# ENVIRONMENTAL IMPACTS OF MINING IN ZAMBIA Towards better environmental management and sustainable exploitation of mineral resources

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Cover: Kanshanshi copper gold mine in Solwezi, Zambia. Photo: Joanna Lindahl.

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#### SUMMARY

Environmental impacts from mining operations are significant and quite often severe, especially in developing nations which lack adequate management of the sector. In Zambia, impacts from mining results from both historical and ongoing mining operations, and the majority of them is located in the Copperbelt district. Recent investments in exploration and mine developments have, however, led to new operations also in other provinces. The main environmental problems associated with mines in Zambia are pollution of air, soil and water, geotechnical issues and land degradation. The contribution from old mining legacy sites have shown to be minor compared to current mining operations.

The governmental framework that regulates the mining sectors environmental compliance is centered on Zambia Environmental Management Agency (ZEMA). The agency authorizes mining projects through an environmental impact assessment (EIA) process, issues environmental permits and is responsible for auditing. The Mine Safety Department also has governmental responsibility for the sectors environmental issues. Existing laws and regulations regarding environmental performance are relatively up to date in Zambia; the main problem for the country is that the implementation is not satisfactory. Partially this is explained by lack of coordination between institutions but also to a large extent on the lack of manpower and technical capacity. A special concern is the lack of supervision towards the active industry and the generally low quality of EIA reports compiled and used in the license process.

In recent years several small and large development initiatives related to the subject of mining has taken place in Zambia. A large World Bank funded mission, the Copperbelt Environment Project (CEP), addressed both the task of strengthening the regulatory framework and mitigating the most acute environmental and social problems lingering from historical mines.

Although a lot already has been done in Zambia, several actions for further development are essential. Proposals for future development work focuses on better management of the active mining industry rather than mitigation of old legacy sites. It is suggested to take actions to better implement existing environmental legislation, improve the quality of Environmental Impact Statements and Management Plans, implement a strategy for good water governance, and to improve technical and geoscientific knowledge (capacity building) for relevant authorities.

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## INTRODUCTION

Zambia has a long history of mining due to its rich resources of mainly copper and cobalt. The previously state-owned mines have been privatized and for the last decade the government has encouraged foreign investments in the mining sector as a way of boosting the country's economic activity. Mining in developing countries like Zambia can however be a treasure or a trouble depending mainly on factors like institutional stability, economic management and overall management of the sector itself (World Bank and International Finance Corporation 2002). An often neglected fact in countries struggling against poverty is that mining has a significant, and quite often severe, impact on its surrounding. For a developing mining nation, it is therefore evident that environment and development are not separate challenges; instead they are unavoidably linked.

Through the MeetingPoints Mining project, the Geological Survey of Sweden has been facilitating partnerships and networks in the mineral sector in several sub-Saharan African countries since 2010. Within the project, a pre-study has been made on the environmental impacts of mining in Zambia. The pre-study aims to analyze the environmental situation, to review the governmental framework that regulates the sector and give an overview of previous measures taken through various development projects. This report presents the findings of the pre-study and draws conclusions from it by giving a number of proposals for future work with a focus on better environmental management of the mining sector.

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#### ENVIRONMENTAL IMPACTS OF LARGE SCALE MINING IN ZAMBIA

There are many environmental impacts resulting from mining activities. In this study, a choice has been made to focus on impacts with mostly local and sometimes regional effects. This means that environmental issues with impacts on a global scale, such as emission of greenhouse gases, are not considered. Impacts resulting from mining is focused on the following topics:

- air pollution,
- soil contamination,
- water pollution and siltation,
- geotechnical issues, and
- land degradation.

Due to Zambia's long history as a mining nation there are many historical legacy sites that cause environmental problems. In many historical mining areas, there are now new operations which make it hard to distinguish between historical and current impacts of mining. Here an attempt has been made to describe the environmental impacts divided geographically by provinces (see Figure 1) and, where possible, into historical, ongoing and future operations.

#### **Copperbelt province**

The copper industry has dominated the mining scene in Zambia for more than eight decades since the first commercial mine was opened 1928 (Simutanyi 2008). The copper industry was gradually nationalized from 1969, and the mining operations were after that run by the state through Zambia Consolidated Copper Mines Limited (ZCCM). Copper production in Zambia peaked in the early 1970s and during a short period the country saw an exceptional investment in the construction of new schools, hospitals and roads using surpluses from copper revenues. After 1975 the copper production declined, and the industry faced a number of challenges due to the lack of investment, over-staffing, poor technology and falling copper prices. In the year 2000, the



mines were privatized and ZCCM's assets were divided and sold to various investors. Zambia's government kept shares in some operations during the privatization and today still owns a minority stake in many of the mines through a holding company called ZCCM-Investment Holdings (ZCCM-IH). During the privatization process, the government made a deal with the new owners that none of the historic environmental legacies and the impacts resulting from them would fall under the responsibility of the new owners. Instead it was decided that the state through ZCCM-IH should take care of remediation actions and monitoring of the historical sites.

## Environmental legacies from historic mining

Environmental problems directly linked to historical mining operations in the Copperbelt are largely related to geotechnical integrity of waste dumps. There are at least 21 waste rock dumps covering more than 388 hectares, 9 slag dumps covering 279 hectares and finally more than 45 tailing dams covering an area of around 9125 hectares (Environmental Council of Zambia 2008). In total, more than 10 000 hectares in the Copperbelt is covered with mineral waste and thus represent a "loss of opportunity" for the local population in terms of other land use such as agriculture, forestry, housing, ranching etc (SGAB et al. 2005). In addition to the geotechnical risks associated with waste dumps, the use of tailing ponds for water supply and fishing, as well as growing crops on the tailing surface has the potential to cause health impacts.

Mine waste containing sulfide minerals is a potential source for acid mine drainage (AMD) if they are exposed to oxygen and water. Acid forms when sulfide minerals weather by oxidation, and if the neutralizing capacity of the surrounding rock is too low to buffer the generated acid, the result will be low pH waters with high metal content. Generally the geology in the Copperbelt area is enriched with carbonates which act as a buffer against acidification. Because of that, acid mine drainage waters is a rare feature in the Copperbelt. The only major exception is a 2 hectares large former ore stockpile in Chibuluma west of Kitwe (SGAB et al. 2005). Drainage water from the area holds a pH of 2–3 and high content of primarily copper and cobalt. No people reside within the contaminated area or in the immediate surroundings to the north following the contaminated watercourse.

Besides the acid mine drainage in Chibuluma and the land degradation issues described above all the historical mine sites naturally also give rise to other environmental impacts such as dust fallout and discharge of suspended solids to surface waters. However, an extensive study states that the contributions from old mining legacy sites are only minor compared to current mining operations (SGAB et al. 2005).

#### Environmental impacts of active mining

Since 2001, most of the previously state-owned and unprofitable copper mines have been revived through extensive investments by new owners. As the mining operations are scaling up production to make profits on the invested capital, the concern for the environment is prone to be overlooked. A number of serious environmental impacts are directly linked to operating copper mines, and the most important ones are described here.

#### Air pollution

In Zambia, the mining industry (mostly the copper smelters) contributes to over 98% of the country's SO<sub>2</sub> emissions. In the early 2000s, the total SO<sub>2</sub> emission was 346700 ton/year (Environmental Council of Zambia 2008). Recent investments in mining activities are expected to yield increased SO<sub>2</sub> emissions because of several new copper smelters. High SO<sub>2</sub> concentrations will directly affect the health of both humans and biota. Oxides of sulphur (SO<sub>x</sub>) can irritate respiratory passages and aggravate asthma, emphysema and bronchitis. Due to normal weather conditions (i.e. wind speed and direction) areas northwest and west of the large Nkana and Mufulira smelters are severely affected by poor air quality. Measurements taken in those areas have shown concentrations between 500 and 1000  $\mu$ g/m (SGAB et al. 2005) which clearly exceeds the Zambian guideline of 50  $\mu$ g/m<sup>3</sup>. Most residential areas in both the city of Mufulira and Kitwe lie directly within the affected vicinity of the smelters and the inhabitants there are daily exposed to concentrations exceeding maximum daily average guidelines for SO<sub>2</sub> (SGAB et al. 2005).

Particulate matter less than 10  $\mu$ m in size (PM10) originates both from smelters and from dusting of tailing dams and unpaved roads. The largest contribution comes from smelters, and the same geographical scenario as described for the SO<sub>2</sub> emissions prevails also for PM10. Children exposed to high concentrations of PM10 are likely to have an increase in lower respiratory symptoms and reduced lung functions (SGAB et al. 2005).

#### Soil contamination

Accumulation of metals in soil is a result from wind-borne dust particles (from dry tailing dams) and particle fall-out from smelters. The main soil contaminants that occur in concentrations high enough to constitute a significant hazard to human health, are copper and cobalt (SGAB et al. 2005). Large areas within the mining region are contaminated compared to natural back-

ground values and a variety of elements occur in elevated concentrations in addition to copper and cobalt. A broad study on soil contamination has been made in the Copperbelt (Czech Geological Survey 2007). The study showed that the highest concentrations for many elements were geographically directly associated with the districts of Kitwe, Mufulira and Chingola, and also to a lesser extent with Kalulushi, Chililabombwe and Chambishi. A summary of the study is presented in Table 1.

It is difficult to estimate how many of the Copperbelts residents who are directly living upon or using contaminated soils for agriculture. It should be pointed out that soils in mineral rich areas often are naturally enriched in metals. Soil samples from the subsurface (70–90 cm) show that chromium and nickel in quite many places actually are higher below the surface soil layer. In the case for copper, subsurface samples show that the surface soil layer contains at least ten times, and quite often more than 50 times, higher concentrations in more or less the whole Copperbelt (Czech Geological Survey 2007).

#### Surface water pollution and siltation in the Upper Kafue River

The mining operations in the Copperbelt all lie within the catchment area of the Kafue River. Kafue's watershed is the most developed in the country and the river is coming under increasing threat from pollution as well as competition in water utilization (Environmental Council of Zambia 2008). The major cities in the Copperbelt region receive their domestic water supply from the Upper Kafue, and concern for potentially contaminating mining activities is always present. The Kafue River and its branches are also used for irrigation as well as for providing local communities with fish.

Several studies have shown that concentrations of many dissolved elements (i.e. ions) are clearly elevated in the Kafue and its tributaries within the Copperbelt. Metal discharges can negatively affect biodiversity and alter species composition in streams. In general the aquatic biota is more sensitive to contamination than higher animals or plants and, therefore, water quality standard with the aim to protect aquatic life are often considerably stricter than standards for drinking water. The dissolved copper content have shown to be considerably higher than standards for protecting aquatic life in more or less all monitoring stations within the Copperbelt region (SGAB et al. 2005). The most significant contributors to metal pollution are the Nchanga, Nkana and Konkola mining operations (SGAB et al. 2005). Downstream the mining

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	Kitwe	Mufulira	Chingola	Kalulushi	Chililabombwe	Chambishi
Population *	522000	161000	210000	96000	90000	11000
Mining operations	Nkana &	Mufulira	Nchanga &	Chibuluma	Konkola	Chambishi
	Mindolo		Chingola			
As (mg/kg)	>5	>5	3	1	0.5	0.5
Co (mg/kg)	>60	>60	>60	35	9	19
Cr (mg/kg)	36	36	36	16	25	16
Cu (mg/kg)	>2200	>2200	>2200	1800	600	300
Hg(mg/kg)	>0.06	>0.06	0.035	0.02	0.02	0.02
Ni (mg/kg)	12	22	7	5	7	5
Pb (mg/kg)	>60	>60	>60	5	5	5
Zn (mg/kg)	>60	>60	>60	20	40	10

Table 1. Average element concentrations presented per city together with information of population and active mines. Concentrations marked in green are higher than international guideline values for soil suitable for residential and agricultural purposes, and concentrations marked in blue are likely to also be higher.

\* Zambia Central Statistical Office 2010.

operations, the concentrations of mining-related contaminants are quickly lowered mainly due to the formation of secondary particles that rapidly settles on the river bed. Since the severe pollution from mines mainly is concentrated to hotspots the water companies around the Copperbelt manages quite well with producing potable water. However, there are exceptions and especially the Mulonga and Nkana water and sewerage companies often struggle with water quality (National Water Supply and Sanitation Council 2010). Additionally accidents do happen from time to time. In media there have been reports of complete water supply failure in Chingola 2006 due to a spill from Konkola's leaching plant, and in 2008, at least 13 people in Mufulira were admitted to hospital after a similar spill from Mufulira's leaching plant. Even though high concentrations from the mining areas are mostly local, elevated concentrations of dissolved sulfur can be traced all the way down to the confluence with the Zambezi River (Pettersson 2002). When the water discharge in Kafue is increased during the rainy season, secondary particles are re-suspended and transported downstream in the river system.

Mining activities in the Copperbelt also severely affects the waterways through extensive siltation. Concentrations of suspended elements (i.e. small particles) are naturally very low in the Kafue River but because of pollution from the mining industry suspended concentrations of copper and cobalt can be seen down to the junction with the Zambezi River (Pettersson 2002). The siltation problem is partially a result of erosion from existing tailing dams and waste dumps (contribution of 9 000 tons/year), but the really large impact comes from ongoing mining operations. For example, dewatering of Konkola mine contributes with 15 000 tons/year and the Nchanga mining area alone contributes with 91 000 tons/year by for example discharging tailings directly to the river (SGAB et al. 2005). Due to extensive siltation caused by mining activities there is a continuous build up in the river channel and the bed sediment in many places is totally dominated by tailing material with high metal concentration.

#### Accumulation of metals in vegetables, fruit and fish

Metals can both accumulate in and adhere to crops via contaminated water, soil or air. Since vegetables and fruit constitute a significant part of the local diet, the ingestion of it is a pathway for human exposure of potentially toxic metals (SGAB et al. 2005). Trace metal uptake in the agricultural plants cassava, sweet potato and maize, have been studied in the Copperbelt at several occasions. In the case of cassava and sweet potato it has been shown that in less contaminated areas, only the plant leaves contains elevated metal concentrations. For cassava and sweet potato grown on heavily contaminated soils, the metal concentrations in roots were also affected (Czech Geological Survey 2007). A correlation of down-wind distance from the Nkana and Mufulira smelters and copper-arsenic content in both cassava and sweet potato leaves exists (SGAB et al. 2005). Compared with cassava and sweet potato, maize grains are less affected by industrial contamination. The result of one study concludes that it is recommended to reduce growing and consumption of cassava and sweet potato in areas where contents of arsenic exceeds 5 mg/kg, copper 200 mg/kg and lead 4 mg/kg. In the same areas, growing of maize should be encouraged and promoted as it was shown not to be affected (Czech Geological Survey 2007).

In Zambia many people are directly or indirectly dependent upon resources provided by aquatic ecosystems, mainly through fishing. In addition to the Kafue River, tailing dams in the Copperbelt are an important source of fish for the local communities. Several fish samples from the Kafue and various tailing dams have shown elevated concentrations of particularly copper and cobalt compared to fish from unaffected waters upstream the mining operations (SGAB et al. 2005). A research experiment with caged fish (threespot tilapia) showed bioaccumulation of many trace elements already after only two weeks exposure downstream a mining operation

(Norrgren et al. 2000). From an ecotoxicological aspect, the pollution of metals in the Kafue is severe and affects aquatic animal health. However, when assessing metal concentrations in fish compared to guidelines values for oral intake it is clear that no immediate health risk is associated with consumption of fish from the Copperbelt (SGAB et al. 2005).

#### **Other provinces**

Historically, mining in Zambia has to a large extent been focused to the Copperbelt region. There are, however, exceptions and one major environmental legacy site can be found in the Central province. Since privatization, the government has been looking to diversify its copperdominated mining industry by encouraging investments in exploration and mine developments of other minerals, such as zinc, manganese, uranium, coal and precious metals. This has led to advanced plans for mine developments as well as new mining operations in regions previously unaffected by large scale mining.

In the following sections, a simple review is given on both existing environmental impacts from mining legacies and mining operations, as well as future possible impacts from promising exploration projects in the Central, the North Western, the Southern and the Luapula province (Figure 1).

#### The legacy of Broken Hill in Central province

The capital of the Central province, Kabwe, was founded in the early 1900s when the Broken Hill lead and zinc deposits were discovered. The Broken Hill Mine was for a long time the largest in the country until it was overtaken by larger copper mines in the early 1930s. Apart from lead and zinc the mine also produced smaller amounts of silver and cadmium. The mine has been closed for almost two decades and the legacy site which occupies 250 hectares is located 1 km south-west of the town centre.

The major environmental problem lingering from the historical mining activities is serious contamination of soils as a result of smelting and dust emissions from waste dumps. The content of lead in soils can reach as high as 26000 mg/kg in the most polluted areas and thus a high content are also to be found in agricultural products (Czech Geological Survey 2007). Land up to 4 km away from Kabwe in all directions, and at least as far away as 14 km to the west is unsuitable for agricultural purposes (Czech Geological Survey 2007).

High concentration of lead in soils, consumption of contaminated vegetables, inhalation of lead rich dust and usage of lead polluted water has led to higher concentrations in the blood of citizens living in Kabwe. Normal blood levels are less than 10  $\mu$ g/dl, and levels above are considered unhealthy according to the World Health Organization. In Kabwe as high concentrations as 300  $\mu$ g/dl has been recorded in children, and investigations show average blood levels of children between 60 and 120  $\mu$ g/dl (www.blacksmithinstitute.org/projects/display/3). Children are particularly vulnerable to toxic effects of lead and can suffer severe and permanent health effects which influence the development of the brain and nervous system (www.who.int/mediacentre/factsheets/fs379/en/).

A number of mitigation measures were undertaken in Kabwe between 2003 and 2011. Nonetheless, Green Cross Switzerland and The Blacksmith Institute has 2013 yet again listed Kabwe as one of the 10 worst polluted places in the world (www.worstpolluted.org/).

#### The new Copperbelt in North Western province

The North Western province is sometimes also referred to as the new Copperbelt for its abundant and relatively newly found copper resources. Since privatization two large scale open pit copper operations (Kansanshi and Lumwana) have started up nearby the town Solwezi, and at least one more project (Trident) has been approved and is about to start up. In addition to copper, the Lumwana mine is also planning on extracting uranium. Unlike the ones in the Copperbelt area, the environmental impacts from mines in the North Western region are not well documented, but a few observations are still made here.

Regarding air pollution, the emissions of both  $SO_2$  and PM10 from new smelters are expected to be lower than in the Copperbelt due to new technology. The dust fall-out from dry tailings is likely to be the same as described for the Copperbelt, and the long term potential for soil contamination is unsecure. Regarding pollution of surface water in the North Western province there are concerns for two reasons. Firstly, the potential for acid mine drainage formation is more likely to occur due to less favorable geological conditions. Secondly, the bedrock naturally contains rather high concentrations of uranium. The run-off from the relatively new mining areas is towards tributaries of both the Upper Kafue and the Upper Zambezi River, where the latter one is less supervised.

#### Abundant coal and uranium resources in Southern province

In the Southern province, several coal mines and at least one nickel mine (Munali) are in operation. In addition, one uranium project has so far been approved by the environmental authority – and more are bound to follow. The approved uranium project has not yet started production due to low commodity prices.

The present and future mines of the Southern region are very different from the copper operations. Because of this they also imply new and previously unknown challenges for the environmental regulators in Zambia. Especially uranium mining is associated with severe risks for both the environment and the workforce. There is a concern that high risk projects are being approved without the correct conditions under which the project should operate.

#### A future manganese mining district in Luapula province

Luapula province has potential to become a new mining district due to its promising resources of manganese, mainly occurring as high-grade (40–65%) pyrolusite ores. Currently a lot of small scale mining of manganese is taking place in the region, but there are plans for large scale operations as well. One thing hindering large scale production is a secure supply of energy for the operations.

Manganese mining operations are different from the copper mines. Particular concern needs to be taken regarding smelters as exposure to manganese dust and fumes can be highly toxic even for short exposure times. A recent study from Mexico showed that people living close to manganese mines and processing plants often suffer from incipient motor deficit (Rodriguez-Agudelo et al. 2006). In addition, waterborne manganese has a high bioavailability and a study from Canada suggest that exposure to manganese rich drinking water is associated with intellectual impairment in children (Bouchard et al. 2011).

#### Indirect impacts of mining

Apart from the described environmental impacts above, mine operations in developing nations often indirectly lead to other social and environmental challenges. One crucial challenge for the new mining districts is the large increase in population. The number of people living in the new mining town Solwezi has almost doubled in less than a decade. Such rapid inward migration causes extreme pressure on civic functions like provision of drinking water and treatment of wastewater. In the Copperbelt, where migration also has been huge, the water treatment plants still struggle to produce potable drinking water from the river to the population living in urbanized areas. Today the biggest threat to drinking water quality in the Copperbelt is not from

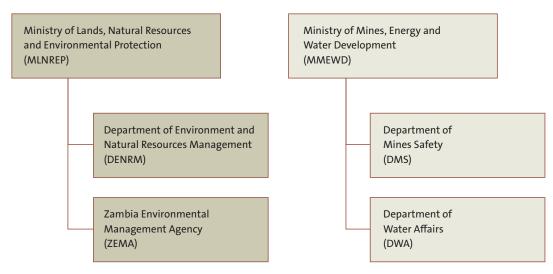


Figure 2. Main governmental institutions with responsibility for environmental impacts of mining.

metal pollution by the mines but from inadequate handling of waste sewage (SGAB et al. 2005). There are many places around the Copperbelt where sewage is flowing directly into the environment which apart from polluting water with faecal bacteria, also have a negative effect on aquatic life due to depletion of oxygen. It might be hard to claim that the mining sector should take responsibility for all the indirect effects of their existence; nevertheless they should not be forgotten even though they are not given much attention in this study.

## LEGAL FRAMEWORK FOR THE ENVIRONMENT

In Zambia, the general framework for environment issues is in many ways quite similar to the situation in most developed countries. There is, however, a lack of coordination between institutions and the implementation of existing laws and regulations is unfortunately not satisfactory.

#### Governmental institutions and authorities

Environmental issues cut across a variety of sectors in Zambia, and a number of government institutions are involved in environmental management issues. The most important responsibilities regarding environmental impacts of mines are dispersed between two ministries (Figure 2).

The Ministry of Lands, Natural Resources and Environmental Protection (www.ministryoflands.gov.zm/) is the former Ministry of Tourism, Environment and Natural Resources (MTENR). Under the Ministry, it is the **Department of Environment and Natural Resources Management** that is responsible for the overall policy formulation on environment, natural resources and pollution control and thus is the focal point for all environmental management issues in the country. The department also co-ordinates, monitors and evaluates the operations of the executive agencies (statutory bodies) that have been created to implement policies on behalf of the government. One such statutory body is **Zambia Environmental Management Agency** (ZEMA, www.zema.org.zm) which was originally established in 1992 under the former name Environmental Council of Zambia. ZEMA is the major environmental institution in Zambia and the lead agency with a mandate by law to "*do all things necessary to ensure the sustainable management of natural resources and protection of the environment and the prevention and control of pollution*". ZEMA's functions include

- advising the government on policy work,
- coordinating the implementation of environmental management in all ministries,
- develop and enforce measures to prevent and control pollution,
- develop guidelines and standards related to environmental quality,
- promoting research and studies,
- controlling the Environmental Impact Assessment process,
- authorize or inhibit industrial projects,
- issuing permits and licenses,
- audit and monitor the compliance of operating industries, and
- publicizing information regarding environmental management and pollution control.

ZEMA is autonomous and run by a board comprising members drawn from a wide range of ministries, business and non-governmental organizations. On paper, ZEMA has a lot of power and is continuously being strengthened as the legislation keeps improving. However, the agency is heavily understaffed and can only manage a few of its responsibilities in a satisfactory way. A special concern is raised for the severe lack of supervision towards the industry after projects have been authorized and pertained all its licenses and permits.

The Ministry of Mines, Energy and Water Development (www.mewd.gov.zm/) has been formed by merging the former Ministry of Mines and Mineral Development (MMMD) with the Ministry of Energy and Water Development (MEWD). Under the Ministry, the **Department of Mines Safety** is a sector specific institution that formulates, monitor and maintain legislation regarding safe and sustainable exploitation of mineral resources. The main focus of the department lies on working environment issues, and they supervise the industries implementation of job safety regulations. The department also has an environment section with the responsibility to

- provide submission of comment to ZEMA in all mining related environmental applications,
- monitor and where needed remediate environmental legacies from the small-scale mining and exploration sectors, and
- administrate an Environmental Protection Fund (EPF).

The other department under the Ministry of Mines, Energy and Water Development that has an important environmental function is the **Department of Water Affairs**. The department is responsible for the overall management of water resources, including both surface- and groundwater. In terms of quantity, the department has long been working on supervising major water resources within Zambia, and they claim to have a good control of the water usage by the mining industry. In terms of water quality, the department is less strong in its performance and they seem to lack both capacity and knowledge to survey major water resources.

International waters, like parts of the Lower Zambezi River, do not fall under the responsibility of the Department of Water Affairs. Instead, since 1987, a special institution by the name **Zambezi River Authority** (www.zaraho.org.zm/) handles hydrological and environmental information pertaining to the Zambezi River and Lake Kariba.

#### Non-governmental organizations and other key actors

In Zambia, there are quite many active environmental NGOs, but most of them have wildlife protection and/or climate change as their main interest. One exception is the **Zambia Institute of Environmental Management** (ZIEM, www.zieminstitute.org/) that is committed to the principle of sustainable development through community based environmental actions. Recently ZIEM have on its own initiative (with funding from the Civil Society Environment Fund)

compiled an Environmental and Social Impact Assessment for the Musakashi River Catchment in order to give an overview of the environmental impacts from the nearby mines (Zambia Institute of Environmental Management 2012). The report has been used firstly to share the findings with the local community and secondly to approach the mining operator and regulator for a discussion about actions that are needed. At this point, it is unclear what the initiative will lead to.

An important actor regarding mines in Zambia is the partially state-owned (87,6%) corporation ZCCM – Investment Holdings Plc (www.zccm-ih.com.zm/). The company hold the responsibility to mitigate and monitor the legacy sites from historical mines. During this year the environmental department within ZCCM-Investments Holdings has been transformed into a fully owned subsidiary with the name Misenge Environmental and Technical Services Ltd. The new company's main business objectives are to

- extinguish all the legacy environmental obligations of the parent company ZCCM-Investments Holdings,
- extend provision of environmental consultancy services to other clients within the mining sector,
- provide quality analytical services, and
- promote excellence in radiation protection for their clients.

## **Environmental acts and national policies**

The body of environmental legislation in Zambia is largely fragmented. It is spread over more than 30 sets of legislation with dispersed responsibility across several line ministries. In 2009, the government developed a **National Policy on the Environment** (NPE) which is supposed to address the scattered policy and legal framework and instead try to harmonize and rationalize it. The NPE has so far not lead to much practical action mainly because it has not been backed by financial resources.

The principal legislation governing environmental management in Zambia is the Environmental Management Act (No 12 of 2011). The Act is an umbrella law which stands over all other environmental legislation in Zambia. Through the Act, the Environmental Council of Zambia was renamed to ZEMA which now is mandated to ensure the sustainable management of natural resources and protection of the environment. The Act is based on many modern principles:

- the environment is the common heritage of both present and future generations,
- adverse effects shall be prevented and minimized,
- the people shall be involved in the development of policies, plans and programmes for environmental management,
- community participation and involvement in natural resource management shall be promoted and facilitated,
- the precautionary principle,
- the polluter pays principles,
- the generation of waste should be minimized wherever practical, and otherwise in order of priority, be reused, recycled, recovered and disposed safely, and
- non-renewable natural resources shall be used prudently, taking into account the needs of the present and future generations.

The new Act is considerably stronger than its predecessor the Environmental Protection and Pollution Control Act (No 12 of 1990 and No 12 of 1999), but even though the new Act repeals

the old one, part of the old regulations are still being enforced. Relevant regulations which are still in use are

- The Waste Management Regulations (SI 71 of 1993).
- The Water Pollution Control Regulations (SI 72 of 1993).
- The Pesticides and Toxic Substances Regulations (1994).
- The Air Pollution Control Regulations (SI 142 of 1996).
- The Environmental Impact Assessment Regulations (SI 28 of 1997).
- The Hazardous Waste Management Regulations (SI of 2001).

Legislation to provide equitable and sustainable use of water in Zambia is incorporated by the Water Resources Management Act (No 21 of 2011). The new act provides for the ownership, control and use of water. It delegates management of water resources through Catchment Councils consisting of the water users of the catchment. The Act also clearly states that anyone wishing to discharge any effluent into a water resource shall do so in accordance with the Environmental Management Act.

For the purpose of enhancing wildlife ecosystems, the Zambia Wildlife Act (No 12 of 1998) gives Zambia Wildlife Authority the mandate to control and manage national parks, game management areas and bird sanctuaries. Exploration of mineral resources is not forbidden in national parks. Exploitation of mineral resources is not allowed if it will cause large environmental impacts.

Regulations specifically related to mines and minerals can be found in the Mines and Minerals Development Act (No 7 of 2008). The Act mainly regulates the rights for exploration, exploitation and processing of mineral resources. There are two statutory instruments under the Act which are related to pollution from mining activities. The first is the Mines and Minerals Environmental Regulations (SI 29 of 1997) which provides the framework for conducting and reviewing environmental impact assessments for the mining sector as well as regulations for auditing project implementation. The second is the Mines and Minerals Environmental Protection Fund Regulations (SI 102 of 1998) which provides the mechanism of setting up and operating an Environmental Protection Fund. The objectives of the Fund are to:

- provide assurance to the Director of Mines Safety Department that the developer shall execute environmental and social impact statements, and
- provide protection to the government against the risk of having the obligation to undertake rehabilitation of a mining area where the holder of the mining license fails to do so.

The contribution by the developer shall be calculated depending on performance, and the last year's total contributions (www.eiti.org/Zambia) can be seen in Table 2.

The Environmental Protection Fund may also receive income from other sources such as government funding, donor contributions etc. Funds from additional sources shall be put into a dedicated account and the money should be used to primarily address the governments environmental obligations from orphaned mine sites around the country.

#### **Environmental requirements to start mining**

In Zambia the first thing a developer needs to do before undertaking a project that may affect the environment is to obtain a written authorization from Zambia Environmental Management Agency (ZEMA). The authorization can only be made after the developer has gone through the **Environmental Impact Assessment (EIA)** process. In Zambia, mining activities are always considered having a large impact on the environment and a mine developer is required to prepare

Table 2. Annual contribution from developers.

Year	Million USD	
2008	1,83	
2009	2,29	
2010	2,98	

a "full EIA" which is referred to as an **Environmental Impact Statement (EIS**). The following steps should be followed by a developer in the process of conducting an EIS:

- Step 1. Preliminary actions
  - a. Setting up an environmental team with specialists.
  - b. Setting up the terms of reference for the study (needs approval from ZEMA).
- Step 2. Scoping
  - a. Review all applicable laws, policies and international obligations.
  - b. Identify possible alternatives to the project layout.
  - c. Identify main impacts to determine which specialist studies are needed (should be decided after consultation with ZEMA).

#### Step 3. Baseline study

- a. Detailed description of existing environment.
- Step 4. Impact evaluation a. Evaluation of predicted impacts for various situations.
- Step 5. Public Participationa. Hear the view of the affected community.
- Step 6. Identification of mitigation measures
  - a. Measures for firstly elimination, and secondly reduction of environmental impacts.
  - b. Include noise control, treatment of effluent waters, air pollution control, waste control and other appropriate measures.
  - c. The cost of mitigation measures must be calculated and included in an Environmental Management Plan.
- Step 7. Assessment of impacts and decision making by the developer
  - a. Comparison of all alternatives by the team.
  - b. Ranking and recommendations by the team.
  - c. Decision by the developer for one alternative and an explanation for the rejection of other alternatives.
- Step 8. Submission to ZEMA followed by a review process
  - a. From the day the EIS is submitted to ZEMA the process by law is not allowed to exceed 65 days.
  - b. ZEMA sends the application for submission of comment to sector institutions (e.g. Mines Safety Department and Department of Water Affairs) who by law are enforced to reply within 30 days.
  - c. ZEMA shall place notifications in national newspapers and do everything possible to distribute the application to ministries, NGOs and affected parties who are allowed to leave written comments within 20 days after the notification in the newspaper.

- d. ZEMA organizes a public consultation in the locality of the proposed project.
- e. ZEMA reviews the application and makes a field visit to verify the content of the EIS.
- f. ZEMA takes all aspects into consideration and writes a recommendation letter to the decision committee stating if the project should be rejected or approved and if so under which conditions.
- Step 9. Decision making
  - a. A decision committee of five people drawn from the board of ZEMA takes the decision.
  - b. The committee communicates its decision through a decision letter which shall be distributed to all parties.
  - c. An approval letter often follows with specific conditions and it also binds the developer to fulfill what is stated under the Environmental Management Plan provided in the EIS.

If the developer is not content with the decision, there is a possibility to appeal to the Minister of Lands, Natural Resources and Environmental Protection. If the developer again is not pleased, it is also possible to appeal to the High Court. A highly interesting case to follow is the application to open up a massive open-pit copper mining operation in the Lower Zambezi National Park (which is under consideration by UNESCO for its potential of being a World Heritage Site). ZEMA disproved the project already in the fall 2012, but the decision was immediately appealed to the Minister. As of fall 2013 no definite answer has yet been given. According to the company (www.zambeziresources.com) behind the appeal the long waiting time for the decision can partially be explained because Zambia was co-hosting the 20th United Nations World Tourism Organization (UNWTO) General Assembly together with Zimbabwe in August 2013. The company says that a positive decision on the appeal would have been controversial and likely evoked protests against the government during the congress. Since the appeal was sent to the Minister, the government has conveniently launched a new Mineral Resources Development Policy that will allow mining in sensitive areas if the benefits of mining outstrip those of maintaining the National Parks. The result of the final decision remains to be seen.

The quality of EIA reports for mining operations varies a lot, but in general they remain low. Characterization of waste, and the handling of waste rock and tailing material, are often subjects in the EIAs that need to be considerably improved. ZEMA has recently developed sector specific guidelines on what should be included in an EIA and how they should be reviewed.

In addition to the written authorization from ZEMA, the developer also needs to obtain a number of **permits and licenses** before undertaking operation. At the moment, up to 30 permits and licenses might be required. This is about to change since ZEMA is working on implementing integrated permits and licenses to make it more perspicuous and easily managed. The most important permits needed for a mine developer are:

- Air Pollution Monitoring Permits
- Water Effluent Dishcarge Licenses
- Water Abstraction Licenses
- Pesticides and Toxic Substances Licenses
- Waste Management Licenses
- Building Permits

Air emission (mg/Nm <sup>3</sup> )		Water effluent dischar	Water effluent discharge (mg/l)		
Sulphur dioxide	1000	Suspended solids	100		
Arsenic	0,5	Arsenic, total	0,5		
Cadmium	0,05	Cadmium, total	0,5		
Copper	1	Copper, total	1,5		
Lead	0,2	Lead, total	0,5		
Mercury	0,05	Mercury, total	0,002		
PM10 Smelters	50	Iron, total	2		
PM10 Other	50	рН	6–9 units		

Table 3. Zambia's National Effluent Statutory Limits.

The important permits and licenses for air pollution and water discharge contain site specific emission standards. The standards generally follow the Zambian Effluent Statutory Limits which is given in Table 3.

The developer is by law obliged to hand in quarterly reports to ZEMA on air pollution monitoring, and biannual reports on quantity and quality effluents to water. ZEMA has the possibility to send an inspector to the premises of any mining project at any time to undertake investigations and audit that the developer undertakes all measurements stated in the EIA report and follow the standards given in the permits and licenses. In practice, this is rarely effectuated and to execute this mandate properly ZEMA need to substantially increase its capacity.

## DEVELOPMENT WORK RELATED TO MINING AND THE ENVIRONMENT The Copperbelt Environment Project

The Copperbelt Environment Project (CEP, www.worldbank.org/projects/P070962/zambiacopperbelt-environment-project-cep?lang=en) was a project aimed firstly to address the environmental liabilities associated with the mining industry, and secondly to improve future compliance of the mining sector with environmental and social regulations. The project arose in the wake of privatization and ran between the years 2003 and 2011. The project was co-funded by the World Bank and the Nordic Development Fund, and the total budget of the project was 42 million USD. The Canadian International Development Agency (CIDA) and the Norwegian Agency for Development Cooperation (NORAD) contributed with funding to specific parts of the project. The World Banks evaluation of the project outcomes gives a performance rating of "moderately satisfactory", the same rating is given for borrower performance while the bank performance is rated as "unsatisfactory". The project consisted of two components.

## Component 1 - Environment Management Facility (EMF)

The purpose of part one was to address the environmental and social problems resulting from Zambia Consolidated Copper Mines Ltd in accordance with the country's environmental laws and regulations. The component was implemented by ZCCM Investments Holdings environmental department based in Kitwe (nowadays Misenge Environmental and Technical Services Ltd).

The first activity funded under the EMF was the preparation of a Consolidated Environmental Management Plan (CEMP). The plan identified issues to be addressed and provided a criterion for the selection of sub-projects to be funded within CEP. Highest priority was given to mitigation measures that addressed widespread public health problems and damage to ecological functions. The most important sub-projects undertaken in the Copperbelt included:

- Resettling villages in Mufulira, Ndola and Kitwe (4.2 million USD).
- Dredging of Luanshya River (1.0 million USD).
- Remediation of two uranium tailing dumps in Kitwe (2.2 million USD).

A high priority measure that CEMP pointed out that was only partially mitigated is the one related to the geotechnical integrity of waste dumps. This is explained by the fact that the government sold the dumps as mining rights to companies willing to reprocess them for copper. Since the feasibility of reprocessing has so far been too low, the geotechnical problems remain.

Although not included in the CEMP document, the project also addressed issues from the mining legacy in Kabwe. Measures undertaken in Kabwe within the project included:

- Rehabilitation of Kabwe mine plant area (2.0 million USD).
- Dredging of Kabwe canal zone and removal of mine waste from Mulungushi road dump (1.6 million USD).
- Water supply to Kabwe community (2.7 million USD).

The original CEMP document was updated after two years, and the results of the CEMP Phase 2 document have been used frequently in this report (SGAB et al. 2005). Originally the thought was to let the CEMP report be the basis for managing environmental issues related to the Copperbelt and Kabwe over a 25 year period. Since the project ended in 2011, the further implementation of the priority list has however ceased.

#### Component 2 - Strengthen the environmental regulatory framework

The second component aimed to strengthen the environmental regulatory framework to ensure that future environmental liabilities arising from mining activities are handled in compliance with national environmental and social safeguards. The component was implemented by the Environmental Council of Zambia which is the predecessor to Zambia Environmental Management Agency (ZEMA).

The component also included capacity building of the Environmental Council in terms of negotiating management activities with investors, issuing pollution permits, monitoring compliance and collecting fees and fines. A large part of the funding for the Councils capacity building was used for procurement of books, protective clothing, IT equipment, vehicles and expensive field monitoring equipment etc.

Both the Council and the Mines Safety Department undertook capacity building, through CIDA, to be able to review environmental impacts assessments and attached environmental management plans critically. Part of the project aimed to strengthen NGOs and relevant training institutions such as the Copperbelt University in order to increase the national capacity to address environmental issues associated with the mining sector.

One significant achievement of the project is the new umbrella legislation, the Environmental Management Act of 2011 which, at least officially but not practically strengthens ZEMA in their authority work. Another direct accomplishment of CEP was the actual implementation of the Environmental Protection Fund (EPF).

When the CEP project first was set up, the plan was to distribute the funds equally between the two parts. In reality, however, component one received 37,5 million USD and component two only 4.2 million USD.

## **Other initiatives**

Many different development projects and initiatives have been and are still taking place in Zambia. Here, an attempt to compile projects directly linked with mining and the environment has been made. However, the list likely only touches a brief part of all the activities in this field.

## Australian Agency for International Development (AusAID)

Australias environmental development cooperation with sub-Saharan Africa is mainly focused on water and sanitation. AusAID however has a Mining for Development initiative that aims to help developing countries to use their natural resources in a sustainable way. One key element in the initiative is the creation of an International Mining for Development Center (IM4DC, www.im4dc.org/) run by the University of Queensland and the University of Western Australia. AusAID has layed down around 28 million USD in a period of 4 years for the operation of IM4DC. So far experts from IM4DC have been in Zambia at two occasions, one in November 2012 to hold a course on management of large volume mine waste facilities, and one in October 2013 to train the staff at Mines Safety Department in accident and incident training. In January 2014, the centre will hold a 2 weeks long course in GIS in Lusaka.

## Czech Republic Development Cooperation

The Czech Republic has funded two large projects related to mining in Zambia. The first one ran between 2004 and 2006 under the name "Assessment of mining and processing of copper and cobalt ores on the environment at the Copperbelt, Zambia". The work was done through the Czech Geological Survey together with University of Zambia School of Mines and the Geological Survey Department of Zambia. The work resulted (among other things) in an environmental-geochemical atlas (Czech Geological Survey 2007). A follow up project ran between 2008 and 2010 under the name "Assessment of impacts of mining and mineral processing on the environment and human health in selected regions of the Central and Copperbelt Provinces of Zambia". The later project also included geochemical mapping of Kabwe (Czech Geological Survey 2008) and was implemented by the same actors as the previous project.

The two development co-operation projects funded by the Czech Republic have not mitigated any of the environmental impacts from mining. The projects have, however, provided excellent background knowledge on the extent of the problems related to soil contamination, stream sediment pollution and effect on agricultural products. It is desirable that results from these projects are used by government administrative units in their efforts to coordinate environmental management and promote public awareness.

## Danish International Development Agency (DANIDA)

DANIDA's support to Zambia has to a large extent been focused on the water and sanitation sector. Since 2005, the water sector has received substantial support through the Water Supply and Sanitation Programme Support Phase 1 and 2. Danish support on environmental issues has been through the Environmental and Natural Resource Management and Mainstreaming Programme (ENRMMP). The program ran between 2009 and 2013 and aimed firstly at strengthening the capacity of the Ministry of Lands, Environment and Natural Resources by providing policy and legislative frameworks to mainstream environmental management. Part of the support was also implemented by setting up a Civil Society Environment Fund to ensure effective participation of NGOs in environmental management issues. At least one project granted through the Fund was related to mining and the environment (Zambia Institute of Environmental Management 2012).

## Finish Department for International Development Cooperation (FINIDA)

FINIDA has co-financed environmental support with DANIDA and also stood behind the ENRMMP project and the Civil Society Environment Fund.

#### Swedish International Development Cooperation Agency (Sida)

In late 1990s, Sida together with Luleå University of Technology funded an extensive research study on the geochemistry of the Kafue River (Pettersson 2002). The results of the study gave valuable knowledge on the natural behavior of the river as well as the extent of the impacts from mining.

Sida has also funded an environmental monitoring programme for the Zambezi River through the Zambezi River Authority with technical support from Stockholm Environment Institute (SEI). The support was followed up together with Denmark (DANIDA) and Norway (NORAD) in a project between 2006 and 2009 that aimed at creating an Integrated Water Resources Management strategy and implementation plan for the Zambezi River Basin. Sida also funded an International Training Programme on Integrated Water Resource Management in the Zambezi Basin between 2006 and 2010. The Swedish support to the Zambezi will likely continue together with the World Bank through a CIWA (Cooperation in International Waters in Africa) project between 2013 and 2018 (www.icp-confluence-sadc.org/icpriverbasinactivity/256/105).

In 2013, a new research project related to mining and the environment in Zambia received funding from the Swedish Research Councils U-forsk programme (www.vr.se). The research will be conducted by the Swedish University of Agricultural Science, and the name of the project is "Towards green economic development in Zambia: forest rehabilitation of abandoned mining areas".

#### SUGGESTIONS FOR FUTURE WORK

To improve the environmental management of mining related impacts in Zambia a couple of suggestions for future work are identified in this pre-study. The suggestions range from large general topics to smaller strategic tasks.

#### Mitigation and monitoring of historical legacies

The work conducted within the Copperbelt Environment Project showed that (although environmental problems resulting from historical mines are generally less severe than what could have been expected) there is no "walk away" solution to the problems related to disused tailings facilities. In an ideal world, all mining areas should be completely rehabilitated. However, it is highly questionable if the benefits of total rehabilitation motivates the excessive cost of doing so.

Nevertheless, it is strongly recommended that continuous monitoring is established and that maintenance efforts are looked over. At least the facilities that made the high priority list within the CEP project should be monitored, these include:

- TD10, Mufulira
- TD25, Kitwe
- Old Dam, Luanshya
- Akatiti TD, Luanshya
- Chonga TD, Luanshya
- TD33c, Nkana
- TD8, Mufulira

A Topic Report on Geotechnical Issues was prepared within the CEP project. The report makes suggestions for engineering works aiming at preventing erosion (and thus siltation of receiving waters), structural instability and overtopping. Future work should take up where the CEP project left off.

A great deal of attention and hard work has already been put into assessing the environmental impacts from historical mines in Zambia. Information on soil contamination within the Copperbelt and also the Kabwe area is abundant. However, there seems to be a lack of knowledge and/or interest in actually letting the data come to use. A suggestion is to strongly promote the work that has already been made, especially for local administrative authorities like the city and municipal councils. Above all, the work done on to which extent industrial pollution affects agricultural plants should be promoted and the information used for adequate planning.

## Improved control and management of operating and future mines

The work to clean up the active mining industry is a real challenge and actions are needed on many levels. Despite progress in recent years, environmental issues are still not integrated adequately or systematically in Zambia's national development process. As long as environmental protection is viewed upon as a threat to development, there is a chance that limited initiatives in this field will not achieve much. Several suggestions, apart from the obvious one of mainstreaming environmental issues on a national level, are made here.

#### Better implementation of existing environmental legislation

The responsibility of environmental legislation is carried out by almost ten line ministries which naturally pose a major implementation challenge. The situation is changing for the better and through the relatively new Environmental Management Act (2011) ZEMA has a comprehensive environmental management mandate. However, ZEMA suffers from inadequate resourcing to fulfill its mandate and has insufficient staff to adequately pursue compliance monitoring and auditing. The lack of effective control of the mines environmental performance leaves the existing legal framework to a large extent unimplemented. For better implementation of the legislation, surveillance of the industry is much needed.

A suggestion to support ZEMA's monitoring work, without directly contributing to the staff body, is to install automatic monitoring stations that measure water quality downstream of point sources. Such stations can be run by solar panels and be equipped with for instance sensors measuring pH, conductivity and turbidity. Measurements can be done every hour and the results can directly be seen online. The system can also be programmed to set alarms when water quality parameters exceeds set limits, and thus the nearest drinking water plants can be warned in case of large spills and authorities can put pressure on the mine operators.

#### Improved quality of Environmental Impact Statements and Management Plans

The EIA performance is improving, but the quality of the reports remain rather low. A checklist of required topics is frequently deemed sufficient, and the EIAs are routine procedure rather than well-advised individual applications. This is a severe concern since mining operations can differ substantially in their environmental impacts depending on geology and other factors. At least the following should be done to help ZEMA and the Mines Safety Department to put higher demands on quality of impact statements and the attached management plans:

• The sector specific guidelines for mining projects prepared by ZEMA should be overlooked according to international standards and preferably together with the Mines Safety Department.

- Technical guidelines on waste characterization must be compiled. The need for better knowledge on how to characterize and thereby properly handle mine waste is crucial, especially when mining projects are being considered in places with different geology than in the Copperbelt.
- Technical guidelines on best practices of mine water management are desirable. To early identify options and initiatives for water conservation and management is very important, especially for mining in regions were water resources are scarce.

The authorities in Zambia would also benefit from comparing technical best practice methods with advanced mining countries. For instance, advanced techniques for flue gas purification and dust prevention is not commonly used by the Zambian mining sector.

#### Technical and geoscientific capacity building

The Environmental team at the Mines Safety Department is in need of increased technical and geoscientific knowledge to adequately execute its sector authority when reviewing mining EIAs. The department has existed for a long time, under which most of it environmental management was not considered an issue. Since the authority now has an enhanced mandate for environmental management and the responsibility keep growing along with the mineral sector, the need for re-orienting the staff is obvious. As a suggestion technical and geoscientific training should first be provided on chosen topics, and secondly the knowledge should be followed up and implemented by assistance in real reviewing cases.

There is also need for broader capacity building on radiation risks related to uranium mining. Workshops with ZEMA, Mines Safety Department, NGOs and other interested parties are suggested. From interviews with representatives from ZEMA, environmental consultants and NGOs, it is concluded that the concern for risks of uranium mining is real and the knowledge poor.

#### Good water governance

Good water governance is a key issue for sustainable development in most countries, and Zambia is no exception. A large World Bank funded project is just starting up in Zambia to support the implementation of an integrated framework for development and management of water resources (www.worldbank.org/projects/P114949/zambia-water-resources-developmentproject?lang=en). One component within the project is to strengthen the institutional capacity for water resources management and development, which is much needed. When it comes to water issues the responsibilities between different government institutions is today unclear. ZEMA is responsible for monitoring the water effluents from mines, Mines Safety Department has the sector specific responsibility for the mines environmental performance and the Department of Water Affairs has the overall responsibility for national water quality except for certain water bodies where the Zambezi River Authority is responsible. The coordination, and more importantly, the cooperation between the different organizations need to be improved.

The Department of Water Affairs is the state institution who should take on a leading role in all water related issues. The department has up until recently mainly focused on water quantity and not quality, and therefore the work load of water monitoring has ended up on other institutions. Since the department is aiming to improve their water quality performance, capacity building is essential. Technical assistance can be provided to the department in the following ways:

• Technical training including basics of water geochemistry, the coupling of background values to regional geology, sampling and measuring techniques. Preferably this is done by imple-

menting a monitoring project such as setting up a baseline survey in the manganese province Luapula.

• Creating a GIS database for water quality. Extensive water quality data already exist from for example the Kafue River, but nearly all of that data collected through different development projects is spread out and not easily accessible. For example all the data sampled within the Copperbelt project is found in a database belonging to ZCCM-Investment Holdings newly formed consultant company. A major contribution to the water sector would be to compile all the data and make it publicly available.

These suggestions can probably be made parallel to the World Bank initiative without interfering as they will most likely focus on management practices rather than technical training. Coordination with the large project is however needed before taking action.

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