10
OCCASIONAL PAPER

Acid Mine Drainage and its Governance
in the Gauteng City-Region

Researched and written for the GCRO by Kerry Bobbins

May 2015

Gauteng City-Region Observatory
UNITY IN DIVERSITY
UNIVERSITY OF JOHANNESBURG
UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

ISBN Number: 978-0-620-65778-5

10 OCCASIONAL PAPER

Acid Mine Drainage and its Governance

in the Gauteng City-Region

Researched and written
for the GCRO by
Kerry Bobbins

May 2015

List of Acronyms

AECOM	AECOM[SM]
AMD	Acid Mine Drainage
BKS	BKS Group (Pty) Ltd
CB	Central Basin
CBD	Central Business District
CBEC	Central Basin Environmental Corporation
CGS	Council for Geo-science
CME	Compliance and Monitoring Enforcement
CRG	Central Rand Gold
CSIR	Council for Scientific and Industrial Research
DBSA	Development Bank of South Africa
DEA	Department of Environmental Affairs
DMR	Department of Mineral Resources
DNT	Department of National Treasury
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWE	Digby Wells Environmental
DWS	Department of Water and Sanitation
EB	Eastern Basin
EBEC	Eastern Basin Environmental Corporation
ECL	Environmental Critical Level
EIA	Environmental Impact Assessment
ERPM/ERM	East Rand Proprietary Mines
FSE	Federation for a Sustainable Environment
GCIS	Government Communication and Information System
GCR	Gauteng City-Region
GCRO	Gauteng City-Region Observatory
GDACE	Gauteng Department of Agriculture, Environment and Conservation
GDARD	Gauteng Department of Agriculture and Rural Development
HDS	High Density Sludge
I&AP	Interested and affected party
IDC	Industrial Development Corporation
IMC	Inter-Ministerial Committee
LHWP	Lesotho Highlands Water Project
MPRDA	Mineral and Petroleum Resources Development Act 28 of 2002
MRA	Mine residue area
MRI	Mine Restoration Investments
MTEF	Medium Term Expenditure Framework
NASA	National Aeronautics and Space Administration
NEMA	National Environmental Management Act 107 of 1998
NGOs	Non-Governmental Organisations
O&M	Operations and maintenance
PAIA	Promotion of Access to Information Act
PMG	Parliamentary Monitoring Group
PPP	Public Private Partnership
QoL	Quality of Life survey
RU	Rand Uranium
SA	South Africa
SALGA	South African Local Government Association
TCTA	Trans-Caledon Tunnel Authority
ToE	Team of Experts
VRS	Vaal River System
WB	Western Basin
WBEC	Western Basin Environmental Corporation
WUC	Western Utilities Corporation
WWF	World Wildlife Fund

Contents

LIST OF ACRONYMS IV
1. INTRODUCTION 1
1.1 The acid mine drainage issue 1
1.2 Aims and structure of the report 3
2. FROM GOLD TO YELLOW: A BRIEF HISTORY OF GOLD MINING AND AMD ON THE WITWATERSRAND 5
2.1 Overview of mining activities in the GCR 5
2.2 Gold and water 7
2.3 A legacy of externalizing costs 9
2.4 Negative impacts on the environment, society and economy 12
3. ACTION TAKEN IN RESPONSE TO AMD 19
3.1 A timeline of key events 19
3.2 Project Eutopia 19
3.3 Preparatory work by an Inter-Ministerial Committee and Team of Experts 22
3.4 Towards action: detailed planning by the Trans-Caledon Tunnel Authority (TCTA) 25
3.5 Environmental Impact Assessment (EIA): initial work done and exemption 30
3.6 Implementation of immediate and short-term interventions 33
3.7 Towards a long-term solution 34
3.8 'Paying for the sins of big business' – funding mechanisms to mitigate AMD 38
4. A REVIEW OF AMD DISCOURSE 42
4.1 Stakeholder interactions 42
4.2 Framing an environmental catastrophe 47
4.3 Precedent-setting 49
4.4 What exactly is Gauteng's water crisis? 50
4.5 Financial Concerns 51
4.6 Opportunities 53
5. CONCLUSION 56
6. REFERENCES 59

List of Figures

Figure 2.1: Gold production and gold grades along the Witwatersrand (all data sourced from Chamber of Mines, 2013). 6

Figure 2.2: An illustration of the imbalance between money spent on developmental and operational costs, and environmental and social remediation costs (information adapted from Adler et al., 2007). 9

Figure 2.3: The externalization of cost by the gold mining industry (redrawn from Alder et al., 2007). 10

Figure 2.4: South Africa's legislative framework for mine closure (DMR, 2010a and Kruger, 2011) 11

Figure 2.5: Water bodies in the GCR and their proximity to radioactive mining waste. 15

Figure 2.6: Human settlement and mine footprints in the GCR (data source: GTI 2009 and 2012). 16

Figure 3.1: Timeline of key events and the development of solutions to address AMD in the GCR. 20

Figure 3.2: Overview of the Western, Central and Eastern Basins of the Witwatersrand Gold Fields (DWA, 2012a). The Western Basin is located in the Krugersdorp, Witpoortjie and Randfontein areas; the Central Basin is located between Durban Roodepoort Deep (DRD) in the west and East Rand Proprietary Mines (ERPM) in the east; and the Eastern Basin is located in the Boksburg, Brakpan, Springs and Nigel areas. 21

Figure 3.3: Overview of the budget for addressing AMD in National Treasury's 2011 MTEF (PMG, 2011a) 41

Figure 4.1: Diagrammatic representation of key actors in AMD discourse 43

List of Tables

Table 2.1: Major water development schemes to date (Rand Water, 2004). 8

Table 3.1: Overview of mining companies participating in the establishment of three environmental corporations (Schoeman, 2011). 21

Table 3.2: Environmental Critical Levels (ECL) calculated by the ToE and overview of the Short Term Action Plan (DWA, 2010) 24

Table 3.3: Summary of capital costs to maintain water levels (DWA, 2010). 24

Table 3.4: Summary of annual operating costs assuming an electricity price of R1,50 per kW/h (DWA, 2010). 25

Table 3.5: Task schedule for the immediate and short-term intervention to AMD (information from AECOM, 2011). 26

Table 3.6: AECOM Environmental Critical Levels (ECLs) calculated for the Western, Central and Eastern Basins in the Witwatersrand and immediate and short-term action plan (AECOM, 2011 and DWE, 2012b). 27

Table 3.7: Summary of capital costs outlined in the AECOM due diligence report (AECOM, 2011). 29

Table 3.8: Summary of operational costs outlined in the AECOM due diligence report (AECOM, 2011). 29

Table 3.9: Aspects to be covered in the EIA and overview of potential impacts and risks to humans and the environment (DWE, 2012d). 32

Table 3.10: Overview of contributions made by mining companies in response to the directive issued by DWA to manage AMD and assume liabilities related to active mining (PMG, 2011b). 38

Table 3.11: Overview of the capital components of the Vaal River System presented on 22 October 2014 (Rand Water, 2014). 41

Acknowledgments

This Occasional Paper would have not been possible without the valuable inputs of various individuals from government, academia, business, labour, civil society and the general public. As part of the preliminary research undertaken for this paper, a call was sent to specific stakeholders to discuss and verify facts to be used in this report. The vision of creating an accurate and reflective body of work became a reality only because many responded positively. In particular I would like to thank the following:

- *Consultants* AECOM (formerly BKS), Digby Wells Environmental (DWE) and Fourth Element;
- *The parastatal* Trans-Caledon Tunnel Authority (TCTA);
- *Non-governmental organisations (NGOs) and institutions*, Earthlife Africa and the South African Human Rights Commission;
- *Mining and reclamation company* Mintails SA, and in particular Anthony Turton;
- *Academics* Mike Muller and Mark Biggars;
- Various *ward councillors*;
- *Speakers and participants* at various AMD-related workshops, seminars and public engagements between July 2012 and June 2013.

Thank you to Graeme Gotz, GCRO, for editing the work.

1. Introduction

1.1 The acid mine drainage issue

Introduction

Acid mine drainage (AMD) in the Gauteng City-Region (GCR) has been described in the media as a ticking time bomb after it was officially reported to have begun surfacing from old mining works on the West Rand in 2002 (Masondo et al., 2011; TAU SA, 2011; Slack, 2013). Acid mine drainage occurs when 'fool's gold' (FeS_2) or iron pyrite found in mined rock oxidises. This occurs when either underground mine shafts, or crushed conglomerate in Mine Residue Areas (MRAs) on the surface, become exposed to oxygen and water creating run-off that is very high in sulphates – effectively sulphuric acid – and is hazardous to both humans and the environment (McCarthy 2010). Over the last decade, a flurry of news articles have highlighted the threat of acid water decant and its likely effects on human health, the environment, water quality, municipal infrastructure and building foundations in the Johannesburg Central Business District (CBD). These reports have fuelled anxieties around when and where decant will take place and who will be affected by AMD.

In response to these concerns, government, through the National Department of Water Affairs (DWA), has introduced a set of immediate and short-term interventions to overcome decant in the West Rand. These have allowed AMD to be framed as an environmental emergency. DWA has also set in motion a process to develop a long-term solution that, through a broader and more inclusive approach, will solve various AMD issues over time including its impact on the Gauteng water supply.

In relation to both these two government interventions – the immediate/short and long-term solutions – very few stakeholders or members of the public know enough about AMD and its governance to understand what the real challenges are and how they should respond. Even fewer are able to piece together the series of events that led up to the current and proposed set of actions taken by DWA to tackle AMD. This paper argues that the current trajectory of government-led responses has suspended meaningful public engagement and debate, and the result is a grey cloud of misinterpreted facts and presumed motives that has cast a shadow of misunderstanding, which in turn exacerbates the anxieties of affected communities and interested stakeholder groups.

A brief background to AMD on the Witwatersrand

AMD is not a new phenomenon, nor is it exclusive to the GCR. It is found internationally in Australia, Canada, the United States of America and Germany. Locally (aside from along the Witwatersrand Gold Fields) it is seen in the Klerksdorp, Orkney, Stilfontein, Hartebeespoort and Evander gold mining areas, in other parts of the Free State, Mpumalanga and KwaZulu-Natal, as well as in the O'Kiep copper district (DWA, 2010).

While AMD is neither a new phenomenon, nor unique to the GCR, it presents itself as being particularly problematic along the Witwatersrand goldfields as a result of a combination of factors. These include the inter-connectivity of the mine voids, the sheer scale of the gold mining operations along the rand, the proximity of mines in relation to one another, and the fact that they are close to urban areas (DWA, 2010).

McCarthy (2010) also notes that the region's geomorphology, its climate, and the distribution of AMD-generating deposits further exacerbates the occurrence of AMD in this area.

When mining on the Witwatersrand first started the diggings were close to the surface, but as the mines expanded, excavations went deeper and intercepted the water table. From the 1930s, pumps were required to draw down groundwater in sunken shafts to expose new sites for deeper-level mining. Over time, a series of technological advances overcame physical constraints to the extraction of gold from deeper and deeper below the surface, extending the life of the mines. It was in the best interests of the mines to draw down water to expose new sites for mining, but this also exposed water to pyrite and heavy metals in the mine shafts (Leyds, 1964).

A decline in mining profits from the 1950s, resulting from a myriad of economic, societal and environmental constraints, led to the closure of many mines in the GCR. Mine closures meant that the pumping of water from the mine voids ceased (McCarthy, 2010). Water started accumulating in the underground mine workings after mines closed and also began flowing into adjacent mines. Due to the interconnected nature of the so-called Western, Central and Eastern Basins that make up the goldfields, the pumping load diffused across the Witwatersrand. Active mines took up the pumping responsibility of redundant mines, raising their costs, and contributing in turn to their closure. As more and more mines closed, and more pumping ceased, AMD began rising to the surface at an even faster rate.

Some environmental texts report that the decant of AMD had been occurring from as early as 1996 (Khumalo, 2011), but it was not until 2002 that government first recognised that this was a pressing issue in the GCR. Reports suggest that the immediate AMD crisis began with a flood event that occurred in the West Rand of Gauteng in 2002, when acid water from the Western Basin (WB) started decanting on the surface (Khumalo, 2011).

In 2008, East Rand Propriety Mines (ERPM), one of the few mines still operating, ceased pumping and underground mine workings and pump stations rapidly became inundated with water as the mine voids began to fill (McCarthy, 2010). This escalated concerns over AMD to crisis proportions.

In 2011, water was still decanting in the West Rand and the threat of decant began growing in the Central Basin (CB) and Eastern Basin (EB). To address the crisis, the state-owned Trans-Caledon Tunnel Authority (TCTA) was instructed to deliver an immediate to short-term solution at a total cost of some R2,2 billion. In late 2012, an immediate-term pumping intervention to control decant on the WB was commissioned, and fast-tracked steps to control water in the CB were initiated. On 9 May 2014, the newly constructed R319 million plant near Germiston in the CB was tested and the pumping, treatment and release of pre-treated AMD at this plant reached full capacity on 30 May 2014 (DWA, 2014). As of late 2014, at the time of this report's finalisation, works for the EB were still in the process of being planned.

AMD as both a technical and a governance problem

This Occasional Paper starts from the premise that the threat of acid water decanting from old mine workings is a present danger that will impact our environment, built infrastructure, health and ultimately the economy if not managed properly (McCarthy, 2010). There is some disagreement, discussed in this report, as to the degree of the threat with some arguing in particular that there is little risk of AMD flooding into, and causing chemical corrosion of, building basements and municipal infrastructure.

That being said, there is ample evidence that suggests when AMD rises to the surface and enters watercourses, it is harmful to aquatic life and is dangerous to anyone reliant on this water for agriculture or household use. It has also become clear that emergency measures to pump and partially treat AMD that discharges into river systems, notably the Vaal, which has a very high salt content, may result in the water quality of Gauteng's water supply being compromised. Unless long-term desalination solutions are found, there is an increasing need for more raw water to be released from the Vaal Dam to dilute streams into which AMD has been discharged. In turn this will upset finely-tuned water balances as far away as the Orange River System, and raise the risk of water shortages and / or dramatic cost increases in the GCR. A consultant's report, introducing a set of studies towards a long-term AMD solution, puts it bluntly:

> *"Should the AMD issue, and specifically the desalination, not be addressed appropriately by 2014/15, the acceptable levels of assurance of water supply will be threatened. This means there will be an increasing risk of water restrictions in the Vaal River Water Supply area." DWA (2012a:2).*

The distribution of old mine workings and the widespread contamination of water and ecosystems as a result of AMD makes this a city-region wide problem with far-reaching impacts. It is of great importance that government, business, academics, civil society and the general public increase their awareness around AMD, and the risks and opportunities associated with it, and then work together to take the necessary precautions towards mitigating its impacts in the GCR. The question is whether this has been adequately enabled by government leadership on the matter.

Over the last few years there has indeed been a flurry of activity to develop shorter- and longer-term solutions to AMD. However, some believe that these interventions are too little too late to solve a problem that manifested over a decade ago. Many texts report that AMD is a fairly simple problem to solve technically, but there is also a sense that the slow response of government – framed by a muddle of politics, sheer cost and liability blame game – has meant that governance challenges have unnecessarily exacerbated public anxieties, and has extended the risks of AMD to society and the environment.

1.2 Aims and structure of the report

Aims of the report

This paper straddles Gauteng City-Region Observatory's (GCRO) current research focus on sustainability and matters of government, governance and intergovernmental relations. It serves as a follow up to the first edition of GCRO's Provocation Series written by Professor Terence McCarthy of the University of the Witwatersrand School of Geosciences. This Provocation was entitled, *The decanting of acid mine water in the Gauteng City-Region,* and was released in September 2010. McCarthy's Provocation built the necessary foundations for this report by clarifying the facts behind the issue of acid water from a mining perspective and suggested recommendations for action in light of conflicting news reports. McCarthy provided recommendations that are relatively straightforward – establish pumping stations to pump water into treatment plants and stabilise water levels in the mine voids (McCarthy, 2010). However, his Provocation also drew out key issues in the discourse around AMD that still appear to haunt current actions and interventions to mitigate the problem. He asked: who will be held liable for costs incurred over decades of mining? And how will gaps between the deeds and responsibilities of government play out in the years to come?

Following on from McCarthy's 2010 Provocation, this paper builds on the technical analysis of AMD, but more importantly investigates the governance of AMD over time. It updates the historical record by providing an objective overview of key events and actions taken in response to AMD. It hopes to spark further argument and debate by presenting factual information to clarify grey areas arising from some alarmist news articles that have surfaced over the last few years (McCarthy, 2010). It also provides critical reviews of some of the public discourse around AMD and its management to date, in an attempt to understand how AMD is a governance challenge in addition to being merely a technical problem.

This said, this report does not attempt to provide recommendations on technical and finance measures for addressing AMD, and which actors should take on the responsibilities and risks associated with mitigating AMD. The report also does not aim to place blame on particular actors, and rather presents AMD discourse in terms of the actors that have shaped it over time.

Structure of the report

This report proceeds through the following structure. **Chapter 2** provides a brief historical overview of gold mining and AMD in the GCR, focusing on the mining industry's approach to externalising costs in relation to labour and the environment. This chapter lays the foundation for the overview of actions taken in response to the threat of AMD decant.

Chapter 3 explores the actions taken over the last few years to mitigate AMD. Key steps taken are presented with the aid of a timeline, compiled through information from interviews with key players and an analysis of media articles and official reports. With the timeline providing a synthetic overview, the bulk of chapter 3 pieces together a narrative of the unfolding immediate/short-term and long-term interventions to address AMD. The chapter ends with an overview of funding mechanisms – including public sector budgets and private sector contributions – to mitigate AMD.

Chapter 4 provides a critical review of public discourse around AMD, and the recent attempts to manage it. It examines: interactions and communications between key stakeholders (also presented visually through a stakeholder diagram); debates around the economic, social and environmental risks associated with both AMD itself, and the attempts to deal with it; how AMD is nestled within a wider set of environmental concerns and debates, in particular over MRAs and the security of South Africa's water supply; and debates around the opportunities presented by an integrated approach to AMD interventions.

Chapter 5 draws together key ideas and content covered in the report and presents on the future considerations of AMD and MRAs, focusing in particular on the wider legacy of mine waste in the GCR.

2. From gold to yellow: a brief history of gold mining and AMD on the Witwatersrand

"The lust for gold spans all eras, races, and nationalities. To possess any amount of gold seems to ignite an insatiable desire to obtain more." (Drye, n.d.)

2.1 Overview of mining activities in the GCR

South Africa is a country well-endowed with mineral resources – in particular gold – that have created large revenues for individuals, companies, and the nation through government taxation (McCarthy, 2010; McCarthy, 2011).

South African gold deposits are the largest known repository of gold on earth, and gold mines also yield uranium, silver, pyrite and osmiridium (GDACE, 2008). Although gold deposits in the interior of South Africa were mined for centuries by indigenous peoples before European colonisation, the first discovery of gold by settlers in the Transvaal was made in the 1850s. In 1854, small quantities of gold dust were found in the Jukskei River, which led to the exploration for gold in the Witwatersrand area and across the Transvaal (Beavon, 2004). Gold deposits were discovered between 1871 and 1886 at Eersteling (south of Polokwane), Pilgrim's Rest, Sabie, Kaapsehoop, Barberton, Leydsdorp, near Malmani, Kromdraai and Wilgespruit.

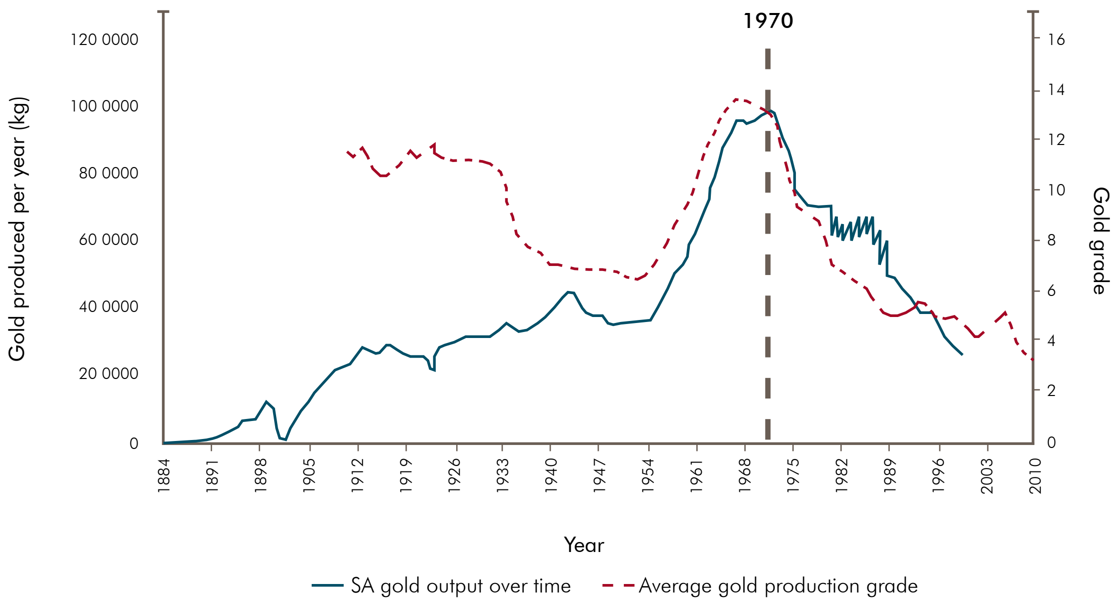
Johannesburg became a centre of gold mining after the discovery of gold at Langlaagte Farm in mid-1886, and the area was declared a public diggings site in September of the same year. Gold was first found along the Witwatersrand conglomerate reefs, and further gold-bearing reefs discovered from Roodepoort in the west to Germiston in the east (McCarthy, 2010). The economic engine of Johannesburg was engaged (Beavon, 2004 and Kaplan, 1985). Johannesburg soon became known as the 'City of Gold', and gold mining became the foundation of the South African economy.

Over a century of mining has lapsed since the discovery of gold along the Witwatersrand. It is estimated that over 47 000 tonnes of gold was produced from 1886 to 2002. Of course, the annual volume of gold production along the Witwatersrand has fluctuated with world events, inconsistent gold grades at various depths, and unavoidable physical constraints (Figure 2.1). External factors, such as the availability of labour, water and electricity, also shaped how much the mining industry was able to produce and at what cost. Global financial arrangements over the years – notably the abandonment of the gold standard in the 1930s, and the official delinking of the dollar from gold in the 1970s – have also impacted the price of gold, and in turn the profitability of the industry.

Figure 2.1 gives an indication of these fluctuations. Gold production increased rapidly until the formation of the Union of South Africa in 1910 with a brief disturbance over the course of the 1899-1902 Boer War (Hartnady, 2009). Production also saw periodic declines due to the First World War, in 1922 after the Rand

Rebellion, and after 1945 due to the Second World War (1939-1945) (Hartnady, 2009). Gold production after 1951 showed a considerable growth phase until 1965. This was due to technological developments that were laid during the 1930s and 1940s, with the intensive exploration of deep extensions of the rand. After 1966, gold production continued at a slower rate, reaching an absolute production peak in 1970. After 1970, there has been a steady decline in production interrupted by occasional short reversals in the trend, for example, over the 1982-1984 period. Oscillations aside, the production curve has closely mirrored changes in the gold grade, which improved as mining went to greater depths through technological advances until its peak in the late 1960s.

Figure 2.1: Gold production and gold grades along the Witwatersrand (all data sourced from Chamber of Mines, 2013).



Mining, in what is now known as the GCR, transformed the then Zuid Afrikaanse Republiek (ZAR) from a weak subsistance economy to a thriving exchange economy. Between 1886 and 1930 much of the dividends however were exported to foreign countries. Very little of the returns from gold mining were available for investment in South Africa and very little was contributed to the reserves of the state (Leyds, 1964). That said, the mines did draw large amounts of capital into South Africa, largely from investors from Britain.

Mining has brought about many positive impacts for South Africa through the growth and development of various linked industries and transport routes, in turn, anchoring many towns and cities. After gold was discovered, the Witwatersrand became the largest urban centre in South Africa virtually overnight. By 1900, it had reached a total population of 166 000 (Pampallis, 1991). Towns such as Heidelberg, Springs, Brakpan, Benoni, Boksburg, Germiston, Roodepoort, Krugersdorp and Randfontein began to develop along the East and West Rand. Coal deposits on the East Rand and settlements close to the gold diggings further stimulated the development of towns in this part of the Witwatersrand (Pampallis, 1991).

As mining in the interior of South Africa expanded, ports along the coast also grew rapidly to cope with the increase of goods and people moving in and out of the country (Pampallis, 1991). Fast developing Johannesburg saw South Africa's early railway network extended, with new lines linking the mining settlements to Cape Town, Port Elizabeth, East London, Durban and Maputo. Links were also made into surrounding agricultural areas, which in turn fostered the growth of commercial farming operations focused on maize, wheat, sugar, meat and other foodstuffs to meet the demands of new urban centres (Pampallis, 1991). Johannesburg was also connected to other towns through new roads and telegraph and telephone networks (Pampallis, 1991).

It is calculated that the Witwatersrand basins still hold some 36 000 tonnes of gold, or 45.7% of all remaining gold resources in the world (GDACE, 2008). The amount of gold that can be extracted viably depends on the price of gold, cost of labour and technological capabilities (GDACE, 2008). At present, new mining projects are being developed and some derelict mines have been reopened to reprocess old waste deposits. Dump reclamation through the reprocessing of mine tailings can be a payable operation, especially on slime dumps at old gold mines where older and more inefficient technologies where previously unable to extract smaller fragments of gold (GDACE, 2008). That said, there is no disputing that the gold mining industry on the Witwatersrand has reached its twilight years, and South Africa is now having to confront the negative impacts of mining on the environment and society, long ignored in the years of easy profits (McCarthy, 2011).

2.2 Gold and water

As Keith Beavon suggests, the location of Johannesburg, and the wider city-region around it, had everything to do with the discovery of gold in the area (Beavon, 2004). Other factors, including the availability of natural resources that would normally be a consideration in the position and growth of any large settlement, were always secondary. Indeed, the poor resource provisions of the area in which Johannesburg was established has been a constant constraint, plaguing both the mining operations and the fast-growing commercial and residential forms around the diggings since their beginning. It was originally expected, as with so many other gold-rush towns, Johannesburg would be no more than a temporary mining camp, and so very little was initially invested in appropriate urban infrastructure. As the urban centre began to grow and made the transformation from a mining camp to a city and metropolis (Beavon, 2004), increasing focus was placed on the required infrastructure development and the spatial planning needed to facilitate this.

Water and gold entwined

The quality and quantity of available water has afflicted gold mining on the Witwatersrand from its earliest days (Leyds, 1964 and Adler et al., 2007). There is an intrinsic link between the excavation of gold and the use of water, which became stronger as mining went to deeper levels. The development of Johannesburg can therefore be said to be written in water due to this inherent link between water and gold mining (Leyds, 1964).

The settlers who first established farms along the Witwatersrand did so alongside the few streams, springs and wetlands in the area, which provided an accessible, but finite, fresh water supply for farm and household use (Leyds, 1964 and Beavon, 2004). These water resources were neither sustainable nor adequate for the development of the mining industry in Johannesburg.

When gold was first discovered in Johannesburg in 1886, water was drawn from the Fordsburgspruit, the Natalspruit located on the eastern end of Commissioner Street, and a spring on the Parktown ridge located around the present-day Johannesburg General Hospital (Rand Water, 2013). From 1887 onwards, the growing demand for water saw the establishment of a number of small water companies such as the Braamfontein Water Company and the Vierfontein Syndicate (Rand Water, 2004). It was already evident at this time that water was essential to keep mines open, both because it was needed by the mines themselves and because of the growing population on the diggings. The first major private water company was the Johannesburg Waterworks Estate and Exploration Co. Ltd, which began building water infrastructure such as dams, gravity-fed reservoirs and pipes (Leyds, 1964, Rand Water, 2004). The Johannesburg Waterworks Company tapped into a more sustainable underground water resource at Zuurbekom farm, and pumps were installed to extract approximately half a million gallons per day (Leyds, 1964).

Institutional and infrastructural developments to guarantee supply

After 1902, the British realised that it was important to ensure the Witwatersrand's long-term water supply, and made provisions to establish the Rand Water Board (Rand Water, 2004). The Board began to take over companies that were supplying, or capable of supplying, water to the Witwatersrand and assumed the role of providing bulk water to different water users.

Increased water demand from a growing population and economic base has been identified as the largest challenge of the Rand Water Board (Rand Water, 2004). To date, the board has implemented and participated in a number of major development schemes to keep up with the growing water demands of the GCR. These are highlighted in the table below (Table 2.1).

Table 2.1: Major water development schemes to date (Rand Water, 2004).

Date	Water scheme
1914 - 1924	The Vaal River scheme including the Barrage
	Vereeniging Pumping Station Zwartkopjes Pumping Station
1924	Vaal Dam – 1938 – 354 Ml/d
1949	Zuikerbosch Pumping Station
1998	Lesotho Highlands Water Project

Rand Water currently sources bulk water from the Vaal Dam and the Vaal River barrage. Water is pumped to water treatment plants where it is purified until fit for human consumption (Rand Water, 2013). The Vaal Dam is linked to other catchments through water transfer schemes such as the Lesotho Highlands Water Project (LHWP). At present, a total of 92% of the water supplied by Rand Water is piped to municipalities and conveyed to domestic, industrial, commercial and other water users and the remaining 8% is supplied directly to mines (Rand Water, 2013).

The Vaal catchment is unique in that it not only supports a large number of water users but also lies in the path of diffuse water pollution from a large number of gold and coal mines as well as return flows from domestic, industrial and agricultural users (DWAF, 2005). Water quality in the Vaal River System (VRS) has become significantly compromised through the degradation and pollution of the Vaal's main tributaries, in no small part due to mining in the region (Wepener et al., 2011).

2.3 A legacy of externalizing costs

Cost externalisation

Though the mining industry has made a significant contribution to the economic development of the GCR, and South Africa more generally, mines often used irresponsible mining methods with little regard for society and the environment (Swart, 2003). Short- and long-term environmental costs associated with mining have historically been deflected from the balance sheets of mining companies (as depicted in Figure 2.2). These environmental remediation costs, not counted as part of mines' direct production expenses, have compound over time, and typically peak after mines have closed and become derelict and ownerless. Historically, the policies of both the mining industry and government, including apartheid, helped to artificially suppress the costs of labour. In the early years of the Witwatersrand, mining companies found assistance from the Boer and British governments in forcing rural Africans into migrant labour arrangements, guaranteeing a supply of cheap labour (Pampallis, 1991). Under apartheid, the migrant labour system was preserved by forcibly removing millions of Africans to Bantustans and homelands, which externalised labour's social-reproduction costs to other parts of the country. The region has inherited this legacy of systematic externalisation of costs in the form of significant environmental and social challenges.

Adler et al. (2007) provide a useful diagrammatic representation of the life of a mine, depicting the externalisation of costs by mines over the long term. Short-term mining costs associated with the prospecting of land, sinking of mine shafts, pumping of underground water and building of processing facilities outweighs the long-term costs of environmental compliance and rehabilitation (Figure 2.2 and Figure 2.3). The developmental and operational costs peak early in the life of a mine and reduce rapidly (Figure 2.3). Revenues climb quickly as the development and operational cost curve falls off, making for large profits over the mine's life-span. The environmental remediation and social costs are delayed into the future, and profits are only affected when these begin to climb much later in the life of the mine (Figure 2.3).

Figure 2.2: An illustration of the imbalance between money spent on developmental and operational costs, and environmental and social remediation costs (information adapted from Adler et al., 2007).

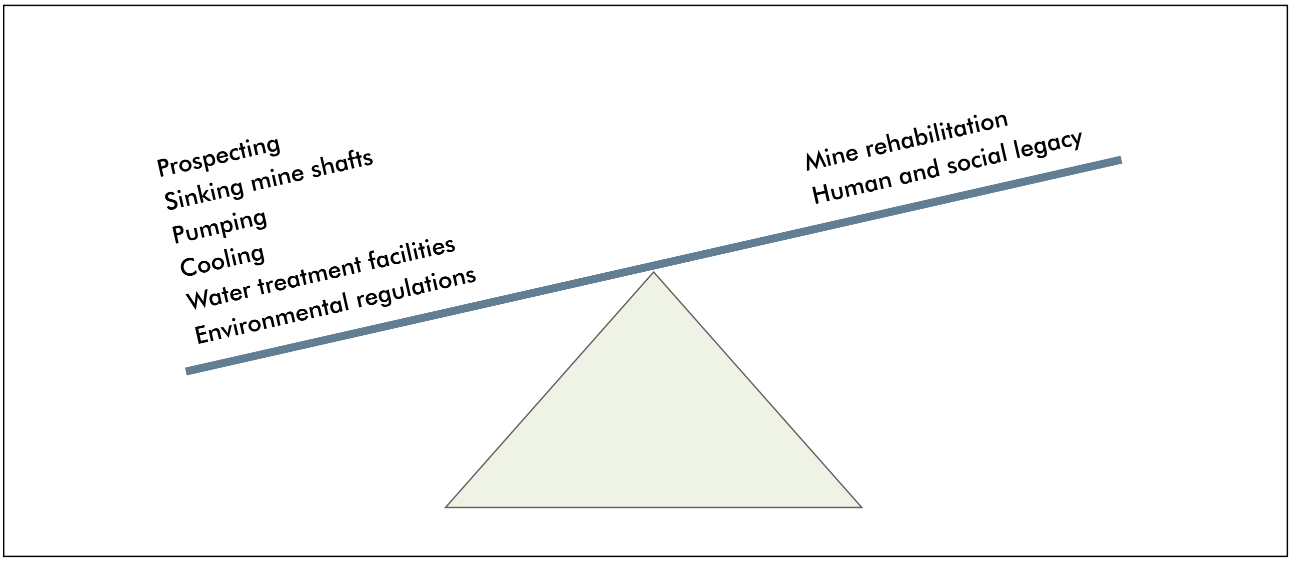
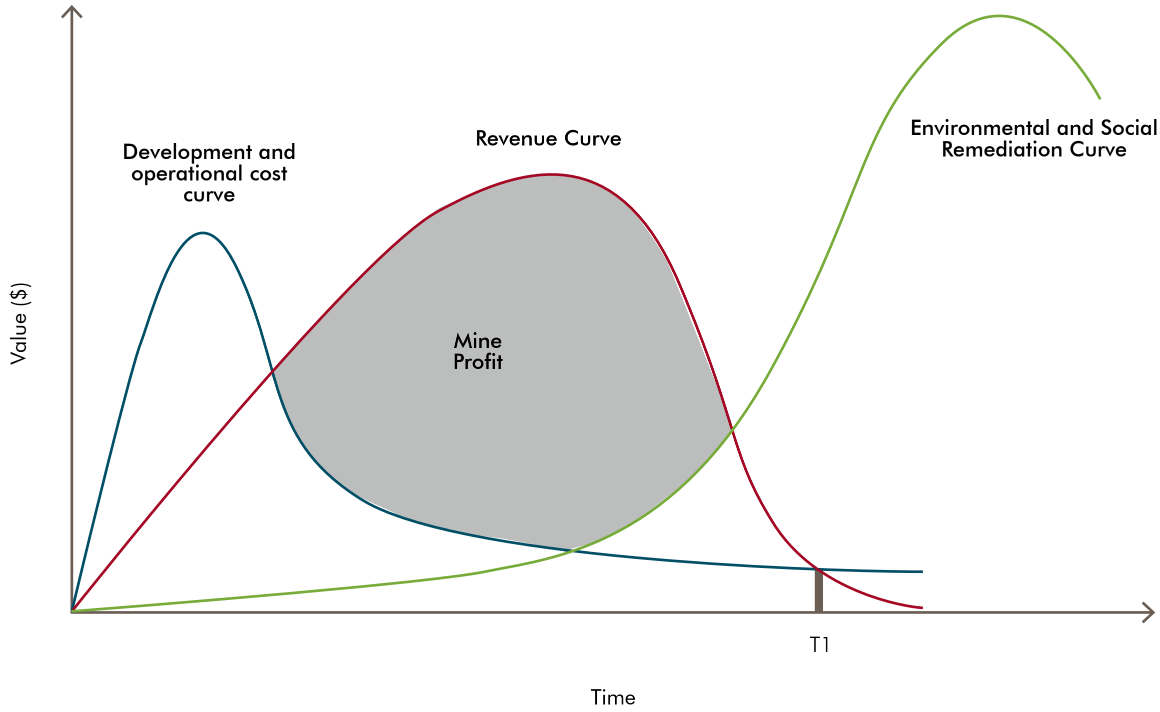


Figure 2.3: The externalization of cost by the gold mining industry (redrawn from Alder et al., 2007).



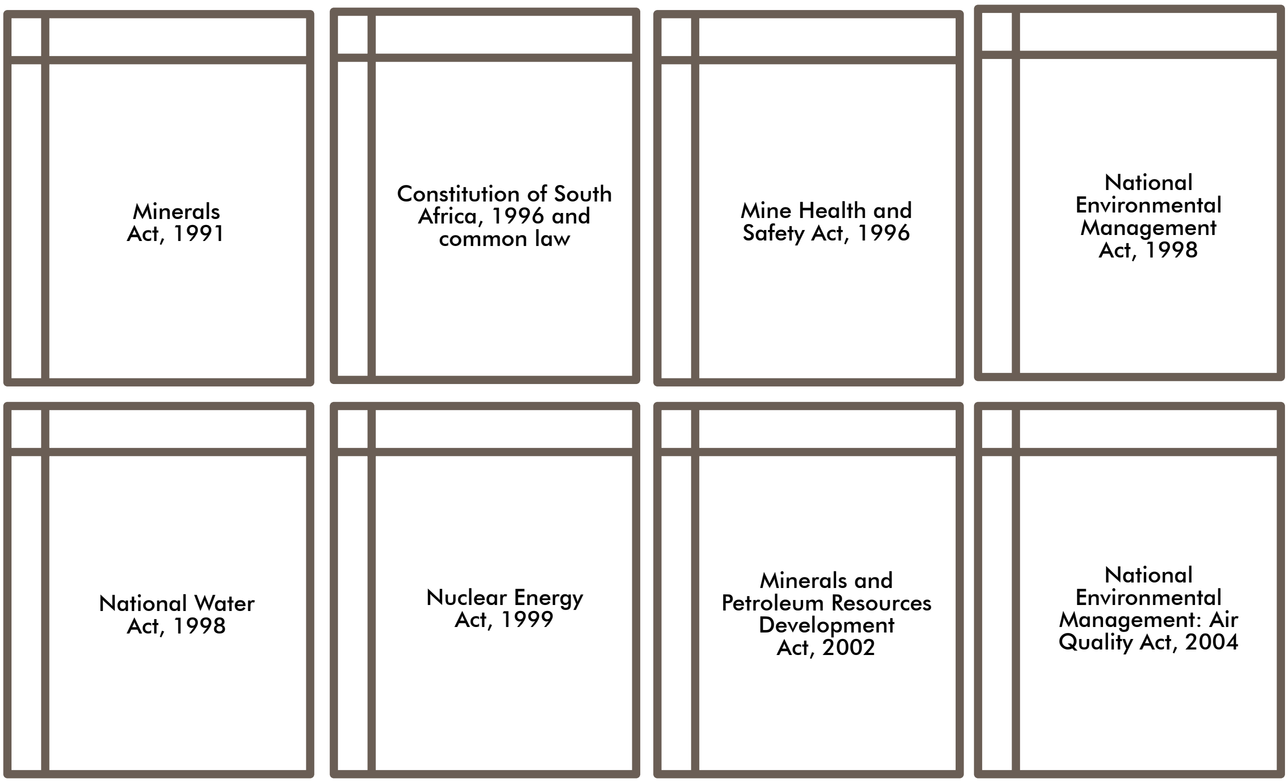
Poor regulation

To address the worst excesses of cost externalisation, the South African government has, over time, introduced various regulatory measures. The first attempt at regulating the mining industry was made in 1903 under the Transvaal Mining Law, but this only dealt with occupational safety issues (DMR, 2010a). Between 1932 and 1951, mining was governed by the Mines, Works and Machinery Regulations Act. In 1956, this was extended to include the Mines and Works Act, promulgated to ensure the rehabilitation of mines through topsoil treatment and vegetation recovery (DMR, 2010a). Although this required some environmental consideration by mines, the first real step towards formalising mining's environmental remediation liabilities began in 1991 when the Minerals Act made provision for mining companies to take financial responsibility for rehabilitation after closure (Swart, 2003).

In terms of the Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA), mines are now legally obliged to plan for rehabilitation after mining activity has ceased, and to consider the lagged social and environmental impacts of mining in the short term. Specifically they are obliged to allocate funds to perform environmental rehabilitation upon the decommissioning or termination of mining activities. These funds can be earmarked in the following ways: a) cash paid into a Department of Mineral Resources (DMR) trust; b) through an investment that will be used as security in the form of a short-term guarantee, called a Section 37(A) Trust; and c) through the provision of a guarantee from a DMR approved bank or short-term insurer, who will see to the rehabilitation up to a specified amount if the mine can no longer continue operations (Kruger, 2011). Non-compliance with required provisions for funding mine rehabilitation carries various penalties (Strydom and McMeekin, 2011).

The legislative framework for mine closure was extended in 2004, by means of regulations for the MPRDA, to encompass a social and labour plan (Regulation 42). The 2004 regulations also integrated key principles from the National Environmental Management Act and the National Water Act (DMR, 2010a and Kruger, 2011). Mine closure is now governed by a loose framework of acts working together with other regulations such as the requirement for Environmental Management Plans. These acts include the Constitution of South Africa (1996), Mine Health and Safety Act (1996), National Environmental Management: Air Quality Act (2004), and Nuclear Energy Act (1999) (Figure 2.4).

Figure 2.4: South Africa's legislative framework for mine closure (DMR, 2010a and Kruger, 2011)



Despite the introduction of new legislation, the legal framework governing mining's social and environmental responsibilities, especially in the event of mine closure, remains diffuse. There is also a perception that while regulations are on the books, the enforcement of these regulations by government departments has not been systematic. Mines have continued to exploit weaknesses in the regulatory environment, and the practice of deflecting social and environmental costs continues (Adler et al., 2007).

2.4 Negative impacts on the environment, society and economy

While most GCR residents would have some broad sense that mines, and large bodies of associated mine waste, cause damage to the environment, the precise nature of their impact on different aspects of the environment (especially on water systems), society (notably on human health) and the economy is not well known (A.T. Kearney, 2012). The rest of this section briefly reviews some of the impacts of both AMD and so-called MRAs. This overview does not aim to blame mines for a legacy of negative impacts (mining's positive contributions have also been considerable), but merely to present the facts of the current situation that must be acknowledged and confronted.

Impacts on the environment

Mine Residue Areas (MRAs)

Acid mine drainage is only a part of the contamination caused by mine waste in the GCR. Areas of localised mine waste are known as MRAs. These may include tailings disposal facilities, waste rock dumps, open cast excavations and quarries, water storage facilities, tailings spillage sites, footprints left after the re-mining of tailings, disposal facilities and a mix of waste that falls within the boundaries of former mine properties. MRAs lead to atmosphere-borne pollution and the water-borne contamination of soil and bedrock around mine sites, and they can also contribute to the collapse of under-mined or dewatered/rewatered ground (GDARD, 2012). Furthermore, MRAs can contribute to AMD through the contamination of underground basins via ingress points on the surface. There are 374 identified MRAs in Gauteng, most of which are associated with gold mining (GDARD, 2012).

MRAs are a particular challenge in light of so-called 'ownerless and derelict mines', a key factor in the poor compliance with legislation around mine closure. DMR has compiled a ranked database of ownerless and derelict mines, which, abandoned by their previous owners, have become the responsibility of the state. The ranking is based on the degree of environmental risk that the mines pose to both the environment and nearby communities. A total of 6 152 ownerless and derelict mines have been identified and, where applicable, the financial cost to rehabilitate them has also been calculated (DMR, 2010a). In 2011, the financial implications of ownerless and derelict mines was estimated at R30 billion and this is expected to increase over time (DMR, 2010a and WWF, 2012).

In light of the sheer number of ownerless and derelict mines in South Africa, efforts made by government to rehabilitate mines have been slow. For example, while 6 mines were allocated funds during 2011/12 for rehabilitation (DNT, 2011), only 3 were successfully rehabilitated (DNT, 2015). This increased to 13 rehabilitated mines in 2012/13 and 28 in 2013/14 (DNT, 2015). As part of a coordinated effort made by DMR, we may see a growing number of mines being rehabilitated in the future. This is due to additional funds being allocated for mine rehabilitation in 2014/15 - 2017/18, where at least 50 ownerless and derelict mines will be rehabilitated per year (DNT, 2015).

Soil contamination by AMD

Soil that has been contaminated by AMD has a lowered pH, generally between 4 and 6, which is acidic to strongly acidic. Soil in the upper 0.3m of topsoil is shown to be the most contaminated with increased levels of heavy metals such as cobalt, nickel, zinc and sulphur (Rösner and van Schalkwayk, 1999). The acidification of topsoil represents permanent soil degradation that creates difficulties for future land use, as only acid-tolerant plants can be grown in acidic soils. Heavy metals from contaminated soil are taken up by plants and transferred to humans and animals through the food chain. This poses severe risks for the agricultural and livestock industries in the GCR causing severe health problems and the degradation of ecosystems (Ochieng et al., 2010).

Impact of MRAs on water quality

Many of the streams that run through mine areas are perennial and their base flow is sourced from underground seepage (Tutu et al., 2008). These streams are therefore particularly susceptible to contamination by MRAs and AMD. Ochieng et al., (2010) explain that mine water impacts negatively on natural water systems by increasing the amount of suspended solids, mobilising iron, aluminium, cadmium, colbalt, manganese and zinc, and increasing the overall pH of water. The consequent deterioration of water quality creates risks for domestic, industrial and agricultural water users (Ochieng et al., 2010).

In a study conducted by Tutu et al., (2008), the quality of surface water in close proximity to MRA and AMD waste-generating deposits was found to have the lowest quality, though it improved downstream. Water in lakes was relatively unpolluted but with levels of pollution being higher at the end of the wet season as a result of increased discharge (Tutu et al., 2008). Groundwater in close proximity to AMD-generating deposits had higher acidity and contained contaminants such as sulphate compounds (Tutu et al., 2008). Tutu's study also found that where groundwater mixed with ponds and streams, the acidity of the water increased due to oxidation and evaporation. Interestingly, water from mining areas that drained into wetlands often had improved water quality due to the modification of the pH through chemical processes that take place within wetland systems. The better quality of water in lakes could be attributed to wetlands that often surround lake feeder streams (Tutu et al., 2008).

The impact of MRAs on water quality is not only through seepage, but also through airborne radioactive material. Dust levels are said to be acceptable at a buffer distance of 500m (Coetzee, 2008) but the sheer number of MRAs scattered around the GCR means that many natural and man-made water resources in the GCR are in close proximity to mine waste and are susceptible to radioactive particles (Figure 2.5).

There are accounts of AMD-related contamination impacting the Blesbokspruit, Klip River system, Wonderfontein, Natalspruit, Tweelopiespruit, and Hartebeespoort Dam (Ochieng et al., 2010). The Vaal River system is most at risk from contamination by AMD and this is not a new phenomenon. The contamination by AMD of streams that feed into the Vaal River catchment poses a great threat to the potable water supply of the GCR. As mining activity increased in the 1900s, so did the amounts of dissolved solids and contaminates entering the Vaal River above the Barrage (Marsden, 1986).

In 1986, Marsden conducted a study on the concentrations of sulphides and total sulphur in areas around mine deposits from which rainwater run-off could enter the VRS. Marsden (1986) found that a high percentage of oxidizable and leachable pollution-causing sulphur had already been removed. Contamination was therefore largely from dissolved salts, and this was less severe when the mine-residue deposits were vegetated (Marsden, 1986). Marsden, who was the environmental protection officer at the Chamber of Mines of South Africa, may have had a particular bias with regards to mine waste in the GCR, but it is important to appreciate the environment's ability to regulate itself within its own environmental threshold. This being said, the regulatory capacity of the environment has recently been significantly affected by the decant of raw acid water into streams, especially those in the WB. The quality of water in the Tweelopiespruit and Wonderfontein catchment has been most severely affected by decant in the WB.

To date, South Africa has been left with a number of sterile dams that serve as a reminder of what we may face in the future if the environmental risks associated with AMD are not taken seriously. Rand Water's "Water Wise" website identifies the Robinson Dam in Randfontein as a product of mismanaged tailings on the West Rand (Rand Water, n.d.). Robinson Dam is part of the Wonderfontein catchment which has been heavily polluted with metals such as uranium. The water in Robinson Dam is said to have deteriorated after a mine began pumping acid water into the dam as an emergency measure in response to decant in the WB in 2002 (Rand Water, n.d.). Water in Robinson Dam is now said to have a pH as low as 2.2, and the dissolved uranium has created a radioactive environment that can support no life at all. The occurrence of sterile water bodies such as the Robinson Dam are the clearest warning of what may result if more care is not taken to prevent the destruction of natural ecosystems and contamination of potable water by mining-related waste.

Impacts of MRAs on society

Communities in close proximity to MRAs are also vulnerable to waterborne and airborne pollution (Scherer, 2013). From its earliest beginnings, Johannesburg's urban form developed around the location of gold mines. The tented diggers' camp that first housed prospectors, immediately adjacent to the mine workings, gave way to a succession of more formal structures, first corrugated iron and then more robust brick buildings, in the same location (Van Onselen, 1982, Beavon, 2004). Those who made considerable wealth from the mining activities moved north, and occupied large residences on or over the Parktown Ridge. The poorer working classes remained behind in the south, housed in cottages, camps and shacks dotted along points of gold production (Van Onselen, 1982, Beavon, 2004). As mining expanded along the Witwatersrand from Randfontein and Carletonville in the west, to Springs in the east, so did the settlements along the rand. A class and racially based society began to evolve in Johannesburg which later built the foundations of an apartheid city (Worden, 2012).

Many older and poorer townships, informal settlements and government-provided low income housing estates are still located close to MRAs. Figure 2.6 indicates settlement proximity to mines with Paardekraal, Pennyville, Noordgesig, Carltonville, Steelvalley, Linkholm, Kingsway, Witpoort Estate and Refilwe/ Cullinan standing out as examples. It is notable that many government-subsidised low income housing projects appear to have been earmarked for land close to slime dams, mine dumps and landfill sites of active or derelict mines (Manungufala et al., 2005). Exposure to carcinogenic, mutagenic and teratogenic elements such as uranium, arsenic, radon, nickel, zinc and other radioactive materials found in mining waste poses huge health and safety hazards.

People living in these areas are often not aware of the dire health risks they are exposed to daily (Manungufala et al., 2005). Where they are aware of health problems arising from adjacent mines, they are often reluctant to raise the issue. While the South African Constitution guarantees that everyone has the right to an environment that does not harm health and well-being (Swart, 2003), there have been very few instances of social and environmental activists fighting the risks and impacts associated with mining. Scherer (2013) believes that this is because communities depend on nearby mines for jobs and opportunities, and also because mines in these areas are perceived to hold huge power which is difficult to contest politically.

Figure 2.5: Water bodies in the GCR and their proximity to radioactive mining waste.

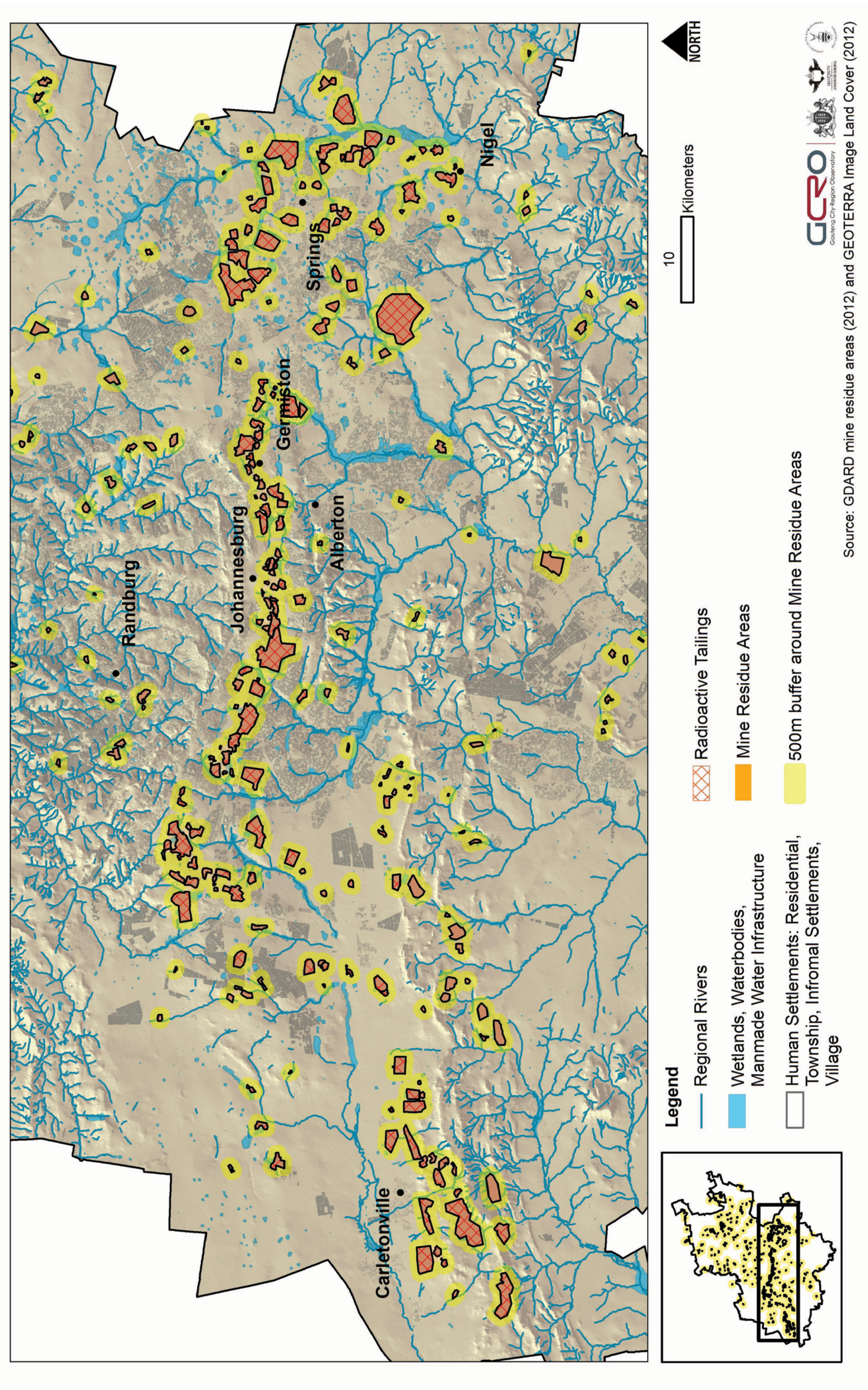
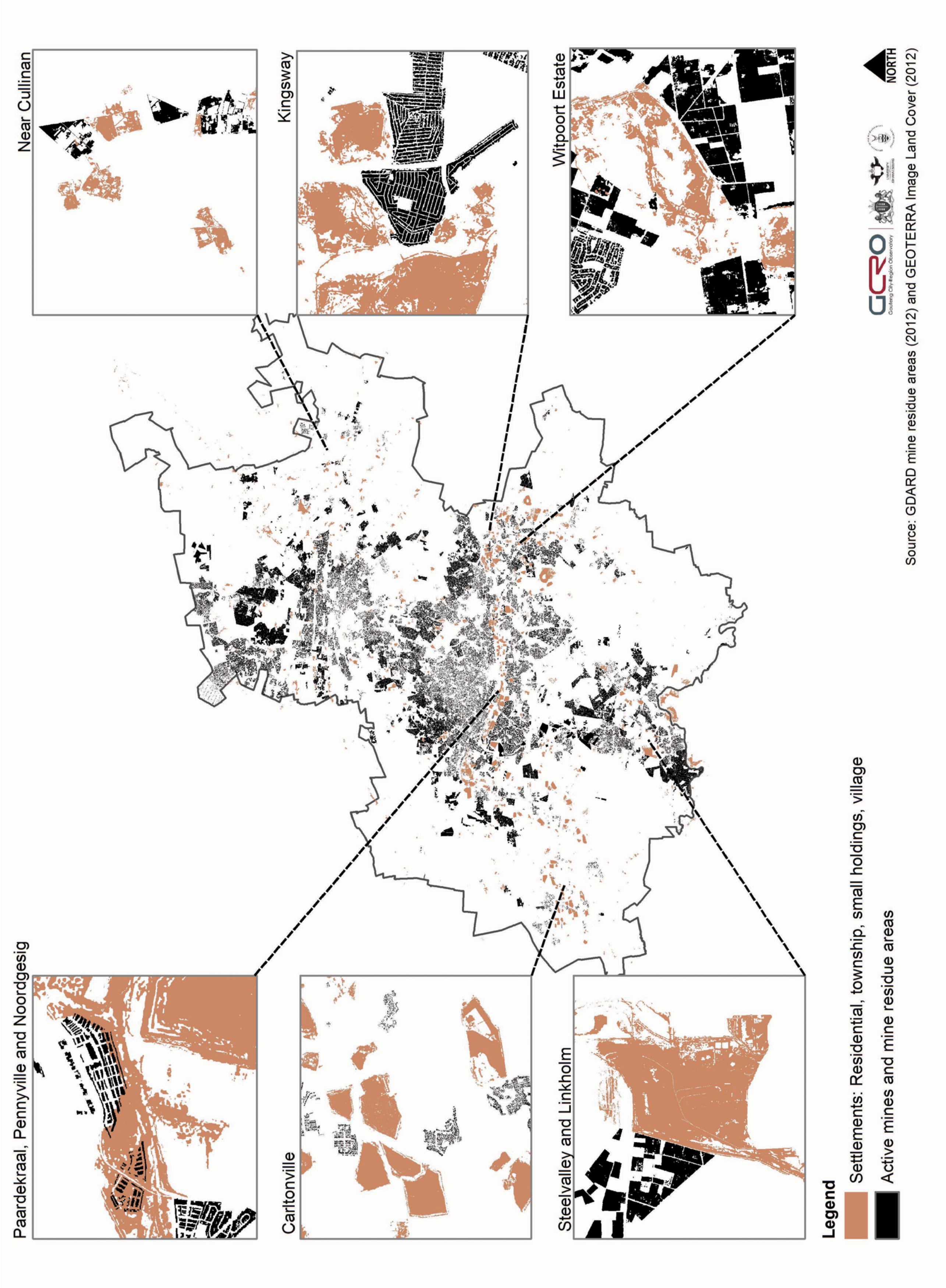


Figure 2.6: Human settlement and mine footprints in the GCR (data source: GTI 2009 and 2012).



Riverlea - A community standing up for their rights

Riverlea is a community in the south-west of Johannesburg that has been affected by the dust of a DRD Gold mine reclamation project. Reprocessing of the tailing dump upwind of Riverlea began in 2010. Since then, residents say they have experienced health issues related to the increased dust fallout as a result of the reclamation project. Communities have confronted DGD Gold about dust levels and the health issues they have experienced. DRD Gold has taken no responsibility for this, explaining to community members that they will need to prove that dust from DRD Gold is responsible for their health issues. The Riverlea community has approached Earthlife Africa to gain information around mining impacts on the community. Under the Promotion of Access to Information Act (PAIA), Earthlife Africa was unable to access this information, including the status of the mining and water licences from government. They were, however, able to obtain half the requested information DWA. To gain more information, residents now aim to take a legal route to obtain information.

(Text has been consolidated from Kings, 2013a and Kings, 2013b)

Google Earth image showing the Riverlea community located in the south-west of Johannesburg. This image illustrates the location of Riverlea in relation to surrounding mine dumps.

Impacts on the economy

While mining has historically made a key contribution to the South African economy, mine waste now also represents a considerable economic cost. As the guardian and regulator of mining, the government has accrued, as property of the state, 6 000 ownerless and derelict mines (Van Schie, 2012 and Baartjes & Gouden, n.d.). The financial liabilities of these mines – notably the direct costs of their remediation – therefore now sit as a tax burden on the broader economy. The indirect costs of AMD have also been described as a 'binding constraint' on the South African economy by Nedbank's chief economist, Dennis Dykes (Blaine, 2011).

The costs of dealing with mine waste and AMD are a drain on public resources. They subtract funding from much-needed support for agricultural and industrial production, tourism promotion, power generation, a host of other essential economic infrastructure investments, and so on. In addition, the environmental impacts associated with mine waste are likely to contribute to an increased burden on public healthcare, which again falls as a major cost to the fiscus (A.T. Kearney, 2012).

3. Action taken in response to AMD

3.1 A timeline of key events

Chapter 2 presented an overview of the history of mining in the GCR and commented on how the mines had negative environmental, social and economic impacts through the externalisation of costs over time. This chapter focuses on the history of actions taken towards mitigating AMD.

In order to facilitate an understanding of the history of actions to mitigate AMD, Figure 3.1 presents a timeline of key events, focusing in particular on the period between 2002 until May 2014. The events presented in the diagram will be explored in further detail in Chapter 4, where the public discourse around AMD and the contractual arrangements for devising and implementing the immediate and short-, and long-term solutions will be reviewed.

3.2 Project Eutopia

In March 2005, DWA issued notices to a number of mines in the GCR in terms of Section 19(3) of the National Water Act (Act 36 of 1998), instructing them to take steps to install temporary AMD treatment options and to develop a longer-term sustainable solution to the problem (WUC, 2008). In response to the directives, three voluntary mining Section 21 cooperative bodies were formed in 2006/7, named the Western Basin Environmental Corporation (WBEC), Central Basin Environmental Corporation (CBEC) and Eastern Basin Environmental Corporation (EBEC). Figure 3.2 provides an overview of the geography of the three basins and Table 3.1 summarises which mines participated in the formation of each corporation (WUC, 2010).

The corporations were formed in reaction to the DWA directive to develop responses to AMD and to assume the AMD-related environmental liabilities of active mines. Some of these corporations worked through subsidiary structures to achieve this purpose. The most notable example was the Western Utilities Corporation (WUC) (see company origin and structure in Box 2) which was mandated by WBEC to undertake extensive studies, piloting and consultation to meet the DWA directive (WUC, 2010).

In October 2008, the WUC released a report titled *Project Eutopia,* detailing its specific solution and strategy to overcome AMD. It proposed treating water to industrial standards and reselling this water to mines and industry (WUC, 2008). The WUC raised R75 million on capital markets during the following four years for research and development of pilot plants. A feasibility study was completed indicating that a minimum of 75 megalitres could be pumped per day and the best location of the high density separation water treatment plant was at ERPM (WUC, 2008). A pipeline would connect the WB and EB preventing the discharge of any polluted water into the Tweelopiespruit River. From 2009 onwards, WUC initiated a series of pilot plants to test its treatment solution.

In 2009 and 2010, WUC began engaging with DWA at a ministerial level on advancing its alternative AMD solution (WUC, 2010). In late 2009, it presented government with a proposed complete self-sustaining solution, said to be capable of operating without any further assistance from mines and able to survive the ultimate closure of existing mines (PMG, 2011a).

Figure 3.1: Timeline of key events and the development of solutions to address AMD in the GCR.

1886-1996

1886
- Gold discovered along the Witwatersrand.

1950s
- Mines began to close (McCarthy, 2010).

1965
- Atmospheric Pollution Prevention Act promulgated.

1991
- Minerals Act promulgated.

1996
- Pumping ceased in WB.
- AMD decant in the WB predicted, but ignored according to environmentalists (Khumalo, 2011).
- Constitution of South Africa promulgated.
- Mine Health and Safety Act promulgated.

1997-2007

1998
- National Water Act promulgated.
- National Environmental Management Act promulgated (NEMA).
- Mining operations ceased in the WB and mine workings filled with water (Odendaal, 2013).

1999
- Nuclear Energy Act promulgated.

2002
- Minerals and Petroleum Resources Development Act promulgated.
- Some reports suggest the immediate AMD crisis began with a flood event that occurred in the WB (Khumalo, 2011), other reports suggest earlier.

2005
- **Mar:** DWA issued section 19 notices to mines to take steps to prevent pollution at their cost (WUC, 2011).

2006
- Western, Central and Eastern Basin Environmental Corporations established (WBEC, CBEC and EBEC) as section 21 companies (WUC, 2010).

2007
- WBEC signs agreement with WUC (WUC, 2010).

2008-2010

2008
- WUC built three pilot plants. Became operational on 10 March (Copans, 2008).
- **28 Oct:** WUC released Eutopia document detailing their strategy to overcome AMD and announced that a feasibility study was underway (WUC, 2008).
- Pumping ceased in CB (DWA, 2010).

2009
- **30 Sept:** WUC plans to treat AMD to industrial quality (SABS), (WUC, 2008).
- **Nov:** WUC completed a definitive feasibility study (Prinsloo, 2009).
- WUC proposal rejected by DWA (PMG, 2011c).

2010
- **Feb:** Cabinet appointed an Inter-Ministerial Committee (IMC), who appointed a Technical Committee. The technical committee appointed a Team of Experts (ToE) to investigate and make recommendations on solving the AMD problem (DWA, 2010).
- **Aug:** CRG orders two submersible pumps from an international technology group called Andrea Ritz priced at 3.5 million euros (CRG, 2011).
- **Nov:** GCRO provocation written by Prof McCarthy on *'The decanting of acid mine water in the Gauteng City-Region'*.
- **15 Dec:** Report by ToE tabled (DMR, 2010b).

2011

2011
- **Jan:** Pumping ceased in EB (PMG, 2011a).
- **9 Feb:** ToE presented the cabinet with a draft AMD report outlining the immediate, short and long-term solutions.
- IMC recommended that the short term solution should be implemented as emergency works (DWA, 2010):
  1. Installation of pumps.
  2. Onsite construction of water treatment plants in each basin.
  3. Installation of infrastructure to convey treated water to discharge into a water course.
- **1 March:** ToE presented to cabinet on 9 Feb and emergency works were approved by IMC and cabinet for implementation (DMR, 2010b).
- **6 April:** DWA directed TCTA to undertake emergency works (DWE, 2012a).
- **27 July:** Successful testing of submersible pumps by CRG (CRG, 2011).
- **Aug:** TCTA BKS Due Diligence report submitted and released.
- **2 Aug:** DWA authorizes TCTA to implement the immediate solution (DWA, 2010).
- Work commenced to upgrade Rand Uranium plant (Odendaal, 2012).
- **12 Dec:** Amended EIA application submitted to DEA for approval (DWE, 2012a).

2012

2012
- Estimated cost of cleaning up South Africa's 6 000 abandoned mines peaks at R30 billion (WWF, 2012).
- **19 Jan:** Capital set aside is inadequate for immediate and short term works (Creamer, 2012).
- **1 Feb:** DWA initiated a feasibility study for a long-term solution – appointed Aurecon SA assisted by SRK consulting together with Turner and Townsend (DWA, 2012a).
- **22 Feb – 10 Mar:** EIA Interest Group meetings took place (DWE, 2012a).
- **25 Jun:** Mine Restoration Investment (MRI) registered on AltX listing (Walt, 2012).
- **11 - 26 Jul:** EIA Interest Group meetings took place (DWE, 2012a).
- **22 Jul:** CRG pumps tested (CRG, 2012).
- **15 Aug:** Bill for cleaning up AMD along the Witwatersrand said to be over R2 billion (WWF, 2012).
- **21 Aug:** DEA and DWA announce that they will jointly apply for an EIA exemption.
- **30 Aug:** Draft report issued on Treatment Technology Options for the long term solution (DWA. 2012d).
- **23 Oct:** Communiqué to the public on the exemption application for the immediate and short term EIA under Section 24G of NEMA (DWE, 2012c).
- BKS becomes known as AECOM.
- **Nov:** Public announcement of the EIA exemption application by BKS and TCTA under section 24M of NEMA (TCTA, 2012b).
- **20 Nov:** DWE releases the final immediate and short term intervention EIA Scoping Report (DWE, 2012d).
- **26 Nov:** Agreement signed between CRG and TCTA to authorise the donation of pumps from CRG. To be used in the High Density Sludge treatment plant in the CB (CRG, 2012).
- **30 Nov:** Ergo and TCTA enter an agreement to construct infrastructure in the CB and allow TCTA access to the South West Vertical Shaft at ERPM (Esterhuizen, 2012).
- **Dec:** TCTA entered an agreement with JSE-listed company Group Five for construction of treatment works and monitoring shafts in the CB (Odendaal, 2013).
- **End of 2012:** DWA sent an invitation to those interested in proposing a long-term solution for AMD along the Witwatersrand (DWA, 2012c).

2013-2014

2013
- **7 Jan:** Section 24M exemption application under NEMA approved by DEA (DEA, 2013).
- **Jan:** Group Five selected to construct treatment works and monitoring shafts in the CB (Odendaal, 2013).
- **Feb:** Long term solutions feasibility study to have been completed (DWA, 2012).
- **9 April:** Long term solution feasibility study extended to 31 July 2013 (DWA, 2013a).
- **May and June:** Documents on the long term solution released on DWA website (DWA website).

2014
- **Jan:** Environmental and social analysis conducted by DWE (AECOM, 2014).
- **Feb:** Golder Associates undertook an engineering and financial screening analysis. This included sludge classification (AECOM, 2014).
- **5 March:** DEA amended the Environmental Authorisation dated 7 January 2013 (I&AP notice).
- **9 May:** CB pumping plant tested for the treatment and release of AMD. Full capacity to be reached on 30 may 2015 (DWA, 2014).
- **June:** Draft EIA scoping report completed by Digby Wells on the construction of the proposed sludge disposal facility and pipeline in the EB (AECOM, 2014).
- **October:** Final EIA completed for the construction of the proposed sludge disposal facility and pipeline in the EB (AECOM, 2014).
- **13 October:** Approval of the Operational Environmental Management Programme (EMPr), (I&AP notice).

Figure 3.2: Overview of the Western, Central and Eastern Basins of the Witwatersrand Gold Fields (DWA, 2012a). The Western Basin is located in the Krugersdorp, Witpoortjie and Randfontein areas; the Central Basin is located between Durban Roodepoort Deep (DRD) in the west and East Rand Proprietary Mines (ERPM) in the east; and the Eastern Basin is located in the Boksburg, Brakpan, Springs and Nigel areas.

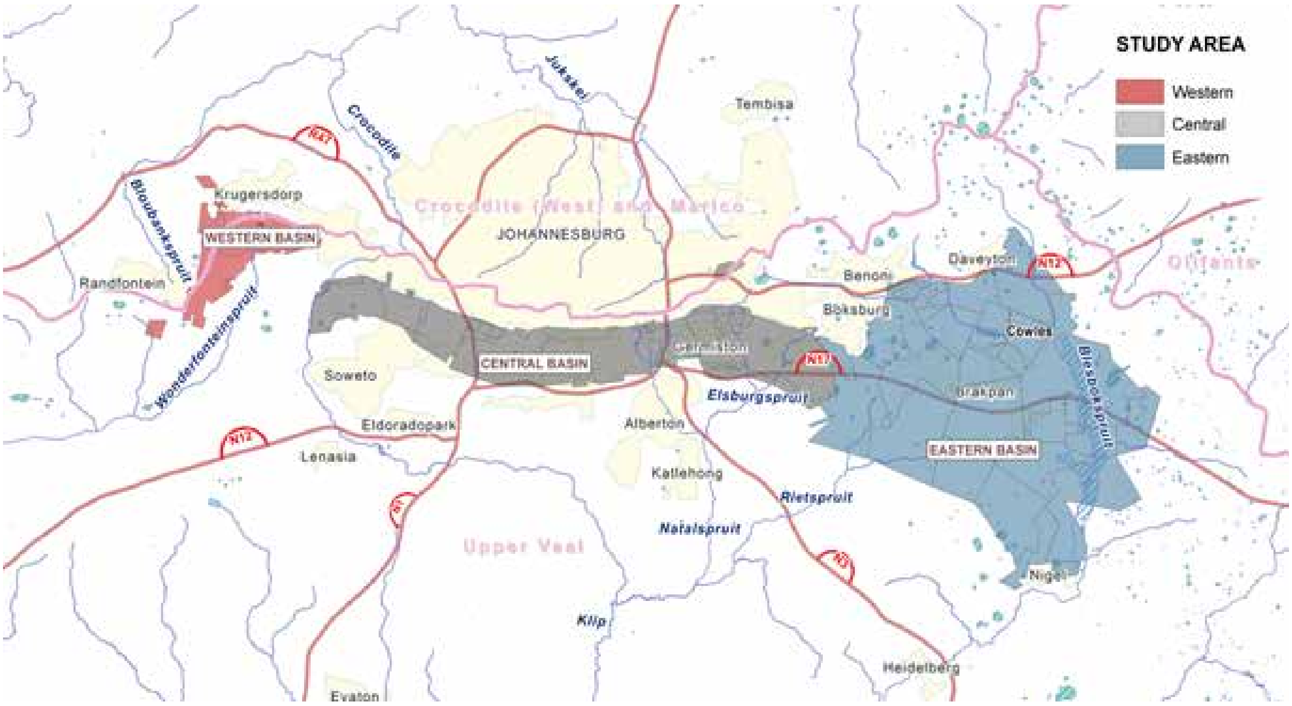


Table 3.1: Overview of mining companies participating in the establishment of three environmental corporations (Schoeman, 2011).

WBEC	CBEC	EBEC
Rand Uranium	East Rand Proprietary Mines	
Mintails SA / Mogale Gold	Central Rand Gold	
DRD GOLD / West Witwatersrand Gold Mines	West Wits Mining Incorporated	ERGO

Despite the time and money invested by WUC in feasibility studies and the establishment of pilot plants, the DWA rejected WUC's proposal on the basis that it was an unsolicited bid and due to the fact that most mines located in the CB were derelict and ownerless (PMG, 2011a). It was asserted that if another entity was to treat and sell water this might result in a water controversy (PMG, 2011a).

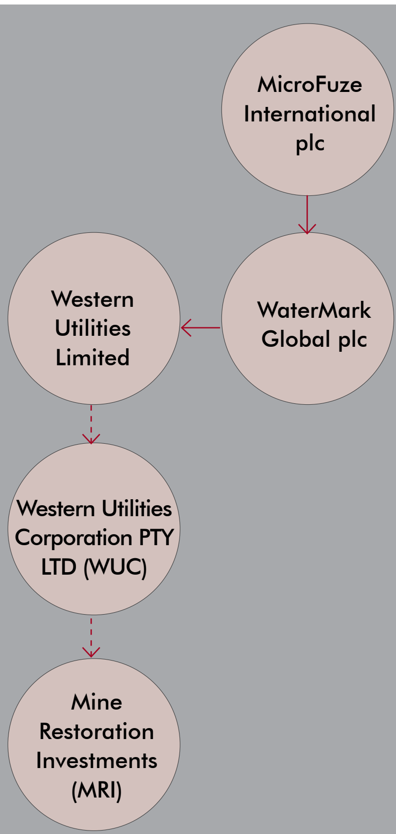
Following the rejection of the WUC proposal, DRD Gold worked in partnership with WUC on a revised proposal in which mines would contribute a portion of the funding required and government would make a contribution on behalf of derelict and ownerless mines (DRD Gold Ltd, 2010).

Overview of Western Utilities Corporation company structure

The Western Utilities Corporation (WUC) has had a series name changes between 2006 - 2012. WUC was first listed on AIM in February 2006 as Microfuze International plc. In 2008, Microfuze International plc changed its name to Watermark Global plc to reflect its focus on developing innovative water management solutions with a focus on AMD. Its wholly owned subsidiary, Western Utilities Corporation (Pty) ltd. (WUC), procured water treatment technology and became a commercialisation entity for the DWA Section 19 directive issued in 2005. AMD became the company's flagship project.

After the WUC proposal was rejected by DWA on the basis of it being an unsolicited bid, the WUC registered on the JSE's AltX in 2012 as Mine Restoration Investments (MRI).

Source: Watermark Global plc (2011), WUC (2011) and Walt (2012)



3.3 Preparatory work by an Inter-Ministerial Committee and Team of Experts

Inter-Ministerial Committee appoints a team of experts to investigate AMD crisis

Early 2010 saw the formation of an Inter-Ministerial Committee (IMC) to respond to decant in the WB specifically, and the threat of AMD in the GCR and South Africa more generally. The IMC appointed a Team of Experts (ToE) that included representatives from the Council for Geoscience, Council for Scientific and Industrial Research (CSIR), DWA, DMR, Mintek, Tshwane University of Technology, University of the Witwatersrand, and University of the Free State to investigate and make recommendations around the AMD crisis (PMG, 2011b). Terence McCarthy, who wrote the GCRO's first AMD Provocation, played an advisory role (DWA, 2010). The ToE's report was entitled *Mine water management in the Witwatersrand Gold Fields with special emphasis on Acid Mine Drainage* and was tabled on 15 December 2010 (DWA, 2010). It was considered, and accepted, by the National Cabinet on 9 February 2011.

The report detailed recommendations for an immediate and short-term implementation plan to mitigate AMD. It did this by investigating the current situation in the Witwatersrand Gold Fields, positioning the crisis within the context of mining in South Africa and by considering the occurrence of AMD at local, national and international level. The report clearly stated that the WB, CB and EB of the Witwatersrand Gold Fields were selected as priority areas, and highlighted that immediate and short-term measures would need to be implemented with urgency due to the proximity of basins to urban areas (Figure 3.2). However, an important matter considered in the report was that these basins were not the only ones in South Africa to have the presence of AMD. They would merely be the first point of focus, part of a more integrated approach over the long term.

In its report, the ToE provided technical recommendations for the three basins, together with an overview of options for governance and monitoring around the core themes of decant prevention and management, ingress control through the reduction of the rate of flooding, and water quality management.

All recommendations presented by the ToE – around the immediate and short-term construction and maintenance of pumping infrastructure, management of ingress through abstraction and canalisation, and management of water quality – were formulated to ensure that the so-called 'environmental critical level' (ECL) of each basin could be maintained (Table 3.2). The ECL is the highest safe level of water within a mine void (expressed either in metres above mean sea level or metres below decant level) where no AMD flows out of mine workings to surrounding ground and surface water systems. The ToE advised that government make a start on implementing its recommendations as soon as possible, with the immediate real time monitoring of water levels, water quality and flows, water ingress rates, subsidence events and seismic events.

The action plan outlined by the ToE indicated that a series of immediate actions were needed to avert an impending crisis and to stabilize the current situation. Where relevant, it advised, these actions ought to ensure public awareness and the involvement of the private sector. The ToE's report also made clear that its recommendations were to be understood as the start of a process towards realising a more sustainable medium- and/or long-term intervention. This longer-term response was not outlined in the report; rather it advised that this solution should be formulated after further research and the monitoring of basins over time. In an attempt to orientate stakeholders towards a longer-term solution, the ToE's report did identify a list of research gaps in the existing literature on AMD in South Africa. It contended that such research would provide a better platform from which to ground any medium- and long-term solutions.

Although the ToE did not provide detailed recommendations on medium- and long-term solutions, it did recognise the link between its proposed short-term actions and longer-term interventions. For example, it recommended that AMD neutralisation methods be urgently applied as this would return the situation to that before the cessation of pumping (DWE, 2012b), but it also explicitly qualified that neutralisation methods could not be a sustainable solution and should be followed up with a more comprehensive approach incorporating the removal of saline mine water discharge into rivers (DWA, 2010). The costs associated with such a longer-term approach, and the methods for recovering these costs, were not detailed in the report.

ToE budget

The ToE's report included an estimation of the capital and operating costs required to pump water from the mine void to maintain the ECL, this also included treatment costs for neutralization plants and ongoing cost for monitoring (Table 3.2 and Table 3.3). It was calculated that capital costs for the installation of pumping and treatment works would be R171.8 million, with further annual operational costs of R76.3 million. No capital budget was proposed for the EB as it was assumed that the Grootvlei mine would maintain and control water in this basin's mine voids (Table 3.4). However, the EB did recommend some operating expenditure for the EB to cover the costs of inspections and compliance with mining legislation.

Table 3.2: Environmental Critical Levels (ECL) calculated by the ToE and overview of the Short Term Action Plan (DWA, 2010)

Basins	Basin ECL (mamsl)	Current level of water in basins (metres below the surface)	Summary of short-term action plan
Western	1 530 (150m below decant level)	Decanting	• Construct emergency 20Ml/d neutralization plant to supplement the treatment of decant • Install pumping infrastructure at a capacity of 40Ml/d to lower water to ECL and maintain in long term
Central	1 503 (150m below surface at ERPM South West Vertical Shaft)	Approximately 500m with water level rising continuously as no pumping is taking place	• Pump water at a capacity of 70Ml/d and treat water: determine optimal pump placement and negotiate cost sharing with other stakeholders (in particular CRG) including private sector involvement • Recommended research into funding mechanisms, institutional models, legal issues, communication strategies and engineering cost-benefit studies
Eastern	1 150 (400m below surface from likely decant point at Nigel)	Controlled by Grootvlei mine at 700m	• Monitoring of pumping and due diligence on the integrity of pumping • Consider a directive to ensure compliance with water license conditions • Regular inspections of mine integrity through mine inspectors

Table 3.3: Summary of capital costs to maintain water levels (DWA, 2010).

Item	Description	Western Basin	Central Basin	Eastern Basin
Pumping costs to maintain water levels at ECL	Pumps and pump installation	R2.8 million*	R5-9 million* (dependent upon number of pump sites)	
Treatment costs for neutralisation plants	For treatment plants at R2 million each	R40 million* (ensuring existing plants are continued)	R120 million* (ensuring Grootvlei infrastructure is maintained)	Assumes Grootvlei mine will be maintained
Total		R42.8 million	R129 million	
Total (all basins)				R171.8 million

** Notation as used by ToE in the DWA (2010) report*

Table 3.4: Summary of annual operating costs assuming an electricity price of R1,50 per kW/h (DWA, 2010).

Item	Description	Western Basin	Central Basin	Eastern Basin
Pumping costs to maintain water levels at ECL	Running costs for pumps	R10 million*	R15 million*	
Chemical costs		R8 760 000	R26 280 000	
Electricity costs		R730 000	R2 190 000	
Labour costs		R730 000	R2 190 000	
Monitoring	Groundwater, shaft water levels, surface water quality, surface water monitoring, data compilation, seismic, meteorological	R3 300 000	R4 300 000	R2 775 000
Total		R23 520 000	R49 960 000	R2 775 000
Total (all basins)				R76 255 000

** Notation as used by ToE in the DWA (2010) report*

3.4 Towards action: detailed planning by the Trans-Caledon Tunnel Authority (TCTA)

Immediate and short-term works to be undertaken by TCTA

An emergency works directive for water management on the Witwatersrand Gold Fields, with special emphasis on acid mine drainage, was issued to TCTA on 6 April 2011, in effect approving some of the recommendations outlined in the final draft of the ToE's report to the IMC. The key recommendations approved as emergency short-term works were:

a. Installation of pumps to extract water from the mines to on-site treatment plants;
b. Construction of on-site water treatment plants in the WB, CB and EB, with the option of plant refreshment or upgrading of existing ones owned by mines;
c. Installation of infrastructure to convey treated water to nearby water courses;
d. Operation of the pump stations and treatment works.

Though the DWA directive focused primarily on the immediate and short-term intervention, TCTA was also advised to liaise with DWA regarding how its involvement should align with longer-term AMD management objectives.

In order to fulfil its short-term works mandate, TCTA appointed AECOM (formerly known as BKS) and Digby Wells Environmental (DWE) to carry out required due diligence and environmental impact assessment (EIA) processes.

A technical due diligence report by AECOM

TCTA contracted AECOM to complete a technical due diligence report on the recommendations provided by ToE. This request was positioned within a broader contract scope consisting of 5 tasks:

Task 1: Undertake a due diligence review of the IMC report and recommendations compiled by the ToE;

Task 2: Develop proposals for integrated regulatory processes for all basins;

Task 3: Produce engineering and tender documents with approved solutions and construction drawings;

Task 4: Monitor contractor activities and the commissioning of works;

Task 5: Monitor works during the defects liability period.

AECOM's work on Task 1 was based on a range of available literature, including: the ToE's report submitted to IMC; technical reports purchased by TCTA pertaining to water resource estimation and mine water quality assessments; and information provided by mining companies and government.

The AECOM due diligence report, entitled: *Witwatersrand Gold Fields: Acid Mine Drainage (Phase 1)*, was completed in August 2011, eight months after the ToE's report. The report outlined revisions to the ToE's immediate and short-term action plan. These revisions – which dealt with the use of AMD neutralization technology, the configuration of infrastructure, pipeline routes and corridors – largely involved the incorporation of more technical detail regarding the location of pumps, construction sites for water treatment plants, discharge points and the neutralisation technology. AECOM put forward a preferred High Density Sludge (HDS) neutralisation treatment technology, involving four steps:

Step 1: Oxidation by aeration

Step 2: Pre-neutralisation and metal removal using limestone

Step 3: Final neutralisation and metals removal with quicklime

Step 4: Remove excess sulphate using gypsum crystallisation

While it largely added technical detail to the ToE's recommendation, the AECOM report also saw some notable adjustments to the proposed short-term measures. For example, AECOM included the EB into the action plan, whereas the ToE had assumed that continued pumping at the Grootvlei mine would control the situation. AECOM's recommended immediate measures for the WB involved the upgrading and retrofitting of existing Rand Uranium (RU) treatment plants. The report also made revisions to the ECL. It is further worth noting that many of the AECOM revisions seemed to lean towards trying to accommodate options for the integration of longer term mine water management, reclamation and reuse into the short-term measures.

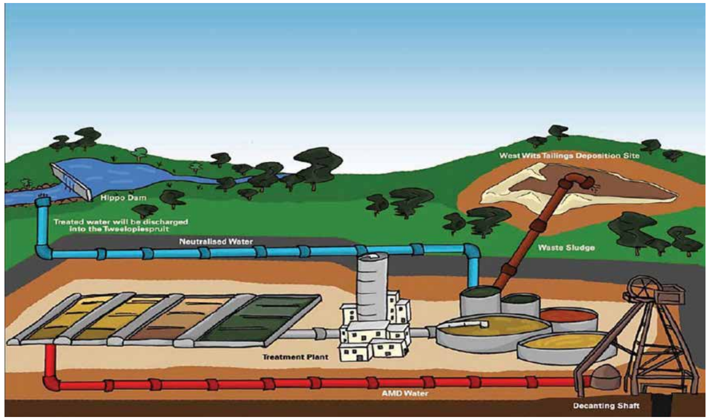
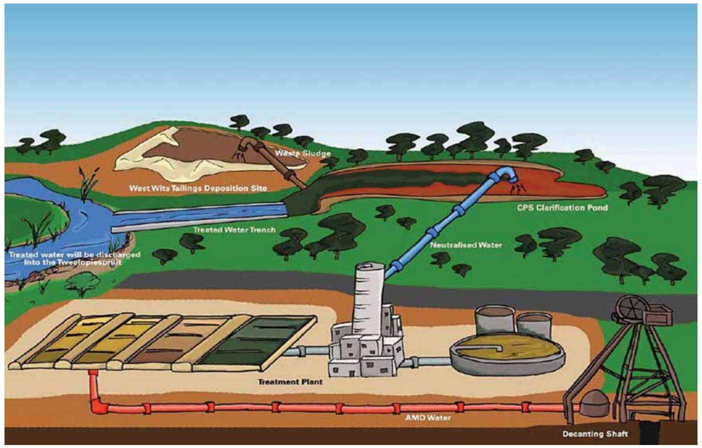
AECOM's estimated timeframes for project tasks indicate that short-term AMD interventions would be tackled simultaneously in the WB and CB and delayed slightly on the EB due to the lowered level of the ECL. The tasks (following the completed due diligence report) were projected to begin with an EIA process, beginning in July 2011 and completed by August 2012. Construction of pumping and treatment works would follow this (Table 3.5).

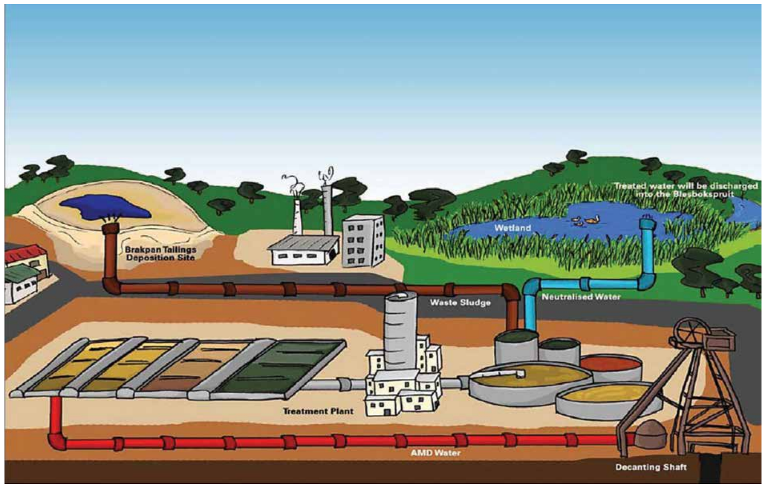
An overview of AECOM's recommendations are presented in Table 3.6, which also specifies each basin's ECL as of April 2011, and provides a graphical representation of the key works. The graphics are taken from the Digby Wells Environmental (DWE) draft scoping report as extracted from TCTA (2012a).

Table 3.5: Task schedule for the immediate and short-term intervention to AMD (information from AECOM, 2011).

Task	Task Description	Western Basin	Central Basin	Eastern Basin
1	Due diligence	Complete	Complete	Complete
2	Environment / IRP	July 11 – Aug 12	July 11 – Aug 12	July 11 – Aug 12
3	Design and documentation	Jul 11 – Jun 12	Jul 11 – Jun 12	Sep 11 – Sep 12
4	Construction supervision	Dec 11 – Aug 12	Dec 11 – Aug 12	Mar 12 – Feb 13
5	Assessment and close-out	Sep 13 – Nov 13	Sep 13 – Nov 13	Feb 14 – May 14
6	Operation and maintenance support	Nov 13 – Dec 15	Nov 13 – Dec 15	Nov 13 – Dec 15

Table 3.6: AECOM Environmental Critical Levels (ECLs) calculated for the Western, Central and Eastern Basins in the Witwatersrand and immediate and short-term action plan (AECOM, 2011 and DWE, 2012b).

Basins	Basin ECL (mamsl)	Summary of short-term action plan (outlined by AECOM)	Visual representation of short-term action plan (Source: DWE, 2012b)
Western	1 550 (160m below surface of Shaft No. 8)	• Abstract AMD through installed pumps at Shaft no. 8 to achieve ECL • Construct a new HDS treatment plant at Randfontein Estate site • Construct a treated water pipeline to discharge point on Tweelopieespruit flowing into Crocodile River • Construct waste sludge dumps and a pipeline to the CPS pit and the West Wits Pit.	 

Central	1467 (To be maintained at 150m below surface at lowest lying shaft)	• Abstract AMD through installed pumps in ERPM's South West Vertical (SWV) Shaft to maintain water below ECL • Construct a new HDS plant at SWV Shaft • Construct a waste sludge pipeline to DRD Gold Crown Knights Gold Plant • Construction of a treated pipeline to a discharge point on Elsburgspruit	
Eastern	1280 (Keep water table at 270m at lowest lying shaft)	• Abstract AMD through installed pumps in Grootvlei No. 3 shaft to maintain ECL • Construct a new HDS plant adjacent to Grootvlei No. 3 shaft • Construct a waste sludge pipeline to DED Gold Daggafontein Gold Plant and co-disposal on Daggafontein Tailings Storage Facility (TSF) and Grootvlei and Brakpan TSF • Construct a treated water pipeline to discharge point on Besbokspruit	

AECOM's projected budget

During the time that lapsed between the ToE's report to the IMC in December 2010 and the completion of the AECOM due diligence review in August 2011, the Grootvlei mine ceased pumping acid water. Grootvlei's seven mine shafts were taken over by Zodwa Mandela and Khulubuse Zuma's Aurora Empowerment Systems in October 2009. It is reported that Mandela and Zuma ordered the removal of 11 pumps and their electrical motors in Grootvlei's no. 3 shaft, and all pumps and motors subsequently disappeared (De Lange, 2011). It was estimated that the pumps cost around R1.4 million each and the pump motors R1.3 million each (De Lange, 2011).

The removal of pumps and motors explains AECOM's incorporation of the EB into its short-term action plan and the addition of capital and operational costs for this basin. The total capital costs budgeted by AECOM were R697 727 075 and the total operational costs R209 719 285 annually Table 3.7 and Table 3.8). Although the total budget values cannot be directly compared to the budget put together by ToE – the ToE's estimates were at a general scale whereas AECOM's were based on more detailed technical plans – the amounts budgeted for items such as treatment plants, chemical and electricity costs escalated considerably in the AECOM budget (Table 3.8). The inclusion of the EB into the short-term intervention to AMD also contributed an additional R264 170 100 to the overall capital costs and R80 536 682 to the annual operational costs budget (Table 3.8).

Table 3.7: Summary of capital costs outlined in the AECOM due diligence report (AECOM, 2011).

Item	Western Basin	Central Basin	Eastern Basin
AMD collection infrastructure	R40 787 729	R697 727 075	R60 096 771
AMD treatment plant	R73 255 525	R90 631 838	R108 010 007
Neutralised water discharge	R1 316 400	R1 172 400	R1 622 400
Sludge handling and disposal	R1 711 806	R6 200 000	R6 800 000
Earthworks and pipe work	R31 008 353	R46 196 290	R28 480 441
Electrical control and instrumentation	R25 960 790	R23 735 832	R30 856 582
Preliminaries and Generals (12%)	R20 884 872	R25 567 663	R28 303 944
Total	R194 925 475	R238 631 500	R264 170 100
Total (all Basins)			R697 727 075

Table 3.8: Summary of operational costs outlined in the AECOM due diligence report (AECOM, 2011).

Item	Western Basin	Central Basin	Eastern Basin
O&M on CAPEX	R3 600 100	R4 128 600	R4 571 500
Chemical costs	R31 177 274	R61 602 829	R60 444 482
Electricity costs	R13 527 200	R15 146 600	R15 520 700
Total	R48 304 574	R80 878 029	R80 536 682
Total (all Basins)			R209 719 285

3.5 Environmental Impact Assessment (EIA): initial work done and exemption

The EIA process for the immediate and short-term intervention

The Bill of Rights included in the Constitution of South Africa states that all South Africans have the right to live in a protected environment that does not harm human health or well-being. One of the legal instruments developed to give effect to this right was the EIA Regulations promulgated in terms of the Environment Conservation Act of 1997 (DEAT, 2005).

The EIA Regulations provide that an EIA process must be undertaken for activities that may result in considerable impacts to the environment and must be submitted to the relevant authority for consideration. The commencement of any activities prior to obtaining EIA authorisation from a relevant authority is prohibited and constitutes an offence (DEAT, 2005).

Digby Wells Environmental (DWE) was appointed by TCTA to conduct the EIA process for the immediate and short-term AMD intervention. Based on the recommendations outlined in the AECOM due diligence report (AECOM, 2011), the purpose of the EIA was to identify potential social and biophysical impacts associated with the HDS neutralisation approach, and to allow for engagement with the public sector around the impact and implications of the immediate and short-term interventions. It was hoped that the outcomes would provide independent suggestions and comments from interested and affected parties (I&APs) that would help inform decision-making by TCTA, DWA and other environmental authorities.

The EIA process offered a series of opportunities for stakeholder engagement around the selected technology. Stakeholder engagements were set up in the scoping phase, EIA phase and environmental authorisation phase (Figure 3.1). During the scoping phase, a risk assessment was completed in order to review and rank environmental and social risks related to the treatment of water from the WB, CB and EB, develop mitigation methods and action plans for key risks and to determine the scope of specialist inputs and investigations. The draft EIA scoping document, entitled *Draft Scoping Report for the Immediate and Short-Term Interventions for the Treatment of Acid Mine Drainage (AMD) in the Western, Central and Eastern Basins of the Witwatersrand Goldfields*, was released in June 2012.

Application for exemption to the EIA

In late 2012, a significant change dramatically altered the course of the EIA process for the immediate and short-term intervention. On 23 October 2012, a communiqué was sent out to all DWE I&APs outlining the terms of an EIA exemption proposed by TCTA under Section 24 of the National Environmental Management Act (NEMA), Act No. 107 of 1998 (explained in Box 3). The exemption application was motivated by a realisation that the ECL in the CB would very likely be breached before the EIA process was complete. In the DWE Draft Scoping Report, it was made clear that it was likely that the construction of treatment plants in the WB and CB would have to commence prior to the finalisation of the EIA, and should this happen, the listed activities would trigger a violation under NEMA Section 24G.

It was initially proposed that TCTA would apply for an exemption from the EIA process under Section 24G of NEMA, for activities that would commence prior to Department of Environmental Affairs (DEA) authorisation. After investigation, DWA instead applied for exemption in terms of Section 24M of NEMA (see explanation in Box 4) to allow for construction of pumping and treatment works to start before the completion of the environmental assessment process. Applying for an exemption application under

Section 24M of NEMA, rather than Section 24G, allowed for the possibility of a retrospective EIA to be done once a process towards a long-term solution had been defined. The change of EIA exemption application was possible due to the progress that had been made in the original EIA process. DWE was already able to describe the environmental situation and document potential risks associated with the HDS technology.

At a joint TCTA and AECOM public participation meeting held on 12 November 2012, it was noted that the purpose of the exemption application was to ensure that TCTA could intervene expeditiously to prevent imminent AMD decant in the CB (TCTA, 2012b). It was explained that the exemption application would be in the immediate best interests of the environment and communities, while allowing the scope to complete a 'combined EIA' covering the immediate and short-term programme of works, as well as the envisaged long-term intervention.

Official exemption of the EIA, and authorisation to proceed with the immediate and short-term intervention for the treatment of AMD in the WB, CB and EB, was granted by DEA on 7 January 2013. Public notification was sent to the I&APs via email in an official document entitled: *Application for Environmental Authorisation in Terms of the National Environmental Act, 1998: GN R.543: Immediate and Short-Term interventions for the Treatment of Acid Mine Drainage in the Western, Central and Eastern Basins of the Witwatersrand Province,* (DEA, 2013*).* This document – referencing a series of reports from November 2012, including various policies, financial assessments, summaries of public participation inputs, findings from site inspections and so on – explained the decision to exempt the immediate and short-term intervention from the EIA requirement. It pointed to the urgency of implementing various measures that would see the release of pre-treated acid water into watercourses in a controlled fashion. Though this carried risks, the document made clear that this would be better than raw acid water decanting in the CB, necessitating further emergency works. The DEA decision also concluded that adequate decision-making and public participation processes had been followed and that the proposed mitigation measures would adequately control the negative impacts of AMD that had been identified (DEA, 2013).

Section 24G NEMA

The unauthorised commencement or continuation of activities in terms of the EIA process can be rectified through an application to the Minister or MEC, depending on who will be the competent authority for the environmental issue at hand. The authorisation will be followed in terms of Section 24G of NEMA, which can allow an opportunity to rectify authorised commencement or continuation of activities in terms of the EIA within 6 months of the starting date of an EIA. If an application is not made within 6 months of an activity listed in EIA Regulations he/she will be guilty of an offence in terms of Section 24F of the act and is subject to a fine or imprisonment decided upon by the Minister or MEC.

Source: DEAT (2005)

Section 24(4)(a) NEMA

In the findings and recommendations flowing from a Section 24M NEMA investigation, the general objectives of integrated environmental management and the principles of environmental management are taken into account in any exemption decisions made by an organ of state. This requires a description of the environment and how it is likely to be significantly affected if an EIA continues. The investigation of the potential consequences for, or impacts on, the environment of the activity allows the opportunity for stakeholders to participate in information and participation procedures.

Source: Extracted from TCTA (2012c)

Key components of Digby Wells Environmental's Final EIA Scoping Report

In an interview held with Grant Beringer of DWE on 26 October 2012, it was made apparent that at that time, as the exemption from the EIA was being applied for, the immediate and short-term EIA process had already begun in earnest, with public participation, specialist studies and expert workshops all already underway (Beringer, 2012). Due to the exemption application, TCTA requested that DWE cease with the full EIA process. Consequently DWE's Final EIA Scoping Report, dated November 2012, became simply an informative document rather than a true EIA report. At large, it merely explained the details of studies underway at the point of the exemption application.

That said, DWE's Final EIA Scoping Report remains a useful document for understanding how the measures to control AMD might themselves carry various risks. It recommended – on the assumption that HDS would be the reference technology for the immediate and short-term intervention, and that this might pose significant risks to communities and the environment – that the EIA grapple with a range of potential impacts, summarised in Table 3.9

While the exemption application effectively ended the EIA process in which these "potential risks and impacts" would have been more closely examined, TCTA did recommended that DWE continue with specialist studies defined in the scoping report since these would remain relevant to future decisions made around AMD (DWE, 2012c).

Table 3.9: Aspects to be covered in the EIA and overview of potential impacts and risks to humans and the environment (DWE, 2012d).

Core aspects recommended for EIA	Potential risks and impacts
Ecological impacts	• Construction may alter and damage habitats. • Increased water levels will impact receiving streams and the permanent inundation of seasonally wet areas. This may also affect base flows and river geomorphology. • Movement of contaminated sediments from decant points. • Impacts on wetlands and aquatic environments due to increased water flows and inundation affecting vertebrates and invertebrates in the system.
Social issues	• Economic and health impacts on downstream water users due to changes in surface water and groundwater quality. • Impacts on agricultural users through irrigation or livestock users.

Human health	• Health impacts associated with exposure to contaminated surface water and soil should decanting take place. • Health effects associated with mining waste produced such as sludge.
Radiation	• Health impacts for humans and animal exposed to radiation. • If sludge was contaminated and its properties allowed for it to be distributed by wind there is a possibility of health impacts on communities.
Water quality and quantity	• Deterioration of water quality and the increased likelihood of flooding leading to the inundation of infrastructure. • Reduced yield of the VRS due to elevated salt loads. • Elevated temperature, conductivity, pH, oxygen, heavy metals, sulphate levels, and micro-organisms which hold direct risks for human, environmental and animal health. • Groundwater quality may be affected through the seepage of discharged contaminated water. Sludge at West Wits Pit might affect the quality of water through groundwater seepage.
Heritage and archaeological	• Contribute to the damage and destruction of historical structure and buildings (over 60 years old) and burial sites in order to build project infrastructure. • Increased water flows in the Tweelopiespruit may influence the Cradle of Humankind World Heritage Site.
Air quality	• Elevated concentrations of lead particulate matter in the atmosphere as a result of sludge deposition on tailings facilities. • Increased release of air contaminants in the operational stage of the project due to increased traffic on dirt roads (estimated 8 trucks per day).
Soil	• May increase soil salinity and may reduce or affect food crops.

3.6 Implementation of immediate and short-term interventions

An overview of the implementation of immediate and short-term AMD interventions can be distilled from official presentations (such as the DWA presentation to a Provincial Workshop on Acid Mine Drainage (AMD) and Mine Residue Areas (MRAs) held on 14 November 2012), news articles (especially those published in Engineering News and Mining Weekly) and government documents (such as DWA's newsletters on its 'Feasibility Study for a Long-Term Solution').

Action was prioritised in the WB because that was where decant was already occurring and the threat most pressing. In line with AECOM's due diligence report recommendations, RU's existing water treatment plant was prioritised for retrofitting. The upgraded plant was commissioned in May 2012 and it is reported to have effectively prevented uncontrolled AMD decant in the WB from September 2012 (Odendaal, 2012). A second phase of upgrade took effect in early 2013 (Odendaal, 2012).

In early December 2012, as the exemption application was being considered, DRD Gold, through its surface tailings retreatment plant company, Ergo, entered into an agreement with TCTA to enable the construction of AMD pumping and treatment facilities in the CB (Esterhuizen, 2012). In terms of this agreement, Ergo granted TCTA access to its property to construct a water treatment plant, as well as access to the South West Vertical Shaft of ERPM to construct and operate a pump station (Esterhuizen, 2012). The agreement also allowed for the building of a sludge pipeline – able to deposit 4 167 m^3 of sludge per day – using servitudes under the ownership of Ergo. It is reported that Central Rand Gold

(CRG) also donated two submersible pumps for the implementation of the short-term intervention in the CB (CRG, 2012). TCTA entered an agreement with JSE-listed company, Group Five, to construct the treatment works and monitor shafts in the CB. Construction of these was scheduled to start in January 2013. Group Five was awarded R319 million to build the infrastructure and given ten and a half months to complete the works, with envisaged commissioning in October 2013 (Odendaal, 2013). However, the final works for the CB only eventually came on stream in May 2014.

Operations to pump and manage AMD have started in the Western and Central Basins. TCTA expected construction to begin in the EB – where the risk of AMD decant has historically been less pressing – in November 2013, after sufficient funding and access to land and infrastructure had been procured (Odendaal, 2013). According to a reply by Minister Nomvula Mokonyane to a parliamentary question on 4 November 2014, construction on a plant for the EB in Springs began in June 2014, with an envisaged completion date of December 2015. This plant would discharge neutralised AMD to the Blesbokspruit (DWS, 2014a).

3.7 Towards a long-term solution

DWA acknowledges that AMD is a larger issue to manage than simply pumping and pre-treating (to neutralise the acidity and remove heavy metals from) the water rising up through old mine shafts. While works are in place in the WB and CB, and at an advanced stage of construction in the EB, a range of issues remain unresolved.

The most important issue is that the pumping and treatment processes introduced through the immediate and short-term solution only neutralise AMD's high acidity and address the metals (notably iron) carried in the water; this partially treated AMD is then discharged into natural watercourses still heavily laden with salt, which is raising saline levels especially in the Vaal River system. Without some form of desalination as part of the treatment of AMD, this problem can only be addressed at present through the dilution of AMD-affected watercourses, in particular through the release of more water from the Vaal Dam. Excessive dilution requirements over the medium to long term are therefore raising concerns over water security in the finely tuned Vaal water supply system. Van Wyk et al. summarise the challenge in a 2010 position paper:

> *"The latest information on the salt concentrations that could be expected from the mine water was used in the analysis, some of which could be as much as 6 500 mg/l. This will push the salinity level of the Vaal River downstream of this point to a level that is unsuitable for the downstream users. The only method to alleviate this unacceptable situation is to release water with a very low salt content from the Vaal Dam to dilute the highly saline water from the mines to a level of 600 mg/l in the Vaal Barrage. …the amount of water that is required from the Vaal Dam to dilute the saline mine water will reduce the long term yield by about 400 million m³ per annum. This means that the yield of the future Phase 2 of the Lesotho Highlands Water Project (LHWP) is effectively lost from the system." (Van Wyk, et al., 2010:4)*

Other long-term uncertainties include: how to manage the liabilities associated with abandoned, ownerless and derelict mines; the unknown impact of AMD pumping on seismic conditions; future prospects for improvement of water quality in underground mines; and the financial models needed to address AMD over the long term, in particular how the considerable long-term costs are paid for (DWA, 2012b and DWA, 2012a).

The DWA decided to take a phased approach to developing a long-term solution that addresses these issues (DWA, 2012a). It was decided to commission an integrated set of studies examining technical, legal, financial and institutional issues. On 29 July 2011, DWA went out on a tender to select a bidder for what became known as the Feasibility Study for a Long-Term Solution to AMD (DWA, 2012a). Bids were adjudicated in September and October 2011. In December 2011, Aurecon was chosen as the preferred bidder, and was issued a contract in January 2012. Aurecon in turn sub-contracted SRK Consulting to conduct a study on the legal responsibilities of stakeholders, and Turner and Townsend to provide advice on institutional and financial models (DWA, 2012a).

Although the initial plan was for an 18 month study, the perceived urgency of the salt loading in the Vaal meant that the contract period was shortened to 13 months, with reports due end February 2013 (DWA, 2012a). In March 2012, Aurecon delivered an inception report, and various reports followed (DWA, 2013a). It is noted in an acknowledgement posted on the DWA website, that a variety of other actors were involved with informing this process. Contractual agreements were made with Shango Solutions, Ledwaba Mazwai Attorneys, IGNIS Project and Finance Solutions, Kayamandi Development Services, Thompson and Thompson Consulting Engineers and Legal Services and Shepstone and Wylie Attorneys. Other contributions are listed on the DWA website (DWA, n.d.). Spanning to July 2013, the long-term study consortium produced, inter alia: an assessment of the water quantity and quality in the Witwatersrand mine voids; options for use or discharge of water; options for the sustainable management and use of residue products from the treatment of AMD; and treatment technology options.

The DWA said that although the study was urgent, the investigations conducted and decisions made would be in the public eye and all decisions had to be publically defensible (DWA, 2012a). It has partly adhered to this commitment. To its credit, DWA has put some of the studies concluded in July 2013 up on a dedicated website, and also issued three 'newsletters' – the first in July 2012, the second in December 2012, and the third in July 2013 – which explained the study process as it unfolded. However, not all the studies have been made public in this manner (as of early 2015) and the last newsletter issued was over eighteen months ago.

The third newsletter issued by DWA provides a useful insight into two matters. First, it makes a little clearer how the immediate and short-, and long-term interventions interventions are sequenced, and how they connect together. Using the Western Basin as an example, it envisaged:

- *"Phase 1A (STI): From 2012 – Upgrade neutralisation Plant to 32 Mℓ/d capacity.*
- *Phase 1B (STI): 2013 – Upgrade neutralisation capacity to ±40 Mℓ/d and install permanent clarifier and permanent pumps. Alternatively, implement joint neutralisation process with mining sector, such as Mintails process.*
- *Phase 2: For 5 to 7 years – Construct ancillary works and commission Pilot Treatment Plants (each 5 to 10 Mℓ/d) to develop Innovative Technologies.*
- *Phase 3: 25 years – Procure new operating contract and process with lowest lifetime costs.*
- *Phase 4: 25 years – Procure new operating contract and process with lowest lifetime costs."*
- *(DWA, 2013b)*

The Minister's November 2014 parliamentary question reply indicates that what was envisaged to start in 2013 as Phase 1B of the short-term intervention was pushed back. Construction works for additional pumping capacity were initiated in October 2014 and were due for completion in June 2015 "while options to increase treatment capacity are being finalised" (DWS, 2014a).

Second, the newsletter clarifies that, operationally, the long-term solution will not be a single, all-encompassing programme initiated at a set date. Rather it will entail an extended process of testing and piloting various "innovative technologies" to arrive at a set of scientific conclusions as to what sort of treatment will work best in the context of the Witwatersrand. This will be done through the building of between four and eight "pilot treatment plants" in the WB. The pilot treatment plants, to be constructed by various "service providers in possession of emerging and innovative technologies", will be carefully evaluated by specialists, inter alia, from the Water Research Commission and the Department of Science and Technology. Service providers whose technology is proven through the 5-7 year process of construction and evaluation will then be encouraged to bid for long-term 25 year operating contracts to manage and fully treat AMD (DWA, 2013b).

In 2013, DWA estimated that the capital cost of the pilot plants to be some R6,6 billion, and the ongoing operational cost of both the short-term measures and the long-term solution's pilot plants to be some R990 million per annum (DWA, 2013b). More recently, the capital costs of the long-term solution have been put at R7,9 billion (TCTA, 2014).

In a presentation made to the Parliamentary Portfolio Committee on 5 November 2014, it was suggested that the next steps on the long-term solution – which would basically involve the expansion of emergency works and desalination of AMD – were close to being concluded, with a proposed implementing agency identified, and their formal appointment 'pending'. A target date for commissioning of works was also stated as 2016/17 (DWS, 2014b). This detail (also contained in presentations by Rand Water, 2014) does suggest that a number of decisions around a long-term solution to AMD have already been made that have not been made public at the point at which this report was being finalised. Accordingly, what has been decided and what has not, is not clear. Personal communications with insiders indicate that final choices on the preferred technology have not yet been made, and though calls for proposals to test various options have been issued, there simply is not enough funding currently available to pay potential service providers to test their methods on an industrial scale (Author's personal communication in 2015). This raises questions about the viability of a 2016/17 start date for the long-term solution.

While the approach taken to the long-term solution, in relation to works that were rapidly installed to deal with AMD decant and its neutralization, seems reasonable at first glance, it does raise the question of how the EIA will be taken forward. As discussed above, a full EIA, in which the impact of the short-term works on the environment was to have been thoroughly assessed, was suspended in early 2013. A key argument for the suspension, and corresponding authorization of works to deal with a decant emergency, was that the EIA would instead be done for the long-term solution, and would retroactively cover what was required for the short-term measures. However, the long-term solution effectively boils down to a cluster of pilot plants, whose technologies, once proven, will then be implemented at scale. This will only happen some years from now. It is not clear when and how, if at all, a proper EIA assessing the impact of all the short- and long-term measures will be done.

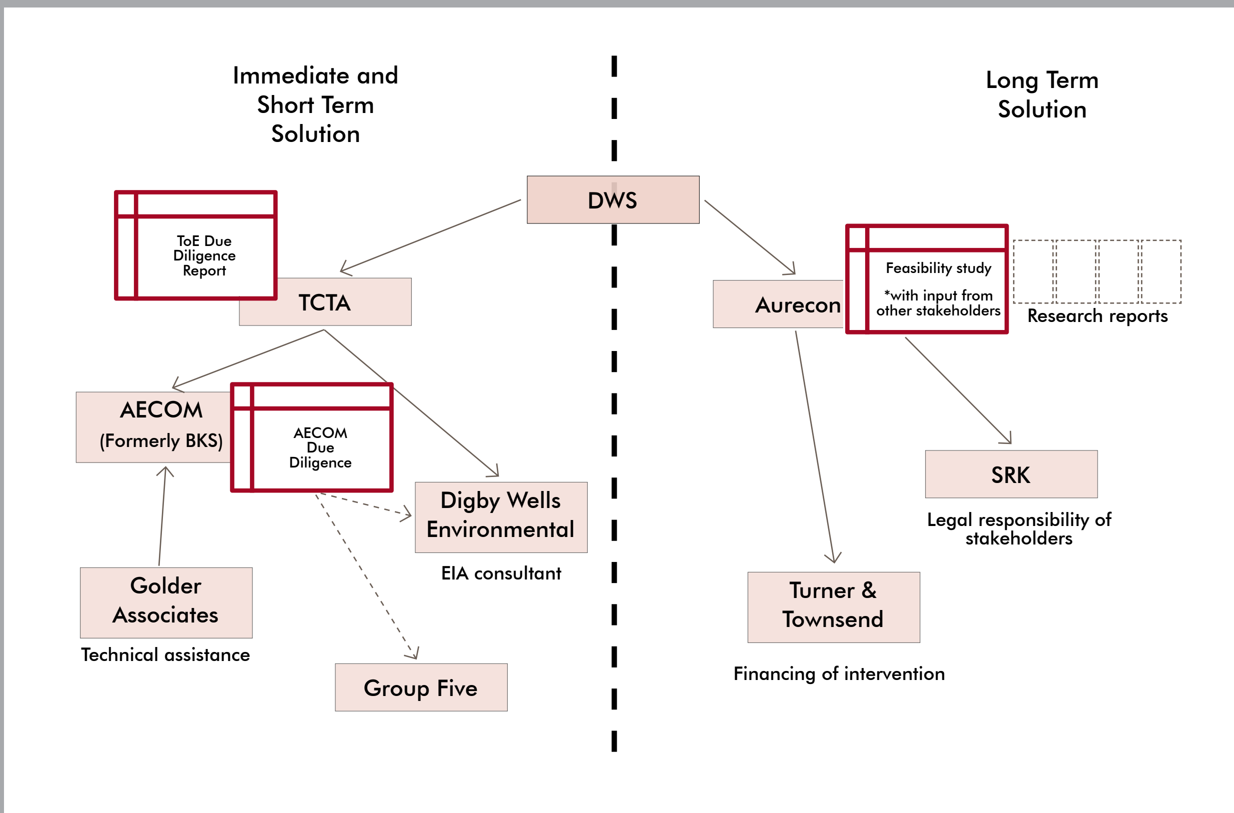
That said, it is clear that an EIA has been done specifically for the Germiston plant currently being built to serve the EB, and due for completion at the end of 2015. The EIA was undertaken by DWE, and the results have raised some consternation that partially treated water from the sludge facility will severely impact the internationally-protected Blesbokspruit wetlands. In response to the concerns, a DWA spokesperson was quoted as saying that the need for the short-term measure "outweighs the otherwise negative environmental and socio-economic impacts of acid mine drainage in these basins should no action be taken, which will inevitably have far-reaching adverse implications for the Vaal River system" (News24, 2014).

Summary of contractual arrangements

A summary of the contractual arrangements part of the immediate and short-, and long-term solutions, from 2011 to 2014, are presented below. What is evident is that a series of government, parastatal and private sector companies have been involved in devising interventions to AMD, with divisions in the skills and capabilities of actors.

As part of the immediate and short-term solution, two due diligence reports have been formulated, one by the ToE and the other by AECOM (with technical inputs from Golder). These have been used by TCTA and DWE to define construction works. The construction work has been undertaken by Group Five under contract to TCTA, guided by the insights from the due diligence reports as well as DWE's preliminary work towards an EIA.

DWA contracted Aurecon to undertake the Feasibility Study for a Long-Term Solution to AMD. Aurecon has in turn sub-contracted Turner and Townsend and SRK. Their work has been substantially informed by AECOM due diligence report and recommendations put forward by the ToE.



Overview of contractual arrangements for the immediate and short-, and long-term AMD interventions

3.8 'Paying for the sins of big business' - funding mechanisms to mitigate AMD

The funding requirements to mitigate AMD have been structured to address priority basins first. This means that public funds were first required to plan and implement the immediate and short-term interventions in the western, central and eastern basins, followed by the long-term intervention to overcome broader water quality concerns in the GCR.

Prior to 2011, public funds were not previously allocated to DWA to address AMD. Rather, funds were allocated to mines to assist with pumping, conducting research and to implement strategic solutions (Matji, 2011). Here, mines, which formed the environmental corporations WBEC, CBEC and EBEC in response to the Section 19 Notices issued in 2005, should also be acknowledged for the investment of private funds towards managing AMD prior to 2011 (Table 3.10).

Table 3.10: Overview of contributions made by mining companies in response to the directive issued by DWA to manage AMD and assume liabilities related to active mining (PMG, 2011b).

Basin	Mining company	Contributions
WB	West Wits Mining	• Contributed R23 980 204 in direct and indirect water treatment costs. • DRD involvement in AMD from as early as WUC.
	Mintails	• HDS plant constructed in 2008 and since then Mintails has treated 9 160 megalitres and discharged 4 019 megalitres at an estimated cost of R40 million.
	RU	• Absorbed costs of partially treating water in the WB and provided support for affected parties. • Engaged with ToE to prepare alternative short-term recommendations and expansions to RU treatment plant.
CB	CRG	• To protect the resource base, CRG ordered two submersible pumps (R35 million) in August 2010. These were engineered for the CB. • As a member of CBEC, CRG volunteered R35 million towards the WUC project.
	ERPM	• R300-400 million invested in the form of shaft infrastructure and HDS treatment plants to WUC. • Absorbed maintenance costs of reserve power allocation and infrastructure which ensured electricity to power submersible pumps, water treatment plants and shafts. • Additional R7.8 million spent from October 2008 on electricity costs to maintain pumping at Grootvlei.
EB	None	None

The need to allocate public money to address AMD for the first time in 2011 held some initial challenges for the National Treasury. Funding required to initiate the immediate and short-term solution in 2011 was discussed at length at a Parliamentary Portfolio Committee on Water and Environmental Affairs. According to the National Treasury presentation to the Committee, a key issue was that funding for AMD on the Witwatersrand did not necessarily have direct benefits for all provinces in South Africa. The National Treasury emphasised that further budget allocations for AMD would therefore require clarity on the severity of AMD in the GCR, how the roles between DWA and DMR would align to overcome the direct threats, and how a more sustainable long-term solution would be devised and implemented (PMG, 2011a). The National Treasury presentation further encouraged national departments to look for ways to alleviate the burden on the fiscus through public-private partnerships, and to organise funding around the enforcement of the National Water Act and other relevant Acts, *inter alia* through DWA's new Compliance Monitoring and Enforcement Unit (CME).

In National Treasury's early estimations at this time, R553 million would be budgeted for combatting AMD in the 2011/12 Medium Term Expenditure Framework (MTEF), (Matji, 2011; PMG, 2011b). Of this sum, a total of R328 million would be allocated to the DMR and R225 million to DWA (Figure 3.3). A total of R225 million was budgeted for DWA's intervention, with R220 million allocated to the short-term solution and R5 million towards developing a long-term solution (PMG, 2011b). This funding for the short-term solution was made available to TCTA via the DWA.

Funds allocated to the DMR were intended to fund mine rehabilitation and research through the Council of Mineral Technology (Mintek) and Council for Geoscience (CGS), fund treatment technologies (Mintek), and to assist mines with pumping extra water from the Grootvlei and Witwatersrand Basins (Figure 3.3). An additional R78 million was sourced from private institutions and others such as the Development Bank of South Africa (DBSA) and the Industrial Development Corporation (IDC).

After National Treasury's presentation of this budget in June 2011, a news article appeared on 19 January 2012 in Mining Weekly, reporting on TCTA's observations that current funding from government was not as 'feasible or desirable' as expected. In particular, the capital set aside for the implementation of 'Phase 1' of the project was said to be inadequate given estimated budgets (Creamer, 2012).

In the due diligence report produced by AECOM and Golder Associates, outlining the immediate and short-term interventions to AMD, it was detailed that the capital costs for Phase 1 (incl. a 15% contingency escalation) would amount to R924 million. TCTA was initially allocated R225 million, and this was increased by a further R208 million from National Treasury. However, TCTA acknowledged that the plans at that point were merely an "interim solution to prevent an environmental catastrophe" (Creamer, 2012) as then budget shortfalls amounted to approximately R492 million. Provision for annual operating costs of R210 million also remained unclear (Creamer, 2012). In other documents from the same period, it was stated that TCTA would need R385 million per year for four years for operation and management (TCTA, 2011; GCIS, 2011). In a presentation made by Keet (2012), it was also said that there was no funding available for the long-term solution, and that this would need to be investigated further to ensure continued implementation.

Actual audited figures from the 2015/16 national budget report that R80.4 million was spent on AMD by TCTA in 2011/12 (DNT, 2015).

In the 2012/13 medium term budgets policy statement, the allocation for AMD was positioned within the broader Water Sector Management programme, which grew from R413.1 million in 2008/2009 to R882.2 million in 2011/12 (DNT, 2012). R110 million was also shifted in respect of AMD between programmes under the Water Sector Management programme and R150 million had been rolled over for AMD in 2013/14 (DNT, 2012). Of the allocated budget of R450.6 million in 2012, 83.6% was to be spent on consultants to draft technical plans for water treatment works over the medium term. The long-term feasibility study was also projected to be completed at a cost of R17 million (DNT, 2012).

Actual audited figures from the most recent national budget indicate that R97 million was spent through TCTA in 2012/13 (DNT, 2015).

Expenditure by TCTA grew dramatically in 2013/14, with a total of R593.7 million on short-term works. TCTA expenditure is currently projected to be R243.5 million in 2015/16, R270 million in 2016/17 and R283.8 million in 2017/18 (DNT, 2015).

While various presentations and official documents do give some overall sense of the pattern and pace of spending on AMD, there is much that remains unclear. Serving as a point of contention at many stakeholder meetings, the exact figures for the proposed measures to address AMD, and in particular the gap between what is needed and what is available from the public purse, have not always been made public.

For example, in the feasibility study for the long-term solution, documents suggest that research has been conducted on the design and costing of measures that could be taken to address AMD in the long term. However, the finance report currently stands as one of the documents from the long-term feasibility study that remains confidential – along with study reports 3, 4, 6 and 7. It is unlikely that the finance and cost figures will be released into the public domain in the near future. It is explained by the inception report that: "These reports will not be made available until the appropriate implementation process stages have been reached as they may potentially compromise future procurement and legal processes" (DWA, 2012a:i).

In a presentation made by TCTA at the Rand Water Tariff Consultation Meeting on 22 October 2014 (TCTA, 2014), some of the outstanding budgetary requirements for AMD were recently revealed (Table 3.11). It was indicated that the expected capital costs of the AMD short-term works (at completion) would be R2.3 billion, followed by the long-term works at R 7.9 billion, as shown in Table 3.11 (TCTA, 2014). It was also presented that there is currently a deficit in the contribution of funds from the fiscus to deal with the costs associated with AMD (short- and long-term works) (TCTA, 2014).

That said, there is mention in the presentations of the Department of Water and Sanitation (DWS) and National Treasury, of approval on the use of the LHWP funding mechanism for AMD mitigation measures, backed by a government guarantee (dated 22 April 2014). This may refer to the fact that TCTA, as the agency that implements the two phases of the LHWP, has the capacity to raise considerable debt finance for capital works, and to recoup the cost of this through the Capital Unit Charge (CUC) component of the Vaal River Raw Bulk Water tariff. This tariff may lead to a water consumption tariff increase for municipalities by as much as 14.5% in 2015/16 (Rand Water, 2014). While this tariff was scheduled for approval on the 15 March 2015, a subsequent document on tariff charges for water services and sewerage and sanitation services for 2015/16, produced by the City of Johannesburg, indicates that the tariff had not been finalised on 18 March 2015 (City of Johannesburg, 2015). According to the document, it states that "there is continuing engagement by SALGA (on behalf of the municipalities) and DWS to finalise the funding of AMD and impact on the proposed tariffs" (City of Johannesburg, 2015:1).

Figure 3.3: Overview of the budget for addressing AMD in National Treasury's 2011 MTEF (PMG, 2011a).

NATIONAL TREASURY
R553 Million

DMR
R328 million

Mine rehabilitation	*R128 million*
Assistance to mines for pumping	*R54 million*
CGS Witwatersrand ingress project	*R56 million*
MINTEK for MINE REHABILITATION	*R60 million*
AMD treatment technology	*R30 million*
TOTAL	*R328 million*

DWA
R225 million

Short-term solution	R220 million
Develop long-term solution	R5 million
TOTAL	R225 million

+R78 million contributed by institutions such as DBSA (R10 million) and IDC (R5 million)

Table 3.11 Overview of the capital components of the Vaal River System presented on 22 October 2014 (Rand Water, 2014).

Sub-Phase	Capital cost (cost at completion)	Contribution from fiscus	Contribution by mines	Implementation Period
LHWP-1	R 19 billion (current outstanding debt)	-		Historical
LHWP-2	R 12.7 billion	-		2014-2024 (water delivery 2022)
AMD short-term works	R 2.3 billion	R 456 million Incl O&M up to March 2015	R 400 million Land, pumps, use of infrastructure etc.	2013-2014
AMD long-term works	R 7.9 billion			2015-2018
Total Capital Expenditure	R 42 billion			

4. A review of AMD discourse

The preceding chapters have given a factual account of how AMD emerged as a challenge in the particular context of gold mining on the Witwatersrand, and recent steps to manage the challenge. However, the story of AMD in the GCR cannot be told simply by laying out a sequence of historical facts. AMD has generated an enormous amount of discussion and debate, often very heated, among interested stakeholders. It is very important to review this 'discourse' around AMD, because it reveals much about how AMD has been governed as an environmental problem.

Building on the information presented in the first three chapters, this section provides a critical overview of AMD discourse, focusing in particular on: (i) the engagements between key stakeholders and public concerns around access to information; (ii) how AMD has been framed as an environmental emergency, and the implications of the precedent this sets; (iii) how debates over the severity of the AMD risk articulate with, and shed light on, broader water debates in South Africa; and (iv) perceptions of opportunities arising from the long-term management of AMD.

4.1 Stakeholder interactions

This section considers the communication and information flows between key actors involved in the governance of AMD. Key issues in this analysis are the roles played by various actors and whether certain players have been able to play a role or not. Of particular concern here are the interactions between parts of government, and the extent to which the public has been kept adequately informed in the processes of planning and implementing solutions to AMD.

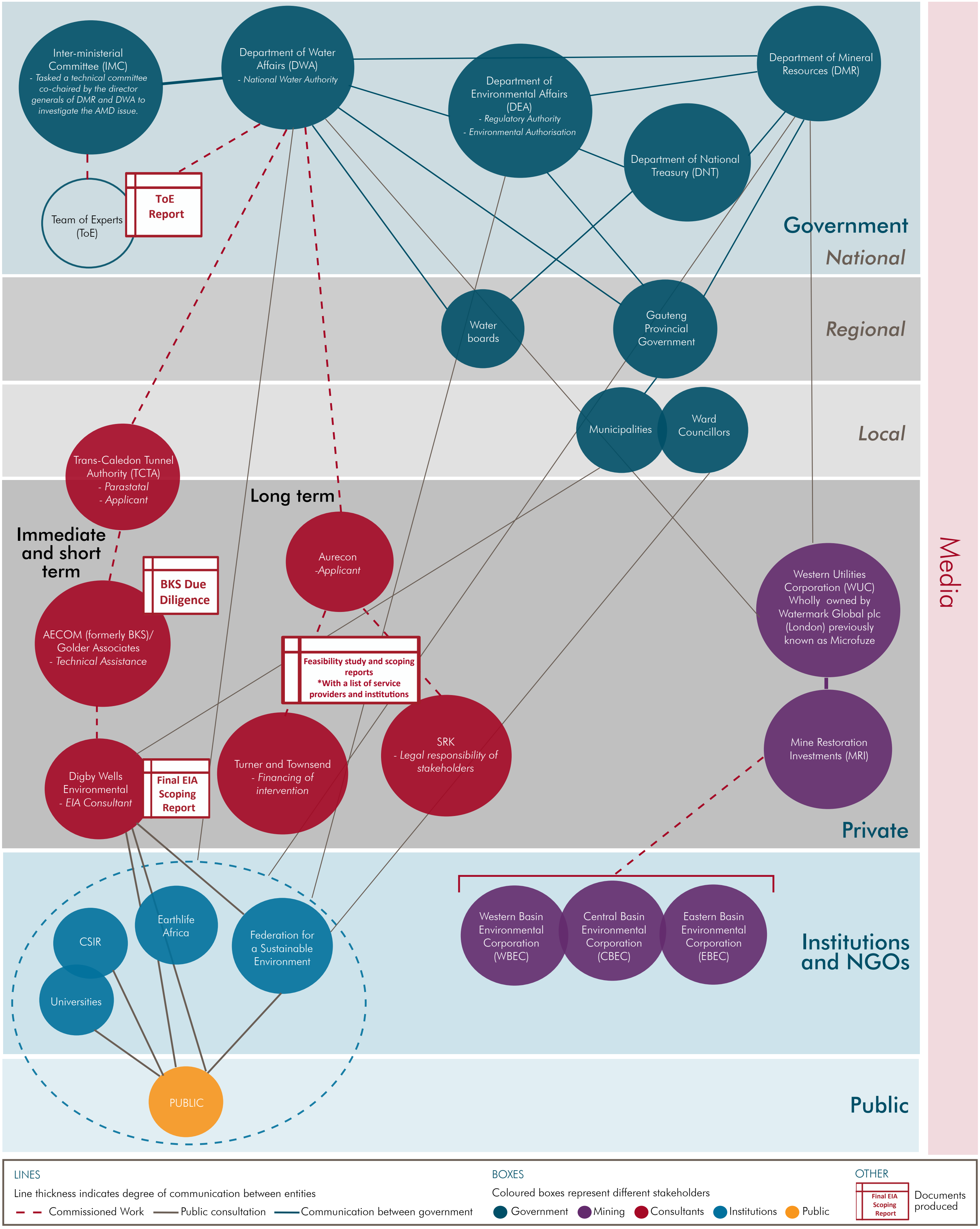
Figure 4.1 is a diagrammatic representation of both the key actors, grouped into five broad categories, and, more importantly, the interactions between them. The degree of interaction is represented by the thickness of the lines between the actors.

The role of government and interaction between parts of government

Government has the responsibility to create policies and laws around the rights and responsibilities of residents and various organisations. Government collects its income from taxes and provides services and infrastructure to improve the country (ETU, 2013). Government is structured into three distinct spheres – national, provincial and local – which in line with the South African Constitution should not be seen as hierarchically organised (ETU, 2013). Each sphere of government has constitutionally and legally defined competencies. As AMD is an issue that revolves around mineral exploitation, mine waste and long-term water security and quality, national government has taken the lead in addressing the matter. Key national departments involved have been Water Affairs, Environmental Affairs, Mineral Resources and National Treasury.

In the Constitution, the provincial sphere of government has no power over water affairs or competencies related to mining. However, it does carry an environmental management mandate. Local government, comprising different categories of municipalities, has water functions only in respect of potable water distribution and waste-water management, but it does bear responsibilities for water quality and the environment. Like provincial government, it has no explicit power over mining matters. A key role of municipalities is to provide democratic and accountable government for local communities and to

Figure 4.1: Diagrammatic representation of key actors in AMD discourse



promote social and economic development. Because of this it has some duty to hear and respond to the needs of communities affected by AMD.

The fragmented nature of policy related to mining matters (Adler et al., 2007), and the poorly carved out roles of different spheres of government, have led to a blurring of inter-governmental responsibilities. On the stakeholder diagram, there are very few lines indicating communication between parts of government and, where there are connections, the line thickness indicates that the communication and the flow of information has been limited. Research suggests a series of communication and information blockages between spheres of government and between departments within each sphere. Repeated calls by the ToE and National Treasury for national departments to better manage AMD between them point to the fragmented and poorly structured nature of government's AMD interventions.

Blockages and a lack of cooperation are demonstrated in the poor closure of the Grootvlei mine, which saw the removal of pumps from the mine workings allowing them to become inundated with water, and the ineffective management of broader issues related to AMD such as MRAs. Poor communication between government departments has only lengthened the background debates and investigations accompanying AMD interventions. In various stakeholder engagements it has been made clear that municipalities are responsible for taking on local action to mitigate AMD and assisting communities with managing local issues around mine waste. However, officials representing local municipalities and ward councillors do not appear to receive information about what this means in practice. Instead, municipal officials and ward councillors attend the *public meetings* organised by contracted specialists in order to find out the necessary particulars. In these meetings, municipal officials have asked, rather than been in a position to answer, relevant questions such as: what happens if the ECL is breached earlier than expected? And what thought has gone into assisting municipalities to manage the impact on settlements if the ECL is breached?

The role of the private sector and commissioned work

The role of the private sector is of course to profit from the development of business ideas and capital investments based on these. In the context of AMD, some of these business ideas relate to infrastructure challenges experienced in the public sector. In many parts of the world, Public Private Partnerships (PPPs) are being increasingly utilised for public-benefit infrastructure project developments (Potta, n.d.). In this domain, there has been some progress made in breaking down traditional barriers between the public and private sector, as recognition builds that PPPs can bring increased skills and capacity to solving problems in the public sector, and bring in much needed capital in the context of stretched public finances (Potta, n.d.). The South African government is increasingly making use of PPPs to achieve its infrastructure objectives. However, it needs to be acknowledged that this area is fraught with complexity, as unsolicited bids from private companies wishing to exploit opportunities in the public sector are strictly regulated. This is what bedevilled the approach to government by the Western Basin Utility Corporation in the late 2000s.

A much easier form of government and private sector interaction is where private sector specialists are contracted to undertake technical commissioned work that lays a basis for government action. The stakeholder diagram indicates strong links between DWA, IMC, ToE and the private sector, comprising various companies that have been commissioned to complete work as part of the short- and long-term interventions (Figure 4.1). There has been a great deal of communication between government and the private sector in conducting feasibility studies, due diligence reports and EIAs. Cooperation between the private sector and government was also critical when formulating the exemption application as part of the short-term EIA under Section 24M of NEMA. Government also made extensive use of consultants in structuring the public consultation process within the process of defining the short-term AMD intervention.

The public, public consultations, and the role of research and non-profit organisations

The public is of course the beneficiary of government's development efforts on its behalf. However, as envisaged in the Constitution and various laws such as the Municipal Systems Act, the public also has a dynamic role to play by participating actively in the affairs of government. This role involves participation processes by means of which the public can input into the decisions and actions government takes. Within these public participation processes, it is up to members of the public to inform themselves of current discourse and policy when information is available, but it is also a responsibility of government to empower the public to participate, *inter alia*, by providing appropriate and sufficient information. In the context of AMD, the public has a *right* to have their human rights upheld around issues of mining and to raise their concerns and give their views in AMD discourse.

To date, consultation with the public has been mainly structured through the private sector with little information and communication feeding directly from national, provincial or local government. Official public participation around AMD has generally been lacking from the early stages of the intervention and there have been very few platforms for the public to engage around the decisions made by government.

There has also been very little transparency in the actions taken around mitigating AMD. Communication from government to the interested stakeholders and the wider public has been conducted mainly through the DWA website via newsletters and press releases such as the March 2012 statement by Minister Edna Molewa. Information made available on government websites is, however, often out-dated and fragmented across projects and inter-governmental departments. The DWA has urged the public to view *Frequently Asked Questions* on its website for further information, and has uploaded a few relevant research reports, including the ToE's report to the IMC. Information on the long-term solution only became available on the DWA website almost a year after reports were completed, and even then, many components of the study remain embargoed. This is still the case despite initial efforts to address barriers in communication as part of the long-term solution – as identified in the feasibility study report on *Communication Strategy and Action Plan* (DWA, 2012e).

The failure to make all reports and documents accessible to the public, and to invite comment on these, means insufficient transparency in public forums to discuss actions being taken by government, and, in turn, stunted debate on the issues. Initially the ToE's report presented to the IMC was not made publically available. This document was only made public after the Centre for Environmental Rights, acting on behalf of the Federation for a Sustainable Environment (FSE), submitted an application to release it into the public domain through the Promotion of Access to Information Act, 2000 and Section 32 of the Constitution 1996 (SA NGO Pulse Net, 2011).

Stakeholders have also questioned the interest of government departments in mitigating AMD, when official representation at the string of public engagements held around AMD appeared to wane over time. Poor government attendance at public engagements creates perceptions that government is centralising the governance of AMD and wants limited transparency, or alternatively, is handling AMD in a hands-off manner.

It is notable that DWE played a significant role in the public engagement process around AMD. It organised a series of public participation workshops with I&APs, identified through responses to newspaper articles and advertisements, site notices and referrals. These workshops did the most to encourage public information sharing during the process. Through the engagements, DWE collated EIA interest group concerns around the immediate and short-term interventions to AMD, up until the point at which the intervention was exempted of the EIA requirement. Public meetings were also arranged by TCTA and AECOM to discuss the exemption application. The responses from the public were varied and many used this as a platform to debate the legacy of mining without engaging the issue of the immediate threat which the exemption application served to avert.

The authorisation of the EIA exemption, because it effectively suspended ongoing public participation around the risks associated with measures to address AMD, left many stakeholders irate with the steps being taken by government. It played into sceptics' perception that government will follow their own decisions regardless of what the public says. It has indirectly created resistance to actions taken by government and, in turn, enthused a 'damned if we do, damned if we don't' approach to AMD mitigation by government.

Throughout the ten years of public debates, committee meetings, media coverage and political consultations around AMD, a number of public concerns have been raised. One key public concern has been around the escalation of budget estimates, which differed to those presented in the ToE and AECOM due diligence reports, as well as budget shortfalls reported in the media and further funding requests made by TCTA. To this day, there remains considerable uncertainty, with associated speculation, over how the taxpayer will absorb the long-term costs of managing AMD, including a possible water levy on Gauteng consumers.

Other public concerns surround the quality and quantity of potable water in Gauteng and the health of the VRS (Section 2.3). A number of alarmist media reports have documented the risks of AMD to the region's watercourses, especially with partially treated water being released in the VRS, potentially impacting potable water supply. What not all members of the public are aware of, is that the unregulated release of AMD into the VRS began in 2002, or even earlier, when decant was first noticed in the WB. The application for exemption from the immediate and short-term EIA was authorised in order to prevent the CB from decanting and contributing to an environmental catastrophe. This was on the assumption that the controlled release of partially treated water is better than the uncontrolled decant of acid water in both the WB and CB. In reality, neither of these situations is ideal and a more transparent process that allowed stakeholders to engage with government around these issues would have assisted with communication and enabled many questions from the public to be answered.

The GCRO's Quality of Life (QoL) survey has indicated that only 12.6% of individuals hear about what their municipalities are doing at public ward meetings. Respondents said that they would rather like to hear about what their municipalities are doing via newspapers, magazines, pamphlets and/or leaflets and on radio. While the QoL results are specific to municipalities, they are instructive to government more generally – increasing communication and transparency around AMD ideally ought to involve modes of communication preferred by the public.

A final note here is that various research groups and non-profit organisations have played a positive role in informing the public and scrutinising government actions to address AMD. Non-profit organisations such as FSE have a necessary role to play in providing a critical view of the current state of affairs, and keeping government on its toes in relation to questions of concern to the public.

'Bad news sells': the role of the media

The role of the media is to speak truth to power in the complicated governance issues facing South Africa (Ross, 1970). As the media speaks to society, it should inform citizens and enable them to make informed decisions on current issues (Ross, 1970). As bad news around AMD sells, reports on AMD, and its impacts, have often been exaggerated.

The media has released a number of sensationalised claims that have exaggerated aspects of the problem and unnecessarily incited public anxieties and fear. The limited amount of information provided by government around issues related to AMD has exacerbated this. The public has been left without a balanced and objective description of AMD and its effects on the environment and society, or of government efforts to manage AMD. For example, many members of the public are still unaware of the fact that there is currently no decant taking place in the WB and that construction began in the CB from as early as the beginning of 2013. A significantly greater information flow from government is required if the public is to develop an informed view unbiased by sensational media reports.

Of course, not all media reporting is the same quality. While many newspapers appear to keep up with the trends in AMD governance where they can, it was found during this research that more objective articles tend to be released by the Mail and Guardian, Mining Weekly, Business Day Live, Saturday Star and Beeld, to name a few.

4.2 Framing an environmental catastrophe

A number of concerns have been raised by stakeholders, NGOs and the public around the design and implementation of interventions to control AMD in the GCR. For example, the DWA's rejection of the WUC proposal in mid-2005, and its hasty uptake of recommendations made by the ToE, have raised questions around some aspects of government decision-making around AMD. This section considers this discourse, looking in particular at the implications of how the issue has been framed as an environmental emergency.

Responding to an environmental concern

The framing of an environmental issue, such as AMD, is essential for ensuring the mutual understanding of the problem (Bardwell, 1991). Environmental problems are typically ill-structured, with many paths worth exploring, and so it is very rare that there is one way of looking at a problem and solving it with a single solution (Bardwell, 1991). This raises the risks of dealing with environmental problems, especially because the chosen solution may have irreversible long-term outcomes (Bardwell, 1991). Bardwell's insights remind us that an environmental problem such as AMD – which needs to be managed in the real world – is complicated by ill-structured perceptions and divergent understandings, which have also changed over time as more information has become available.

Government's response to AMD has been mixed. It is fair to say that DWA took some early steps towards developing a long-term sustainable solution to AMD, notably through the issuing of a Section 19 directive to mines in March 2005 instructing them to reduce pollution at their own cost. This saw government taking a regulatory approach in holding mines accountable for environmental degradation, prompting mines to rehabilitate under South Africa's legislative framework (Figure 2.4). However, the potential threats associated with AMD appeared to escalate between 2005 and 2010, as, despite efforts made by WUC to formulate a sustainable long-term solution in liaison with DWA, their proposal was rejected on the grounds that it was an unsolicited bid. A critical tipping point was reached here: on the one hand, the problem escalated because nothing much was done between 2005 and 2010; on the other, in large part driven by media and interest group accusations that its response was delayed and inadequate (Winde et al., 2011), government's decisions and actions after 2010 could be regarded as a 'knee-jerk' reaction that too casually framed the AMD challenge as an environmental emergency, requiring exceptional departures from due process.

There is a clear dichotomy in the discourse around how government's response to AMD should be perceived. One view criticises government's actions around AMD as being under committed and lax, based principally on the perception that government delayed in acknowledging AMD as an environmental and social problem. The second response accuses government of taking hasty decisions around AMD in response to some scientists' opinion that AMD would affect the buildings in Johannesburg CBD, with dire implications for the GCR water supply and man-made infrastructure (Winde et al., 2011). This response is centred on the notion that the rejected WUC proposal has created a space for on-going commercial gain by the private sector through the continued ill-framing of AMD as an imminent catastrophe.

Narrowing the scope

The immediate and short-term intervention to address AMD has been criticised as being a narrow response to a large environmental concern. The narrow scope is said to have arisen from the very compilation of the experts as part of the ToE; the approach taken by the ToE in investigating AMD; and the short-sighted selection of the ECL as the basis for basin monitoring.

The first criticism contends that the experts selected to be part of the ToE were mainly from government-affiliated institutions, who may have limited their research scope according to mandates and funding when a broader and longer perspective was what was required. The second criticism is that the experts provided a very thin overview of scientific data available on the ECL of each basin, and predicated their projected dates of decant on unproven relationships between AMD and rainfall (Winde et al., 2011). The third critique is that the basis for choosing the ECL to gauge the rate of water rise in the basins has been refuted by various scientists and engineers, who argue that the ECL is not an effective measure of safe water levels in the mine basins given their shape and inter-connected form.

For some stakeholders and observers, the sum of these criticisms is that the ToE's conclusions were poorly informed and/or based on a misinterpretation of the available facts, leading to an exaggeration of the risks associated with AMD (Winde et al., 2011). As the recommendations of the ToE's report were primarily used to inform the emergency response taken by government, it arguably may have led to a narrowed approach to mitigating AMD.

Behind the perception that government has been led to take a short-sighted and narrow response to AMD are two key contentions. One is that it is not a given, as implied by the perceived need to pump water from the mine voids, that AMD will be an on-going problem that will require a continuous stream of money to mitigate. The argument here is that it is not possible to determine what will happen in the mine voids in future, especially after they fill to levels that existed prior to pumping in the first place, and that pumping may in fact be part of the problem. Given the current budget constraints and concerns over the fast-escalating cost estimates associated with AMD, this is a matter of some importance for the long term.

A second contention, less debatable, is that the short-term emergency response to AMD obscures a much broader set of water security issues at play. The salt loading of the VRS, as a result of AMD pumping and partial treatment, as well as other factors such as unregulated sewerage effluent flowing into the system, is a major concern with regards to Gauteng's potable water supply (DWA, 2012a). As noted earlier, in order to minimise the impacts of increased salt loading, excessive discharges from the Vaal Dam are required to dilute the water to an acceptable quality at and below the Vaal Barrage and downstream rivers (DWA, 2012a). This wider challenge is an immediate one, but which the long-term intervention is many years away from solving. By implementing immediate and short-term measures in such haste, some contend, government may have foreclosed the possibility of certain technological solutions that could have addressed the much bigger salt-loading problem, being implemented at the same time, and integrated with the short-term solution's chosen infrastructure and treatment technologies. Certainly the long-term solution will need to take into account the technologies that have been implemented as part of the short-term intervention, but certain technological options for a better long-term solution may not be viable as add-ons to what is already installed.

Taking a stepped approach

As with any environmental problem, many paths may be taken to intervene in AMD, with one solution not likely to completely address AMD in its first attempt. Taking a stepped approach to intervening in AMD may allow for proper research and monitoring and evaluation to take place and to provide a more informed basis for further interventions. Such an approach might well be interpreted as lax or sluggish by some stakeholders. However, with the necessary transparency between government, stakeholders and the public – especially through the sharing of all results from the various research exercises – a much better basis for a consensual approach to, and in turn improved governance of, a long-term sustainable solution to AMD could be laid.

4.3 Precedent-setting

Environmental management in South Africa is highly regulated, but the implementation of environmental laws and enforcement of environmental prohibitions is inconsistent (Diemont et al., 2012). The administration of environmental laws has been described as fragmented and dispersed with responsibilities divided among different government departments. This can result in the slow implementation of environmental protection or remediation measures, in turn leading to frustration and mistrust.

It could be argued that DWA and DEA, as well as other parts of government with roles to play, need to be exemplary in working together, and in following their own rules and procedures, so as not to give cause for frustration and mistrust, nor make decisions that set unfortunate precedents. There have been a number of points in the process where government has indeed felt compelled to make decisions that set worrying precedents.

The framing of AMD as an environmental emergency has narrowed the scope for public engagement and collaborative action around AMD. NEMA came into effect to provide for cooperative environmental governance. It established principles for decision-making on matters affecting the environment and established procedures and institutions, notably the EIA, to promote public participation in the management of the environment (Diemont et al., 2012). However, the process of developing an immediate and short-term solution to AMD was exempted from the NEMA requirement for a full EIA, thereby enabling government to disregard the need for full public and stakeholder participation as anticipated in the law. However justified the departure from normal procedures may have been, given the urgency of addressing imminent decant, this sets an unfortunate precedent.

The EIA exemption in the AMD process also feeds into a growing concern among some stakeholders around the cynical abuse of exemption applications under NEMA increasingly being used to side-step prosecution (in relation to which there is now a growing call for amendments to NEMA to disallow non-compliance).

In a letter written by Melissa Fourie, the Executive Director of the Centre for Environmental Rights, to the Chief Director of Legal Services at DEA on 12 May 2011, it was identified that Sections 24F and 24G of NEMA 1998 (Act 107 of 1998) are commonly used to bypass environmental prohibitions (Fourie, 2011). In a news article published by the Business Day Live (11 October 2012), it was reported that a total of 86 Section 24G applications were granted to transgressors who applied for authorisation after they had begun listed activities in the previous year and R8.3 million was paid in fines. This figure had risen from 58 applications reported in 2010/11 for which R127.6 million in fines had been paid (Blaine, 2012). It has been reported that repeat offenders get off too lightly, criminal fines are too low and there is a perception that prosecutors are less likely to prosecute contraventions of S24F and S24G (Fourie, 2011). This has allowed the exemption application to become a legal 'escape route' for offenders, and, through clever project budgeting, fines associated with bypassing the EIA processes are often planned for in advance (Fourie, 2011).

In the same light, the contraventions of NEMA 1998 in the AMD process has led some stakeholders to question the intentions of government and TCTA, and whether an escape route was sought as likely delays became more evident. In the communiqué sent by DWE on 23 October 2012, it was explained that TCTA and relevant authorities met over a period of time to discuss alternative processes that could be followed, and it was decided that not applying for a Section 24G would be untenable (DWE, 2012c). While it may well have been warranted, it has raised mistrust amongst some stakeholders, and arguably given those who would cynically abuse the exemption clauses further licence to do so. In other words, it may set a precedent that sees future contraventions of NEMA become more commonplace.

4.4 What exactly is Gauteng's water crisis?

Acid mine drainage is framed by a much broader debate around the challenges facing South Africa's water sector. Often referred to as South Africa's water crisis, the media has reported that infrastructure capacity concerns, a declining skills base, lack of efficiency, water wastages through infrastructure leaks, pollution, poor sewerage control and mine waste all contribute to these challenges (Mail and Guardian, 2014; SAPA, 2014; Groenewald, 2013; SABC, 2013; Bennett, 2009).

Reading deeper into the media articles, one can discern a layer of underlying politics around the management of South Africa's water resources. The media has offered certain water experts a voice to present their views in the public domain. Given the sensitivity and lack of publically available information on AMD, for example, objective and dispassionate discourse has often given way to a politicised debate in which it is difficult to know right from wrong. There is a deep sense of contestation around what exactly South Africa's water crisis is, and whether there really is one at all.

From as early as 2008, some water experts in South Africa have suggested that the country will face a water crisis (Turton, 2008). This is a result of the dilution capacity of natural streams being exceeded, the spatial development patterns of South African cities and the historic legacies that have created a trend toward disrespecting basic human rights (Turton, 2008). The solution to this crisis, these experts argue, is the provision of new infrastructure and the maintenance of old infrastructure. Recent water shortages – in the Eastern Cape, Free State, Mpumalanga, North West and Gauteng (Groenewald, 2013) – are said to be a result of poorly maintained infrastructure and vandalism (Infrastructure News and Service Delivery, 2014). In some cases, writers have put forward exaggerated versions of this view and argued that it is a sign of South Africa's failing democracy (Oneale, 2014).

On the converse, other leading water experts have suggested that we are not experiencing a water crisis, and challenges in the water sector are a result of not applying the basics of good water management (Mail and Guardian, 2014; Muller, 2011). Their position is in part informed by the perception that players who support the notion of a 'water crisis' will gain commercial value from promoting this idea in the media. They contend that there are a lot of invested interests in South Africa's water sector and, in particular, in AMD discourse, and in turn that the hype created around AMD itself is being fostered by key stakeholders with commercial interests in AMD (Muller, 2011), which has detracted from a need to give serious attention to broader water issues at play.

Conflicting views in the domain of political and academic debate have introduced twists and turns in AMD discourse. An example of this is the uncertainty around whether the buildings in the Johannesburg CBD will be flooded as a result of AMD decant. In 2007, it was reported by the media that the basements of buildings located in the Johannesburg CBD were already being affected by acidic seepage from the surrounding environment, with the water predicted to reach the surface during 2012 (Winde et al., 2011). In a study commissioned by the banks, Winde et al., (2011) named experts who made these sensationalised claims and further went on to falsify them. Winde et al., (2011) concluded that if government was to take a 'do nothing' approach to AMD, flooding would not take place. Other specialists have, however, argued that the report was a red herring merely aimed at boosting business confidence (Macleod, 2011). The initial allegations and subsequent counterarguments were played out in the media, illustrating the contrary political interests in this contested space.

While some may have a valid point that aspects of the AMD problem have been overplayed, the challenge posed by AMD remains real and live. The fact that DWA has framed the AMD long-term solution in terms of a broader water security concern and has meticulously taken action towards the setting up of treatment options based on cost and technology, says a lot about the potential effects of AMD on South Africa's water supply. Significant evidence suggests that the AMD decant that took place in the west Rand, and the release of pre-treated water into rivers, will continue to affect society and the environment (Tutu et al., 2008; Akcil & Koldas, 2006; Bell, et al., 2001; Rosner & van Schalkwyk, 2000). Local officials of the West Rand District Municipality suggest that the public is picking up the costs of AMD as well as the lasting effects of the immediate and short-term solution. Similarly, FSE, a non-profit organisation that has declared no commercial interest in AMD (Liefferink, 2010), continues to fight for communities that are affected by AMD and mine waste.

4.5 Financial Concerns

There is an emerging debate around the total costs of managing AMD that will weigh on the South African fiscus, now and in the future, and who will bear those costs and how. A response by Minister of Water and Sanitation, Nomvula Mokonyane, to a parliamentary question on 4 November 2014, attests to significant uncertainty in this regard. The question posed was: "With regards to the Auditor-General's estimated R30 billion that will be needed to clean up acid mine drainage in the existing abandoned mines, what progress is her department making in (a) West Rand and (b) other affected areas to clean up acid mine drainage". The Minister replied somewhat caustically: "In the absence of information which informed the Auditor-General's estimation of R30 billion required for Acid Mine Drainage remediation in abandoned mines, it is not possible for the Department to provide meaningful comment. However, the Department has estimated that an amount of R10 billion is required for Acid Mine Drainage mitigation in the Witwatersrand Gold Fields" (DWS, 2014a).

The Minister's figure of R10 billion roughly tallies with information offered by TCTA in a presentation to a Rand Water tariff consultation meeting on 22 October 2014. The presentation suggested that the full capital costs for the short-term solution at the point of completion would be R2.3 billion, and that for the long-term solution would be R7.9 billion (TCTA, 2014).

Given that the long-term solution is still in evolution, it is likely that the true total figure is impossible to establish accurately at this time. What is certain, however, is that the costs associated with AMD mitigation are large, even in the short term, and that there are significant shortfalls in the budget required to meet these expenses.

Embedded in the uncertainty over the true total costs of AMD mitigation, the extent of budget shortfalls for works in the process of being implemented, and how these shortfalls will be addressed, is an emerging contestation over who will carry the costs – for both infrastructure development and ongoing operations – of AMD mitigation measures. Up until now, the cost of various measures has been covered via the national fiscus, but this "every tax-payer pays" approach appears to be giving way to an alternative method that will see water users in the VRS pay more through water consumption tariffs.

In its presentation to the Rand Water tariff consultation session on 22 October 2014, TCTA highlighted an "Inter-Ministerial decision … that the Vaal River System tariff will be a contributor to the cost recovery of the AMD project" (TCTA, 2014). The VRS tariff is in effect the raw water price that the Rand Water Board must pay to DWS for what it abstracts for purification and distribution, as bulk water, mainly to municipalities. Municipalities in turn pay Rand Water a bulk water tariff. In turn, they recover this cost by selling water to domestic and business consumers, with local water tariffs set by each municipality annually. An increase in the raw water tariff has a knock-on effect, through the bulk water and then the municipal water tariffs, and ordinary consumers ultimately end up carrying the cost.

Concrete ideas around an AMD addition to the VRS tariff began to be presented and discussed, mostly off the public radar, from around mid-2014. In the second half of the year, various presentations at more open forums started to clarify the financial implications. In its October 2014 presentation to the Rand Water tariff consultation session, TCTA put up for discussion a proposed new R0,23 (or 23 cents) per cubic metre (m^3) AMD tariff to be added in to the mix of components that make up the total raw water tariff. Interestingly, this new tariff component was specified as only an operations and maintenance (O&M) tariff, and would be allocated to DWS. The capital component – called the Capital Unit Charge (CUC), which funds all of TCTA infrastructure developments in the VRS, including the two phases of the LHWP *and* AMD works – was projected to *decline* from R1.80/m^3 to R1.69/m^3. The decline was specifically to smooth the impact of the newly introduced AMD O&M component, and was feasible only through TCTA extending its debt repayment period for the first phase of the LHWP. The total raw water tariff thus increased by 8.77%, from R2.82/m^3 to R3.06/m^3.

While this may not seem drastic at first glance (although it does stand well above inflation), three things are worth noting. First, when carried through into the Rand Water bulk water tariff it has meant that Rand Water – also battling with other cost escalations such as the price of electricity – has put forward a 2015/16 tariff increase of 14,5%. Municipalities, and in turn ordinary residents, will therefore bear the brunt of a tariff hike roughly three times current inflation.

Second, the new R0.23/m^3 AMD O&M tariff is projected to increase to R0.29/m^3 in 2016/17 and then to R0.99/m^3 in 2017/18. This would represent a very dramatic increase of the current R3.06/m^3 raw water tariff.

Third, Rand Water has projected that, on the basis of the new R0.23/m^3 AMD tariff, it would be paying DWS approximately R1.1 billion in 2015/16 (Rand Water, 2014). This would cover the estimated current annual O&M expense of treating AMD of R990 million. However, especially in light of the reduction in the CUC component for 2015/16, it is as yet unclear how future adjustments to the VRS tariff structure will be made to also cater for the huge, and currently under-budgeted, capital costs. Presentations continue to refer rather vaguely to a mix of funding from the VRS tariff, PPPs, the fiscus, an environmental levy on mines, and sales of product from AMD.

In personal communications, municipal officials have responded heatedly to the imminent introduction of an AMD tariff, and its projected escalation. They argue that the rest of South Africa has benefitted considerably from mining in the GCR, and so it is unfair to expect Gauteng residents and business to alone pick up the costs of AMD. Intriguingly, the lines of this debate parallel those in the discourse around e-Tolls, with some arguing that a national fuel levy is the most appropriate alternative to the user-pays approach because Gauteng contributes disproportionately to the national economy.

Regardless of the exigencies around new tariff mechanisms to fund AMD treatment, or the merits on either side of an emerging debate over whether Gauteng residents should disproportionately carry the cost of mining's legacy, what is of concern is that very little information on these financial implications of AMD has flowed into the public domain. Presentations repeatedly refer to the need for more information to those affected. "Consultations must be finalised with VRS users to explain the tariff increment" or "Communicate with stakeholders" they say. Yet apart from a few presentations loaded onto websites, little to none of this had as yet occurred at the point at which this report was finalised.

4.6 Opportunities

Given the GCR's multi-billion Rand financial burden as a result of AMD, and a broader mining legacy (WWF, 2012), there is an emerging discourse around the possibilities of capitalising on perceived negatives of our mining legacy by turning liabilities into opportunities (Winde and Stoch, 2010). The treatment of AMD, the processing of mining waste, and post-mining land development opportunities may create revenues that offset some of the direct financial and indirect social and environmental costs inherited from mining.

As outlined in a paper written in 2010 by Winde and Stoch (2010), there are a myriad of opportunities associated with karst landscapes found in Gauteng. They suggest that post-mining development efforts should capitalise on the opportunities in karst landscapes for groundwater storage and harvesting in underground karst aquifers, underground hydropower generation, thermal energy generation and tourism (Winde and Stoch, 2010). Mining wasteland opportunities include the establishment of game reserves in areas that have sinkholes and the possibility of using wastelands to produce biofuels, taking pressure off land better suited for food production (Winde and Stoch, 2010). Mine voids could also be utilised as underground repositories for nuclear waste (Winde and Stoch, 2010) or to commercially store carbon dioxide from coal-based power stations (Winde and Stoch, 2010).

In response to research gaps outlined in the ToE's report, where a number of core research gaps were identified, there has been a broad uptake of opportunities to research possible technologies to overcome

AMD. Many of these technologies promise to provide a more holistic approach, as well as more cost efficient and effective processes to addressing AMD than the methods currently being applied for the short-term solution.

In 2012, partly as a way to deal with its large funding gap, DWA made a call to interested parties and service providers to propose short-term or long-term sustainable management solutions for AMD (DWA, 2012c). The DWA indicated that it was open to entering a commitment with the parties proposing solutions in terms of a Declaration on Protection of Information. The call was made for insights into the disposal of waste; details of treatment options or technologies; the design, construction, operation and maintenance of infrastructure for distribution and treatment of water and waste; the use of waste products; and financing (DWA, 2012c). Proposals could also be in respect of the protection of water resources and the environment from pollution; the removal of salts contributed by AMD to river systems in order to protect downstream water users and ensure security of supply; as well as the management and safe disposal of any by-products from the treatment of AMD (DWA, 2012c).

Although the results have not been announced, this call for proposals promised the opportunity to create more meaningful relationships between government, the private sector and community stakeholders.

Outside DWA's 2012 call, a number of private sector entities have moved on their own accord to develop technological solutions to AMD, which might offer long-term business opportunities. One such entity is Mine Restoration Investments (MRI), which registered on the JSE's AltX in June 2012. MRI see themselves as providing commercially viable options for overcoming AMD in the GCR in the long term (Walt, 2012). Watermark Global plc, the main shareholder of MRI, sold over WUC which had already invested R75m in researching technology to manage and treat AMD (McKay, 2012). Interestingly, MRI is also investing in other environmental cost solutions, such as the briquetting of coal fines (essentially fragments of coal smaller than 6mm which need to be compacted together to be used) (Walt, 2012). MRI is looking to develop off-take agreements with DWA. MRI CEO, Jaco Schoemann, believes that after the work the entity has done over the last six years, it is in the best place to provide a cost-effective solution to AMD. He envisages that were MRI to participate in tenders for the long-term solution, the entity would be able to mount the biggest rehabilitation project the country has ever seen (Walt, 2012).

A number of alternative technological solutions have been developed or are being researched. It is not possible to review all of these technologies in a report such as this, but a few are worth mentioning.

There is an interesting joint research initiative between the University of the Witwatersrand and the National Aeronautics and Space Administration (NASA). This collaborative research is investigating the possibility of purifying AMD with the use of a nanocomposite membrane that provides a win-win solution for industry and the environment. This technology makes the process of purifying water from waste easier and it can be used to treat waste associated with mining, oil, gas and nuclear exploration.

Mintails is a gold mining and ore processing company located on the West Rand region of SA's Witwatersrand Basin that is 'making the most of AMD'. In a media release in the Mining Mirror of October 2012, the company states that it has a key focus on the rehabilitation and improvement of the environment in which it operates and strives to make a new legacy by creating a better place for the people directly affected by its mining activities (Mining Mirror, 2012). By reclaiming redundant surface tailing facilities, Mintails restores the environment to internationally acceptable standards. The production of gold through the reclamation process funds the business, provides shareholders with investment values, and provides developmental opportunities to employees and community (Mintails, 2013). In illustration, the Mining Mirror piece reported that Mintails had purchased 100Mt of tailings with a rehabilitation and liabilities cost of almost R400 million. By centralising the mine residue and rehabilitating the footprint, Mintails aimed to reduce the final rehabilitation liability to less than R100 million.

Jan Jacobs, the general manager of Mintails, says that they may have started out as a tailings treatment company, but they have become a more encompassing mine closure company with a specific focus on improving the environment (Mintails, 2012). The company's vision is built around six core values: sustainable growth, environmental responsibility, profitable business, the development of opportunities and skills of employees, the creation of workplaces that are healthy and safe, and the creation of partnerships with the community (Mintails, 2013).

Companies like Mintails play an important role in reducing the likelihood that the costs of rehabilitating surface tailings may one day be shifted to the tax-payer (Mintails, 2012). As part of its current mining process, Mintails has developed a method of converting AMD-affected water into 'grey water' that can be used for industrial purposes. Mintails pumps roughly 15 million litres of AMD from the WB and uses it for its own mining production processes and deposits (Mintails, 2012).

Mintails sees its AMD operations as a way of changing the nature of the mining business by turning mine waste into a profitable venture that also enables effective mine closure and rehabilitation (Mintails, 2012). DWA has enquired into the feasibility of establishing a 40 million litre/day HDS treatment plant at an estimated cost of R50 million. The plant will convert AMD-affected water into industrial grey water at an estimated operational cost of R6/m3. Mintails responds that this is nearly as high as purchasing pure drinking water at R7/m3 (Mintails, 2012). The company says it can treat 40 million litres/day at approximately 40% less than this and, in the process, lower the level of the water void to the ECL and reach ore-bodies that are currently flooded, thereby accessing some 2 million ounces of minable gold resources.

While various private sector entities are experimenting with the possibilities around profitable AMD treatment ventures, it is also increasingly clear that the state itself cannot avoid seeing AMD as an opportunity to increase supply in the VRS. All the evidence indicates that partially treated but still highly saline AMD, discharged into the Vaal, will begin to have an impact on yield as early as 2015. Otherwise saleable water will need to be released in considerable quantities to dilute AMD-affected watercourses downstream of the Vaal Barrage. This will impact not only overall water security but also the price of water, as restrictions feed back as a need to recover a greater amount from each unit of water sold in order to meet debt obligations on the LHWP, as well as the need to bring forward planned augmentation schemes in order to boost supply.

In this context, full desalination of AMD through the immediate implementation of the long-term solution, and its sale to users in the VRS through off-take agreements, is an 'opportunity' that *must* be taken up by government itself. It represents the only way forward to avoid the massive reductions in yield that will result from having to dilute AMD, the short-term spike in capital costs from having to bring forward huge transfer schemes, and the associated tariff increases that inevitably follow from both of these eventualities. However, what remains unclear, and still far from open public debate, is the cost implications for residents and businesses in the GCR of government implementing this (long-term) desalination solution through the cost-recovery measures that are currently available – notably the raw water tariff for the VRS.

5. Conclusion

Mines have contributed favourably to the development of cities and towns across South Africa. One such example is Johannesburg, where vast amounts of wealth generated by gold mining led to dramatic development along the Witwatersrand or 'Rand'. This development has not always been a straightforward process, largely because Johannesburg was poorly situated in terms of natural resources, especially water. Fast growing settlements that flanked the Witwatersrand have been plagued by resource constraints from their early beginnings. Physical constraints associated with low grade ore, located far beneath the Earth's surface, contributed to an inherently unstable gold mining industry. These factors still impact the industry today.

It was first expected that Johannesburg would be no more than a temporary mining camp, and therefore many of the urban planning, infrastructure and environmental management issues faced by the fast growing settlement would not need to be properly dealt with. This tendency, together with the city's uncontrolled pursuit of material gain, has led it down a path of externalising costs at the expense of the environment and society. Though externalised, these environmental and social liabilities have been retained along the way. As gold mining reaches its twilight years along the Witwatersrand, the region is now beginning to experience and deal with the consequences of many years of unbounded mining activity and ill-enforced mining legislation. This has been inherited in the form of a mining waste legacy.

Acid Mine Drainage (AMD), a symptom of the Witwatersrand's retained mining liabilities, is not a new or unique phenomenon. AMD exists in a host of other mining settings around the world including Australia, Canada, United States of America and Germany (DWA, 2010). It is, however, particularly problematic along the Rand due to its geomorphology, location of AMD-generating deposits and climate (McCarthy, 2010). AMD has occurred along the Rand for many years prior to decant and it was controlled through pumping activities in each of the three basins. The discontinuation of pumping in the basins, and subsequent decant on the WB, has presented as an 'environmental emergency' that has become muddled in governance and political concerns. This is another reason why AMD has become particularly problematic along the Rand.

This paper straddles the GCRO's research focus on matters of government, governance and intergovernmental relations and its work on sustainability transitions. It is a follow up to McCarthy's 2010 Provocation on the analysis of, prognosis for and possible solutions to the decant of acid mine water in the GCR. Building on McCarthy's technical findings, this paper adds to the historical record of AMD by providing an objective overview of key events and actions taken by government, as well as a critical review of public discourse around AMD and its management to date. The factual information contained in this paper is aimed at clarifying grey areas that have arisen from alarmist news articles, and at documenting, more systematically, how AMD has been and should be positioned as a governance concern.

It has been shown in this paper that the DWA first took a regulatory approach to managing AMD, by holding mines accountable for environmental degradation and prompting them to rehabilitate under South Africa's legislative framework through the issuing of a Section 19 directive to mines in 2005. The potential threats associated with AMD appeared to escalate between 2005 and 2010, despite the efforts made by WUC to formulate a sustainable long-term solution through constant communication with DWA.

The proposal that was developed by the WUC was rejected on the grounds that it was an unsolicited bid and it was decided that government would intervene directly.

Since 2011, government has taken more direct action to manage AMD in the GCR. Action has been sequenced through an immediate and short-, and long-term solution. The immediate and short-term solution, which is focused on preventing decant, controlling ingress and partially treating water pumped from the mine void, has come on stream in the western and central basins. Construction in the eastern basin has commenced. The long-term solution, to be designed to address broader water concerns in the GCR, is currently being scoped. It will involve further treating water to address high salt loads so that is can be safely released into the VRS.

Informed by an evolving body of research, and new information distilled from commissioned reports, monitoring and evaluation studies and expert opinion, the understanding of AMD has evolved over time. Initially framed as an environmental catastrophe located in the west Rand, the real impacts of AMD in terms of its broader effects on the Gauteng water supply are now being realised. Focus has shifted from the proposed HDS technology as part of the immediate and short-term solution, mine void geohydrology, and environmental critical levels (ECL) (with associated concerns over where and when acidic water would rise to the surface, potentially affecting basements and underground infrastructures). More and more, the attention has begun to fall on AMD's impact on the overall hydrological system and its implications for water security in the GCR. This is the premise for DWS's long-term solution, which seeks to address broader water security concerns in the VRS, in part by focusing more directly on the complete and continual management of AMD.

To complete works as part of the immediate and short-term solution, government followed a strong technical approach to address AMD. Although it was certainly important to move with speed and technical proficiency in managing the threat of AMD decant, this paper has assembled evidence that the task of governing AMD is not exhausted simply by putting treatment plants and pipes in place. Addressing AMD also required a strong and consistent process of communicating with stakeholders and the wider public. This *governance component* of AMD management has been relatively weak.

During the early phases of government action to address AMD, the media released exaggerated, and sometimes sensationalised, claims about AMD that unnecessarily incited public anxiety. To some extent this occurred because, until 2012, there was very little information available from DWA, especially regarding the immediate and short-term solution. As part of the long-term solution, DWA did make an attempt at posting documents on a website dedicated to explaining the long-term intervention. However, documents on this website are now over a year and a half old, with the most recently posted document dating back to July 2013. Many key documents from the long-term feasibility study – that would help to deepen public awareness – are still embargoed. The public has therefore been left without a balanced and objective description of AMD and its effects on the environment and society.

The situation has been exacerbated by the poorly carved out roles of different spheres of government, which has created an inconsistent message from different parts of the state. This was most clearly played out at p*ublic meetings* before the contravention of NEMA 1998, which saw the bypassing of EIA requirements for the immediate and short-term solution and the suspension of public consultation processes. Here, contracted specialists ran the meetings and it was clear that officials representing local municipalities and ward councillors were no better informed than members of the general public. Since the EIA exemption there has been even less information on AMD in the public domain and very few opportunities for engagement with the public.

Better access to information, and the active involvement of the public and stakeholders, is a critical component of good governance, and fundamental to managing AMD as an environmental concern. Significantly greater information flows from government are required if the public is to have an informed view unbiased by sensational media reports. This requirement arguably becomes more, not less, pressing as the technical solutions of the short-term solution are fully activated and concerns of the long-term solution – in particular the restoration of water security in the VRS – loom larger.

As AMD is released into the hydrological system after being pre-treated using the HDS technology, the water quality of the VRS will be severely affected. Water in the system will be needed to dilute partially-treated AMD, and until the second phase of the LHWP comes online, predicted for 2023, the available yield in the VRS will contract dramatically. Water restrictions and steep price increases will be in store for residents and businesses in the GCR, unless the long-term solution can be implemented quickly. The debate over who will pay for this, why, and how, is not in the public domain.

The political economy question over who will pay and how, and the lack of platforms for appropriate and well-informed public deliberation, is equally a concern for the broader mining legacy that has been inherited by the city-region. AMD is merely a sub-set of a much larger array of mining-related liabilities. This legacy includes the some 6 152 ownerless and derelict mines and Mine Residue Areas (MRAs) that currently scatter the South African landscape and continue to pollute the soil, air and water. With rehabilitation costs estimated to be in excess of R30 billion (WWF, 20102), this wider waste legacy has profound implications for South Africa's economy and society, and the GCR in particular.

Mining is still seen as the primary driver of the South African economy, and the benefits of mining activity are regarded as superseding any negative effects on the environment. As many mines become more marginal, and profits contract, there is little incentive to do anything more than meet the minimum requirements contained in a loose assortment of laws and regulations. Government has certainly begun to pick up more responsibilities in this space. As described in the recent 2015 Estimates of National Expenditure, a fund will be dedicated to the rehabilitation of mines. However, this still represents a very small and slow start to addressing over a century of mine waste. Although some opportunities for profitable redevelopment of MRAs are becoming clearer, and some far sighted firms are beginning to experiment with new technologies and innovative business models, much more work needs to be done to create the necessary incentives for mines and government to collaborate in rehabilitating past sites of mining and to allow these spaces to be successfully re-purposed for future use. Just as McCarthy's 2010 Provocation concluded, there are still no clear answers on who will be liable for the costs of AMD, and beyond this the wider legacy of mine waste in the GCR.

6. References

- A.T. KEARNEY (2012). The Call for Clean Water. https://www.atkearney.com/documents/10192/9340f721-aac2-411c-905b-ca8f9bd15b78
- ADLER, R. A., CLAASSEN, M., GODFREY, L., & TURTON, A. R. (2007). Water, mining and waste: an historical economic perspective on conflict management in South Africa. The Economics of peace and Security Journal, 2:2, 32-41.
- AECOM, formerly known as BKS (2011). Witwatersrand Gold Fields: Acid Mine Drainage (Phase 1). Report prepared by BKS in August 2011. BKS report no. Jo1599/05. Centurion: Trans-Caledon Tunnel Authority.
- AECOM (2014). Environmental impact assessment for the construction of the proposed sludge disposal facility and pipeline associated with the treatment of acid mine drainage in the eastern basin of the Witwatersrand, Gauteng: final scoping report. Document prepared by Digby Wells Environmental in October 2014. Aurecon report no. AEC2588.
- AKCIL, A. & KOLDAS, S. (2006). Acid Mine Drainage (AMD): causes, treatment and case studies. Journal of Cleaner Production, 14(12-13), pp. 1139-1145.
- BAARTJES, N.L AND GOUDEN, K.G. (n.d.). Causes of Mine Decline in South Africa. EcoPartners. http://www.imhc.co.za/assets/pdf/papers/Declining%20Mining%20in%20SA%20Paper-Neale%20Baartjies.pdf
- BARDWELL, L. V. (1991). Problem-Framing: A perspective on Environmental Problem-Solving. Environmental Management, 15:5, 603-612.
- BEAVON, K. (2004). Johannesburg: the making and shaping of the city. Leiden, Koninklijke Brill.
- BELL, F. G., BULLOCK, S. E., HALBICH, T. F. & LINDSAY, P. (2001). Environmental impacts associated with an abandoned mine in the Witbank Coalfield, South Africa. International Journal of Coal Geology, 45(2-3), pp. 195-216.
- BENNETT, G. (2009). Water crisis is here. Johannesburg: Moneyweb.
- BERINGER, G. (2012). Manager of the Closure and Rehabilitation Department and EIA manager of the immediate and short-term EIA process. Research interview held on 26 October 2012.
- BLAINE, S. (2011). Acid mine drainage a 'binding constraint' on economy. Business Day Live. 15 February. http://www.bdlive.co.za/articles/2011/02/15/acid-mine-drainage-a-binding-constraint-on-economy;jsessionid=A4DC219673A49EB27BF9AF68CD7DDF6C.present2.bdfm
- BLAINE, S. (2012). Companies use environmental act to 'avoid prosecution'. Business Day Live, 11 October. http://www.bdlive.co.za/national/science/2012/10/11/companies-use-environment-act-to-avoid-prosecution.
- CHAMBER OF MINES (2013). Historical Summary. http://www.bullion.org.za/content/?pid=79&pagename=Historical+Summary
- CITY OF JOHANNESBURG (2015). Amendment of tariff charges for water services and sewerage and sanitation services. Environment and infrastructure services. City of Johannesburg Mayoral Committee. http://www.joburg.org.za/images/stories/2015/idp/Water/revisedwatertariffs19march2015.pdf
- COETZEE, H. (2008). Radiometric surveying in the vicinity of Witwatersrand gold mines. Proceedings of the Third International Seminar on Mine Closure, Johannesburg, South Africa. 14-17 October 2008, 617-626.

- COPANS, G. (2008). Companies join forces to address mining-related water pollution. Mining Weekly. 2 May 2013. http://miningweekly.com/article/companies-join-forces-to-address-miningrelated-water-pollution-2008-05-02
- CREAMER, T. (2012). TCTA warns of funding shortfall for acid water projects. Mining Weekly. 19 January. http://www.miningweekly.com/article/tcta-again-warns-of-funding-shortfall-for-acid-water-projects-2012-01-19.
- CRG (2011). Successful testing of submersible pumps. 27 July. http://investors.centralrandgold.com/phoenix.zhtml?c=215882&p=irol-newsArticle&ID=1589321&highlight=
- CRG (2012). Agreement reached with Trans Caledon Tunnel Authority. 27 November. http://www.sharenet.co.za/free/sens/disp_news.phtml?tdate=20121127090000&seq=12&scheme=default
- DE LANGE, J. (2011). Grootvlei left in ruins. Miningmx. 19 June. http://www.miningmx.com/opinion/columnists/Grootvlei-left-in-ruins.htm.
- DEA (2013). Application for environmental authorisation in terms of the national environmental management act, 1998: GN R.543: Immediate and short-term interventions for the treatment of acid mine drainage in the western, central and eastern basins of the Witwatersrand Gold Fields, Gauteng Province. Email to I&AP on 7th January. Pretoria: Department of Environmental Affairs
- DEAT (2005). NEMA Section 24G Guideline, Integrated Environmental management Guideline Series 2. Pretoria: Department of Environmental Affairs and Tourism.
- DIEMONT, M., RAPSON, G., & GILMOUR, K. (2012). Webber Wetzel Environmental Law, Chapter 20. http://www.webberwentzel.com/wwb/action/media/downloadFile?media_fileid=7582
- DMR (2010a). Progress on the Management and Rehabilitation of Derelict and ownerless mines. Presentation to the Parliamentary Select Committee on Finance. 12 October. Pretoria: Department of Mineral Resources. http://www.pmg.org.za/report/20101012-mining-charter-and-derelict-and-ownerless-mines-progress-report-depar
- DMR (2010b). Statement on Acid Mine Drainage: Inter-Ministerial Committee (IMC) meeting with the Team of Experts. Statement issued by Department of Mineral Resources. 15 December. Pretoria: Department of Mineral Resources.
- DNT (2011). Medium Term Budget Policy Statement. Vote 32: Mineral Resources. Pretoria: Department of National Treasury. Pretoria: Department of National Treasury. http://www.treasury.gov.za/documents/mtbps/2011/adjustments/Vote%2032%20Mineral%20Resource.pdf
- DNT (2012). Budget 2012 Estimates of National Expenditure. Vote 38: Water Affairs. Pretoria: Department of National Treasury, 22 February. http://www.treasury.gov.za/documents/national%20budget/2012/ene/FullENE.pdf
- DNT (2013). Budget Speech. Speech made by the Finance Minister of South Africa, Mr Pravin Gordhan. 27 February. http://cdn.bdlive.co.za/images/pdf/Budget2013.pdf.
- DNT (2015). Estimates of National Expenditure. http://www.treasury.gov.za/documents/national%20budget/2015/ene/FullENE.pdf.
- DRD GOLD LTD (2010). Sustainable Development Report 2010. http://www.drd.co.za/assets/sustainability/reports/2010/environmental.htm
- DRYE, W. (n.d.). El Dorado Legend Snared Sir Walter Raleigh. National Geographic. http://science.nationalgeographic.com/science/archaeology/el-dorado/
- DWA (n.d.). Acknowledgements. DWA website. https://www.dwaf.gov.za/Projects/AMDFSLTS/acknowledgements.aspx
- DWA (2010). Mine Water Management in the Witwatersrand Goldfields with specific emphasis on Acid Mine Drainage. Pretoria: Department of Water Affairs.

- DWA (2012a). Inception Report. Feasibility for a Long-Term Solutions to address the Acid Mine Drainage associated with the East, Central and West Rand Underground Mining Basins in the Gauteng Province. Pretoria: Department of Water Affairs. http://www.dwaf.gov.za/Projects/AMDFSLTS/Documents/Inception%20Report%20[final].pdf
- DWA (2012b). Feasibility Study for a Long Term Solution to address the Acid Mine Drainage associated with the East, Central and West Rand Underground Mining Basins in the Gauteng Province. AMD FS LTS Newsletter, 1st Edition, July 2012. Pretoria: Department of Water Affairs. http://www.dwa.gov.za/Projects/AMDFSLTS/Documents/AMD%20FS%20LTS_Newsletter%2001%20(Low%20Resolution%20-%204MB).pdf
- DWA (2012c). Invitation to those interested in proposing long-term solution for the management of Acid mine Drainage in the Witwatersrand. Pretoria: Department of Water Affairs. http://www.dwaf.gov.za/Projects/AMDFSLTS/RFI.aspx
- DWA (2012d). Treatment Technology Options. Feasibility for a Long-Term Solutions to address the Acid Mine Drainage associated with the East, Central and West Rand Underground Mining Basins in the Gauteng Province. http://www.dwaf.gov.za/projects/amdfslts/Documents/2013/Treatment%20Technology%20Options%20[Draft].pdf
- DWA (2012e). Communication Strategy and Action Plan. Feasibility for a Long-Term Solutions to address the Acid Mine Drainage associated with the East, Central and West Rand Underground Mining Basins in the Gauteng Province. https://www.dwaf.gov.za/Projects/AMDFSLTS/Documents/Report%209.1%20Communication%20Strategy%20and%20Action%20Plan%20Final%20Signed.pdf
- DWA (2013a). Extensions of feasibility study for completion on 31 July 2013. Feasibility study for a long-term solution to address the acid mine drainage (AMD) associated with the East, Central and West Rand underground mining basins in the Gauteng Province. Email to I&AP on 16th April. Pretoria: Department of Water Affairs.
- DWA (2013b). Feasibility Study for a Long Term Solution to address the Acid Mine Drainage associated with the East, Central and West Rand Underground Mining Basins in the Gauteng Province. AMD FS LTS Newsletter, Edition 3 – July 2013. Pretoria: Department of Water Affairs. https://www.dwaf.gov.za/Projects/AMDFSLTS/Documents/AMD-FS_Newsletter_Edition%203_High%20Res.pdf
- DWA (2014). Acid mine drainage – release of central basin's treated acid mine water. Media advisory. 9 May 2014. Pretoria: Department of Water Affairs. https://www.dwa.gov.za/Communications/PressReleases/2014/Acid%20Mine%20Drainage%20-%20Releasing%20of%20Central%20Basins%20Treated%20Acid%20Mine%20Water.pdf.
- DWAF (2005). Olifants/Doorn Water Management Area: Internal Strategic Perspective (Report P WMA 04/0000/00/0304). Pretoria: Department of Water Affairs and Forestry. http://www.dwaf.gov.za/Documents/Other/WMA/17/OlifantsDoornISPFeb05full.pdf
- DWE (2012a). AMD – Project – EIA Interest Group. Immediate and short-term Interventions in the Western, Central and Eastern Basins of the Witwatersrand Goldfields. 22 February 2012. http://www.amdshort.co.za/documents/EIA%20Interest%20Group%20Meeting.pdf
- DWE (2012b). Draft scoping report for the immediate and short-term interventions for the treatment of acid mine drainage (AMD) in the Western, Central and Eastern Basins of the Witwatersrand Gold Fields (DEA Ref #: 12/1220/2403). Document prepared by Digby Wells Environmental in June 2012 for project BKS1310.
- DWE (2012c). Environmental impact assessment for the short-term intervention for the treatment of acid mine drainage in the Witwatersrand Gold Fields: Delay of submission of the Final scoping report. Communique to I&APs. 23 October 2012. Johannesburg: Digby Wells Environmental.

- DWE (2012d). Final Scoping Report for the immediate and short-term interventions for the treatment of Acid Mine Drainage (AMD) in the Western, Central and Eastern Basins of the Witwatersrand Gold Fields. BKS1310, DEA REF # 12/1220/2403. Document prepared by Digby Wells Environmental in November 2012 for project BKS1310.
- DWS (2014a). Response of Minister Nomvula Mokonyane to question 403 in the National Assembly, 4 November 2014. https://www.dwa.gov.za/communications/Q&A/2014/NA%20403_ORAL.pdf
- DWS (2014b). Briefing note on Acid Mine Drainage and its implications to groundwater, rivers and dams, presentation 2. Portfolio committee on water and sanitation. http://pmg-assets.s3-website-eu-west-1.amazonaws.com/141105dwapart2.pdf
- EDUCATION AND TRAINING UNIT (ETU). (2013). The Three Spheres of Government. http://www.etu.org.za/toolbox/docs/govern/spheres.html
- ESTERHUIZEN, I. (2012). DRD Gold, TCTA agree on terms to tackle acid mine water. Engineering News. 7 December. http://www.engineeringnews.co.za/article/drdgold-tcta-agree-on-terms-to-tackle-acid-mine-water-2012-12-07
- FOURIE, M. (2011). Concerns about and suggestions for amendment of sections 24F and 24G of the National Environmental Management Act, 1998 (Act 107 of 1998). Letter to Linda Garlipp, chief director of legal services DEA. http://cer.org.za/wp-content/uploads/2011/08/CER-Submission-on-S24G-May-2011.pdf
- GCIS. (2011). Water Affairs in race against time to tackle AMD. 7 September. Government Communication and Information System. http://www.buanews.gov.za/rss/11/11090715551001
- GDACE (2008). Mining and Environmental Impact Guide. Johannesburg: Gauteng Department of Agriculture, Environment and Conservation
- GDARD (2012). Study on reclamation and rehabilitation of mine residue areas for development purposes: phase II (Strategy and Implementation Plan). Johannesburg: Gauteng Department of Agriculture and Rural Development.
- GEOTERRAIMAGE PTY LTD (GTI) (2009). Gauteng Land-Cover Dataset, 10m resolution. Version 5. South Africa: Pretoria.
- GEOTERRAIMAGE PTY LTD (GTI) (2012). Gauteng Urban Land-Cover Dataset, 2.5m resolution. Version 5. South Africa: Pretoria.
- GROENEWALD, Y. (2013). SA Faces water crisis. Johannesburg: City Press.
- HARTNADY, C. J. H. (2009). South Africa's gold production and reserves. South African Journal of Science, 105:1, 328 – 329.
- INFRASTRUCTURE NEWS AND SERVICE DELIVERY (2014). Could SA be facing a water crisis?. Johannesburg: Infrastructure News and Service Delivery.
- KAPLAN, L. V. (1985). The development of various aspects of the gold mining laws in South Africa from 1871 until 1967. PhD thesis: University of the Witwatersrand, Faculty of Law, Johannesburg.
- KEET, M. (2012). Mine Water Management, Acid Mine Drainage Challenges in the Witwatersrand. Are We in Track? – WISA Mine Water Symposium. http://www.ewisa.co.za/misc/CONFERENCESWISA/AMD_TreatmentTechnologiesSymp/PDF%20-%20session%201/3.Marius%20Keet%20Final_AMD%20WISA%20NOV%202012.pdf
- KHUMALO, N. (2011). The government will face legal action if it does not present an action plan to environmentalist about acid mine drainage within the coming week. Sowetan. 28 January 2011. http://www.sowetanlive.co.za/news/2011/01/28/acid-mine-ultimatum
- KINGS, S. (2013a). Gold Dust Cripples Riverlea. Mail and Guardian, 22 February 2013. http://mg.co.za/article/2013-02-22-00-gold-dust-cripples-riverlea

- KINGS, S. (2013b). Riverlea to Sue State Depts, DRD Gold over Poisonous Dust. Mail and Guardian, 25 April 2013. http://mg.co.za/article/2013-04-25-riverlea-to-sue-water-minerals-depts-drd-gold
- KRUGER, F. (2011). Funding for Mine Rehabilitation. Corporate Financial Solutions. http://corporatefinancialsolutions.co.za/MineRehabilitation.asp
- LEYDS, G.A. (1964). A history of Johannesburg, The early years, Cape Town, Nasionale Boekhandel Beperk BPK.
- LIEFFERINK, M. (2010). Response to Prof. Mike Muller's statement regarding the risks of acid mine drainage in Business Day. [Online] Available at: http://www.environment.co.za/poisoning-carcinogens-heavy-metals-mining/response-to-prof-mike-mullers-statement-regarding-the-risks-of-acid-mine-drainage-amd-in-business-day.html [Accessed 8 December 2014].
- MACLEOD, F. (2011). Acid mine report is a 'ruse'. Johannesburg: Mail and Guardian.
- MAIL AND GUARDIAN (2014). Water expert warns of crisis by 2020. Johannesburg: Mail and Guardian.
- MANUNGUFALA, T. E., SABITI-KALULE, M., & AUCAMP, I. (2005). Investigation into the slimes dams, mine dumps and landfills (residue deposits) as environmental constraints to low-cost housing projects in Gauteng, South Africa. World Congress on Housing: transforming housing environments through design – XXXIII IAHS.
- MARSDEN, D. D. (1986). The current limited impact of Witwatersrand gold-mine residues on water pollution in the Vaal River System. Journal of the South African Institute of Mining and Metallurgy, 86:12, 481-504.
- MASONDO, S., DU PLESSIS, C, McLEA, H, and SAPA. (2011). Rain brings acid mine spillage closer. Times LIVE. 17 January 2011. http://www.timeslive.co.za/local/article856813.ece/Rains-bring-acid-mine-spillage-closer
- MATJI, M. P. (2011). Acid mine drainage: funding and recommendations. Presentation to the parliamentary portfolio committee on water and environmental affairs. http://www.fse.org.za/Downloads/FSE%20WRITTEN%20SUBMISSION%20TO%20PPC.pdf
- McCARTHY, T. S. (2010). Decanting of acid mine water in the Gauteng City-Region. Johannesburg, GCRO.
- McCARTHY, T. S. (2011). Impact of acid mine drainage in South Africa. A Afr J Sci, 107:5/6, 1-7.
- McKAY, D. (2012). MRI in hunt for Water Affairs AMD tender. Miningmx. 25 June 2012. http://www.miningmx.com/news/markets/MRI%20in%20hunt%20for%20Water%20Affairs%20AMD%20tender.htm
- MINING MIRROR (2012). Making the Most of AMD, 25:4, 10-14. http://www.miningweekly.com/article/tcta-again-warns-of-funding-shortfall-for-acid-water-projects-2012-01-19
- MINTAILS (2012). Turning Mine Dumps into Gold. Mine tailings processor Mintails may have the answer to SA's acid mine drainage crisis. Mogale City: Mintails. http://www.mintails.co.za/images/stories/News/mintails_mining_prospectus.pdf
- MINTAILS (2013). Mintails Vision and Values. Mintails Website. Mogale City: Mintails http://www.mintails.co.za/about-mintails-limited/vision-and-values
- MULLER, M. (2011). Notes for Presentation on The Politics of water: a distorted discourse. Johannesburg: University of the Witwatersrand Department of Sociology and Harold Wolpe Open Dialogue Series, 5 May 2011. http://www.wolpetrust.org.za/dialogue2011/Microsoft%20Word%20-%20The%20Politics%20of%20Water%20%20a%20Distorted%20Discourse%20VF.pdf
- NEWS24 (2014). Mine drainage threatens sanctuary. Online news article, 1 November 2014. http://www.news24.com/SouthAfrica/News/Mine-drainage-threatens-sanctuary-20141101

- OCHIENG, G. M., SEANEGO, E. S., and NKWONTA, O. I. (2010). Impacts of mining on water resources in South Africa: A review. Scientific Research and Essays, 5 (22), pp 3351-3357
- ODENDAAL, N. (2012). TCTA signs R319m AMD agreement with Group Five. Mining Weekly. 10 December. http://www.miningweekly.com/article/tcta-signs-r319m-amd-agreement-with-group-five-2012-12-10
- ODENDAAL, N. (2013). Group Five starts work on TCTA AMD contract. Engineering News. 22 February. http://www.engineeringnews.co.za/article/group-five-starts-work-on-tcta-amd-contract-2013-02-22
- ONEALE, L. (2014). Water Crisis in South Africa Signals a Failing Democracy, Las Vegas: Liberty Voice.
- PAMPALLIS, (1991). Foundations of the New South Africa, Maskew Miller Longman, Cape Town.
- PMG (2011a). Acid Mine Drainage: hearings (day 2). Summary recorded on 21 June 2011. Parliamentary Monitoring Group.
- PMG (2011b). Acid Mine Drainage: hearings (day 3). Summary recorded on 22 June 2011. Parliamentary Monitoring Group.
- POTTA, A. (n.d.). Public Private Partnerships: Accelerate development in sub-Sahara Africa. Deloitte: Johannesburg. https://www.deloitte.com/assets/Dcom-SouthAfrica/Local%20Assets/Documents/PPPs%20accelerate%20development%20in%20sub-Sahara%20Africa.pdf
- PRINSLOO, L. (2009). Study confirms of planned acid mine drainage initiative. Mining Weekly. 20th November. http://www.miningweekly.com/article/definitive-feasibility-study-completed-for-amd-solution-2009-11-20
- RAND WATER (n.d.). Water quality and pollution FAQ: How does mining contribute to water pollution in South Africa? http://www.waterwise.co.za/site/water/faq/pollution.html#
- RAND WATER (2004). History of Rand Water. http://www.randwater.co.za/AboutUs/Pages/Background.aspx
- RAND WATER (2013). Core business activities. http://www.randwater.co.za/AboutUs/Pages/CoreBussiness.aspx
- RAND WATER (2014). Tariff Consultation Process. Presentation to the SALGA meeting on Water Tariff Increases in the Vaal River System. http://randwater.co.za/SalesAndCustomerServices/Tariffs/Forms/AllItems.aspx?RootFolder=%2fSalesAndCustomerServices%2fTariffs%2fTariff%20Consultation%20 2013-14&FolderCTID=0x01200019A67D709E6358468AB53F4444F04824
- ROSNER, T., & VAN SCHALKWYK. A. (2000). The environmental impact of gold mine tailings footprints in the Johannesburg Region, South Africa. Bull Eng Geol Env., 59, 137-148.
- ROSS, K. (1970). What is the role of media? IoL NEWS. 1 January. http://www.iol.co.za/news/south-africa/what-is-the-role-of-media-1.462078#.Uevzl9JsfSw
- SA NGO PULSE NET (2011). Civil society Organizations’ statement in regard to the Inter-ministerial Committee on Acid Mine Drainage (IMC) and the release of heavily polluted toxic acid mine drainage into our streams and rivers. 31 January. http://www.ngopulse.org/press-release/civil-society-organisations-statement-regard-inter-ministerial-committee-acid-mine-dra
- SABC (2013). Old infrastructure blamed for Eastern Cape water crisis. Johannesburg: SABC.
- SAPA (2014). Worst water crisis in 110 years. Johannesburg: News24.
- SCHERER, F. (2013). Mining Industry Struggling with Poor Public Image. Political Analysis South African, 12 February 2013.

- SCHOEMAN, J. (2011). Presentation to the Parliament Portfolio Committee on Water and Environmental Affairs on the Western, Central and Eastern Basin. Long Term Solution to AMD. 28 June.
- SLACK, K. (2013). Is sustainability just a sideshow at Africa mining conference? OXFAM. http://politicsofpoverty.oxfamamerica.org/tag/acid-mine-drainage/
- STRYDOM, B., AND McMEEKIN, D. (2011). Mining rehabilitation fund – what is they are no longer needed? Thoughts on Section 37A of the income Tax Act. Johannesburg: Bowman Gilfillan. http://www.bowman.co.za/News-Blog/Blog/ThoughtsonSection37AIncomeTaxAct
- SWART, E. (2003). The South African Legislative Framework for Mine Closure. Colloquium on Mine Closure for Sustainable Development, South African Institute of Mining and Metallurgy, Johannesburg
- TAU SA, (2011). South Africa's poisoned water. http://www.environment.co.za/acid-mine-drainage-amd/page/11
- TCTA (2011). AMD Witwatersrand Basin Due diligence Presentations. Presentation to Portfolio Committee. 7 September. Centurion: Trans-Caledon Tunnel Authority.
- TCTA (2012a). Management Report. Project management and implementation division. Centurion: Trans-Caledon Tunnel Authority
- TCTA (2012b). Invite to public meetings. AMD short-term intervention: exemption application. Email to I&APs on 16 November.
- TCTA (2012c). Motivation for exemption from the environmental impact assessment (EIA) regulations for the proposed short-term interventions. November 2012. http://www.amdshort.co.za/documents/Revised%20exemption%20application%20-%2021%20November%202012.pdf
- TCTA (2014). Proposed CUC and BO&R charges for inclusion in the bulk raw water charges for 2015/16. Rand Water Tariff Consultation Meeting. http://randwater.co.za/SalesAndCustomerServices/Tariffs/Forms/AllItems.aspx?RootFolder=%2fSalesAndCustomerServices%2fTariffs%2fTariff%20Consultation%202013-14&FolderCTID=0x01200019A67D709E6358468AB53F4444F04824
- TURTON, A. (2008). Three strategic water quality challenges that decision-makers need to know about and how the CSIR should respond. Pretoria, CSIR.
- TUTU, H., McCarthy, T.S., & CUKROWSKA, E. (2008). The chemical characteristics of acid mine drainage with particular reference to sources, distribution and remediation: The Witwatersrand Basin, South Africa as a case study. Applied Geochemistry, 23, 3666-3684.
- VAN ONSELEN, C. (1982). 1 New Babylon: Studies in the social and economic history of the Witwatersrand 1886 – 1914. Johannesburg: Ravan Press (Pty) Ltd.
- VAN SCHIE, K. (2012). Taxpayers lumped with R30bn bill to clean up derelict and ownerless mines. The Saturday Star. 16 AUGUST 2012. http://www.iol.co.za/the-star/taxpayers-lumped-with-r30bn-bill-to-clean-up-derelict-and-ownerless-mines-1.1363389#.Ubm3EudmiSp
- VAN WYK, J. J., RADEMEYER, J, M., AND VAN ROOYEN, J. A. (2010). Position Statement on the Vaal River System and Acid Mine Drainage. Pretoria: Department of Water Affairs. http://www.dwaf.gov.za/Projects/AMDFSLTS/Documents/Vaal%20River%20System%20&%20AMD%20Version%203.pdf
- WALT, M. (2012). Mine Restoration Investments lists in JSE's AltX. Mining Weekly, 25 June. http://www.miningweekly.com/article/mine-restoration-investments-lists-on-jses-altx-2012-06-25
- WATERMARK GLOBAL PLC (2011). About WaterMark Global PLC. http://www.watermarkglobalplc.com/company/index.htm
- WEPENER, V., VAN DYK, C., BERVOETS, L., O'BRIEN, G., COVACI, A., & CLOETE, Y. (2011). An assessment of the influence of Multiple Stressors on the Vaal River, South Africa. Physics and Chemistry of the Earth, 36:1, 949-962.

- WINDE, F. & STOCH, E. J. (2010). Threats and Opportunities for post-closure development in dolomitic gold-mining areas of the West Rand and Far West Rand (South Africa) – a hydraulic view. Part 2: Opportunities. Water SA, 36:1, 75-82.
- WINDE, F., STOCH, E. J., ERASMUS, E., AND SCHRADER, A. (2011). Desktop Assessment of the Risks for Basement Structures of Buildings of Standard Bank and ABSA in Central Johannesburg to be Affected by Rising Water Levels in the Central Basin (Vol. I of III). North- West University, Potchefstroom, May.
- WORDEN, N. (2012). The making of Modern South Africa: Conquest, Apartheid, Democracy (5th Edition), West Sussex: John Wiley & Sons Ltd.
- WUC (2008). Project Eutopia. Project Information Bulletin No 1. 27 October. Pretoria: Western Utilities Corporation.
- WUC (2010). Presentation made at the UASA Water Security Seminar. 26 March. Pretoria: Western Utilities Corporation. http://www.h2o4life.co.za/pdf/26-03-2010_AMD.pdf
- WUC (2011). Long term solution to AMD. Presentation to Parliament Portfolio Committee on Water and Environmental Affairs on the Western, Central and Eastern Basins. Presented on 28 June.
- WWF (2012). Financial Provisions for Rehabilitation and Closure in South African Mining. Discussion document of Challenges and Recommended Improvements (Summary). WWF-SA Report Series. Cape Town: World Wildlife Fund.

GCRO
(Gauteng City-Region Observatory)

4th Floor University Corner
11 Jorissen St (Cnr Jorissen and Jan Smuts)
Braamfontein
Johannesburg
Gauteng
South Africa
Tel +27 11 717 7280
Fax +27 11 717 7281

info@gcro.ac.za www.gcro.ac.za

Gauteng City-Region Observatory

UNIVERSITY OF JOHANNESBURG

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG