

INAP'S GLOBAL ACID ROCK DRAINAGE GUIDE AND THE CURRENT STATE OF ACID ROCK DRAINAGE ASSESSMENT & MANAGEMENT IN SOUTH AFRICA

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ABSTRACT

Acid rock drainage (ARD) is arguably one of the greatest threats to the sustainable development of South Africa's mineral wealth. Current impacts from ARD are experienced at both local and regional scales and cause significant deterioration in the quality of scarce water resources. Internationally, research into the process of ARD formation and methods to minimise its impacts has been conducted for over 50 years, resulting in a considerable body of scientific and engineering guidance and knowledge on ARD. Recently, the International Network for Acid Prevention (INAP) has consolidated the available information and produced a Global ARD Guide (GARD Guide) that summarises the best technical and management practices with the objective of creating a body of work with high industry and external stakeholder credibility. The GARD Guide aims to assist the industry in providing high levels of environmental protection, assists governments in the assessment and regulation of affairs under their jurisdiction, and enables the public to have a higher degree of confidence in the and understanding of acid prevention plans and practices. In addition, this paper further aims to provide a comparison of current ARD assessment and management practices in South Africa to the best practices outlined in the GARD Guide and illustrate how the GARD Guide can be used to further improve ARD management in South Africa.

1. INTRODUCTION

Although pre-European mining in South Africa dates back 2000 years, it was the discovery of gold and diamonds in the mid to late 1800s which started large-scale mining in South Africa. Mining of gold, platinum, diamonds and coal took place on a regional scale, and many examples exist of occurrences of acid rock drainage (ARD) associated with current and historical (abandoned) mines in these sectors. ARD from the mining industry in South Africa has also recently featured a number of times in the media due to its current and potential impact on regional water resources. Examples include the decant of mine water from the Western Basin in the Witwatersrand gold fields into the Tweelopiesspruit, threatening a world heritage site, decant of mine water from a number of operating and abandoned coal mines in the Olifants River catchment affecting water resources for downstream water users, and decant from operating and abandoned gold and coal mines in the Vaal River catchment affecting the water resources for many downstream water users.

Internationally, research into the process of ARD formation and methods to minimize its impact have been ongoing for more than 50 years. As such, there is a considerable scientific and engineering guidance available on ARD through organizations such as International Network for Acid Prevention (INAP), Mine Environment Neutral Drainage (MEND), the British Columbia Ministry of Energy, Mines and Petroleum Resources (BC MEMPR), Acid Drainage Technology Initiative (ADTI), the Australian Centre for Minerals Extension and Research (ACMER), the South African Water Research Commission (WRC), the South African Department of Water Affairs and Forestry (DWAf), the Partnership for Acid Drainage Remediation in Europe (PADRE), and other programs. However, this research is generally available through disparate references and is not easily accessible.

Recently, the International Network for Acid Prevention (INAP) consolidated the available information and produced a Global ARD Guide (GARD Guide) that summarises the best technical and management practices with the objective of creating a body of work with high industry and external stakeholder credibility. The GARD Guide aims to assist the industry in providing high levels of environmental protection, assists governments in the assessment and regulation of affairs under their jurisdiction, and enables the public to have a higher degree of confidence in the and understanding of acid prevention plans and practices.

2. OBJECTIVES OF THE GARD GUIDE

The Global Acid Rock Drainage Guide (INAP, 2009) or GARD Guide aims to summarize the best technical and management practices to create a body of work with high industry and external stakeholder credibility. It assists the industry in providing high levels of environmental protection, assists governments in the assessment and regulation of mining, and enables the public to better understand acid prevention plans and practices. Overall, the guide provides a structured system to identify and catalogue proven techniques for characterization, prediction, monitoring, treatment, prevention and management of ARD.

The GARD Guide is a technical document designed primarily for a scientist or engineer with a reasonable background in chemistry and the basics of engineering with little specific knowledge of ARD. The principal user will typically be an employee of the mining industry, regulatory agency, research organization, non-governmental organization (NGO) or consulting company.

The GARD Guide has been prepared as a road map through the process of evaluating, planning, design, and management of ARD over the life cycle of mining. The GARD guide has also been prepared as a compendium of the concepts, the techniques, and the processes to be considered in successful ARD management over the mine-life cycle. It provides a broad, but not highly detailed, understanding of ARD technologies and management. However, a comprehensive approach to ARD management will be created where the concepts and guidance in the GARD Guide are translated into site-specific actions.

The GARD Guide also aims to provide references to identify more detailed information on ARD for those looking for specifics on ARD technologies and approaches.

The GARD Guide is not a design document; design requires a high level of understanding and site-specific knowledge of a particular project or mine. Detailed design of ARD mitigation techniques will continue to be conducted by knowledgeable practitioners.

The following are specific objectives of the GARD Guide:

1. Articulate the issues associated with sulphide mineral oxidation
2. Improve the understanding of best global practice, customized where necessary for special geoclimatic conditions
3. Promote a risk-based, proactive, consistent approach by encouraging planning for and implementation of reduction and control of ARD at the source
4. Leverage the world's ARD expertise and share expertise with developing countries
5. Support the 'Equator Principles' developed by a consortium of lending institutions and the International Council of Mining and Metal's (ICMM's) objectives by achieving 'global best practice' in future mining projects.

3. SCOPE OF THE GARD GUIDE

The GARD Guide deals with the prediction, prevention, and management of drainage produced from sulphide mineral oxidation, often termed "acid rock drainage" (ARD)¹, "saline drainage" (SD)², "acid mine drainage" or "acid and metalliferous drainage" (AMD), "mining influenced water" (MIW), and "neutral mine drainage" (NMD)³. The GARD Guide also addresses metal leaching caused by sulphide mineral oxidation. While focused on mining, the technology described will be helpful to those practitioners that encounter sulphide minerals in other activities (e.g., rock cuts, excavations, tunnels). Some of the approaches in the GARD Guide are also relevant to issues arising from reactive non-sulphide minerals.

Development of the Global Acid Rock Drainage Guide (GARD Guide) was sponsored by the International Network for Acid Prevention (INAP) with the support of the Global Alliance and started in late 2006. The GARD Guide was created through the contributions of many individuals and organizations. INAP established broad-based Steering and Advisory Committees to direct preparation of the document. A team lead by Golder Associates prepared a draft of the Guide in 2008. INAP also received input from several other contributors, peer reviewers, workshop participants and interested stakeholders. INAP gratefully acknowledges all of this assistance.

There is a considerable body of knowledge on ARD management in the scientific and engineering literature. Many technical documents and guidelines have been produced that summarize certain aspects of the state-of-knowledge and in some cases provide guidelines for managing ARD. In addition, the series of International Conferences on Acid Rock Drainage (ICARD), BC MEND, ACMER, and other conferences regularly review ARD research and management.

¹ ARD characterised by acidic pH, moderate to elevated metals and elevated sulphates.

² SD characterised by near neutral to alkaline pH, low metals and moderate calcium, magnesium and sulphate.

³ NMD characterised by near neutral to alkaline pH, low to moderate metals and low to moderate sulphates.

The ICARD proceedings in particular are valuable summaries of ARD technology and the reader is encouraged to review these proceedings, especially case studies.

4. APPROACH OF THE GARD GUIDE

The GARD Guide approach proceeds from site characterization to preparation, and ultimately implementation of an ARD management plan as depicted in Figure 1. It includes a loop for verification and calibration of predictions and assessments as part of evaluating the performance of the ARD management plan. The approach to ARD management also provides the framework for technical chapters in the GARD Guide and is discussed in the next section of the paper.

ARD management is applied at all phases of a mine from “cradle to cradle” as part of an environmental management system (EMS), which includes a continuous improvement process. (The term “cradle to cradle” characterizes the objective to return land used for mining to biologically productive use after mining is finished.) The ARD management plan is based on technical understanding and knowledge but is defined within corporate policies, government regulations, and community expectations. The ARD management plan is based on site characterization and ARD/NMD/SD prediction science and incorporates engineering measures aimed at ARD prevention and control. Water treatment may be included as a contingency, or as a necessity for existing mines, in the plan.

Implementation of the ARD management plan requires the use of management systems and communication between stakeholders. The plan’s performance is monitored through a range of metrics usually based on evaluation of mine water quality. The overall performance of ARD management is evaluated against site-specific environmental requirements and the criteria established by corporate policies, government standards, and community expectations. In this way, the ARD management process is a continuous loop.

The level of assessment and planning for each phase of mining varies based on the information available, the extent of rock excavation and the potential environmental impact. For example, relatively little disturbance and excavation of rock containing sulphide minerals usually occurs during exploration. However ARD management plans are required for exploration drilling, bulk samples, and test pits/underground workings. A poorly planned exploration drilling program could cause long-term ARD problems through disturbance of the natural groundwater conditions and provision of new vertical flow paths. In addition, site characterization, including ore and waste characterization and ARD prediction, must begin at the start of mineral exploration.

With its potentially wide-ranging and multigenerational consequences, ARD is an important “sustainable development” or “sustainability” issue. Environmental impacts of ARD can be serious and enduring. Depending on where a mine operates, ARD can also impact the well-being of people surrounding the mine, now and in the future.

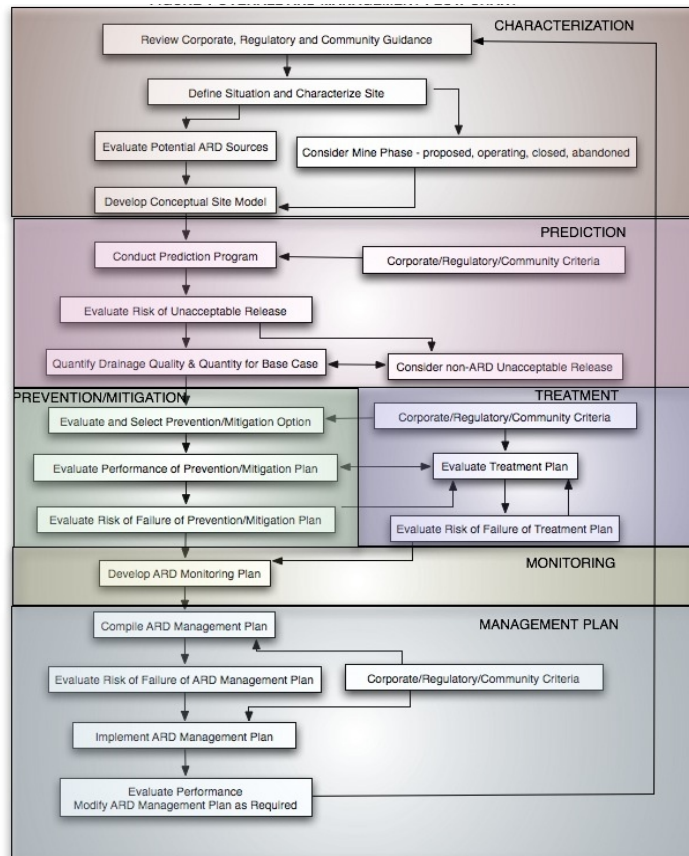


Figure 1. Overall ARD management flow chart

Poor management of ARD not only can harm the environment but poor management can also harm the mining industry’s reputation and communities’ acceptance of individual mining operations. Applying the concept of sustainable development, on the other hand, offers an opportunity to involve multiple stakeholders in ARD management, improve risk management, and optimize the minerals, socioeconomic and business benefits of a mining operation. The Mining and Sustainable Development (MMSD) Project, an effort initiated by nine of the world’s largest mining companies, describes sustainable development as a goal to:

“maximize the contribution to the well-being of the current generation in a way that ensures an equitable distribution of its costs and benefits, without reducing the potential for future generations to meet their own needs” (MMSD, 2002).

In practice, sustainable development requires an integrated, balanced, and responsible approach that accounts for short-term and long-term environmental, social, economic, and governance considerations. These sustainable development considerations were used as guiding principles throughout the Guide.

Gard Guide Organization and Content

The GARD Guide currently has 11 chapters. The chapters are presented in an organized fashion, addressing all aspects related to ARD management while building on each other. The 11 chapters are as follows:

1. Introduction
2. ARD Process
3. Corporate, Regulatory and Community Aspects
4. Characterization
5. Prediction
6. Prevention and Mitigation
7. Treatment
8. Monitoring
9. Management and Performance Assessment
10. Communication and Consultation
11. ARD Management in the future

The contents of each chapter are summarized in the following sections.

Chapter 1 - Introduction

Chapter 1 sets the stage for the GARD Guide by explaining its objectives, introducing the GARD Guide terminology and definitions, and providing general background. The chapter establishes that a comprehensive approach to ARD

management reduces the environmental risks and subsequent costs for the mining industry and governments, reduces adverse environmental impacts, and promotes public support for mining. The chapter also emphasizes that the extent and particular elements of the ARD management approach that should be implemented at a particular operation will vary, based on many site-specific factors, not necessarily limited to the project's potential to generate ARD. Therefore, the Guide alone is not a substitute for specialist involvement, but expert support from multiple disciplines is required for proper ARD management.

Chapter 2 – ARD Process

In this chapter, which is the most technical of the GARD Guide, the process of sulfide oxidation and formation of ARD is summarized. This process is very complex and involves a multitude of chemical and biological aspects that can vary significantly depending on environmental, geological and climate conditions. Since neutralization reactions also play a key role in determining the compositional characteristics of drainage originating from sulfide oxidation, these are also addressed in this chapter, as is metal leaching, which can occur under acidic, neutral, or alkaline conditions.

Chapter 3 - Corporate, Regulatory and Community Aspects

In this chapter, corporate, regulatory, and community aspects related to ARD are identified and summarized. Several examples are provided of corporate guidelines pertaining to ARD management and regulations from around the globe.

The issues and approaches to ARD prevention and management are the same around the world. However, the specific techniques used for ARD prediction, interpretation of ARD test results, and ARD management may differ depending on the local, regional or country context and must also be adapted to climate, topography, and other site conditions. Furthermore, mining companies operate within the constraints of a “social license” that, ideally, is based on a broad consensus with all stakeholders. This consensus tends to cover a broad range of social, economic, and environmental elements (the three pillars of sustainable development) as well as governance elements. ARD plays an important part in the mine's social license because ARD tends to be one of the more visible environmental consequences of mining.

Chapter 4 – Characterization

Environmental concern depends largely on the characteristics of the sources, pathways, and receptors involved. Characterization of these aspects is therefore crucial to the prediction, prevention and management of ARD. Environmental characterization programs are designed to collect sufficient data to answer a number of questions, including:

1. Is ARD likely to occur? What type of drainage is expected?
2. What are the sources of ARD? How much ARD will be generated and when?
3. What are the significant pathways that transport contaminants to the receiving environment?
4. What are the anticipated environmental impacts of ARD release to the environment?
5. What can be done to prevent or mitigate/manage ARD?

To address these questions, Chapter 4 presents the chronology of an ARD characterization program and identifies the data collection activities typically executed during each mine phase, for each source, pathway and receptor, and for individual material types and mine facilities.

Chapter 5 – Prediction

One of the main objectives of site characterization is prediction of ARD potential and drainage chemistry. Because prediction is directly linked to mine planning, in particular with regard to water and mine waste management, the prediction effort needs to be phased in step with overall project planning.

Significant advances in the understanding of ARD have been made over the last several decades, with parallel advances in mine water quality prediction and use of prevention techniques. However, quantitative mine water quality prediction can be challenging due to the wide array of the reactions involved and potentially very long time periods over which these reactions take place. Despite these uncertainties, quantitative predictions that have been developed using realistic assumptions (while recognizing associated limitations) have proven to be of significant value for identification of ARD management options and assessment of potential environmental impacts.

Chapter 5 includes significant guidance on generic, overall approaches for ARD prediction, as well as considerable detail regarding individual geochemical testing methods and modeling techniques.

Chapter 6 – Prevention and Mitigation

The fundamental principle of ARD prevention is to apply a planning and design process to prevent, inhibit, retard, or stop the hydrological, chemical, physical, or microbiological processes that result in the impacts to water resources. Prevention should occur at, or as close to, the point where the deterioration in water quality originates (i.e. source reduction), or through implementation of measures to prevent or retard the transport of the ARD to the water resource (i.e. recycling, treatment and/or secure disposal). This principle is universally applicable, but methods of implementation are site specific.

The GARD Guide advocates a risk-based approach to planning and design as the basis for prevention and mitigation. This approach must be applied throughout the mine life cycle. The risk-based process aims to quantify the long-term impacts of alternatives and to use this knowledge to select the option that has the most desirable combination of attributes (e.g., protectiveness, regulatory acceptance, community approval, cost). Mitigation measures implemented as part of an effective control strategy should require minimal active intervention and management.

More than one, or a combination of measures, may be required to achieve the desired objective. Chapter 6 includes an overview of the most common ARD prevention and mitigation measures available during the various stages of the mine-life cycle.

Chapter 7 – Treatment

Sustainable mining requires the mitigation, management, and control of mining impacts on the environment. The impacts of mining on water resources can be long term and persist in the post-closure situation. Mine drainage treatment may be a component of overall mine water management to support a mining operation over its entire life.

The objectives of mine drainage treatment are varied. Recovery and re-use of mine water within the mining operations may be desirable or required for processing of ores and minerals, conveyance of materials, operational use (dust suppression, mine cooling, irrigation of rehabilitated land), etc. A key objective of mine water treatment is often the protection of human and ecological health in cases where people or ecological receptors may come in contact with the impacted mine water through indirect or direct use.

In Chapter 7, an overview of treatment alternatives is presented, including a presentation of information requirements and the benefits and disadvantages of individual treatment techniques.

Chapter 8 – Monitoring

Monitoring is the process of routinely, systematically and purposefully gathering information for use in management-decision making. Mine-site monitoring aims to identify and characterize any environmental changes from mining activities to assess conditions on the site and possible impacts to receptors, and is critical in decision making related to ARD management, for instance through assessing the effectiveness of mitigation measures and subsequent implementation of adjustments to mitigation measures as required.

Chapter 8 presents and discusses the development and components of an ARD monitoring program, including the definition of monitoring objectives, the design and implementation of a monitoring program, the evaluation of monitoring results, and the use of feedback systems to ensure that the monitoring program meets its intended objective.

Chapter 9 – Management and Performance Assessment

Chapter 9 focuses on ARD management and performance assessment, the various aspects of which are commonly embodied in an ARD management plan. The need for a formal ARD management plan is usually triggered by the results of an ARD characterization and prediction program or the results of site monitoring. The ARD management plan identifies the materials and mine wastes that require special management. Risk assessment and management are included in the plan to refine strategies and implementation steps. To be effective, the ARD management plan must be fully integrated with the mine plan. Operational controls such as standard operating procedures, key performance indicators, and quality assurance/quality control programs are established to guide its implementation. The ARD management plan identifies roles, responsibilities and accountabilities for mine operating staff. Data management, analysis and reporting schemes are included to track progress of the plan. Throughout the GARD Guide, it is stressed that the development, assessment and continuous improvement of an ARD management plan are a continuum over the entire life of a mine.

Chapter 10 – Communication and Consultation

The level of knowledge of ARD generation and mitigation has increased dramatically over the last few decades within the mining industry, academia, and regulatory agencies. However, in order for this knowledge to be meaningful to the wide range of stakeholders generally involved with a mining project, it needs to be translated into a form that can be readily understood. This consultation should convey the predictions of future drainage quality and the effectiveness of mitigation plans, their degree of certainty and contingency measures to address uncertainty. An open dialogue on what is known, and what can be predicted with varying levels of confidence, helps build understanding and trust, and

ultimately results in a better ARD management plan.

Communicating and consulting with stakeholders about ARD issues is essential to the company's social license to operate. Due to the generally highly visible nature of ARD, special measures and skilled people are needed to communicate effectively, and the involvement of representatives from all relevant technical disciplines in a mining company may be required. Chapter 10 provides guidelines, "how to" information, and "dos and don'ts" regarding effective communication of ARD-related issues.

Chapter 11 – ARD Management in the Future

This chapter briefly examines the current state and the future of ARD research and management. It begins with a discussion of the relevance and application of sustainable development to ARD management since, today and in the future, ARD management is viewed and managed through a sustainable development "lens". The second section briefly examines the state of research and possible future developments in ARD science and engineering. The final section reviews the roles of the various stakeholders in advancing ARD science and management.

5. COMPARISON OF CURRENT ARD MANAGEMENT PRACTICES IN SOUTH AFRICA TO BEST PRACTICES PRESENTED IN THE GARD GUIDE

This section compares current ARD assessment and management practices in South Africa to those best practices outlined in the GARD Guide. The comparison is not aimed to be comprehensive but rather highlights some of the key differences in practices and opportunities for using the GARD Guide to improve ARD assessment and management in South Africa.

As illustrated in the summary of Chapter 4 of the GARD guide above, the Guide poses five typical ARD-related questions asked during environmental characterization studies, namely:

- Is ARD likely to occur? What type of drainage is expected (ARD/NMD/SD)?
- What are the sources of ARD? How much ARD will be generated and when?
- What are the significant pathways that transport contaminants to the receiving environment/receptors?
- What are the anticipated environmental impacts of ARD release to the environment?
- What can be done to prevent or mitigate/manage ARD?

The same questions are commonly asked during environmental characterization studies conducted in South Africa. However, the data and information which the answers are based on, and hence the manner in which those questions are answered, generally differ compared to the Best Practices in the GARD Guide. The key differences relate to characterization and prediction, prevention, mitigation and treatment, and ARD management.

Characterization and Prediction

There are enough case studies in South Africa demonstrating that sufficient understanding (as described in Chapters 4 and 5) exists of ARD sources, conceptualisation of ARD processes and systems, and general cause and effect relationships across source-pathway-receptor systems. However, current characterisation practices typically fall short in the following aspects:

- Number of samples: Although guidelines exist and are freely available and often quoted, in practice, characterisation studies often fall short of the guidelines provided in the GARD Guide. The reason most often cited is cost. However, a lack of baseline data results in uncertainty. This uncertainty is often not addressed according to the guidelines, nor effectively communicated and reported. Furthermore, this uncertainty hinders decision making regarding ARD management and mitigation measures leading to long decision-making processes.
- According to the GARD Guide, site characterisation is a process that takes place from the start of a project across all its life cycles, resulting in ever-increasing knowledge of the site characteristics. Current practice in South Africa focuses mostly on the planning phase, where typically static and kinetic geochemical test work are done with some degree of prediction/modelling. Activities during the operating phases tend to be limited and only when closure is contemplated, is there activity again to develop further site understanding. However, the operating phase provides the best opportunity to develop time-related data and the understanding that is required (but often lacking) for closure planning. This lack of time-dependent data at closure makes prediction of future mine water qualities difficult and uncertain, further complicating the authorisation of closure and transfer of liability.

Both these aspects, in particularly the latter, provide an excellent opportunity for mine operators to develop the required time dependant data during the operational phases of mining projects to better position mine operations for the closure phase. It is important that the designs and operating manuals for mine waste facilities and mine workings incorporate the necessary methods and monitoring protocols for the required temporal data. One example is the development of instrumented field plots to measure and record ARD rates of mine wastes during the operating phase of the facility. This data will make future prediction of impacts and the effectiveness of rehabilitation measures after closure much more accurate, further providing more credible data for the closure regulatory and negotiation processes.

As far as prediction is concerned, the following key differences are noted:

- Practitioners utilise most of the required static geochemical (mineralogy, whole rock, acid potential, neutralisation potential, short term leach) and kinetic geochemical (humidity cells) tests available from commercial laboratories in South Africa in their prediction programs. Results are compared with international standards and classification systems. However, these standards tend to focus on the potential of material to generate acidity and do not consider salinity which, in a water-scarce country, such as South Africa, is an additional consideration when classifying the ARD potential of material to impact on water resources. It should also be noted that analytical results generated by South African laboratories do not always meet international quality assurance/quality control (QA/QC) standards.
- Perhaps not only unique to South Africa is the general lack of (field) verification and calibration of model predictions. Although practitioners generally would make recommendations for verification and calibration, very limited implementation of these recommendations take place. This is particularly pertinent to predictions of potential impacts, which are typically developed during the planning phase of projects when environmental authorization is required, as mentioned above, but which are not being calibrated or verified subsequently during the operational phase of the project.
- Although geochemical modelling capability exists in South Africa, it is extremely limited compared to the demand for geochemical modelling and understanding. Reasons for this include, at least in part, environmental geochemistry being a relatively specialised and focussed scientific discipline, limited number of local environmental geochemistry graduates (there is currently no focussed undergraduate environmental geochemistry course in South Africa) and the historical “brain drain” experienced in the 1990s in South Africa.

An approach that could address some of the shortcomings of geochemical modelling capability is the use of analogue sites where appropriate. Mineral resources such as coal, platinum and gold occur in settings with similar geology and mineralogy both in South Africa and globally and, due to the long history of mining in South Africa, many examples of operating and closed mines exist to use in the prediction of mine water impacts from ARD. In some cases, abandoned mines provide real life-size kinetic geochemical “tests” that, with the right monitoring, can provide very useful calibration data for similar and associated mines and commodities.

Prevention, Mitigation and Treatment

The GARD Guide promotes the concept of “prevention is better than cure”. Due to the long history of mining in South Africa, most ARD mitigation is re-active and consequently costly. Although planning processes are becoming more oriented towards prevention, the precautionary principle is often strictly applied compared to international practices. This can be seen particularly in the use of engineered barriers for mine residue facilities containing materials with an ARD/NMD/SD potential. Design of modern mine residue disposal facilities in South Africa still tends to use local industry best practices which, for example, have very limited engineered barrier systems (such as liners) compared to international practice, where engineered barrier systems are often incorporated in designs as a precaution to pollution associated with ARD.

The current legacy of ARD in South Africa often feels insurmountable given the vast resources required to effectively mitigate it. However, progress is being made, and one particular ARD mitigation initiative in South Africa that is noteworthy, is the re-mining of old gold tailings facilities in the Witwatersrand gold mining basin. Most of these tailings facilities generate SD (and in some cases ARD) with a significant cumulative salt load to the environment. These tailings facilities are being re-mined and the re-processed tailings deposited on modern, engineered mega tailings facilities that typically incorporate best practices for ARD management.

As far as treatment is concerned, research and development in South Africa has led to significant advances in the treatment of ARD. South Africa developed world leading technologies in active treatment systems, in particular neutralization using limestone, sulphate removal using sulphate reducing technology, and mine water desalination technology.

Significant progress has also been made in regional management and treatment of ARD. A number of regional mine water treatment plants are being developed and could become important support to local water service providers. An example of such a successful regional ARD treatment scheme is the Emalahleni Mine Water Reclamation plant near Emalahleni in Mpumalanga province. This effort is a joint venture between Anglo Coal and BHP Billiton and currently treats approximately 20ML/day of ARD from old defunct coal mine sections. Various advancements are also made in the re-use of waste streams generated in the water purification process.

ARD Management and Regulation

One of the key challenges faced in South Africa is the government’s institutional capacity to regulate ARD. Although useful ARD assessment and management tools such as the Best Practice Mine Water Management series (DWAF, 2008) recently developed by the Department of Water Affairs are available, there is a general lack of ARD skills and capacity in the government. The lack of capacity makes the enforcement of ARD management practices difficult, often resulting in the inconsistent application of standards and authorisation requirements. As a result, mining companies often “self regulate” on ARD management using industry norms and standards as guidelines.

The acceptance of the GARD Guide, both by industry and the government, as best practice in ARD management will go a long way in providing consistency in the application of best practice ARD assessment and management in South

Africa. Furthermore, due to the general skills shortage, the use of 3rd party reviewers as proposed in the Best Practice Mine Water Management series on Impact Prediction studies (DWAF, 2009), is another mechanism that will help reduce the long-term liability often associated with inadequate impact predictions and mitigation design.

6. PATH FORWARD

The path forward for ARD prevention in South Africa involves the collaboration of a number of participants. The primary drivers for the prevention of ARD are the mining companies. They need to do the planning, make the commitments, and earn the social license through demonstration of excellence. Next are other stakeholders, such as communities, regulators, NGOs, etc. Many of these stakeholders, in large degree, are the beneficiaries of the mining company's good works, but in turn, they can enhance and return these good works. INAP is one of those stakeholders as well. The final, and perhaps the most important element of the path forward, is you, the user of the GARD Guide.

You, the people of the mining industry and its stakeholders who use the GARD Guide, will ultimately determine its success - not only by good use of its technical and management elements, but in how you articulate your commitment to the successful prevention and management of ARD to your neighbors and others of the public. This will determine its credibility and its success.

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