TECHNOLOGY OVERVIEW

DIVERSIONARY STRUCTURES

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1. INTRODUCTION

Water coming in contact with net acid-producing solid materials in mining environments often results in mining-influenced water (MIW). Diversionary structures are designed to prevent clean water from becoming MIW by coming into contact with mining solid waste (net acid-producing materials) and/or to divert MIW to treatment or collection systems and away from sensitive environments. Diversionary structures can be used to reduce the volume of, or exposure to, MIW that may present risks to human or ecological receptors and that may require treatment. In addition to preventing water from coming in contact with net acid-producing material, diversionary structures can also be used to prevent erosion of mining waste and transport of soluble metals into surface water.

There are several types of diversionary structures:

- engineered channels, tunnels, pipelines, or other structures to divert surface water run-on and/or MIW runoff
- engineered slurry walls, sheet pile walls, grouting, or other subsurface structures to divert or contain groundwater
- bulkheads and plugs in mine workings to control influx or discharge of MIW

2. APPLICABILITY

MIW is generated through the contact of surface water or groundwater with exposed mineralization and solid mine waste. Once generated, MIW can flow to sensitive environments where humans and the environment can be adversely affected. Mines were commonly designed to efficiently and effectively drain water, often without regard for the fate of the water once it left the mine. Clean surface water and groundwater may flow into mines and solid mine waste, where it can become contaminated. Mine water flowing from portals may percolate and flow through acid-producing waste rock fanning below the portals. Once produced, MIW may flow into and damage or destroy sensitive streams and wetlands or affect downstream groundwater supplies. By diverting clean water away from mine workings and solid mine waste, generation of MIW can be eliminated or reduced. By diverting MIW to treatment systems and away from sensitive environments and receptors, unacceptable risks and damages can be eliminated or reduced.

Diversionary structures can be applied over a wide range of sites, ranging from simple runoff/runoff diversions to highly complex engineered surface and subsurface structures. They are applicable to a wide range of flow rates and contaminant types. They can be constructed at the surface to divert and contain surface water, within mine workings to control and manage mine water within and leaving the mine, and in the subsurface to control groundwater flowing to or from mines and solid mine waste. Gusek and Figueroa (2009, pp. 56–60) discuss and provide case studies for several examples of diversionary structures or processes including surface run-on

MIW collection/diversion channels, groundwater interception/seals, underground grouting/ backfill, and freezing. Borden, Peacey, and Vinton (2006) provide a discussion of subsurface cutoff walls constructed at the toe of waste rock piles to collect and divert MIW to reduce adverse impacts to down gradient alluvial groundwater.

3. ADVANTAGES

Diversionary structures can be applied to a wide range of site conditions, making them suitable for remote sites as well as active and/or easily accessible mine sites. They can be engineered for a wide range of flow conditions and for sites with variable flow conditions and can be readily integrated with other treatment options.

Diversion of clean water before it encounters mines or solid mine waste can eliminate or reduce generation of MIW, eliminating and/or substantially reducing treatment costs.

Diversion of MIW to treatment or containment systems can immediately mitigate ongoing adverse impacts resulting from MIW discharge to sensitive environments and receptors.

4. LIMITATIONS

Diversionary structures are problematic as a sole remediation technology in some situations, particularly where MIW cannot be completely avoided through diversion of upstream clean water. Where MIW generation cannot be eliminated, diversionary structures are commonly applied in conjunction with other treatment technologies.

5. PERFORMANCE

Diversionary structures are a proven technology for eliminating and/or reducing the generation of MIW, controlling mine discharge, and controlling MIW to prevent or reduce ongoing impacts to sensitive environments, reduce risks, and mitigate adverse impacts.

Leviathan Mine. At the Leviathan Mine in east central California, a long, reinforced-concrete channel was constructed through the mine site to segregate MIW from clean water in Leviathan Creek and divert it to evaporation ponds (Gusek and Figueroa 2009, p. 57). Pre- and post-project water quality data in Leviathan Creek reflected a significant decrease in metal loading and modest improvements in water quality downstream of the site.

Dunka Mine. Drainage ditches were constructed to route water away from solid mine waste. Although most of these were relatively shallow ditches (~2 m), the ditch at the southern end of the mine is 670 m long and up to 18 m deep, excavated through bedrock into the mine. Diverting upstream flow reduced the watershed contributing to flow to the waste rock piles by up to 54%.

Copper Hill Mine. Tailing facility seepage ponds designed to collect surface runoff sometimes overflowed during high-precipitation events. To remedy this problem, surface runoff was collected and diverted away from the tailings facility using a concrete trench. The diverted clean surface water was released to an adjacent creek. The diversion resulted in a 90% decrease in spillage when compared to the previous year's records (Gusek and Figueroa 2009, p. 57).

Bingham Canyon Mine. Concrete cutoff walls were installed in 24 drainages at the toe of large waste rock piles formerly used for copper heap leach operations. The East Side Collection System cutoff walls are effectively capturing discharge at the toe of the waste rock piles and subsurface alluvial flow and diverting this MIW to the mine process stream. When the Eastside Collection System was upgraded 1993–1996, water quality in the shallow saturated alluvium began to improve almost immediately. Water quality in the deeper bedrock wells has responded to the removal of the contaminant loading from the surface much more slowly (Figure 5-1).

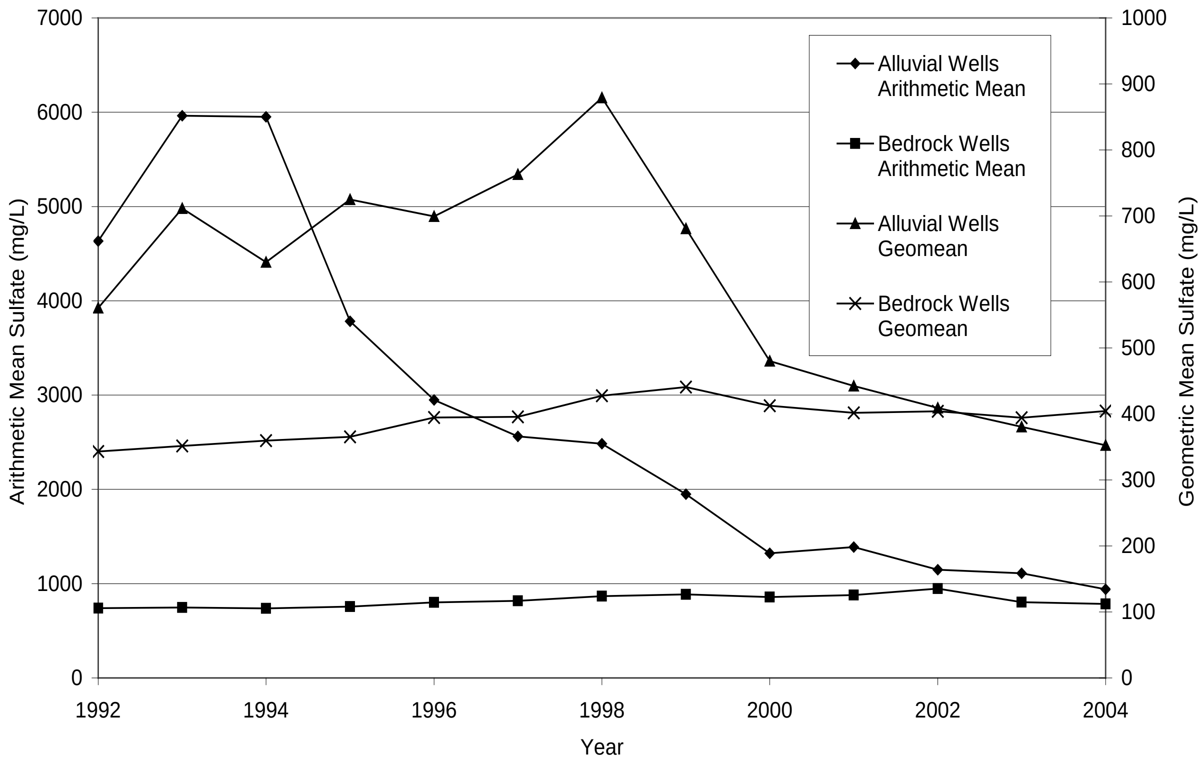

Figure 5-1. Annual mean sulfate concentration in alluvial and bedrock monitoring wells. (*Source:* Borden, Peacey, and Vinton 2006)

6. COSTS

Costs are primarily associated with capital costs for system design and construction and periodic maintenance. At the Bingham Canyon Mine, the large-scale Eastside Collection System, including construction of the concrete cutoff walls, cost in excess of $50,000,000 for capital costs. At the Dunka Mine, costs for construction of the large ditch cost in excess of $600,000. To the extent that diversionary structures can reduce the generation of MIW that requires treatment, remedial costs may be substantially reduced over time.

7. REGULATORY CONSIDERATIONS

Diversionary structures are often applied in conjunction with MIW treatment involving other technologies. Diversionary structures may require additional regulatory considerations than would be otherwise applicable to other MIW technologies. For example, engineering review and permitting, stream diversion, water rights, water discharge, and wetlands impacts may be required.

8. STAKEHOLDER CONSIDERATIONS

Diversionary structures commonly involve significant surface disturbance that can be of concern to stakeholders worried about land use, water rights, and disruption of ecological resources. Concerns may also be raised about flood hazards, groundwater impacts, and mine stability.

9. LESSONS LEARNED

Diversionary structures can be a cost-effective way of reducing MIW generation and treatment requirements, while immediately addressing ongoing site risks and adverse impacts. In particular, surface diversions can be effectively designed and maintained. Subsurface diversionary and control structures require a thorough understanding of site subsurface conditions and careful monitoring to assure that the systems are achieving the desired results.

Installation of flow-through bulkheads has proven to be an effective approach for management of MIW. Complete plugging of mine portals has sometimes been ineffective at controlling discharge of MIW. Plugs and bulkheads have blown out under pressure, and even where plugs and bulkheads hold, backing up of MIW behind the structures can result in unintended discharge in unexpected locations. Thorough consideration of site conditions and careful monitoring is necessary to assure that the systems are achieving the desired results and are not producing unexpected and undesirable effects.

10. CASE STUDIES

Table 10-1. Case studies using diversionary structures

Stowell Mine, CA
Dunka Mine, MN

11. REFERENCES

Borden, R. K., V. Peacey, and B. Vinton. 2006. "Groundwater Response to the End of Forty Years of Copper Heap Leach Operations, Bingham Canyon, Utah," Proceedings, 7th International Conference on Acid Rock Drainage, March 26–30, St. Louis. Lexington, KY: American Society of Mining and Reclamation. http://www.imwa.info/docs/imwa_2006/0214-Borden-AU.pdf

Gusek, J. J., and L. Figueroa. 2009. Mitigation of Metal Mining Influenced Water (Management Technologies for Metal Mining Influenced Water, vol. 2). Littleton, CO: Society of Mining, Metallurgy, and Exploration, Inc.