

ENVIRONMENTAL MANAGEMENT IN CHROME MINING ALONG THE GREAT DYKE: A CASE STUDY OF ZIMASCO OPERATIONS

Tendai Chakupa

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Supervisor: Mrs Zahn Munch

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Declaration

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ABSTRACT

In an area where mining activities dominate, there are likely to be problems that need effective environmental management approaches, which can be facilitated through legislation and environmental management systems (EMS). The Great Dyke in Zimbabwe is a strategic economic resource with significant quantities of chrome and platinum. Chrome mining occurs across the whole length of the Great Dyke with most of the operations under Zimasco claims. Zimasco mining operations fall into two categories: the organization's own claims operated in its own right and claims that are leased out to a second party forming a tribute system from which tributor miners produce chromite ore exclusively for Zimasco.

This study examines the environmental management approaches used by Zimasco operations, in particular the National Occupational Safety Association (NOSA) Integrated Five Star System, in order to identify the usefulness of EMS in the mining industry. Firstly, the current environmental impacts associated with the mining activities were identified and problem areas highlighted, after which environmental management approaches linked to national legislation were examined in terms of their contribution towards sound environmental management. A legal compliance checklist was carried out on the existing mines to assess levels of compliance to standards stipulated in the Environmental Management Act Chapter 20:27. This was followed by questionnaire surveys used for impact identification and the data was analysed using the aspect and impact analysis matrix. Underground mines with effluent discharges were assessed by means of an effluent analysis as a way of determining the effectiveness of the approaches on the mines. Recommendations for changes were made following a Strength Weaknesses Opportunities and Threats (SWOT) analysis of the approaches and system. Major environmental problems highlighted included unattended waste rock dump and pits as well as dissolved substances in effluent discharge. Although evidence of compliance to environmental legislation for the mining operations was found at administrative level, this was often not executed in operation. Limited hazards were observed in effluent discharge from mines under full implementation of the EMS.

It is recommended that all mining operations need to be covered by an EMS system for improved environmental management and sustainable development. Effective implementation of legislation and EMS on the ground provides a better platform for sound environmental management.

OPSOMMING

In „n area waar grootskaalse mynbou aktiwiteite die omgewing kan affekteer word effektiewe omgewingsbestuur benodig. Die Groot Dyk in Zimbabwe is „n strategiese ekonomiese hulpbron met groot hoeveelhede chroom en platinum. Chroom word grotendeels onder Zimasco kleims langs die Groot Dyk ontgin. Zimasco mynbedrywighede val in twee kategorieë: eerstens eie kleims wat direk deur Zimasco bedryf word, en tweedens kleims wat aan „n tweede party verhuur en bewerk word en chroom eksklusief aan Zimasco lewer.

Die omgewingsbestuursbenadering wat deur die Zimasco mynbedrywighede gebruik word, veral die NOSA Geïntegreerde Vyfster Stelsel, is bestudeer om vas te stel of omgewingsbestuurstelsels (OBS) effektief kan wees in die mynbedryf. Eerstens is die huidige omgewingsimpte veroorsaak deur mynbedrywighede geïdentifiseer en probleemareas uitgelig. Verder is die omgewingsbestuursbenadering in die lig van nasionale wetgewing bestudeer om die bydrae tot gesonde omgewingsbestuur toe te lig. „n Lys is opgestel waarin die mate waartoe geselekteerde myne aan bestaande wetgewing voldoen bepaal is. Vraelyste is ook gebruik om die omgewingsimpak te identifiseer en data is met behulp van die aspek en impak analise matriks geanaliseer. „n Afvoeranalise is op ondergrondse myne gedoen ten einde die effektiwiteit van omgewingsbestuursbenadering op die myn te bepaal, terwyl „n SWOT analise van beide die benadering en die NOSA Vyfster Stelsel uitgevoer is met die oog op aanbevelings.

Die belangrikste omgewingsimpakte langs die Groot Dyk sluit in: afvalrotshope, kuipe en slote vanaf oppervlakbedrywighede asook opgeloste afval in afloop vanaf ondergrondse myne. Bewyse van voldoening aan omgewingswetgewing is wel gevind in myndokumentasie, maar nie altyd in die praktyk nie. Laer vlakke van toksiese uitvloeiels vanaf myne waar OBS geïmplementeer is, is bewys van die suksesvolle gebruik van „n geïntegreerde OBS.

Alle mynaktiwiteite moet ingesluit word in „n OBS stelsel om beter omgewingsbestuur en volhoubare ontwikkeling te verseker. Effektiewe implementering van wetgewing en OBS op die laagste vlak in mynaktiwiteite bied „n beter platform vir gesonde omgewingsbestuur in die mynbedryf.

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ABBREVIATIONS AND ACRONYMS

AMMZ	Associated Mine Managers of Zimbabwe
BMI	Business Monitor International
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
EIA	Environmental Impact Assessment
EMA	Environmental Management Act
EMAg	Environmental Management Agency
EMS	Environmental Management System
NOSA	National Occupational Safety Association
IMS	Integrated Management Systems
ISO	International Organisation for Standardization
SHE	Safety, Health & Environment
SI	Statutory Instrument
TDS	Total Dissolved Substances
TSS	Total Suspended Solids

CHAPTER 1: INTRODUCTION

In any mining operation a sound underlying environmental management system is imperative in the sustainable management of resources and sustainable global development. Numerous environmental impacts have to be monitored constantly and consciously, hence the need for environmental management.

Zimasco Private Ltd (hereafter called Zimasco) mines chrome along the Great Dyke, an important geographical and geological feature in Zimbabwe, and has both surface and underground operations. The Great Dyke is a strategic economic resource with significant quantities of especially chromite and platinum and other minerals including nickel, copper, cobalt and gold.

Zimasco has direct and indirect chrome ore mining operations across the whole length of the Great Dyke. The direct operations are those mines solely run by Zimasco and indirect operations refers to those mines leased out to second part known as a tributor. These operations include:

- underground mining at Shurugwi and Lalapanzi (South Dyke);
- open pit mining in Mhondoro Ngezi (Middle Dyke); and in Shurugwi
- adit and underground mining at Mtorashanga (North Dyke).

The locations of these mineable areas (not the specific mines) of the Great Dyke are shown in Figure 1.1 below on the area highlighted as the Great Dyke.

Most of the mines in the Northern & Middle Dyke division are operated under the tribute system, however in the lower part of the dyke there are large underground mines operated directly by Zimasco, a large scale tributor. Small scale tributors were previously referred to as cooperatives where two or more individuals could obtain a lease of a mining operation. Consequently there is great need to establish specific environmental management approaches and systems in such establishments.

The mining operations are distributed randomly along the Great Dyke of Zimbabwe. There is evidence of environmental problems due to past mining in the Great Dyke; as noted in Piha &

Shoko (2000). Maponga & Ruzive (2002) attributes major environmental problems to poor mining methods, waste storage, and disposal systems as well as daily activities associated with tribute mining along the Great Dyke. Unsystematic dumping of waste and haphazardly located dumping sites are causing problems such as erosion and pollution in water bodies (Maponga & Ruzive 2002). Most of the mining operations of Zimasco are undertaken on different scales and if not carefully monitored, such operations may not fully comply with environmental policies of the company.

For large mining operations such as Zimasco environmental management systems and procedures are important to attain both the good image of the organisation and a safe environment. Therefore, there is a need to establish how environmental management measures are implemented on the direct and indirect operations (tribute). Zimasco has a system in place which specifies its environmental management procedures. It follows the NOSA Integrated Five Star system which is administered by the National Occupational Safety Association (NOSA) and integrates three core aspects, namely safety, health and environment. It is Zimasco's responsibility to ensure environmental management and compliance to both environmental and national legislation and this can be achieved by implementing an environmental management system or a safety, health and environmental system.

In Zimbabwe environmental issues are considered to be important and the regulatory structure in the country supports environmentally friendly mining management. The mining industry is principally regulated by the Ministry of Mines and the Chamber of Mines through the Mines and Minerals Act. However, as outlined in the BMI (2010), environmental issues in mining are attended to at a project inception and developmental stage through the Environmental Management Agency. The main instrument used for environmental management is the Environmental Management Act Chapter 20:27 of 2003.

Great emphasis is placed on mining environmental management, mainly because mining at all levels, whether on great or small scale, has a negative environmental impact that need to be accurately monitored and managed. As such it becomes the role of the governing agencies and developers to ensure mitigation of negative environmental impacts. Maponga & Ngorima (2003) suggests that if appropriate measures are put in place, environmental management can be enhanced. It is therefore within this context that the researcher aims at analyzing existing measures in the chrome mines to determine if effective environmental management is

maintained. Although this is an area that is well researched and documented, it is the researcher's belief that mining is an ongoing, dynamic activity that is executed in an environment that is also constantly changing. Therefore environmental management cannot be a once off activity and existing measures need to be strengthened continuously while new measures need to be invented or developed on a regular basis.

Mineral resources are classified under non-renewable natural resources; hence the concept of sustainable development needs to be an underlying influence in mining environmental management. Mining can potentially have a negative impact on the environment and possibly result in the pollution of freshwater systems through effluent discharge, air pollution from dust and chemicals, land degradation from surface mining approaches, underground water pollution from slime dams and leachates. However, sustainable development through sound environmental management can be achieved in mines if appropriate measures are developed and implemented. According to Hilson & Murck (2000), improved implementation of environmental management tools and cleaner technologies, among other factors, can improve performance in environmental and socio-economic arenas and consequently foster sustainable development. It is therefore important to note that environmental management is an important aspect of the sustainable utilization of mineral resources without compromising its availability for future generations. Sengupta (2000) considered mining to be very unique in the sense that one cannot choose where to acquire the mineral, given that it is very dependent on its availability, (for example some operations can be found in ecologically sensitive areas) as a result appropriate measures need to be implemented at any given place.

Mining has been very important in the growth of Zimbabwe's economy; Holloway (2000:16) stated that "mining has played a pivotal role in the economy of Zimbabwe from pre-colonial times". The Mines and Minerals Act (Chapter 21:05) enabled many mining operations to become established in the country, including a number of small scale miners, particularly chrome and gold miners. Small scale mining is prevalent along the Great Dyke and may continue with the implementation of the law on indigenization / black empowerment. Large companies with large claims have resolved to engage small scale and medium operators to mine chrome and sell it to them at a negotiated price. Current labour statistics indicate that tributors amount to two thirds of the total number of employees (Chibvuri 2010).

Each stage of mining involves a series of activities with a potential negative impact on the environment if measures are not put in place to manage them. Sinding (1999) identified the different phases/stages of mining as “exploration, development and construction; production; and decommissioning and post-production activities”. These stages are standard for most mining operations, but they vary in level and method of operation. Chrome mining, for example, varies from simple surface extraction to the most complicated underground operations, depending on the occurrence and level of the chrome seam. Environmental management can therefore vary in degree of complexity, depending on the level of operation. It is crucial that each phase of operation is carefully planned, as a failure to do so can lead to degradation of the environment and poor management of mineral resources.

1.1 RESEARCH PROBLEM FORMULATION

Given the importance of environmental management in the prevention of degradation of the environment, several questions have been identified:

- a. What are the environmental impacts associated with chrome mining in the Great Dyke of Zimbabwe?
- b. What are the legislative and policy frameworks governing chromium mining in Zimbabwe?
- c. To what extent are the mining operations at Zimasco complying with the existing legislation and policy?
- d. What is the nature of the environmental management approaches being used by Zimasco and its tributors?
- e. What are the challenges associated with the implementation of the environmental management systems or programs by Zimasco and its tributors?

Laws governing environmental issues in Zimbabwe were, just like in most other Southern African countries in the past, known to be too fragmented and overlapping and therefore difficult to enforce (Holloway 2000, Maponga & Ruzive 2002, and SAIEA 2003). The laws and regulations have however since been revised. In Zimbabwe the Environmental Impact Assessment (EIA) policy was implemented in 1997 and in 2002, and upon realization that the policy had its weaknesses, the Environmental Management Bill was drafted (SAIEA 2003), followed by the Environmental Management Act (Chapter 20:27) which was enacted in 2003

(SAIEA 2003). The Environmental Management Agency was then formed as a governing board overseeing all environmental management issues through the new act.

Many of the problems previously encountered in mining environmental management could have been a result of weaknesses in the laws governing environmental issues. The environmental management agency in Zimbabwe ensures that all mining operations undertake EIAs and carry out rehabilitation measures on mining sites (Environmental Management Act Chapter 20:27). Some of the operations started after the law had been enacted and as such, compliance with legislation should be one of the major factors contributing towards sound environmental management and mining sustainability in general.

Whilst mining operations are largely done under the tribute system, the claim holders are the ultimate custodians of the environment, and apart from regulatory requirements, they have their own system and best practices dealing with environmental issues. In the tribute agreements, environmental rehabilitation is made the responsibility of the tributors (Piha & Shoko 2000). However, according to the Mines and Minerals Act (Chapter 21:05), the final liability of the claims and their environmental restoration lies with Zimasco. According to Maponga & Ruzive (2002), an “unsystematic dumping of waste” occurs, which implies that there are no environmental measures in place at most of the tributor operations. It is therefore in Zimasco’s interest that tributors adhere to the agreement (Piha & Shoko 2000), which also leaves a question whether these agreements provide enough ground for environmental management.

The research focused on determining the nature of the environmental management approaches employed by Zimasco, and examining their support of environmental and mining sustainability. In order to investigate this, specific aims have been identified, as described in the following section.

1.2 AIM AND OBJECTIVES OF THE STUDY

The main aim of the study is to analyse the existing measures at Zimasco mining operations to see if it leads to effective environmental management. To achieve this, a set of objectives have been formulated:

1. to establish the environmental impacts associated with Zimasco mining operations along the Great Dyke;

2. to determine the value of implementation of environmental legislation in environmental management in Zimbabwe;
3. to determine the environmental management approaches used on the mining operations;
4. to assess the usefulness of these environmental management approaches in addressing environmental impacts resulting from the mining operations; and
5. to recommend potential growth areas within the company with regards to environmental management.

1.3 SCOPE OF THE STUDY

Considering that the main aim of the study is to analyse the existing environmental management measures employed by Zimasco on their chrome mines, categorization and extent of environmental damage on the Great Dyke is of limited use, however references to past studies on the extent of damage will be consulted. This research is aimed at addressing impacts arising on the mine sites rather than the entire environment of the Great Dyke, with the intention of analysing environmental management approaches specifically addressing those impacts. This is because environmental management measures are best applied to address impacts at its source (Stapleton et al. 2001). As such, sample analysis was only limited to effluent at the point of discharge from the mine sites, to determine whether pollution of water bodies and the land is likely to result from the mines.

The geological details of the Great Dyke are discussed because they determine the nature and method of mining that occurs. The Great Dyke contains a number of mineral resources such as platinum and gold, and its geological component may be mentioned to further explain the need for environmental management and the subsequent sustainable extraction of these resources.

It is not within the scope of the study to scrutinise any other operations apart from those under Zimasco claims and name. This is important to note because there are a number of mining organizations operating within the study area. Data on other mining operations may be discussed in the light of the general impacts of mining on the environment in the study area.

1.4 STUDY AREA

Mining operations under Zimasco claims in the North and Middle Dyke cover the area from Guruve Impinge to Mhondoro Ngezi, as highlighted on the map in Figure 1.1 below. The North Dyke consists of Guruve, Impinge and Mtorashanga areas, whilst the Middle Dyke consists of Darwendale and Ngezi. According to an environmental study carried out in 2000 for the North Dyke, the chrome claims on the North Dyke only covers 300km of the land (Piha & Shoko 2000). Administrative issues of the North and Middle Dyke are conducted at the central offices in Mtorashanga where environmental management concerns of the division are also dealt with.

Following the Bushveld igneous intrusion in South Africa, the Great Dyke is second in holding the largest reserve of platinum and is endowed with world class chrome ore reserves (BMI 2010). It is estimated that the chromitite layers represent a resource of about 10 billion tonnes of chrome ore (Piha & Shoko 2000). Estimates show that Zimbabwe hosts over 80% of the world's resources of the metallurgical chromites, mainly on the Great Dyke. Chrome seams are found on the 540km length of the Dyke. The Great Dyke also contains a number of economically important minerals, most of which have been under extraction since 19th century. According to Prendergast and Wilson (1989) all of the minerals are hosted in the ultramafic sequence. Apart from chrome, other minerals found are the platinum group elements (PGE), as well as gold, nickel, asbestos, magnetite and copper.

It is its features and structure that makes the Great Dyke useful in the geology, geography and economy of the country. The Great Dyke is a unique geological feature, which outcrops as a narrow linear body that traverses most of Zimbabwe in north-north east direction. It is estimated to be 550 kilometres long and between three and eleven kilometres wide (Nyamukondiwa 2005). In extreme cases it can stand out from the surrounding areas by as much as 1100 meters, while in other areas it is indistinguishable from the surrounding topography. It is also strongly enriched in a range of relatively rare elements other than chromium such as platinum, palladium, rhodium, ruthenium, nickel and gold, as such it is of great economic importance to the country. Figure 1.1 illustrates the extent and location of the Great Dyke.

According to Mukasa et al. in Piha & Shoko (2000), the dyke represents a layered magma system largely composed of mafic and ultramafic rocks. Mafic rocks are rich in iron and

magnesium bearing minerals for example amphibole, pyroxene and biotite, but also contain moderately high quantities of calcium, silica and aluminium. Ultramafic rocks are strongly enriched in magnesium bearing minerals such as olivine and orthopyroxene. The stratigraphically controlled, systematic changes in the major and trace elements content of the rocks of the Great Dyke are significant with respect to the economic importance of certain rock horizons, and fundamentally influence soil types and vegetation patterns.

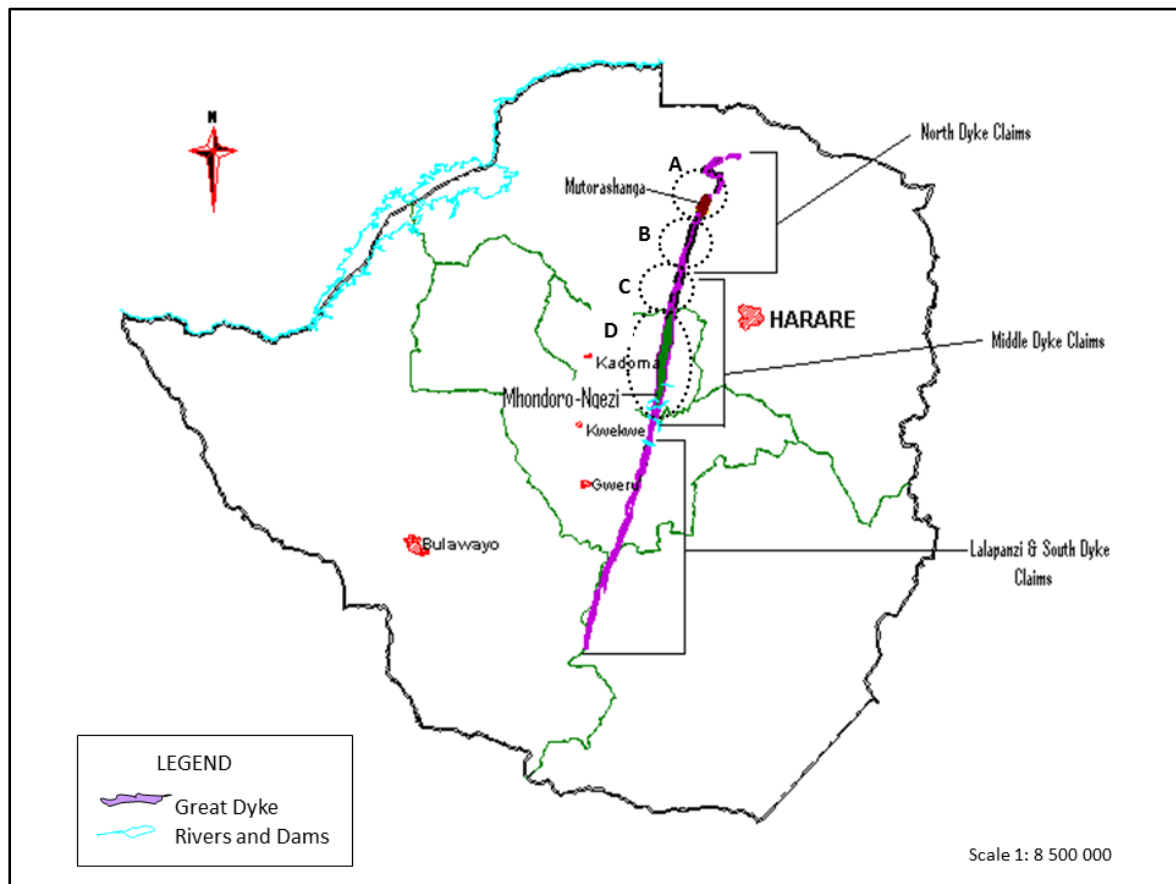


Figure 1.1: Location of the Great Dyke, showing its upper, middle and lower part

Chromium ores have been mined from the Great Dyke continuously since 1919 with some of the major mining activities being undertaken in Mtorashanga, Vanad, Sutton, Caesar (North Dyke), Mhondoro Ngezi (Middle Dyke) and Lalapanzi (South Dyke) (Nyamukondiwa 2006). Chromite output has been exported as unrefined ore for a long time until the 1950's, where after the smelters were established in Gweru, Kwekwe, and Kadoma. Some of the chrome was exported as refined alloy. At this time large producers included Zimasco and Zimbabwe Alloys, but currently Zimasco is the main producer of chrome ore. For a long time Zimasco operated as Union Carbide, but changes have occurred since it was bought from Union Carbide by local investors and today it is partly owned by Sinosteel, a Chinese company.

Currently claims owned by Zimasco accounts for 39% of the total claims along the Great Dyke (Chibvuri 2010). In this study the focus of investigation is on the North Dyke claims (labelled A and B), the Middle Dyke claims (labelled C and D) as well as the Lalapanzi and South Dyke claims as highlighted on the map in Figure 1.1.

1.5 RESEARCH DESIGN

The research design for the analysis of existing environmental management measures of chrome mining at Zimasco is shown in Figure 1.2.

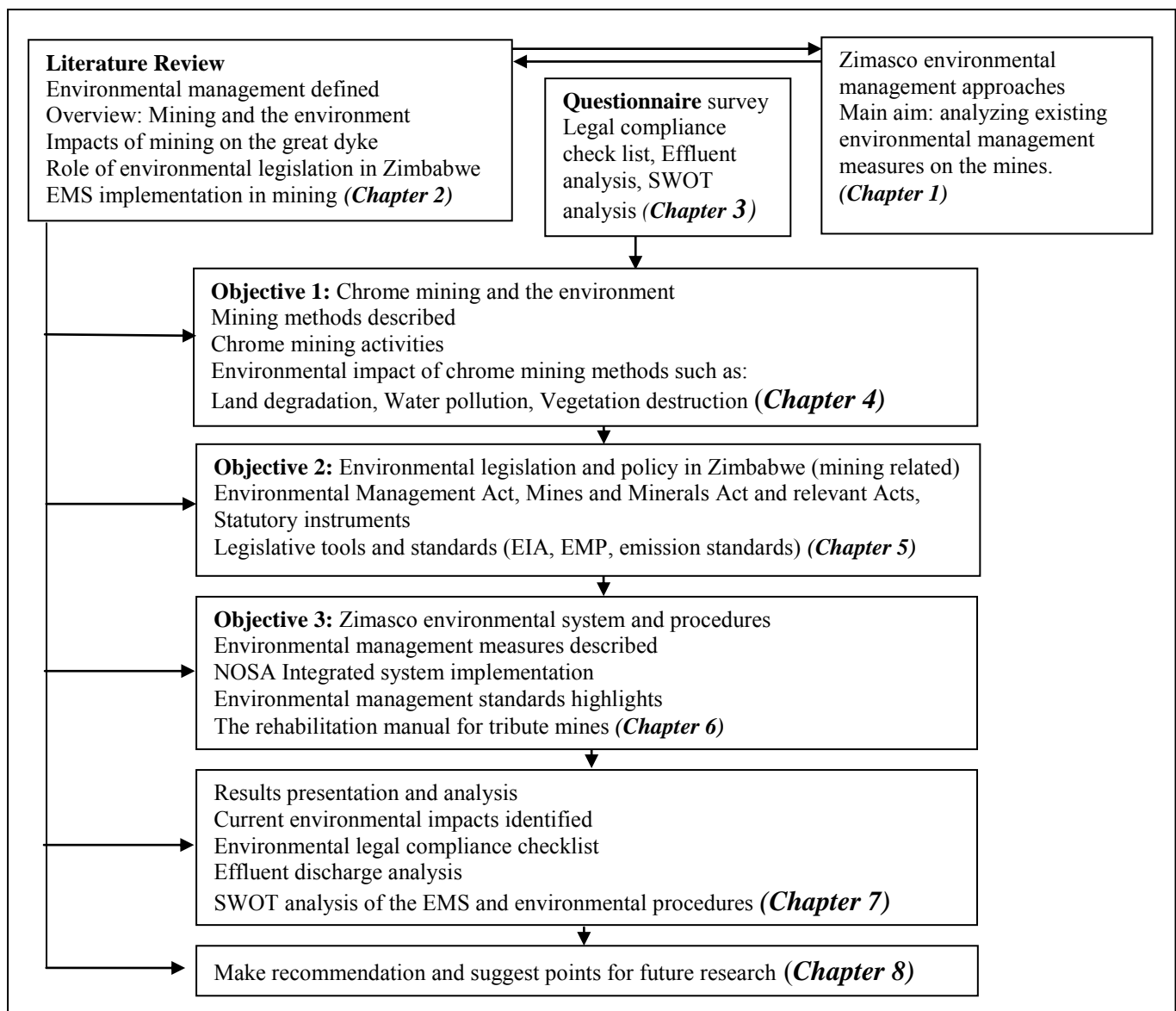


Figure 1.2: Research design

1.6 STRUCTURE OF THE THESIS

This report consists of eight chapters. Chapter 1 presents the introduction and background information to the assessment of the environmental measures and strategies employed in the chrome mining. It is in this chapter that the main aim of the study has been expounded, together with the subsequent objectives developed to achieve the main aim. The outline of the research design and methodology employed are described. A literature review then follows in Chapter 2, where literature relevant to the research problem is discussed, including general impacts of mining on the environment and as well as specific environmental impacts of chrome. The different strategies in environmental management, for example using environmental management systems such as ISO 14001 and NOSA integrated systems, are also outlined. This chapter furthermore examines how previous researches were carried out.

Subsequent chapters follow with discussions of each objective highlighted in Chapter 1. Different methods have been employed to meet the specific requirements of each objective and these are explained in Chapter 3. These methods included questionnaire surveys, practical assessment of legal compliance and practical effluent analysis from selected mines with major effluent discharge. In Chapter 4 the different chrome mining methods specific to the Great Dyke and their implications on the environment are reviewed, while Chapter 5 follows with a general overview of environmental legislation and policy framework pertaining to environmental management in Zimbabwe, with particular reference to mining and environment related aspects. In Chapter 6 environmental management approaches that are used on the mining operations are discussed. Of major importance are the safety, health and environmental system known as the NOSA Integrated Five Star System and the procedures for the indirect operations. A description of how the system is being implemented is also given. In Chapter 7 research results are reported and analysed in accordance with the main aim of the study. The final section (Chapter 8) outlines recommendations to Zimasco and ends with the summary and conclusion where the suggestions for further study are described.

Chapter 1 has provided the directions of the report and the background to the research problems, which suggested that mining is associated with high levels of environmental degradation and emphasises that measures are needed to safeguard the environment. In the literature review (Chapter 2) the nature of environmental management in the mining industry is outlined.

CHAPTER 2: ENVIRONMENTAL MANAGEMENT: A THREAT OR OPPORTUNITY IN THE MINING INDUSTRY?

The argument begins with what comes first in any extractive industry: whether to start with operations and consider environmental issues later or to take environmental issues into account initially. This is because the primary goal of any development is financial gain rather than any other concern. With the growth of developmental projects globally and associated detrimental effects on the environment, there has been an increase in the awareness, at both individual and corporate levels, of the importance of addressing environmental concerns prior to beginning an operation. The inception of the environmental impact assessment is one good example of the growing consciousness of environmental impacts on a global scale. There is a growing need for better living as well as a burning need to consider environmental implications of any project prior to its development.

The relationship between environmental practices and corporate performance has been a bone of contention for many organizations (Tinsley & Pillai 2006). There has been conflict between developmental goals and public demand for environmental protection, consequently environmental management has not been considered a part of the organizational structure, essentially due to the cost presumed for environmental management. Conflict always arises when the cost of environmental management exceeds economic gain. Consciousness about environmental issues is becoming more pronounced, with sustainable development increasingly promoted. This is described by the Brundtland commission in Chenje et al. (1998) as the need to meet present needs without compromising the future needs. According to Manjengwa et al. (1999), environmental conservation and development need not to be in conflict with each other. Kleiner (in Tinsley & Pillai 2006) argued that environmental regulators and scientists do not agree on what constitutes being a friendly environment and similarly managers do not have a common understanding of what environmental awareness means within their own companies.

2.1 DEFINING ENVIRONMENTAL MANAGEMENT

It is often difficult to define environmental management: Kotze & Nel (2009) argued that it means different things to different people, depending on the context being used.

Most of the things we do as human beings affect the environment in one way or the other and in this context we need to understand what environmental management entails. Generally it may refer to the way we use or exploit our environment, similar to any management practice such as financial management, which can be poor or good. Environmental management can simply be defined as sound environmental practices that lead to a safe and friendly environment. Tinsley & Pillai (2006) pointed out that environmental management improves environmental performance. They furthermore claimed that there are many benefits to effective environmental management, depending on how proactive the organization is, its willingness to learn, its innovation and its environmental integration.

Company managers and the general public are very much aware of need for sound environmental management but as outlined in Tinsley & Pillai (2006), they are not sure of its benefits or its use. This can be attributed to a general lack of environmental awareness. Several definitions have since been given by different authors (Kotze & Nel 2009, Tinsley & Pillai 2006, Barrow 1999), but because of the complexities in understanding what constitutes the environment, the definitions are quite numerous. In simple terms, environmental management can be described as another form of overall management strategy meant to enhance efficiency within an organization. However, for the purpose of this study the researcher will adopt the definition by Kotze & Nel (2009:5): “The planning, doing, checking and acting activities of ‘managers’ and ‘governing agents’ as they relate to either the green environment or combinations of green and brown environments”, where green environment comprises of all living things and brown environment refers to the physical and non-living things (Kotze & Nel 2009).

2.2 MINING AND THE ENVIRONMENT

Mining causes serious environmental problems on many different fronts if it is unchecked (Sinding 1999, Hilson 2002, Piha & Shoko 2000). However, with the incorporation of various measures of environmental management, several environmental problems can be dealt with before they become widespread and uncontrollable. Hilson & Murck (2000) noted that with good management practices in place, environmental management can be enhanced. Overall environmental performance of an organization is measured by a reduction in environmentally related problems, as indicated by the laws, regulations and environmental standards in place. Many organizations have adopted environmental management systems as

a tool in environmental management to facilitate compliance to laws and regulations (Tinsley & Pillai 2006).

A general overview of the impacts of mining and/or mineral resources extraction on the environment reveals that impacts could be positive and/or negative; this section will deal with the latter. It is important to consider at what stage mining and mineral resource extraction can be detrimental to the environment. In the following section the general impacts of mining on the environment are discussed, followed by a review of the different phases of mining and their interaction with the environment.

2.2.1 General impacts of mining on the environment

An old argument against mining is well defined by Agricola, a German scholar, based on his observations in the sixteenth century as highlighted in Bridge (2004). The scholar argues that the woods and the groves are destroyed because there is an endless need for wood for timber, machines and smelting of metals. And when the woods and groves are felled, beasts and birds are exterminated. Furthermore, when the ores are worked, the water which has been used poisons the brooks and streams and either destroys the fish or drives them away. These arguments therefore suggest that there is greater negative result from mining than the value that can be produced by mining. Jensen (2000:111) highlights the destructive nature of mining, yet describes it as a necessary evil: “mining seems to have been the bad boy of industry - forcefully tearing raw materials from the Mother Earth, leaving gaping wounds and deadly pools.” Jensen continues to say that “mining seemed to be indicative of Third World growth pangs, just like growth pangs in a teenager, much needed yet with unpleasant side effects”. From these descriptions of mining it can therefore be noted that no one can talk of mining and ignore environmental issues resulting from mining activities. Furthermore it affects all components of the environment, namely land, water and air (Eggert 1994). Habitats of local flora and fauna can be destroyed and other land uses such as agriculture, forestry and tourism are often prohibited (Eggert 1994). However, with good environmental management practices it is technically possible to deal with environmental problems associated with mining.

The reader is referred to Bridge (2004) for a detailed critique of mining activities and its impact on the environment. Four major areas, including earth moving, the big sink, ecosystems and the community will be highlighted below:

- a. Earth moving: mining as a physical landscape modification, where removal of top soil causes landscape degradation (Ghose 2003).
- b. The big sink: Mine wastes (BGRM 2001) can take the form of physical and chemical pollution. Figure 2.1 gives a schematic illustration of various mine wastes. Pollution resulting from mining can have detrimental effects even a hundred years after mine closure (Allan 1995). Problems usually associated with tailings, a type of mine waste, include water pollution, dam safety and stability and visual impact (Cooke & Johnson 2002).

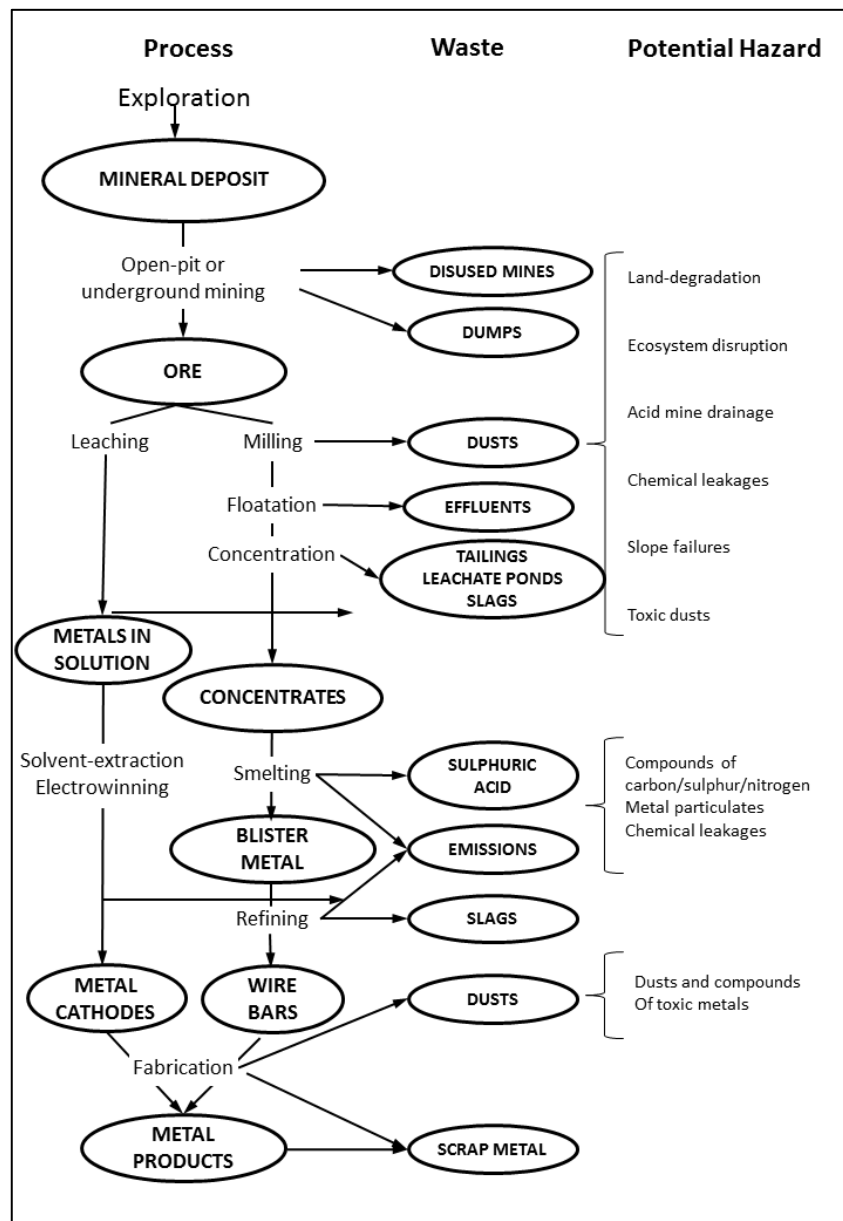


Figure 2.1: An illustration of how mining can destroy the environment throughout its lifecycle. Adapted from Warhust (in Bridge 2004)

- c. Ecosystems: Mining as a driver of regional and global environmental change. An argument was brought forward by Salomons (1995) and Holmes (2003) indicating that impacts of mining may seem smaller in scale when compared to agriculture and forestry, but the environmental impacts may extend well beyond the site. Allan (1995) asserted that contamination of terrestrial and aquatic ecosystems is largely a local problem, but a global concern. Sinding (1999) described mining phases that have significant negative interaction with the environment and need management as: exploration, development and construction, production, decommissioning and post-production activities. Hilson & Murck (2000) highlighted these stages as exploration, extraction and refining, and reclamation. It is believed that impacts at each phase of mining have the potential to drive environmental change in several ways at different scales (Ashton et al. 2001, Environment Australia 2000). Eggert (1994) asserted that mining and mineral processing produce waste products and ecological disruption which may generate potential environmental hazards at each stage.

Understanding how these stages affect the environment is the key entry point towards implementing sound environmental management measures. It therefore means that no stage can be overlooked when addressing environmental issues, particularly when undertaking an environmental impact assessment (EIA).

- d. Community: Mining and the social environment:

Human beings are adversely impacted by mining activities in a number of ways: labourers can be exploited socially and economically, leading to social upheaval and wars (Holmes 2003), health and safety issues are prevalent (Bridge 2004), while physical hazards may occur (Lombe 2003). Young (in Van Heerden 2006) identified physical threats such as diseases, trenches/holes in the ground, explosions and mudslides as having impacts on the local people if not addressed.

According to Veiga et al. (2001), a mining community can be regarded as sustainable if it adheres to the principles of ecological sustainability, economic vitality and social equity. It is further explained that these principles span throughout the lifecycle of a mine to the post-closure period. Mining companies are supposed to leave a lasting legacy to the communities, which many do not incorporate in their planning stages.

Especially small scale mining communities are affected by the lack of incorporating environmental sustainability principles described in Viega et al. (2001) in some African countries such as Tanzania (Straaten 2000) and Zimbabwe (Maponga & Ngorima 2003).

Having looked at the general impacts of mining on the environment, the focus now moves to the level of environmental degradation associated with chrome mining in Zimbabwe. This could mainly be attributed to the different methods of mining employed and probably the levels at which mining operations occur within the country. Chrome mining of particular interest in this study has been associated with small scale mining operations (Ashton et al. 2001, Piha & Shoko 2000).

2.2.2 Specific environmental impacts associated with chrome mining

The environmental impacts as a result of chrome mining emanate from the chemical composition of chrome, mining methods employed, level of operation and waste disposal systems.

Chromium in its various states can be very toxic to plants as well as human beings (Saner 1980). Chromium in excess of 200mg per day and levels in excess of 0.005mg per litre in drinking water can lead to dermatitis, penetrating ulcers, perforation of the nasal septum and inflammation of the larynx and liver. Continued exposure has been associated with an increase in bronchial cancer (Saner 1980).

Major challenges in poor waste disposal have been noted by Maponga & Ruzive (2002), which could result in a chain of other problems, such as destruction of vegetation and retardation of any regeneration of slope along the Great Dyke, siltation of rivers linked to river morphology (Ruzive 2000), erosion and sedimentation of watercourses (Ashton et al. 2001), underground and surface water pollution (Chirongoma 2007).

There are both underground and surface mining along the Great Dyke. Surface methods include strip mining and “pig routing”, which involves rudimentary methods such as picking chrome ore lumps with hands. “Pig routing” can be used where chrome seams are exposed near or onto the surface (Worst 1960). The primary hazards associated with this method of mining are the shallow trenches and holes (associated with “pig routing”), deep trenches and removal of large areas of topsoil (Piha & Shoko 2000). Underground methods involve the

use of shafts and adits. Adits are small, unventilated cuts which follow seams for a short distance of about 300m, these have a shorter mine life as compared to the inclined shafts. Inclined shafts may go as deep as 700m and mine life is usually 20 to 30 years. The primary effect of these underground methods is the creation of large dumps, but vegetation clearance is often localized. Piha et al. (1997) observed that the environmental impacts associated with these mining methods included siltation of water bodies, vegetation destruction, noise and dust pollution, water pollution and aesthetic intrusion.

There has been a strong link between environmental degradation along the Great Dyke and the type of mining operations that are undertaken. Zimasco operates on two major levels: the first is the claim owner; the second is the tributor and/or contractor. The tributors can operate on a larger scale or smaller scale. Small scale tributors dominate the area in terms of numbers and these are often associated with “pig routing”. In the environmental assessment study by Piha & Shoko (2000), large scale tributors are described as operations whereby part of the chrome is mined using inclined shafts, whereas “pig routers” can also use small adits and shafts and bring the ore to the surface by hand. According to Maponga & Ruzive (2002) most of the environmental problems are attributed to the nature of tribute agreements. However, the management, environmental monitoring and mine closure ultimately rest with the claim holders. The claim holders have their own health, safety and environmental policy and employs people to ensure that the tributors working on their claims adhere to legislation and general mining practices (Piha & Shoko 2000).

Small scale mining has characterized most of the rural areas of the developing world and in Africa in particular, but many of the studies carried out on small scale mining were mainly on gold production. Small scale mining is often associated with low-technology mineral extraction and processing; this has however formed and created wealth in rural Africa (Hilson 2002). Environmental problems emanating from activities by these small scale miners are associated with poverty (Maponga 1995, Lombe 2003). In Zambia for example, Kambami (2003) contended that small scale mining operates at rudimentary levels where basic tools are used to extract minerals, mainly because they cannot afford any form of mechanized equipment. The environmental implications of small scale mining operations in most of the developing countries may not be seriously addressed because it is the source of livelihoods to many rural communities. Estimates showed that in the Southern African region, 30% of the mining outputs is contributed by small scale miners and it accounts for 90% of all mines

(Lombe 2003). The report from the World Business Council for Sustainable Development 2002 on Artisanal and Small Scale Mining in Ali (2009) showed that about 80-100 million people in the developing world depend on small scale mining. There is a significant contribution from small scale mining to the socioeconomic wellbeing of people in rural areas (Ghose 2003), however the author argued that the environment is often disregarded industry-wide. Ali (2009) asserted that small scale mining, as compared to large scale mining, provides a livelihood to many people, but the incomes tend to be sporadic and coupled with poor regulation of environmental and safety issues.

Apart from poverty as the underlying factor in environmental problems associated with small scale miners, the issue of poor regulation and a lack of legislation in most of the developing countries have led to the prevalence of negative environmental impacts. Where the legislation exists, there is poor monitoring by law enforcing agencies, in many cases the government. There have been illegal operations by small scale miners in many developing countries; however more of these cases were reported in gold and diamond mining, for example in Zimbabwe (Maponga & Ngorima 2003, Maponga & Anderson 1995).

From the definition of environmental management that has been adopted for this study (Kotze & Nel 2009), it shows that environmental management involves the participation of environmental managers and governing agencies alike in dealing with environmental issues. It is within this scope that the next section will discuss the different ways in which governing agencies and environmental managers deal with the environmental aspects of their operations. An overview is given of environmental legislation and environmental management systems as they have been applied in mining environmental management.

2.3 ENVIRONMENTAL LEGISLATION AND MINING: AN OVERVIEW

“For centuries denuded landscapes, fouled streams and dirty air were accepted by the society as part of the price that had to be paid for mineral production. Even environmental legislation devised by industrialized countries in the 1960’s and 1970’s was largely designed without mining in mind.” (Eggert 1994:133) This author continued by saying that “with the advent of sustainability in the 1990’s, times have changed” and “current policies are under rigorous review and mineral rich developing countries are designing environmental policies where none existed before”. The above quote shows that for a long time mining has been causing environmental degradation and water and air pollution have been greatly associated

with mineral production. These problems are the same problems that we are facing today and most of the effects that have not been addressed for centuries are now being felt, for example global warming resulting in global climatic changes. Thus, some of these irreversible problems resulted from several centuries of what the researcher would call environmental ignorance.

Upon realization of the need for environmental protection, environmental legislation and regulations were established. Developed countries (the European community and the United States of America) were pioneers in the successful development and implementation of this approach. Zimbabwe has joined other countries in signing to international environmental conventions and formal agreements committing them to address environmental issues of common interest. With the development of an environmental conscience, government at all levels were prompted to control the depletion of natural resources and environmental damage (Sengupta 2000). A common problem is that the majority of developing countries have only recently implemented national environmental legislation, and of the laws pertinent to mining related activity, most are far from stringent, and fail to effectively regulate all aspects of the industry accordingly (Hilson 2002).

Maponga (1995) noted that Zimbabwe does not suffer from lack of environmental regulations, but rather from lack of effective implementation power. Some of the noted problems included shortage of manpower, while expertise and lack of transport were the major constraints which hindered monitoring environmental compliance in the country. However, environmental legislation in Zimbabwe has a history of being too fragmented and contradictory (Maponga 1995, Maponga & Ruzive 2002, SAIEA 2003). This was mainly because the term “environment” was not clearly defined by legislation as it was divided into land, water and air. Many parts of legislation were in place to address these different facets of the environment with the principal agency responsible for environmental management being the Ministry of Natural Resources and Tourism acting through the Natural Resources Board. The Mines and Minerals Act had overall authority over the mining sector (Maponga 1995, Ashton et al. 2001), but received criticism from most of the environmental groups, for example for allowing prospectors and miners to access all land, including the National Parks (Mines and Minerals Act Chapter 21:05 section 26).

The shortcomings and gaps of environmental legislation in Zimbabwe led to the upgrade of the laws in the early 1990's by the Ministry of Environment and Tourism through the then

Department of Natural Resources. Currently, the Environmental Management Act (Chapter 20:27) is the main piece of legislation governing environmental issues in Zimbabwe; its advent has seen the repealing of some Acts such as the Atmospheric Act. In terms of research it was difficult to assess the performance of an industry as guided by environmental legislation because it was too fragmented.

Kolk (2000) believed that legislation is the main influencing force for organizations to facilitate environmental change. Legislation is used as an instrument in environmental management, but it cannot be said for the whole world. Sengupta (2000) stated that legislation has resulted in a number of significant changes in the traditional approach to both mining and resource development, examples of which include environmental impact assessments (EIAs) and public enquiries, conditions for permit approval, resources management and land use planning, land reclamation and rehabilitation and an environmental program that meet all existing regulations and standards for air, water and land quality (Sengupta 2000). There is room for environmental improvement if legislation can be used to enforce specific standards of environmental management.

Environmental management can be practiced as a regulatory requirement. One of the main requirements that have become prevalent globally is dealing with potential environmental impacts through the use of EIAs. However, an organization can commit to environmental management by employing voluntarily environmental management systems (EMS). The next section describes what an EMS is as well as the possible benefits of implementing an EMS in an organization, with special reference to ISO 140001 standards.

2.4 THE IMPLEMENTATION OF ENVIRONMENTAL MANAGEMENT SYSTEMS

Barrow (1999) described an environmental management system (EMS) as a component of the overall management system that includes organizational procedures and environmental responsibilities and processes that helps an industry to comply with environmental regulations, identify benefits, and ensure that environmental policies are adopted and followed. Tinsley & Pillai (2006) explained an environmental management system as a useful tool that ensures that environmental improvement is met. Others referred to it as a problem identification and problem solving tool, based on the concept of continual improvement that can be implemented in an organization in many different ways, depending

on the sector of activity and the needs perceived by management UNEP (in Wilkie 2005). Stapleton et al. (2001) defined an EMS as a continual cycle of planning, implementing, reviewing and improving the processes and activities that are undertaken by an organization. The growing awareness and acceptance of environmental management systems are important developments in the improvement of environmental management practices in the mining industry (Hoadely et al. 2002). In response to the growing concern over environmental issues and the increasingly stringent environmental legislation in many countries, the ISO produced the ISO 14001 standards. The ISO 14001 seeks to provide a structured environmental management system which will be applicable to all types and sizes of organizations, and to accommodate the diverse geographical cultural and social conditions existing throughout the world.

McDonald et al. (2003) argues that the approval of the ISO 14001 standard marked the change in world environmental management forever; though not all organizations agree ISO 14001 is the widely used around the world and is based on the Plan-Do-Check-Act (PDCA) model, comprehensively illustrated by Sheldon & Yoxon (2006). In this model the steps are:

- setting up (this encompasses commitment and initial review);
- planning (where aspects and impacts, legal and other requirements, policy, objectives, targets, and environmental management plans are considered),
- doing stage which consists of communication, competence, training and awareness, documents and control, operational controls);
- acting - a management task where all stages of management review will take place, and
- checking –EMS auditing throughout the life cycle.

2.4.1 The ISO 14001 standard

The ISO 14001 standard is an internationally renowned environmental management system and is a recognized environmental standard in the NOSA Five Star System. It is therefore imperative to study its components and functioning in environmental management. There are key elements to the success of an environmental management system and these are:

2.4.1.1 Environmental Policy

Environmental policy can be defined as the overarching statement that describes the organization's intent and position on the environment. The three pillars of an environmental policy according to Stapleton et al. (2001) are: commitment to compliance to legislation and any other regulations, pollution prevention, and continual improvement to environmental performance. It can be a standalone policy and integrated with safety, health and quality policies. Top management commitment can be evidenced in the environmental policy. It is important to ensure top/senior management commitment to environmental management and consequently, environmental management system implementation. According to Sheldon & Yoxon (2006), no EMS installation can be successful without top level involvement, while McDonald et al. (2003) argued that top management commitment is important because it is usually this group of people who sets out the vision for an organization on its environmental policy.

2.4.1.2 The identification of environmental aspects and impacts in mining

One of the objectives of this study is to identify an organization's environmental aspects and impacts. Aspects can refer those activities, products and services that have a direct and indirect impact on the environment (Stapleton et al. 2001). Impact, on the other hand, is any positive or negative change to the environment, for example the impact of uncontrolled waste disposal would lead to general land pollution. In mining, environmental impacts may vary depending on the operations or method of mining. Identifying environmental aspects of an organization is one of the most challenging but potentially rewarding exercises. Environmental aspects can have positive impacts on both the environment and the company, so it is important to carefully investigate those (Stapleton et al. 2001). Identifying aspects and impacts can help management organize and prioritize environmental issues and target those that are most important (Bronson & Noble 2006). It is important to note that when designing an EMS, the process of identifying impacts and aspects is done in the planning stage, so that implementation of the EMS becomes easier.

2.4.1.3 The application of legal requirements in mining and environmental management

Compliance with environmental legislation and regulations is a very important element of an EMS and environmental management in general (Tinsley & Pillai 2006) and the failure to do

so could result in penalties. Adherence to any other requirements is also necessary, including a company's specific code, national and international treaties.

Among other important aspects that are worth mentioning in this study is the environmental management program/plan, which according to the Zimbabwean environmental regulations is a pre-requisite for any mining operation (Environmental Management Act Chapter 20:27).

2.4.1.4 EMS auditing and its importance in a mining setup

EMS auditing aids the monitoring of the effectiveness of the systems to ensure continual improvement, an underlying principle in EMS implementation (Varnas et al. 2009). Verifying whether objectives and targets are being met is done through audits. As argued by Bronson & Noble (2006), a well crafted EMS or one that meets ISO 14001 specifications (i.e. one with well specified environmental programs and enough documentation on objectives and targets) does not necessarily guarantee environmental performance, it is important to frequently monitor whether the specifications are being met. This can lead to the managerial review of the system who can then advocate for policy change if necessary.

2.4.2 Benefits of implementing an environmental management system

There are various benefits of implementing an EMS according to ESA Consulting in Wilkie (2005):

- shows an organization's commitment to quality and the environment;
- reduces costs;
- helps in meeting legislative requirements;
- meets customer needs and enhances customer satisfaction;
- improves environmental performance;
- reduces mistakes, defects and accidents;
- raises awareness of environmental issues;
- improves team work and staff morale;
- enhances employee involvement; and
- Provides a competitive advantage.

An EMS can be used as an environmental aspect and identification tool and for turning environmental impacts identified in the EIA into practice (Marshal in Varnas et al. 2009).

When applied to the mining industry it can mean that environmental impacts that would have been identified during the preliminary stages (EIA) can be managed through the use of an EMS. Recent studies have been done to link EIAs and EMSs in project implementation (Hacking & Sanchez 2002, Varnas et al. 2009). In this regard it is interesting to note that in Zimbabwe the EIA is a regulatory requirement as expounded in the EMA (Chapter 20:27) and Varnas et al. (2009) suggested that in order to ensure fulfilment of commitments made in the EIA, an EMS can be used as follow up system. Also of note is that an EIA is undertaken well before project implementation, whilst an EMS is devised or used during implementation. An organization may choose to produce an EIA as a regulatory requirement and afterwards never to consider it, but by voluntarily implementing an EMS, environmental impacts can be dealt with. One other advantage of EMS implementation is that what could have been overlooked in the EIA can then be further scrutinized, the EIA looks at potential impacts whereas the EMS can consider both the potential and the actual impacts. An EMS can therefore enhance compliance with legislation and regulations. One important factor noted by Bronson & Noble (2006) is that an EMS prioritizes environmental concerns so that the managers can target those with the most significant environmental impacts.

An EMS can be described as a proactive environmental management approach (Hunt & Johnson 1995, Barrow 1999). As an example, Stapleton et al. (2001) pointed out that pollution prevention is the cornerstone of an effective EMS. In terms of pollution prevention, strategies need to be devised to reduce the negative effects of pollution before it reaches the environment, thus the incorporation of an EMS helps to identify environmental aspects of any activity or operation that could result in pollution. Effective implementation of an EMS can lead to overall environmental improvement.

By being proactive, an EMS can be regarded as a regulatory system or tool which an organization uses to ensure environmental improvement and the satisfying of industry needs (Bronson & Noble 2006).

2.4.3 Integrating an environmental management system with other systems

Wilkie (2005) described the different management systems an organization can use such as environmental, quality, health and safety, and argues that where the systems overlap or have common goals unnecessary work and duplication could be avoided by an integrated management system. Eventually many companies aim at what other authors refer to as

cleaner production and environmental management. The concept of cleaner production is defined as a superior level of environmental performance, which can only be achieved through improved strategy and housekeeping, sound process control, optimized plant layout, and the implementation of efficient management techniques (Hilson & Nayee 2002).

Integrating the different systems is generally believed to make auditing easier and more effective (Tinsely & Pillai 2006). According to Zorpas (2010), there has not been a common or agreed IMS outline and as a result, different organizations devise their own. The Zimasco group of companies for example, has adopted the NOSA Integrated Five Star System, a framework for the management of safety, health, the environment (SHE) and risks in an integrated manner with emphasis on effectiveness at an operational level. The integrated system is a development of the original NOSA Five Star System represented by green stars, and while the old system focused on safety only, the new integrated system places equal importance on safety, health and the environment (Haase 2003). However, as in the case of mining companies, environmental responsibility to their operations extend to post-closure monitoring, hence social and environmental impacts remain high on management's agenda, argues a mining auditor from NOSA (Haase 2003).

Another appealing result from a well-managed integrated system is that of cleaner production, though there has been no agreed definition of the term, as indicated in Hilson & Nayee (2002). Adopting their definition which was specific to the mining industry, cleaner production can be a direct result of a well-crafted health, safety and environmental system. Cleaner production can be described as a superior level of environmental performance which can be achieved through improved strategy, housekeeping, sound process control, optimized plant layout and the efficient implementation of management techniques.

2.4.4 Analysis of environmental management systems

In the quest to find the best environmental management systems and approaches, different methods can be used. People's views on any management approach can be obtained through questionnaire surveys. The scope of the research will determine the nature of the questions, for example open ended questions can be mixed with structured questions and this can help in gathering new ideas and a scope beyond that of an initial inquiry (Huntington 2000). The use of Strength, Weaknesses, Opportunities and Threats (SWOT) analysis has been identified as a strategic management technique; it has proved to be of use even in environmental

management. As mentioned in Paliwal (2006), SWOT is based upon both the researcher's own observations during field visits as well as professional views from managers, government agencies and consultants. Apart from this, SWOT can be facilitated through semi-structured interviews and literature search on the subject. However, some critics such as Yuksel et al. (2007) have highlighted its weakness in lacking analytical frameworks, and Barney (1995) argued that there is a need to fill in blanks in the SWOT technique, moving beyond suggesting strengths and/or weaknesses to analyse them. On the other hand Nouri et al. (2008) have hailed its simplicity and practicality as a strategic management tool, which is also the basis on which it was used in this research.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 RESEARCH METHODOLOGY AND METHODS

The manner in which research is organized, the logic or reason for selecting particular techniques and the way in which sets of data are selected, assembled and analyzed is defined as “methodology”. Methods and techniques *per se* are not synonyms for methodology. Methodology is the way one selects and employs various methods and techniques – instruments or tools – to attain a given intellectual goal. The methods employed are the tools (Latham 2005).

This research is based on both qualitative and quantitative methods of collecting and analyzing data. Qualitative data was used because the subject under study is too complex and cannot be answered by a simple yes or no hypothesis. Both environmental management and mining are broad topics and despite the sample size in this study being very small, meaningful results can still be generated using qualitative data (Shuttleworth 2008). Common tools used included questionnaires, interviews and field observations. The questionnaire was simplified and shortened in order to meet the literacy level of the bulk of respondents. The questionnaire included three sections: the identification of site specific environmental aspects and impacts, knowledge of environmental measures in place and soliciting the level of legislation compliance.

Secondary data sources consisted of EIA reports and other documents. Field work comprised of the collection of effluent samples for chemical assessment to establish the quality of water discharged from the mines into the environment. A combination of different methods was employed for each of the different objectives with the ultimate goal of meeting the specific need of each of them.

3.2 SAMPLE SIZE AND SELECTED MINE SITES

3.2.1 Questionnaire sample size description

The questionnaires and interviews were given to a sample that was representative of large and small scale operators under Zimasco claims (under its environmental jurisdiction). In total, the study population consisted of 36 operations of which fourteen were large scale and twenty two were small scale operators. All questionnaires were completed by mine supervisors, who

in most cases obtained their environmental knowledge from in-house safety, health and environmental training provided by the Zimasco SHE department comprising of the SHE manager, Safety and Environmental Officers and a graduate trainee. Data about the type of operations is described in the next section.

The number of people interviewed was 30, involving twenty two (22) small scale tributors, seven (7) large scale tributors and one (1) SHE personnel member. Figure 3.1 below highlights the distribution of interviewees.

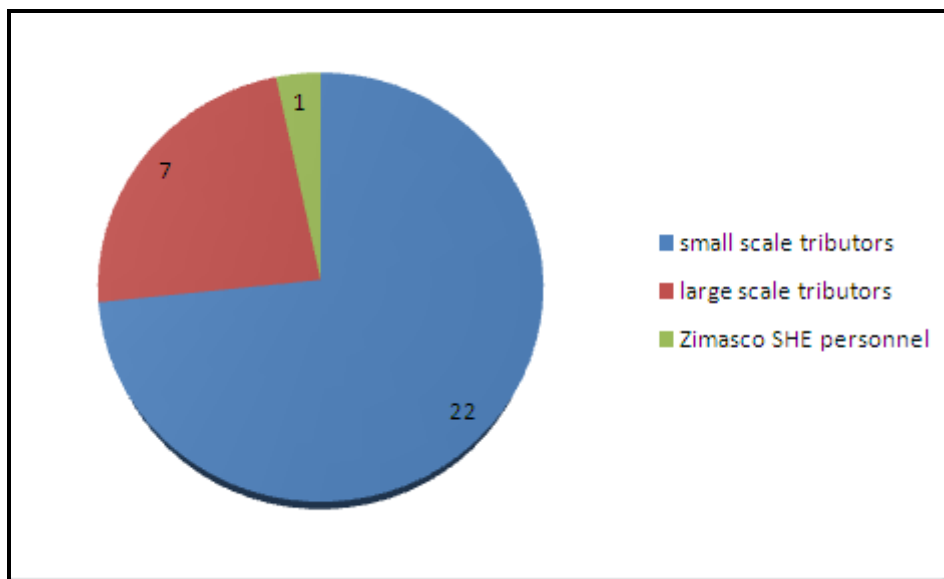


Figure 3.1: Number of people interviewed from each group

3.2.2 Mine site selection

As previously mentioned, several mining activities exist along the Great Dyke, other than those being undertaken by Zimasco. This study concentrates on specific sites mined only by Zimasco because prevalent environmental problems along the Great Dyke originate from the different and individual mining operations in the area and Zimasco is a major claim holder within the study area. Addressing environmental issues just like any other situation needs to be done at grassroots or source level. In this case the source or the grassroots level is each specific mine, whether tribute, cooperative or Zimasco.

According to the Zimasco employee classification there are large scale tributor mines and small scale tributors based on level of production and mining methods. Large scale mines are expected to produce 2000 tonnes per month and small scale 200 tonnes per month of chrome

ore (Zimasco staff, 2010 pers.com). These are referred to as “indirect operations”, however ultimate environmental monitoring and management of the claims rests upon Zimasco. For the purpose of this study these indirect operations and two direct operations will be investigated. There are seven underground mines, seven open cast mines and twenty two (22) small scale tributor mines. For sample analysis the two large mines solely operated by Zimasco were added. The tables below highlight the tributor operations and indicate their locations, large scale tributors are displayed in Table 3.1, while Table 3.2 displays small scale tributors. The distribution of both small scale and large scale tributor mines in Zimbabwe is highlighted on the map on Figure 1.1 and Appendix A0 to A3 shows their location on the Great Dyke. The Appendix in which the particular mine is shown, appears in brackets next to the mine name in both Table 3.1 and 3.2.

Table 3.1: Selected large scale tributor mines and their locations

Name of mine (Appendix)	Location	Type of mine	Name of mine (Appendix)	Location	Type of mine
Pedlin (A3)	Middle Dyke	Underground	Tugs (A3)	Middle Dyke	Open cast
Beesouth (A3)	Middle Dyke	Underground	Wiriranayi (A3)	Middle Dyke	Open cast
Hoceberg (A3)	Middle Dyke	Underground	Dific (A0)	North Dyke	Underground
Kinsey (A3)	Middle Dyke	Open Cast	Mitchell (A1)	North Dyke	Underground
G.N. Global (A3)	Middle Dyke	Open Cast	RiverDeep (A0)	North Dyke	Underground
Mzila (A3)	Middle Dyke	Open Cast	Runsgate (A0)	North Dyke	Underground
Black Laden (A2)	North Dyke	Open Cast	JR Goddard (A2)	North Dyke	Open Cast

Table 3.2: Selected small scale tributor mines and their locations.

Name of mine (Appendix)	Location	Name of mine (Appendix)	Location
Checko (A3)	Middle Dyke	Jane 3 (A0)	North Dyke
Gumbo O (A3)	Middle Dyke	Sajeni (A1)	North Dyke
Genric (A3)	Middle Dyke	Bhibho (A0)	North Dyke
Kamwendo (A3)	Middle Dyke	Big Deeper (A1)	North Dyke
Kushinga (A3)	Middle Dyke	Convoy (A0)	North Dyke
Mukandatsama (A3)	Middle Dyke	Stekas (A1)	North Dyke
Nehanda (A3)	Middle Dyke	Taisireva (A1)	North Dyke
Nhongo (A3)	Middle Dyke	Tavakuenda (A1)	North Dyke
Nyandoro (A3)	Middle Dyke	Two Stars (A0)	North Dyke
TIB Investments (A3)	Middle Dyke	J&I (A1)	North Dyke
TOPS (A3)	Middle Dyke	Shauke (A1)	North Dyke

Fifty percent (50%) of the mines were randomly selected for sampling, giving a true representation of the small scale operations. The small scale mines are double the number of large tribute mines along the Great Dyke. This is mainly because their operations are not mechanized, therefore affordable, and the common term used to refer to them is “pig routing”, based on the method used in extracting the mineral.

3.3 METHODS FOR OBJECTIVE 1: ESTABLISHING CURRENT ENVIRONMENTAL IMPACTS RESULTING FROM THE MINING OPERATIONS UNDER STUDY

In order to meet the specific requirements of this objective, a description of the mining methods used for chrome ore extraction along the Great Dyke was necessary, because these methods vary depending on the level of chrome seams and the different operators. For example, small scale miners in the Zimasco context extract chrome ore manually. Furthermore, the different mining support services are discussed to highlight the different activities involved in the chrome mining industry along the Great Dyke. The data gathering methods included the use of questionnaires and field observations. These are described in the next section.

3.3.1 Use of questionnaire survey

Questionnaires were distributed to the different mining operations selected for the study. The main aim of the questionnaire was to identify the different environmental aspects and impacts resulting from the operations. Supporting questions involved obtaining data about the type, method and period of operation, environmental aspects and impact identification. A sample questionnaire is supplied in Appendix B. The questionnaire was addressed to all operators, assuming that the respondents would be cooperative.

3.3.2 Questionnaire distribution and collection

The questionnaire (Appendix B) was designed in English to be completed by the mine manager (who is also the SHE representative for the tributor mines), as well as the SHE personnel of the Zimasco direct operations. The questionnaire consists of 3 sections, where section A covered the environmental aspect and impact identification, section B follows with the role of environmental legislation and finally, section C dealt with the implementation of environmental management systems and procedures in Zimasco.

Considering the nature of mining work, time allotted for other tasks such as the completion of a questionnaire may be considered a compromise to production. Therefore the respondents were allowed adequate time, a maximum of three days, to examine the questions and to find answers yielding the most meaningful results to the research.

In order to obtain a significant respondent rate, prior to the distribution of questionnaires, the researcher visited each of the sampled sites in the company of the Safety Health and Environment (SHE) department. During these visits the overall aim of the research was explained, making it known to the miners that they would receive questionnaires. The questionnaire was made in simple English which could be easily understood by the respondents, it is easy to analyse the kind of data needed in English. Distribution was done by hand so as to ensure that the necessary respondents would be reached. Collection was done in the same manner, to minimize any chances of questionnaires not being returned. However, it should be noted that it was not intended to force respondents to cooperate; they had the right to refuse. An important limitation is the possibility that respondents would not cooperate, because especially small scale miners are basically concerned with production more than they would consider the environmental consequences of their operations. Their main aim is poverty alleviation rather than environmental management. This was noted by Maponga & Ruzive (2002) as the major force (cause) of environmental problems in the same area.

3.3.3 Field observations

Even though determining current environmental impacts associated with mining operations was largely based on questionnaire survey, field observations were used to determine environmental impacts on the physical biosphere of the area. This acted as a supporting technique in establishing the impact of the mining operations on the natural landscape, river morphology, vegetation diversity and density. Because of a lack of resources on the researcher's part, some parameters were not measured, for example air pollution levels. Through observations and photographic capturing, landscape disfigurement was nonetheless recorded. This process was necessary to determine the manner in which these impacts are being addressed at source level. Based on the chosen study sites, a site visit to each selected mining area was done, visiting all the mines in operation as well as the abandoned sites to check for any evidence of rehabilitation. Information about the existing and abandoned mines was obtained from the SHE department and the Mining Engineering department.

3.3.4 Data analysis

Data analysis was executed using the aspects and impacts analysis matrix adapted from Tinsley & Pillai (2006). The environmental aspect is described as an element of an

organization's activities, products or services with either a beneficial or a negative impact on the environment, while an environmental impact is described as the positive or negative change that occurs in the environment. Stapleton et al. (2001) affirmed that identifying and managing environmental aspects yield positive results at the bottom line and provide significant environmental improvements.

The first step as identified by Tinsley & Pillai (2006) is to assign a probability to the likelihood of the aspects and impacts occurring. Measuring the probability of occurrence can be done from score 1 which could be less than 20 per cent probability, to a score of 5, which is an 80-100 per cent probability of occurrence. Table 3.3 below highlights scores on probability of occurrence.

Table 3.3: Probability of occurrence: Adapted from Tinsley & Pillai (2006)

Score	Probability of occurrence
5	80-100% probability
4	60-80% probability
3	40-60% probability
2	20-40% probability
1	0-20% probability

3.4 METHODS FOR OBJECTIVE 2: ENVIRONMENTAL LEGISLATION AND POLICY IMPLEMENTATION

Firstly, environmental legislation and any policy or legislation related to the environment was identified. This was done through literature study of the relevant Environmental Acts as these documents contain legislative obligations of the responsible ministry. This task would have been challenging were it not for comprehensive legislative company documents and an accessible company lawyer (for consultation) at Zimasco, who periodically updates any changes in legislation. Another source of information was the EIA documents which provided secondary data. Of major importance was the Environmental Management Agency with whom other related legislation with direct and indirect links to the environment was discussed. A list of all relevant legislation was therefore considered. Specific methods of achieving this objective included the use of questionnaires, as well as practical assessment through the use of legal compliance checklists. The details of these methods are given below.

3.4.1 Use of questionnaire

Section C of the composite questionnaire (see Appendix B) was used for objective two (assessing environmental legislation compliance). It included brief structured questions on the monitoring and auditing functions of the environmental legislators, i.e. the Environmental Management Agency. This method of data collection is preferred because respondents could supply confidential information on the questionnaire without difficulty. The same procedure for questionnaire distribution and collection applied as in section 3.3.2.

3.4.2 Interviews with key actors

Unstructured interviews were conducted with Zimasco (SHE Department) in order to obtain their understanding of the manner in which legislation and policy implementation is executed to ensure environmental management on mining operations.

3.4.3 Practical assessment

A practical assessment was done to determine legislation compliance on the mining operations. The legal compliance checklist was employed, whereby legal aspects outlined in the different instruments would be audited for availability at every visited site. An example of the checklist can be found in Appendix C. The checklist is based on the existence of the evidence of the legal requirements, such as a waste disposal site, effluent discharge permits and the Environmental Impact Assessment report (EIA).

3.5 METHODS FOR OBJECTIVE 3: DETERMINING ENVIRONMENTAL MANAGEMENT APPROACHES USED ON THE MINING OPERATIONS

Developing this objective required a practical study and discussion of the environmental approaches used by the organization on the different operations. These approaches are filtered down to all the operations, but with different levels of application and implementation. Specific methods of investigation included document review and interviews with the key actors from the Zimasco SHE department. Section C of the questionnaire (see Appendix B) provided the supporting data in answering this objective.

3.6 METHODS FOR OBJECTIVE 4: ASSESSING THE VALUE OF THE ENVIRONMENTAL MANAGEMENT APPROACHES IN ADDRESSING ENVIRONMENTAL IMPACTS

Achieving this objective was limited to one measurable and significant environmental aspect (effluent discharge), identified in the first task of impact identification, mainly because it involved practical analysis. This has been acknowledged as one of the limitations of the study. However, the decision to analyse effluent discharge was based on the argument made by Stapleton et al. (2001), which pollution prevention is one of the key factors in the success of an environmental program/system and that environmental management systems' principles have been based on principles of pollution prevention.

Selected mines were sampled for effluent discharge analysis; among these were the two mines operated by Zimasco in the Southern part of the Great Dyke, together with tributary mines. Zimasco operated mines (from a different part of the Dyke) were sampled for comparison purposes. Nine mines were examined for effluent analysis, which included all underground tributary mines (these are mines which discharge effluent) and two direct underground mines, listed in Table 7.6. Samples were collected from the identified mines in the company of the SHE personnel for advice on the water sampling procedures. Samples were then taken to Harare for analysis. The parameters assessed were: total dissolved solids (TDS), total suspended solids (TSS), dissolved oxygen (DO), chemical oxygen demand (COD), as well as nitrates and chromium. These parameters were measured using the effluent standards of the Environmental Management (Effluent and Solid Waste Disposal Regulations; Statutory Instrument Number 6 of 2007, S.I.6 of 2007). Mine sites (point of discharge) were targeted for water sampling. Where water was discharged directly into a nearby stream or river channel, samples were collected directly from the river/stream.

3.7 METHODS FOR OBJECTIVE 5: RECOMMEND AREAS THAT NEED IMPROVEMENT IN TERMS OF ENVIRONMENTAL MANAGEMENT WITHIN THE ORGANIZATION

The approach used to achieve this objective was based on the business management strategy of SWOT analysis, which has been recommended for its simplicity and practicality (Nouri et al. 2008) and has been hailed as a strategic management tool. It involves the identification of strengths, weaknesses, opportunities and threats of the system based on both internal and

external factors. The analysis was done on the overall approach of the organization and then on the NOSA integrated system, as it forms the basis of environmental standards and its implementing strategy. The SWOT analysis was founded on all the data collected, including the results of the sample analysis and interview questions to the SHE Department. As highlighted earlier, existing strategies need to be strengthened and new strategies employed for an ongoing industry such as mining to ensure sustainable utilization and management of resources.

It has been considered necessary to provide a brief overview of the mining methods and their interaction with environment. In general it can be noted that the Great Dyke is a geologically and geographically important area which need to be wisely exploited. Chrome ore deposits are world class and generally vast. However it is associated with poor, scanty vegetation on soils that have high chrome content consequently fauna supported is also limited. The main activity on the dyke is mining with a few other human activities which primarily support mining. The different mining methods used on the Great dyke and their environmental implications are discussed in the following Chapter 4 partly highlighting the likely environmental impacts associated with each mining method .

CHAPTER 4: CHROME MINING METHODS AND THE ENVIRONMENT

Although there has been a significant improvement towards environmental management on the mining sites, there are significant ecological consequences resulting from any mining activity (Ashton et al. 2001). Commonly noted environmental effects of mining include destruction of landscapes and ecosystems by open cast mining, waste accumulation and ground water accumulation by leachates, lowered ground water levels and concentration of toxic elements such as chromium boron, copper and zinc. There are also environmental health problems that result from unsafe mining operations. These and other problems peculiar to the mining of chrome along the Great Dyke are discussed below. The environmental impacts emanate from three levels of operations within the same area, under the umbrella name of one main organization. For this to be understood, a brief discussion of these operations is given before the actual environmental impacts are discussed.

What makes the situation of chrome mining along the Great Dyke different from other operations is the fact that there are different levels of mining operations falling under the same organization (in the study area). As mentioned earlier, there are mines operating as tribute/contract mines but according to the Mines and Minerals Act all the claims belong to Zimasco, hence the focus of the study on Zimasco. Small scale tributors are commonly known as “pig routers” because they mine their chrome from adit shafts and operate manually to bring the ore to the surface. This has been made possible by the geological structure of the Great Dyke where mineable chrome can be accessed easily. Large scale tributors on the other hand, operate their mines using inclined shafts; as such there is a need for substantial infrastructure in the form of hoists, head gears, pumps etcetera.

4.1 MINING METHODS USED

The different mining methods used include underground (adit and inclined shafts), open cast or strip mining and “pig routing” or surface manual. BGRM (2001) highlighted the factors determining the choice of method to be used: location, geometry, morphology, depth, environment and sometimes mining tradition.

4.1.1 Surface manual

Surface manual involves the extraction of chrome to manually pick up the chrome from the seams, which is possible for seams that are close to and/or exposed to the surface. This mainly involves the digging of shallow trenches and holes which can be accessed without mechanical aid. This group of miners forms a very big number of operators in terms of cooperatives and individuals (now called small scale miners). On average, these operators produce a very low tonnage of chrome ore since they do it manually. As we shall learn later, these may not seem to have significant site environmental impacts but if left unchecked, serious land degradation could be caused and mineable land destroyed. Mine life is very short and miners at this level can easily be displaced by bigger establishments. Figure 4.1 below highlights the size of pits and the amount of rubble produced on the surface by using picks and shovels.

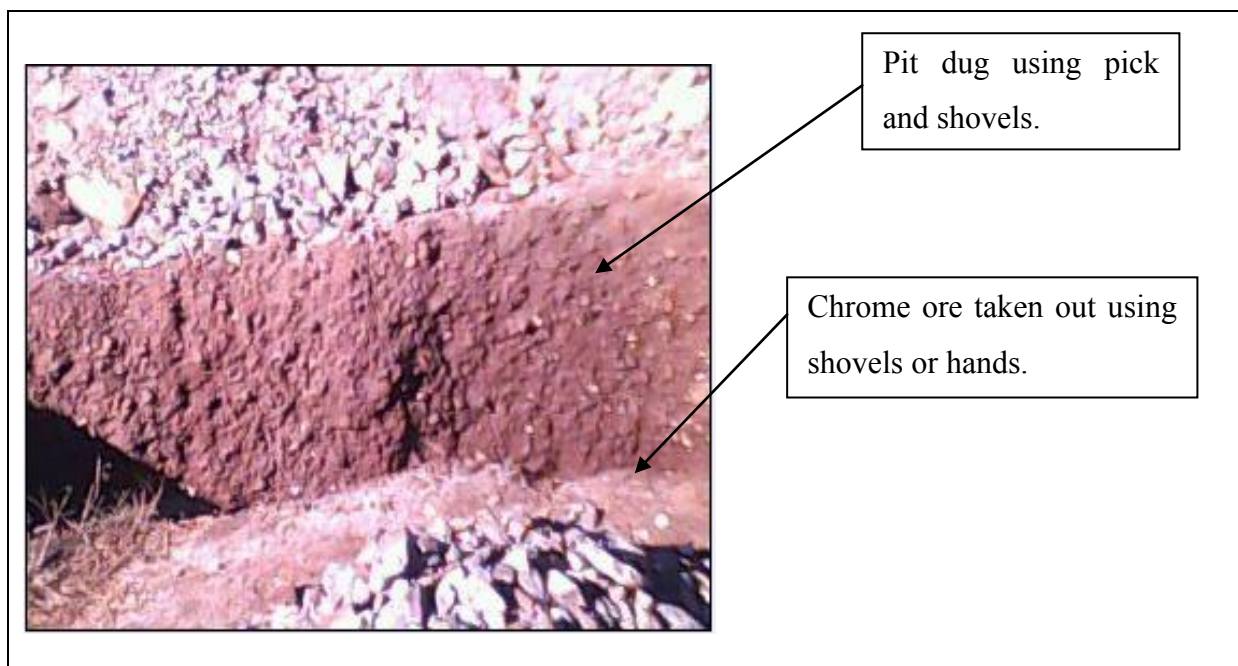


Figure 4.1: An example of surface manual mining operation

4.1.2 Surface mechanized mining

Surface mechanized mining involves the use of machines to a limited extent. Excavation is done using machines but the depth is dependent on the machine. An example of such operations is given in Figure 4.2 below.

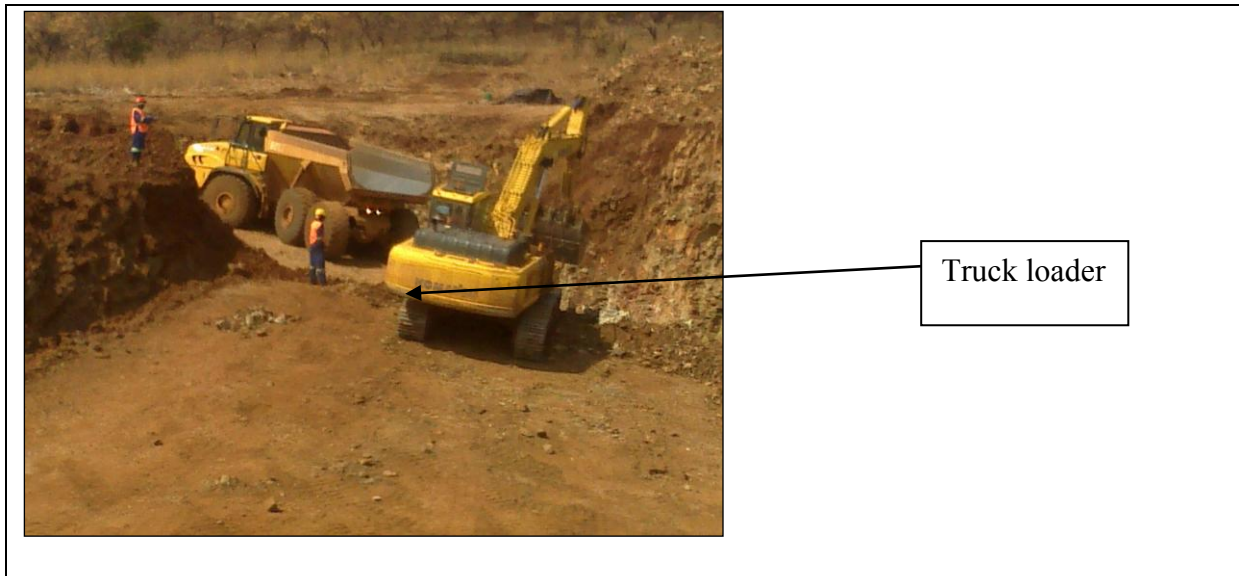


Figure 4.2: An example of surface mechanized mining operation

4.1.3 Underground mining operations

Underground mining can be done in two different ways, namely adits and inclined shafts. Underground adits follow the seams for short distances and these are generally small and usually unventilated cuts. A series of regularly spaced horizontal and near horizontal drives are up to 250m long. They are constructed parallel to the strike of the seam where it outcrops along steep hill sides. Mining is usually done by hand drilling and blasting a narrow hanging wall cut. Chrome ore is then lifted by hand, transporting it down the adits to the surface either by rails and cocopan or by wheelbarrow. These have a very short mine life of about less than five years and are generally operated by small scale tributors, though some larger scale tributors can resort to adits during periods of economic slowdown and in wet seasons. Recently, due to the economic problems, some tributors have resorted to adits rather than inclined shafts. Ventilation and underground sanitation are essential in these operations in order to maintain good environmental health. Environmental problems can also arise as a result of poor management of waste.

Inclined shafts also known as reuse mining; can go to depths more than 700m, with a deep pilot shaft with regularly spaced seam drives. This is believed to be the standard mining method on the Great Dyke underground chrome mines. It involves the stopping of seam drives on levels spaced at fixed intervals down an inclined pilot shaft, sunk parallel to the

chromite seam. Drilling and blasting are followed by lifting of the ore by hand and tramping it to the pilot shaft. From there it is hauled to the ground mechanically.

The above operations are usually done by tributors who can afford the equipment. These generally create large dumps which must be maintained and strategically positioned to avoid erosion and dump instability. Improper siting of the dumps occurs on steep slopes and along streams or river channels.

4.2 MINING METHODS AND THE ENVIRONMENT

The mining of chrome is characterized by a high stripping ratio, whereby more waste is generated from the extraction of ore than with any other minerals. Problems of waste disposal are seen to be a permanent feature in the mining sector. The surface operations on the Dyke are usually done manually using picks and shovels, where trenches are left unfilled and orphaned, which could be dangerous to the miners and animals in the area.

There currently are a limited number of deep underground operations in the study area, the sampled mines indicates that a third of the surface operations in the North and Middle Dykes are underground operations. Differences have been noted in BGRM (2001) between underground methods and surface methods. These include the quantity of waste produced per unit of ore as lower in underground mines when compared to surface mines, the ground area affected by underground mines is smaller than surface operations and mechanical risks are greater for underground than surface operations. As compared to other mineral resource extraction, for example gold along river systems, environmental problems along the Great Dyke tend to be concentrated within the area of operations. This is also attributed to the mining methods that are employed.

It is important to discuss how the tributors and cooperatives operate with their main board, as it will clarify the way in which environmental management issues are being implemented on these operations.

4.3 LARGE SCALE AND SMALL SCALE TRIBUTORS

Both the large scale and small scale tributors operate legally on the Zimasco claims. They are legally bound to produce and sell the chrome ore to Zimasco at the rates determined by chrome performance at the market and reviewing is done on a monthly basis. The Zero Base

Analysis is used to determine chrome ore supply and sale. What is important to note is that large scale tributors are paid higher than smaller scale producers (Piha & Shoko 2000). It has been observed by Maponga & Ruzive (2002) that the pricing system determines the ability of the operators to improve environmental performance, resulting in environmental problems experienced in the chrome mining sector. Chrome ore price is also largely determined by its grade, the weight percentage of chromitite as discussed in the previous chapter. Chrome ore is transported for grading and assessment using independent contractors who in this case are regarded as direct employees of Zimasco.

4.4 OTHER IMPORTANT ACTIVITIES DIRECTLY ASSOCIATED WITH THE MINING OF CHROME ALONG THE GREAT DYKE

This section discusses activities that are limited to the North and Middle Dykes. Owing to the fall of the price of chrome ore in the mid-1993, Zimasco handed over most of its operations to tributors and cooperatives, such that currently the main function of the organization is administration, supervision of their claims, purchase, stockpile and movement of ore. They are also involved in the management of the housing area. One of the mines operated solely by Zimasco closed down in 2007 due to unstable market conditions, however in Shurugwi, which forms part of the South Dyke, a large mine is still owned by the organization. Most of the chrome ore originates from here, but it is of a lower grade than the ore obtained from the Middle and North Dykes.

In the North and Middle Dykes, the management of mining operations and environmental decisions for both tributors and cooperatives are executed by Zimasco's administration offices. The administration offices entail management, magazine, workshops, fuel stores, carbide, ammonium nitrate stores and ancillary buildings such as first aid, tea room and others. In 2000 the total number of administrative employees at Mtorashanga was 106 according to Piha & Shoko (2000), but currently the number is well above 250. This shows that the organization is expanding. Its headquarters are in Harare, where most corporate decision-making is done.

Apart from the administration, housing is an important aspect of mining. Zimasco owns over 800 houses in Mtorashanga, of which 53 are low density housing units. Most of the houses are inhabited by administration workers, while some are leased to the tributors who operate close by. As a result of these inhabitants of the area, other facilities were developed to

provide essential services, such as two secondary schools, three primary schools and two nursery schools and shops, churches and one stadium. It is the responsibility of Zimasco (Engineering Department) to provide services such as electricity, water, a proper sewage system and general maintenance of the houses. The infrastructure is owned and operated by Zimasco; according to the Piha & Shoko (2000) all the houses were built to equip the then nearly 800 employees of the organization. However, recently there has been need to increase housing facilities for the rising employee number.

The organization does not have housing units in Ngezi, the closest office point for the operations in the Middle Dyke. Housing and amenities are provided by the tributors and management is mainly done from Mtorashanga. Each tributor and cooperative provides housing for the workers, although most of the houses are substandard. Maponga & Ruzive (2002) argued that the reason for the poor housing is the way in which chrome pricing is done and consequently these cooperatives do not get enough money to supply adequate housing and amenities of their workers.

4.5 MINING SUPPORT OPERATIONS

Some operations are directly linked to the actual mining of chrome within the study area which is really important in terms of environmental management. The different supporting operations are discussed below, including timber production and chrome ore sorting. Timber production can be regarded as an environmental measure which helps in reducing indiscriminate tree cutting as wood is used for mine shafts and adit support. All these supporting operations have some environmental implications worth noting.

4.5.1 Chrome ore sorting in the North and Middle Dyke

Chrome ore from the different mines is supposed to be ferried to Kwekwe for smelting while some is exported as ore. Before it is ferried, the ore need to be sorted, graded and tested; therefore it is likely to generate considerable dust. Chrome ore sorting occurs at Kildonan, about 10km from the main offices at Mtorashanga, going south-westwards in the northern part. Darwendale-siding is used for the Middle Dyke (see Figure 1.1). Facilities exist at the screening plants where the sorting of lumpy and fine ore is done. For these operations there are also housing facilities that have been provided for the workers.

4.5.2 Timber production for mine support

The mining of chrome has resulted in the establishment of timber fields to produce timber for mine support. Zimasco owns farms that grow eucalyptus for this purpose. Locally known as Matimba estates, this is estimated to cover 1300 hectares of unmined land in the North Dyke. The wood that is produced is then sold to the tributors and cooperatives for mine shaft supports, and serves as one way to reduce vegetation destruction. The *Eucalyptus grandis* and *E. tereticornis* are most suited for mine support and are favoured by the local climate. However, because the timber is sold to the tributors and cooperatives, indigenous wood is also used, especially for adits and the construction of huts, as has been observed during one site visit. According to Maponga & Ruzive (2002), the growth of villages around mine sites has exerted much pressure on the available resources and particularly on wood, for firewood and poles for hut construction

4.5.3 Transportation of chrome ore from mine sites

Transportation of chrome ore must be done from tributor and cooperative stockpiles to Kildonan, from where it is transferred to Kwekwe by rail. Transport is provided by a separate contractor but who is regarded as a direct Zimasco-employee. It is important to note that most of the roads are dusty and chrome ore is transported uncovered. A likely environmental impact is soil erosion and dust generation.

The actual extraction of chrome ore is done with simple tools to the most sophisticated tools, depending on the depth of the seam and the size of operation. Small scale miners use simple picks and shovels because the seams are close the surface or exposed. Large scale miners operate with more sophisticated equipment, whether on surface or underground.

In this chapter, the effects of specific mining activities on the environment have been discussed. Based on the fact that all mining activities have obvious environmental consequences, it is important to review the regulations pertaining to mining and environmental management. Chapter 5 highlights the environmental legislation and policy framework in Zimbabwe.

CHAPTER 5: ENVIRONMENTAL LEGISLATION AND POLICY FRAMEWORK IN ZIMBABWE

Environmental management largely involves practices by environmental agencies and governing agencies. It therefore means that environmental management cannot be discussed without mentioning the applicability of legislation. According to Kolk (2000), environmental legislation is the influencing factor for companies to achieve environmental change. In the mining industry especially, environmental management has not been practised, but legislation brought significant changes in the developed world and later on in the developing world. It has also been noted that most modern legislation requires organizations to identify risk at work places, assess risks, take measures to eliminate and control harmful exposures, communicate hazards and ensure that control measures are implemented (NOSA 2009). In this chapter, the discussion will be based on how legislation fosters environmental management in the mining industry. Discussion on how legislation has effected environmental change in the mining industry in Zimbabwe is done in the subsequent sections of this chapter. Special reference on how legislation is being implemented will be made to the Environmental Management Agency, the overseeing board of environmental management in Zimbabwe.

5.1 ENVIRONMENTAL LEGISLATION AND POLICY IN ZIMBABWE

Environmental management previously resorted under the Natural Resources Board within the Ministry of Environment and Tourism. The Natural Resources Act was used in legislation implementation; however it had many loopholes and basically could not adequately address environmental issues. Major changes were made which led to the formation of the Environmental Management Agency (EMAg) and the passing of the Environmental Management Act (EMA) in 2003. This new Act, together with other relevant Acts, is discussed in the following sections.

5.2 THE ENVIRONMENTAL MANAGEMENT ACT CHAPTER 20:27

Through the creation of the Environmental Agency and Environmental Fund, its mandate is to provide for the sustainable management of natural resources and environmental protection, pollution, environmental degradation prevention and also to amend references to intensive conservation areas, committees and associated matters in various Acts.

The Environmental Management Act (EMA) Chapter 20:27 was ratified in 2003 after years without specific environmental management legislation. A legal basis for environmental protection was inadequate in addressing conventional air and water pollution issues, as well as other environmental concerns such as hazardous waste, emission of greenhouse gases, leaking underground tanks and environmental emergency preparedness plans. However, the EMA has been put in place to solve some of these problems. As mentioned in Chapter 1, fragmentation and inconsistencies existed in laws pertaining to environmental issues, such as Acts' overlapping requirements. At present, the EMA overrides other Acts in environmental management. The arrival of this Act saw the repealing of the Atmospheric Pollution Act and the Hazardous Substances Act.

Before the EMA was passed, there were no legal requirements for the organizations to carry out environmental impact assessments (EIAs) of new and existing projects regardless of potential environmental damage. New developments that performed EIAs were voluntary, in response to increased global awareness of environmental protection. Currently, all new projects with a potentially significant environmental impact are required to complete EIAs as specified in the Statutory Instrument (S I) 7 of 2007 (EIA and Ecosystems) of the Environmental Management Act (Chapter 20:27). It is within the power of the Director General of the Environmental Management Agency to cancel the EIA certificate issued if the project is likely to cause irreversible damage to the environment. Mining is one major activity identified and specified in the Environmental Management Act, affecting operations along the Great Dyke since they are nomadic in nature, and any new development would require an EIA.

5.2.1 EIA specifications with regards to mining

An EIA is a decision-making tool for both the project developers and the regulating agencies (Sinding 1999). It therefore acts as a regulatory instrument as it also sets the framework for monitoring compliance.

Mining is one of the major activities identified under section 99 of Environmental Management Act (Chapter 20:27) requiring the implementation of the EIA document, considering its potentially negative environmental impacts. The document should contain the following items:

- a. a detailed description of the project and the activities to be undertaken in implementing it;
- b. reasons for selecting the proposed site of the project;
- c. a detailed description of the likely impacts the project may have on the environment or the segment thereof, covering the direct, indirect, cumulative, short term and long term effects of the project;
- d. measures proposed for eliminating, reducing or mitigating any anticipated adverse effects the project may have on the environment, identifying ways of monitoring the environmental effects of the project;
- e. an indication of whether the environment of any other country is likely to be affected; and
- f. an indication of how the developer proposes to integrate biological diversity in the project and a description of the methodology used by the developer to compile the Environmental Impact Assessment report (Environmental Management Act Chapter 20:27).

The elements included in the EIA report are: executive summary, project description, environmental planning and design, public consultation, environmental setting, assessment of environmental impacts, resource evaluation and summary and recommendations.

The Environmental Management Act has regulations covering specific environmental issues such as water, air, pollution, invasive alien species and hazardous substances. These are important environmental aspects in the mining industry. However, severity may depend on the scale and method of mining as well as the mineral being extracted. Various statutory instruments (SI) pertaining to the management of waste have been implemented, including the effluent and solid waste disposal regulation (S.I.6 of 2007) governing discharge into surface or ground water, hazardous substances, pesticides and other toxic substances regulation (S.I.12 of 2007) and the hazardous waste management regulation (S.I.10 of 2007). No person shall generate, store, sell, transport, use, recycle, discharge or dispose of hazardous waste to the environment, except under a license. Table 5.1 describes the classification criteria for effluent discharge as stipulated in the regulatory instrument S.I.6 of 2007.

Table 5.1: Classification Criteria of Effluent According to Statutory Instrument 6 of 2007

Classification	Risk	Reasons for Classification
Blue	Safe	Complies with Blue standards
Green	Low hazard	Waste meets green standard or blue license conditions not being met
Yellow	Medium hazard	Waste meets yellow standard or green license conditions not being met
Red	High hazard	Waste meets red standard or yellow license conditions not being met.

5.2.2 Environmental Management Agency obligations

The Environmental Management Agency has the obligation to conduct environmental auditing and inspection. Section 106 of Environmental Management Act Chapter 20:27 states that, environmental audits will be carried out periodically (biannually) to ensure that the implementation of the project complies with the requirements of the Act. As part of the auditing, the developer must submit the environmental report on any issues raised in the EIA report or other issues arising as a result of implementation. Environmental inspection comprises of periodic inspection of the developer's premises to check on environmental compliance.

5.3 ENVIRONMENTAL ASSESSMENT GUIDELINES

The Environmental Assessment Guidelines (1997) have been prepared by the Ministry of Environment and Tourism as a course of action on issues to be considered when carrying out an EIA.

The guidelines are based on the following principles:

- a. the EIA must enhance and not inhibit development, by contributing to environmental sustainability;
- b. the EIA is a means for project planning, and not just evaluation;
- c. identifying means for managing project impacts is an essential component of the EIA policy;
- d. the EIA policy depends on the normal regulatory functions of permitting authorities to implement EIA results;
- e. the EIA policy involves the participation of all government agencies with a mandated interest in the benefits and costs of a project;

- f. the EIA policy pays particular attention to the distribution of project costs and benefits; and
- g. public consultation is an essential part of the EIA policy.

In the development of the EIA, three products are generated before the final report is produced. The steps for the EIA process in Zimbabwe are shown in Figure 5.1.

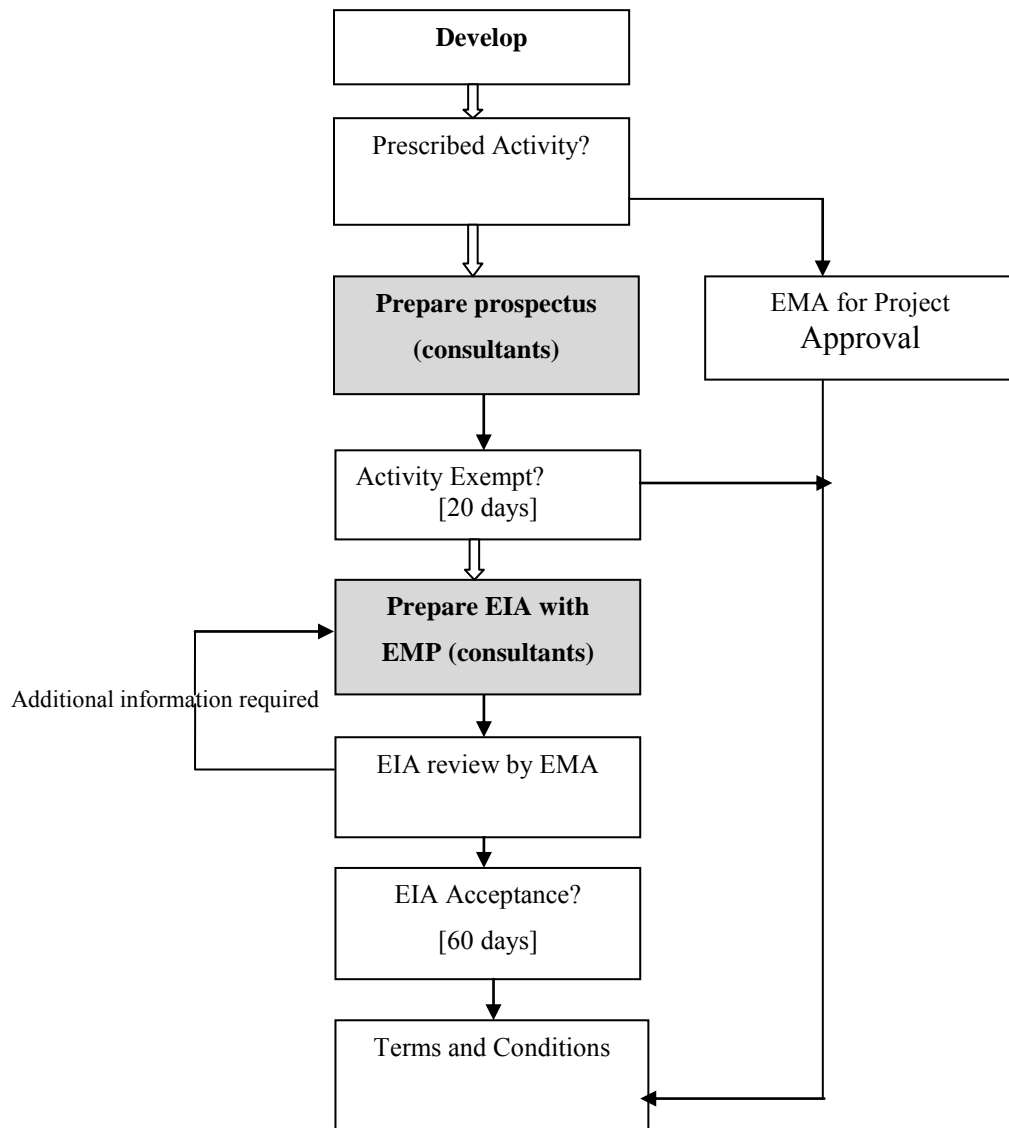


Figure 5.1: The EIA flow diagram: Adapted from MMET (1997)

A short and precise document known as the *prospectus* needs to be generated, to inform the Agency that a prescribed activity is being considered. Then, the *preliminary EIA* is produced as the initial assessment of the environmental impacts of a project. The Ministry has 60 days to review the document. Following this is the *detailed EIA* which is a comprehensive

document to review; it is at this stage that the EIA certificate can be issued. These three steps are discussed in more detail in the following section.

5.3.1 The Prospectus

The prospectus informs the Minister of Environment and Tourism about considerations of the prescribed activity. It must therefore consist of sufficient information to allow the Ministry to determine the need for an EIA study based on specific screening criteria listed in screening guidelines. Preparation and submission of the prospectus is done at the concept stage of the early pre-feasibility study of the project cycle. The prospectus contains some of the following aspects:

- a. a description of the project purpose, size location, and preliminary design for example, site technology, construction and operational procedures;
- b. stages of the project cycle;
- c. location map to the project site and site plan; as well as
- d. a general discussion of the project processes likely to cause problems and proposed management measures.

Of major importance is public consultation during the EIA process. The proponents are required to produce an environmental management plan showing the strategy for environmental management activities.

5.3.2 The Environmental Management Plan

The Environmental Management Plan (EMP) is a significant component of the EIA, showing the specific plan highlighting the environmental objectives and targets, explaining the means and time frame of meeting the objectives and targets of the environmental assessment. It shows how mitigatory measures are to be taken. It therefore helps the organization maximize compliance and reduce environmental harm. Once the EMP has been completed, it is easily incorporated into the organization's EMS.

In Zimbabwe, the EMP should be prepared in terms of section 96 (Environmental Management Act Chapter 20:27), subsection 2, and should contain the following:

- a description of the functions exercised by the specified authority in respect of the environment;
- a description of the environmental standards set or applied;
- a description of the policies, plans and programs that are designed to give effect to the plan;
- the degree of compliance required of other persons;
- arrangements for cooperation with other persons on environmental management; and
- a description of the manner in which the specified authority will ensure that its functions are exercised in a way that will facilitate compliance with this act, other relevant enactments and environmental standards so as to achieve the optimum management and protection of the environment.

Table 5.2 gives an example of a simple EMP for a mine slimes dam construction, which is not exhaustive as there are several other factors that can be included such as topography, geomorphology, geology, surface water resources, among others.

According to Stapleton et al. (2001), each organization is unique and so are the EMP's. They vary in detail and length, depending on the organization's level of operation and its understanding of environmental responsibilities. As such, Zimasco has identified specific objectives that are to be met in their EMP's. They have also compiled varying EMP's for the different types of mining within their operations, such as surface and underground mining. The specific objectives for the Zimasco EMP's are as follows:

- to protect the environment and the community surrounding the mining operations for the lifetime of the company;
- to protect the groundwater, surface water, air quality as well as animal and human life dependent on the river system draining the mining area;
- to facilitate the return of the land used for mining to the habitat character and ecological function existing before mining was established or to the standard acceptable to the local authority or the Environmental Management Agency;
- to operate and decommission the mine with minimum practicable negative environmental impacts; and
- to ensure that the division complies with the stipulated legal requirements.

Table 5.2: An example of the EMP for a slimes dam construction

Project Phase	Environmental component	Environmental impact	Mitigation measures	Implementing agent	Monitoring agent
Implementation Stage	Soils	Soil contamination from slimes seepage	Monitor seepage amount and quality through monitoring piezometers	Safety Health & Environmental (SHE) Department	Environmental Management Agency (EMAg)
Implementation Stage	Air quality	Dust emission from road, access routes, and levelling at site	Wet working area reduce dust emission through sprinkling water on the roads, access routes and excavated surfaces	EMAg SHE Department	EMAg
	Noise and vibration	Earth moving plant will make noise	Ensure healthy working standards are adhered to. Prescribe noise reduction measures if appropriate	SHE department	EMAg
	Local economy	Increased tonnage of ore milled requires more man power with downstream knock on	Endeavour to employ as many locals as possible	Human Resources Department	EMAg

5.4 MINING LEGISLATION RELATED TO THE ENVIRONMENT

In this section the legislation pertaining to mining with a strong bearing to environmental management is discussed. Of major importance is the Mines and Minerals Act (Chapter 21:05).

The Mines and Minerals Act (Chapter 21:05) directly addresses issues of mining, but it is relevant to environmental management. Before the Environmental Management Act (Chapter 20:27) was put in place, this Act superseded other acts. It has faced much criticism from major environmental groups because it did not limit land access for mining developments, thus prospectors and miners were allowed access to all land in the country, including National Parks (The Mines and Minerals Act (Chapter 21:05-1996)). Restrictions were only

applied to access to water (Section 29) and timber (section 36). Miners were allowed to take up to 50% of the timber on the land.

One important aspect of the Mines and Mineral Resources Act relevant to environmental protection is the submission of the siting of works plan for approval to the mining commissioner. This is found in Sections 234-241 of the Act. Closely related to environmental protection concerns is the fact that the work plan should show rivers/streams, mountains/hills and other natural features close to or around the area proposed for development.

Other relevant areas include the removal of buildings and machinery from an abandoned, forfeited or cancelled mining location (Section 267). The miner is expected to fill in all shafts, open surface workings and excavations or to deal with them otherwise to ensure the safety of people and livestock and this should be done within 30 days of abandonment (Section 269). Timber on “Town Lands” cannot be cut without permission of the Mining Commissioner. Water from mining operations on “Town lands” shall not pollute surface water with mine water but must be disposed of in the nearest natural water channel (Section 312). Prospectors are required to fence or enclose the mouths of all shafts and other workings for the protection of people and livestock. These should be maintained during the period of prospecting (Section 370). The minister can make regulations as deemed expedient regarding the safety, sanitation, housing and feeding of employees, welfare and other administrative matters (Section 403).

Other Mining Regulations include the Mining (Management and Safety) Regulations of 1990 which covers aspects of safety and health in mining environments and Mining (Health and Sanitation) Regulations of 1995 controlling health and safety in and about the mining operations.

5.5 NATIONAL LEGISLATION RELEVANT TO ENVIRONMENTAL MANAGEMENT

Regulation of mining activities is also enhanced by other Acts with sections or parts relevant to the environment. When undertaking an EIA, the following Acts need to be considered and consulted. Where there is duplication, the EMA (Chapter 20:27) overrides. Table 5.3 lists the different acts and their functions.

Table 5.3: National legislation relevant to environmental management

Act	Function
Water Act (Chapter 20:24)	It is under the management of Zimbabwe National Water Authority (ZINWA), the Act is responsible for the consumptive and non-consumptive uses of water from the surface and underground sources. Approval for the abstraction and storage of water is given by ZINWA after a permit has been issued on application. In the underground mining of chrome water is abstracted from the ground hence this Act is of much relevance. It is this water that will be discharged into the environment, some directly into rivers. In terms of environmental protection it addresses pollution of water, through prohibiting the discharge of water containing organic or inorganic matter into both public or private water and underground water.
The Natural Resources Act	This act provides for the protection soils, minerals, animals and other natural features such as wetlands. Its underlying principle is conservation and improvement of natural resources.
The Parks and Wildlife Act (Chapter 20:26) of 1996	The Act provides for the conservation of preservation, propagation or control of wildlife, fish and plants of Zimbabwe and the protection of natural landscapes and scenery. Through the Parks and wildlife Board it provides for the establishment of national parks, botanical reserves, botanical gardens, sanctuaries, safari areas and recreational parks. Permits are required for prospecting and mining within the Parks and Wildlife Estate. However in this study there are no parks and wildlife estates that occur within the study area.
Explosives Act Chapter (307-1961)	This Act deals with the manufacture, purchase, possession, delivery, storage, use and conveyance of explosives. There must be permits for these activities to be carried out. Mentioning of this Act is in line with safety issues of the main SHE policy of the organization; however there is not much relevance to environmental protection.
Public Health Act (Chapter 15:09)	Public health involves the prohibition and regulation of activities likely to pollute streams which can later cause environmental health problems. It covers all aspects of health and safety issues of workers in all environments. There are sections which include water and sanitation as well as the prohibition of nuisances in working environments.
The Forestry Act (Chapter 19:05) of 1996	Through the establishment of the Forestry Commission it facilitates the administration, control and management of state forests, control of burning, regulation of trade of forest produce and to provide for the conservation of timber resources. The use of timber by miners and prospectus is regulated by the Act. Illegal cutting of wood for mine support, housing and firewood is prevalent along the great dyke as miners opt for cheap timber resources other than the one provided by Zimasco through Matimba Estate.
National Museums and Monuments of Zimbabwe Acts (Chapter 25:11)	This Act provides for the protection of historical and archaeological sites. No alteration should be made to any of these sites. No materials on the sites are to be moved without the consent of the executive director of the National Museums and Monuments of Zimbabwe. This particular act is worth mentioning with regards to environmental protection, even if there are no particular sites identified along the Great Dyke (study area), however new developments may need consider this Act.
Rural District Councils Act	The rural district councils are responsible for making by-laws which govern the conservation of natural resources and prevention of pollution among other environmental issues. This act is very important when carrying out EIAs and in the implementation of environmental management measures, because much of the study area lies in the rural part of the country. Efforts have been made to urbanize Mtorashanga, but these have been hampered by the economic and political downturn in the country.

The main environmental legislation in Zimbabwe is the Environmental Management Act, Chapter 20:27, however, requirements of other related legislation have to be met to ensure

that issues not included in the EMA can be implemented. A specific example is that of the siting of the works plan and the mine closure plan, specified in the Mines and Minerals Act, Chapter 21:05. Based on the definition of environmental management adopted in this study, this chapter covered management issues from the governing/regulatory agencies' point of view, while the next chapter discusses the environmental management approach and procedures of the organization under study.

CHAPTER 6: ZIMASCO ENVIRONMENTAL MANAGEMENT SYSTEMS, STANDARDS AND PROCEDURES

Apart from the external influence brought about by the legislation, organizations today have internal systems which it controls exclusively in principle. Such systems enable organizations to comply with regulations effectively and consistently (Stapleton et al. 2001). As such, many organizations do comply with certain environmental standards that have been set internationally to facilitate the protection of the environment, such as the ISO 14001 environmental standards. Zimasco implemented the Integrated NOSA Five Star as the safety, health and environmental management (SHE) system which recognizes the ISO 14000 environmental standards, ISO 9000 quality standards and the OSHAS 18000 for occupational health and safety. However with the structure of the organization there are some operations that are under the full implementation of the NOSA integrated Five Star system whereas others have environmental measures which are derived from the EMS but are not audited externally by the NOSA Company. Below is a discussion of the NOSA system and how it is implemented in Zimasco.

6.1 THE NOSA INTEGRATED FIVE STAR SYSTEM

The NOSA Integrated Five Star System is one example of an integrated management system (IMS). According to Ellis & Rickman (2003), many organizations have a single department handling SHE issues, reflecting the trend towards integration. However, as the previously mentioned authors argued, integration should be a preferred option for many organizations “but not all”. A well planned IMS is believed to be efficient, the sharing of systems procedures and practices rather than duplicating them can guarantee efficiencies in audits. It is based on the Plan-Do-Check-Act routine where managers are expected to continuously check their system, giving them the opportunity and mechanism to review their health, safety and environmental performances. The checking is based on certain benchmarks such as corporate standards, regulatory requirements or organization’s best practices (Ellis & Rickman 2003).

The NOSA Integrated Five Star System is basically a risk based management system, the main idea to optimize profits and minimize loss, including loss relating to people, assets, process material and the environment. It is made up of 5 sections and 72 elements. The five sections are:

- premises and housekeeping (11 elements);
- mechanical, electrical and personal safeguarding (17 elements);
- management of fire and other emergency risks (8 elements);
- incident recording and investigation (5 elements); and
- organizational management (31 elements).

Environmental elements are mentioned in Section 1 (Premises and housekeeping) and Section 5 (Organizational management), including: factory and yard, resource conservation, waste management, pollution risk control and environmental monitoring. These elements are then used to devise environmental management standards based on the approach of the system, in this case a risk-based or proactive approach.

6.1.1 The NOSA approach

As a SHE service provider, NOSA has its own approach in conducting business which could aid the understanding of the NOSA Integrated Five Star system's implementation by organizations. Part of their mission is to offer risk management services, consulting, auditing and certification, as illustrated in Figure 6.1.

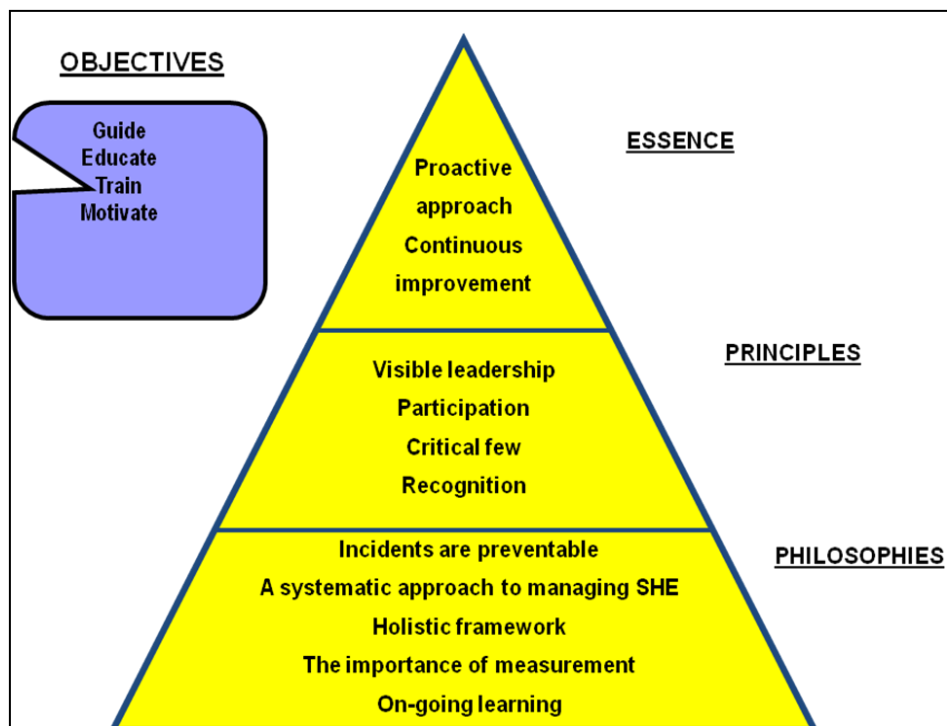


Figure 6.1: The NOSA approach. Adapted from NOSA (2009)

Figure 6.1 illustrates the safety, health and environmental management standards offered by the NOSA Integrated Five Star System. The environmental standards are derived from the elements given in section 6.1, which describes the components NOSA Integrated Five Star system and are reviewed yearly. A brief discussion of the standards follows in Table 6.1 below.

The model depicted in Figure 6.2 shows how risk management is linked with the NOSA Integrated Five Star System Approach. The NOSA system components, also known as loss exposure areas (safety, health and environment) a protected against any loss using the risk based approach. Risk management involves first identifying and assessing risks, with the aim of ensuring that effective control measures are in place to combat any possible risk. The NOSA Integrated Five Star System adopted the risk based approach to ensure effective loss control. In terms of environmental management it therefore implies that the system can control site specific environmental problems as they are identified at source point. Furthermore, in Zimbabwe, financial loss due to penalties can be reduced when environmental problems are handled effectively at the mining sites. The effectiveness of the NOSA Integrated system can therefore be measured from the onset where environmental aspects and impacts are identified, so that any control measure needed can be set up. However, there are many factors that could determine the system's success, such as management commitment among others.

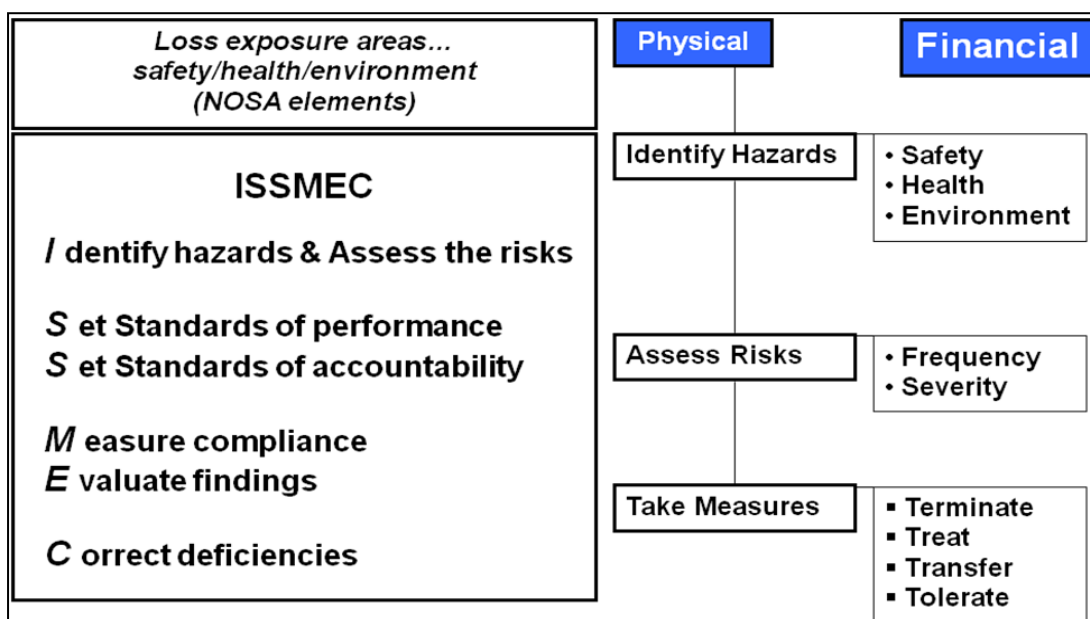


Figure 6.2: NOSA Integrated Five Star System and Risk Management.

Adapted from NOSA (2009)

6.1.2 Safety, health and environment related management systems

The NOSA Integrated System takes cognizance of other management systems to form one system catering for safety, health and environment (SHE). The three related systems are ISO 9000 (QMS), ISO 14000 (EMS) and OHSAS 18000 (Occupational Health and Safety), discussed below.

6.1.2.1 ISO Standards

The ISO Standards Body is an internationally recognized environmental organization which has been created to initiate world standards. Initially, the ISO 9000 series of quality management systems was introduced, followed by the ISO 14000 series of environmental management systems. According to Stapleton et al. (2001), the two models share common elements since ISO 9001 was used as a source document to draft ISO 14001, with the main difference in the technical requirements of each standard.

ISO 9000 sets quality management principles, such as the system approach, which involves the identifying, understanding and managing of a system of interrelated processes, contributing to the effectiveness and efficiency of the organization.

The ISO 14000 series of environmental management systems is widely used and sets standards and guidelines for environmental management principles based on environmental policy, planning, checking, corrective action and management review. The commonly used EMS standard is ISO 14001, which may or may not require certification. Certification and accreditation is not a legal requirement, hence some organizations may choose to use its principles in an integrated manner with other systems, similar to what Zimasco is doing.

6.2 ENVIRONMENTAL BENCHMARKS

Environmental benchmarks can simply be referred to as the environmental expectations of the organization and according to Ellis & Rickman (2003) benchmarks are used for audits. As mentioned before, the benchmarks include corporate standards, regulatory requirements and best practices.

As has been discussed earlier, Zimasco implements an integrated SHE system. Stapleton et al. (2001) stated that, while the systems can be integrated, the purposes for each system must be kept in mind, as an EMS naturally has a broader context than other systems. Following the

argument above, the researcher identified separate environmental standards which were set for Zimasco.

The underlying environmental principle is to conduct business responsibly and in a manner designed to protect the public and the environment (Environmental Management Standards Manual 2003). The identified list of standards is shown in Table 6.1 below. These standards are mandatory and apply to all Zimasco operations and contractors; however, they are implemented as best practice to the tributors in some instances. Standards such as rehabilitation and re-vegetation and environmental auditing are clearly directed at all operations, including tributors.

Table 6.1: Zimasco Corporate Environmental Standards

NUMBER	DESCRIPTION OF STANDARD	OBJECTIVE
1.0	Environmental Policy	Express commitment to address environmental issues
2.0	Environmental Plans	Plan to manage or minimize environmental impacts as they emerge
3.0	Environmental Impact Assessment (EIA)	Assist in decision making with options that are environmentally friendly and formulation of mitigatory measures
4.0	Noise & Vibration	Identify source, set perimeters for monitoring and minimizing noise pollution
5.0	Air Emissions	Minimize impact and comply with legislation
6.0	Waste Management/Minimization	Ensure proper handling and management of waste as well as complying with legislation
7.0	Water Pollution – Ground & Surface Water	Ensure that water is clean and complying with applicable laws
8.0	Hazardous Substances	Safe handling, transportation and storage of hazardous substances as well as complying with legislation and SHE system(NOSA)
9.0	Noxious Weeds	Prevent spread of noxious weeds on land owned by the organization
10.0	Environmental Incidents/Accidents Reporting & Investigations	Reduce environmental risks through reporting, investigation and remedial action plans
11.0	Resource Conservation	Sustainable utilization of natural resources and law requirement
12.0	Rehabilitation & Re-vegetation	Ensure land returns to its ecological state through sustainable rehabilitation and re-vegetation programs as required by the legislation
13.0	Mine/Plant Commissioning/Decommissioning/ Mine Closure	Ensure that all applicable laws are complied with before, during and after operations
14.0	Training	Cater for environmental training needs
15.0	Environmental Auditing	Check EMS and equipment performance in reducing environmental risk as well as verifying compliance with legislation

6.3 THE REHABILITATION MANUAL

The rehabilitation manual was established in 1999 (Piha & Shoko 2000), to cater for the tributors working on Zimasco claims. It highlights existing legislation pertaining to mining and gives the details of the responsibilities of both Zimasco and the tributor following the outlines of the Tribute Agreement. Further details of the rehabilitation methods and guidelines for starting new developments for both surface and underground operations are included. Most of the environmental issues are thus laid out in the manual, including practices for a) abandoning shafts, adits and strip mined sections; b) waste dumps, topsoil management and landscaping; c) water management and erosion control; d) machinery, buildings and civil works; and e) roads and tracks.

Because the mine claims are being worked on by the third party tributor, management of the environment has been complicated for the organization, however, the tributor is made responsible for “rehabilitation” by tribute agreements (Piha & Shoko 2000). Ten percent (10%) of the money paid to the tributors is retained for the environmental rehabilitation in the event that tributors fail to do it.

The existence of an environmental system and procedures in Zimasco shows its commitment to environmental management and to continual environmental improvement. The Zimasco corporate environmental standards discussed in Table 6.1 above highlight major environmental concerns that the chrome miners need to address at site level in order to minimize serious environmental problems within the area. Following the examination of these issues, an inspection of the manner in which the system and procedures have addressed environmental problems arising from the mining operations becomes necessary. The next chapter highlights the significant research findings.

CHAPTER 7: RESEARCH RESULTS

This chapter contains results obtained from the fieldwork with questionnaires and interviews, conducted on the mine sites under Zimasco claims along the Great Dyke. Observations made on the impacts of chrome mining along the Great Dyke are discussed to support results acquired from the questionnaire survey. Data is presented in tables and analyzed using different approaches appropriate to answer each objective. The final section describes the SWOT analysis of the environmental approach and the effectiveness of the environmental management system of the organization in addressing environmental impacts arising from its operations.

7.1 ENVIRONMENTAL ASPECT AND IMPACT RESULTS FROM QUESTIONNAIRE SURVEY

From the questionnaire survey the researcher identified environmental aspects and impacts resulting from the chrome mining operations, in the selected and sampled mines. It has been noted that 80% of the miners could identify the environmental aspects and impacts of their operations. The description of the aspects and impacts followed the definitions given in the ISO 14000 standard. This is because the NOSA Integrated Five star system takes cognizance of the ISO 14001 environmental standard (though not in full), and according to Tinsley & Pillai (2006), using these internationally laid out standards is important for consistency. Stapleton et al. (2001) affirms that identifying and managing environmental aspects yield positive results at the bottom line and provide significant environmental improvements. Based on this fact, the first step in this research presentation of results is to highlight the identified environmental aspects and impacts resulting from the mining operations. The identified environmental aspects and impacts of chrome mining are shown in Table 7.1 below, while Table 7.2 shows the perceived impact of the identified aspects on the environment.

Table 7.1: Environmental aspects and impacts of chrome mining

Adapted from Tinsley & Pillai (2006)

Aspect	Mining Activity	Impact
Dust generation	Ground clearance for open pit mining	Air pollution, negative visual impact, dust fall out on plants and animals
Oil spillage		Water and land pollution
Noise generation	Blasting, drilling	Noise pollution
Waste rock	Waste rock dumping and movement	Loss of productive land, loss of vegetation, habitat loss, aesthetic intrusions
Chromium content	Chrome ore extraction	Ground and surface pollution
Dissolved substance	Discharge of mine runoff	Ground and surface water pollution, soil contamination.
Vegetation destruction	Land clearing for open pit mining, exploration tree cutting for mine support and firewood	Loss of habitat, biodiversity loss
Solid waste generation		Land pollution
Water discharge	Mine dewatering,	Ground and surface water pollution
Air emissions	Blasting	Air pollution
Pits and trenches	Creation of adits and shafts, abandoned adits and shafts leaving pits and trenches	Loss of habitat, vegetation, landscape degradation, aesthetic intrusion.

Table 7.2: The aspect and impact analysis matrix

Aspect	Probability of occurrence	IMPACT											Total
		Good Score					Bad Score						
		5	4	3	2	1	0	-1	-2	-3	-4	-5	
Dust generation	4								x				-8
Oil spillage	2								x				-4
Noise generation	3								x				-6
Waste rock dump	5										x		-20
Chromium content	4									x			-12
Dissolved substances	4											x	-20
Vegetation destruction	3									x			-9
Solid waste generation	5										x		-20
Water discharge	5											x	-25
Air emissions	2							x					-2
Pit and trenches	5											x	-25

The analysis matrix in Table 7.2 shows that the identified aspects have a significant impact on the environment. As outlined in Tinsley & Pillai (2006), the larger the negative figure, the larger the environmental impact and the larger the positive, the less of an impact on the environment. Major environmental threats occur in water discharge, waste rock dump and pits and trenches. Some of the water that is discharged directly into the environment has unacceptable levels of dissolved substances and chromium content which may consequently cause water pollution of the nearby streams and channels. Some of the mines are established close to river channels such that the water easily gets contaminated. The impacts of waste rock dump is of major concern along the greater part of the Dyke, the distribution of some of

the dumps resulting from surface adits has been illustrated by Chirongoma (2007), and it was noted that these have become a permanent feature of the Dyke. Figure 7.1 below highlights the type of waste rock dumps from small scale miners and their distribution on the hilly terrain of Mtorashanga (see on Figure 1.1 for Mtorashanga) in the North Dyke.

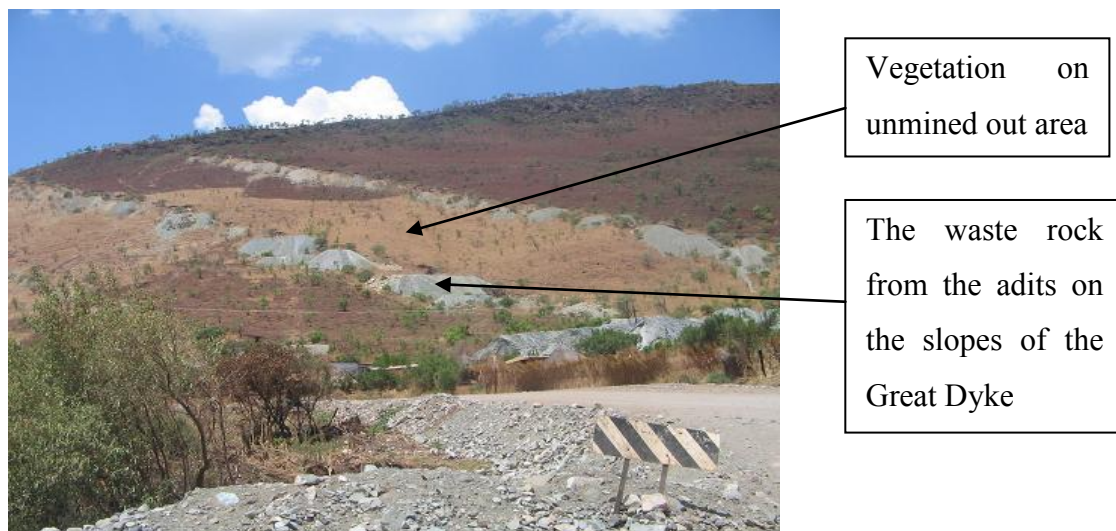


Figure 7.1: Waste rock dumps in the North Dyke: Adapted from Chirongoma (2007)

The aesthetic value of the mined out area deteriorates and pits and trenches result from these adits and shafts, becoming dangerous to people and animals in the area. A chain of other problems can result, such as those identified in Maponga & Ruzive (2002): the dumping of waste rocks in a river blocks channels and causes siltation and dispersion of heavy metals in soils and water channels. As have been noted, chrome seams occur in cyclic units and any further mining activity that could be undertaken is compromised as a result of these rock dumps. Piha & Shoko (2000) argued that mining practices in the adits can pose a serious threat to life in and around the chrome seams.

7.2 ENVIRONMENTAL LEGISLATION COMPLIANCE

7.2.1 Practical assessment of legislation compliance by Zimasco

This section begins by assessing compliance by Zimasco to the national environmental and environmentally related legislation in the direct and indirect operations. Table 7.3 below highlights the manner in which SHE issues are handled in addressing specific concerns identified in national legislation. However, some terms used in the national legislation may not be used within the SHE system of the company. For example, EIA cannot be found in the SHE system, but the issues pertaining to it are covered therein. This assessment is based on how the legislative issues are addressed by the entire systems and procedures of the organization, but practical assessment was done using the legislative checklist.

Table 7.3: An assessment of how Zimasco complies with environmental /environmentally related legislation

National Legislation	Zimasco compliance	Tributor compliance
Environmental management Act EIA policy guidelines	NOSA System Tribute Agreement Rehabilitation manual	Rehabilitation manual
Water Act	NOSA system Tributor rehabilitation manual	Rehabilitation manual
Mines and minerals Act Other mining regulations	Detailed in the rehabilitation manual NOSA system	Rehabilitation manual Tribute agreement
Public Health Act	Tributor rehabilitation manual	Rehabilitation manual
Parks and Wildlife Act	Mentioned in the Tributor rehabilitation manual	Rehabilitation manual
National Museums and Monuments Act	Tributor rehabilitation manual	Rehabilitation manual
Natural resources Act	Tributor rehabilitation manual NOSA integrated five star system	Rehabilitation manual
Forest Act	Tribute Agreement, NOSA	Rehabilitation manual
Rural District Councils Act	None	None

7.2.2 Practical assessment of legislation compliance by tributors

A practical assessment was carried out in order to determine compliance to the Environmental Management Act (Chapter 20:27) requirements as the basic legal instrument for environmental concerns in Zimbabwe. The large scale (14) and small scale (22) tributors from the selected mines highlighted in Tables 3.1 and 3.2 in Chapter 3 were analysed separately. Actual names of the mine sites were not included at this stage of reporting. This was done to ensure confidentiality (only) in the legal compliance checklist, while the main

objective (checking compliance to legal aspects) were being effectively checked and presented. The seven major legal aspects identified were a valid EIA report, a copy of the EMP, a rehabilitation plan, a mine closure plan, a valid effluent discharge permit, together with the absence of noxious weeds and a domestic waste disposal site as listed in Table 7.4 below.

Table 7.4: Legal compliance checklist (see Appendix C) at the time of the research visit for the selected tribute mines

Legislative aspect	Large scale tributors (14)		Small scale tributors (22)	
	%yes	%no	%yes	%no
Valid EIA report	100	0	100	0
Copy of Environmental management plan	100	0	100	0
Rehabilitation plan	100	0	0	100
Mine closure plan	100	0	0	100
Valid effluent discharge permit	100	0	0	100
Existence of noxious weeds e.g. lantana camara	0	100	0	100
Domestic waste disposal site	93	7	100	0

From Table 7.4 above it can be seen that the larger tributor mines have a significant level of legal compliance on almost all aspects as compared to the small scale tributor mines. The compliance level is said to be significant for larger scale tributors because they have almost all legislative aspects documents in place and updated; however this only serves to explain that levels of compliance is well commended, but not implying sound environmental management. EIA/EMP documents and reports have been identified on most of the operations because they are conducted by Zimasco on behalf of all the tributors working on its claims. EMA inspections and audits in Zimbabwe currently require an EIA/EMP document or report, therefore every prescribed activity produces one before operation. Determining whether issues raised in an EIA are met in Zimasco or in the mining industry in general, is one area that needs to be established through research. It may be difficult to quantify the actual state on the ground for all environmental aspects identified in Objective One (section 7.1) above, however effluent analysis was be done to evaluate the usefulness of legislation on the ground, answering part of Objective Four (section 7.5) below.

7.3 HOW EFFECTIVE ARE THE ENVIRONMENTAL APPROACHES ON ZIMASCO MINING OPERATIONS

A comparison was made of effluent discharge from all the seven large underground tributary mines in the Middle and North Dykes and two Zimasco operated mines which are under full implementation of NOSA. Small scale tributaries do not have any effluent discharge on their mines; this is attributed to the methods of mining that is employed. Samples were taken at the point of effluent discharge and parameters measured against those stipulated in S.I.6 of 2007 Standards of the Environmental Management Act (Chapter 20:27). See Appendix D for the classification table showing the limits of each parameter in effluent discharge (EMA Standard SI of 2007). Stapleton et al. (2001) cited pollution prevention as one of the three key commitments to the environmental management of a successful EMS, together with continual improvement and legislation compliance. Table 7.5 below highlights the major parameters analyzed for levels of effluent contamination, of major importance is the classification based on the Environmental Management Act (Effluent and Solid Waste Disposal Regulations, S.I.6 of 2007). Details of the technical aspects of the classification criteria were previously highlighted in Table 5.1.

Table 7.5: Effluent analysis for underground mines

	pH units	Nitrates (mg/l)	Sulphates (mg/l)	COD (mg/l)	DO % saturation	TSS (mg/l)	TDS (mg/l)	Chromium Total(mg/l)	Class
Horceberg	9.40	3.20	0.35	32.2	30.1	95	583	0.01	yellow
Dific	9.61	0.01	0.36	15.0	39.8	138	1978	0.11	red
Pedlin	8.51	0.01	0.25	16.0	43.1	103	1349	0.01	red
Beesouth	8.60	0.01	0.25	16.0	50.5	78	712	0.01	red
Mitchell	8.20	<0.01	0.26	16.0	50.2	158	1054	0.01	red
RiverDeep	9.50	3.30	0.35	58.6	48.0	165	1892	0.01	red
Runsgate		<0.01	<0.01	63.5	29.4	98	590	0.01	yellow
Zimasco Peak mine	8.60	0.01	0.02	50.7	62.0	48	1254	<0.01	green
Zimasco 1347	8.10	0.01	0.02	54.2	68.0	39	1051	0.01	green

When all parameters for a particular mine have been measured and classified according to Table C.1 in Appendix D and 99% of parameters are in the blue class but only one is in the red class, the effluent is automatically classified as red. For example, the mines lying in the red class (Mitchell and RiverDeep) have the highest levels of TSS exceeding the expected levels. This shows that dissolved substances are discharged into the environment. Beesouth

and Pedlin (see Table 3.1 with a list of selected mines) indicated that, where every parameter is within expected levels, the DO is very much below the expected levels. All of the tributator mines lie in the yellow to red class as highlighted in Table 7.5 above, whereas the two identified Zimasco-run mines are in the green class. Green indicates that the potential hazard is low, this implies that effluent discharged from these mines have lower possibility of causing land and water pollution. Effluent discharged from the tributator mines have a high risk of causing land and water pollution. A full implementation of the NOSA Integrated Five Star System on all tributator operations may reduce environmental pollution, thereby enhancing environmental management. Zimasco operated mines are audited under the NOSA Integrated Five Star System causing their environmental systems to be well maintained to reduce any possible risk. This is achieved through the use of settling ponds which are available in both tributator and Zimasco operated mines, however effective administration of these ponds is more characteristic of Zimasco main mines than it is for the tributators. Settling ponds are used to filter and reduce pollutants found in the effluent before it is discharged into the environment (Chriongoma 2007). An interview conducted with the SHE department indicated that Zimasco operated mines do have standard settler ponds, whereas those of tributators are usually below standard (Zimasco staff, pers.com 2010).

7.4 SWOT ANALYSIS OF THE ENVIRONMENTAL MANAGEMENT APPROACHES ON THE CHROME MINES

This analysis is based on the data obtained from the questionnaires and interviews with key informants, however no direct or indirect quotes were used. Table 7.6 gives a summary of the SWOT analysis.

Table 7.6: SWOT Analysis of the Environmental Management Approaches

Strengths	Weaknesses
<ol style="list-style-type: none"> 1) The organization has a SHE management system in place. Environmental impacts together with occupational health and safety aspects are easily identified when there is a system in place. The advantages of having a system have been discussed in Chapter 2; however one important aspect that can be highlighted is that it shows a certain level of commitment to environmental management. The organization is NOSA certified, it gives an impressive environmental commitment to both the local people and the market at large. 2) Data management is efficient. 3) Environmental as well safety and health decisions are made at corporate level which shows commitment of the whole organization to environmental performance. 4) The existence of the environmental officer role indicates that there is total commitment to environmental management. 5) Up to date legislative database, amendments and new clauses are effectively and efficiently identified. Legal compliance audit often carried out. 6) Internal and external audits are often carried out both by Zimasco management and the NOSA personnel. Rating is based on performance. 	<ol style="list-style-type: none"> 1) The SHE system is not implemented in full in all the operations as such not all operations are audited externally. Services to the Tributor operations, whether small scale and large scale, are offered as best practices. 2) There are no environmental representatives at sites, environmental management issues do not have specific responsible personnel at both large scale tributor and small scale mines; mostly it is the mine manager or site clerk who has such responsibilities. On the questionnaire survey, 50% of the respondents indicated that environmental management is part of the operations but implementation is done by the mine manager - who in most cases does not have appropriate qualifications for environmental management. The environmental officer from Zimasco administration features as a monitoring personnel rather than an implementing agent.
Opportunities	Threats
<ol style="list-style-type: none"> 1) Extension of the NOSA system to the tributors is a great opportunity for total environmental improvement on chrome mines. According to the Zimasco staff (pers com 2010), the opportunity of an extension came as result of the realization of the need to protect people and the environment. This can be made easier by the fact that there is the environmental officer responsible for all the operations to ensure environmental compliance with regulations. Hilson and Nayee (2002) also noted that because environmental audits, impact appraisals and reviews are periodically conducted on the mines, implementation of an EMS can be easy. This extension would implicate great environmental as well safety and health issues training. 	<ol style="list-style-type: none"> 1) Too many small scale operators who need training on environmental management issues to ensure total environmental commitment. Most of the small scale operators are nomadic in nature making it very difficult to ensure effective environmental monitoring. Rehabilitation on adits is difficult, because they are done on hilly and steep slopes. 2) Poor economic conditions force both Zimasco and its tributors to be more concerned of making money rather than improving environmental performances. Miners are more concerned with meeting monthly targets at the expense of the environment. 3) Indigenization means that more tributors are likely to be formed to promote black empowerment. 4) Trained tributor personnel on environmental issues are faced by challenges of high labor turnover such that training needs become more demanding and frequent. Training is the responsibility of the organization, but tributor recruitment and salary services is entirely part of the tributor's responsibility. The labourers are usually uneducated and in most cases formal contracts are absent and often short-lived.

The existence of an environmental management system for dealing with environmental issues has been identified as a major strength in most environmentally sensitive organisations. Overall environmental decisions are made at corporate level, indicating great commitment to the environment. The system has however been weakened by the lack of environmentally trained representatives at almost all small scale mine sites in the Great Dyke, further marred by external factors such as poor economic conditions in the country leading to high labour turnover. A new breed of environmentally illiterate mine workers is therefore frequently created which is a negative factor in environmental management.

7.5 SWOT ANALYSIS OF THE NOSA INTEGRATED FIVE STAR SYSTEM

Strengths and weaknesses of the system were identified by using questionnaire and interview points from the key actors. Highlighted are the major areas that can enhance effective implementation of the system towards sound environmental management. Table 7.7 below summarises the results of the SWOT analysis.

Table 7.7: SWOT Analysis of the NOSA Integrated Five Star System

Strengths	Weaknesses
<ol style="list-style-type: none"> 1) It is prescriptive, unlike ISO which gives general guidelines. Produces specific standards which are specifically audited. 2) Comprehensive in safety issues. 3) Standards are reviewed constantly, aids in continual environmental improvement which is one of the key underlying principles of an environmental management system. 4) Integration reduces duplication. 	<ol style="list-style-type: none"> 1) Very few elements which cover environmental issues. 2) Gives problems during Associated Mine Managers of Zimbabwe (AMMZ) environmental audits, audited on different mines which uses different environmental management systems because that other systems are comprehensive on environmental issues. 3) Integration can cause some weaknesses, especially in the case where there is no balance between other aspects (safety and health) and environmental issues. It seems that integrating quality, occupational health and safety is more practical than linking and integrating all these with environment.
Opportunities	Threats
<p>The greatest opportunity is that the system acknowledges or recognizes other separate systems such as the ISO 14001 environmental standards. There is therefore an opportunity for the system to include key points into the system that are noted during environmental audits. In Zimbabwe for example, the different systems are audited against the same environmental standards when AMMZ audits are carried out. It has been noted that the organization under study has never won the AMMZ competitions mainly because their environmental elements are not exhaustive. It could therefore be an opportunity for the organization in question to pick up salient features that could have been identified during the audits and incorporate them in the whole system. This can be done in order to achieve sound environmental management at operational level.</p>	<p>Possibility of financial strain to the organization and consequently the tributors.</p>

The major environmental impacts identified at the mine sites include waste rock generation, marring of the landscape through creation of pits and trenches and water discharge in larger scale mines. Clear standards and measures have been set up to control these problems, but the under-defined environmental management roles on mine sites have created reluctance to promote effective environmental management practices. Compliance to legal requirements have been noted to be significant on presentation of legislative aspects such as EIA reports, EMP documents, waste discharge permits, merely outlining intended environmental management procedures. A follow-up of the practical procedures on the ground is not comprehensive on the part of the law makers. Where follow-up is done, for example in checking levels of pollutants in effluent discharge, permits are issued based on potential

hazard classification. There are no stringent control measures on heavy polluters except for licensed fines. The existence of the NOSA Integrated Five Star System in the organization proved to reduce the level of environmental damage caused. The effluent analysis results showed that mines under full implementation of the NOSA Integrated System have lower potential hazard than the other mines. Effective environmental management along the Great Dyke on Zimasco chrome mines could be achieved through the proposed extension of the NOSA Integrated Five Star System to all tributator mines. This is possible notwithstanding its weaknesses identified during the SWOT analysis which could be complimented by integrating key points from other systems such as the ISO 14001 set of standards. The key points rendering an EMS effective can easily be identified during the AMMZ environmental audits and any other environmental competitions, the key points possibly not requiring any certification. The next chapter highlights recommendations deduced.

CHAPTER 8: CONCLUSIONS AND RECOMMENDATIONS

The main aim of this study was to analyze the environmental management approaches in Zimasco mining operations. Different steps were taken, herein discussed as objectives. The first objective was to identify the environmental aspects and impacts associated with mining along the Great Dyke; secondly, to determine the value of environmental legislation in environmental management in Zimbabwe as well as thirdly, to establish how the environmental management approaches are implemented. The fourth objective was to assess the usefulness of environmental management approaches using SWOT; and fifthly to recommend some areas of growth for environmental management within the Zimasco framework.

Environmental impacts identified by the miners themselves include land and water pollution resulting from effluent discharged from large mines, pits and trenches mainly associated with small scale miners. There are high levels of dissolved substances in the effluent discharged into the environment therefore implying pollution of the nearby water bodies and the soil. Biodiversity loss occurs due to the cutting down of trees during exploration and for mine support, as well as for wood fuel in homes.

The aspects and impact analysis matrix showed that waste rock dump (because of the high stripping ratio in chrome mining) has a major and significant impact on the Great Dyke. Quantification of the dumps could not be done in this study; however, a general survey of the Great Dyke indicated that waste dumps are a major problem. These are contained to smaller scale miners whose main aim is production; rehabilitation therefore seems very difficult because most of their workings are on steep slopes. A key obstacle to sound environmental management is that there is no follow up on rehabilitation from environmental regulators and Zimasco, when it does occur, it is not effective.

Zimasco complies with the stipulated legislation: as evidenced by the presence of most of the legislative aspects in most tributor mines in the form of the EIA reports, effluent discharge permits and mine closure plans for the larger operations. However, most small scale operations investigated; do not comply with legislation lacking the necessary plans and documentation. This has been attributed to a general lack of competence on the part of legislators and a lack of awareness on the part of the operators.

The corporate environmental policy is clear and non-discriminative but the implementation and procedures on the different operations vary with the level of operation. Other studies (Piha & Shoko 2000, Piha et al. 1997) have shown that the greatest risks to the environment result from these small scale miners; they are more producers than managers. This implies that environmental management is not critical in the day to day running of their operations, as highlighted by Maponga & Ruzive (2002).

The NOSA Integrated Five Star system provides improved opportunities for environmental management and performance. As has been noted in the SWOT analysis, system standards are reviewed continually to ensure constant improvement. This has been proved by the low levels of pollutants released into the environment from the two mines directly run by Zimasco. From the environmental management's point of view, implementing the NOSA system to the indirect larger operations could be a sound provision for pollution prevention, generally cleaner production and sustainable exploitation of chrome ore reserves.

The use of questionnaires for data collection was not the most practical method for the kind of mining operations along the Great Dyke. It showed that attending to a questionnaire was not part of their daily agendas, instead of taking a maximum of three days to complete the questionnaire; the process took longer than anticipated, the responds were first obtained after one week and the exercise spanned for 2weeks. The questionnaire, however, raised awareness in the miners of the implications of their actions on the environment, which could be an important step towards successful and sound environmental management.

8.1 RECOMMENDATIONS

1. A need exists to increase environmental awareness among the operators in order to minimize environmental degradation. From the researcher's point of view, increasing the level of awareness of environmental problems resulting from chrome mining could be a first step in better environmental management.
2. Environmental legislators need to be grounded on practical solutions of minimizing environmental damage, rather than concentrating on punitive actions on violators. Concerns have been raised that the environmental legislators have become money making machines rather than environmental managers (Chirongoma 2007). Operators are heavily fined for not producing permits and/or EIA documents

3. There is a need for the main organization to be clear on environmental rules regarding second part or third part operators on their claims.

8.2 FURTHER STUDY

4. It is deemed necessary to carry out an environmental health assessment, on all the mining operations under Zimasco.
5. The role of EIA reports in environmental management in the mining industry in Zimbabwe should be determined. This seems emphasised by the fact that EIAs are very useful tools in environmental management but in Zimbabwe, environmental regulators have shifted concern from environmental management to report presentation.

Generally the mining of chrome is associated with a high stripping ratio, thereby suggesting waste rock and dumps as a major threat to the environment. This is supported by previous research by Maponga & Ruzive (2002), which identified waste rock as the major problem along the Great Dyke of Zimbabwe. Several other problems, such as downstream siltation can result from poor management of the waste rock dumps. Another major problem identified with most underground mines is that of effluent discharge, a major threat in the drainage system of the area. Chrome ore deposits do not favour vegetation growth as such, though huge tracts of land could be destroyed on all stages of mining.

Therefore, environmental problems associated with chrome mining can be minimised through sound environmental approaches which are effectively administered through a system such as the Integrated NOSA system. For small scale miners simple rehabilitation measures such as that of back filling can be effective and long lasting, yet the number of small scale miners leaving the trenches and pits un-rehabilitated can result in far reaching problems in the environment and in any future utilisation of the land. It has been noted that chrome ore deposits occur in cyclic forms such that some chrome ore can be accessed through pitting and trenching. The same spot can however be used for underground mining at a later stage, such that if the pits and trenches are left unattended has serious environmental implications and eventually hinder sustainable development.

In summary, it is true to say that effective environmental management measures can exist on the Zimasco mining operations provided there is an EMS/SHE system in place; however some inadequacies in the policies and measures need attention, as well as implementation on the ground.

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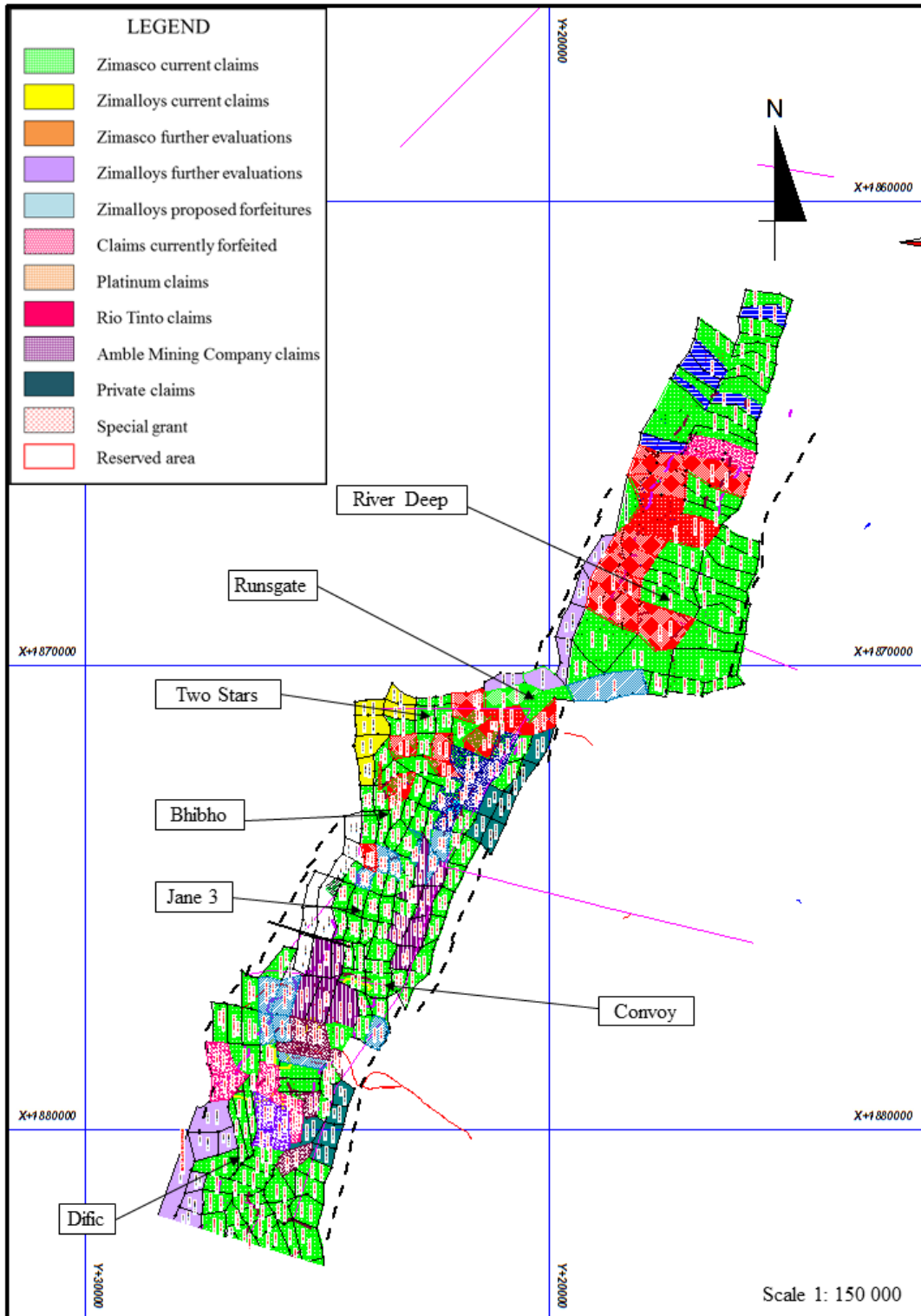
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PERSONAL COMMUNICATIONS

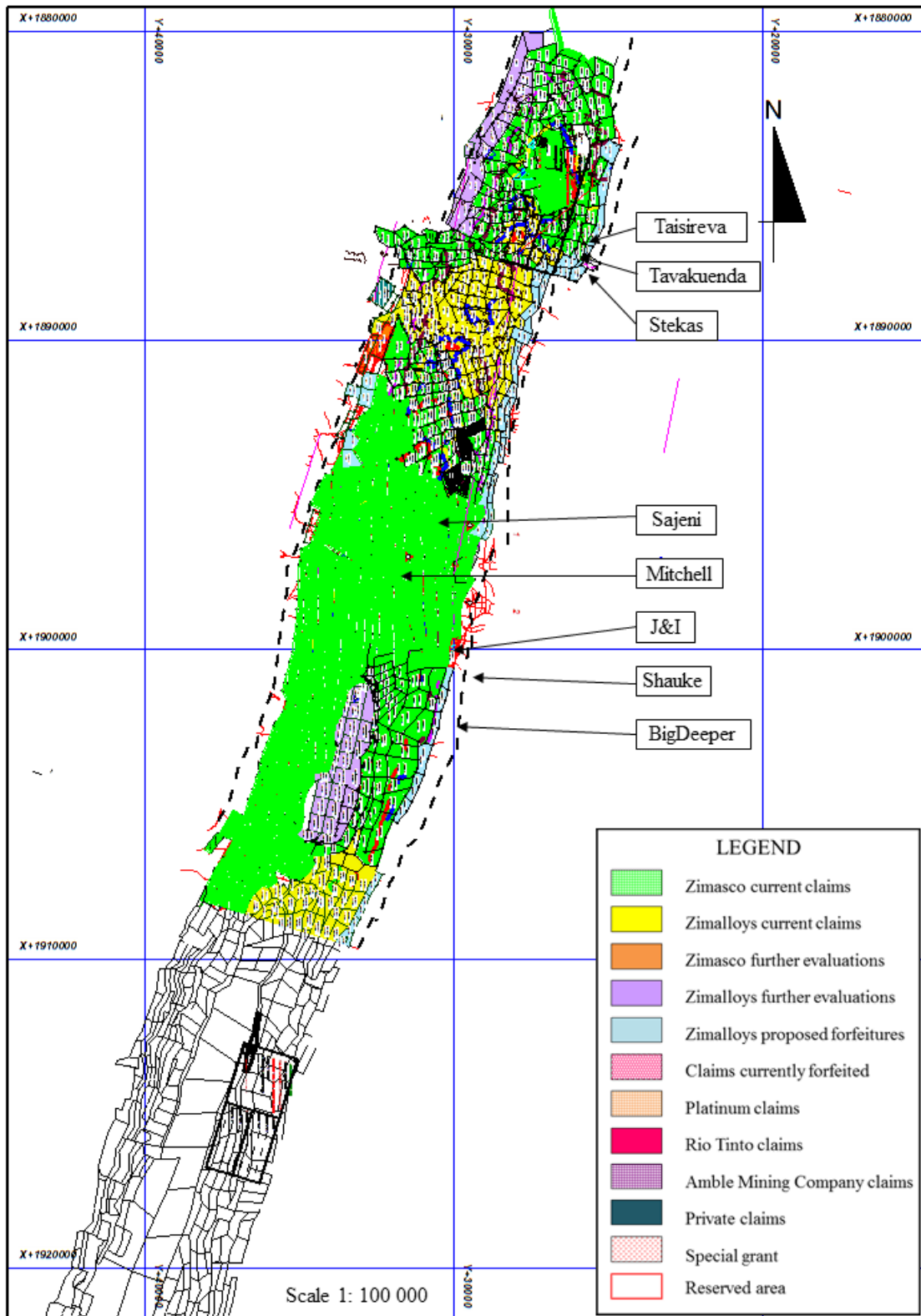
Zimasco Staff 2010. Environmental Officer, Zimasco Mtorashanga. Interview on 03 October about SWOT points on environmental management approaches.

APPENDICES

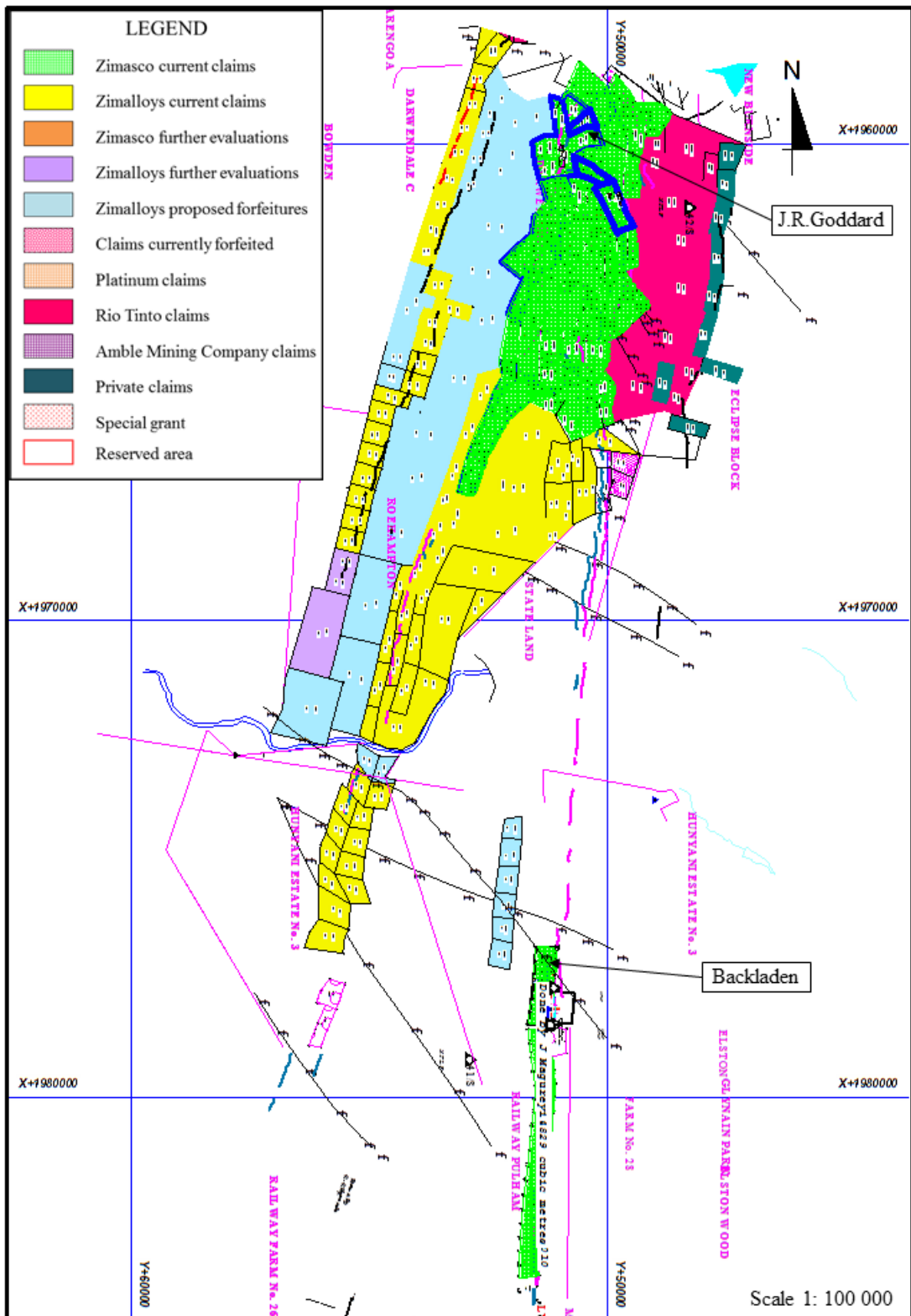
APPENDIX A0: NORTH DYKE A



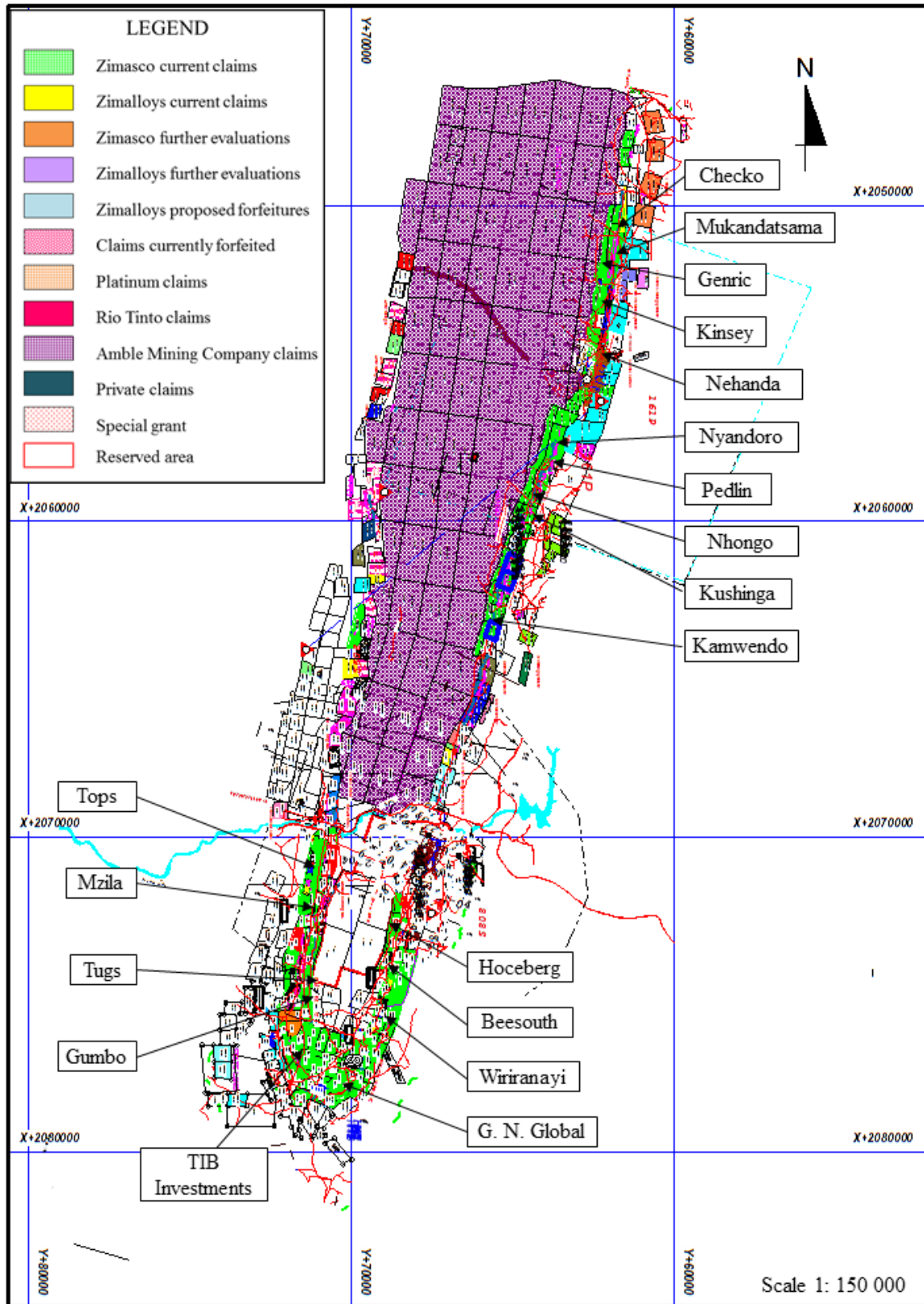
APPENDIX A1: NORTH DYKE CLAIMS B



APPENDIX A2: NORTH DYKE C



APPENDIX A3: MIDDLE DYKE CLAIMS



APPENDIX B: QUESTIONNAIRE

A QUESTIONNAIRE DESIGNED TO DETERMINE THE ENVIRONMENTAL ASPECTS AND IMPACTS OF CHROME MINES, AND MANAGEMENT MEASURES IN PLACE.

Questionnaire

I am a student carrying out a research on environmental management in chrome mines along the Great Dyke. I greatly treasure your co-operation in answering the questions below. Please tick where applicable and fill in the answers in spaces provided.

Section A

1) Type of respondent's operation

Co operative	{	}
Tributor	{	}
Zimasco	{	}

2) Which part of the Dyke are you operating from?

North	{	}
Middle	{	}
South	{	}

3) Please indicate the method of mining you are using

Surface manual: Adits	{	}
Surface mechanized :(strip-mining)	{	}
Underground: Adits	{	}
Underground: Inclined Shafts	{	}
Other? Please Specify		

4) At which stage of operation are you?

Exploration	{	}
Design	{	}
Production	{	}
Closure	{	}
Other? Please Specify		

5) For how long have you been in operation?

0-1 year	{	}
1-5 years	{	}
5-10 years	{	}
>10 years	{	}

6) Is any of the following features near your operations? Outside the brackets please indicate the distance of the feature from your operations.

River/Stream	{	}
Settlement	{	}
Farm	{	}

If any please briefly describe how you interact with each of them, in your own words.

.....

.....

.....

.....

.....

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.....

7) Please identify the environmental aspects of your operations (here defined as the process or activity of the mining operations that could benefit or destroy the environment. eg chemical spillage, oil spillage, vegetation destruction

.....

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.....

8) What could be the possible impacts of the identified environmental aspects? For example chemical spillage can cause land and water pollution.

.....

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.....

Section B

9) Is environmental management part of your operations?

Yes	{	}
No	{	}

a) If yes please indicate environmental management tools on your operations

Environmental Management System	{ }
Environmental Impact Assessment	{ }
Rehabilitation manual	{ }
Environmental Management Plan	{ }
Environmental Management Act	{ }
Other? Please specify	

.....

b) Who is responsible for the implementation of the above environmental tools above?

.....

c) If no to 9 above please briefly explain why?

.....

Section C

10) What are the environmental legislative obligations on your operations?

.....

11) Do you have any environmental monitoring programmes done on your operations?

Yes	{ }
No	{ }

If yes indicate name of authority and how often. For example EMA-twice per year

.....

12) Have you ever been audited by EMA

Yes twice per year	{ }
Yes once in four years	{ }
No	{ }

APPENDIX C: CHECKLIST

AN EXAMPLE OF AN ENVIRONMENTAL LEGAL COMPLIANCE CHECKLIST

Name of mine.....

Date.....

Audit team.....

Responsible person.....

Item no	Description	Requirement	Comment	Compliance status	Date of inspection
1	Environmental issues	Copy of EMP			
		Valid EIA report for operational projects			

APPENDIX D: MINE EFFLUENT CLASSIFICATION

The Classification Table for Mine Effluent Using Effluent Standards from Statutory Instrument 6 of 2007. The measurements are in mg/l unless otherwise stated. Source: (Chirongoma 2007)

Table C.1: Mine Effluent Classification Table

Parameter	Blue	Green	Yellow	Red
COD (mg/l)	≤ 60	≤90	≤150	≤200
DO % saturation	≥60	≥50	≥30	≥15
Nitrogen Total (mg/l)	≤10	≤20	≤30	≤50
pH (pH units)	6-9	5-6; 9-10	4-5; 10-12	0-4; 12-14
Sulphate (SO ₄) (mg/l)	≤250	≤300	≤400	≤500
TDS (mg/l)	≤500	≤1500	≤2000	≥3000
TSS (mg/l)	≤25	≤50	≤100	≤150