THE GARD GUIDE AND ITS GENERAL APPLICABILITY TO MINE WATER ISSUES[1]

Robert L. Kleinmann[2] and Terry Chatwin

Abstract. The Global Acid Rock Drainage Guide (GARD Guide) [http://www.gardguide.com/index] is a free, easy-to-access, easy-to-use assemblage of information and guidance that the International Network for Acid Prevention (INAP) has generated. Although most members of ASMR who are concerned about mine water issues are probably already aware that it exists, it is not being used as heavily in the U.S. as it is elsewhere. Why is that? We suspect that many of you are not aware of all that it contains, or are under the misperception that it is only applicable to companies dealing with acidic metal mine drainage. In reality, it also deals with neutral and saline drainage, and with coal mine water issues. However, a superficial visit of the site will miss much of the coal mine drainage guidance, since you must follow links within some of the chapters to find it all. This paper will guide you through the GARD Guide, with an emphasis on the material that is most relevant to ASMR members. We ask you to look at the GARD Guide, and to consider adding case examples that will make it more relevant to other users.

Additional Key Words: coal mine drainage, neutral drainage, saline drainage

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[2] Bob Kleinmann is a Senior Management Technical Advisor, U.S. Dept of Energy, National Energy Technology Laboratory, P.O. Box 10940, Pittsburgh, PA 15236-0940, was responsible for most of the coal mine drainage related aspects of the Guide, and is Editor-in-Chief of *Mine Water and the Environment*; Terry Chatwin is the technical manager of INAP, 2105 Oneida Str., Salt Lake City, UT 84109

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Introduction

The Global Acid Rock Drainage Guide (GARD Guide) [http://www.gardguide.com/index] (INAP, 2009) primarily addresses the prediction, prevention, and management of drainage produced by sulfide mineral oxidation, often termed 'acid rock drainage' (ARD), or 'acid mine drainage' (AMD). It was prepared by the International Network for Acid Prevention (INAP) to benefit the entire mining industry and intended to address almost all commodities produced by mining, including base metals, coal, iron ore, precious metals, diamonds, and uranium, wherever the ores contain sulfide minerals, especially pyrite. The GARD Guide also addresses metal leaching caused by sulfide mineral oxidation, the product of which may not be acidic due to neutralization reactions. If the water has a pH above 6, the water is referred to as 'neutral mine drainage' (NMD) or sometimes, 'saline drainage' (SD). Generally, if the total dissolved solids (TDS) measurement is less than 1,000 mg/L, it is referred to as NMD; if greater, then it is known as SD (USGS, 2004).

The GARD Guide focuses on mining and pertains to water that is contaminated by ores, wastes (overburden, waste rock and residues/tailings), and mine workings (including in situ mining). However, while focused on mining, the information provided and the technologies described can also be helpful to those that encounter sulfide minerals in other activities (e.g., road-cuts, excavations, tunnels). Some of the approaches in the GARD Guide are also relevant to issues arising from reactive non-sulfide minerals. Given that this meeting is taking place in the western U.S., where salinity issues are of paramount importance, we would not be surprised to learn that many readers of this paper have to deal, on a daily basis, with SD, which may or may not contain elevated levels of metals of concern. Therefore, an example is provided on another approach to handling such water, with the hope that it encourages some of you to think "outside of the box" in dealing with your mine water problems.

The target audience for the GARD Guide is adapted from a model developed by the PIRAMID Consortium (2003), which assumed "the reader to be a scientist or engineer with a reasonable background in chemistry and the basics of engineering, albeit with no specific knowledge of acid rock drainage. The underlying science and technology of ARD are discussed in sufficient detail that the reader can understand their application, but the discussion stops short of being a formal scientific treatise on the relevant aspects of, for example, geochemical kinetics and solute transport hydrodynamics. Rather, the document guides readers through the logical framework of ARD management, enabling them to quantify the nature of the problematic drainage and the potential for management that exists on the site, leading to the selection of the most appropriate form of prevention and remediation."

The GARD Guide was assembled by the International Network for Acid Prevention (INAP) through a two-year effort by many of the world's experts in these areas, and was rolled out in the summer of 2009. The objective of the GARD Guide organizers was to consolidate and summarize the state of the art and thereby enable practioners to use the best practices developed through experience at many other sites. It is a "how to" guide, focused around proven field-tested technologies; it is not a regulatory tool or a design manual. Each mine site is different and the Guide recognizes that various countries and localities have varied regulations and discharge criteria [http://www.gardguide.com/index.php/Chapter_3]. However, by outlining what are considered best practices, by providing some of the science behind some of these practices, and by encouraging a risk-based management approach, INAP hopes to improve the state of the art of practioners around the world.

Once assembled, the GARD Guide was placed on the internet to make these best practices universally accessible, because those who do not learn from the experience of others are condemned to make the same mistakes. However, it has not received as much use as we had hoped. Perhaps the fact that it is available at no cost makes it appear less valuable? We prefer to think that many practioners still have not heard of it or are not aware of all that it contains, and that if more people know about it, more people will use it, which is the main reason this paper is being presented and published here. Also, it was also intended that the GARD Guide would evolve over time, in wiki fashion, incorporating progress and incorporating actual case studies. To make that happen, we need your help.

GARD Guide Content

Mine water problems have been associated with mining since at least Roman times; the Rio Tinto River in Spain gets its name from the dramatically colored water that still runs off from the old mine sites there (Fig. 1). The GARD Guide endorses a pro-active approach and encourages at-source control and mitigation strategies. Preventing ARD must begin at exploration and continue throughout the mine-life cycle. The authors refer to this as "cradle to cradle" planning, which incorporates the concept that land that has been mined should be left in a biologically productive state. INAP recognizes that continuous ARD planning and management is imperative to successful ARD prevention. Proper planning and management of ARD can prevent environmental impacts from occurring. “Treating acid drainage once it has occurred, or mitigating environmental impact after it has occurred, is usually an admission that something has gone wrong either in the characterization, planning, design or operation of a mine” (Dowd, 2005).

The GARD Guide is essentially an on-line book, containing 11 chapters plus a glossary. Given its breadth, it is necessarily superficial in some areas, but references are provided throughout to help readers learn more about any specific topic that interests them. After describing how the Guide is organized, the varied nature of mine water, and how it is managed and regulated around the world (Chapters 1, 2, and 3), Chapter 4 provides an overview of mine water characterization, including geochemical, hydrological, biological, and geophysical characterization. Perhaps because of its breadth, it has garnered a lot of readership; it has been accessed almost 15,000 times.

Figure 1. Acidic mine water draining from an area in Spain once mined by the Romans

Chapter 5 gets more specific, focusing on techniques used to predict water quality before mining is initiated, how these predictions affect mine planning, and how predictions and plans change over time as mining proceeds. Overburden sampling, static and kinetic tests, hydrology, and modeling are all addressed. Because prediction of water quality at coal mines is handled very differently than at other mine sites, with different decision criteria, it has been given its own section: http://www.gardguide.com/index.php/Introduction_to_CMD_Prediction. Unfortunately, to find this section, one almost has to be looking for it. You can link to it from the chapter's table of contents, or notice the one link that exists to the section in the rest of the chapter, after wading through text that is oriented more to hard rock mining operations. The casual coal-mining oriented reader will miss the section entirely, and will conclude that the chapter authors are ignoring the differences between how the issue is handled at coal and metal mines. In fact, the linked section sees one third as much usage as the rest of the chapter. We have learned of coal-mining oriented readers that never made it past this chapter, concluding, despite its claims to the contrary, that the Guide was written for the rest of the mining and regulatory community. There was a good rationale for organizing the chapter this way, since incorporating it into the text would have been awkward, but in hindsight, we should have made the link to the coal mine drainage material much more obvious. Perhaps, by the time that you read this, this flaw will already have been corrected.

One of the chapters that readers apparently find most useful is Chapter 6, on prevention and mitigation of acid rock drainage. Techniques are discussed in a fair amount of detail, and 'best practices' are described. These include: wet and dry covers, liners, special handling, adding sources of alkalinity or other material to reduce the rate of acid generation, water management, remining, and ways to avoid acid generation in the first place.

The other most popular chapter is Chapter 7, which addresses the many varied approaches to conventional and passive water treatment at active and abandoned mine sites. It has been accessed almost 20,000 times. Here again, there are significant differences between how coal mine drainage and metal mine drainage are normally dealt with, but the text is largely integrated, with only tangential discussions (on aeration methods used at coal mines and the history of passive treatment) being provided as links. Recommendations between alternative approaches are of course site-specific and time-specific (some methods require a lot of maintenance and are most appropriate while mine sites are operating); the advantages and disadvantages of the various methods are discussed and, of course, as in the rest of the Guide, many references are provided.

Chapter 8 is a fairly exhaustive discussion of monitoring, from baseline monitoring before mining to technology that can be used during and after mining to properly and accurately track water quality and its impacts downstream. There is surprisingly little overlap with Chapter 4 (Characterization), which is more of an overview treatment; Chapter 8 gets down to details.

Chapters 9, 10, and 11 differ markedly from the rest of the Guide in that they have a somewhat different audience. While the other chapters are meant for those who deal with mine water regularly, Chapter 9 focuses on those who are higher up the corporate ladder, who may or may not want to know all of the details but who have to know how to plan, coordinate, and manage all or a significant part of the entire process. Chapter 10 is focused on communication, both inside the corporate structure and with those outside of it, including stakeholders, regulators, and consultants. Just as is in rest of the Guide, the nature of mine water management changes as a mine evolves from a concept to a major source of jobs and income for a region to when mining ceases and the land is developed for some other use. The importance of stakeholder perception, inclusive engagement, conflict resolution, and dispute management are all addressed. Finally, Chapter 11 attempts to project how technology and policies will change in the future, given a sustainable development mindset.

Applying Guide-type Thinking to Other Mine Water Problems

As mentioned above, it is wrong to assume that all mine water is acidic. If the once acidic water partially dissolves or interacts with other rocks and minerals, including limestone, dolomite, clay, and feldspar, it may have a circumneutral pH and still contain elevated concentrations of metals and sulfate. Such waters still have to be treated, and many of the predictive, preventative, and remedial approaches discussed for ARD are also valid for such sites. At other locations, sulfide mineral oxidation is not a major problem at all, but the water may still be contaminated due to dissolution of exposed minerals. Such is the case at some sites in the western U.S. and at many arid mine sites around the world, where total dissolved solids (salinity) is the major water pollution problem. Yet even here, we can learn from what others are doing.

By way of example, consider how the problem is being addressed in New South Wales, Australia. There, in the Hunter River watershed, a salinity trading scheme has been developed that allows agriculture, mining, and electricity generation to operate side by side, sharing the use of the river. The region supports a range of agricultural activities. Also located in the valley are over 20 of the world's largest coal mines and three power stations, including Australia's largest electricity generator.

The state's Environment Protection Authority (EPA) developed a market-based strategy rather than reapplying traditional pollution control thinking. They took the water management concept of in-stream mixing zones that has been used, with regulatory approval, at some locations (e.g. Chugh et al. 2007; U.S. EPA 1991), and extended it over a large area, integrating the contaminant loading provided by all sources and many companies. It was the equivalent of taking the bubble concept of air pollution control and integrating it with cap-and trade. The NSW Minerals Council bought into the concept, but the salinity trading scheme was only established after extensive consultation with the community and completion of a field trial, which was overseen by the staff of the National Minister for the Environment.

The central idea of the scheme is to discharge most of the high TDS water during and shortly after storm events when the water in the river is relatively fresh. This is when the river can best handle saline discharges. Previously, using traditional regulated control, individual discharges were minimized, but 'trickle' discharges were allowed all the time without an effective link back to the state of the river. In dry time, the river became very salty, and unusable for irrigation, just when it was needed most. In wet weather, the opportunity to discharge without a negative impact was often missed. The result was high and variable salinity, with no guarantees that particular levels of freshness could be maintained.

Through careful control, the mixture of river and discharge water is now kept below an agreed level of electrical conductivity. The EPA has found that when the river level is high, they can permit virtually unlimited discharges and still not exceed the established limit (900 EC, which equivalent to 0.9 S/cm). When the river level is at an intermediate level, members coordinate their discharges to avoid exceeding the limit. The river is nominally divided into numbered blocks. A block is a section of water that flows past an established location in a single day. For each block, the flow level and the ambient salinity are measured, and then the amount of salt (if any) that can be added to the block (so that salinity will stay under the limit) is calculated.

There are 1000 salt discharge credits — different license holders have different numbers of credits. License holders can only discharge salt into a river block in proportion to the credits they hold—1 credit allows a discharge of 0.1% of the total allowed in that block. So, suppose a certain block could handle 112 tonnes of additional salt. Then, a license holder with 20 credits could discharge 2.24 tonnes (112 x 20 x 0.1%), and a license holder with 45 credits could discharge 5.04 tonnes (112 x 45 x 0.1%), into that block.

License holders may find that they need to discharge more than they are entitled to due to site-specific conditions. Credit trading gives each license holder the flexibility to increase or decrease their allowable discharge from time to time while limiting the combined amount of salt discharged across the valley. The trading system is online, allowing license holders to trade quickly and simply. The trades can be for one or many blocks (i.e. for a single day or longer periods), and the terms of the trade are negotiated by the parties involved. A register ensures the information on credit holdings is publicly available at all times.

Every two years, 200 of the credits expire and 200 new credits are created and sold by public auction to replace those that have expired; the new credits have a lifespan of 10 years. New industry can enter the scheme by buying credits at auction, or by acquiring credits directly from other scheme participants (Dept of Environment and Conservation NSW, 2006).

Moving the GARD Guide Forward

The knowledge gained from both positive and negative field results contributes greatly to current and future ARD management plans and enhances the credibility of consultation processes on ARD. Also, application of ongoing science and engineering research supports continual improvement in ARD management. For both of these reasons, INAP wants to include case studies of what has and has not worked at mine sites around the world. The authors have incorporated their knowledge and experience in the material that is already on-line, but real-world experience told from the perspective of those who have dealt with these issues would greatly strengthen the Guide. So, we are turning to you, who deal with mine water management issues every day, to share your stories and experience. If you are willing to do so, please contact either of the authors of this paper. We will be glad to help with the writing if you provide the details. Our hope is to start including such case studies by the end of 2011, but we need your help to make that happen.

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