Development of a Web Enabled Mine Water Management Vulnerability Assessment Tool ($MINE_{WATER}$) to facilitate Resource Protection

Report to the
WATER RESEARCH COMMISSION

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WRC Report No 2451/1/18
ISBN 978-0-6392-0042-2

OCTOBER 2018

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Printed in the Republic of South Africa

EXECUTIVE SUMMARY

South Africa is a water scarce country, which requires the country to carefully use and conserve the little water it has. The two main contributors, through diffuse pollution, to water resources are mainly (1) mining-impacted water and (2) agriculture (sediment, nutrients, agro-chemicals and salinity through irrigation return flows) (Department of Water Affairs, 2013). Acid Mine Drainage has been reported in a number of areas within South Africa (including Witwatersrand Gold Fields, Mpumalanga and KwaZulu-Natal Coal Fields), and may continue long after mine closure, especially if the site has been abandoned, or waste piles and pits were not properly sealed (Council for Geoscience et al., 2010). Depending on the origin of the discharged water (e.g. run-off water, process water, etc.), consequences for the receiving water bodies vary significantly, comprising increasing sediment loads, as well as contamination with dissolved pollutants such as sulphates and heavy metals. The process of management of these impacts will therefore need to continue, with ongoing assessments and adaptation, as conditions change.

South Africa has developed policies, regulations and frameworks on the use and protection of natural resources. In addition to these, principles and guidelines have been developed to assist the mining industry and its regulators (including Department of Mineral Resources, Department of Water and Sanitation and local government in improving water use and management respectively. However, not all mines comply with the regulations and policies, hence acid mine drainage still has a major impact on the water resources of South Africa (Morgan, 2012).

Due to the above-mentioned challenges, this project was carried out with a broad objective of assisting the water and mining sectors in their attempts to protect water resources. This project aims to extend the principles and approaches mentioned, by developing a web-based mine water management vulnerability assessment tool. This tool can be used for self-assessment by the mining sector (and potentially as an audit tool by the Regulators, including the Department of Water and Sanitation and Department of Environmental Affairs to assist with improved mine water management and associated resource protection.

The first task carried out was to conduct a literature review in order to:

- Determine the current status quo of mining and mine water in South Africa.
- Determine the current international and South African mine water management practices.
- Identify key aspects to consider when determining mine water vulnerabilities.

In addition to conducting a literature review, relevant mining stakeholders' engagements were conducted to identify key requirements from each in order to incorporate these within the tool.

This was followed by the development of a draft spreadsheet-based mine water management vulnerability assessment tool based on the licence conditions, key stakeholder requirements and with practices from elsewhere as found in the literature. In addition to the vulnerability assessment tool being used as a self-assessment, the tool also seeks to facilitate and support the development of strategies and timely actions relating to measures that should be put in place to address mine water management challenges. The tool therefore aims to assist mines and stakeholders to identify critical areas requiring attention concerning mine water management.

The $MINE_{WATER}$ tool takes into consideration water management for new, operational and closing mines, and has ten categories that are assessed within a mine, namely:

- Planning
- Policies/Regulations/Best Practice
- Mining processes
- Water monitoring
- Waste management
- Human resources
- Infrastructure asset management
- Water conservation and demand management
- Finances
- Mine closure and rehabilitation

The areas of assessment have looked beyond just water management and includes all areas of concern. This aspect is seen as important to gain the interest of mine personnel as it aims to integrate regulation and compliance in one tool. The output indicates the area/s of vulnerability by category.

Consultations with selected mines were conducted and the draft tool was reviewed during the consultation. At the same time, users indicated a number of amendments which were incorporated into the tool. The final tool, both web-based and in excel format is accessible on the RiskQ website (www.riskq.co.za).

The aim of the project was to produce the guide: *"Development of a web enabled mine water management vulnerability assessment tool to facilitate resource protection"* with the aim to assist mines and stakeholders to identify critical areas requiring attention concerning mine water management. Software tools to determine the mine water management vulnerability associated with mines were also developed which are discussed in this document.

ACKNOWLEDGEMENTS

The following organisations and individuals are thanked for their contributions to this project:

Financial Support
Water Research Commission

Reference Group
The reference group responsible for this project consisted of the following persons:

- Dr J Burgess Water Research Commission
- Dr B Delcarme Cape Peninsula University of Technology
- Mr O Malete Kimopax
- Ms Lee Boyd Golder Associates
- Mr Stanford Macevele Department of Water and Sanitation

Participating Mines
The following mines are thanked for their willingness to participate and enthusiastic support in piloting the draft mine water management vulnerability assessment tool within their mines:

- Anglo American 1 – Platinum
- AngloGold
- Exxaro

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LIST OF ABBREVIATIONS

AMD	Acid Mine Drainage
DEA	Department of Environmental Affairs
DMR	Department of Mineral Resources
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
EMP	Environmental Management Programme
WC/WDM	Water Conservation and Water Demand Management

DEFINITION OF TERMS

- **Acid mine drainage (AMD):** occurs when sulphide-bearing rock reacts with air and/or water, producing acidic waters containing dissolved metals that may drain as runoff into water bodies.
- **Mine rehabilitation:** Modern mine rehabilitation aims to minimize and mitigate the environmental effects of mining.
- **Mine water:** water that enters the mined ground which is likely to undergo physicochemical changes due to mining operations.
- **Mine:** an opening or excavation in the ground for the purpose of extracting minerals.
- **Mineral deposit:** An occurrence of any valuable commodity or mineral that is of a sufficient size and grade (concentration) to have potential for economic development under favourable conditions.
- **Mining:** the process of extracting useful minerals from the earth's crust.
- **Monitoring:** the periodic or continuous surveillance or testing to determine the level of compliance with process or statutory requirements in various media or in humans, plants, and animals.
- **Ore:** The naturally occurring material from which a mineral or minerals of economic value can be extracted profitably or to satisfy social or political objectives.
- **Overburden:** material of any nature, consolidated or unconsolidated, that overlies a deposit of useful and minable materials or ores, especially those deposits that are mined from the surface by open cuts or pits.
- **Ownerless and derelict mines** (sometimes called abandoned mines)**:** excavations, structures, or equipment remaining from a former mining operation that, for all practical purposes, have been deserted while no intent of further mining is evident.
- **Pollutant:** any organic substance, inorganic substance, a combination of organic and inorganic substances, a pathogenic organism, or heat that, when introduced into the environment, adversely impacts the usefulness of a resource.
- **Prospecting:** the physical search for minerals, fossils, precious metals, or mineral specimens.
- **Reclamation:** rehabilitation or return of disturbed land to productive uses; includes all activities of spoil movement, grading, and seeding; and the return of productivity equal to or exceeding that prior to its being disturbed.
- **Tailings:** the residue of an ore that remains after it has been processed and the desired mineral has been extracted.
- **Waste:** the material associated with an ore deposit that must be mined to get at the ore and must then be discarded.

1. PROJECT BACKGROUND

1.1 Introduction

The issue of resource pollution in South Africa is important because the country has a water scarcity, which requires the country to carefully use and conserve the little water it has available. The two main contributors, through diffuse pollution, to water resources are (1) mining-impacted water and (2) agriculture (sediment, nutrients, agro-chemicals and salinity through irrigation return flows) (Department of Water Affairs, 2013). Acid Mine Drainage has been reported in a number of areas within South Africa (including Witwatersrand Gold Fields, Mpumalanga and KwaZulu-Natal Coal Fields), and may continue long after mine closure, especially if the site has been abandoned, or waste piles and pits were not properly sealed (Council for Geoscience et al., 2010). Sources of diffuse release of possibly polluted water within a mine include run-off from contaminated surfaces such as slimes dams, rock dumps, high-grade ore piles, metallurgical plants, seepage from unlined return-water dams, leakages from broken canals, pipelines, spillages from recovery plants, etc. (Coetzee, 2006). Depending on the origin of the discharged water (e.g. run off water, process water, etc.), consequences for the receiving water bodies vary significantly, comprising increasing sediment loads, as well as contamination with dissolved pollutants such as sulphates and metals. The process of management of these impacts will therefore need to continue, with ongoing assessments and adaptation, as conditions change.

South Africa has developed policies, regulations and frameworks on the use and protection of natural resources such as National Water Act (1998) and Department of Water Affairs (2013). In addition to these, principles and guidelines (such as the South African Best Practice Guidelines (Department of Water Affairs and Forestry, 2008)) were developed to assist the mining industry and its Regulators (including Department of Mineral Resources (DMR), Department of Water and Sanitation (DWS) and local government) in improving water use and management. However, not all mines comply with the regulations and policies, hence AMD still has a major impact on the water resources of South Africa (Morgan, 2012).

Due to the above mentioned challenges, this project emanated, with a broad objective of assisting the water and mining sectors in their attempts to protect water resources. This project aims to extend the principles and approaches mentioned, by developing a web-based mine water management vulnerability assessment tool. This tool can be used for self-assessment by the mining sector (and potentially as an audit tool by the Regulator) to assist with improved mine water management and associated resource protection.

The products from this project include:

1. A web-based mine water management vulnerability assessment tool (where an excel-based tool will also be accessible)
2. A guideline document on how to use the mine water management vulnerability assessment tool

The final guideline document contains two sections:

1. Section 1 – Tool principles
2. Section 2 – How to use the tool

1.2 Project Aims

The aims of the project are to:

- Develop a web-based mine water management vulnerability assessment tool to determine areas of vulnerability and adherence to water use licence requirements.
- Support improved efficiency and effectiveness in mine water management.
- Conduct workshops to train users in the use of the tools.

1.3 Project Methodology

It is envisioned that the above aims will be satisfied through completion of the following tasks:

a. Conduct a literature review which includes: (i) review of current international and South African mine water vulnerability/risk assessment and management practices and (ii) overview of the current status quo of mine water management in South Africa. The literature review will include consideration of legislative compliance requirements, typical water use licence requirements, management approaches and procedures followed, monitoring and management systems utilised and current best practices.
b. Capture an updated understanding and insight of specific sector needs, and use this to define mine water vulnerability assessment tool components and required tool functionality.
c. Collate required features/functions for subsequent tool development.
d. Conduct consultative engagements with different relevant stakeholders to get guidance on the aspects to include within the tool.
e. Based on the findings from previous tasks, develop a draft spreadsheet-based vulnerability assessment tool and associated priority action plan. This will be used as proof of concept to gather further insights during the piloting stage (and prior to any required web development).
f. Pilot draft spreadsheet-based tool selected mines (e.g. at typical mine types including Gold, Platinum, Coal-mines).
g. Refine the draft spreadsheet-based tool with inputs from the pilots.
h. Conduct workshops in selected regions (e.g. Gauteng, Mpumalanga and North West).
i. Based on feedback from workshops, further refine the spreadsheet-based tool
j. Perform final round of tool amendments.
k. Develop web-enabled mine water management vulnerability assessment tool.
l. Develop a guideline document that describes how to use the developed tool.

2. LITERATURE REVIEW

The first task for the project was to conduct literature review which included:

(i) review of current international and South African mine water vulnerability/risk assessment and management practices and

(ii) overview of the current status quo of mine water management in South Africa.

(iii) consideration of legislative compliance requirements, typical water use licence requirements, management approaches and procedures followed, monitoring and management systems utilised and current best practices.

These literature review aspects are presented below.

2.1 Mine Water Management in South Africa

2.1.1 Introduction

In South Africa, mines are classified according to the potential impacts that the mining activity may have on water resources as discussed below (DWAF, 2008:A5):

Category A: Any mine with a potentially significant and/or permanent impact on water quality. All gold and coal mines, irrespective of size. Any kind of extractive metallurgical process, including heap leaching. This includes most other precious and base metal mines. Any mine where sulphide-producing or other acid-generating material occurs in the mineral deposit.

Category B: Mines with potentially significant and/or permanent impact only on non-water quality aspects of the water environment, such as yield or availability of water, dynamics of the river, riparian uses, etc.

Category C: All other mines not covered by A and B. This includes big mines with no significant impact on the water environment and small-or low-impact mines and prospecting operations.

2.1.2 Mining stages and associated water use

Mines use large amounts of water for processing, transporting and cooling. This water is abstracted from different water resources such as dams, rivers and streams. Water is used at different operational stages of mining which are associated with different types of environmental impacts, however differ according to the intensity of each stage. Below are the different operational stages of a mining project and each stage is associated with different environmental impacts.

- **Exploration:** includes information about the location and value of the mined mineral/material. Application of EIAs, field studies, surveys may also be included in this stage.
- **Development:** this is where the planning of the development of the mine is conducted. Planning is done following the findings from the exploration stage that prove that there is sufficient mineral of acceptable grade.
- **Active mining:** this is where the mined material is extracted and processed.
- **Disposal of waste rock:** ore is normally buried under a layer of soil or rocks (called overburden) that should be removed to allow access to the ore deposit. The removed overburden should be disposed as waste. The process of separating ore and non-mined material is called beneficiation. The beneficiation process generates waste which is a combination of ore and non-mined

material called tailings. All this waste (overburden and tailings) should be disposed of in an environmentally acceptable manner.

- **Site reclamation and closure:** this is a stage where mining is no longer taking place and the site is returned to the condition that most resembles the pre-mining condition.

The table below illustrates the different stages of mining and their possible water usage and impacts.

Table 1: Mining stages water use and potential impacts of each stage to the environment (adapted from Miranda et al., 2010; DWAF, 2006).

Stage	Activity/ water use	Potential impact to water resources
Exploring	• Drilling/trenching • Trench blasting • Exploration camp development Road construction	• Runoff of sediments/ increased suspended sediment load to surface water • Increased demand for local water resources • Spills of fuels and other contaminants
Development	• Mine construction (vegetation removal, stripping of soils) • Mine infrastructure development (power lines, roads, etc.)	• Toxicity impacts to organisms (terrestrial and aquatic plants and animals) • Increased demand for water resources • Increased erosion and siltation • Altered patterns of drainage and runoff
Active mining	• Construction of plants, offices, buildings • Blasting to release ores	• Chemical contamination of surface and ground waters • Increased demand for water resources
Disposal of waste rock	• Milling/grinding of ore • Chemical leaching/concentration of ore • Smelting/refining of ore	• Discharge of chemicals and other wastes to surface waters • Emissions of sulphur dioxide and heavy metals
Mine closure/ Post Operation	• Reseeding/re-vegetation • Re-contouring waste piles/ pit walls	• Persistent contaminants in surface and groundwater • Expensive, long-term water treatment • Persistent toxicity to organisms • Loss of original vegetation/biodiversity • Abandoned pits/shafts that pose hazards and health risks to humans • Abandoned pits and shafts are likely to cause acid mining drainage • Erosion sediment in river • Changing groundwater flow patterns post mining affects area negatively

2.2 Mining impacts

2.2.1 Potential sources of pollution in a mine

The potential causes/sources of pollution depend on the specific mining operation, the type of mineral processing and beneficiation and also any other associated activities. Potential causes of mine water include:

- **Waste rock**: rock that is deemed unsuitable for processing is usually piled up near the open pit and if left uncovered, may be a source of acid drainage.
- **Ore stockpiles**: piles of material containing lower quantities of the target metal are usually stockpiled for future processing and may be a source of acid rock drainage if left uncovered.
- **Pit walls**: an increased surface area of potentially sulphide-bearing rock can be exposed through construction of an open pit, creating additional opportunities for acid drainage.
- **Tailings impoundments**: tailings from the mining processing stage are typically pumped as a thick sludge to a large impoundment. Depending upon the moisture content of the tailings and waste management practices, toxic materials can leach into groundwater. In addition, major storm events can mobilize tailings, rupturing the dam and causing toxic releases into nearby streams.
- **Tailings pipes**: in some cases, mines may release contaminated water in a controlled or uncontrolled manner into nearby streams.
- **Abandoned pits and mine workings**: mine drainage may continue long after mine closure, especially if the site was abandoned, or waste piles and pits were not properly sealed.
- **Acid mine drainage**: which happens when a mined material become exposed to oxygen, rain and mine water (water found in mined ground) during the mining process. This leads to the formation of acid if iron sulphide minerals (e.g. pyrite) are abundant and there is an insufficient amount of neutralising material to counteract the acid formation. The acidic water formed leaches and dissolves metals and other contaminants from mined material to form an acid concentrated solution. This acidic solution may runoff into streams, rivers, groundwater sources and the surrounding environment causing pollution.
- **Metal contamination and leaching:** which is caused when metals such as arsenic, cobalt, copper, cadmium, lead, silver and zinc contained in excavated rock or exposed in an underground mine come in contact with water. Metals are leached out and carried downstream as water washes over the rock surface. Although metals can become mobile in neutral pH conditions, leaching is particularly accelerated in the low pH conditions, such as those created by acid mine drainage.

  Even in very small amounts, metals can be toxic to humans and wildlife. Metals can travel for great distances, contaminating streams and groundwater. Metals are particularly problematic because they do not break down in the environment. They settle to the bottom and persist in the stream for long periods of time, providing a long-term source of contamination to the aquatic plants and insects that live there, and the fish that feed on them (Cloete et al., 2010).
- **Wet tailing impoundments:** the impacts of wet tailings impoundments on water quality can be severe. These impacts include contamination of surface waters and groundwater beneath these facilities. Toxic substances can leach from these facilities, percolate through the ground and contaminate groundwater, especially if the bottom of these facilities is not fitted with an impermeable liner. Tailings are a high volume waste that can contain harmful quantities of toxic

substances, including arsenic, lead, cadmium, chromium, nickel, and cyanide (Cloete et al., 2010). Although it is rarely the environmentally-preferred option, most mining companies dispose of tailings by mixing them with water to form slurry and disposing of the slurry behind a tall dam in a large wet tailings impoundment.

Ultimately, tailing ponds will either dry out in arid climates, or may release contaminated water in wet climates. In both cases specific management techniques are required to close these waste repositories and reduce environmental threats. During periods of heavy rain, more water may enter a tailings impoundment than it has the capacity to contain, necessitating the release of tailings impoundment effluent. The release of this effluent can seriously degrade the water quality of surrounding rivers and streams, especially if the effluent is not treated prior to discharge (World Bank, 2007).

- **Erosion and sedimentation:** mineral development disturbs soil and rock in the course of constructing and maintaining roads, open pits, and waste impoundments. In the absence of adequate prevention and control strategies, erosion of the exposed earth may carry substantial amounts of sediment into streams, rivers and lakes. Excessive sediment can clog riverbeds and smother watershed vegetation, wildlife habitat and aquatic organisms. In surface waters, elevated concentrations of particulate matter in the water column can produce both chronic and acute toxic effects in fish (World Bank, 2007).

  Minerals associated with deposited sediments may depress the pH of surface runoff thereby mobilising heavy metals that can infiltrate into the surrounding subsoil or can be carried away to nearby surface waters. The associated impacts could include substantial pH depression or metals loading to surface waters and/or persistent contamination of ground water sources (World Bank, 2007).

- **Abandoned mines:**
  Case study adopted from (Frost and Sullivan, 2011) states:

The Krugersdorp Game Reserve (KGR) has been experiencing excessive water pollution due to uncontrolled discharge of contaminated water (or decant) from some abandoned mines within its catchment area. This has resulted in a drastic increase in the animal mortality and aquatic life of the reserve. Despite close attention being paid to such problems, little has been done in trying to find lasting solutions. The animal health problem manifested soon after decant began from two mining companies with water treatment plants near Krugersdorp. Despite neutralising the acidity, the treated water still has higher than normal metal concentration and it flows into the Tweelopiespruit just before the KGR through a hole in the ground called “Buks se Gat”. In the reserve, the water has filled a once dry dam. Though treated, the water is still murky brown and turns plant life orange, a result of high iron and manganese levels.

2.2.2 Potential impacts of mine water to the environment

The release of mining waste to the environment may result in the permanent destruction of ecosystems. In many cases, the polluted sites may never be fully restored, for pollution is so persistent that there is no available remedy (Oelofse, 2008). While regulators and mine managers recognize the importance of minimising water use and containing mine wastes, water contamination remains one of the most common environmental impacts associated with mining (DEAT, 2008).

- **Impact of mine water to the catchment yield**

In mining, activities that occur in different stages of operation such as exploration and site preparation as indicated in Table 1 above, has a detrimental impact on the yield of the catchment. The activities could include:

  - Construction of paved areas, buildings, haulage roads, etc. This activity increases the surface runoff generated.
  - Large areas covered by tailings dams, slurry ponds, waste discard dumps, etc., may be isolated from the natural drainage paths due to the interception and collection of polluted water.
  - Unrehabilitated open cast areas are permeable and generate virtually no runoff. The seepage generated by rainfall onto unrehabilitated spoils is typically polluted and cannot be discharged to the natural streams thus further decreasing the natural runoff.

The higher the concentration of pollutants in water, the more the reduction of catchment yield.

Groundwater modification may also lead to the reduction of catchment yield specifically under the natural base flow. The discharge may result in:

  - Lowering of the ground water table in a region, which may decrease the hydraulic gradient driving the discharge of groundwater.
  - Modification to ground water aquifers, such as in the case of a deep opencast pit may result in a reversal of flow direction into the pit and away from the natural surface stream.

- **Impact of mine water to surface water quality**

Potential mining impacts on surface water quality depend on the specific mining operation and the type of mineral processed. The potential mine water pollutant sources to surface water include:

  - Mine dewatering.
  - Runoff and seepage from ore stockpiles.
  - Runoff and seepage from tailings dams and return water dams.
  - Runoff and washwater from vehicle parking platforms and workshops.
  - Spillage and runoff from ore processing plant.
  - Spillage from vehicle refuelling bays.
  - Seepage and runoff from waste rock dumps.
  - Sewage treatment plant effluent and seepage from sewage sludge drying beds.

- **Impact of mine water to groundwater bodies and groundwater quality**

Mining may impact ground water in a number of ways including:

  - Dewatering, which may result in the drawdown of the ground water body.
  - Subsidence, depression and sinkholes may also affect the groundwater bodies.

- Recharge of ground water from waste tailing dumps and polluted seepage which may migrate to the groundwater.

DEAT, 2008 indicated that the study conducted in 2003 revealed that the groundwater in the mining district of Johannesburg, South Africa, is heavily contaminated and acidified as a result of oxidation of pyrite contained in the mine tailings dumps, and has elevated concentrations of heavy metals. Where the groundwater table is close to the surface, the upper 20 cm of soil profiles are severely contaminated by heavy metals due to capillary rise and evaporation of the groundwater. The contaminated ground water was said to be discharging in streams in the area and the effect was estimated to persist beyond 10 km from the source.

- **Impact of mine water to sensitive water habitats**

The potential impact of mining on sensitive water habitats including marshes, wetlands, reed beds and pans requires special attention (Van Niekerk, 1993). Natural wetland is known for a number of ecological functions, such as, capture of sediment and silt load from the upstream catchment, attenuation of floods, stabilisation of the base flow in downstream rivers, etc. However mining activities compromise the full functioning of the wetland by the altering of the geomorphology of the wetland due to the discharge of waste material which settles in the wetland, and the discharge of pollutants, such as soluble heavy metals coupled to excess acidity (Van Niekerk, 1993), for which a natural wetland has limited assimilative capacity.

- **Impact of mining to water quantity**

Mining requires significant volumes of water, especially in the extraction and processing phases. For example, on average it takes 716 cubic meters of water to produce a tonne of gold (Miranda et al., 2010). Most water at the mine site is used to grind and separate minerals from host rocks, to wash and transport materials, to control dust, and to cool drilling machinery.

Mining can deplete surface and groundwater supplies. Groundwater withdrawals may damage or destroy streamside habitat many miles from the actual mine site. Large scale underground mining requires extensive surface infrastructure. Degradation of vegetation in surrounding catchments, the creation of large impermeable areas and concentrated run-off in stormwater systems leads to highly modified flood responses in small catchments that can threaten channels, habitats and infrastructure downstream.

3. SOUTH AFRICAN AND INTERNATIONAL KEY WATER AND ENVIRONMENTAL REGULATIONS/POLICIES/STRATEGIES

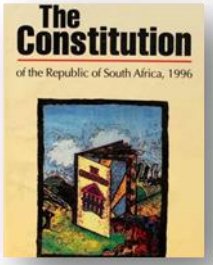
South African

3.1 Introduction

South Africa is a water scarce country, which drives the need for the country to use and conserve the little water it has. South Africa has developed policies, regulations and frameworks on the use and protection of this natural resource. Mining adversely affects water quality as explained above and poses a significant risk to water resources.

Mines have to comply with South African constitutional and common law by conducting their operational and closure activities with due diligence and care for the rights of others. The government has the role of being a guardian which acts as a responsible mechanism in ensuring a safe and healthy environment for South African citizens at large. Hence the State has developed a number of regulations and policies to manage environmental risks from mining. The following are summarised water and environmental related regulations relating to mining.

3.2 Constitution of the Republic of South Africa (Act 108 of 1996)



Following the change of government in 1994, a new constitution (Act 108 of 1996) was adopted where the government addressed protection of all the natural resources. The Constitution of South Africa compels all to ensure the rights of South African citizens. Section 24 of the constitution provides that everyone has the right:

- to an environment that is not harmful to their health or well-being;
- to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that,
    - prevent pollution and ecological degradation;
    - promote conservation; and
    - secure ecologically sustainable development and the use of natural resources while promoting justifiable economic and social development.

3.3 National Water Act (NWA) (No. 36 of 1998)

The purpose of the National Water Act (Act 36 of 1998) (NWA) is to ensure that the nation's water resources are protected, used, developed, conserved, managed and controlled. Emphasis of effective management of South Africa's water resources is through the basic principles of Integrated Water Resources Management that seeks to achieve social equity, economic efficiency and ecosystem sustainability. The guiding principles recognise the basic human needs of present and future generations which include:

- the need to protect water resources,
- the need to share some resources with other countries,
- the need to promote social and economic development through the use of water and
- the need to establish suitable institutions in order to achieve the purpose of the Act.

It obliges any user of water to avoid/minimize pollution of water resources and stipulates that water use authorizations must be obtained for all water uses. The use of water for mining activities is controlled by the National Water Act. Water use in terms of section 21 of NWA of 1998 includes:

- Taking water from a resource to use it
- The storing of water
- Impeding or diverting the flow of water in a watercourse
- Activities that reduce stream flow
- Waste discharges and disposals
- Alteration of the watercourse
- Removal of groundwater
- Using water for recreational purposes

3.4 Regulation Government Notice (GN) 704 (Regulation 704 of 1999)

The NWA was promulgated and Regulation GN 704 of 1999 passed on the use of water for mining and related activities aimed at the protection of water resources. According to this Regulation, water users (such as mines) are required to submit water-use licence applications to the DWS for the authorisation of water uses associated with planned and/or existing mining operations.

The following is outlined by the regulation:

- Notification of intention to the Department, whether operating a mine or ceasing to operate a mine
- Application of exemption of regulations (2,5,6,7,8,9,10 or 11)
- Application of exemption for restrictions locality
- Application of exemption for use of material
- Comply with the capacity requirements of clean and dirty water systems
- Reasonable measures to protect water resources
- Responsible person must undertake security and additional measures
- Comply with regulation of temporary or permanent cessation of the mining activity
- Comply with additional regulations relating to winning sand and alluvial minerals from a watercourse or estuary
- Comply with additional regulations for rehabilitation of coal residue deposits
- Arrangement of technical investigation and monitoring
- General – support of the mine manager to comply with provisions
- Offences and penalties
- Repeal of regulations
- Commencement

3.5 National Environmental Management Act (NEMA) (Act 107 of 1998)

The purpose of the Act is to ensure that the environmental rights contemplated in Chapter 2: section 24 of the Constitution of South Africa (Act 108 of 1996) are realised. NEMA sets out:

- The fundamental principles that need to be incorporated in the environmental decision making process;
- The principles that are necessary to achieve sustainable development;

- Provision for duty of care to prevent, control and rehabilitate the effect of significant pollution and environmental degradation; and
- Allows for the prosecution of environmental crimes.

Dealing with environmental management, NEMA covers the following principles:

- Obliges anyone who pollutes or degrades the environment to take reasonable measures to prevent such pollution or degradation from occurring.
- If pollution cannot be reasonably avoided, to minimise and remedy pollution and reuse or recycle where possible, and otherwise dispose in a responsible manner.
- Use non-renewable resources in a responsible and equitable way, taking into account the depletion of the resource.

3.6 Minerals and Petroleum Resources Development Act (MPRDA) (Act 28 of 2002)

The government has now enforced a new objective that all mineral rights should be owned by the state (Hobbs et al., 2008). Therefore it has become the government's responsibility to ensure that every mining operation has to comply with vulnerability/risk assessment to protect the water resources.

The objectives of this Act are to:

- Constitute the official policy concerning the exploitation of the country's minerals;
- Address environmental sustainability of the mining industry;
- Apply penalties for non-compliance and require that an environmental impact assessment be undertaken for mining operations.

The MPRDA regulates:

- The prospecting for, and optimal exploration,
- Processing and utilisation of minerals,
- Provision for safety and health in the mining industry and
- Control of the rehabilitation of land disturbed by exploration and mining.

Considering all the mining impacts mentioned in the sections above, it was deemed necessary to develop strategies/initiatives that will support the NWA and NEMA. These strategies/initiatives are developed by the government departments for relevant industries (including mining) to assist in protecting, conserving and rehabilitating the environment. This section summarises water management related strategies in South Africa.

3.7 Water use and mining authorisation

According to the NWA, the authorization of water use is based on the risk of impact on the water resources. Three types of water use authorisation determine those water use activities which require a license and those activities which do not require a license as indicated in the following table:

Schedule 1	General Authorisations	Water Use Licenses
These are activities that do not require registration for water use. Small quantities of water are used and have minimal or no risk on the water resources (e.g. taking water directly from any source for domestic use).	Some of these activities require registration and some do not, and have limited water use with low risk on water resources.	These are activities that have greater water use with high risk on water resources if not controlled. Activities such as taking water from a resource to use it; storage, such as keeping water in a dam; and diverting the flow of water for activities such as opencast mining.

Whilst the DWS regulates water use, the DME regulates the mining authorisations with respect to all minerals as follows:

- A prospecting permit is issued for one year only (can be renewed).
- A mining permit is granted for smaller operations and shorter periods (less than 2 years).
- A mining license is granted for larger operations and longer periods (more than 2 years).

Despite the availability of the above mentioned regulatory requirements for the mining sector, adherence to these is often non-existent. It was reported in parliament, in 2012 that 53 mines in South Africa were operating without a valid water use licence (as listed in the table below). For those mines that do have a water use licence, enforcement to ensure compliance is often lacking. Below is the status that was provided with respect to mine licensing (Morgan, 2012);

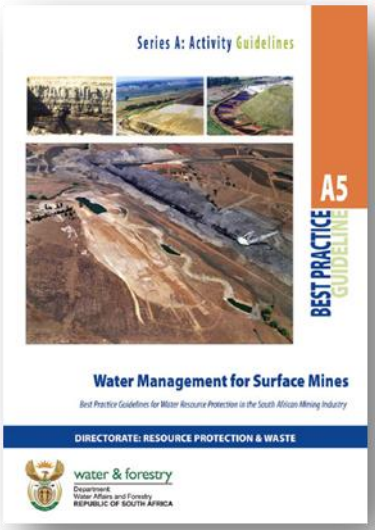
Table 2: Mines status to water licensing

NAME OF MINING COMPANY	LOCATION OF MINE	WATER LICENSE APPLIED FOR (YES/NO)	STATUS
PRE-DIRECTIVES ISSUED			
Blaizepoint Trading 96 CC	Free State	Yes	Contravention of Licence conditions
Chemstof (PTY) Ltd	North West	Yes	Facility operating without water use licence
Rockwell Diamonds Inc.	Northern Cape	Yes	Contravention of license conditions
DIRECTIVES ISSUED			
Befco Mineral Merchants (Pty) Ltd	North West	Yes	Facility operating without water use licence
Chemstof (PTY) Ltd	North West	Yes	Facility operating without water use licence

No.	NAME OF MINING COMPANY (1)(a)(i)	LOCATION OF MINE (1)(a)(ii)	WATER LICENCE APPLIED	STATUS (1)(b)
1	Sudor Coal -Elandsfontein	Mpumalanga	Yes	In process
2	Klipspruit Colliery	Mpumalanga	Yes	In process
3	Exxaro: GLISA	Mpumalanga	Yes	In process
4	Arnot:	Mpumalanga	Yes	In process
5	Kendal (zaid) Colliery	Mpumalanga	Yes	In process
6	Delmas Coal:/ Kuyasa Coal	Mpumalanga	Yes	In process
7	Shanduka Graspan Colliery	Mpumlanaga	Yes	In process
8	Stuart Coal	Mpumalanga	Yes	In process
9	Umcebo Colliery Doornrug Coal Mine	Mpumalanga	Yes	In process
10	Umcebo Mooifontein Colliery	Mpumalanga	Yes	In process
11	Umcebo Nowesco (Brakfontein)	Mpumalanga	Yes	In process
12	Shanduka Bankfontein Colliery	Mpumalanga	Yes	In process
13	Shanduka Coal: Middleburg Townlands	Mpumalanga	Yes	In process
14	Xstrata plc Arthur Taylor Colliery (Open Cast)	Mpumalanga	Yes	In process
15	Phokathaba Platinum Mine	Limpopo/ Mpumalanga	Yes	In process
16	Sheba Gold Mine	Mpumalanga	Yes	In process
17	Nkomati Mine	Mpumalanga	Yes	In process
18	Harmony Gold	Welkom	Yes	In process
19	Simmer and Jack	Stilfontein	Yes	In process
20	Gold Fields	Welkom	No	No licence application received
21	De Beers – Kimberley	Northern Cape	Yes	In process
22	PMG Mine	Northern Cape	No (Pre Notice sent in July 2010)	No licence application received
23	Misty Falls	Northern Cape	Yes	Awaiting outstanding information
24	Clisa 42 (Pty) Ltd	Northern Cape	Yes	In process
25	Buffelsfontein Platinum Mine	North West	Yes	Awaiting outstanding information from mine
26	Samancor Chrome Limited	North West	Yes	In process
27	Vametco Alloy Mine	North West	Yes	Awaiting outstanding information from mine
28	Anglo Platinum Mine	North West	Yes	Awaiting outstanding information from mine
29	Aquarius Platinum SA	North West	Yes	Awaiting outstanding information from mine
30	Lonmin Platinum (Marikana)	North West	Yes	In progress
31	Exxaro	KwaZulu-Natal	Yes	Awaiting outstanding information from mine

	NAME OF MINING COMPANY	LOCATION OF MINE	WATER LICENCE APPLIED	STATUS
32	Zuland Anthrancite Colliery	KwaZulu-Natal	Yes	Awaiting outstanding information from mine
33	Richard Bay Mineral	KwaZulu-Natal	Yes	Application
34	Imbila Mines	KwaZulu-Natal	Yes	In progress
35	Somkele Mines	KwaZulu-Natal	Yes	In process
36	Springlake Colliery	KwaZulu-Natal	Yes	Awaiting outstanding information from mine
37	Uitkomst Colliery	KwaZulu-Natal	Yes	Awaiting outstanding information from mine
38	Panbuilt Siding	KwaZulu-Natal	Yes	Awaiting outstanding information from mine
39	Maquasa West	KwaZulu-Natal	Yes	Awaiting outstanding information from mine
40	Hlobane Colliery	KwaZulu-Natal	Yes	In process
41	Simmer & Jack	Gauteng	Yes	In process
42	Mintails SA (Pty) Ltd	Gauteng	Yes	In process
43	Gold Fields-Driefontein	Gauteng	Yes	In process
44	Harmony Gold	Gauteng	Yes	In process
45	Gold View	Gauteng	Yes	In process
46	Mooiplaats Colliery	Gauteng	Yes	In process
47	Imbabala Colliery	Gauteng	Yes	In process
48	Vunene Colliery	Gauteng	No	Pre-application process
49	Umlabu Colliery	Gauteng	Yes	In process
50	Central Rand Gold	Gauteng	Yes	In process
51	Knights Gold	Gauteng	Yes	Awaiting outstanding information from mine
52	Glen Douglas	Gauteng	Yes	In process
53	Lieliefontain Colliery	Gauteng	Yes	In process

3.8 Best practise guidelines



In addition to the legislation/regulation/policies, the relevant Department of Water and Sanitation has developed a series of best practice guidelines for water resource protection in the South African mining industry. These guidelines were aimed at enabling South African mines to follow a structured process to determine whether the impact of their operation or planned activity is acceptable with regards to water related aspects.

The Best Practice Guidelines have been produced in three series namely:

1. A hierarchy series based upon the water resource protection and waste management hierarchy,
2. A general series of guidelines for general water management strategies, techniques and tools; and
3. An activity series for specific mining related activities.

With regards to mine water, the hierarchy is based on a precautionary approach and sets the following order of priority for water management:

- Prevent or minimise pollution/contamination of water used, by implementing necessary management measures or strategies.
- Reuse or reclaim contaminated water, in cases where complete pollution prevention was not possible.
- Treat water that cannot be reused or reclaimed.
- Reuse treated water.
- Discharge or disposal of excess water.

3.9 Environmental Management Programmes (EMPs)

The Department of Environmental Affairs requires any person who applies for an exploration permission, prospecting right or mining permit to submit an Environmental Management Plan (EMP). No person may prospect, mine or undertake exploration operations or any other activity without an approved EMP, permit or permission or without notifying the landowner. The purpose of the EMP is to ensure that all necessary measures are identified and implemented in order to protect the environment and comply with environmental legislations. Below are the EMP steps to be followed in order to comply or reduce the environmental impact associated with mining activities and other activities that lead to environmental degradation.

Figure 1: EMP Steps (Adopted from www.fairtrade.travel/uploads/files/manuals/.../What_is_an_EMP)

3.10 National Water Resource Strategy

The National Water Resource Strategy is a strategy developed by the Department of Water and Sanitation to ensure protection of water resources. The purpose of the National Water Resource Strategy is to:

- facilitate the proper management of the nation's water resources,
- provide a framework for the protection, use, development, conservation, management and control of water resources for the country as a whole,
- provide a framework within which water will be managed at regional or catchment level, in defined water management areas,
- provide information about all aspects of water resource management,
- identify water-related development

These measures are designed to protect the *health* of the water resource. They look after the quality of water, quantity of water, the animals that live in the water resource, and the vegetation (plants) around the water resource. All these must be healthy for the water resource to function properly and to provide water.

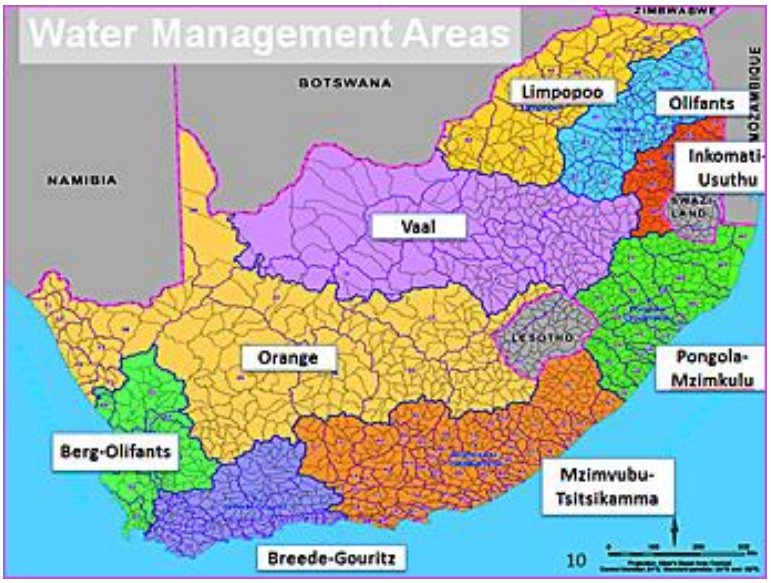
3.11 Catchment Management Strategy

The National Water Act requires that a catchment management agency (CMA) be established for each water management area. The CMA is responsible for developing the catchment management strategy for its water management area.

The purpose of the catchment management strategy is to:

- Set principles for allocating water to existing and new water users.
- Provide the framework for managing water resources within the water management area.
- Ensure that water resources in the water management area are protected, used, developed, conserved, managed and controlled.

The catchment management strategy therefore specifies the catchment management agency's intention for the water resources in the water management area and the way in which these water resources will be managed. The following picture illustrates the current water management areas and catchment management agencies.



3.12 Integrated Water Resource Management

Integrated water resource management is a process for co-ordinated planning and management of water, land and environmental resources. It takes into account the amount of available water (surface and groundwater), water use, water quality, environmental and social issues as an integrated (combined) whole to ensure sustainable, equitable and efficient use. Integrated water resource management is also about providing sufficient information about water resources for proper planning and informed decision making between water resources managers and development planners. It requires co-operation and co-ordination between planners, institutions and individuals where water-related planning takes place. A further key aspect of integrated water resource management is participation of people in decision making where decisions are decentralised.

3.13 Water Conservation and Water Demand Strategy for the Industry, Mining and Power Generation Sectors (2004)

The strategy promotes efficient use of water and encourages demand side management of water. Objectives of the framework are as follows:

- To facilitate and ensure the role of Water Conservation (WC)/Water Demand Management (WDM) in achieving sustainable, efficient and affordable management of water resources and water services
- To contribute to the protection of the environment, ecology and water resource
- To create a culture of WC/WDM within all water management and water services institutions
- To create a culture of WC/WDM for all consumers and users
- To support water management and water services institutions to implement WC/WDM
- To promote the allocation of adequate capacity and resources by water institutions for WC/WDM
- To enable water management and water services institutions to adopt integrated planning
- To promote international co-operation and participate with other Southern African countries, particularly basin-sharing countries, in developing joint WC/WDM strategies.

Below is a review of key international mine water management practices.

International

3.14 Federal Water Pollution Control Act (Act of 2002)

The Federal Water Pollution Control Act requires all point source discharges from mining operations to be authorized under the National Pollutant Discharge Elimination System (NPDES) permit to control water pollution by regulating point sources that discharge pollutants into waters of the United States, as described in Section 402 of the Clean Water Act. The construction of impoundments to serve as repositories for tailings and treatment of waste from mining and mineral processing operations are regulated by Section 404 of the Act as well as Section 402, in the case of discharges from these impoundments into any waters of the United States.

3.15 Crown Minerals Act (Act No 70 of 1991)

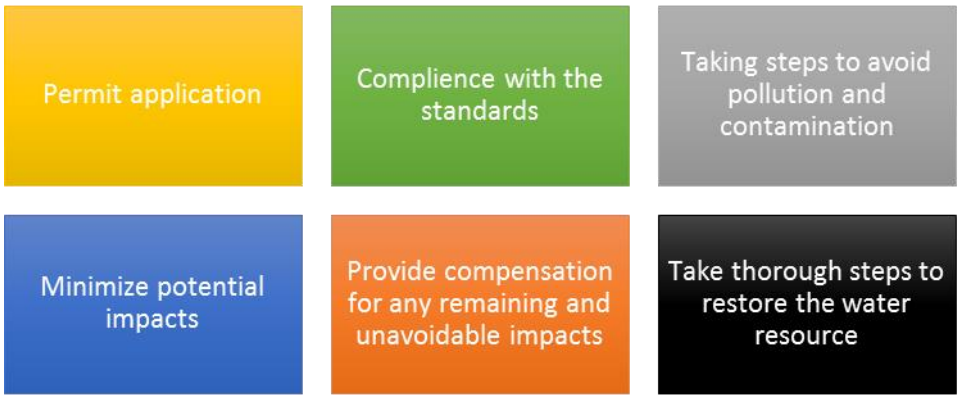
Crown Minerals Act (1991) of New Zealand requires that a permit and an access arrangement are needed before any prospecting, exploration or mining activities can take place. The Act specifies the following:

- The issuing of minerals programmes for the allocation of rights to prospect, explore or mine Crown-owned mineral resources.
- The financial return the Crown receives in exchange for those rights.
- Conditions on permits to encourage responsible resource development in line with good practice.
- The collection of information on the mineral estate by the Crown, to promote efficient management of resources, to promote informed investment decisions, and to improve security of supply in the gas and electricity market.
- Rules for entry onto land to prospect explore or mine the Crown's minerals, including limitations on entry to areas of special importance and to areas of particular conservation value.

3.16 Australian requirements

Franks et al., 2010 reported that in Australia, cumulative impacts are required to be assessed as part of the project approval process, which is primarily the responsibility of state governments. The environmental impact assessment procedures require developments to address cumulative impacts. The development of a draft terms of reference is the responsibility of the proponent, with a period of public comment and then finalisation by the Department of Environment and Resource Management (DERM). In 1995, the Australian and New Zealand Mineral and Energy Council (ANZMEC) published a baseline environmental guideline for operating mines in Australia (Council of Geoscience et al., 2010).

Looking at the international regulation and the South African regulations with regards to mine water management, it can be identified that there are similarities although the context might be different under which these regulations were developed. Following are the similarities that were noted:



4. INTERNATIONAL VULNERABILITY/RISK ASSESSMENT PRACTICES

4.1 South African approach to mine water vulnerability assessment

There are many approaches and systems available to assess or evaluate risks of different sources and/or contaminants to water pollution (Heath, 2009). A number of these are discussed by Usher et al., 2004 in the WRC Report 1326/1/04.

DWAF, 2008:H2 suggested the following approach for pollution prevention assessment procedure.

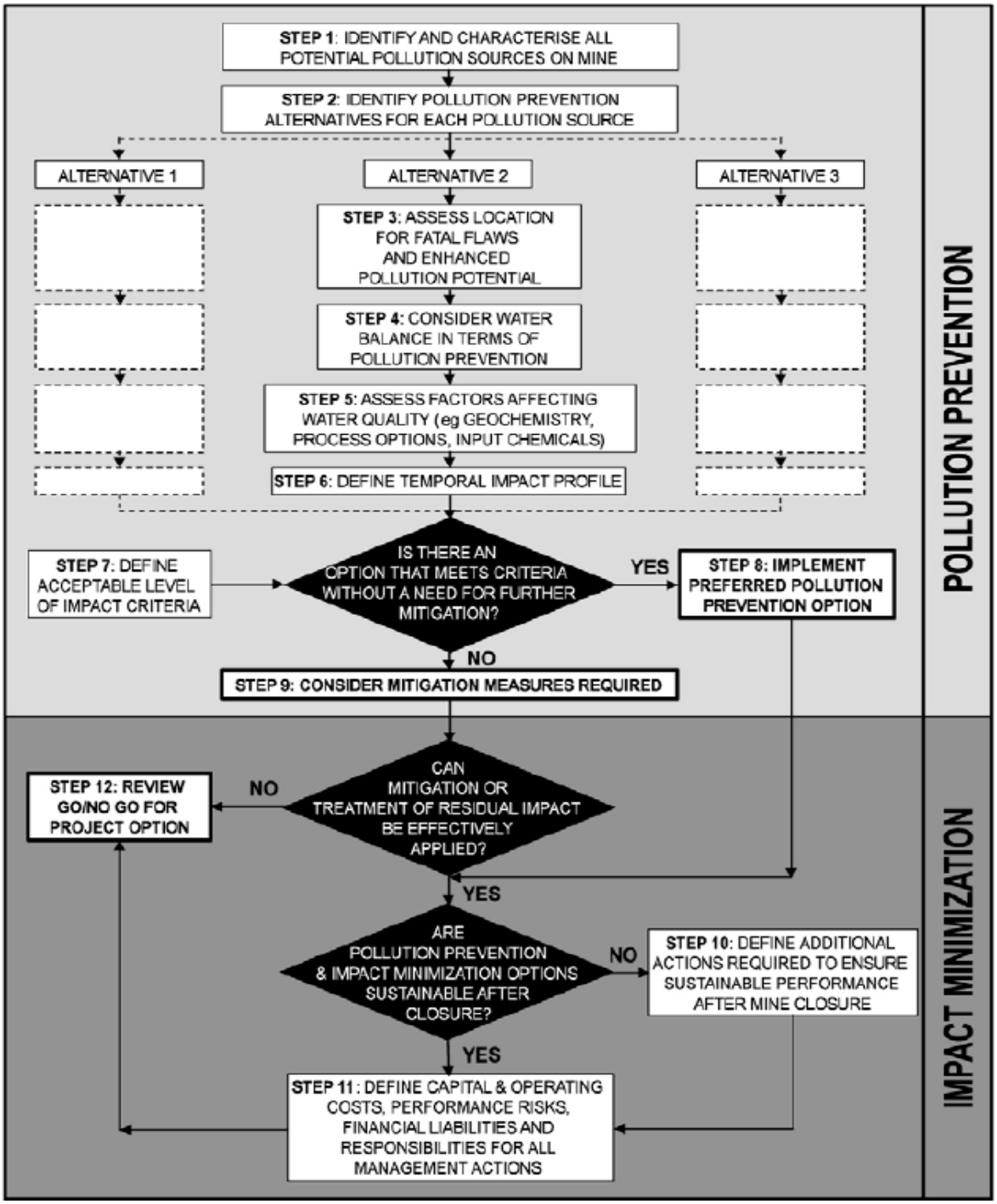
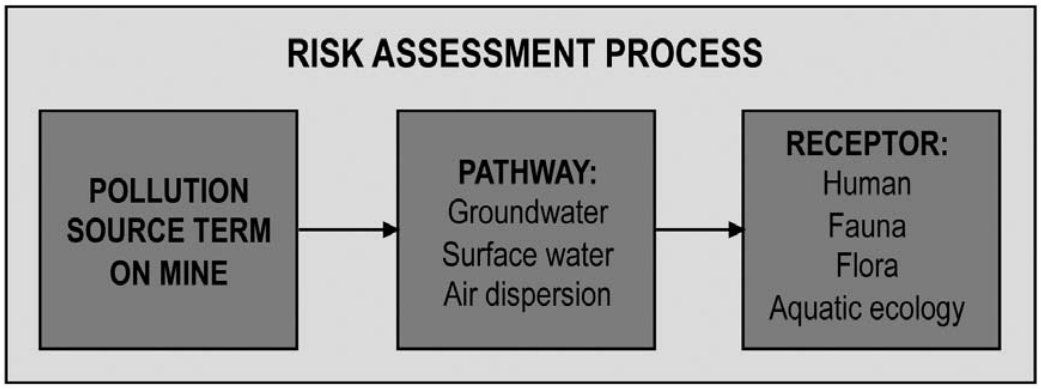


Figure 2: Pollution prevention assessment procedure

DWAF, 2008:H2 also suggested the following approach for risk assessment.



Some references focus on risk analysis based on typical contaminants (Heath, 2009) that could potentially have an impact on source pollution. The risk is related to the potential of the contaminant that originates from a specific source to pollute either surface, atmospheric or groundwater. Activities are specific for different types of mines and hence the pollution type and severity will vary depending on the activity and the type of mine. Mines also produce a variety of potential contaminants, depending on the ore deposit type, mining processes and mineral processing activities at specific sites.

4.2 International approach to mine water vulnerability assessment

(USEPA, 1989) suggested that a risk-based approach method can be applied towards long-term water management. This requires mines to quantify the potential current and long-term risks associated with mining activities, and then apply appropriate management actions to minimize or mitigate the potentially significant risks. Below is a suggested approach for baseline risk assessment.

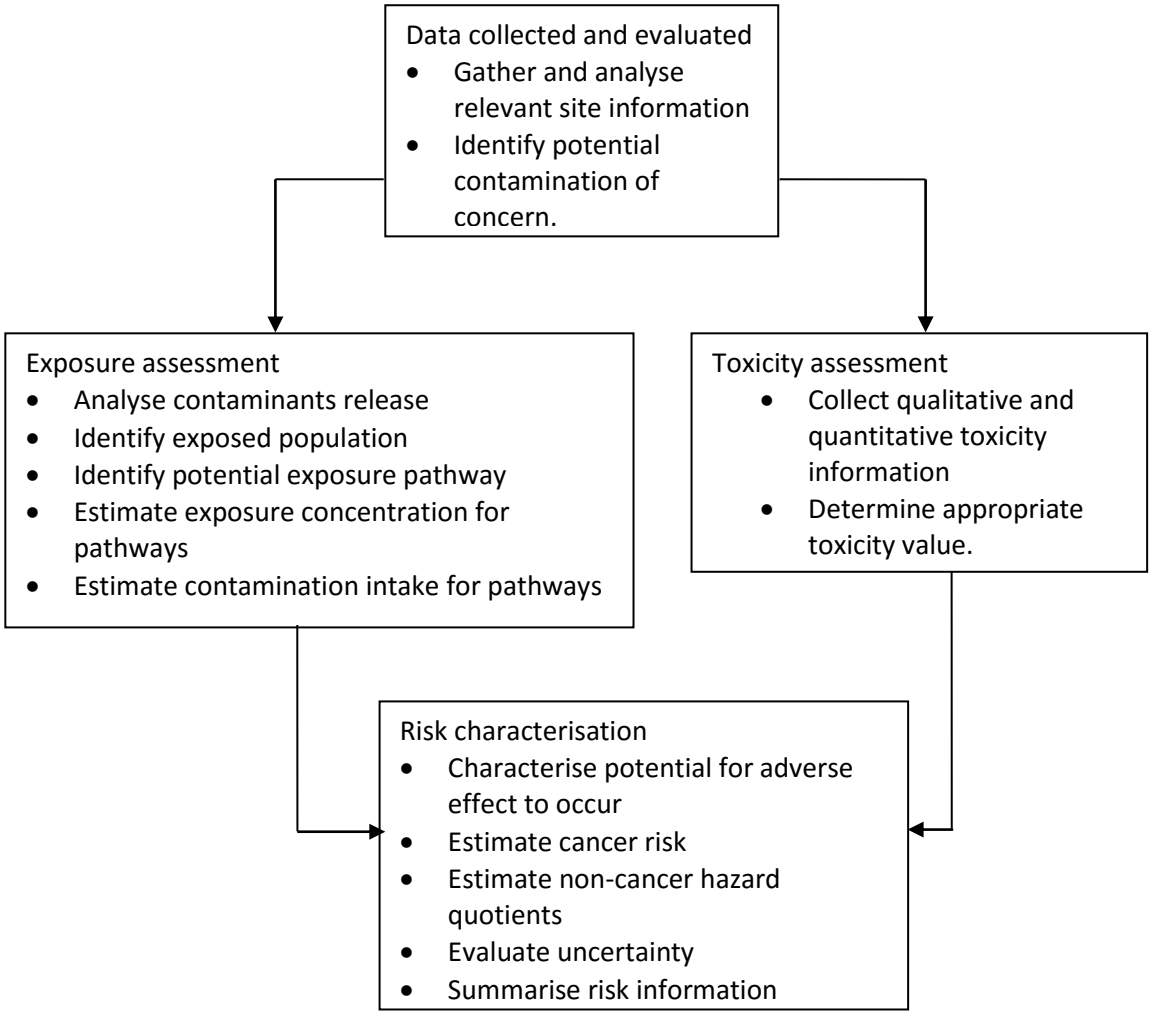


Figure 3: Baseline risk assessment (Source: USEPA, 1989)

Mine water related risks may be increased as a result of a mine operating practices and the commodities mined. Mine exposure to water risks varies according to the geological characteristics of the ore bodies being mined, the climate and type of operations (Miranda, 2010). Miranda et al., 2010, suggested the framework below as a Water Resource Institute (WRI) framework to assessing mine water management.

		Surrounding environment	Type of commodity	Type of operation	Corporate Policy/ Approach	Disclosure/ Engagement	Regulatory Climate
Questions for Companies*		*Operating in water scarce regions?* *Competing with other users? Seismic hazard?*	*Grade of ore and ratio of ore to final product?*	*Extraction method, waste disposal, water management procedures?*	*Does the company conduct water footprint analyses?* *How are water risks assessed?*	*Does the company disclose water risks?* *Engage with stakeholders?*	*How will prices, water quality regulations, or other permits affect the company?*
Risk Level	**High**	• Arid/semi arid environments • Presence of other competing uses (agriculture, ranching) • High seismic hazard • Very high rainfall and/or frequent, major storm events • High permeability aquifers	• Low grade ore • Precious metals • Diamonds • Copper • Nickel • Oil shale/ sands	• Open pit that reaches below water table • Dewatering required • High acid drainage potential • Tailings disposed in rivers • Energy derived from hydropower • Large water withdrawals • Large mixing zone for discharges	• No water accounting or footprint analysis • Does not consider water risks	• No reporting against existing frameworks (e.g. GRI) • Does not report tailings effluents • Minimal engagement w/ stakeholders	• Operating in countries with uncertain regulatory climate • Water scarcity a major concern for policy makers • Effluent releases and water withdrawals exceed permits
	Medium	• Moderate seismic hazard • Moderate rainfall with distinct dry season	• Coal • Uranium • Crude oil • Zinc • Lead • Iron ore	• Open pit above water table • Dewatering water recycled • Potentially acid generating material capped and controlled • Tailings stored in impoundment • Energy derived from coal/ natural gas • Moderate water withdrawals • Small mixing zone for discharges (1-2 miles)	• Water balance/ accounting at mine site • Stated policy to reduce water consumption • Developing additional water metrics	• Reports some water indicators (e,g, GRI EN8, EN10, MM3) • Regularly consults with stakeholders at site and global levels	• Company is taking steps to anticipate changes in regulations • Effluent releases and water withdrawals are well within permits
	Low	• Moderate rainfall • Low seismic hazard	• Cement • Other industrial minerals • Natural Gas	• Energy derived from renewable sources • Old mine workings capped and covered • Low acid generating potential • Water flows carefully controlled at site • Water discharges meet ecosystem requirements • All water consumed is reused/ recycled	• Comprehensive direct/indirect footprint analysis • Water risks have been measured and taken into account • Company sets targets to reduce water footprint	• Company discloses data on waste characteristics, flows, water risks • Seeks input and participation of stakeholders	• Company is operating beyond compliance • Zero discharge facility

Figure 4: World Resource Institute's water risk framework for the mining sector is given below (Miranda, 2010)

In South Australia, the risk management framework for water planning and management sets out the general context and process for risk assessments in accordance with the South Australian Natural Resources Management Act (NWR Act of 2004) as indicated below (Wilson et al., 2014).

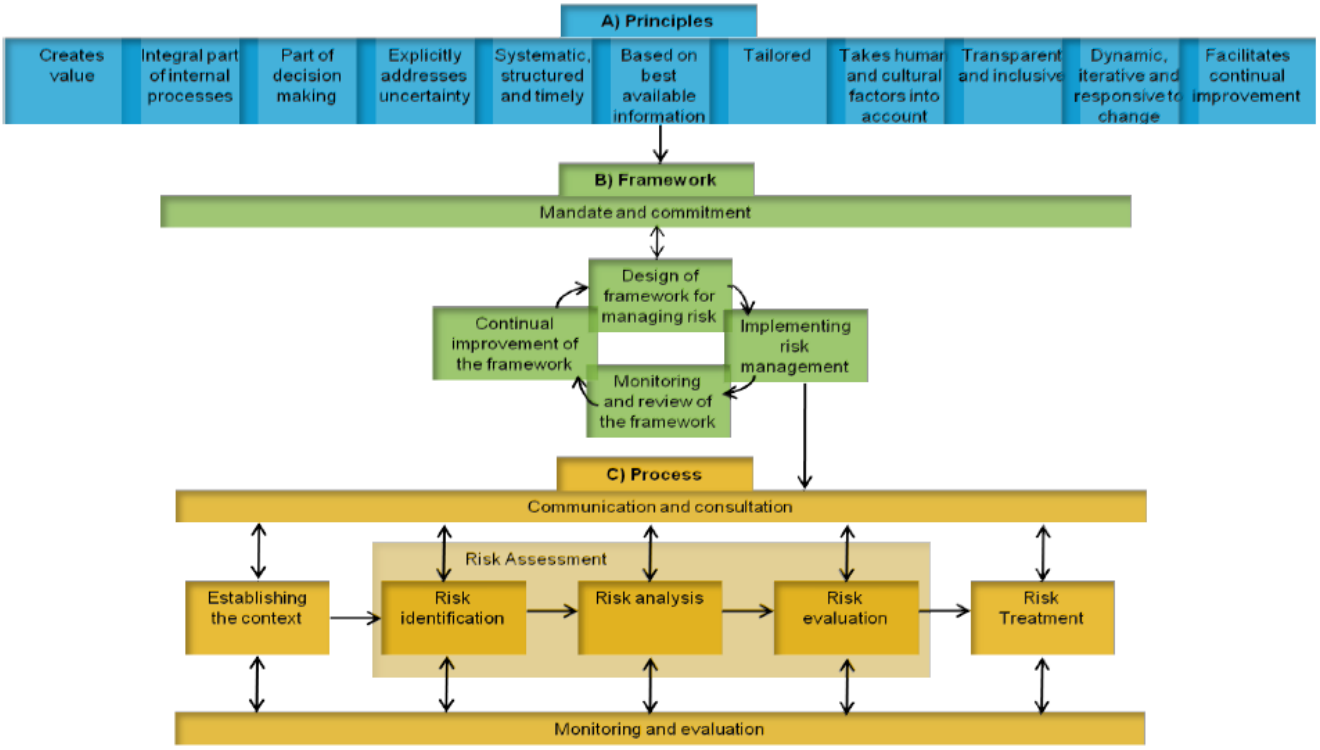


Figure 5: South Australian risk management framework for water planning

5. MINE WATER VULNERABILITY TOOL DEVELOPMENT ($MINE_{WATER}$) PROCESS

5.1 Approach

There are many approaches and systems available to assess or evaluate vulnerabilities and/or risks of different sources and/or contaminants to water pollution (Heath, 2009). A number of these are discussed by Usher et al. (2004) in the WRC Report 1326/1/04. Some references focus on risk analysis based on typical contaminants (Heath, 2009) that could potentially have an impact on source pollution. Activities are specific for different types of mines and hence the pollution type and severity varies depending on the activity and the type of mine. Mines also produce a variety of potential contaminants, depending on the pore deposit type, mining processes and mineral processing activities at specific sites.

It was suggested during the Inaugural reference group meeting, that the following should be considered when developing the tool:

- Legal requirements from different stakeholders/Authorities involved in mining (e.g. Department of Water and Sanitation (DWS), Department of Environmental Affairs (DEA), etc.) should be considered, tabled and included.
- The tool should provide a standard format of reporting.
- The tool should enable the users a simple and effective means of reporting water management issues to different stakeholders/Authorities.
- The tool should be applicable to all types of mines

5.1.1 Stakeholder engagements

The process of tool development included relevant stakeholder's engagements in order to identify key requirements for each that should be incorporated within the tool. Stakeholder engagements conducted through this project are summarised below.

Department of Water and Sanitation (DWS) consultation workshop

In September of 2015, the Department of Water and Sanitation conducted a consultation workshop at their offices in Pretoria (draft agenda in the Appendix). The main purpose of the workshop was to review the draft mine water management policy developed by the department with inputs from relevant stakeholders. The workshop was attended by representatives from different departments/fields including:

- Department of Mineral Resources
- Department of Environmental Affairs
- Department of Water and Sanitation
- Organisations representing the public
- Mines
- Consulting companies

In addition to the dialogue about the draft policy, a presentation on the current status of mine licensing, environmental impacts and projections on costs of required maintenance was given. Challenges experienced by the sector and future needs were discussed and summarized below.

Challenges noted

The following were noted to be key challenges:

- Integrated approach to mining closure
- Gap on policy enforcement – which department is responsible, what are the consequences, etc.?
- Environmental monitoring lacking/poor
- Mines operating in already disturbed areas
- Financial management for the lifetime impact

Future needs

It was noted that there are still gaps that need to be addressed concerning the following:

- Recommended short and long term appropriate treatment technologies
- Incentive investments to brown field sites
- Research to avoid pollution
- Policy about mines selling treated water to municipalities
- Investigations on green technology – new mining ventures should indicate how they are going to handle water management including cost benefits during and after mine closure
- Research needs of cost related to rehabilitation
- Public involvement – participation of interested and affected parties

Grootdraai Dam forum meeting

In November of 2015, the project team attended the Grootdraai Dam forum meeting which was held in Ermelo (draft agenda in the Appendix). This is a long existing forum that operates within the Vaal Barrage and Vaal Dam catchments. The main purpose of the forum is to facilitate communication and dissemination of information between stakeholders and role players participating within these catchments. The meeting was attended by representatives from different departments including:

- Department of Water and Sanitation
- Mines
- Eskom power stations
- Water Boards
- Department of Mineral Resources
- Municipalities
- Consulting companies

Mines and Eskom power stations presented their water quality status and challenges experienced. Department of Water and Sanitation indicated their initiatives with respect to monitoring, licensing and Catchment Management Agencies. The following were noted to be key challenges:

Challenges noted

- Unlicensed mines
- Ownership of closed mines
- Decanting of old, abandoned mines
- Climate changes challenges (e.g. lack or poor monitoring due to drought conditions)
- Poor water quality discharged into the environment

5.1.2 First draft tool

The approach used to develop the mine water vulnerability assessment tool through this project was to utilise the existing regulations/policies/guideline documents and licence requirements as a basis. Considerations from key stakeholder requirements and practices from elsewhere, found in the literature, were also made. This means, the areas of assessment have looked beyond just water management and includes all areas that may have an effect on water management.

The following was considered when developing the tool, based on the legal/licence considerations, existing guidelines and literature reviewed:

1. Identify key categories to be assessed that have an impact on mine water management.
2. Identify key requirements in each of these categories. This leads to understanding what questions to ask.
3. Identify possible situations that the mine could be in, related to the categories. This leads to understanding what possible answers to provide in response to the questions.
4. The user should indicate the most appropriate answer.
5. The output should indicate the area/s of vulnerability by category
6. An action plan can then be developed to address the way forward according to the output results.

5.1.2.1 Tool categories

The following summarised aspects were identified, through the literature survey and stakeholder engagements to be key aspects to consider when determining mine water vulnerabilities and risks:
NOTE: these were the team's initial thoughts and were later refined.

Table 3: Key categories and potential vulnerabilities related to water management

Category	Potential vulnerabilities/risks
Planning	• The exploration stage has been conducted (including surveys, field studies, investigation of amount of ore) • Have conducted EIAs • Have developed and implemented a pollution prevention plan that includes all mining stages • Have investigated the cost implications for each stage of mining • The ownership of the mine is clearly defined and understood • Management commitment to cleaner production is evident • Public participation has been conducted to inform affected users of the potential impacts
Finance	• Sufficient budget is available to operate, maintain and pay salaries • Sufficient budget is available to implement all plans developed (e.g. pollution prevention, emergency preparedness, asset management, operation and maintenance)

Category	Potential vulnerabilities/risks
Policies/Regulations/ Frameworks	• A valid water use license is available and fully implemented • Regulation 4(a): waste rock dumps, road construction, within 100m of ephemeral drainage lines • Regulation 4(b): diversion of ephemeral drainage lines around the open pit • Regulation 4(c): backfill of open pit with waste rock • Regulation 5: use of waste rock for construction purposes including roads, dams and erosion control measures and other (noise reduction berm)
Mining activity	• Have developed and implemented erosion control methods • Monitoring and evaluation of potential environmental pollution is conducted according to the license • Emergency preparedness procedures have been developed and implemented • Operations and maintenance plan has been developed and implemented • Frequent (e.g. annual) monitoring of potential risks is conducted • The properties on which the water use will take place are clearly described
Mine closure and rehabilitation	• Have budgeted for mining closure procedures and pollution prevention • Have developed a mine closure and rehabilitation plan
Waste Management	• Acceptable waste disposal methods are being employed • Environmental waste minimisation training programmes to workers have been developed and implemented • The amount and quality of water containing waste discharged into the environment is metered and monitored
Monitoring	• Water quality monitoring is conducted as per license conditions • Groundwater monitoring is conducted as per license conditions • Soil monitoring is conducted as per license conditions • The frequency of monitoring is in accordance to the license • The amount of water taken from a water resource is measured and recorded
Water Conservation and Demand Management	• Have developed internal water use efficiency targets that are aligned with WC/WDM Guidelines of DWS for mining • The mine has developed and adopted water separation practises for the purpose of confining any unpolluted water from contaminated water, e.g. clean water cut off canal as per GN 704 • A water balance for the specific mining activity is being conducted, based upon climate variations and water use
Infrastructure Asset Management	• Asset management plan has been developed and implemented • Maintenance plan of necessary water management infrastructure with necessary requirements (e.g. fencing, restriction boards/warning signs, control stockpiling) has been developed and implemented

Category	Potential vulnerabilities/risks
Human Resources	• Staff has been trained and are aware of pollution prevention methods and mine water use methods • Technical management staff have the correct skills/qualifications with regard to health and safety of the work conducted • Environmental awareness training and programmes are conducted

5.1.2.2 Questions and answers to tool categories

Five key questions, related to the categories presented above, had to be identified under each of the relevant categories. Each question has a range of possible answers that the user can choose from. The following answers were provided as possible appropriate answers that the user can choose from. For each question, an appropriate answer has to be selected.

- Strongly disagree or do not know – not started
- Disagree – Just started
- Neutral – Partially complete/in place
- Agree – substantially complete/in place
- Strongly agree – Fully complete/in place

5.1.2.3 Tool Scoring/weighting

The answers described in section 5.1.2.2 above were allocated scores as indicated in the table below. As it can be seen from the table below, the most negative answers are allocated the lowest scores, whilst the most positive answers are allocated the highest score. Therefore a higher score and/or percentage is an indication of low vulnerability and the lowest score and/or percentage is an indication of increased vulnerability. The percentage vulnerability score calculation is illustrated in Table 4 below.

Table 4: Vulnerability Scoring

Vulnerability Scoring Rules	
Strongly disagree or don't know	0
Disagree	1
Neutral	2
Agree	3
Strongly agree or not applicable	4

Table 5: Vulnerability Status Calculation Example

Individual Vulnerability Rating	Score	Max	Vulnerability Scoring	Vulnerability Status
1. Planning (New)	11	20	**55%**	High Vulnerability
2. Policies/Regulations/Good Practise	20	20	**100%**	Low Vulnerability
3. Mining Processes (New)	9	20	**45%**	Extreme Vulnerability
4. Water Monitoring (New)	13	20	**65%**	Moderate Vulnerability

NOTE:

75-100%: Low Vulnerability

60-75%: Moderate Vulnerability

50-60%: High Vulnerability

<50 – Extreme Vulnerability

Tool categories have the same weighting, meaning they are considered equally important.

5.1.2.4 Tool output

Based on the response, a vulnerability level per category is calculated and the results are displayed via a "spider diagram" (see example below). A percentage vulnerability score is calculated according to the score obtained from the total score. The legend at the bottom of the figure below indicates how the vulnerability status is presented.

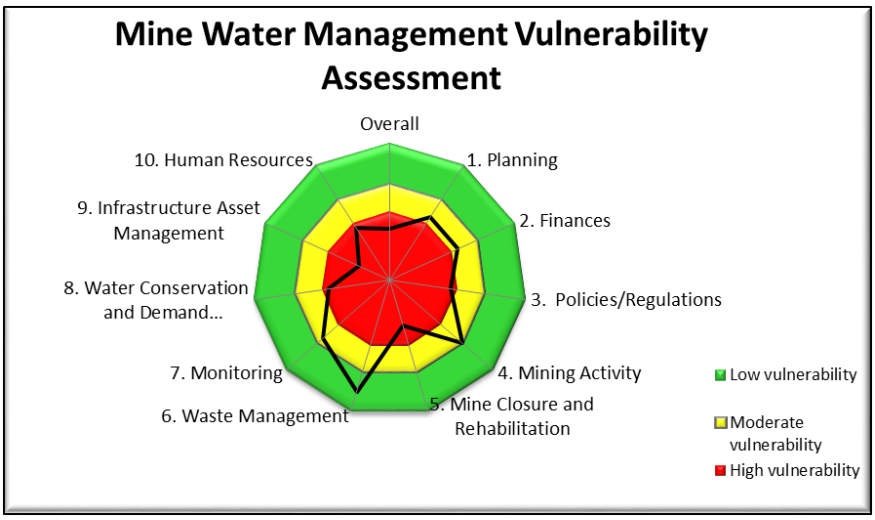


Figure 6: Mine Water Vulnerability Assessment Output example

Table 6: Table format vulnerability output example

Overall Mine Water Management Vulnerability Rating	Vulnerability status
1. Planning	Medium Vulnerability
2. Finances	Medium Vulnerability
3. Policies/Regulations/Frameworks	High Vulnerability
4. Mining Activity	Low Vulnerability
5. Mine Closure and Rehabilitation	High Vulnerability
6. Waste Management	Low Vulnerability
7. Monitoring	Medium Vulnerability
8. Water Conservation and Demand Management	High Vulnerability
9. Infrastructure Asset Management	High Vulnerability
10. Human Resources	High Vulnerability

The output assist the mine to identify which areas of the assessment have the highest vulnerability that may contribute to mine water management.

5.1.2.5 Action plan development

An action plan can then be developed to address the way forward according to the vulnerability assessment output results.

The purpose of the action plan is to:

- Prioritise where the mine needs to improve and set associated targets,
- Determine the approaches on how to achieve the desired improvements,
- Allocate resources to systematically address the prioritised vulnerabilities,
- Set actions to achieve these improvements and targets and
- Monitor, evaluate and communicate progress.

It was thought that the plan should contain the following five characteristics;

- There must be a logical connection between the indicator raised and the proposed strategic approach,
- Each strategic approach must be actionable, specific, realistic, time bound and achievable,
- Where the strategic approach requires capital input this must be indicated and included into future budgetary revisions,
- Strategies must be prioritized, highlighting those that yield the greatest impact with the minimum cost implication,
- The strategy prioritization must be guided by approved budget allocations and supply chain management requirements.

The following table provides an example of the approach adopted for the completion of an action plan.

Table 7: Action plan template

Monitoring		Status	Comments and Current Interventions	Agreed Action	Responsible Person (Who)	Completion Date (When)	Proposed Budget
1	A surface and ground water quality monitoring programme is implemented according to DWS guidelines	Agree					
2	A surface and ground water flow monitoring programme is implemented according to the DWS guidelines	Disagree					
3	A biomonitoring programme is implemented according to the DWS guidelines	Strongly agree					
4	Water monitoring reports are provided to DWS on a monthly basis	Agree					
5	The monitoring programme is audited timeously and recommended changes are implemented	Strongly agree					

This process should encourage stewardship of mine water management by mines through ownership of vulnerability assessment and priority action plan development and implementation of associated required improvement processes.

5.1.3 First draft tool pilots

The first draft tool developed, with considerations from the stakeholder meetings, was sent to selected mines for comments as initial pilot. The draft spreadsheet tool was piloted at the following mines:

- Coaltech – Coal
- AngloGold – Gold
- Anglo American – Platinum

Feedback from the pilots of the first draft tool was as follows:

The tool pilots have indicated that the draft spreadsheet-based mine water management vulnerability assessment tool is easy to use and appropriate for the purpose. Users have indicated a number of required amendments, which need to be incorporated into the tool.

5.1.3.1 General Comments

- It may be useful to separate the tool for newly built mines and old existing mines.
- It is advisable to separate the mining license status and the water use license status.
- The tool should allow for an indication of the operating company.
- The tool should allow for an indication of the location of the mine.

- The arrangement of sections to follow a sequential method should be considered.
- For mine size and catchment, a drop down menu could be useful for selection.
- Identify if the overall score indication should be included in the spider or not.

5.1.3.2 Tool contents comments

- Criteria 1: Planning
    - This section is more applicable to new mines, old mines are expected to have gone through the process.
    - This information may not be easy to provide for old mines due to changing management and systems.
    - This section should focus on the development of plans, not necessarily implementation.
- Criteria 2: Finance
    - Questions from this section could be taken to relevant categories so that it does not become a category on its own.
- Criteria 3: Policies/regulations/frameworks
    - The category title should be reviewed. Maybe use “best practise” instead of “frameworks”.
    - OR remove frameworks and only focus specifically on relevant policies and regulations.
    - Consider including a question about submission of relevant reports to the Regulator.
- Criteria 4: Mining activity
    - Review the title, maybe change it from “mining activity” to “mining process”.
    - This section should capture key water use related questions at different stages of mining.
    - The questions should however be relevant to different types of mines. Therefore, it should focus at the most common activities.
    - No planning question should be captured in this criteria.
- Criteria 5: Mine closure and rehabilitation
    - Consider what should be done in terms of mine closure.
    - This could include financial implications of mine closure and rehabilitation.
    - This could include environmental impact as well (water related).
- Criteria 6: Waste management
    - Consider defining what kind of waste is referred to (e.g. hazardous, solid, sludge, etc.).
    - Consider what is required in terms of waste management according to the water use license.
- Criteria 7: Monitoring
    - Consider the key components that should be monitored according to the water use license.
    - Mainly focus on quality and quantity aspects about abstracting and discharging.
    - Consider including the question about making the information available/reporting to the Regulator.
- Criteria 8: Water conservation and demand management (WCDM)
    - Consider combining stormwater and rainwater harvesting.
    - Consider including the question about implementation of water conservation and management plan.
- Criteria 9: Infrastructure asset management

- Consider including a question about the availability of water related infrastructure asset register.
- Then the implementation of asset management plan.
- Consider including a question about the performance of infrastructure and their value.

- Criteria 10: Human resources
  - This section should focus on three things: numbers, skills and training.

Comments and feedback received from tool users were used to make further amendments/refinements to the tool.

5.1.4 Second draft tool

The second draft spreadsheet-based tool assessed two phases of mining, that is, new mines and existing mines. The closing mines phase was incorporated into the existing mines, not a separate phase on the tool.

- New Mines in this study refer to the mines that are not yet operational, however in their development stage (past the exploration stage).
- Existing Mines refer to the mines that have started operations, that is, have moved up to the active mining stage.

5.1.4.1 Introduction section

The introduction section where generic information about the mine is captured, was introduced. The screenshot below is an example of the generic information required.

Responsible person filling in questionnaire	Responsible person filling in questionnaire:
Mine Name	Mine name:
Type of Mine (e.g. Coal, Gold, Platinum)	Date completed:
Mine Size/catergory	Mine operating company:
Catchment affected	Type of mine (e.g. Coal, Gold, Platinum):
License condition (e.g. valid, in application, etc.)	Mine size/category
Date Completed	Mining license status
	Water use licence status
	Catchment affected
	Location of the mine (Town name)

- Ease of use, a drop down menu to select from, for some information has been provided as shown in the screenshot examples below.

Responsible person filling in questionnaire:	Warren Retief
Mine name:	Waxi
Date completed:	2016-05-20
Mine operating company:	XYZ
Type of mine (e.g. Coal, Gold, Platinum):	Gold
Mine size/category	B
Mining license status	
Water use licence status	
Catchment affected	Western Cape South Coast Rivers
Location of the mine (Town name)	Paarl
Type of mine (e.g. Coal, Gold, Platinum):	Gold
Mine size/category	B
Mining license status	Valid
Water use licence status	In process of application
Catchment affected	
Location of the mine (Town name)	

A
B
C

Valid
Expired
In process of application
In process of renewal

Once the generic information has been captured on the introduction section, the tool allows the user to identify if the assessment conducted is for a new mine or an existing mine as shown in the screenshot below.

Mine Water Management Vulnerability Assessment Tool

Responsible person filling in questionnaire:	Warren Retief
Mine name:	Waxi
Date completed:	2016-05-20
Mine operating company:	XYZ
Type of mine (e.g. Coal, Gold, Platinum):	Gold
Mine size/category	B
Mining license status	Valid
Water use licence status	In process of application
Catchment affected	Western Cape South Coast Rivers
Location of the mine (Town name)	Paarl

5.1.4.2 Assessment Section (New versus Existing Mine Assessment)

As indicated before, the second draft tool assessed two mining phases. The following categories were different for the assessments of the two phases, whilst the other sections were the same or not applicable for new mines. This means, though the categories were found in both assessments, the questions were however different.

- Planning
- Policies/Regulations/Good Practise
- Mining processes
- Water Monitoring
- Finance

Screenshots indicating difference in the assessment of the two types of mines are presented below.

1. Planning (New)	
1,1	Exploration stage has been conducted (including surveys water resources, investigation of amount of water required, etc.)
1,2	Environmental Impact Assessment has been conducted and are inclusive of water related plans
1,3	A pollution prevention plan that includes all mining stages has been developed
1,4	Clear roles and responsibilities are clearly defined in terms of water use and conservation
1,5	Environmental Management Plans have been developed

1. Planning (Existing)	
1,1	Impact on the environment or water systems has been conducted for the extension or upgrade of the mine
1,2	An application for renewed water use licence has been submitted to DWS
1,3	Proposed upgrades for storage, use and disposal facilities of water have been approved by DWS
1,4	All relevant mine plans (e.g. asset management plan, monitoring plans, operations and maintenance plans, water demand and management plan, IWWMP) are frequently updated to incorporate the new water services structure/s
1,5	Appropriate technology/ies for upgrading storage, treatment and disposal of water have been investigated

2. Policies/Regulations/Good Practise (New)	
2,1	A valid mining and water use authorisation has been applied for and issued
2,2	Resource protection measures have been developed and comply with Environmental Management Plans
2,3	Water usage is recorded and monitored
2,4	Environmental Management Plan has been developed
2,5	Integrated Water and Waste Management Plan has been developed

2. Policies/Regulations/Good Practise (Existing)	
2,1	A valid mining and water use authorisation is available and fully implemented
2,2	Resource protection measures have been developed, implemented and comply with Government Notice 704
2,3	Water use reports are submitted to DWS as per applicable authorisation requirements
2,4	Environmental Management Plan is fully implemented and reviewed annually
2,5	Integrated Water and Waste Management Plan is fully implemented

3. Mining Processes (New)	
3,1	Measures are put in place to minimise demand on water resources
3,2	Measures are put in place to avoid contamination of surface and ground waters
3,3	Measures are put in place to minimise erosion and sediment runoff
3,4	Measures are put in place to avoid fuel spillages and other contaminants
3,5	Studies on future projections of water demand versus availability are conducted

3. Mining Processes (Existing)	
3,1	Measures are put in place to minimise demand on water resources
3,2	Measures are put in place to avoid any contamination and discharge of chemicals and other wastes to surface and ground waters
3,3	Measures are put in place to avoid/minimise erosion and siltation of nearby surface water bodies
3,4	Water usage to facilitate transport of ore is appropriately managed
3,5	Studies on future projections of water demand versus availability are conducted

4. Water Monitoring (New)	
4,1	A surface and ground water quality monitoring programme has been developed according to DWS Best Practise Guideline A1
4,2	A surface, ground water resource and return water dam quality monitoring programme has been developed according to DWS Best Practise Guideline A1
4,3	Pre-mining conditions have been monitored according to DWS Best Practise Guideline A1
4,4	Water monitoring reports for pre-mining conditions are provided to DWS
4,5	The monitoring programme is audited timeously and recommended mitigation measures are developed for identified risks

4. Water Monitoring (Existing)	
4,1	A surface, ground water resource and return water dam quality monitoring programme is implemented according to the applicable authorisation requirements or SANS 10286
4,2	A surface and ground water quantity monitoring programme is implemented according to the applicable authorisation requirements
4,3	A biomonitoring programme is implemented according to the applicable authorisation requirements
4,4	Water monitoring reports are provided to DWS on a monthly basis
4,5	The monitoring programme is audited timeously and recommended mitigation measures are developed for identified risks

9. Finances (New)	
9,1	Appropriate budget is available for storage, treatment, disposal and monitoring of water within the mine
9,2	Economy feasibility assessment for the chosen water technology options has been undertaken
9,3	Cost implications for water use and disposal at each stage of mining has been investigated
9,4	Budget to conduct research for alternative water use and/or water treatment technology options has been allocated
9,5	Budget has been allocated for disaster management (e.g. spillages, drought)

9. Finances (Existing)	
9,1	Appropriate budget is available for storage, treatment, disposal and monitoring of water within the mine
9,2	Appropriate budget has bee allocated for mine closure and rehabilitation
9,3	Appropriate budget has been allocated to implement Infrastructure Asset Management plans
9,4	Budget to conduct research for alternative water use and/or water treatment technology options has been allocated
9,5	Budget has been allocated for disaster management (e.g. spillages, drought)

Some of the questions for the rest of the categories have changed as shown in the screenshots below.

5. Wastewater Management	
5,1	A wastewater management programme is organised and continuously reviewed to improve water use efficiency
5,2	Wastewater is classified and disposed off according to the DWS requirements
5,3	The quantity and quality of wastewater that is discharged into the environment is measured and
5,4	Sewage and mine water effluent discharge and storage is controlled and monitored
5,5	Re-usable water is separated and recovered from waste streams

6. Human Resources	
6,1	Sufficient water and environmental management staff is available as per organogram
6,2	Technical management staff have the correct skills/qualifications with regards to mine water management
6,3	Operational staff with the correct skills and experience in the water management are available
6,4	Staff regularly attend appropriate water management training (including environmental management, water treatment, waste minimisationprevention , minimisation and control, waste management)
6,5	Staff has been trained in terms of standard operating procedures in dealing with disaster management (e.g. spillages)

7. Water Infrastructure Asset Management	
7,1	An up to date water and sanitation services asset register is available
7,2	An appropriate water services asset management plan is being implemented
7,3	Technical assessment of water and wastewater related systems is conducted annually and required follow up actions are implemented.
7,4	A preventative maintenance plan of necessary water and sanitation infrastructure is performed
7,5	Maintenance and repairs supplies are readily available to avoid unnecessary delays in operations

8. Water Conservation and Demand Management	
8,1	A Water Conservation and Water Demand Management (WC/WDM) strategy which includes a standard water balance is implemented with special attention to reclamation.
8,2	Internal water use efficiency targets that are aligned with WC/WDM guidelines
8,3	WC/WDM measures consider technologies for optimisation of water usage
8,4	Where possible, rainwater and stormwater runoff is harvested for re-use purposes
8,5	Regular audits of water processes are conducted with supportive recommendations

10. Mine Closure and Rehabilitation	
10,1	A mine closure plan and rehabilitation has been developed
10,2	Residual impacts have been identified through monitoring system
10,3	Post closure water management plan options have been addressed
10,4	Financial and contractual agreements for post closure water management and maintenance of infrastructure with future responsible parties have been addressed
10,5	Product life cycle assessment (LCA) including process/activity, extraction, processing, manufacturing, recycling and disposal is performed

At the end of both the assessment, there is a button that allows the user to view the outputs as shown in the screenshot below.

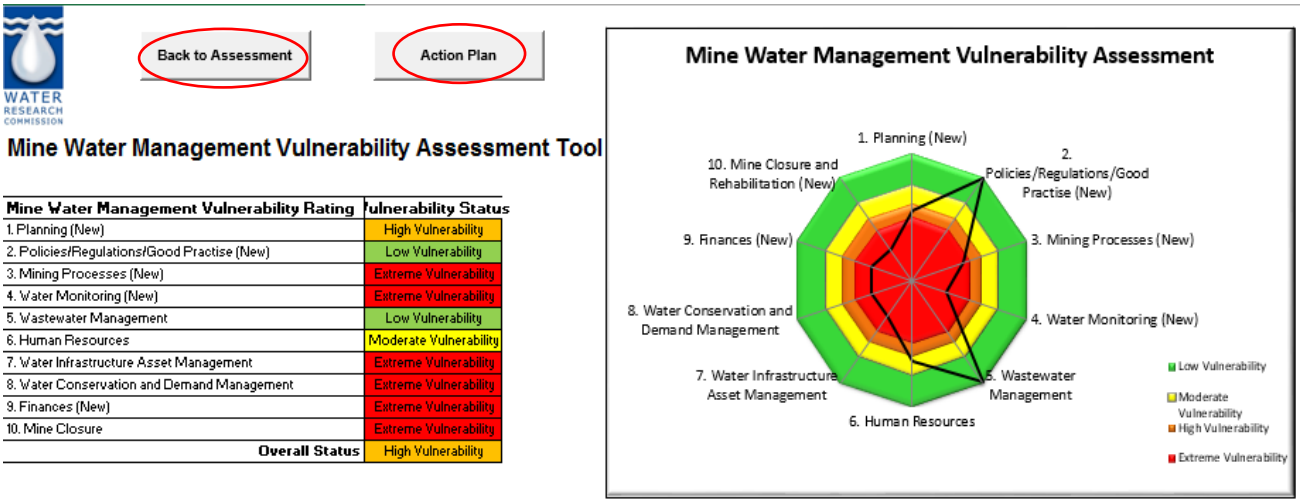
9. Finances		Answer
9,1	Appropriate budget is available for storage, treatment, disposal and monitoring of water within the mine	Disagree
9,2	Economy feasibility assessment for the chosen water technology options has been undertaken	Disagree
9,3	Cost implications for water use and disposal at each stage of mining has been investigated	Neutral
9,4	Budget to conduct research for alternative water use and/or water treatment technology options has been allocated	Disagree
9,5	Budget has been allocated for disaster management (e.g. spillages, drought)	Neutral

10. Mine Closure and Rehabilitation		Answer
10,1	A mine closure plan and rehabilitation has been developed	Neutral
10,2	Residual impacts have been identified through monitoring system	Disagree
10,3	Post closure water management plan options have been addressed	Strongly disagree or don't know
10,4	Financial and contractual agreements for post closure water management and maintenance of infrastructure with future responsible parties have been addressed	Neutral
10,5	Product life cycle assessment (LCA) including process/activity, extraction, processing, manufacturing, recycling and disposal is performed	Disagree

5.1.4.3 Outputs Section

As discussed in section 5.1.2.2, a number of options as relevant answers to each question are provided (e.g. strongly agree, agree somewhat, disagree; which were reviewed later). An output indicating the areas of vulnerability by category is provided.

- On this page, buttons that allow the user to continue to developing an action plan based on the outputs, or go back to the assessment section were included as shown in the screenshot below.



- Depending on the option selected, the user is referred to that section.
- If “back to assessment” is selected, the user will be directed to the section discussed in section 5.1.4.2
- If the “Action Plan” option is selected, the user will be directed to the section discussed below.

5.1.4.4 Action Plan Section

An action plan can then be developed to address the way forward according to the vulnerability assessment output results (action plan example attached).

This section was automatically populated with the answers provided on the assessment section. That is, when the user gets to this page, only the blank columns can be filled. No changes can be made on the status answers.

At the top of the page, buttons that allow the user to go back to the assessment or introduction sections were included as shown in the screenshot below.

Mine Water Management Vulnerability Assessment Action Plan

Introduction | Back to Assessment

Mine name: *Waxi*

Date: 2016-05-20

1. Planning		Status	Comments and Current Interventions	Agreed Action	Responsible Person (Who)	Completion Date (When)	Proposed Budget
1,1	Exploration stage has been conducted (including surveys water resources, investigation of amount of water required, etc.)	Agree					
1,2	Environmental Impact Assessment has been conducted and are inclusive of water related plans	Neutral					
1,3	A pollution prevention plan that includes all mining stages has been developed	Neutral					
1,4	Clear roles and responsibilities are clearly defined in terms of water use and conservation	Neutral					
1,5	Environmental Management Plans have been developed	Neutral					
2. Policies/Regulations/Good Practise		**Status**	**Comments and Current Interventions**	**Agreed Action**	**Responsible Person (Who)**	**Completion (When)**	**Proposed Budget**
2,1	A valid mining and water use authorisation is available and fully implemented	Strongly agree or not					
2,2	Resource protection measures have been developed and comply with Environmental Management Plans	Strongly agree or not					
2,3	Water use reports are submitted to DWS as per license requirements	Strongly agree or not					
2,4	Environmental Management Plan is fully implemented and reviewed annually	Strongly agree or not					
2,5	Integrated Water and Waste Management Plan is fully implemented	Strongly agree or not					

5.1.5 Comments related to the second reference group meeting

The second draft spreadsheet tool was presented and reviewed at the reference group meeting held on the 14th March 2016. The following comments are based on the second reference group suggestion/recommendations:

- The project team should conduct site visits/consultations to better understand mine water management, and pilot the tool.
- The key categories that should be allocated consider in terms of mine water management should be identified during consultations.
- The tool categories *should* be reviewed to identify which are the key/vital categories in terms of mine water management and be differentiated from the secondary or supporting categories. The importance of categories depends on the stage of the mine/mining. For example at the development phase, the importance of categories will be different from the existing or a closing mine.
- For a new mine, the following are the key categories:
    - Planning
    - Policies
    - Infrastructure
- For an existing mine, the following are the key categories:
    - Finances
    - Policies
    - Infrastructure
    - Mining activities
    - Closure
- For closing or a mine approaching closure, the following are the key categories:
    - Planning
    - Finances
    - Monitoring
    - Closure
- The idea of reviewing the answers to be relevant to each category or question was commended.
- Scoring and weighting of the tool categories should be according to their level of importance.

5.1.6 Second draft tool pilot

The second draft spreadsheet-based mine water vulnerability assessment tool was piloted to selected mines and stakeholders for further review. The following mines and stakeholders were consulted in the process:

- Anglo Gold Mine
- Exxaro Mine
- SHE Legal
- Mine Water course offered by Professor Christian Wolkersdorfer of Tshwane University of Technology

Below is the feedback received from the site visits and consultations.

5.1.6.1 Anglo Gold mine consultation

On the 3rd of May 2016, the project team met with Anglo Gold mine representatives at their offices in Orkney. The meeting was attended by:

- Charl Human – Environmental Manager
- Carlo de Waard – Senior Environmental Co-ordinator
- Unathi Jack – Emanti Management (Project Leader)
- Warren Retief – Emanti Management (Student)

The second draft spreadsheet-based tool sent to the mine prior the meeting. A brief presentation about the project was made by the project team. The draft excel tool was also presented.

Description of Anglo Gold mine

Anglo Gold mine is a gold mine that utilises a deep mining method. Potable water to the mine is provided by Midvaal Water. Some of the potable water provided is used for processing (e.g. cooling, boilers).

- There are shafts that use groundwater sources and water from the Vaal River is also utilised.
- Approximately 80Ml/day of process water is used for processing within the mine, of which about 60% is recycled. The mine has a wastewater treatment system.
- Three (3) of the 11 shafts, are currently operational.
- Though the mine practices water conservation and demand management strategies, there is no rainwater harvesting nor stormwater collection. Stormwater that falls on a dirty/contaminated area is contained.
- The major challenge experienced by this mine is pumping of seepage from connecting closed mines.
- Anglo Gold indicated that they are aware of their issues, therefore this kind of tool may not assist them in addressing the flooding issue, which is their main challenge.
- The mine would however, like to test the tool and see if it reflects the situation they understand.

Comments on the tool

The project team together with the mine representatives went through each and every question of the tool. The following were suggested/recommended focussing on the existing mine tool:

- The ten categories were noted to be the important aspects to consider when conducting mine water management.
- Instead of asking for implementation of license in the policies and regulations section, the tool should ask for compliance against the license.
- Policies and regulations sections should include DWS best practise guidelines implementation questions.
- There are no specific skills requirements for operational staff, therefore the tool should ask for “adequate understanding of water management” rather than “skills”.
- The use of the term “emergency preparedness” as opposed to “disaster management” is recommended in the human resources section.
- A water conservation and water demand strategy is expected to include standard water balance, therefore the tool does not have to specify that the strategy includes water balance.
- Audit periods vary with different mines, therefore the audit question should be linked to the license requirements.

- The use of “financial provision” as opposed to “appropriate budget” is recommended.
- The tool should include a question about financial and contractual agreements for post closure water management.
- The use of the term “assessed” as opposed to “addressed” is recommended for post closure water management plan.
- The tool should include a question about post monitoring and provision for post closure monitoring.
- The tool should consider including a question about resource water availability/demand
- The tool should consider including a question about the mine’s regional context, that is, interconnectivity of mines.
- Knowledge of mine infrastructure (underground and above the ground) should be determined.

5.1.6.2 Exxaro mine consultation

On the 26th of May 2016, the project team met with Exxaro mine representatives at their head office in Pretoria. The meeting was attended by:

- Emela Mochubele – Manager water efficiency
- Rhulani Shingwenyana – Engineer
- Unathi Jack – Emanti Management (Project Leader)
- Shawn Moorgas – Emanti Management (Project Team)

The second draft spreadsheet-based tool was sent to the mine prior the meeting. A brief presentation about the project and the draft tool was made by the project team.

Description of Exxaro mine

Exxaro is a coal mine with different branches in various regions, e.g. Limpopo, Mpumalanga, etc. Potable and process water depends on the region and location of Exxaro mines.

- Water management strategy at Exxaro is driven by steering committees that are formed by representatives from different Exxaro mine branches.
- There are also cross functional forums that include representatives from other departments.
- Exxaro is involved in joint initiative forums where different mines discuss common mining issues and possible solutions.
- Exxaro has a “use it or lose it” principle that forms part of their water conservation and demand management.
- Rain/stormwater is collected and stored in the sump. Some of Exxaro mines are at their closure stage.
- Exxaro indicated that this kind of tool could assist them in identifying the most vulnerable areas with respect to mine water management.

Comments on the tool

The project team together with the mine representatives went through the sections of the tool. The following were suggested/recommended focussing on the existing mine tool:

- The tool should be specific to water management related plans not environmental related plans.
- The use of “license” reference as opposed to “authorisation” was suggested.
- The tool should explain what is meant by wastewater.

- Resource/catchment vulnerability assessment question should be included in the planning section.
- The Infrastructure section should include movable and fixed assets.
- Return water dam monitoring should be removed.
- Reference to license requirements should be made with respect to monitoring with the exclusion of SANS 10286.
- Audit periods vary with different mines, therefore the audit question should be linked to the license requirements.
- It should be noted that water demand changes through the mine lifecycle.

Comments related to the second reference group recommendations

The following comments are based on the second reference group suggestions/recommendations:

- The importance of categories depends on the stage of the mine/mining. For example at the development phase, the importance of categories will be different from the existing or a closing mine.
- For a new mine, the following are the key categories:
    - Planning
    - Policies
    - Finances
    - Infrastructure
- For an existing mine, all ten categories are equally important. That means, if one category is not properly managed, it will affect the others.
- For closing or mine approaching closure, the following are the key categories:
    - Finances
    - Policies
    - Infrastructure
    - Water Monitoring
    - Mine Closure
- The idea of reviewing the answers to be relevant to each category or question was commended.

5.1.6.3 SHE Legal consultation

SHE Legal is a legal consultancy that specializes in environmental law, marine law, occupational health and safety and environmental science. On the 24th May 2016, the project team met with a SHE Legal representative at their offices in Claremont. The meeting was attended by:

- Karli Mackintosh – Safety, Health & Environmental Legal consultant
- Unathi Jack – Emanti Management (Project Leader)
- Warren Retief – Emanti Management (Student)3

The second draft spreadsheet-based tool was shared with SHE Legal representative prior the meeting. A brief presentation about the approach on the development and functioning of the draft excel tool was made. Discussions on the mine legal requirements were held and the following were noted:

General comments

- How much time is estimated to take to complete the tool?
- Water vulnerability risk can be minimised through compliance with legislation, therefore legal compliance is an important aspect for assessing vulnerability using the tool.
- How will the tool be completed, by a team or one person?
- It is recommended to have an additional tool for closing or closed mines.

Comments on the tool

Planning

- An EIA or EMP should include water management and pollution control impact assessment at the prospecting stage or during expansion, according to section 68 (2) of MPDR.
- Section 73 of MPDR states the requirements for the design and management of stock piles. The tool should include a question about stockpiles.

Policies/Regulations/Good Practice

- A question about the consideration of local authority legislation and/municipal bylaws dealing with stormwater, water supply and effluent should be included as a requirement of GN 704.
- Development of emergency response plans is a requirement of Regulation GN 704 (section 2), NEMA (section 30), National Water Act (section 20).

Water infrastructure asset management

- New infrastructure design and upgrading/expansion should take into consideration EIA Regulations listing notice 1 of 2014 in Appendix 1.

Finances

- The question about investigation of cost implications of water use and disposal should come before the one about financial provision.

Mine closure and rehabilitation

- There is a need for a final performance assessment that ensures that all residual environmental impacts have been identified, quantified and arrangements for the management thereof have been addressed.
- An application for a closure certificate is required in terms of MPDR (55) Regulations.
- Cost estimates and financial provision for closure and post closure management should be made.

5.1.6.4 Mine water course

From the 9-11 May 2016, Warren Retief and Unathi Jack attended the mine water short course that was held in Pretoria. The course was offered by Professor Christian Wolkersdorfer of Tshwane University of Technology. Below is the course programme.

SCHEDULE – FROM GROUND WATER TO MINE WATER

Start	End	May 11, 2016	May 12, 2016	May 13, 2016
9:00	9:45	Introduction & History	Mine Water Geochemistry	Meeting in eMalahleni
9:45	10:30	Technical Terms	Mine Water Geochemistry	Mine Water Sampling
10:30	11:00	Break	break	Mine Water Sampling
11:00	11:45	Technical Terms	Mine Water Geochemistry	Mine Water Sampling
11:45	12:30	Water and Water Inrushes	Prediction of Mine Flooding	Mine Water Sampling
12:30	14:00	lunch	lunch	Mine Water Sampling
14:00	14:45	Dewatering; Recharge	Mine Water Treatment	Mine Water Sampling
14:45	15:30	Dewatering; Recharge	Mine Water Treatment	Mine Water Sampling
15:30	15:45	Break	break	Mine Water Sampling
15:45	16:30	Mine Flooding	Mine Water Treatment	Mine Water Sampling
16:30	17:15	Mine Flooding	Mine Water Treatment	End of Course

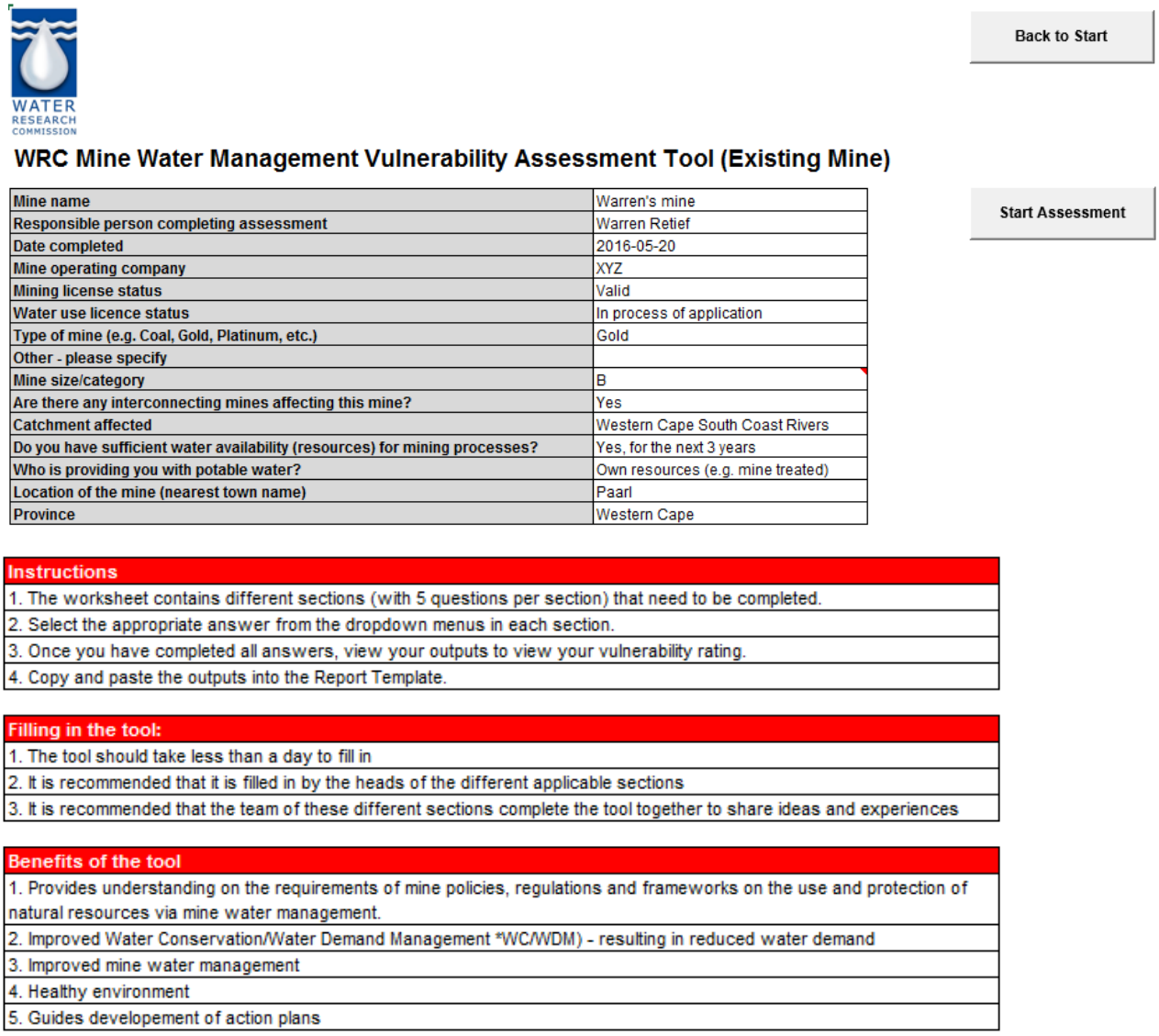
The course was attended by approximately 50 candidates from different countries and fields/departments (including academic institutions, Department of Agriculture, Council of Geoscience, consultants, laboratories, Department of water and Sanitation and mines). The tool was not piloted, however the project team noted some aspects to be considered within the tool. Discussions were held by the project team and the Professor about the tool based on the hard copy printout provided.

5.1.7 Third draft tool

Considering the comments and feedback from the consultations presented above, and the second reference group comments, the following key refinements were made.

5.1.7.1 Introduction section

- The introduction section in each of the phases, where generic information about the mine is captured, was extended to capture additional details (e.g. resource water availability, interconnecting mines, etc.). In addition to this, more guidance on filling in the tool and benefits have been provided as shown in the screenshot examples below.



Back to Start

WRC Mine Water Management Vulnerability Assessment Tool (Existing Mine)

Start Assessment

Mine name	Warren's mine
Responsible person completing assessment	Warren Retief
Date completed	2016-05-20
Mine operating company	XYZ
Mining license status	Valid
Water use licence status	In process of application
Type of mine (e.g. Coal, Gold, Platinum, etc.)	Gold
Other - please specify	
Mine size/category	B
Are there any interconnecting mines affecting this mine?	Yes
Catchment affected	Western Cape South Coast Rivers
Do you have sufficient water availability (resources) for mining processes?	Yes, for the next 3 years
Who is providing you with potable water?	Own resources (e.g. mine treated)
Location of the mine (nearest town name)	Paarl
Province	Western Cape

Instructions
1. The worksheet contains different sections (with 5 questions per section) that need to be completed.
2. Select the appropriate answer from the dropdown menus in each section.
3. Once you have completed all answers, view your outputs to view your vulnerability rating.
4. Copy and paste the outputs into the Report Template.

Filling in the tool:
1. The tool should take less than a day to fill in
2. It is recommended that it is filled in by the heads of the different applicable sections
3. It is recommended that the team of these different sections complete the tool together to share ideas and experiences

Benefits of the tool
1. Provides understanding on the requirements of mine policies, regulations and frameworks on the use and protection of natural resources via mine water management.
2. Improved Water Conservation/Water Demand Management *WC/WDM) - resulting in reduced water demand
3. Improved mine water management
4. Healthy environment
5. Guides developement of action plans

Figure 7: Tool introduction section example

5.1.7.2 Assessment section

The tool was adjusted to consider 3 stages of mining, namely:

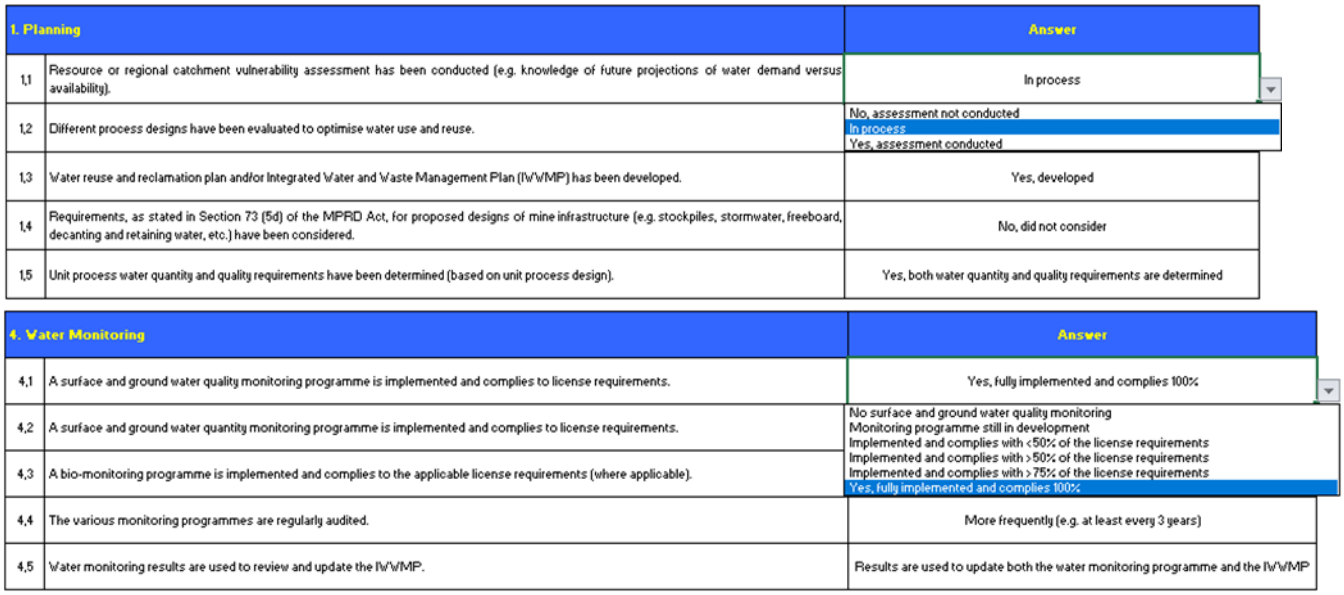
1) New Mines (prospecting stage)
   - New mines in this study refer to the mines that are not yet operational, however in their development stage (past the exploration stage).
2) Operating Mines (operating mines)
   - Operating mines refer to the mines that have started operations, that is, have moved up to the active mining stage. These mines include:
     - Mines that are operating at their full capacity, or
     - Mines that are in their early stages of operation or approaching closure, therefore operating at less than 100 percent of their capacity.
3) Closing Mines (mines approaching closure or have just closed)
   - Closing mines refer to the mines that are approaching the closure stage or in the process of closing.

The three stages of mines consider categories that are applicable for each stage as indicated below:

New Mines	Existing mines	Closing mines
Planning	Planning	
Policies/Regulations/Best Practice	Policies/Regulations/Best Practice	Policies/Regulations/Best Practice
	Mining Process	
	Water Monitoring	Water Monitoring
	Wastewater Management	
	Human Resources	
Infrastructure Asset Management	Infrastructure Asset Management	Infrastructure Asset Management
	Water Conservation and Water Demand Management	
Finances	Finances	Finances
	Mine Closure	Mine Closure

Depending on the stage of mining, the questions in the tool categories are different for the assessments. This means that, the questions in each stage are different, even though the categories title are the same.

- The tool answers were reviewed and made relevant to each question. That means, each question has a range of possible answers that the user can choose from (which are not generic for all questions) as shown in the screenshot example below.



1. Planning		Answer
1,1	Resource or regional catchment vulnerability assessment has been conducted (e.g. knowledge of future projections of water demand versus availability).	In process
1,2	Different process designs have been evaluated to optimise water use and reuse.	No, assessment not conducted In process Yes, assessment conducted
1,3	Water reuse and reclamation plan and/or Integrated Water and Waste Management Plan (IWWMP) has been developed.	Yes, developed
1,4	Requirements, as stated in Section 73 (5d) of the MPRD Act, for proposed designs of mine infrastructure (e.g. stockpiles, stormwater, freeboard, decanting and retaining water, etc.) have been considered.	No, did not consider
1,5	Unit process water quantity and quality requirements have been determined (based on unit process design).	Yes, both water quantity and quality requirements are determined

4. Water Monitoring		Answer
4,1	A surface and ground water quality monitoring programme is implemented and complies to license requirements.	Yes, fully implemented and complies 100%
4,2	A surface and ground water quantity monitoring programme is implemented and complies to license requirements.	No surface and ground water quality monitoring Monitoring programme still in development Implemented and complies with <50% of the license requirements Implemented and complies with >50% of the license requirements Implemented and complies with >75% of the license requirements Yes, fully implemented and complies 100%
4,3	A bio-monitoring programme is implemented and complies to the applicable license requirements (where applicable).	
4,4	The various monitoring programmes are regularly audited.	More frequently (e.g. at least every 3 years)
4,5	Water monitoring results are used to review and update the IWWMP.	Results are used to update both the water monitoring programme and the IWWMP

The output is presented in a “spider diagram” (radar chart) and tabular format (in a spreadsheet-based version) for each mining stage.

5.1.7.3 Output section

Based on the response, a vulnerability level per category is calculated and the results are displayed via a “spider diagram” or table format (see examples below). The output for new or closing mines will include only the categories applicable to them, whilst the existing mine output will include all 10 categories (see examples below).

The legend at the bottom of the figure below indicates how the vulnerability status is presented.

Table 8: Mine Water Vulnerability Assessment Output example (Operating Mine)

Mine Water Management Vulnerability Rating	Vulnerability Status
1. Planning	Extreme Vulnerability
2. Policies / Regulations / Good Practise	Low Vulnerability
3. Mining Processes	Extreme Vulnerability
4. Water Monitoring	High Vulnerability
5. Wastewater Management	Moderate Vulnerability
6. Human Resources	Low Vulnerability
7. Water Infrastructure Asset Management	Low Vulnerability
8. Water Conservation and Demand Management	Low Vulnerability
9. Finances	High Vulnerability
10. Mine Closure and Rehabilitation	Extreme Vulnerability
Overall Status	Moderate Vulnerability

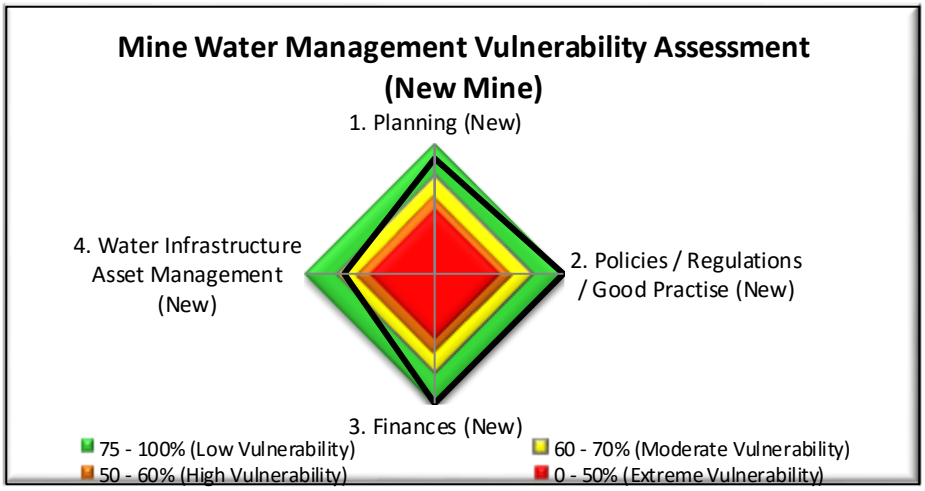


Figure 8: Mine Water Vulnerability Assessment Output example (New Mine)

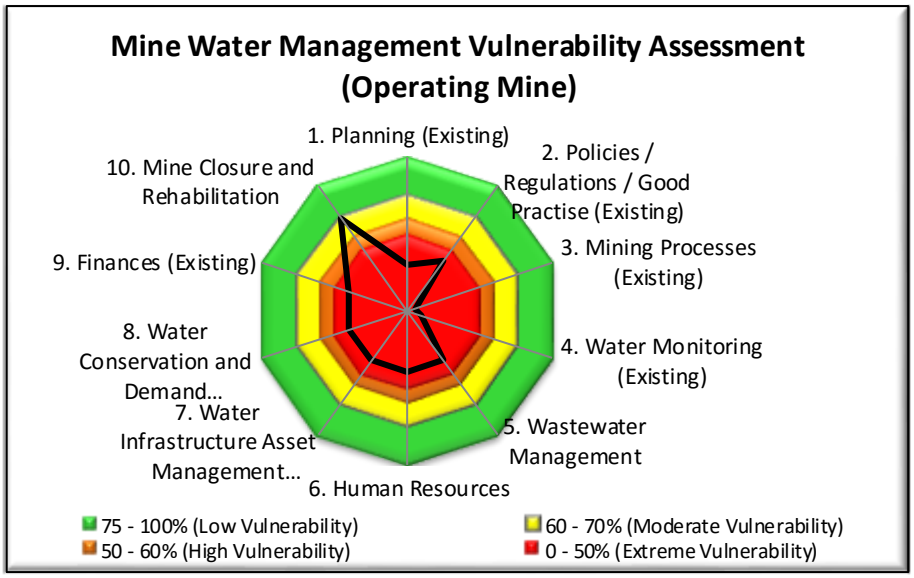


Figure 9: Mine Water Vulnerability Assessment Output example (Operating Mine)

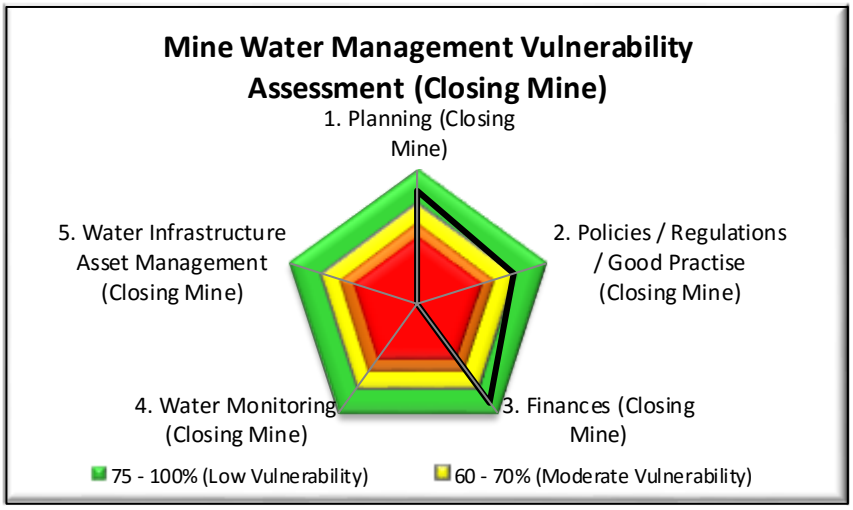


Figure 10: Mine Water Vulnerability Assessment Output example (Closing Mine)

5.1.8 Third draft tool refinements

5.1.8.1 Department of Water and Sanitation

The third draft tool was sent by e-mail to different sections in the Department of Water and Sanitation head office. The policy research and monitoring and evaluation team sent their feedback to the project team. The feedback provided was as follows:

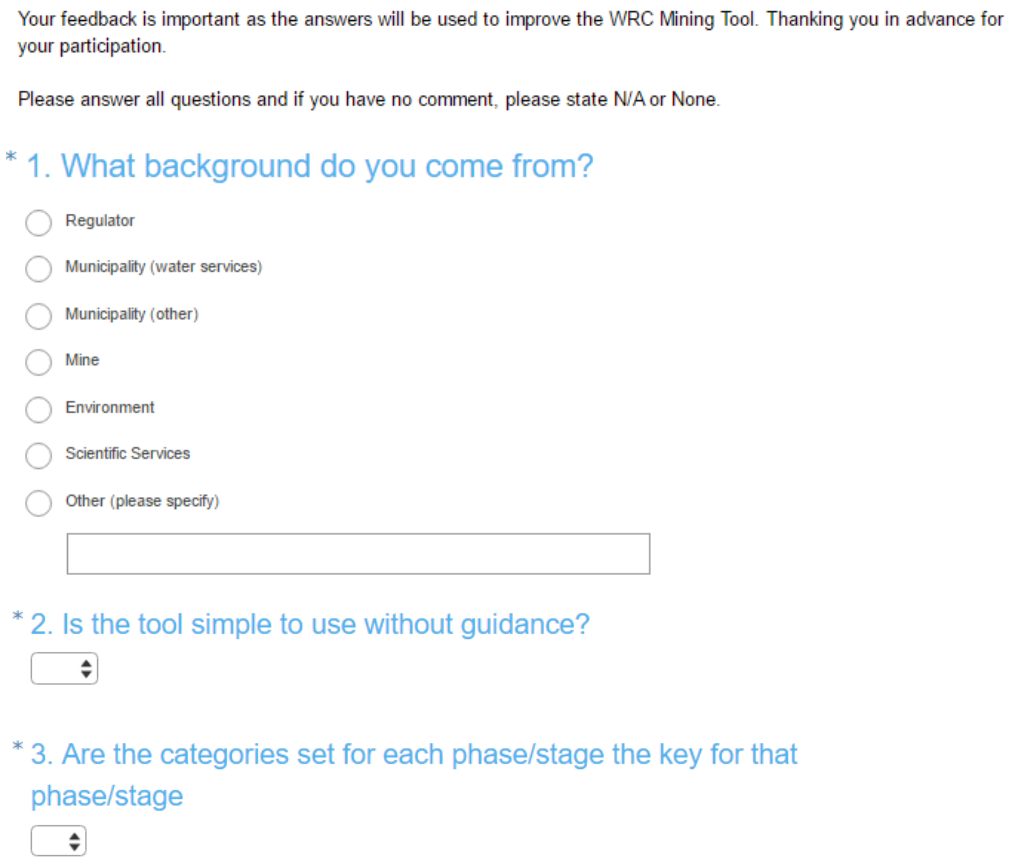
- The tool should be aligned to the “one environmental system”.
- The category of “new mine” should also include questions/aspects relating to the prospecting stage.
- The question on impact prediction should also cover the cost benefit analysis for new mines as will be a requirement in terms of the draft mine water management policy.
- Interventions on “action plan” should be specific to areas of high vulnerability (i.e. where the indicator is green, it means no intervention required).

- Verify if possible to link the tool to the “Mining Atlas” as developed by WRC.

5.1.8.2 Survey Monkey

The question that were asked in the survey required one or a combination of the following kind of responses (as shown in the screenshots below):

- A yes/no
- A multiple choice
- Explanation from the user



Your feedback is important as the answers will be used to improve the WRC Mining Tool. Thanking you in advance for your participation.

Please answer all questions and if you have no comment, please state N/A or None.

* 1. What background do you come from?

- Regulator
- Municipality (water services)
- Municipality (other)
- Mine
- Environment
- Scientific Services
- Other (please specify)

* 2. Is the tool simple to use without guidance?

* 3. Are the categories set for each phase/stage the key for that phase/stage

* 4. How do you see the tool assisting the user?

- [ ] Improving operations
- [ ] Improving understanding of mine setup
- [ ] Improving water management
- [ ] Improving water conservation
- [ ] No assistance
- [ ] Other (please specify or state N/A or None)

* 5. How do you see the results of the tool being used?

- [ ] Reporting to mine management
- [ ] Reporting to the Regulators
- [ ] Progress tracking
- [ ] Benchmarking (comparison between similar mines)
- [ ] Other (please specify or state N/A or None)

* 6. What issues could hinder implementation of the action plan?

* 7. Are there any confusing / inappropriate questions (not making sense)? (specify which one and suggest how to ask it)

* 8. Are there any questions that you would like to add?

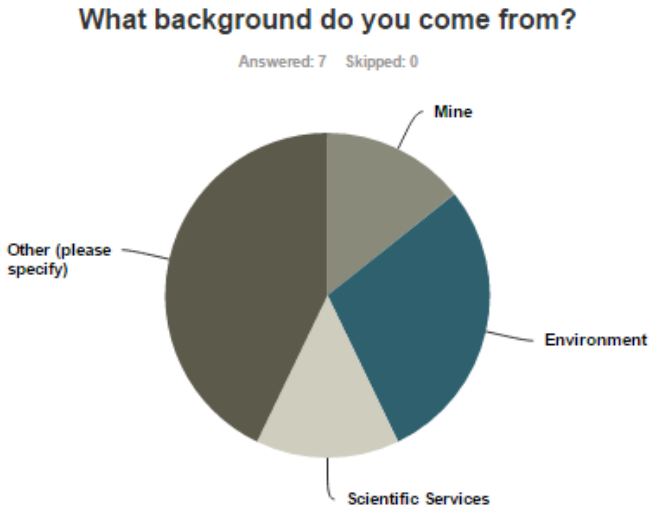
* 9. Are there any questions that you would suggest should be taken out?

* 10. Are there any issues that have been overlooked/not addressed?

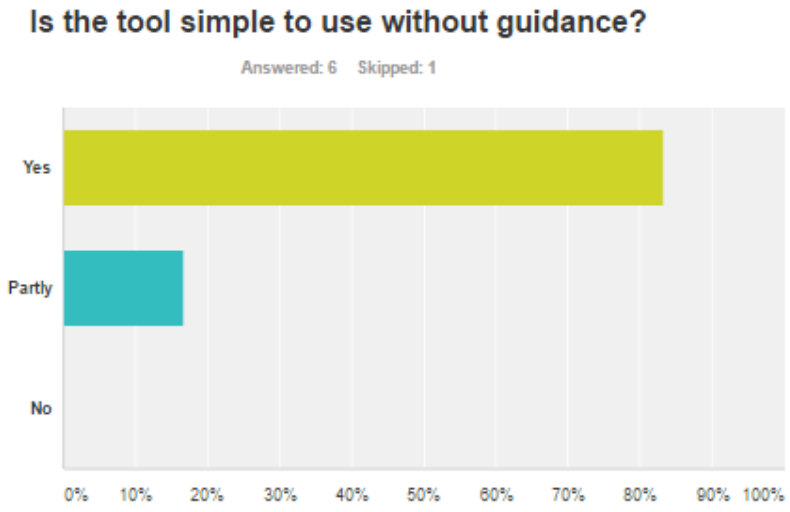
Survey Monkey feedback

Out of the 75 survey requests that were sent, 7 responses were received. The survey results are presented below.

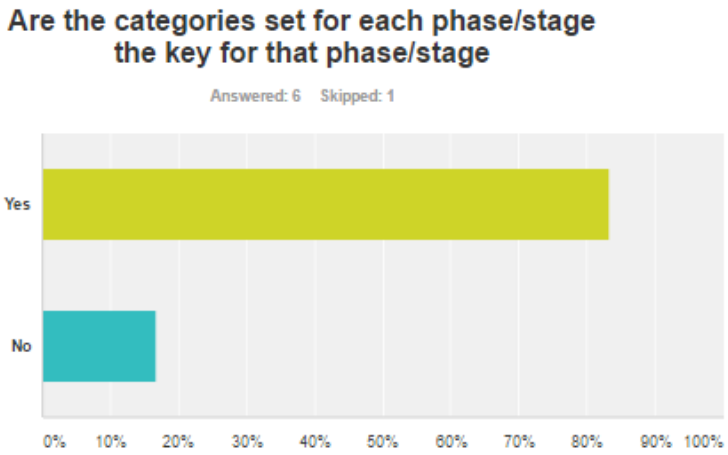
Question 1



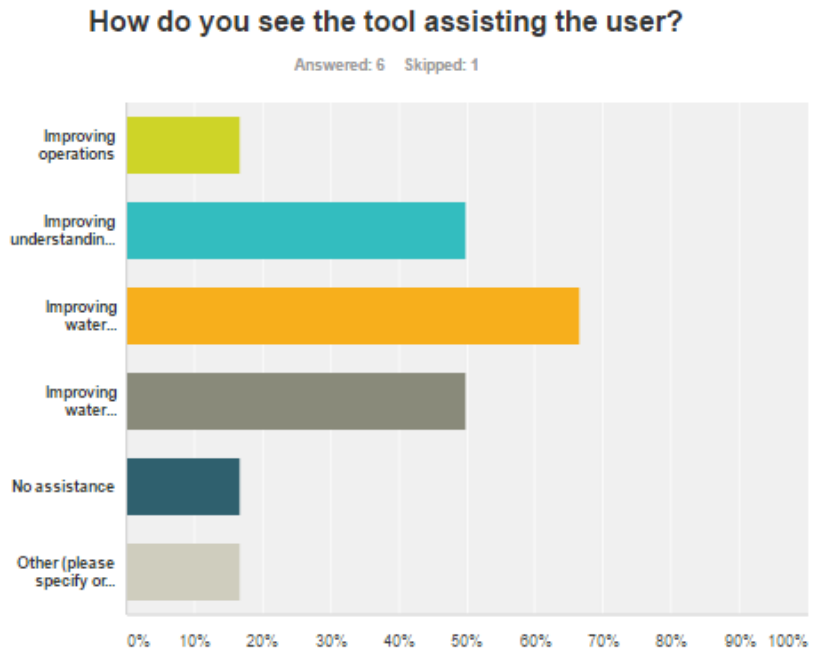
Question 2



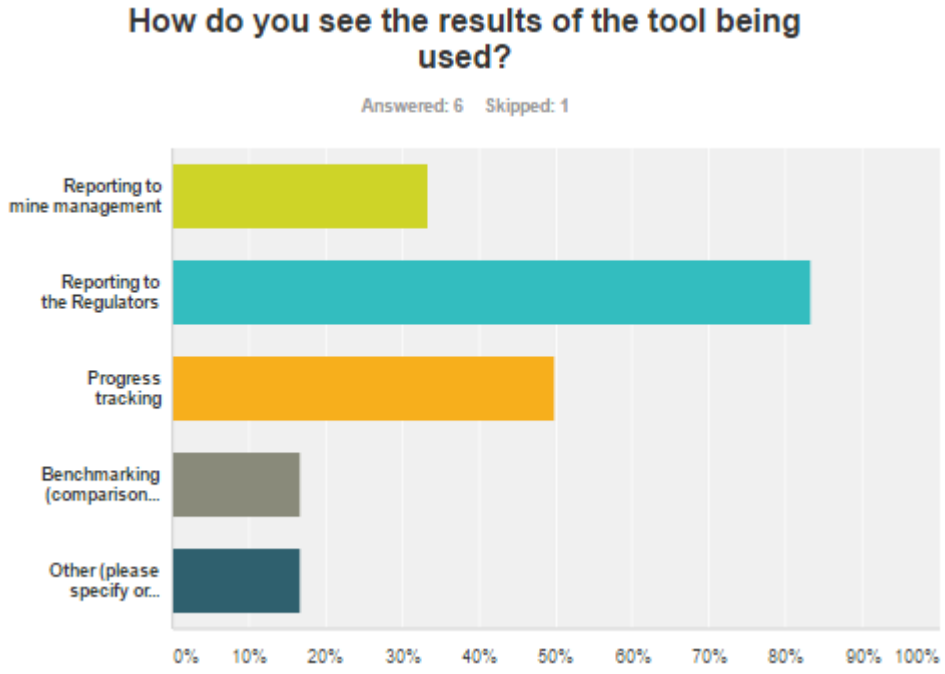
Question 3



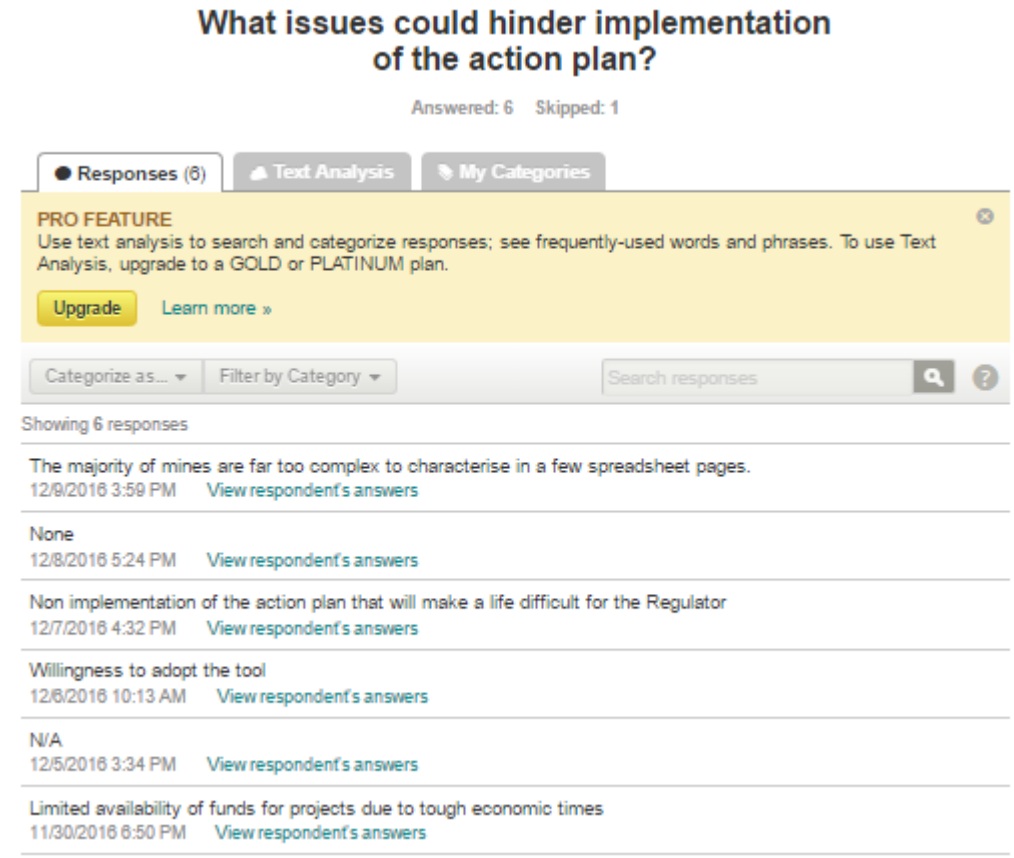
Question 4



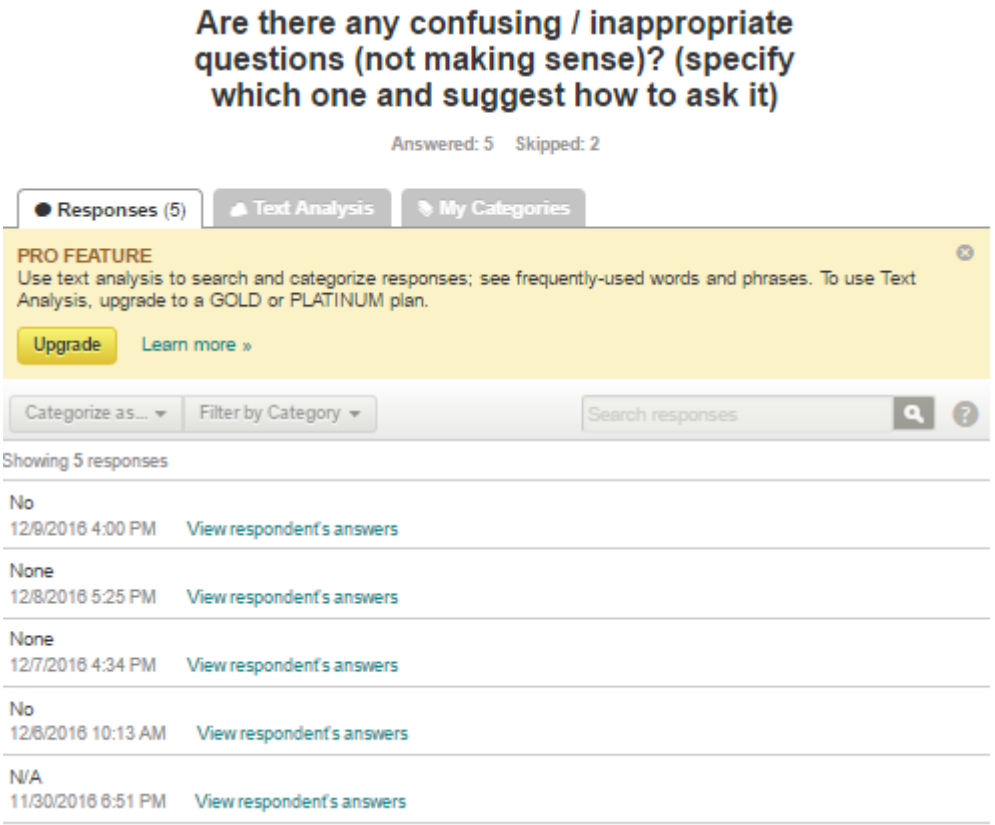
Question 5



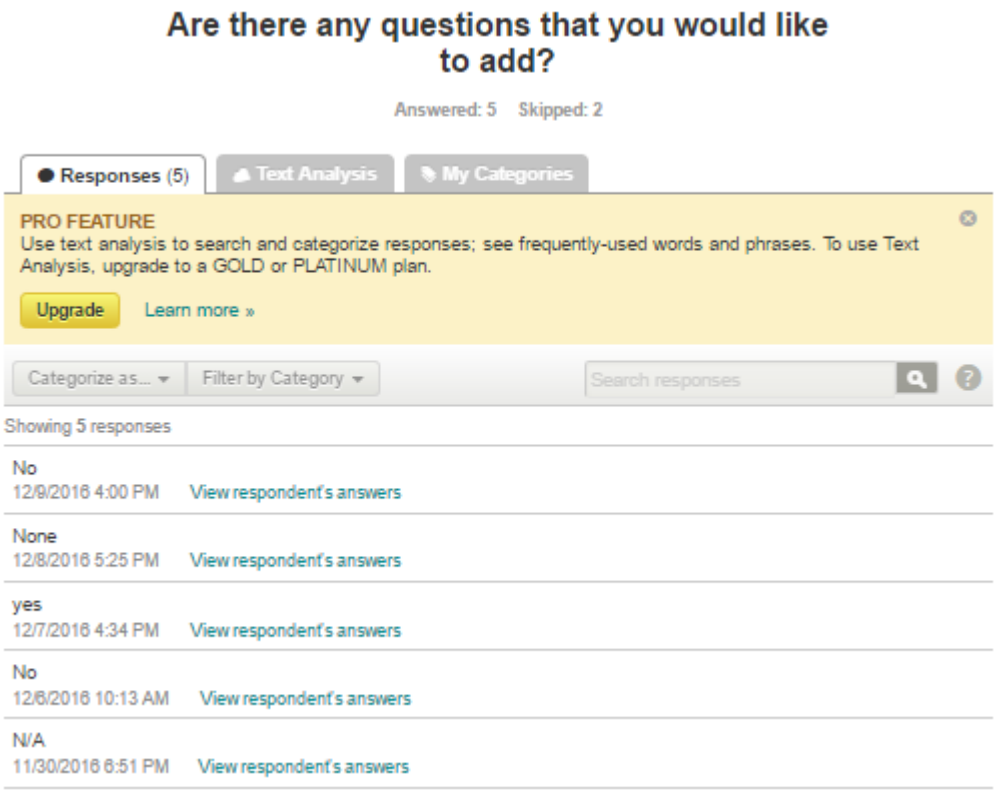
Question 6



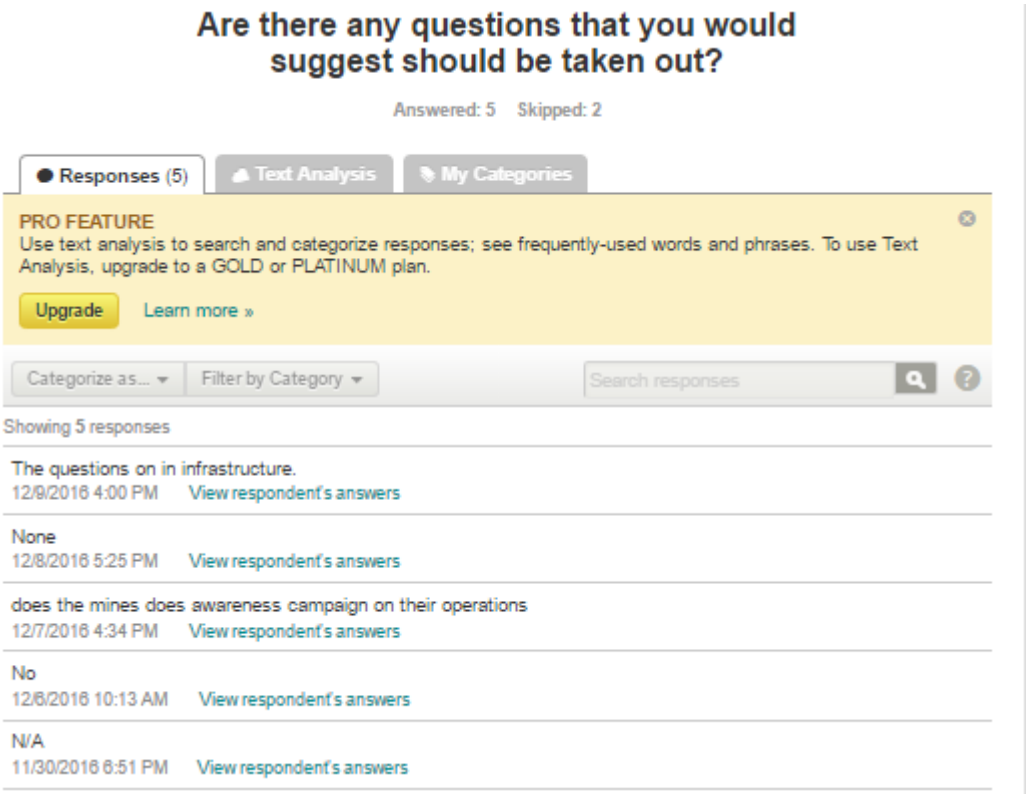
Question 7



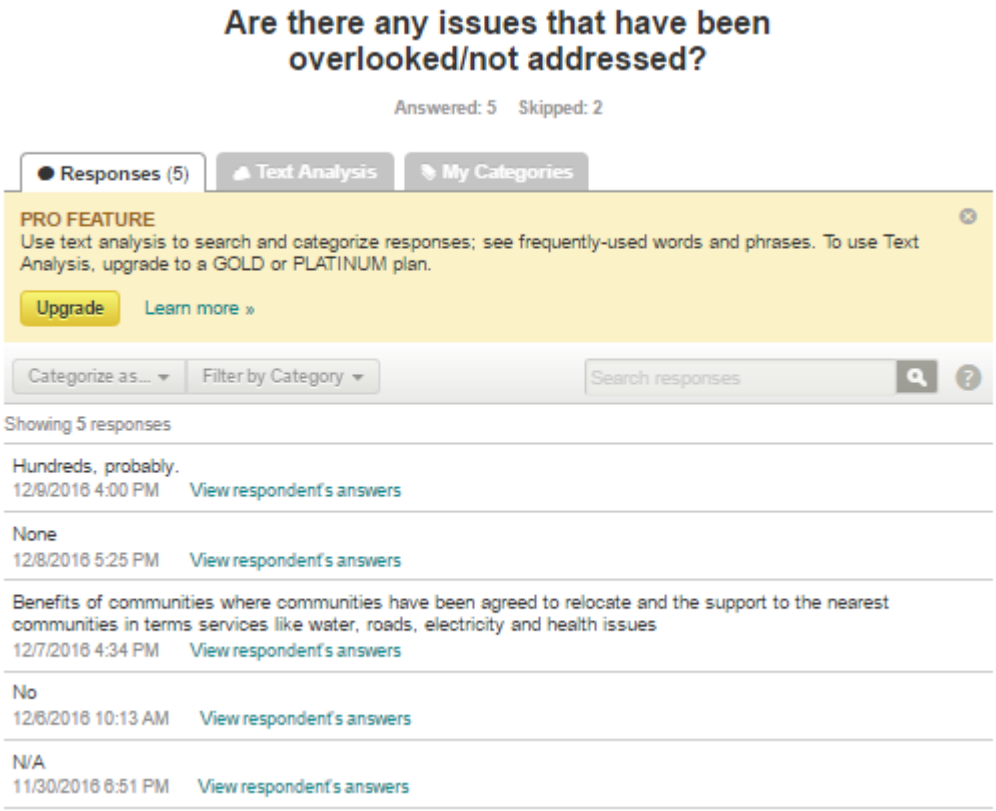
Question 8



Question 9



Question 10



Summary

Considering the feedback provided at different platforms, the following can be noted:

- The tool could be useful for the sector.
- The tool is simple and easy to use
- The tool could be used for a number of reasons (e.g. reporting to the Regulator, tracking progress on the mine water management practices, etc.).
- Despite the potential usefulness of the tool, if the action plan is not implemented, the tool is not effective.
- Economic status may hinder the implementation of the action plan

6. FINAL DEVELOPED MINE WATER VULNERABILITY TOOL DEVELOPMENT (MINE$_{WATER}$)

The project team continuously refined the tool according to the continuous feedback received. Simultaneously, the web enablement of the tool was carried out. A guideline on how to use the tool was developed. Details on how to use the tool are presented in the guideline document. This section provides a summary on the structure and functioning of the web enabled tool.

6.1 Tool categories

The reference group and the mines acknowledged that the ten categories used in the tool are key attributes to mine water management.

Planning This category assesses if the mine (whether new or existing) has effectively and sufficiently planned for mine water management.	**Policies/ Regulation/Good Practise** This category assesses the mine compliance with respect to regulatory and best practice requirements. These are however considered in other listed categories.
Mining processes This category assesses if the mine adequately practices mine water management in all stages/phases of mining.	**Water monitoring** This category assesses whether this requirement is addressed. It also assesses if the information gathered is used to address identified issues.
Wastewater management This category assesses if the water containing waste from the mine is appropriately managed.	**Human resources** This category assesses if the mine has sufficient people with the required skills for mine water management.
Infrastructure asset management This category assesses if appropriate and effective infrastructure asset management is practised.	**Water conservation and demand management** This category assesses if the mine practices effective and appropriate water conservation methods.
Finance This category assesses if the mines' financial management covers mine water management aspects.	**Mine closure** This category assess if environmental management, during and after mine closure, has been prepared for.

6.2 Questions and answers to tool categories

Five key questions, related to the categories presented above, were identified under each of the ten categories. Each question has a range of possible answers that the user can choose from. As mentioned

earlier that the tool considers three phases/stages of mining; each phase considers categories that are most relevant. This means that the ten categories are not found in all the mining phases. Also, the categories that are commonplace to the three phases of mining may not contain exactly the same questions. This is because the questions are structured to understand issues at that particular phase.

6.3 Tool vulnerability calculation

Each answer to the question is allocated a score. The more negative answers are allocated the lowest scores, whilst the more positive answers are allocated the highest score. This means that the maximum score for each section is 5 (i.e. five questions x 1-maximum score). A percentage vulnerability score is calculated according to the score obtained from the total score. The percentage vulnerability score is calculated for each category by dividing the acquired score in that category by the maximum score (5) and multiply that by 100. Therefore a higher score and/or percentage is an indication of low vulnerability and the lowest score and/or percentage is an indication of increased vulnerability.
Tool categories have the same weighting. This is due to the understanding from mines that all categories are equally important. That is, if one category is not properly managed, it will definitely affect the others.

Table 9: Vulnerability status calculation example

Individual Vulnerability Rating	Score	Max	Vulnerability Scoring
1. Planning	2.50	5	**50%**
2. Policies / Regulations / Good Practise	5.00	5	**100%**
3. Mining Processes	1.25	5	**25%**
4. Water Monitoring	2.80	5	**56%**
5. Wastewater Management	3.50	5	**70%**
6. Human Resources	4.00	5	**80%**
7. Water Infrastructure Asset Management	4.25	5	**85%**
9. Finances	2.75	5	**55%**
8. Water Conservation and Demand Management	4.25	5	**85%**
10. Mine Closure and Rehabilitation	2.00	5	**40%**

6.4 Tool output

Based on the response, a vulnerability level per category is calculated and the results are displayed via a "spider diagram" or table format. The output for new or closing mines will include only the categories applicable to them, whilst the existing mine output will include all 10 categories as presented in section 5.1.7.3. The legend at the bottom of the figure below indicates how the vulnerability status is presented.

6.5 Action plan development

An effective action plan is based on the following planning phases,

1. Analysing the current situation via the vulnerability assessment.
2. Deciding where the mine wants to be, and strategizing the approaches on how to get there via the action plan.
3. Setting of actions required to achieve the strategic approaches, via the action plan.

It was decided that an effective plan should contain the following five characteristics;

- There must be a logical connection between the indicator raised and the proposed strategic approach,
- Each strategic approach must be actionable, specific, realistic, time bound and achievable,
- Where the strategic approach requires capital input, this must be indicated and included into future budgetary revisions,
- Strategies must be prioritized, highlighting those that yield the greatest impact with the minimum cost implication,
- The strategy prioritization must be guided by approved budget allocations and supply chain management requirements.

7 CONCLUSIONS AND WAY FORWARD

- Users should consider the summarised findings from the assessment and consider the present and possible/likely future conditions related to the aspects considered. The decision should be made based on these together with the aspects mentioned in section 1.
- Outputs from the tool can easily be copied/pasted into a planning report.
- It is recommended that should the conditions change, a review of the tool be conducted.
- A need to profile and train users in the use of the tools may be necessary. This may be done by conducting workshops and/or one-on-one training sessions depending on the nature of the area.
- It was suggested that different knowledge transfer options can be pursued and/ or targeted for the application of the tool (e.g. WISA conference, SETA, IMWA conference, mine water co-ordinating body).

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www.riskq.co.za to access the $MINE_{WATER}$ tool.

APPENDIX

DRAFT AGENDA

MINE WATER MANAGEMENT EXPERTS DISCISSION MEETING

VENUE: G18, EMANZINI BUILDING , PRETORIA, 171 FRANCIS BAARD STREET(FORMER SCHOEMAN)

DATE: 07 SEPTEMBER 2015

TIME: 09H00 - 14H00

CHAIRPERSON: Mr. Anil Singh – DDG WATER SECTOR REGULATION

	ITEM	RESPONSIBILITY
	MORNING TEA	
09h00 - 09h10	**Welcome Purpose, Apologies and Agenda confirmation/addition**	**Chairperson**
09h10 - 09h30	Status quo on Acid Mine Drainage and current interventions	Chief Director: Mine Water Management: **Mr. M Keet**
09h30 - 10h00	**Draft Mine Water Management Policy Positions Overview**	Chief Director: Water Policy: **Ms M Brisley**
10h00 - 12h30	Discussion, inputs and proposal on the policy document.	**All**
12h30- 13h00	Way Forward and closure	**Chairperson**
13h00	**LUNCH**	**All**

Grootdraai Dam forum meeting draft agenda

AGENDA
GROOTDRAAI DAM FORUM

Tuesday 24 November 2015
10:00 – 13:00

1	Welcome	Chairperson
2	Introduction of Attendees	All
3	Apologies	All
4	Minutes of the Previous Meeting	All
5	Matters Arising from the Previous Minutes	All
6	Additions to the Agenda 6.1 _____ 6.2 _____ 6.3 _____ 6.4 _____ 6.5 _____	All
7	Items for discussions Water Quality Monitoring and Assessment 7.1 Rand Water 7.2 DWS 7.3 DWS Solid Waste Management 7.4 CME	
8	Catchment Activities – Feedback from Stakeholders 8.1 Tutuka Power Station 8.2 Camden Power Station 8.3 Majuba Power Station 8.4 Majuba Railway Line Project 8.5 New Denmark Colliery 8.6 Golfview and Leliefontein 8.7 Msobo Coal (Spitzkop and Tselentsi) 8.8 Mashala Resources / Penumbra Coal Mining 8.9 Mooiplaats Colliery 8.10 Umlabu Coal Mine 8.11 Vuyasa Coal Mine 8.12 Thutsi Colliery 8.13 Imbabala Coal Mine 8.14 Govan Mbeki Municipality 8.15 Gert Sibande Municipality 8.16 Msukaligwa Municipality 8.17 Pixley ka Seme Municipality 8.18 Lekwa Municipality 8.19 DMR 8.20 DARDLEA	
9	Water Use License Status	DWS
10	Pollution Incidents	All
11	Waste Water Treatment Works Task Team	DWS
12	CMA Process	DWS
13	Discussion of Additions to the Agenda	All
14	Date of Next Meeting	Chairperson
15	Closure	Chairperson