tend to be older, less engineered tailings retention structures.

Cross-valley dumps utilise an engineered dam to contain the tailings. As they are located in valleys containing water courses, they require suitable decant and/or spillway structures. Cross-valley dumps have generally been constructed to modern engineering standards, but remain subject to hazards associated with both their larger size and height and especially the need to store and spill both process water and natural water entering the impoundment from the upstream catchment area. In most cases, the relatively flat surrounding topography of the Copperbelt helps to truncate the potential for flooding so that peak flows can be readily accommodated. However, in the present era of climatic extremes, there is an increased risk that overflow structures may not be adequate to fully contain more stringent flood events approaching the probable maximum flood.

The environmental hazards associated with tailings deposition in the Copperbelt and Kabwe districts are widely variable. With respect to Copperbelt paddocks, general problems include the erosion of unvegetated perimeter slopes and attendant sedimentation of nearby watercourses, dyke instability, dusting due to wind erosion and off-site seepage of contaminated leachates. Cross-valley structures tend to present a lesser dusting hazard due to the presence of water, however, a range of additional considerations exists. The build-up of water within saturated tailings can result in sustained contaminant seepage to groundwater while decant or spillway overflow may discharge both dissolved and particulate metals to the downstream catchment. Risks of catastrophic failure exist in the event of overtopping (depositing a quantity of tailings beyond what the structure can hold).

While technically waste-materials, tailings typically contain a residual heavy metal sulphide component and are thus a potential source of acid leachate and contaminant metals. While many of the paddocks of the Copperbelt contain only concentrator tailings, other facilities (for example the Musukashi facility at Chambishi and paddock TD33C at Nkana) received calcine slurries from the smelting process. These are highly enriched in iron with relatively high concentrations of potentially toxic elements such as cobalt and copper. At Kabwe, a single waste dump has been used for the storage of flotation tailings, kiln and smelter slag and leach plant slimes.

2.3.6 OTHER MINE SOURCES OF CONTAMINANTS

In the MCM baseline study and in the KCM EMP storm water drainage from the mine site showed higher levels of contaminants than effluent coming directly from tailings materials. Chemicals used in processing may be poorly stored or spilled around the plant area and rainwater picks up these contaminants and carries them into the stormwater system. Historical spills of various substances around the mine area has also contributed to contaminated soils within the mine site in the mines where this has recently been tested (KCM mines). Runoff from rain can transport these contaminants outside of the mine site and into the water system. Simple improvements in housekeeping within mine areas can contribute to substantial improvements in this source of contamination.

BOX: HUMAN INTERACTION IN MINE SITES

- At TD27 in Nkana/Kitwe, various groups of young men dig for coal, sift through debris for cobalt slag to sell to small industries, sift through both industrial and domestic waste for scrap metal.
- At the dump site for debris cleared from KCM areas in Nchanga mine, within two weeks of the debris being deposited, at least 30 men had gathered to sift for wire and other metal debris to be sold to scrap metal dealers.
- At the Kitwe Slimes Dam (TD25) in Nkana/Kitwe, although the slimes dam was capped with top soil, this is eroding away because contractors drive onto the dam and illegally dump garbage. About 100 residents of Nkana East in houses bordering the dam grow crops on the dam. Moreover, because of its location in central Kitwe, pathways have been cut where people use it as a short-cut. If erosion continues, it may cause the dam to collapse, inundating houses that lie below the dam (about 30 high cost houses).
- In Kabwe, people can freely enter and leave the mine area, which has become a centre for scavenging. During a site visit, young men and a woman with a baby were observed in the mine area which because of high levels of lead could pose significant health risks, especially to children playing in and around the mine site. Within the last year, two boys drowned in one of the pits that is filled with water; although ZCCM-IH had built a wire fence around the pit to prevent access, people had stolen the fence.
- At Makoma Dam in Luanshya people have been cutting down trees around the dam for charcoal. As a result, the dam, which also serves as the municipal water supply for AHC is silting up. When people who cut the trees were taken to the police, the police let them go because they said there was no specific law to fine them with. In other areas, people are cutting down trees, which are planted to stabilise the dump or tailings, thus causing them to be prone to erosion. This contributes to silting up of rivers that are used for irrigation and fishing downstream and to the migration of dust from the tailings into neighbouring fields, contributing to possible soil infertility.
- At several tailings dams outside of Kitwe (TD36, TD37 and TD40) that are far from population centres, vandals have stolen the brick from the decant structures so that the dams do not drain properly. Runoff from the dams will thus increase every year unless this is fixed in such a way that it will not be vandalised again.

The reasons cited for such activities include:

"*We never used to have this problem of people cutting down trees in these areas. They used to police the area with forest rangers. You used to need a permit to take charcoal. Now there are no forest rangers and people are using charcoal because electricity is expensive. It is simple. They need to police these areas.*" – Water Utility

"*People are getting into these areas because poverty is increasing. Electricity is expensive so they are doing what they can to survive. Unless you address the underlying issue of poverty, the situation will not change.*" - *NGO*

2.4 SUMMARY OF MINING ACTIVITIES AND RELATED ENVIRONMENTAL HAZARDS

The main mining activities acting as a source of human health and ecological health hazards are summarised in Table 2.1. The levels of these contaminants and the extent to which they pose a hazard to human or ecological health are analysed in later chapters of this report.

Table 2.1 Sources of Environmental Hazard and the Mine Sites with Which They are Associated

SOURCES	MINE SITES	KEY CONTAMINANTS/ HAZARDS
UNDERGROUND WORKINGS Tunnels, shafts and adits	Nkana, Konkola, Nchanga, Chingola B, Mufulira, Luanshya, Baluba , Chambishi, Kabwe	• Subsidence and collapse of workings • Discharge of mine drainage water • Physical hazard from unstable structures • Pollutants in mine drainage water include copper and cobalt in the Copperbelt and copper, zinc and arsenic at Kabwe. However in Kabwe lead concentrations in water of flooded mine shafts have recently declined to near background levels. Given high buffering capacity of rock in Copperbelt and Kabwe, it is unlikely that metal mobilisation would have impacted regional groundwater quality
OPEN PIT Large open cast operations for the extraction of high bulk, often low grade ores to depths of ca. 300 m. Typically requiring prior removal of overburden and barren rock.	Nchanga, Chingola, Nkana, Chambishi, Ndola Lime, Kabwe	• Pit wall instability and collapse • Changes to the groundwater and surface water regimes and patterns during mining and post-closure • Poor water quality due to leaching of metals from pit walls or backfilled material • Access-safety hazards for people accessing site (illegally)
WASTE DUMPS **(GENERIC EVALUATION)** Sub-ore grade solid soil, rock and bedrock excavated as part of open pit and underground mining operations. Additionally, dumps for the storage of slag and oxide processing wastes and ore stockpiles. Key sources include run-off, leaching and physical instabilities.	Mine sites have been identified according to type of dump. See below.	• Significant physical hazard and low order chemical toxicological hazard [copper, cobalt, lead, arsenic, zinc] • Runoff from the dumps may contribute a substantial sediment load, including particulate metals [as above] to streams and rivers • Leachate beneath dumps may potentially contaminate groundwater (extent unknown). Geochemical impact is limited due to the highly buffered nature of most wastes, limited ARD potential and low metal mobility • Scavenging, cultivation or tree cutting by charcoal burners represent major contributing factors to site erosion and instability
OVERBURDEN DUMPS Soil, saprolite and barren rock excavated before the ore is reached in open pit operations. Because of the deep lateritic weathering of the Copperbelt region, much overburden has the same properties as the soil in the area (generally not toxic). Materials range from silt fines through to hard rock.	Nchanga, Nkana, Ndola Lime, Chambishi	As above plus: • Change in original land use (productivity) • Disruption of surface drainage • Visual impact
WASTE ROCK DUMPS Storage sites for waste rock excavated and hauled from underground mining operations. May include small percentage of ore grade material. Because they tend to consist of harder, less erodible materials, waste rock dumps are comparatively stable.	Nkana, Mufulira, Konkola, Luanshya, Baluba, Chibuluma, Ndola Lime, Chambishi, Kabwe	• Most of the waste rock is considered to be acid consuming but zones of acid generating rock may be present. In Copperbelt not highly toxic

SOURCES	MINE SITES	KEY CONTAMINANTS/ HAZARDS
SLAG STOCKPILES May comprise molten slag dumped in place or granulated slag deposited either directly or by hydraulic means	Nkana, Mufulira, Luanshya, Kabwe	• High transition metal concentrations [iron, copper, cobalt *etc*] Potentially severe source of surface and groundwater contamination through runoff during rainy season • Contribute to dust pollution of surrounding areas • Present a safety hazard for those playing in/scavenging in dump
ORE STOCKPILES Mineralised rock is stockpiled from mine operations prior to the metal components being recovered in the processing plant.	Nkana, Nchanga, Chibuluma, Chambishi, Kabwe	• Most concentrated in heavy metals, however, relatively low metal leaching rates under natural surface environment conditions. In Copperbelt, these are not likely to be highly toxic
CONCENTRATOR Crushing and froth flotation plant (found at all mines). Flotation involves the separation of sulphides and other metallic minerals from crushed gasgue minerals by adhesion to bubbles produced by the addition of xanthates and frothing agents. The non metallic waste is then discharged as tailings.	Nkana, Konkola, Nchanga, Mufulira, Luanshya, Ndola Lime, Chambishi, Kabwe	• Reagents are generally low toxicity and non-persistent in the environment. Effluents discharged with tailings are alkaline • Emissions from concentrate-dryer stacks • Water quality may potentially be affected by metalliferous suspended matter in tailings discharges
PYROMETALLURGICAL PLANT Smelting and electrowinning plant for the refinement of copper-cobalt concentrates. Effluents from cobalt refining typically require neutralisation with lime before being discharged into tailings facilities. Discharge of slag, oxide waste and calcine slurry	Operational at Nkana, Mufulira, Chambishi (Co) and formerly, Luanshya.	• Gas phase stack emissions of SO_2 and volatiles such as lead, arsenic, cadmium, cobalt, *etc*. • Metalliferous effluents of both acidic and alkaline composition from leaching and electrowinning processes • Contaminated dust
TAILINGS LEACH PLANT Where formerly worked tailings are washed with sulphuric acid for re-processing, followed by solvent extraction of copper from the pregnant solution and then electrowinning. (Nchanga)	Nchanga	• Severe sediment to surface drainage adjacent to tailings stockpile
ACID PLANT • Emissions reduction system implemented at smelters to reduce acidic gas emissions and to recover sulphuric acid • Production of highly acidic discharge waters, which require liming prior to their release into tailings facilities or surface watercourses	Chambishi, Nkana	• Sulphur dioxide emissions • Discharge waters can be enriched with non-sulphur volatiles

SOURCES	MINE SITES	KEY CONTAMINANTS/ HAZARDS
TAILINGS FACILITIES (GENERIC) Impoundments or paddock dumps comprised of crushed, largely non-metallic mine processing wastes. Tailings impoundments or ponds are formed in stream valleys which require incorporation of decants and spillway structures to accommodate design flood flows. Otherwise, tailings are discharged into self-contained paddock structures formed by perimeter dykes or bunds.	All sites Nkana, Chambishi and Mufulira (calcine slurries discharged)	• Scavenging, vandalism, cultivation or tree cutting by charcoal burners represent major contributing factors to exposure of tailings to air, making them more prone to wind erosion and to site instability • In many areas water-filled tailings dams are used for fishing and recreation, with possible exposure to heavy metals and bilharzia • Particulate and dissolved silt • Dust contaminated with heavy metals sometimes reducing agricultural productivity • Physical hazard associated with instability of embankments, decant and spillway structures • Visual impact
PADDOCK DUMPS Tend to be older, less engineered impoundments that consist of ring dykes formed by depositing the coarser sand fraction of the tailings, separated by the action of spigots and cyclones. Many contain significant metal content which may make re-processing economic	Nkana, Konkola, Nchanga, Mufulira, Luanshya, Chambishi, Kabwe	• Erosion and sedimentation on perimeter slope • Physical hazard posed by dyke stability • Seepage control and off-site contamination of water courses by silt and chemicals • Wind blown dust • Contamination of ground water
CROSS VALLEY DUMPS Utilise an engineered dam to contain tailings in valleys generally containing natural active water courses.	Nkana, Mufulira, Luanshya, Konkola, Chambishi	• Particulate and dissolved metal contamination in decant or spillway effluents • Seepage of contaminated leachate to underlying aquifers
MINE & PROCESS WASTE WATER Includes groundwater pumped of underground and open pit mine workings, effluents from concentrator and pyrometallurgical operations and runoff from precipitation collecting across the mine site.	In several towns water pumped from mine provides a source of potable water. At Konkola, mine water contributes significantly to the total discharge of the Kafue River. Konkola is one of the wettest mines in the world, pumping 350,000 m^3 of water daily into the Kafue River, a significant percentage of the Kafue water volume (40%) used by downstream users	• Sediment load (may be high in suspended solids) • Impact on water quality as a result of underground mining activities, sewage, fuel and diesel spills in the sumps

3. IMPACT OF MINING HAZARDS ON HUMAN HEALTH, ECOLOGY

The previous chapter outlined sources of mining-related environmental impacts. This chapter evaluates the potential impact of mining hazards on human health, animals, plants and the Kafue River system.

3.1 HUMAN HEALTH ASSESSMENT METHODOLOGY

An environmental health assessment was carried out as part of the SA.[6] This assessment uses a practical risk-based approach to assess health priorities and does not seek to provide a formal quantitative risk assessment. A formal quantitative risk assessment would be premature at this stage because of a lack of consistency in the quality of past data gathered (the reliability of lab analysis, particularly for metals such as lead that require refined measurement because they are measured in small quantities) and because of significant data gaps.

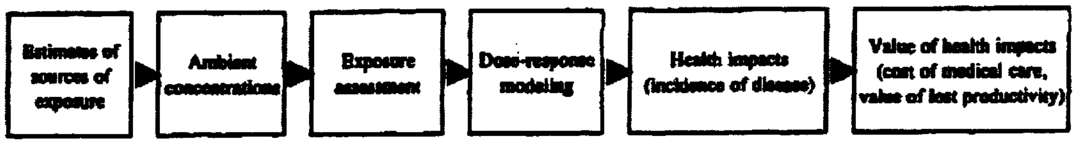
In order to organise data collected during the environmental health assessment, a set of grids was constructed for each mine site and community, showing available information on contaminants, potential for exposure of the population to these contaminants, ambient concentrations where available, vulnerable populations, potential health impacts and characterisation of health risk (see Annex H for a summary grid) Where data supported a confident assessment, a judgement has been entered as to how likely it is that a health effect has occurred in the target population (normally, community residents or susceptible subgroups living in the community) and the magnitude of the likely effect.

The grids compiled for the health assessment constitute an "evergreen" document, suitable for the preliminary risk assessment that can be amended and referred to in the future as more data becomes available.[7] The environmental health assessment did not assign a monetary value of health impacts. To do so would require further information on the frequency of outcomes in the population, the average health care resources devoted to each case and the costs of lost productive activity and social amenity.[8]

The grids represent adaptations of the methodology used in the 1998 World Bank Technical Paper No. 398 Pollution Management Series "Setting Priorities for Environmental Management, An Application to the Mining Sector in Bolivia" for the evaluation of health impact and potential benefit from reducing pollution. The document provides a framework to prioritise activities and investments for environmental management (see Figure below).

[6] As noted in Part I, this work was completed by Dr. Tee Guidotti, George Washington University and John Meagher of Intercet Ltd. The mission leader was Sarah Keener.
[7] The site specific grids are available upon request (skeener@worldbank.org).
[8] The grids do not need to be complete. If there is little or no likelihood that there is an adverse health effect associated with a given environmental hazard, there is no need to investigate it exhaustively.

Methodology for estimating health benefits from reducing pollution



Source: **Authors' calculations**

Following the logic of this method, after collecting data on sources of exposure, the next step is to assess the routes or pathways by which people would be exposed (air, food, soil, dust, water), the likely number of people exposed and the ambient concentrations in these routes. Also important to the analysis are the conditions that make a given toxin available for absorption or dispersion. Thus, for example, heavy metals are more likely to precipitate out of water where the pH level is high (alkaline) and will therefore tend to settle at the bottom in sediment and thus be less available to be consumed in water or absorbed by animal or plant life downstream.

Data on sources of exposure and ambient concentrations provides little benefit unless subsequently translated into a probable exposure level that corresponds to the opportunity and magnitude of exposure experienced by people in the community. For example, in the case of water in the Kafue, in order to understand the significance of having 3 grams per litre of a given toxin, one must know whether people rely on this water for drinking and how much of the water they drink.[9] Similarly for contaminated crops or fish, one would need to know how much of the parts used as food product are normally consumed and how they are prepared. For example, certain types of toxins may tend to concentrate in certain organs, such as the liver, of fish. If the fish's liver is not typically eaten, then this would have an impact on the amount of toxins consumed. Similarly, if a fruit such as mangoes is tested with the skin, one would have to know whether the skin is typically ingested as well. An additional factor in exposure that is not often considered is that even if ingested or inhaled, only a portion of the metals present in food or air are absorbed by the body. While it may be realistic for many solutes in potable water to assume 100% absorption, mineralogical controls on heavy metal bioavailability in soils, mine wastes and dusts often reduced the availability of the toxin to be absorbed by people or animals to between 5% and 25% of the total concentration.

Once the exposure assessment is complete, the next step is to examine existing research on how people respond to different doses of the toxins and to estimate the likely health impact.[10] The most direct route to assessing whether environmental factors may be affecting people is to test blood, hair and urine samples for concentrations of specific toxins. A final step would be to assess, to the degree possible, the

[9] In the absence of information assumptions are sometimes made (for example 2 litres of water per adult per day is a typical assumption).

[10] The severity of health effects from a toxin is not always linear (gradually increased health effects with increased dose) and is not the same for all populations as some may be more susceptible to negative effects of a toxin. With some toxins, people may have no health effects but once they are exposed to a threshold level of the toxin, health effects may suddenly be severe.

costs of this health burden on the population (though there are certainly many costs that could not easily be quantified).

The principal limiting factors in evaluating and prioritising risks in the Copperbelt were information gaps needed to assess actual exposure of people (the exposure assessment) and, in some cases, ambient concentrations in soil, food and air for certain toxins (fewer than 20 independent studies assessed this). A very common gap concerns site specific information on how residents use water sources and whether soil and plants are contaminated and how much they are consumed. Information on the bioavailability (percent that could be absorbed by the body) of different toxins in different media (plants, soil, air, water) was not available for this assessment, but could be carried out in follow-up studies under the EMPs and CEMP. Direct information on whether residents may have been affected by environmental toxins in the form of blood, urine or hair samples was available in the form of blood samples for Kabwe only. These gaps are further discussed in Section 6.

In the absence of sufficient information to calculate risk, environmental health professionals use judgement, comparison to known disease incidence patterns and straightforward logic. The World Bank methodology previously referred to as the basis for the Bolivian assessment is, technically, a means of structuring qualitative risk assessments where data do not support quantitative risk estimates. Qualitative, as opposed to quantitative, risk assessment is particularly necessary when comparable data are not available for every site and exposure situation. Devoting extensive resources to intensive data collection on all exposures of all toxins via all pathways is not always cost-effective, particularly in a context where limited public resources may be being diverted from other priorities that have been identified by the population (water supply, sanitation, health care) that could have a larger health benefit. If exposure is unlikely or an element is not toxic, no further evaluation is necessary. If it is unlikely to be present at significant levels of exposure based on corollary evidence but the absence has not been documented, it is reasonable to suggest that this finding be validated by the simplest cost-effective method available but not to assign it a high priority. If it is simply unknown whether the hazard is present, it makes sense to find out but to set priorities. If a hazard may be present but is only likely to affect individuals on occasion, there is a question of cost-benefit when resources are limited.

The method used in this assessment follows the conventional assessment of environmental hazards rather than providing a suitable methodology for quantitative risk assessment. In this general approach, hazards to humans (and ecological health) are considered from two points of view, which are classic in public health investigation but unusual in risk assessment. The first is whether there is an increased risk of an adverse health outcome occurring among individuals who are exposed (measured by the relative risk in epidemiology). The second is whether there is, at the same time, a sufficiently increased risk and a sufficient population exposed that the hazard is a major determining factor in causing a specific health outcome in the population (measured by the attributable risk in epidemiology). The latter is more reliable than simply examining health statistics for the following two reasons:

- First, many of the symptoms associated with exposure to various pollutants are the same as those for common disease. For example, exposure to large amounts of copper can cause gastrointestinal distress, a symptom common to many other ailments. Similarly, exposure to SO_2 can cause respiratory symptoms similar to those of a respiratory infection, also one of the top five ailments in Zambia and may exacerbate respiratory infections.

- Second, standardised reporting for diseases is highly unlikely to identify disorders arising from environmental exposures, except for a few sentinel conditions (such as bilharzia, which may be an indicator of water quality). With the exception of a special medical program for lead in Kabwe, none of the health care providers consulted during this assessment had seen and been able to identify as such cases of heavy metals poisoning. This is because clinical cases of these disorders tend to be much less common than common diseases, they are almost never identified as such in a health care system geared to common ailments, they require confirmatory tests which are not available and the environmental connections are frequently obscure or cannot be easily documented by the provider of health services in an office setting. In addition, the overall financial and staff constraints that the health care system is currently experiencing translates into a lack of specialsed equipment or expertise; according to the Kitwe Occupational Health Board, there are no physicians trained in toxicology or occupational health in Zambia.[11]

With this methodology, evaluation of environmental conditions within a mine plant area is undertaken or advised when conditions are known or likely to have an impact on the surrounding population or environment (as was the case, for example, in Mufulira where poor housekeeping within the mine site meant that storm water runoff going into outside streams actually had a higher content of metals than did tailing effluent). In towns with a high proportion of miners (most towns except Ndola and Kabwe because the mine is closed), occupational health and safety within the mine area can also translate into increased incidence of occupationally-related disease which may not stem from the environment outside the mine site (see Annex I).

Data gaps do not necessarily need to be filled. It only makes sense to give detailed investigation (which may be expensive) priority if a hazard is likely to be a major determinant of human health status in the population or of ecosystem health and viability. Investment in remedial action should be proportional to the risk and potential for intervention. It makes little sense from an operational point of view, for example, to thoroughly document a hazard about which nothing can be done or a physical hazard for which the solution is obvious.

[11] A larger problem has been the recent exodus of trained physicians from Zambia to other countries where salaries are higher.

3.2 ENVIRONMENTAL HEALTH CONTEXT

Determinants of health in the Copperbelt and Kabwe are strongly influenced by socioeconomic factors of which the most obvious are poverty, lack of access to reliable public health services, poor hygiene or poor water quality, malnutrition and inadequate and hazardous transportation infrastructure. Data from Mufulira and Kitwe, in 1998 and 2000 confirm that the top 10 diagnosis at regional clinics included several illnesses which may be linked to poor sanitation, poor hygiene or poor water quality (malaria, gastro-intestinal disease and intestinal worms.)[12] These types of environmental health problems are particularly acute in Kabwe and Ndola, two cities which accounted for a large share of Zambia's cholera cases in the past year. For example, Ndola has consistently had more than half total cases of diarrhea with severe dehydration (presumed to be cholera) reported for the Copperbelt in 1999 (56%, 1245 cases), in 2000 (59%, 288 cases) and the first quarter of 2001 (77%, 162 cases). Last year Kabwe accounted for most of the other half of all of Zambia's cholera cases.

It is thus difficult, without further information, to discern a "signal" of environmentally-mediated disease against the background of "noise" representing the high morbidity from similar diseases from different causes or those related to conditions of poverty and inadequate basic services. The high prevalence of HIV infection (estimated at approximately 20% of the population) may place a large fraction of the population at risk for disorders in which immune function plays a major role, from infections to the immunological mechanisms of response to toxic chemical exposures. Individuals with chronic disease may be more susceptible to toxic effects of chemical exposures, depending on the nature of their condition.

In towns with functioning smelters (Chambishi, Mufulira, Kitwe) there is sufficient evidence to consider air pollution from smelters and other sources also as an environmental health concern. In Kabwe, the levels of contamination of lead are sufficient to pose an immediate health threat to populations living in townships where soil lead concentrations are high. Thus, in terms of mine-related pollution, the two principal areas of concern from health are likely to be lead in Kabwe and smelter emissions in the Copperbelt.

3.3 HUMAN HEALTH HAZARDS

The toxicity of a compound reflects both its chemical and physical characteristics. For example, a metal such as lead has a much more serious associated health impact than copper. Further, lead that has been dissolved in acidic mine water (note that most of the Copperbelt water is non-acidic) is more available than lead which may be in tailings that have been covered or than lead which may be precipitated into sediment at the bottom of a stream. Metals in watercourses may present less of a risk to people if these

[12] Other potential factors in poor environmental health may include the common practice of cultivation with untreated or partially treated sewage water (see Annex on Diversion of Sewage Effluent), and increased rainfall from global climate changes which may contribute to higher rates of malaria.

watercourses are not used for drinking. Some metals may be present in a form, or interact with other substances present to become more or less available for absorption by the human body (bioavailability).

Health effects may arise depending on the frequency, level and duration of exposure, the route of exposure (inhalation, ingestion of contaminated food or water, in rarer cases skin contact with contaminated soil or water) and the characteristics of the "host", who may or may not have a hereditary or acquired state of susceptibility to adverse effects of exposure, such as preexisting asthma.

The ore-derived metals that are most prevalent in the Copperbelt are copper and cobalt, while at Kabwe they include lead, zinc, cadmium and arsenic. In addition, smelting processes in the Copperbelt contribute to high levels of emissions of sulfur dioxide. The section below assesses the routes of exposure to the most common toxins and the likelihood that these toxins are reaching people, and then explores the health effects typically associated with these toxins.

3.4 MOST LIKELY POTENTIAL PATHWAYS FROM CONTAMINANT SOURCE TO PEOPLE

Water: In most areas in the Copperbelt water flowing directly from mine sites or from tailings exceeds guidelines in terms of suspended particles and in terms of copper composition. However, once the water reaches the Kafue, it is generally within acceptable water quality guidelines according to the current monitoring network which has extensive sampling stations at daily, weekly and occasionally monthly intervals depending on the location (see Table 3.2 and 3.3 on water quality in the Kafue and its Copperbelt tributaries). This was confirmed by one independent study, in which the highest levels of copper, manganese and cobalt reported over a years worth of data collection were still in the sub- part per million range and were acceptable for human health at various farms throughout the region.[13]

This does not mean that the water is of high quality as drinking water. During numerous visits to downstream communities in the Copperbelt, all of those consulted noted that water was contaminated and they had other sources of potable drinking water since the water from the mine site did not taste good.[14] Water from the mine site was often used indirectly (through irrigation ditches dug adjacent to streams) for irrigation and for washing clothes. A more thorough assessment of whether some downstream users in more isolated areas use the streams for drinking is required during the EMP process, as is testing for lead and arsenic which are not routinely included in water tests. Information on the number of people dependent on each stream is not available.[15] Irrigation with contaminated water can in some cases be absorbed into plants though the degree varies widely. If these plants are ingested, then people may also

[13] Ulf Pettersson and Johan Ingri, "Impacts from mining activities on the water quality in the Kafue River, Copperbelt Zambia. A study of dissolved-suspended solids and deposited sediment in a Zambezi river tributary," Division of Applied Geology, Lulea, Sweden, 1998

[14] See Annex B for complete list of site visits.

[15] The only exception was an estimate by a Binani employee of 5,000 people living and depending on the Luanshya River.

absorb higher levels of the contaminants, though the level of absorption ("uptake") is rarely 100% as noted above. An ECZ representative noted that in the past there had been a case where sulphuric acid got into the river and people got sick from eating the fish.

Dust: Dust from tailings that have not been covered with vegetation (about 50% of the tailings in the Copperbelt and Kabwe) can be blown into adjacent communities. This represents a localised problem which is more serious from a health perspective in Kabwe than in the Copperbelt because of the composition of the ore. The number of people living immediately on these sites is not known. In Kitwe and Kabwe many sites are close to population centres, while in Nchanga/Chingola, many sites are more remote. Further details on the populations accessing the sites could be gathered during the EMP process. Enormous quantities of copper and other metals dust is also emitted from the smelters in Chambishi, Kitwe and Mufulira (or about 1,200 tons of dust per month for Mufulira and Kitwe of which approximately 400 tons is copper dust). This deposits the metals that are in the ore on plants and in the soil of areas in the plume path of the smelter, where they may be taken up by plants. Absorption from soil to crops varies widely, generally according to the characteristics of the plant. Eventually, if the crops are consumed, this can increase exposure to the population (again, the "uptake" is rarely 100%). The longer the smelter has operated, the more accumulation of potential metals. This type of dust probably affects a larger number of people than dust from tailings.

Air: Certain gases (SO_2) and particles from processing technologies are released into the air where they can be inhaled by people along the plume path of the smelter after it reaches ground (generally some distance from the stack though the prevalence of fugitive emissions, or leaks of gases prior to the stack, at smelters in the Copperbelt means that populations in close proximity to the smelter have higher levels of exposure). The level of exposure on the ground typically depends on the concentration of gas released at the source, the heat of the gas (and therefore its density) as it leaves the stack, wind speed and velocity, the terrain and the distance from the plant. Particles may carry gases adsorbed onto their surface and may contain or carry metal as well as carbonaceous debris from burning. There is considerable interest just now in the unexpectedly strong health effects associated with fine particles that are products of diesel exhaust and other sources of combustion. The problem in the Copperbelt is not so subtle and this contemporary literature is probably less relevant than the historical literature on the "sulphur-particulate" complex in chemically "reducing" air pollution from industrial activity using mid-century technologies. The particles in this instance would have been, historically, more coarse and contained a high metal content and probably were saturated with SO_2. Their effects would have been more acute and related to acute irritation and airways inflammation than the much more subtle effects described in the contemporary literature for fine particulate air pollution.

Soil: People, other than children, are unlikely to directly ingest soil. However, plants grown in soil can, to varying degrees, absorb a certain percentage of contaminants from soil and if they are consumed, pass a portion (though often not all) contaminants on to the person or animal consuming them.

Skin deposition: It is possible that chemicals such as PCBs may, if deposited on the skin, be absorbed into the body. However, a greater risk in general is ingestion of chemicals and microbiological hazards (such as sewage-contaminated foods) from contamination spread by the hands. Infection of the skin may result from contact with pathogens in sewage, especially if there is a break in the skin, but this is relatively uncommon and is not directly related to mining.

Food: As noted above, crops that grow in contaminated soils may have the capacity to absorb a proportion of toxins and to pass them on to people or animals. Fish living in contaminated streams can absorb toxins and if eaten, pass some portion of the toxins on to those who consume them. Crops in the plume path of smelters can also become directly coated with metal-rich dust which can then potentially be ingested. There are a few studies on food contamination in the path of the smelter in Mufulira and only one study on the potential for contamination of fish in river systems.

3.5 BY-PRODUCTS ASSOCIATED WITH MINING AND SMELTING IN THE COPPERBELT AND KABWE

The by-products of copper and lead mining respectively are (those that are likely to be present in significant quantities are marked with an asterisk):

Copperbelt

- Copper*
- Cobalt*
- Cadmium
- Chromium
- Manganese
- Nickel
- Sulphur dioxide*
- PCBs (unconfirmed)
- Lime dust (Ndola only)

Kabwe

- Lead*
- Zinc
- Cobalt
- Cadmium*
- PCBs

**Major hazard sources for most mines in the region. Others are present but in comparatively smaller quantities or more localised areas.*

Table 3.1 summarises the composition of ores and tailings found in the Copperbelt and Kabwe and indicates hazards based on the levels of contaminant found in relation to safe standards for human health.

Table 3.1: Summary of Composition of Ore/Tailings Mined in the Copperbelt and Kabwe

Site	Ore/Tailings
Chingola	The predominant elements are not highly toxic. The orebody mined in the area contains little lead or arsenic, in contrast to other copper sulphide ores. Elemental analysis on tailings samples show arsenic and lead levels (representative levels are 0.4 to 1.1 and 1 to 17 ppm, respectively, as reported in 1997). Leachate extraction is also low.

Site	Ore/Tailings
Kitwe	The predominant elements are not highly toxic. The orebody mined in the area contains little lead or arsenic, in contrast to other copper sulphide ores. The elemental composition (copper, 0.6 to 2.3%; cobalt, 0.03 – 0.15%; and sulphur 0.63 – 2.82%) predictably generates acid but not heavy metals in mine drainage and tailings runoff. Arsenic levels in Nkana copper concentrates have been measured at 8 to 23 ppm. Overburden dumps, which are numerous in the area, are unremarkable except for an elevated copper content. The lead and arsenic contents have been tested and are not elevated. The leachate that is actually produced is confirmed to be unremarkable, with low lead and arsenic levels and no remaining acidity. The geochemistry of tailings in the area is favourable with respect to human health, because the predominant elements are not highly toxic and render the water undrinkable due to taste and discoloration before toxic levels occur: they include iron (3.4 – 6.4%) copper (approximately 0.15 to 0.5%), cobalt (0.2 – 0.85%) manganese (0.01-0.11%) and nickel (0.003%). The lead content of the tailings, a major factor in determining toxicity in most such situations, is only 0.002 – 0.003%.
Luanshya	The predominant elements are not highly toxic. The orebody mined in the area contains little lead or arsenic, in contrast to other copper sulphide ores but consistent with ores elsewhere in the Copperbelt. The arsenic content in Luanshya copper concentrates has been measured at 10 to 55 ppm, levels that are the highest observed in the Copperbelt. The elemental composition would predictably generate acid but not heavy metals in mine drainage. The lead and arsenic contents have been tested and are not elevated. Because of the carbonate content, the pH is high (a measure of acidity and alkalinity), meaning that the acid formed in the leachate is quickly and completely neutralised. The leachate that is actually produced is confirmed to be unremarkable, with low lead and arsenic levels and no remaining acidity.
Mufulira	The predominant elements are not highly toxic. The orebody mined in the area contains little lead or arsenic, in contrast to other copper sulphide ores. The arsenic content in Mufulira copper concentrates has been measured at 5 to 18 ppm. The elemental composition predictably generates acid but not heavy metals in mine drainage and tailings runoff. Carbonate rocks (limestone, dolomite) buffer the acidity and much reduce the potential environmental damage.
Ndola	The product at Ndola is lime, a compound of low toxicity. The composition of the quarry rock is predominantly calcium oxide (97%). The waste dumps consist of carbonate (31% to 64%), calcium oxide (29 to 48%), variable silica (0.38 to 16.%) and iron, sulphur and sulphate. Copper and cobalt are present only in small quantities (102 and 30 ppm, maxima, respectively). The dust is likely to show a similar composition and does not pose substantial health threat, although it is reported as a nuisance by residents as it can stick when wet.
Kalulushi	The former ore stockpile at Chibuluma has been removed, but residual wastes contaminate the soil. The mineralogy of the residual waste is dominated by copper sulphides and the contaminated soils are low pH (minimum 2.53) and rich in sulphate (max. 3.59%), copper (max. 7.33%) and cobalt (max. 1.91%). These values all exceed international trigger levels for agricultural or residential soils. The generation of acid seepage from the former stockpile site and the attendant mobilisation of copper, cobalt and other trace metals represents a potential hazard. Further site evaluation is therefore warranted. The Chibuluma waste rock storage site (WR5) remains operational. Mineralogical data, showing an abundance of pyrite, copper sulphides and a total of 2-3% carbonate, suggest that the waste is likely to be net acid-generating. A contaminated leachate hazard therefore exists. The compilation of additional geochemical data to verify the extent of this hazard is a priority. Tailing geochemistry data for Chibuluma are strictly limited and require further testing. Currently, the tailings pH is near neutral, however significant sulphide components are present (pyrite and chalcopyrite). Following the exhaustion of carbonate buffering, the tailings may potentially become a source of long-term acid leachate.

Site	Ore/Tailings
Kabwe	The principal concern in Kabwe is lead, to the exclusion of other exposures. (Mine Plant Area)-1994, mean soil values (top 10 cm) were lead 6.4%, zinc 8.3% and Cadmium 0.0095%. At 0.5 m depth, mean metal values were lead 1.9%, Zinc 2.3% and cadmium 0.0033%.[16] At soil 1 meter deep levels were 140 mg/kg (0.0140 %) lead (in Kasanda) and 65 mg/kg (0.0065%) lead in soil at 1 meter depth at Katondo.

3.6 ASSOCIATED HEALTH EFFECTS OF HAZARDS

3.6.1 COPPER

Copper is, at low concentrations, a nutritional trace element (~1 to 3 mg per day is required by the body) and thus is toxic to people only at very high levels. It can be processed by the body and thus does not accumulate like some other heavy metals such as lead that are more difficult to eliminate. However, infants have less ability to process heavy metals and thus may be susceptible to health effects at lower levels. At high levels, on the order of 15 mg consumption, individual tolerance for the metal varies widely. Vomiting, diarrhoea and cramps were exhibited by individuals after consumption of copper in drinking water at 7.8 mg/l for 1.5 years. However, in most cases, once copper reaches these levels the water looks and tastes bad and thus discourages consumption. Although it varies from site to site, based on case studies conducted during the SA, if one took the maximum level of copper concentrations reached from 1995 – 2000, it would take between 25 ml consumption (at Chingola stream close to Nchanga mine) to 2 litres (directly from the Wusakile storm drain in Kitwe – an unlikely consumption point) to cause gastrointestinal symptoms. If one were not consuming during the maximum copper concentrations, substantially more water would need to be consumed to cause symptoms. Residents of each community downstream of mine sites were queried by the SA team about their consumption of water from these streams; all communities noted that they did not drink the water and pointed to alternative sources (wells or piped water). A more systematic assessment of whether there were isolated communities reliant on effluent streams for drinking water should also be carried out during the EMP/CEMP as the SA team visited only a sample of sites. One circumstance when consumption of water from these sources may increase occurred in Chambishi, where residents use a stream into which effluent flows for drinking water when the local water supply system breaks down. Thus, increasing problems with utility management may result in greater exposure to water-born mine contaminants.

Substantial quantities of copper are also emitted from smelters in Mufulira and Kitwe and deposited as dust on downwind communities, in soil and on plants. However, the likelihood of a significant health impact from these levels is not high. This low level of risk can be inferred from studies that have already been conducted on diminishing soil concentrations of copper with distance from the source at other locations.

[16] AMC (February 2000) Sable Zinc Kabwe Project: Environmental Scoping Study, p. 11.

3.6.2 LEAD

Lead is a serious problem in Kabwe but is unlikely to be a significant threat to health in the Copperbelt proper,. Lead can be a by-product of copper mining to the degree that the ore that is mined also contains this element. In the Copperbelt the natural levels of lead are low, though lead may have accumulated over many years on plants and soil downwind of smelters (though the amount being emitted at any one time may not be extremely high, the longer the smelter has operated, the greater the risk that it has accumulated).[17] Because Kabwe is a lead mine, the natural levels of lead are very high and the amount in the ore is sufficient to be considered a threat to health. Because the lead was smelted over a long period of time (the first smelter was opened in 1928), it was distributed both by air downwind of the smelter site and, to a great degree, by water and dredging of the canal that comes from the mine site through various neighbourhoods (Chowa, Railway, possibly others that have not been sufficiently tested). Lead tailings and other sites also are contaminated. Lead levels in soil correlate with blood lead level tests that have been completed; as noted above, lead concentrations in soil reached as high as 26,000 ppm (2.6%). (WHO guidelines consider 1,000 ppm or 0.1% to be unacceptable, though in many countries any level over 50 ppm in soil can trigger concern.) The exact number of people who may be affected is unknown but could be substantial given the levels of contamination. Further details on Kabwe are presented in Section 4 chapter on Kabwe.

[17] Data from SmelterCo. emissions from May to October 2000 do not provide ground level concentrations of lead (the concentration of elements is highest from the stacks, but as the materials are dispersed concentrations drop). However, at stack level emissions exceeded ground-level guidelines by a factor of up to 25 times – which may or may not be significant depending on dispersion - and thus merits further evaluation during the EMP/CEMP.

Table 3.2: Copperbelt and Kafue River Water Quality Results (Based on Average Monthly Values, January 2000-April 2001) Compared to WHO Drinking Water Guidelines

Notes: Data on lead and arsenic concentrations were not available but should be tested during EMP
pH<4 is considered acidic. Shading indicates over WHO drinking water guideline for copper.

Station	Lab. pH (unit)	Dissolved Solids (mg/L)	Total Copper (mg/L)	Dissolved Copper (mg/L)	Total Cobalt (mg/L)	Total Manganese (mg/L)
WHO Drinking Water Guideline	—	—	*2*		—	*0.5*
KITWE- NKANA						
Wusakili Storm Drain (605)	7.9	791	0.9	0.78	0.4	0.36
Harrison Street Drain (North Uchi) (607)	7.8	1,226	0.88	0.65	1.39	0.42
South Uchi (610)	10	1,569	1.1	0.92	0.3	0.42
Mindola Dam North Overflow into Ichimpe (629)	7.8	704	0.17	0.1	0.16	0.13
Uchi Prior to Kafue River (630)	7.8	866	0.4	0.24	0.63	0.33)
Mindola Shaft Water (631)	7.8	1,413	0.19	0.12	0.19	0.16
CHINGOLA – NCHANGA						
Tailings Leach Plant Main Drain (303)	6.9	2,434	180	59.18	7.05	20.44
Pollution Control Dam Spillway (306)	8	1,374	51.98	0.76	2.38	9.52
Muntimpa Dam Overflow (308)	8.3	2,725	0.78	0.12	0.44	2.18
Concentrator Effluent To Nchanga Stream (309)	7.9	371	78.23	1.41	2.35	3.04
Drying Bed Discharge (311)	8	497	10.62	0.61	3.13	1.01
MUFULIRA						
Butondo Dam Seepage (402)	7.9	1,660	0.5	0.2	0.1	0.2

Station	Lab. pH (unit)	Dissolved Solids (mg/L)	Total Copper (mg/L)	Dissolved Copper (mg/L)	Total Cobalt (mg/L)	Total Manganese (mg/L)
WHO Drinking Water Guideline	—	—	*2*		—	*0.5*
Main Mine Effluents (404)	8.1	1,376	2.2	0.3	0.1	0.4
Tailings No.11 Decant Effluent (421)	7.3	2,142	0.4	0.2	0.1	3
Tailings Dam 10 Discharge (TD10) (430)	7.9	307	0.4	0.2	0.1	0.1
Tailings Dam 11 Discharge (TD11) (435)	8	2,204	0.3	0.1	0.1	0.1
LUANSHYA – RAMCOZ						
TPH Discharge into Luanshya River (703)	7.6	470	10.335	0.283	18.455	3.319
Underground Water ex 28# via 18# (714)	7.7	831	0.795	0.047	0.039	0.192
U/G Water Ex. 14# : Fisansa Stream Entry (743)	7.8	985	0.135556	0.043	0.019	0.136
Musi Tailings Dam Discharge (745)	7.7	939	0.837	0.044	0.145	1.096
CHILILABOMBWE – KONKOLA						
Effluent ex Lubengele Tailings Dam & Stream (208)	8	187	0.15	0.08	0.08	0.08
Combined Drain = Conc. Spills & U/G Water (209)	8.1	298	0.96	0.11	0.09	0.12
Engineering Workshop Drain (225)	8.1	268	0.46	0.09	0.08	0.17
CHAMBISHI						
New Dam Overflow (504)	7.9	1,158	0.4	0.3	1.4	0.4
Musakashi Dam Overflow (509)	8.1	2,215	0.2	0.1	0.4	0.3

Station	Lab. pH (unit)	Dissolved Solids (mg/L)	Total Copper (mg/L)	Dissolved Copper (mg/L)	Total Cobalt (mg/L)	Total Manganese (mg/L)
WHO Drinking Water Guideline	—	—	*2*		—	*0.5*
KAFUE RIVER						
Kafue River Upstream of Pump Station (120)	7.7	109	0.1	0.08	0.08	0.08
Kafue Downstream of Kakosa (122)	7.7	136	0.12	0.08	0.08	0.08
Hippo Pool on Kafue River (130)	7.7	148	1.49	0.14	0.22	0.28
Kafue Pump Stn (Chingola Municipal Council) (131)	7.6	151	0.39	0.13	0.2	0.24
Kafue River at Mufulira Pump Station (140)	8	404	0.44	0.17	0.1	0.12
Kafue River at Chambishi Pump Station (150)	8	202	0.2	0.1	0.13	0.13
Nkana Raw (Kafue River) (160)	7.8	334	0.17	0.11	0.12	0.13
Kafue River at Ndola Road Bridge (162)	7.8	292	0.2	0.12	0.13	0.17

Table 3.3: Copperbelt and Kafue River Water Quality Results (Based on RANGE Of Monthly Values, January 2000-April 2001) Compared to WHO Drinking Water Guidelines

Notes: data are presented as Minimum recorded value – Maximum recorded value, shading indicates over WHO drinking water guideline for copper.

Station	Lab. pH (unit)	Dissolved Solids (mg/L)	Total Copper (mg/L)	Dissolved Copper (mg/L)	Total Cobalt (mg/L)	Total Manganese (mg/L)
WHO Drinking Water Guideline	—	—	2		—	0.5
KITWE- NKANA						
Wusakili Storm Drain (605)	7 - 8.4	486 - 1,382	0.3 - 10.2	0.2 - 9.8	0.2 - 0.9	0.09 - 1.3
Harrison Street Drain (North Uchi) (607)	7.1 - 8.9	741 - 1,848	0.3 - 5.9	0.17 – 5	0.5 - 5.7	0.15 - 1.3
South Uchi (610)	7.5 - 11.9	987 - 2,211	0.1 - 5.2	0.09 - 7.5	0.1 - 1.2	0.1 - 7
Mindola Dam North Overflow Into Ichimpe (629)	6.4 - 8.2	520 - 982	0.1 - 0.3	0.09 - 0.2	0.09 - 0.3	0.06 - 0.2
Uchi Prior to Kafue River (630)	7.3 - 8.2	594 - 1,186	0.2 - 0.7	0.1 – 1	0.2 - 1.9	0.09 - 0.97
Mindola Shaft Water (631)	7.6 - 8.3	1,035 – 1,660	0.1 - 0.4	0.09 - 0.3	0.09 - 0.4	0.09 - 0.25
CHINGOLA- NCHANGA						
Tailings Leach Plant Main Drain (303)	4.6 - 9.2	1,033 – 4,147	33.9 – 398	0.8 – 207	0.9 - 18.5	5.8 - 45.67
Pollution Control Dam Spillway (306)	7.7 - 8.3	758 - 2,438	8.4 – 144	0.18 - 2.08	0.43 - 7	2.97 - 18.07
Muntimpa Dam Overflow (308)	7.9 - 8.7	1,991 – 3,484	0.26 - 1.5	0.1 - 0.5	0.18 - 1.13	0.6 - 4.68
Concentrator Effluent To Nchanga Stream (309)	7.7 - 8.2	276 - 546	8.38 – 190	0.1 - 15.65	0.33 - 19.2	0.6 - 8.03
Drying Bed Discharge (311)	7.5 - 9.4	373 - 668	1.08 - 47.72	0.13 - 5.53	0.48 - 41.35	0.2 - 7.45
MUFULIRA						
Butondo Dam Seepage (402)	7.6 - 8.1	485 - 2,610	0.1 - 3.1	0.1 - 0.5	0.1 - 0.1	0.1 - 0.5

Station	Lab. pH (unit)	Dissolved Solids (mg/L)	Total Copper (mg/L)	Dissolved Copper (mg/L)	Total Cobalt (mg/L)	Total Manganese (mg/L)
Main Mine Effluents (404)	7.8 - 8.6	1,082 – 1,597	0.5 - 6.8	0.1 - 1.2	0.1 - 0.1	0.1 - 2.9
Tailings No.11 Decant Effluent (421)	6.8 - 8.1	1,428 – 2,400	0.1 - 1.1	0.1 - 0.7	0.1 - 0.1	0.1 - 5.1
Tailings Dam 10 Discharge (TD10) (430)	7.7 - 8.2	97 - 705	0.1 - 1.5	0.1 - 0.4	0.1 - 0.1	0.1 - 0.1
Tailings Dam 11 Discharge (TD11) (435)	7.7 - 8.4	1,534 – 2,648	0.1 – 1	0.1 - 0.5	0.1 - 0.1	0.1 - 0.2
LUANSHYA-RAMCOZ						
TPH Discharge into Luanshya River (703)	7.1 - 8	310 - 681	1.02 – 143	0.065 - 0.9	0.03 - 233	0.085 - 41.25
Underground Water ex 28# via 18# (714)	7.3 - 8	660 - 971	0.19 – 2.86	0.02 - 0.093	0.01 - 0.07	0.07 - 0.53
U/G Water Ex. 14# : Fisansa Stream Entry (743)	7.6 - 7.9	985 (787 - 1,322)	0.0475 - 0.27	0.02 - 0.08	0.01 - 0.045	0.06 - 0.33
Musi Tailings Dam Discharge (745)	7.4 - 8.1	574 - 1,092	0.235 - 8.13	0.02 - 0.08	0.028 - 0.72	0.39 - 3.2
CHILILABOMBWE-KONKOLA						
Effluent ex Lubengele Tailings Dam & Stream (208)	7.7 - 8.3	116 - 291	0.01 - 0.9	0.01 - 0.23	0.01 - 0.15	0.01 - 0.28
Combined Drain = Conc. Spills & U/G Water (209)	7.9 - 8.3	258 - 363	0.1 - 5.38	0.01 - 0.4	0.01 - 0.25	0.01 - 0.72
Engineering Workshop Drain (225)	7.6 - 8.4	178 - 391	0.07 - 3.08	0.01 - 0.38	0.01 - 0.13	0.01 - 0.8
CHAMBISHI						
New Dam Overflow (504)	6.7 - 8.1	490 - 2,510	0.1 - 5.4	0.1 - 3.8	0.1 - 8.9	0.1 - 2.2
Musakashi Dam Overflow (509)	7.4 - 9.2	260 - 7,330	0.1 - 0.6	0.1 - 0.2	0.1 - 3.1	0.1 - 1.4
KAFUE RIVER						
Kafue River Upstream of Pump Station (120)	7.2 - 8.1	50 - 237	0.01 - 0.33	0.01 - 0.18	0.01 - 0.15	0.01 - 0.2

Station	Lab. pH (unit)	Dissolved Solids (mg/L)	Total Copper (mg/L)	Dissolved Copper (mg/L)	Total Cobalt (mg/L)	Total Manganese (mg/L)
Kafue Downstream of Kakosa (122)	7.1 - 8.2	70 - 251	0.01 - 0.32	0.01 – 0.1	0.01 - 0.1	0.01 - 0.13
Hippo Pool on Kafue River (130)	7.1 - 8.2	74 - 385	0.08 - 23.2	0.08 - 0.32	0.1 - 0.96	0.1 - 1.6
Kafue Pump Stn (Chingola Municipal Council) (131)	7 - 8.2	73 - 508	0.08 - 1.34	0.1 - 0.4	0.08 - 1.52	0.1 - 1.12
Kafue River at Mufulira Pump Station (140)	7.8 - 8.2	20 - 1,050	0.1 - 1.25	0.1 - 0.5	0.1 - 0.1	0.1 - 0.2
Kafue River at Chambishi Pump Station (150)	7.5 - 8.3	67 - 510	0.1 - 0.36	0.1 - 0.1	0.1 - 0.3	0.1 - 0.2
Nkana Raw (Kafue River) (160)	7.4 - 8.3	130 - 1,203	0.13 - 0.24	0.09 - 0.16	0.09 - 0.22	0.05 - 0.24
Kafue River at Ndola Road Bridge (162)	7.5 - 8.3	122 - 668	0.1 - 0.37	0.06 - 0.25	0.06 - 0.2	0.06 - 0.25

Lead is of particular concern in Zambia from a health point of view. The groups of people most at risk are clearly children, born and unborn, although adults are also at risk.[18] Children exposed to even low doses of lead may suffer subtle brain damage and learning disorders, including low IQs, impaired attention, speech and language deficits and behaviour problems. Infants are also highly susceptible to the effects of lead, as their brain continues to develop while lacking a completely intact blood-brain barrier and their immature behaviour increases the likelihood of exposure to lead in soil and house dust. Older children may manifest the delayed effects of lead toxicity as reduced performance in school and even mental retardation. Studies in the United States and elsewhere have associated a one microgram per decilitre increase in blood lead with a 0.25 point decline in IQ. These effects may be long-term. Older children are most susceptible to the encephalopathic (brain damage) form of lead toxicity than adults at similar levels of exposure, may show slow growth and development and are susceptible to anaemia and gastrointestinal symptoms.

Adults tend to manifest lead toxicity as peripheral neuropathy (loss of sensory and motor function in the body) and may also show symptoms of gastrointestinal pain and anaemia. Because of the background morbidity in Zambia, it is difficult to distinguish among various causes of these symptoms and many cases of lead toxicity are likely to be overlooked, especially when laboratory testing is not performed. Women of childbearing age are at special risk, as the potential for harmful impacts on foetal development is significant and fertility can be affected.

Exposure to lead has a cumulative effect as it is not easily eliminated from the body. Other sources of lead such as fumes from leaded gasoline, lead paint, lead water pipes or pottery are also likely contributors in Zambia. It is the cumulative impact from all of these sources more than the exposure to any one source that is important in determining the total body burden (cumulative amount a person has absorbed regardless of source) and the ultimate health impact; this is why testing of blood for lead content is important. In areas where lead is present, soil and house dust are important sources of exposure, particularly among young children. In other countries that also have the contributing sources, blood levels can easily average 25 micrograms per decilitre and exceed 40 micrograms per decilitre in some cases (health damage may begin to occur when lead in the blood exceeds 10 micrograms per decilitre).

People in Kabwe are exposed to lead by breathing in airborne particles in heavily contaminated areas (dust from the mine site for example), by playing in or touching contaminated soil or tailings and then failing to wash ones hands (thus transferring this contamination to food which is consumed or by putting hands in one's mouth), by drinking water with high lead levels or by eating food which may have been grown in highly contaminated soils. Certain crops absorb more lead from soil than others; for example, rape, a staple vegetable of the Zambian diet, tends to absorb more lead than some other crops. There may be other paths of exposure which need to be assessed; these include water from wells that are in

[18] The foetus is at high risk in mothers who are exposed to lead because lead readily crosses the placenta and interferes with the normal development of the nervous system, which in the unborn child is not protected by the blood-brain barrier.

townships bordering the canal. Soil remediation, suppression of lead-containing dust, hygiene education, housekeeping measures to control leaded dust and protecting water sources are thus the mainstay of measures to control exposure and interrupting pathways of exposure.

3.6.3 ARSENIC

Arsenic is famous as an acute poison but levels associated with its acute toxicity are high and irrelevant to levels typically encountered in the environment. Recent studies suggest that no health damage occurs until persons are exposed to a threshold level; the lowest level at which arsenic effects of any kind have been found is 100 micrograms per liter in drinking water (Wildavsky, 1995). At levels on the order of 1 to 10 mg/day, a level which is often associated with groundwater contamination in high-risk areas, arsenic is linked to a risk of cancer of the lung and skin. A 50 µg/l threshold currently constitutes the permissible potable water threshold for arsenic in most countries of the world. However, epidemiological and clinical evidence of adverse effects at lower levels has prompted the WHO to adopt an interim guideline of 10 µg/l and the US-EPA is currently evaluating the use of an analogous value.

Arsenic differs significantly from heavy metals (such as lead, zinc, copper) in the environment, as its mobility and solubility is retained across a wide pH/Eh range. It therefore can also represent a hazard even in non-acidic waters.

Although arsenic is a frequent contaminant of copper sulphide ores, it is not present to any appreciable extent in the Zambian Copperbelt. Levels in soil and water tend to be low. Luanshya had the highest levels among the towns visited in the Copperbelt with 10 to 55 ppm or mg/kg, in the mined copper concentrates.

However, samples from some of the tailings dumps contained levels of between 200 and 450 mg/L. As with lead, water quality and soil data on arsenic are incomplete and though unlikely to pose a significant health threat in the Copperbelt beyond the tailings dumps, some representative testing should be completed during the EMPs/CEMP. Testing for arsene in flue gas is also recommended to determine its existence and concentration levels.

Kabwe has no arsenic data for wastes or leachates. There are, however, arsenic minerals in the ore (discrete arsenates and arsenic sulfosalts). This is indicated in the appendices of the Kabwe Rehabilitation Report (ZCCM-IH). There is, therefore, some possibility of arsenic contamination in waste leachates, thus further monitoring is recommended.

3.6.4 COBALT, CADMIUM, MANGANESE, SELENIUM, ZINC

Exposures to cobalt, cadmium, magenese, selenium and zinc have been reviewed for health impact and are not likely to exceed thresholds of toxicity based on data reviewed for the Copperbelt. Annex P provides further details on the health effects of these elements when found at higher concentrations than those likely in Kabwe and the Copperbelt.

3.6.5 SO_2 AND DUST EMISSIONS FROM SMELTERS

Smelters commonly emit gases (locally referred to as *senta*) with high concentrations of sulfur dioxide and particles, which are rich in copper content. The combination of particulate air pollution and high concentrations of sulfur dioxide (the "particulate-sulfate complex") is particularly toxic. Normally, sulfur dioxide gas is cleared in the upper respiratory tract and causes primarily irritation in the nose and throat. In combination with particles of a size that are easily inhaled and that penetrate at high efficiency to the lower respiratory tract, sulfur dioxide absorbs onto the surface of the particles and penetrates more deeply at greater efficiency, causing inflammation of lower airways. Historically, this particulate-sulfate complex pattern has described the classic "killer smogs" characterizing sometimes lethal air pollution episodes early in the twentieth century: Meuse Valley (Belgium) and Donora (Pennsylvania) being the most famous and well-investigated. That such phenomena have not been reported from the Copperbelt reflects the effects of open terrain and prevailing winds, which act against the formation of stable inversion layers.

As the World Health Organisation Guidelines for Ambient Air Quality (2000) states for sulphur dioxide "acute responses occur within the first few minutes of exposure and further exposure does not increase effects." Because of this near immediate response of the body to inhalation of SO_2, peak exposure is an important parameter because if evidence exists that certain health effect levels of sulphur dioxide are attained even for brief periods of time (high hourly, peak concentration measurements in a month) the likelihood is very high that adverse health effects will be presented to exposed populations. According to the US EPA, exposure to SO_2 at concentrations of 2620 $\mu g/m^3$ in 24 hrs can cause premature death among the ill and elderly. Further, elevated incidences of respiratory and pulmonary disease may be causally linked to short-term exposures in excess of 500 $\mu g/m^3$.

In 1996, Zambian regulations reduced the ground-level air quality guideline from the 500 $\mu g/m^3$ (originally specified by ZCCM) to a limit of 125 $\mu g/m^3$.[19] This value is stringent in relation to many internationally adopted guidelines, including those of the US-EPA (365 $\mu g/m^3$) and is directly compliant with the guideline of the World Health Organisation (125 $\mu g/m^3$).

Exceedances of these critical thresholds have frequently been recorded in the vicinity of MCM's Mufulira smelter and to a lesser extent, at Kitwe's SmelterCo smelter (data for Chambishi were not available, see Annex J for additional Water Quality and Air Monitoring information). Average concentrations are important for chronic effects, but SO_2 exposures need to be controlled consistently below recommended

[19] In 1996 Statutory Instrument No. 141 (Licensing and Emission Standards) supplemented Statutory Instrument 119 (Mineral Resource Extraction Regulations).

guidelines and documented health effect threshold levels because even short exceedences, especially at higher levels of SO_2 will likely produce health effects in those exposed.

Residents who may be more sensitive to the impact of SO_2 emissions include those with existing respiratory ailments (asthma, tuberculosis – both very common ailments) or cardiac problems or the elderly with pulmonary disease. In addition, SA site visits to the smelter at both Mufulira and Kitwe revealed that many employees of the smelters were not wearing sufficient protective masks and thus may receive occupational exposure to SO_2.

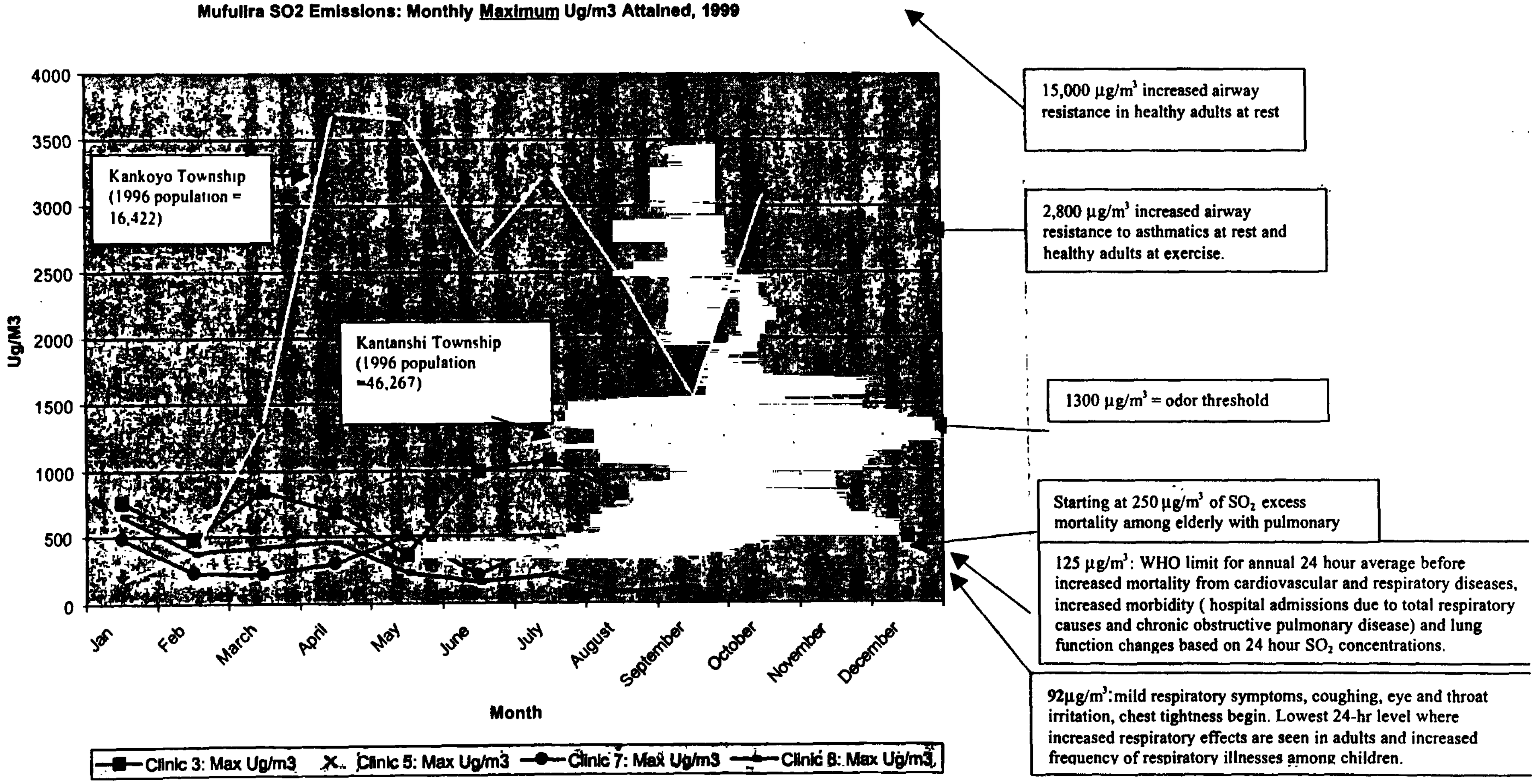
SO_2 will also affect residents differently depending on their location relative to how the wind is blowing and dispersing the gases; those closer and downwind of the smelter will likely experience a greater impact than those farther away and upwind. The documented impact of SO_2 in Mufulira is particularly acute in the townships of Kankoyo and, to a lesser extent, Kantashi (potentially affecting up to 75,000 people in the near vicinity – within 1 km – of the smelter plume)[20] – see Figure below. In Kankoyo in 1999, levels were sufficient to cause mild respiratory symptoms, coughing, eye and throat irritation, chest tightness, increased frequency of respiratory illnesses among children and, for at least a portion of the year, excess mortality among the elderly with pulmonary diseases.

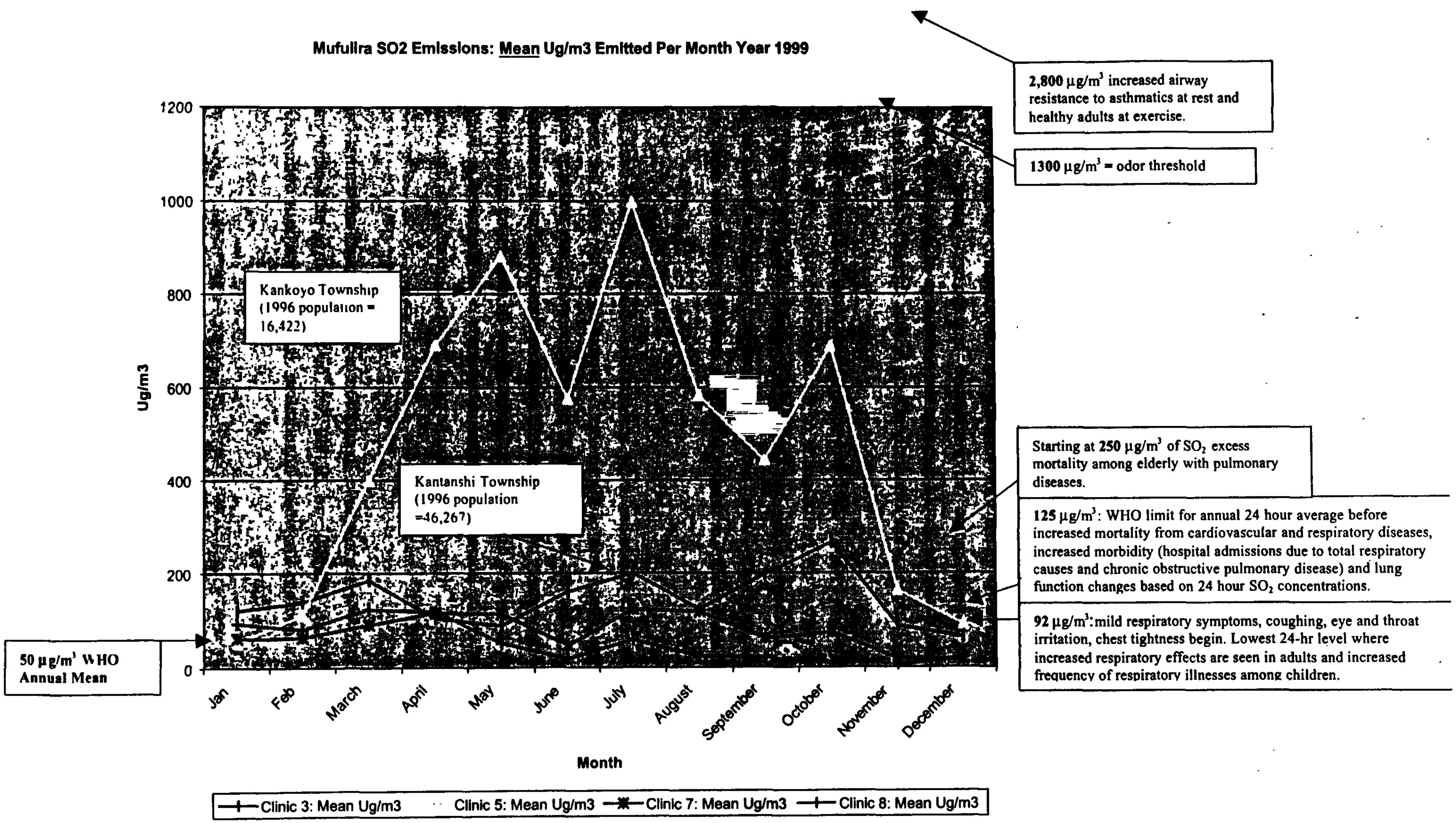
It is not surprising that residents of Kankoyo consider SO_2 emissions as a primary environmental concern. Data on SO_2 concentrations confirm that this township experiences the highest levels of SO_2 in Mufulira, and is the only township where the monthly maximum is typically above the odor threshold of 1,300 ug/m^3. Nonetheless, there are reports that the current residents at Kankoyo are the recent subtenants of miners who have moved out of the township, and may have taken up residence out of a desperate but opportunistic hope for later compensation.

In Kitwe, very rough estimates of those potentially affected include about half of the total population or over 53,000 residents (year 2,000 population data) in townships around 3 km of the smelter - Wusakile, Nkana East, Natwange, Twibukishe especially to the west such as Nkana West. For the greater part of the year most of these townships experienced SO_2 levels at least once a month in the range where asthmatics could be affected. In some cases to the west, average mean SO_2 levels reached asthmatic irritation levels for nearly 8 months out of the year. Wusakile used to be a mining township, though the number of residents who no longer work for the mines has increased. Anecdotal information from residents suggests that in Kitwe emissions may increase at night, when it is assumed most residents are indoors.

[20] ZCCM Environmental Impact Statement; 2.0 Background, Synopsis,(MUFEX.WPD), 1996, pg 6

Figure: Selected Data on SO_2 Mufulira
Data Source on Emissions: Mopani Copper Mines




Mufulira SO2 Emissions: Mean Ug/m3 Emitted Per Month Year 1999
2,800 µg/m³ increased airway resistance to asthmatics at rest and healthy adults at exercise.
1300 µg/m³ = odor threshold
1200
1000
800
600
400
200
0
Ug/m3
Kankoyo Township (1996 population = 16,422)
Kantanshi Township (1996 population =46,267)
Starting at 250 µg/m³ of SO2 excess mortality among elderly with pulmonary diseases.
125 µg/m³: WHO limit for annual 24 hour average before increased mortality from cardiovascular and respiratory diseases, increased morbidity (hospital admissions due to total respiratory causes and chronic obstructive pulmonary disease) and lung function changes based on 24 hour SO2 concentrations.
92 µg/m³: mild respiratory symptoms, coughing, eye and throat irritation, chest tightness begin. Lowest 24-hr level where increased respiratory effects are seen in adults and increased frequency of respiratory illnesses among children.
50 µg/m³ WHO Annual Mean
Jan
Feb
March
April
May
June
July
August
September
October
November
December
Month
Clinic 3: Mean Ug/m3
Clinic 5: Mean Ug/m3
Clinic 7: Mean Ug/m3
Clinic 8: Mean Ug/m3

More recent measurements for Kitwe's SmelterCo smelter from January to September of the year 2000 indicated increases in SO_2 concentrations of about 40% compared to the previous year. The average monthly mean SO_2 exposure increased to 451 $\mu g/m^3$ and average maximums of 1785 $\mu g/m^3$ SO_2. One potential cause may be increased copper production translating into higher emissions of SO_2 to the environment.

Current plans under ODA financing to improve the technology at SmelterCo and proposed improvements at Chambishi smelter (which already has an acid plant) are expected to generate reductions in the level of emissions in the years to come. Thus, the key focus of current efforts should be on modeling the expected changes, monitoring a baseline and the actual changes at the community level and ensuring that the levels are as low as they can be to prevent ongoing health effects.[21] For example, the impact of a revival of the copper industry and thus increased quantity of smelting, on the absolute level of emissions should be assessed as part of the comprehensive environmental management plans. Although planned improvements to the SmelterCo smelter should decrease the percentage of SO_2 that is released, the impact on the absolute level of SO_2, which is what ultimately affects health, should be examined.

Mufulira remains the only smelter where there are presently no plans to improve emissions. This is of particular concern since, as part of the revitalisation of the copper industry, private mine companies plan to increase quantities of ore being processed (and therefore the quantities of SO_2 being emitted). Moreover, if the Konkola Deep Mining Project were to proceed ore production would be tripled, though it would be more likely that the SmelterCo smelter would be used to process ore since it is managed by KCM.

A secondary impact from smelter emissions is the accumulation over a period of time of metal-enriched dust in soil and plants in the plume path of the smelter. Depending on the crop, the types of metals and the level of metals in the soil, this has the potential to be absorbed into plants and then eventually ingested by people. Understanding the impact of such possible contamination requires understanding more about how contaminated different areas are, how different crops do or do not absorb contaminants present and how much people consume of the potentially contaminated crops. As illustrated in Table 3.4 based on information from selected mines, there are enormous gaps in this type of data that would need to be addressed in the context of the EMPs.

At Kabwe, the ISF, Sinter and Waelz plant have, in addition to SO_2, released substantial concentrations of lead to the atmosphere (30,000, 110,000 and 20,000 Nm^3/hr respectively), plus other partially volatile metals such as cobalt and vanadium for which quantitative data have not been collected. This issue is further explored in Section 4 on Kabwe.

[21] Levels of SO2 experienced in the Copperbelt are sufficiently high and data on SO2 health effects world-wide is sufficiently proven that extensive epidemiological studies would not likely provide much benefit.

Table 3.4: Potential for Soil/Food Contamination – Selected Mines

Location	Soil	Food Grown in Smelter Path	Likelihood of Health Impact
Kitwe/ Nkana	Some deposition of heavy metals (consistent with composition of ore - mostly copper, some smaller amounts of lead or arsenic) likely west and northwest of smelter, but data not available. Needs to be tested.	No data available. Should be tested.	Low
Mufulira	Up to 18 mg/kg lead. Up to 20 mg/kg arsenic at highest concentration downwind of smelter. However, most other values are <10 mg/kg, except in specific spots such as the engineer's office (30 mg/kg). Levels of copper in soils as high as 166 mg/kg have been found downwind of smelter (compared to control sample of 19 mg/kg)[22]	Some concentration of lead in mangoes (10 times normal amount).[23] Other studies required	Low. Not likely to constitute a public health hazard though potential for bioconcentration in crops needs to be assessed
Mufulira	Up to 18 mg/kg lead. Up to 20 mg/kg arsenic at highest concentration downwind of smelter. However, most other values are <10 mg/kg, except in specific spots such as the engineer's office (30 mg/kg).	Some concentration of lead in mangoes (10 times normal amount). Other studies required	Low. Not likely to constitute a public health hazard though potential for bioconcentration in crops needs to be assessed
Luanshya/ Ramcoz	Deposition of metals would be expected west of the smelter but no data available. Needs to be tested.	No data available. Should be tested.	Low. Not likely to constitute a public health hazard though potential for bioconcentration in crops needs to be assessed
Kabwe	Level of lead in soil in path of smelter and adjacent to canal running from the mine is high and varies substantially by area. Up to 26,000 ppm (1000 is WHO acceptable limit). More comprehensive spatial testing required. Soil in area at 1 meter depth 140 mg/kg Kasanda and 65 mg/kg Katondo	Some bioaccumulation; giant rape 163 ppm in soil of 400 ppm compared to ECZ guideline 200 for animal feed and 530 for soil. Could be higher if gardens grown in high concentration areas. No known testing of fish for bioaccumulation.	High. Confirmation that some individuals have already been affected and are being treated under ongoing ZCCM-IH program, but need for more widespread testing.

3.6.5.1 Community Feedback on Smelter Emissions

During consultations with various residents during the SA, mine pollution was mentioned as a primary development concern only in townships immediately adjacent to mine smelters (these include residents of Wusakile and Nkana East in Kitwe and residents of Kankoyo and Kantashi in Mufulira and probably residents in Chambishi though the SA did not complete site visits there) where residents expressed a greater concern about "*senta*" (SO_2 from the smelter) which they said caused coughing and respiratory problems. In Mufulira residents associate many different illnesses (some correctly, some not) with *senta* and the level of concern was particularly high among the town administrator. In towns without smelters, local government officials did not seem as concerned about mine pollution, but were more focused on immediate priorities such as salary payments for workers on strike and solid waste collection. This was

[22] From E. Kapungwe, J. Volk and L. Namayanga, "Assessment of the Effect of Air Pollution on the Environment in Mufulira on Copperbelt Province in Zambia," Dec. 2000.
[23] I.B.I.D.

also true in Kabwe where the municipal council did not express any pressing concerns about mine pollution.

When prompted specifically about mine pollution issues, the overall priority issue was *senta* and the effect it would have on health and on crops. Several communities were aware that compensation had been paid at one time to a group of farmers whose crops were damaged. A representative of the Mine Workers Union suspected that higher SO_2 emissions were timed at night and on the weekends when fewer people would notice.

The Kitwe District Board of Health Quarterly report went on to say:

"The contributing factor to this illness could be due to fumes, which come from the Nkana plant. The fumes pollute the air so much that children and adults are made to cough. Though there is no research to prove this, reports [from residents] are used as proof. The fumes affect even vegetation, more common in Nkana West, Wusakile and part of Nkana East. Because of the fumes flowers and vegetables are rarely grown in most affected areas. The fumes can have more serious effects on the human lungs which can lead to complications in the future."

The report went on to say that lack of air pollution law compliance/enforcement made the Kitwe community more susceptible to chest infections and complications. As already described, average mean SO_2 concentration in 2000 was at a level that could aggravate upper respiratory tract infections. As with all clinical data, care must be taken in interpretation in that many disease vectors cause this type of a health effect association.

Historically, Copperbelt miners held a different view of the fumes than non-miners; according to the Environmental Support Project manager in Mufulira;

"Miners used to associate the level of fumes with the size of their bonus at the end of the month. Only when they no longer received bonuses based on production did they start to associate the fumes with the more negative aspects- the smell and physical effects...

In Kankoyo residents want the mines to build an acid plant. They also want the soil structures rehabilitated. They say it is not easy to get information from the mines and that the mines said many of these requests were beyond their scope."

The fundamental spatial shift that occurred when miners purchased and then often rented out, their houses, means that the new residents have less to gain by increasing copper production. This is the case in Konkoyo township in Mufulira where most residents are low-income and not miners.

3.6.6 PHYSICAL HAZARDS

At several defunct mine sites there were reports of death or injury because children or adults were accessing an area either to play or scavenge. Although this affects only a small proportion of the population, it could be easily prevented and thus is worth mentioning. In the Copperbelt hazards are linked to the physical structure more than contact with the composition of the ore or tailings or slag.

However, in Kabwe, where unrestricted access to the site exists, women with infants were visible scavenging in the mine area itself. In such cases, exposure to lead dust around the site can also cause health problems.

3.6.7 LOCAL TOXIC ISSUES

PCBs: Zambia, as a signatory to the global POPs treaty, is committed to destroy its stores of PCBs eventually and to keep them secure until this happens. PCB reserves have been identified, isolated and plans are to destroy them so they are not mistakenly used as a food source. An estimated 100 tonnes of PCB oil, PCB capacitors and contaminated materials are currently stored at three sites, Nkana Old Cobalt Plant, a container in Kalulushi (outside the Radiation Waste Storage Shed) and in Kabwe (transformers at the site). The status of PCB storage sites maintained by ZCCM-IH is summarised in Tables 16A and 16B (found in Annex G).

PCBs if properly managed and disposed of pose little threat from skin contact unless it is prolonged. The human body can tolerate a body burden of PCBs without obvious toxicity and the effects are long in developing. The primary risk is probably delayed neurological development in children who consume PCBs. This is not to be minimised but it is not likely to be a widespread, repeated or common problem and there is no feasible intervention to help those who have been exposed to date.

PCBs in the Copperbelt are sometimes stolen from electrical transformers (a cause of electricity outages) or storage barrels and sold as cooking oil. This is an egregious criminal practice of knowingly misrepresenting its origin and selling it illegally as cooking oil. It is unclear how common this practice is, although it has certainly occurred and is much discussed. Although this practice is clearly to be condemned and ZCCM-IH and the mine companies need to take steps to secure PCBs from theft, the actual effect of this practice on the health of people in the Copperbelt is likely to be moderate or small.

The major exposure route identified in the case of the Zambia is consumption. This can pose health problems such as chloracne and increased cancer risk. There is little reason to believe that the PCB storage sites represent a significant environmental hazard unless PCBs are stolen or the PCB reservoirs are mismanaged and PCBs enter into water sources where they are bioconcentrated and ingested via fish. Although these compounds have a reputation for protean effects, the toxicity of PCBs to human beings is generally not great and is probably less than the ecosystem damage that the persistent compounds cause. This is likely to be a local and sporadic problem reflecting criminal activity or desperate social circumstances. It is a risk to individuals but not likely to be a driving force for health status in the population.

Radioactive Sources: Radon and so-called "radon daughters" are products of decay of radionuclides that have the tendency, because they carry an electrostatic charge, to be carried into the deep lung on small particles. There, they may irradiate tissue and increase the risk of cancer. Radon is a gas and when it is formed, by radioactive decay, it migrates into air. Radon and its decay products present a hazard mostly in underground mines and in confined spaces, such as basements, where ventilation is inadequate. Radon is a natural product found in rock and is likely to be the major source of radioactivity confined to the mines (see Table 14 in Annex G for potential locations of industrial aerosol/radon/te-norm waste exposure). It is unlikely that substantial quantities of radioactive waste are present to present a risk to the population (Table 15 in Annex G provides a status of the Kalulushi radioactive storage site).

Ndola Lime Dust: The Ndola Lime Plant generates large quantities of airborne calcium carbonate particles that deposit as a whitish dust on surfaces in the vicinity, including plants, automobiles and buildings, where it is difficult to remove if it gets damp. This is a considerable annoyance and may limit the desirability of settlement and the attractiveness of economic development in the immediate area. However, from the standpoint of human health the problem is a nuisance rather than a public health issue. Calcium carbonate is not a highly toxic material and, like many other dusts, its effect is a non-specific irritant, a so-called "nuisance dust."

3.7 IMPACT OF MINING ON FLORA AND FAUNA

3.7.1 TERRESTRIAL FLORA AND FAUNA

The Copperbelt region has characteristic vegetation communities with associated wildlife. Some areas are designated as National Forest Reserves and some important species exist, notably ground orchids.

From the baseline data available, it is possible to arrange the vegetation types of the Copperbelt in catenary sequences along biotic/edaphic gradients (See Annex D). The main habitat types found are various types of closed forest, open forest with grass understorey, termitaria and grasslands:

The baseline reports for the former ZCCM mining license areas refer to the presence of Miombo and Acacia woodland and grasslands, but do not describe the habitats clearly in terms of vegetation associations or communities. In addition to a lack of detailed information for the mining areas, there is no regular monitoring or recording of vegetation trends in Zambia and no national repository for biodiversity data. The national distribution and status of vegetation types is therefore unknown and there is insufficient botanical detail to form a reliable baseline for ecological monitoring or hazard assessment.

Of particular importance in the Copperbelt are a number of epiphytic and ground orchids and relic species that are at risk of extinction if the current rate of habitat loss for these species continues. Habitat loss is attributable to a variety of causes, of which mining is only one. Integrated or cumulative effect assessment will therefore be required in the region to determine the relative importance of threats and to identify suitable mitigation measures.

There has not been an adequate faunal inventory the Copperbelt's mining license areas to enable identification of which animals or plants are most affected. The ZCCM EIS statements provide only non-systematic observations, based on incidental sightings of fauna in close proximity to access roads. The status of flora and fauna in ZCCM's mining license areas was surveyed in 1996 as a component of SRK's EIS program but the original data for these surveys are not available and accordingly it is difficult to determine the suitability of the existing reports as a basis for future management decision-making. A clear requirement exists to classify wildlife species within license areas with respect to their frequency and their relative vulnerability to mining impacts.

Identification of all potential (terrestrial) ecological receptors within the Copperbelt region is therefore not possible on the basis of the available information. However key receptors will include:

- Characteristic habitats that are relatively undisturbed by human activity;
- Ecosystems with established traditional uses;
- Rare or declining endemic species (*e.g.*, ground orchids);
- Agroecosystems;
- Wetlands; and,
- Designated areas for wildlife (*e.g.*, National Forest Reserves).

3.7.2 AQUATIC LIFE

The ZCCM EISs each contain an Appendix describing the effects of mining on aquatic life on mine sites. Typically, this information is derived from a single dry-season survey of aquatic life. The surveys included measurements of:

- water quality (including dissolved oxygen, pH, turbidity, salinity, colour, conductivity, ammonia, nitrite and metals);
- zooplankton and phytoplankton;
- macrophytes (larger aquatic plants);
- invertebrates and vertebrates; and,
- fish.

The collection of smaller organisms was achieved through the use of a plankton net. No mention is made of the collection of benthic invertebrates[24]. This is an important omission, since these organisms are likely to have been extensively impacted in areas where substantial sediment releases have occurred.

3.7.3 ECOLOGICAL HAZARDS

The ZCCM EISs include a reconstructional analysis of the biological impacts of mining. The ZCCM EISs were not based on actual monitoring of ecological impacts. They made the assumption that areas not affected by mining could be assumed to represent pre-mining conditions and compared mined and

[24] Benthic invertebrates are animals that live in the sediment and do not have rigid spinal columns. They are the standard tool for testing of aquatic ecotoxicity.

non-mined areas to gain some understanding of possible ecological effects. These background analogues are variably located within and beyond mining lease areas.

Specific mining activities likely to cause significant ecological effects have not been identified in the ZCCM surveys. To fully identify and evaluate impacts on vegetation and wildlife it would be necessary to establish the proportion of each mining license area affected by specified activities and also to establish the proportion of each habitat or vegetation type affected by mining activities of different magnitude and duration. Activities observed to cause adverse impacts differ between license areas, but routinely include:

- Dust deposition;
- Atmospheric deposition (*e.g.*, SO_2 from smelters);
- Removal of vegetation for construction of new mining infrastructure;
- Damage/ depletion of vegetation cover, *e.g.* due to high concentrations of toxic heavy metals or extreme acidic conditions (tailings dumps, *etc.*);
- Vegetation-mortality due to acid spills;
- Dwarfing or stunting of trees as a result of air-borne (particularly acid) pollution;
- Disturbance of wildlife by mining activities and the presence of people;
- Removal of native vegetation for siting of construction camps; and,
- Modification of vegetation around settlements, *e.g.*, for gardening.

Tailings and overburden dumps present particular problems, as they exhibit hostile conditions for the re-establishment of vegetation. They are often characterised by nutrient deficiencies and high to toxic concentrations of heavy metals and associated sulfosalts. Tailings pile salinities vary seasonally. Salts may be leached down through the soil profile in the rainy season but migrate to the surface in the dry season, often with attendant evaporative precipitation and hard-pan formation.

In addition, in the Copperbelt, many older tailings paddocks hold a low sulphide concentration (<0.5%). Upon oxidation of these phases, the mobilisation of metals is generally inhibited by the presence of carbonate gangue minerals which effectively buffer the tailings pore-waters. In specific instances, management practices may, however, have served to increase metal mobility. At Nkana TD26, for example, the infilling of erosion-derived tailings paddock voids with domestic waste may potentially have resulted in the mobilisation of copper, cobalt and other potentially toxic elements in humic and fulvic complexes. Also at Nkana, older paddocks such as TD25 have been used for cultivation. The extent to which crops have bioassimilated contaminant metals from the tailings substrate remains to be investigated. Studies of maize grown on mine tailings in Zimbabwe and Thailand (Williams and Smith, 1994; Williams, 1997) have shown that uptake of arsenic and heavy metals is strongly influenced by the ambient concentration of iron (inverse correlation). In the case of arsenic, absorption by maize is enhanced in the presence of sub-optimum phosphate concentrations, for which arsenate forms an analogue.

Baseline wildlife surveys commissioned by ZCCM have identified differences between mine impacted and unimpacted areas in terms of tree height and volume. The exact causal links are not, however, identified. Further, it is not clear in all cases whether:

- changes are apparent in the species-composition of vegetation;
- characteristic species have disappeared from the affected area; and,
- observed changes are likely to be reversible following cessation of mining activities.

In the Chambishi Mine License Area, extensive depletion of vegetation cover is apparently attributable both to mining activity and clearance by charcoal burners. In mine-affected areas vegetation diversity is lower than in unaffected areas (Table 3.5). However, no detail is available regarding precise changes in the species composition. For example, acid deposition caused by the deposition of SO_2 downwind of smelters can cause significant changes in plant species composition as most plant species are adapted to soils of a certain pH range and not all species are tolerant of acidity. However, the Kafue Basin is well buffered and impacts are thus likely to be modest. Livestock and other terrestrial fauna are also likely to be affected to some extent, but this has not been quantified. In summary, specific effects are not well documented for the Copperbelt region and need to be studied in more detail.

Table 3.5 Characteristics of Vegetation Affected and Unaffected by Mining in the Chambishi Mine License Area

Chambishi Mine License Area	No. tree species per ha.	No. shrub species per ha.	No. grass species per ha.	No. herb species per ha.	No. tree stems per ha.
Areas affected by mining	12	4	2	5	560
Areas not affected by mining	18	8	3	7	960

Surveys commissioned by ZCCM at Chambishi also refer to a high vegetation mortality rate in the vicinity of the acid plant.

Plant species react very differently to different elements, but little research has been done on the responses of species native to Zambia, except for those routinely used for re-vegetation programmes.

3.7.4 WILDLIFE (FAUNA)

As no quantitative estimates have been attempted of habitat-use by wildlife in mining lease areas of the Copperbelt, the extent to which mining activities have reduced numbers and/or activity of wildlife is unclear.

Clear impacts in specific locations include total habitat loss in many areas of plant installation, tailings deposition and overburden storage. Habitat disturbance or partial loss is evident in settlements associated with mine operations. Such impacts are variably compounded by direct effects of chemical toxification (air, soil and water), hydrological changes due to mining activity, food chain dislocation (through the removal or reduced abundance of species at specific trophic levels) and noise influences. Aquatic systems have been widely subject to both eutrophication chemical toxification and siltation.

In livestock, high levels of copper on herbage are a well-documented cause of poisoning of livestock grazing in the vicinity of copper smelters. Fatal poisoning of pigs can occur at levels of copper supplement of 250 ppm in their food.

BOX: SUPREME DAIRY FARM DOWNSTREAM TD33C

Supreme Farm is located at least 10 km downstream of TD33c on the Chibuluma Stream outside of Kitwe and has been in operation for 17 years. The farm has about 100 dairy cows, chickens and some pigs. A number of people live around the farm on the banks of the stream. They had wells adjacent to the stream which were used for drinking because they said the stream water tasted like soda water. The stream was devoid of fish or plant life. According to the farm owner, residents come to her when the stream quality is bad and she goes to Mopani as she has a car.

Crime has increased in the past few years and cattle are sometimes stolen. She uses fertilizers and some pesticide but assumes that this as well as the waste from the cows is absorbed into the ground before it enters the stream.

In terms of mine pollution, the concerns of the farm owner were:

- She never used to have any smell from the mine but now it comes to Chambolina and was quite heavy last year.
- She reported getting a red substance on her vegetables which she thought was iron oxide (not clear if this was from the water or the smelter emissions)

The cows sometimes drink from a borehole on the property and at others drink from the stream. She did not appear concerned about any effect stream water might have on the cows (plant upset incidents which could result in sudden increase in copper concentrations in streams are likely to occur on very short-term basis).

3.7.5 AQUATIC ECOLOGY

The reported effects of mining varied widely, ranging from apparently unimpacted streams to those entirely devoid of aquatic life. The streams evaluated ranged from small feeder streams to large tributaries of the Kafue, some of which are fished by local populations. In most of the surveyed locations, impacts of either mining or secondary human activity were noted, typically identified in the reports as being associated with the following:

- low pH (untreated or partially-treated acid releases, resulting in short-term but intense acidification of receiving waters);
- high turbidity/high suspended solids (inadequate settling in ponds);
- high metals concentrations (attributed to inadequately treated effluents from processing plants);
- low dissolved oxygen levels (often associated with untreated or partially treated sewage discharges from municipal water and sewer providers); and,
- high ammonia (again, sewage discharge).

Wet season surveys were not conducted, however the execution of such surveys is recommended in the EIS documents. It is likely that during the wet season a number of additional water quality impacts on biota may be induced due to:

- leaching of metals from spoils piles;
- increased sediment loading from inadequately re-vegetated paddocks and overburden dumps; and,
- increased loading of hydrocarbons and other chemicals associated with contaminated stormwater runoff.

At Mufulira, the levels of contaminants in stormwater runoff was higher than the level directly from tailings, probably because of very poor housekeeping in and around the plant site.[25]

Most of the literature reviewed did not present information on the chemistry of fish tissue. However, the Konkola Deep EA (AMEC, 2001) does present results of fish testing primarily from Konkola's Lubengele Tailings Dam. The results indicate that:

1) concentrations of key metals (cadmium, copper, cobalt, lead, zinc) in fish at the Lubengele Tailings Dam are high;
2) fish are an important food source in the area; and,
3) other than copper, metals concentrations in fish tissue are also high at background stations[26], suggesting that for many species, the level of metals contamination from non mining sources may be significant.

The Konkola EA also notes that aquatic species (fish, aquatic invertebrates and snail) were reduced in numbers and diversity in the Lubengele Tailings dam. Furthermore, the diversity of snails (many associated with bilharzia) was found to increase below the Lubengele Dam. As stated in the EA (AMEC 2001), some key points are:

- *"Fish is one of the most important food resources in Chililabombwe district. Within the Konkola Mining Licence Area, unauthorised fishing occurs in the Lubengele Tailings Dam and streams draining into it while outside the area fishing occurs in the Kafue River, especially upstream of the Lubengele/Kafue River confluence. Fishing is small-scale and intended for subsistence family needs and local trade.*
- *Toxicity tests on fish have revealed the following:*
  - *The concentrations of calcium, cobalt, copper, lead and zinc in fish from both the Lubengele Tailings Dam in Konkola Mining Licence Area and control areas is far in excess of the*

[25] SRK (March 2001) Mopani Copper Mines plc Environmental Study – Stage 1: Environmental Baseline Study for Mufulira Division.
[26] Background stations are those stations presumed to be unaffected by mining activities.

FAO/WHO permissible maximum levels (Food and Agricultural Organisation 1980; World Health Organisation 1996).

- *Statistical comparisons between the Konkola Mining Licence Area and control areas and among fish species revealed no significant differences in the concentration of most elements. Analysis did show significant differences in the concentration levels of copper between the Konkola Mining Licence Area (average 985 mg/kg) and control areas (average 153 mg/kg) for pooled data for adult Tilapia and Serronochromis species. Thus the mining operation has had negative effects on copper toxicity levels in these species.*
- *Differential toxicity levels in juvenile and adult Tilapia fish (higher in adult fish) indicates that concentrations of copper increase with the age of the fish.*

- *Tilapia rendalli and Serronochromis are the most commonly eaten fish in Chililabombwe district and the excessively high toxicity levels in these fish may have serious negative health effects on the population since the fish from the dam may be marketed.* (Note: KCM felt that the expected impact from consumption of the fish would be less, if consumed in reasonable amounts, than the impact of eliminating this nutrition and income source by restricting access).
- *It is not clear whether the high concentration levels in fish from control areas is a result of the geochemistry of the area or pollution originating from across the border to the north and northeast of control areas where copper, cobalt and zinc are/were mined in the Democratic Republic of Congo. Further investigations are needed to clarify this situation.*
- *Species diversity (fish) appears to be higher upstream of the Konkola Mining Licence Area than in the Lubengele Tailings Dam. This may be a consequence of the construction of the Lubengele Tailings Dam wall, which has isolated the dam or as a result of mining activities/pollution.*
- *Very few aquatic insects and no aquatic snails were collected from Lubengele Tailings Dam.*
- *Kakosa Tailings Dam had no insects or molluscs. A similar situation was observed at the confluence of the Lubengele channel with the Kafue River where the mining wastewater from the Lubengele Tailings Dam is discharged into the Kafue River. Freshwater snails were collected from all sampling sites, except for the Kakosa dump pond and the Lubengele/Kafue River confluence.*
- *The regulation of water flow by the Lubengele Tailings Dam has increased the diversity of snail species, many of which are involved in the transmission of bilharzia."*

Table J.1 in Annex J presents a selection of water quality data from a number of plant sites. Based on the limited data reviewed, copper would appear to be the element of greatest concern for direct toxicity to aquatic biota, far exceeding the Canadian freshwater aquatic life guidelines in many cases. A more comprehensive review of this data is warranted, particularly with respect to short-term events. It has been reported, for example, that limited duration (<1 week) plant releases have resulted in the acidification of watercourses and the release of significant quantities of metals.

3.7.6 KAFUE RIVER

3.7.6.1 Impact on Hydrology, Water Quality

The EMP commitments of individual mine operations are almost exclusively concerned with issues arising within the mine license areas, with minimal consideration for catchment-wide issues such as downstream environmental quality within the Kafue River. Given the importance of the Kafue River to many people's livelihoods, a specific assessment has been made of the impacts of mining activity on the River and the extent to which these might pose a risk to users of the system. Several independent scientific studies of the Kafue River provide data of value for impact assessment of the Kafue system, for example *Impacts from mining activities on the water quality in the Kafue River, Copperbelt, Zambia* (L. Norrgren *et al.*, 2000, Arch. Environ. Contam. Toxicol. 38:334-341). Additional data are archived by ZCCM. Summary data are presented in Table 3.2 on water quality compared to drinking water standards and Table J.1 in Annex J for water quality compared to fish, plant, livestock guidelines.

Generally speaking, discharges to the Kafue River are reported to meet Zambian effluent guidelines. These are, in turn, comparable to World Health Organisation drinking water guidelines. However, there are locations where these criteria are intermittently violated, usually with respect to combinations of copper, iron and manganese. There have been reports of high suspended solids and also low pH episodes in the Kafue River, but these are not borne out by the data.

It is important to note that there are other factors aside from copper mining which may contribute to poor water quality in the Kafue. These include:

- substantial emission of raw sewage directly into the Kafue because sewage treatment ponds are diverted for irrigation;
- river-side irrigation and deforestation which contributes to erosion and sedimentation;
- lack of proper waste disposal which can lead to runoff from items such as leaded batteries into streams; and,
- small scale emerald mines directly on the banks of the Kafue with poor drainage control.

Pettersson (1998), identifies the following are water quality impacts for the Copperbelt area (associated with both mines and some of these other activities):

- Concentrations of copper, cobalt and SO4 are much higher in the mining areas. Dissolved copper shows highest concentrations during the wet season, in sharp contrast to other elements, which appear to be diluted by higher wet season flows. It was surmised that higher copper concentrations were derived from wash-out of copper-rich spoil piles in the mining areas.

- The Kafue is relatively low in dissolved trace metal concentrations in water relative to other world mines in non-carbonate rich zones. However, secondary particles (oxyhydroxides) are highly enriched in copper, cobalt and other metals. The bioavailability and toxicological significance of these particulate metals requires further characterisation.

- DDT (and breakdown products) and PCBs are present in measurable amounts.

Thus, while it is stated in the EMPs that the effect of mining on the Kafue is likely to be minimal (due to dilution), there is at least some existing evidence to suggest that this is not the case.

The ZCCM EISs referred to document comprehensive monitoring programs established to measure flow rates both within the mine sites and to external discharge points on the Kafue. The data acquired through monitoring do not, however, facilitate calculation of the temporal hydrologic changes induced from mining operations, due to the absence of a quantitative pre-mining baseline. This is particularly important in locations where either substantial withdrawals from watercourses occur or where channels have been re-routed. It is therefore difficult to evaluate the contaminant concentrations to which the environment is likely to be exposed.

Similarly for major water courses such as the Kafue River, comprehensive Kafue River hydrologic data are not available. However, independent monthly discharge hydrographs for Kafue stations at Raglan's Farm (upstream of Konkola), Smith's Bridge (near Mufulira) and Machiya Ferry (downstream of Luanshya) have been examined as a component of this EA and are included in Annex J on water and air quality data.

Impacts of the mines on wet season flows are negligible in percentage terms, given the large flow rates naturally prevailing. However, dry season flows are radically enhanced, particularly in the upstream reaches. As noted previously, during 1995, up to 40% of the water in the Kafue River originated from the Konkola Mine (Pettersson and Ingri, 1999). With the anticipated further development of Konkola (the "Konkola Deep" project), it is probable that this percentage will increase.

Calculation of net discharges (discharges minus withdrawals) to the Kafue River lies beyond the scope of this EA, however, should be included in EMPs. Such calculations (which would include both mine and non-mine withdrawals and discharges) would, however, be valuable, permitting a more comprehensive evaluation of the hydrologic impacts on the Kafue as well as the relative importance of mining discharges as sources of contaminant loadings.

3.7.6.2 Impact on Aquatic Life and Livestock

No comprehensive study of the effects of mining on aquatic biota in the Kafue River was incorporated in the ZCCM EIS surveys. Independent studies have, however, been undertaken. The principal reported impacts are:

- At least one incident of cattle losses ascribed to toxic levels of copper associated with iron and manganese oxyhydroxides in sediment and coating aquatic reeds and other vegetation.
- A microtoxicity test showed that no early life stages of Tilapia juveniles survived on sediment from the Kafue River collected in the mining area (Mwase, 1994).
- The Hippo Pool on the Kafue downstream of Nchanga is now largely devoid of hippopotami, ostensibly due to sediment discharges from the mines. However, the disappearance of the hippopotami may reflect other factors, including the disturbance of humans and water quality degradation due to sewage discharges or other toxins.

Given the amount of sediment discharged into the Kafue River, localised smothering of fish eggs and benthic invertebrates is probable. Since heavier particles will drop out of suspension quickly in quiescent waters, most sediment deposition will occur close to the location where sediment enters the water course. Sedimentation is, therefore, typically a greater problem in Kafue River tributaries than in the Kafue itself. However, finer particles (clay and fine silt) may be carried much further downstream, resulting in high turbidity, depleted dissolved oxygen balances and attendant impacts on aquatic biota.

Very few studies have been conducted on fish contamination in the Kafue, Norrgren *et al* (2000) conducted a two-week ecotoxicological monitoring program involving the use of caged threespot Tilapia. The caged Tilapia were placed in two locations: 1) the Kafue River upstream of Chililabombwe (a "background" site) and 2) the Kafue downstream of Kitwe (an "impacted" site). The results of the study showed a marked increase in metal concentrations (primarily cobalt, manganese and lead) in fish gills at the latter location over the two week study period. In liver samples, significant increases were found in cadmium (cadmium), cobalt, copper, iron, manganese and nickel. Cobalt concentrations showed the most marked increase between the background and impacted sites (average dry weight body burden increased from 3.28 to 20.8 µg/g in gills, 8.1 to 74.4 µg/g in livers). Additional studies are required with larger samples of fish that have been raised in these watercourses, who may have accumulated toxins over a longer period of time.

In conjunction with the fish study, samples of water were collected for the analysis of major and trace elements. Results for these samples showed substantial increases in metals concentration between the upstream and downstream sites. The results of the caged Tilapia study do not confirm a significant impact on fish health, on the health of other aquatic biota, nor on humans. However, the significant increases in contaminant concentrations are of concern, suggesting that further studies are warranted. Recommendations are provided in greater detail in Section 6.

The effects of short-term low water quality events (related to uncontrolled toxin discharges and spills) are not recorded in the ZCCM EISs. Higher predators (*e.g.*, birds, crocodiles and humans) may also be affected by contaminated fish.

Water quality data for the Kafue River (see Table J.1 in Annex J) compiled by ZCCM show copper concentrations well above freshwater aquatic life guidelines, possibly at levels toxic to some biota. A comprehensive review of the available data is suggested.

3.8 SUMMARY

Table 3.5 summarises the health and ecological impact associated with different mining processes in the Copperbelt and Kabwe.

Table 3.6: Overview of Mine Facilities and Potential Impacts

MINE FACILITY	ZCCM-IH RESPONSIBILITIES[27]	POTENTIAL HUMAN HEALTH IMPACT / PEOPLE AFFECTED	POTENTIAL ECOLOGICAL IMPACT
UNDERGROUND WORKINGS	• Private mine owners are responsible for underground workings in the Copperbelt • ZCCM-IH retains responsibility for Kabwe workings	• At least 3,000 squatters currently live on mine land that needs to be assessed for risk from subsidence. Degree of potential risk unknown and actual number affected likely to be much less than this. (ZCCM-IH liability) • Small number likely affected	• Subsidence and erosion can result in vegetation loss.
OPEN PIT	• ZCCM-IH has responsibility for several open pits at Nchanga, Nkana • ZCCM-IH retains responsibility for Kabwe pit remediation	• Only Nchanga open pit is active and thus level of risk to employees is higher than for the remaining closed pits which generally do not have many people illegally accessing them. Several open pits are not near population centres and thus this risk may be relatively small. • However, collapsing pit walls could incur into adjacent roadways as at Chingola. • Small number likely affected	• Mine de-watering provides major water input to Kafue River, with significant positive impact during periods of low flow. • In Kabwe negative impacts on aquatic ecosystems because water is contaminated by lead and zinc. • In Chambishi pumping water out of pit has lowered groundwater table, in Konkola, the wettest mine no such effect has been documented.
WASTE DUMPS (GENERIC EVALUATION)	• All defunct dumps (approximately 70% total) may fall to ZCCM-IH's responsibility • Defunct OB dumps at Nchanga, Nkana and most other mines. Some remain undecided. • Waste Rock Dumps: Many are undecided in Ndola, Mufulira and elsewhere. New mine companies may want to re-mine these dumps. • Slag Stockpiles: ZCCM-IH retains liability only at Kabwe • Ore Stockpiles: ZCCM-IH has claimed responsibility for several ore stockpiles in Nchanga	• Some dumps used for scavenging or agriculture but in the Copperbelt, because copper is not highly toxic and other potentially toxic substances such as lead and arsenic are present in the ore in small quantities, likely risk from consumption of food grown on dumps is low. • Secondary risks from use of site for illegal trash dumping, causes rats, mosquito breeding vectors which residents around TD25 in Kitwe complained of. Uncontrolled trash dumping at TD25 contributed to substantial contamination of stream emerging from site (likely greater contributor of contaminants than the tailings themselves) • Most significant dust exposure problems occur around Kabwe dump, where high atmospheric lead, zinc and cadmium concentrations are recorded. • In Kabwe, several people were killed because they were scavenging in the slag stockpile and part of the dump collapsed	• Eroded materials may interfere with drainage facilities and lead to off-site sedimentation • Serious impact to aquatic life due to reduced oxygenation of sediment impacted rivers, suffocation of benthic fauna and potentially increased metal loads in riverine sediments. • Natural revegetation and/or planting programmes can be impeded by physical instability of slopes, lack of soil organic matter and, occasionally, phytotoxicity factors. • Nkana slag dump effluents are mixed with process plant effluents. Variably low pH, metalliferous waters with little life-sustaining potential. Wider fates and contaminant impacts require investigation • Impacts primarily a function of surface drainage control. Leachates from sulphide ore stockpiles may be metalliferous and acidic.
CONCENTRATOR	ZCCM-IH retains responsibility for defunct concentrator at Kabwe. None in the Copperbelt.	Little or no health impact.	• Impacts are primarily a function of effluent management and efficiency of sedimentation in tailings facilities.

[27] Subject to change.

MINE FACILITY	ZCCM-IH RESPONSIBILITIES[27]	POTENTIAL HUMAN HEALTH IMPACT / PEOPLE AFFECTED	POTENTIAL ECOLOGICAL IMPACT
PYROMETALLURGICAL PLANT	Current operation of smelters falls under new mine owners' responsibilities, though ZCCM-IH may be liable for historical environmental damage	• In Copperbelt atmospheric emissions of SO_2 and possibly other volatiles exert a high impact on populations in smelter plume paths. From SO_2, respiratory symptoms, increased morbidity from respiratory disease, increased mortality esp. from cardiopulmonary disease. Populations affected include: • Kitwe (Nkana west, Wusakile - up to 53,000 people potentially affected) • Mufulira (Kankoyo, Kantanshi - up to 75,000 people potentially affected) and • Chambishi (data on wind dispersion not available so unknown number of people affected) • At Kabwe, populations in Kasanda township are likely to have been in smelter path in the past. Historical impact from lead may be significant. • Acid corrosion of infrastructure. • Significant number of people affected.	• Documented impacts include vegetation 'die-back' from high SO_2 loads. In Copperbelt, during SA complaints of inability to garden in back yard registered in immediate vicinity of smelter in Wusakile (Kitwe) and Kankoyo (Mufulira). • Possible soil acidification from SO_2 wash-out and dry deposition (despite bedrock buffering, many laterite soils are leached of bases and thus inherently acidic). Acid intolerant plants become eliminated from vegetation.
TAILINGS LEACH PLANT	None.	• Limited human impact	• Sedimentation of surface watercourses, including the Kafue River (Hippo Pool). • Impacts on benthic fauna, fish hatchery areas and possibly larger fauna (hippo, crocodile) though other sources of pollution may also be major contributing factors. Reduced feeding and breeding success for benthic fauna and fish. Reduced aquatic diversity. Possible mortality of aquatic organisms caused by reduced biological oxygen demand.
ACID PLANT	ZCCM-IH continues to own SmelterCo. though it is managed by KCM.	• Limited human impact • Inhalation of Sulphur dioxide	• Acidification and increased metal loads to surface drainage receiving effluents resulting in changes in species composition and loss of sensitive species. • Open liming of drainage waters at Chambishi produces severe, localised gypsum precipitation over riverine sediments and aquatic flora.
TAILINGS FACILITIES (GENERIC) - Paddock Dumps - Cross Valley Dumps	Several defunct tailings sites have fallen under ZCCM-IH responsibility. Some have failed causing siltation in streams (*e.g.*, Luanshya, 33C in Nkana). In Luanshya, dams are used for municipal water supply.	• Health impact from drinking contaminated water likely to be low because contaminated drainage systems are not known to be used for drinking (requires more thorough confirmation for broader number downstream users in EMP) and because high levels of copper tend to create bad taste in water which discourages consumption. SA site visits confirmed knowledge that streams were either contaminated (not suitable for drinking) or tasted bad so were not used. High reliance on wells or on piped water systems for drinking water. Bioavailability and solubility of metals in tailings is low. • Impact on water utilities treatment costs downstream	• Siltation of dambos and watercourses arises due to erosion of poorly consolidated or unvegetated paddocks or collapse of tailings because of poor maintenance – this can reduce water available downstream • High levels of silt can smother fish eggs and other aquatic life, thus reducing variety and number of fish in streams. However other compounding non-mining factors may be more significant influences (sewage) • Reduced aquatic life in tributary streams to the Kafue affects an unknown number of people dependent on fishing • Possible minor decrease in fertility of soil in adjacent area to

MINE FACILITY	ZCCM-IH RESPONSIBILITIES[27]	POTENTIAL HUMAN HEALTH IMPACT / PEOPLE AFFECTED	POTENTIAL ECOLOGICAL IMPACT
		reportedly high because siltation increases cost to treat water and can reportedly clog water reservoirs and pipes for domestic water users (particularly for Chingola, Mufulira). If mine siltation is found to be the cause, this may impede water access or increase cost to several thousand water consumers. • Extent of fish consumption from contaminated tailings lagoons unknown, but KCM EMP noted that there was some health impact from consumption of fish from Lubengele Tailings, but that the nutritional impact of restricting all fishing would outweigh the impact of eating the fish in moderate quantities. Should be assessed further. • In some cases there may be physical risk to adjacent houses if area is not stable (possibly withTD25) • Tailings dams with water in Konkola have been documented as hosting bilharzias. • Settlements exist on the margins of dumps (TD26, TD27) in Kitwe and may be subject to significant dusting exposure. • Older Nkana paddocks are used for cultivation. Heavy metal exposure through crop contamination warrants investigation, though likely risk to health in Copperbelt is low because of ore composition. In Kabwe no known cultivation on tailings, though EMP should assess if there is any cultivation adjacent to tailings as composition of ore does pose higher health risk from plants absorbing metals.	tailings dam • At Chambishi, ferruginous tailings effluents have caused precipitation of iron on streambeds and suffocation of benthic fauna.
MINE & PROCESS WASTE WATER	• Dewatering responsibilities have been transferred largely to the private sector, except at Kabwe.	• Mine water serves as source for municipal water supply in several towns providing potentially very significant health benefit to thousands of water consumers through increased access to piped water. However, high suspended solids increases cost of treatment. • Better co-ordination between mine companies and utilities can lead to more precise treatment, thus reducing costs. Currently occurring with AHS-MMS.	• Occasional ochre (iron oxide) precipitation and suffocation of aquatic flora and benthic fauna where minewaters discharge to surface water bodies. • Increased turbidity (suspended solids) resulting in alterations to composition of aquatic flora and fauna and usually decreased diversity • Effects on riverine ecology and fisheries • Effects of subsidence on surface resources • Effects on surface water resources • Effects on groundwater resources

4. ENVIRONMENTAL ISSUES (KABWE MINE SITE)

4.1 ENVIRONMENTAL HEALTH CONTEXT

As noted in Part I, Section 3.2.1 on the overview of Kabwe, three predominant environmental health problems are lead, sewage contamination of drinking water and malaria control.

Malaria is the leading cause of both morbidity and mortality at all ages, by a considerable margin. Since mine closure, the Kabwe Municipal Council (KMC) has not been able to continue implementing past malaria prevention programs (insecticide spraying). Poor solid waste collection (typically a municipal responsibility but KMC has no capacity) has also created vectors for mosquitoes to breed in solid waste dumps in some of the high-density informal settlements.

4.2 MINING ENVIRONMENT ISSUES

The ZCCM-IH Kabwe Mine Lead-Zinc complex was officially closed on June 30, 1994. A Kabwe Mine Site Rehabilitation and Decommissioning Plan (February, 1995) was produced by a team comprising the ZCCM-IH Kabwe mine, ZCCM-IH Group Environmental Service personnel and with guidance from Steffen Robertson & Kirsten.

ZCCM-IH considers the most pressing issue in Kabwe during rehabilitation and decommissioning is the reduction of lead in blood, which has the greatest potential impact on children in the community. A monitoring program has been initiated and will continue under the CEP.

4.3 OVERVIEW OF LEAD CONTAMINATION

As a consequence of past mining operations, lead contamination is pervasive in Kabwe around and southeast of the mine site. It is less intense but also present downwind, to the west of the smelter stack.

As noted previously, sufficient lead contamination has been measured in settlements around the mine site and in the community to be considered a threat to health. There are three elements to this hazard. The first is lead exposure associated with mining activity. The second is the natural presence of lead in the soil in this community and the potential for exposure from some other sources. The third is the susceptibility of this population due to the high prevalence of anaemia (which increases absorption of lead) and malnutrition. Together, they boost body stores of lead into dangerous and potentially toxic levels. Dr Clyde Hertzman of the University of British Columbia interpreted blood levels (from 1995) from residents in communities around the mine site and soil levels from the area. He found that they correlated and presented a profile of high risk. He observed that the contaminated soil was the more significant source of lead in blood. Subsequent medical examination of follow-up data by the SA team confirms this impression. However, further study needs to be carried out on the source of contamination.

Bioaccumulation in food has also been documented. Crops grown and marketed in the Kabwe area appear to accumulate excess lead, particularly giant rape (163 ppm in soil of 400 ppm, compared to the ECZ recommended guideline of 200 for animal feed and 530 for soil). This suggests that crops grown in areas of higher soil contamination could potentially pose a health hazard for human consumption and should be tested further. Such "hot spots" of soil contamination may include houses in Chowa, assuming that owners have gardens (ZCCM has told those involved in the testing program in the most contaminated areas not to garden) and other districts including informal settlements and the plant area (some locations of which have measured lead content in soil as high as 13.7 to 40.9 % (this value on the plant site), but with great variability and more typical levels from 0.6 to 2.0%. See Figure 9 in Annex D for details.

4.3.1 LEAD IN SOIL AND TAILINGS

A substantial toxicological hazard is posed by the integrated waste repository for tailings, leach plant slimes and smelter wastes located immediately south-west of the plant at Kabwe. Two major programs of assessment have been completed on the dump, one of which (Swedish AB, 1994) focused on the chemical toxicity hazard and related water quality issues. The Kabwe dump occupies an area of approximately 1 km^2. Leach residues account for approximately 62% of the deposited material and hold lead, zinc, copper, cadmium and vanadium concentrations of 3.6%, 3.5%, 0.18%. 20 mg/kg and 0.15% respectively. Leach tests on this material, using pH 7 solution, showed limited mobilisation of lead, but substantial zinc liberation (320 mg/kg). Nevertheless, lead exposure from the dumps was, significant as a consequence of 'dusting.'[28] As these dumps have since been capped, new tests should be conducted to assess the new levels of exposure to contaminated dust.

The undisturbed soil appears to present a substantial threat of lead toxicity by itself. The lead ore that was the basis of Kabwe's mining activity also reaches the surface in lead-rich outcrops. There is considerable lead content in soil in the area, down to one meter depth (140 ppm at Kasanda and 65 ppm at Katondo).

On the surface, additional deposition due to smelting activity and water-borne off-site transport of contaminated soils has elevated lead levels to unacceptable levels, as high as 26,000 ppm (2.6%) in Chowa and 1% in Kasanda, an area not extensively tested. (WHO guidelines consider levels exceeding 1,000 ppm or 0.1%, to be unacceptable.) Evidence demonstrates that smelter emissions have deposited lead contamination that adds to the existing high levels of lead in soil, which already constitutes a natural health hazard for residents in the Kabwe area.

The close correlation between soil lead and blood lead levels of residents suggests that soil levels are the principal determinant of blood lead levels in this population. However, other sources may be important in contributing to the total body burden. Mining and smelting activity have resulted in additional lead to the

[28] Additional information on the distribution of heavy metals around the mine site is contained in Master of Science theses by Zulu (December 1995) and Tembo (February 1993).

soil, sufficient to push individual body burdens of residents well into the toxic range. The use of leaded gas in Zambia may contribute a proportionally smaller amount but in an individual with high body burden of lead to begin with, this contribution may mean the difference between subclinical and toxic levels.

Zinc and cadmium levels are also elevated in the soil in many areas around Kabwe as well as the Mine Canal sediments. However, relative to lead, zinc and cadmium concentrations are a minor issue, (See Annex P)

As noted previously, testing by ZCCM has measured zinc concentrations in soil up to 30,000 ppm in Kasanda, however the majority of results were less than 5,000 ppm. The Sable Zinc EA (African Mining Consultants Ltd., 2000) notes that "*low grade mineralised waste rock has been dumped in the Kasanda Township. Part of the township is built over waste rock. Dumping of waste rock over many years has probably contributed to the elevated metal levels in the surface soils* Where the protection of human health is the primary concern, acceptable zinc concentrations may be much higher (in the order of 10,000 ppm on residential land and 30,000 ppm on commercial land in British Columbia).

Cadmium has greater toxicity than zinc and is therefore of greater potential concern. However, cadmium levels in the soils are generally within comparable regulatory guidelines. The British Columbia guideline for cadmium in agricultural/residential soils is 35 ppm and 3 ppm where land is used to grow produce for human consumption. Results from ZCCM's 1990, 1993 and 1994 soil surveys indicate soil concentrations are between 2 and 36 ppm. Thus, cadmium levels in the soil may be a concern where crops are being grown, however the lead concentration in the soil in all likelihood will be the greater issue.

Tailings from mine operations, containing 3.1% to 10.5% lead (31,000 to 105,000 ppm), were deposited in tailings dumps located immediately south of the open pits and plant site. These dumps were covered with slag from 1997 on, as resources permitted, to a depth of 10 cm to reduce blowing of the fine lead-containing dust particles in the area. This protective measure is incomplete because of financial constraints. Scavenging has not been observed in these dumps. Where coverage has been in place for several years, vegetation is growing.

4.3.2 Air Quality

Since the ZCCM mine closure, air pollution has been well below the WHO guideline for lead.

4.3.3 Kabwe Drainage Canal

A drainage canal from the plant site has been (and continues to be) an important source of off-site lead contamination. Surface water runoff from the plant area is contained within a perimeter ditch and discharges to a canal ("Main Canal") leading south-east from the plant site. The canal runs along the northeastern perimeter of Chowa and the facing settlement of Railway and south of the unplanned settlement of Katondo (see Figure 4). Soil erosion of highly contaminated sediment from the mine site is transported into this canal when it rains and deposited along its length. More importantly, when it floods and if the canal has not been cleared of reeds and waste, it can overflow into adjacent neighbourhoods of Chowa, Railway, Katondo, thus distributing lead to these areas and potentially to wells in the vicinity. While there are no wells in Chowa and Railway, there are an increasing number in Katondo as residents cope with decreasing reliability of municipal water. Such floods occurred in 1996 and last year.

According to plant personnel, a sedimentation pond did previously exist to reduce the offsite transport of sediment. This pond apparently filled rapidly, suggesting that it was quite successful in reducing sediment loads to the canal. The pond has since been back-filled and sediment now flows directly into the canal.

Deposition of this sediment in the upstream reaches of the canal, combined with vegetative growth and the common practice of residents dumping waste into the canal, has resulted in a reduction of canal flow capacity in past years. This necessitated the dredging of sediment for many years and its use in construction of berms on the canal banks. Once the dredged soil dried, it became susceptible to wind transport, thus possibly increasing the area of soils with high lead concentrations. Testing of lead in soil and in private wells (which may have been affected by this dust) has not been spatially extensive and has not sufficiently included Katondo township which also border the canal and was adjacent to these berms. Locals have also constructed bricks from soils found near the canal, thus, increasing the potential area of high lead content. The berms were recontoured and used as topsoil when adjoining neighbourhoods of Chowa were built.

More recently, some berms were removed and placed in tailings dumps on the mine site as it became clear that these contaminated sediments were largely responsible for high soil lead levels in adjacent neighbourhoods (such as Chowa). Dredging will continue to be required as long as contaminated soils on the plant site remain exposed and the canal continues to carry a high sediment load.

Approximately 6 km from the mine site, the canal enters a reed dambo, considered to be the headwaters of the Muswishi River. The Muswishi is in turn a tributary of the Chowa River, which discharges into Mulungushi Dam approximately 40 km from Kabwe. This river system continues eastward before ultimately heading south to discharge into the Zambezi River (ca. 300 km downstream from Kabwe).

The mine water quality network included sampling points upstream and downstream of the dambo. Prior to mine closure in June 1994, dissolved lead was detectable in samples from the canal upstream of the dambo, typically at low concentrations. Following mine closure, lead concentrations were reported to be near or below detection limits. Dissolved lead concentrations in the Muswishi River (downstream of the dambo) were usually (but not always) lower than the upstream sample. Monthly samples from June through July 1994 appear to be at detection limit (1 µg/L), well below water quality criteria for lead[29].

It is important to note, however, that lead solubility is relatively low in waters with near-neutral pH and hardness typical of surface waters. In the Kabwe canal, most lead is likely found in either bottom or suspended sediments[30]. Transport of most lead beyond the dambo is considered unlikely, since suspended solids are likely to be effectively filtered by vegetation within the dambo.

There is a possibility of high lead (which is know to bioaccumulate) levels in aquatic organisms in the canal and the Muswishi. While reported dissolved lead levels in water are low, it is likely that highly contaminated sediment remains in the canal. It is our understanding that no testing of aquatic life (aquatic invertebrates, fish) from the canal or the Muswishi River has been conducted, nor has dredging continued beyond the unplanned Katondo settlement. When interviewed, locals indicated that fish from the canal were not consumed – it is not known whether fish are consumed from the Muswishi in the reaches immediately downstream of the dambo. It is considered prudent to recommend testing of fish and pending the outcome of these results, to confirm whether (or not) fish is being consumed by the local populace.

4.3.4 MINE WATER AS WATER SUPPLY

Water quality is a potential concern should mine water be used to augment the municipal water supply (which has been requested at times by members of Kabwe Municipal Council); mine water is currently monitored by ZCCM-IH during flooding since the closure. (Pre-closure lead levels in mine water were typically 0.01 to 0.12 ppm lead, at a pH of ≥7.3 which is within a typical neutral range (6.5-8.5 pH). Based on available data from 1994, water quality monitoring for lead suggests that the removal of sediment has reduced the amount of lead available to equilibrate with dissolved lead in water. The limestone geology of the area is favourable to preserving water quality, which results in buffering of excess acid and precipitation of metals.

4.3.5 SUMMARY

In summary:

- natural background lead concentrations in the soil are high;
- deposition of lead particulate from the former smelter has increased soil lead concentrations resulting in widespread contamination;
- the contamination is pervasive to the southeast and west of the former mine site;

[29] WHO drinking water guidelines = 10 µg/L; Canadian Freshwater Aquatic Life guideline varies from 2-7 µg/L depending on hardness.
[30] The ratio of lead in suspended solids to lead in dissolved form has been found to vary from 4:1 in rural streams to 27:1 in urban streams (EPA, 1986).

- bioaccumulation of lead into edible plants is occurring and it is not known if these plants are sold at market, potentially spreading the effect;
- sediments from the Mine Canal contain high lead;
- the settlement of Chowa has been contaminated by dredged material from the adjacent canal. Lead levels in soil in the unplanned settlement on the other side of the canal have not been adequately characterised; and,
- lead concentrations in the canal water are generally not a concern, regular dredging of sediments in conjunction with the natural buffering capacity of carbonates appear to have mitigated against impacts on water quality within the canal However, lead concentrations in aquatic organisms are unknown.

4.4 TESTING PROGRAMS

4.4.1 SOIL LEAD CONTAMINATION

Soil sampling to assess the extent of lead soil contamination around Kabwe has been conducted in seven programs since 1975. Results are summarised as follows:

Testing Program	# of Samples	Locations Tested	Depths (m)	Areas Covered	Lead Ranges (ppm) WHO Limit = 1,000 ppm
1975	19		0-0.15	Kasanda, Chowa, Luangwa	260 – 21,000
1990	76	15	0-1.0	Kasanda, Katondo (1 location)	700 – 34,000
1993 (Swedish Geol. Unit)	16	8	0.15	Kasanda	
1994	72	24	0, 0.5, 1.0	Chowa, Kasanda, Makululu	<1,000 - 36,000
1994 Mine Plant	120	40	0-0.1, 0.5+	Plant Site	200 – 409,000
1994 with Blood Testing	53	53	surface	Kasanda/Chowa/Mukobeko, Lukanga	<1,000 – 7,600
1999 AMC/Sable	48	24	0-0.5, 1.5-2.0	Kasanda, Chowa, Katondo Regional (12 bearings, 1.2 - 3.2 km radial distance	25 - 15,820

The data are more than sufficient to conclude that the level of contamination is high and presents a risk to health, especially for children. The neighbourhoods at greatest risk include Chowa, Kasanda and Railway and may include Katondo, an informal settlement for which little data exist. Lower levels of risk may be present in Mukobeko (where levels up to 0.6% have been found), Lukanga and Luangwa. Foci of high lead levels in soil have also been identified north of the Great North Road. Although the population of these townships is known, it is impossible to predict how many live close to the most contaminated areas nor how many have been affected until further research is conducted.

The following generalisations can be made from soil sampling results collected to date:

- background soil lead concentrations are on the order of 100 to 200 ppm on the basis of host rock concentrations and lowest measured soil concentrations at locations furthest from the mine;
- the distribution of soil contamination is generally consistent with prevailing wind directions;
- sediments from the Mine Canal, however, appear to have caused significant localsed hotspots in adjacent settlements upwind of the plant site;
- lead concentrations were generally low (< 1,000 ppm) north and northeast of the mine area;
- lead concentrations within 2 km of the mine area are likely to exceed 1,000 ppm;
- lead concentrations drop off sharply below 0.5 m depth;
- the shallow nature of the contamination is consistent with airborne deposition; and,
- Kasanda is an exception in that lead concentrations remain high to more than 1 m depth as much of the township appears to have been built on mine waste rock.

Soil testing has been sparse and additional soil sampling is warranted to better establish trends and to identify hot spot areas within the nearby communities. The primary concern with past programs is that they may have too quickly focussed on only Kasanda and Chowa (the areas of highest impact) at the exclusion of other affected communities. Future soil assessment should include Katondo, Makalulu, Luangwa, Lukanga and Mukobeko as well as Kasanda and Chowa. Further soil assessment should focus on areas of high potential exposure such as child play areas (most commonly in back yards), school yards, community centres, recreational fields and bare land areas.

Future sampling programs require the development of a detailed, documented, independent quality assurance/quality control protocol. The protocol should cover sampling site selection, sample collection and laboratory analyses. Inconsistencies in past soil sampling programs exist with respect to laboratory detection limits and sample extraction/digestion techniques.

4.4.2 Blood Lead

The first blood testing program was undertaken in 1994 involving 866 individuals from four townships: Kasanda, Chowa, Mukebeko, Lukanga. The greatest number (358) tested were from Kasanda, representing about 7% of the population. Mukebeko and Lukanga were included as control populations on the basis that these communities do not include former smelter workers and are located further from the former mine area. The validity of this assumption is suspect.

Blood lead testing results from 1994 are summarised as follows:

	Kasanda	Chowa	Mukobeko	Lukanga
Number of Samples	358	168	122	113
Average Blood Lead (µg/L)	45	35	13.1	14.7
Range	2-118	3-110	3-54	3-57
Average by age:				
0-5 yrs	58	50	16.3	18.6
6-16 yrs	52	44	15.2	17.7
17+ yrs	37	50	12.2	13.0

The above test results clearly indicate that the greatest exposures were identified in Kasanda and secondly Chowa. These results are consistent with expectations based on proximity to the former mine area, wind directions and general trends in soil survey results.

The WHO acceptable standards for blood lead concentrations is 10 µg/L. In reviewing the above data, Dr. Hertzman noted that even the populations in Mukobeko and Lukanga exceeded the levels identified in Canada's major hot spot communities with lead contamination (11- 13 µg/L). Given that there exist naturally high occurrences of lead concentrations in soil in the Kabwe area, it may be necessary to determine a local baseline blood lead level when setting remedial goals.

Also apparent is that the youngest populations (0-5 yrs) in all four townships, have the highest levels of exposure. This finding is of particular concern as this is the most vulnerable population. The results are consistent with typical childhood play behaviour, which results in a high level of soil contact and incidental ingestion. Similarly in Trail Canada, the long-term goal is to have 90% of children with blood lead levels under 10 µg/dL and 99% of children with blood lead under 15 µg/dL.

Since 1994, ZCCM has conducted additional blood lead testing in Chowa and Kasanda 1996-97 and 1999-2000. The results were summarised by ZCCM (ZCCM, July 2000) as follows:

Sample Area	Number of Houses	Number of Residents	Average Lead in Blood 1996/7 g/dL	Average Lead in Blood 1999/00 g/dL	Range of Results 1996/7 g/dL	Range of Results 1999/00 g/dL
Chowa Township	967	7,736	68	44.2	27.7-117.6	7.6-93.0
Kasanda Township	671	5,368	70.4	44.3	27.2-108.6	13.6-66.6

The results show a decline of the average lead in blood from ~70 g/dL in 1996/7 to 44 g/dL in 1999/00 in the sample population. The decline in lead levels represents a 35% reduction in lead in blood since the mitigation measures started. However, the extent of testing and the number of individuals tested have not been provided. Furthermore, the program has excluded the originally tested populations from Mukobeko and Luangwa, which had lower but still elevated levels of blood-lead. The nearby communities of Makululu, Luangwa and Katondo had only limited testing.

Those that were found to have high blood lead levels were treated by ZCCM medical staff who were retained for that purpose. Those tested received an educational briefing on lead contamination and measures to prevent recontamination. Testing in this area may have been facilitated because it was a mine township; when the mine was operational, ZCCM provided regular check-ups to test for lead in blood. Several residents noted that they missed the regular health care they had with ZCCM. However, possibly because of funding constraints, more extensive testing in neighbouring communities such as Katondo (an informal housing area) was not carried out. In addition, since miners can now rent out their homes, it is not clear whether new residents are being captured in the program. For example, when miners in mine townships purchased their houses in 1996, many subsequently rented their houses out and moved to Makululu settlement (an informal settlement).

A more thorough assessment of the sources of ongoing contamination and how such contamination may have spread through human interactions is recommended. This would involve much wider testing sampling of soil, water and blood lead levels of children. Some preliminary specific recommendations on how such testing could be structured have been provided to ZCCM by the toxicologist/MD associated with the SA, but a full assessment design would need to be developed with a neutral internationally reputable professional in the environment and medical field, costed and then weighed against expected benefits. At least in areas suspected to have high rates of contamination, a testing program would also involve census testing rather than sampling for lead contamination (in terms of blood lead levels, testing would focus on the most vulnerable, children). Census testing could have significant implications for the cost of the program; in some areas that have not been tested there are large populations (Katondo has an estimated 39,000 residents, Chowa has about 4,000 and Kasanda has about 3,100). If such a program is undertaken, it will require careful examination of the resources needed to address the results and findings, including:

- adequate and validated laboratory facilities;
- health care personnel for explaining the tests and the results to residents; and,
- eventually resources for treatment.

4.5 PHYSICAL HAZARDS

With at least 14 investors and limited resources to implement access controls to the site, local people entering the site to scavenge is common and as the Kabwe Municipal Council (KMC) noted "*nobody has control of the site.*" According to KMC, former miners are active in scavenging as they know where to find metal strips in the mine. Some lead metal and slag scavengers have performed secondary smelting on site but this particular operation was small in scale and did not last long. It may have contributed to local contamination levels but is unlikely to affect levels in the community beyond.

Most other scavenging involves digging for coal, buried copper-containing cable and metal-rich slag that can be reprocessed. Some involves scavenging sheet metal and other usable materials from plant buildings and facilities that were initially intended to house businesses, which subsequently proved non-viable. Scrap metal dealers from the Copperbelt and Lusaka purchase the scrap.

At least two incidents have resulted in fatalities in recent years. One occurred when a group of men were digging into slag and pulled out a buried piece that triggered a collapse in their excavation, killing three. The other occurred when some boys entered the now water-filled open pit to play and subsequently drowned.

During site visits women with infants were observed within the mine site. There did not appear to be sufficient security to ensure that children did not enter the site. Given the susceptibility of these groups to lead exposure, direct exposure to dust around the site presents a serious health concern.

4.6 SOCIAL ISSUES / FEEDBACK

In addition to the current problems with water supply, sanitation and solid waste provision in Kabwe, residents spoke of the lack of adequate health care. They remembered when ZCCM was operational; miners would receive regular, good quality care because they would see a doctor every 6 months to check for lead exposure. Now, according to one local NGO,

"*(ex) Miners are dying earlier now because they are not receiving treatment. Standards in hospitals have declined. There is no medicine and people assume they cannot afford it. People also used to get vitamin supplements and food from the mines, now they are not getting these so they are more likely to get sick.*"

As in other mine towns, information on mine pollution is scarce. One resident reported that people came within the past year to collect water and soil samples, but they were never informed of the results.

The KMC noted that with mine closure the water table had risen, causing problems with sanitation and drainage, particularly in the extremely large informal settlement of Makululu. According to KMC, there are 42,000 people with shallow wells in Makululu and problems with flooding and drainage have translated into problems with cholera. ZCCM has placed boreholes between Makululu and the mine to monitor any water quality impact arising from the flooded mine workings and thus to prevent contamination of shallow wells. The KMC also mentioned land scarcity as an increasing number of rural people come to the city, unemployment with the restructuring of Zambian Railways and problems with cost recovery for water and sewer services which has made it difficult to run the services properly.

When members of a Rotary Club group, composed of community leaders, business persons and government representatives, were asked about their concerns over mine pollution and then pollution issues in general, they did not view mine pollution as a major issue since the mine was closed, but noted the following:

With Regard to Mine Pollution:

- There is one area around the mine that is caving in and children sometimes play near this, which is a hazard.
- There is a rumour that some of the mine tunnels are flooding and that some of the houses above this area may be sinking (in Kasanda).

- With Regard to the Environment:

- People have started to leave plastic wreaths at the gravesites and this can damage the environment.
- Deforestation is getting worse.

Their environmental concerns differed from those of residents in the low-cost Katondo township who focused on water supply (they wanted wells), lack of health care, sanitation and drainage as issues. With regard to the canal in Katondo, one resident noted:

"We tell our children not to play in the Canal because it is contaminated and full of faeces, but the children do not always listen. There are lots of mosquitoes that come from the canal. Malaria has affected our children."

As noted above, some residents dump waste in the canal. It is thus not surprising that in Chowa, another neighbourhood bordering the canal which was contaminated during flooding of the canal, one group of residents' priorities for neighbourhood improvement were 1) improving sewer/drainage and reducing flooding; and 2) introducing dust bins to the neighbourhood.

The discord between the level of knowledge about mine pollution that continues to exist in Kabwe and the actual impact of contaminated soil and dust within residential areas should be addressed by the CEP. This will require a carefully developed risk communication program with outreach to specific groups working with residents such as teachers, NGOs, health care providers and community educators.

5. PRELIMINARY APPLICATION OF RISK BASED APPROACH TO MINING ENVIRONMENT ISSUES

5.1 PROGRESSION FROM HAZARD TO RISK

As noted earlier, methodologies for the prioritisation or ranking of hazards based on the concept of probable risk have been developed for use under previous World Bank funded mining sectoral development projects, for example in Bolivia (World Bank Tech. Paper No. 398, 1997) and Ecuador (PRODEMINCA, 2001). Under such schemes, hazard magnitude is evaluated on the basis of factors such as the ambient concentration or environmental emission of toxic elements and the degree of toxicity associated with various elements. Risk is then qualitatively evaluated on the basis of value judgements regarding the degree of human interaction with each hazard and the associated level of exposure via pathways such as air, food, soil and water.

The overall environmental conditions in the Copperbelt and Kabwe, in which major environmental issues such as contaminated drinking water and deforestation are also present, warrant placement of the analysis of risk in the context of other potentially important factors affecting human and ecological health. These other factors include lack of clean water supplies, deteriorating sanitary conditions, rampant and increasing deforestation for charcoal, illegal poaching of wildlife and a host of smaller scale industrial activities other than mining that are poorly regulated.

5.2 PRIORITY MINE-RELATED ENVIRONMENT ISSUES (COPPERBELT AND KABWE)

Based on a qualitative application of the impact of various issues on health, ecology and the environment outlined in the previous chapters, the following issues emerge as important to improving the mining environment in Zambia. Other areas that are unlikely to emerge as higher priority, but that should be assessed are summarised in the subsequent chapter on data gaps. This represents only a preliminary application of the risk-based model and provides a starting point for further investigation and assessment under the EMPs/CEMP. In terms of overall mining environment issues, these three emerged as priorities:

1) Kabwe health effects of lead contamination, primarily in soil and possibly in food, due to past mining.

2) Sulphur Dioxide Emission from Mufulira, Nkana and Chambishi smelters and their negative impact on health of downwind populations.

3) Sedimentation into streams and the impact this has on water available to downstream users, on the cost of treatment to downstream utilities (particularly in Mufulira and Chingola), on fish and wildlife in the Kafue.

Some of these issues are likely to be under ZCCM-IH's direct control (some of the tailings and dumps for example) while others remain under the control of the private mine companies and can be addressed only through the EMP process (sulphur dioxide).

A more comprehensive understanding is required of the probable contribution to total human lead exposure derived from air, soil, water and other pathways and subsequently from individual sources (*e.g.* the canal, the waste pile) in Kabwe. The findings of these investigations should then be used to help prioritise rehabilitation efforts to minimise those pathways of higher lead exposure. Support to ZCCM-IH's ongoing remediation program in Kabwe would likely emerge as a priority eligible for some financing under the EMF of the CEP.

Emissions of sulphur dioxide and metals are likely to diminish markedly following plant modifications currently in progress. Many of these changes will recoup their investment in recovery of product and better operating efficiency. Investment by the new owners in emissions control and operating efficiency will reduce the resulting air pollution from current high levels but whether WHO air quality guidelines will be achieved ultimately remains to be determined. Residual sulphur dioxide and metals emissions from smelters can only be influenced through the EMPs agreed to with investors. It will therefore be important that the CEP support the GRZ's capacity to analyse this complex issue. In particular, analysis should focus on the total burden of SO_2 which will be reaching communities rather than only focusing on the percentage being retained by the smelter. In one example, in modeling 10 years into the future of the benefits of implementing smelter improvements for SmelterCo in Kitwe, while the SO_2 "footprint" on the Kitwe community shrinks the concentration in the highly populated area west of the smelter is still above 250 $\mu g/m^3$ 3 km out and WHO 24 hour levels of 50 are exceeded throughout most of the populated areas up to 6 km or greater north, south and up to 9 km west of the smelter (See Annex J).

Sedimentation has caused substantial impacts on watercourses in the Copperbelt and Kabwe. Sediment generation is attributable to the erosion of dumps, tailings paddocks, tailings dams (including the breaching of tailings impoundments) and other mine facilities. The silts, sands and clays which are eroded pose a substantial problem to the aquatic ecosystem, destroying aquatic habitats, suffocating fish eggs, impeding fish gill function and causing a variety of other problems. The sediments also cause increase treatment costs for drinking water systems. Under the CEP some sites in the Copperbelt that would likely increase sedimentation if not rehabilitated will likely be financed. However, a large proportion of sediment is likely to emanate from currently operating sites and these will be governed by commitments made in investor EMPs.

It is believed that the physical effects of sedimentation are more significant than their toxicological aspects. Water pH generally is typically near or above neutral and consequently the leaching of toxic substances in the sediment is unlikely. There is some possibility of metals leaching in buried bottom sediments, but this is considered to be a relatively minor issue. In Kabwe, the offsite migration of lead-rich sediment is a more significant toxicological issue, since these sediments are directly toxic.

Mines are not the only sources of sediment to Copperbelt and Kabwe-area watercourses. Agriculture adjacent to streams is extremely widespread and contributes to erosion and siltation of the Kafue. Although there is a law against such practices, it is almost never enforced. Small-scale emerald mines also contribute to siltation of the Kafue. These mines are relatively time consuming to access, are small in scale and thus, receive relatively little environmental oversight and have pits very close to the Kafue River.

Although the preliminary application of this ranking has focused on those issues with the greatest impact on human and ecological health, there are other economic impacts that are also important, but that would need to be further characterised during the EMP/CEMP process. For example, siltation and metals from tailings can degrade streams and reduce aquatic life thus reducing potential income from fish sales and SO_2 can impede vegetation growth. Similarly, downstream of the Musakashi tailings dam at Chambishi, residents complained that they cannot use the stream water for bathing since 1998, causing them to use other sources.

5.3 RISK MANAGEMENT

The mitigation of mining related hazards on a priority basis, as defined by adverse human impact, must constitute a central aim of both the CEMP and EMF. In Section 1.2 (Part II), the limited applicability of a 'standards' based approach within the specific context of Zambia's economic, cultural and technological setting was outlined. In addition to a lack of capital resources for systematic monitoring and thus effective identification of instances of regulatory exceedance, the approach is flawed by the fact that 'hazards' are identified with out any indication of the associated 'risk.'

To prioritise the rehabilitation of sites within the Copperbelt and Kabwe mining districts, it is most important to identify significant public health threats and to establish operational priorities that begin with these. Control of such prominent hazards will, predictably, result in control of contaminates that are released from the same source and that show similar behaviour. Achieving compliance with numerical standards for media quality, particularly those based on aesthetic considerations, should be an ultimate goal but secondary to control of imminent and potentially widespread toxic and physical hazards. Risk should outweigh attainment of a standard as a criterion for priority in management.

5.4 PRELIMINARY IDENTIFICATION OF PRIORITY SITES

Annex G contains a tabulation of the major facilities in the Copperbelt and Kabwe and their dominant features based largely on work completed in 1996 under the ZCCM EIS. Tables 1 to 17 in the Appendix provide a synopsis of the number, distribution and general environmental characteristics of the principal sites (tailings facilities, overburden dumps ore stockpiles, waste rock dumps, slag stockpiles, open pits, underground workings, processing plants, water impoundments, sewage plants, solid waste dumps and hazardous waste storage sites) at current and former ZCCM operations. Because the basis for the majority of this data was ZCCM's 1996 EMPs, this list needs to be updated with better and more recent information on human interactions with the mine sites, on the number of downstream users potentially affected and on how the site has changed physically since 1996 (some sites have been updated others have not) in order to fully assess risk.

In the ZCCM EMPs, an environmental significance ranking of Low to High was assigned, although this did not take into account adequate information on the human interactions with these sites, nor how the sites have changed physically since 1996. In the case of Luanshya, for example, severe economic hardship of RAMCOZ which ran the mine has resulted in a lack of maintenance of mine sites and a dramatic deterioration in their stability. This would not have been reflected in the data from 1996. ZCCM-IH could update the existing information with audits that have been performed on sites and with some evaluation of the numbers of people affected by each site and then begin the process of risk evaluation. The existing site tables can provide a useful starting point. Once a list of priority sites is confirmed based on their potential for having an impact on people, animals or plants, sites judged to pose serious dangers should then be selected for more complete environmental audits.

It is important to note that major facilities listed in this appendix are limited to mine installations and exclude mine sites proper; thus, these tables would need to be expanded to include these sites for the CEMP.

A summary of environmental issues to be addressed at select mine sites is presented in table format in Annex H.

The information presented in these two appendices can serve as a starting point when evaluating the EMPs and designing the CEMP.

5.5 STAKEHOLDER PERSPECTIVE ON ENVIRONMENTAL PRIORITIES

One objective of the social assessment work is to gather views of a wide variety of stakeholders on environmental priorities and concerns and on concerns and perceptions with regard to mine pollution and the CEP. Accordingly, discussions were held with NGOs, local government representatives and administrators, sectoral ministry representatives, provincial authorities, health care providers, mine companies and others. In addition, key informant interviews were held (in local languages) with a number of individuals living in areas likely to be affected by mine pollution (see Part I for list of those consulted).

When asked about overall development priorities, residents almost never raised the issue of mine pollution. Most were primarily concerned with water supply, sanitation and solid waste disposal and overall employment/income. Other concerns included access to land and inputs for that land such as fertiliser and seed and, among government officials, the impact of deforestation.

As noted above, mine pollution was mentioned as a primary development concern only in townships adjacent to mine smelters. However, the issue of smelter emissions continues to represent the most common mine-environment concern of residents. More localised issues did emerge such as the flooding of the stream from the Musakashi dam in Chambishi which can affect crops or the environmental problems created by illegal trash dumping on TD25. In Kabwe, concern about lead contamination was primarily limited to those who had participated in the ZCCM testing program. One of the reasons for the lack of concern is simply a lack of information on the related health and ecological impacts of mining. Mines in both regions have been operating for many years and most people have not known a situation where mines did not exist. Moreover, poverty means that many residents are more concerned with earning an income than with potentially long-term effects from environmental contaminants.

BOX: CASE STUDY - KITWE SLIMES DAM (TAILINGS DAM 25) IN CENTRAL KITWE

Kitwe slimes dam sits in between two urban neighbourhoods – Nkana East and Parklands. The slimes dam has been capped with laterite but this is eroding because of how the dam is used. Its uses include:

- Illegal dumping of municipal refuse by garbage collectors. Dumping has increased since privatization as ZCCM no longer has security personnel to guard the dam. This attracts rats and can serve as a vector for mosquitoes. Kitwe stream goes through the dam and there was visible refuse in the stream including animal carcasses.
- Since 1988, about 100 residents from houses bordering the dam have used it for cultivation, primarily of maize and groundnuts.
- Because of its central location, it has become a common shortcut with several pathways. These pathways contribute to erosion.

Pollution Issues:

The impact of pollution in Kitwe stream from dumping and from informal settlements upstream (such as Kandabwe – see box) is likely greater than from sediment from the tailings dam.

Because of the way in which the dam is used, it is prone to erosion. If this continues, about 30 high cost houses that are downstream of the dam could be inundated during the rainy season.

Erosion can contribute to wind blown dust into Nkana East or Parklands.

Health Impact of Pollution Issues:

At levels measured in 1996, elemental analysis of the tailings dam showed fairly high copper content and low lead. Although the composition is high in copper (suggesting a very inefficient process and a source of copper in runoff) it is not dangerous from a health perspective. Arsenic was not measured but it is low in parent ore and thus not likely to be high in the tailings. If lead is low, arsenic is probably low too.

Medical care providers for Nkana East emphasized senta and the universality of symptoms – everybody got cough and acute bronchitis, whether they were previously sick or not. Medical staff denied that they saw disorders related to mine dust – this was confirmed on repeated questioning.

6. MONITORING REQUIREMENTS AND DATA GAPS

As noted in previous sections, some existing data gaps will need to be filled in order to rule out sources of hazards and to better assess the extent of the actual impact on people, animals and plants from hazards that are known to exist. Some of these gaps stem from a lack of systematic reporting of appropriate data and inconsistencies in reporting formats by investors. The work that has been completed to date has also historically been oriented towards regulatory reporting requirements of the mine companies, rather than towards assessing how people, animals and plants interact or use sites and groundwater resources in order to determine likely levels of risk (thus the paucity of information on soil contamination, food contamination, aquatic life and animal contamination). A small number of sporadic independent studies have been carried out (probably less than 20), largely by academics, which have delved more thoroughly into the routes by which contaminants may be affecting people, plants or animals. However, these are too few to provide an adequate basis for assessment (for example only one study with a small sample has been done on the impact of contaminated water on fish life).

6.1 DATA GAPS TO BE FILLED THROUGH EMPS AND CEMP

ZCCM-IH could conduct more accurate analysis and negotiation of EMPs if some of these key data gaps were addressed. Some shorter-term data gaps that should be filled in the EMPs/CEMP include:

1) Further modeling and data on current emissions is required, at the community level, of heavy metals dust (specifically lead and arsenic) from smelters (see point on setting up longer term monitoring on air quality below).

2) Although it is not likely to be a major source of health impact, it will be important during the EMP/CEMP to model the impact on people of having lead/copper/other heavy metals in food and soil in populated sites downwind of smelters (modeling the cumulative intake of these metals from different sources at representative sites). This would require analysis of the nature of contamination of the crops/soil, whether people consume crops grown in these areas, how often they consume them and the degree to which they are likely to absorb them (how bioavailable they are).[31] Such modelling would also guide decisions on how frequently and how much to spend on monitoring these other heavy metals.

[31] Simple, cost-effective mechanisms for improving the validity of input data for risk assessment modelling have been developed in recent years, notably the Physiologically Based Extraction Tests of Ruby *et al* (1996) and Williams *et al* (1997). Both involve the leaching of samples of contaminated soil or mine waste in a simulated human stomach and small intestine environment (with respect to chemistry, temperature and pH) to assess probable bioassimilation of contaminants following ingestion. The cost of establishing such procedures is negligible (ca. $US500 excluding standard analytical equipment for leachates) and could readily be accommodated as a component of risk assessment under the CEP.

3) The EMPs/CEMP should systemically evaluate which mine sites are contributing the greatest load of suspended solids to river systems and which river systems are most vulnerable to its effects either because of strong dependence of downstream users or because of fragile ecology. This will require assessing the number of downstream users and how they use the river system and how dependent they are on its use.

4) The EMPs/CEMP may have to undertake more extensive testing in those mines which have not had the benefit of a recent EMP. This would include Luanshya or other mines that simply adopted the 1996 ZCCM EMP; one potentially significant factor is that tailings and other sites may have deteriorated substantially since 1996 due in part to lower security around the sites with the dismantling of ZCCM. Particular emphasis should be placed on systems which may be close to failure; for example, if a tailings dam were to fail, how much siltation could a downstream dambo handle before other watercourses silt up. This could build upon or be integrated into research currently being carried out by Oxford University on dambos.

5) As noted previously, the EMPs/CEMP should include careful review of squatter settlement areas and the risks and hazards associated with these areas based on site visits and specific technical field studies. This should include the gathering of baseline information on those settlements that may be at risk of resettlement (names of residents, date of arrival). The risk of subsidence, caving or other localised hazards to these settlements would need to be assessed. In addition, if possible, the degree of risk should be characterised (low, medium, high)

6) In many of the ZCCM EMPs the potential for lead and arsenic contamination in the Copperbelt has been ruled out as irrelevant because of low levels in the parent ore. Given the serious health impacts from these two toxins, the presence of such toxic substances in tailings and other waste dumps could be relatively easily ruled out (see also notes on baseline below). A simple confirmation of this assumption is needed and could be achieved at low cost by analysing the content of tailings recovered from representative dumps at each mine.

7) The EMPs/CEMP should include an assessment the potential health impact of contaminated water-filled tailings dams. The one study that has assessed risk from this source (KCM EMP) estimated that there could be a health impact, but that the level of that impact was low. This needs to be confirmed or refuted for other tailings dams that are in populated areas. In addition, more specific information on the type of impact needs to be gathered and shared with users of these water bodies to determine whether the risk is outweighed by the loss of potential nutrient source or income. This would require gathering data on the ways in which people use the more populated tailings dams (drinking, fishing, *etc.*), as well as on the degree to which they rely on income and nutrition from using the dam and its fish. The next step would be to determine the level of contamination of fish and model the health impact of consumption based on actual consumption patterns and on recommended consumption

patterns. Such case study analysis could be conducted at representative tailings, with a priority on those with higher population centres.

8) As noted above, one study has been conducted on contamination of Tilapia fish in the Kafue. This study introduced fish to the Kafue rather than evaluating the impact of fish that have been breeding in the river. This type of research needs to be repeated and linked to consumption patterns of those living on the borders of the Kafue to determine what health impact there may be over time, if any.

9) *Food Contamination Research:* The SA team found that cultivation next to streams draining from tailings was extremely common. Normally residents do not use the tailings water directly, but dig irrigation wells or canals adjacent to the stream. This may provide a sufficient filter for any metals, but the impact on food crops should be assessed during the EMP. Data gaps could be filled by a relatively simple set of laboratory studies examining contamination by certain pathogens under representative growing conditions using water from the same source used by the larger gardens. For example, it is recommended that a small sample (n = 5 should suffice) of plants of cane, giant rape, pumpkin, maize, beans and groundnuts from a single garden irrigated with water from streams known to be draining tailings dumps and with a documented high concentration of trace metals, preferably at the highest levels identified in the region. The plant products should be analysed for trace metals and compared to similar samples from a reference garden. If trace element analysis indicates potential health-related risk, testing may be necessary on crops from specific locations. If trace element content of edible portions is not elevated or if elevations are within acceptable limits (esp. for lead, arsenic, cadmium), no further testing is required. The reason for making this a laboratory study is that it is preferable that this determination be performed under controlled, realistic but "worst-case" conditions. A similar study should be conducted on tailings but with a focus on finding when cultivation on tailings is safe (and therefore including a sample from a range of tailings sites). This is important because of the need for land and the fact that residents already grow and consume crops from some of these sites.

10) There are also significant gaps in our understanding of the risk presented by foods irrigated with untreated or partially treated sewage, a ubiquitous practice in the Copperbelt. A test similar to that suggested for tailings could be carried out. However, it is not clear whether such an exercise would fall within the scope of the CEP EMP or under the scope of another project with a broader environmental mandate such as the ESP.

11) *Soil Contamination Research*: Soil studies should be performed for heavy metals downwind and upwind of smelter points, in community areas especially those that are accessible to children. In particular, copper, cobalt, manganese, lead, cadmium, zinc, vanadium and nickel would be the suggested metal analytes. Arsenic and selenium should also be included as important metalloid elements. Given this wide spectrum, a comprehensive trace element analysis is entirely feasible and may actually be cheaper than individual analytes. Lead is the metal most toxic to children, however

so much copper is expelled in dust via smelter stack emissions documentation is needed to estimate exposure to this metal via the soil route.

12) As noted above, there is a need to better understand how people are currently using the various sites and on the potential economic and social costs or benefits of such use.

6.2 ESTABLISH ONGOING, ROBUST MONITORING SYSTEMS

One objective of the EMPs should be to carefully assess current reporting and monitoring requirements to ensure that relevant data are being collected using appropriate methods. Some suggestions that the EMPs might consider in their recommendations for monitoring systems include the following.

Discussions need to take place among key stakeholders in the mining sector (ECZ, ZCCM-IH, mine companies, Ministry of Health in some cases, Mine Safety Department and University experts and some representatives of civil society) on several levels:

1) The first task is to select a monitoring system to produce accurate information in a manner that is useful for assessing health and/or ecological impact (past monitoring has tended to focus only on what is being emitted and not on what actually reaches people, animals or plants or what percentage they can absorb).

2) Second, consensus would need to be sought on the model of regulation and therefore who holds responsibility for monitoring. Methods to improve feedback from those affected by pollution should be explored in the monitoring system adopted.

3) Third, resources to implement the monitoring system would need to be identified.

Responsibilities for monitoring depend to a large extent on the model of regulation that is ultimately adopted by ECZ. Under an "auditing" model, ECZ might agree with the regulated parties the type, frequency and location of indicators to be monitored but then require the regulated parties (the mine companies or ZCCM-IH depending on the site) to actually collect and report the data. The role of ECZ would be to conduct random samples of these data to audit whether data collected and reported are accurate. Such a model is useful when resources are limited. Another more resource-intensive model involves the regulator actually collecting much of the data needed for monitoring and regulation in addition to auditing environmental standards. To prevent bias or the perception of bias, monitoring procedures should be documented, quality assurance systems implemented and periodic independent verification carried out. In addition, residents in affected areas should be briefed on the monitoring system adopted and the process for residents to report what may be violations of regulations should be clear and accessible to all.

The following sections identify environmental aspects requiring monitoring.

6.2.1 AIR

1) *Collect ground-level ambient air data in communities exposed to heavy metals, particulate matter and dust from pyrometallurgical operations to verify or refute concerns about health effects.* Stack sampling is inadequate for monitoring the potential impact of these contaminants on the population. A systematic assessment of air quality for a full year to cover a cycle of seasons is suggested upwind and downwind of smelter sources at ground level for points at least up to 10 km is recommended to most useful for human health concern. Air quality monitoring stations should be placed in the community in a network providing at least minimal coverage of populated areas. The Norwegian Institute for Air Research has designed a monitoring program and strategy for the Zambian Copperbelt, contingent on the resources to build and maintain it.[32] To date, atmospheric monitoring has focused on SO_2. Testing should expand to include exposure to lead, arsenic and selenium in addition to the other metals typically tested in the region (such as antimony, bismuth, tellurium and cadmium) at intervals to monitor the cumulative load of these elements. The analysis must be sensitive enough to detect small amounts of metals ($\mu g/m^3$) range. Four primary analytes are suggested: total suspended particulate, respirable particulate (PM10), silica and asbestos. If financial resources permit, a much larger area downwind of smelters (50 – 100K) along plume paths could be included. Available data suggest that while this would provide a more complete picture of historical contamination patterns, these data are unlikely to change short-term management plans for rehabilitation or remediation. While regulatory emission controls are considered adequate, it is notable that Zambia's permissible limits for SO_2 and Se remain approximately 25% higher than those adopted in other copper producing nations such as Peru and Chile.

2) *Collect dust dispersion data.* The need for a geochemically (and toxicologically) based system for prioritisation or ranking of dust hazard sources is apparent. Many tailings wastes in the Copperbelt are toxicologically benign. The isolated compilation of dust flux or aeolian (wind) erosion data (itself an important and currently unfulfilled commitment of the ZCCM EMPs) is insufficient as a basis for risk assessment.

3) *Collect data on greenhouse gases.* Because of the UN Framework Convention on Climate Change, monitoring of greenhouse gases now needs be considered. Zambia is under obligation to give reports (inventories) of its CO_2 discharges annually. Accordingly, the appropriate data should be collected to prove compliance with the statutory thresholds (Statutory Instrument Nos. 119 and 141, 1994 and 1996).

[32] Size selective sampling should be employed to best characterise the respirable fraction of particulate and thus support a relationship or a lack of one to respiratory effects in the community. Filter media for gravimetric dust sampling should be employed and specific testing, either colorimetric or using infrared techniques should be used for silica testing. Mixed cellulose ester filters can be used for metals analysis of collected dust samples. Graphite furnace atomic absorption spectroscopy or inductively coupled plasma spectroscopy is the analytical technique recommended to provide the low sensitivity required for ambient metals human health risk assessment.

6.2.2 WATER

1) *Water quality.* Water analysis has been routinely performed by ZCCM at many monitoring sites, however the sensitivity of the technique used was approximately 0.1 ppm for most cation and analytes. In addition, the data the SA mission reviewed was largely isolated to a relative few analytes in water (suspended solids, sulphur, manganese, zinc, copper, pH, TDS, Sulphate, iron and cobalt). However, environmental management programs and impact statements expressed a commitment to conduct quarterly water analysis for a complete set of metals, that would include nickel, arsenic cadmium, lead and other compounds such as PCB and pesticides. The SA review determined that the quarterly suite of WHO analytes in water analysis has not always been performed. ZCCM-IH notes that lead is collected only at Nkana and Ndola Bridge. Some of the human health endpoints for metals, though they may not be likely to be present in water in the Copperbelt, would require parts per billion detection ranges to verify that no chronic health risk is present. Addition of these data would be required to provide a comprehensive picture of water pollution throughout the Copperbelt. However, at present the technical capacity to conduct such comprehensive analyses is limited in Zambia, the monitoring strategy would require considerable investment and other priorities are likely to be more pressing. An alternative would be to assess the likelihood of risk in the Copperbelt from these other elements of water contamination during the EMP process and determine whether the cost of such a large investment is warranted by the potential risk.

Existing EMPs adequately prescribe procedures for the analysis of water quality data and the reporting of permissible discharge exceedances. However, environmental audits performed on the Nchanga, Nkana, Mufulira and Konkola mines in 1997-98 indicate that these commitments were not, at that time, met. Non-compliance with statutory effluent limits was documented as a frequent occurrence, notably at Nkana (excess cobalt and copper in Uchi stream discharges), Nchanga (high TSS in Mushishimi discharges) and Konkola (high TSS in Kakosa discharges).

Procedures for corrective action following non-compliant discharge events are not outlined in existing EMPs. Comprehensive guidelines, defining not only the discharge criteria to be met, but responsive actions and timescales should be included in the CEMP. Of particular importance will be clear plans to publicise ways in which communities can contact mine companies if they notice an exceedance and clear protocol for mine companies to contact downwind and downstream communities in the likelihood of an exceedance that may have some health or ecological impact that could be avoided if warnings were provided.

A water quality issue of potentially greater impact to health than contamination of water from mining is contamination of watercourses from raw sewage from water and sewer utilities (although outside of the scope of ZCCM/CEP). In the past, testing the impact of raw sewage seepage into the Kafue River has been very ad hoc. Of the three Commercial Utilities in the Copperbelt, only Mulonga Water and Sewer has recently started to test for organics by using KCMs laboratory. The AHC-MMS has recruited a water quality expert and is establishing its own laboratory and comprehensive testing program that will cover a range of organic and chemical substances at various intake and outtake points along the Kafue in the Copperbelt. Unfortunately, this programs would not address Ndola – which lies outside of AHC-MMS' authority but which has some of the most serious issues in terms of poor quality of intake and poor water treatment – nor Kabwe, which lies outside of the Copperbelt.

Discussion should take place between ECZ and water service providers to assess how the two monitoring systems (mine/ZCCM chemical and water utility organic, coliform and fecal coliform) could regularly be combined for joint analysis. If a Kafue River Basin working group were to be formed under the Water Resources Action Plan, they provide an appropriate forum for commissioning analysis, presentation and discussion of results.

Significant amounts of water quality data had been accumulated by ZCCM and subsequent mine owners. The SA review indicated the data is accessible in a computerised database. This database should be made available to independent researchers (*e.g.*, Copperbelt University, ECZ) at sites where water is extracted from the Kafue.

2) *Collect flow data.* While the surface water flow monitoring networks appear to be adequate, quality control of the data collected has not been comprehensive. A 1998 audit of Konkola mine site highlights the use of imprecise flow monitoring techniques. Accurate monitoring of discharge[33] (particularly to external discharge points affecting the Kafue River) is imperative. Full recommendations for flow monitoring techniques should be incorporated in the CEMP.

3) *Analyse dissolved oxygen.* Dissolved oxygen is a key parameter for the health of aquatic ecosystems. Dissolved oxygen measurements should be periodically taken, particularly at those locations where sewage has affected the watercourse. Responsibility for improvements in dissolved oxygen levels will likely fall under the responsibility of water and sewage treatment providers. However, given the low incremental cost to the mines in performing dissolved oxygen measurements in addition to sampling for other parameters, it is recommended that the mines perform this function.

4) *Collect data on benthic invertebrates.* Monitoring this aquatic resource will help to determine impact. Species to be monitored should be chosen after consultation with biologists familiar with the Kafue River ecosystem.

5) *Monitor groundwater.* Long-term strategies for groundwater management is lacking. This data, in conjunction with modeling hydrochemical evolution of pit waters will enable hydrogeological hazards to be forecasted. Appropriate mineralogical, geological and hydrogeological data should be collected. Again, it will be important to determine how groundwater is currently being used by the

[33] Preferably through the use of flow measurement structures (such as weirs or flumes) or through calibrated natural sections – the latter will require training or personnel in flow measurement techniques.

population to assess how much to invest in this monitoring technique. For example, important factors to assess would be the degree of reliance on wells and other groundwater sources and whether these are used for drinking or other purposes (in urban areas of the Copperbelt wells are prevalent in informal settlements but not in formal settlements).

6) *Monitor storm water.* Existing EMP and audit documents suggest that stormwater handling is managed only with respect to its impact on mine operations, but that stormwater at both Mufulira and Konkola mines was found to be more contaminated that water coming directly from tailings. The separation of clean from contaminated stormwater is a fundamental concept in mine hydrological management. This reduces the volume of contaminated runoff, thus reducing storage and treatment costs. The development of a stormwater management plan for each site is therefore considered critical for both environmental control and the economics of mine operations.

6.3 BASELINE TO BE ESTABLISHED THROUGH EMPS/CEMP

The EMPs, CEMP and in many respects, the EMF, require a multi-disciplinary environmental baseline incorporating a much broader spectrum of environmental parameters than previously addressed in EIS statements for the Copperbelt's mining license areas. Spatial coverage must also be augmented, to permit monitoring and assessment of the temporal impact of project actions and interventions beyond the license areas.

It is feasible to produce a dedicated baseline database for the Copperbelt as an integral component of the CEMP work program. This will facilitate the quantification of environmental changes (positive or negative) over time and will underpin the evaluation of CEP performance within the context of the project's specified output indicators (Section 3.5 of Part II). In the interests of time and cost economy, the augmented baseline should rely primarily on the collation of existing data, rather than the instigation of new surveys. However, assessment of human interaction with mine sites and of levels of soil and food contamination have been particularly weak in existing data and would need to be supplemented with additional research.

The ability to manage and interrogate baseline data would be enhanced greatly by setting up within a relational database and GIS for all baseline data. Appropriate platforms for this purpose include MapInfo and Arcview.

1) *Regional Geochemistry.* Regional geochemical data (derived from soils and fluvial sediments) were, prior to the 1970s, generated almost exclusively for mineral reconnaissance. However, such information is now recognised as a critical resource for environmental auditing, monitoring of temporal environmental change, land use planning and risk assessment at scales ranging from site-specific to global. Regional geochemical data for the Copperbelt were compiled by the Geological Survey Department of Zambia in the 1970's and provide a potentially valuable index of the ambient

abundance of a range of toxic elements (copper, cobalt, *etc.*) in the surface environment at that time. Limited re-sampling for comparative purposes would provide a rapid and cost effective mechanism for evaluating environmental changes during recent decades. Following suitable QA/QC analysis, geochemical data for the Copperbelt could be incorporated into the CEMP database as a baseline against which to quantify project impacts and future environmental change.

2) *Contaminant Inventory.* The compilation of an inventory of potential contaminant sources in the Copperbelt will be a fundamental requirement for baseline database development under the CEMP. For example, further appraisal of tailings geochemistry and mineralogy is required for all sites. Such an inventory will provide the basis for the design of systematic monitoring programs for execution by regulatory agencies and for the appraisal of temporal changes in contaminant discharges. Contaminant source inventories additionally include information regarding the composition of contaminant fluxes from specific sites, thus providing a partial basis for the prediction of human and ecotoxicological risk. A complete assessment of potential risk must take into account the way in which people use the sites and the water sources coming from the sites.

3) *Land Use / Land Use Potential.* Current land-use and land use potential maps may prove a valuable form of baseline data for use under the CEP. Land usage in the vicinity of defunct mining and mineral processing facilities is a determinant of sensitivity to contamination. Hence, such information assists in the prioritisation of rehabilitation options. Land use potential mapping could additionally be applied in cost-benefit analysis rehabilitation plans for contaminated land.

4) *Ecosystem monitoring.* There is little reliable information available about the ecosystems exposed to mining-related impacts. The types, distribution and status of wildlife habitats and species in mined areas should be monitored. Suitable indicators of impact are required so that ecological 'health' can be used to provide early warning systems for environmental damage. Monitoring data should be used to derive thresholds of damage above which remedial action is taken to restore ecosystem function. In particular this should include ecosystems valued by people and those with inherently high wildlife value.

6.4 OTHER STUDIES

In order to assess the potential risk of ingestion of pathogens and metal contaminants from sites irrigated by diverted sewage and surface runoff from tailings, we recommend a simple scientific investigation as outlined. This study should have a high priority as its findings may directly influence policy and the priorities set by the CEP.

Epidemiological studies may be undertaken for specific purposes but their purpose should be clear. Some studies may be required to further characterise significant problems and provide information required to guide effective management of the problems. Others may provide important background information but may not directly affect management. The former, such as the study outlined above, may merit funding as part of the operational response and may be considered data-gathering to support the EMP. The latter may be considered research, valuable in itself but to be pursued outside the Environmental Management Plans.

The greatest priority for epidemiological investigation observed by the consultants is a systematic survey of blood lead and exposure assessment in communities in and around Kabwe. The issues associated with the design and implementation of such as study have been explored in communications to ZCCM-IH.

Conventional epidemiological studies of health risk in the Copperbelt would be subject to numerous complications and limitations due to the high morbidity existing in the population and the large number of confounding health hazards acting against a backdrop of poverty and socioeconomic limitations on access to diagnostic services. Epidemiological studies conducted in the Copperbelt must be carefully designed to take these factors into account. The following are practical epidemiological investigations that have a high probability of yielding useful information that could be applied in public health interventions:

- Evaluation studies assessing the response to specific public health interventions: mosquito control, drinking water supply protection, wastewater treatment.
- Etiologic investigation of food consumption, using case-control methodology (cohort studies would be impractical).
- Cross-sectional surveys of schoolchildren or adults, *e.g.*, for blood lead levels.

Cooperative academic and scientific arrangements to build infrastructure to conduct environmental monitoring, epidemiological studies and risk assessment should continue to be fostered through the World Bank, ZCCM-IH, ECZ, WHO with the international and national private sector and public sector to help Zambian citizen's improve their environment and total quality of life. Capacity building in the education, research and environmental monitoring in both the publicly-supported and private sectors of Zambia is a major priority for the country. The development of operational systems to remediate problems under the CEP and monitor their effectiveness creates opportunities for training environmental scientists, managers and technicians.

Regardless of their application, such studies may provide valuable opportunities to train Zambian scientists and students in the scientific method and study design. Whenever possible, students and university faculty should be allowed and encouraged to participate.

7. OPTIONS FOR ENVIRONMENTAL REHABILITATION

7.1 CONTEXT

In planning to rehabilitate lands impacted by past mining activities, environmental protection needs to be recognised as an ongoing process. To be effective, environmental protection should be incorporated into the mining plans (and in some cases community plans), especially those for disposal of waste materials. Restoration of disturbed sites to pre-development conditions is not practical; however, rehabilitation of sites is possible. This approach focuses on improving the likelihood of natural functions and processes occurring within the context of the disturbance, like vegetation re-establishing. For example, a focused approach can be adopted to rectify high concentrations of sediment and contaminants being released from priority sites, as discussed in Section 5.2 of Part II.

7.2 GENERAL OPTIONS FOR ENVIRONMENTAL REHABILITATION

This section discusses rehabilitation measures which may be applied in counter-acting high releases of sediments and protecting against structural failures at sites remaining under the care of ZCCM-IH. Additional sites at privatised operations may also warrant attention in accordance with EPPCA regulations, depending on action plans proposed under the respective EMPs for individual mine sites. It is important that closure plans for private operations be adequate for a walk-away position. A walk away position means that minimal or preferably no long term maintenance work is required after the sites revert to the care of GRZ, in accordance with the terms of the MDAs (Mine Development Agreements) and EMPs.

The following measures for environmental protection within and around the perimeter of Copperbelt mines sites should be given consideration and detailed implementation plans prepared as appropriate in the EMPs. The measures are presented in the general order of priority for their potential application.

7.2.1 VEGETATION

Exposed tailings and overburden dumps and general mine site areas should be reclaimed as much as possible with a vegetative cover to achieve long-term mass stability, long-term erosion stability, reduction of environmental contamination and to return of the sites to productive use if appropriate. Dense grass and tree cover is very effective in limiting erosion and siltation on exposed soil surfaces. For future dumps, proper reclamation should be integrated into the planning and design from the start. With good planning, ultimate disposal costs can be minimised by optimising disposal layouts, embankment sideslopes, hydrologic design measures and other factors with both short-term operational criteria and long-term reclamation objectives in mind.

In the past, successful re-vegetation programs have been undertaken in the Copperbelt. Photos 11 and 12 are examples of successfully re-vegetated dumps at Chambishi and Mufulira. However, from the 1970s to present, formal re-vegetation programs appear to have been very limited in scope.

Vegetation has grown naturally on many of the older tailings dumps, but large tracts of dump surfaces have also remained barren and hence are prone to erosion for decades. Formal procedures for mass planting of tree and grass vegetation should be developed as the primary means of reclaiming and stabilising the tailings and overburden dumps, which are the principal sources of sediment at the Copperbelt mines.

To attain a self-sustaining plant community, a transition between short-term and long-term vegetation is preferred. This objective may be achieved simply by allowing natural invasion of native species after short-term vegetation has been established.

In general, flatter portions of overburden dumps and plant site areas could be considered for cultivation, provided that soil chemistry conditions are demonstrated to meet standards for agricultural production. Tailings dumps would need to meet certain criteria for cultivation (to be established through assessing the health impact of such cultivation in relation to the EMP/CEMP).

Revegetation will be most effective if developed in consultation with residents adjacent to the sites. One of the primary challenges is to grow vegetation or trees that will not be cut down for charcoal or harvested for consumption and ZCCM has experimented with different types of trees that may be less attractive for charcoal use. In many cases, residents are already cultivating on sites. At times the style of cultivation may not be consistent with the reduction of erosion or minimising exposed tailings (as is the case at TD25 in Nkana/Kitwe). Measures for involving the community should be incorporated into rehabilitation (see Part III, Recommendations).

7.2.2 PERIMETER COLLECTION SYSTEM

Many of the tailings dumps have been constructed at slopes which are too steep to support a ground cover and hence are susceptible to ongoing erosion and slumping. In situations where it is not practical to reconfigure the slopes to enable vegetative growth, but excessive sediment load is being transported off site, a perimeter collection system of drainage ditches should be considered. A collection system would typically comprise a combination of drainage collector ditches, discharging into sediment basins or sediment traps. The collection system designed may include engineered structures as described below.

7.2.3 ENGINEERED STRUCTURES

Water Conveyance Structures

Water conveyance structures consist of swales, dykes and ditches which serve to collect rainy season runoff and control its energy in flowing downslope to protect the surrounding ground from excessive erosion or collapse.

In general, it will be prohibitively expensive to effectively retrofit water conveyance structures onto the existing structures aside from ensuring that flood flows are conveyed in a manner that does not jeopardise structural stability. However, in designing new waste dumps or tailings facilities, more attention should be given to installation of temporary and permanent drainage measures as a means of preventing erosion, both during construction and in the long term following closure.

Water conveyance structures include decants, some of which have been stolen and vandalised, which is one factor leading to instability at several tailings dumps, such as TD 33C. Closure plans should be based on a walk-away position, where long term maintenance of water conveyance structures is minimal.

Water conveyance structures should have adequate outlets – either man-made or via a natural waterway. Riprap aprons and energy dissipaters are used to reduce the velocity of channel flow in the transition from a channel to a natural waterway. Types of conveyance structures and channel and outlet protection include the following:

- Pipe slope drains and chutes.
- Lined drainage channels, including diversions. Liners can consist of gravel, grass or synthetic material.
- Check dams to reduce flow velocity and control erosion.

Sediment Retention Structures

Sediment retention structures are utilised to trap eroded soil particles being carried by runoff. They function by slowing the velocity of runoff and letting suspended soil particles settle by gravity, thus limiting the amount of siltation to streams.

Sediment retention structures require periodic maintenance and cleaning. If excessive sediment is allowed to accumulate in them, they will cease to function and need to be cleaned or replaced. As a result, such structures should not be regarded as a permanent solution to erosion control or a substitution for a proper dump design and effective vegetation program, in the case of new mine developments. Different types of sediment retention structures are described below.

Sediment Basins or Traps

Drainage-ways collecting runoff from tailings and overburden dumps can be directed into sediment basins or traps to collect siltation and prevent it from entering the stream system. They may be formed in natural depressions, supplemented by excavation and perimeter embankments. Depending on flow rates, a spillway (typically lined with rock riprap) is usually required, along with outlet protection to minimise erosion.

Sediment Barriers

Simple engineered sediment barriers may also be used to control siltation. They are used to treat runoff from smaller areas (<5 ha). Sediment traps can be constructed from:

- straw bales;
- filter fabric; and,
- gravel and earth berms.

Sediment barriers are most effective when located along the contour of exposed slopes and at the bottom of the slopes; also across smaller drainage ways and swales.

Human activities have been the cause of erosion at a number of locations within the Copperbelt, as well as the cause of secondary environmental hazards (*i.e.,* from illegal waste dumping which provides vectors for malaria, rats). In the past, ZCCM had a police force which could monitor access to these sites much as private mine owners can patrol their mine area. After the dismantling of ZCCM post-privatisation, however, there are insufficient security personnel to restrict access and a wide range of activities take place (deforestation is extremely common, scavenging, cultivation, vandalism). In many cases, there may be other solutions to restricting access and any rehabilitation plan will need to explore these options with the community using or adjacent to a given site. Communities will need to be involved in the development of a site management plan and to be educated about the potential hazards to themselves from the site or from their actions to the site's stability. The reality is that economic necessity is driving many people to scavenge at sites and care should be taken to avoid depriving people of income. Some options include hiring these people to carry out some of the rehabilitation works and educating them on how to continue their activity in a manner that does not affect site stability. Part III provides some specific recommendations on how to better involve communities in the site management plan.

Stakeholders involved in land allocation will also need to be involved in the site management plan. Specifically, there have been instances when politicians have sold land that is not available for sale or has already been sold to others (as in Kalulushi). They would need to be briefed on which land is and is not available for sale or allocation and which land is or is not safe for use or habitation.

7.2.4 Treatment in Wetlands

Many examples of metals removal occurring in natural and constructed aerobic wetlands have been documented in Canada, Australia, the UK and the USA (CANMET, 2001). Chemical and physical processes occurring in aerobic wetlands include oxidation, hydrolysis, chelation, adsorption complexation, sedimentation and filtration.

Aerobic wetlands are frequently constructed to act as sedimentation basins aided by various plant-mediated filtering mechanisms. Concentrations of metals such as copper and iron can be significantly decreased through biotic processes as drainage flows through an aerobic wetland. Further, oxyhydroxide precipitates of ferric iron are capable of scavenging other metal ions and removing them from solution by adsorption and coprecipitation with ferric hydroxide.

Aerobic wetlands facilitate a wide variety of biologically-mediated chemical reactions and treatment processes which favour removal of metal contaminants from aquatic environments. Processes include biological oxidation and plant uptake.

Aerobic wetlands can be constructed to replicate conditions in natural wetlands. Metals are removed by precipitation and exchange reactions, while plant uptake and other processes can remove dissolved metals. Plants, especially the plant rhizosphere, provide large surface areas for oxygen exchange and also act as hydraulic baffles, thereby increasing the mass transfer of oxygen. Plant growth and decay provide a constant supply of degradable organic matter. The organic matter provides sorption sites and stimulates bacterial activity.

The efficiency of natural wetlands in removing metals has been demonstrated in a pilot project at Chambishi undertaken by Constantin von der Heyden of Oxford University. His work shows that a natural dambo is very efficient at the removal of copper and cobalt from effluent of the Chambishi slag and concentrate processing plant. There is great potential in using either natural or constructed wetlands at others locations – details of this research are presented in Annex I.

Wetlands can be constructed along or adjacent to smaller tributary streams by placing low earthen berms to form a pond in a configuration which enhances the growth of reed vegetation. The constructed wetland functions to filter sediment and removes trace elements from the runoff. Furthermore, the wetland would be expected to assist in the treatment of sewage-contaminated water. The constructed wetlands should be designed to minimise ecological impacts and especially to any downstream water users.

7.3 MINE FACILITIES AND ENVIRONMENTAL REHABILITATION – COPPERBELT

Table 7.1 summarises general environmental rehabilitation measures which may be considered for defunct mine facilities in the Copperbelt and Kabwe. Site specific conditions may warrant further rehabilitation efforts.

Rehabilitation measures proposed in Table 7.1 for the respective mine facilities are summarised as follows:

Underground workings:

- remove any hazardous materials, seal access and delineate unsafe areas.

Open pits:

- restricted access to zone of potential instability around pit rim; evaluate long term range of water levels and potential for recreational use; and,
- reprofiling is not practical.

Waste rock dumps:

- rehabilitation is not warranted, aside from assessing long term geochemical effects.

Overburden dumps

- revegetate and control sediment runoff channels; and,
- reprofiling is not justified.

Slag stockpiles:

- reprocess where justified economically by metals contents; and,
- revegetate lower slopes and control sediment runoff.

Ore stockpiles:

- to be processed by private mines.

Plant facilities:

- decommission and revegetate; and,
- clean area of contaminated soil that may be entering storm water system during rains.

Tailings facilities:

- prepare closure plans; erosion control measures; upgrade spillway capacity to accommodate a major flood (for cross valley dumps); and,
- vegetate.

Mine and process waste water:

- no long term effects anticipated after mine closure.

Hazardous wastes:

- dispose in secure sites; limit occupational exposure.

In selecting, designing and applying specific rehabilitation measures, it should be recognised that EMF funds needed for construction of engineered works must be borrowed and repaid with interest. Hence, it will be difficult to justify attending to more than the highest priority sites where discharges are demonstrably affecting the quality of life, especially the health of resident population in proximity to the sites. In this regard, major intrusive earth-moving works for stabilising slopes of open pits, overburden and tailings dumps will generally offer limited benefits in terms of environmental protection in relation to the costs incurred.

Where engineered works are adopted, they should be applied in a fashion which ensures that the objectives in managing discharges are achieved at a reasonable cost, without the need for significant ongoing maintenance, *i.e.* the installed works should enable a walk-away situation or at most, passive care where the site needs only infrequent monitoring and/or basic routine maintenance of structures. This will be important given the fact that many of these structures will likely revert to local authorities, who, as demonstrated in Part I of this report, are already overwhelmed with the increased number of responsibilities they have post-privatisation. The engineered works referred to in this section are all in common use at mines throughout the world and hence, the risk of failure, aside from inadequate engineering and applications therefore is minimal. Further, large-scale removal or transport of contaminated materials which could pose risks to the public or ecology is not envisaged.

In general, the main risk associated with rehabilitation works is incurring excessive costs. There is also a risk of unfulfilled expectations of the public and intervenors regarding the benefits of remedial works, temporary disruption of any nearby residents associated with installations such as drainage ways and sediment ponds and the need to relocate any population residing on unsafe lands.

Professional judgement should be exercised to identify and prioritise the most effective and acceptable rehabilitation options and more than one technical option should be presented for each site.

The engineered works proposed are relatively straightforward to construct, involving a combination of labour and light machinery - mainly bulldozers, backhoes and haulage trucks. Community labour can be engaged for much of this activity, especially for vegetation programs. Such labour should be compensated, given the challenges of supervising unpaid labour in the similar projects in the region. Aside from lead dusting considerations at Kabwe, occupational health exposure rehabilitation activities are minor. Safety devices such as coveralls, hard hats, protective eye glasses and steel toed boots will generally suffice.

Table 7.1: Mine Facilities and Environmental Rehabilitation

MINE FACILITY	POTENTIAL IMPACT ON HEALTH AND ECOLOGY	POTENTIAL ENVIRONMENTAL CHANGES TO SITE OVER TIME	OPTIONS FOR REHABILITATION / LAND USES	COMMUNITY MANAGEMENT ISSUES
UNDERGROUND WORKINGS	Localised hazard to squatters on subsidence area (possibly AMCO in Kitwe) Health: low to none Ecology: low to none	Subsidence and collapse of workings Discharge of mine drainage water Loss or partial loss of land use	Removal of chemicals and other hazardous materials Seal off from surface entry workings Delineate areas unsafe for human habitation and usage Monitoring subsidence effects on ponding and stream flows; maintain stream flows and alignments, if necessary.	Signs to keep people from settling on unsafe areas Locate buildings out side of subsidence zone Manage agriculture activities Discussion with key stakeholders with regard to land allocation to ensure they do not allocate land that is not safe
OPEN PITS	Health: localised hazard for those illegally accessing area if pit is unstable Ecology: limited environment for flora and fauna. Visual Environment: pit may be unsightly, consumes land that could be used for other purposes	Stability of the pit walls Collapsing pits may affect adjacent roadways, though impact on population not likely to be high because of distance from population centres. Potential break back (cracking and settlement around rim of pit), raveling and instability of pit walls and hydrogeological problems associated with the development of pit lakes.	Evaluation of the zone of settlement or potential instability behind rim of pit (unstable areas closed to public) Not practical to reprofile unstable pit slopes Hydrologic forecast of long term water levels and water quality; prepare plan for utilisation of pit lake for recreation and possible aquaculture. Where feasible, develop a beach area for recreational access; prepare access trails and vegetate flatter areas.	Signs to keep people from settling on unsafe areas. Community involved in management of in pit lake as a reserve and recreational site. Discussion with key stakeholders with regard to land allocation to ensure they do not allocate land that is not safe
WASTE ROCK DUMPS	Health: low to none Visual Environment: cannot establish more than sparse vegetation and consumes land that could be used for other purposes.	Possible increased metals (copper) in runoff to streams though type of metals are relatively benign. Can reduce number of fish. Minor siltation to streams Because they tend to consist of harder, less erodible materials most waste rock dumps are comparatively stable, limited exposure to slope raveling and erosion.	May vegetate slopes where feasible; *i.e.*, where sufficient soil is present in rock interstices Assessment of long-term mineralogical and geochemical evolution of sulphide assemblages may be required	Signs to keep people from settling on unsafe areas. In some cases there may be physical risk if area is not stable. Limited for land use; unproductive for agriculture. Community education to ensure that new vegetation/trees are not cut down. Employment of community members to carry out plantings. Planting species not used for charcoal or firewood. Explore with community sustainable ways of using the site.
OVERBURDEN DUMPS	Health: low to none Ecology: minor siltation to streams Visual Environment: should support vegetation	Change in original land use (productivity) Disruption of surface drainage.	Implementation of siltation reduction measures Drainage improvements to minimise slope gulleying and down-catchment siltation Should naturally revegetate or can be planted or seeded with local species.	Community education to ensure that new vegetation/trees are not cut down. Employment of community members to carry out plantings. Planting species not used for charcoal or firewood. Explore with community whether there are sustainable ways of using the site.
SLAG STOCKPILES	Health: low to none – localised issue for those living near stockpile and illegally accessing site. Ecology: some increased metals runoff to streams Visual Environment: sparse to no vegetation. Air – minor dust to adjacent communities Water – siltation and heavy metals contamination during rainy season	Stockpiles are stable and resistant to erosion. Limited changes over time.	Reprocess and eliminate stockpile where economically justified. Perimeter collection ditches and sediment basins. Vegetate lower slopes.	Community education to ensure that new vegetation/trees are not cut down Employment of community members to carry out plantings Planting species not used for charcoal or firewood Explore with community whether there are sustainable ways of using the site

MINE FACILITY	POTENTIAL IMPACT ON HEALTH AND ECOLOGY	POTENTIAL ENVIRONMENTAL CHANGES TO SITE OVER TIME	OPTIONS FOR REHABILITATION / LAND USES	COMMUNITY MANAGEMENT ISSUES
ORE STOCKPILES	Increased heavy metals, acidity or pollution. In Copperbelt heavy metals not likely to be highly toxic. Health: Low to None – localised issue for those living near stockpile and illegally accessing site. Ecology: runoff water may affect water quality Visual Environment: consumes land that could be used for other purposes	Long term impact only if ore is not processed.	Temporary stockpiles awaiting processing.	Minor if ore is processed.
CONCENTRATOR	High suspended solids loads effects of high metal discharges on surface water quality	Temporary impact during mine operations.	Decommissioning of all infrastructure Closure plans to include restitution of drainage ways and revegetation.	Monitor water quality and limit any agriculture and water extraction adjacent to site as appropriate.
PYROMETALLURGICAL PLANT	Health: High – exposure to air-borne SO_2 and potentially to accumulated metals deposited on plants and soil in downwind areas. SO_2 produces impact while smelter is operational, but deposits of metals in soils can last after smelter is closed. Ecology: In immediate vicinity residents report that plants do not grow well	Increased quantities of production may lead to increases in SO_2 unless sufficient improvements are undertaken at smelters	Decommissioning of all infrastructure Closure plans to include restitution of drainage ways and revegetation. Represents a priority issue to be addressed under the EMP/CEMP with private mine companies	Through EMPs, mine companies should be encouraged to warn residents to take positive measures when there are times of very high SO_2 levels. Communities need an accessible avenue for complaint when emissions levels are high.
TAILINGS LEACH & ACID PLANT	Potential for release of acidic water. Sediment discharge to watershed; siltation and metals contamination during rainy season.	Temporary impacts during plant operations.	Decommissioning of all infrastructure Closure plans to include restitution of drainage ways and revegetation.	Through EMPs, mine companies should be encouraged to implement warning system for downstream users not to drink water when effluent levels surge above normal, to develop networks of downstream users who they could notify
TAILINGS FACILITIES: CROSS VALLEY DUMPS[34]	Health: generally low impact (to be confirmed through further testing in EMP/CEMP) Ecology: impact on aquatic life and water available downstream likely high but other compounding non-mining factors may be more significant (*e.g.* sewage). Possible minor impact on fertility of soil in adjacent area to tailings dam. Visual Environment: large tracts of land may remain unvegetated, dusty and unused.	Long-term stability of the embankments Discharge water quality and loading to receiving environment	Analysis of capacity of spillway to convey major flood events (*e.g.* 1 in 1000 years) Dam break analysis in event of failure Upgrade spillway as appropriate for closure; seal off decant Restrict habitation in floodway area below dam. Establish vegetative cover	Slope failures at several tailings dams linked directly to vandalism and community use of the site Community education to ensure that new vegetation/trees are not cut down and to gain agreement on site use plan that does not affect stability of site Employment of community members to carry out plantings Planting species not used for charcoal or firewood Explore with community whether there are sustainable ways of using the site Through EMPs, mine companies should be encouraged to implement warning system for downstream users not to drink water when effluent levels surge above normal.
TAILINGS FACILITIES: PADDOCK DUMPS[35]	Health: impact low Ecology: minor impact on aquatic life and water available downstream. Possible minor impact on fertility of soil in adjacent area to tailing dump. Visual Environment: large tracts of land may remain unvegetated, dusty and unused	Erosion and sedimentation on perimeter slopes Seepage control and off-site contamination of water courses by silt and chemicals Wind blown dust	Drainage collection ditches or swales on dump surface; discharge down slope in a rock -lined spillway and into sediment basin; seal decants Establish perimeter collection ditches and silt traps. Route drainage ways through natural or constructed wetlands where feasible. Establish vegetative cover (may require soil capping to assist with vegetative growth)	Amenable to establishment of vegetation including trees; community involved in tree planting and protection. May be suitable for limited agriculture crop production and grazing (to be tested in EMP/CEMP)

[34] Engineered dams utilised to retain tailings; are located in valleys containing natural water courses.

[35] Tend to be older, less engineered impoundments that consist of ring dykes formed by depositing the coarser sand fraction of the tailings, separated by the action of spigots and cyclones

MINE FACILITY	POTENTIAL IMPACT ON HEALTH AND ECOLOGY	POTENTIAL ENVIRONMENTAL CHANGES TO SITE OVER TIME	OPTIONS FOR REHABILITATION / LAND USES	COMMUNITY MANAGEMENT ISSUES
MINE AND PROCESS WASTE WATER	Increased turbidity (suspended solids) makes treatment of municipal water more difficult and expensive At areas where metals content is high (Chingola) reduces fish and plant life in riverine ecology and fisheries But may also have positive impact in terms of diluting other metals in streams and providing drinking water source for municipal water supplies. Effects on surface water and groundwater	In several towns water pumped from mine provides source of potable water. In Chililabombwe and Nchanga, provides significant amount of water to Kafue. Sediment load (may be high in suspended solids). Impact on water quality as a result of underground mining activities, sewage, fuel and diesel spills in the sumps.	Temporary impacts during mine operations. Hydrology and water quality in long term will tend to revert to pre-existing conditions	Better co-ordination between mine companies and utilities can lead to improved municipal water treatment, reduced costs. Currently occurring with AHC-MMS and KCM.
HAZARDOUS WASTES: PCBS	Health: Low impact as long as precautions to secure PCBs from theft are taken and to ensure they are not accidentally released during transport or disposal. Ecology: low and limited to immediate area if leaking into soil and groundwater	If security of site is not maintained, there is risk of theft or leakage	Dispose of PCB and radioactive wastes in secure sites and eventually eliminate in accordance with POP convention Limit occupational exposure to radionuclides	Appropriate safeguards to protect disposal sites from unauthorised entry and vandalism
HAZARDOUS WASTES: RADIONUCLIDES	Health: Low to general population, unknown risk to underground mine workers Ecology: Low	Excessive exposure of workers to radionuclides can lead to respiratory disease and lung cancer		

7.4 KABWE

The following review of ZCCM-IH Kabwe Rehabilitation and Decommissioning plan is structured in three main components:

1) the ZCCM-IH Plan and progress made to date are summarised;
2) potential approaches to address lead contamination are outlined; then,
3) the ZCCM-IH Plan is critically reviewed.

7.4.1 KABWE MINE SITE REHABILITATION AND DECOMMISSIONING PLAN

The Kabwe Mine is divided into five major components of mining activities for which ZCCM-IH proposes the following rehabilitation and protection plans:

7.4.1.1 Mine Workings

Open Pit

Rehabilitation and Decommissioning Planned Activities:

- Construct a perimeter fence to prohibit entry and protect the public.
- Assess open pit slope stability annually for next ten years.

Underground

Salvageable materials were removed from the underground workings, including PCB transformers, chemicals and other hazardous materials. Other salvageable material from underground, including winding rope, water pumps and scrap are yet to be disposed of.

The mine was flooded in October 1996. The water surface was observed to have stabilised within a few meters of the adjacent ground surface.

Mine Openings to the Surface

All seven openings to the surface have been sealed with reinforced concrete caps comprising the Davis Shaft, the Ore Shaft and five vent raises.

7.4.1.2 Plant Complex

The following companies and individuals purchased portions of the Mine Plant complex area from ZCCM-IH:

1	Kabwe Power and Metal Limited	8	A. Kangwa
2	Quasim Mining Enterprises	9	F. Luwisha Motor Garage
3	Kabwe Municipal Council	10	ADD
4	VC & M Trading Company	11	E. Silwamba
5	Nakasa Enterprises	12	M. Kambikambi
6	Chikaka Enterprises	13	Kalimba Enterprises
7	Aupie Limited	14	Sable Zinc Kabwe (SZK).

ZCCM had originally planned to convert the plant complex into an industrial/commercial development, while demolishing unsafe structures (five buildings) and rehabilitating contaminated soils. However, to date only 20% of buildings targeted for demolition have been decommissioned.

ZCCM-IH still plans to decommission or sell the following facilities:

- The Mine garage and administrative offices (still being used by the Kabwe Mine Closure Project).
- The buildings that house the winders for the Ore Shaft and the Davis Shaft.
- A storage room with mining equipment.
- Three dumps of oxide ore material are to be removed from the ZCCM-IH area for the use of new investors. One dump is on the eastern side of the water treatment plant. Two dumps of oxide ore from Mwomboshi near Lusaka and from an area east of NO2 ore body are in an area North of the ore stockpile.
- Other materials at the Imperial Smelting Furnace (ISF) area have remained there as raw materials for new investors.

Scrap railway wagons are yet to be disposed.

7.4.1.3 Waste Dumps

Most of the ZCCM-IH waste dumps and tailings (leach residue material) contain enough zinc to make reprocessing a viable alternative. Most of the dumps and tailings deposits were acquired in 1999 by Sable Zinc for reprocessing[36], except for one slag dump containing Waelz Kiln slag (No. 57, 57a, 57b) for which ZCCM-IH retains liability. ZCCM-IH plans the following rehabilitation and monitoring activities at the dump sites remaining with ZCCM-IH:

- Reprofile the Waelz Kiln dumps to improve slope stability and promote vegetative growth (20% of dumps have been reprofiled to date).
- Place granular slag cover material (on the leach residue dump) to prevent fugitive dust (completed).
- Plant trees around portions of the dump to control erosion and improve the appearance of the dumpsite. The trees will also serve as windbreak. The following tree species have been planted:

[36] Refer to African Mining Consultants, February 2000, Sable Zinc Environmental Scoping Study.

- Eucalyptus hybrid
- *Toona ciliata* (Cedrella)
- *Achrocarpus frazinifolia*
- *Acacia spp.*

- Monitor seepage from the waste dumps in boreholes (to be drilled).

Dump surfaces have been covered with coarse slag.

7.4.1.4 Mine Canal, Dredged Materials and Reed Dambo

ZCCM-IH plans to maintain the canal as an open channel. Materials from which metals can be leached are periodically being cleaned. Reed and vegetative growth, which abstracts rainy season floods, is to be removed annually from the canal to allow for uninterrupted drainage of effluent from the sewage treatment plant to the Reed dambo at the head of the Muswishi River.

ZCCM-IH plans to remove sources of lead along the canal next to Katondo and Chowa townships.

7.4.1.5 Groundwater Resources

The Makululu groundwater field, located three kilometres west of the plant site, supplies water to 12,000 residents of Kasanda, Chowa, Luangwa and the plant site as well as another 30,000 residents in Makululu shanty township. The Makululu water works is hydraulically connected to Kabwe mine water. Water quality in boreholes between the Makululu water works and the Mine is being monitored to detect if mine contaminated groundwater is affecting the Makululu water quality.

The results obtained to date have indicated the Mukululu water has not been affected by the mine water. This is in accordance with expectations as the mine is situated down gradient of the well field. However, pump tests should be conducted to determine draw down levels and the potential for reversing the gradient and effects thereof between the mine and well field. ZCCM-IH is also assessing the effect of metals leaching on underground water quality.

Monitoring of water quality will continue for the next five years to establish if the possibility of pollution of Makululu water from the flooded mine.

7.4.2 KABWE COMMUNITIES LEAD REHABILITATION PLAN

The distribution of lead in the Kabwe area and plans for rehabilitation and protection of the population are described in the mine decommissioning report by ZCCM (1995). Dr. Clyde Hertzman's study (1996) conducted for ZCCM focused on Chowa and on those with "known" high blood lead levels. His study identified a combination of initiatives to reduce exposure pathways to contaminated soil, including:

- Replacing the soil in play areas, domestic outdoor areas, work areas and vegetable gardens.
- Removing house dust through vacuum cleaning. (although this is a recommendation in the study, it is not practical within the Zambian setting).
- Reduce the use of outside bare ground for activities such as cooking.
- Improving hand washing and clothes washing to interrupt transmission of lead.
- Planting grass and other vegetation to eliminate bare soil areas (see Photo 14).
- Reduce road dust.
- Reducing dependence upon crops that readily absorb lead.
- Providing cleaner environments for pregnant women and young children.

The applicability of some of the above measures to the Kabwe context is questionable and additional discussions with community members is required to develop strategies appropriate to the specific cultural and physical context of Kabwe. For example, during the SA mission it was observed that in many of the areas where soil had been replaced, it had already eroded because of a lack of vegetation in yards (likely compounded by problems with municipal water supply which limit water availability for all uses including watering gardens). Further, a rehabilitation program cannot be effective without an intensive education and consultation of stakeholders. For example, it would be important where soil is replaced that NGOs who are currently installing latrines and digging drainage canals not disturb this soil (as the NGO PUSH is currently doing in Katondo). Finally, rape is the key vegetable staple in the Zambian diet and it unfortunately is also a concentrator of lead.

In March 2001, ZCCM-IH indicated that they embarked on a program to sample blood/lead levels in children of age 2-5 years in Kasanda and Chowa for the next five years; however, this program was not verified in the field. Lead levels in the soil are also being analysed across Kabwe.

It is important to note that ZCCM-IH's implementation of these strategies varies considerably and that the range of impacted population may be greater than above described.

7.4.2.1 Contaminated Soil Mitigation

ZCCM-IH plans to dispose of lead contaminated soil from along the canal in Chowa township. Some of the contaminated material has been removed, with an estimated 21,000 ***(35,000)*** tonnes remaining to be disposed Design and implementation of the soil removal program should adequately identify acceptable disposal sites and mitigation measures to address potential negative environmental impacts associated with the program (*e.g.*, contamination of a new location).

ZCCM-IH has indicated that the desired levels for lead in soil are less than 500 ppm in the communities and <100 ppm in garden areas on the basis that certain plants (*i.e.*, giant rape) can concentrate lead from the soil. These objectives are generally in line with international standards for example: in the US (400 ppm), the UK (500 ppm) and Canada (140 ppm). The remedial measure proposed by ZCCM-IH is to add soil cover containing low lead (Kamakuti soil contains 200 ppm lead).

In Chowa Township, 80% of the house lots have been covered with lead free soil. ZCCM-IH also plans to replace garden soils. As noted above, the effectiveness and sustainability of this measure needs to be assessed.

7.4.2.2 Monitoring of Lead in Blood in the Affected Communities

The combined population of Chowa and Kasanda is 13,000 with a total of 1,638 households[37] (see Section 4.4.2 Blood Lead)[38]. The 'lead in blood management program' is intended to eliminate the more significant sources of lead through application of mitigative measures as described above.

The blood lead monitoring program provides the levels and extent of lead poisoning in the community and therefore is used as a guide on the effectiveness of intervention measures at reducing blood lead levels. Individuals who are found to have blood lead levels above 40 g/dL are treated using chelating therapy, as administered by the former plant occupational health nurse. The Nurse and the Environmental Site Co-ordinator also investigate and educate all "known" households with a lead problem on improvement in environmental hygiene. This intervention program is fraught with problems and is inadequate for the need. ZCCM-IH has been provided with a medical consultation on the management of this issue in Kabwe and is reviewing its response.

According to ZCCM-IH, a community lead awareness education campaign has also been implemented for school children and their mothers, however this was not verified in the field. Mothers interviewed by the SA team who lived adjacent to the contaminated canal reported that they tried to tell their children not to play in the canal because it was "contaminated." However, when prompted for the type of health effects that might come from such exposure, none of the people were aware of the severity or type of possible symptoms, suggesting that a substantial information and education gap remains.

7.4.2.3 Reviews/Audits

ZCCM submitted to GRZ a progress report on the Kabwe Mine Site rehabilitation and decommissioning activities up to May 1999. A team of Environmental Council of Zambia (ECZ) Inspectors conducted an environmental audit of the site from March 31 to April 2, 2000. The objective of the audit was to verify progress on rehabilitation and decommissioning activities.

7.4.3 POTENTIAL MITIGATION OPTIONS FOR LEAD IMPACTS

In broad terms, two possible approaches exist to address the effects of soil lead contamination: complete rehabilitation or risk management. Complete remediation, meaning the removal or treatment of all lead

[37] ZCCM-IH (July 2000).

[38] Population figures from Municipal Council from May 2001 showed 3,996 people in Chowa and 666 households and 3,120 people in Kasanda with 520 households.

contamination, is the ideal, as it offers finality to both the affected parties and the responsible parties. With this approach lead values in soil everywhere in the Kabwe study area would be reduced to less than an established standards (*i.e.*, U.S. EPA guideline of 400 ppm). However, for complex sites with widespread impacts, this is generally not practical from both technical and economic perspectives. In such cases, risk management provides an effective alternative approach. Risk management relies on mitigative measures to reduce human exposure to lead contamination. The Kabwe rehabilitation plan has been developed on the principles of risk management.

Risk management focuses on measures that will produce the greatest effect in reducing or eliminating the exposure of people to environmental contaminants. Actions are prioritised on the basis of those that will achieve the greatest reduction in risk. Correspondingly, the effectiveness of risk management is measured by the reduction of risk, rather than the attainment of specific soil quality standards. In Kabwe, the success of the risk management plan is being measured by its effectiveness in reducing blood-lead concentrations in children. As stated by Hertzman (1996) "*the principal criterion for success of such a program would not be the achievement of a particular level of blood lead in children, but rather demonstrating that the average blood lead levels in childhood were continuously dropping and the range compressing downwards*."

Risk management is the most appropriate approach for Kabwe from a technical perspective given the complex and widespread nature of lead impacts. Risk management approaches have been implemented at similar large complex sites within Canada and the USA (*i.e.*, Trail, British Columbia; Leadville, Colorado; Bunker Hill, Idaho) on the basis that complete clean-up is neither economically or technically feasible even in those wealthy nations. The need for a rationalised approach is further underscored in Zambia given the sparsity of financial resources. Beyond a certain threshold, financial resources would be better invested in improving nutrition, medical aid or water supply and sewerage services.

Risk management and rehabilitation are not exclusive approaches for addressing environmental contamination. A good risk management plan may integrate a component of rehabilitation in areas where maximum benefit may be achieved. This usually comprises small localised areas of high impact (*i.e.*, source areas) or areas of high exposure for sensitive individuals (*i.e.*, playgrounds).

A number of technical options are available for rehabilitation of lead contaminated soils. Because lead is a basic element, it cannot be degraded. Thus, rehabilitation of lead contaminated soil is largely achieved through removal of the lead from the impacted area and re-locating it to a more acceptable location.

7.4.3.1 Covering/Capping Affected Areas With Clean Soil

The simplest and most cost-effective means to mitigate the effects of lead contamination in soil is to provide a barrier to prevent contact with lead contamination. Barriers generally take two forms. A security fence may be erected to prevent access of unprotected persons to a site with lead contamination.

Alternatively, a horizontal barrier such as a soil cap, a paved surface or synthetic membrane may be placed over the contaminated areas to allow productive use of the land surface.

The most practical barrier option is generally to cover the affected areas with clean soil (soil containing low concentrations of lead). Covering contaminated area removes the primary pathways of exposure: inhalation of dust, dermal contact and soil ingestion. Furthermore, where the thickness of cover exceeds the rooting depths of plants, this approach will also eliminate or reduce uptake into plants and subsequent human exposure through ingestion.

Because the contamination is not removed, the cover must be maintained. Proper grading and establishing of vegetation will minimise erosion and ensure long-term stability. In some areas, adding soil cover without taking away an equivalent volume of soil may not be acceptable, as it will raise local ground elevations altering local drainage patterns.

7.4.3.2 Removal and Replacement with Clean Soil

Excavation and removal of contaminated soil is the most robust remedial option available to deal with lead contaminated soils. The approach requires a place for secure disposal of the contaminated soil. At Kabwe, the mine waste dump would be the most likely disposal option.

Widespread removal of contaminated soils is unlikely to be practical given the vast area of impact around Kabwe and the fact that some dense residential areas lie on top of contaminated soil. However, this approach may be suitable for limited areas of high concentration or high potential for exposure of the most sensitive populations (children and pregnant women). The cost of this option is at a minimum twice the cost of covering the affected areas, as contaminated soil must be both hauled away and clean soil returned. Additionally, there may be costs associated with the disposal and procurement of clean soil.

7.4.3.3 Phytoremediation

Phytoremediation is a process whereby selected plants are used to uptake lead from the soil. Lead is stored in the plant tissue, which is then harvested for disposal as hazardous waste or potentially as smelter feed for metal recovery. More specifically, this process is phytoextraction because the plant simply extracts but does not degrade lead.

At this time phytoremediation for lead is an experimental technology that is not yet proven in full-scale applications. The U.S. Army Environmental Centre (2001) is currently conducting a field trial to evaluate and improve phytoextraction of lead from soil. The potential for applying this new technology to Kabwe should be reviewed but the following considerations **may impose limitations** on its feasibility:

- Phytoremediation is most efficient when there is a high but not phytotoxic concentrations of the contaminant. In this regard, the high soil levels Kabwe may favour use of this technology in theory.

However the distribution of lead in the city appears to be spotty and concentrated in built-up areas rather than open fields.

- Phytoremediation has been most successful for cleansing bodies of slow-moving water and marshy ground. Much of the area around Kabwe is arid.
- A substantial water source needed to support a viable phytoremediation system is not immediately available where it would be needed. The cost of an irrigation system could be prohibitive. The channel next to Chowa and Railway is itself contaminated and dry much of the year.
- The local plant most efficient in concentrating lead is a food crop, giant rape. Unless plots of land where rape is grown are guarded, the plant will be harvested and consumed. The ingested lead may aggravate the problem.
- Assuming that the crop can be grown in a residential district without being harvested by residents, it is likely to become a black market commodity after harvest. In a community where food supplies are limited and selling produce is an source of cash, the harvested crop will inevitably be diverted and consumed.
- Assuming that rape or even a non-consumable crop could be grown on lead-rich areas, harvested and kept secure from thieves, it would have to be disposed of. Burning at a central location would require transport, supervision and capture of particulate emissions to ensure that lead is not re-released into the community. Burning as biomass would distribute the crop into the community and release lead in a wider area, indoors. Composting or burying the crop could create hot spots of lead and a potential problem for subsequent agricultural use of the land.

7.4.3.4 Phosphate Lead Stabilisation

Through the addition of phosphorus, lead may be chemically bound (complexed) into lead pyropmorphite. This mineral form of lead is stable over a large range of pH and temperature. This renders the lead non-leachable and greatly reduces its bioavailability (Ma *et al.,* 1993).

Phosphate products including apatite, super tri-phosphate and phosphoric acid may be used to stabilise lead in soil (Trail Task Force, 2001). Phosphate is applied to the soil and allowed to react with the lead. The resulting complex, lead pyropmorphite, is a very stable compound under a wide range of pH and temperatures.

Phosphate lead stabilisation has been successfully demonstrated in field trials, however it has not been applied on a large-scale. As such, it is remains relatively experimental and would require pilot testing to determine its efficacy in the Kabwe area soils. The economics of this approach would depend on proximity to a suitable supply of phosphate. It is not known whether a local source is available with

Zambia. The most well known source on the African continent is Togo, which widely exports phosphate ore for fertiliser production.

7.4.3.5 In-House Remediation

Lead-laden dust may accumulate in residential dwellings. Re-suspension of this dust combined with restricted ventilation can result in greater exposure than would be experienced outdoors. The installation of hard flooring surfaces such as wood or stone and regular cleaning these surfaces may reduce indoor exposure to lead. Regular cleaning (*e.g.*, weekly) using a damp mop has been demonstrated to reduce indoor dust levels (Hertzman and Marion, 1995). Measures appropriate given the specific set-up within Kabwe households would need to be further explored in consultation with residents.

7.4.3.6 Community Education

Through education and outreach programs, affected communities need to be informed of changes in activities that would reduce their exposure to lead. This is particularly important as a major source of remediation will be in homes rather than simply at mine sites. The success of these measures is dependent on the effectiveness of the information dissemination and acceptance by the community. The education programs will be most effective if they take into account cultural factors, local customs and education levels.

Specific behaviour modifications that have been shown to reduce lead exposure include the following:

- Regular washing of hands, especially before meals can greatly reduce the level of accidental lead ingestion from soil. This is action is particularly appropriate for children who may play on areas of bare soil.

- Reduction of hand-to-mouth activity for infants can reduce lead exposure. Childhood behaviour must be corrected to avoid putting items in their mouths (sticks, stones, toys, *etc.*) and/or appropriate clean objects (*i.e.*, pacifiers) should be substituted.

- Cleaning of feet and removal of footwear prior to entering buildings will reduce the amount of lead tracked indoors. Pets, if allowed indoors, may also track contaminated soil into the household.

- Proper nutrition can have the added beneficial effect of reducing lead adsorption and hence toxicity. Specifically, diets high in iron and calcium are believed to reduce lead adsorption. Conversely, poor nutrition increases the toxicity of ingested lead. Therefore, educational and/or food aid programs aimed at improving diet may have a doubly beneficial effect on health.

- Effective delivery of information is crucial to reducing lead exposure through behaviour modifications. Information sessions in schools, churches or other regular public gatherings are effective ways to reach large numbers. Local health agencies may also be used to help educate on a more individual level.

7.4.4 CRITICAL REVIEW OF KABWE PLAN

The ZCCM-IH Decommissioning and Rehabilitation Plan contains many measures that should allow for practical remediation of lead exposure. However, the program has suffered from underfunding, has therefore not been fully implemented and has only recently been reviewed by more than one outside expert. Both the EA and the SA team reviewed the plan and assessed the one other outside review undertaken closer to the start of the program in 1996 by Dr. Clyde Hertzman of the University of British Columbia. Both recent reviews confirm that if resources were available under the CEP, some actions could be taken that would improve the overall efficacy of the program in protecting residents from excessive lead exposure. One set of recommendations with a particular emphasis on health aspects has already been provided to ZCCM-IH by Dr. Tee Guidotti, a member of the SA team. In addition, the EA team reviewed similar case studies in North America (*i.e.*, Trail British Columbia, Leadville Colorado, Bunker Hill, Idaho, Riverdale, Ontario) and drew upon its own experience with lead contaminated sites.

7.4.4.1 Source Reduction

The ZCCM-IH plan is most comprehensive in the implementation of efforts to prevent further releases of lead into the local air and soil environment. With the shutdown of the smelter, the primary source of lead particulate emissions is gone. Specific actions ZCCM-IH has undertaken to reduce secondary re-distribution of lead include:

- fencing around contaminated areas of the former plant complex;
- dredging and removal of contaminated soil from the Mine Canal; and,
- covering with coarse slag and re-grading the Waelz Kiln dump.

However, some of these actions have not had long term success; for example, scavengers and/or vandals have removed portions of the site fencing.

One area that is relatively easy to address is the reduction of road dust. Ideally, road surfaces would be paved to eliminate dust emissions from traffic. An alternative would be the application of calcium chloride, which acts as a temporary binding agent, but must be reapplied on an annual basis. At a minimum, new road base, preferably coarse granular materials (gravels) could be used to reduce dust generation. Priority should be given to the busiest sections of roads that run through the residential areas of Kasanda and Chowa and possibly other areas if they are found to also be contaminated.

7.4.4.2 Soil Replacement

ZCCM-IH has provided new, relatively low lead content "clean" topsoil to approximately 80% of households in Chowa. The plan will extend this program to all residences in Chowa and Kasanda. The soil provided is black (presumably organic-rich) Kamakuti soil containing approximately 200 ppm lead. Approximately 0.05 m of new soil is to be placed in residential yards and 0.10 m in gardens.

The added 0.05 m cover thickness is the absolute minimum that could be considered adequate. This may not be sufficient to establish turf grasses that would anchor soil preventing wind and water erosion. However, without vegetation and maintenance of the vegetation, the cover cannot be expected to endure. It was clear during the site visit in Chowa that in some areas the cover has already been eroded. Again, it will be important to develop and design solutions in consultation with residents regarding their practices in their yards.

The adequacy of the 0.10 m of new soil in garden areas is questionable, as thickness of replacement soil should be consistent with the rooting depths of the cultivated vegetation. For garden areas, it would be preferable to remove at least 0.1 m of topsoil prior to adding the 0.1 m new soil. The rationale is that airborne deposition of lead generally impacts only the upper 0.05 m of undisturbed soil (US EPA, 1986). This is confirmed by results from 1990 and 1993 soil surveys in Kasanda and Katondo townships indicate that soil lead concentrations were higher at surface than at 0.15 m (ZCCM, 1995). Later, 1994 results from Kasanda indicated in some areas that the top 0.6 m had been disturbed and had the characteristics of waste-rock masses. It is also noted that the "clean" soil topsoil containing 200 ppm lead is still above the recommended standard of 100 ppm. Further efforts should be made to find a more suitable topsoil for gardens.

Clean soil should also be furnished to cover bare areas throughout the Kasanda and Chowa townships. At present this has not been done. This may be a lower priority action than residential properties, however such areas should be pursued once all residences are complete. Bare play areas frequented by children should be identified for more immediate covering.

7.4.4.3 In-House Rehabilitation

Regular damp mopping of hard-surface floors is the only practical approach to removal of lead-contaminated dust in homes in Kabwe. Disposal of water down the drain will inevitably redistribute some lead into the water system. As in other parts of Zambia, the carbonate content of soil and water may help to precipitate lead and reduce the downstream risk. Downstream water quality should be monitored for lead content. It is likely that the risks of water quality from disposal of lead-dust by wet removal are much less than the risk inherent in the current situation of lead-contaminated homes.

Many homes in Chowa, Kasanda and Katondo may have dirt floors. A cleanable hard surface flooring (wood or stone) could be put into these houses.

Alternatively, the provision of reed mats for flooring may be a more cost-effective option. Methods minimising exposure to dust must be implemented when cleaning the mat. Regular cleaning or replacement of the reed mats could help to reduce both the accumulation and re-suspension of indoor dust. The reed mat may actually act as a reservoir for trapping dust.

7.4.4.4 Community Education

The extent of ZCCM's public education program for reducing lead exposure is not clear from available documentation. Community education to modify critical behaviours is the least expensive and amongst the most effective mitigation measures for reducing harm from lead contamination. In Chowa, those households that were sampled and tested in 1995 received a briefing on lead poisoning, however there has been no community-wide education on preventative measures.

According to ZCCM-IH, a former plant occupational health nurse and the Environmental Site Co-ordinator investigates and educates households with lead problems on environmental hygiene. There is also a community awareness campaign directed at school children. The substance, frequency of communication, forums of communication and the number of households contacted are not well documented. This suggests that the efforts to date have been rather informal and likely implemented on an ad-hoc or reactive basis. Thus, there is a need to prepare a community education plan and education campaign documents to guide workers and to reach the maximum possible number of individuals.

Available documentation suggests that community education efforts have been largely directed towards improvements in hygiene. This presumably encompasses activities such as regular hand washing, improving clothes washing, reducing dirt tracked into households and reducing the use of bare ground for play areas and for cooking. Other factors that should be incorporated into the education campaign include:

- basic nutrition advice to reduce the effects of high blood lead;
- provision of iron and calcium supplements;
- establishing and maintaining soil cover over yard areas; and,
- substitution of alternative crops with lower rates of lead uptake to replace giant rape.

ZCCM-IH has explained that there would be resistance to abandoning giant rape as it is a staple in the local diet. Nonetheless, alternative equivalents should be explored. Community members could be enlisted on a paid trial basis to evaluate other crops from the perspectives of agricultural suitability, consumption preference and lead uptake rates.

7.4.5 Risks Associated with Rehabilitation

The rehabilitation activities proposed for Kabwe, *i.e.*, reduction of road dusting, soil replacement and in-house dust removal can all be undertaken with minimal health exposure to residents and workers provided that proper occupational health procedures are followed. Simply controlling or limiting site access while carrying out rehabilitation activities is not practical because sites are located where people are living. The measures prepared can be undertaken with a combination of light construction equipment (haul trucks, loading graders and backhoes) and community labour, thus providing employment opportunities in the community. Once an education campaign is carried out, a risk exists that the existing public health system will be overwhelmed with queries about lead contamination.

7.4.6 SUMMARY AND RECOMMENDATIONS

Current efforts to rehabilitate the sites where lead is known to be present at high levels in Kabwe are not sufficient. However, rehabilitation to acceptable North American standards by standard methods faces insurmountable challenges in Kabwe. Major sources of lead on the mine site are capped with slag and fenced. The perimeter, however, is easily breached and local reclamation activity undoubtedly contributes to passive exposure of family members when local residents, themselves at risk, come home after attempts to scavenge or reprocess lead. The dredging of the channel southeast of the mine site deposited large amounts of lead-contaminated soil in a residential area, where it is available to be spread by human activity throughout the neighbourhood and into homes. The sources of ambient lead ideally should be capped, stripped or rehabilitated through planting vegetation and maintaining meticulous cleanliness within houses, but these homes are now private property and residents do not have the means to do this for themselves. An unknown complication in efforts to rehabilitate for lead is the probable presence of high levels of lead in the soil naturally due to weathering. As it is not practical to relocate the city, this may impose a practical limit on targets for rehabilitation in Kabwe.

The discord between the level of knowledge about mine pollution that continues to exist in Kabwe and the actual impact of contaminated soil and dust within residential areas should be addressed by the CEP. This will require a carefully developed risk communication program with outreach to specific groups working with residents such as teachers, NGOs, health care providers and community educators.

A key issue for ZCCM-IH and for the project appraisal team will be how to handle the medical care of residents who may have been affected by lead contamination and how to co-ordinate medical care and community education with site rehabilitation.

Because of the toxicity of lead, it is urgent that the CEP provide resources to adequately fund rehabilitation programs which have been underfunded in the past. Rehabilitation will need to bring together a number of stakeholders, including the public health authorities and health care providers and educators and would require extensive community education in addition to engineering solutions. Once the cost of some elements is determined, the program and the actions below, will need to be weighed against alternative uses of these funds. Some elements of such a rehabilitation program might include:

- A more thorough assessment of the sources of ongoing contamination and how such contamination may have spread through human interactions.[39] This would involve much wider testing of soil, water and blood lead levels of children.

- Reducing offsite migration of lead contaminated sediment by covering the contaminated sediment onsite (*e.g.*, paving, placing new topsoil, gravelling) and perhaps constructing and maintaining for the foreseeable future a new sedimentation pond.

- Evaluation of lead levels in fish from the canal and from Muswishi River close to the dambo. If lead levels are high, determine if local populations are consuming the fish, thus another exposure pathway that would need to be controlled. Canal waters adjacent to plant site may be devoid of fish due to the presence of sewage and consequently fish collection may need to occur closer to the dambo.

- A full assessment design would need to be developed with a neutral internationally reputable professional in the environment and medical field, costed and then weighed against expected benefits.

- At least in areas suspected to have high rates of contamination, a testing program would also involve census testing rather than sampling for lead contamination (in terms of blood lead levels, testing would focus on the most vulnerable, children). Census testing could have significant implications for the cost of the program; in some areas that have not been tested there are large populations (Katondo has an estimated 39,000 residents, Chowa has about 4,000 and Kasanda has about 3,100). If such a program is undertaken, it will require careful examination of what resources would be required to deal with the results including adequate and validated laboratory facilities, health care personnel for explaining the tests and the results to residents and eventually resources for treatment.

- Urgent development of a risk communications strategy with the assistance of specialists in risk communication on sensitive topics.

- Professional communication to the population in appropriate forum (radio, presentations to schools, meetings with resident development committees and NGOs) and language of steps they can take <u>immediately</u> to reduce their risk, to explain the program and steps for clean-up (housekeeping measures, reduction of dust in homes, planting of vegetation though not for consumption).

- Given the magnitude of the clean-up task in Kabwe, it would be prudent to form a local task force as soon as possible which should include representatives of local government, representatives of educators, representatives of health care providers and mine companies. Such a task force could be involved and briefed on the initial assessment of the problem, on development and implementation of a communications strategy and on providing feedback on options for remediation.

[39] In October 2001, ZCCM-IH expanded its soil sampling program and collected additional soil samples within Kabwe; however, the results of these samples were not known at the time of writing this document. In addition, the adequacy of the geographic scope of this recent sampling program was not evaluated for this document.

- Provision of people (and supporting funds) to whom residents can direct questions and obtain answers and concerns about the program.

- Development and implementation of a land use plan appropriate to environmental conditions at the mine site and surrounding areas.

- Evaluation of rehabilitation options such as capping tailings and other lead-rich sources, removing high lead content soil and replacing with clean soil and resettlement if no other options are viable. Such options would need to be carefully assessed from a social (actual practices that may interfere with such capping such as gardening, digging) as well as an environmental/engineering perspective, including mitigating any negative impacts associated with each rehabilitation activity. Note that where lead contaminated soil is removed, precautions should be taken to control dusting and to ensure that soil is disposed into a landfill which is covered with non-erodible soil or adequately vegetated to minimise erosion.

- Treatment for lead poisoning is most effective if: 1) there is no further exposure; 2) there is follow-up blood lead monitoring available; and 3) qualified medical care and treatment is available. The public health system is currently not set up to deal with such issues and cannot cope with the problem. The current intervention program is managed by the former corporate owner and operator of the plant. Although a sincere response to a serious need, the program lacks the resources to provide effective long-term management of lead-intoxicated residents and to prevent lead poisoning in new residents, especially young children. It is likely that exposure in utero is also now occurring that may affect newborn infants in Kabwe. Interim measures may be required, targeting the worst cases for chelation treatment and removal from lead-contaminated homes. This may require outside medical assistance, community education, training and funds for treatments that may not be available through the stretched public health system.

- Development plans for the sites and facilities acquired by the new investors. These plans should be reviewed by ZCCM-IH, ECZ and other parties in accordance with the applicable regulatory procedures.

- In the case of operations at Sable Zinc, an Environmental Management Plan should be prepared for review and approval by MSD and ECZ. Mitigation measures for Sable Zinc reprocessing operations should address dust control, water management, plant effluent discharges, contingency plans for leaks and spills and final reclamation plans for the site facilities and tailings dumps.

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PART III:
ASSESSMENT OF THE
COPPERBELT ENVIRONMENT PROJECT (CEP)

1. ANALYSIS OF PROJECT ALTERNATIVES

As outlined in Part I, the CEP would:

- Prepare an EMP consolidating the EMPs prepared by investors and by ZCCM-IH for each privatized facility, establishing the overall environmental management priorities within the broader context of environmental and social sustainability, and indicating how these liabilities are to be addressed.
- Establish an Environmental Mitigation Fund (EMF) that will serve as a mechanism to fund environmental and social mitigation measures to mitigate the historical legacy of mining-related environmental degradation, based on the priorities set within the CEMP.
- Fund priority mitigation measures to address current and ongoing environmental liabilities of ZCCM that may not otherwise be financed or addressed.
- Strengthening the regulatory framework for environmental management in the mining sector.

The CEP will help ensure full compliance of the mining sector with national environmental regulations.

1.1 NO PROJECT OPTION

Because the CEP provides support for a process of environmental rehabilitation and protection rather than for a specific pre-determined set of investments, it is difficult to predict the CEP's impact on specific indicators such as the quantity reduction of siltation to the Kafue. However, one can assess what would likely occur if there were no improvements in the three areas the CEP is focused on.

- The CEP provides minerals sector investors with an assurance that the GRZ is committed to addressing its environmental liabilities, as defined at the time of sale; for some investors such assurance was a key factor in the decision to purchase the mine. As such, it may serve as an important impetus for further investment in the mining sector, a key component of Zambia's employment generation strategy. In Luanshya, which is currently suffering severe economic hardship because of non-performance of the mine, potential new investors may condition investment on the clean-up by the GRZ of some of the most deteriorated sites. Should the CEP not proceed, shareholder confidence in mine companies that have invested in Zambia may decline.

- Furthermore, criticism of the privatisation program could intensify and focus on the notion that the privatisation process was undertaken without adequate social and environmental safeguards, particularly in towns such as Luanshya and Kabwe. Some critical reports have been called to the attention of the OECD, and the "Rights and Accountabilities in Development" group at Oxford has presented a report to the United Nations Commission on Economic, Social and Cultural Rights.

- The rate of failure of additional tailings dams, such as TD33c, is likely to be higher without the CEP. Failures will result in increased siltation entering tributaries of the Kafue, contributing to the drying up of streams for downstream users (primarily farmers irrigating along riverbanks – their number is not known) and impacts on aquatic resources. This may also marginally contribute to problems with turbid water for downstream utilities, increasing the costs of water treatment potentially to tens of thousands of customers. In Luanshya, the situation is particularly serious since raw tailings have entered the Luanshya River; continued siltation may ultimately offset the stability of the main dam providing potable water to the town. At least 10,000 households would be affected by the lack of water, and an additional 5,000 people are estimated to be dependent on the Luanshya river which would be silted up. In Kitwe, failure to properly manage TD25 could result in collapse into as many as 30 households adjacent to the site.

- The rate of accidents and possibly deaths on defunct mine sites will likely be higher without the CEP; in recent years, several deaths have occurred in Kabwe (4), in Kitwe, in Mufulira and in other locations of scavengers or of children who have been playing in the sites.

- In Kabwe, given the nature of the hazard, the costs of inaction are particularly high. These costs would include continuing and new cases of lead poisoning in children and adults who have recently moved into certain areas with high lead levels, of children who are accessing contaminated sites, and of people who are scavenging in the mine area. Under-funding of a program to treat residents for lead poisoning would be expected to continue or get worse, leaving those subject to lead poisoning without adequate medical care or external and expert review of the treatment being given. Erosion and wind-blown dust would likely continue, spreading contamination and its associated adverse health effects.

- Lack of counterpart EMPs, adequate testing data on pathways and contaminants or public participation in the EMP process will likely result in a bias towards mine companies' interests in the EMPs that investors adopt. Since these EMPs will be critical because of the stability period given to investors, this could have long-term (15 to 20 years) implications for the level of improvement in environmental conditions associated with the mining industry. Even if the completion of counterpart and then consolidated EMPs did not result in substantive changes to actions that would be taken, public perception may continue to be that the environmental future of these areas was agreed upon without their views being taken into account, particularly views on the importance of reducing SO_2 emissions. An opportunity to educate residents about current plans for improvement would also be missed. For towns where investors did not have adequate funding or expertise to complete their own EMPs and just adopted ZCCM's Environmental Impact Statements (Luanshya), much of the information referred to is outdated (1996 or 1997) and has data gaps with regard to human pathways. ZCCM-IH would not likely have the financial capacity to complete additional work without the CEP.

- Without the CEP, there would be no CEMP mechanism with which to encourage mine companies to develop better community outreach and emergency communication or warning plans for downstream users in the event of uncontrolled releases (*e.g.*, breaches) or releases exceeding regulated limits (*e.g.*, sulphur dioxide emissions).

- With insufficient support to the regulatory function, mines (particularly those without an international mining reputation to protect) may see little benefit from implementing environmental controls and may focus only on short-term profits. Increased copper production, which is possible over the next several years, could ultimately result in increases in the amount of pollutants in the Copperbelt. In contrast, decreased copper prices could impact resources available to address environmental management at the sites. Without regulation, companies may not dedicate adequate resources for carrying out environmental management.

1.2 ALTERNATIVES TO THE PRESENT CEP PROGRAM

There are (at least) three potential alternatives to the current CEP approach.

1.2.1 FOCUS ON SPECIFIC REHABILITATION INVESTMENTS

One alternative to the CEP approach would be to identify specific sites to rehabilitate rather than relying on the process of site prioritisation within the CEMP. This approach would exclude from financing sites that may be important to rehabilitate, but for which responsibility is currently ambiguous (*i.e.*, Luanshya, or sites contained in EMPs yet to be completed). Such an approach would not benefit from the expanded information base that is likely to emerge from the CEMP. Finally, the advantage of a fund is that it could provide a mechanism whereby other donors could potentially contribute additional resources with a relatively simple administrative burden.

1.2.2 EXPAND THE SCOPE OF THE CEP TO ADDRESS A BROAD RANGE OF ISSUES ARISING OUT OF MINE PRIVATISATION

The privatisation of Zambia's copper mines have created both positive and negative consequences for the region; many social issues that have emerged in former mining areas, represent long-term development issues that are common to other regions of Zambia, or even to non-mining townships within the Copperbelt that have not had the historical benefit of ZCCM services. Populations consulted during the CEP prioritised issues such as the provision of reliable water supply, sewage, solid waste, health care and employment opportunities. However, ZCCM-IH does not have the capacity, nor the mandate, to manage programs in a variety of sectors. Moreover, long-term solutions to these issues requires addressing the underlying causes rather than investing in infrastructure or services for which there is no possibility of sustaining maintenance following closure of the CEP. Solutions to these core developmental issues would therefore be most sustainable, and efficiently addressed through the variety of ongoing programs within these sectors (see Part I , Section 1.3).[1]

Although the CEP is not designed to compensate those who have been harmed by past mine pollution there will certainly be pressure to allocate CEP resources to compensation. As noted in Part I, Section 3, the changing composition of townships next to smelters (Kankoyo in Mufulira, Wusakile in Kitwe for example) means that there are more unemployed people who are not tied to the mines, and who therefore have no reason not to seek legal action against the mines/GRZ. However, such an allocation would be at the expense of mitigation of existing sources of pollution which would then persist after the project. The CEP must therefore focus on mitigation of pollution sources rather than on compensation.

1.2.3 INCORPORATE CAPACITY BUILDING/REGULATORY COMPONENTS OF THE CEP INTO EXISTING PROJECTS (ESP OR THE CIDA - CANMET)

Strengthening the capacity of environmental regulation, safety and oversight in the mining sector falls within the scope of objectives of the ESP project and the CANMET project described in Part I, Section 1.3. The ESP project objectives have much in common with those of the CEP in terms of improving environmental management and regulation, but with a broader scope (national, all environmental issues). These broader non-mining environment issues will continue to threaten air quality and the Kafue River water quality. Most of the stakeholders participating in the ESP would potentially also participate in the CEP. The CANMET project, in contrast, focuses primarily on strengthening the MSD in its capacity to ensure mine safety.

The alternative of incorporating capacity building from the CEP into the ESP may not be practical because the ESP would need to be amended, a lengthy and often complicated process. Further, given the

[1] The most salient example relates to the urgent need to limit the practice of raw sewage flow into the Kafue river by utilities. The problems with the utilities relate to (i) historically poor management practices that meant the sewage treatment plants were not maintained; (ii) low cost recovery because of poor management and in some areas and low ability to pay. Analysis of alternatives to improve this situation could not merely focus on building new treatment capacity, but would also need to focus on improving financial and technical management, and on building a level of service commensurate with the populations' ability to pay for that service. The MTSP includes a component to look at institutional structure/management issues in CUs of Council townships in the Copperbelt.

numerous objectives under the ESP, and the critical importance of the current EMP/CEMP approval process to the next 20 years of mining environment, incorporation would probably result in insufficient attention to the mine sector component. Finally, as a bilateral project that is already under implementation, CANMET may have a limited capacity to broaden its mandate at this stage. However, it is certainly important that these three critical interventions are closely co-ordinated both formally as well as informally. Such co-ordination may need to be formulated into a combined matrix of objectives and actions under the three programs and this could possibly be explored during project appraisal (see subsequent recommendations on gap analysis).

1.2.4 Postpone CEP Until Formation of Kafue Integrated Watershed Management Plan

The benefits of specific interventions ~~as envisaged in rehabilitating~~ degraded sites under the CEP are difficult to assess in the context of other sources of siltation and pollution affecting the Kafue watershed, especially those associated with deforestation along the Kafue River and its tributaries. It can be argued that it is premature to design specific interventions before a comprehensive watershed management plan is available. It can be contended that before committing to the CEP, PPF or other funds should be applied to fast track an assessment of ALL sources of environmental degradation in the upper Kafue watershed, with emphasis placed on impacts from past and current mining activities in the Copperbelt Province.

A Watershed Resources Action Plan (WRAP) was recently conceived under the direction of the Ministry of Energy and Water Development and the Water Board as described in Part I, Section 1.3. This organisation could be enlisted to augment the focus on preparing a management plan for the upper Kafue River basin as its top priority. A water quality monitoring program would be an essential component of the plan, including installation of monitoring stations located at points selected to establish impacts associated with Copperbelt mining activities and with other activities such as raw sewage discharge, small scale emerald mining on the Kafue banks, riverbank agriculture, and to distinguish those impacts from background conditions in the watershed. Such information would be highly useful in any event for the preparation of the CEMP.

The watershed management plan could include constitution of an Environmental Management Fund for the Kafue watershed as a whole. This EMF could have similar objectives in its application to that presently planned under the CEP, but with a broader scope, particularly with respect to protection of existing forests, for encouraging reforestation and for limiting current encroachment into national forest reserves. The fund could be applied to promote and implement environmentally sustainable income generating projects in the upper Kafue Basin (mainly Copperbelt), education on agricultural practices that protect the watershed, with emphasis on environmental protection aspects.

The Kafue pilot is not likely to start for at least another year after which time would be needed to conduct a detailed technical study of the Kafue River. Given the fact that some sites are currently in such disrepair that they risk failure (which would result in excessive siltation of rivers), the short-term costs of postponing rehabilitation actions on some sites would exceed the potential benefits of taking a more systemic approach to site selection. The CEMP could, within its time constraints, assess and identify "critical points" in the Kafue where incremental siltation or the interaction of pollution from two independent sources (such as a sewer outtake next to a tributary with tailings or plant material) would result in negative ecological or health consequences.

Moreover, funding mechanisms for community based environmental activities already exist in such ongoing projects as the PEF under the ESP and the ZAMSIF project, which has recently made an effort to increase community based environmental projects in its portfolio. It would be more efficient to better target these sources (that have not been fully used), than to create additional levels of administration through ZCCM-IH, an agency with no comparative advantage in the management of community based micro-projects. Finally, postponement of actions until the Kafue pilot would ignore pressing needs of Kabwe, which is not on the Kafue.

1.2.5 ADDITIONAL COMMENTS

The proposed CEP structure draws upon experience from a number of ongoing, or previously executed World Bank programs in the minerals sector, for example in Ecuador, Bolivia and Argentina. The concurrent process of task identification and institutional capacity building has proved effective in all such instances.

Finally, the only other alternative to the current CEP structure would be for GRZ to seek grant funding sources (the CEP is a concessional long-term credit which must be repaid in hard currency) from other donors. Given the magnitude of the clean-up required in Kabwe and in the Copperbelt, it is recommended that the GRZ seek such funding sources to complement the CEP and to minimise the future debt burden on the country. The fund mechanism within the project may facilitate such supplemental financing.

2. POTENTIAL IMPACTS OF THE CEP

2.1 GENERAL

A range of mine environment issues have been outlined in Part II, with the issue of most perceived importance to the population in the Copperbelt being smelter emissions. The CEP will not comprise direct investments in all of these sites/issues as some of the assets belong to private investors (see Section 4.3). Because the smelters (with the exception of SmelterCo which belongs to ZCCM) are now the private property of the mines, the most effective tool for influencing how they are managed and how much they emit is through the EMPs which will effectively serve as the "regulatory tool" over the next 15 to 20 years. In Mufulira, investor plans for the smelter have not yet been expressed, and are unlikely to emerge until MCM is fined for excessive emissions starting in 2005 (if the SmelterCo smelter is refurbished, more mines may use that smelter instead of relying on Mufulira thus the expected useful life of the Mufulira smelter may not justify a large investment in rehabilitation). It is preferable to have the private investors comply with Zambian regulations and take responsibility for investments and refurbishing. Decisions on whether public resources would be used to subsidise a private investor need to be carefully evaluated against the need for such subsidies and the alternatives to not providing a subsidy (for example, would the subsidy make the difference between the company continuing to operate or pulling out) since these are resources that would otherwise be used for important development objectives. Given the high cost of investments in smelters, this would not be a viable expenditure from the CEP, which would address this issue through strengthened negotiation of EMPs.

In addition, significant sources of pollution causing health and environmental impacts are not mining-related and thus fall outside the scope of CEP as noted in the previous section (and in Part I, Sections 3.3 and 3.5). The potential positive impact on human health or aquatic life in the Kafue of implementing the CEP might therefore be more significant if improvements were made in these other sectors.

Bearing these reservations in mind, environmental and social assessment of the CEP points to tangible benefits it would produce. Although the specific investments to be undertaken have not yet been defined, this report outlines types of activities that could be included in the project and assesses their associated potential (generic) benefits and risks (see Table 2.1 and subsequent descriptions).

Table 2.1: CEP – Potential Activities, Impacts and Risks

Project Component	Type of Activities	Positive Impacts	Risks
ZCCM-IH Contractual Obligations Under MDAs (CEP – decommissioning of defunct sites based on contractual agreements with investors. As detailed in Part I, financing for existing contractual agreements with investors has already been financed from the LRP and therefore unlikely to come from the CEP)	Decommissioning of portions of plant and mine sites; removal of contamination sources	• Fulfilment of legal/contractual obligations to investors • Improved environment at mine site operations; reduced health risks for scavengers at mine sites	• Cost overruns • Short-term health exposures to workers (*e.g.*, generation of dust, heavy equipment traffic) • Legal exposure of ZCCM-IH for non-performance

EMF	Stabilisation of tailings dumps through erosion control, conversion of decants, sediment traps, spillway upgrades	• Stabilisation of failing tailings dumps
		• Reduced impacts to water, soil:
		  • Less siltation and thus less drying up of tributaries flowing to Kafue and to downstream users (farmers primarily), particularly during rainy season
		  • Reduced risk of collapse of tailings dumps (*e.g.*, TD25)
		  • Protection of municipal potable water supply, *e.g.*, at Luanshya
		  • (medium term) once rehabilitated, potentially more land available for agriculture, certified solid waste sites or other activities
		• Employment opportunities for local contractors, labourers, communities (short-term)
		• More efficient water treatment downstream (less costly) though the degree may be marginal unless (KCM and other) private investors also implement their proposed environmental management of sites currently in use
		• Net environmental impact will depend on pollution stock and pollution flow and on how much specific sites contribute to the stock (such as siltation in the Kafue from Pollution Control Dam in Nchanga and how this is affected by current owners and overlays past silt, rainy season silt, other sources of stream pollution such as raw sewage dumping)
			• Materials in the Copperbelt are not very toxic & therefore pose few environmental health risks from physical exposure
			• Rehabilitation may require temporary restriction of illegal farming (if, for example, a site were being capped)
			• If rehabilitation solutions are over engineered, rely on overly intrusive construction works, are capital intensive without a justified need, or do not account for how the site is used (or typically vandalised), costs may be high, thus limiting number of sites rehabilitated); and,
			• Vandalism may be ongoing, and continue to threaten stability of sites

EMF	Revegetation of various sites in the Copperbelt	• Promotes site stability by reducing erosion • May increase options for productive land use of sites depending on site characteristics • Employment opportunities for local contractors, labourers, and communities (short-term)	• If communities were not adequately informed this new vegetation may be cut down • If community involvement is not adequate, there could be a risk of displacing current cultivation
EMF	Revegetation of various sites in Kabwe	• Promotes site stability by reducing erosion • Certain types of vegetation (*e.g.*, rape) can concentrate metals and therefore "clean" soil to a certain degree	• Improper handling and disposal of vegetation containing high levels of lead can result in contributing to blood lead levels if people ingest this vegetation (*e.g.*, rape is a staple of the local diet) • Extreme caution should be exercised in using edible vegetation since there is a risk this would be consumed rather than used merely to "absorb" metals in the soils and because capacity to secure sites from trespassers is very weak in Kabwe
EMF	Development of community management plans for sustainable use of sites including consultation of key relevant stakeholders on alternatives for rehabilitation, on end-use for the site, on ultimate ownership and on environmental impact	• Increased community awareness and understanding • Increased participation of local communities in natural resource management • Reduced risk of vandalism and higher chance of long-term site stability • Less deforestation around sites • Reduced risk of those using the site being unnecessarily denied access and income • Smoother hand-over of sites from ZCCM to GRZ or Local Government • More cost effective rehabilitation plans tailored to end-use of site	• Process for agreement on plan and end-use may take time, slow down rehabilitation • In areas where, after all alternatives are explored, it is decided that the hazards of scavenging outweigh the benefits (as perhaps with lead mines), then some scavengers may lose income source • In areas where agricultural or other use of mine land is proven to be hazardous, then these groups may lose income source • Some stakeholders may not see benefit of involvement or of refraining from certain activities on the site
CEP/EMF	Community education modules on hazards and site use	• Long-term site stability • for Kabwe, improved health of adults and children who would scavenge mine, fewer fatalities on sites	• Need for income may outweigh perceived safety threat of accessing site • Because of current incentives with regard to land allocation, politicians may continue to illegally allocate/sell land in these areas, even when that land may not be safe for habitation

Project Component	Type of Activities	Positive Impacts	Risks
CEP/EMF	Community consultants for preparation of proposals to ZAMSIF	• Provide potential alternative income generating activities for scavengers, farmers who may have activities altered by a specific mine site management plan, or improve income potential of this vulnerable group	• All proposals may not be accepted by ZAMSIF
CEP/EMF	Health education, risk communication in Kabwe	• Immediate reduction in exposure to lead	• Information may stimulate panic/anxiety if not properly presented • May increase law suits against GRZ • Existing public health system may be overwhelmed and unable to handle the requests and questions of concerned patients
CEP/EMF	Funding for testing and medical treatment programs for lead contamination	• Reduction in health impact of lead contamination	• Sustainability of program if the source of lead is not addressed during the project cycle • May increase law suits against GRZ • If sources of contamination not addressed, treatment can cause harm
EMF	Physical mitigation measures in Kabwe (to be determined, but could potentially include capping sources of lead, soil cover programs in residential areas, other dust containment measures in residential areas)	• Reduce potential exposure to lead, significant potential health benefits for future generations • Improved health of children who are most at risk	• If not co-ordinated with a careful education and monitoring campaign, lead exposure may not actually decrease • If any lead mounds are moved, or if the sources of contamination are not understood, there is potential for contamination of other sites if not properly carried out • If wide range of stakeholders are not briefed on how to sustain rehabilitation measures within the household and neighbourhood, their actions may end up exposing soil (for example, some NGOs are involved in digging drainage canals and pit latrines in low cost neighbourhoods)
EMPs/CEMP	Preparation of ZCCM-IH counterpart EMPs/CEMP and public consultation	Preparation of Counterpart EMPs: • Provide a co-ordinated approach to environmental management to maximise positive benefits (to the river systems for example which are affected by both ongoing mine sites and defunct ZCCM sites) • Provide recent and independent data on levels of contamination particularly with regard to pathways to human, livestock or ecological exposure and potential impact • Strengthened negotiating position by GRZ with regard to the CEMP that will govern environmental management in the mining sector over the next 15-20 years • More efficient and focused rehabilitation efforts • Identify occupational health and safety requirements during rehabilitation efforts	• In some towns, greater information on the health impact of past mine pollution may contribute to an increase in law suits against ZCCM for damages, legal costs for ZCCM likely to increase • The time required for public consultation may delay the finalisation of EMPs and therefore action on some urgent rehabilitation measures • Even with better information/justification for undertaking certain actions, the mine companies may not agree to change SO_2 technology or to reduce levels to a degree that they have a positive health impact (if production increases for example) • Mine companies may not have sufficient resources to complete an EMP, particularly smaller mine companies in Kabwe
EMPs/CEMP (Cont'd)	Preparation of ZCCM-IH counterpart EMPs/CEMP and public consultation (Cont'd)	Preparation of Counterpart EMPs (Cont'd): • Protection of the public by increasing training in hazardous materials management and transportation, and by developing a regionally consistent emergency response and contingency plan Public Consultation: • Ensuring some correlation between issues that stakeholders are most concerned abut and the attention they receive in the EMP (*i.e.*, SO_2) • Better awareness among stakeholders of plans for environmental contaminants, are of concern from a health perspective	
EMP/CEMP	Encourage more cohesive approach among mine companies for community warnings/education of hazards	• Increased signs at hazardous sites • Encourage investors to adopt warning and communication plant to downstream users and to provide a means for residents to seek information from mine	• Signs may continue to be stolen or ignored
Capacity Building	Training for ECZ Developing consensus on ECZ model for regulation of mining sector	• More focused, and thus more effective environmental regulation • Clearer roles for mines, Mine Safety Department, ZCCM and ECZ	• With current working conditions staff turnover is extremely high. Unless these are addressed, training may not have much of an impact on the organisation

Project Component	Type of Activities	Positive Impacts	Risks
Capacity Building	Development and implementation of a formal management system within ZCCM-IH including corporate strategy, analysis of the range of responsibilities ZCCM-IH holds (financial, legal, responsibilities to conform to regulations) post-privatisation, specification of objectives in terms of improved environmental management, definition of roles and resources, and independent audit of the management system. Should contain elements of an environmental management system.	• Increase likelihood of ZCCM-IH being able to carry out its functions under the project, meet regulatory requirements • More efficient allocation of ZCCM-IH staff and resources relative to core responsibilities	• If over-designed, the management system could be cost intensive without added benefit
Capacity Building	Training for ZCCM-IH Hazardous materials (including PCBs, radioactive waste) management and disposal training and development of disposal strategy	• Protection of the public by limiting access to hazardous sites, including PCB and radionuclides waste storage sites • Protection of the public by increasing training in hazardous materials management and transportation, and by developing a regionally consistent emergency response and contingency plan	• As long as regulations are followed, risks should be minimal (PCBs pose little risk from skin contact unless it is prolonged) • In areas where ZCCM-IH security personnel is minimal (as in Kabwe) particular care must be taken to ensure that PCBs are secure from theft - - theft of PCB-laced oil from ZESCO electrical transformers was reported to the SA team and represents a problem of unknown magnitude. The oil is typically illegally marketed as cooking oil to unknowing consumers, a practice that endangers health
Capacity Building	Financial support for training/research for other institutions (academic, research) in mine environment issues	• Increased understanding of environmental and health impact of mine pollution from independent third party reviewers (rather than just from the mines)	
Capacity Building	Training for medical staff in Kabwe on the health impact of lead poisoning and treatment	• Capture and therefore treatment of more cases of lead poisoning	• May increase cost of medical services, or may be ineffective if medical services do not have funds for testing for or treating such exposure • Could raise anxiety level of residents
Capacity Building	Encourage programs of quality assurance (including sampling protocol), laboratory validation with reputable international laboratories and institutions (particularly for blood lead analysis in Kabwe)	• Standardised and recognised sampling protocol • More reliable laboratory data, particularly for substances that need to be measured in small increments because of their toxicity	• There is a risk of duplicating/creating lab facilities in the public sector that are currently available and functioning well in the private sector: care needs to be taken to assess which facilities should participate in such a program (public, private, ECZ, ZCCM, MSD, university labs *etc.*)

2.2 ZCCM-IH CONTRACTUAL OBLIGATIONS

ZCCM-IH is contractually obligated to decommission and to undertake environmental rehabilitation activities under the terms of the Mine Development Agreement (MDAs) negotiated with the respective private investors (primarily KCM). These obligations, which are summarised in Part I, Section 4 of this report, must now be acted upon, or ZCCM-IH will risk being exposed to legal actions by the investors and other affected parties to recover the cost of remedial actions that parties may incur in order to proceed with mine developments.

It is the understanding of the EA/SA team that the contractual agreements completed to date have been funded out of the LRP program and that funding from the CEP will not be required. The one exception to this is that sites for rehabilitation may emerge from mines that are currently in transition such as Luanshya; however, these sites would presumably be subject to the same scrutiny as other sites (ranking as priorities based on their impact on health, ecology, environment) rather than to become eligible for funding simply because of a new agreement with new investors. Risks associated with implementing decommissioning and rehabilitation activities under the CEP are minimal. They include short-term occupational health exposures to labourers and cost overruns, both of which are considered to constitute manageable risks.

2.3 EMF

There are two generic risks to rehabilitation activities in both the Copperbelt and Kabwe. First is the risk that sites will be selected for rehabilitation based on other factors rather than those that pose the greatest threat to human or ecological health and welfare. Measures to mitigate this risk are further described in Section 3.3. These measures focus on the adoption of a simple and transparent system for ranking, on expert technical review of this ranking, and on the presentation of results to a wide stakeholder group through the CEMP process and through presentation to a project steering committee which should include local government and NGO representation. The second risk concerning specific works is that costly, over-engineered solutions, or overly intrusive construction works are selected (thus reducing the number of sites that can be rehabilitated) at the expense of simple solutions which are effective for the specific end-use of the site. Again, recommendations have been made of ways to address this risk, including the presentation of more than one sub-project alternative and relation of that to how the site currently is or will be used.

Another risk is that of vandalism, a major contributing factor to the degradation of sites. This may continue, negating rehabilitation. Factoring in current site use in developing technical rehabilitation plans, involving communities in developing site plans, and facilitating site users involvement in other activities through assistance with income generating proposals to ZAMSIF constitute possible options to mitigate this risk (see Section 3.3.1).

2.3.1 REHABILITATION OF PRIORITY SITES IN KABWE

Given the toxicity of lead and its link to negative health effects, it is likely that financing of planned or future rehabilitation activities in Kabwe (see Part II, Section 7.4 on rehabilitation options) would emerge as a priority for financing under the EMF of the CEP. If properly implemented, this program could prevent negative physical and mental effects of future lead contamination, particularly in those neighbourhoods suspected of having high lead levels.

The interventions in Kabwe that are likely to pose the most immediate and tangible benefits are those focused on communication, education on housekeeping and hygiene measures residents themselves can take to avoid lead contamination, prevention for newborns, young children and recently arrived. Other interventions directed at the sources of lead themselves, as discussed in Part II, Section 7.4, are not expected to expose the resident population or workers to significant health risks, provided that exposure to short-term hazards is minimised or mitigated during the process of excavating contaminated soils, placing clean soil cover, establishing physical or vegetative cover, and any other rehabilitation measures. If actions such as soil replacement are taken within residential areas, widespread stakeholder and resident education programs will be essential to make these actions effective. For example, the NGO PUSH (Programme for Urban Self Help) is currently active in Katondo township in digging drainage canals and digging pit latrines; such activities would need to be assessed in terms of how they would affect any potential soil replacement measures. Technical solutions will likewise need to be determined in close consultation with local residents and to take into account residents' practices and perceptions in and around the household.

The risk communications strategy that should be part of the programs supported in Kabwe may translate into increased demands on an already fragile public health system of people wanting to be tested for lead poisoning. It is recommended that the CEP be examined for how it could support current health care workers in responding to client inquiries regarding lead. This may involve updating educational materials, or contracting a medical toxicologist to visit clinics, to answer questions or to train medical staff and develop a protocol for answering these questions.

Another risk of the program is that if sources of lead are not sufficiently removed, it may be harmful for individuals to continue to receive treatment for lead. This risk should be addressed by having a reputable third party medical toxicologist with experience to re-evaluate the protocols for ZCCM's existing lead program, and if applicable, recommend alternative methodologies and protocols for future treatment.

A secondary risk of the Kabwe Decommissioning and Rehabilitation program is the possible physical disruption of residential population in the event that any areas are deemed unsuitable for continued habitation.

2.3.2 REHABILITATION OF PRIORITY SITES IN COPPERBELT

During the field work undertaken for the SA, it became clear that rehabilitating ZCCM-IH liable sites in the Copperbelt would have only a partial impact on environmental quality. Because the majority of ZCCM-IH sites include tailings, overburden dumps, or ore stockpiles, they pose the greatest danger from runoff during the rainy season, and thus probably contribute less to downstream pollution than those sites currently operating which discharge throughout the year. In many cases, pollutant sources from both ZCCM-IH and private mine sites intermingle (See box in Section 2.4 of Part III on Pollution Control Dam in Nchanga). Therefore, the primary impact on siltation will come not only from the actions under the EMF with respect to ZCCM-IH sites, but from the co-ordination of actions as guided by the CEMP of both private mines and ZCCM-IH to reduce the total load of siltation on the Kafue River system.

Siltation can smother fish eggs and reduce the variety and numbers of fish, and decrease water availability for downstream users. Nuisance dust for sites that are near communities (see Annex G for site location relative to communities) may also be reduced. It is also expected that the number of accidents around mine sites would decrease with the proposed community education sub-component of the EMF. Some sites could eventually be used for income earning purposes (see next Chapter on recommendations). The EMPs would need to assess whether sufficient baseline measurements exist to quantify the current siltation load from ZCCM and non-ZCCM sites (and therefore to assess net improvements).

It would be difficult quantify the net impact of reduced siltation on aquatic life and on downstream users without information on the incremental contribution of other non-mining pollution factors (*i.e.,* raw sewage, riverbank farming, other sources of erosion). The most likely forum for such analysis to be conducted would be under the proposed Kafue River Basin Pilot Study under the WRAP, as described in Part I.

Because the heavy metals in ore found in the Copperbelt are not particularly harmful to human health, the risks of negative physical impacts associated with rehabilitation activities are likely to be minimal, provided that appropriate engineering, reclamation, project management, and occupational health and safety practices are followed. These practices should be defined as part of the EMPs and CEMP. There is also a risk of unfulfilled expectations of the public and intervenors regarding the benefits of remedial works, temporary disruption of any nearby residents associated with installations such as drainage ways and sediment ponds. Improving warning signs around sites may reduce the number of accidents around sites.

2.3.3 RESETTLEMENT/SETTLEMENT

The need for resettlement under the CEP could become a serious possibility in the following situations:

- sites are considered unsafe and no reasonable precautions can be taken to avoid exposure to hazards;
- mine companies reverse their pragmatic stance and insist that the GRZ move squatters off their MLAs; and,
- in specific areas of Kabwe no other viable options are found for rehabilitation of lead-levels.

As noted in Part I, Section 4.3.7, a preliminary review of available data during the SA showed that at least 3,000 squatters were on mine/ZCCM land that needs to be assessed for safety. It will be important that the EMPs systematically catalogue the numbers of squatters and the numbers of others currently using mine land, and that they assess safety in these areasBefore ZCCM-IH carries out any action that might deprive sitting holders -- whether legal or "squatters" under current rules -- of their homes or farms, it should develop a land acquisition and resettlement policy that is fully consistent with Zambian law and with the rules of the World Bank under OP4.12, the Operational Policy on Involuntary Resettlement.

Based on past experience, the risks and problems associated with resettlement are high. These include substantial delays due to political interference, and very high costs which could absorb project funds that may be better used elsewhere. Therefore, the rationale for moving squatters off ZCCM land must be very evident to all parties, and the benefits in terms of reduced risk for example need to be well documented and outweigh these costs.

2.3.4 DANGEROUS OR HAZARDOUS MATERIALS

Although some of the current storage and disposal of PCBs and radionuclides has been funded under the LRP, a portion may be financed under the CEP. PCBs and radionuclides are presently being stored at sites in Kalulushi, old Cobalt Plant (Nkana Mine) and the Kabwe Mine. No immediate risks to residential populations or animals were identified during the course of this EA. As noted in Part II, Section 3.6.11, if properly managed and disposed of, PCBs pose little threat from skin contact unless it is prolonged. There is little reason to believe that the PCB storage sites represent a significant hazard unless the PCBs were stolen, or the PCB reservoirs were mismanaged and such that PCBs entered a water sources where it could bioconcentrate via fish. ZCCM-IH is developing plans for ultimate disposal of hazardous materials at secure sites, or for treatment in the case of PCBs, as discussed in Part II, Section 3.6.11. A policy, legal and institutional framework for the management of PCBs is under development by the GRZ (through the ECZ), and was scheduled to be established by October 2001. Where hazardous materials must be transported to a disposal site, recently enacted legislation (The Hazardous Waste Management Regulations) stipulates the transportation and bonding procedures to be followed for protection of the public.

Sections 3.2.4 and 3.2.5 of Part III contain recommendations to ensure that current plans for the containment and eventual disposal of PCBs and radionuclides are carefully followed to mitigate any risks from the storage, transport, or handling of these materials.

2.4 ENVIRONMENTAL MANAGEMENT PLANS

Preparation of EMPs should facilitate the rehabilitation of high priority mine sites regardless of ownership and ensure that sites which may fall between GRZ and private investor responsibility are adequately addressed (see Box).

BOX: The Complexity of Allocating Responsibility For Mine Pollution: The Case of the Nchanga Pollution Control Dam and the Benefits of a Consolidated EMP

Although development agreements between investors KCM and GRZ suggested that GRZ/ZCCM-IH would be responsible for the clean-up of historical mine pollution, there are several areas where it may be difficult to sort out the "historical" from the "current." The Pollution Control Dam at Nchanga is one such case. At this dam a large quantity of tailings and mine waste is supposed to settle to minimise the amount of pollution going into the stream system. The dam is currently being used by KCM and the amount of solids going into the dam will increase if KCM's production increases. The dam is essentially full, and thus is not efficiently fulfilling its function. As a result, silt flows directly into a pipeline/stream which eventually ends up in a tributary of the Kafue. The pre-existing silt could be deemed to be historical, but the site is currently in use by KCM which is also contributing to siltation.

In order to ensure that this major contributor to silt in the Kafue is addressed will require a co-ordinated and joint agreement between KCM and ZCCM as to who should be responsible for clean up. Thus, KCM's EMP may present one proposal for the site, but in order to be effective, a joint agreement and acceptance is required – through ZCCM-IH's counterpart EMP and the subsequent agreement on a consolidated EMP. Only through assessing the actions of different actors conjointly will one be able to evaluate the cumulative impact on the environment.

Risks associated with the EMPs relate mainly to delays in implementing the CEP because of the time required to collect monitoring data and to allow for effective public consultation. Undue delays in commencing remedial actions may result in further failures and sediment releases from tailings facilities and disruption of some of the decommissioning activities planned for the privatised mines and the Kabwe mine site. ZCCM-IH may also be exposed to the threat of litigation as stakeholder awareness increases of perceived impacts associated with past and present mining activities.

Another risk of EMPs and of rehabilitation efforts in general is that they focus excessively on higher cost engineered solutions that do not adequately account for how a site is currently or will be used. Section 3 of Part III includes recommendations on measures to minimise this risk.

2.5 INSTITUTIONAL CAPACITY STRENGTHENING (ICS)

Strengthening of the human resources and delivery capacity of the governmental agencies and academic institutions charged with implementing the CEP is essential to the long-term success of the project. Training should be provided not only to regulators in the ECZ and MSD, but to health workers in Kabwe, laboratory technicians in the application of analytical methods, and forestry and vegetation specialists in techniques of silviculture which will be most effective in erosion control as an example. If funding is made available to independent scholars, such as those at the University of Mines in Lusaka or at the Copperbelt University, it should help broaden the currently small base of independent studies.

The regulatory agencies (ECZ and MSD), as well as ZCCM-IH, will benefit from increased capacity in respect to their engagement in the following activities:

a) SHORT TERM

- EMP and SMP negotiations with individual mining operations.
- EMP and SMP implementation, monitoring and auditing.
- Air quality monitoring (equipment, data acquisition, data quality control, and QA through staff training).
- Chemical management including PCB's and other hazardous waste.

b) LONG TERM

- General mine waste management planning.
- Water quality monitoring (effluents).
- Rehabilitation of tailings and waste dumps by ZCCM-IH and mines (post-closure monitoring of rehabilitation activity by ECZ/MSD inspectors).

Risks associated with the ICS component are that knowledge and capacity gains may be temporal as staff may move on to other employment opportunities, especially new ones in the private sector. This is not necessarily a negative outcome, as inclusion of personnel trained in the formal environmental industry will benefit the private operations and indirectly the public interest.

3. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS FOR PROJECT IMPLEMENTATION

A process has been set out in Section 5.2 of Part II to prioritise sites warranting rehabilitation measures based on the level of risk posed by specific hazards. It is proposed that this process be applied during the forthcoming counterpart EMPs and CEMP phase to select sites and prepare designs for a rehabilitation program funded under the EMF. Recommendations on project design are presented by component, beginning with the establishment of a consultative process for the project.

3.1 EMPS/CEMP

3.1.1 CONSULTATIVE PROCESS FOR THE EMPS/CEMP

As noted previously, privatisation has created a more complex regulatory 'landscape'. Major environmental concessions were made to investors, including stability periods during which investors are: i) protected from any changes made to environmental or mining regulations, and ii) exempt from liabilities, obligations or litigation for pollution levels below what is authorised in their respective EMPs. Furthermore, the social assessment shows that the issue causing the greatest level of concern among the population in the Copperbelt (current emissions of sulphur dioxide), does not fall under ZCCM-IH's direct control. Nevertheless, the manner in which these issues are dealt with in the EMPs will be under the project's control. It is therefore important that the EMPs should:

- cover those issues of mine pollution that are of most concern to the population (air pollution from sulphur dioxide and reduction in vegetation from sulphur dioxide) and are most likely to cause harm (lead, arsenic);
- serve as a vehicle to communicate findings to a broad spectrum of stakeholders on the current state of mine pollution and what can be done about it;
- bring together key stakeholders who may benefit (or lose) from implementation of the combined EMP of ZCCM and the privatised companies and provide them with an opportunity to voice their concerns; and,
- are widely distributed in a format that is easily accessible (this may involve developing the capacity to put the information on CD-ROM if the final reports are very large, and the development of simpler short summaries of sites and issues by town that can be translated into local languages).

Effective participation in EMPs will require outreach to stakeholders to ensure that their views are represented. During field work for this SA it was evident that the level of knowledge of mine pollution is highest about the most visible form of pollution, smelter emissions, but low about other forms of pollution, including lead in Kabwe, that pose a threat to human health. It was also clear that there has been no regular dissemination of information to communities on mine pollution, even when there may be excess emissions or effluents. The EMP could provide an opportunity to raise the level of awareness on current mine pollution issues, which are harmful to health and which are not.

With regard to public consultation on the EMPs, it is not yet clear whether an EMP is subject to the same regulation as the Environmental Impact Statements (Statutory Instrument 28, see summary in Annex C) since the EMP describes a series of proposed clean-up measures rather than one specific investment. If the EMP does fall under the same guidelines, these are fairly specific, and funding will need to be incorporated into the CEP to assist ZCCM and possibly ECZ with this role. Even if the EMP is not required by law to comply with this regulation, the EMP component would ideally include feedback at the following stages:

3.1.1.1 During Scoping/Development of TORs

According to Zambian regulations on projects requiring an EIS (as opposed to a project brief), the developer (ZCCM-IH) needs to ensure that the public's views are taken into account in preparing the Terms of Reference. The developer needs to organise a meeting with community-based organisations, local authorities, government agencies and affected parties to determine the scope of the TORs. In this case, ZCCM-IH could potentially call upon parties in the steering committee – assuming that an adequate range of local authorities and community based organisations are represented – to fulfil this function.

3.1.1.2 During Preparation

During preparation, the EMP/CEMP team should be instructed to obtain feedback from the local level on priorities in the EMP/CEMP. This could take the form of a workshop in several municipalities to:

1) present summary information on the analysis of mine pollution to date and on specific sites and the threat they do or do not pose to health, ecology;
2) inform about proposed solutions/actions;
3) raise awareness about the CEP; and,
4) seek feedback on the EMP proposed.

3.1.1.3 During Review

Once a revised draft EMP is available, ZCCM-IH should:

- Distribute a brief summary of the relevant conclusions on mine pollution and sites to each town's local authorities, including clear explanations of what is known about the impact of different types of pollutants on people, animals, and vegetation and including a presentation of the specific sites in each town. This would also provide an opportunity to discuss the social issues that affect the site and serve to introduce the concept of a site management plan. Full documents should be available if requested.

- Distribute the EMPs/CEMP to key stakeholders who may consult with their own constituents (this can include NGOs working in affected communities, universities, think tanks, key government agencies such as the WRAP Kafue pilot group, the Ministry of Agriculture, and others currently on the core and expanded steering committee) at least 20 days prior to any consultative meetings (a preliminary list of specific stakeholders by town is included in Annex B).

- Advertise document availability and all planned meetings as specified in SI 28.

- Display the EMPs/CEMP document in public places in each town for at least fifteen days.

- Organise meetings in the Copperbelt to gather views of key stakeholders on the EMPs/CEMP after the EMPs/CEMP has been available for at least 20 days. At a minimum, meetings should be held in those towns most likely to be affected by agreements contained in the EMPs (for example, Chambishi, Kitwe, Mufulira, Chingola, Luanshya)

- Organise a meeting in Kabwe to gather views of key stakeholders on the EMP after it has been available for at least 20 days.

Experience with KCM's EMP suggests that the simple task of distributing and getting timely feedback on long and complex documents is a daunting one. The following lessons emerged:

1) It will be important to make the CEMP/EMPs available on CD-ROM and via the web (for the international, NGO, professional scientific and academic audience).
2) It will be important to have brief, simple summaries by town for a more focused audience to absorb (town specific stakeholders).
3) ZCCM-IH will likely require a neutral and skilled facilitator to organise meetings, ensure adequate distribution, record statements and provide feedback.[2]
4) Those who are not available to come to meetings should be permitted to submit written comments.
5) Meetings should be scheduled with sufficient advance notice to participants.

In cases where the EMPs outlines a significant health impact that the population is not already aware of, there may need to be additional briefing meetings within specific towns and organisations working at the community level to adequately answer questions and to reduce anxiety.

[2] One of the important roles of a facilitator is to ensure that participants receive an equal opportunity to express themselves in a forum they would be comfortable in. Thus, a facilitator can ensure that specific individuals/groups do not so dominate a discussion that others who may be less timid are never heard from by seeking views in a variety of forums or by moderating the discussion. A facilitator can also serve to translate into and from local languages; many people may have a capacity to express themselves in English, but may be more comfortable and more likely to speak up if they also have the option of speaking in local languages.

It is likely that ZCCM-IH will require short-term assistance with the process of dissemination and consultation. Specific skills to be sought include neutral facilitation (including in local languages), document production, and internet or web page expertise.

Support to ECZ for EMP/CEMP Review

Given the importance of the EMP to future mine environment management in Zambia, and given the new role that ECZ must play in critically reviewing this, it will be important to bolster ECZ's technical capacity to review the EMPs and to effectively negotiate in order to protect Zambian interests. As noted above, some of this support may be in the form of facilitation consultants to ensure adequate stakeholder consultation on the EMPs. In addition, over the short-term, assistance should be in the form of highly qualified technical expertise in mine environment issues who could critically review the EMPs.

3.1.2 Approach to Informal Settlements on Mine Land and Site Use

It is recommended that the CEP include funding for assistance to ZCCM-IH to develop a formal policy on squatter settlements on ZCCM-IH lands and on procedures for resettlement, consistent with the World Bank operational policy on resettlement. The EMPs may also need to catalogue the numbers of squatters currently living on ZCCM or mine land, and assess whether safety poses a threat sufficient to necessitate resettlement. As noted previously, several areas hosting over 3,000 squatters have already been earmarked for evaluation. The EMPs would need to assess whether there are other areas that should be assessed; local officials should be able to assist with the compilation of this information together with site visits. In addition, in order to carry out a proper hazard ranking, the EMPs will need to include extensive field work and consultations with residents near sites to assess:[3]

1) how the site is currently being used by the surrounding population (agriculture, scavenging, vandalism, *etc.*);
2) numbers of people using the site;
3) how pollution from the site currently affects people; and,
4) how site use may or may not affect site stability.

[3] There are at least two possible approaches to hazard ranking. Under a first approach all sites (there are hundreds of them in the Copperbelt) are exhaustively tested, visited and chronicled before setting priorities. Alternatively, as was the case in Bolivia, a first review of sites was carried out based largely on qualitative information, looking at these and other indicators in broad brush strokes (for example, estimating the number of people using a site in broad ranges such as less than 5,000 people, 5,000 - 10,000 *etc.*). Once a narrowed list of likely priorities emerged, a second stage of more detailed investigation and site visits would be carried out and more precise data on the number of people using the site, *etc.* would be collected. This two-stage approach is probably the most pragmatic route within the time constraints of the EMP/CEMP, and given ores are broadly comparable in most sites except Kalulushi.

Annex K shows some selected data available from Knight-Piesold audit visits between 1998 and 2001 regarding some of these issues. This could be used as a starting point for information to be collected during the EMPs.

3.1.3 ARCHAEOLOGICAL SITES

During the completion of ZCCM's Environmental Impact Statements (1996-98), a review of existing archaeological sites in the Copperbelt region was carried out and is presented in Annex E. Numerous sites from the early stone-age, middle stone age and late iron age had been previously identified or granted protected status under the National Monuments and Heritage Commission. The assessment found that there were several sites that were not properly maintained, and were being impinged upon either by natural factors or by mine tailings. For example, in Konkola a protected iron age site has been covered with tailings deposits from the Lubengele Tailings Dam. Post-privatisation declines in security around mine areas has probably caused an increase in human interaction with the sites.

It does not appear likely that any of these sites would be affected by rehabilitation activities under the CEP, but this would need to be carefully confirmed once specific sites had been selected for rehabilitation as World Bank policy on cultural properties specifies that projects involving "movement of .earth, surficial environmental changes or demolition" require such assessment. If there were to be an archaeological site affected by rehabilitation, the CEP should follow World Bank guidelines on cultural property which require the Bank to assist in the protection and enhancement of cultural properties encountered, rather than leaving that protection to chance.

Some sites may not be directly affected by the CEP, but may fall on ZCCM controlled land. The EMP process could also facilitate a re-assessment of these sites, and encourage mine companies and ZCCM to adopt a plan for site preservation. Such a plan would likely involve forming links to national or international institutions that could advise on site preservation or intervene to preserve the sites (local institutions would include museums, the National Monuments and Heritage Commission, international institutions could include UNESCO.

3.1.4 EMERGENCY RESPONSE AND CONTINGENCY

Previous EMP studies lack information pertaining to mitigation or reduction of potential emergencies (*e.g.*, uncontrolled releases) associated with mining operations. While emergency preparedness plans of a site-specific nature remain critical, the CEMP should additionally include generalised guidelines for emergency preparedness. This must include procedures for the identification of sites where uncontrolled releases of substances could potentially cause adverse environmental impacts. Such sites may include, but not be limited to, hazardous and/or dangerous waste storage areas (including radioactive material, PCBs, acid, fuel), tailings dumps, waste rock dumps, areas of subsidence or instability, and areas affected by airborne emissions. Formal notification processes should be developed to determine roles and responsibilities for timely communication, emergency services, regulatory agencies and local residents. Such notification should also comprise warnings to refrain from water consumption (even if unlikely) for downstream users in the event of any accidental releases into water systems. It could also extend to notifications to stay indoors at times when sulphur dioxide emissions are at levels likely to cause health effects.

Common elements of emergency preparedness and response planning include identifying the following:

- potential events that could lead to malfunctions or emergency actions;
- safeguard actions to prevent malfunctions or emergencies;
- procedures and processes to follow in the event of an emergency;
- resources required to carry out the procedures and processes;
- reporting procedures to government agencies and other relevant parties;
- communication structures to inform affected local residents; and,
- training requirements.

3.1.5 RADIATION PROTECTION AND SAFETY

A formal plan to address radiation protection and safety issues has not been prepared by ECZ or the Radiation Protection Service under the Ministry of Health. The Radiation Protection Service (RPS) of the Radiation Protection Board is mandated to ensure radiation protection and safety to miners exposed to ionising radiation. A radiation protection and safety program should therefore be initiated under the CEP to address two issues:

1. Improvement of the managerial capability to address radioactive waste storage and disposal.
2. An integrated environmental monitoring program for radon.

The RPS is currently lacking in institutional effectiveness for the following reasons:

- inadequate financial support (from government);
- inadequate trained manpower/information/training programs;
- lack of appropriate waste management facilities and equipment;
- inadequate public awareness campaign programs;
- lack of clear-cut disposal regulation guidelines/strategies on waste management; and,
- absence of waste inventories/databases.

The Radiation Protection Service (Radiation Protection Board) must be strengthened to ensure sound management of industrial aerosols for effective identification and assessment of hazards from naturally occurring Radionuclides. These have been identified to pose a potentially high risk to miners and the surrounding environment.

Proposed Program

A program should be developed under the EMP areas to manage the existing Technically Enhanced Naturally Occurring Radioactive Materials (TE-NORM) waste originating from the mines. The program should include the following aspects:

- Establish a local management/monitoring team comprising stakeholders from ZCCM-IH, new mine owners, RPS, Mines Safety Department, ECZ and NGOs to monitor occupational exposure, heavy metals and radionuclides in metallurgical and mine plants.
- Train local teams to manage the TE-NORM waste.
- Characterisation of the TE-NORM wastes in the Copperbelt.
- Formulation of Action Plans (surveillance, storage and final disposal).
- Acquisition of monitoring equipment.

3.1.6 PUBLIC COMMUNICATIONS/OUTREACH

During SA field work, several residents and NGOs noted that there was no longer a system of communication between some mines and communities. In one example, farmers from Lukoshi settlement, downstream from Musakashi dam at Chambishi, maintained that they did not know when the mine was going to release water from the stream and that when the releases were early (in August) they did not have time to harvest their crops along the riverbank before they were inundated. They noted that they were now not allowed into the mine site to ask questions, and that the next recourse, the ECZ office in Ndola, was too far for them to go (see Box on Lukoshi Settlement in rural Mufulira). It is likely that the mine had to release water from the rains in order to prevent the dam from failing. Although some of the larger mine companies have made an effort to have a community liaison officer, it would be important that the CEMP assess how mines can better communicate to specific groups such as those downwind from smelters or downstream so that these populations can take precautionary measures when necessary.

3.2 THE EMF

3.2.1 THE COMMUNITY COMPONENT

One of the primary impediments to the sustainable rehabilitation of sites is human interaction. It is common for vandals to steal decants to tailings dams (as was the case with TD40 in Kitwe), eventually contributing to their failure. This issue highlights the complexity of rehabilitating mine sites. If such rehabilitation is to be sustained beyond the life of ZCCM, the options evaluated for rehabilitation must be discussed with those who will ultimately use the site, and must take into account how the site may be used. For example, sites that are far from population centres may be treated differently from those that are in central, heavily trafficked, areas. This also means that in order to be effective, the EMF must address not only the engineering aspects of rehabilitating the sites, but also measures to ensure that the sites are adequately maintained in the future. This will require a process of stakeholder participation that results in a community/site management plan where the roles of each institution are clear and agreed upon by all parties. The EMF could thus comprise: (a) a set of criteria for which sites should be rehabilitated first; and, (b) a set of criteria for sub-projects that are geared towards making these sites safe and where feasible, productive in the long-term. Thus, the types of activities that can be financed under the EMF could be expanded from engineering services and works to include:

- Contracting the services of a community organiser or NGO to develop a plan to manage a specific site in consultation with site users and local leaders, and to educate people next to the site about the health/ ecological/ environmental impact of inappropriate use. If this consultation resulted in the need for a more elaborate project (if, for example, scavenging represented the major threat to a site and those scavenging wanted to come up with an alternative income-generating plan), then the project community organiser could help this group to prepare a proposal for funding to ZAMSIF, which has a comparative advantage in the supervision of community based projects. (Note that in Kabwe a much broader and more intensive education component may be needed):

- As part of this education, engage the participation of neighbouring populations in the rehabilitation of a site, planting of trees, *etc.*

- Community-based water testing program using local schools near the Kafue and its tributaries and education of children and families downstream of or around mine sites.[5]

- Where a site is deemed dangerous (as in lead), it may be necessary to facilitate community policing of selected sites, and community participation in building fences or signs around hazardous sites.

The EMF may need to set aside a portion of its funds (perhaps 10% - 20% of sub-project costs) for such community components. In addition, in designing the approach to mitigation of a site, consideration should be given to using labour intensive methods and hiring from within the adjacent community or from those currently using the site. Many of the rehabilitation options (planting vegetation, reforestation, digging) are likely to be amenable to such methods. ZCCM-IH will need to seek assistance from various partners in implementing these sub-components since its expertise does not include the supervision of community projects.

Projects that are clearly linked to mining, such as education of those surrounding a given mine site, should be eligible for direct funding under the EMF. Projects that involve finding alternative income sources for those who may no longer scavenge on a site would not receive direct EMF funding, but the EMF could finance experts/consultants to assist these groups prepare proposals to either the ZAMSIF project or the PEC fund under the ESP. In addition, some NGOs are active in education efforts geared towards low income groups in some of the neighbourhoods near mine sites (PUSH, for example which

[5] Such a program was set up in Australia and served both as an educational tool teaching when not to drink water from the stream, and as a monitoring tool by providing relatively inexpensive water samples from a large downstream area.

trains community based trainers and educates on other health issues; in Mufulira the town council has trained community animators through the ESP project) and would be potential partners in implementation of community education around mine sites (or in residential areas in the case of Kabwe).

Some of the challenges to implementing projects with community participation in the Copperbelt stem from the low levels of social capital in urban areas (see Part I, Section 3) which means that in many formal settlements, communities are neither cohesive nor well organised. Some NGOs have tried to promote and work through newly formed Resident Development Committees (RDCs), but these are less common in more urbanised areas of Kitwe for example. In only one Copperbelt town, Mufulira, are there community workers and a District Environment Officer trained in interacting with community members on environmental issues (the ESP pilot program). This group will be an important partner to ZCCM-IH in any activities in the Mufulira, but such links to communities on environmental issues are not present in Kabwe or in any other Copperbelt towns. As explored in Part I, NGOs with extensive community based project experience tend to focus on a relatively small number of specific communities and do not always have the staff resources to expand to a new area; former mine areas have relatively few community based organisations. The most sustainable means of working around these sites will be to work through whichever local leaders, RDCs, NGOs, or associations have influence in a specific site area. Consultants to help with this process could come from international NGOs or others with a proven track record on the ground community based programs. On a case-by-case basis ZCCM-IH will need to identify the organisations that are active and respected for a specific site, and seek out their partnership.

One of the obstacles to smooth implementation of World Bank projects with community input in the Copperbelt has been the challenge of sustaining community interest and initiative when there are delays in procurement or factors outside the control of the community. In a community-based water project in peri-urban areas in the region, for example, communities were successfully organised by an NGO, CARE International, and provided contributions towards a water point, but then delays in central government procurement and construction led to delayed project implementation and dissipation of community interest. In the development of community environmental action plans in Mufulira, community workers noted that a priority issue in Kankoyo, one of the communities adjacent to the smelter was the reduction in SO_2 emissions. However, the project team had little direct control over this factor, leading to some frustration with the process.

The types of interventions that the EMF component is likely to finance with communities will be focused around specific issues at specific sites, and may therefore have less risk of creating expectations common of more general community development programs. The area with the greatest risk of creating unrealised expectations is in the assistance proposed for developing community proposals to ZAMSIF, or delays in the processing of such proposals. Care should be taken to avoid promising such financing. ZAMSIF has established a good track record of processing proposals. ZAMSIF staff should also be invited to some of the sites to provide a presentation on their program.

Costing of potential interventions will be important to determine how much of the EMF should set aside. The one exception to the percentage rule is likely to be Kabwe since it is likely that a massive education and risk communications strategy will be needed, particularly in those neighbourhoods that have not received any education to date on lead, but that are found through the CEMP to be at risk.

In approving sub-projects, ZCCM-IH will need to walk a fine line of taking care not to create more hardship for those earning income from the sites, and yet not rewarding those who are vandalising and thus creating incentives for more illegal activities on the mine sites.

3.2.2 THE SITE MANAGEMENT PLAN

Once the relevant stakeholders have had a chance to agree about the future use and management of a site, and ZCCM-IH has had an opportunity to evaluate the site in light of its current and future use, these parties should sign the agreed plan. This plan would:

1) present and discuss alternatives that were considered for site rehabilitation and present the results of a simplified cost/benefit model of the different alternatives. More than one rehabilitation option should have been considered (including a simple, lowest cost option) and some review of the potential to achieve the same objective using local labour versus more sophisticated, capital intensive approaches should be included;
2) explain any potential negative environmental impacts (including any destruction of known archaeological sites) associated with the various options for rehabilitation, or indicate how such a negative impact would be avoided (particularly important for sites involving the movement of hazardous materials such as lead dust in Kabwe, PCBs or radionuclides);
3) identify the current use of the site (numbers of people, nature of use), and explain how the site rehabilitation might affect those using the site;
4) identify mitigation measures for any negative social or environmental effects of rehabilitation;
5) define the end-use for the site;
6) define how the site will be maintained (if required) so that it does not pose a danger in the future, and specify who will maintain the site in the short, medium, and long-term;
7) outline any community education components for those around and currently using the site, or any other community proposals that a group requires assistance in developing for presentation to ZAMSIF; and,
8) list those who specifically had been consulted in the process of formulating the plan, record the outcome/feedback from these consultations and state how these were addressed in design, and agree on who would represent a given group or community.

Once the technical options for site rehabilitation had been established, it is recommended that the site management plans be reviewed for their cost effectiveness and technical merit by a technical expert familiar with Zambia and with pragmatic approaches to mine rehabilitation in a developing country (preferably African) context. Educational programs or medical programs in Kabwe should similarly be reviewed by risk communications specialists, and an expert medical toxicologist. If found to be necessary, resettlement programs would also be subject to review by a social/resettlement specialist. As noted above, the project steering committee could include a retainer for such social and technical review on an as needed basis. In addition, ZCCM-IH might consider forming a site-planning group. This group could be composed of the relevant town clerk, any NGOs active on the specific site area, the resident development committee chairperson of any nearby community that is using the site, and a representative of any parties that may be affected by the mitigation.

3.2.3 WORLD BANK COMPLIANCE

World Bank Compliance – Because activities to be funded under the EMF cannot be specified in detail prior to the establishment of the fund, the setting of priorities and the fuller investigation and selection of remedial measures, the EMF will need to put in place a process for environmental and social safeguards review in order to ensure compliance with WB Safeguard Policies[6]. The screening and review process will include the participation and consultation of stakeholders through various vehicles like a project steering committee with wide stakeholder representation (including NGOs and local government) to ensure adequate screening and consensus among stakeholders.

Remedial activities undertaken by the EMF will be screened for safeguards compliance, in addition to the environmental assessment requirements of GRZ. Those projects that trigger Bank safeguard policies would necessitate a more detailed environmental and social evaluation, careful third-party review and assistance, as well as prior approval by the World Bank. A manual of procedures could detail the specific triggers for such review.

Thus, the EMF will be required to establish procedures for 1) screening each proposed activity to determine which safeguard policies are triggered; 2) carrying out environmental assessments, including effects on cultural property; 3) preparing resettlement action plans, dam safety plans, pest management plans; and 4) consulting with the affected publics and NGOs and disclosing safeguard documents. The Bank will need to assist the EMF in developing the capacity to make these determinations and carrying out the work in coordination with the ECZ and the Bank. In addition, the Bank will need to develop a mechanism for monitoring the process.

3.2.4 APPROACH TO ZCCM-IH LANDS – VALUE CREATION

The guiding approach to addressing environmental liabilities on ZCCM-IH held lands should be to convert as many liabilities as possible into assets having a demonstrable social and economic value. ZCCM-IH's role as manager of the lands should be clearly defined in terms of the rehabilitation works

[6] With OP 4.01, Environmental Assessment. In some cases OP 4.12, Involuntary Resettlement, OP 4.37, Dam Safety, OP 4.09, Pest Management, or OP 11.03, Management of Cultural Property, may be triggered. The triggering of other safeguard policies, e.g., Natural Habitats, cannot be ruled out, but seems less likely, based on the information gathered for the CEP EA

planned under the EMPs and paid for from the EMF. This expected value created by rehabilitating the land would factor into the simplified cost/benefit model noted above.

Tailings Reprocessing

Soil erosion from tailings and overburden dumps is one of the significant environmental issues to be addressed under the CEP. In the case of the tailings dumps, especially the older deposits (pre 1960s and 70s) formed from less efficient processing technology than has been utilised in recent decades, reprocessing may be economically viable using mobile processors. A unit could be established as part of the CEP, under ZCCM-IH management, to characterise the metal composition of the older deposits and, with the participation of the MMD, encourage Small and Medium Enterprises (SMEs) to engage in reprocessing activities. It should be noted that low income groups currently conduct their own artisinal form of reclamation through scavenging for pyrite, coal and stripped metal at some sites. These groups should not be displaced by these other activities. These activities would be subject to meeting current environmental standards, including reclamation of the residual tailings. Reclamation would include runoff management, re-sloping to promote plant growth, and establishment of a vegetative cover. As an inducement to follow good reclamation practices, the EMF could provide for a target reward for each hectare of previously bare tailing dump area which satisfies defined reclamation criteria following processing.

A small amount of funds should be dedicated out of the EMF to investigate the economic feasibility of reprocessing, beginning by establishing with private operators the minimum metal contents required for profitability.

Tree Planting and Carbon Credits

Much of the lands retained by ZCCM-IH is relatively barren, but is capable of supporting a tree cover. Personnel interviewed with the Forests Department and National Institution for Scientific and Industrial Research indicated that several tree species (including acacia, bluegum, sesban and a variety of indigenous trees) are suited to growth in the alkaline tailings materials. Also, many of the older tailings and overburden dumps have naturally generated a varied population of native tree species. Tree planting programs should be coupled with community education and employment programs. Revegetation programs should consider numerous factors, including indigenous vs. introduced species, the use of pioneer species, fire management, community usage of this resource. ZCCM-IH can participate in the carbon market as a host for carbon sequestration projects under the Clean Development Mechanism, a tool that allows governments or private institutions in industrialised countries to receive 'certified emissions reductions' by financing projects that reduce net greenhouse gas emissions in a developing country.

Bare tailings and overburden dumps that will not have been reforested otherwise, can be reclaimed with tree species and marketed as Clean Development Mechanism projects to investors from developed countries. Local communities adjacent to these areas can benefit from such projects by planting trees, managing the forested areas, and/or receiving proceeds from the sale of the carbon credits accrued by the carbon sequestration.

3.2.5 CRITERIA FOR SITE REHABILITATION UNDER EMF

The final selection of criteria for site rehabilitation will be made during preparation of the CEMP. The various methods available range from those that are quantitative and require fairly sophisticated data and calculations, to those that are more qualitative, with relatively simple methods. The benefits of increased precision from a more complex quantitative model will need to be carefully weighed against the cost of gathering the data required and of delays in implementation of rehabilitation works. Several considerations specific to Zambia should be taken into account in determining which methods to use:

- As explained in Part II, the ores in the Copperbelt region are broadly comparable (with the possible exception of Kalulushi) with most mines being copper mines.[7]
- The mobility and concentration of heavy metals in sites in the Copperbelt would, in general, not rank high on the toxicity scale (with the exception perhaps of the small number of storage areas for hazardous materials). Most Copperbelt wastes produce low metal concentrations in their leachates due to one or both of the above factors.
- The ore/composition of tailings in Kabwe does rank high on the toxicity scale.
- There are many sites under ZCCM-IH potential list of responsibilities, particularly if one includes those where responsibility remains ambiguous (over 50 sites including some undecided, but not including Luanshya or Kabwe).
- With the exception of Kabwe, many of the physical hazards and instability of the site stems from human interaction in the form of vandalism or scavenging rather than from the content of the ore.[8]

Some of these considerations can be more thoroughly confirmed during the EMP. Some of these factors might weigh in favour of a simple model. A simpler model could also offer greater transparency, because the criteria for ranking a site could be easily presented to a wide stakeholder audience.

In Bolivia, a two step process was used to rank hazards. First, all sites were evaluated based on available information on the following type of criteria. A numeric scale would be assigned to each category:

[7] However, there are significant differences in that some mines work a large amount of oxide ore (*e.g.*, Nchanga), while others (*e.g.*, Konkola) work only sulphides. This difference does have a significant effect on the types of waste produced and their toxicity.

[8] Physical hazards associated with subsidence arising from underground mining and areas of potential collapse in old pits which relate to geological structure, lithology and hydrogeological factors are discussed in Section 2.3.1.2.

Table 3.1: Sample Preliminary Spreadsheet from Bolivia

	1	2	3	4	5	6	7	8	9
Hazard	Likely to Exist?	Severity and Extent of Problem	Number of Persons Exposed	Health Hazard Ranking	Extent of Damage to materials, buildings, *etc.*	Materials hazard ranking	Sensitivity of Exposed Ecosystems	Environmental Hazard Ranking	Row Score
Chemical or Metal									
Lead				9				3	
Arsenic				8				2	
Cadmium				7				3	
Zinc				2				2	
Copper				?				?	
Acid generation				0		2		3	
Etc. depending on ore in Copperbelt, Kabwe									
Physical Hazards				9					

Column 1: very likely = 2 , possible in small quantities = 1, not likely = 0

Column 2 : does the hazard exist in sufficient quantities and in a form to damage human health, economic infrastructure, or ecology – this can be assessed taking into account the type of commodity produced, the number of years operating and whether a mine is currently operating, distance from population centres, the type of processing, and the size of production. In the case of the Copperbelt it would also probably include likelihood of imminent collapse of tailings into streams.

Column 3: These are fairly aggregated ranges rather than specific numbers

Column 5: Determined based on distance from buildings, proximity to urban infrastructure and roads (for example in Luanshya some site failures could cut off the road from one township to another). Isolated from buildings and materials = 1, some buildings, materials exposed = 2, extensive urban infrastructure = 9

Column 7: isolated from water bodies = 1, drains into streams = 5, drains into sensitive ecosystems = 9

**Values are then added across and the final column in added down to produce a site score that can be compared to other sites.

Additional factors in the case of the Copperbelt could be the stability of the site, likelihood of failure/breach in the case of tailings dams, and some rough indicator of economic potential from future use.[9] The table above produces a site score which can be compared to other sites.

ZCCM-IH currently has much of the information necessary to carry out this type of an initial ranking (tailings composition by site from 1996, proximity to streams, proximity to population centres, *etc.*), though it may need to fill in some fairly discrete gaps. For example, information on sites was collected in 1996 as part of ZCCM's EIS for the mines in the Copperbelt. This initial list of sites (Annex K) could be updated with information on the current status of the site (since many sites may have deteriorated physically since 1996 with the reduction in ZCCM security personnel) and on the current use of the site by the population. More recent, albeit partial information was extracted by the SA team from audits carried out between 1998 and 2001. These more recent audits show where sites are not stable and where vandalism has been a problem. This partial data is presented in Annex H.

In Bolivia, once a smaller list of priority sites emerged from the steps above, more detailed investigations and site visit were carried out to (1) confirm the initial identification as having potentially significant impacts; and, (2) define the data needed to estimate the damage to health, ecosystems, and economic infrastructure. Such a two-staged ranking process may make sense given the large number of sites in the Copperbelt and Kabwe. A number of methods that could be used in a second stage of analysis to produce a more accurate understanding of the damage from a site to people or animals are described in Annex K. For further examples of the Bolivia model, see *World Bank Technical Paper No. 398, Setting Priorities for Environmental Management, An Application to the Mining Sector in Bolivia.*

An important consideration in this process, will be to keep it simple and cost-effective relative to the nature of the toxins at a particular site, and to how the sites and resources are actually used (or not used) by the population. In cases where lead is expected to be present (Kabwe) such detailed investigations may be warranted as it could possibly result in net improvements in human health. In some other areas in the Copperbelt, such detailed research (on bioassimilation for example) may not be cost effective at all sites, but could be carried out for select sites given the similarity of the ore, and its relatively non-toxic nature (with the exception of Kabwe and possibly Kalulushi). It may also be important to rule out the possibility that the location of sites next to or downstream from other pollutant sources would interact to make the metals more available. The determination of how much detailed analysis to carry out before funding site restoration needs to be made by weighing the benefit this refined analysis will produce versus the benefit of using public resources on other core development issues.

Alternatively, the project preparation team may prefer to use a more quantitative model at all sites, or at some select sites to better refine the ranking. Annex N provides reference to such a model (MINDEC).

[9] Considerations could include whether the site was in a central area and already being used for activities such as agriculture, versus sites that are more remote. Other factors could include potential for re-mining as noted in previous sections.

MINDEC provides information on the probability of transport of chemicals from sites adjacent to water courses.

The next step in determining which sites are eligible for rehabilitation is to prepare a conceptual rehabilitation plan, complete with a cost estimate and assessment of benefits and value thereof associated with the rehabilitation. At sites where income may be generated through reprocessing of tailings or slag, or by tree planting as examples, such income should be taken into account. Income derived by the affected community through provision of labour should also be accounted for. The projects with the highest benefit to cost ratio would then be selected for implementation, subject to approval by the CEP Steering Committee, and technical review.

3.2.6 STATUTORY OBLIGATIONS OF ZCCM-IH

The ECZ has established limits for effluents to water systems. It is currently assessing how to charge companies that exceed these limits, and at some point in the future is likely to start implementing these fines. Statutory obligations on the part of ZCCM-IH for lands it has taken over should be considered in a similar way to those taken on by the private investors; *i.e.,* a grace period should be negotiated between ZCCM-IH and ECZ that would provide ZCCM an opportunity to bring its sites into compliance (if they are not already in compliance) before it started to incur fines. Stakeholders, including the communities, NGOs and affected residents and landholders in proximity to ZCCM-IH lands, should be informed of the plan and on the date by which ZCCM-IH should be in compliance. Recognition will need to be made by all parties that financial resources are not available to rectify more than the most pressing issues of environmental degradation associated with historic mining activities.

3.3 INSTITUTIONAL CAPACITY STRENGTHENING

Zambian legislation governing management of the environment is considered to be generally adequate. Under the laws of Zambia, commitments made in the EMPs will become legally binding. The regulatory agencies have statutory power to enforce EMP commitments and penalties can be imposed in cases of breach.

In spite of the extensive powers vested in the regulatory agencies, their effectiveness in practice will be limited by their capacity to monitor compliance with the EMP commitments.

Recommendations are presented in this section to enhance the capacity of the key institutions. The following factors are considered as current impediments to enforcement of environmental legislation and adherence to EMP commitments:

- limited technical and managerial capacity to assess and rectify environmental infractions;
- poor communication amongst enforcement agencies;
- inadequate consultative process and procedure;

- lack of autonomy on the part of the regulators;
- lack of provision for public participation;
- lack of public awareness (or understanding);
- inadequate staffing in part related to poor renumeration levels;
- inadequate resources for monitoring or random auditing;
- lack of awareness and knowledge of specifics of environmental legislation; and,
- overly broad ECZ mandate which results in dilution of attention to some critical issues.

3.3.1 ZCCM-IH Staffing

In order to manage the CEP, ZCCM-IH will benefit from strengthening its staffing in several areas. For the duration of the project, it will likely need an experienced community liaison to assist with supervision of the contracted NGOs and community development consultants, to help organise the stakeholder consultations and to facilitate development of community/site management plans. The fact that ZCCM-IH holds legal liability for suits related to mine pollution during the stability period also points to the urgent need for specialised legal counsel in environmental litigation.

3.3.2 Environmental Council of Zambia (ECZ) and Mine Safety Department (MSD)

Harmonisation between the Mines Safety Department (MSD), which focuses on mining lease issues, and the Environmental Council of Zambia (ECZ), which represents all stakeholders interests, would facilitate the granting of approvals and monitoring of mine operations. In addition, harmonisation may also contribute to more efficient use of resources by minimising duplication of efforts. Activities of the Line Ministries, and research organisations involved in monitoring and regulatory activities must also receive consideration.

ECZ has established a local presence in the Copperbelt by opening an office in Ndola in July of 1999. This field office will help to facilitate interaction with the MSD and to monitor implementation of the EMP. However, Ndola is the one town in the Copperbelt that does not have a major mine, and both MSD and ZCCM-IH are in Kitwe. In order to concentrate on a key sector, mining, ECZ should consider having an officer based in Kitwe.

Distinct roles should be defined for ECZ, MSD, ZCCM-IH, and the various boards (Radiation Protection Board), along with areas of collaboration, including joint inspections of mine lease development and applications. Fees collected through the Environmental Support Fund can be applied to the joint monitoring activities of the two agencies. Presently, ECZ is allowed to retain fee collections to cover the cost of inspections and monitoring, whereas any fees collected by the MSD must be directed to the Ministry of Finance. Hence, a mechanism is needed to allow MSD to access a portion of the fees currently being collected by ECZ to help support MSD operations. An MOU was recently prepared between ECZ and MSD on partitioning of roles and the subject of harmonised fee sharing.

To encourage private sector development, reassurance and evidence of a transparent and consistent approval process for development is required. Without this, industry may not be aware of the requirements needed to successfully secure the necessary approvals and permits. Further private sector investment in the mining industry may be hindered if there is a lack of confidence in the approvals process.

It is also recommended that a gap analysis be conducted for both the Environmental Council of Zambia and the Mines Safety Department before implementation of the Institutional Strengthening Component of the CEP3. This analysis should focus on comparing each agency's mandate to the activities it is presently carrying out, and comprise a matrix on which activities were being supported by the ESP, CIDA - CANMET, or other donors to determine which role the CEP should play. The results of the analysis could then be used to identify priority areas requiring additional funding and/or institutional strengthening. The results could also be used to determine where areas of harmonisation could more easily be established.

MSD resources are particularly over-extended. This situation has affected the Department's ability to carry out its mandate. For example, MSD is not able to carry out audit verification by conducting "spot checks" because it lacks the logistical resources. It is recommended that MSD fills current vacant positions and provides adequate training in mine safety and environmental protection. To attract qualified candidates, MSD will need to pay appropriate salaries comparable to other agencies, including ECZ. Job responsibilities should be clarified and periodically reviewed.

In addition, ECZ should be specifically tasked to monitor and evaluate the cumulative effects on the Kafue River basin of the mining industry activities within the region.

ECZ and MSD being regulatory agencies, have a basic mandate and technical competency, but require an organisational focus and training to enable them to adequately carry out their functions in CEP implementation.

Plans should be formulated now to initiate augmentation of the capacity of the ECZ and MSD by accessing uncommitted funds currently available under the World Bank's Environmental Support Program.

Finally, ECZ personnel should be trained in risk assessment procedures to the extent that Council personnel are in a knowledgeable position to review the investor and counterpart EMPs and participate effectively in development of the CEMP. ECZ should also engage- either by hire, or through a consultancy – expertise in geotechnical engineering, with experience in waste and hydraulic management aspects of the surface mining industry.

3.3.3 FRAMEWORK FOR PROFESSIONAL CO-OPERATION

A program for increasing national capacity should have the following elements:

- educational opportunities at the professional and graduate levels for the most talented students;
- mid-level technician training programs emphasising reliability in sampling and routine services;
- networking within the country to maximise training and educational opportunities;
- international benchmarking, preferably through bilateral and multilateral arrangements supported for several years and reviewed periodically;
- equipment, that is based on sustainable technology with maintenance supported by an "annuity" investment, for pollution monitoring deployed in a rational monitoring network that is also used to instruct technician training. This equipment must be regularly calibrated, repaired and maintained; and,
- inclusion of existing laboratories in quality assurance programs and interlaboratory comparison rounds.

At present, inter-institutional collaborations appear to be lacking. Most collaborative work in mine environment issues appears to be individual and the result of personal relationships. Professional collaboration based on personal relationships is effective and necessary for responsive collaboration but reduces the value of the collaboration to the professional community. Formalising the relationships into professional organisations, perhaps in partnership with those in other countries, may help build the networks mentioned above and help create the professional community required to socialise new professionals and advocate for support.

The elements of this program that may be most relevant to possible CEP interventions include an evaluation of the scope for improving the reliability of laboratory analysis (both in Kabwe monitoring of blood lead and in other labs used for environmental monitoring) through quality assurance programs with laboratories in South Africa or in other countries.

3.3.4 CIDA – CANMET PROGRAM

It is suggested that the CIDA's CANMET program described in Part I, Section 1.3 consider broadening its scope to encompass applied research and capacity strengthening activities related to environmental management and restoration. Specific areas where CANMET could provide assistance include:

- Vegetation programs: selection of appropriate vegetation types for use in reclamation; seedling production; and enlistment of community resources for planting.
- Application of carbon trading mechanisms to qualify for credits for carbon sequestration in exchange for GHG emissions produced in developed countries.

- Related capacity strengthening of institutions with technical skills applicable to reclamation, including Mine Environmental Neutral Drainage (MEND) – Department of Forestry and the Tree Improvement Research Centre, National Council for Scientific Research, and NGOs.
- Training related to proper handling of hazardous materials and simple field sampling procedures to quickly determine presence or absence of PCBs (e.g., field sample strips for PCB at the 50 ppm level).

3.4 CONSULTATIVE PROCESS FOR THE PROJECT (STEERING COMMITTEE, REGIONAL STAKEHOLDER FORUM)

ZCCM-IH's objective in the CEP is to rehabilitate as many high priority sites as possible so that continued maintenance and management is eventually no longer required and the land owned by ZCCM-IH can be given back to the GRZ (walk-away solutions). Solutions need to be low maintenance in light of limited capacity and resources of those institutions who will likely take over sites once they have been rehabilitated (local government for example). Once rehabilitated, some of the sites on excess lands held by ZCCM-IH may be viable for other uses. During the SA field work several suggestions were put forward including the creation of golf courses or other recreation facilities, certified waste sites, agriculture, and land sold or rented to private companies to generate rental income for maintenance of other sites - though none of the options has been thoroughly investigated. In towns like Kitwe, much of the former mine land lies in central locations. The CEP would need to facilitate the eventual transfer of these ZCCM resources to GRZ or to individuals. This will require close co-ordination between the stakeholders that are likely to have an eventual stake in these areas. Such co-ordination could be implemented through a steering committee for the project (this action may have already been taken by ZCCM-IH). The committee should include representatives of:

- Ministry of Mines and Minerals Development;
- Ministry of Environment and Natural Resources;
- Ministry of Local Government and Housing;
- Ministry of Community Services;
- Provincial Authorities;
- Local government administrators (Town Clerk of all towns should at least initially be invited to the steering committee meetings as they will all be affected by the EMPs/CEMP, once the project was underway and the CEMP had been completed, those town clerks of towns where the majority of works would be concentrated – such as Kitwe, Luanshya, Kabwe, Chingola – should continue on the steering committee);
- Mine Companies (KCM, MCM, Chambishi Metals, *etc.*);
- Zambia Association of Commerce and Industry;
- Copperbelt University Institute of Environmental Management;
- Non-Governmental Organisations (both community-based and advocacy); and,
- Ministry of Health.

There are other line agencies that may not need to be involved in the day to day management decisions of the CEP, but that should be brought in at the start of the CEP, and periodically as issues arise. These agencies, and their area of relevance include:

- Department of Forestry (deforestation and reforestation around sites);
- Members of Parliament and local elected officials of areas where there will be rehabilitation activities (issues of land allocation, resettlement of squatter settlements);
- Water Utilities currently affected by siltation: AHC-MMS, Mulonga Water and Sewerage, Nkana Water and Sewerage; and,
- Commission on Lands (eventual transfer of ZCCM-IH land to local authorities or others).

ZCCM-IH could serve as the secretariat responsible for the steering committee. Among the key functions of the steering committee would be to gain consensus on the EMPs/CEMP, to develop a transparent understanding of the criteria to be used to select sites for rehabilitation under the EMF, and to co-ordinate decisions on the plans for specific sites. The steering committee will also serve a particularly important function of ensuring close co-ordination between the ECZ – the body responsible for approving the EMPs – and ZCCM-IH – the body with substantive experience in the mine and mining environment sector. The steering committee would also oversee the process of social and environmental screening for sub-projects submitted for financing under the EMF.

The steering committee could thus provide overall direction, consensus building, and co-ordination to the project. However, once specific sites were selected for rehabilitation based on formal risk assessment, a more localised site co-ordinating team would be required. Such a team could report progress to the steering committee (see recommendations in Section 3 of Part III under the EMF).

The steering committee should have access to highly experienced specialists with knowledge and practical African-based experience in several areas: geotechnical engineering in the mining industry, toxicology, construction, community development and risk communication. This specialist(s) would serve as a reviewer for rehabilitation designs and cost estimates proposed by ZCCM-IH and other stakeholders. The reviewer would also ideally participate in the regulatory approval process by interacting with ECZ and MSD.

One of the challenges for the CEP is the fact that a principle implementing agency, ZCCM-IH, is at the same time a shareholder in the private mines, and a quasi-governmental body. Therefore, as part of the steering committee ZCCM-IH can bring together stakeholders, but it also has its own specific interests related to its contractual liabilities and its investments. At present there is no other regional forum for bringing together stakeholders in the sector, and the number of advocacy NGOs in the environment sector in the Copperbelt is extremely limited. In some other countries, public-private foundations have been formed to monitor industry compliance with standards, to influence industry trends and to fund independent research on specific environmental issues. The Clean Air Strategic Alliance (CASA) is one such example formed around the issue of improving air quality in Alberta, Canada[10]. It is a non-profit organisation comprised of government, industry, and NGOs committed to "developing and applying a comprehensive air quality management system for the people of Alberta through a consensus-based process." (See http://www.casahome.org/ for additional information.) CASA evaluates industry performance with respect to these goals, conducts research, and includes several sub-regional airshed groups.

Setting up a body such as CASA requires that industry, government, stakeholders, and advocacy NGOs have sufficient time and financial resources to support the research and monitoring that give meaning to the alliance (industry, government and NGOs provide financial and volunteer resources). At present the NGO sector, and particularly the environmental advocacy NGOs in the Copperbelt are in their early stages of development (the SA identified only two advocacy NGOs – Citizens for a Better Environment and the Catholic Commission for Peace and Justice – with activities in the mine environment sector in the Copperbelt). Other NGOs tend to be interested in learning more about these issues, but have their focus and energies on the stated priorities of the specific communities with which they work (water supply, health care, education, *etc.*) and thus may not have the time to devote to the specific issue of the mining environment. It may be some time before there are enough stakeholders with the time, interest, and resources to support such an organisation in the region.

As a first step towards developing a better network among mines, NGOs, academics and government on these issues, the CEP could consider setting a small amount of seed funding aside to match research into mine environment issues with a focus on rehabilitation options. Other issues of research could include those of greatest concern to the population, such as SO_2 emissions. Numerous academics at the Copperbelt University and Zambian School of Mines at the University of Lusaka have expertise in the area, and may be interested in forming or augmenting academic networks with institutions in countries outside of Zambia that also have extensive mines (some within the region as well as some outside of the region such as Bolivia, for example) to work on specific research topics.[11] The professional community of geologists and earth scientists appears to be among the best developed professional networks in the country. Results of such studies could be presented at forums sponsored by the steering committee with participation of mines, NGOs, academics and others.

[10] From: http://www.energy.gov.ab.ca/enviro/airqual/index.htm - "In 1990 and 1991, through the Clean Air Strategy for Alberta, Albertans were consulted about the province's approach to air quality issues. As a result of these consultations, the Government of Alberta accepted a recommendation to implement a Comprehensive Air Quality Management System which would identify issues, prioritize problems, co-ordinate resources, develop action plans, and evaluate results.

In March of 1994, the Ministers of Environment and Energy announced the establishment of the Clean Air Strategic Alliance (CASA) as a new way to manage air quality issues in Alberta."

[11] The Copperbelt University is already participating in a multi-country research effort, "Mining, Minerals and Sustainable Development" and submitting a paper on Mining and Society.

3.5 PERFORMANCE INDICATORS

A series of performance indicators has been outlined by the World Bank in the draft CEP Project Appraisal Document. These provide valuable benchmarks against which to evaluate proposed project actions and assess impacts. Outcome/Impact Indicators (over the project lifetime) include the:

- Finalisation, review and approval by the Environmental Council of Zambia (ECZ) of site-specific EMPs for all mining sector investments.
- Identification of environmental and social obligations resulting from ZCCM's past mining operations, and mitigation of associated hazards on a priority basis, as required by Zambia's environmental legislation.
- Establishment of a system to monitor the implementation of EMP actions, including regular monitoring of pollution flows and loads resulting from mining operations.

The type of output indicators one would expect to see on ZCCM-IH sites would include:

- decreased siltation load to the Kafue and its tributaries;
- increase in vegetative cover;
- reduction in erosion;
- reduction in deforestation;
- reduction or elimination in the breach of tailings;
- reduction in destructive vandalism;
- more restricted access to sites deemed unsafe under any circumstances; and,
- more evidence of warning signs at sites.

Aside from ensuring the security of tailings facilities, definitive output indicators will be difficult to formulate without a better baseline and information on sources of pollution (releases from private mines, ZCCM lands, and the combined output from all Copperbelt facilities entering defined points in the watershed) and on the current state of sites and their use. Existing baseline datasets are available, but are incomplete both spatially and with respect to topical diversity. A cost-effective mechanism for the compilation of additional data may involve collaboration with the executing agencies of independent (national and international) biological, environmental, and social research programs. The collation of existing data (hydrology, geochemistry, ecological, land use, *etc.*) held by GRZ ministries is also warranted.

Other indicators that the CEP would control only indirectly through strengthening the EMP process would include:

- reduction in absolute amount of SO2 reaching communities in Chambishi, Kitwe and Mufulira; and,
- reduction in levels of metals flowing into the Kafue from private mines and its tributaries.

If some of the recommendations above are adopted, additional indicators could include:

- the completion and agreement on site and community management plans for all sites financed under the CEP; and,
- the completion of a ZCCM-IH policy towards land and informal settlements.

Kabwe

Knowledge Attitude and Practice surveys (KAP) commonly used for other environmental health data could be carried out to form a baseline for the project, and then monitored to measure improvement among households and community workers in terms of knowledge of lead avoidance strategies. Other performance indicators could include availability of educational materials on lead avoidance in area schools. In addition, once a complete assessment of lead contamination has been carried out, this could be used as a baseline from which to set targets for improvement over the course of the project. An ultimate target would be the reduction of lead in blood samples, though there may be many factors affecting this.

Sulphur Dioxide

As arguably the most important mine environment issue in the Copperbelt with regard to human health, it will be important that the EMP/CEMP closely examine the investor proposals for SO_2 reduction and negotiate a target for this indicator. At present Zambian SO_2 regulation is based on capturing a certain percentage of emissions (70%). However, such a target does not guarantee that actual exposure levels for residents will decrease enough to reduce the health effects if production levels increase substantially. The EMPs/CEMP will need to assess this indicator carefully, and propose a target that is realistic and at the same time protects to the greatest extent possible the health of residents downwind from smelters. The long-term objective should be to reduce emissions to levels at which they no longer cause significant health effects to downwind populations. If reductions are not economically viable, the EMPs/CEMP should assess the feasibility of alternatives (resettlement) for those populations most affected (Kankoyo in Mufulira, select neighbourhoods in Kitwe which vary depending on the time of year and wind direction).

Sediment Release

A clear parameter indicative of project performance would be the level of total solids released from individual sites and the levels of total accumulated solids measured in the Kafue River at monitoring points chosen to represent the cumulative effect of the majority of mine sites. Potential locations of monitoring points on the Kafue River would be near the water intakes at Chingola and Kitwe, and downstream of RAMCOZ. Total solids loads in the Kafue River will also be affected by external factors, especially the effects of deforestation in the headwaters of the Kafue. It is therefore recommended that attention should be focused on point source reductions of sediment from the individual mines and properties remaining with ZCCM.

Social

The CEP provides a valuable opportunity to increase the participation of citizens, NGOs, educational institutions, local government and others in the improvement of the mine environment in the Copperbelt and Kabwe. Several recommendations have been presented to ensure this participation at key points in the project. Evaluation of this participation is not typically subject to quantification, but can be effectively assessed through beneficiary assessments carried out during project supervision. Such assessments should focus on consultation of affected communities and NGOs to discuss how they were included in the project process. Some of the potential indicators could include who was consulted during the development of the site management plan, whether local leaders immediately adjacent to a site are aware of the plan and the project, and whether those using the site are aware of safety issues.

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ANNEX A:
CONTRACTUAL REQUIREMENTS

ANNEX A: CONTRACTUAL REQUIREMENTS

The EA was undertaken by Komex International Ltd. (Komex) and by a team of social and health assessment specialists (Section 2 main volume) in strict accordance with their respective Terms of References (TOR) of the client and principal CEP executing agency, ZCCM–Investments Holdings Plc (ZCCM–IH). Komex adhered closely to OP 4.01 protocols in the execution of the initial EA for the CEP. The original TOR for the EA of the CEP specified the following tasks (March 30, 2001):

- Review the environmental obligations of ZCCM-IH and private investors.
- Review and assess pre-existing environmental audits, impact studies, engineering studies prepared by ZCCM and the Resettlement Action Plan (RAP) prepared by KCM. The RAP will be funded by ZCCM-IH.
- Identify and assess environmental and social risks associated with past and ongoing mining activities.
- Review Environmental Management Plans (EMPs) prepared by ZCCM and IEMPs prepared by the private investor (KCM).
- Review and assess existing decommissioning and rehabilitation plans.
- Assess the adequacy of procedures for warning and emergency response.
- Provide recommendations for the development of a final, consolidated EMP for the Copperbelt Environment Project.
- Assess institutional and capacity-building requirements for effective execution of the consolidated EMP.

Komex issued a draft EA in April 2001. ZCCM-IH and the World Bank conducted the initial review of the draft EA in July 2001. This review, in combination with the findings of the initial scoping mission and consultations for the SA, highlighted the utility of combining the perspective of beneficiaries of the SA with the analysis of environmental issues in the EA. Addenda were made to each of the team's contracts to merge the two reports.

Broad tasks identified under Komex's Addendum No. 1 (November 22, 2001) for conducting additional work for the enlarged scope of the EA were:

i) Integrate comments provided by the Social Assessment and World Bank legal specialists;
ii) Include the assessment of remediation alternatives for Kabwe Mine;
iii) Integrate the social assessment findings to include re-assessment of socio-economic effects of privatisation; and,
iv) Incorporate sulphur dioxide issues.

The terms of reference for the social assessment outlined four key tasks:

(1) to gather information and analysis of key social (and in this case environmental) issues and impacts of the proposed project and to describe the social and environmental context within which the project will take place;
(2) to gain a better, though preliminary, understanding of the health impact of current mine pollution in order to eventually be able to explain what current mine pollution meant for the health of people of the Copperbelt and Kabwe;
(3) to design a framework to engage stakeholders in the project, in consultation on EMPs, and to disseminate key information from the EMPs (participation strategy); and,
(4) to seek feedback from various stakeholders on key elements of the project, to gather views and perceptions of current mine pollution, and to better understand how mining pollution ranked among people's overall concerns.

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ANNEX B:
SITE VISITS, COMMUNITY CONSULTATION AND METHODOLOGY

ANNEX B: SITE VISITS, COMMUNITY CONSULTATIONS AND METHODOLOGY

MINE SITE VISITS: SA TEAM

Site visits took place between May 3 – 15 and July 3 – 20, 2001.

Nchanga Mine, Chingola
Open Pit C
Open Pit Mimbula 1 & 2, Fitula
Open Pit 19
Open Pit C
Open Pit B

Nkana Mine, Kitwe
TD27 & TD26
TD25 (Kitwe Slimes Dam)
TD40
TD33c
SmelterCo Smelter
Mindola Dam

Mufulira Mine, Mufulira
Mufulira Smelter

Luanshya
Mokoma Dam
Mine Site

Kabwe
Mine Site
Canal Dredging Area
Mine Dumping Area

Ndola
Ndola Lime Plant

Konkola Mine, Chiliabombwe
Lubengele Tailings Dam

SITE VISITS: EA TEAM

Site visits took place between March 22 – April 5, July 12 – 13 (Kabwe) and October 9–30, 2001

Kalalushi
Interim Storage Radiocative Waste Storage Site
PCBs stored in transport container
Chamber of Mines

Luanshy
Akatiti Dump
Chola Dump
Chonga Dump
Makoma Dump
Musi Dump

Chambishi Mine
Open Pit Mukasashi TD
Luano TD

Chambishi Metals
Plant site

Kabwe
Plant area
Sable zinc area
Waste dumps
Townships comsrising Kabwe townsite

Mufulira
TD8
TD3
TD5
WR11

Kitwe
Nkana plant site area and scrap yard
PCB Storage Site at Old Cobalt Plant
Smelter Co.
TD 25 / TD 26 / TD 27 / TD 33c / TD 36
Area E open pit
Mindola open pit and overburden dumps
Slag stockpile
Nkana ML3

KCM
Chingola plant site area TD5
Kakosa TD
Chingola overburden dumps
Chingola C pit and overburden dumps
North Changa tailings reprocessing area
Fitula pit (closed)

Kansanshi
Tailings Dump A
Tailings Dump D

Water Intakes
Kitwe
Chingola town
Chingola – AMC
Luanshya:
- Makoma reservoir
- plant intake

Note: visits were supplemented by information provided by resident Zambian Members of the EA team.

FIELD INTERVIEWS (INFORMAL, OPEN ENDED): EA TEAM

Mr. Edward Zulu
Chief Inspector, ECZ
Lusaka

Mr. William Kanyanta Chishimba
Senior Scientific Officer, National Council for Scientific and Industrial Studies
Ndola

Mr. Lishomwa Mulongwe
Principal Research Officer, Silviculture
Department of Forestry
Kitwe

Mr. Noah Zimba
Former Manager of Kitwe Herbarium
Lusaka

Mr. B. S. Kampwende
Deputy Sector Co-ordinator
Ministry of Mines
Lusaka

Mr. Henry Mutafya
Senior Inspector of the Environment
Mines Safety Department

CANMET
Ms. Brenda Dixon, Field Manager (Zambia)
Ms. Gail Bowkett, Manager, International Relations (Canada)
Mr. Brian Tisch, Project Manager (Canada)

ZCCM IH (Kitwe)
Mr. Joseph Makuba (Environmental Manager)
Mr. Cyril Lukeke (Environmental Officer)
Mr. James Kalowa (Environmental Officer)
Mr. Joseph Kabwe (Environmental Officer)

ZCCM IH (Kabwe)
Mr. George Mbesha

Mr. D. H. Littleford
Managing Director
Sable Zinc
Kabwe

Mrs. Mutale
Environmental Support Program
Lusaka

Mr. Paulman Chunga
Legal Specialist
Lusaka

Mr. Kaluwe Morgan
Forest Extension Technician
District Forestry Office

Kanyembo Ndholovu
Head Technician
AHC-MMS

Mr. Jonathon Kampata
Water Affairs Hydrological Branch
Lusaka

Community Consultations, SA Team

- Sustainable Agriculture Association, Staff Copperbelt Technology Assessment Site, Lukoshi (downstream of Chambishi Metals Musakashi dam), July 10, 2001
- Mwaiseni Informal settlement on the Uchi downstream of the TD26/TD27 and the Nkana Mine, July 16, 2001
- Residents of Squatter settlement (Kandabwe) in Nkana MLA, July 7, 2001
- Scrap metal scavengers on dump between OB5 and OB6, from Chiwempala neighbourhood, Nchanga-Chingola, July 9, 2001
- Farmers living adjacent to Fitula Open Pit, Nchanga Mine, July 9, 2001
- Scavengers (three groups – coal miners, pyrite miners, metal scavengers) Uchi Cross Valley Tailings Dump (TD27), July 4, 2001
- Residents/cultivators using Kitwe Slimes Dam (TD25), July 4, 2001
- Medical personnel adjacent to Kitwe Slimes Dam (TD25), July 4, 2001
- Farmers and farm owner, Supreme Farms in Luto, downstream of TD33c on Chibuluma Stream, July 14, 2001
- Emerald miners, Kafue River, downstream of Nchanga, Konkola and Nkana mines where the majority of mine effluent enters the river, July 20, 2001
- Resident Development Committee and farmers, Mulenga Compound, downstream of Nkana mine area on the Wusakile stream, July 7, 2001
- Farmers using sewage irrigation, Ndeke Compound on Wusakile stream, July 7, 2001
- Sugar Cane Grower on Nchanga mine site, Chingola, July 9, 2001
- Housewives, Kankoyo township, Mufulira, May 8, 2001
- Ward Chairman and local activist, Wusakile township, Kitwe, May 9, 2001
- Fishermen on Mindola Dam in Kitwe, July 17, 2001
- Fishermen on Makoma Dam in Luanshya, July 5, 2001
- Community group using raw sewage for irrigation in Mufulira, July 3, 2001
- Medical Staff at Wusakile Mine Hospital, May 9, 2001
- Chowa RDC members, Kabwe, July 12, 2001
- Katondo residents, Kabwe, July 12, 2001
- NGOs (Oxfam, World Vision, PUSH, Catholics for Environmental Justice and Peace, Advocacy for Environmental Restoration), varied dates in May and July 2001
- Universities and think tanks (University of Zambia, Copperbelt University, National Institute for Scientific and Technological Research), , varied dates in May and July 2001

SA Methodology: Community Consultations

Issue	Method	Topics	Locations
General consultations on project	Direct interviews by team*	View of project, information on perception of mine pollution, overall environmental priorities In each town discussions with: • Local government • NGOs involved in environment sector in town • Local leaders, local stakeholders, RDCs where they exist • District board of Health • Environmental and social liaison (if there is one) for mine companies • Provincial authorities (health, forestry, ECZ)	1. Kitwe 2. Chingola 3. Chililabombwe 4. Mufulira 5. Luanshya 6. Ndola 7. (Chambishi) Meetings in Chambishi held with mine company only 8. Kabwe
Impact of pollution on fish stocks in Kafue	Focus group discussion and semi-structure interview with fishermen	• Where do they get the fish (from any contaminated sources?)? • Have the size, number, quality of fish diminished over time? • Are there any problems with the fish they get? • What do they think any problems with fishing are due to?	1. Along the Kafue (downstream of Nchanga, downstream of Chambishi,. downstream of Nkana)
Residents fishing and eating fish from tailings dams that may be contaminated	Semi-structured interviews	• Do they see any problems from fishing from the tailings dam? • What type of fish are consumed and are they consumed whole? • Typical consumption of fish per day/month for adult/child	1. Residents of Kawama in Chililabombwe 2. Interviews with those marketing fish in Mufulira 3. Fishermen on Makoma Dam in Luanshya 4. Fishermen at Mindola dam in Kitwe
Residents drinking water from Kafue, irrigating with water from Kafue	Case study using focus group discussion	• Do residents drink water directly from the Kafue? • How else to they use this water? • Is the water clean?	1. Community, RDC, and farmers in Ndeke and Mulenga that Oxfam works with in Kitwe using Wusakile stream 2. Community members (farmers) and local agricultural NGO along banks of Kafue downstream of Nchanga and downstream of Chambishi
Residents using tailings or streams from tailings in a manner that they are not supposed to be used (either drinking, or stopping up tailings and/or sewer at night to use as irrigation)	Semi-structured interviews with those cultivating near these areas and with residents living on border of tributary streams	• Do residents drink water directly from the streams? • Do residents sell produce from fields irrigated from this source? • Do residents have other sources of income? • How important is this source of income?	1. Residents using Chibuluma stream in Kitwe (downstream of TD33C) 2. Community, RDC, and farmers in Ndeke and Mulenga that Oxfam works with in Kitwe using Wusakile stream 3. Residents of informal settlement (Mwaseni) along the Uchi streams

Issue	Method	Topics	Locations
Squatters and others farming on mine land and on dumps	Semi-structured interviews with farmers Discussions with City Council Discussion with mine police	• Do residents sell produce from these? • Do residents have other sources of income? • How important is this source of income? • Are soils fertile?	1. Nkana/Kitwe (Kandabwe compound) 2. Numerous tailings dams and dumps
Low income groups that are scavenging around mines and former mine areas for scrap, firewood	Semi-structured interviews	• What are they doing in these areas? • What income do they get from these activities? • What is the profile of these groups? • How to ensure that people are not harming themselves by stealing PCB oil for example? • What will they do if these areas are fenced off?	Locations in Kitwe, Chingola, Luanshya,
Areas where tailings pipelines have burst or where there have been excessive dumping into streams	Semi-structured interview	• Do people think that these tailings/chemicals pose a threat? How do they find out when there was a breach?	Residents downstream of 33c farming and living next to Chibuluma Stream, residents and farmers downstream of Chambishi Mine
Residents downwind of smelters or near to other sources of pollution	Semi-structured interview	• Perception of impact of mine pollution • Overall priorities and development problems • Occupation/history • Perceived environmental priorities	1. Residents of Kankoyo Township in Mufulira 2. Residents of Wusakile Township in Kitwe Residents of Chowa, Katondo Township in Kabwe

* Because of a strike of municipal employees during field visits which meant that all but the most essential employees such as the town clerk were largely unavailable, the team was unable to hold discussions all of the intended municipal employees in all towns (such as health department). However, most intended interviews were held in most towns.

INDIVIDUAL INTERVIEWS (INFORMAL, OPEN ENDED): SA TEAM

Inteviews took place between May 3 – 15 and June 29 – July 21, 2001

Dr. Jewette H. Masinja
Permanent Secretary
Ministry of Environment & Natural Resources

Christopher Chileshe
Senior Hydrologist
Department of Water Affairs (Lusaka)

P. Kimena
Deputy Director
Department of Infrastructure and Support Services
Ministry Local Government and Housing

Chiseke Mutale
Program Director
Environmental Support Programme
Ministry of Environment & Natural Resources

Greenwell Mukwavi
Co-ordinator
Pilot Environment Fund
Environmental Support Program
Ministry of Environment and Natural Resources

Christopher Sinyinza
District Environmental Facilitator, ESP Project
Mufulira

Edward Mwale
Operations Coordinator
ZAMSIF

Martha Linyando
Acting Director, Planning Unit
Ministry of Community Development and Social Services

F. Nyirenda
Environmental Health Specialist
Central Board of Health

Manengu Musambo
Health Economist
World Health Organization

ZCCM-IH
John M. D. Patterson (Technical Investment Manager)
Joseph Makumba (CEP Project Manager)
Joseph Kabwe (Water Quality Specialist)
James Kalowa (Air Quality Specialist)
Cyril Lukeke (Environmental Officer)
Nchanga Tembo (Procurement Specialist)
Calvin Sakala (Project Accountant)
Sino Nkeke (Waste Management Specialist)

Environmental Council of Zambia
Edward Zulu (Chief Inspector)
Douglas Kunda (Chief Inspector – Planning and Environmental Management)
Shadrack Nsongela (Senior EIA Officer)
Francois Huppé (Pollution Control Specialist)

Mines Safety Department, Ministry of Mines and Minerals Development
Gerard K. Kangamba (Director)
Henry C. Mutafya (Senior Inspector of Environment)
Chester Mwanakasale (Senior Inspector - Large Scale Mines)

Dr. D.C. Mwila
Occupational Health Physician
Occupation Health & Safety Management Board
Kitwe

Provincial Level Interviews

Dr. Peter Mijere
Pronvincial Health Director
Copperbelt Province

G.L. Kasanda
Director
Provincial Health Board
Central Province

O. Tembo
Acting Provincial Forestry Officer
Provincial Forestry Office, Ndola

E. Sikanyika
Acting District Forestry Officer
Provincial Forestry Office, Ndola

Rhoda Chasaya
Senior Technician
Provincial Forestry Office, Ndola

Tiina Paasky
PFAP II Provincial Adviser
Provincial Forestry Office, Ndola

Local Level Interviews

Charles C. Mwandila
Director of Administration
Mufulira Municipal Council

Kitwe City Council
Ali D. Simwinga (Town Clerk)
Promise C. Kaminsa (Deputy Director of Public Health)

Her Honor the Mayor and members of the Chililabombwe City Council

Peter Banda
Deputy Director Administration
Chililabombwe City Council

A. Mwanakalunga
Town Clerk
Luanshya Municipal Council

Dr. J.C. Bwalya
District Director of Health
Luanshya District Health Board

Felix Muhiana
Director of Administration
Chingola Municipal Council

Swithin Hamweene
Manager – Administration
Chingola District Helath Board

Dr. Davies Musonda
Chief Health Inspector
Chingola District Health Council

J.B. Mumbi
Town Clerk
Kabwe Municipal Council

Mr. Kamboli
Director, Engineering Services
Kabwe Municipal Council

Mr. Chiila
Chief Settlement Officer

Dr. Sewya
Kabwe Municipal Council

Vivian C. Chiloti
Director of Housing and Social Services
Kabwe Municipal Council

Dr. Dixon Suya
Director
District Health Board, Kabwe

Exildah Rose Samp
Occupational Health Nurse
Kabwe Mine Site

Patrick Katoti
Ndola City Council

District Director of Health
Kabwe

Micheal Kafula
Councilor, Wusakile Ward
Wusakile Township

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Acting Manager, Planning
Kitwe Health Management Team

Mary Mubila
Maternity project
Kitwe Health Management Team

Florence Wkingamina
Youth friendly coordinator
Kitwe Health Management Team

Luquendo Munda
Accountant
Kitwe Health Management Team

Staff
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Nkana Water and Sewerage

A. Mwaba
Deputy Director of Engineering
Nkana Water and Sewerage

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Kafubu Water and Sewerage (Ndola)

George Mukosai
Director of Engineering
Kafubu Water and Sewerage (Ndola)

Mr. Sinbeye
Technical Director
Mulonga Water and Sewer

Mavuto E Gondwe
Director – Occupation Health and Safety
Mine Workers Union of Zambia

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Manager
AHC-MMS

Tinus Kriek
Technical Manager
Saur International (with AHC-MMS)

Charles Muchimba
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Mine Workers Union of Zambia

Patrick Kampengele
Knight Piesold Engineering
Kitwe

Dr. E.M. Chishimba
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Agricultural Research Station, Mufulira

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Administrator
Copperbelt Technology Assessment Site,
Mufulira

Isaac Mauleka
Assistant Seed Analyst, Mufulira
Ministry of Agrticulture

Mining Companies

Alexie Mpishi
Environmental Services Officer
Mopani Copper Mines

Mathew Mwale
Senior Environmental Officer
Mopani Copper Mines

Vincent Chalwe
Environmental Coordinator
Mopani Copper Mines

Martin L. Matindo
Environmental co-ordinator – Konkola
Konkola Copper Mines

T Kapalasha
Senior Environmental Services officer
Roan Antelope Mining Corporation (RAMCOZ)

Wilson Manda
Assistant Concentrator Superintendent
Roan Antelope Mining Corporation (RAMCOZ)

N S Phiri
Concentrator Superintendent
Roan Antelope Mining Corporation (RAMCOZ)

Dr. Sixtus Mulenga
VP, Health, Safety, and Environment
KCM

Grace Mikunga
Public and Corporate Affairs Officer
KCM

Martin Matindo
Environmental Co-ordinator – Konkola
KCM

Theo Hacking
Manager- Environment
KCM

Jiang Xiaolu
Environmental Officer
NFC

Fred Mwendabai
General Manager
Ndola Lime

Lubinda wa Lubinda
Plant Metallurgist
Ndola Lime

Joseph Chishimba
Senior Metallurgist
Ndola Lime

Shadrack Mutwale
Accident Prevention Officer
Ndola Lime

Dr. Chan
Manager
Chambishi Metals

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Mining Warden – Mines Development Department, Kitwe
Pirala East Emerald Protected Area

NGOs

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VP, Red Cross Society of Zambia
Wusakile Township

Peter Sinkamba
Director
Citizens for a Better Environment

Alex Mutale
Director of Information
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Bernard Handima
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Catholic Commission for Peace and Justice

Andrew Bwualya
Trainer
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Programme Manager
Oxfam, Kitwe

Ann Mumbi
Programme Coordinator Governance and Capacity Building
Oxfam. Kitwe

Kabanda Bwendo
Project Officer - Agriculture
Oxfam, Kitwe

Eva Mazala
Project Officer - Agriculture
Oxfam, Kitwe

Patrick Mungaila
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Claire Chihili
Accountant: ZAMTAN ADP
World Vision International, Kitwe

Agnes Zalila Machiya
Development Officer: ZAMTAN ADP
World Vision International, Kitwe

D.T. Chilumbu
Country Co-ordinator
Advocacy for Environmental Restoration

Mwape Lubilo
Kenneth Mun
Simon Kunda
Programme for Urban Self Help (PUSH)
Lusaka Office

Manuel Neves
Bwalya Musonda
PUSH, Kabwe

Academic/Institutions

C.K. Mwamba
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National Institute for Scientific and Industrial Research

Dr. N.C.H. Lubaba
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S.C. Banda
Head, R&D Coordination and User Liaison Section
National Institute for Scientific and Industrial Research

G.M. Chishimba
Principal Scientific Officer
National Institute for Scientific and Industrial Research

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Programme Manager, Santren eLearning
School of Mines
The University of Zambia

Dr. Imasiku Nyambe
Senior Lecturer
Univ ersity of Zambia School of Mines

Dr. Enala T. Mwase
Biology-parasitologist
The University of Zambia

Dr. Osbert N. Sikazwe
Lecturer – Economic Geology
School of Mines, Geology Department
The University of Zambia

Dr. Mitulo Silengo
Dean
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Alex Romano Mutale
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School of Technology, Mining Department
Copperbelt University

D.A.Phiri
Lecturer
School of Built Environment
The Copperbelt University

John Kangwa
The Copperbelt University

Sam Kangwa
The Copperbelt University

Dr. Kanyembo
The Copperbelt University

Alex Mwale
The Copperbelt University

Portia O. Ceruti
Ph. D. Candidate in Soil Science
University of Stellenbosch

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ANNEX C:
ZAMBIAN REGULATION ON PUBLIC CONSULTATION IN ENVIRONMENTAL IMPACT STATEMENTS / ASSESSMENTS

ANNEX C: ZAMBIAN REGULATION ON PUBLIC CONSULTATION IN ENVIRONMENTAL IMPACT STATEMENTS/ASSESSMENTS

According to Zambian Statutory Instrument 28, projects are grouped into two broad categories – those that are not expected to have a major impact on the environment and thus only require project briefs, and those that are expected to have a major impact on the environment and thus require full environmental impact statements. Projects which involve resettlement are automatically grouped into the latter category. It will need to be determined whether the investments funded under the EMF - as clean-up operations - will require an EIS or a project brief.

With regard to public consultation on environmental impact statements, the regulation requires public consultation both on the terms of reference and on the actual statement as follows:

> "To ensure that public views are taken into account during the preparation of the terms of reference, the developer shall organise a public consultation process, involving Government agencies, local authorities, non-governmental and community-based organisations and interested and affected parties, to help determine the scope of work to be done in the conduct of the environmental impact assessment and in preparation of the environmental impact statement."

The regulation also requires that the developer of the project shall take all measures necessary to seek the views of the people in the communities which will be affected by the project, including:

"(a) Publicising the intended project, its effects and benefits in the mass media, in a language understood by the community, for a period of not less than fifteen days and subsequently at regular intervals throughout the process; and,

(b) After the expiration of the period of fifteen days, referred to in paragraph (a), hold meetings with the affected community in order to present information on the project and obtain the views of those consulted."

Once the environmental impact statement has been drafted and sent to the ECZ, the ECZ shall:

(a) Distribute copies of the environmental impact statement to relevant ministries, local government units, parastatals, non-governmental and community-based organisations, interested and affected parties;

(b) Place copies of an environmental impact statement in public buildings in the vicinity of the site of the proposed project; and,

(c) Place a notification in at least two national newspapers three times a week for two consecutive weeks, and broadcast a notification on national radio, detailing the place and time where copies of an environmental impact statement are available for inspection and the procedures for submitting comments."

The ECZ may organise or cause to be organised public meetings in the locality of the proposed project. Comments on the environmental impact statement can be received by the ECZ within twenty days of the last date of notification in national newspapers, radio. This period can be extended by 15 days if particularly sensitive issues have arisen during the public consultation, or if there are logistical problems in the consultation process. Following this, the Council may have a public hearing on the comments.

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ANNEX D:
PHYSICAL ENVIRONMENTAL SETTING

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FIGURES

1. PHYSICAL ENVIRONMENTAL INFORMATION: COPPERBELT MINING AREAS

1.1 INTRODUCTION

This Appendix summarises available information on the physical environmental setting of the CEP. The appendices to the EISs prepared by SRK for each of the former ZCCM operations in the Copperbelt were used as an important source of information.

1.2 LOCATION

The CEP project area covers approximately 150 km by 50 km. It is centered on longitude 28°15′ and latitude 12°40′ close to Zambia's northern border with the Democratic Republic of Congo (Fig. 1). The orientation of the area is broadly NW-SE, as defined by the region's principal structural feature, the Kafue Anticline. Physiographically, it is dominated by flat or gently undulating topography of the Central African Plateau. Altitudes range from 1200 m in the southeast to 1450 m in the northwest.

1.3 GEOLOGY

The geological setting of the Zambian Copperbelt comprises a Neoproterozoic extensional basin with an infill of ca. 10,000 m of Katangan sediments. These are conventionally sub-divided into the Roan Supergroup and the Lower and Upper Kundelungu Supergroup. The base of the Katangan sequence has an age of approximately 870 million years, with the top of the sequence probably dating to around 650 million years.

The geology of the Roan Supergroup is of greatest relevance with respect to the economic geology of the Copperbelt. The Supergroup is sub-divided into three lithostratigraphic divisions, the Siliciclastic Unit, the Mixed Unit and the Carbonate Unit. The Siliciclastic Unit constitutes the basal sequence, consisting of red beds of hematitic conglomerates, sandstones and siltstones. These red beds have a recognized thickness of 450 m. The overlying Mixed Unit consists of a cyclic sequence of dominantly reduced fine grained Siliciclastic and carbonate rocks. These are, in turn, overlain by the Carbonate Unit, consisting of dolostone and interbedded dolomitic shale.

1.4 HYDROLOGY

Approximately 90% of the region, including most areas of mineral extraction and beneficiation, is drained by the Kafue River and its dendritic tributary network. The Kafue River bissects the Copperbelt in a south-southeasterly orientation, rising from headwaters close to the Congo border, approximately 100 km upstream of the Konkola Division. Discharges affected by mining occur along an 80 km length of channel extending from Konkola and Nkana. Important tributary systems with respect to contaminant fluxes include the Kakosa stream at Konkola, the Mushishima Stream at Nchanga, the Mufulira Stream at Mufulira, the Lukashi and Musakashi streams near Chambishi, and the Mindola, Kitwe, Uchi, Wusakile, Lwanshimba and Chibuluma streams at Nkana.

1.4.1 KAFUE RIVER

A functioning flow monitoring network is essential to the assessment of the effects of mining and other activities on the Kafue River. Discharge data are essential for dilution calculations, flow frequency analysis, and a variety of other purposes. Based on the list of hydrometric stations for the Kafue River obtained during this EA, the monitoring network appears adequate. The frequency of flow measurements and the state of repair of the gauges are, however, suspect. A proper assessment of the adequacy of the existing Kafue River flow monitoring network will be a necessary component of the CEMP. At a minimum, the network should include measurements of all large tributaries, and of the Kafue River itself at points upstream of the Copperbelt, at Kitwe, and downstream of the Copperbelt.

1.4.2 PLANT SITES

Monitoring Network

Based on the information contained in the EMPs, the plant site flow monitoring networks appear to be quite comprehensive. Water quality and flow sampling occurs at many locations (for example, 50 locations at the Nkana Mine), at daily, weekly, and monthly sampling frequencies. The networks include key external discharge points. Exceptions appear to be adequately identified in the EMPs and environmental audits. The required frequency of monitoring is highly dependent on the variability of the discharge. Highly variable discharges need to be monitored frequently, while more constant discharges require less monitoring. The frequency of monitoring at key external discharge points (e.g. to the Kafue River, Luanshya River, etc.) is of importance, and needs to be examined in greater detail in the CEMP.

Accuracy of Measurements

African Mining Consultants and Golder Associates (1998), in their review of the Konkola Mine (LML3), describe the method used by Konkola personnel for streamflow measurements. This entails estimating average channel velocities by measuring the flow velocity of a floating object, and multiplying this velocity by an approximate channel cross-sectional area. This methodology is probably adequate to gauge relative changes in flows, but results in a very crude flow estimate. At a minimum, flow measurement structures (e.g. weirs, flumes) or calibrated natural sections (at standard streamflow measurement practice) should be established for all external discharge and key internal measurement locations.

1.5 WATER QUALITY

1.5.1 KAFUE RIVER

Long-term baseline water quality information was not available for review. Water quality samples are known to have been collected by GRZ authorities, but the adequacy of this sampling program has not been assessed.

An independent study by Norrgren *et al.* (2000) presents water quality data collected over a one year period (1995-96) in the Copperbelt. The key findings (related to water quality) of the paper were:

- Concentrations of cobalt, copper, and sulphur are much higher in the mining areas. Dissolved copper showed highest concentrations during the wet season, in sharp contrast to other elements, which appeared to be diluted by higher wet season flows. It was surmised that higher copper concentrations were derived from wash-out of copper-rich spoil piles in the mining areas.
- The Kafue is relatively low in dissolved trace metal concentrations in water relative to other world mines in non-carbonate rich zones. However, secondary particles (oxyhydroxides) were highly enriched in cobalt, copper, and other compounds. The metals attached to these particles may be bioavailable. More information on this topic is presented in the next section.
- DDT (and breakdown products) and PCBs are present in measurable amounts.

It is clear from a review of the data that not all of the elevated compounds can be attributed to mining. For example, lead exhibited the greatest percentage increase in metals concentrations across the Copperbelt. This is more likely the impact of the municipalities and leaded gasoline than mining.

It is crucial, therefore, to incorporate both mining and non-mining discharge monitoring in any future water quality assessment projects.

1.5.2 PLANT SITES

Water quality monitoring networks at the mine sites are generally quite extensive (some of the sites, such as Nkana and Konkola, have 50 or more sample locations). Sample analyses include major cations, nutrients, key indicator parameters, and some trace metals. Samples are analyzed using a combination of portable laboratory equipment (Hatch Kits) and the mine laboratories (primarily for metals). The frequency of sample collection (daily, weekly, or monthly) depends on the sample location. It is not evident from the EMPs what rationale is applied in determining the required frequency of sampling. Ultimately, it is the variability in water quality, which should dictate sampling frequency. Sampling frequency is of particular concern in highly variable discharges (such as effluent from plant operations during an upset, or from eroding structures during periods of intense rainfall). Water quality results are tabulated in a computerized database (EQWin) at most mines.

Non-compliance with statutory effluent limits was documented in site audits as a frequent occurrence at some locations. These include Nkana (excess Co and Cu in Uchi stream discharges, high TSS in Wusakile storm drain), Nchanga (high TSS in Mushishima discharges) and Konkola (high TSS in Kakosa discharges). The inadequacy of sewage treatment plants (inadequate capacity and/or maintenance) was also mentioned in many of the EMPs and audits. Water quality discharges were typically violated due to:

- plant upsets or (less often) leaching: metals (Cu, Co)
- erosion (high TSS)
- sewage treatment plants (coliforms, nitrite, ammonia)

The aesthetic impact of mining discharges (particularly with respect to excess TSS) is certainly severe. The export of dissolved metals appears to be small relative to other mining areas of the world, though certainly there are specific locations where metals concentrations exceed statutory limits. There is concern, however, that suspended sediments, or secondary particles formed during liming of discharges, may become bio-available directly or through conversion when deposited in bottom sediments. This is of particular concern in the Kafue River and larger tributaries, where metals may be incorporated into the food web (including fish populations).

1.6 HYDROGEOLOGY

Due to the challenges and expense associated with mine de-watering, there has been a significant effort made to understand the groundwater flow regime at those mines where pumping is required. The aquifers in which mining occurs are highly productive. Konkola, for example, is reputed to be the "wettest" mine in the world (pumping rates of approximately 300,000 m^3/day, or 3.5 m^3/s).

The EMPs adequately describe the hydrogeological settings of the mines, but the work presented has a geotechnical (mine de-watering) rather than an environmental focus. There is no information on regional groundwater users, of the impact of mining on regional shallow groundwater (the most likely source for domestic water supplies) levels, or of the impact of mining on groundwater chemistry.

1.7 CLIMATE

A permanent meteorological station is located at Ndola, about 50 km east of Nkana. Additional data collection facilities exist at Kafironda in the north-west, Nkana and Mufulira. Climatically, the Zambian Copperbelt has three distinct seasons. The winter months of May to July are characterized by cool, dry conditions, with mean daily maximum temperatures of around 20°C, and gross rainfall of below 150 mm. August to October is characterized by hot, dry conditions, with maximum temperatures of around 36°C. A wet summer season, during which over 90% of the region's mean annual precipitation of 1350 mm falls, extends from November to April. The 30 year maximum 24 hour precipitation has been calculated as 126 mm and the 100 year maximum 24 hour event as 149 mm. Precipitation and evaporation data from Kafironda Station are presented in Table C.1. These indicate an exceedance of precipitation by evaporation for two thirds of the year.

The predominant wind direction in the Copperbelt is from the north-east (thus producing a net atmospheric contaminant plume to the south-west), with maximum speeds of about 30 m/sec in the summer months and 22 m/sec in the winter. During the summer months, sporadic moist air movements from the Atlantic Ocean over Congo produce westerly winds and intense thunderstorms.

TABLE D.1: MONTHLY MEAN PRECIPITATION – KAFIRONDA STATION

Month	Mean Rainfall (mm)	Mean Evaporation (mm)
January	292	144
February	234	134
March	221	130
April	76	125
May	5	163
June	0	147
July	0	171
August	1	220
September	4	253
October	30	257
November	155	178
December	323	150
Annual Total	**1341**	**2072**

1.8 SOILS

Soils of the Copperbelt are typically lateritic, with weathering depths in excess of 50 m and deep zones of saprolitic development. These laterites are characteristically acidic, leached of silica and base nutrients, and highly enriched in iron and aluminum oxides.

2. PHYSICAL ENVIRONMENTAL INFORMATION: KABWE

The following summary of the physical environmental characteristics of Kabwe was obtained from Zambia Consolidated Copper Mines Limited's Kabwe Mine Site Rehabilitation and Decommissioning Plan, Appendices, Figures and Photographs, February, 1995. For more detailed information, consult this report and its appendices.

2.1 LOCATION

Kabwe is situated about 130 km north of Lusaka and is located in the Central province. Kabwe provides a strategic linkage between Lusaka and the northern region, which includes the Copperbelt, Northern and Luapula provinces.

2.2 TOPOGRAPHY

The terrain of the Kabwe area is generally a gentle relief, as is common in the Central African plateau. Kabwe Division is located at an altitude of 1180 m above sea level. The highest point is at Kalulu (1223 m) located about 10 km north west of Kabwe.

The terrain slopes in all directions from Kalulu, from which a radial drainage pattern has developed forming the headwaters of the streams that drain into the Kafue and Lunsemfwa River systems.

Surface drainage from the Kabwe Mine is mainly into the Main Canal, which flows eastwards towards the Muswishi River into the Lunsemfwa drainage.

2.3 GEOLOGY

In the Kabwe district, a series of discrete Pb-Zn orebodies is hosted in the Katanga System (see Copperbelt geology for stratigraphic detail). The system is locally sub-divided (base-upward) into the Lower and Upper Broken Hill series (phyllites, quartzites and schists), the Nyama Formation (dolomites and volcaniclastics) and the Lukunga Formation (phyllites). Together, these lithofacies are interpreted as a cyclic, shallow-marine sequence, which has subsedquently been subject to low-grade metamorphism.

All Kabwe orebodies are hosted in massive dolomite. Mineralization occurs in the form of steeply dipping, structurally controlled veins, pods and pipes with strike lengths of up to 800 m. Mineralizing fluids were introduced during the emplacement of a series of granitic intrusions, and were focused within the intesection zone of at least two regional structural conduits.

The Kabwe orebodies typically comprise a sulphide core surrounded by an oxidation zone of secondary Pb and Zn phases. The sulphide mineral assemblage consists of medium to fine frained pyrite (FeS2), sphalerite (ZnS) galena (PbS) with minor Cu and As minerals such as bornite, covellite, chalcocite and tetrahedrite. In the transition zone between sulphide and oxide facies, galena is substantially converted to cerrusite (PbCO3). In the oxidation zone, the main ore minerals are willemite (ZnSiO4), smithsonite (ZnCO3) and cerrusite (PbCO3). A range of secondary vanadates, carabonate arsenates, sulphates, molybdenates and copper phases is also present.

2.4 HYDROLOGY AND HYDROGEOLOGY

The main aquifer in the area is the Central Dolomite which comprises dolomites and limestones.

Kabwe Division lies on the boundary of the Kafue/Lunsemfwa watershed with only gentle relief. The drainage pattern shows radial surface flows from a central dome, which corresponds approximately to the area of the Central Dolomite. Streams to the west and southwest drain to the Kafue catchment, while those to the north and east drain to the Lunsemfwa. Under these conditions, it is envisaged that the Central Dolomite feeds the headwaters of the relationship between the surface drainage and the underlying geology.

There are currently three major abstractions from the aquifer: the Kalulu water fields, Makululu (Central Dolomite) aquifer and the Davis Shaft dewatering.

2.5 CLIMATE

The Government of Zambia have operated a meteorological station at Kabwe since 1950.

Precipitation - Rainfall occurs mainly during October to May. The mean annual rainfall for the region is between 900 to 1000mm, and at Kabwe it is 900mm. From these records, the Probable Maximum Precipitation (PMP) is estimated at 67mm in a 24-hour period.

Evaporation - Evaporation records have been taken at the Kabwe Meteorological Station since 1950. Evaporation for the region ranges from 48 to 295mm, with an average of 90mm per year.

Temperature - For the period 1950 to 1994, the mean monthly temperatures range from a minimum of 14.2°C to a maximum of 26.8°C. The mean temperature for the period is 20.2°C.

Winds - The prevailing winds in the Kabwe area are from the south east to the northwest. The annual wind speed is 52 m/s.

2.6 SOILS

Soils of the Kabwe area are dominated by acrisols (using FAO/UNESCO soil map). Acrisols are a ferruginous weathered tropical soil type common throughout the area but that mostly occur over the dolomite and under the Kalulu Forest.

A polzolic type of soil is common in the Katanga schist and quartzites and over the Basement Complex.

The surficial solid depth typically ranges between 2 to 10m.

In the wetland areas (dambos) black clayey vertisol occur which crack when dry.

The dolomite host rock of the Kabwe region has metal levels of 0.02% Pb, 0.1% Zn and 0.005% Cd. During weathering over geologic time the soils will most probably contain these elements. The amount of elements in the soils will depend upon the age of the soils and the rate of weathering of the parent rock and anthropogenic activities.

The measured lead levels in the surficial soils of the Kasanda Township range from 0.04 – 0.20% Pb, depending upon the distance form the plant. These lead levels are considerably higher that those measured in the host rock.

3. ECOLOGICAL INFORMATION: COPPERBELT MINING AREAS

This annex summarises available ecological information for the Copperbelt obtained from literature sources, consultations and ecological surveys produced for the Copperbelt by ZCCM and their commissioned consultants (notably SRK) as a discrete component of the EISs prepared for each of ZCCM's former holdings.

Due to the considerable area encompassed by the Copperbelt, it has considerable potential to support wildlife. It also includes several areas of National Forest. Examples include Lamba Headwaters National Forest to the west of Chingola, Konkola National Forest to the west of Chililabombwe, Luano National Forest east of Chingola, and Misaka National Forest. The status and condition of these areas needs to be taken into account in relation to the CEP. In addition, incorporation of wildlife management options into mine restoration plans should be considered.

3.1 BACKGROUND

Few areas of the Copperbelt remain free from modification by human activities, notably logging for charcoal, clearance for subsistence-level maize and cassava production, grazing and ranching. In addition, almost total destruction of natural vegetation is associated with many mining facilities, in particular in areas of tailings and overburden storage.

Detailed ecological studies are lacking for many parts of Zambia. Many of the earlier studies on vegetation were carried out primarily with a focus on timber production and resources, and did not necessarily record wider characteristics of the vegetation. This applies equally to the baseline studies carried out by SRK (and their sub-contracted consultants) as a component of the EISs for the former ZCCM mine license areas.

Some potentially valuable vegetation studies were, however, conducted several decades ago by Martin (1932-41) and Trapnell (1937,1943), and followed up by Lawton (1959, 1962, 1964), Lees (1962) Savory (1961, 1963), Trapnell (1959), D.B. Fanshawe (1960-64) and Silvester Chisumpa (1980s). From 1995 to 1997, a team from the Missouri Botanical Garden carried out additional surveys which have contributed to ecological understanding of Zambia's vegetation. However, relatively little of Zambia's vegetation is undisturbed by human activity, making it difficult to interpret the results of ecological studies. This is particularly true of the Copperbelt, which has become the most industrialised province of Zambia and has undergone major ecological changes as a result.

3.2 VEGETATION COMMUNITIES REPRESENTED

From the baseline data available, it is possible to arrange the vegetation types of the Copperbelt in catenary sequences along biotic/edaphic gradients:

- Closed Forest
  a. Parinari forest
  b. Marquesia forest
  c. Swamp forest
  d. Riparian forest
  e. Chipya
- Open forest with Grass
  a. Miombo woodland
  b. Munga woodland
- Termitaria
  a. Miombo
  b. Riparian
  c. Munga
- Grasslands

Parinari forest: Canopy dominants are restricted to *Parinari excelsa* and *Syzygium guinense* ssp *afromontanum* with odd emergent *Entandraphragma delovoyi*. *Marquesia macroura* and *Erythrophlem suaveolens* are canopy associates especially in the South Mutundu block which is close to Congo DR.

Marquesia Forest: Canopy dominants are restricted to *Anisophyllea pomifera, Marquesia acuminata, Marquesia macroura, Podocarpus milanjianus* locally and *Syzygium guinense* sp afromontanum.

Chipya: Chipya on the Copperbelt is a three-storied woodland with an open evergreen to deciduous canopy 21-27m high characterised by *Acacia albida* (locally), *Albizia antunesiana, Burkea africana, Combretum mechowiamum, Erythrophleum africana, Ficus sycomorus* (locally), *Parinari curatellifolia, Pterocarpus angolensis, Terminalia sericea*. The understorey is discontinuous, evergreen to semi-deciduous, and 6-12m high. The shrub-layer, is 2-3m high and is evergreen to semi-deciduous. Occasionally the shrub-layer takes the form dense shrub/scrambler. Finally there is a luxuriant ground flora, 0.6-2m high of sub-shrubs and tall herbs including the chipya indicators, especially *Aframomum biuriculatum, Clematopsis scabiosifolia, Clerodendrum tanganyikensis, Clerodendrum uncinatum, Desmodium barbatum, Indigofera sutherlandiodes, Lanner edulis, Ochna leptoclada, pteridium aquilinum, Smilax kraussiana* and *Psorospermum febrifugum*.

Swamp forest: This is a three-storied forest with a closed evergreen canopy around 27m high characterised by *Ilex mitis, Mitragyna stipulosa, Syzygium cordatum* and *Syzygium owariense, Xylopia aethiopica* and *X. rubescens*. The discontinuous evergreen understorey is between 9-18m high and is characterised by *Aporriza nitida, Garcinia smeathmanni, Gardenia imperialis* and *Phoenix reclinata* palms. There is a dense evergreen shrub-layer which is continuous, at 2-4.5m high with species like *Cephaelis peduncularis, Craterispermum laurinum* and *Dracaena camerooniana* as dominant. The ground is usually bare or covered with pure stands of stout semi-succulent herbs such as *Afromomum angustifolia, Costus sarmentosus* and *Renealmia engleri* to 1-3m high in flooded or seepage swamp or pure stands of Acanthaceous sub-shrubs. Climbers are rare, mostly *Artabotrys monteiroae* and *Landolphia buchananii* in the canopy and *Sabicea laurentii* and *Smilax krussiana* in the understorey.

Riparian forest: This usually forms a more or less continuous strip on gorge sides and narrow alluvial strips and spreads out on to the wider alluvial flats beside rivers. At best development consists of a three storied forest with a closed evergreen canopy of 21m high or more, characterised by *Diospyros mespilliformis, Kyaya aethotheca, Parinari excelsa* and *Syzygium cordatum* associated with *Adina microcephala, Bridelia micrantha, Cleistanthus milleri, Faurea saligna, Homalium africanum, Ilex mitis, Manikara obovata* and *Raphia* palms in some cases. There is a discontinuous evergreen understorey around 15m high with species like *Chysophyllum magalismontanum, Clausena anisata, Diospyros lyciodes, Gracinia* sp, *Gradenia imperralis*, and *Rhus quartiniana* well represented. Climbers are a feature especially *Abrus precatorius, Cocculus hirsuta, Comretum microphyllum, Jasminum fluminense, Paullinia pinnata, Strychnos angolensis* and *Tacazzea apiculata*. Epiphytes, especially Orchids are frequent.

Miombo: Miombo woodland is a two storied woodland within an open or lightly closed canopy of semi-evergreen trees 15-21m high, characterised by species of *Brachystegia, Isoberlinia, Julbernadia* and *Marquesia macroura* with *Pericopsis angolensis, Anisophyllea pomifera*. (locally), *Erythrophleum africanum* and *Parinari curatellifolia* as frequent associates. The understorey is characterised by species such as *Albizia antunesiana, Anisophyllea boehmii, Brachystegia stipulata, Dalbergia nitidula, Diospyros batocana, Diplorhynchus condylocarpon, Ochna scheinfurthiana, Phyllocosmus lemaireanus, Pseudolachnostylis maprouneifolia, Rothmania englerana, Strychnos* spp, *Syzygium guinense* spp *macrocarpum* and *Uapaca* species. The underwood consists of either dense grass/suffrutex layer 0.6-1.3m high or a dense evergreen thicket 1.3-3.6m high.

Munga woodland: This is also referred to as Acacia woodland. It is usually associated with flat topography but strips of munga woodland also follow the streams and their small tributaries. Munga is an open park-like, 1-2 storied deciduous woodland with scattered or grouped emergents up to 18m high characterised particularly by Acacia, Combretum and Terminalia species. The understorey is absent or patchy sometimes dense and thicket like 1.3-4.5m high. Semi-deciduous or deciduous.

Grasslands: These are mainly associated with drainage lines or with underground drainage. Grasslands typically comprises a dense mat of grasses, sedges, herbs, sub-shrubs and to some extent some ground orchids. The grasses are perennial bunch-like, cushion-like or tussocky. *Loudentia simplex* is the characteristic species. Associated common genera include Acroceras, Alloteropsis, Andropogon, Aristida, Bothriochloa, Brachiaria, Digitaria, Panicum, Setaria, Echinochloa, Eragrostis and Trachypogon.

The baseline reports for the former ZCCM mining license areas refer to the presence of Miombo and Acacia woodland and grasslands, but the habitats are not described clearly in the form of vegetation associations or communities.

3.3 FAUNA

No adequate faunal inventory exists for the Copperbelt's mining license areas. The ZCCM EIS statements provide only non-systematic observations, based on incidental sightings of fauna in close proximity to access roads. A clear requirement exists to classify wildlife species within license areas with respect to their frequency, and relative vulnerability to disturbance.

3.4 MONITORING DATA AND INFORMATION ON STATUS AND DISTRIBUTION

There is no regular monitoring or recording of vegetation trends in Zambia, so the national distribution and status of vegetation types is unknown. Limited work has been undertaken through the Provincial Forestry Action Program (PFAP). However, the results do not provide sufficient botanical detail to form a reliable baseline for ecological monitoring.

Zambia has no national repository for biodiversity data. However botanical information is held by Forestry Research in Kitwe and Mount Makulu Agricultural Station (largely grasses and crop species). The University of Zambia also holds some limited data. IUCN have collated information on wetlands and the more important wildlife areas. ZAWA, the Zambian Wildlife Authority may also hold relevant information. In compiling a baseline ecological inventory for the Copperbelt, it will be imperative that these organisations are contacted, and available information collated.

Of particular importance in the Copperbelt are a number of epiphytic and ground orchids and relic species that are at risk of extinction if the current rate of habitat loss for these species continues. Habitat loss is attributable to a variety of causes. Integrated or cumulative effect assessment will therefore be required in the region to identify suitable mitigation measures.

3.4.1 ADEQUACY OF EXISTING ECOLOGICAL SURVEYS OF MINING LICENSE AREAS

The status of flora and fauna in ZCCM's mining license areas was surveyed in 1996 as a component of SRK's EIS program. The original data for these surveys are not available and accordingly it is difficult to determine the suitability of the existing reports as a basis for future management decision-making. The stated objectives of the surveys and reviews were to:

- Document the existing status of wildlife in the thirteen mining license and surrounding areas in order to assess the impact of mining activities on wildlife habitat.

- Describe the 'natural' or baseline conditions in the areas unaffected by mining in order to provide a basis to establish closure objectives and wildlife enhancement programs.

Due to restricted time and resources, only superficial studies were made, with a focus on vegetation (trees), larger mammals and birds. While relatively detailed inventories of vegetation appear to have been made, only dominant trees, shrubs and some grasses were identified to species-level. Only incidental sightings of birds and mammals were recorded and other faunal-groups were not studied. At each site, the following information was obtained:

- Measurements of diameter at breast height (DBH) and basal area (BA) for trees in 10m x 10m temporary plots.
- Estimates of tree height in the same plots.
- Description (list) of main shrub and grass species in the same plots (no estimates of relative abundance).
- Incidental sightings of wildlife obtained while driving along established roads.
- Records of animal presence/ habitat-use along temporary transects (no indication that transects were set up to target particular groups or designed to reflect their different needs and in some cases roads used as transects, likely to bias results).
- Subjective estimates of habitat suitability for game species.

The ZCCM EIS baseline studies do not provide details of the sampling strategy. For example, the number of temporary vegetation-recording plots is not specified and no information is given concerning methods used to select sampling locations. The intensity of sampling is therefore unknown and it is not possible to evaluate the extent to which all characteristic vegetation types have been sampled.

Similarly, the ZCCM EIS studies do not specify the number of transects established in each license area or the methods used to select their locations. The reports do not specify the vegetation types in which the transects were located, or indicate how many transects were established per vegetation type. Again, it is therefore impossible to evaluate the coverage or intensity of the sampling design from the information available in the baseline summaries.

3.4.2 EVALUATION OF WILDLIFE SUITABILITY

For each license area, six criteria were used to evaluate sites and rank them according to their suitability for wildlife:

- Vegetation carrying capacity,
- Other land uses,
- Human population,
- Present stock,
- Terrain,
- Water.

Criteria were ranked 0=very poor/low; 1=poor/low; 2=good/high; 3=very good/high vegetation, carrying capacity, present stock, terrain, availability of water. The parameters 'other land uses' and 'human population' were ranked in reverse (i.e. 0=very high; 1=high; 2=low and 3=very low). It is notable that the criteria are not truly independent. Human population and prevalence of 'other land uses' are, for example, clearly linked. It is therefore not appropriate to use additive scores to rank license areas, as attempted in the EIS studies. The results do, however, provide some estimate of the general suitability of each license area for wildlife.

It is notable that the EIS baseline studies evaluate habitat suitability for wildlife on the basis of existing conditions. No reference attempt is made to evaluate post-rehabilitation potential. Such an approach would greatly facilitate cost-benefit analysis, and the prioritisation of remediation expenditure under the CEP.

Table D.2 summarises available ecological information for all mining license areas.

TABLE D.2: SUMMARY OF INFORMATION ON WILDLIFE HABITATS AND SPECIES, AND THE IMPACTS OF MINING AND OTHER ACTIVITIES

Mine Licence Area	Habitats Referred to	Dominant Plant Species	Wildlife	Presence of Threatened Species	Impacts of Mining	Impacts of Other Activities	Subjective Habitat Quality Rating[1]	Notes
Kabwe ML.1*			Little information. Wildlife adversely affected by loss of habitat		Vegetation supressed, fairly disturbed		III	Disturbed site; some vegetation has been planted, including these tree species: Eucalyptus hybrid, *Toona ciliata, Achrocarpus frazinifolia, Acacia spp.*
Nkana ML.3	Wetlands and aquatic habitats Miombo and Acacia woodlands	*Julbernidia spp, Brachystergia floribunda, Isobelinia angolensis*. Grasses *Hyperhenia and Setaria spp*	Crocodiles, hippos and wetland birds			Farming, gardening, collection of poles, grass for thatching, firewood, charcoal burning, livestock grazing all contribute to wildlife habitat loss	II	Need for afforestation, fire management, resolution of land-use conflicts
Konkola ML.7	Aquatic habitat (artificial, e.g. sewer ponds)		Common duiker, Grysbok, Giant rats and other mammals may be present in very low numbers. Rich bird life: cattle egret, sacred ibis, Squaco heron, Darters, African jakana and purple heron. Crocodiles and hippos		Relatively insignificant	Illegal settlement: farming, gardening, collection of poles, collection of thatch, firewood collection, charcoal burning and livestock grazing. Careless fires	II	• Aquatic habitat adversely affected by eutrophication • Encourage early burning to reduce dry season fires
Ndola Lime ML.8							II	
Nchanga ML.10	Miombo woodland	Brachystergia longifolia, Diospyros batokana, Hymenocardia acida and Erythrophleum africanum. Understorey of Pseudolenchnostylis maprouneifolia, Hyprrhenea and Setaria spp	Giant rat, Bush squirrel, Grysbok, Common duiker. Birds: tits, weavers, pigeon, kingfisher, swallow, owl, guinea fowl		Vegetation suppressed in vicinity of active open pit and rock dump	High population of illegal settlers. Farming and tree-clearance causing drying up of streams. Much of area very disturbed	III	• Re-afforestation with indigenous tree species. • Management of soil erosion and in-filling of excavated areas. • Fire management (fire breaks and early burns)
Mufulira ML.15	Miombo woodland Aquatic	Brachystergia, Julbernadia, Isoberlina, Marquesia macruora and parinari curatellifolia Common grasses noted were *Setaria, Digitata* and *Hyperrhenia*	No wildlife recorded in surveys by Mwima *et al.*, (1997). Velvet monkeys, Guinea fowl, Bush squirrels, Giant rats, Wildcats and bushbabies recorded by Sichinga and Chirwa (1996). Possibly crocodiles. Water supply limited Fish in streams		Vegetation around plant area is scanty and stunted. Much dumping of waste material and wind-blown dust. Damage to vegetation by machinery, disturbance from noise	Mutundu area badly affected by farming, tree-cutting for charcoal and various household uses	II	• Land use zoning • Controlled tree-cutting and re-afforestation
Luanshya ML.16	Miombo woodland	*Brachystergia boehmii, Isoberlina angolensis, Marquesia macruora, Uaparcapa kirki, Parinari curatellifolia, Dombeya rotundifolia* and *Termitalia* species			Stunted tree growth possibly due to SO_2 emissions Land subsidence with loss of vegetation.	Understorey, *Hyperrhenia, Setaria* and *Andropogon* grass species damaged by late fires	II	• Some natural regeneration of Miombo woodland • Some stunted growth • Fire management to prevent late damage to grasses (burn April to June) • Maintain low levels of human disturbance if possible
Baluba ML.17	Miombo woodland	Trees: Julbernadias, Bracystergias, *Maquesia macruora* and *Isoberlina angolensis*. Grass species *Hyperrhenia, Setaria, Andropogon* and *Setaria vetisellata*.			Only significant damage towards main entrance	Illegal settlement absent and woodland relatively undisturbed	I	

[1] Classification: I: area with very high potential for wildlife use; II: Area with some potential for wildlife use but may require detailed ecological survey; III: Area with low potential for wildlife but which should not be ruled out for ecological survey. (Based on SRK findings).

Mine Licence Area	Habitats Referred to	Dominant Plant Species	Wildlife	Presence of Threatened Species	Impacts of Mining	Impacts of Other Activities	Subjective Habitat Quality Rating[1]	Notes
Chibuluma South ML 39	Miombo woodland	*Julbernadia spp, Brachystergia spciformis, Parinari curatellifolia and Isoberlina angolensis*	None seen by Mwima *et al* (1997) but Bushbuck, Common duiker and other mammals may be present in low numbers		No mining impacts yet? Access and survey routes created	Gardening for maize, cassava and vegetables Illegal settlement	II	In the absence of mining high potential for wildlife if settlement/ land use pressures can be regulated
Chambishi ML.19	Miombo woodland	*Brachystegia, Julbernadia* and *Isoberlinia*	Grysbok droppings seen. Velvet monkeys.	*Pterocarpus angolensis, Faurea saligna, Erythrophleum africanum, Afzelia quazensis*	Waste dumping, infrastructure development causing habitat loss. Disturbance by machinery noise Vegetation mortality in vicinity of acid plant with complete loss of 2 ha near tailings dam	Charcoal burning, farming, collection of poles and thatch, firewood collection, charcoal burning, livestock grazing. Careless fires	II	• Some relatively undisturbed trees • Restoration of excavations with re-vegetation as possible • Regulation of land uses • Fire management (fire breaks)

* Kabwe was based on information obtained from the ZCCM Site Decommisioning and Rehabilitation Plan and on observations noted during October 2001 field visit.
Note: Data unavailable for cells left blank.

3.5 WILDLIFE AND GAME POTENTIAL

Options for game ranching were reviewed for all ZCCM mine license areas as a component of the EIS program. The main resource, equipment and personnel requirements for game ranching are defined and suitable stock species recommended. While the probable percentage of each mine which may be amenable to game ranching is specified (Table C. 3), such areas are not actually delineated.

TABLE D.3: GAME-RANCHING PROPOSALS FOR SOME MINES

Mine Licence Area	Total Area of Mine License Area (km^2)	Recommended Ranch Area (km^2)	Recommendations
Nkana ML 3	118.17	12	Fairly rich and diverse vegetation that can support wildlife. Following species of animals to be stocked: Roan Antelope, Sable Antelope, Eland, Impala, Reedbuck and Hartebeest. The area can also stock Helmeted Guinea Fowl and Francolins.
Konkola ML 7	110.78	11	Probably suitable for Roan, Sable, Eland, Hartebeest, Waterbuck, Kudu, Impala, Zebra and Common duikers, but further survey required
Ndola Lime ML 8	3.845	-	Not recommended
Nchanga ML 10	117.63	-	Not recommended without remediation, otherwise possibly could support Roan Antelope, Sable Antelope, Common waterbuck, Puku, Kudu, Eland, Zebra, Southern Reedbuck, Impala and Hartebeest. The area can also sustain game birds such as Guinea fowl, Francolins
Kansanshi ML 11	42.43	6.0	Possibly suitable for re-stocking with Roan, Sable, Eland, Hartebeest, Impala, Reedbuck and birds; Guinea fowl, Francolin and Quail.
Mufulira ML 15	129.5	13.0	No recommendations concerning species suitable for re-stocking: area significantly affected and probably requires habitat rehabilitation.
Luanshya ML 16	43.71	9.0	Relatively good for wildlife. Suitable for ranching 'big and small antelopes'
Baluba ML 17	633.59	9.5	High wildlife potential if water provided
Chibuluma South ML 39	9.6	2.0	No specific recommendations given. Good for wildlife but only a small area available
Chambishi ML 19	144.5	9.0	Suitable for Sable, Roan, Waterbuck, Hartebeest, Impala, Common Duiker, Eland, Zebra and Kudu
Total Area		**71.5**	

3.6 AQUATIC BIOTA

3.6.1 PLANT SITES

Aquatic investigations were performed at most mine sites. Data collected included water quality sampling (generally temperature, dissolved oxygen, pH, turbidity, salinity, color, conductivity, ammonia, nitrite, chlorine, nitrate, phosphate, some heavy metals), and surveys of zooplankton, phytoplankton, invertebrates, vertebrates and macrophytes. A single dry-season survey was performed at each mine. The biota was sampled using a plankton net. Benthic invertebrate sampling appears to be absent from these surveys, as were physical measurements at the sampling locations (substrate composition, depth, velocity, etc.).

No wet season sampling appears to have been done.

Species diversity indices and other quantitative measures of aquatic health appear not to have been calculated.

The aquatics program conducted to date will provide a broadly qualitative reference point to examine the effects of future mitigation work. In some locations, for example, the sample locations were entirely devoid of aquatic life. Future sampling may show the re-establishment of aquatic life, thus indicating an improvement in water quality. More subtle changes in aquatic biota will not likely be discernible given the currently available database.

3.6.2 KAFUE RIVER

No formal studies of aquatic biota in the Kafue River have been performed. Similarly no studies of metal concentrations in fish caught for human consumption have been conducted. A caged fish (Tilapia) study was conducted as part of an environmental study of the Kafue River (Norrgren *et. al.*, 2000), which showed an uptake of metals in the gills and liver of Tilapia over the course of the two week study.

There have been other reports (noted in Norrgren *et. al.*) of impacts on aquatic biota which have been ascribed to mine discharges:

- There are reported incidents of cattle losses ascribed to toxic levels copper associated with iron and manganese oxyhydroxides in sediment (ZCCM, 1982)
- A microtoxicity test showed that no early life stages of Tilapia juveniles survived on sediment from the Kafue River collected in the mining area (Mwase 1994)
- It has been reported (SRK, 1997) that the Hippo Pool near Nchanga is now largely devoid of hippopotami, ostensibly due to sediment discharges from the mines. However, the disappearance of the hippopotami may be due to other factors, including disturbance by humans, water quality degradation due to sewage discharges or other toxins, etc.

4. ECOLOGICAL INFORMATION: KABWE DISTRICT

Ecological information pertaining to the former ZCCM lead mine site is limited, thus information regarding the Kabwe district is provided in this section.

The area around Kabwe is dominated by Miombo woodlands. In several places there are extensive stretches of Chipya woodland typical of the lake basin. Swamp forests are scattered in water shed areas. There are also intrusions of Mopane woodlands especially torwards the Luano valley. There is evidence of major ecological damage or degradation in several places in Kabwe, caused by a variety of processes, including mining excavation and deforestation. However remnants of original vegetation are still available in many places.

4.1 MIOMBO WOODLAND

Like other typical Miombo woodlands, those in this area are two storeyed woodlands with an open or lightly closed canopy of semi-evergreen trees, characterized by Brachystegia species, Isoberlinia species and Jilbernadia species, with *Pericopsis angolensi, Anisophyllea pomifera Erythrophleum africanum* and *Parinari curatellifolia* as common associates. The lower storey may be clearly or vaguely defined by such species as *Albizia antunesiana*, *Anisophyllea boehmii*, *Diplorhynchus condylocarpon*, *Ochna* species and others. Suffrutices are quite typical in the woodland such as Becium species, fadogia species, Sphenostylis species and Lannea sp. The grass layer is usually moderately dense or very dense. Common genera include Hyparrhenia, Panicum, Sporobolus, Eragrostis and others.

4.2 CHIPYA WOODLAND – LAKE BASIN

Essentially a three-storied woodland with an open evergreen to deciduous canopy characterized by *Acacia albida*, *Pericopsis angolensis*, *Albizia antunesiana*, *Burkea africana* and Combretum species. The understorey is typically discontinuous mainly composed of *Combretum celastroides*, *C. ghasalense*, *Diplorhynchus condylocarpon*. The shrub layer, 2-3m high and evergreen or semi-evergreen, occurs in the form of dense shrub/scrambler thickets. A luxuriant ground flora of subshrubs and tall herbs, including Chipya indicators *(especially Aframomum biauriculatum)* is a distinct feature.

4.3 SWAMP FOREST

Swamp forest is edaphically dependent, controlled by ground water available during the year. It occurs in three forms (a). estuarine swamp which is flooded all the year round (b) seepage swamp with the water table at or just above the ground level all year round and (c) seasonal swamp flooded during the rainy season.

4.4 MOPANE WOODLANDS

This is mainly limited to the Luano valley. It is one-storey vegetation with an open deciduous canopy. It is dominated by *Colophospermum mopane* with elements of Acacia species. The major ecotones are with Miombo and Acacia woodlands.

4.5 FOREST PRODUCTS

Timber harvesting of indigenous species is widespread, as is production of charcoal. In fact, in excess of 10% of the charcoal sold in Lusaka originates from Kabwe. There is still noticeable wild harvesting of honey, most of which is sold along the roadside. Collecting and selling of mushrooms is a major engagement during the rainy season. Collection of edible wild fruits is common practice in Kabwe. At peak seasons it is practiced along the entire road.

5. BIOPHYSICAL CONTEXT OF COPPERBELT MINE LICENSE AREAS

5.1 ADDITIONAL BASELINE DATA REQUIREMENTS

A considerable amount of information about the biophysical characteristics of the Copperbelt has been collected over the years. However, assessment of the environmental and social consequences of the CEMP and, in many respects, the EMF, requires baseline information for a much broader spectrum of environmental parameters than previously addressed in Environmental Impact Statements for the Copperbelt's mining license areas. Spatial coverage must also be augmented, to permit monitoring and assessment of cumulative impacts of project actions, to evaluate the relative significance of regulated and unregulated activities and to assess interventions beyond the license areas. In other words, coverage of environmental and social information for the Copperbelt region is incomplete.

It would be feasible to produce a dedicated baseline database for the Copperbelt as an integral component of the CEMP work program. This would facilitate the quantification of environmental changes (positive or negative) over time, and would underpin the evaluation of CEP performance within the context of the project's specified output indicators.

Baseline data gaps have been identified in Section 6 of Part II of the main report.

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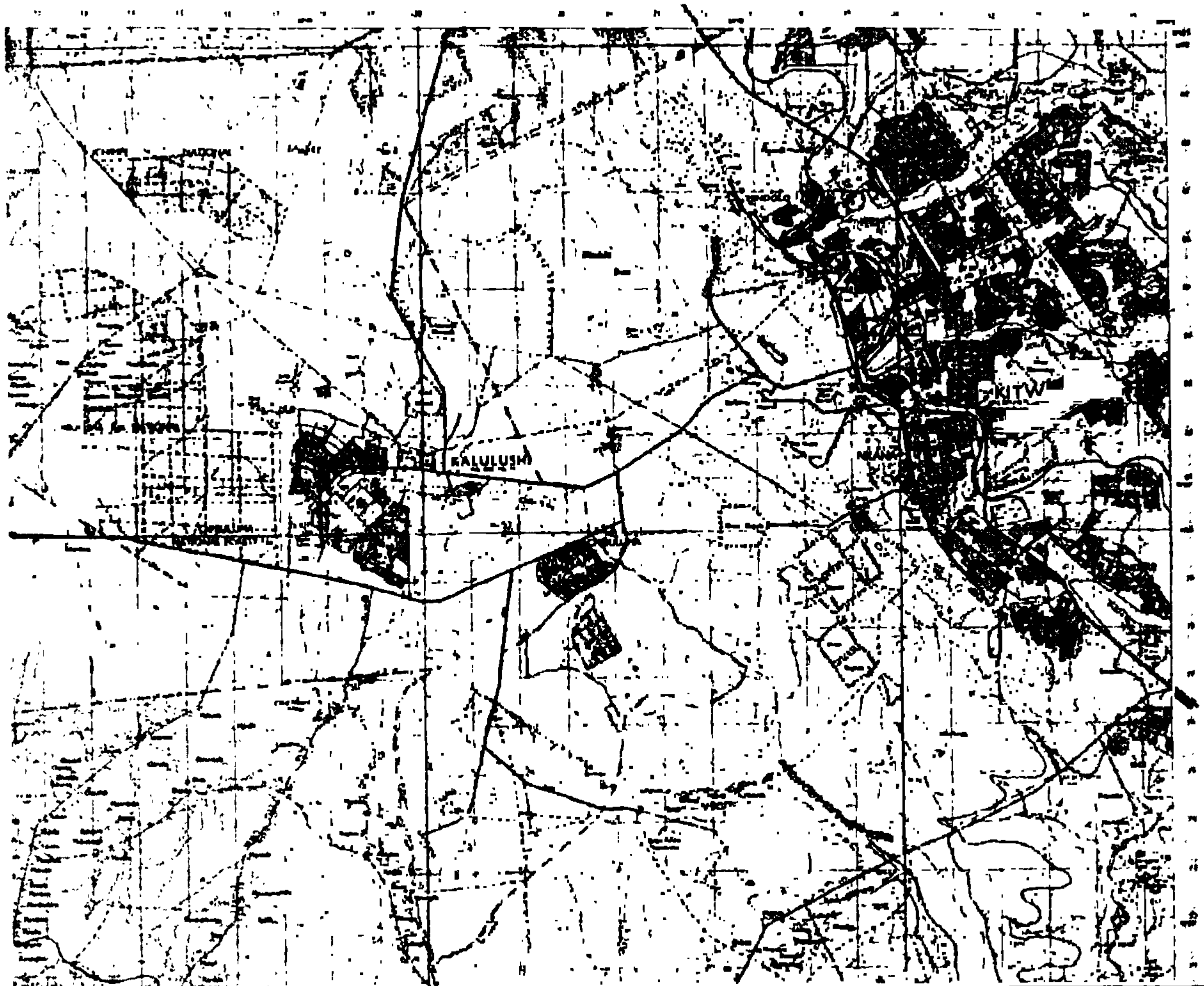

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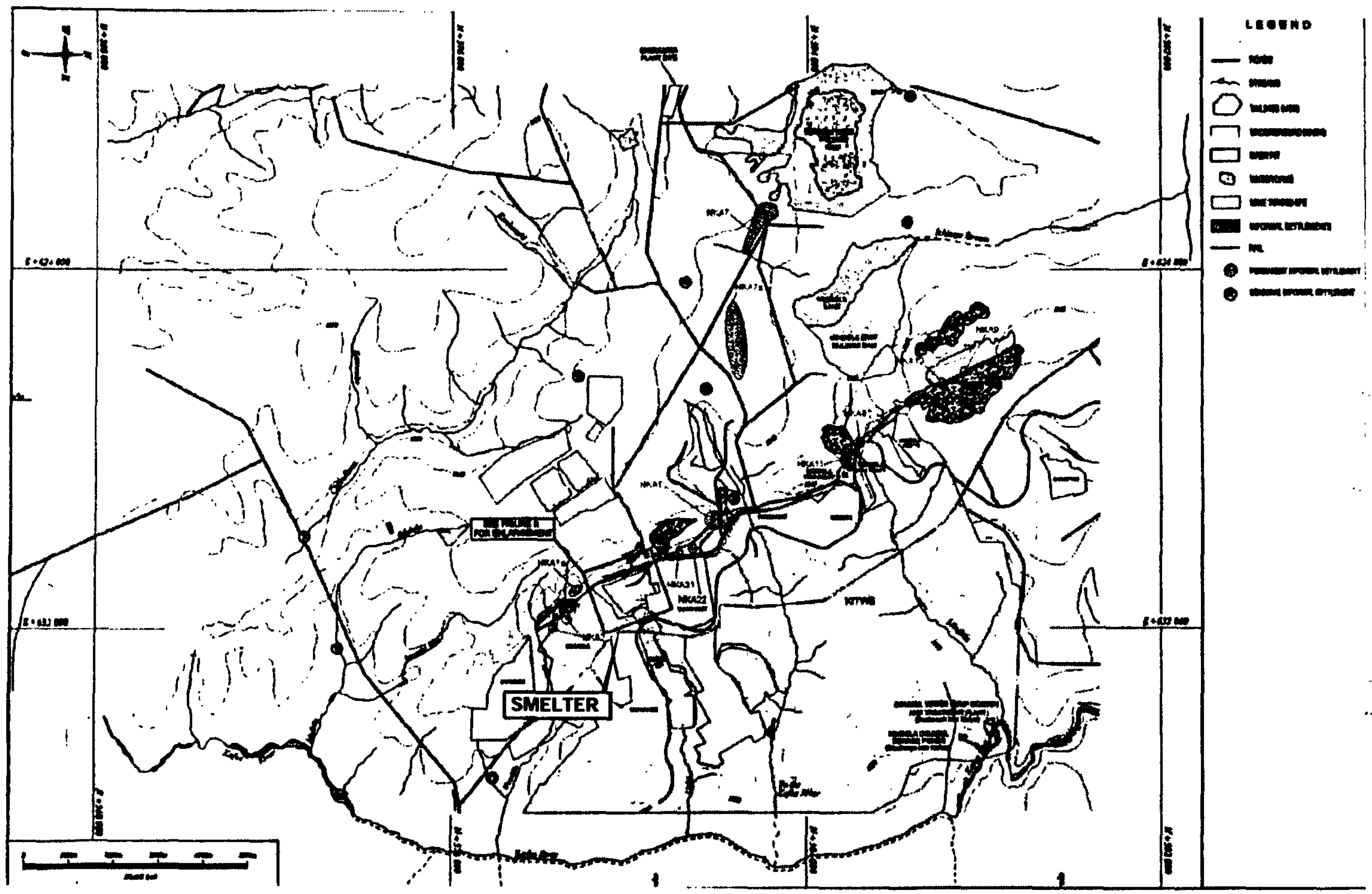
Scanning source: Republic of Zambia topographic map: Series ZS51, Sheet: 1228 C3, Edition: 2-ZS 1986; Scale: 1:50,000

ZCCM INVESTMENTS HOLDINGS PLC ESA OF THE COPPERBELT ENVIRONMENT PROJECT - ZAMBIA	KOMEX INTERNATIONAL LTD. ENVIRONMENTAL AND ENGINEERING CONSULTANTS		
KITWE - KALULUSHI AREA PLAN	DRAWN BY: OTHERS	EDITED BY: M.T./S.S.	DATE: FEB.6/02
	APPROVED:	FIGURE: 1	
PREPARED SOLELY FOR THE USE OF OUR CLIENT AS SPECIFIED IN THE ACCOMPANYING REPORT. NO REPRESENTATION OF ANY KIND IS MADE TO OTHER PARTIES WITH WHICH KOMEX INTERNATIONAL LTD. HAS NOT ENTERED INTO A CONTRACT.	J:\53670000\Topo1228C3.DWG		



Scanning source: GRZ/ZCCM Privatisation Negotiating Team, Package Definition - Group, Environmental Sub-Group, KNNN Co Package, Final Draft of ZCCM's Environmental Remedial Work agreed upon by ZCI-Lead Consortium & ZCCM Limited, Konkola, Nchanga, Nkana Divisions & Nampundwe Mine; "Nkana Overall Area - Diagrammatic Layout of Environmental Remedial Sites" Figure A; Date 25 August 1999

ZCCM INVESTMENTS HOLDINGS PLC EA OF THE COPPERBELT ENVIRONMENT PROJECT - ZAMBIA			KOMEX INTERNATIONAL LTD. ENVIRONMENTAL AND ENGINEERING CONSULTANTS
NKANA AREA PLAN	DRAWN BY: OTHERS	EDITED BY: M.T./S.S.	DATE: FEB.6/02
	APPROVED:		FIGURE: 2
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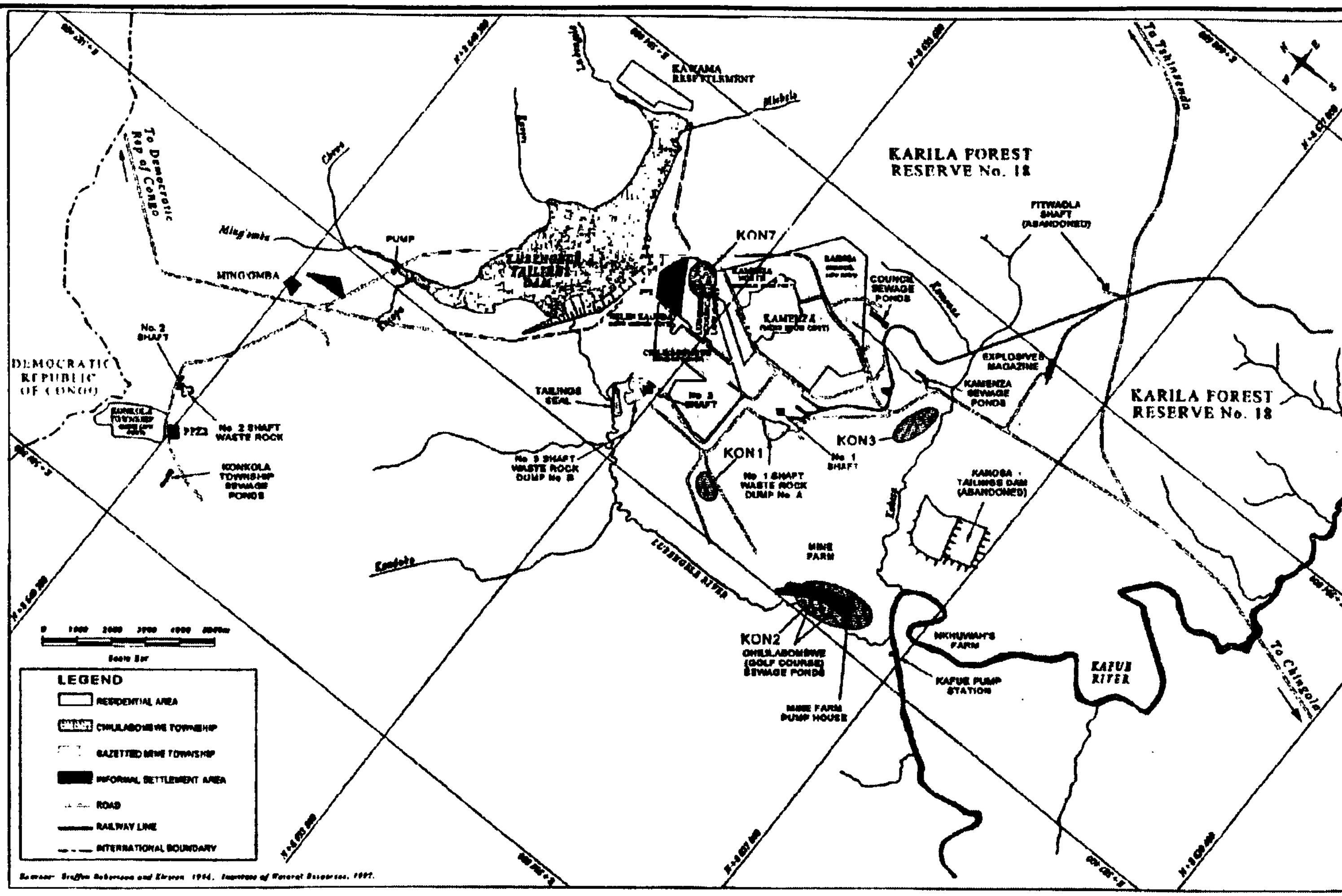

Scanning source: GRZ/ZCCM Privatisation Negotiating Team, Package Definition - Group, Environmental Sub-Group, KNNN Co Package, Final Draft of ZCCM's Environmental Remedial Work agreed upon by ZCI-Lead Consortium & ZCCM Limited, Konkola, Nchanga, Nkana Divisions & Nampundwe Mine; "Konkola Overall Area - Diagrammatic Layout of Environmental Remedial Sites" Figure A; Date 30 September 1999

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KOMEX INTERNATIONAL LTD.
ENVIRONMENTAL AND ENGINEERING CONSULTANTS

KONKOLA AREA PLAN

DRAWN BY:	EDITED BY:	DATE:
OTHERS	M.T./S.S.	FEB.6/02
APPROVED:		FIGURE: 3

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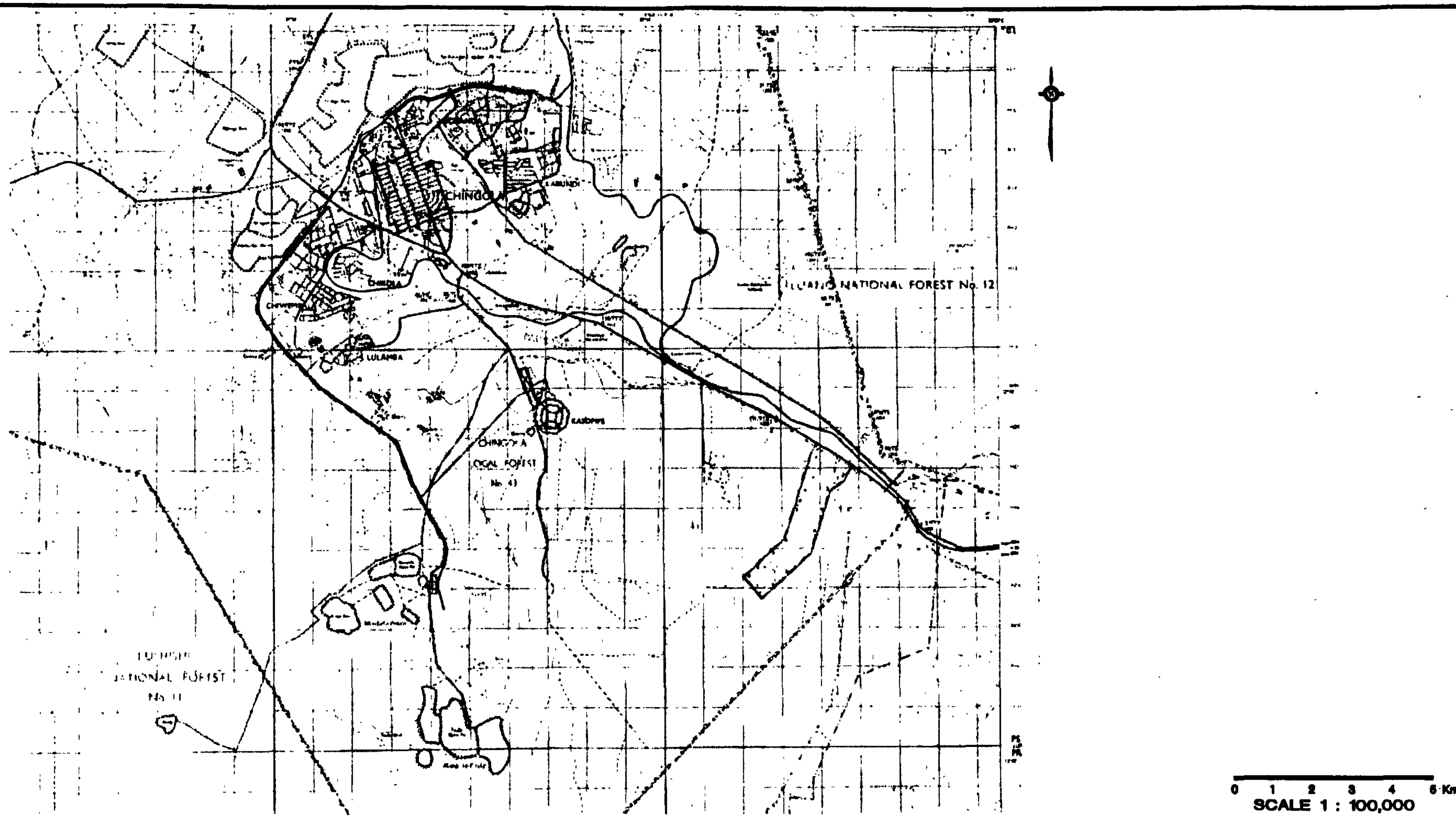

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Edition: 1-ZS 1978; Scale: 1:50,000

ZCCM INVESTMENTS HOLDINGS PLC ESA OF THE COPPERBELT ENVIRONMENT PROJECT - ZAMBIA	KOMEX INTERNATIONAL LTD. ENVIRONMENTAL AND ENGINEERING CONSULTANTS	
CHINGOLA AREA PLAN	DRAWN BY: OTHERS	EDITED BY: M.T./S.S.
	DATE: FEB.6/02	APPROVED:
	FIGURE: 4	

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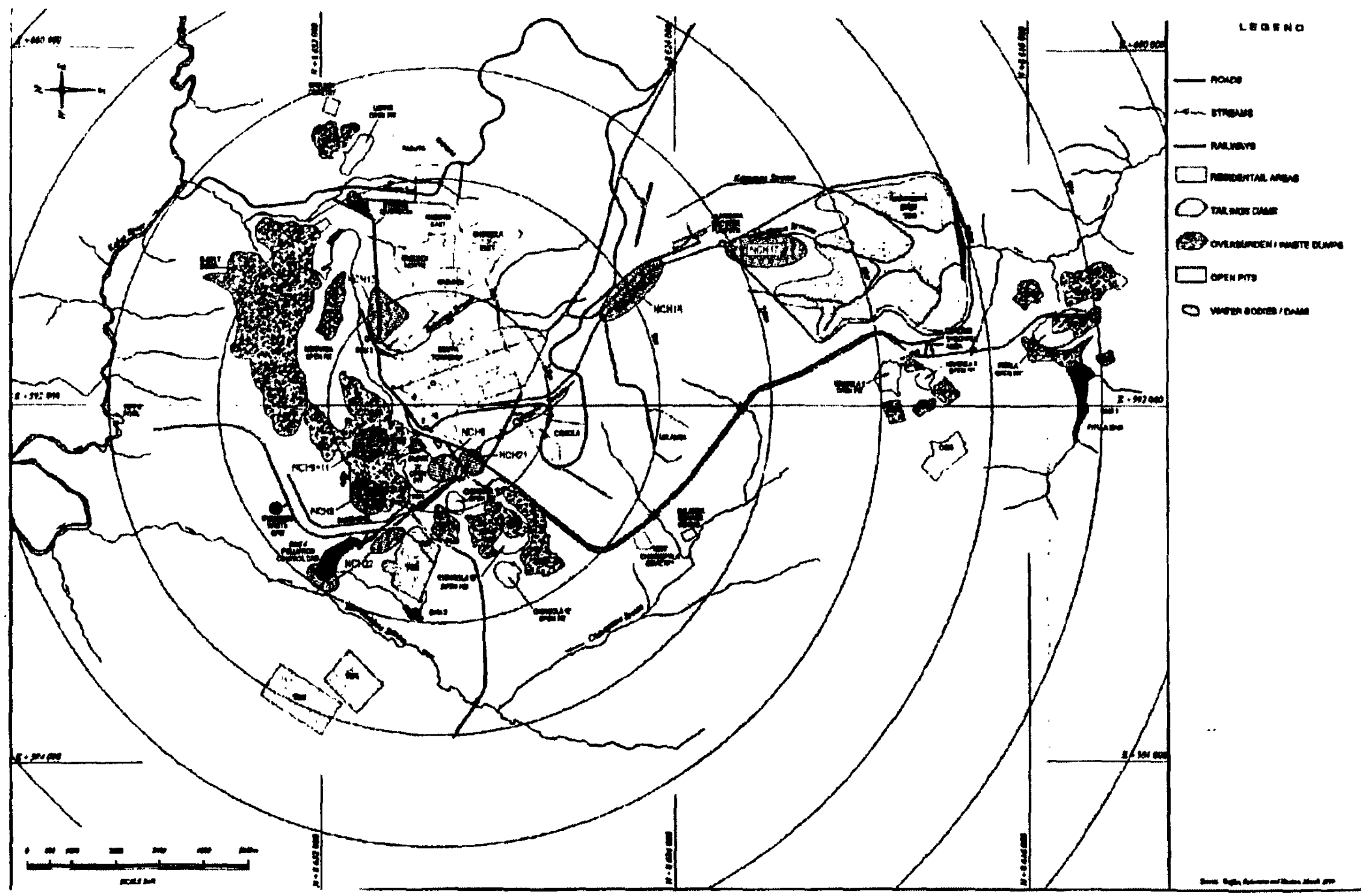
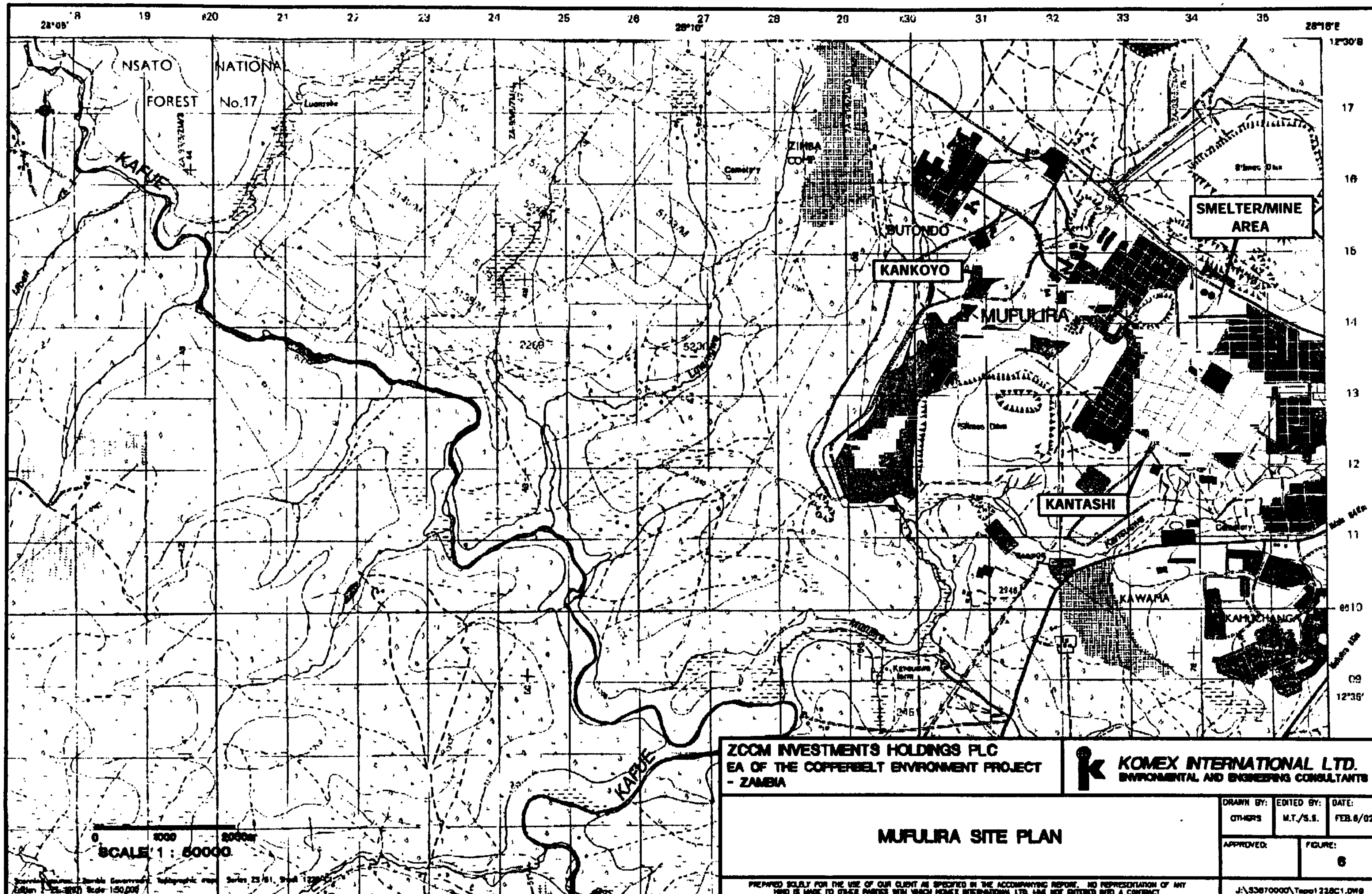


Scanning source: GRZ/ZCCM Privatisation Negotiating Team, Package Definition - Group, Environmental Sub-Group, KNMN Co Package, Final Draft of ZCCM's Environmental Remedial Work agreed upon by ZCI-Lead Consortium & ZCCM Limited, Konkola, Nchanga, Nkana Divisions & Nampundwe Mine; "Nchanga Overall Area - Diagrammatic Layout of Environmental Remedial Sites" Figure A; Date: 25 August 1999

ZCCM INVESTMENTS HOLDINGS PLC EA OF THE COPPERBELT ENVIRONMENT PROJECT - ZAMBIA	KOMEX INTERNATIONAL LTD. ENVIRONMENTAL AND ENGINEERING CONSULTANTS		
NCHANGA AREA PLAN	DRAWN BY: OTHERS	EDITED BY: M.T./S.S.	DATE: FEB.6/02
	APPROVED:	FIGURE: 5	
PREPARED SOLELY FOR THE USE OF OUR CLIENT AS SPECIFIED IN THE ACCOMPANYING REPORT. NO REPRESENTATION OF ANY KIND IS MADE TO OTHER PARTIES WITH WHICH KOMEX INTERNATIONAL LTD. HAS NOT ENTERED INTO A CONTRACT.	J:\53670000\Nchanga-Area.DWG		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MUFULIRA
KANTASHI
KAWAMA
KAMUCHANGA
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ZCCM INVESTMENTS HOLDINGS PLC
EA OF THE COPPERBELT ENVIRONMENT PROJECT - ZAMBIA
KOMEX INTERNATIONAL LTD.
ENVIRONMENTAL AND ENGINEERING CONSULTANTS
MUFULIRA SITE PLAN
DRAWN BY: OTHERS
EDITED BY: M.T./S.S.
DATE: FEB.6/02
APPROVED:
FIGURE: 6
PREPARED SOLELY FOR THE USE OF OUR CLIENT AS SPECIFIED IN THE ACCOMPANYING REPORT. NO REPRESENTATION OF ANY KIND IS MADE TO OTHER PARTIES WITH WHICH KOMEX INTERNATIONAL LTD. HAS NOT ENTERED INTO A CONTRACT.
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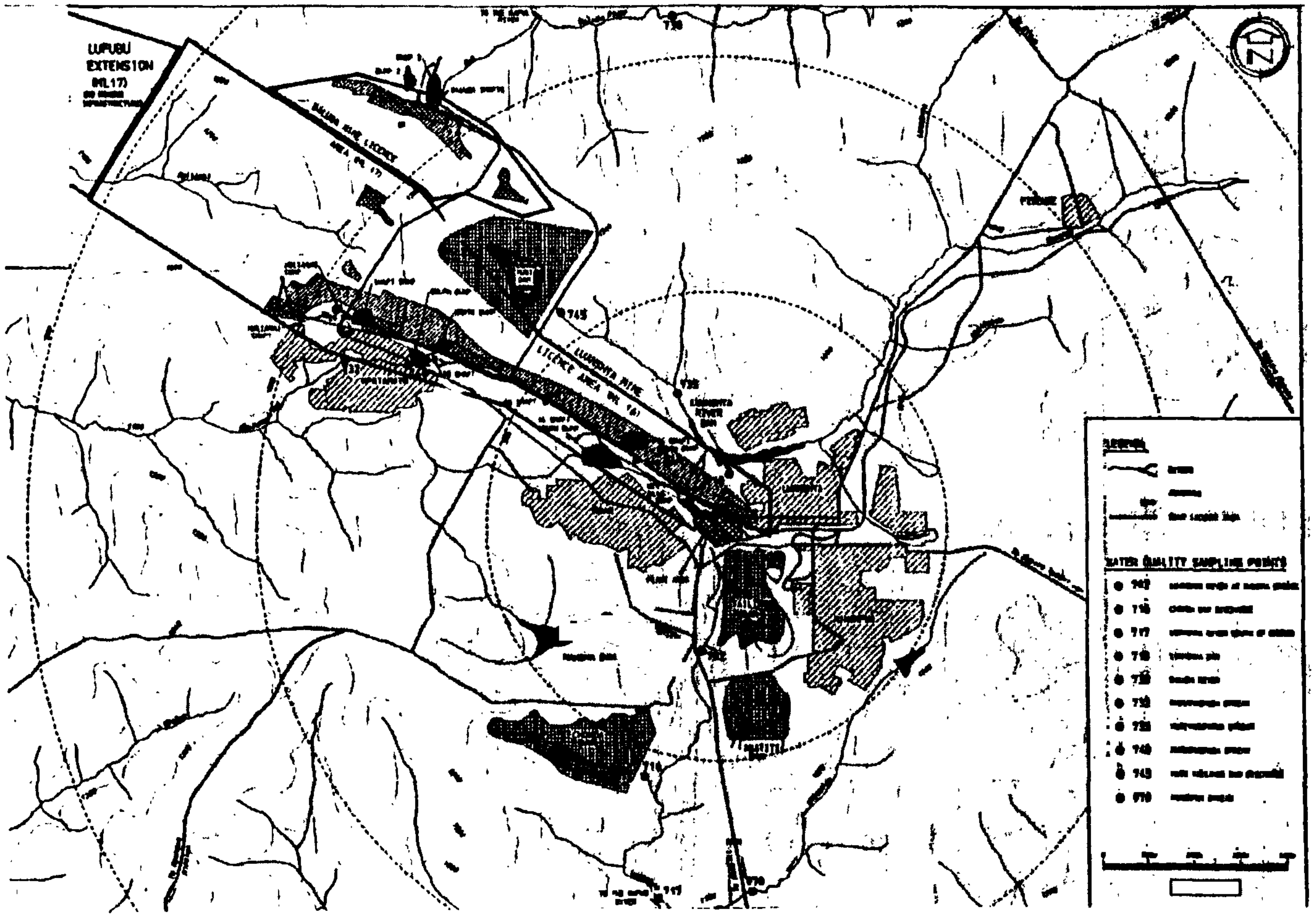

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Scanning source: Steffen, Robertson & Kirsten: ZCCM Luanshya Division ML16 and ML17, Environmental Management Plan; Figure No. 4.1 "Site Water Management Plan", Scale: 1:50,000

ZCCM INVESTMENTS HOLDINGS PLC ESA OF THE COPPERBELT ENVIRONMENT PROJECT - ZAMBIA	KOMEX INTERNATIONAL LTD. ENVIRONMENTAL AND ENGINEERING CONSULTANTS		
LUANSHYA AREA AND SITE WATER MANAGEMENT PLAN	DRAWN BY: OTHERS	EDITED BY: M.T./S.S.	DATE: FEB.6/02
	APPROVED:	FIGURE: 7	
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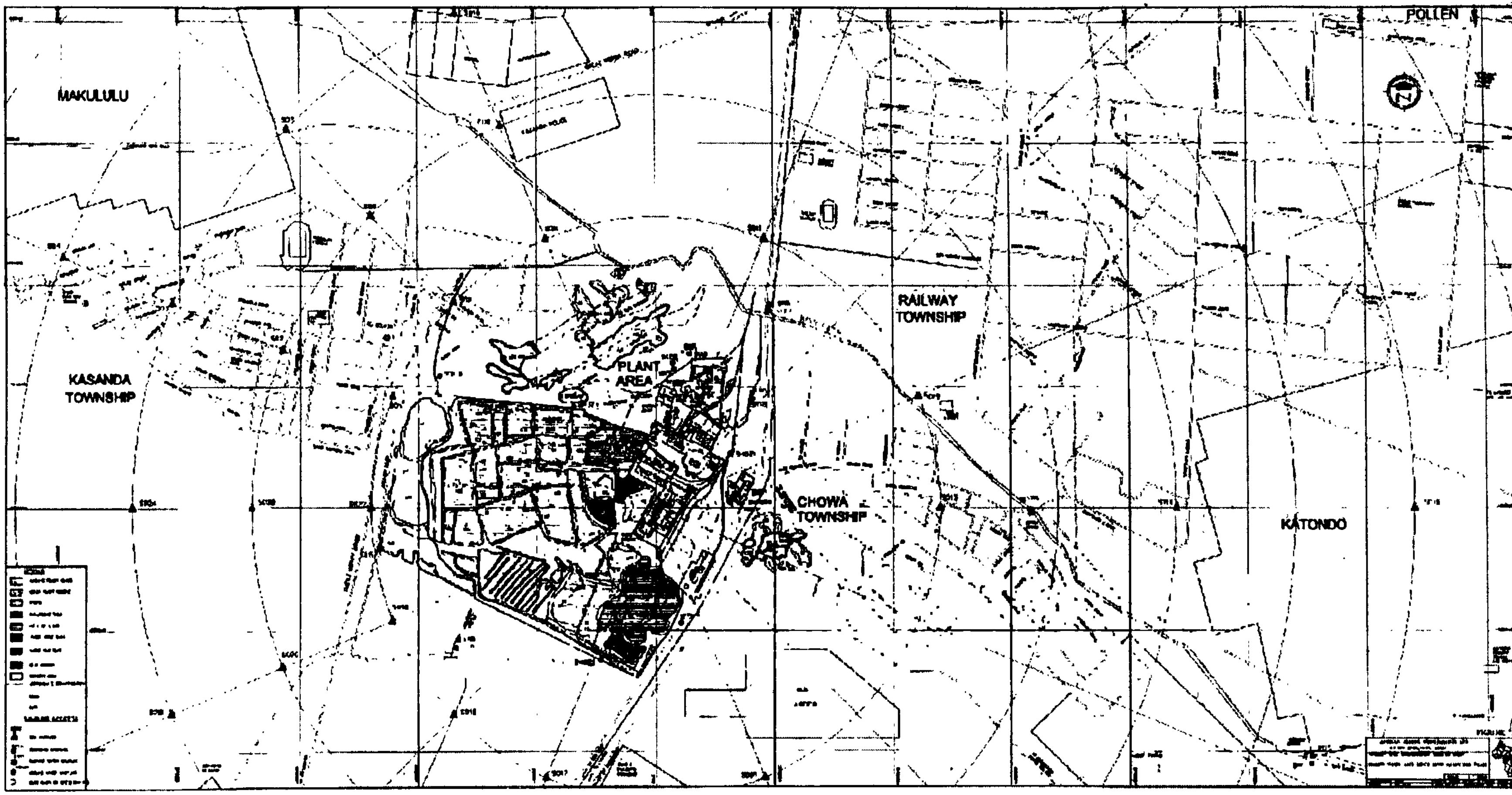

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Scanning source: African Mining Consultants Ltd., Kitwe, Zambia; Figure 3.2: Kabwe Town & Mine Site Sampling Plan, ; Rev No. 0; Scale 1:7500; Date: Nov '99

ZCCM INVESTMENTS HOLDINGS PLC
ESA OF THE COPPERBELT ENVIRONMENT PROJECT - ZAMBIA

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KABWE TOWN AND MINE SITE PLAN

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OTHERS	M.T./S.S.	FEB.6/02
APPROVED:		FIGURE: 6

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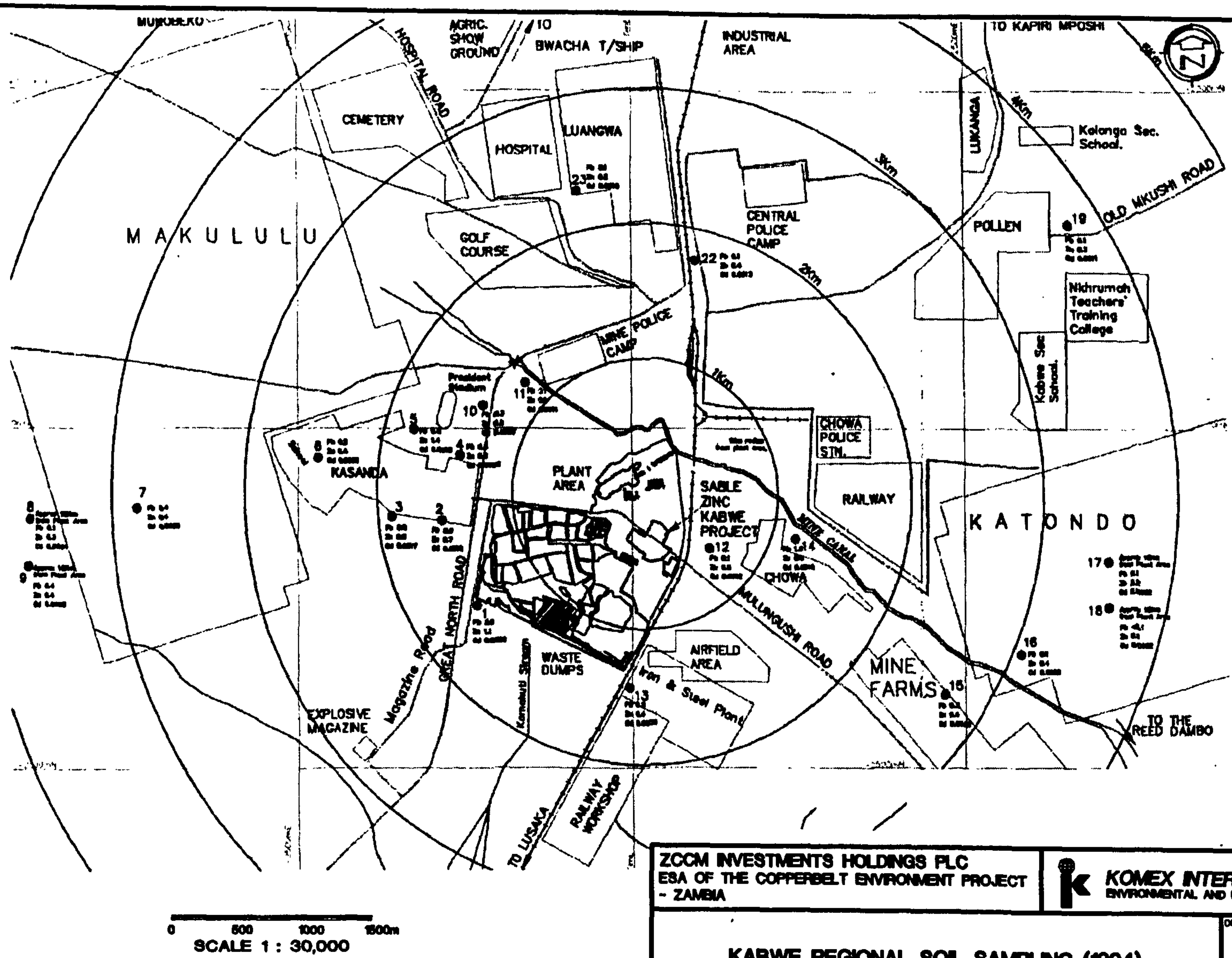

Scanning source: African Mining Consultants Ltd., Kitwe, Zambia; Figure 2: Kabwe Regional Soil Sampling (1994), Metal Levels in Surface Soils – Lead, Zinc & Lead, Zinc & Cadmium (%); Rev No. 0; Scale 1:25,000; Date: Dec '99

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KABWE REGIONAL SOIL SAMPLING (1994)

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APPROVED:		FIGURE: 9

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ANNEX E:
SITES OF ARCHAEOLOGICAL / CULTURAL INTEREST
(COPPERBELT)

ANNEX E: SITES OF ARCHAEOLOGICAL / CULTURAL INTEREST

During the completion of ZCCM's Environmental Impact Statements (1996-98), a review of existing archaeological sites in the Copperbelt region was carried out and is presented below. No more recent studies have been done, and it is likely that with the decline in security around mine areas, there has been an increase in human interaction with the sites. The assessment found that there were several sites that were not properly maintained, and were being impinged upon either by natural factors or by mine tailings. It is not likely that any of these sites would be affected by remediation under the CEP, but this would need to be confirmed once specific sites had been selected for remediation. If there were to be a sight affected by remediation, the CEP should follow World Bank guidelines on cultural property.

CHINGOLA TOWN/NCHANGA MINE

Archaeological sites have been identified in Nchanga Mine Licence Area. These include the Chingola gardens site, the Hippo pool site and the Mushima stream site.

TABLE E. 1: ARCHAEOLOGICAL SITES IN NCHANGA MINE LICENCE AREA

Site Name	Co-ordinates	Age 1	Status	Site Type
Chingola Gardens	12-30S 27-50E	ESA	Unconfirmed	Chance Find
Hippo Pool Site	12-30S 27-51E	MSA/LIA	Confirmed	Open Site
Mushima Stream	12-28S 27-51E	ESA/MSA	Confirmed	Open Site

Source: ZCCM (1996)

CHINGOLA GARDENS

A large part of the area is arable land used by the local community. It is unknown what was found at the site, which was classified as Early Stone Age as no records of the find were available from the archaeologist at Copperbelt Museum.

THE HIPPO POOL SITE

The hippo pool archaeological site is located within the Hippo Pool P.F.A. No. 3. Protected Area. The National Monuments Board has recorded the hippo pool site as a confirmed archaeological open site with findings from the Middle Stone Age/Late Iron Age. The banks of the pool are sandy and overgrown with reeds. Trees, grasses and rocky outcrops cover the area farther from the banks.

Although no evidence of remains from Middle Stone Age and Late Iron Age have been recorded, it is highly likely that most of the evidence has been disturbed by the human and animal activity on the fringes of the pool.

THE MUSHIMA STREAM SITE

The National Monuments Board has recorded the Mushima Stream as a confirmed open site with findings from the Early Stone Age/ Middle Stone Age. The site is within the Hippo Pool P.F.A. No. 3 protected area, about 300 metres south of the Kafue Bridge, on eastern side of the Chingola-Chililabombwe road.

[1] Age Index: MSA-Middle Stone Age, LSA-Last Stone Age; LIA-Late Iron Age; EIA-Early Iron Age

CHILILABOMBWE TOWN/KONKOLA MINE

The National Monuments and Heritage Commission has recorded four archaeological sites in the Konkola mine Licence area. Three of these sites are indicated in the Table below.

TABLE E. 2: ARCHAEOLOGICAL SITES CURRENTLY RECORDED IN THE KONKOLA MINE LICENCE AREA

Site	Status	Coordinates	Site Type	Age[2]
Chililabombwe Springs	Unconfirmed	12-12S:27-49E	Open	MSA-LSA
Lubengele	Protected	12-20S:27-49E	Open	EIA-LIA
Kakosa Stream	Unconfirmed	12-24S:27-51E	Open	MSA-LSA

Source: SRK (1996); ZCCM Environmental Management Plans

CHILILABOMBWE SPRINGS

This unconfirmed open site is reported to be located north of No. 3 shaft and the Lubengele Tailings Dam. However, the exact location of the site has not been established.

LUBENGELE STREAM

The NMHC has recorded this as a protected open site. This site is probably on the beach of the Lubengele Tailing Dam. No evidence of Early Iron Age - Late Iron Age remains have been found. It is probable that the site was on the bank of the Lubengele Stream and has now been covered by tailing deposits.

KAKOSA STREAM

This unconfirmed site is located near Kakosa Bridge on the Chingola Road on the right riverbank. Four large stones were reportedly found placed near to each other. One of the stones had a flat surface with a pedal stool shape. There was no other apparent evidence of remains from the Middle/Late Stone Age (SRK, 1996).

The study of the Konkola Mining Licence Area, Chililabombwe, for archaeological sites has established that squatter settlement, farming, and charcoal burning has adversely affected the cultural heritage resources in the area. In some zones they have been destroyed by mining operations (SRK, 1997).

LUANSHYA TOWN/RAMCOZ MINES

Luanshya Mine Licence Area contains one historical and four archaeological sites. There are no archaeological sites in the Baluba Mining area. The archaeological sites in the Luanshya Division Licence area are given in Table 2.7.

[2] Age Index: MSA-Middle Stone Age, LSA-Last Stone Age; LIA-Late Iron Age; EIA-Early Iron Age

TABLE E.3: ARCHAEOLOGICAL SITES: LUANSHYA MINING LICENCE AREA

Site Name	Co-ordinates	Category	Status	Site Type	Age3
Collier Monument	13-07S 28-23E	Historical	Declared	Monument	IA
Luanshya Carved Area	13-07S 28-24E	Archaeology	Confirmed	Open Site	ESA/MSA
Kakoma Stream	13-09S 28-24E	Archaeology	Confirmed	Open Site	MSA
Musiyakupalwa	13-06S 28-23E	Archaeology	Protected	Open Site	ESA/MSA
Roan Antelope	13-08S 28-23E	Archaeology	Confirmed	Open Site	L1A

A field survey was undertaken in 1996 by the Director of National Museum Board to assess the condition or archaeological and historical sites recorded in the Luanshya area. The results of the report of 1996 survey are given below:

The survey highlighted the very wide range of sites, which have been destroyed completely, and those that have been substantially disturbed by human activities. The site survey data collected further highlight the long-term effects of ignorance, negligence, and destruction in the name of progress, which in future should be addressed progressively by all those concerned to try and minimise the destruction of national heritage in the mine licence areas.

COLLIER MONUMENT

The condition of the Collier Monument is excellent though it is not easily accessible to the public because of its location in the restricted mine area. The mine authorities are doing their best to maintain and protect the monument. Of particular interest to the survey team was, however, the revelation that the monument has been shifted out from the original site where in 1902 W C Collier shot dead a Roan Antelope, whose blood stained the copper outcrop beneath.

The shifting of the monument was necessitated by the fact that the original site fell within the carved area, which is likely to sink down due to early underground mining in the 1920s and 1930s. The original site is, however, not very far from the present site where the monument now stands.

LUANSHYA CAVED AREA

The site used to lie south of Luanshya mine "new" (northern) Township above Luanshya stream's north bank. Below the site to the south is Luanshya Dam, which runs east-west, parallel to the northern upper talus of the dambo stream.

It was noted that the site was completely destroyed. No traces of the recorded MSA archaeological material could be seen on the surface of the area where the site was located. A lot of garbage dumps and industrial waste were strewn all over the east-west uppermost talus of the Dam, above which is a tarmac road looping the "new" (northern) Township.

[3] Age Index: MSA-Middle Stone Age, LSA-Last Stone Age; LIA-Late Iron Age; EIA-Early Iron Age

KAKOMA STREAM

The site existed on a higher mound above the eastern bank of Roan Antelope dambo after Luanshya stream's southeastward hook across the Luanshya-Roan road. The construction of the mines Tailings Dam [now silted] south of the mines smelter complex appears to have facilitated the obliteration of the site.

The site is now destroyed beyond recognition. Its unconfirmed status, and material evidence, which was reported to be chance finds, may have contributed to its obliteration. The whole Dam area has fully silted and is no longer in active use.

MIKOMFWA

The site has not been surveyed to establish its present condition.

MUSIYAKUPALWA ("MUSIYAKAPATWA")

The site is located on the talus of the northern bank of "Musiyakapatwa" perennial dambo stream, which together with the northwest dambo, flows southeast into Luanshya stream, upstream of the Dam wall embankment. In addition to the recorded ESA and MSA, the site has elaborate evidence of Iron Age (IA), with iron slag and laterite blocks strewn all over the upper talus of the northern and north-western dambos. However, no cultural material relating to ESA and MSA on either bank slope of the dambos was noted. On this basis it was difficult to reconfirm the ESA and MSA status and condition of the site.

We further noted a subsurface disturbance of the site by local people who utilise the area of the site for farming. Terraced ridges trend down east west across the site, with some iron slag and laterite blocks heaped deliberately at intervals over the site area. The plough zone (10-20cm) has been disturbed remarkably through repeated farming, and this has in turn caused erosional run-off of surface cultural material down into the stream.

"Musiyakapatwa" is, however, the only site in the Luanshya mine licence area, which is devoid of disturbance by direct mining operations. This is mainly because of its distance from active mining operations. As a control against unauthorized activity on the site, a metal board with a warning against tampering the site should be erected at the site. It was observed that the Forestry Department of Luanshya should be made aware of the value of the site and the need to ensure its protection for posterity.

Since it appears that no action has been taken since the SRK report 1997 and in view of the importance of these cultural sites, the Copperbelt Museum Board through CEP could survey these sites to implement necessary measures.

ROAN ANTELOPE DAMBO

The Roan Antelope Dambo site was located downstream of Luanshya stream, way below Luanshya Dam, and immediately south below the present site of the Collier Monument. Roan Antelope Dambo is itself part of the lower Luanshya stream. The dambo stream channel below the Dam and past the Collier Monument has little water in it following the damming upstream. The channel has also silted with sand, gravel, and copper/cobalt slag rolling down from the north bank. Several artificial gulleys run down the southern/western talus of the dambo, bringing in lots of sand and industrial garbage. The stream is so choked with silt and industrial waste that the site is now completely obliterated.

CONSERVING THE PAST IN THE MINE LICENCE AREAS

Vandalism and looting of archaeological and historic sites in Luanshya licence mine area is presently minimal to non-existent. No evidence of site disturbance in the areas surveyed was noticed. Mining operations and other related development projects in the mine areas have since the 1930s received undue attention and prioritisation at the expense of heritage protection. The report further notes that countless remains of past human activity have been consciously or unconsciously destroyed in the name of progress. While it is clearly impossible to preserve all remains of past human activity, but much as already been destroyed in the area and the pace of destruction appeared to accelerate in tune with past expansions of mining operations. Only a small proportion of the document record of past human activity in the area remains undoubtedly intact.

Preservation of heritage sites and monuments in the mine areas must be understood as a normal planning process. It is a material planning consideration, which should form part of the mine authorities' planning process because it should be integral to the mine authorities' environmental conservation objectives.

KITWE TOWN/NKANA MINE

Nkana Mine Licence Area, has a single recorded archaeological site according to the National Monuments Commission. The recorded archaeological site is Lazaraies Dam site.

TABLE E. 4: ARCHAEOLOGICAL SITES CURRENTLY RECORDED IN NKANA LICENCE AREA

Site Name	Coordinates	Age[4]	Status	Site Type
Lazararies Dam Site	12-50S 28-12E	LSA	Confirmed	Open site

LAZARARIES DAM SITE

The National Monuments Commission has recorded this site as a protected open site. According to the co-ordinates given, the Lazararies dam site was located where the concentrator is situated. This site has therefore been disturbed by mining activities.

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[4] Age Index: MSA-Middle Stone Age, LSA-Last Stone Age; LIA-Late Iron Age; EIA-Early Iron Age

ANNEX F:
DIVERTING SEWAGE EFFLUENT

ANNEX F: DIVERTING SEWAGE EFFLUENT

Although not a mining environment issue, the practice of diverting sewage treatment facilities to irrigate water was encountered at numerous locations during SA site visits. The practice can lead to increased discharges of raw sewage into the Kafue and its tributaries since the sewage is diverted from its proper treatment path. The SA health team reviewed information on one study examining this issue which was completed as part of an ESP-supported community pilot in Mufulira. A discussion of this topic is presented below.

USE OF SEWER EFFLUENT FOR IRRIGATION

The "Prefeasibility Study on the Possibility of Using Treated Sewer Effluent for Irrigation" conducted for the Pilot Environment Fund consists of a literature review and profile of sewage treatment in Mufulira. The only direct measurements were conducted on the sewage water, not on the crop products. This study identified arsenic and selenium and possibly lead as the toxic agents of greatest hazard to humans. It noted the high prevalence of diseases related to waterborne pathogens in Mufulira without attributing any given proportion to the use of sewage water for irrigation. It concluded that the use of sewer effluent for irrigation should be discouraged until the facility at Kawama is rehabilitated and meets minimal standards for sewage treatment.

The use of sewage for irrigation carries a number of recognised hazards:

- Transmission of human pathogens on the surface of the product, either food or fibre, by hand-to-mouth contact
  - Bacteria
  - Viruses (including hepatitis B)
  - Parasites (including helminths)
- Transmission of human pathogens by ingesting product contaminated on the surface
  - Bacteria
  - Viruses
  - Parasites
- Inhalation or mucosal deposition of droplets of contaminated water
  - Bacteria
  - Viruses
  - Parasites
- Contamination of wounds received while working (esp. staphylococcus and Clostridium spp.)
- Cross-contamination of sites by pathogens that may be carried by workers
  - Other agricultural sites
  - Fecal contamination
  - Contamination around the home (esp. helminths)
- Ingestion of chemicals that are deposited on the surface of the product
  - Heavy metals
  - Transition elements (arsenic, selenium)
  - Pesticides
- Ingestion of chemicals that may bioaccumulate in the product
  - Heavy metals
  - Transition elements (arsenic, selenium)
- Transmission to livestock of contaminated foods
  - Some pathogens (e.g. agents of trichinosis and taeniasis)
  - Persistent chemical hazards (most likely heavy metals)

Wastewater can and is reclaimed for irrigation in developed countries. The guiding philosophy of wastewater reclamation management is that treatment should be tailored to the specific reuse. Greater public health risks require more stringent treatment. Irrigation of food crops merits the highest level of treatment below non-potable water in guidelines applied in California. This means secondary treatment followed by coagulation, direct filtration and disinfection with chlorine. Obviously, this is not feasible in Zambia.

The risk of using reclaimed wastewater for irrigation must be inferred from the literature on sewage, as a worst case, and on contaminated water, as a best case. Levels of risk associated with partially treated sewage probably fall in between, but may be modified by physical factors such as ultraviolet exposure, which is bactericidal. The balance between risk and benefit to a population may be favourable in the short term on a population basis in which malnutrition is a significant health problem. There are, however, risks in basing food production on an unsustainable practice that places the population at long-term risk. The degree to which these hazards pose an actual threat to health probably varies with the following physical factors:

- Whether the crop is continually wet or allowed to dry out;
- Exposure to ultraviolet light;
- Degree of treatment of sewage before it reaches the crop (specifically, retention time at each stage); and,
- Morbidity patterns in the population producing the sewage (e.g. presence and concentration of cholera, hepatitis).

It is unlikely that the risk can be assessed without new data relevant to the tropics and to the Zambian situation. This is likely to require an actual trial and measurement of hazard characteristics through a growing cycle. Other, easier approaches are probably not feasible in this situation.

It is not likely that conducting studies on food grown in the community will answer the question because:

- Farmers are not likely to cooperate out of fear of an unfavourable outcome.
- Conditions may not be optimal or highly variable.
- Pathogens of greatest concern may not be present at a given moment in the sewage flow.

Epidemiological investigations of farmers in Zambia growing and local residents consuming crops irrigated with sewage effluent are unlikely to resolve the issue:

- The communities have a high prevalence of morbidity from the diseases of concern associated with other causes.
- The communities have a high prevalence of morbidity from disorders that mimic the effects of the diseases of concern, such as malaria.
- A major confounding factor is the reportedly favourable health status of farmers and their families due to a reliable source of nutrition and income.
- The demographic characteristics of farmers in some areas are skewed to overrepresent retired miners and older residents. Matching would require a sampling frame and may not be practical in the field.
- Case ascertainment is uncertain because the health care system provides only presumptive diagnoses and rarely confirms a diagnosis with laboratory tests. Hepatitis, in particular, is certainly underreported.

In order to determine the actual risk, it would be necessary to conduct the following analyses on common food crops:

- Microbiological studies of the surface of the crops, above and below water, during its growth (bacteria, viruses, ova and parasites);
- Microbiological students of the surface of the crops after drying out, mimicking distribution (bacteria, viruses, ova and parasites);
- Chemical analysis of the surface of crops at harvest; and,
- Chemical analysis of the ingested portion of food crops at harvest.

Of these studies, virus assays will probably be the most expensive and difficult; hepatitis may be the single most important because of its hardiness. It is important that these studies be conducted under tropical field conditions, to duplicate natural ultraviolet irradiation. The Sewage used should, to the extent possible, be drawn from a source with a high-risk of hazard and should characterised as completely as possible during the course of the study.

LAND TREATMENT OF SEWAGE

Use of land-based natural treatment systems dates from the late 1800's in the United States and in Europe with " sewage farming" being a relatively common first attempt to control water pollution. These early practices have evolved into the various forms of natural treatment systems used today such as constructed wetlands, infiltration systems, and overland flow systems. Natural treatment systems are capable of removing, to at least some degree, most of the major constituents of domestic wastewater that are considered pollutants including – suspended solids, organic matter, nitrogen phosphorus, and micro-organisms.

The practice in Copperbelt towns of diverting sewage water for irrigation of vegetable gardens etc could likely, with proper training, be adapted to a planned program of overland flow treatment.

In overland flow, pre-treated wastewater is distributed across the upper portions of graded, vegetated slopes and allowed to flow over the slope surfaces to runoff collection ditches at the bottom of the slopes (Metcalf&Eddy, 1991). Although the process has been adapted to a wide range of soil types, overland flow is normally used at sites with relatively low permeable surface soils or subsurface layers. The percolation through the soil profile is relatively minor and the treated effluent is collected as surface runoff with some losses to evapotranspiration. The systems are operated using alternating application and drying periods with the length of the periods dependent on the treatment objectives. The distribution of the wastewater may be accomplished by means of sprinklers or through the use of gated pipes.

Overland flow, like all natural treatment systems, typically requires some form of pre-treatment. Typically, screening or primary sedimentation is required to remove gross solids which can clog distribution systems and also lead to unsightly nuisance conditions. The practice of discharging the sewage into sedimentation basins prior to discharge could be adapted for this purpose. The solids could be periodically dredged from the ponds and composted to provide a natural fertiliser or soil amendment.

Public health aspects of land treatment are related to concerns about bacteriological agents and the possible transmission of disease to animals and humans as well as crop quality when crops are irrigated with wastewater effluents. The survival of pathogenic bacteria applied to soil or sprayed in aerosol droplets has received considerable attention. It is important to realise that any connection between pathogens applied to land through wastewater and contraction of disease in animals or humans would require a long and complex path of epidemiological events, however, precautions should be taken in dealing with possible disease transmission.

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ANNEX G:
OVERVIEW OF COPPERBELT AND KABWE MINE INSTALLATIONS, ACTIVITIES, AND ASSOCIATED ENVIRONMENTAL SIGNIFICANCE

ANNEX G: OVERVIEW OF COPPERBELT AND KABWE MINE INSTALLATIONS, ACTIVITIES, AND ASSOCIATED ENVIRONMENTAL SIGNIFICANCE

RATIONALE

The identification of environmental hazards associated with past and ongoing mining and mineral processing activities under the CEP is a critical precursor to the designation of corporate liabilities, and the design of the CEMP. Prioritization of such hazards will subsequently provide the mechanism for identifying remedial actions to be financed under the CEP's Environmental Mitigation Fund.

Although this EA report focuses primarily on liabilities resting with ZCCM-IH, this appendix includes information on mine facilities of both new mine owners and ZCCM-IH. A list of mine facilities with assigned responsibilities was non existent when this EA was initiated, thus this list was assembled, based on information contained in the EMPs prepared for each of the 11 former ZCCM operations and subsequent audit reports. The list of facilities may not be exhaustive and liabilities indicated in the following tables are subject to change, based on negotiations between ZCCM-IH and new investors.

For the Copperbelt, Section 3 of the EMPs prepared for each of the former ZCCM operations (Nkana, Nchanga, Chambishi, Konkola, Mufulira, Chibuluma, Chibuluma South, Luanshya, and Ndola) details the components of mining and mineral processing operations which constitute potential hazards. These EMPs were prepared exclusively by the international geoscience consultant SRK during the period 1996-98. This information, plus the post-privatization Interim EMPs prepared for KCM properties (Konkola, Nchanga, Luanshya, and Mufulira), forms the basis of the overview of minerals-sector hazards provided here. In addition, information contained in environmental audits of dumps conducted between 1998 and 2001 by Knight Piesold was incorporated into these tables. With respect to Nchanga, Konkola, Nkana, Luanshya, Mufulira and Chambishi, this pre-existing information has been supplemented by field observations made by members of the Komex International team during the execution of the EA.

For Kabwe, an analogous inventory of hazard sources has been provided by a Swedish AB (1993 and 1994). Environmental Audit, and within the ZCCM's Kabwe Site Rehabilitation and Decommissioning Plan (1995).

The following mine facility hazard sources are present in the Copperbelt and Kabwe:

Underground mine workings *	**Tailings paddocks and cross-valley impoundments ***
Open pits *	**Process waters and waste waters**
Waste rock and overburden dumps *	**Sewage**
Slag dumps and ore stockpiles	**Municipal waste**
Concentrators *	**Industrial aerosols and radioactive sources**
Pyrometallurgical plant *	**PCB's**
Acid plant *	

*Hazard sources highlighted with asterisks in the above listing do not warrant further description in this appendix, as relevant information has been provided in the main body of the text (Section 2.3 of Part II). Brief descriptions of all other listed hazard sources are, however, provided below.

Tables G.1 – G.17 provide inventories of the occurrence and potential significance of each of these sources, plus a qualitative restoration priority rating based on (a) proximity and potential impact of human populations, (b) interaction with water resources, (c) presumed toxicological hazard.

SLAG STOCKPILES AND ORE STOCKPILES

Slag stockpiles comprise molten slag (from pyrometallurgical plant) dumped in place, or granulated slag deposited either directly or by hydraulic means. Granulated slag dumped directly behaves like waste rock in terms of slope formations and stability. Hydraulically placed slag is deposited in paddocks similar to those used in tailings disposal.

Ore oxide and slag stockpiles are highly metalliferous, and constitute a source of contaminated leachate and fugative dust. All are, however, expected to be removed, and the foundation areas reclaimed following mine closure. Where such stockpiles are left in place, stability and erosion control aspects should be treated as for overburden dumps. In addition, leachate runoff may require chemical treatment for the removal of Co, Cu and other metals.

MINE AND PROCESS WASTE WATERS

Minewaters and process wastewaters present both a potential hazard, and a wasted resource if not re-utilised to the maximum possible extent. At many Copperbelt mines, subterranean waters are treated for potable supply, and/or for use in beneficiation operations. The water from underground mine workings is characteristically gravity-settled before being pumped to surface. Consequently, the water reaching surface is generally low in TSS. No additional treatment is generally applied for discharged minewater. Water for potable supply, for example at Chambishi, is clarified and chemically treated with chlorine gas.

The water and other effluents from Cu and Co beneficiation are variably discharged to surface watercourses and tailings facilities. Treatment is generally restricted to sludge settlement and lime dosing of leach-cycle effluents.

At Kabwe, the groundwater supply from the Makululu field mine is hydraulically connected to the underground mine. Monitoring results to date indicate that the water quality is satisfactory.

SEWAGE

Although the release from sewage plants is regulated under the Water Supply and Sanitation Act No. 28 of 1997 and the Water Pollution Control (Effluent and Wastewater) Regulations SI No. 72 of 1993, many Copperbelt plants are overloaded and not meeting those standards. In some cases (e.g. Chambishi), essentially raw sewage is being discharged, with a resulting impact on the Kafue River and a downstream water supply intake. The main hazards associated with inadequate sewage treatment accrue to downstream uses of residents and farmers who are exposed to potentially severe health risks. Sewage collection systems are also in need of rehabilitation. Leakage from broken pipes poses a risk of potable water supply contamination.

At Kabwe, the existing sewage treatment plant in a state of disrepair and raw sewage is being discharged into the main canal. This poses health risks to the general population and potentially also to contamination of the aquifer supply water to Kabwe.

MUNICIPAL SOLID WASTE

Although the disposal of municipal solid waste is the responsibility of the individual communities in Copperbelt, in some cases indiscriminate and unlicensed disposal is occurring. The primary hazard associated with this practice is the generation of organic leachate which infiltrates and contaminates groundwater, with a resultant impact on potable water quality in areas of groundwater abstraction. An example of a solid waste tip is ZCCM's Nkana ML3, where Tailings Dump TD 27 is being utilized as a garbage dump.

INDUSTRIAL AEROSOLS AND RADIOACTIVE WASTES

The host lithologies of the Copperbelt's stratiform Cu deposits are uraniferous. This, coupled with carbonate fracture conduits produces a significant radon (Rn) hazard in the underground workings. Radon is a naturally occurring gas phase U^{238} series decay product with a half-life of 3.8 days. As an alpha-emitter, Rn and its decay products Pb, Po and $Bi^{214/210}$ can induce lung cancer among following respiration through radon/radon progeny aerosol disposition.

A preliminary survey undertaken by the Industrial Aerosol Project ZAM/9/006 in 1998 revealed that 40% of the surveyed mine sites had mean Rn levels above the statutory action level of 1000Bq per m^3 (equivalent to 6mSv per year as recommended by the International Atomic Energy Agency). The annual dose equivalent limit for workers in Zambia is 0.5Sv per year in any tissue except the lens of the eye, for which the limit is 0.15Sv per year. This survey raises concern for occupational and environmental protection from Rn originating from mining and metallurgical/mineral processing industry aerosols.

Industrial ionising radiation sources are used at several locations in the Copperbelt's mines, notably low level Cs sources in Plant process and radioactive Co sources in process assay instrumentation. Locations of both potential Rn and spent-source exposure to ionising radiation are identified in Table 7.9.

Low-level radioactive waste materials are stored at a site in Kalulushi. The types of radioactive sources include Co^{60}, Cs^{137}, Pu^{238}, Ra^{226} and Am^{241}. The site appears to adequately address aspects relating to protection of staff, public and the environment as required by law.

EQUIPMENT AND WASTE CONTAINING POLYCHLORINATED BIPHENYLS

Stocks of PCBs have accumulated from historical mining activities. An estimated 100 tonnes of PCB oil, PCB capacitors and contaminated materials are currently stored at two sites in Copperbelt at the , Nkana Old Cobalt Plant and a container at Kalulushi (outside the Radiation Waste Storage Shed). In addition, a total of 50 transformers are located within the plant site at the Kabwe mine, and an additional 10 transformers are located in the underground workings.

Potential hazards associated with release of PCBs into the environment include:

- Contamination of underground water regimes through seepage contaminated water.
- Contamination of surface water bodies through run-off of contaminated water running into public streams.
- Contamination of food chains.
- Exposure of communities through theft and resale of PCB oils.

PCBs are persistent organic pollutants (POPs) and are of environmental concern as they are toxic, persistent, bio-accumulative, and mobile. When exposed to high temperatures, they degrade to furans and dioxins, both of which are carcenogenic. PCB contamination of groundwater used for potable supply may have significant human health implications at concentrations in the µg/l (parts per billion) or low mg/l range.

The status of ZCCM maintained PCB storage sites and inventories are summarized in Table G16A.

PRIORITIZATION OF SITE SPECIFIC HAZARD SOURCES

Tables G.1 – G.17 provide inventories of the occurrence and potential significance of each of the above types of hazard source at each Copperbelt mine encompassed in the CEP, and at Kabwe. For all occurrences, a tentative restoration significance rating is also provided (high, medium or low). Although judgements reported in previous studies (for example ZCCM EIS's) of Copperbelt and Kabwe mine installations provided an important source of baseline information, the procedure used by the EA team to assign significance was as follows:

i. ZCCM EIS statements (SRK, 1996) were evaluated for each mine to establish conditions of individual facilities as of that date. Potential hazard levels (and thus restoration priority) were independently assessed, based on data provided in the EIS volumes.

ii. Environmental audits of the Konkola, Chambishi, Nkana and Mufulira mines (SRK, Golder, Knight Piesold, 1996-2001) were reviewed to establish any temporal change of environmental hazard status subsequent to the collation of data used in the ZCCM EIS reports.

iii. Information provided within the Kabwe Rehabilitation Plan (ZCCM, 1995), including extracts of an environmental audit (Swedish AB, 1994), and progress reports on site rehabilitation (to June 2001) were used to assess the hazard status of facilities and installations at Kabwe.

iv. Site visits to Nkana, Chambishi, Konkola, Nchanga, Luanshya, Kalulushi, and Kabwe were undertaken by members of the Komex team during the period March – October 2001. These facilitated re-assessment of several potential hazard sources previously identified in the ZCCM EIS statements (and all other documents referred to above), and evaluation of the extent of temporal changes in their condition during the period 1996-2001. In effect, these visits formed an evaluation of the present-day validity of the ZCCM EIS's. In most instances, the physical and chemical conditions described for tailings and waste dumps within the ZCCM EIS's were found to remain valid. For example, Nkana paddock TD33 is described as of poor stability and with limited vegetation cover in both the EIS and audit statements compiled in 1996 and 1997 respectively. This state remains to the present day, and a number of peripheral collapses have occurred during the interim period.

v. An independent hazards priority ranking was applied to each installation and/or facility by the Komex team. This procedure was essentially qualitative, based on the following factors listed in order of their relative significance:

  (a) Probability of human interaction – (based on proximity of formal and informal settlements, and/or encroachment for agriculture or other activities).
  (b) Chemical toxicity hazard – (based on chemical data for effluents, tailings, waste rock, overburden and other chemical contaminant sources presented in ZCCM EIS's).
  (c) Impact on water resources.
  (d) Evidence of aqueous or atmospheric mobilization - (based on evidence of hydraulic or Aeolian erosion).
  (e) Impact on ecology.

(f) Land use loss.
(g) Aesthetic impact.

TABLE G.1: UNDERGROUND WORKINGS

	Mine /Lease Area	Liability	Subsidence		Distance to Population Centre	Water Quality Impact	Remarks	Significance
			Area (Ha)	Type				
1	Nkana ML 3	New Investor	1504.56	45° Subsidence	< 1 km from Mindola, Wusakile, Nkana west Townships	Y	Wusakile stream canalised across the southern areas of the subsidence. Some drainage takes place in the subsidence area via drainage ditches.	L
2	Nkana ML 3	New Investor	63.03	80° Cave line	< 1 km from Mindola , Wusakile, Nkana west Townships	Y	Mindola stream flow managed across the subsidence area.	L
3	Konkola ML 7	New Investor	1504.56	45° Subsidence	1.5 km from Lubengele Township	Y	Lubengele stream is canalised and piped across part of the subsidence area. No surface water management at NO. 1 shaft.	L
4	Konkola ML 7	New Investor	63.03	80° Cave line	<1.5 km from Lubengele Township	Y	Lubengele stream is canalised and piped across part of the subsidence area. No surface water management at NO. 1 shaft.	L
5	Nchanga ML 10 Block A	New Investor	35.99	45° Subsidence	2 km from South Township	N	No major stream across the undermined area. Continual and effective management of storm water is carried out across the undermined area .	L
6	Nchanga ML 10 Chingola B	New Investor	1.84	45° Subsidence	1.5 km from Chikola Township	N	No major stream across the undermined area. Continual and effective management of storm water is carried out across the undermined area	L
7	Nchanga ML 10 Nchanga LOB	New Investor	610.70	45° Subsidence	1.5 km from South Township	N	No major stream across the undermined area. Continual and effective management of storm water is carried out across the undermined area	L
8	Nchanga ML 10 Chingola B	New Investor	40.57	80° Cave line	1.5 km from Chikola Township	N	No major stream across the undermined area. Continual and effective management of storm water is carried out across the undermined area	L
9	Mufulira ML 15	New Investor	939	45° Subsidence	< 0.5 km from Kantashi Township	Y	Very elaborate water management across Mufulira stream subsidence area. Mufulira stream backfilled, little subsidence on the original stream.	L
10	Luanshya ML 16	New Investor	478.47	45° Subsidence	< 0.5 km from Mpatamatu Township	Y	Subsidence almost stabilized and the floor of the depression very stable and extensively vegetated. No surface water management	L
11	Luanshya ML 16 Area A	New Investor	56.94	80° Cave line	< 1 km from Roan Township		Subsidence almost stabilized and the floor of the depression very stable and extensively vegetated. No surface water management	L
12	Luanshya ML 16 Area B	New Investor	25.94	80° Cave line	< 1 km from Roan Township		Subsidence almost stabilized and the floor of the depression very stable and extensively vegetated. No surface water management	L
13	Luanshya ML 16 Area C	New Investor	1.77	80° Cave line	< 1 km from Mpatamatu Township		Subsidence almost stabilized and the floor of the depression very stable and extensively vegetated. No surface water management	L
14	Luanshya ML 16 Area D	New Investor	1.99	80° Cave line	About 1 km from Mpatamatu Township		Subsidence almost stabilized and the floor of the depression very stable and extensively vegetated. No surface water management	L
15	Baluba ML 17	New Investor	200.29	45° Subsidence	About 4 km from Mpatamatu Township	Y	No surface water management	L
16	Baluba ML 17	New Investor	18.62	80° Cave line	About 4.5 km from Mpatamatu Township		No surface water management	L
17	Chambishi ML 19	New Investor	67.84	45° Subsidence	2 km from Chambishi Township	N	No major streams across the subsidence area although the Lusala stream runs over the western ore resource	L
18	Kabwe	ZCCM-IH	1200	80° Cave line	<0.5 km from Kasanda and Chowa Townships		No significant subsidence reported; opening to surface sealed with concrete	L

Blank fields indicate that information is either unavailable or of uncertain validity.

TABLE G.2: OPEN PITS

	Mine / Lease Area	Name/ activity (A/I)	Liability	Area (ha)	Depth (m)	Depth to water (m)	Wall stability	Distance to Population Centre	Reclamation Plan (Y/N)	Remarks	Significance
1	Nchanga ML 10 Luano	I	ZCCM-IH	36.3	130	45	Unstable	< 1km from Kabuta Township		Northern face generally stable but the southern face unstable, failure in the hanging wall has resulted in subsidence to a distance of about 150 beyond the crest of the pit.	M
2	Nchanga ML 10 Nchanga Open Pit	A	New Investor	560	437	-	Unstable	0.5 km from South Township	Y	Signs of distress in the central and western cuts of the north wall. West wall has given stability problem in the past. A serious sloughing resulting in the death of ten miners has occurred very recently.	M
3	Nchanga ML 10 Block A	I	New Investor	88	150	-	Unstable	1.5 km from South Township	N	A failure on the north face has resulted in a major slough from the crest to the base of the pit. Wall failures have been recorded in the west wall as well.	M
4	Nchanga ML 10 Chingola B	I	New Investor	21.2	100	-	Stable	2 km from Chikola Township	N		L
5	Nchanga ML 10 Chingola C	I	ZCCM-IH	60	127	-	Stable	2 km from Chikola Township	N		L
6	Nchanga ML 10 Chingola E	I	ZCCM-IH	27	100	100	Stable	2.5 km from Chikola Township	N		L
7	Nchanga ML 10 Mimbula 1 & 2, Fitula	I	ZCCM-IH	31.5	132	80	Unstable	3.5 km from Lulamba Township	N	Failure has occurred in the in the north face and west face.	M
8	Nkana ML 3 Mindola Open pit	I	New Investor	110	144	-	Unstable	1.5 km from Mindola Township	N	Hanging wall relatively steep and instability can be expected with the crest of the slope ravelling.	M
9	Nkana ML 3 Nkana Area 'E' Open pit	I	New Investor	20	50	-	Stable	< 0.5 km from Nkana West Township	N		L
10	Chambishi ML 19 Chambishi Open Pit	I	New Investor	78	150	-	Stable	2 km from Chambishi Township	N		L
11	Ndola Lime ML 8	A	Undecided	-	50	-	Stable	About 5 km from Ndola Townships		No major slopes have been established at Ndola open pit.	L
12	Kabwe	I	ZCCM-IH	68	20	<5	Stable	<0.5 km from Kasanda & Chowa Townships	Y	Located adjacent to main plant; limited fencing to prevent public access.	M

TABLE G.3: OVERBURDEN DUMPS

	Mine/ Lease Area	No.	Liability	Area (ha)	Vol. (Mm³)	Active / Inactive (A/I)	Reclamation Erosion (0-3 / A-C)[1]	Distance to Population Centre	Dust Control	Water Quality Impact	Remarks	Significance
1	Nchanga ML 10	OB 1	New Investor	500		A	1,C	2 km from Kabundi North Township		Y	Located at Nchanga Open Pit Rim. 50% grass cover. Erosion gulleys evident. Note several ore stockpiles on dump.	M
2	Nchanga ML 10	OB 2	ZCCM-IH	100		A	1,C	1.5 km from South Township		Y	10% grass cover. Erosion gulleys evident. Ore stockpile on dump.	M
3	Nchanga ML 10	OB 4	ZCCM-IH	30	-	A	0,B	2 km from Chikola Township		Y	Located North of Chingola Open Pit. No significant vegetation with erosion gulleys evident. A large subsidence area exists on the north of OB2 due to block caving.	H
4	Nchanga ML 10	OB 5	ZCCM-IH	110		A	O,B	1 km from Chikola Township		Y	Located at Chingola Open Pit Rim. No significant vegetation with erosion gulleys evident	M
5	Nchanga ML 10	OB 6	ZCCM-IH	-	-	A	0	1.5 km from Chikola Township		Y	Located at Chingola Open Pit Rim No significant vegetation.	M
6	Nchanga ML 10	OB 7	ZCCM-IH	10	-	A	0	3.5 km from Lulamba Township		Y	Located at Mimbula 2 Open Pit. North-eastern side heavily eroded.	M
7	Nchanga ML 10	OB 8	ZCCM-IH	45		A	1	5 km from Lulamba Township		Y	Located Near Mimbula 2 Open Pit. Portion of the dump on the northern and southern flanks well vegetated with grass and trees but the rest of the dump not vegetated.	L
8	Nchanga ML 10	OB 9	ZCCM-IH	60		A	1,B	8 km from Lulamba Township		Y	Located at Fitula Open Pit Rim. North 60% cover South 20% cover Erosion gulleys evident	L
9	Nchanga ML 10	0B 10	ZCCM-IH	10		I	3,A	9 km from Lulamba Township		N	Located South of Fitula Open Pit. Well revegetated. Severely eroded on the slopes, especially the south-western section.	L
10	Nchanga ML10	OB 11	ZCCM-IH	84	17	A	3,C	9 km from Lulamba Township		N	Located South of Fitula Open Pit. 70% vegetative cover. Erosion along ramp road.	L
11	Nchanga ML 10	0B 13	ZCCM-IH	40	12	A	3	8 km from Lulamba Township		N	Located at Fitula Open Pit Rim. 70% cover of grass, trees and shrubs.	L
12	Nchanga ML 10	0B 14	ZCCM-IH	20	2.2	A	2,B	6 km from Lulamba Township		N	Located South-West of Mimbula 2 Open Pit. Well revegetated. Erosion along the ramp road.	L
13	Nchanga ML 10	OB 15	ZCCM-IH	26	2.3	A	1,B	8.5 km from Lulamba Township		N	Located North-East of Fitula Open Pit. 50% grass cover. Ore stockpile on dump.	L
14	Nchanga ML 10	OB 18	ZCCM-IH	50	13	A	0,B	1.5 km from Kabuta Township		N	Located at Luano Open Pit Rim. Negligible cover. Steep sided at an angle of repose. Very significant erosion of side slopes.	M
15	Nchanga ML 10	OB 19	ZCCM-IH	40	6	A	1,B	2.5 km from Chikola Township		N	Adjacent to Chingola Open Pit. Poor vegetation with erosion gulleys evident.	M

[1] Reclamation: 0 – barren state; 1- some material vegetation; 2 – formal vegetation program; 3 – substantial vegetation
Erosion: A – highly eroded offsite siltation; B – moderately eroded; C – little eroded siltation.
Blank fields indicate that information is either unavailable or of uncertain validity.

	Mine/ Lease Area	No.	Liability	Area (ha)	Vol. (Mm³)	Active / Inactive (A/I)	Reclamation Erosion (0-3 / A-C)[1]	Distance to Population Centre	Dust Control	Water Quality Impact	Remarks	Significance
16	Nchanga ML 10	OB 20	New Investor	60	36	A	0	1.5 km from South Township		N	For backfilling of Nchanga Open Pit. No vegetation.	M
17	Nchanga ML 10	OB 21	New Investor	55		A	0	1.5 km from South Township		N	For backfilling of Nchanga Open Pit. The dump is in the middle of the pit. It may be removed to give access to mine ore. No vegetation.	L
18	Nchanga ML 10	OB 22	New Investor	40	44	A	2	2 km from South Township		Y	Adjacent to Block A Open Pit. 20% tree cover planted in 1994 – 1996.	L
19	Nchanga ML 10	OB 23	New Investor	15		A	1,A	1 km from Kabundi North/Kabuta Townships		Y	Located West of Luano Open Pit. No significant vegetation. Very significant erosion on slopes.	M
20	Nkana ML 3	OB 53	ZCCM-IH	13.8	1.9	I	3,C	<0.5 km from Nkana West Township		Y	Dump plateau fairly good condition and well vegetated on the upper surface. Access ramp severely eroded. Embankment slopes generally stable but north-eastern and southern corners badly gullied.	L
21	Nkana ML 3	OB 54	ZCCM-IH	42.3	8.4	I	1,C	3 km from Mindola Township	Y	Y	Dump in reasonable condition. Embankments stable apart from some gullying on the western slopes. Dump surface graded. Some part of the access ramps extensively gullied. Toe drains partly full with silt. Sparsely vegetated in most areas with some trees in the southern part.	L
22	Nkana ML3	OB 63	Undecided	60.3	17.9	A	1, B	1 km from Mindola Township	Y		Active but non-operational for many years. Fairly good condition and well-graded plateau. Sparsely vegetated on the surface. South-eastern and western walls gullied. Southern and eastern walls severely eroded. Toe drain clear. Used for lead/acid battery disposal.	L
23	Ndola Lime ML 8	Old Dump	Undecided	7.2	1.79	A	3	About 5 km from Ndola Townships	Y	Y	Upper surface well graded and drained. Vegetation well established on the plateau and slopes. Embankment in good condition and stable. Good vegetation but some portions lack vegetation.	L
24	Ndola Lime ML 8	North West and South West Dump	Undecided	6	1.05	A	1, B	About 5 km from Ndola Townships	N		Generally in good conditions. Some erosion and gullying on slopes. Part of the dump is vegetated.	L
25	Chambishi ML 19	OB 1	New Investor	40	127	I	3, C	2 km from Chambishi Township	Y		Situated in the 45° caving line. Widespread instability in the northern area, extensive cracking and slippage of material into the open pit caused by subsidence. The dump is generally well vegetated with grass and trees	L
26	Chambishi ML 19	OB 2	New Investor	7	1.0	I	1, B	2 km from Chambishi Township	Y		Generally in good condition, with good vegetation. Some erosion has taken place	L
27	Chambishi ML 19	OB 5	New Investor	25	2	I	1, B	2 km from Chambishi Township			Wall generally in good condition, for several large gullies.	L

TABLE G.4: WASTE ROCK DUMPS

	Mine/ Lease Area	No.	Liability	Area (Ha)	Vol. (M tonnes)	Active / Inactive (A/I)	Reclamation Erosion (0-3 / A-C)[2]	Distance to Population Centre	Dust Control	Water Quality Impact	Remarks	Significance
1	Nkana ML 3	WR 14	New Investor	1.5	1.3	A	0,C	1 km from Mindola Township		Y	Northern embankment in good condition. Southern bank steep with tension cracking.	L
2	Nkana ML 3	WR 28	New Investor	6.3	-	A	0,C	<1 km from Nkana West Township	N	Y	Reclamation of waste rock for crusher feed has removed the dump to original ground level in most areas. Some tension cracking along the wall crests. The lower northern part very steep faces.	L
3	Nkana ML 3	WR 29	New Investor	11.7	-	I	0,C	< 0.5 km from Nkana West Township		Y	Surface firm and well drained. Generally in good condition. Used as scrap yard for unserviceable mine equipment, mine plant waste and builder's rubble. Minor ponding of rainwater. Southern area used as slag dump (No. 67)	M
4	Nkana ML 3	WR 42	New Investor	4	-	A	0	<1 km from Nkana West/ Wusakili Townships		Y	Parts of the dump overlie caving ground. Tension cracking, sinkholes and slippage have caused instability in the northern plateau and western part of dump. Sinkholes and cracks infilled with waste rock. Toe drains along the northern sides. Western edge over the caving area hazardous. Capacity of the dump uncertain due to material loss in the caving area.	L
5	Konkola ML 7	WR A	New Investor	22.5	7.5	A	0, C	<0.5 km from Lubengele Townships		N	Located on caving ground and affected by tension cracking and sinkholes. Surfaces well graded and embankment stable. No vegetation on the dump.	M
6	Konkola ML 7	WR B	New Investor	11	3.1	A	1, C	<0.5 km from Lubengele Townships		N	Overlies caving ground but not seriously affected by settlement. The plateau well levelled. The embankments stable and in good condition. Generally bare, only small patches of grass over 10% of the dump. Slopes unvegetated.	L
7	Mufulira ML 15	WR 11	New Investor	17.4	3.15	A	1, C	<1 km from Kankoyo Townships	Y		No material has been dumped for many years. The plateau well graded and drained. The embankments are stable and there are no signs of erosion or gullying. The lower southern berm is in good order and the surface is well levelled. Minimal vegetation cover – apart from trees on top and side dump. Some trees at the toe area	L
8	Mufulira ML 15	WR 13	New Investor	5.9	0.22	I	1, C	<1 km from Butondo/ Kankoyo Townships	Y		Affected by caving settlement, particularly in the northern and north western areas. Deep and active gullies in the northern end of the dump. The remainder of the dump is in reasonably good condition. Minimal vegetation cover.	M
9	Mufulira ML 15	WR 14	New Investor	-	-	A	0	<1 km from Kankoyo Townships	N		Fairly low and generally well graded. Two aggregate crushing plants sited on the surface for many years. The surface is well drained. No vegetation on sides slopes.	L
10	Mufulira ML 15	WR 17	New Investor	14	8.6	A	1	<1 km from Mufulira Townships	N		Overlies caving ground and experienced tension cracking in the past due to caving settlement but cracks infilled. No vegetation on side slopes. The plateau is well graded.The walls are in good condition and there are toe drains to the west and south.	L
11	Luanshya ML 16 Shaft 28	WR 9	New Investor	12.8	2.9	A	0	<1 km from Mpatamatu Township	N	Y	Steep slopes subject to slippage. Lack vegetation and susceptible to dust blow up in dry season	M

[2] Reclamation: 0 – barren state; 1- some material vegetation; 2 – formal vegetation program; 3 – substantial vegetation
Erosion: A – highly eroded offsite siltation; B – moderately eroded; C – little eroded siltation.
Blank fields indicate that information is either unavailable or of uncertain validity.

	Mine/ Lease Area	No.	Liability	Area (Ha)	Vol. (M tonnes)	Active / Inactive (A/I)	Reclamation Erosion (0-3 / A-C)[2]	Distance to Population Centre	Dust Control	Water Quality Impact	Remarks	Significance
12	Luanshya ML 16 Irwin south dump	WR 14	New Investor	9.7	0.5	I	1,B	<0.5 km from Mpatamatu Township	N	Y	Some sections of dump require reprofiling. Steep slopes subject to slippage. Significant amount of gullies due to running water during the rain season.	M
13	Luanshya ML 16 Shaft 18	WR 15	New Investor	3.6	0.2	I	1, B	1 km from Mpatamatu Township	N	Y	Some sections of dump require refilling. Steep slopes subject to slippage. Significant amount of gullies due to running water during the rainy season.	L
14	Luanshya ML 16 14 South dump	WR 18	New Investor	28.9	3.4	I	2, B	<0.5 km from Roan Township	N	Y	Sparingly vegetated with grass and some guava trees. Eastern, southern and western slopes have significant gullies due to water erosion and lacking in vegetation.	M
15	Luanshya ML 16 North dump	WR 19	New Investor	16.3	2.2	I	3	1 km from Roan Township	Y	Y	Dump to surface thickly vegetated with grass and trees 100% vegetated	L
16	Luanshya ML 16 Muliashi dump	WR 32	New Investor	3	0.2	I	3	1 km from Mpatamatu Township	Y	Y	Both dump surface and slopes thickly vegetated with grass. A 100% vegetation.	L
17	Baluba ML 17 Baluba West	2	New Investor	4.3	2.6	A	1,	5 km from Mpatamatu Township	Y	Y	Dump top surface thinly vegetated with grass. Steep slopes subject to slippage. At 1.03 percent total copper there is possibility of reclamation for extraction of copper.	M
18	Baluba ML 17 Baluba East	WR 3	New Investor	4.2	4.3	A	0,	5 km from Mpatamatu Township	N	Y	Lacking in vegetation and susceptible to dust blowing in the dry season. Steep slopes subject to slippage. At 1.03 percent total copper there is possibility of reclamation for extraction of copper. Requires reprofiling.	M
19	Chibuluma ML 18	WR 5	New Investor	3	-	A	1	<0.5 km from Kalulushi Township	N	Y	Comprising of scattered waste rock piles (some of this reportedly contains ore grades so it can be considered to be a stockpile. No vegetation on areas where rock is placed - however vegetation is prevalent in all other areas between the dumps.	L
20	Ndola Lime ML 8	R4	Undecided	0.32	0.008	A	0	About 5 km from Ndola Townships	N	N	Being reclaimed by Chilanga cement Plc. for cement processing. Surface well drained little vegetation	L
21	Ndola Lime ML 8	R5	Undecided	1.3	1.86	A	1	About 5 km from Ndola Townships	N	N	Very little vegetation cover	L
22	Chambishi ML 19	WR 17	New Investor	10	2	I	1, C	2 km from Chambishi Township	Y	Y	Vegetation sparse on the walls very minor erosion.	L
23	Chambishi ML 19	WR 18	New Investor	1 9	1.0	I	1,	2 km from Chambishi Township	Y	Y	The upper surface of the dump is generally except for some tension cracks. Some vegetation.	L
24	Kabwe		ZCCM-IH & New Investors (Sable Zinc)	1.5	0.2	I	0	<0.5 km from Kasanda and Chowa Townships	N	N	Most of the waste rock has been sold for crushing into aggregate.	L

TABLE G.5: SLAG STOCKPILES

	Mine/ Lease Area	No.	Liability	Area (Ha)	Vol. (M tonnes)	Active A/I	Reclamation Erosion	Distance to Population Centre	Dust Control	Water Quality Impact	Remarks	Significancey
1	Nkana ML 3	SL 48	New Investor	120	18	A	0, C	<0.5 km from Wusakili Township		Y	Tipped molten slags. Well graded and in good condition. In the past subjected to wide spread and severe tension cracking, with deep cracks up to 50m long and 400mm wide but all cracks infilled now.	L
2	Nkana ML 3	SL 67 (New Slag Dump)	New Investor	80	-	I	0, C	<1 km from Wusakili Township	N	Y	A new slag dump overlying the southern par of waste rock dump 29. Dumped with builder's rubbles and metal scrap. Material broken and graded.	L
3	Nkana ML 3	SL 68 (Reverb Slag Dump)	New Investor	6.5	0.5	A	2, C	3 km from Nkana West Township	N	Y	Used for disposal of flotation tailings. Walls topsoiled and grassed. Crest road capped with laterite to protect slopes from runoff erosion. Some gullying in southewestern corner and crest road. Minor erosion on the southern, eastern and northern side. Sparsely vegetated on the paddock surface.	L
4	Mufulira ML 15	SL 12	New Investor	21.5	8.33	A	0,	<0.5 km from Kankoya Township	N	Y	None active areas well maintained. Portion of dump being reprocessed. No vegetation	L
5	Mufulira ML 15	SL 15	New Investor	16.8	5.7	A	0, C	<0.5 km from Kankoya Township	N	Y	Dump top surface and slopes in good condition. No vegetation.	L
6	Luanshya ML 16	SL 21 (New Slag Dump)	New Investor	125	1.29	A		< 0.5 km from Roan Township		Y	The dump is in good condition and the surface is, for the most part, well graded and drained. The embankments are in good order. There is a large crack in the dump at the southeastern end which has been monitored for adverse movements for many years. No recent movements have been recorded, however, and it is believed that the area is now stable.	L
7	Kabwe	Waelz kiln & ISF	ZCCM –IH	16.5	3	I	0	<0.5 km to Kasanda & Chowa Townships	N	Y	Coarse grained (1 – 20 mm) Spontaneous combustion in western area due to presence of carbon in slag Tested for 2.2% Pb and 4.4% Zn,; Zn and S leachate.	M

TABLE G.6: ORE STOCKPILES

	Mine/ Lease Area	No.	Liability	Area (Ha)	Vol. (M tonnes)	Active A/I	Reclamation Erosion	Distance to Population Centre	Dust Control	Remarks	Significance
1	Nkana ML 3	SP 3	ZCCM-IH	1.6	-	A	1,C	2 km from Mindola North Township	Y	Surface well graded. Minor erosion and tension cracking along the southern crest. Some vegetation on the dump surfaces. Toe drains in south, east and north parts.	M
2	Nkana ML 3	SP 10	ZCCM-IH	2.4	-	A	3,C	1 km from Mindola North Township	Y	Non-operational for many years. In good condition with surfaces smoothly graded and well vegetated. Embankment slopes protected from runoff erosion by bund.	L
3	Nkana ML 3	SP 51	ZCCM-IH	11.0	-	A	0,C	2 km from Mindola North Township	N	Upper surface well graded and walls generally in good condition. Minor erosion and gullying along the western embankment.	L
4	Nkana ML 3	SP 55	New Investor	1.0	-	A	0,C	<1 km from Nkana West Township	N	Infrequently used and largely cleared of material. Dumped with scrap metals and builder's rubble in the northern side. The dump is generally well graded.	M
5	Nchanga ML 10	SP 11	ZCCM-IH	14	-	A	0,C	5 km from Lulamba Township		Walls generally stable, except the northern and lower berms, which are severely eroded and gullied.	L
6	Nchanga ML 10	SP 13	ZCCM-IH	10	76	A	0,	5 km from Lulamba Township		Bare no vegetation. Erosion of surface limited due to structural nature of the material.	L
7	Nchanga ML 10	SP 14	ZCCM-IH	12		A	0,C	9 km from Lulamba Township		The virtually empty down to ground level	L
8	Chibuluma ML 18	SP 3	New Investor	-	-	A	2,	<1 km from Kalulushi Township		All material cleared years ago.	L
9	Chambishi ML 19	SP 3	New Investor	12.5	1.45	I	1	2 km from Chambishi Township		Generally in good condition but vegetation is parse.	L
10	Chambishi ML 19	SP 4	New Investor	12.5	1.24	I	0	2 km from Chambishi Township		Walls of the dump stable but no vegetation.	L
11	Kabwe	-	ZCCM-IH & New Investors	0.1	-	I	0	<0.5km to Kasanda & Chowa Townships		Disposal plans not determined.	M

TABLE G.7: PROCESSING PLANTS

	Mine/ Lease Area	Plant Type	Liability	Operating Status	Distance to Population Centre	Air Quality Control	Impact Level	Remarks
1	Nkana ML 3	Concentrate dryer	New Investor	Active	< 0.5 km from Wusakile/ Nkana West Township		Low	Not a source of environmental concern. No sulphur dioxide produced from concentrates
2	Nkana ML 3	Smelter Furnaces	New Investor	Active	< 0.5 km from Wusakile/ Nkana West Township	120m stack	High	Kitwe residents especially Wusakile township affected by SO_2 emission. Part of the concentrates are oxidised producing sulphur dioxide vented through 78m stack
3	Nkana ML 3	Converters	New Investor	Active	< 0.5 km from Wusakile/ Nkana West Township	84m high stack	Low	
4	Nkana ML 3	Cobalt Plant	New Investor	Active	< 0.5 km from Wusakile/ Nkana West Township	40.8m stack	Low	
5	Nkana ML 3	Acid Plant	New Investor	Active	< 0.5 km from Wusakile/ Nkana West Township			Miners exposed to SO2 gases. Sulphur dioxide in the tail gases not measured
6	Konkola ML7	Concentrate dryer	New Investor	Active	< 1.5 km from Kameza, Lubengele Township		Low	Low emission
7	Nchanga ML 10	Concentrate dryer	New Investor	Active	< 0.5 km from South Township	14.4m stack	Low	Low emission
8	Mufulira ML 15	Concentrate dryer	New Investor	Active	< 0.5 km from Kankoya/ Kantashi/Mufulira Townships		High	High level of dust emission
9	Mufulira ML 15	Electric Furnace	New Investor	Active	< 0.5 km from Kankoya/ Kantashi/Mufulira Townships	60.96m stacks	Low	
10	Mufulira ML 15	Pierce Smith Converter	New Investor	Active	< 0.5 km from Kankoya/ Kantashi/Mufulira Townships	41.3m stacks		Sulphur dioxide bearing gases
11	Mufulira ML 15	Anode Furnace	New Investor	Active	< 0.5 km from Kankoya/ Kantashi/Mufulira Townships		Low	Pollutants mainly from combustion of coal
12	Luanshya ML 16	Dryer	New Investor	Active	< 0.5 km from Roan Townships			
13	Luanshya ML 16	Reverberatory Furnace	New Investor	Active	< 0.5 km from Roan Townships	54.8 metre stack		Sulphur dioxide bearing gases
14	Luanshya ML 16	Pierce Smith Converters	New Investor	Active	< 0.5 km from Roan Townships	39 metre stacks	High	No sulphur dioxide fixing device and hence emissions of up to 98 % are expected
15	Luanshya ML 16	Anode Furnaces	New Investor	Active	< 0.5 km from Roan Townships		Low	pollutants arise mainly from the combustion of coal
16	Ndola Lime ML 8	Rotary kiln	New Investor	Active	About 5 km from Ndola Townships	50 metre stack	Medium	Ndola Lime does not sample emissions at the stack, no provision for gas sampling
17	Ndola Lime ML 8	Vertical shaft Kiln	New Investor	Active	About 5 km from Ndola Townships	56 metre stack	Medium	Ndola Lime does not sample emissions at the stack, no provision for gas sampling
18	Chambishi ML 19	Cobalt Roaster	New Investor	Active	1.5 km from Chambishi Township			
19	Chambishi ML 19	Acid Plant	New Investor	Active	1.5 km from Chambishi Township			
20	Kabwe	Concentrator and Leach Plant	ZCCM –IH New Investor	Inactive	<0.5 km from Kasanda & Chowa Townships	--------	None	Plant facilities to be converted into an industrial commercial development; unsafe structures to be demolished.

Blank fields indicate that information is either unavailable or of uncertain validity.

TABLE G.8: PADDOCK TAILINGS DUMPS

	Mine/ Lease Area	No.	Liability	Area (Ha)	Vol. (M tonnes)	Active / Inactive (A/I)	Reclamation Erosion (0-3 / A-C)[3]	Distance to Population Centre	Dust Control	Water Quality Impact	Remarks	Significance
1	Nkana ML 3 Mindola East	TD 15	New Investor	130	34	I	3, C	About 1 km from Mindola Township	Y	L	Embankment and tailing benches in good condition, erosion damage regularly repared. Slopes well vegetated	L
2	Nkana ML 3 Cottin Dam	TD 19	ZCCM-IH	1.4	0.017	I	3,C	< 1km from Mindola Central Township	Y	L	Main upper plateau well vegetated but lower berm is bare. Walls generally well vegetated except in northern embankment. A perimeter crest bund protects the walls from runoff erosion. Gullies in the northern walls repaired.	L
3	Nkana ML 3 Nkana Dam	TD 25	ZCCM-IH	105	27	I	3, C	< 1km from Nkana East Township	Y	M	Comprises of two paddocks. Surfaces are well levelled, firm, capped with topsoil and well vegetated. Embankment generally in good condition with minor erosion. Internal walls between eastern and western paddocks severely gullied and no vegetation. Toe drains in good condition, discharging into Kitwe stream.	L
4	Nkana ML 3	TD 31	ZCCM-IH	21	0.25	I	3, C	< 1km from Nkana West Township	Y	M	Dam slopes very flat with thin layer of tails. Well vegetated especially in the northern part of the dam. Vegetation in the southern part affected by slimes overflowing from silt traps.	M
5	Nkana ML 3	TD 33C	ZCCM-IH	136	38	A	0, C	> 3 km from Nkana west Township	N	H	Created by infilling gaps between three former dams. Upper surface flat without vegetation. Aeolian erosion is eminent. Large inactive gullies visible in southwestern end of the dump. Breaches on western flank in 1997 and 2000. Released tailings into Chibuluma River.	H
6	Nkana ML 3	TD 35	ZCCM-IH	42.5	10.7	I	3, B	About 2 km from wusakile Township	N	L	Paddock dam with dump plateau well vegetated and a crest bund around the entire perimeter. Eastern walls in good condition while the southern and western walls are considerably eroded with gullies of about 1m wide. No toe drains or silt traps.	L
7	Nkana ML 3	TD 36	ZCCM-IH	30	8.7	I	3, B	About 1.5 km from Nkana West Township	N	L	Plateau wall graded and vegetated with grass and trees. Outlet channel partly silted and requires clearing. Moderately severe erosion of walls but now stabilised. Large gullies at the southeastern and northeastern corners. Wind- blown tailings cover the western and end of the northern walls.	H
8	Nkana ML 3	TD 37	ZCCM-IH	35	6	I	3, B	< 2 km from Wusakile Township	Y	H	Main plateau generally in good condition but with large gullies measuring up to 12m wide, 6m deep. Vegetation is well established over most dump surface apart from eastern wall. Dumped with mine scrap and old pipes. Minor erosion on the western, southern and upper eastern walls.	M
9	Nkana ML 3	TD 38	ZCCM-IH	58	13.8	I	3, B	About 2 km from Wusakile Township	Y		The plateau well vegetated though northern area bare and affected by Aeolian and ruoff erosion. The walls extensively gullied but erosion now stabilised.	L

[3] Reclamation: 0 – barren state; 1- some material vegetation; 2 – formal vegetation program; 3 – substantial vegetation
Erosion: A – highly eroded offsite siltation; B – moderately eroded; C – little eroded siltation.

	Mine/ Lease Area	No.	Liability	Area (Ha)	Vol. (M tonnes)	Active / Inactive (A/I)	Reclamation Erosion (0-3 / A-C)³	Distance to Population Centre	Dust Control	Water Quality Impact	Remarks	Significance
10	Nkana ML 3	TD 39	ZCCM-IH	56	12.4	I	3, B	About 2 km from Wusakile Township	Y		In good condition though subject to Aeolian and runoff erosion. The plateau well vegetated in the southern and north western but surface bare in the north. All embankments severely gullied. Western wall well vegetated with grass in the western ends of northern ends of the northern and southern walls.	M
11	Nkana ML 3	TD 40	ZCCM-IH	12.2	2	I	3, B	1.5 km from Wasakile Township	Y		In fairly good condition with plateau well vegetated. All three embankments extensively gullied though active erosion is minimal.	L
12	Nkana ML 3	TD 41	ZCCM-IH	12.2	2	I	3, B	3 km from Chamboli Township	Y		In fairly good condition and well vegetated in most areas. The rockfill wall to the north and the southern and eastern embankments in good condition. Western wall severely gullied. No toe drains to the north, south or west; small drain to the east.	L
13	Nkana ML 3	TD 52	New Investor	80	8	A	2, B	2 km from Chibuluma Township	N	L	Upper surface well graded. Northern, north eastern and south eastern walls topsoiled grassed and good conditions. Southern and western walls severely eroded. There is toe drain around the dump perimeters.	L
14	Konkola ML 7	D	ZCCM-IH	7	0.066	I	1, B	1 km from Kameza Township	Y	L	High-grade oxide stockpile. The vegetation cover and the amount of tailings remaining vary between each paddock. The vegetation cover within each paddock is never greater than 50%.	L
15	Konkola ML 7	L (Kakosa Dam)	ZCCM-IH	94	9.7	I	1, B	3 km from Kameza Township	Y	L	There is approximately 60% vegetation cover on the northwestern paddock. The paddocks to the south are less vegetated and although there is vegetation this is patchy.	H
16	Nchanga ML 10	TD 3 Kamana South Dam	New Investor	155	Not available	A	3, C	Over 7 km from Chikola Township	Y	L	Dump plateau vegetated. Northern and eastern embankments not vegetated and have minor gullying. Western wall has some vegetation and a few minor gulleys. Southern wall also part vegetated and also gullied.	M
17	Nchanga ML 10	TD 4	New Investor	88.7	23.5	A	3, C	About 6 km from Chikola Township	Y	L	Dump plateau vegetated. Northern and eastern embankments not vegetated and have minor gullying. Western wall has some vegetation and a few minor gulleys. Southern wall also part vegetated and also gullied. The dam will be removed for reprocessing.	L
18	Nchanga ML 10	TD 7	New Investor	25	Not available	A	1	3 km from Chikola Township	N	M	Walls have little vegetation. Garden refuse has been dumped from the crest, but tends to slide to the toe, due to steep gradient.	M
19	Mufulira ML 15	TD 3	New Investor	155.3	Not available	A	3, C	< 1km from Kantashi Township	Y	L	Twin paddock impoundment. Dam to be reprocessed. Northern paddock, firm with well established vegetation (grass and trees); some gullying of walls. Southern paddock, well grassed and walls have large gulleys (but not deteriorating). The slopes sparsely vegetated	L
20	Mufulira ML 15	TD 4	Undecided	Not available	Not available	I		<1.5 km from Kantashi Township			Submerged in caving area water dam	L
21	Mufulira ML 15	TD 5	Undecided	20	Not available	I	1, A	About 0.5 km from Kankoya Township	Y		Wall of the dam partially vegetated but heavily eroded. Top of the dam well eroded.	M

	Mine/ Lease Area	No.	Liability	Area (Ha)	Vol. (M tonnes)	Active / Inactive (A/I)	Reclamation Erosion (0-3 / A-C)[3]	Distance to Population Centre	Dust Control	Water Quality Impact	Remarks	Significance
22	Mufulira ML 15	TD 8	Undecided	172	30	A	3, 2, A	<1 km from Kankoya Township	Y	L	Well vegetated in patches - a bare area in the western and northern parts of the dam. Lots of garden refuse has been deposited to encourage vegetation establishment. Extensive gullying has taken place in many areas on the dam - may be the result of subsidence. Side walls barren and badly eroded. Trees have been planted on the western slopes to reduce dust.	L
23	Luanshya ML 16 Old	TD 24 (OLD)	New Investor	180	48.1	I	3, B	0.5 km from Mikomfwa Township	Y	L	Lower slopes are very steep and highly gulleyed. Grass and trees planted on garden refuse on the dump surface in the 1960s. Vegetation is well established. Approximately 90% of the total dam area is vegetated.	L
24	Luanshya ML 16	TD 25 (Akatiti)	New Investor	246	37	I	3,B	1 km from Mikomfwa Township			The lower northern, southern and eastern walls are in good condition but there is some erosion and gullying evident on the main western embankment, which is generally devoid of vegetation. The plateau is well graded and grass cover is well established.	L
25	Chibuluma ML 18	TD 1	New Investor	47	6.65	A	0, B	1 km from Kalulushi Township	N	L	Much of the dump lies in the caving area. Surface well graded but no vegetation - serious wind erosion on top causing duning on leeward side of dam. There is severe erosion in southeastern corner (near the Chingola Road). Stable walls	L
26	Chibuluma ML 18	TD 2	New Investor	2.5	0.11	A	0, C	0.5 km from Kalulushi Township	N	L	Tailings have been partially reclaimed - particularly towards the centre of the dam. Wall breached in one corner - outside wall stone pitched.	L
27	Chambishi ML 19	TD 6	New Investor	141	12	A	3, C	3.5 km from Chambishi Township	N	L	In good condition and vegetation well established on the slopes	L
28	Chambishi ML 19	TD 7	New Investor	Not available	0.65	A	1, C	1 km from Chambishi Township	Y	L	Walls in good condition and well vegetated. Surface lack vegetation but firm and not prone to aeolian erosion. Part of dump complex of TD 7, 7A, 8, and 9 covering a total of 40ha.	L
29	Chambishi ML 19	TD 7A	New Investor	Not available	0.12	A	1,C	1.5 km from Chambishi Township	N	L	No dumping has taken place for many years. Some material reclaimed for assay purposes. Dump in good condition. Embankment stable and few trees well established. Part of dump complex of TD 7, 7A, 8, and 9 covering a total of 40ha.	L
30	Chambishi ML 19	TD 8	New Investor	Not available	0.2	I	1, C	1.5 km from Chambishi Township	Y	L	Walls in good condition and stable. Slopes well vegetated with established grass and trees. The surface is bare but firm and no prone to wind erosion. Part of dump complex of TD 7, 7A, 8, and 9 covering a total of 40ha.	L
31	Chambishi ML 19	TD 9	New Investor	Not available	0.38	A	1, C	1.5 km from Chambishi Township		L	Walls in good condition and well vegetated. Part of dump complex of TD 7, 7A, 8, and 9 covering a total of 40ha.	L
32	Chambishi ML 19	TD 10	New Investor	1.7	0.1	I	I, C	2 km from Chambishi Township	Y	L	Contains highly erodible vat leach residues. Fine materials have been subjected to severe erosion and gullying. Considerable quantities of tailing material have been washed away out of the dump.	L
33	Chambishi ML 191	TD 15	New Investor	28	1.0	A	1, C	2.5 km from Chambishi Township	Y	L	Upper surface well graded and some vegetation. Embankment in good condition with minor erosion. Vegetation well established in some areas of the slopes.	L
34	Kabwe	-	ZCCM-IH & New Investor	100	8	I	0	<0.5 km from Kasanda & Chowa Townships	N, Y	M	See waste types in Table G.17.	M

TABLE G.9: CROSS VALLEY TAILINGS DUMPS

	Mine/ Lease Area	No.	Liability	Area (Ha)	Vol. (M tonnes)	Active A/I	Reclamation Erosion	Distance to Population Centre	Dust Control	Water Quality Impact	Remarks	Significance
1	Nkana ML 3 Mindola west basin	TD 15A	New Investor	729	135	A	3,2,C	4 km from Chibuluma Township	Y	L	Walls fairly well vegetated with grass and trees. Minor runoff erosion and gullying. Aeolian erosion at the southern end evident. Garden refuse spread on complete wall slopes.	L
2	Nkana ML 3 Lower Uchi Dam	TD 26	ZCCM-IH	35	8.4	I	0, C	< 0.5 km from Nkana East Township	N	H	Flat plateau with no vegetation especially in the eastern area. Substantial erosion in the eastern wall of Upper Uchi settled here. Embankment generally stable but with some old gullies in the southern and eastern walls. Evidence of acidic runoff.	H
3	Nkana ML 3 Upper Uchi Dam	TD 27	ZCCM-IH	81	21	I	1, A	< 0.5 km from Nkana East Township	Y	H	Major gullying evident on all surfaces. Large canyon in the middle and across the dam. Rehabilitation work carried out over the years has reduced erosion and loss of material to minimum. Perimeter walls vegetated. Currently used for township and industrial waste dumping.	H
4	Nchanga ML 10 Muntimpa Dam	TD 5	New Investor	1786	404	A	2, B	5 km from Chikola Township	N	M	Cross valley dam. Some revegetation work has been carried out on the crest and downstream wall of the Dam.	H
5	Mufulira ML 15	TD 10	New Investor	Not available	23	I	1,2, C	1 km from Butondo Township	N	L	Portion of top of dam is well vegetated but there is a very bad dust problem. Slopes not eroded and stable but with little vegetation. Extensive dune formation on the western wall. Much of the existing vegetation is covered with wind blown tailings. Garden refuse is used to encourage vegetation but it is being burnt for recovery of metals.	H
6	Mufulira ML 15	TD 21	New Investor	480	60	A	1,C	<1 km from Kantashi Township	N	H	Also known as TD 11.Tailings dam complex consisting of several dams:TD2,6,7, and 9. Majority of western portion of dam is inundated. 50 m wide unvegetated beach area around pond - dust problem. TD 2 and 9 portions of dam well vegetated – portion of TD 2 covered in tailings spillage from line feeding dam.	H
7	Luanshya ML 16	TD 16 (Musi)	New Investor	450	Not available	A	2, C	2 km from Mpatamatu Township	N	M	Some gullying on dam walls. Active revegetation programme in progress. Thick vegetation where older planting used a layer of topsoil. Approximately 10% of the total dam area is vegetated.	M
8	Luanshya ML 16	TD 26 (Chonga)	New Investor	250	Not available	A	2, C	4 km from Roan Township	N	L	Revegetation of dam slopes with trees and grass. Tailings beach susceptible to dust blow in the dry season. Approximately 4% of the total dam area is vegetated.	M
9	Konkola ML 7	K (Slimes Seal)	New Investor	45	2.9	I	3, C	1 km from Lubengele Township	Y	L	The dam is very well vegetated. The tailings that are deposited here were done so to fill dambo area and control the mosquito problem. There are portions of the dam that require vegetation.	L

	Mine/ Lease Area	No.	Liability	Area (Ha)	Vol. (M tonnes)	Active A/I	Reclamation Erosion	Distance to Population Centre	Dust Control	Water Quality Impact	Remarks	Significance
10	Konkola ML 7	C (Lubengele Dam)	New Investor	450	90	A	1, 2, C	1 km from Lubengele Township	N	M	A cross valley dam with large beach area. Dust from beach area controlled by raising and lowering water level. There are patches where vegetation has established - this is where garden refuse has been disposed of. A 20m wide area along the crest is well vegetated. Top half of the side slope is well vegetated, bottom half not. Gulleying of dam wall.	M
11	Chambishi ML 19	TD 16 (Luano Dam)	New Investor	249	32	I	3, C	2.5 km from Chambishi Township	N	M	Main embankment in good condition. Vegetation well established.	L
12	Chambishi ML 19	TD 19 Musakashi Dam	New Investor	90	5.7	I	2,C	4 km from Chambishi Township	Y	H	Surfaces of the walls have been topsoiled and grassed and vegetation is now well established.	M

TABLE G.10: GROUNDWATER EXTRACTION POINTS – UNDERGROUND FACILITIES

	Mine / Lease Area	Liability	Mine Water Suply (m^3/day)			Water Discharge		Remarks
			Surface	Ground	Location	Flow (m^3/s)	Chemistry pH	
1	Nkana ML3	New Investor	Not available	39,000	Central/SOB	Not available	Not available	
2	Nkana ML3	New Investor	Not available	41,000	Mindola		Not available	
3	Konkola ML 7	New Investor	Not available	330,000	Konkola	296,400	8.1	33,600 m^3/day of underground water used for domestic use. Konkola pumps approx. 70 tonnes of water for every tonne of ore hoisted.
4	Nchanga ML 10	New Investor	Not available	80,000	Nchanga	80,000		
5	Mufulira ML 15	New Investor	Not available	90,000	Mufulira	70,000	7.6	Elaborate surface water management in the areas of TD3, TD8. Pumping from wells. TD 3 part of which flooded the mine
6	Luanshya ML 16	New Investor	Not available	21,000	Luanshya	Not available	Not available	
7	Baluba ML 17	New Investor	Not available	14,500	Baluba	Not available	Not available	
8	Chambishi ML 19	New Investor	Not available	25,000	Chambishi	Not available	Not available	
9	Chibuluma ML 18	New Investor	Not available	18,000	Chibuluma	5,000	Not available	No pumping from Chibuluma East, which is flooded to 45m below shaft collar.
10	Kabwe	ZCCM-IH	None	-	Kabwe	-	-	Dewatering activities ceased upon mine closure in 1994.

Blank fields indicate that information is either unavailable or of uncertain validity.

TABLE G.11: WATER IMPOUNDMENTS

	Mine lease area	No.	Liability	Area (Ha)	Active (A, I)	Spillway capacity (m^3/day)	Reclamation plan (Y/N)	Remarks
1	Nkana ML 3	Ndeke	AHC		A	1,400	N	Oxidation pond
2	Nkana ML 3	Mindola	AHC		A	2,200	N	Oxidation pond
3	Konkola ML 7	Golf course	AHC	22.2	A	19,000	N	Sewage Pond
4	Konkola ML 7	Konkola ponds	AHC	22.4	A	3,470		Sewage pond
5	Konkola ML 7	Kamenza	AHC	14.8	A	13,000		Sewage pond
6	Nchanga ML 10	WD1 Fitula Dam	ZCCM-IH	35	A			Reservoir collects runoff from the Fitula stream and its tributaries. It occurs in the mined portions of the Fitula open pit.
7	Nchanga ML 10	WD2 (TD2)	New Investor	6	A			On the tributary of Chingola stream. Earthfill embankment. Currently silted up as a result of TD2 reclamation.
8	Nchanga ML 10	WD3 Railway Dam	New Investor	3	A			
9	Nchanga ML 10	WD4 Pollution Control Dam	New Investor	35	A			Earth and rockfill structure with concrete weir spillway. Reservoir silted up within 4 months of commissioning.
10	Mufulira ML 15	Magazine Dam	New Investor	131	A			Built on Mufulira stream. Earth dam with spillway to Valley Dam.
11	Mufulira ML 15	Kantashi Big	AHC	25.8	A	10,320		Sewage pond
12	Mufulira ML 15	Kankoyo North	AHC	6.0	A	2400		Sewage pond
13	Mufulira ML 15	Kankoyo South	AHC	5.9	A	2360		Sewage pond
14	Mufulira ML 15	Butondo Big	AHC	8.0	A	3200		Sewage pond
15	Mufulira ML 15	Valley Dam	New Investor	-	A	-		Stores water to supplement supplies to Mufulira townships. Impoundment storage capacity is 16.6 M m3, 95% of which is live storage.
16	Chambishi ML19	Werners Dam	ZCCM-IH	-	A	-		Used as Pollution control dam
17	Chambishi ML 19	New Dam	ZCCM-IH	-	A	-		Used as Pollution control dam
18	Luanshya ML 16	Luanshya Dam	AHC	225	A			Store capacity of 1.5 M m^3. Water supply for the township water purification plant. Fed by Kafubu River, discharge from underground workings and the Luanshya Dam. Surfaces above the water level are grassed but the impoundment walls are bare and have minor gulleying. Approximately 80% of the total (non-water covered) dam area is vegetated.
19	Luanshya ML 16	Makoma Dam	AHC	240	A			Store capacity of 6.22 M m^3. Stores water Luanshya mine townships domestic water.

Blank fields indicate that information is either unavailable or of uncertain validity.

TABLE G.12: MUNICIPAL SEWAGE PLANTS

	Mine / Lease Area	Liability	Sewerage Operational Status	Plant throughput[4]		Plant discharge[5]	Remarks
				Location	Flow (m^3/day)	Flow (m^3/day)	
1	Nkana ML 3	City Council	Active	Nkana East	45,700	Not available	Mine ML3 has no sewage treatment plant but depends on Kitwe City council facilities. Discharge directly into the Kafue
2	Nkana ML 3	City Council	Active	Ndeke Pond	14,000	Not available	Mine ML3 has no sewage treatment plant but depends on Kitwe City council facilities. Discharge directly into the Kafue
3	Nkana ML 3	City Council	Active	Mindola	2,200	Not available	Mine ML3 has no sewage treatment plant but depends on Kitwe City council facilities. Discharge directly into the Kafue
4	Konkola ML 7	AHC	Active	Golf course	19,000	Not available	Effluent discharged into Lubengele stream a tributary of Kafue River.
5	Konkola ML 7	AHC	Active	Konkola	34,000	Not available	Discharge generally to crop irrigation with surplus discharge to the Mutondo stream a tributary of the Kafue River
6	Konkola ML 7	AHC	Active	Kamenza	13,000	Not available	Discharge generally to crop irrigation with surplus discharge to the Kakoso stream a tributary of the Kafue River
7	Nchanga ML 10	AHC	Active	Nchanga	28,000	40,000	Partly treated sewage directly discharged to the Nchanga stream a tributary of the Kafue.
8	Nchanga ML 10	AHC	Active	Lulamba	6,000	1,500	Partly treated sewage directly discharged to the Chabanyama stream which discharged into the Mushishima stream, a tributary of the Kafue.
9	Mufulira ML 15	AHC	Active	Kantashi Big	13,000	28,760	Partly treated sewage discharged to the Kansuswa stream and some used for irrigation
10	Mufulira ML 15	AHC	Active	Kankoyo North	3,507	Not available	Partly treated sewage discharged to the Mufulira stream and some used for irrigation
11	Mufulira ML 15	AHC	Active	Kankoyo South	2,164	Not available	Partly treated sewage discharged to the Mufulira stream and some used for irrigation
12	Mufulira ML 15	AHC	Active	Butondo Big	3,841	Not available	Partly treated sewage discharged to the Mufulira stream and some used for irrigation
13	Chambishi ML 19	AHC	Active	Chambishi	Not available	5,000	Partly treated sewage including storm water ingress discharges directly into the Lulamba stream which subsequently discharges into the Lukoshi, a tributary of the Kafue
14	Luanshya ML 16	AHC	Active	Luanshya	Not available	25,000	Raw sewage including stormwater ingress. Total flow of three sewage systems: Luanshya, Roan and Mpatumatu.
15	Kabwe	City Council	Non-operational	-	-	-	Raw sewage discharging into main canal since plant operations ceased in 1999.

[4] Actual and accurate figures for Sewage Plants not available as the flows in most cases are not measured. The given figures are estimates based on the population of the mine townships.

[5] Data for Sewage Plants discharges is unavailable because they are not measured. A rough estimate would be 8% to 20% of the Plant received sewage load, depending on the efficiency of the plant. Figures are omitted in the column where they are not given from the data source. This is because the estimated percentages need to be verified with the sewerage experts.municipal solid waste

TABLE G.13: MUNICIPAL SOLID WASTES

	Mine/ Lease Area	Liability	Dump operational status	Location	Area (ha)	Vol. (Tonnes /day)	Remarks
1	Nkana ML 3	ZCCM-IH	A	Uchi (Tailings Dam 26)	Not available	45	Several other companies dump refuse at the site
2	Nchanga ML 10	AHC	A	Old quarry near the Chingola-Chililabombwe Road	Not available	48	Several other companies dump refuse at the site
3	Mufulira ML15	AHC	A	Three Tailing dams outside Mufulira Town	Not available	58	Several other companies dump refuse at the site
4	Luanshya ML 16	AHC	A	Bush in an unpopulated area outside town	Not available	56	Several other companies dump refuse at the site
5	Konkola ML 7	AHC	A	Old Quarry near the golf course	Not available	29	Several other companies dump refuse at the site

TABLE G.14: POTENTIAL LOCATIONS OF INDUSTRIAL AEROSOL/RADON/TE-NORM WASTE EXPOSURE

COMPANY	LOCATION				
	Underground Mine (Radon)	Processing Plant Toxic Heavy Metals	Te-Norm Waste		Significance
			Active Sources	Spent Sources	
ZCCM-IH	Nil	SmelterCo	Nil	1999 at Kalulushi radio-active waste storage site	H
Chambishi Metals Plc (ML 19)	Nil	Cobalt Processing Plants	Inventory not available	Nil	H
Chibuluma Mine Plc (ML 18)	Chibuluma Mine		Inventory not available	Nil	H
Konkola Mine Plc (ML 7)	Nchanga Mine Konkola Mine Nampundwe	Nkana SmelterCo	Inventory not available	Nil	H
Mopani Copper Mines Plc	Mufulira Mine Nkana Central & SOB Mindolo Mine	Mufulira Smelter	-Nkana 5 in use, 4 in stores -Mufulira 3	Nil	H
NFC ML Africa Mining Plc (ML 19)	Chambeshi Mine	Concentrator	Inventory not available	Nil	H
Roan Antelope Mining Corporation (RAMCOZ) (ML 17)	Baluba Mine	Concentrator	Inventory not available	Nil	M

TABLE G.15: STATUS OF KALULUSHI RADIOACTIVE WASTE STORAGE SITE

VICINITY OF NEW ACTIVITIES	There are no new activities taking place within the vicinity of the site.
ALARM SYSTEM	No alarm system is installed at the site for either alerting the emergency teams or the public.
FIRE DETECTION	No fire detection and fire extinguisher is installed within the building other than a fire hydrant located about 20 meters from the storage shed.
FENCING	The storage shed is fenced off using a screening wire fence.
RADIATION WARNING SIGNS	Adequate radiation warning signs are displayed both around the fence and the building.
VENTILATION SYSTEM	There is no air conditioner fitted inside the facility to regulate temperature.
TYPE OF DOORS	Two types of doors are fitted. The internal doors are sliding which block radiation beams to "shine" through, while the external doors are the ordinary kind.
INTEGRITY OF THE STRUCTURE	The integrity and stability of the roof and walls is high.
EMERGENCY RESPONSE PROCEDURE	There are no written Emergency Response Procedures is in place.
CONDITIONING PROCEDURE	Written Conditioning Procedure is in place.
INVENTORY AND LABELLING	An up-to-date inventory of the radioactive source is available – description of isotope, activity (strength), manufacturer, serial no., model, and surface dose rate at the time of conditioning, type of leak test applied, date of test and source integrity. Shielding drums are labelled. The identification tag is an engraved stainless steel plate with all the particulars of the source.
OPERATIONAL GUIDELINES	There are no written General Radioactive Waste Management guidelines other than those for Conditioning of the sources. Written Emergency Response Procedure for the radiation-shed building is not available. Guidelines for handling and storage of PCBs contaminated materials is available.

TABLE G.16A: STATUS OF ZCCM MAINTAINED PCB INTERIM STORAGE SITES

LOCATION	ZCCM-IH PCBs are stored at Old Cobalt Plant within the plant area for Mopani Copper Mines in Kitwe and in a container at the Radiation Storage Site in Kalulushi
ALARM SYSTEM	Both storage facilities do not have any alarm systems in case of fire or break-in.
FIRE DETECTION	Both facilities do not have any fire detection devices
FENCING	Both facilities are fenced off
WARNING SIGNS	Warning signs at both facilities are inadequate
VENTILATION	Ventilation facilities are very poor. The PCBs at Kalulushi are stored in a transport container with no need for ventilation
INTEGRITY OF THE STRUCTURES	The container in Kalulushi is in a poor state and actually is a wrong type of storage facility for PCBs materials. Any leakages contaminate the soil directly. Soils around the container are contaminated with PCBs oils The Nkana facility is in an extremely poor state. The walls have allowed the oil to seep through resulting in walls looking oily thus contaminating the spoon drain around the building. There is potential for soil and ground water contamination as well water pollution of the Kafue river contamination arising from this particular storage site. The spoon drain join the main storm water drain which feed storm water into Uchi stream- a tributary of the Kafue river
EMERGENCY PROCEDURE	Procedures for handling and storage of PCBs is available
CHARACTERIZATION PROCEDURE	There is no characterization procedure for PCB contaminated oils and equipment
STORAGE DRUMS	Storage drums are in poor state
OPERATIONAL GUIDELINES	There are no written specific guidelines for handling and storage of radioactive waste contaminated oils and equipment

TABLE G.16B: TRANSFORMERS AT KABWE MINE AND AREA

	Location	Number
Plant Site		
	Main Switch Yard	8 Transformers
	Concentrators	2 Transformers
	Plant area (office, workshops, stores, locater leach plant, Waelz Kilns, ISF, Tippler, Charger, Refinery	45 Transformers
Underground		
	Davies Shaft	12 Transformers
	Subvertical Shafts	4 Transformers
	Ore Shafts	3 Transformers
	Kasanda Township	4 Transformers
	Boreholes	4 Transformers
	Other in Kabwe Area	10 Transformers

TABLE G.17: KABWE MINE SUMMARY OF MATERIAL TYPES IN WASTE DUMPS
(Source: ZCCM, February 1995, Kabwe Mine Site Rehabilitation and Decommissioning Plan.)

Waste Type	Time of Deposition	Base Area m^2	Volume m^3	Tonnes	Lead Content Tonnes	Zinc Content Tonnes
Leach Residues	1926-onwards	385,500	2,696,000	4,961,400	228,200	292,700
Sink/Float Tails	March 1993	7,200	8,700	23,800	1,300	4,400
Wash Plant Simes	1953–onwards	79,400	227,400	411,500	28,000	53,500
Pyrite Tails	1930–onwards	38,400	170,700	443,600	12,000	39,900
ISF Slag	1953–1962	61,400	588,200	723,500	11,600	60,100
Waelz Kiln Slag	1975–onwards	164,800	827,800	1,241,600	16,100	52,100
Other Waste		11,800	92,300	169,900	6,800	16,800
TOTALS		721,500	4,611,100	7,975,300	304,000	519,500

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ANNEX H:
SUMMARY GRID

SEE THE EXCEL FILE FOR THE ANNEX H GRID THIS FILE IS FOR THE TITLE PAGE ONLY

Overview Grid: Environmental Health Assessment

Primary Issue	Detailed Issue	Sites	Characteristics Observed on Site Visit	Exposure Levels Documented or Inferred	Health Risk	Susceptible Populations	Number Likely to be Affected
					Likelihood of a health effect occurring, regardless of frequency.		
Air pollution	General (SO2 and PM10)	1) Kitwe (Nkana west, Wusakile), 2) Mufulira (Kankoyo, Kantanshi), 3) Chambishi, 4) Kabwe (lead only up until 1995), 5) (Luanshya - smelter currently not working but would present an issue if opened)		The highest predicted daily SO2 concentration is 2100 ug/M3 and the highest annual concentration is 750 ug/M3 calculated at 420% and 750% over the WB guideline for S02 (in 2010). In 1996, SO2 dispersion modeling conducted for the Nkana smelter using the U.S. EPA Industrial Source Complex Model (short term version) showed that "a large portion west of the smelter would experience high (S02) concentrations, exceeding internationally acceptable concentration guidelines. Very high hourly averages, above 1500 ug/M3 So2 are observed up to 5 km downwind and west of the smelter. A large part to the west of the smelter (~2km to 3km) could experience daily average concentrations above 300 ug.m3. Similarly the predicted annual average concentrations in this sector would be above 50 ug/m3." The report went on to say that fugitive emission were not included in the simulations, the model has with an uncertainty of prediction of +/- 50% with improved concentration prediction accuracy with fairly strong wind speeds and neutral atmospheric conditions.	Respiratory symptoms, increased morbidity from respiratory disease, increased mortality esp. from cardiopulmonary disease.	Infants, aged, persons with preexisting cardiopulmonary disease, (theortetical) persons in immunocompromised states.	(1) Kitwe (Nkana west, Wusakile - up to 53,000 people potentially affected), (2) Mufulira (Kankoyo, Kantanshi - up to 75,000 people potentially affected), and (3) Chambishi (data on wind dispersion not available so unknown number of people affected)
	"Senta" emissions detectable by odour	Reported to team by residents in Kankoyo, Nkana West, Wusakile (+possibly other areas not visited by team)		Odour reported throughout district on occassion. (Odour threshold for S)2 is 1300 ug/m3.	Odour indicates concentration of SO2 within range of possible health risk.		
	Human health risk associated with current emissions		Acute health effects (cough, shortness of breath) reported during episodes of "scenta".	Emissions level of SO2 exceeds limits based on health risk and are within range of expected human health effects. SO2 emissions modeled in March 2001 for the year present to 10 years in the future exceed WHO, Zambian,World Bank and Rep of South Africa guidelines for all scenarios simulated for the Nkhana/SmelterCo smelter. More sulfur is captured and SO2 emissions decrease over time and exceedances are not as frequent in this model. However, the concentrations modeled are consistently in a range which cause human health effects.			
Tailings dumps	General	Nkana: TD25, TD26, TD27, TD33C, TD35, TD36, TD37, TD40	Gardens on property, Nkana East Slime Dump, Wusakile stream and Uchi Slime Dump. Some tailings exposed at Uchi and Nkana East, associated with fine dust. Deforestation evident, with tree harvesting observed.	See below.	Significant potential health risks in physical safety, water contamination.	Population accessing site and water draining from it.	Probably many but not a majority of population of district.
	Erosion, instability	Nkana: TD27, TD33C, TD35, TD36		Documented presence of instability, e.g. Konkola C	Physical safety hazard.	Regular users of sites deemed unstable.	Relatively few persons who access unstable sites.
	Erosion, siltation	Nkana: TD35, TD36, TD37, TD40	Extensive deposits of silt observed on ground at Uchi (TD26) and Nkana East.				

Overview Grid: Environmental Health Assessment

Primary Issue	Detailed Issue	Sites	Characteristics Observed on Site Visit	Exposure Levels Documented or Inferred	Health Risk	Susceptible Populations	Number Likely to be Affected
					Likelihood of a health effect occurring, regardless of frequency.		
	Runoff, surface water contamination	Nkana: TD25, TD36, TD37, TD40			Windblown dust may be a respiratory and eye irritant and general nuisance.		
	Runoff, drinking water contamination	Uchi (TD26, 27) [potential, not observed]	Not confirmed that stream used for drinking water at TD27. Report that water obtained there from pipe down the road.	Pb level of Chibuluma Stream water, which drains tailings ponds at Nkana Mine, Nov 1999 - Oct 2000 was =<0.10 mg/l, within standard.	Heavy metal contamination a possibility but not confirmed.		
	Irrigation with water	Nkana: Uchi (TD26)	Irrigation with sewerage water observed at Wusakile.				
	Groundwater contamination	Nkana: TD27, TD33C, TD35, TD36	Muni waste dumped at TD27.				
	Failure and risk of washout	Nkana: TD36, TD37, TD40	These TDs risk washout because decant structures have collapsed, causing siltation.				
	Waste dumping on site	Mufulira: TD10 Nkana: TD26, TD27	Municipal dumping activity at Uchi, illegal dumping at Nkana East.				
Overburden dumps	General	Nchanga: OB4, OB6, OB7, OB9, OB10, OB11, OB14, OB15; Nkana OB3, OB4					
	Erosion, instability	Nchanga: OB3, OB4; Nkana: OB53, OB54, OB63			Indirect: degrades site for future use and reduces economic viability.		Probably few.
	Erosion, local	Nchanga: OB9, OB10	All OB sites.		Windblown dust may be a respiratory and eye irritant and general nuisance.	Downwind residents.	Downwind population. Variable.
	Erosion, siltation	Nchanga: OB6, OB7, OB19; Nkana: OB53	Visibly high levels of siltation in area streams in Chingola.	NA for human exposure.	Siltation interferes with muni water supply, therefore makes it more expensive, and more difficult, for water utility to treat drinking water. In Chingola and Mufulira utilities complain that sedimentation has blocked some drinking water pipes, and has silted up the reservoir. This can affect the entire population, the majority of which are dependent on piped water.	Entire population.	Entire district supplied by piped water.
	Runoff, surface water contamination	(Nkana OB63 - liability undecided)		Nkana OB63 reported to have been used for acide lead battery disposal. Pb hazard may exist.	Metals contamination in water draining overburden dumps is unlikely to be a significant health hazard, as material is not rich in soluble metals or ore.		Entire district supplied by piped water.

Overview Grid: Environmental Health Assessment

Primary Issue	Detailed Issue	Sites	Characteristics Observed on Site Visit	Exposure Levels Documented or Inferred	Health Risk	Susceptible Populations	Number Likely to be Affected
					Likelihood of a health effect occurring, regardless of frequency.		
	Runoff, drinking water contamination	NA			Metals contamination in water draining overburden dumps is unlikely to be a significant health hazard, as material is not rich in soluble metals or ore.		Entire district supplied by piped water.
	Irrigation with water	NA	Does not appear to be common.	Probably low for heavy metals and other potentially toxic elements.	Primary risk is bioaccumulation of heavy metals; this has not been demonstrated.	Infants and children.	Probably few.
	Groundwater contamination	NA			Metals contamination in water draining overburden dumps is unlikely to be a significant health hazard, as material is not rich in soluble metals or ore.		
	Failure and risk of washout	Possibility for all sites.					
	Waste dumping on site	NA			Uncontrolled dumping may lead to health problems		
Open pits	General	Chingola C, Luano, Mimbula1, Mimbula 2, Fitula		Presence of physical hazard observed at sites.	Physical safety hazard.		Probably few.
	Erosion, instability	Chingola C	Extensive erosion, instability and evidence of subsidence observed at Chingola C.		Physical safety hazard.	Regular users of sites deemed unstable.	Probably few.
	Erosion, local	Chingola C, Luano, Mimbula1, Mimbula 2, Fitula			Indirect: degrades site for future use and reduces economic viability.		
Slag dumps	General	Nkana: SD48					
	Runoff, surface water contamination	NA					
	Scavanging activity	Nkana: SD48	Scavanging for residual ore observed at TD2*.	NA	Physical safety hazard.	Regular users of sties deemed unstable.	Probably few.
	Groundwater contamination	NA	Little metal left in soluble form, therefore not bioavailable.				
Ore Stockpiles	Runoff, surface water contamination	Nchanga: SP11 (most stockpiles retained by new owners)					
Municipal Solid Waste	Dumping on site	Uchi (TD26)	Municipal dumping activity at Uchi, illegal dumping at Nkana East.	Ground-level air pollution from burning garbage, rats, physical safety hazards documented.	Principal risk is physical safety hazard associated with scavaging.	Regular users of sties deemed unstable.	
Sewerage Disruption		NA - Ndeke Township					
	Irrigation using sewerage water	TD27	Irrigation with sewerage water observed at Uchi, Nkana (Mulinga Township).				

Overview Grid: Environmental Health Assessment

Primary Issue	Detailed Issue	Sites	Characteristics Observed on Site Visit	Exposure Levels Documented or Inferred	Health Risk	Susceptible Populations	Number Likely to be Affected
					Likelihood of a health effect occurring, regardless of frequency.		
Food contamination	General	TD27	Food harvested for local consumption and market.	Unknown.			Market area and local residents (e.g. 7,000 in Uchi area)
	By sewerage	TD27	Food harvested for local consumption and market.	Unknown.	High. Residents report no health effects but this is not confirmed.	Consumers and local residents subsisting on crop.	Market area and local residents (e.g. 7,000 in Uchi area)
	By metals	TD27	Food harvested for local consumption and market.	Unknown in general.. Sampling near cane field at Nchanga (310) revealed high suspended solids and sulfate, elevated total Cu (mean 16.63 mg/l) and total Co (mean 1.70 mg/l) but Pb, Cd and As not available. Ore is low in these metals.	Probably low. Data suggest low levels of heavy metals are likley to be present. Other metals are not commonly associated with human toxicity.		Market area and local residents (e.g. 7,000 in Uchi area)
PCB contamination	Leakage or theft from storage site	Storage depots at MCM Old Cobalt Plant, Kalulushi and Kabwe	NA	Unknown. Heaviest exposure likely to occur if there was theft and sale as cooking oil. It is not known how often this has occurred.	Probably low. PCBs are not potent human toxins.	Persons consuming PCBs as cooking oil.	Unknown. Probably small.
Lime Quarrying and Production							
Lime Industry	Dust deposition (nuisance effect)	Ndola (not yet sold)					
Lead Mining and Smelting							
Lead industry	Soil deposition	Kabwe	Smelter at Luanshya is not currently operating and is not expected to operate for the near future.				

Overview Grid: Environmental Health Assessment

Primary Issue	Detailed Issue	Sites	Assessment of Population Health Risk	Gaps Analysis and Recommendations
			Evaluation of whether this factor is a driver in determining health status of this population.	
Air pollution	General (SO_2 and PM10)	1) Kitwe (Nkana west, Wusakile), 2) Mufulira (Kankoyo, Kantanshi), 3) Chambishi, 4) Kabwe (lead only up until 1995), 5) (Luanshya - smelter currently not working but would present an issue if opened)	High	Continuous monitoring system for air quality in Zambia has been proposed by Guerreiro and Sivertsen (Norwegian Institute for Air Research), 1998. Chambishi data not examined.
	"Senta" emissions detectable by odour	Reported to team by residents in Kankoyo, Nkana West, Wusakile (+possibly other areas not visited by team)		Reporting system may be useful.
	Human health risk associated with current emissions			Direct health impact cannot be assessed against high background morbidity due to respiratory disorders.
Tailings dumps	General	Nkana: TD25, TD26, TD27, TD33C, TD35, TD36, TD37, TD40	High for sewerage contaminated areas. Moderate overall.	Water quality information from watercourses draining tailings dumps is available but limited. Few determinations have been made of levels of heavy metals, esp. Pb, Cd, and if Se, As. Important to rule out their presence in drainage water streams. If not present, no further monitoring needed.
	Erosion, instability	Nkana: TD27, TD33C, TD35, TD36	Low.	Potential safety hazard may be mitigated by denying access or engineering site.
	Erosion, siltation	Nkana: TD35, TD36, TD37, TD40	High because of interference with water supply.	

Overview Grid: Environmental Health Assessment

Primary Issue	Detailed Issue	Sites	Assessment of Population Health Risk	Gaps Analysis and Recommendations
			Evaluation of whether this factor is a driver in determining health status of this population.	
	Runoff, surface water contamination	Nkana: TD25, TD36, TD37, TD40	Low.	
	Runoff, drinking water contamination	Uchi (TD26, 27) [potential, not observed]	Low.	
	Irrigation with water	Nkana: Uchi (TD26)	Low.	
	Groundwater contamination	Nkana: TD27, TD33C, TD35, TD36	Low.	
	Failure and risk of washout	Nkana: TD36, TD37, TD40	Low.	
	Waste dumping on site	Mufulira: TD10 Nkana: TD26, TD27	Low.	
Overburden dumps	General	Nchanga: OB4, OB6, OB7, OB9, OB10, OB11, OB14, OB15; Nkana OB3, OB4	High for siltation interfering with water supply. Moderate if siltation further reduces economic viability and income.	
	Erosion, instability	Nchanga: OB3, OB4; Nkana: OB53, OB54, OB63	Low.	
	Erosion, local	Nchanga: OB9, OB10	Low.	
	Erosion, siltation	Nchanga: OB6, OB7, OB19; Nkana: OB53	High because of interference with water supply.	
	Runoff, surface water contamination	(Nkana OB63 - liability undecided)	Low.	

Overview Grid: Environmental Health Assessment

Primary Issue	Detailed Issue	Sites	Assessment of Population Health Risk	Gaps Analysis and Recommendations
			Evaluation of whether this factor is a driver in determining health status of this population.	
	Runoff, drinking water contamination	NA	Low.	
	Irrigation with water	NA	Low.	None.
	Groundwater contamination	NA	Low.	None.
	Failure and risk of washout	Possibility for all sites.	Low.	None.
	Waste dumping on site	NA	Low.	None.
Open pits	General	Chingola C, Luano, Mimbula1, Mimbula 2, Fitula	Low.	None.
	Erosion, instability	Chingola C	Low.	None.
	Erosion, local	Chingola C, Luano, Mimbula1, Mimbula 2, Fitula	Low.	None.
Slag dumps	General	Nkana: SD48		
	Runoff, surface water contamination	NA		
	Scavanging activity	Nkana: SD48		
	Groundwater contamination	NA		
Ore Stockpiles	Runoff, surface water contamination	Nchanga: SP11 (most stockpiles retained by new owners)		
Municipal Solid Waste	Dumping on site	Uchi (TD26)		
Sewerage Disruption		NA - Ndeke Township		
	Irrigation using sewerage water	TD27		

Overview Grid: Environmental Health Assessment

Primary Issue	Detailed Issue	Sites	Assessment of Population Health Risk	Gaps Analysis and Recommendations
			Evaluation of whether this factor is a driver in determining health status of this population.	
Food contamination	General	TD27		Propose study to determine risk.
	By sewerage	TD27	Probably moderate.	Propose study to determine risk: infectious agents.
	By metals	TD27	Probably low.	Propose study to determine risk: metals content in foods.
PCB contamination	Leakage or theft from storage site	Storage depots at MCM Old Cobalt Plant, Kalulushi and Kabwe	Probably small.	None. Recommend removal and destruction of remaining stores.
Lime Quarrying and Production				
Lime industry	Dust deposition (nuisance effect)	Ndola (not yet sold)		
Lead Mining and Smelting				
Lead industry	Soil deposition	Kabwe		Continue monitoring program in Kabwe. Soil Pb determinations recommended to ensure that this is not a problem in other areas.

ANNEX I:
OCCUPATIONAL HEALTH ISSUES: A REPRESENTATIVE SITUATION

ANNEX I: OCCUPATIONAL HEALTH ISSUES: A REPRESENTATIVE SITUATION

Because such a large proportion of Copperbelt residents are or have been miners, their exposure to pollutants on the job may account for some of the illnesses that are reported through the public health system, rather than exposure outside of the mine site. The SA team reviewed a 1999 Anglo American Occupational Hygiene Audit of the Nkana Mine[1] and met with stakeholders in country in the occupational health community with regard to the important linkage of occupational health to public environmental health. Some conclusions of the 1999 Nkana Occupational Hygiene Audit were as follows:

> "Illumination in general, and exposure to gases and fumes at the Nkana smelter require attention, while the other occupational hygiene hazards such as dust, heat and ionising radiation are of secondary importance at this stage."
>
> "Safety programmes are in place at all the Nkana mines, but the holistic implementation of those strategies is questionable, especially in respect of the provision of safety equipment. However, despite this observation, the general safety statistics are commensurate with those found in similar industries."
>
> "Mine health services are less effected compared to the public health services mentioned above. However, pulmonary tuberculosis (TB), which is not attributed to mining, is causal to about 34% of medical retirement of mine employees. Another major contributor to medical retirement of employees is noise induced hearing loss (NIHL) caused by exposure to occupational noise. This disablement is causal to 17% of medical retirements. Both of these disabling factors could, however, be reduced effectively through prevention and treatment programmes."

Based on our tour of the Nkana and Mufilira smelters, increased lighting and improvement of the implementation of hearing and respiratory protection programs as recommended would be helpful. Tours of two facilities indicated significant numbers of employees not using hearing protection or respiratory protection although muffs and respirators were worn. Some smelter employees were seen using dirty towels as a respirator (Mufilira and SmelterCo). This practice could actually increase contact with dusts and heavy metal residues rather than decrease it. Visibility around the plant facilities was greatly diminished in many areas shortly after sunset (Kitwe, Smelter Co) speaking to the need for improved illumination around the plant to reduce accidents. The 1999 AATS report provided cost-effective recommendations to improve the hearing protection program we would suggest that they be followed.

In relation to occupational dust exposure in mines, the AATS audit had the following comments and recommendations:

> "The latter limit (5mg/m3) applies for total respirable dust (inert dust) and does not account for individual components in the dust with higher toxicity. If such components occur in the dust, the limit values then also become the limiting factor. It is, however, unlikely that any component other than alpha quartz may constitute such a limiting component on the Copperbelt. Alpha quartz becomes a limiting factor at concentrations in excess of 5%. All indications are, however, that such quartz levels rarely occur in the area."

[1] Occupational Hygiene Audit of the Nkana Mine, A van der Linde, AATS, Report Reference R/09B/B30/10,99, October 1999

> "The average working dust concentration (combined intake, face and returns) during 1998 at the Nkana mine was 40 ppcc (0.2 mg/m3)."
>
> "This dust level is about 5% of the maximum exposure levels and should not be causal to significant occupational health effects. That is not to say that the current dust abatement programme may be altered. The above finding is borne out by medical records which show almost an absence of the diagnosis of pneumoconiosis."

Subjects with chronic silicosis have a three-fold increase in incidence of TB compared to similarly aged individuals exposed to silica.[2] Tuberculosis risk is increased for subjects with long exposures to silica dust but are not silicotic.[3] Tuberculosis is present in working populations at Nkana, Konkola, Mufilira and elsewhere but an occupational relationship cannot be demonstrated based on occupational hygiene data collected do far because silica exposure has not been characterized to the best of our knowledge from the data reviewed. Exposure to silica and mining dusts has been associated as an aggravating factor for pulmonary tuberculosis in other South African mining industries[4] therefore characterizing, documenting and controlling silica exposure in the Copperbelt to control it to an acceptable level may have the potential to reduce some pulmonary TB disease incidence. While the AATS review indicates that TB may be unrelated to mining, and for the largest part of the community this may be true, this statement cannot be qualified without characterizing silica exposure for workers and the community.

We recommend the addition of routine silica industrial hygiene monitoring as part of the industrial hygiene program where applicable at Nkana and other mines in the Copperbelt. Currently the composition of dust and the exposure limits as stated above are based upon the dust not containing silica. However, the content of silica to the best of our knowledge has not been determined. If the dust contains 50% silica, at an average exposure of 0.2 mg/m3 most health conservative international occupational exposure levels (e.g. 0.1 mg/m3 silica for US OSHA PEL) would be approached or exceeded. Higher dust level exposure would require even a lower percentage of silica to be hazardous to workers. Appendix 2 contains a table of pnuemoconiosis incidence for 1998 and 1999 in Zambian mines from the latest published report by the Ministry of Mine Safety. [5] Nkana had six pnuemoconiosis cases in the last two years with one case that progressed to stage 3 and one in combination with TB. The largest numbers of pneumoconiosis in the Zambian mining industry occurs at Mufilira for the two years reviewed with a total of seventy-eight cases, thirty-nine for each of the two years. Given that Zambia requires screening for pneumoconiosis as a condition for employment in the mining industry and incidence of occupational pneumoconiosis exists in the Zambian mining industry, a more pro-active approach to monitor for silica would seem to be in order. Work practices, dust control measures and adjustment of the dust standard used for risk assessment reflective of the silica content should be made as required to reduce exposure to silica.

Asbestos was not mentioned as an industrial hygiene concern in the AATS review of the occupational health programs. However, blue crocidolite asbestos was on display at Mopani Copper Mine (MCM) headquarters in Kitwe as a mineral present in some of the Copperbelt mining deposits. Since crocidolite is considered one of the more biologically active forms of asbestos, with a low occupational exposure threshold value, a question arises as to if and how exposure to asbestos has been characterized,

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[2] Adverse Effects of Crystalline Silica Exposure, Official Statement of the American Thoracic Society, American Medical Association, June 1996, pg. 761-762

[3] Adverse Effects of Crystalline Silica Exposure, Official Statement of the American Thoracic Society, American Medical Association, June 1996, pg. 761-762

[4] Hnizdo, E et al, "Risk of Silicosis in a Cohort of White South African Miners", American Journal of Industrial Medicine, Vol. 24: pp. 447-457 (1993)

[5] Annual Report of the Mine Safety Department for the Year 1999, Ministry of Mines, Republic of Zambia, June 2000, pg.16

documented and controlled for occupational health concerns in the Copperbelt mining industry as a whole. Asbestiform materials, such as crocidolite are recognized lung carcinogens and can cause fibrotic lung disease. Asbestos is used and sold as roofing tiles and water pipes so this may be a community health hazard that has not been characterized. Our review did not indicate how much asbestos is encountered during mining operations, if this is considered a source of community or occupational exposure or any evidence that this hazard has been characterized.

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ANNEX J:
DATA ANNEX

COPPERBELT, KABWE, AND KAFUE RIVER
WATER QUALITY RESULTS

AIR MONITORING INFORMATION

Table J.1: Copperbelt, Kabwe, and Kafue River Water Quality Results (based on monthly values, January 2000-April 2001)

Note: data are presented as *Average value (Minimum recorded value – Maximum recorded value)*

Station	Flow Rate (m³/day)	Lab. pH (unit)	Dissolved Solids (mg/L)	Suspended Solids (mg/L)	Dissolved Sulphate (mg/L)	Total Copper (mg/L)	Dissolved Copper (mg/L)	Total Cobalt (mg/L)	Dissolved Cobalt (mg/L)	Total Iron (mg/L)	Dissolved Iron (mg/L)	Total Manganese (mg/L)	Dissolved Manganese (mg/L)
KITWE - NKANA													
Wusakili Storm Drain (605)	1,027 (426 - 3,024)	7.9 (7 - 8.4)	791 (486 - 1,382)	54 (45 - 61)	405 (130 - 969)	0.9 (0.3 - 10.2)	0.78 (0.2 - 9 8)	0.4 (0.2 - 0.9)	0.31 (0.09 - 1)	0.3 (0.1 - 0.5)	0.15 (0.09 - 0.3)	0.36 (0.09 - 1.3)	0.26 (0.09 - 1.2)
Harrison Street Drain (North Uchi) (607)	19,418 (14,571 - 22,585)	7.8 (7.1 - 8.9)	1,226 (741 - 1,848)	53 (45 - 59)	675 (432 - 1,132)	0.88 (0.3 - 5.9)	0.65 (0.17 - 6)	1.39 (0.6 - 6.7)	1.12 (0.4 - 4.6)	0.34 (0.12 - 1.1)	0.19 (0.09 - 0.86)	0.42 (0.15 - 1.3)	0.3 (0.09 - 0.94)
South Uchi (610)	12,399 (6,873 - 23,102)	10 (7.6 - 11 9)	1,569 (987 - 2,211)	57 (48 - 67)	847 (500 - 1,565)	1.1 (0.1 - 5.2)	0.92 (0.09 - 7 5)	0.3 (0.1 - 1.2)	0.22 (0 1 - 0.92)	0.3 (0.1 - 0.6)	0.16 (0.1 - 0.5)	0.42 (0.1 - 7)	0.35 (0 09 - 6.5)
Mindola Dam North Overflow into Ichimpe (629)	—	7.6 (6.4 - 8.2)	704 (520 - 962)	22 (10 - 38)	394 (255 - 582)	0.17 (0.1 - 0.3)	0.1 (0.09 - 0.2)	0.16 (0.09 - 0.3)	0.11 (0.07 - 0.2)	0.24 (0.1 - 0.5)	0.12 (0.09 - 0 22)	0.13 (0.06 - 0.2)	0.09 (0 03 - 0 13)
Uchi Prior to Kafue River (630)	68,069 (48,397 - 83,658)	7.8 (7 3 - 8.2)	866 (594 - 1,186)	44 (32 - 57)	510 (328 - 794)	0.4 (0.2 - 0.7)	0.24 (0.1 - 1)	0.63 (0.2 - 1.9)	0.4 (0.1 - 1.2)	0.25 (0.09 - 0.4)	0.13 (0.09 - 0.3)	0.33 (0.09 - 0.97)	0.21 (0.09 - 0 8)
Mindola Shaft Water (631)	43,325 (36,520 - 46,515)	7.8 (7.6 - 8.3)	1,413 (1,035 - 1,660)	27 (15 - 50)	785 (387 - 1,200)	0.19 (0.1 - 0.4)	0.12 (0.09 - 0.3)	0.19 (0.09 - 0 4)	0.13 (0.09 - 0.3)	0.23 (0.1 - 0.35)	0.13 (0.09 - 0.2)	0.16 (0.09 - 0.25)	0.11 (0.05 - 0.18)
CHINGOLA - NCHANGA													
Tailings Leach Plant Main Drain (303)	7,836 (143 - 11,063)	6.9 (4.6 - 9.2)	2,434 (1,033 - 4,147)	11,501 (2,415 - 53,149)	1,365 (520 - 2,394)	180 (33.9 - 396)	59.18 (0.8 - 207)	7.05 (0.9 - 18 5)	3.27 (0.3 - 12.98)	178 (21.05 - 447)	6.72 (0.2 - 41.5)	20.44 (5.8 - 45 67)	11.96 (1.8 - 31.5)
Pollution Control Dam Spillway (306)	46,016 (2,918 - 215,448)	8 (7.7 - 8.3)	1,374 (758 - 2,436)	4,619 (799 - 13,330)	727 (366 - 1,354)	51.98 (8.4 - 144)	0.76 (0.16 - 2.08)	2.38 (0 43 - 7)	0.49 (0.15 - 1.4)	74.81 (12.1 - 191)	0.55 (0.1 - 2)	9.52 (2.97 - 18.07)	6.24 (1.27 - 12.28)
Muntimpa Dam Overflow (308)	72,542 (23,744 - 165,726)	8.3 (7.9 - 8.7)	2,725 (1,991 - 3,484)	44 (18 - 157)	1,625 (725 - 2,295)	0.78 (0.26 - 1.5)	0.12 (0 1 - 0.5)	0.44 (0.18 - 1 13)	0.14 (0.1 - 0.48)	1.18 (0.25 - 3.6)	0.2 (0.1 - 0.5)	2.18 (0.6 - 4.68)	1.62 (0.36 - 4.3)
Concentrator Effluent To Nchanga Stream (309)	609 (10 - 6,336)	7.9 (7.7 - 8.2)	371 (276 - 546)	2,195 (315 - 9,916)	136 (91 - 196)	78.23 (8.38 - 190)	1.41 (0.1 - 15.65)	2.35 (0.33 - 19 2)	0.25 (0.1 - 1)	67.78 (6.65 - 132)	0.39 (0.1 - 1.18)	3.04 (0.6 - 8.03)	1 05 (0.4 - 4.2)
Drying Bed Discharge (311)	1,391 (768 - 3,018)	8 (7.5 - 9.4)	497 (373 - 668)	325 (46 - 2,103)	245 (144 - 368)	10.82 (1.08 - 47.72)	0.61 (0.13 - 5.53)	3.13 (0.48 - 41.35)	0.27 (0.1 - 0.98)	13.64 (0.55 - 190)	0.3 (0.08 - 1.12)	1.01 (0.2 - 7.45)	0.33 (0.12 - 1.55)
MUFULIRA													
Butondo Dam Seepage (402)	458 (22 - 4,393)	7.9 (7.6 - 8.1)	1,660 (485 - 2,610)	21 (3 - 132)	884 (215 - 1,520)	0.5 (0.1 - 3.1)	0.2 (0.1 - 0.5)	0.1 (0.1 - 0.1)	0.1 (0.1 - 0.1)	0.6 (0.1 - 4.7)	0.2 (0.1 - 0.4)	0.2 (0.1 - 0.5)	0.1 (0.1 - 0.1)
Main Mine Effluents (404)	55,432 (27,799 - 86,206)	8.1 (7.8 - 8.6)	1,376 (1,062 - 1,597)	106 (12 - 570)	688 (570 - 790)	2.2 (0.5 - 6.6)	0.3 (0.1 - 1.2)	0.1 (0.1 - 0.1)	0.1 (0.1 - 0.1)	3.5 (0.1 - 20)	0.3 (0.1 - 0.5)	0.4 (0.1 - 2.9)	0.1 (0.1 - 0 2)
Tailings No.11 Decant Effluent (421)	659 (270 - 864)	7.3 (6.8 - 8.1)	2,142 (1,428 - 2,400)	57 (5 - 306)	1,161 (685 - 1,360)	0.4 (0.1 - 1.1)	0.2 (0.1 - 0.7)	0.1 (0.1 - 0.1)	0.1 (0.1 - 0.1)	7.6 (0.7 - 44)	0.7 (0.1 - 3.4)	3 (0.1 - 5.1)	2.4 (0.1 - 4.8)
Tailings Dam 10 Discharge (TD10) (430)	35,223 (0 - 173,522)	7.9 (7.7 - 8.2)	307 (97 - 705)	9 (5 - 14)	127 (30 - 362)	0.4 (0.1 - 1.5)	0.2 (0.1 - 0.4)	0.1 (0.1 - 0.1)	0.1 (0.1 - 0.1)	0.3 (0.1 - 0.7)	0.2 (0.1 - 0.4)	0.1 (0.1 - 0.1)	0.1 (0.1 - 0.1)
Tailings Dam 11 Discharge (TD11) (435)	45,334 (4,223 - 139,167)	8 (7.7 - 8.4)	2,204 (1,534 - 2,648)	10 (7 - 27)	1,198 (836 - 1,455)	0.3 (0.1 - 1)	0.1 (0.1 - 0.5)	0.1 (0.1 - 0.1)	0.1 (0.1 - 0.1)	0.3 (0.1 - 0.6)	0.2 (0.1 - 0.4)	0.1 (0.1 - 0.2)	0.1 (0.1 - 0.1)
LUANSHYA													
TPH Discharge into Luanshya River (703)	7,276 (2,875 - 9,250)	7.6 (7.1 - 8)	470 (310 - 681)	2,186 (29 - 18,950)	232 (121 - 371)	10.335 (1.02 - 143)	0.283 (0.065 - 0.9)	18.455 (0.03 - 233)	0.022 (0.01 - 0.15)	26.449 (1.48 - 272)	0.218808 (0.037 - 1.62)	3.319 (0.085 - 41.25)	0.133 (0.05 - 0.342)
Underground Water ex 280 via 180 (714)	8,402 (6,500 - 10,620)	7.7 (7.3 - 8)	831 (660 - 971)	209 (35 - 577)	434 (325 - 508)	0.795 (0.19 - 2.88)	0.047 (0.02 - 0.093)	0.039 (0.01 - 0.07)	0.015 (0.01 - 0.033)	4.225 (1.44 - 13.5)	0.062759 (0.03 - 0.115)	0.192 (0.07 - 0.53)	0.017 (0.01 - 0.03)
U/G Water Ex. 140 : Fisenge Stream Enrty (743)	10,127 (3,750 - 14,000)	7.6 (7.6 - 7.9)	985 (787 - 1,322)	14 (6 - 23)	496 (367 - 595)	0.136566 (0.0475 - 0.27)	0.043 (0.02 - 0.06)	0.019 (0.01 - 0.045)	0.017 (0.01 - 0.045)	0.327 (0.135 - 0.63)	0.076 (0.022 - 0.16)	0.136 (0.06 - 0.33)	0.095 (0.02 - 0.32)
Musi Tailings Dam Discharge (745)	9,109 (4,375 - 18,500)	7.7 (7.4 - 8.1)	939 (574 - 1,092)	463 (30 - 2,000)	506 (311 - 624)	0.637 (0.235 - 3.13)	0.044 (0 02 - 0.08)	0.145 (0.028 - 0.72)	0.019 (0.01 - 0.04)	10.078 (0.2 - 46.2)	0.242 (0.05 - 0.61)	1.096 (0.39 - 3.2)	0.491 (0.01 - 0.74)
KONKOLA													
Effluent ex Lubengele Tailings Dam & Stream (298)	149,172 (20,013 - 306,568)	8 (7 7 - 8.3)	187 (116 - 291)	17 (2 - 80)	50 (8 - 86)	0.15 (0.01 - 0.9)	0.06 (0.01 - 0.23)	0.06 (0.01 - 0.15)	0.06 (0.01 - 0.1)	0.26 (0.01 - 1.48)	0.26 (0.01 - 1.48)	0.08 (0.01 - 0.28)	0.06 (0.01 - 0.2)
Combined Drain = Conc. Spills & U/G Water (299)	325,914 (288,461 - 363,070)	8.1 (7 9 - 8.3)	298 (258 - 363)	144 (18 - 813)	72 (52 - 93)	0.96 (0.1 - 5.38)	0.11 (0.01 - 0.4)	0.09 (0.01 - 0.25)	0.06 (0.01 - 0.1)	1.65 (0.08 - 17.35)	1.65 (0.08 - 17.35)	0.12 (0.01 - 0.72)	0.06 (0.01 - 0.23)
Engineering Workshop Drain (225)	12,577 (325 - 31,651)	8.1 (7.6 - 8.4)	268 (178 - 391)	103 (7 - 590)	72 (48 - 121)	0.46 (0.07 - 3.08)	0.09 (0.01 - 0.38)	0.06 (0 01 - 0.13)	0.06 (0.01 - 0.1)	1.17 (0.07 - 9.87)	1.17 (0.07 - 9.87)	0.17 (0.01 - 0.8)	0.09 (0.01 - 0.23)

Station	Flow Rate (m^3/day)	Lab. pH (unit)	Dissolved Solids (mg/L)	Suspended Solids (mg/L)	Dissolved Sulphate (mg/L)	Total Copper (mg/L)	Dissolved Copper (mg/L)	Total Cobalt (mg/L)	Dissolved Cobalt (mg/L)	Total Iron (mg/L)	Dissolved Iron (mg/L)	Total Manganese (mg/L)	Dissolved Manganese (mg/L)
CHAMBISHI													
New Dam Overflow (504)	1,926 (134 - 3,760)	7 9 (6 7 - 8.1)	1,158 (490 - 2,510)	6 (5 - 15)	1,003 (164 - 5,179)	0.4 (0.1 - 5 4)	0.3 (0.1 - 3 8)	1.4 (0.1 - 8.9)	1.3 (0.1 - 8.8)	0.1 (0.1 - 0.3)	0.1 (0.1 - 0.1)	0.4 (0.1 - 2 2)	0.3 (0.1 - 2)
Musakashi Dam Overflow (509)	11,950 (649 - 77,200)	8.1 (7 4 - 9.2)	2,215 (260 - 7,330)	8.8 (4 - 18)	1,494 (145 - 5,046)	0.2 (0.1 - 0.8)	0.1 (0.1 - 0.2)	0.4 (0.1 - 3.1)	0.4 (0.1 - 2.2)	0.3 (0.1 - 0.5)	0.1 (0.1 - 0.1)	0.3 (0.1 - 1.4)	0.2 (0.1 - 1.3)
KAFUE RIVER													
Kafue River Upstream of Pump Station (120)	—	7 7 (7.2 - 8.1)	109 (50 - 237)	6.8 (1 - 16)	5.1 (1 - 16)	0.1 (0.01 - 0.33)	0.08 (0.01 - 0.18)	0.08 (0.01 - 0.15)	0.06 (0.01 - 0.13)	0.15 (0.03 - 0.38)	0 07 (0.01 - 0.1)	0.06 (0.01 - 0.2)	0.07 (0.01 - 0 1)
Kafue Downstream of Kakosa (122)	—	7.7 (7.1 - 8.2)	136 (70 - 251)	18.5 (2 - 37)	15 (1 - 49)	0.12 (0.01 - 0.32)	0.06 (0.01 - 0.1)	0.06 (0.01 - 0.1)	0.06 (0.01 - 0.1)	0.32 (0.03 - 1.55)	0.08 (0.01 - 0.18)	0.08 (0.01 - 0.13)	0.06 (0.01 - 0.13)
Hippo Pool on Kafue River (130)	—	7.7 (7.1 - 8.2)	148 (74 - 385)	20 (6 - 43)	27.13 (1 - 126)	1.49 (0.06 - 23.2)	0.14 (0.06 - 0.32)	0.22 (0.1 - 0.96)	0.12 (0.06 - 0.27)	1.85 (0.1 - 12.47)	0.2 (0.06 - 0.8)	0.28 (0.1 - 1.6)	0.14 (0.08 - 0.38)
Kafue Pump St (Chingola Munincipal Council) (131)	—	7.6 (7 - 8.2)	151 (73 - 508)	20 (7 - 84)	31.79 (2 - 188)	0.39 (0.06 - 1.34)	0.13 (0.1 - 0.4)	0.2 (0.06 - 1.52)	0.1 (0.06 - 0.14)	2.91 (0.1 - 39.54)	0.21 (0.06 - 1.24)	0.24 (0.1 - 1.12)	0.14 (0.08 - 0 58)
Kafue River at Mufulira Pump Station (140)	—	8 (7.8 - 8.2)	404 (20 - 1,050)	14 (3 - 62)	187 (10 - 617)	0.44 (0.1 - 1.25)	0.17 (0.1 - 0.5)	0.1 (0.1 - 0.1)	0.1 (0.1 - 0.1)	0.53 (0.1 - 1.6)	0.21 (0.1 - 0.7)	0.12 (0.1 - 0.2)	0.1 (0.1 - 0.1)
Kafue River at Chambishi Pump Station (150)	—	8 (7.5 - 8.3)	202 (67 - 610)	10 (5 - 26)	79.75 (19.5 - 260)	0.2 (0.1 - 0.36)	0.1 (0.1 - 0.1)	0.13 (0.1 - 0.3)	0.11 (0.1 - 0.1)	0.23 (0.1 - 0.4)	0.1 (0.1 - 0.1)	0.13 (0.1 - 0.2)	0.1 (0.1 - 0.15)
Nkana Raw (Kafue River) (160)	—	7.8 (7.4 - 8.3)	334 (130 - 1,203)	18 (11 - 27)	181 (54 - 503)	0.17 (0.13 - 0.24)	0.11 (0.09 - 0.16)	0.12 (0.09 - 0.22)	0.09 (0.04 - 0.16)	0.22 (0.13 - 0.35)	0.12 (0.09 - 0.17)	0.13 (0.05 - 0.24)	0.09 (0.07 - 0.14)
Kafue River at Ndola Road Bridge (162)	—	7.8 (7.5 - 8.3)	292 (122 - 668)	17 (11 - 31)	176 (43 - 342)	0.2 (0.1 - 0.37)	0.12 (0.06 - 0.25)	0.13 (0.06 - 0.2)	0.1 (0.04 - 0.14)	0.27 (0.1 - 0.4)	0.13 (0.07 - 0.22)	0.17 (0.06 - 0.25)	0.11 (0 03 - 0.18)
WHO Drinking Water Guideline		—	—	—	—	2		—		—		0.5	
Canadian Freshwater Aquatic Life Guideline		6.5-9	—	—	—	Depends on hardness (CaCO3) 0.002 mg/L (Hard=0-120 mg/L) 0.003 mg/L (Hard=120-180 mg/L) 0.004 mg/L (Hard>180 mg/L)		—		0.3		—	
Canadian Livestock Water Guideline		—	3000	—	1000	0.5 mg/L for sheep 1.0 mg/L for cattle 5.0 mg/L for swine and poultry		1		—		—	
Canadian Irrigation Guideline		—	500-3500 depending on crop	—	—	0.2 mg/L for cereals 1.0 mg/L for tolerant crops		0.05		5		0.2	
FAO Irrigation Guideline		6.5-8.4	<450 mg/L: no impairment 450-2000 mg/L: moderate >2000: severe	—	—	0.2		0.05		5		0.2	

Stack Emissions Heavy Metal Concentrations from Mufulira Smelter, Selected Months 2000 (Data Source: Mapani Copper Mines)

MOPANI COPPER MINES PLC
MUFULIRA DIVISION

SMELTER DEPARTMENT

AIR EMISSION STATUTORY REPORT - JULY TO SEPTEMBER 2000

DUST EMISSIONS

MONTH	SCRUBBER		ELECTRIC F/CE STACK	
	(tph)	(Nm^3/Hr)	(tph)	(Nm^3/Hr)
JUL	0.038	20275	0.190	83063
AUG	0.130	29792	0.465	125942
SEPT	0.095	26948	0.570	130395

MONTH	SCRUBBER STACK (mg/Nm^3)	E/ FCE STACK (mg/Nm^3)
JUL	1874	2287
AUG	4364	3692
SEPT	3538	4371
Limits (Inter	38000	4000

HEAVY METAL CONTENT

MONTH	SCRUBBER (mg/Nm^3)				E/FCE STACK (mg/Nm^3)			
	As	Cd	Cu	Pb	As	Cd	Cu	Pb
JUL	1.947	0.067	557.583	0.937	0.077	0.062	767.430	1.639
AUG	3.617	0.122	621.611	2.182	4.010	0.066	1195.162	2.585
SEPT	3.078	0.071	666.662	1.769	3.803	0.067	727.368	2.166
LIMITS (I	0.500	0.050	1.000	0.200	0.500	0.050	1.000	0.200

ASSAYS USED IN ABOVE TABLE

Electric Furnace Flue Dust

MONTH	As (ppm)	Cd (ppm)	%Cu	%Pb
JUL	1295	36	34	0.08
AUG	1086	18	32.37	0.07
SEPT	851	19	16.85	0.68

Scrubber K (Special sample)

MONTH	As (ppm)	Cd (ppm)	%Cu	%Pb
JUL	1039	36	29.75	0.05
AUG	829	28	14.25	0.06
SEPT	870	20	16.64	0.05

RY Chisanga
(S.A.M.E)

MOPANI COPPER MINES PLC
MUFULIRA DIVISION

SMELTER DEPARTMENT

AIR EMISSION STATUTORY REPORT - OCTOBER TO DECEMBER 2000

DUST EMISSIONS

MONTH	SCRUBBER		ELECTRIC F/CE STACK	
	(tph)	(Nm^3/Hr)	(tph)	(Nm^3/Hr)
OCT	0.0346	26446	0.11	129682
NOV	0.004	26112	0.11	122270
DEC	0.034	24996	0.26	106996

MONTH	SCRUBBER STACK (mg/Nm^3)	E/ FCE STACK (mg/Nm^3)
OCT	1306	849
NOV	153	900
DEC	1360	2430
Limits (Intermediates)	30000	4000

HEAVY METAL CONTENT

MONTH	SCRUBBER (mg/Nm^3)				E/FCE STACK (mg/Nm^3)			
	As	Cd	Cu	Pb	As	Cd	Cu	Pb
OCT	0.525	0.037	434.626	0.654	6.031	0.019	311.540	6.509
NOV	0.100	0.004	48.775	0.031	0.900	0.023	299.133	0.908
DEC	2.624	0.015	379.196	0.272	6.045	0.027	677.471	0.486
LIMITS (Long term)	0.500	0.050	1.000	0.200	0.500	0.050	1.000	0.200

ASSAYS USED IN ABOVE TABLE

Electric Furnace Flue Dust

MONTH	As (ppm)	Cd (ppm)	%Cu	%Pb
OCT.2000	514	22	37	0.06
NOV.2000	556	26	33.25	0.10
DEC.2000	1275	23	30.35	0.19

Scrubber Inlet Dust	(Special sample)			
MONTH	As (ppm)	Cd (ppm)	%Cu	%Pb
OCT	401.5	28	33.22	0.06
NOV	654	25	31.64	0.02
DEC	2076	11	27.66	0.02

[illegible]
RY Chabinga
(S.A.M.E)

Ground Level SO2 and NO2 Sampling: Copperbelt and Lusaka for Comparison
Source: Passive Sampling of SO2 and NO2 Ambient Air Concentration in Zambia, September, 1998, Guerreiro and Siverstein, Norwegian Institute for Air Research

Table 1: Sampling sites for the SO_2 and NO_2 passive samplers.

City/ Town	Site name (position)	Area	Emission source	Position to emission source	UTM co-ordinates X	UTM co-ordinates Y	Passive samplers SO_2	Passive samplers NO_2	Sampling period (days)
Lusaka	Embassy of Norway	City backg.			640,3	295,3	1	1	11.13
Lusaka	Fealex building	City centre	Traffic	20m W from main road	637,3	295,0	1	1	7.24
Ndola	Buteko Avenu	City centre	Traffic	Main road			1	1	5.78
Ndola	Mukuba Hotel	City/ Ind.	INDENI	≈1,5 km WNW			1	1	5.10
Luanshya	Phiri office	Township/ Industrial	RAMCZ	≈1 km NE	651,9	548,4	1	1	4.00
Luanshya	Section 5 clinic	Township/ Industrial	RAMCZ	≈1 km W	650,0	548,3	1	-	3.96
Luanshya	14 shaft clinic	Township/ Industrial	RAMCZ	≈2 km WNW	649,1	549,2	1	-	3.96
Luanshya	Section 9 clinic	Township/ Industrial	RAMCZ	≈3 km W	647,8	549,0	1	-	3.96
Luanshya	Section 25 clinic	Township/ Industrial	RAMCZ	≈8 km W	642,8	550,5	1	-	3.96
Mufulira	Clinic 5	Township/ Industrial	ZCCM	≈ 1 km NW	633,2	614,8	1	1	2.73
Mufulira	Clinic 7	Township/ Industrial	ZCCM	≈ 4 km NW	630,5	616,2	1	-	2.73
Mufulira	Clinic 3	Township/ Industrial	ZCCM	≈ 1 km SW	633,0	613,8	1	-	2.70
Mufulira	47 Entebbe street	City/ Industrial	ZCCM / Traffic	≈ 2,5 km SE	636,0	612,6	1	1	2.68
Nkana	Central shaft	Industrial	ZCCM/ Scaw	≈ 1 km NW	630,0	580,9	1	-	2.05
Nkana	Fire brigade	Industrial/ Township	ZCCM/ Scaw	≈ 0,5 km S	630,9	579,9	1	-	2.04
Nkana	Wusakili hospital	Township	ZCCM/ Scaw	≈ 0,75 km E	631,6	580,2	1	1	2.05
Nkana	Nkana hospital	City	ZCCM/ Scaw	≈ 1,5 km N	630,7	581,8	1	1	2.00
Nkana	Golf - club house	Leisure	ZCCM/ Scaw	≈ 3 km W	627,7	581,8	1	-	1.99
Nkana	Golf - club 900m east	Leisure	ZCCM/ Scaw	≈ 2,1 km W	628,6	581,5	1	-	1.98
Nkana	Miseshi shop	Township	ZCCM/ Scaw	≈ 4 km NNW	629,3	585,3	1	1	1.92

4. Measured concentrations

The passive SO_2 and NO_2 samplers were brought to NILU for analysis. The

Table 2: Measured ground level daily concentrations, averaged over the sampling period.

Sampling period				Site name (position)	UTM coordinates		Concentration (µg/m³)	
From:		To:			X	Y	SO_2	NO_2
date:	hr:	date:	hr:					
21.9.98	10:00	2.10.98	13:00	Lusaka, Nor Embassy	640,3	295,3	2	7
21.9.98	11:20	28.9.98	17:00	Lusaka, Featex build.	637,3	295,0	4	14
22.9.98	13:45	28.9.98	08:30	Ndola, Buteko Avenue			10	18
22.9.98	16:00	27.9.98	18:30	Ndola, Mukuba Hotel			38	2
23.9.98	13:55	27.9.98	13:55	Luanshya, Phiri office	651,9	548,4	14	6
23.9.98	15:10	27.9.98	14:13	Luanshya, Section 5 clinic	650,0	548,3	194	-
23.9.98	15:15	27.9.98	14:17	Luanshya, 14 shaft clinic	649,1	549,2	107	-
23.9.98	15:25	27.9.98	14:25	Luanshya, Section 9 clinic	647,8	549,0	167	-
23.9.98	15:45	27.9.98	14:40	Luanshya, Section 25 clinic	642,8	550,5	91	-
24.9.98	16:20	27.9.98	09:58	Mufulira, Clinic 5	633,2	614,8	382	7
24.9.98	16:40	27.9.98	10.10	Mufulira, Clinic 7	630,5	616,2	19	-
24.9.98	16:55	27.9.98	09:50	Mufulira, Clinic 9	633,0	613,8	672	-
24.9.98	17:20	27.9.98	09:40	Mufulira, 47 Entebbe street	636,0	612,6	6	7
25.9.98	11:35	27.9.98	12:47	Nkana, Central shaft	630,0	580.9	1493	-
25.9.98	11:45	27.9.98	12:40	Nkana, Fire brigade	630,9	579,9	385	-
25.9.98	11:55	27.9.98	13:00	Nkana, Wusakili hospital	631,6	580,2	19	10
25.9.98	12:10	27.9.98	12:05	Nkana hospital	630,7	581,8	55	11
25.9.98	12:20	27.9.98	12:00	Nkana Golf - club house	627,7	581,8	80	-
25.9.98	12.25	27.9.98	11:50	Nkana, golf club 900m east	628,6	581,5	107	-
25.9.98	13.25	27.9.98	11:35	Nkana, Miseshi shop	629,3	585,3	44	11

5. Air quality guidelines

The air quality guidelines for SO_2 and NO_2 from the Norwegian Pollution Control Authority (SFT, 1992) and World Health Organisation (WHO) are given in Table 3.

Emissions at 4 Community Monitoring Stations, Nkana (SmelterCo) 1997-1999

EMISSION INVENTORIES	Emissions tonnes Sulphur	% emission	Mean	Max
JANUARY 1997	5061	61.4	1899	4820
Fire Brigade			379	2914
Central Shaft			101	523
Nkana Hospital			514	1396
Wusakile Hospital				
February 1997				
Fire Brigade	4722	57.2	2842	6811
Central Shaft			667	3139
Nkana Hospital			282	561
Wusakile Hospital			1869	4026
March 1997				
Fire Brigade	4322	40.8	200	1593
Central Shaft			788	5508
Nkana Hospital			93	1631
Wusakile Hospital			89	898
April 1997				
Fire Brigade	4158	77.9	1063	4361
Central Shaft			1	1
Nkana Hospital			49	270
Wusakile Hospital			1	5
May 1997				
Fire Brigade	4415	47.2	274	1682
Central Shaft			1754	8203
Nkana Hospital			424	2384
Wusakile Hospital			110	1237
June 1997	3795	48.2	82	267
Fire Brigade			1294	2432
Central Shaft			187	777
Nkana Hospital			13	44
Wusakile Hospital				
July 1997				
Fire Brigade	4407	89.9	80	640
Central Shaft			1630	3430
Nkana Hospital			12	32
Wusakile Hospital			60	70
August 1997				
Fire Brigade	3400	42.1	503	7168
Central Shaft			2270	7687
Nkana Hospital			540	7716
Wusakile Hospital			230	1723
September 1997				
Fire Brigade	3227	48	61	206
Central Shaft			1733	2569
Nkana Hospital			84	368
Wusakile Hospital			31	66
October 1997				
Fire Brigade	3826	47.6	113	1020
Central Shaft			1100	1865
Nkana Hospital			89	935
Wusakile Hospital			33	166
November 1997				
Fire Brigade	4003	58.1	671	1554
Central Shaft			753	3233
Nkana Hospital			181	585
Wusakile Hospital			406	2166
December 1997				
Fire Brigade	3939	46.9	313	1225
Central Shaft			716	2184
Nkana Hospital			71	289
Wusakile Hospital			141	306
Averages	4019	52	534	2118

EMISSION INVENTORIES	Emissions tonnes Sulphur	% emission	Mean	Max	Dust	Copper in dust
JANUARY 1998						
Fire Brigade	6003	71.7	591	1109	760	228
Central Shaft			1070	6041		
Nkana Hospital			161	336		
Wusakile Hospital			351	1035		
February 1998						
Fire Brigade	3076	52.2	723	1930	567	170
Central Shaft			754	1845		
Nkana Hospital			186	450		
Wusakile Hospital			604	2254		
March 1998						
Fire Brigade	3802	59.1	302	1417	663	199
Central Shaft			1380	3809		
Nkana Hospital			106	295		
Wusakile Hospital			145	485		
April 1998						
Fire Brigade	3789	70.4	85	491	556	167
Central Shaft			98	3616		
Nkana Hospital			15	1048		
Wusakile Hospital			5	181		
May 1998						
Fire Brigade	4199	47.2	192	491	950	285
Central Shaft			1066	1740		
Nkana Hospital			461	1261		
Wusakile Hospital			31	78		
June 1998						
Fire Brigade	4506	55.8	69	491	1027	308
Central Shaft			1224	4304		
Nkana Hospital			122	292		
Wusakile Hospital			24	5		
July 1998						
Fire Brigade	4720	58	40	172	923	277
Central Shaft			1370	2312		
Nkana Hospital			98	142		
Wusakile Hospital			32	59		
August 1998						
Fire Brigade	4203	48.4	13	30	820	246
Central Shaft			1412	4861		
Nkana Hospital			17	486		
Wusakile Hospital			15	85		
September 1998						
Fire Brigade	3951	52.5	95	617	646	194
Central Shaft			1790	4422		
Nkana Hospital			147	786		
Wusakile Hospital			58	178		
October 1998						
Fire Brigade	3113	43.2	121	1314	767	230
Central Shaft			312	1369		
Nkana Hospital			18	178		
Wusakile Hospital			10	79		
November 1998	3761	47.8	426	1993	737	221
Fire Brigade			686	1787		
Central Shaft			247	1624		
Nkana Hospital			168	459		
Wusakile Hospital						
December 1998						
Fire Brigade	4317	59.3	161	616	761	228
Central Shaft			703	3730		
Nkana Hospital			29	370		
Wusakile Hospital			48	1309		
Averages	4120	55	371	1375	765	228

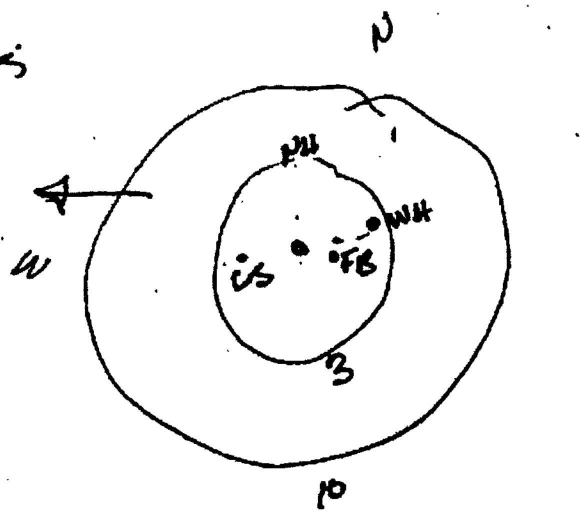
Jan - Mar 1988
Avg mean — 531 ug/m3
Avg Max — 1040 ug/m3

Avg Mean - 285 ug/m3
Avg Max - 1166 ug/m3

EMISSION INVENTORIES	Emissions tonnes Sulphur	% emission	Mean	Max	Dust	Copper in dust
JANUARY 1999						
Fire Brigade	3364	88.1	648	2122	810	183
Central Shaft			377	2190		
Nkana Hospital			181	980		
Wusakile Hospital			258	883		
February 1999						
Fire Brigade	3667	90.7	878	4337	737	221
Central Shaft			573	2283		
Nkana Hospital			438	4800		
Wusakile Hospital			383	1418		
March 1999						
Fire Brigade	3881	84.3	340	1140	787	230
Central Shaft			800	1835		
Nkana Hospital			100	283		
Wusakile Hospital			200	730		
April 1999						
Fire Brigade	3435	65.9	14	27	828	157
Central Shaft			1816	6310		
Nkana Hospital			115	588		
Wusakile Hospital			10	16		
May 1999						
Fire Brigade	3694	84.2	34	93	670	201
Central Shaft			1149	2022		
Nkana Hospital			178	808		
Wusakile Hospital			20	39		
June 1999	3334	71	118	827	559	166
Fire Brigade			1010	3684		
Central Shaft			274	844		
Nkana Hospital			74	324		
Wusakile Hospital						
July 1999	3846	66.9	488	1379	634	190
Fire Brigade			1085	2061		
Central Shaft			108	480		
Nkana Hospital			110	687		
Wusakile Hospital						
August 1999	2906	57.8	1	429	737	221
Fire Brigade			1001	8833		
Central Shaft			100	2217		
Nkana Hospital			43	467		
Wusakile Hospital						
			………………	repeat		
September 19	2277	66.7	1			
Fire Brigade			1001			
Central Shaft			100			
Nkana Hospital			43			
Wusakile Hospital						
October 1999						
Fire Brigade	2846	86.8	90	882	743	223
Central Shaft			304	778		
Nkana Hospital			35	285		
Wusakile Hospital			18	197		
November 1999						
Fire Brigade	4237	72	501	1216	803	241
Central Shaft			486	969		
Nkana Hospital			143	283		
Wusakile Hospital			93	256		
December 1999						
Fire Brigade	2817	58.8	85	499	780	234
Central Shaft			92	788		
Nkana Hospital			17	48		
Wusakile Hospital			22	150		
Averages	3314	63	324	1261	687	206

NKANA

ug/m³ ug/m³ Tonnes Tonnes



EMISSION INVENTORIES	Emissions tonnes Sulphur	[illegible]	[illegible]	[illegible]	Dust	Copper in dust
January 2000						
Fire Brigade	9448	71.4	1119	7388	673	302
Central Shaft			325	1664		
Nkana Hospital			268	540		
Wusakile Hospital			609	1227		
February 2000						
Fire Brigade	2108	59	1101	2969	647	184
Central Shaft			403	1059		
Nkana Hospital			198	347		
Wusakile Hospital			300	652		
March 2000						
Fire Brigade						
Central Shaft						
Nkana Hospital						
Wusakile Hospital						
April 2000						
MCM NKANA	650	84.2				
SMELTERCO	3080	60.3			694	286
Fire Brigade			280	9664		
Central Shaft			1259	8279		
Nkana Hospital			45	994		
Wusakile Hospital			51	389		
May 2000						
MCM NKANA	772	92.2				
SMELTERCO	3080	94.2			690	192
Fire Brigade			1	1		
Central Shaft			873	4664		
Nkana Hospital			1	1		
Wusakile Hospital			1	1		
June 2000						
MCM NKANA	844	90.8				
SMELTERCO	2714	68			617	186
Fire Brigade			12	94		
Central Shaft			1547	2898		
Nkana Hospital			81	305		
Wusakile Hospital			18	140		
July 2000						
MCM NKANA	636	94.6				
SMELTERCO	3291	72.04			660	189
Fire Brigade			1	1		
Central Shaft			1589	8886		
Nkana Hospital			65	189		
Wusakile Hospital			87	183		
August 2000						
MCM NKANA	482	83.01				
SMELTERCO	2618	72.96			488	137
Fire Brigade			1	1		
Central Shaft			349	1980		
Nkana Hospital			1	1		
Wusakile Hospital			1	1		
September 2000						
MCM NKANA	225	70.96				
SMELTERCO	2386	81.36			953	814131
Fire Brigade						
Central Shaft			291	748		
Nkana Hospital						
Wusakile Hospital						
October 2000			24/13787	12(4)1064		
MCM NKANA						
SMELTERCO						
Fire Brigade			451			
Central Shaft						
Nkana Hospital						
Wusakile Hospital						
November 2000						
MCM NKANA						
SMELTERCO						
Fire Brigade						
Central Shaft						
Nkana Hospital						
Wusakile Hospital						
December 2000						
MCM NKANA						
SMELTERCO						
Fire Brigade						
Central Shaft						
Nkana Hospital						
Wusakile Hospital						

without 1's → 451

without → 596 ug/m³ avg

without 1's → 1795 ug/m³

premise the "1" values under the assumption the monitor was not operational. - J.M.

Table J.2: Kafue River Hydrometric Stations (source: Pettersson and Ingri, 1999)

Station ID	Name	Drainage Area (km^2)	Approximate Mean Monthly Flow Range (m^3/s) [1]
4-050	Raglan's Farm	4,999	~0-110
4-130	Smith's Bridge	8,699	~10-300
4-280	Michiya Ferry	22,920	~15-400

[1] Tabular discharge data was not available for review – flows were drawn from Figure 2, Pettersson (1998). Low ranges of the flow are approximate only.

Table J.3: Trace element concentration (µg/g dry weight) in gills from threespot *Tilapia* exposed for two weeks in-situ at two localities in the Kafue River (from Norrgren et al, 2000)

Local 1	Ca	Cd	Co	Cu	Fe	Mg	Mn	Ni	Pb
	5278	0.31	3.28	115	491	1224	70.5	0.41	1.26
(n+8)									
	±1459	±0.02	±0.59	±30	±49	±157	±7.1	±0.07	±0.35
Local 2									
	5283	0.33	20.8	170	396	1669	122	1.46	3.06
(n+8)									
	±1143	±0.08	±2.4	±30	±49	±152	±16	±0.25	±0.67

AIR QUALITY DATA

Table J.4 Community Monitoring Stations, Mufulira

	Distance from Smelter	Community
Clinic 3	3 km	Kantoshi
Clinic 5	Less than 3 km	Kankoyo
Clinic 7	Close to 10km	Butondo
Clinic 8	Between 3 and 10 km	High cost township

Table J.5 Mufulira Smelter SO2 Emissions Data, January – September, 2000

	Jan	Feb	March	April	May	June	July	August	September
Clinic 3: Mean Ug/m3	22	275	NA	90	22	63	68	30	89
Clinic 3: Max Ug/m3	292	5425	NA	507	196	375	218	74	768
Clinic 5: Mean Ug/m3	13	40	NA	140	105	361	654	449	852
Clinic 5: Max Ug/m3	67	817	NA	828	784	1647	3138	698	2854
Clinic 7: Mean Ug/m3	18	6	NA	37	21	32	119	102	7
Clinic 7: Max Ug/m3	161	45	NA	195	191	145	512	131	92
Clinic 8: Mean Ug/m3	29			5	75	44	15	102	26
Clinic 8: Max Ug/m3	381			5	966	523	47	131	115

Data Source: Data from Mopani Copper Mines supplied to SA team

Table J.6 Mufulira Smelter SO2 Emissions Data, January – September, 1999

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Clinic 3: Mean Ug/m3	122	138	186	105	88	161	201	123	197	265	88	65
Clinic 3: Max Ug/m3	757	484	842	683	364	992	1076	823	667	1035		499
Clinic 5: Mean Ug/m3	54	112	400	691	880	576	997	583	442	688	162	92
Clinic 5: Max Ug/m3	166	388	1338	3705	3657	2620	3265	2472	1545	3114		758
Clinic 7: Mean Ug/m3	61	63	91	116	113	47	125	118	62	75	18	17
Clinic 7: Max Ug/m3	485	230	221	304	506	211	465	338	358	480		48
Clinic 8: Mean Ug/m3	95	82	123	118	52	19	60	25	22		3	22
Clinic 8: Max Ug/m3	662	381	422	460	232	160	211	82	113			150

Data Source: Data from Mopani Copper Mines supplied toSA team

Table J.7 Mufulira Smelter SO2 Emissions Data: Percent of Months Different SO_2 Levels Exceeded, 1999

1999	Percent of Months that SO2 levels exceeded...			
SO2 levels	Clinic 3 - 3 km	Clinic 5 – Less than 3 km	Clinic 7 – Close to 10 km	Clinic 8 – Between 3 and 10 km
Monthly Mean SO2>92	75%	92%	33%	17%
Monthly Mean SO2>250	8%	67%	0%	0%
Monthly Mean SO2>1000	0%	0%	0%	0%
Monthly Max SO2>92	100%	100%	91%	90%
Monthly Max SO2>250	100%	91%	64%	40%
Monthly Max SO2>1000	18%	73%	0%	0%
Monthly Max SO2>1300	0%	73%	0%	0%
Monthly Max SO2>25,000	0%	0%	0%	0%

Data Source: Base data from Mopani Copper Mines, calculation by SA team

Table J.8: Ambient Air Quality - Mufulira

AMBIENT AIR QUALITY (SO_2 in $\mu g/m^3/day$)														
	1995						**1996**							
	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Clinic 3	205	194	152	128	169	106	133	75	154	132	148	81	61	352
Clinic 5	645	936	762	304	218	84	261	121	211	512	228	2086	182	469
Clinic 7	89	93	133	30	33	34	38	27	56	101	78	171	25	112
Clinic 8	49	25	37	20	28	20	104	52	39	35	39	34	19	28

Table J.9: Ambient Air Quality – Nkana – Kitwe (SmelterCo)

Ambient Air Quality (SO_2 µg /m^3/day)									
Month	**Jul = 95**	**Aug >95**	**Sep 95**	**Oct >95**	**Nov >95**	**Dec >95**	**Jan >96**	**Feb >96**	**Mar >96**
STATIONS									
Wusakile Hospital	1.00	16.00	30.00	80.00	134.00	141.00	286.00	240.00	195.00
Central Shaft	369.00	287.00	518.00	132.00	462.00	372.00	171.00	502.00	939.00
Nkana Hospital	36.00	77.00	30.00	182.00	161.00	62.00	137.00	139.00	167.00
Fire Brigade	4.00	19.00	44.00	52.00	293.00	403.00	467.00	577.00	412.00

Table J.10: Kitwe SmelterCo Emissions (May to October 2000)

Source: KCM EMP

	Particulates									
	tonnes per day	Mg/Nm3	SO2	Arsenic	Bi?	Cadmium	Copper	Cobalt	Lead	Hg?
No. 2 conventional reverb	3 to 15	1500 - 5000	35,000 to 60,000	.003 to 0.9	1.0 to 5.0	.04 to 0.5	10 to 100	1.0 to 10	0.5 to 5.0	.001 to .05
No. 3 conventional reverb	3 to 15	1500 - 5000	35,000 to 60,000	.003 to 0.9	1.0 to 5.0	.04 to 0.5	10 to 100	1.0 to 10	0.5 to 5.0	.001 to .05
Converters dry ESP outlet	1 to 10	200 to 1000	120,000 to 244,000	.003 to .1	0.2 to 5.0	.003 to .05	3.0 to 10	0.1 to 0.5	0.2 to 5.0	.0003 to .05
Zambian Limit (mg/Nm3)	na	1461 to 3205*	1,000	0.5	na	0.05	1	na	0.2	0.05
IFC Guidelines (mg/Nm3)	na	20	1,000	0.5	na	0.05	1	na	0.2	0.05
Degree over guideline**	na	Up to 250 times IFC guideline,	Up to 244 times guideline	Up to 55% over guideline	na	Up to 10 times guideline	Up to 100 times guideline	na	Up to 25 times guideline	Within guidelines

* Intermediate limit from permit (ECZ 2000)

** For all elements except Hg, World Bank Group guidelines have historically been exceeded

Table J.11 – Summary of predicted impacts from SmelterCo improvements with comparisons to the WHO, WB and RSA guidelines (source: Environmental Management Services Report, March 2001)

Scenario	Averaging Periods	WHO/Zambian Guidelines/Standards (μg/m³)	Predicted Highest Concentration	% Of Guideline	WB Guidelines (μg/m³)	Predicted Highest Concentration	% Of Guideline	RSA Guidelines (μg/m³)	Predicted Highest Concentration	% Of Guideline
Year 0	Highest hourly	-	18000	-	-	18000	-	786	18000	2290.06
	Highest daily	125	3600	2880	500	3600	720	262	3600	1374.06
	Highest annual	50	1600	3200	100	1600	1600	79	1600	2025.32
Year 4	Highest hourly	-	12000	-	-	12000	-	786	12000	1526.72
	Highest daily	125	2600	2080	500	2600	520	262	2600	992.37
	Highest annual	50	1000	2000	100	1000	1000	79	1000	1265.82
Year 10	Highest hourly	-	11000	-	-	11000	-	786	11000	1399.49
	Highest daily	125	2100	1680	500	2100	420	262	2100	801.53
	Highest annual	50	750	1500	100	750	750	79	750	949.37
Year 10a	Highest hourly	-	10500	-	-	10500	-	786	10500	1335.88
	Highest daily	125	2100	1680	500	2100	420	262	2100	801.53
	Highest annual	50	750	1500	100	750	750	79	750	949.37

WHO = World Health Organisation; WB = World bank; RSA = Republic of South Africa

Table J.12 – Breakdown of Cerifications by Mine in 1998 and 1999

Division/ Mine	1998					1999				
	T	P1	P2	P3	PT	T	P1	P2	P3	PT
Chambishi	0	0	0	0	0	1	0	0	0	0
Chibuluma	0	0	0	0	0	10	0	1	0	0
Chilanga (Lusaka)	0	0	0	0	0	0	0	0	0	0
Chilanga (Ndola)	0	0	0	0	0	0	0	0	0	0
Kabwe	0	0	0	0	0	0	0	0	0	0
Konkola	30	4	0	0	0	21	2	0	0	0
Ramcoz	45	4	0	0	1	42	4	0	0	0
Nampundwe	0	0	0	0	0	0	0	0	0	0
Mufulira	54	16	11	7	5	40	29	4	4	1
Maamba	5	0	0	0	1	2	0	0	0	0
Nchanga	78	4	0	0	1	71	1	0	0	0
NdolaLime Company	0	0	0	0	0	1	0	0	0	0
Nkana	80	3	0	1	1	92	1	0	0	0
PreciousMetals Plant	0	0	0	0	0	0	0	0	0	0
TOTALS	292	31	11	8	8	283	37	5	4	1
GRAND TOTAL	350					330				

T= Tuberculosis; P1= Pnuemoconiosis stage 1; P2= Pneumoconiosis stage 2; P3= Pneumoconiosis stage 3; PT = Pneumoconiosis with tuberculosis.

T+ Tuberculosis; P1= Pneumoconiosis stage 1; P2= Pneumoconiosis stage 2;
P3= Pneumoconiosis stage 3; PT- Pneumoconiosis with tuberculosis

Figures Below are From Environmental Management Services report modeling the impact of improvements to SmelterCo smelter over the next ten years, with additional illustration by SA health team.

Year 0 hourly data for sulphur dioxide concentrations
Including sulphur dioxide concentrations from the

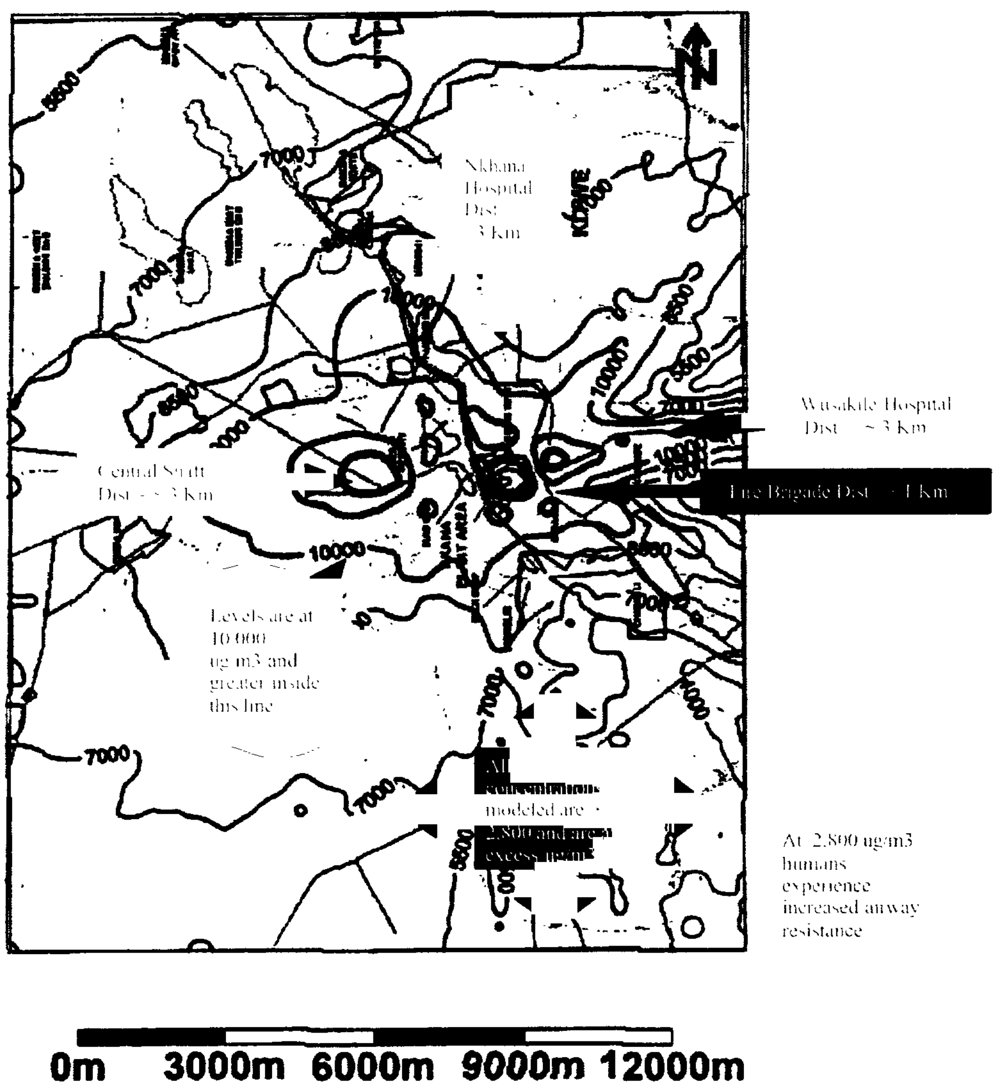


Figure 3.1 Year 0 highest hourly sulphur dioxide concentrations (μg/m³) for SmelterCo operations, Kitwe, Zambia

Dispersion Modelling for SmelterCo operations, Kitwe, Zambia
Report No: EMS/2001/A_Z-01 Rev 3

Year 0 daily data for sulphur dioxide concentrations Including sulphur dioxide concentrations from the SmelterCo cobalt plant and acid plant

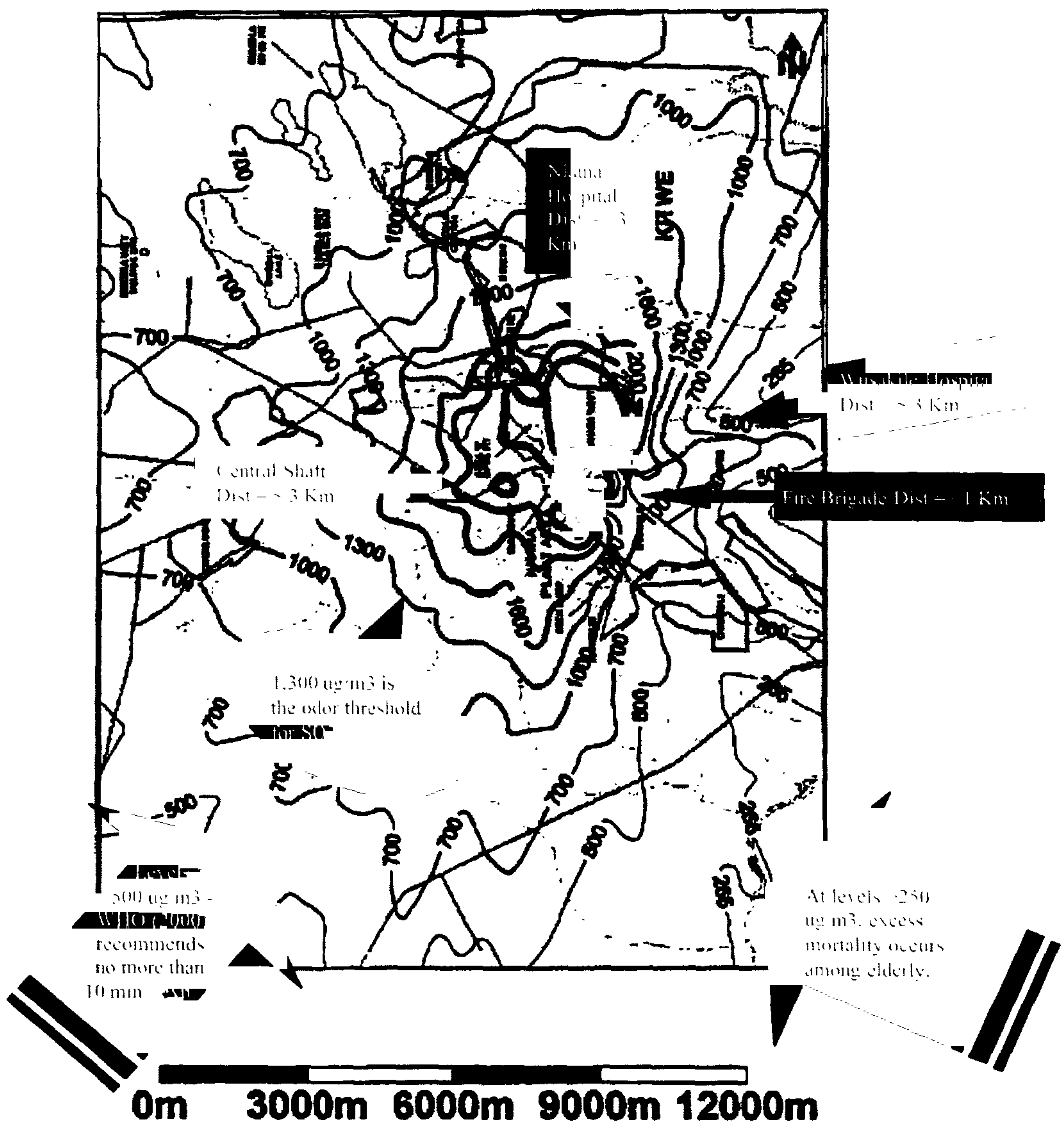


Figure 3.2 Year 0 highest average daily sulphur dioxide concentrations ($\mu g/m^3$) for SmelterCo operations, Kitwe, Zambia

Dispersion Modelling for SmelterCo operations, Kitwe, Zambia
Report No: EMS/2001/A_Z-01 Rev 3

Year 0 annual data for sulphur dioxide concentrations Including sulphur dioxide concentrations from the SmelterCo cobalt plant and acid plant

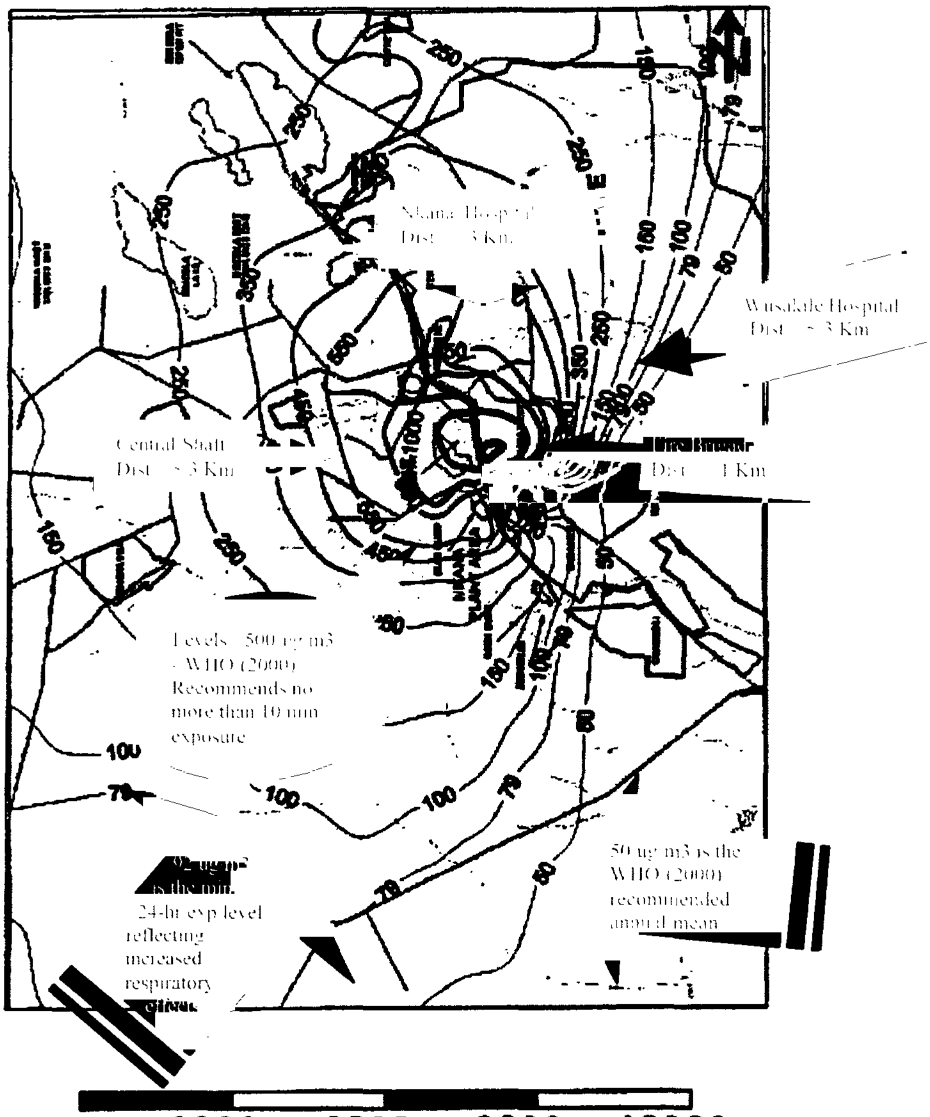


Figure 3.3 Year 0 average annual sulphur dioxide concentrations ($\mu g/m^3$) for SmelterCo operations, Kitwe, Zambia

Dispersion Modelling for SmelterCo operations, Kitwe, Zambia
Report No: EMS/2001/A_Z-01 Rev 3

Year 10a annual data for sulphur dioxide concentrations Including sulphur dioxide concentrations from the SmelterCo cobalt plant and acid plant

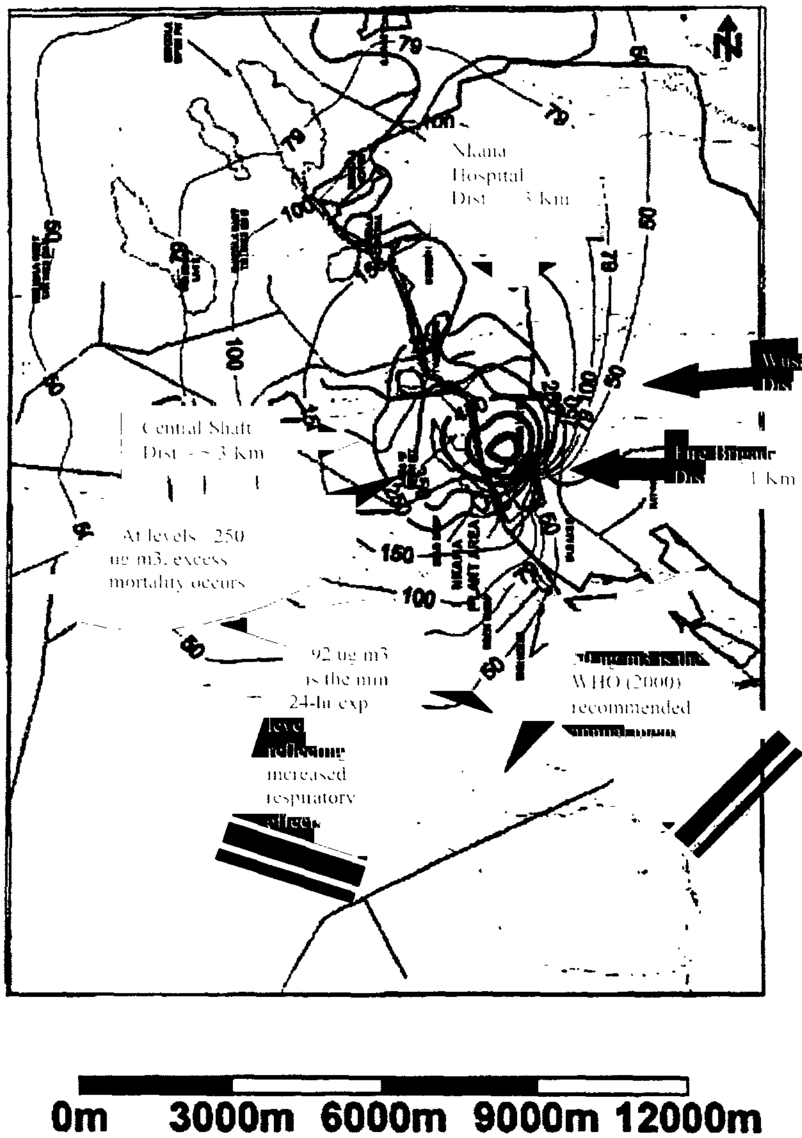


Figure 3.6 Year 10a average annual sulphur dioxide concentrations (µg/m³) for SmelterCo operations, Kitwe, Zambia

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ANNEX K:
PRIORITY ENVIRONMENTAL ISSUES AT SELECT MINE SITES

ANNEX K: PRIORITY ENVIRONMENTAL ISSUES AT SELECT MINE SITES

The EIS volumes compiled for ZCCM, and those available for privatised operations (KCM Interim statements) specify within their EMPs a range of actions for environmental monitoring and hazard mitigation. Under the existing conceptual design for the CEP, many of these actions will be integrated into a Consolidated EMP for the Copperbelt. This appendix provides an analysis of the adequacy of existing EMP actions, with emphasis on their utility for management and mitigation of the prevalent hazards identified in Annex E of this report.

ECONOMIC CONSIDERATIONS

Economic viability is an important consideration in the evaluation of EMP actions. Those outlined in EMPs prepared by ZCCM carry a gross cost of approximately US$ 200 million. Liability for certain actions has, through mines sales, been transferred to the private sector, or to other bodies (see Section 4 of Part I). For example, costs associated with potable water supply and sewage treatment, estimated at US$93 million, will now be funded by the Assets Holdings Company and the Commercial Utilities (CUs) under the Mine Townships Rehabilitation Programme. Costs associated with underground workings, plant area, active tailings facilities and buildings will now be addressed by private sector mine owners. Irrespective of this, a mechanism for prioritisation of actions is clearly required.

PRIORITY ISSUES

The following table exemplifies the integration of environmental restoration priorities on a generic basis and site-specific hazards for selected Copperbelt mines. Areas of particular concern in the operational phase (thus constituting short-term priorities) and upon closure (long-term priorities) are indicated, and management commitments for control and mitigation are summarised. Recurrent priority issues include surface water quality and discharge (all sites), suspended sediment loads (e.g., Konkola and Nchanga), SO_2 emissions (Mufulira, Nkana and Chambishi) and dusting (e.g., Nkana, Mufulira, Konkola and Nchanga).

Table K.1 is based on information presented in audits produced by Knight Piesold, SRK, and Golder. Where possible, information was screened and updated on the basis of the EA Team site visits.

Management commitments are identified under the last column, but responsible parties are yet to be determined (as part of the EMP, counterpart EMP and CEMP processes).

TABLE K.1: SUMMARY OF THE PRIORITY ENVIRONMENTAL ISSUES TO BE ADDRESSED AT SELECT MINE

MINE (LIFE)	PRIORITY ISSUES	MANAGEMENT COMMITMENTS
Nkana ML3 (From 1931 to approx. 2016)	**Operational** • Sulphur dioxide emissions (smelter complex, acid plants, cobalt roaster) • Water discharges to the Uchi, Wusakile and Luanshimba Streams (pH and dissolved metals) • Inadequate monitoring of potable water quality and sewage effluents • Dust from the mine residue disposal facilities, including the Nkana slag dump **Closure** • Approximately 9,000 workers, mining community (approx. 110,000 people) dependant on the mine for many services • Underground workings: surface caving, associated loss of land use, and contamination of water (90,000 m^3/d pumped from the workings to surface) • Plant: disposal of disused buildings, soil contamination • Mine residue facilities (four waste rock dumps, three tailings disposal complexes, two slag dumps and miscellaneous dumps): stability, storm-water runoff, seepage and dust	• Monitoring: air quality from the stacks; water quality; effluent quality; and subsidence above workings • Special studies: assessment of the impact of air emissions on residents in Kankoyo and on vegetation and soils; assessment of soil contamination in the plant area; aquatic assessment of streams during high flow; and policy and strategic plan for socio-economic programmed • Environmental protection: ongoing efforts to reduce sulphur dioxide emissions; control sediment release from dumps (TD 3 and 8); and upgrade potable water and sewage systems • Rehabilitation and closure: • Seal openings to surface, flood workings, erect barrier around caving area • Demolition and removal of unwanted plant buildings, placement of 0.5 m cover over contaminated areas, landscape site, restore natural drainage systems • Landscape mine residue deposits where necessary, control runoff, vegetate (natural revegetation of the waste rock dumps) • Assessment of the extent of rehabilitation of contaminated streams
Konkola ML7 (From 1957 to approx. 2011)	**Operational** • Substantial augmentation of flow in the Kafue River (large volumes of water pumped from underground) • Suspended solids and metals in water from underground and the plant area • High coliforms in sewage effluent **Closure** • Approximately 5,000 workers, mining community (approx. 39,000 people) dependant on the mine for many services • Underground workings: surface caving, associated loss of land use, and contamination of water (330,000 m^3/d pumped from the workings to surface) • Plant: disposal of disused buildings, soil contamination • Mine residue disposal facilities (three waste rock dumps, four tailings disposal complexes): stability, storm water runoff, seepage and dust • Contamination of streams (Lubengele and Kakosa Streams) and drainage lines by sediments	• Monitoring: water quality and flow; potable water quality; effluent quality; air quality (as required) and subsidence above workings • Special studies: aquatic assessment of streams during high flow; and policy and strategic plan for socio-economic program • Environmental protection: ongoing efforts to reduce solids discharges to the Kakosa Stream; upgrade potable water and sewage systems; and control of sediment release from the Kakosa tailings dam • Rehabilitation and closure: • Seal openings to surface, flood workings, erect barrier around caving area • Demolition and removal of unwanted buildings, placement of 0.5 m cover over contaminated areas, landscape site, restore natural drainage systems • Landscape mine residue deposits where necessary, control runoff, revegetate (natural revegetation of the waste rock dumps) • Assessment of the extent of rehabilitation of contaminated streams (Lubengele and Kakosa Streams) required

MINE (LIFE)	PRIORITY ISSUES	MANAGEMENT COMMITMENTS
Nchanga ML10 (From 1946 to approx. 2010)	**Operational** • Suspended solids and metals in water from the pollution control dam to the Chingola/Mushishima Stream • Dissolved solids in water from the Muntimpa Dam and runoff from mine residue disposal facilities to the Nchanga Stream **Closure** • Approximately 8,606 workers, mining community (approx. 68,000 people) dependant on the mine for many services • Open-cast workings: stability of the pit walls; and water collecting in the pits • Underground workings: surface caving, associated loss of land use, and contamination of water (80,000 m^3/d pumped from the workings to surface) • Plant: disposal of disused buildings, soil contamination • Mine residue disposal facilities (eleven overburden dumps associated with the north pits and eight overburden dumps associated with the south pits, two tailings disposal complexes): stability, storm water runoff, seepage and dust • Polluted water holding facilities: stability and discharges to water bodies • Contamination of streams (Chingola/Mushishima, Nchanga, Muntimpa Streams and sections of the Kafue River) by sediments	• Monitoring: water quality and flow; potable water quality; effluent quality; air quality from the dryer stack; and subsidence above workings • Special studies: aquatic assessment of streams during high flow; policy and strategic plan for socio-economic program; geochemical assessment and mass balance for the Muntimpa tailings dam (for rehabilitation planning); and assessment of soil contamination in the plant area (for rehabilitation planning) • Environmental protection: upgrade potable water and sewage systems; dredging of the pollution control dam (WD 4) to reduce metal loadings into the Chingola/Mushishima Stream and control of sediment release from various dumps • Rehabilitation and closure: • Erect a barrier to inadvertent access • Seal openings to surface, flood workings, erect barrier around caving area • Demolition and removal of unwanted buildings, placement of 0.5 m cover over contaminated areas, landscape site, restore natural drainage systems • Landscape mine residue deposits and areas from which dumps have been reclaimed where necessary, control runoff, revegetate (natural revegetation of waste rock dumps) • Retain water holding facilities as water bodies, or breach and rehabilitate (decisions to be based on assessments) • Assessment of the extent of rehabilitation of contaminated streams
Mufulira ML15 (From 1933 to approx. 2009)	**Operational** • Sulphur dioxide emissions (smelter and refinery) • Water discharges (plant effluent) to the Mufulira Stream, Kafue River system (pH and dissolved solids) • Inadequate monitoring of potable water quality and sewage effluents • Dust from the tailings dumps **Closure** • Approximately 6,500 workers, mining community (approx. 82,000 people) dependant on the mine for many services • Open-cast workings: stability of the pit walls; and water collecting in the pit • Underground workings: surface caving, loss of land use and contamination of water (81,000 m^3/d pumped from the workings to surface) • Plant: disposal of disused buildings, soil contamination • Mine residue facilities (three overburden dumps, three waste rock dumps, three tailings disposal complexes and miscellaneous dumps): stability, storm-water runoff, seepage and dust • Contamination of streams by sediments	• Monitoring: air quality from the stacks; water quality and flow; potable water quality; effluent quality; and subsidence above workings • Special studies: assessment of the impact of air emissions on residents in Wusakile; assessment of soil contamination in the plant area; aquatic assessment of streams during high flow; and policy and strategic plan for socio-economic program • Environmental protection: ongoing efforts to reduce sulphur dioxide emissions; control sediment release from dumps; upgrade potable water and sewage systems; and reduce dust emissions from the tailings dam • Rehabilitation and closure: • Seal openings to surface, flood workings, erect barrier around caving area • Barriers to access to the pit • Demolition and removal of unwanted plant buildings, placement of 0.5 m cover over contaminated areas, landscape site, restore natural drainage systems • Landscape mine residue deposits where necessary, control runoff, revegetate (natural revegetation of the waste rock dumps) • Assessment of the extent of rehabilitation of contaminated streams (Kitwe, Uchi, Mulu, Chibuluma and Luanshimba Streams) required

MINE (LIFE)	PRIORITY ISSUES	MANAGEMENT COMMITMENTS
Chambishi ML19 (From 1965 to approx. 2016)	**Operational** • Alkaline pH, sulphates and dissolved metals from the plant to the Chambishi and Musakashi Streams. Atmospheric emissions from Co plant **Closure** • Approximately 920 workers, mining community dependant on the mine for many services • Open-cast workings: stability of the pit walls; and water collecting in the pits • Underground workings: surface caving, associated loss of land use, and contamination of water (24,000 m^3/d pumped from the workings to surface) • Plant: disposal of disused buildings, soil contamination • Mine residue disposal facilities and low-grade ore stockpiles (two overburden dumps, one waste rock dumping area, a fine oxide dump, paddock dumps, two small tailings dams, three large tailings disposal complexes and three low grade ore stockpiles): stability, storm-water runoff, seepage and dust • Polluted water holding facilities: stability and discharges to water bodies	• Monitoring: water quality and flow; potable water quality; effluent quality; air quality from stacks; and subsidence above workings • Special studies: aquatic assessment of streams during high flow; policy and strategic plan for socio-economic program; and assessment of soil contamination in the plant area (for rehabilitation planning) • Environmental protection: upgrade potable water and sewage systems; and control of sediment release from various dumps • Rehabilitation and closure: • Erect a barrier to inadvertent access • Seal openings to surface, flood workings, erect barrier around caving area • Demolition and removal of unwanted buildings, placement of 0.5 m cover over contaminated areas, landscape site, restore natural drainage systems • Landscape mine residue deposits and areas from which dumps have been reclaimed where necessary, control runoff, revegetate (natural revegetation of the waste rock dumps) • Retain water holding facilities as water bodies, or breach and rehabilitate (decisions to be based on assessments), consider reclaiming sediments
Ndola Lime ML8 (From 1960 to approx. 2094)	**Operational** • Dust emissions from mining and processing operations (main sources are lime kilns and hydrator, dust from mining and handling operations is less of a problem) • Water discharges from workings to Itawa and Kafubu Stream (supply water to the city of Ndola) **Closure** • Approximately 547 workers (only 1% of the population of Ndola) and the mine does not provide service to the residential area • Open-cast workings: stability of the pit walls; and water collecting in the pit; long term stability of the pit walls and break back • Underground workings: contamination of water (40,000 m^3/d pumped from the workings to surface) and alteration of drainage patterns • Plant: disposal of disused buildings, soil contamination • Mine residue disposal facilities (three waste dumps and two reject rock dumps): stability, storm-water runoff, seepage and dust	• Monitoring: air quality from the kiln stacks; water quality and flow; and potable water quality • Special studies: impact of dust emissions on the health of residents of Itawa and Ndeke; aquatic assessment of streams during high flow; and policy and strategic plan for socio-economic program • Environmental protection: effort to reduce dust emissions; upgrade potable water and sewage systems; and control sediment release from mine residue deposits to the surface water system • Rehabilitation and closure: • Allow flooding of the pits and erect a barrier to inadvertent access • Demolition and removal of unwanted buildings, placement of 0.5 m cover over contaminated areas, landscape site, restore natural drainage systems • Landscape mine residue deposits where necessary, control runoff, revegetate (natural revegetation of the waste rock dumps)

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ANNEX L:
HEALTH PERSPECTIVE ON HAZARD SOURCES FOR SELECTED TOWNS

Table L.1: Health Perspective on Hazard Sources for Selected Towns

Source of data on composition: ZCCM Monitoring and 1996 EIS, except where otherwise noted
Additional data from select site visits during SA

	Ore/Tailings	Overburden Dumps	Water	Air	Soil	Food	Other Comment
Nchanga-Chingola	The orebody mined in the area contains little lead or arsenic, consistent with other ores in the Copperbelt. Few data exist for these more toxic elements because they were presumed to be present in the ore only at very low levels. (The possible presence of accumulated lead and arsenic can be ruled out through soil samples.) Elemental analysis on tailings samples show arsenic and lead levels (representative levels are 0.4 to 1.1 and 1 to 17 ppm, respectively, as reported in 1997). Leachate extraction is also low.	The predominant mineral in the overburden is quartz, with aluminium oxide second by mass. Arsenic and lead are present at low levels in the overburden (representative levels are <3 and 3 to 9 ppm, respectively, with a high for lead of 86 ppm in sample from OB05) and tailings (representative levels are 4 to 10 and 13 to 43 ppm, respectively, as reported in the 1996 EIS). Leachate extraction tests suggest that neither is extracted from the overburden efficiently although they may come out of tailings more readily.	Chingola Stream, downstream of the mine and draining overburden and tailings dumps, does show highly elevated levels of metals. They include: iron (mean 124 mg/l, maximum 1760 mg/l), copper (95, 632), cobalt (3.5, 54) manganese (10, 103). The metal content tends to increase during the rainy season, despite the increased potential for dilution. At these concentrations, water would probably often be discoloured and taste badly. Gastrointestinal symptoms due to copper toxicity would occur with consumption of 25 ml of water at times in which the water carried the maximum concentration or approximately 150 ml at the mean, which is the more likely exposure level to be encountered throughout the year.. In Nchanga Stream (at site 310), which runs parallel to Chingola stream and drains both dumps and surface runoff above open pits, metals contamination is less but still substantial: iron (mean 26 mg/l, maximum 1000 mg/l), copper (17, 899 which is higher at maximum than in Chingola stream), cobalt (1.7, 124), manganese (1.23, 43). This water would also be unpotable. In both Chingola Stream and Nchanga Stream downstream, the levels of suspended solids are very high	Some SO2 is produced from a tailings leach plant though below levels that would have health effects. Health authorities, however, report that some SO2 from Chambishi smelter reaches Chingola.	Should be tested as sediment and dust may have blown into soil immediately adjacent to mine sites.	In the absence of a major smelter, contamination is likely to be around mine sites. In numerous areas around the mine site people were observed growing crops (i.e. sugarcane). The potential for bioaccumulation from soil to crops is not known but could be assessed during EMP.	

	Ore/Tailings	Overburden Dumps	Water	Air	Soil	Food	Other Comment
			(27,526 mg/l and 28,240, respectively). High sediment levels are visible in the flow in Chingola Stream. This high sediment level presents a public health risk because it fouls water intakes for water treatment facilities and adds considerably to the load for chlorine disinfection, requiring more chlorine but resulting in less sure disinfection.				
Kitwe/Nkana	The orebody mined in the area contains little lead or arsenic. The elemental composition (copper, 0.6 to 2.3%; cobalt, 0.03 – 0.15%; and sulfur 0.63 – 2.82%) predictably generates acid but not heavy metals in mine drainage and tailings runoff. Arsenic levels in Nkana copper concentrates have been measured at 8 to 23 ppm.. The lead content of the tailings, a major factor in determining toxicity in most such situations, is only 0.002 – 0.003%.)	Overburden dumps, which are numerous in the area, are unremarkable except for an elevated copper content. The lead and arsenic contents have been tested and are not elevated. Because of the carbonate content, the pH is high (a measure of acidity and alkalinity), meaning that the acid formed in the leachate is quickly and completely neutralised. The leachate that is actually produced is confirmed to be unremarkable, with low lead and arsenic levels and no remaining acidity.	Uchi Stream, draining TD26 and the mine site area, shows an elevated content of metals from the tailings, with variable stream water copper concentrations averaging 0.926 mg/litre and peaking at 22.0 and cobalt concentrations averaging 1.36 mg/l and peaking at 25.8 at the Harrison Street Drain (607) from 1995 through early 2001. These levels render the water undrinkable. Levels this high are unlikely to be consumed but if they were might affect health acutely when the levels are high. (It would take consumption of approximately two-thirds of a litre of maximally contaminated water to cause gastrointestinal symptoms due to copper toxicity.) The high metals content is indicative of leaching. Wusakili Stream receives runoff from the Nkana mine area, as reflected in elevated and variable stream water copper concentrations averaging 0.524 mg/litre and peaking at 7.200 mg/l and cobalt concentrations averaging 0.295 mg/l and peaking at 3.000 at the Wusakile Storm Drain (coming right out of the mine site) from 1995 through early 2001. Levels this high are unlikely to be consumed but if they were might affect health	Emissions of sulfur dioxide at the smelter may exceed emissions limits by a factor of twenty at times. Elevations in sulfur dioxide affect primarily Nkana East and the nearby communities of Ndeke and Ndeke Village, and at times Wusakile according to residents there. At some tailings, tailings material is exposed in the vicinity, although not on the site itself, and is likely to contribute to the windblown dust. The potential for health risk of this dust is probably low. Although the dust is fine, most particles are probably above the respirable size range, the concentrations likely to be achieved in wind are relatively low and transient	It is unlikely that lead or arsenic would accumulated to high levels in soil, reflecting airborne deposition, but possible over many years. This would be easy to determine or rule out by direct measurement. Soil deposition studies (undated but probably 2001) show a peak in surface deposition of copper and sulfur at 1 and 1.5 km due west of the smelter, respectively, and slightly higher peaks at 1.5 km, for both northwest of the smelter.		Trash dumping (TD25) is common in the area and has lead to scavenging and reclamation activities. In some locations (e.g. TD31) this impedes water flow. At one site (OB63), lead batteries have been dumped and burned, possibly creating a local lead hazard. Industrial waste dumping at TD27 should be assessed for its potential to interact with tailings.

	Ore/Tailings	Overburden Dumps	Water	Air	Soil	Food	Other Comment
			directly when the levels are high. (It would take consumption of approximately two litres of maximally contaminated water to cause gastrointestinal symptoms due to copper toxicity.) The high metals content is indicative of leaching. Downstream, the water becomes more alkaline (less acidic), metal levels drop (except for some enrichment of copper and cobalt at certain times of the year, presumably leached from tailings by runoff during the rainy season) and the stream is in compliance with water quality standards by the time it enters the Kafue River. By comparison, elemental analysis of water discharged into Chibuluma Stream (624) downstream, which drains from TD33c shows less variable stream water copper concentrations averaging 0.17 mg/litre and peaking at 0.30 mg/l and cobalt concentrations averaging 0.11 mg/l and peaking at 0.20, mostly in 2000, with very low lead levels (mg/l throughout).	(compared to occupational exposures associated with lung disease) and the content is likely to be low in silica content. (This should be checked.) The metal content of the tailings dust is unlikely to present a health hazard. The dust may aggravate existing respiratory disease and mucosal irritation, however, and thus may have some effects on symptoms.			
Luanshya	The orebody mined in the area contains little lead or arsenic. The arsenic content in Luanshya copper concentrates has been measured at 10 to 55 ppm, levels that are the highest observed in the Copperbelt.	Overburden dumps, which are numerous in the area, are unremarkable except for an elevated copper content. The lead and arsenic contents have been tested and are not elevated.	Surface water quality in the area varies considerably but is consistently low in dissolved lead (0.06 at the Musi Drain Discharge in 1998 No tailings dams are monitored for water quality. Drainage pipes are reported to be defective or silted up, so much runoff flows into local streams. Discharges from 1995 through 2000 at the Tailings Pump House into the Luanshya River show elevated levels of copper (mean 11.4 mg/l, maximum 390.5 mg/l), cobalt (3.4, 919.7), iron (34.3, 919.7) and manganese (5.6,	Soil deposition of heavy metals is therefore expected to the west of the smelter site. When the smelter was operating the west side of Luanshya is reported to have been the most affected by scent. Dust is not a major problem because of vegetation growth on tailings dumps, which	Soil deposition in the plume of the smelter at Luanshya may have deposited substantial quantities of metals in the past. In 1998, the stack was emitting 3625 mg/m³ of dust, of which 14.8% was copper, 0.082% was arsenic, 0.032 was lead and 0.012% was cadmium (mercury was not quantifiable).	Cultivation does take place on mine property and is a concern because of the risk of erosion. There are no data on soil contamination where cultivation is taking place	

	Ore/Tailings	Overburden Dumps	Water	Air	Soil	Food	Other Comment
			440.7), levels that would at peak levels render the water unfit to drink because of an unacceptable taste At a point 20 km downstream, at the Makoma Road Bridge, the water quality is much improved: copper (mean 2.9 mg/l, maximum 50.0 mg/l), cobalt (0.4, 9.8), iron (8.3, 82.3) and manganese (2.0, 51.7), with a high but improved content of suspended solids (1202, 20,754). Further downstream, where the Luanshya River exists the RAMCo(Z) surface rights area, the water quality is within Zambian standards (and WHO guidelines): copper (mean 0.092 mg/l, maximum 0.76 mg/l), cobalt (0.015, 0.13), iron (0.36, 3.96) and manganese (0.053, 0.30), and the suspended solids are much reduced (49, 2064).	remains largely intact.	The mine has been operating the longest of the complexes in the Copperbelt. This suggests, but does not prove, the possibility of significant soil contamination with relatively more toxic metals over the many years that the smelter has been in operation. Much would depend on plume dispersion and local winds. The presence of significant contamination could be ruled out easily by local soil samples and analysis.		
Mufulira	The orebody mined in the area, as in all of the Copperbelt, contains little lead or arsenic, in contrast to other copper sulphide ores. The arsenic content in Mufulira copper concentrates has been measured at 5 to 18 ppm.	Overburden dumps, which are numerous in the area, are unremarkable except for an elevated copper content. The lead and arsenic contents have been tested and are not elevated.	Water quality in effluent from various operations show the highest metals content in the effluent from the refinery and concentrator operations, all at weakly alkaline. Although in some cases the levels exceed statutory limits for copper, they do not present a health risk. Downstream, at Mufulira stream leaving the mine area, the water quality is within statutory limits and by the time it reaches the Kafue River concentrations are negligible. This probably reflects the precipitation of metals in the carbonate-rich, alkaline chemical environment.	In Mufulira, the area of primary concern is downwind (west) of the smelter facilities, primarily in the district of Konkoya and secondarily in the nearby district of Katanshi. Other districts west of the smelter are at lesser risk for frequent exposure resulting on changes in wind direction. Districts upwind (east) of the smelter are at low risk of prolonged exposure, although occasionally	Soil deposition is heavy in metals but most of these metal species are relatively low in toxicity. Smelter copper emissions were 40 to 1,000 times above the stack emission limit. Soil deposition studies demonstrate correlation with smelter plume and soil levels up to 166.55 +/- S.D. 104.51 mg/kg (Kapungwe 2000). Copper is a chemical marker for dust emissions from	Lead levels in crops grown in the area show 320-340 mg/kg Pb found in avocado, mango and miombo plant leaves both upwind and downwind of smelter (35 mg/kg is considered normal). If consumed, these levels would contribute significantly to body burden, particularly in residents who have absorbed lead from other sources. It is not clear, however, whether these values	

	Ore/Tailings	Overburden Dumps	Water	Air	Soil	Food	Other Comment
				affected. he levels are far above the levels at which the earliest respiratory symptoms would be expected to occur and approach levels at which almost everyone in the population would be expected to experience symptoms and some discomfort and at which serious health impacts, such as elevated mortality, may occur.	smelter emissions. The high levels of copper suggest substantial deposition in soil. From the standpoint of human health, however, the greater concern is heavy metal and arsenic contamination. Soil sampling performed by MCM demonstrates up to 18 mg/kg Pb content of soil at site of highest concentration downwind of smelter stack. This is not considered a substantial public health hazard in itself but may be magnified by bioaccumulation in food crops. Arsenic is less clear. Soil sampling performed by MCM demonstrates up to 20 mg/kg As content of soil at site of highest concentration downwind of smelter stack; most values are <10. However, local concentrations may be higher, such as one site upwind of stack with 30 mg/kg, at the engineers' office. This suggests that local activity may be more important as	reflect the content of the fruit. Arsenic is less clear. Soil sampling performed by MCM demonstrates up to 20 mg/kg As content of soil at site of highest concentration downwind of smelter stack; most values are <10. However, local concentrations may be higher, such as one site upwind of stack with 30 mg/kg, at the engineers' office. This suggests that local activity may be more important as a determinant of concentrations than Mg deposition from air. These levels are not considered to be public health hazards. Data on levels of arsenic in food crops was not available.	

	Ore/Tailings	Overburden Dumps	Water	Air	Soil	Food	Other Comment
					a determinant of concentrations than Mg deposition from air. These levels are not considered to be public health hazards.		
Ndola	The composition of the quarry rock is predominantly calcium oxide (97%). The waste dumps consist of carbonate (31% to 64%), calcium oxide (29 to 48%), variable silica (0.38 to 16.%) and iron, sulfur and sulphate. Copper and cobalt are present only in small quantities (102 and 30 ppm, maxima, respectively).		Surface water quality at the Ndola Lime site is within statutory limits for chemical contamination. Surface waters tend to drain into rather than out of the plant, because it occupies the low ground. Surface waters in the area show low concentrations of suspended solids arsenic, lead and other metals generally. The pH of surface water is 7.6 and above.	The Ndola Lime plant produces large quantities of dust consisting predominantly of calcium carbonate. This type of dust is classified as a miscellaneous, non-toxic particulate matter, or (in older terminology) "nuisance dust" Complaints from residents have been registered because this dust has a tendency to stick when wet. However, the health implications are minimal. There may be some sulfur dioxide emissions form the Chilanga Cement Plant, which is adjacent to the Ndola Lime Plant and its biggest customer. This should be evaluated in the EMP.	NA	NA	
Kabwe	Lead tailings were also deposited in tailings dumps south of the mine site.		Data available are from 1994. The geology of the area is favourable to preserving water quality in being	Dust from tailings that were not fully covered because of	high concentrations of metals in soil in and around Kabwe. The	Likewise plants showed a similar pattern of metal	Some lead metal and slag scavengers have

	Ore/Tailings	Overburden Dumps	Water	Air	Soil	Food	Other Comment
			limestone, which results in buffering of excess acid and precipitation of metals. Water quality in the Main Canal in 1994 showed low levels, <0.01 mg/l throughout the year, reported to varied considerably from month to month in 1993 and then to have dropped in 1994. By comparison, zinc levels were much higher (between 3 and 106 mg/l) and generally varied with sulphate levels. Cadmium levels were generally at or below 0.02 mg/l. The Main Canal eventually discharges into a dambo, at which point lead levels in water were between 0.001 and 0.004 mg/l. Lead levels continued in this general range in Kanakutsi Stream and at the point of discharge into the Muswishi River. There is some fishing and agriculture in this area, consisting of small plots. There has been no testing of fish for bioaccumulation. During site visits to Katondo township some residents had built wells to compensate in part for deteriorating municipal water supply. These wells should be tested for lead contamination as they are not a great distance from the canal which flooded one year.	financial constraints, or from other sources may contribute to airborne levels of dust high in lead content.	highest levels were found to the west, two kilometres downwind of the plant, with average levels of lead, zinc, copper and cadmium of 548, 89, 61 and 27 mg/kg (ppm), respectively, compared to other sites, such as a site 4 km northeast of the mine (32.2, 18, 3 and 0.1, respectively) Soil samples in some locations reached lead levels of almost 3% and the extent of lead contamination in the area was widespread.	content. Tembo (1993) conducted soil and food testing in the Kabwe area for his master's thesis at the University of Zambia. Food purchased in Kabwe markets, but of unknown provenance and limited in sample size, showed remarkably consistent amounts of lead, on the order of 30 mg/kg, but more variable amounts of zinc, copper and cadmium. These levels exceeded FAO and WHO guidelines. The highest lead levels were found in sweet potato stem. Lead levels generally exceeding 30 mg/kg in lead content were rape, Chinese cabbage and certain soybeans. When food was sampled from known provenance, maize leaves up to 15 km from Kabwe to the east had lead levels than from 76 to 84 mg/kg but those 20 km away had 4. To the west, however, lead levels in maize leaves were in excess of 790 mg/kg up to 6 km out and 24 to 40 beyond. Zinc and	performed secondary smelting on site but this operation was small in scale and did not last long. It may have contributed to local contamination levels but is unlikely to affect levels in the community beyond.

	Ore/Tailings	Overburden Dumps	Water	Air	Soil	Food	Other Comment
						copper showed a similar pattern, which was less distinct for cadmium. Distant from Kabwe, only traces were found. These levels were also high compared to international comparisons.	

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ANNEX L:
HEALTH PERSPECTIVE ON HAZARD SOURCES FOR SELECTED TOWNS

Table L.1: Health Perspective on Hazard Sources for Selected Towns

Source of data on composition: ZCCM Monitoring and 1996 EIS, except where otherwise noted
Additional data from select site visits during SA

	Ore/Tailings	Overburden Dumps	Water	Air	Soil	Food	Other Comment
Nchanga-Chingola	The orebody mined in the area contains little lead or arsenic, consistent with other ores in the Copperbelt. Few data exist for these more toxic elements because they were presumed to be present in the ore only at very low levels. (The possible presence of accumulated lead and arsenic can be ruled out through soil samples.) Elemental analysis on tailings samples show arsenic and lead levels (representative levels are 0.4 to 1.1 and 1 to 17 ppm, respectively, as reported in 1997). Leachate extraction is also low.	The predominant mineral in the overburden is quartz, with aluminium oxide second by mass. Arsenic and lead are present at low levels in the overburden (representative levels are <3 and 3 to 9 ppm, respectively, with a high for lead of 86 ppm in sample from OB05) and tailings (representative levels are 4 to 10 and 13 to 43 ppm, respectively, as reported in the 1996 EIS). Leachate extraction tests suggest that neither is extracted from the overburden efficiently although they may come out of tailings more readily.	Chingola Stream, downstream of the mine and draining overburden and tailings dumps, does show highly elevated levels of metals. They include: iron (mean 124 mg/l, maximum 1760 mg/l), copper (95, 632), cobalt (3.5, 54) manganese (10, 103). The metal content tends to increase during the rainy season, despite the increased potential for dilution. At these concentrations, water would probably often be discoloured and taste badly. Gastrointestinal symptoms due to copper toxicity would occur with consumption of 25 ml of water at times in which the water carried the maximum concentration or approximately 150 ml at the mean, which is the more likely exposure level to be encountered throughout the year.. In Nchanga Stream (at site 310), which runs parallel to Chingola stream and drains both dumps and surface runoff above open pits, metals contamination is less but still substantial: iron (mean 26 mg/l, maximum 1000 mg/l), copper (17, 899 which is higher at maximum than in Chingola stream), cobalt (1.7, 124), manganese (1.23, 43). This water would also be unpotable. In both Chingola Stream and Nchanga Stream downstream, the levels of suspended solids are very high	Some SO2 is produced from a tailings leach plant though below levels that would have health effects. Health authorities, however, report that some SO2 from Chambishi smelter reaches Chingola.	Should be tested as sediment and dust may have blown into soil immediately adjacent to mine sites.	In the absence of a major smelter, contamination is likely to be around mine sites. In numerous areas around the mine site people were observed growing crops (i.e. sugarcane). The potential for bioaccumulation from soil to crops is not known but could be assessed during EMP.	

	Ore/Tailings	Overburden Dumps	Water	Air	Soil	Food	Other Comment
			(27,526 mg/l and 28,240, respectively). High sediment levels are visible in the flow in Chingola Stream. This high sediment level presents a public health risk because it fouls water intakes for water treatment facilities and adds considerably to the load for chlorine disinfection, requiring more chlorine but resulting in less sure disinfection.				
Kitwe/Nkana	The orebody mined in the area contains little lead or arsenic. The elemental composition (copper, 0.6 to 2.3%; cobalt, 0.03 – 0.15%; and sulfur 0.63 – 2.82%) predictably generates acid but not heavy metals in mine drainage and tailings runoff. Arsenic levels in Nkana copper concentrates have been measured at 8 to 23 ppm.. The lead content of the tailings, a major factor in determining toxicity in most such situations, is only 0.002 – 0.003%.)	Overburden dumps, which are numerous in the area, are unremarkable except for an elevated copper content. The lead and arsenic contents have been tested and are not elevated. Because of the carbonate content, the pH is high (a measure of acidity and alkalinity), meaning that the acid formed in the leachate is quickly and completely neutralised. The leachate that is actually produced is confirmed to be unremarkable, with low lead and arsenic levels and no remaining acidity.	Uchi Stream, draining TD26 and the mine site area, shows an elevated content of metals from the tailings, with variable stream water copper concentrations averaging 0.926 mg/litre and peaking at 22.0 and cobalt concentrations averaging 1.36 mg/l and peaking at 25.8 at the Harrison Street Drain (607) from 1995 through early 2001. These levels render the water undrinkable. Levels this high are unlikely to be consumed but if they were might affect health acutely when the levels are high. (It would take consumption of approximately two-thirds of a litre of maximally contaminated water to cause gastrointestinal symptoms due to copper toxicity.) The high metals content is indicative of leaching. Wusakili Stream receives runoff from the Nkana mine area, as reflected in elevated and variable stream water copper concentrations averaging 0.524 mg/litre and peaking at 7.200 mg/l and cobalt concentrations averaging 0.295 mg/l and peaking at 3.000 at the Wusakile Storm Drain (coming right out of the mine site) from 1995 through early 2001. Levels this high are unlikely to be consumed but if they were might affect health	Emissions of sulfur dioxide at the smelter may exceed emissions limits by a factor of twenty at times. Elevations in sulfur dioxide affect primarily Nkana East and the nearby communities of Ndeke and Ndeke Village, and at times Wusakile according to residents there. At some tailings, tailings material is exposed in the vicinity, although not on the site itself, and is likely to contribute to the windblown dust. The potential for health risk of this dust is probably low. Although the dust is fine, most particles are probably above the respirable size range, the concentrations likely to be achieved in wind are relatively low and transient	It is unlikely that lead or arsenic would accumulated to high levels in soil, reflecting airborne deposition, but possible over many years. This would be easy to determine or rule out by direct measurement. Soil deposition studies (undated but probably 2001) show a peak in surface deposition of copper and sulfur at 1 and 1.5 km due west of the smelter, respectively, and slightly higher peaks at 1.5 km, for both northwest of the smelter.		Trash dumping (TD25) is common in the area and has lead to scavenging and reclamation activities. In some locations (e.g. TD31) this impedes water flow. At one site (OB63), lead batteries have been dumped and burned, possibly creating a local lead hazard. Industrial waste dumping at TD27 should be assessed for its potential to interact with tailings.

	Ore/Tailings	Overburden Dumps	Water	Air	Soil	Food	Other Comment
			directly when the levels are high. (It would take consumption of approximately two litres of maximally contaminated water to cause gastrointestinal symptoms due to copper toxicity.) The high metals content is indicative of leaching. Downstream, the water becomes more alkaline (less acidic), metal levels drop (except for some enrichment of copper and cobalt at certain times of the year, presumably leached from tailings by runoff during the rainy season) and the stream is in compliance with water quality standards by the time it enters the Kafue River. By comparison, elemental analysis of water discharged into Chibuluma Stream (624) downstream, which drains from TD33c shows less variable stream water copper concentrations averaging 0.17 mg/litre and peaking at 0.30 mg/l and cobalt concentrations averaging 0.11 mg/l and peaking at 0.20, mostly in 2000, with very low lead levels (mg/l throughout).	(compared to occupational exposures associated with lung disease) and the content is likely to be low in silica content. (This should be checked.) The metal content of the tailings dust is unlikely to present a health hazard. The dust may aggravate existing respiratory disease and mucosal irritation, however, and thus may have some effects on symptoms.			
Luanshya	The orebody mined in the area contains little lead or arsenic. The arsenic content in Luanshya copper concentrates has been measured at 10 to 55 ppm, levels that are the highest observed in the Copperbelt.	Overburden dumps, which are numerous in the area, are unremarkable except for an elevated copper content. The lead and arsenic contents have been tested and are not elevated.	Surface water quality in the area varies considerably but is consistently low in dissolved lead (0.06 at the Musi Drain Discharge in 1998 No tailings dams are monitored for water quality. Drainage pipes are reported to be defective or silted up, so much runoff flows into local streams. Discharges from 1995 through 2000 at the Tailings Pump House into the Luanshya River show elevated levels of copper (mean 11.4 mg/l, maximum 390.5 mg/l), cobalt (3.4, 919.7), iron (34.3, 919.7) and manganese (5.6,	Soil deposition of heavy metals is therefore expected to the west of the smelter site. When the smelter was operating the west side of Luanshya is reported to have been the most affected by scent. Dust is not a major problem because of vegetation growth on tailings dumps, which	Soil deposition in the plume of the smelter at Luanshya may have deposited substantial quantities of metals in the past. In 1998, the stack was emitting 3625 mg/m³ of dust, of which 14.8% was copper, 0.082% was arsenic, 0.032 was lead and 0.012% was cadmium (mercury was not quantifiable).	Cultivation does take place on mine property and is a concern because of the risk of erosion. There are no data on soil contamination where cultivation is taking place	

	Ore/Tailings	Overburden Dumps	Water	Air	Soil	Food	Other Comment
			440.7), levels that would at peak levels render the water unfit to drink because of an unacceptable taste At a point 20 km downstream, at the Makoma Road Bridge, the water quality is much improved: copper (mean 2.9 mg/l, maximum 50.0 mg/l), cobalt (0.4, 9.8), iron (8.3, 82.3) and manganese (2.0, 51.7), with a high but improved content of suspended solids (1202, 20,754). Further downstream, where the Luanshya River exists the RAMCo(Z) surface rights area, the water quality is within Zambian standards (and WHO guidelines): copper (mean 0.092 mg/l, maximum 0.76 mg/l), cobalt (0.015, 0.13), iron (0.36, 3.96) and manganese (0.053, 0.30), and the suspended solids are much reduced (49, 2064).	remains largely intact.	The mine has been operating the longest of the complexes in the Copperbelt. This suggests, but does not prove, the possibility of significant soil contamination with relatively more toxic metals over the many years that the smelter has been in operation. Much would depend on plume dispersion and local winds. The presence of significant contamination could be ruled out easily by local soil samples and analysis.		
Mufulira	The orebody mined in the area, as in all of the Copperbelt, contains little lead or arsenic, in contrast to other copper sulphide ores. The arsenic content in Mufulira copper concentrates has been measured at 5 to 18 ppm.	Overburden dumps, which are numerous in the area, are unremarkable except for an elevated copper content. The lead and arsenic contents have been tested and are not elevated.	Water quality in effluent from various operations show the highest metals content in the effluent from the refinery and concentrator operations, all at weakly alkaline. Although in some cases the levels exceed statutory limits for copper, they do not present a health risk. Downstream, at Mufulira stream leaving the mine area, the water quality is within statutory limits and by the time it reaches the Kafue River concentrations are negligible. This probably reflects the precipitation of metals in the carbonate-rich, alkaline chemical environment.	In Mufulira, the area of primary concern is downwind (west) of the smelter facilities, primarily in the district of Konkoya and secondarily in the nearby district of Katanshi. Other districts west of the smelter are at lesser risk for frequent exposure resulting on changes in wind direction. Districts upwind (east) of the smelter are at low risk of prolonged exposure, although occasionally	Soil deposition is heavy in metals but most of these metal species are relatively low in toxicity. Smelter copper emissions were 40 to 1,000 times above the stack emission limit. Soil deposition studies demonstrate correlation with smelter plume and soil levels up to 166.55 +/- S.D. 104.51 mg/kg (Kapungwe 2000). Copper is a chemical marker for dust emissions from	Lead levels in crops grown in the area show 320-340 mg/kg Pb found in avocado, mango and miombo plant leaves both upwind and downwind of smelter (35 mg/kg is considered normal). If consumed, these levels would contribute significantly to body burden, particularly in residents who have absorbed lead from other sources. It is not clear, however, whether these values	

	Ore/Tailings	Overburden Dumps	Water	Air	Soil	Food	Other Comment
				affected. he levels are far above the levels at which the earliest respiratory symptoms would be expected to occur and approach levels at which almost everyone in the population would be expected to experience symptoms and some discomfort and at which serious health impacts, such as elevated mortality, may occur.	smelter emissions. The high levels of copper suggest substantial deposition in soil. From the standpoint of human health, however, the greater concern is heavy metal and arsenic contamination. Soil sampling performed by MCM demonstrates up to 18 mg/kg Pb content of soil at site of highest concentration downwind of smelter stack. This is not considered a substantial public health hazard in itself but may be magnified by bioaccumulation in food crops. Arsenic is less clear. Soil sampling performed by MCM demonstrates up to 20 mg/kg As content of soil at site of highest concentration downwind of smelter stack; most values are <10. However, local concentrations may be higher, such as one site upwind of stack with 30 mg/kg, at the engineers' office. This suggests that local activity may be more important as	reflect the content of the fruit. Arsenic is less clear. Soil sampling performed by MCM demonstrates up to 20 mg/kg As content of soil at site of highest concentration downwind of smelter stack; most values are <10. However, local concentrations may be higher, such as one site upwind of stack with 30 mg/kg, at the engineers' office. This suggests that local activity may be more important as a determinant of concentrations than Mg deposition from air. These levels are not considered to be public health hazards. Data on levels of arsenic in food crops was not available.	

	Ore/Tailings	Overburden Dumps	Water	Air	Soil	Food	Other Comment
					a determinant of concentrations than Mg deposition from air. These levels are not considered to be public health hazards.		
Ndola	The composition of the quarry rock is predominantly calcium oxide (97%). The waste dumps consist of carbonate (31% to 64%), calcium oxide (29 to 48%), variable silica (0.38 to 16.%) and iron, sulfur and sulphate. Copper and cobalt are present only in small quantities (102 and 30 ppm, maxima, respectively).		Surface water quality at the Ndola Lime site is within statutory limits for chemical contamination. Surface waters tend to drain into rather than out of the plant, because it occupies the low ground. Surface waters in the area show low concentrations of suspended solids arsenic, lead and other metals generally. The pH of surface water is 7.6 and above.	The Ndola Lime plant produces large quantities of dust consisting predominantly of calcium carbonate. This type of dust is classified as a miscellaneous, non-toxic particulate matter, or (in older terminology) "nuisance dust" Complaints from residents have been registered because this dust has a tendency to stick when wet. However, the health implications are minimal. There may be some sulfur dioxide emissions form the Chilanga Cement Plant, which is adjacent to the Ndola Lime Plant and its biggest customer. This should be evaluated in the EMP.	NA	NA	
Kabwe	Lead tailings were also deposited in tailings dumps south of the mine site.		Data available are from 1994. The geology of the area is favourable to preserving water quality in being	Dust from tailings that were not fully covered because of	high concentrations of metals in soil in and around Kabwe. The	Likewise plants showed a similar pattern of metal	Some lead metal and slag scavengers have

	Ore/Tailings	Overburden Dumps	Water	Air	Soil	Food	Other Comment
			limestone, which results in buffering of excess acid and precipitation of metals. Water quality in the Main Canal in 1994 showed low levels, <0.01 mg/l throughout the year, reported to varied considerably from month to month in 1993 and then to have dropped in 1994. By comparison, zinc levels were much higher (between 3 and 106 mg/l) and generally varied with sulphate levels. Cadmium levels were generally at or below 0.02 mg/l. The Main Canal eventually discharges into a dambo, at which point lead levels in water were between 0.001 and 0.004 mg/l. Lead levels continued in this general range in Kanakutsi Stream and at the point of discharge into the Muswishi River. There is some fishing and agriculture in this area, consisting of small plots. There has been no testing of fish for bioaccumulation. During site visits to Katondo township some residents had built wells to compensate in part for deteriorating municipal water supply. These wells should be tested for lead contamination as they are not a great distance from the canal which flooded one year.	financial constraints, or from other sources may contribute to airborne levels of dust high in lead content.	highest levels were found to the west, two kilometres downwind of the plant, with average levels of lead, zinc, copper and cadmium of 548, 89, 61 and 27 mg/kg (ppm), respectively, compared to other sites, such as a site 4 km northeast of the mine (32.2, 18, 3 and 0.1, respectively) Soil samples in some locations reached lead levels of almost 3% and the extent of lead contamination in the area was widespread.	content. Tembo (1993) conducted soil and food testing in the Kabwe area for his master's thesis at the University of Zambia. Food purchased in Kabwe markets, but of unknown provenance and limited in sample size, showed remarkably consistent amounts of lead, on the order of 30 mg/kg, but more variable amounts of zinc, copper and cadmium. These levels exceeded FAO and WHO guidelines. The highest lead levels were found in sweet potato stem. Lead levels generally exceeding 30 mg/kg in lead content were rape, Chinese cabbage and certain soybeans. When food was sampled from known provenance, maize leaves up to 15 km from Kabwe to the east had lead levels than from 76 to 84 mg/kg but those 20 km away had 4. To the west, however, lead levels in maize leaves were in excess of 790 mg/kg up to 6 km out and 24 to 40 beyond. Zinc and	performed secondary smelting on site but this operation was small in scale and did not last long. It may have contributed to local contamination levels but is unlikely to affect levels in the community beyond.

	Ore/Tailings	Overburden Dumps	Water	Air	Soil	Food	Other Comment
						copper showed a similar pattern, which was less distinct for cadmium. Distant from Kabwe, only traces were found. These levels were also high compared to international comparisons.	

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ANNEX M:
CHAMBISHI WETLANDS PILOT

ANNEX M: (REFERENCED IN C7 OF PART II) CHAMBISHI WETLANDS PILOT

Abstract of paper presented by Constantin von der Heyden (School of Geography, Oxford University) to:
International Conference on Wetlands and Remediation (05 – 06 September 2001)
Burlington, Vermont, USA
Organised by Battelle, USA

COPPER/COBALT REMEDIATION WITHIN A NATURAL WETLAND IN THE COPPERBELT, ZAMBIA

Due to widespread mining activities within the Copperbelt Province of Zambia, many of the region's natural wetland systems have received largely untreated effluent from the extensive process and mine related industry over the past few decades. Discharges from the wetlands are usually within statutory limits, and the systems have been extensively used as pollution remediation sites. However, the processes leading to the effluent remediation have not been investigated, nor has the remediative capacity of the systems been quantified. A study undertaken by the author investigated the processes leading to copper and cobalt remediation within one dambo wetland receiving effluent from the Chambishi slag and concentrate processing plant.

Research at the site began in April 2000 and will end in June of 2001, encompassing a full dry – wet – dry season cycle. The study site, a dambo of 0.4km^2, and the control site, a dambo of 1.2km^2, lie within the same catchment basin. The Chambishi site receives surface water input from the processing plant tailings dam. Both wetlands are fed by shallow groundwater while the surface water output occurs through defined channels.

The wetland inlet and outlet are gauged. Several serial transects have been constructed across the wetland, and 34 piezometers have been sunk along the transects. Groundwater hydrological and geochemical characteristics are determined through piezometer studies, whilst the changes in surface water chemistry are measured along the transects, quantifying the changes occurring in a water column as it moves through the wetland. Hydrological studies from the wetland inlet and outlet are combined with the geochemical data to determine the system mass balance.

Findings to date show marked decrease in dissolved copper concentration within the upper portion of the wetland with a more gradual decrease in cobalt concentrations throughout the length of the system. Low concentration for all constituents is noted at the wetland outlet. Water pH and alkalinity increase dramatically along the flow path, whilst the total dissolved solid concentrations decrease. Chemical mass balance for the period August 2000 – April 2001 showed the following results (retention of constituents in the wetland, as determined by inflow/ outflow flux data):

- Copper retention: 98 %
- Cobalt retention: 60%
- Sulphate retention: 2%
- Sodium retention: 2%

Both sulphate and sodium are expected to be conserved through the system (verified by the 2% retention data) indicating that changes noted in SO_4 and Na concentration at the wetland outlet are a function of dilution.

The findings suggest that the high carbonate groundwater input into the system is crucial to the remediative capacity of the wetland, and chemical precipitation (oxides and hydroxides) and groundwater

dilution are the major processes leading to effluent remediation. Plant uptake of heavy metals, sulphide precipitation and organic chelation appear to be secondary remediation processes within the system studied. The mass balance highlights the role of the wetland in metal (Co and Cu) removal from the water column and underpins the potential for constructed analogues, based on the natural processes identified, in effluent remediation.

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ANNEX N:
RISK-BASED MECHANISMS TO ASSIST WITH PRIORITISATION

ANNEX N: RISK-BASED MECHANISMS TO ASSIST WITH PRIORITISATION

Simple, cost-effective mechanisms for improving the validity of input data for risk assessment modelling have been developed in recent years, notably the Physiologically Based Extraction Tests of Ruby *et al* (1996) and Williams et al (1997). Both involve the leaching of samples of contaminated soil or mine waste in a simulated human stomach and small intestine environment (with respect to chemistry, temperature and pH) to assess probable bioassimilation of contaminants following ingestion. The cost of establishing such procedures is negligible (ca. $US500 excluding standard analytical equipment for leachates), and could readily be accommodated as a component of risk assessment under the CEP.

Two examples of risk-based mechanisms to assist with prioritisation of sites are explained below.

ECOTOXICOLOGICAL FIELD TESTS

Ecotoxicological biomarker assays form an additional, highly cost-effective mechanism for site prioritisation, with potential applicability under the CEMP. Biomarkers are of immense value to regulatory authorities in developing countries, as they circumvent the need for costly laboratory analytical hardware.

Neutral-red retention (NRR) assays have been used to assess the ecotoxicological impacts of mining-derived contaminants such as arsenic and mercury in gold and base-metal producing countries such as Zimbabwe, Thailand and the Philippines (e.g. Williams *et. al.*, 1999, Weeks and Williams 1994). The NRR method utilises invertebrates or other donor species from potentially impacted aquatic or terrestrial systems, from which coleomic fluids are extracted. Cells within the fluid are injected with a neutral red dye, and dye retention within the cell lysosomes monitored for a period of up to 60 minutes under a binocular microscope. The ability of cell lysosomes to retain the dye is inversely proportional to stress status. This, in turn, is strongly responsive to ambient levels of heavy metals and metalloids. Cell rupturing within a few minutes, indicative of high ambient levels of bioavailable toxins, may provide a sound ecotoxicological basis for the assignment of priority remediation status to waste piles or the aquatic systems which they impact.

The technical skill and capital resource level required for NRR surveys is not substantial. Training of government authority scientists in several developing countries has previously been effected through dedicated courses lasting 7 days.

MODELLING

Several risk assessment algorithms are potentially suitable for identifying high priority sites (e.g., those sites with the greatest potential to cause adverse human impact), and are recommended for systematic use under the CEP. Examples include the US-EPA Risk Assistant model and UK Department of Environment CLEA codes. Both models are conceptually similar, and involve the characterisation of contaminant concentrations in each identifiable medium to which human populations may be exposed (i.e., soil, dust, water, food). A total human toxin dose or exposure level is then determined through the input of data depicting loads from each formerly identified pathway. Clinical and epidemiological dose-response curves are incorporated within the model to predict the resultant carcinogenic and toxic (non-carcinogenic risk).

An additional model, recently developed specifically for use in the ranking of mine waste hazards is MINDEC, developed during the period 1997-2000 by the British Geological Survey under funding from the UK Department for International Development. The model, now field tested in several gold and base-metal producing developing countries (e.g., Chile and Zimbabwe) uses relatively simplistic chemical or mineralogical input data for waste composition and hydraulic properties to provide an indication of probable leachate quality, and the extent of contamination likely to be incurred in surrounding surface waters or aquifers. This information is subsequently fed into a risk assessment algorithm based closely on Risk Assistant to calculate the potential human health consequence of consumption of the mine-contaminated water. MINDEC requires simple input data and is a decision-support software tool that is aimed at environmental planners in developing countries who may have several mines to evaluate. MINDEC can aid in the process of risk evaluation, highlighting which mines are greatest cause of concern (see www.bgs.ac.uk/dfid-kar-geoscience/mindec/home.html):

> "MINDEC carries out an assessment of the risk to water consumers at a receptor site downstream from a mine waste site based on estimated concentrations of mine-derived contaminants in surface drainage and groundwater. Input to the model includes basic information for each mine site, including leachate pH, volume and age of tailings, annual precipitation, and the percentages of leachate entering groundwater and surface drainage. It is a cost-effective evaluation of hazards from mine waste using a simple expert system to classify mine wastes according to the hazard they represent, using only readily-acquired information, and hence assign priorities and approaches for avoiding or remediating the hazards." (British Geological Survey)

Evaluation of the model's utility for the prioritisation of hazards in the Copperbelt is recommended.

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ANNEX O:
STAKEHOLDERS ANALYSIS OF THE CEP

ANNEX O: STAKEHOLDERS ANALYSIS OF THE CEP

The SA has identified the following stakeholders in the CEP project:

Local Government: (includes local councils and the administrative bodies): Among other objectives, the CEP intends to support clean-up of old mine sites, restoration of the sites to some non-mine use (agriculture, tourism, recreation for example) and eventual handing over of the sites to another organisation/government body such as local government. The decision of how the site will be used will thus require the input of local government and community representatives. In addition, at many of the sites, their stability is tied to the way in which local residents and others use them.

In each municipality there are administrators, or officers of the Council, and elected representatives, or Councillors. Councillors are elected every three years to the Municipal Council and select among themselves a Mayor to chair the Municipal Council. Councillors are supposed to focus on discussion of policy, serve part-time, receive only a nominal allowance, and are elected for fixed terms. The bulk of day to day administration of local government is carried out by the officers of the Council, permanent, technically specialised staff, headed by the Town Clerk. The officers are supposed to provide professional and technical advice to the Municipal Council. The local government system seems to be characterised by a general suspicion among and between councillors (elected) and council officers (administrative). This may stem from an absence of a clear definition of the respective responsibilities.

Sectoral representatives from each central Ministry are accountable to the District Council. District Councils exist in every municipality. Only in Mufulira, which is an Environmental Support Project pilot, is there an environmental officer at the district level. Other relevant stakeholders at the district level include the District Health Management Team and the District Agricultural Officers who are responsible for forestry programs.

In the past year, the central government created a new post at the district level, the district administrator, who receives funding directly from central government. It is not always clear what relationship the district administrator is to have vis-à-vis the town clerks. There have been reports of resentment of district administrators, who may be perceived as representing central government interests and being better funded than local government.

Members of Parliament/National Politicians and Local Politicians (Councillors): In several instances people reported that planned resettlement schemes, or efforts to remove squatters on mine sites had been stopped by the intervention of politicians (both members of parliament and local councillors) who received some of their political base from these settlements.

Downstream Communities: Because the CEP is likely to make some contribution to reducing silt going into streams that are tributaries of the Kafue, this should improve the quality and quantity of the water downstream, or at a minimum ensure that it does not get worse. However, the nature of potential improvement will depend on other contributors – current mine owners for example who emit effluent year-round versus only rainy season for defunct sites likely to be covered by the project, others farming on stream banks that contributes to erosion and siltation – and to what degree they contribute to stream pollution.

Scavengers: At almost every mine site that was close to a population centre visited, there were scavengers hunting for stripped metal, coal, or other refuse. If it is determined that such activities cause the site to be unstable, these groups may be affected.

Environmental Council of Zambia: The ECZ is responsible for review and approval of Environmental Impact Statements and Environmental Management Plans. It is also responsible for public disclosure and comment on EMPs. It is relatively weak in its expertise in mining, and has no offices in any of the major mining towns (its regional office is in Ndola). The large new number of private mine companies have complicated its task of regulation.

Mine Safety Department: The MSD is responsible for all occupational health in mine areas. Historically it has also played a role in monitoring mine pollution.

Mine Companies: Mine companies such as MCM and KCM have a responsibility to their shareholders to make the mines profitable (they have not yet attained this goal). A key part of profitability will likely stem from increasing production and containing costs that are not related to the core mining business (social services). At the same time, several of these companies have an international reputation to protect, and have been seeking ways of demonstrating that they are good for the communities in which they function. At the time of negotiations, the companies viewed resources (via the CEP) to guarantee that some of the past environmental legacies were cleaned up as a key component of their decision to invest. They may prioritise clean-up of sites or issues that are directly on their property. Mine companies may resist efforts to increase public awareness of mine pollution issues, or to increase their communication with downstream or downwind residents in the event of an excessive emission/pollution incident.

ZCCM-IH: As a significant shareholder in many of the mines, ZCCM has an interest in ensuring that the mines become profitable. At the same time, as the government has retained liability for any pollution within the grace period, ZCCM has an interest in getting the mine companies to reduce their pollution. However, the regulatory body with the most direct influence will be the ECZ, and thus close co-ordination between ZCCM-IH and ECZ will be important to the project.

Communities Living Near Smelters: in Chambishi, in Kitwe and in Mufulira. These communities have a direct interest in ensuring that the EMP process includes their voice and their desire to reduce air pollution since up until now there has been no formal, systematic forum for their concerns (with the exception of one-time meetings with communities as part of the MCM environmental baseline).

Public Health Authorities: These groups are particularly relevant in towns where there is likely to be some impact of mine pollution on health: these include towns with smelters (Chambishi, Kitwe, Mufulira) and Kabwe which has a lead mine.

Residents of Squatter Settlements on Mine Land: See section on squatters.

AHC-IH, Selected CUs: If silt is reduced, this should make it easier to treat water downstream, particularly at Mufulira and Chingola (Mulonga Water and Sewer). In Luanshya, further deterioration in the tailings dams would threaten the source of drinking water for the town.

NGOs: There are several different types of NGOs active in the project area, though the level of community based activities is relatively low in ex-mine areas because of the historic social support of ZCCM. Advocacy NGOs in the environment include Citizens for a Better Environment, Advocacy for Environmental Restoration, and Blacksmith Institute based in New York which provides support to local advocacy organisations in environmental issues. NGOs active at the community level, or working to develop community based organisations include Oxfam, World Vision, PUSH, and numerous religious organisations.

Academic/Research Institutions: Universities and Institutes can play an important role in improving the base of research on both mine pollutants, and on remediation techniques specific to the Copperbelt and Kabwe. The Copperbelt University has an Institute of Environmental Management which is divided into several areas: water, air, solid waste, legislation and management. The School of Mines at the University of Lusaka also includes academics who have conducted research on mining, some of whom are former miners. In addition, a National Institute for Scientific and Industrial Research has conducted research on mine pollution issues. The Institute is based in Lusaka.

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ANNEX P:
HEALTH ASSESSMENT – HEALTH EFFECT OF HAZARDS NOT POSING HIGH RISK IN COPPERBELT OR KABWE

ANNEX P: HEALTH ASSESSMENT – HEALTH EFFECT OF HAZARDS NOT POSING HIGH RISK IN COPPERBELT OR KABWE

The following elements are not likely to be present in the Copperbelt or Kabwe at levels that would produce health effects.

COBALT

Cobalt is a metal often found in association with copper and recovered during copper mining in the Copperbelt. Cobalt is also an essential nutrient, but at very low levels. Cobalt is toxic to the heart but poisoning is rare. More common effects are asthma and chronic dermatitis resulting from exposure to cobalt dust. The levels of exposure required for this far exceed those encountered in water. Cobalt poisoning therefore tends to be a problem of occupational health in certain industries, not an environmental problem associated with the copper industry.

CADMIUM

Cadmium is a metal with substantial toxicity to the kidney at high concentrations. The levels of cadmium associated with toxicity are much higher than those reported in environmental measurements in Zambia. Cadmium levels in soil in the Kabwe area are not a direct concern for human health, except in cases where crops are being grown. Where this occurs the cadmium levels in soil should be assessed. However, in all likelihood lead concentrations will be of greater concern as these metals have been co-deposited.

MANGANESE

Manganese is a light metal occurring as a normal constituent of many minerals but very little of the metal is available for absorption by the human body. At high exposure levels it is associated with a neurological condition identical to Parkinson's disease, usually in the context of welding. Manganese levels in water are not thought to present a risk for human health at levels that are tolerated by the gastrointestinal tract. Levels observed in water in the Copperbelt are not associated with toxicity.

SELENIUM

Selenium is a metalloid, like arsenic, that sometimes exists in nature associated with copper. Selenium-containing emissions from copper smelting are possible in the Copperbelt and representative sampling is recommended. Selenium is an essential trace element in the human body, where it plays a role in antioxidant enzyme systems. These systems resist inflammation and act counter to the cancer-inducing actions of many carcinogens. Human health problems related to selenium are very localized and mostly relate to selenium deficiency, which may be associated with cardiac disease and a unique form of arthritis that mostly reverses when supplemental selenium is given. However, selenium compounds may also have toxic effects. Many selenium compounds in the form of dusts and one gas (hydrogen selenide) are irritating to skin, respiratory tract and mucous membranes and would produce associated problems with airborne exposure. Chronic exposure has been a very rare and localized problem (restricted to

China) associated with hair loss, dermatological lesions and neurological disorders. One mechanism may be that selenium interferes with normal thyroid hormone activity.

Although measurements have not been taken, the consensus of the consultants is that selenium toxicity is not a significant health issue. Representative sampling of soils and local emissions should be carried to confirm this though.

ZINC

Zinc is present in ores at Kabwe. Testing by ZCCM has measured zinc concentrations in soil up to 30,000 ppm in Kasanda township in Kabwe, however the majority of results were less than 5000 ppm (a value that is considered high). Zinc is an essential nutrient; therefore it is unlikely that soil concentrations could reach levels where toxicity is a concern. For example, the British Columbia (Canada) Contaminated Sites Regulation soil-zinc standard for protection of human health on residential land is 10,000 ppm and on commercial land, 30,000 ppm.

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ANNEX Q:
ADDITIONAL SOCIAL ASSESSMENT DATA

ANNEX Q: ADDITONAL SOCIAL ASSESSMENT DATA

TABLE R.1: PROVISION OF WATER AND SEWAGE SERVICES TO DOMESTIC CONSUMERS POST PRIVATIZATION

Town	Est. Number Domestic Connections to CU (~2000)	Est. Number Domestic Connections to AHC (~1999)	% Domestic Connections Supplied by AHC
Kitwe	17,135	6,768	28%
Luanshya	4,078	9,529	70%
Mufulira	6,488	9,596	60%
Chingola/Nchanga	9,499	5,786	38%
Ndola	15,067	0	0%
Chililabombwe	NA	4,866	100%
*Excludes standposts			
Total Connections	52,267	36,545	41%
Est. Domestic Customers Served Excluding Standposts	296,111	295,421	50%

Data Source: 1999 and 2000 financial models and social assessments for MTSP and Sector Work

SOLID WASTE PROVISION

TABLE R.2: NDOLA SOLID WASTE DISPOSAL (1999 Scott Wilson Survey Data)

Ndola	High Income	Medium Income	Low Income	Rural Income
Collected by municipality or other govt. agency	4%	2%	0%	0%
Collected by private establishment	27%	2%	0%	0%
Dumped by household members into yard or nearby ditch	54%	92%	57%	70%
Dumped by household members into govt. or municipal waste site	2%	2%	2%	0%
Burned	12%	3%	41%	30%

TABLE R.3: LUANSHYA SOLID WASTE DISPOSAL (1999 Scott Wilson Survey Data)

Luanshya	High Income	Medium Income	Low Income	Rural Income
Collected by municipality or other govt. agency	0%	6%	0%	0%
Collected by private establishment	42%	6%	0%	3%
Dumped by household members into yard or nearby ditch	52%	50%	57%	31%
Dumped by household members into govt. or municipal waste site	2%	12%	2%	13%
Burned	2%	26%	41%	49%
N	50	50	90	61

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ANNEX R:
NGOS IN PROJECT AREA

ANNEX R
NGOS IN PROJECT AREA

Chingola/Nchanga Mine

- FODEP – involved in civic education and advocacy
- Future Vision for Africa – a community based organisation involved in advocacy
- CETZAM – involved in small business development by offering small loans
- Other NGOs operating in the town are involved in looking after orphans and vulnerable children

Chililabombwe/Konkola Mine

- Vizacho – a community based organisation involved in advocacy
- DAPP – involved in community development projects
- Other NGOs operating in the town are involved in looking after orphans and vulnerable children
- Lions Club – targets less privileged groups
- Hope Foundation – assists women, children, widows to help them become more self-sufficient, and to establish income generating activities
- Red Cross Youth
- Breast Feeding Mother Support
- Nutrition Committees
- Child Care and Adoption Society

Luanshya/RAMCOZ Mine

- We for Zambia
- Home Based Care (looks after the sick, particularly AIDS and TB patients)
- Programme for Urban Self Help (PUSH)
- DAPP
- Rosalinda
- Community Based Rehabilitation Project (CBRP)

Mufulira/MCM

- Mufulira Women Entrepreneur
  - Promotes environmental awareness in the district
  - Motivates members to be effective entrepreneurs
  - Supports government in development programmes
- Amnesty International
  - Educated the public about environmental rights e.g. right to a clean environment
- Children in Distress
  - Helps orphans in their needs
- OXFAM (GB)
  The NGO has a presence in Mufulira through the Copperbelt Livelihoods Improvement Programme (CLIP). The programme works with local Community Based Organisations and focuses on building sustainable livelihoods for poor households through:
  - Support to small scale agriculture producers through provision of input credit, facilitating access to land, extension services and markets
  - Ensuring growth in off-farm income by facilitating provision of micro-credit, market access and business development support
  - Facilitating access to quality basic education for children from poor households

  - Strengthening institutional and policy framework through Organisational Development Support to Local Authorities, NGOs and Civil Society.

- The Mufulira Peri-Urban Development Framework (MPUDF),
  - Strengthening advocacy capacities of local community based organisations (CBOs).

- Frères des hommes (Brothers to All Men) a French NGO
  - Runs 4 community schools in Minambe, Mutundu, Murundu and Kawama West.
- Agape Care Health Foundation
  - Health education on HIV/AIDS
- Saint Vincent De Paul
  - Work in poverty alleviation
- Zambia Youth Project
  - Agro-economical activities
- Entrepreneurship activities

Ndola/Ndola Lime

- DAAP
- Rotary Club
- Lions Club

Kitwe

- Children In Distress
- Citizens for a Better Environment – environmental advocacy NGO active on environmental issues throughout the Copperbelt
- DAPP – involved in community development projects
- OXFAM (GB) – Oxfam is active in some areas in Kitwe (Mapuso, Kakosa and Mulenga compound)
- World Vision International – World Vision is active with community based development programs in compounds south of Kitwe (Zamtan, Kamfinsa, Kakolo-Maposa, Mulenga). It provides micro-loans, agriculture assistance, water supply and sanitation, HIV-AIDS awareness, fuel efficient stoves to reduce the demand for charcoal and education. It focuses on specific communities, and developing a program around their identified needs.

Kabwe

- PUSH: Programme for Urban Self Help. PUSH provides 6 month training and community improvement activities for low income peri-urban households who are paid with food for work. PUSH is currently working in Katondo and Makululu settlements and is involved with activities such as building pit latrines, drainage canals, collecting garbage, constructing roads. Participating households (mostly women, many female headed households) rotate and receive education in AIDS, literacy, hygiene and environmental health and other issues. PUSH could be one avenue for community awareness programs regarding mine pollution. It is active in Katondo, an informal settlement in digging drainage canals.
- Rotary Club: Group of influential community members that undertake community activities and programs.

Other Environmental NGOs

- Advocacy for Environmental Restoration: Lusaka-based advocacy group with focus on the Kafue River Basin, but also with a broader interest in the review of EMPs and activities that may have an environmental impact in the region

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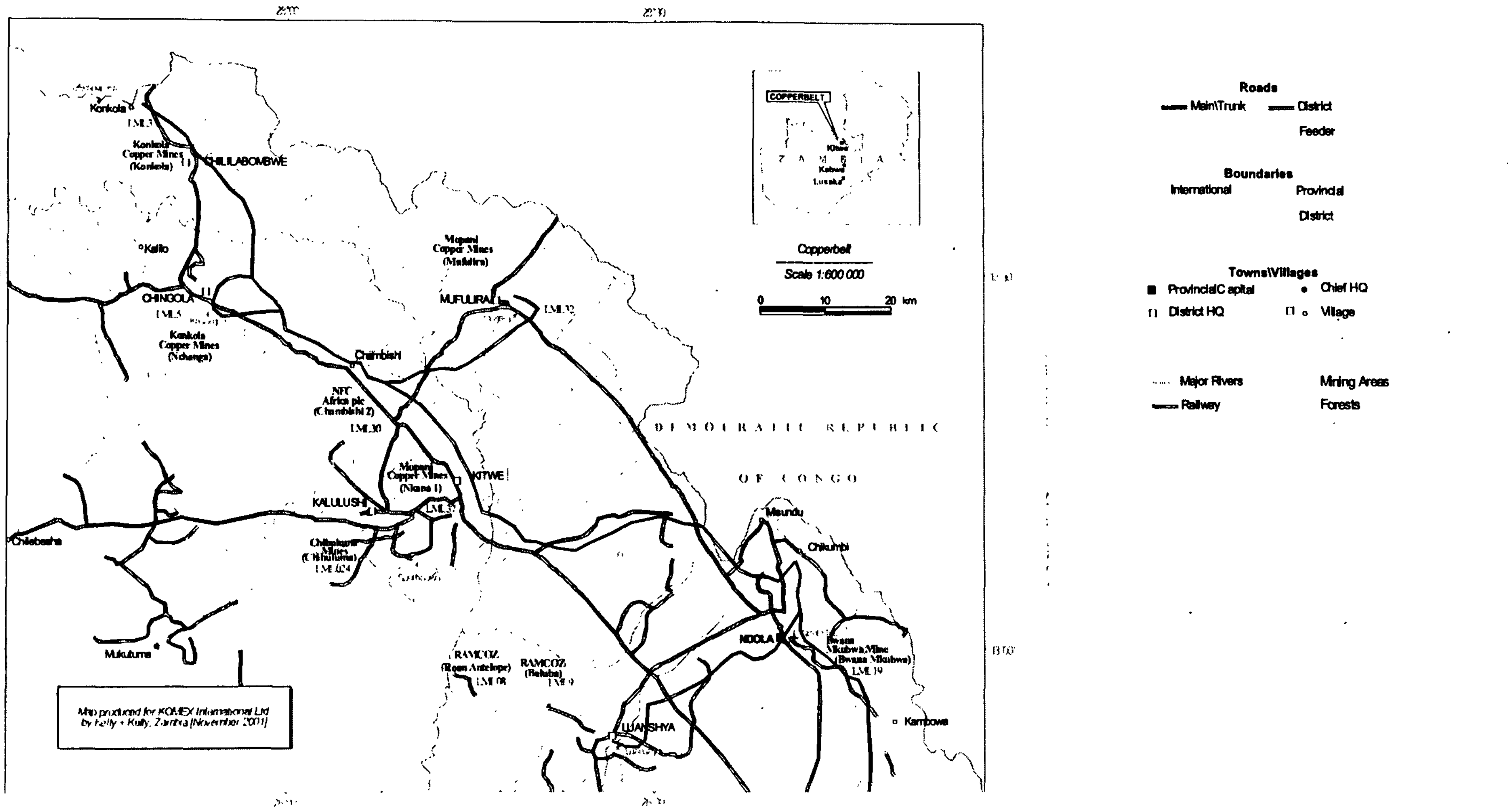

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ESA OF THE COPPERBELT ENVIRONMENT PROJECT -ZAMBIA

KOMEX INTERNATIONAL LTD.
ENVIRONMENTAL AND ENGINEERING CONSULTANTS

COPPERBELT MINE LOCATIONS

DRAWN BY	EDITED BY	DATE
LL	x	22 Jan 02
APPROVED	FIGURE	
	2	

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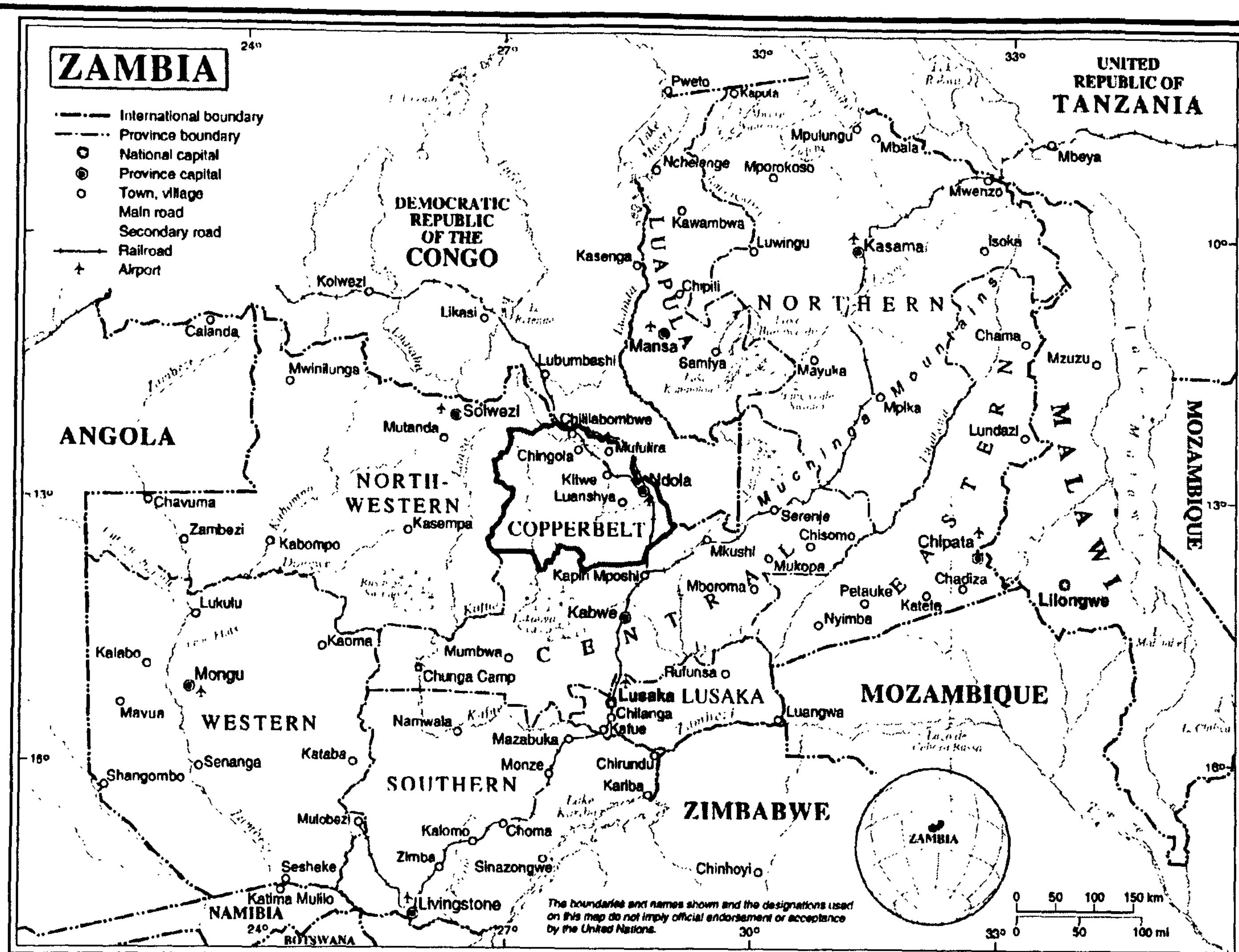

Map No. 3731 Rev. 3 UNITED NATIONS
July 2000

Department of Public Information
Cartographic Section

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MAP OF ZAMBIA - COPPERBELT LOCATIONS AND KABWE

DRAWN BY:	EDITED BY:	DATE:
OTHERS	M.T.	JAN21/02
APPROVED:	FIGURE: 1	

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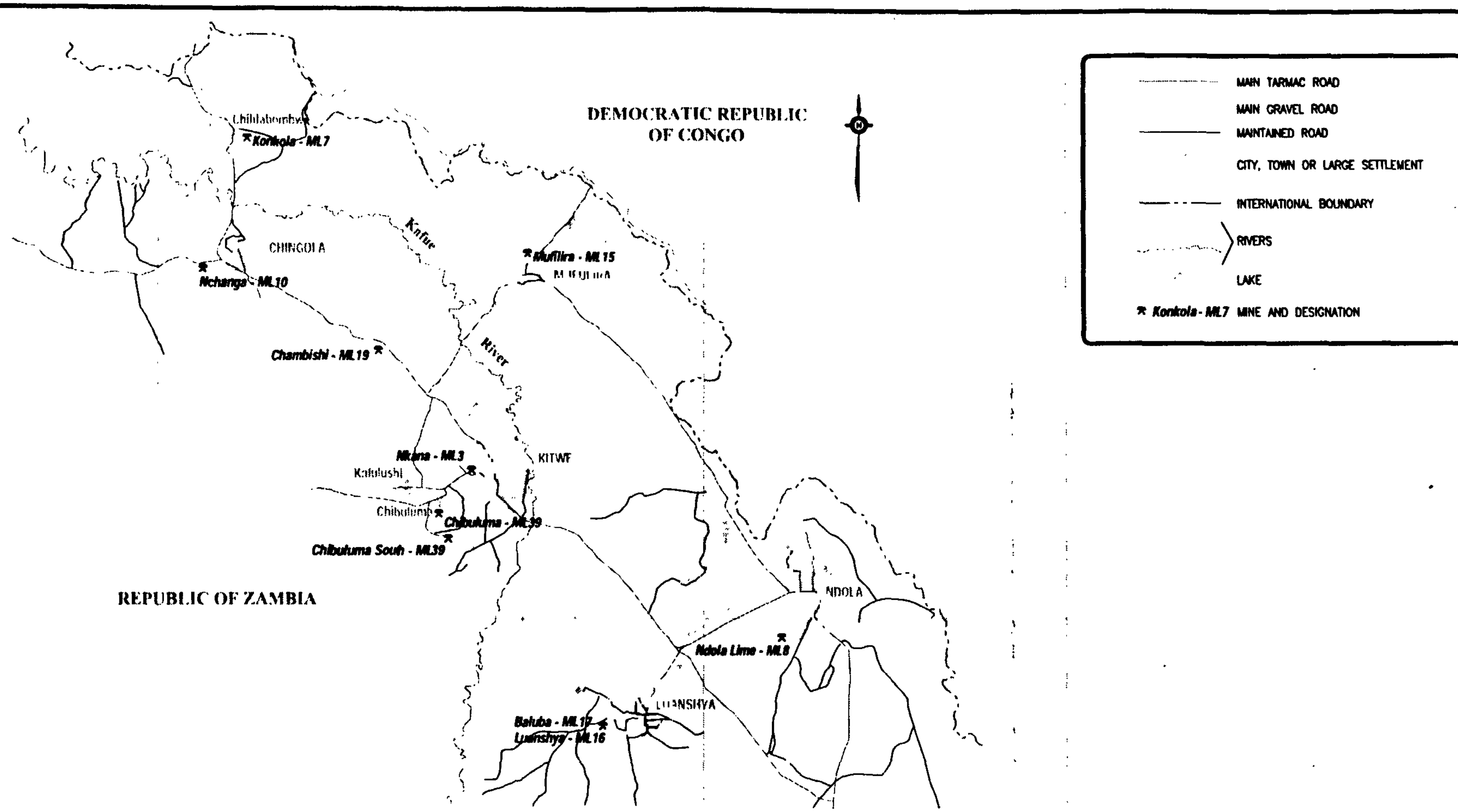
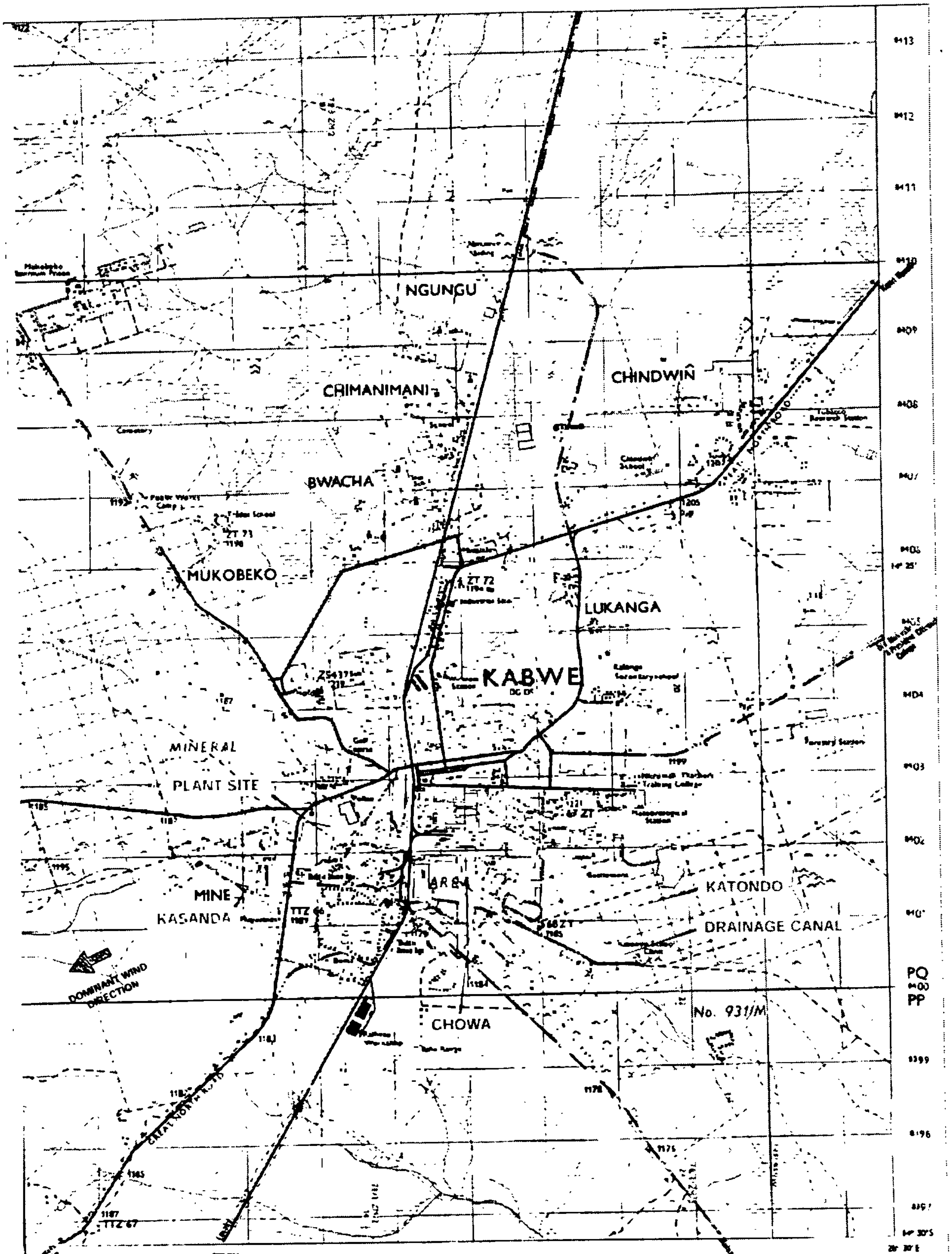


Digitizing source: Republic of Zambia, Topography and Surface Infrastructure, published by the Surveyor-General, Lusaka, 1989. Original scale 1:250,000 Projection: Transverse Mercator; Spheroid Clarke 1880; Grid: UTM; Origin: Lat 0°, Long 27° with false coords of 500,000 mE, 10,000,000 mN

0 — 1.5 — 3.0 km
SCALE

ZCCM INVESTMENTS HOLDINGS PLC ESA OF THE COPPERBELT ENVIRONMENT PROJECT - ZAMBIA	KOMEX INTERNATIONAL LTD. ENVIRONMENTAL AND ENGINEERING CONSULTANTS		
COPPERBELT HYDROGRAPHY AND MINE LOCATIONS	DRAWN BY: M.T.	EDITED BY: M.T.	DATE: JAN21/02
	APPROVED:	FIGURE: 3	
PREPARED SOLELY FOR THE USE OF OUR CLIENT AS SPECIFIED IN THE ACCOMPANYING REPORT. NO REPRESENTATION OF ANY KIND IS MADE TO OTHER PARTIES WITH WHICH KOMEX INTERNATIONAL LTD. HAS NOT ENTERED INTO A CONTRACT.	J:\53670000\MINELOCS.DWG		



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KABWE AREA PLAN

4

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PHOTO 1: Nkana open pit

PHOTO 2: Nchanga Chingola open pit

PHOTO 3: Nchanga Chingola dumps

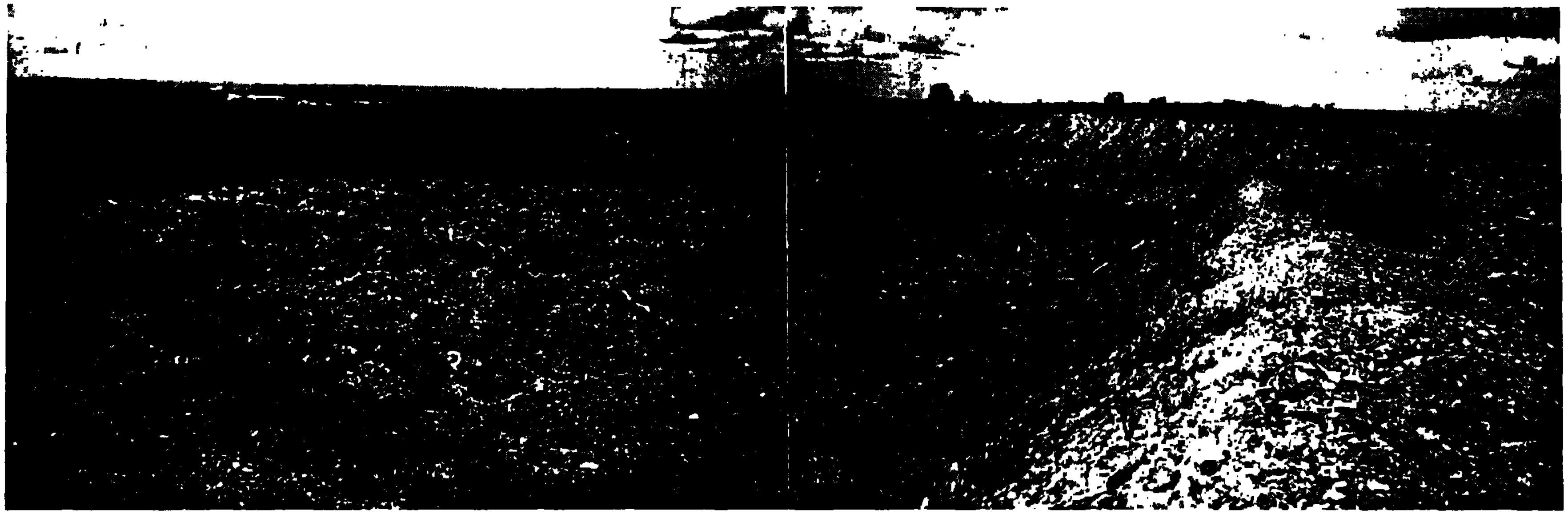

PHOTO 4: Nkana Mindola footwall dump

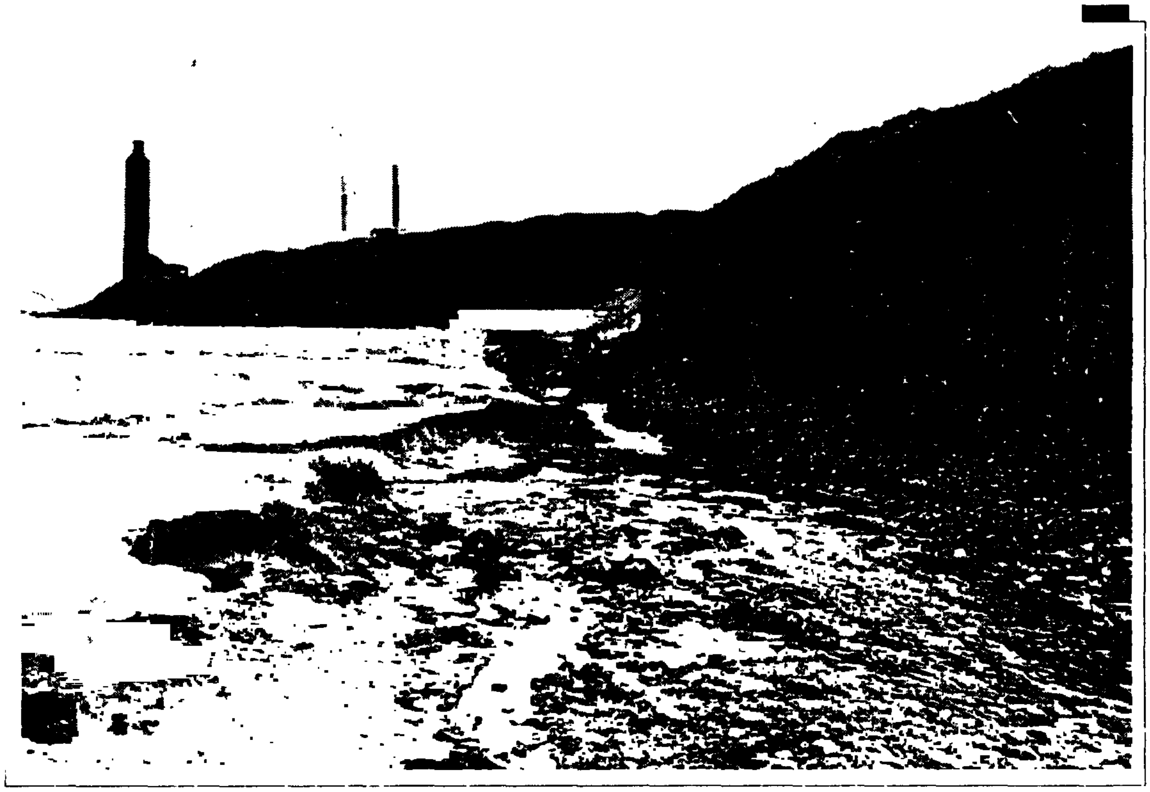

PHOTO 5: Nkana plant slag stockpile

PHOTO 6: Chambishi concentrator

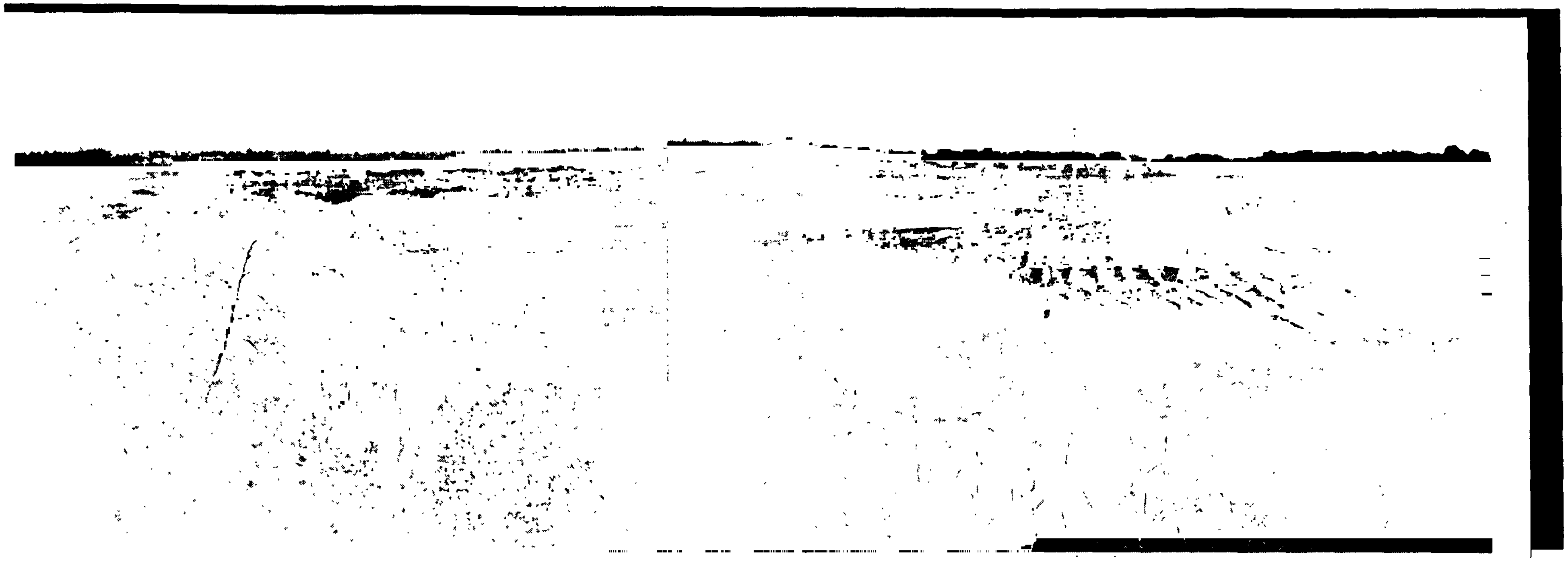

PHOTO 7: ZCCM-IH Nkana TD25

PHOTO 8: ZCCM-IH Nkana TD33C

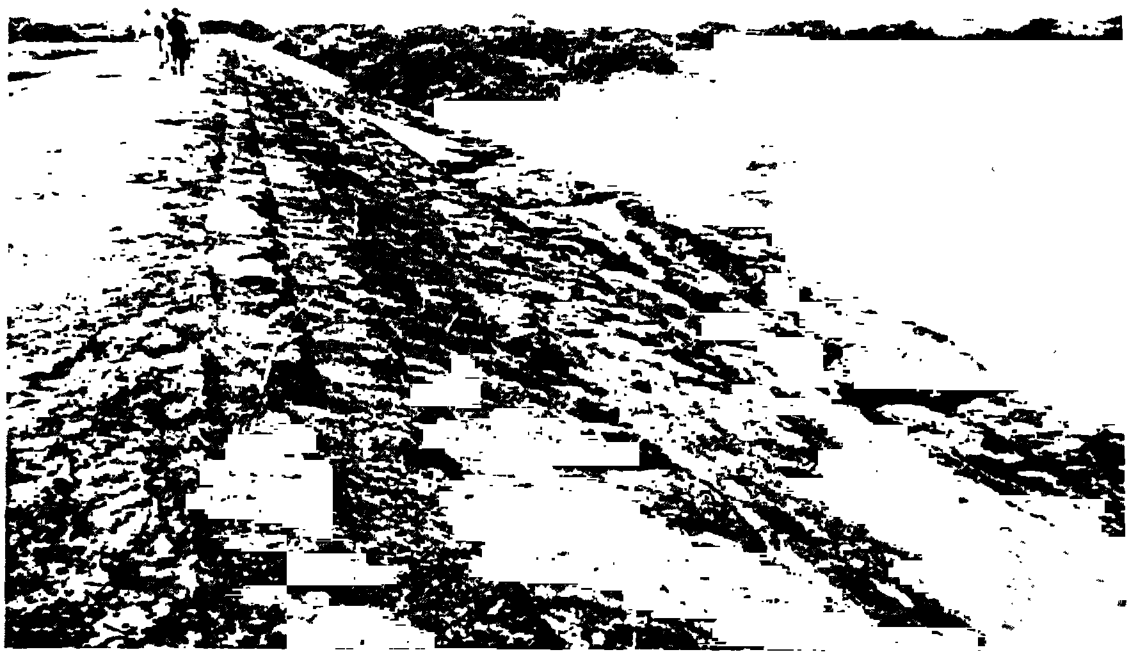

PHOTO 9: ZCCM-IH Kuskosa TD

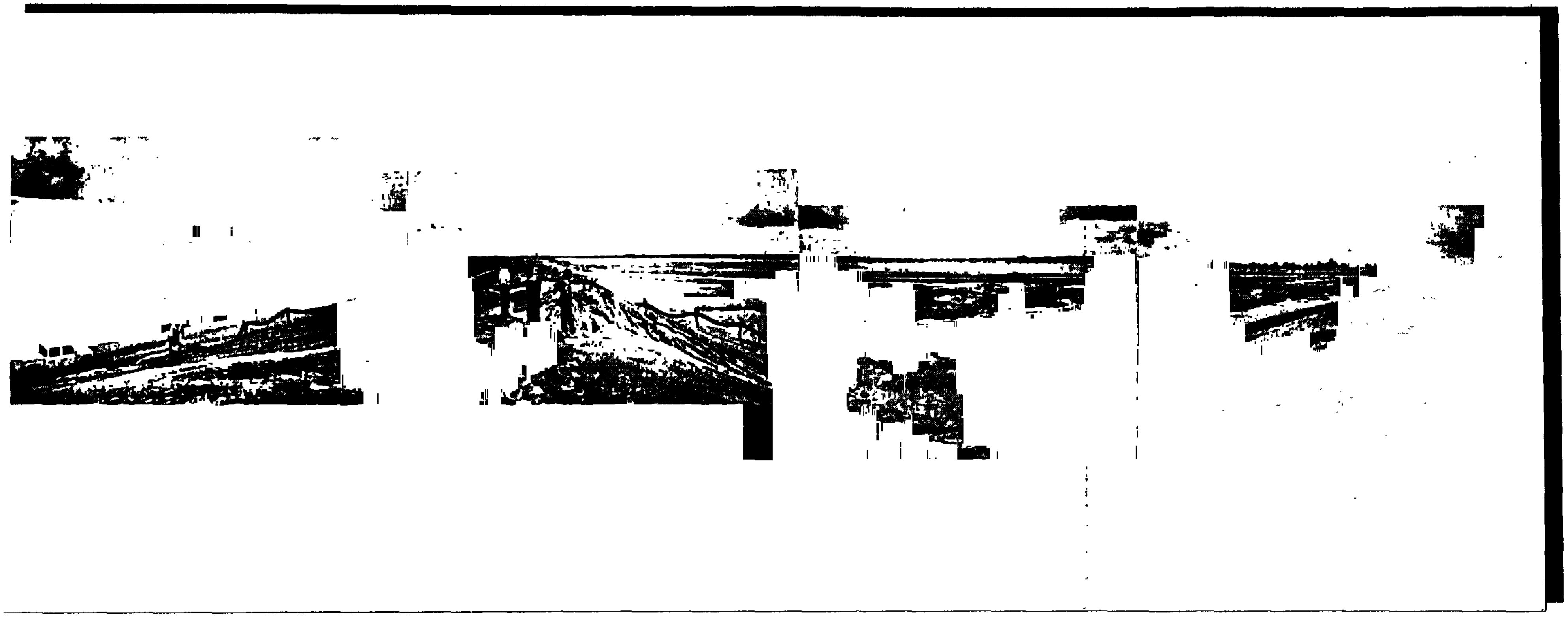

PHOTO 10: KCM Nchanga TD5

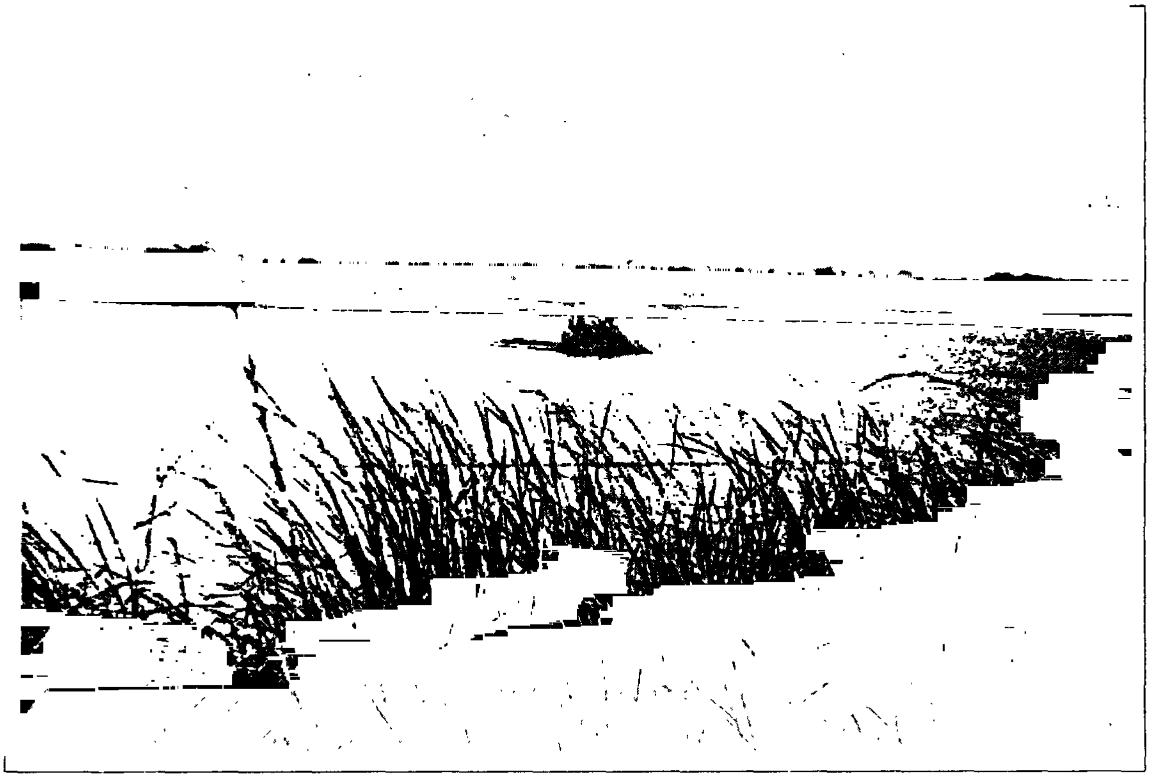

PHOTO 11: Chambishi Musakashi Cross Valley TD

PHOTO 12: Nkana ML3 municipal solid waste TD27

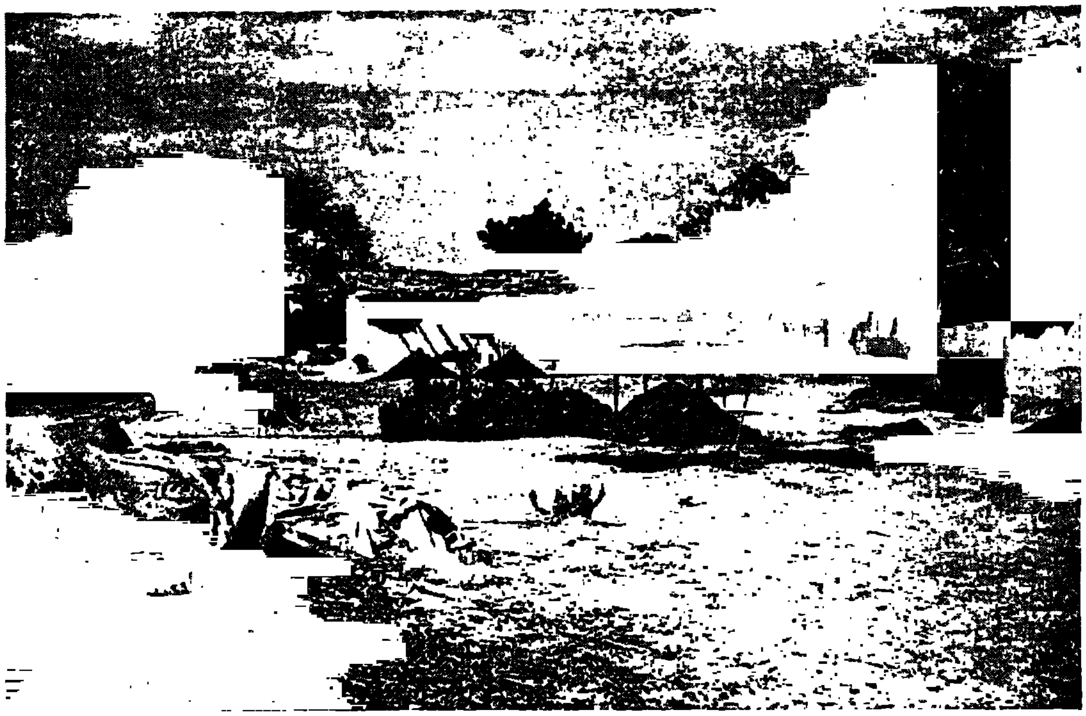

PHOTO 13: Kabwe Settlement - scavenging for coal.

PHOTO 14: Kabwe Chowa Township. Dredged soil to north of canal - utilized for brick making.

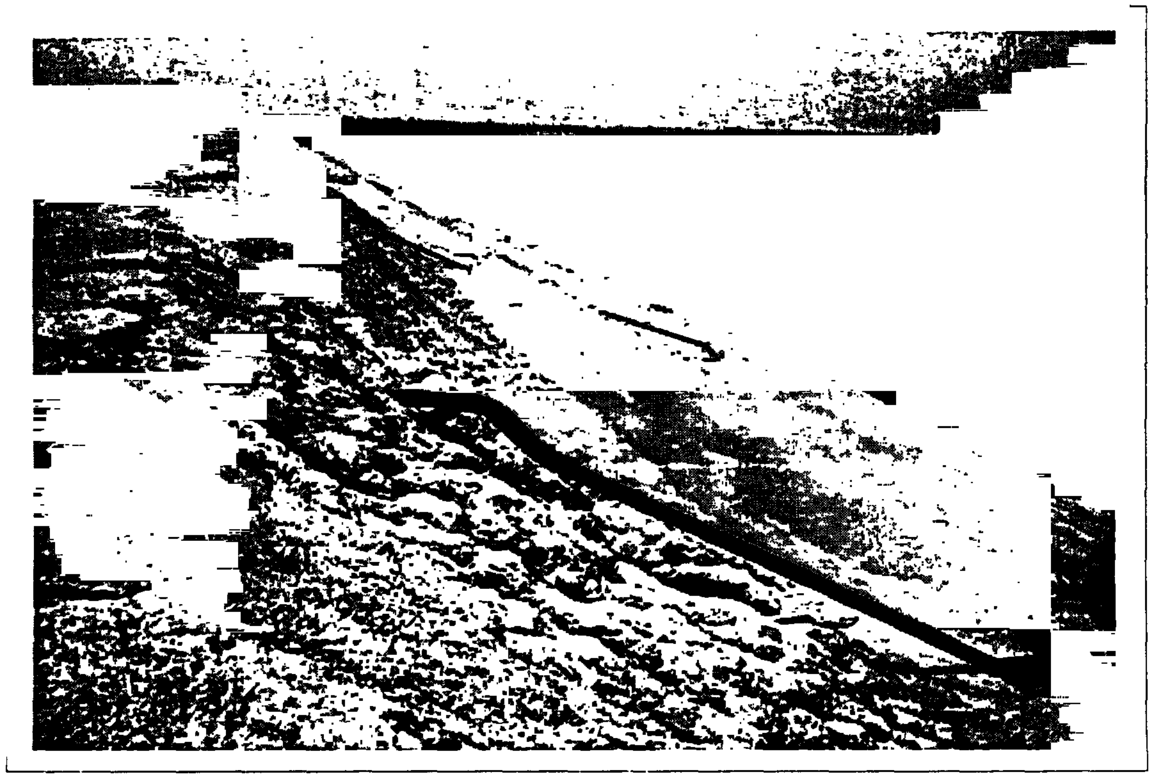

PHOTO 15: Luanshya Mine Chola TD - erosion on embankment undermining drain pipes.

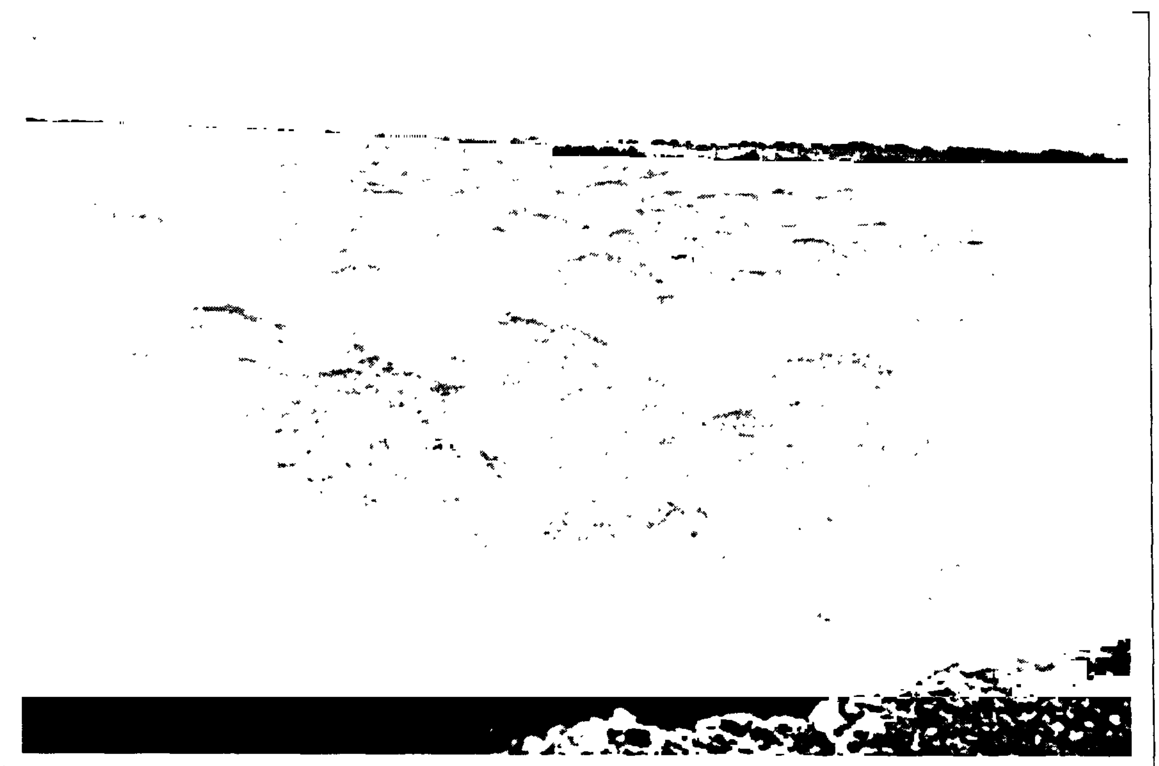

PHOTO 16: Mufulira TD 5 (left), TD 8 (central), TD 11 (background) - natural tree cover is well established.

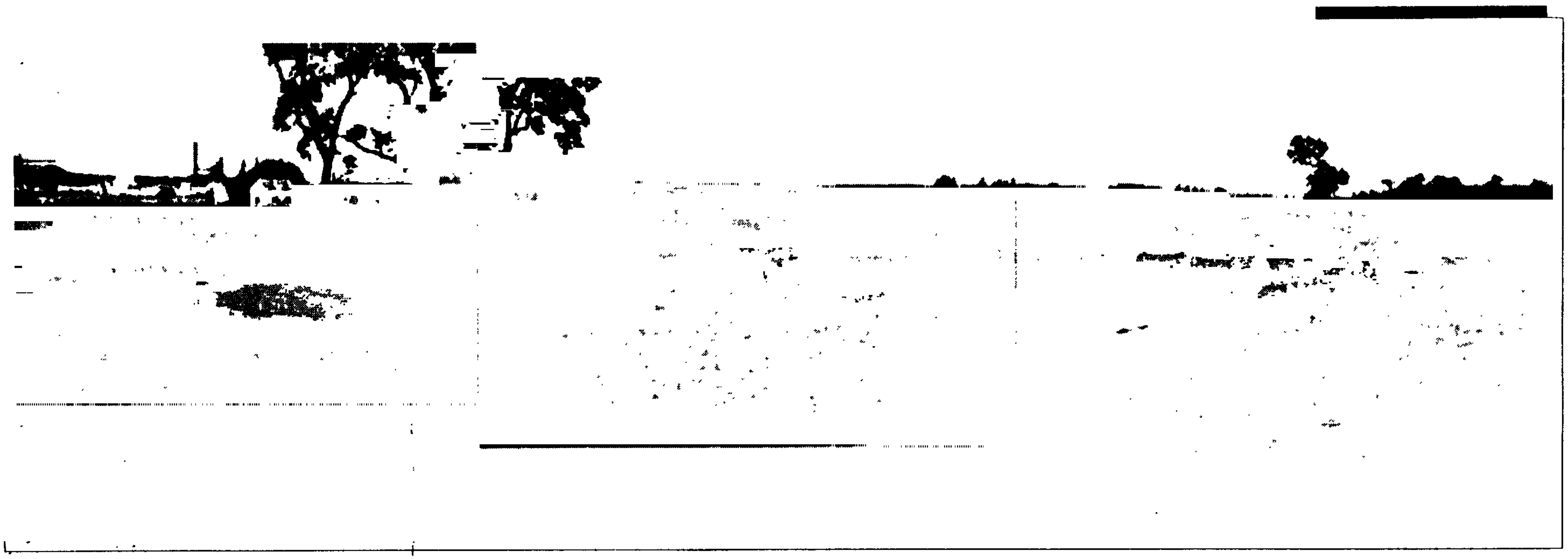

PHOTO 17: Kabwe Mine Site Area.