

AN ASSESSMENT OF ABANDONED MINE RECLAMATION IN SOUTH AFRICA  
USING A SURVEY OF ENVIRONMENTAL EXPERTS

by

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## AN ABSTRACT OF THE THESIS OF

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Abandoned mines are those in which mining activity has ceased and there is no entity or company that can be traced to take responsibility for their maintenance or reclamation. It has been reported that there are approximately 6,150 abandoned mines in South Africa and it is estimated that it will cost \$US4.2 billion to rehabilitate these mines over a very long period of time. The South African Department of Mineral Resources has set a reclamation target of 12 abandoned mines per year. This low target is what led to the interest in understanding the dynamics of abandoned mine reclamation in South Africa.

An online survey of environmental experts in South Africa was conducted from December 2014 to January 2015 to elicit their opinions on the public's perception of abandoned mine reclamation and to assess whether their views are aligned in terms the cost of reclamation, sources of funding, how to accelerate the process of reclamation and credible sources of information for environmental issues. A total of 54 responses were collected, with good representation of respondents from each province in South Africa although the majority came from Gauteng, Western Cape and Kwa-Zulu Natal.

The results of the survey revealed that there are several challenges that are slowing down the process of reclamation in South Africa including limited sources of

funding, water resources at risk, and disproportionate ratio of experts between the private and public sector. About 80% of the respondents in the survey said that the public would not be willing to contribute towards a reclamation fund. A majority of the respondents who consider themselves experts in reclamation were of the opinion that the government and the mining industry should be primarily responsible for reclamation. After careful review of the results and other government reports related to reclamation in South Africa, it appears that the establishment of an abandoned mine reclamation fund would be a good policy for South Africa, as would be conducting studies to explore possible funding options, ring-fencing tax money for special purposes such as reclamation of abandoned mines, and developing guidelines and standards for abandoned mine reclamation or land reclamation.

## DEDICATION

This is dedicated to my grandparents, without their support and love, I would not be where I am today. To my son, Ulikhaya, thank you for being strong enough to bear with the distance and time apart from your mom. I am so privileged to have a family that believes in me, my parents, sisters, aunts, and my boyfriend Bulumko, I truly appreciate your encouragement and prayers.

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Objectives and justification of study

Mining has played a crucial role in the economic development of many countries around the world. In South Africa, mining accounts for 18.00% of the country's gross domestic product (GDP), it is estimated to be the world's fifth largest mining sector in terms of GDP value (Kearney 2012). However, it is agreed among environmentalists, social activists, and other critics of the mining industry that these benefits have come at a high cost to society and the environment (Adler et al. 2007).

Prior to the establishment of stringent environmental regulations such as the National Environmental Management Act (No. 107 of 1998) (NEMA) in South Africa, mining companies were able to desert their mines once the cost of extraction and operation exceeded their profits, without facing any legal or financial ramifications. In the United States, mines that have been deserted and are no longer being maintained, and in which further mining is not intended, are called abandoned mines. Abandoned mines for which no owner or responsible party can be found are called orphaned mines (Fields 2003). The term derelict and ownerless mine is used to define the same phenomenon in South Africa (Department of Mineral Resources 2009). For the purpose of this study, all mine sites in which mining activity has ceased and for any reason no member or company is taking responsibility will be called abandoned mines.

Abandoned mines have recently received a lot of attention in South Africa mostly because of the associated water problems, the health and safety concerns and the increased level of illegal mining activities. The impact of abandoned mines on public

and environmental health has become so serious in South Africa that the government is faced with a liability of more than US\$4.2 billion to rehabilitate about 6,150 abandoned mines around the country (UNESCO 2013). The South African Department of Mineral Resources in its national strategy for abandoned mines set a reclamation target of 12 mines per year, this low target is what led to the interest in understanding the dynamics of abandoned mine reclamation in South Africa.

Reclamation of abandoned mines involves the process of turning the undesirable features (quarries and pits) into something perceived as desirable and safe by the public (forests, reservoirs, recreation sites, etc.) (USGS 2000). This definition sounds simple, but in reality, reclamation is complicated; limiting factors include securing financial support for reclamation and the challenge of finding an appropriate balance between economic growth and environmental protection (Kramer 2008; van Zyl, et al. 2012). Reclamation of abandoned mines is not uniform across locations, different methods and techniques are used based on a number of factors including the topography, biophysical environment and type of previous mining activity. A number of best practices applied in daily reclamation operations have resulted due to the continuous development and application of research methodologies, field techniques and innovative procedures (Pfannenstiel et al 2002).

The aim of this study is to investigate what the opinions of experts are regarding the public's perception of abandoned mine reclamation and to assess whether these views are aligned in terms the cost of reclamation, the sources of funding, how to accelerate the process of reclamation and credible sources of information for environmental issues. The issue of abandoned mines and their reclamation is not

unique to South Africa but even developed countries such as the United States have had to deal with the environmental degradation that resulted from decades of no regulation in mineral development. In this study, a quantitative tool in the form of an online survey was used to gather information from environmental professionals on abandoned mine reclamation with the aim of answering the research questions below.

## 1.2 Research Questions

1. What are the challenges to abandoned mine reclamation in South Africa?
2. If an abandoned mine reclamation fund were to be established, where would the monies be sourced from?
3. How does an increase or decrease in household income and distance from an abandoned mine affect one's willingness to pay towards a reclamation fund?

The next chapter reviews literature on expert surveys and then the environmental and social costs of abandoned mines are discussed. An evaluation of several case studies is done to extract best practices that have been recommended by national and international organizations with experience in managing abandoned mine reclamation projects. Chapter 3 describes the methods used to carry out the study, elaborates on the study area, survey design, sample population, survey distribution, collection and analysis of the data. Chapter 4 presents the results obtained from the study. Chapter 5 discusses the implications of the results and compares the findings with other similar studies. There are lessons that can be learned from United States environmental regulation and these can be useful in development of strategies to address reclamation

in developing countries but they need to be modified to suite local conditions. In conclusion, Chapter 6 provides some recommendations and direction of future research.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Expert surveys

In some areas of research where there is insufficient published literature on the subject matter and specialized knowledge is required, samples are drawn not from the general population but rather from a group within the population that is expected to have substantial knowledge on the topic at hand. These expert surveys, and the term 'expert' is used sparingly because mostly the level of expertise is self-ranked, have some advantages over sampling from the general population such as interest in the subject matter or higher level of knowledge than the general population. On the other hand, they also have disadvantages that limit their precision such as low sample size (Camerer 2001).

This type of qualitative collection of data has been used in a wide array of studies and is useful in elucidating the understanding of complex ideas. Expert surveys have been used for a very long time, for example Farhar et al (1978) surveyed 551 experts who were members of weather modification and atmospheric science organizations in the United States to gain an assessment of the readiness of weather modification for operational application. At this time there was a lot of uncertainty among scientists and so this research was important to reflect the opinions of those interested in weather modification and also to contribute data that may be useful in policy development. In 1975, David Okrent also invited 7 experts in the United States to provide their opinion on low probability earthquakes. The reports from this survey provided a convenient source of knowledge at a time when detailed knowledge on the cause or source of an

earthquake was far from adequate. In more recent years, expert surveys been used in studies such as Morgan et al (2001) where a panel of 11 experts were interviewed to obtain individual qualitative and quantitative estimates of the likely impact of the doubling of carbon dioxide (CO<sub>2</sub>) climate change on minimally disturbed forests. They found that the results of the survey offered a much richer diversity of opinion than in qualitative harmonized summaries such as the IPCC. Furthermore, Buchhols et al (2009) surveyed experts to analyze their perception of the 35 sustainability criteria for bioenergy commonly found in sustainability frameworks given that there had been no consensus on what experts consider as critical indicators of sustainability. Similarly in this study, they concluded that the information obtained was useful in laying a foundation for further discussions and development of sustainability assessment for bioenergy systems.

Outcomes of expert surveys should be reported and interpreted with caution because they are prone to a variety of cognitive limitations. Questions may be understood differently by different individuals if great care is not taken when developing the questions (Morgan et al, 2001). To overcome this problem, some have used pilot studies among smaller groups in to assess the weaknesses of the questionnaire in preparation for the major study. Validity of conclusions in expert elicitation has also been questioned because of the overconfidence of the 'experts' in their estimations (Mc Bride et al 2012, Morgan 2014).

Due to the existence of various procedures and methods of expert elicitation Knol et al (2010) developed a widely applicable seven step method for the use of expert elicitation in environmental health impact assessment. The procedure is quite flexible

and its fundamentals were followed in this study as well, it consists of the following steps:

- (1) Characterization of uncertainties, where the type of uncertain information to be extracted is identified and characterized according to the types of uncertainties;
- (2) Scope and design of the elicitation, in which the number of experts to be requested and the most suitable form of elicitation is determined;
- (3) Selection of experts, where the necessary types of experts and the balance between different disciplines or viewpoints is considered;
- (4) Design of the elicitation procedure, in which the types of questions and the appropriate format and wording of the questions and answers are determined, taking into account possible effects of heuristics and biases;
- (5) Preparation of the elicitation session, in which a protocol for the elicitation period is developed and background information is distributed;
- (6) Elicitation of expert opinions and
- (7) Possible aggregation and reporting, in which the expert opinions may be grouped and the results of the elicitation are reported.

There are other things to consider when conducting an expert elicitation such as the number of experts required and whether the elicitation will be in the form of a face-to-face interview or an online survey or even a mailed questionnaire. There are no definite guidelines on the number of experts to be included in an expert elicitation although Cooke et al (2006) do suggest a minimum of six experts to be included or otherwise the robustness of the results may be compromised. In terms of selection of the format of the elicitation, interviews are most preferable but surveys also have the



advantages of being less expensive, easily standardized and may be taken at the time that is most suitable for the respondent (Steinert 2009, Knol et al 2010).

### 2.2.1 Environmental impacts of abandoned mines

Current laws and regulations require that the mine operator has funds set aside for closure and reclamation of the mine once operation ceases. However, thousands of operations were abandoned before these laws were passed and their locations and conditions are often unknown (U.S Bureau of Mines 1999). Abandoned mines pose significant threats to the environment and human health due to their impact on water quality, threats of burst dams, and even spontaneous combustion of mine wastes. The impacts of abandoned mines do not only affect human health but are degrading entire ecosystems. Several studies show that acid mine drainage (AMD) has changed the distribution and concentrations of fish populations in Canada, annihilated the aquatic flora and fauna in rivers in South Africa and destroyed terrestrial species in the Ural Mountains of Russia (Larson 2013, Bell et al 2001).

Abandoned mines are a global problem that many countries are yet to effectively deal with. There are hundreds of thousands of abandoned mines worldwide, in the United States alone, more than 400 000 sites have been reported on federal land. The topic of socially and environmentally responsible or sustainable mining is one that is progressive and focused mainly on present or future mines (Peck et al 2005). Larson (2013) calls the problem of abandoned mines 'orphaned pollution' due to its persistent nature and because the responsible party is untraceable or no longer exists. This legacy requires that we look back into the past and come up with new and creative ways to remove or at least moderate the threat in a manner that is beneficial to all parties

involved. This requires collaborations between various stakeholders, new action frameworks and modification of regulations to allow flexible interaction between sectors.

Environmental externalities associated with abandoned mines can be categorized into three main groups according to their effect: 1) water contamination, 2) air pollution, 3) land destruction.

1) Water contamination: this externality primarily manifests itself in the form of acid mine drainage. AMD is a cocktail of toxic pollutants which is produced by reactions between iron sulfates, oxygen and water. It is characteristically yellow in color and significantly reduces the pH of water. Acid mine drainage on the Witwatersrand, in Gauteng, has reached a critical point, due to the toxic water that has seeped into rivers, streams and underground sources. Many river systems such as the Vaal River system, which provide water to major cities and townships are under threat of further contamination with acid mine drainage. Gold tailings dumps have been a feature of the landscape around the large gold mining towns since mining began, and have been discharging polluted water for decades. High levels of mercury has been found in fish species due to exposure to polluted aquatic systems (Yager 2013; Bell et al 2001; Maramba et al 2006).

The gold mining industry in South Africa, principally the Witwatersrand Goldfield, is in decline but the post-closure decant of AMD is an enormous threat, and this could become worse if remedial activities are delayed or not implemented. On the West Rand and East Rand, toxic water has already destroyed life in the streams, and with pumping of the water from the mine having been stopped, it is expected that the AMD will overflow and reach the surface (McCarthy et al 2008). AMD from coal mining is

problematic in the Highveld Coalfield in Mpumalanga, and has been reflected by media attention on the consequences of severe pollution seen in the Loskop Dam and the Olifants River Catchment (CSIR 2009). These water contamination issues are not unique to South Africa but are a signature stamp wherever abandoned mines exist and where mines are not properly reclaimed. Figure 1 lays out the externalities of coal mining and most of them are similar or even worse for gold which is coupled with radioactive wastes.

2) Air pollution: mine waste dust and smoke emanating from sinkholes releases toxic substances into the atmosphere. Spontaneous combustion of carbonaceous material, aggravated by the oxidation of pyrite, is the most common cause of burning spoil. The release of methane and other gasses into the atmosphere is a problem not only for the health of the residents of nearby communities but also impacts global climate change (Singer 2011, Mishra et al 2012, Bell et al 2001). Some abandoned mines contain explosive gases which are easily ignited (U.S Bureau of Mines 1999).

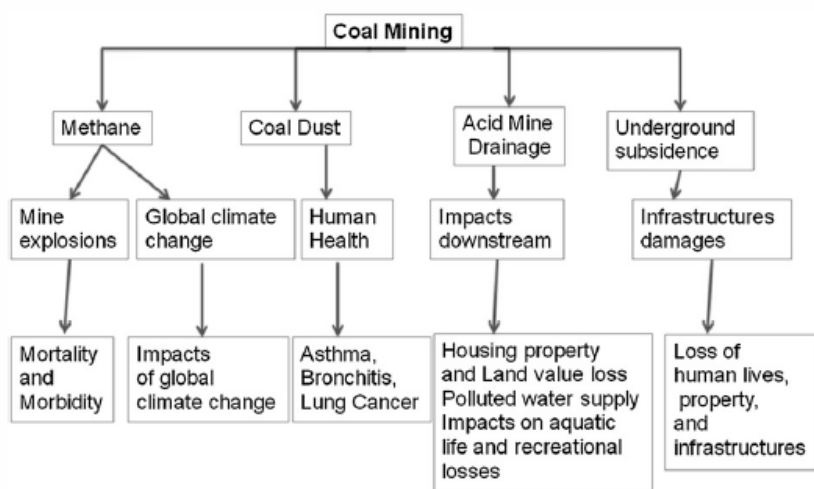


Figure 1: Coal mining externalities (Mishra et al 2012)

3) Land destruction: due to the fact that many abandoned mines are left in a state that mirrors the activity that was previously taking place, there is severe destruction that occurs in the land. Many sites contain pits, shafts and quarries that were never closed (US. Bureau of Mines 1999). These sites are also prone to subsidence, which may be defined as ground movement that takes place because of the extraction of mineral resources or the abstraction of fluids. Degradation or failure of a pillar left in place to support the mine may lead to overexerted pressure on the remaining pillars until the integrity of the land is undermined, leaving a death trap for any curious adventurer who dares to go near these sites (Bell et al 2000; Bell et al 2001). This may also lead to hazards during redevelopment and damage of property and infrastructure (Mishra et al. 2012). In an award winning photographic compilation by Godfrey (2012), the South African Department of Economic Justice highlighted the destructive impacts of mines on humans and land titled legacy of mines; it documents the various dangers and threats posed by abandoned mines and the impact it has had on nearby communities.

### 2.2.2 Social costs of abandoned mines

Abandoned mines have a negative impact on the health and safety of those in close proximity with them. The devastating fact about abandoned mines is that they are usually surrounded by low income communities of individuals who were once employed in those mines but now live in hostels with little or no basic services provided. Benefits of mining have never been equitably shared and local communities living in nearest to mineral development suffer the most. These communities are threatened by air and water pollution, and physical hazards posed by sites containing open shafts and unstable ground (Godfrey 2012). Although it is sometimes difficult to measure or put a

dollar value to the social costs related to abandoned mines, they can be categorized into three:

- A) Health costs – exposure to mine wastes, contaminated soils, water and air has a negative impact on the health of those in proximity with the sites. The affected individuals are then faced with medical bills and at times they die of diseases caused by exposure to mine wastes or the related hazardous environment (Ndlovu, Naude and Murray 2013; Dugard, MacLeod and Alcaro 2012).
- B) Reclamation costs – reclamation comes at a cost, and one way or another, society pays. The cost of reclaiming a single abandoned mine may range from thousands of dollars to millions of dollars depending on the size, location, the nature of the contamination present, and the resources affected (US Forest Service 2007). There are ways to reclaim abandoned mines without spending tax payers' money, such as using classical model firms for re-mining, but in most countries, these options are usually restricted by laws that limit the possibility for making profits while ameliorating the environmental threat (Larson 2013).
- C) Opportunity costs – these in the form of alternative land uses and ecosystem services forgone. Failure to reclaim abandoned mine land precludes other purposes such as a development project, forestry or for educational purposes that could have been beneficial to society (Sullivan and Amacher 2009).

In the United States, there has been a tremendous amount of progress in environmental regulation and specifically reclamation of abandoned mines since the enactment of the Surface Mining Control and Reclamation Act (SMCRA) in 1977.

SMCRA is a comprehensive environmental statute that not only addresses present and

future environmental issues associated with the extractive industry but also has specific guidelines to deal with abandoned mines across the United States. The Office of Surface Mining (OSM) has collected over \$10.1 billion in fees imposed on current mining and has distributed over \$7.6 billion in grants to its partners in 24 States and three Indian tribes to remediate dangerous abandoned mine sites. There is still a lot to be done; it is reported that there are nearly 5200 coal mines that are yet to be fully reclaimed amounting to an estimated \$3.0 billion worth of health and safety problems and more than \$2.0 billion of general welfare and environmental problems (OSMRE, 2014).

This is admirable and desirable for all nations, but in most cases, like that of South Africa, it is not possible to charge a tax on current mine operators or mining companies to rehabilitate abandoned mines because of agreements such as The Fanie Botha Accord. This agreement basically gives the State the responsibility of ensuring pollution control measures exist, the maintenance of such measures, and all costs pertaining to mines and works abandoned before July 1976. Only when a company resumes mining works at a particular site is the State no longer responsible for pollution abatement, but the company (MMSD, 2002). This then leads us back to the question of who will ultimately pay for reclamation of these abandoned mines and can how this process be accelerated.

These questions need to be answered urgently because no single source of funding, whether it be national, provincial, or private, is adequate on its own to address the magnitude of the problem that exists. The slower the process of reclamation is, the

higher the threat is to society and we all end up 'paying' through health and safety hazards or the opportunity costs of not reclaiming abandoned mines.

### 2.3 Lessons learnt and reclamation best practices

History has shown that mining operations may cease at any point in time for a number of reasons. Many mining legacies are much more than the result of mine abandonment in the absence of stringent legal and regulatory frameworks for closure and environmental responsibility, but may be linked to greater social or economic situations that are stressful to the communities dependent on mining and may contribute to the termination of mining activity (Peck, et al. 2005). Some factors that may lead to cessation of mining activity as identified by Smith and Underwood (2000) and Environment Australia (2002) include: depletion of mineral reserves, unexpected changes or deterioration in geological conditions; changes in market conditions; changes in other external economic factors that make reserves unfeasible at a given time; liquidation of the company; adverse environmental conditions or; hostile political conditions or social disruption.

Among the environmental issues still to be confronted by the mining industry, that of abandoned mines has been the most challenging. In the past, it was common and acceptable practice to abandon a mine site when mineral extraction was completed. The land was left without vegetation and unprotected, while waste materials were left in piles or randomly dumped into mine cavities or pits. There was little concern for the environment and no thought of how mining might adversely affect the surrounding ecosystem in the future (van Zyl et al. 2002). Hence one could say that sustainability

was not a concern for the mining companies or the governments because economic growth was the chief priority.

Action towards rehabilitation of abandoned mines by both the mining industry and public authorities has been hindered by many obstacles including the fact that there is usually no clearly assigned responsible party; the potential costs of wide scale rehabilitation are great; the absence of criteria and standards for rehabilitation; the legal, financial and technical instruments being used, and the approaches to social issues, are unsuitable for such sites and their neighboring communities (Balkau 2005, Post Mining Alliance 2005).

From assessing a number of reclamation programs in the United States and in Canada, it is agreed that there has been a significant amount of work done to deal with contaminated and abandoned mine sites. In terms of program options or how to dissect the elephant, there are several approaches that may be taken but these key areas are targeted in programs such as the U.S. Department of the Interior's (DOI) Bureau of Land Management (BLM) and U.S. Department of Agriculture's (USDA) Forest Service Abandoned Mine Land (AML) program and Canada's National Orphaned/Abandoned Mines Initiative (NOAMI):

- 1) Gathering information- the main objective here is to develop capacity for the development of a National inventory of abandoned mines based on compatible inventories from each state or province and including an acceptable system for categorization and priority ranking. The watershed approach has been recommended to concentrate inventories in the watersheds most at risk for environmental impact and exposure models to concentrate inventories in the



areas where the public are most likely to come in contact with physical hazards (AMLU, 2000). The priorities of the U.S abandoned mine reclamation fund are outlined in Section 403(a) of SMCRA in five categories as follows:

Priority 1- the protection of public health, safety, general welfare, and property from extreme danger of adverse effects of past mining practices.

Priority 2- the protection of public health, safety, general welfare, and property from adverse effects of past mining practices.

Priority 3- the restoration of land and water resources and the environment previously degraded by adverse effects of coal mining practices including measures for the conservation and development of soil, water (excluding channelization), woodland, fish and wildlife, recreation resources, and agricultural productivity.

Priority 4- the protection, repair, replacement, construction or enhancement of public facilities such as utilities, roads, recreation, and conservation facilities adversely affected by coal mining practices.

Priority 5- the development of publically owned land adversely affected by mining practices including land acquired for recreation and historic purposes, conservation, and reclamation and open space benefits.

According to McGowan (2001), priority 1 sites are more likely to be reclaimed than priority 2, 3, 4 and 5 sites. It was also found that reclamation status of an abandoned mine site is related to that site's location, priority level and problem type.

2) Community Involvement- this area focuses on involvement of the community in decision making about closure and reclamation and to ensure that the targeted end-use and reclamation standards are acceptable to local communities. Public

education about the need to preserve the unique habitat created by abandoned mines is necessary in order to protect endangered and threatened species as well as education about the chemical and physical hazards of abandoned mines (AMLU 2000; Peck et al. 2005).

- 3) Legislative Barriers to Collaboration- the aim here is to conduct an examination of the legislative requirements to assess barriers to collaboration. This area addresses regulatory or institutional barriers, liability disincentives, and collaborative opportunities regarding voluntary abatement, remediation, and reclamation of orphaned/abandoned mines (Peck, et al. 2005).
- 4) Funding Approaches- review of a variety of funding approaches to be considered for the cleanup or management of liabilities related to abandoned mines is necessary. This information can be gathered by surveying experts and conducting workshops of individuals with expertise in this area. According to NOAMI Toolkit of Funding Options (2006), there are five possible sources that can be explored for reclamation of abandoned mines:
  - a) Direct government funding from general revenues
  - b) Direct government funding through tapping existing revenue streams generated by mining
  - c) Creation of a fund through a new levy on mining production
  - d) Federal-Provincial or territorial cost sharing arrangements from general revenues
  - e) Creating funding partnerships with mining companies to fund abandoned mine reclamation.

- 5) Guidelines to Legislation Review- development of guidelines is necessary to address both the broad application of legislation and policies and the wide spectrum of regulatory agencies that regulate contaminated sites, operating mines, and orphaned and abandoned mine sites. This is to ensure that approaches across jurisdictions are consistent, clear, transparent, coordinated and efficient (Peck, et al. 2005).
- 6) Reclamation- Reclamation is not uniform across locations, different methods and techniques are used based on a number of factors including the topography, biophysical environment and type of previous mining activity. The Forestry Reclamation Approach has been promoted by state mining agencies and the Office of Surface Mining as an appropriate and desirable method for reclaiming coal mined land to support forested land uses under Surface Mining Control and Reclamation Act in the United States. This approach establishes guidelines for achieving successful reforestation on mined lands, which involves: a) creating a suitable rooting medium for good tree growth that is no less than four feet deep and made of topsoil, weathered sandstone, and/or the best available material, b) Loosely grading the topsoil or topsoil substitute established in step one to create a non-compacted growth medium, c) Using groundcovers that are compatible with growing trees, d) Planting various types of trees: early successional species for wildlife and soil stability, then commercially valuable crop trees and e) Use of proper tree planting techniques (ARRI, 2005).

It is important to consider all these key areas of focus so that nothing is overlooked and to avoid underestimation of the challenges in the South African context.

## CHAPTER 3

### METHODS

#### 3.1 Introduction

Approval to conduct this study was obtained from the Human Subjects Committee at Southern Illinois University Carbondale (Appendix A). A formal expert survey was conducted to elicit opinions about abandoned mine reclamation in South Africa, the level of interest among professionals and the public, awareness of the environmental risks and support for an abandoned mines reclamation fund. Commonly used in cases where there is insufficient knowledge on a particular subject in the published literature, expert elicitation is a structured approach of consulting experts to obtain a better understanding of uncertain issues. It seeks to clarify and synthesize the published and unpublished knowledge and perception of experts (Cooke 1991; Knol et al. 2010; Wardekker 2011). Expert surveys have been used by several national and international agencies including the Intergovernmental Panel on Climate Change, European Environmental Agency and U.S. Environmental Protection Agency (Knol et al. 2010).

Although abandoned mine reclamation is a well-documented process in developed countries such as the United States, this is not true for South Africa and many other developing countries. The design and scope of this elicitation was based on related literature analysis and review of government reports published on public platforms. There are several methods and approaches to expert elicitation such as workshops, panels, interviews, or questionnaires as reviewed in Knol et al. (2010), an online questionnaire was used in this because of the following reasons 1) location of the

researcher is different from that of the intended participants, 2) considering the broad scope of the issue, it is desirable to reach experts throughout the country 3) cost and time efficiency.

### 3.2 Study Area

The longitude and latitude of South Africa is 30.0000° S and 25.0000° E. This study was focused on South Africa in a broader context rather than focusing on a particular area affected by past mining activities. This was motivated by the desire to widen the focus of the dialogue to a national level and show the need for greater collaboration between provincial and national government on the issue and also to include all provinces even those not adversely affected by abandoned mines in planning, response and funding strategies. Many studies that have investigated the impact of abandoned mines in South Africa are localized such as McCarthy et al. (2011) and CSIR (2009). Furthermore, the report by the auditor general of South Africa on abandoned mine rehabilitation in South Africa showed that the distribution of abandoned mines is highly correlated with densely populated areas (see Figure 2) and this is a matter of national concern as it affects public health and safety, the country's water resources and will ultimately affect the economy.

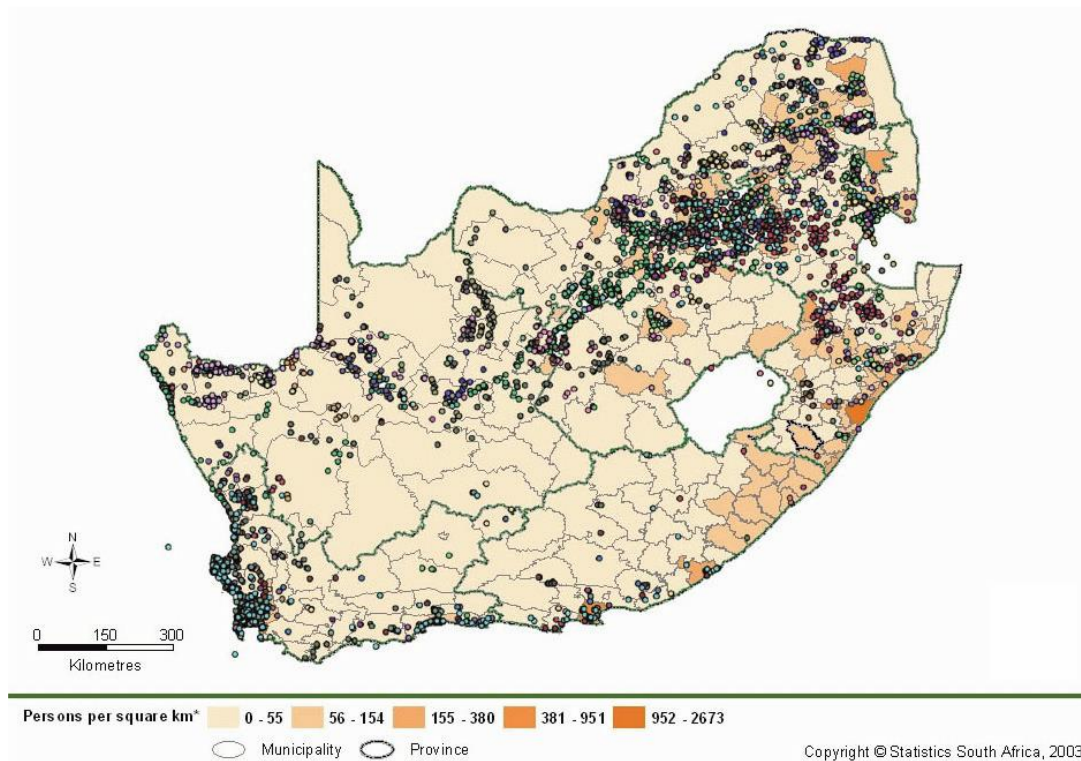


Figure 2: Correlation between abandoned mines in South Africa and population density. (Source: Auditor General of South Africa, 2009)

As figure 2 shows, regions of concern are those that are clustered with large numbers abandoned mines of abandoned mines. From the map above, it can be deduced that the problem of abandoned mines is concentrated in the Gauteng, North West, Mpumalanga, Limpopo, Western Cape and Kwa-Zulu Natal to varying extents. It is not only the quantity of abandoned mines that matters but the type of mining activity that used to occur in that site.

### 3.3 Survey participants

A majority of the participants for the study were obtained from a group on LinkedIn called Environmental Consultants in South Africa. As a member of the group, I was able to send a request for participation to selected experts within the group. Although the group has more than 1600 members, only about 450 members' profiles were accessible to send in mails to. Participants were selected on the following basis: 1) their job title was related to environmental consultancy, mine/land rehabilitation or ecological/environmental impact assessment and 2) they currently live and work in South Africa. The survey link was distributed to 400 experts in the group and 49 responses were collected which gives a response rate of 12.25%.

Additional experts with relevant experience were obtained by conducting searches on Google Scholar to identify experts who had published on topics closely related to abandoned mines in South Africa or land rehabilitation. A total of 32 experts were contacted by email, 5 experts (15.63%) responded to the survey and 6.25% opted out. This resulted in a total of 54 respondents for analysis in the study. Selected experts were provided with information about the study, an invitation to participate and a questionnaire/survey online. The survey was opened for a period of seven weeks between December 3, 2014 and January 20, 2015.

### 3.4 Survey demographics- Gender, age, race and occupation

The table below presents the details of the respondents by age and race group (Table1). A total of 30 (55.56%) of the respondents were female and 24 (44.00%) were male, 77.78% of the respondents indicated that they have completed a post degree qualification and 22.22% have gone up to degree level.

Table 1: Details of respondents by age and race group

<b>Age group</b>	<b>Number</b>	<b>18-34</b>	<b>35-49</b>	<b>50-64</b>	<b>65 and Older</b>	<b>Total</b>
	(n)	%	%	%	%	%
Male	24	54.20	33.30	4.20	8.30	100.00
Female	30	56.70	33.30	10.00	0.00	100.00
	<b>Black/African</b>	<b>Colored/Mixed Race</b>	<b>White</b>	<b>Asian</b>	<b>Other</b>	<b>Total</b>
	%	%	%	%	%	%
Male	54.20	4.20	41.70	0.00	0.00	100.00
Female	46.70	1.90	43.30	6.70	3.30	100.00

A majority of the respondents are employed in the private sector (52.83%) and 28.30% work in the public sector while the remaining 19.00% works in Non-Governmental Organizations and other sectors (Figure 3). A substantial portion of the respondents are currently living in Gauteng and Western Cape in South Africa (Figure4).



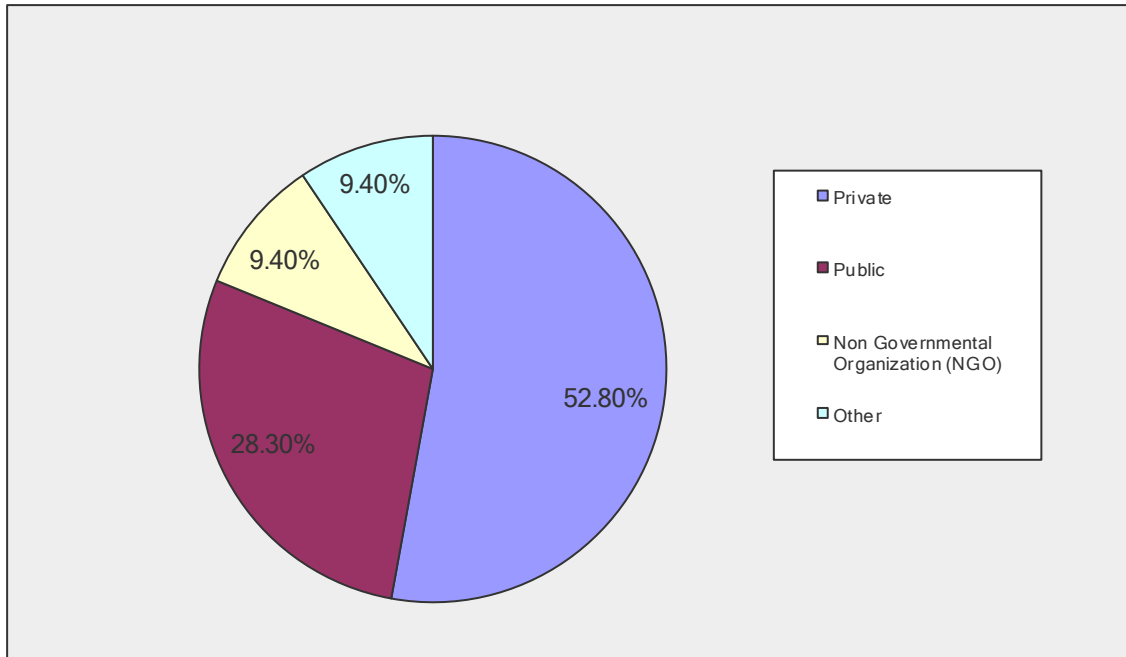


Figure 3: Respondents' occupation by sector

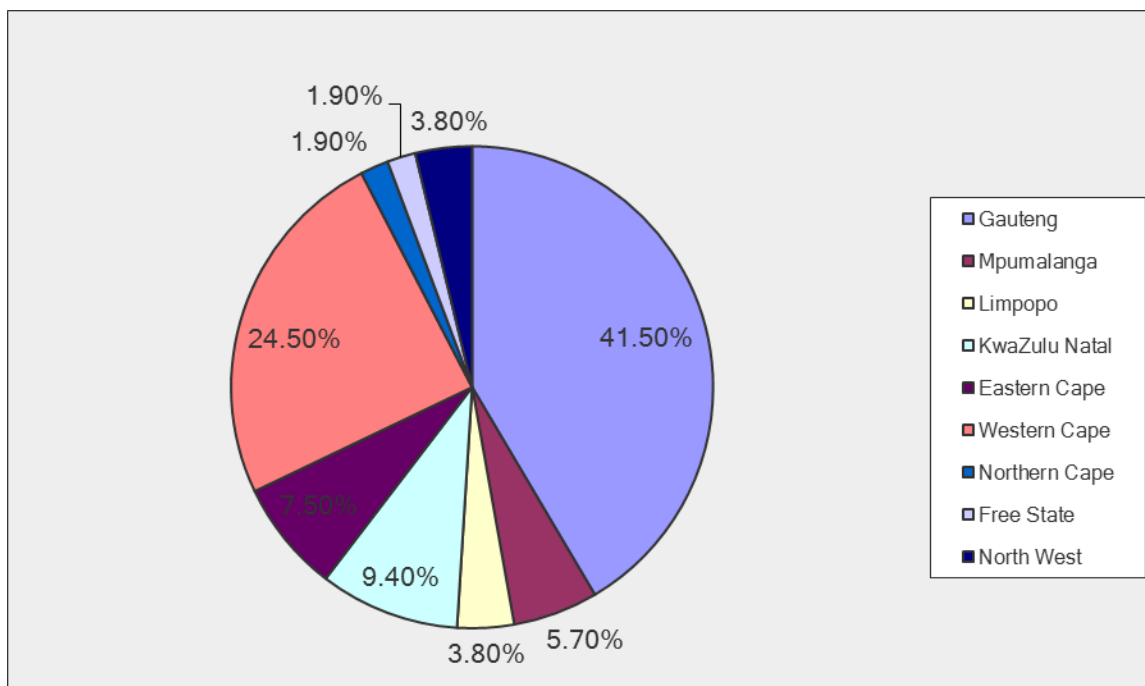


Figure 4: Distribution of respondents by province in South Africa

### 3.5 Survey Design, Distribution and Response Collection

The survey questionnaire was designed and distributed using Survey Monkey- an online survey tool that allows you to design the survey, collect responses and analyze results. The design of the survey was based on other similar studies such as Borick, Rabe and Lachapelle (2014) where a survey was used to elicit public opinion on the potential risks of hydraulic fracturing in New York and Pennsylvania. Other reference studies include Bergmann et al. (2006) and Longo et al. (2008), who assessed willingness to pay for environmental and social attributes of electricity from renewable sources by means of a choice experiment in Scotland and England, respectively.

The questionnaire was formulated on the basis of 1) literature review on abandoned mine reclamation in South Africa compared to the United States 2) analysis of government documents and reports from the Auditor General in South Africa and 3) a pilot study among 6 students as a trial run for logistical issues. The survey questions were mostly multiple-choice and open ended. The first section of the questionnaire captures demographic information about the participants. The second section focuses more on their knowledge and opinions about abandoned mine reclamation, their concern with environmental issues and predictions of the public's awareness and willingness to pay towards an abandoned mines reclamation fund (Appendix B).

The survey used both qualitative and quantitative questions, often making use of a scoring scale; mostly a Likert scale was used. This is a non-comparative scaling technique in which respondents are asked to indicate their level of agreement with a given statement using an ordinal scale. The respondents were often provided an

opportunity to support arguments in a comments section. A survey link was created and sent to participants through email or LinkedIn messaging. Survey monkey contains multiple collectors thus one is able to distinguish whether the responses are coming from email invitation or the general web link. Responses were collected online and separated by type of collector.

### 3.5 Research Questions

#### 3.5.1 Research question 1

It is understood that abandoned mine reclamation is a complicated task that connects many areas of expertise and requires substantial knowledge in order to carry out successful projects. The first question in this study is: “What are the challenges to abandoned mine reclamation in South Africa?” This question seeks to reveal what are the factors that may hinder or slow down the process of reclamation of abandoned mines in South Africa. To answer this question, a number of responses from questions 7, 12, 17 and 25 were combined and analyzed in combination with other reports.

#### 3.5.2 Research Question 2

Identification of the sources of funding is key as that is prerequisite for establishment of an abandoned mine reclamation fund. The second research question is: “What mechanisms to finance an abandoned mine reclamation fund if it were to be established?” Several questions were asked in the survey to elicit opinions from the respondents. Question 22 of the survey requires the respondents to suggest mechanisms which they view as suitable to collect monies for the establishment of an abandoned mine reclamation fund. Respondents were also asked to estimate the

probability of the population that would be willing to pay towards reclamation and the amount they would be willing to pay in question 23.

### 3.5.3 Research Question 3

The final question is: “How does an increase or decrease in household income and distance from an abandoned mine affect one’s willingness to pay towards a reclamation fund?” This aims at assessing whether the respondents believe that they and the public would be willing to contribute towards reclamation fund if they live closer or are directly affected by the environmental risks of abandoned mines. The research question is answered using data from question 25 of the survey and supported by similar studies that have assessed the willingness to pay towards environmental goods or improvement of environmental conditions.

### 3.6 Data Analysis

Firstly, data was coded and cleaned up for further analysis, this included representation on an excel sheet and removal of duplicates. Table 2, 3 and 4 below represent the coding categories for questions 1-4, 5-7 and 15, 17 respectively. Some questions were not coded because the data was already numeric, only a label was inserted in the value label field on SPSS. Analysis of the survey data included performing descriptive statistics and cross tabulation of responses from multiple questions using SPSS. Mainly descriptive statistics were extracted from the survey results and textual analysis to convey the main points that respondents highlighted in their comments. IPinfoDB ([http://www.ipinfodb.com/ip\\_locator.php](http://www.ipinfodb.com/ip_locator.php)), a web application, was used to convert the respondent IP addresses to geographic location data (longitude and latitude). Subsequently ArcGIS was used to map the location of the respondents was which verified with the response they had given to question 8, where they were asked to indicate which province they lived.

Table 3: Coding categories for questions 1-4

<b>Q1</b>	<b>Q2</b>	<b>Q3</b>	<b>Q4</b>
1=18-34	0=Male	1=Single, never married	0=Less than degree
2=35-49	1=Female	2=Single, but living with a significant other	1*=Degree
3=50-65		3=In a domestic partnership or civil union	2*= Post degree qualification
4= >65		4=Separated 5=Divorced 6=Widowed 7=Married	*since there were no respondents with less than a degree, reduced number of categories

Table 3: Coding categories for questions 5-7

<b>Q5</b>	<b>Q6</b>	<b>Q7</b>
1=Black\African	0=R1- R4 800	1=Public
2=Colored\Mixed race	1=R4 801- R9 600	2=Private
3=White	2=R9 601- R19 200	3=NGO
4=Asian\Indian	3=R19 201- R38 400	4=Other
5=Other	4=R38 401- R76 800 5=R76 801- R153 600 6=R153 601- R307 200 7=R307 201- R614 400 8=Above R614 400 999=No response	

Table 4: Coding categories for questions 15 and 17

<b>Q15</b>	<b>Q17</b>
1=Strongly oppose	1=Most experts agree that the risks associated with abandoned mines in the affected provinces are HIGH.
2=Somewhat oppose	2=Most experts agree that the risks associated with abandoned mines in the affected provinces are LOW.
3=Neutral	3=Most experts are divided on whether abandoned mines pose any risk
4=Somewhat support	4=Not sure
5=Strongly support	999=No response
6=Not sure	

## CHAPTER 4

### RESULTS

The results of this study indicate that among environmental professionals, there is an awareness of the environmental and social impacts of abandoned mines but a majority of the respondents are of the view that the public should not be expected to contribute towards environmental rehabilitation of abandoned mine lands.

#### 4.1 Research question 1: The challenges of abandoned mine reclamation in South Africa

Some identified factors that are slowing down the process of abandoned mine rehabilitation in are:

- 1) Limited sources of funding- Specifically, the responsibility of mine rehabilitation is at the hands of government alone; the mining industry is not interested in correcting issues caused by legacy mines and the according to the responses of the survey, the public cannot afford or would not be willing to contribute.

Establishment of an abandoned mines fund requires that we consider where the funding for reclamation will come from. Respondents were asked if they thought the general public of South Africa would be willing to pay towards an abandoned mine fund, 80.00% of them said no, the public of South Africa would not contribute towards a fund, 15.56% said they were not sure and 2.22% held that the public would be willing to contribute. When the respondents were asked whether they would recommend contributing towards an abandoned mine rehabilitation fund, 84.00% of the respondent said it was not likely, 5.00% were passive and 11.00% said they were most likely to recommend it. The similarity in

the responses to these two questions suggests the strong opinion of the respondents that the public is definitely not a reliable potential source of funding. Even though the respondents are of the view that the public generally supports the rehabilitation of abandoned mines, a cumulative 64.00% of the respondents believe that it is impossible for 75-100% of the population to contribute towards rehabilitation but 11.11% said that they believe that it is possible that 0-25% of the population may willing to contribute towards an abandoned mine fund. A majority of the respondents said that the government and the mining industry should be primarily responsible for reclamation (Figure 5 and 6).

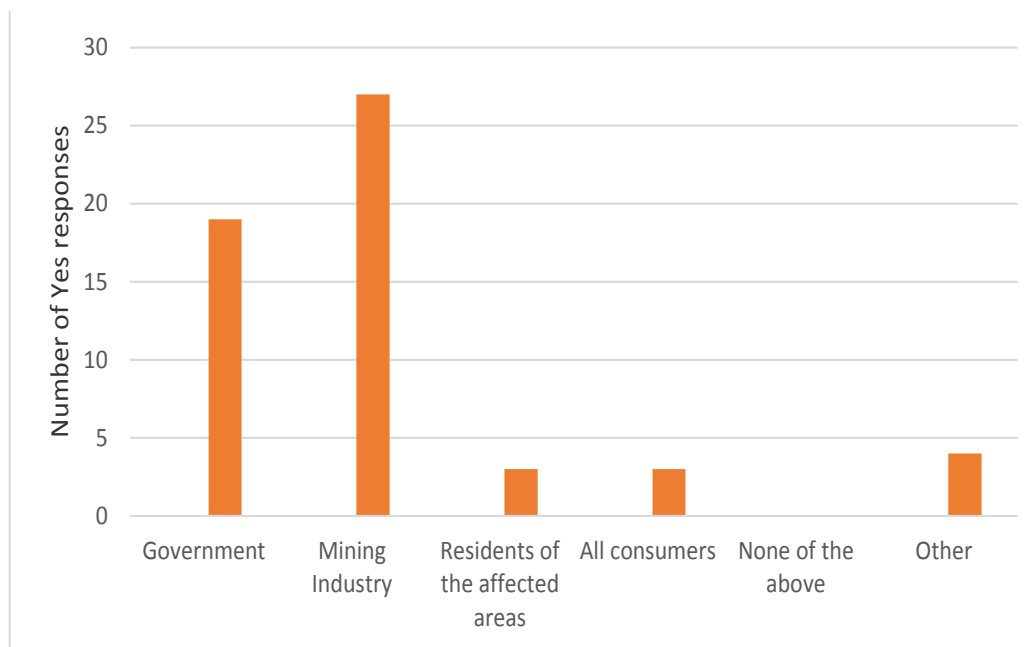


Figure 5: Respondents opinion of who should be financially responsible for reclamation.



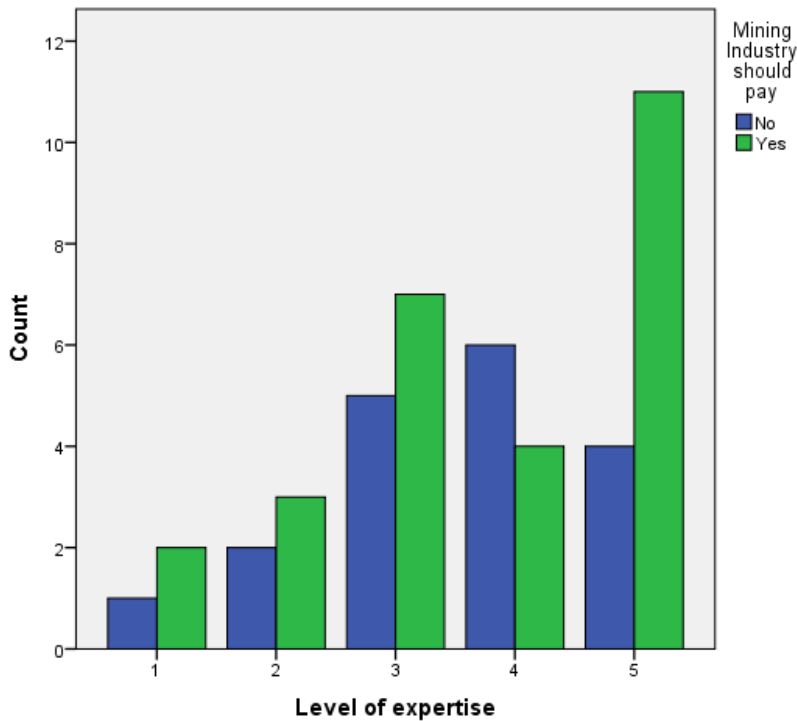


Figure 6: Most respondents who consider themselves as experts in environmental/ land rehabilitation say that the mining industry should be financial responsible for reclamation of abandoned mines.

- 2) Water resources are at risk- when respondents were asked to rank the risk which they considered most important that is related to abandoned mines. Water was ranked at the top of the list, followed by pollution/contamination and then health issues, land destruction/damage and safety issues. Almost 38.00% of the respondents said water problems were the number one concern related to abandoned mines, 15.60% said it was the second and 22.20% said it was the third highest concern (Table 5).

Table 5: Respondents' ranking of water problems

	<b>Ranking</b>	<b>Frequency</b>	<b>Valid Percent (%)</b>	<b>Cumulative Percent (%)</b>
Valid	1	17	37.80	37.80
	2	7	15.60	53.30
	3	10	22.20	75.60
	4	4	8.90	84.40
	5	5	11.10	95.60
	9	2	4.40	100.00
	Total	45	100.00	
Missing	No Response	9		
	Total	54		

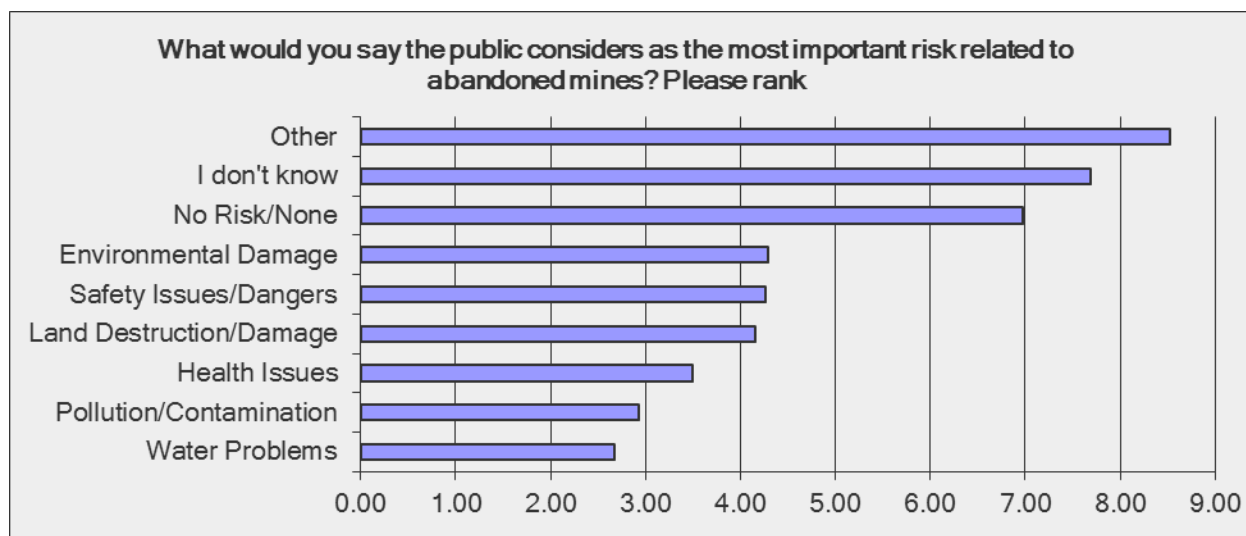


Figure 7: Water problems had the smallest average ranking score which means that a majority of the respondents thought it was a major concern.

3) Disproportionate ratio of experts between the private and the public sector – a cross tabulation of the results from question 7 and question 12 shows that a majority of the respondents who consider themselves experts in reclamation or have substantial knowledge in the subject matter are working in the private sector. The figure below illustrates this dynamic, which shows that the respondents in the public sector are more evenly distributed in their self-ranked level of expertise.

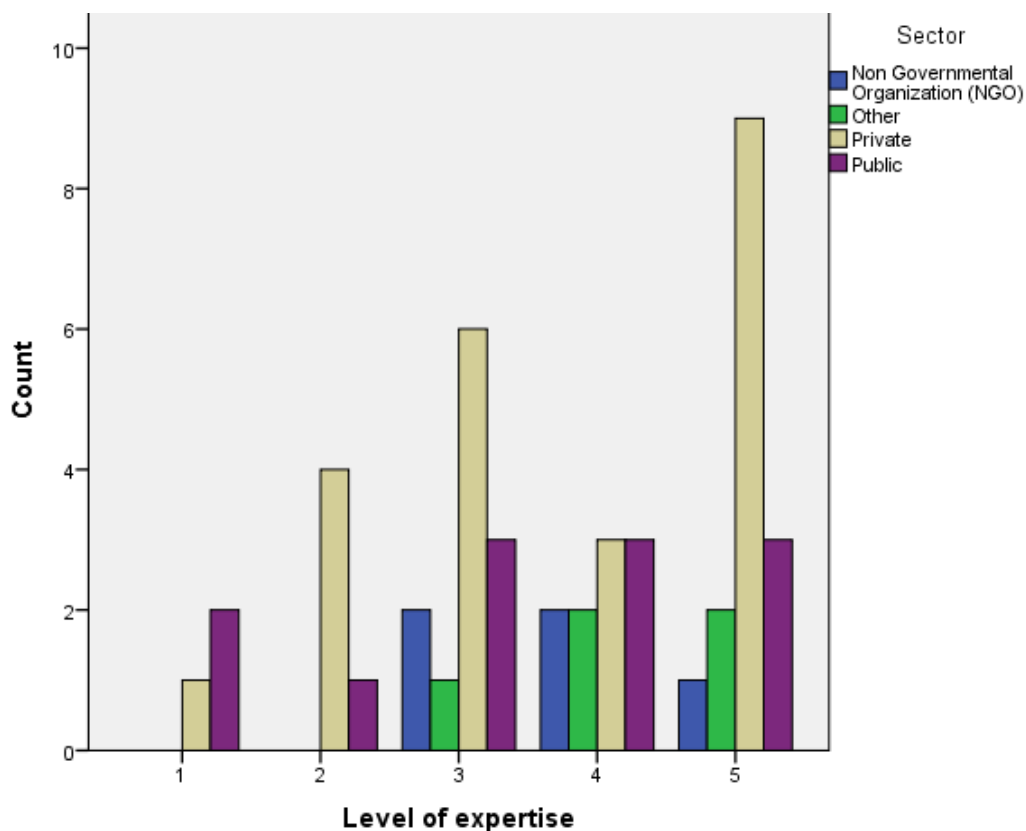


Figure 8: Analysis of respondents' expertise by sector of occupation.

- 4) The collaboration between the various sectors needs to improvement- when respondents were asked whether they approve, are neutral or disapprove of the way the Department of Mineral resources has been addressing the issue of abandoned mines, 53.30% of the respondents said they disapprove, 8.90% said they approve and 28.90% said they were neutral about the matter. Another 8.90% left comments and generally said that there is room for improvement.

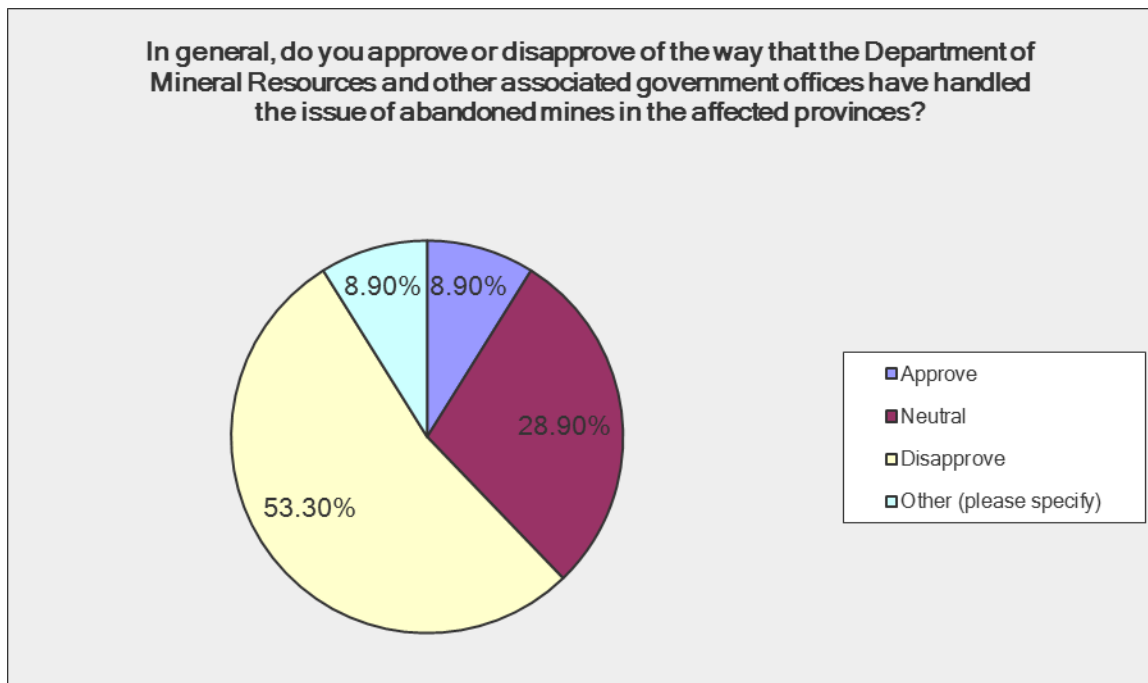


Figure 9: Respondents' opinion of DMR reclamation efforts.

5) Few environmental professionals consider themselves experts in land rehabilitation- A self-ranking system was used in question 7 to assess the level of expertise in reclamation within the group of respondents. The categories range from 1 to 5 (unfamiliar, casually acquainted, familiar, quite familiar, and expert). As seen in Table 6 below, only 17.80% of the respondents ranked themselves as experts, 33.30% said they were quite familiar, another 33.30% said they were familiar, 13.30% said they were casually acquainted and 2.20% said they were unfamiliar with abandoned mine reclamation.

Table 6: Respondents' level of expertise in reclamation

<b>Level of expertise (self-ranked)</b>	<b>Frequency</b>	<b>Valid Percent (%)</b>	<b>Cumulative Percent (%)</b>
1	1	2.20	2.20
2	6	13.30	15.60
3	15	33.30	48.90
4	15	33.30	82.20
5	8	17.80	100.00
Total	45	100.00	
No Response	9		
Total	54		

6) Experts are of the opinion that a majority of the public know very little about abandoned mine rehabilitation- In question 13 of the survey, the experts were asked to predict the publics' perception or awareness of abandoned mine reclamation. A cumulative 73.20% of the respondents said the public either never heard of it or are casually familiar with reclamation. Another 22.20% said that they thought the public is familiar with reclamation and 4.40% indicated that the public is quite familiar, none of the respondents believed that the public is extremely familiar with reclamation of abandoned mines (Table 7).

Table 7: Respondents' prediction of public awareness about abandoned mine reclamation

<b>Predicted public awareness</b>	<b>Frequency</b>	<b>Valid Percent (%)</b>	<b>Cumulative Percent (%)</b>
1	10	22.20	22.20
2	23	51.10	73.30
3	10	22.20	95.60
4	2	4.40	100.00
Total	45	100.00	
No Response	9		
Total	54		

## 4.2 Research Question 2: Mechanisms of funding and probability of contribution from the general population

### 4.2.1. Sources of funding

The respondents were asked about ways to collect money to finance the abandoned mine reclamation fund, results are presented in Table 8 below. The mining industry once again received the highest votes, 55.56% of the respondents said that there should be a corporate tax targeted at the mining industry, 8.89% were of the opinion that a sales tax on gold or electricity could also be a source of money. On the other hand 8.89% said the fund should be financed through voluntary annual donations. Some respondents (15.56%) chose to leave comments to express their strong opinion that it was unfair that the public would even be expected to contribute to such a fund.

Table 8: Mechanisms of fee collection suggested by respondents

	<b>Funding option</b>	<b>Frequency</b>	<b>Valid Percent (%)</b>	<b>Cumulative Percent (%)</b>
Valid	Corporate tax targeted at the mining industry	25	55.60	55.6
	General corporate tax	3	6.70	62.20
	Other (please specify)	7	15.60	77.80
	Personal income tax based on income level for everyone	1	2.20	80.00
	Personal income tax based on income level from which the low income class is exempted	1	2.20	82.20
	Sales tax on gold and/or electricity	4	8.90	91.10
	Voluntary annual donation	4	8.90	100.00
	Total	45		
Missing	No response	9		
	Total	54		



#### 4.2.2. Prediction of probability of population contribution

When respondents were asked to predict the proportion of the population that would be willing to contribute towards a reclamation fund, a total of 84.40% of the respondents said that there is a 0-0.50 probability of this event occurring (Table 9). The respondents expressed that there is less probability of collecting a contribution from the total population of the country but 15.50% of the respondents do seem to think it is highly likely to certain that 0-25% of the population would contribute.

Table 9: Respondents' prediction of the probability of receiving a contribution from 0-25% of the population

<b>Probability</b>		<b>Frequency</b>	<b>Valid Percent (%)</b>	<b>Cumulative Percent (%)</b>
Valid	Impossible event	15	33.30	33.30
	Unlikely event	14	31.10	64.40
	Even chance	9	20.0	84.40
	Highly likely event	2	4.40	88.90
	Certain event	5	11.10	100.00
	Total	45	100.00	
Missing	no response	9		
Total		54		

In general, more than 82.00% of the respondents think it is impossible to unlikely to get 25-50% of the population to contribute towards a reclamation fund. Table 10 shows the frequency of the responses in each category. Only 2.00% said they think it is highly likely and none of respondents thought this would certainly happen.

Table 10: Respondents' prediction of probability of receiving a contribution from 25%-50% of the population.

Probability		Frequency	Valid Percent (%)	Cumulative Percent (%)
Valid	Impossible event	19	42.20	42.20
	Unlikely event	18	40.00	82.20
	Even chance	7	15.60	97.80
	Highly likely event	1	2.20	100.00
	Total	45	100.00	
Missing	No response	9		
Total		54		

The majority (84.10%) of the respondents held that it is impossible to unlikely that 50-75% of the population would contribute towards a reclamation fund. Meanwhile, 6.80% said that there is an even chance of this range of the population contributing or not and 9.10% were of the opinion that it is highly likely that this event would occur (Table 11).

Table 11: Respondents' prediction of probability of receiving a contribution from 50-75% of the population

<b>Probability</b>		<b>Frequency</b>	<b>Valid Percent (%)</b>	<b>Cumulative Percent (%)</b>
Valid	Impossible event	25	56.80	56.80
	Unlikely event	12	27.30	84.10
	Even chance	3	6.80	90.90
	Highly likely event	4	9.10	100.00
	Total	44	100.00	
Missing	No response	10		
Total		54		

When asked to predict the probability of 75-100% of the population contributing towards a reclamation fund, the respondents maintained that there is a very low probability that this will occur (Table 12). At least 11.10% of the respondents were of the opinion that there is a 0.75-1.0 probability that almost the entire population could contribute some fee towards a reclamation fund.

Table 12: Probability that 75-100% of the population would contribute towards a reclamation fund as predicted by the respondents

Probability		Frequency	Valid Percent (%)	Cumulative Percent (%)
Valid	Impossible event	29	64.40	64.40
	Unlikely event	7	15.60	80.00
	Even Chance	4	8.90	88.90
	Highly likely event	1	2.20	91.10
	Certain event	4	8.90	100.00
	Total	45	100.00	
Missing	No response	9		
Total		54		

The figure below gives a good visual representation of the responses and their distribution as the population range increases.

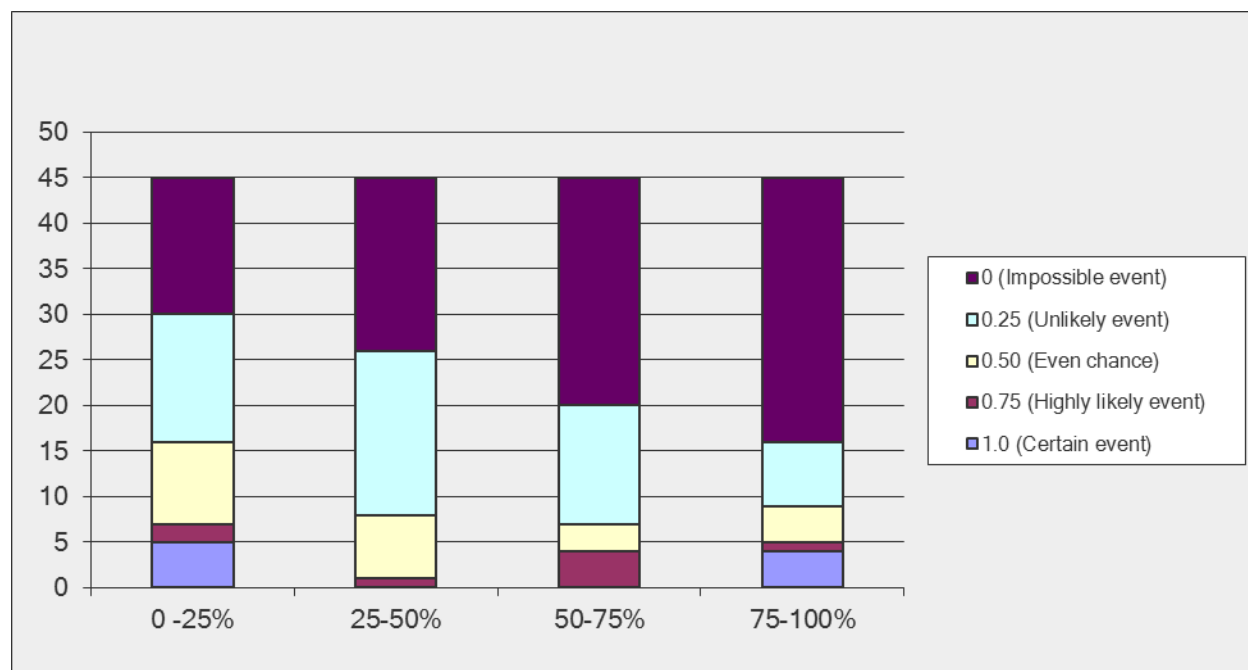


Figure 10: Stacked column chart of the results of the respondents' probability predictions.

#### 4.2.3. Higher income households may be willing to contribute a higher amount than low income households

In question 24 of the survey, the respondents were asked to estimate how much money (in South African Rands) households of varying income levels would be able to contribute per month. The results show that 95.50% of the respondents think that low income households would be able to contribute less than R10 per month which is less than a dollar per month. Almost 5.00% of the respondents said that these households may contribute between R11 and R50 per month, which is an average of nearly \$US3.

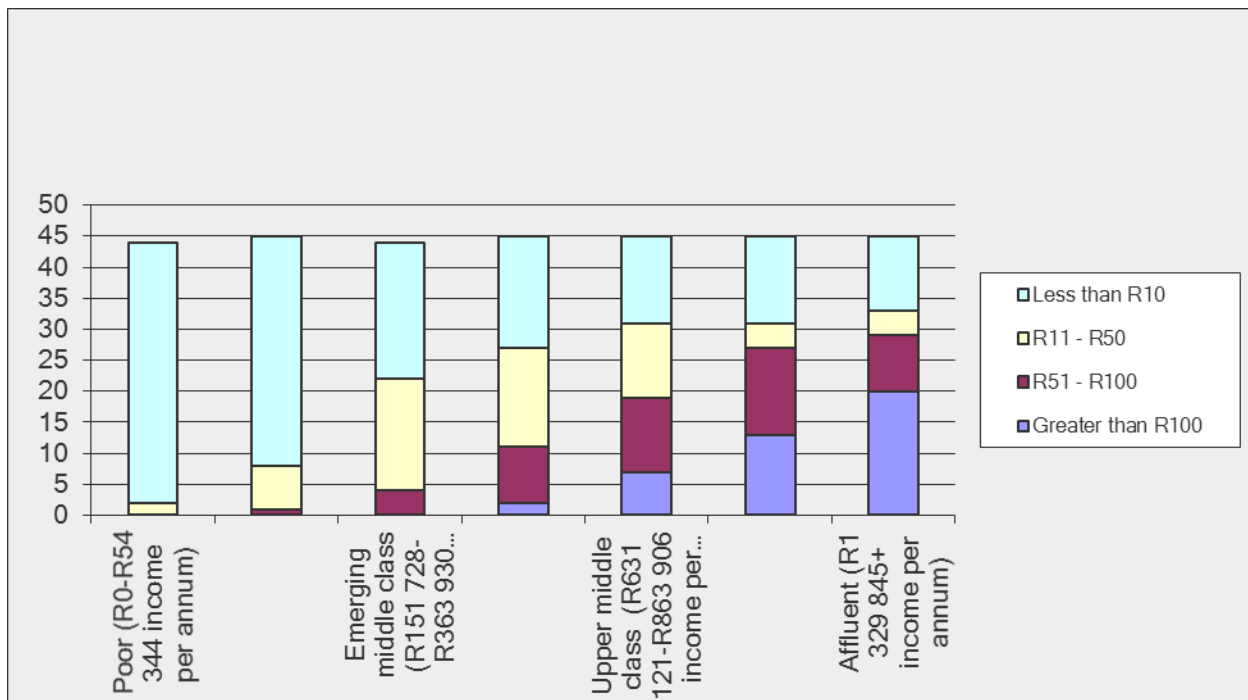


Figure 11: Respondents' estimation of how much households with different income levels would be willing to pay.

As expected, the estimated amount per household increases with increasing household income, 44.40% of the respondents estimated that affluent households that earn an annual income of R1 329 845 and above would be willing to contribute an amount greater than R100 (~\$10). Tables 13 and 14 present this information in greater detail.

Table 13: Estimation of the household contribution from low income households

Estimated amount		Frequency	Valid Percent (%)	Cumulative Percent (%)
Valid	Less than R10	42	95.50	95.50
	R11-R50	2	4.50	100.00
	Total	44	100.00	
Missing	No response	10		
Total		54		

Table 14: Estimation of the household contribution from affluent households

Estimated amount		Frequency	Valid Percent (%)	Cumulative Percent (%)
Valid	Less than R10	12	26.70	26.70
	R11-R50	4	8.90	35.60
	R51-R100	9	20.00	55.60
	Greater than R100	20	44.40	100.00
	Total	45	100.00	
Missing	No response	9		
Total		54		

4.3 Research Question 3: How does distance from abandoned mine site affect willingness to pay towards reclamation fund?

Respondents were asked whether they think the public's willingness to pay towards a reclamation fund would increase, decrease or stay the same as the distance from an abandoned mine site increases. Table 15 shows that nearly 49.00% of the respondents said the public's willingness to pay would decrease as the distance from the site increased, 24.40% said it would increase, 17.80% said it would stay the same.

Table 15: Respondents' opinion of the relationship between willingness to pay and distance from abandoned mine site.

<b>Willingness to pay as distance from site increases</b>		<b>Frequency</b>	<b>Valid Percent (%)</b>	<b>Cumulative Percent (%)</b>
Valid	Stays the same	8	17.80	17.80
	Decrease	22	48.90	66.70
	Increase	11	24.40	91.10
	Other	4	8.90	100.00
	Total	45	100.00	
Missing	no response	9		
Total		54		



Figure 12: Text analysis of the respondents comments on the survey (Sinclair and Rockwell 2015).

The major themes that come out of the text analysis are: rehabilitation, public, mining, owners, abandoned, government, mines, responsible and companies. Textual analysis reveals that the respondents are aware of the issues related to abandoned mines and the limitations of a creating a reclamation fund. It also reveals the strong opinion of the respondents on who should be responsible for reclamation.



## CHAPTER 5

### DISCUSSION

There are many valuable insights that can be drawn from the results of this study, although the data obtained cannot be used to make inferences about the entire South African population, it is useful in developing a hypothesis for further investigation. It would be interesting to perform a similar study on a sample from the general population to compare and assess the accuracy of the respondents' predictions. The first research question revealed some of the challenges of abandoned mine reclamation in South Africa. As reviewed in Peck et al. (2005) and Balkau (2005), we have seen that reclamation may be hindered by lack of clearly defined roles and responsibilities, potential costs of reclamation, lack of criteria and standards for rehabilitation, use of financial, technical or legal instruments and approaches to social issues that are incompatible with specific sites and their neighboring communities.

Most of these obstacles were also observed in the data obtained from the survey. In the face of mounting costs of reclamation, securing sources of funding for reclamation is a major challenge that has been identified in this study. The respondents made it expressly clear that they are of the opinion that the mining industry should be financially responsible for the cost of reclamation in South Africa. In order to achieve this, there would need to be an amendment of certain pieces of legislature in South Africa to allow mining companies and non-governmental organizations to rehabilitate abandoned mine sites without being bound by the polluter pays principle of the National Environmental Management Act. Legislation of 'Good Samaritan' permits shields

companies from liability associated with remediation of abandoned mines as long as they comply with permit conditions (Larson 2013).

Government may also impose a levy on current mining activity and channel the monies towards a reclamation fund. This is done in the United States through an environmental policy called SMCRA. The states then have to apply for funding based on their inventory of abandoned mines and what category of prioritization they fall under. Again, in South Africa this would require amendment or dissolution of agreements such as the Fanie Botha Accord and doing this may have a negative impact on future foreign investments in the mining industry. Increasing expectations of stakeholders such as governments and communities for environmental sustainability and other benefits from the mining industry was listed as the sixth most challenging business risk facing the mining industry in Ernst & Young (2013). Therefore if responsibility of reclamation is partly assumed by the mining industry, it must be profitable or worthwhile for the firms or they may chose not to participate in the market.

The fact that a majority of the respondents ranked water problems as the greatest risk associated with abandoned mines is not surprising as the impacts of acid mine drainage on water resources and the ecosystem have been reported in many studies such as Bell et al. 2000; McCarthy 2011 and CSIR 2009. The protection of these water resources that serve millions of people is dependent on the rate at which the DMR is able to reclaim these abandoned mines. Therefore the problem of funding needs to be unlocked urgently.

Considering that a number of respondents who regard themselves experts are employed in the private sector and more than 53.00% percent of the respondents

indicated that they disapprove of the way abandoned mine reclamation is currently conducted suggests that the relationship between the private sector and public sector needs improvement. The disproportionate ratio of experts between the sectors is consistent with the report by the Auditor General of South Africa in 2009 which indicated that the organizational structure of the public agency responsible for oversight of reclamation did not support the internal control objectives of the department for the rehabilitation of abandoned mines. The contents of this report red flagged many other issues and inefficiencies within the department which slow down the rate of reclamation such as lack of an inventory or database of abandoned mines, lack of a strategic plan for rehabilitation of abandoned mines in South Africa, lack of capacity delayed the implementation of projects, for seven projects the actual costs increase by an average of 30.54% compared to the estimated cost. There has been some progress made since 2009, for example, the Council of Geosciences was appointed to develop, maintain and rank a database of abandoned mines in South Africa. A National Strategic Plan has also been developed since then, however remaining challenges include those that have been drawn from this study.

When the respondents were asked to predict the proportion of the population would be willing or able to contribute towards reclamation, most of them indicated that they think it is impossible that the entire population would do so (see Figure 10), but they thought it may be more likely that 0-25% of the population may be willing to pay some amount. This is reasonable, considering that more than 45.00% of the population in South Africa lives below the national poverty line (World Bank 2015).

Close observation of the respondents' prediction of public willingness to pay towards reclamation in Figure 11 reveals that perhaps there is a possibility that affluent households may be more willing to contribute towards a reclamation fund than low income and middle class households. As the income of the household increases, the respondent's prediction of how much the public would be willing to pay increases. If these predictions are true, then this could potentially be a source of funding although the instrument of collection may have to be voluntary or more flexible than a levy or tax. It is noted that the respondents' predictions are merely that and the reality may be very different.

In the final research question, we tried to find out whether proximity to the abandoned mine site would affect an individuals' willingness to pay towards reclamation. Using responses from question 25 of the survey, it was found that 48.80% of the respondents thought that the willingness to pay towards reclamation would decrease as distance from contaminated site increased (Table 15). This observation is consistent with a comment made by one of the respondents who said that there a certain level of NIMBY (not in my back yard) attitude when it comes to problems related to abandoned mines. As long as the environmental or physical hazards are not in their back yard, the public may be less willing to contribute towards reclamation.

Overall the findings of this study show that there are challenges to abandoned mine reclamation in South Africa that are consistent with the report of the auditor general in 2009. These are not unique to South Africa but even the United States and Canada have faced and are still dealing with some of these obstacles. Moving forward, the South African government has to strengthen its internal structures by ensuring that it

builds capacity of its employees and systems to be able to manage reclamation projects efficiently. The DMR also has to find ways to strengthen its relationships with the private sector and NGOs so that all stakeholders are fully engaged in solving this problem. Refer to “Best practices in community involvement” (NOAMI 2003) and “Potential funding approaches for orphaned/abandoned mines in Canada” (Castrilli 2003) for guidelines.

The respondents were also of the opinion that the general population considers different sources of information than they do. The sources that respondents considered credible were: environmental groups, the internet and National government respectively. While for the public, they predicted that the sources they considered credible were: television, newspapers and environmental groups in that order.

#### Rehabilitation by the Department of Mineral Resources South Africa

The department has four main programs: Administration, Mine Health and Safety, Mineral Regulation and Mineral Policy and Promotion. The program that is concerned with rehabilitation of abandoned mines is the Mineral Policy and Promotion program, management of abandoned mines falls under a subprogram called Mine Environmental Management. The focus of the Mineral Policy and Promotion program is to review existing policies and develop new policies to promote investment growth. Essentially the aim here is to promote investment and to boost investor confidence through restating the national developmental position.

This is a necessary function; South Africa is a developing country whose economy is significantly dependent on the mining industry. It is stated in the DMR annual plan that rehabilitation remains a priority although it is expensive and dependent

on the funds allocated to the program. The department has set a target of spending R327.6 million to rehabilitate 120 mines between 2013 and 2016. Again, the key phrase here is that rehabilitation will depend on the funds that are purposefully and strategically funneled towards those programs that are responsible for mine environmental management. The question then is whether reclamation of abandoned mines will take priority in budgeting over mineral promotion and investor attraction, seeing that they fall under the same program.

Unless the aim is to encourage re-mining of the abandoned mines, placing the Mine Environmental Management as a subprogram of a division whose chief priority is to attract investment seems to be conflicting as one will take priority over the other. It is my opinion that the Mine Environmental Management portfolio would be best fitted with the Mineral Regulation Program. The main function of this program is to regulate the minerals and mining sectors to promote economic growth, employment, transformation and sustainable development. The key focus areas in this division are compliance, monitoring and evaluation of mining activities. Currently the program focuses on existing and prospecting mines including granting and administration of mining permits and ensuring compliance with the Mineral and Petroleum Resources Development Act (28 of 2002). Expansion of this role to deal with environmental issues of past mining activities seems suitable and more aligned with the objectives of the mineral regulation program which is more focused on implementation of policy and regulation of the sector.

### What funding options are available for South Africa?

Rehabilitation of abandoned mines is a public good that is provided by internalizing the cost of a past market failure. The government in this case bears the financial responsibility since it is the institution that should have ensured that there are policies and regulations in place to prevent mine abandonment (Schwarcz 2013). The respondents of the survey conducted in this study therefore are accurate in their argument that it should be mainly the government and the mining industry should be responsible for the cost of reclamation (Figure 5). It is necessary that the agreements between the government and the mining industry are flexible such that investors are not repelled by command and control policies but rather are given incentives to contribute towards reclamation of abandoned mines. For any business, the number one priority is to make a profit but there is a growing trend of corporate social responsibility that can be leveraged by government as well as looking into how re-mining can be made attractive to the mining industry (Warhurst and Mitchell 2000).

Another solution to the problem of funding for rehabilitation of abandoned mines could be ring-fencing of tax money. Ring-fencing is used extensively across the world, it is a subset of economic regulation that is often suggested as a potential regulatory solution to problems in banking, finance, public utilities, and insurance (Schwarcz 2013). In South Africa, ring-fencing is already used to finance institutions such as the National Research Foundation, the Industrial Development Corporation and the Human Research Council, all of which are at least partly funded by taxpayers' money allocated specifically for those purposes (Mail & Guardian 2011). In the survey, one respondent mentioned this as a possible solution but also included that the government was not

willing to ring-fence tax money for a carbon tax. The respondent's views were similar to those found in Blaine (2013) where arguments against a carbon tax in South Africa were presented. The issue then becomes that no matter what mechanism you use to collect the money, it all goes to one pool and is distributed to various departments according to the National Treasury budget.



## CHAPTER 6

### CONCLUSIONS AND RECOMMENDATIONS

South Africa is a developing nation and has taken great strides to become environmentally sustainable whilst developing the economy. The reclamation of abandoned mines will require more than white papers and policies but will test the functionality and efficiency of those responsible for implementation of policies. In dealing with this issue and seeking financial solutions for reclamation, these are some recommendations that emerge from the study:

- 1) Establish a rehabilitation fund
- 2) Conduct studies to explore possible funding options
- 3) Ring-fence tax money for special purposes such as reclamation of abandoned mines
- 4) Develop guidelines and standards for abandoned mine reclamation or land reclamation
- 5) Review and consider amendment of environmental policies to include Good Samaritan permits which allow re-mining and participation of private sector and NGO's in reclamation of abandoned mines as a profit generating social responsibility.
- 6) Continue to develop and maintain an inventory of abandoned mines
- 7) Work closely with universities and colleges in order to ensure that those with the required skill sets are placed in relevant jobs
- 8) Conduct professional development workshops for existing employees

- 9) Assess stakeholder relations and look for opportunities to consult and involve them in decision making.
- 10) Move the Mine Environmental Management subprogram from Mineral Policy and Promotion program to Mineral Regulation as their objectives are more aligned.

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## APPENDICES

## Research request

This is a survey regarding your thoughts on the public's perception on abandoned mine reclamation and your opinion on who should pay for rehabilitation of abandoned mines, and how to raise funds to accelerate the current rate of rehabilitation activities. The survey is part of a Master of Science research for the above mentioned student at Southern Illinois University. This survey has been developed as part of a multidisciplinary research project that will help us make sound, comprehensive and rooted contributions to the discussions of finding a way forward from derelict and ownerless mines to rehabilitated and safe spaces for people and the environment. The information you provide in this survey will contribute significantly to our understanding of what needs to be done in order to speed up the process of rehabilitation of abandoned mines in South Africa and how to achieve this. It is very important that we hear from experts such as you to get a fair representation of all views.

The results of this research project will be made available to policymakers and the general public to help provide this needed information to all who can use it. In taking part in the survey, you can help us inform policy makers and the general public about a critical issue threatening the welfare of the affected communities and environment today.

If you wish to be removed from this list so that you don't receive any further emails, please email Andisiwe Stuurman at [astuurman@siu.edu](mailto:astuurman@siu.edu). If you do not do so, you will be contacted again with this request 2 times during the next 3 weeks. If, once you have completed the survey, you would like not to receive reminders, please email Andisiwe Stuurman at [astuurman@siu.edu](mailto:astuurman@siu.edu) as well.

Your participation in this effort is entirely voluntary. If you choose to participate by completing the survey, we ask that you complete the survey as soon as possible to ensure that the information can be processed in a timely way. We expect it will take you 30-45 minutes to complete the survey.

Please be assured that your answers to the survey will be anonymous. We will not be able to link your identity to your survey responses. Further, only people directly involved with this project will have access to the surveys. The information you provide in the questionnaire will only be used for statistical reporting, and your name will not be used in any way.

Thank you.

## Questions about Respondents

### 1. What is your current age?

- 18-34
- 35-49
- 50-64
- 65 and Over

### 2. What is your gender?

- Female
- Male

**3. Which of the following best describes your current relationship status?**

- Married
- Widowed
- Divorced
- Separated
- In a domestic partnership or civil union
- Single, but living with a significant other
- Single, never married

**4. What is the highest level of education you have completed?**

**5. Which of the following categories best describes your racial identity?**

- Black/African
- Colored/Mixed Race
- White
- Asian/Indian
- Other

**6. Which of the following categories best describes your annual household income?**

- R1- R4 800
- R4 801- R9 600
- R9 601- R19 200
- R19 201- R38 400
- R38 401- R76 800
- R76 801- R153 600
- R153 601- R307 200
- R307 201- R614 400
- Above R614 400

**7. Which sector do you work in?**

- Private
- Public
- Non Governmental Organization (NGO)
- Other

**8. In which province are you currently living in South Africa?**

- Gauteng
- Mpumalanga
- Limpopo
- KwaZulu Natal
- Eastern Cape
- Western Cape
- Northern Cape
- Free State
- North West

**9. Which two languages are most spoken in your household?**

- English
- isiZulu
- Afrikaans
- isiXhosa
- Sesotho
- Sepedi
- Setswana
- Sign language
- isiNdebele
- Xitsonga
- Tshivenda
- Siswati
- Other

**Questions about expert's opinion on public perception of abandoned min...**

**10. How closely have you been following the news around the issue of abandoned mines and their associated environmental concerns? On a scale of 1-5, where 1 indicates "not all" and 5 indicates "very closely", please indicate your level of interest on abandoned mine rehabilitation.**

- 1
- 2
- 3
- 4
- 5

**11. In your opinion, which provinces in South Africa are most adversely affected by environmental and social issues related to abandoned mines?**

- Gauteng
- Mpumalanga
- Limpopo
- KwaZulu Natal
- Eastern Cape
- Western Cape
- Northern Cape
- Free State
- North West

**12. The process of restoring previously mined land to a natural or economically usable state is called Rehabilitation or Reclamation. On a scale of 1-5, where 1 indicates "Unfamiliar" and 5 indicates "Expert", Please indicate your level of substantive expertise on this topic?**

- 1
- 2
- 3
- 4
- 5

**\*13. On a scale of 1-5, where 1 indicates "never heard of it" and 5 indicates "extremely familiar", how much would you say the general public knows about abandoned mine rehabilitation or reclamation?**

- 1
- 2
- 3
- 4
- 5

**14. On a scale from 1 to 5, where 1 indicates "no risk" and 5 indicates "extreme risk," how serious a risk do you believe abandoned mines pose to health, safety and environment?**

- 1
- 2
- 3
- 4
- 5

**15. In general, would you say that the public currently strongly support, somewhat support, are neutral, somewhat oppose, or strongly oppose the rehabilitation of abandoned mines?**

- Strongly support
- Somewhat support
- Neutral
- Somewhat oppose
- Strongly oppose
- Not sure

**16. What would you say the public considers as the most important risk related to abandoned mines? Please rank**

<input type="text"/>	Water Problems
<input type="text"/>	Pollution/Contamination
<input type="text"/>	Health Issues
<input type="text"/>	Land Destruction/Damage
<input type="text"/>	Safety Issues/Dangers
<input type="text"/>	Environmental Damage
<input type="text"/>	No Risk/None
<input type="text"/>	I don't know
<input type="text"/>	Other

**17. Which of the following statements comes closest to your views?**

- Most experts agree that the risks associated with abandoned mines in the affected provinces are HIGH.
- Most experts agree that the risks associated with abandoned mines in the affected provinces are LOW.
- Most experts are divided on whether abandoned mines pose any risk.
- Not sure

**18. In general, do you approve or disapprove of the way that the Department of Mineral Resources and other associated government offices have handled the issue of abandoned mines in the affected provinces?**

- Approve
- Neutral
- Disapprove
- Other (please specify)



**19. Who should be responsible for the cost of abandoned mine rehabilitation in your opinion and that of the public? Please select yes for all that apply.**

	Public	You
Government	<input type="checkbox"/>	<input type="checkbox"/>
Mining Industry	<input type="checkbox"/>	<input type="checkbox"/>
Residents of the affected areas	<input type="checkbox"/>	<input type="checkbox"/>
All consumers	<input type="checkbox"/>	<input type="checkbox"/>
None of the above	<input type="checkbox"/>	<input type="checkbox"/>

Other (please specify)

**20. In your opinion, what is the total cost that the public would allocate to the rehabilitation of a single coal mine?**

- Less than R10 million
- R10 million - R50 million
- R50 million - R100 million
- R100 million - R500 million
- Greater than R500 million

Other (please explain)

**21. In your opinion, would the general public of South Africa be willing to contribute towards a fund for rehabilitation of abandoned mines?**

- Yes
- No
- Not sure
- Other (please specify)

**\*22. If the above were possible, what do you think would be the best mechanism to collect this contribution from the public?**

- Personal income tax based on income level for everyone
- Personal income tax based on income level from which the low income class is exempted
- General corporate tax
- Corporate tax targeted at the mining industry
- Sales tax on gold and/or electricity
- Voluntary annual donation
- Other (please specify)

**\*23. What proportion of the South African population do you think would be willing to contribute towards a fund for abandoned mines? The rows indicate the proportion of the population and in the columns please give your estimate of the probability of a tax contribution from each population group.**

	0 (Impossible event)	0.25 (Unlikely event)	0.50 (Even chance)	0.75 (Highly likely event)	1.0 (Certain event)
0 -25%	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
25-50%	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
50-75%	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
75-100%	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**\*24. Based on your expert opinion, how much do you think the various income classes of South Africa would be willing to pay per household towards the abandoned mine rehabilitation fund on a monthly basis?**

	Less than R10	R11 - R50	R51 - R100	Greater than R100
Poor (R0-R54 344 income per annum)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Low emerging middle class (R54 345-R151 727 income per annum)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Emerging middle class (R151 728-R363 930 income per annum)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Realized middle class (R363 931-R631 120 income per annum)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Upper middle class (R631 121-R863 906 income per annum)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Emerging affluent (R863 907-R1 329 844 income per annum)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Affluent (R1 329 845+ income per annum)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**25. Do you think that the public's willingness to pay towards a fund would increase, decrease or stay the same as the household's distance from the abandoned mine increases?**

- Increase
- Decrease
- Stays the same
- Other (please specify)

**26. Which of the following sources of information do you think the public uses? Which ones would you say are the most credible sources of information on the risks and benefits associated with abandoned mines? Please select top 3**

	Public	You
National Government	<input type="text"/>	<input type="text"/>
Provincial Government	<input type="text"/>	<input type="text"/>
Municipalities/ local government	<input type="text"/>	<input type="text"/>
Environmental groups	<input type="text"/>	<input type="text"/>
The Mining Industry	<input type="text"/>	<input type="text"/>
Television	<input type="text"/>	<input type="text"/>
Newspapers	<input type="text"/>	<input type="text"/>
The Internet	<input type="text"/>	<input type="text"/>

**27. Would you and/or the public say that mining has a positive effect, negative effect or no effect on the quality of life in South Africa?**

	Public	You
Positive effect	<input type="text"/>	<input type="text"/>
Negative effect	<input type="text"/>	<input type="text"/>
No effect	<input type="text"/>	<input type="text"/>

Other (please specify)

**28. Are there any other views you would like to share on abandoned mine rehabilitation in South Africa and the public's perception of the issue?**

**29. How likely is it that you would recommend contributing towards an abandoned mine rehabilitation fund to a friend or colleague?**

Not at all  
likely - 0

1

2

3

4

5

6

7

8

9

Extremely  
likely - 10

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