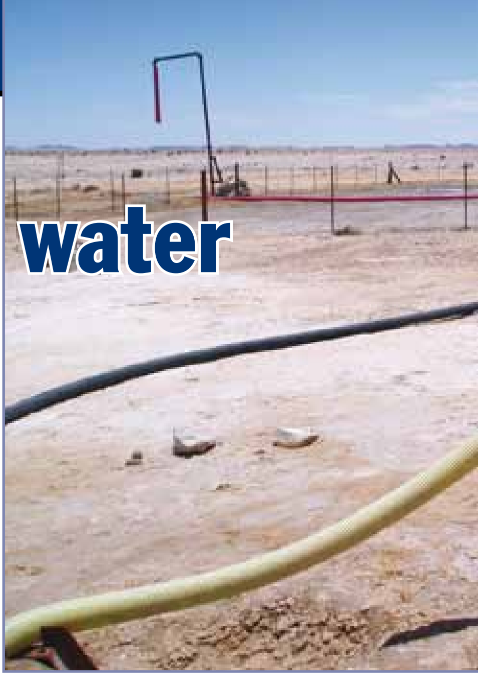
Making the most of mine water



Specialists from SRK Consulting's water resources division explain how careful planning with respect to water supply and disposal can play a vital role in the outcome of a mine

Water is often a major stumbling block in the development, operation or closure of a mining operation. Too little can lead to inefficient or limited processing capacity, and too much can cause flooding which can seriously impede or cease operations.

Often, potential impacts to water resources become the major concern for the environmental regulation of mines, and the migration pathway of potential contaminants to vulnerable receptors such as rural communities, livestock and aquatic ecosystems.

Consequently, it is essential that through all stages of the mine life cycle, that water management is both effective and applicable. This principle feeds not only into operational control but also into predictions about future changes in mine water management.

ASPECTS AND CHALLENGES

Detailed water management planning, from sourcing water to its discharge through the various mine processes, is best done at the mine-planning stage and is a very important component to review throughout production and into the closure stage of a mining operation.

At the start of a mining project, the primary driver is the mineral resource and its 'mineability'. However, based on SRK's water management experience across the globe, we believe that water resources and their management are often not given sufficient consideration during the early stages of project development when the attention of project owners is usually solely focused on mineral resources and mine planning. This often results in risks that could be mitigated easily at the start of the project becoming issues, particularly during the mine's operational phase.

SRK is often requested to provide assistance in dealing with inefficient mine dewatering systems or pollution control issues that could have been avoided if adequate hydrological and hydrogeological investigations and monitoring had been given sufficient resources early in the project's development.

In some cases, mine water supply or mine dewatering processes influence production rates, and can cause stoppages and even shutdowns if supplies become scarce. Therefore, the safest approach for a mine is to integrate water studies with the mine design and planning in an iterative process, to provide adequate and safe mine design and thereby cost-effective water management systems.

An additional advantage of considering water management early in a mine project is

cost saving. For example, early in the project, valuable hydrogeological data can be gathered during the exploration drilling stage at a very low cost compared with a dedicated hydrogeological site investigation later on.

Depending on climate, mineral commodity and geographic location, the development of a mining project will face various challenges associated with water. Some of the key considerations that are governed by or related to water include:

- Water supply;
- Mine dewatering;
- Risk of mine flooding;
- Tailings dam stability and seepage;
- Diversion of surface water features such as rivers;
- Risk of acid rock drainage, pollution control and mitigation;
- Impacts of dewatering and mine activities on other water users and/or the environment, and
- Mine closure.

WATER SUPPLY

Mining projects often require significant volumes of water and are dependent on a secure supply. The main use is usually in the processing of ore, but water consumption can also be significant in extraction and product transport.

Water supply can be particularly challenging in arid regions. The operator must tailor the process to match the resource, ensure future water sources are 'reserved' to avoid depletion by other developments, minimise wastage in the mine circuit and consider alternative supplies such as piping water from other catchments, or using grey water from urban centres. It may also be necessary to set up alliances with other mines, industries or local government to introduce economies of scale.

The quality of water supplied is also important, as water supplied for domestic use is more regulated than for ore processing. So called 'closed water systems' are often preferred where water is in short supply, however the reuse of process water is not without problems. Re-circulating water can increase salinity and levels of processing chemicals that can have a negative influence on the plant efficiency.

In addition, the build up of certain components within the recirculation circuit may lead to the need for water treatment that further adds to capital and operational expenditure.

MINE DEWATERING

Dewatering is an essential aspect of many mining projects and is often required to achieve two key goals:

- To maintain dry and safe working conditions, and
- To manage pore water pressures in pit slopes.

Mine dewatering reduces water inflow into a mine and can comprise a simple in-pit sump with a dewatering pump, to sophisticated schemes involving perimeter abstraction wells and drainage galleries.

Although in many cases water derived from the host rocks is not contaminated, it often collects suspended solids and can become contaminated due to mining activity. Such water will require treatment before being discharged or re-used.

When dewatering a saturated formation and thereby decreasing pore pressure, the effective normal stress in the rock mass is increased, resulting in more stable slopes. Pore water depressurisation is often incorrectly or only partially integrated into slope analysis, and requires geotechnical engineering and hydrogeology disciplines to work closely together for optimal results.

The most important outcome of this is that steeper slopes can usually be achieved by dewatering the rock formations around the pit walls. Mining and disposing of waste host rock is expensive, as is the construction and management of pollution control/treatment when dealing with contaminated discharge from disposal sites. Therefore, there are numerous and considerable cost savings to be made by steepening mine slope angles. Depending on the depth of the mine in question, increasing the slope angles by 1° can lead to millions of dollars in savings.

Other advantages of mine dewatering include: improvement in mining conditions, drilling, blasting, loading, hauling and scheduling, all of which positively impact mine productivity.

Pore water depressurisation in open pits can result in steeper, more stable pit slopes

Photo: Gary Whitton Shutterstock.com

WATER BALANCE

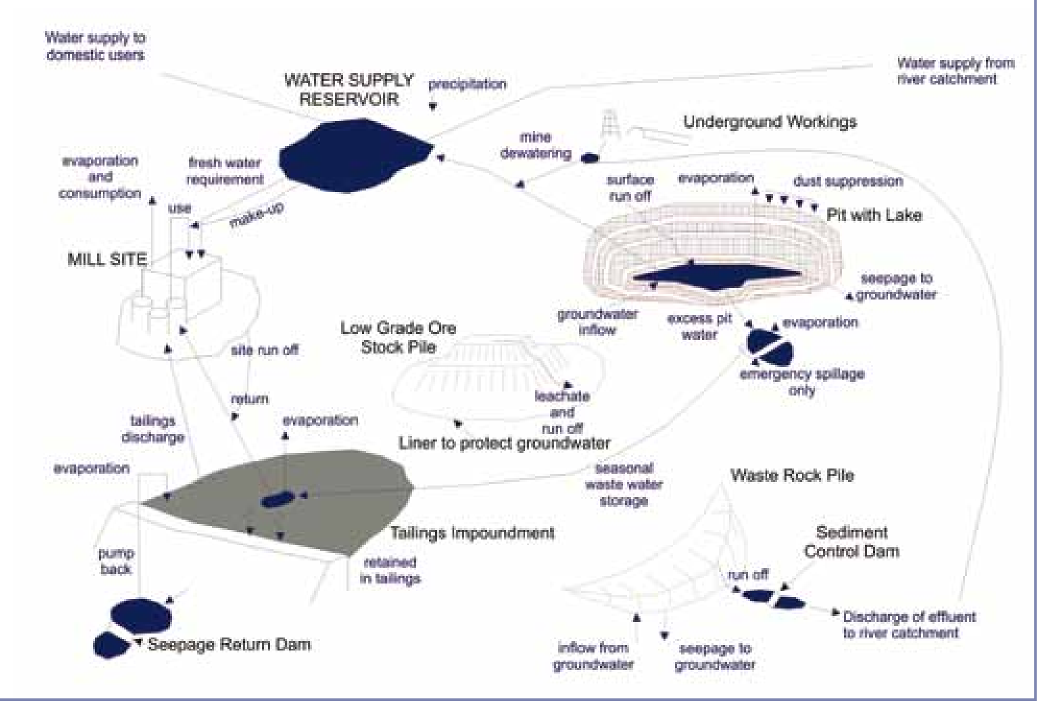
A mine water balance comprises a flow sheet in which water flow rates between the various mine infrastructure components are represented for target production scenarios. The water balance illustrates the relationship between water inputs, such as direct precipitation, mine dewatering and abstraction sources, and outputs such as water loss by evaporation, lock-up in tailings and discharge to the environment. Between the input and output is the processing and usage circuit in which water is retained, reused, treated or re-circulated between the various mine components.

While ore processing may require the supply of a constant amount of water, input and output from mine dewatering, precipitation and drainage typically vary seasonally and over the life of mine. This strongly influences control on the water storage capacity, treatment requirements and discharge rates.

Therefore, a mine water balance has to include all these factors on a seasonal (monthly) basis and over the life of mine, in order to develop appropriate water management plans and adequate infrastructure.

The mine water balance is a powerful optimisation tool. It helps minimise the need for make-up water demand in a processing plant by ensuring maximum water recycling. This in turn protects water resources from unnecessary abstraction, reduces the cost of treatment and minimises discharge into the environment. ►

Groundwater recovery and pit lake formation on cessation of mining



Conceptual relationships in a mine water balance (adapted from Smith and Mudder, 1991)

TAILINGS AND ROCK WASTE WATER

Effectively designed tailings and waste rock storage facilities will reflect a strategy of minimised material handling which mitigates unnecessary water treatment. Water stewardship can then be enhanced with approaches as simple as the engineered diversion of water away from the waste facility.

In addition, the geochemical characterisation of mine materials early in project evaluation and development leads to a better waste facility design, as both the short and long term exposure of problematic wastes can be minimised. In this way, both the volume and extent of contaminated water potentially requiring treatment are reduced, minimising environmental risk and saving costs in the long term.

TREATMENT AND DISCHARGE

As a general rule, the treatment of mine waters should be regarded as a secondary option. Within a mine design the prevention of water contamination is a more cost effective solution long term and needs careful consideration in the early design stages of a mine's development.

Once a contamination source has been created it is often extremely difficult to contain, and this can lead to the necessity for water treatment in perpetuity which has long term liability issues.

ENVIRONMENTAL PROTECTION AND MINE CLOSURE

Mines can cause both negative and positive environmental impacts, some of which are irreversible. For this reason, baseline studies need to be carried out in parallel with the engineering studies during the feasibility stages.

The baseline study aims to determine the natural conditions that prevail in an area before the start of mine development. The Environmental and Social Impact Assessment (ESIA) study aims to assess the potential impacts of the development of the project on both the environment and on communities in the area. The water environment is often a key element of the ESIA that requires careful consideration, as the impact on water resources often has consequences on both communities and natural ecosystems.

Mine closure is often not considered in any detail at the early stages of mining. However, early planning for closure minimises water issues and reduces the environmental impact. Such planning also makes good economic sense, because unplanned water treatment generally incurs high capital and operational costs and can create a negative perception. The objective of early planning is to maximise the range and efficiency of operational water management systems that can easily be integrated as part of the closure plan.

For mines operating below the water table, cessation of dewatering needs to be managed to minimise impacts. Similarly, the chemistry and internal dynamics of the resulting pit lake or water discharges need to be understood.

Groundwater and surface water modelling is a key tool for assessing and predicting the potential effects of mine closure on the water environment. The model developed during the feasibility study must be updated during the mine development and operational phases. This allows it to be calibrated more accurately and used as a management tool to support aftercare strategies.

CONCLUSIONS

Mine water management is an essential consideration in successful mine design and operation. Integrating this discipline with other elements of mine development and management is necessary in order to effectively address the assessment, development, operation and closure of a mining operation.

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