Integrated mine water management planning for environmental protection and mine profitability

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ABSTRACT: The lack of sound mine water management is a common cause of permit violations, an impediment to sustainable mine reclamation and an expensive irritation to mine operators. Often neglected in mine planning, integrated mine water management planning is recommended as an essential ingredient for avoiding expensive solutions and for maximizing the productive capability of reclaimed mine landscape. One goal of integrated mine water management planning is to provide ample lead time so that reclamation landscape can be achieved at low cost during mine operation. Expensive solutions can be avoided by advance planning and pro-active intervention. Compatibility between environmental protection and mine profitability can be achieved through integrated mine water management planning.

1 INTRODUCTION

It is widely accepted that mine planning requires multi-disciplinary attention to a broad range of considerations in order to achieve maximum economic returns and optimal benefits to all stakeholders. Mine water management is one of these disciplines which needs to be considered early during mine planning. It is a particularly important consideration because water management may affect vegetative cover, sustainability of mine closure drainage facilities, aquatic habitat, and surface erosion. The latter, surface erosion, is a principal hazard which governs long term sustainability of a reclaimed mine, upon mine closure.

The purposes of integrating mine water management and mine planning are to reduce mine developmental costs, improve regulatory compliance, and to provide a sound basis for developing sustainable mine closure drainage systems. In broad terms, integrating mine water management and mine planning is designed to minimize environmental impacts at minimum cost.

Though widely accepted as a necessary ingredient to mine planning, there are many continuing examples where sound water management was omitted during mine planning. This results in unnecessary costs to the owner and significant negative environmental impacts. The extra costs of avoiding water management issues far exceeds the extra costs of integrated planning.

The purposes of this paper are to explore various approaches for incorporating mine water management in mine planning, to provide helpful guidelines to the mine planner, and to give some examples of mine planning, taking appropriate account of water management issues based on the author's experience in a large number of mine water management projects in North America and overseas.

2 APPROACHES TO WATER MANAGEMENT

There are various approaches to water management in mining, depending mainly on the attitude and understanding of the planner. Several approaches are summarized below.

2.1 Disregard of water issues

There are many examples of disregard for water management issues in mining development. Most of these examples in North America pertain to practices during the first half of the twentieth century. Although these occurrences are not a reflection of current attitudes, they do provide a legacy which has negatively affected the reputation of modern mine developers. There are numerous examples of failed tailings dams, sterile landforms at mine disturbed areas and barren terrain resulting from acid mine drainage (abandoned mine at Kamkotia, Timmons, Ontario). Often environmental problems are associated with abandoned mines which were closed pre-maturely, prior to modern regulations which require bonding for reclamation. More recently, there are many examples of mine waste disposal in third world countries which cause serious environmental impacts due to a disregard for the environment. Many of these will require substantial investment to comply with new environmental awareness and guidelines by governments, international agencies and mine owners.

2.2 Reactive approach: finding remedies to comply with regulations

One approach that is common in North America in the 1990's is to apply remedies to water related environmental problems in order to comply with governmental regulations. Because of the high environmental standards in most parts of Canada and the U.S.A., this approach normally achieves appropriate environmental standards. However, it is reactive, not pro-active. As such, this approach is often more costly, less sustainable and less effective than a pro-active approach which minimizes problems at source and which deals with problems early before they occur.

The reactive approach may result in large settling ponds, structural erosion control methods, rigid drainage systems, high maintenance water handling facilities (i.e., riprap, drop structures), and expensive water management schemes for mine decommissioning.

The reactive approach involves minimum initial effort to achieve regulatory compliance. Little value is given to the cause of environmental impacts. The focus is on short-term compliance. It is driven by penalties for violating permit

regulations. It is implemented long after the problem could be alleviated by modifying the mine development plan.

The reactive approach has short term objectives. This may prove to be very costly for the owner because short term views may overlook future water management constraints to existing development.

2.3 Pro-active approach: integrated mine water management

The recommended approach is to properly integrate mine water management into mine development planning in order to minimize adverse environmental effects by addressing the causes of the problems early instead of the symptoms. Often small changes in the mine development plan can result in large im-provements in water control. For example, controlling land-scape development during mining may be far less costly than reconfiguring the landscape after mine closure.

Integrated mine water management planning involves the meaningful participation of water management and environmental specialists together with mine planners. The types of solutions offered by this pro-active participation of a multidisciplinary team, are as follows.

- Fail-safe solutions with built-in redundancy to handle exceedances and failure of primary control systems.
- Self-healing drainage systems which require little or no riprap erosion protection.
- Gravity drainage systems instead of expensive pumping systems.
- Provision of infiltration areas to avoid treatment of surface water containing high sediment loads.
- Reduced erosion because of improved control of surface drainage.
- Sustainable drainage systems which need not be rebuilt upon mine decommissioning.

Integrated mine water management planning is based on an adequate hydrologic and environmental database, ongoing data collection, partnership with regulating agencies, and comprehensive planning.

The pro-active approach is recommended for all mine developments because of reduced capital and maintenance costs for water handling facilities by solving causes instead of remedying impacts and by integrating future water management constraints into ongoing mine development. The pro-active approach involving integrated mine water management planning also offers improved sustainability upon mine decommissioning.

3 GUIDELINES FOR INTEGRATING WATER MANAGEMENT AND MINE PLANNING

3.1 Multidisciplinary input

Integrated mine water management involves input by specialists of various disciplines, recognizing the complexity of mine development, operation and decommissioning. For sound water management and sustainable drainage following mine decommissioning, it is often necessary to consider surface water hydrology, hydrogeology, water quality, revegetation, wetlands, aquatic habitat and landscape architecture (for surface drainage).

3.2 Acceptance of environmental and economic goals

Often considered to be mutual exclusive, environmental standards and economic profitability are goals which must be en-dorsed by all participants in mine development, operation and decommissioning. With advance planning, environmental objectives are often compatible with profitability and can be achieved at moderate cost.

3.3 Partnerships among planners, designers, operators and regulators

Adversarial relationships between planners, designers, operators and regulators must be abandoned in favour of partnerships. Each participant in a mine development must take ownership of the process. Integrated water management plan-ning is impossible without trust and good will. A pre-requisite for trust, of course, is a commitment to environmental stand-ards, long term sustainability and mine profitability.

3.4 Acceptance of water issues equal to mining concerns

Neglecting water issues is often the cause of environmental exceedances and non-sustainable development. In defining the most important hazards, comprehensive risk assessments frequently identify water related impacts such as erosion and water quality as the major risks which threaten project feasibility.

3.5 Innovative solutions identified at early stages of mine development planning

Implementing remedial measures upon termination of mining activity often involves high cost. Modification to mine plans prior to construction or mining activity, is often less costly and far more effective in reducing environmental impacts. Examples of such innovative solutions include.

- Conservation (stockpiling) of select soils for future reclamation to reduce erosion potential.
- Stockpiling of stones and riprap for future erosion protection.
- Selective placement of boulder or granular soils at future water ways to provide self-armouring and self-healing capability. This can avoid the need for expensive riprap erosion protection material.
- Placement of mine waste at waste dumps in such a manner that the opportunity of concentrated flow paths and associated erosion can be minimized by appropriate landscape design.
- Locating operational drainage systems appropriately so that substantial changes are not required upon decommissioning.
- Provision of flat landscape areas which can be easily converted into wetlands for improved biomass productivity as well as reduced peak runoff.
- Development of drainage courses and landscape by replicating natural analogues to maximize longetivity at minimum cost.
- Provision of infiltration areas to reduce surface runoff and high sediment flows.
- Configuration of landscape during mining to facilitate the development of drainage courses for mine closure.
- Integration of drainage system designs for mine operation and for mine decommissioning.
- Provision of shallow beach slopes at end-pit lakes so that the shoreline is stabilized by emergent and submergent vegetation of the littoral zone.
- Supply of peat soils for reclamation soils to maximize water absorption with a minimum depth of soil placement.

3.6 Sound understanding of natural analogues

Costly erosion protection solutions may be avoided by replicating the natural environment. Examples include natural channel regime, soil covers for erosion control and shoreline protection of end-pit lakes by littoral zone vegetation.

3.7 Data Collection and Monitoring

High safety factors are common in the absence of an adequate hydrologic database. This results in unnecessary costs for surface water control. Therefore, significant savings are possible by reducing uncertainty and associated safety factors through improved estimates of hydrologic parameters based on an appropriate database. For large mine developments, the hydrologic database should be comprehensive because small reductions in hydrologic design parameters can result in large savings in construction of mine water handling facilities.

A small investment in a comprehensive ongoing hydrologic monitoring program can yield large benefits by improving the available database and by refining the hydrologic design parameters.

3.8 Inventory of baseline fluvial geomorphic conditions

Prior to land disturbance, the geomorphic features of natural streams and drainage systems at the proposed development site should be documented. The resulting data will serve a basis for evaluating the adequacy of future reclamation systems. The data may also serve as natural analogues which may be replicated by mine closure drainage systems. Without baseline data, it is difficult or impossible to compare the sustainability of future reclamation drainage facilities with the original systems. The inventory of baseline conditions could include the following conditions.

- Stream bed, bank and regime characteristics
- Aquatic habitat
- Water quality
- Wildlife
- Vegetation
- Erosion and sedimentation conditions

3.9 Early establishment of design criteria

Design criteria should be established early in the planning process, prior to capital investments. The selection of design criteria should take appropriate account of the consequences of failure. The criteria should therefore be flexible, allowing for variation depending on specific site conditions. For example, the design criteria should require minimal erosion protection where erosion would result in low rates of chronic erosion with self-healing channels achieved by self-armouring after extreme events.

Government regulators must be included in the process of selecting design criteria during the mine planning process. They should have enough information at their disposal to provide a basis for accepting reduced design criteria.

3.10 Planning by iteration

Mine planning is rarely a linear process. At best it involves a series of iterations which serve to improve the mine plan incrementally. The iterations allow for efficient review and input by multidisciplinary specialists. The number of iterations can be reduced by involving the multidisciplinary specialists in brainstorming sessions at the onset of a planning process.

4 CONCLUDING REMARKS

A pro-active approach for mine water management is recommended because it will improve environmental compliance and reduce costs of water management during mine operations and for mine decommissioning. This requires early participation of multidisciplinary specialists including water management specialists in the mine planning process; partnerships among planners, designers, operators and regulators; innovative solutions for water management; comprehensive hydrologic study and data collection; and design of sustainable drainage system for mine decommissioning.

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