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ABANDONMENT OF MINE TAILINGS PONDS

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Canadian Water Resource
Journal, 14p. 1987.

Skinner

RECEIVED AUG 4 1988

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ABSTRACT

In response to growing concern about the long term environmental impact of abandoned mines and their tailing ponds, regulating authorities are beginning to request that abandonment plans be submitted with license applications. This paper suggests criteria that such plans should meet and emphasizes the need to ensure that adequate funding will be available to implement abandonment plans. Anvil Mines in the Yukon is described as an example.

INTRODUCTION

Until it was shut down during the 1982-85 recession, Cyprus Anvil operated the largest mine in the Yukon, a lead-zinc mine at Faro. Tailings from the mine were deposited in a tailings pond in the valley bottom and the creek, which was originally there, was diverted along a bench above the valley. As part of its expansion plans for the eighties, the company applied for a water license for a new larger tailings pond and for an extension to the diversion channel. The company was given permission to proceed with construction but a water license was withheld until the company submitted a satisfactory abandonment plan.

The author was retained by the Yukon Water Board to advise on the company's plans for final abandonment of the mine and its associated facilities, the most important of which were the tailings pond and the creek diversion. At the time, everyone was confident that the mine would

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have an operating life of at least 30 years. Since there were almost no precedents for this type of problem, the first step was to develop some general guidelines for abandonment plans. Then, as the review and approval process unfolded, one overriding problem emerged - how could the regulatory authority ensure that, when the time came, the approved abandonment plan would actually be carried out.

In this paper, background information on mines and tailings ponds is given to set the problems with abandonment in perspective. Next, the general guidelines developed for planning for abandonment are presented, followed by specific suggestions on the key problem of how to ensure that accepted plans are implemented. Finally, these are illustrated with the Anvil mine example.

BACKGROUND

In a typical open pit metal mine, the waste rock is first stripped away and then the ore is mined and taken to the mill for processing. There it is crushed, ground up, mixed with water and the metal concentrate is separated out from the slurry by a process that depends on the particular ore. The reject material, known as the tailings, are transported, usually by pipeline, to a tailings pond for disposal. The water may be recycled through the mill or it may be decanted from the pond and discharged. Tailings ponds used to be given scant attention and treated almost as an afterthought to the mining plan. But now with many large open pit mines generating millions of tons of tailings every year, tailings ponds and tailings dams are being treated as the important structures that they are.

Often the most practical location for a tailings pond is in the valley bottom. This is especially true in British Columbia and the Yukon with

their rugged terrain. Usually there is already a creek there, and it has to be diverted. A typical tailings pond in a valley has a containment dam at its downstream end and sometimes also at its upstream end; and the creek would be diverted from its original location, around the pond, often along a natural bench some distance above the valley floor. With such a design, great care has to be taken with the design, construction, monitoring and maintenance of the dams and diversions to ensure the continued safe physical containment of the tailings. It is also important to ensure that releases or seepage of water from the pond which may contain heavy metals and residual chemicals from the separation process do not contribute to water quality problems in the surrounding environment. As long as a mine is operating, personnel and equipment are available for maintenance but, after it has been abandoned, that will not be the case. Ensuring that diversions and tailings ponds will continue to perform satisfactorily after abandonment, therefore poses a quite different and much more difficult problem.

Some of the relevant questions about mine and tailings pond abandonment have been addressed in recent studies concerned with uranium mining - one by the Cluff Lake Board of Enquiry in Saskatchewan (1978) and one by the U.S. Nuclear Regulatory Commission (1979). These were landmark studies involving wide ranging examination of related topics, testimony by recognized experts and extensive public hearings. Although not directly concerned with the abandonment of metal mines, they provide a useful perspective on the design of disposal facilities that have to perform satisfactorily for a very long time.

GENERAL CONSIDERATIONS IN PLANNING FOR ABANDONMENT

Benefits and Costs

Ideally, a large project should be developed in a way that maximizes net benefits, that is, maximizes the differences between benefits and costs. If the benefits and costs, both tangible and intangible, are borne by the same people, and they are in control of the project, then decisions about it can be left to them since they can be expected to trade off benefits and costs in the way which best suits them. However, when the benefits accrue to one group and the costs are borne by another, it becomes much more difficult to decide on the "best" course of action. With a typical large Canadian mine, the beneficiaries include the workers at the site, service businesses and suppliers in the area, company management personnel, shareholders in the company, people all across Canada who benefit from taxes paid by the company, and consumers all over the world, who benefit from marginally cheaper metal products because of the production from the mine in question. The costs are likely to be mainly in the form of environmental disturbance and resource depletion, which are borne mainly by residents in the area including both present and future generations.

Simply listing some of the benefits and costs makes it clear that a precise cost-benefit analysis for any particular scheme would be out of the question. However, the principle that costs and benefits should roughly balance, provides a useful criterion that can be helpful in ruling out schemes where the environmental damage would greatly outweigh the benefits, or schemes where minimal environmental benefits could only be achieved at great cost.

Recognizing that the benefits from a mine will be widely distributed while the costs will fall mainly on area residents, suggests that regulatory authorities have a special responsibility to see that their interests are protected, particularly those of future generations. If the abandonment plan is flawed to the extent that the tailings are released into the environment or the water quality in the rivers downstream is seriously degraded, or if the abandonment plan is never implemented, then most of the costs will fall on them.

the mine.

Planning Horizon

Historical evidence shows that there are very few long lived institutions, that human institutions and human values are transitory, and that few last more than a few centuries at most. Places or artifacts which are sacred to one generation, such as graveyards or national monuments, rapidly lose their meaning and hence their power to influence succeeding generations. This suggests that any abandonment plan should require as little maintenance as possible. It is not reasonable to expect any arrangement for continuing maintenance to be honoured for very long after a mine has ceased production.

Assuming they have no utilization or aesthetic value, is not a cultural assessment. Although they may have a value for future re-mining for other metal values retained in the tails.

The time horizon for an abandonment plan should be very much longer than that used in the design of even the most important structures today. Ideally the tailings should remain safely contained forever. However although a dam can be designed to withstand severe floods and earthquakes, no one would pretend that it could withstand ice action in the event of another ice age. Since the last ice age ended about 10,000 years ago, this seems like a reasonable planning horizon to aim for.

Elegant - quote in our paper on long-term stability

Effects of Uncertainty

The difficulties of planning for abandonment are compounded by uncertainty. Uncertainty arises from lack of knowledge, from the inherent uncertainty associated with natural phenomena such as floods or earthquakes and from uncertainty about possible technological advances. Also, one cannot be sure how plans will be implemented when it actually comes time to close down a mine in perhaps 20 or 30 years time. Modern decision theory, although not directly relevant to decisions about abandonment, offers useful insights into rational behaviour in the face of risks. The most helpful is that the degree of safety should be related to the consequences of failure. It is possible to justify much more stringent safety measures when the consequences of failure could be catastrophic than when the consequences would result in only minor inconvenience. Another useful concept is that where it is possible to resolve uncertainties through experimentation, it is often economical to do so. Also, in the face of uncertainty, flexible plans that can be adjusted to circumstances as they arise are obviously better than rigid plans that can not.

Existing Standards

Most jurisdictions have standards for the safe containment of tailings and water quality standards for the effluent discharged from the tailings pond while the mine is operating. These have generally evolved over time, often following considerable study and discussion. Usually they are quite specific about concentrations which may not be exceeded; and many also state that no waste discharge shall be toxic to fish. They probably represent the concensus of informed opinion on measures which will adequately protect the environment, yet not involve costs that would be

prohibitive. Since the main impact of a mine following abandonment will be felt through changes in the quality of water flowing through and past the abandoned tailings pond and the possible release and dispersal of the tailings themselves, it is reasonable to require that the tailings facilities should continue to meet existing standards for safe containment and for water quality, indefinitely.

Implementation and Funding

Planning for abandonment should be an integral part of the general mine planning process. The most satisfactory and economic abandonment plans are likely to be those prepared as part of the original plan for development of the mine; and the least satisfactory those tacked on at the end as an afterthought. Mining plans are continually being adjusted in response to changing markets and knowledge about the orebody as mining proceeds. Abandonment plans should be updated as part of this general process to ensure that it is physically and financially feasible to implement the plans when the time comes.

For a regulatory authority, the most difficult question about mine abandonment is how to ensure that the plan is implemented when the mine is finally abandoned. Implementing an abandonment plan can be costly with the cost being incurred at a time when the mine has closed down and is no longer producing revenue. The mining company may be reluctant to spend funds on a non-productive facility and, at this stage, the authorities may have little leverage to compel this expenditure. The obvious solution is to have an "abandonment fund" built up during the productive life of the mine and dedicated to financing the final abandonment plan. However, there are some practical problems with this including:

1. It is often difficult to know when a mine has been finally abandoned. Mines may close down and open up again depending on markets, metal prices ore grades and so on.
2. It is difficult to estimate what it may cost to implement an abandonment plan many years in the future. The required size of the facility may change, the technology may change and standards for acceptable design and construction may change.
3. It is difficult to devise a suitable financial instrument that will guarantee the availability of funds when required, yet not tie up capital needlessly and unproductively. Mining companies are extremely reluctant to have funds tied up and, in Canada, it is not certain that such funds would be exempt from taxes.

Despite the difficulties, the costs associated with abandonment are real and must be borne by someone; and this clearly should be the mining company and not the taxpayers.

*The public
pays anyway
the long run.*

Looking at precedents for guidance, the regulations of the United States Nuclear Regulatory Commission are the most comprehensive. They require an abandonment plan to be submitted along with evidence of financial commitment. Individual states can have their own regulations but they must be at least as stringent as the federal ones. The uranium tailings regulations distinguish between "closing out costs", those for abandonment as discussed in this paper, and "long term costs", those associated with monitoring for radioactivity over a very long period. For the abandonment of the mine and tailings pond, the company must provide financial assurance in a form satisfactory to the Authority and in an amount calculated as that which an independent contractor would charge for the work. Thus should the mine default, the government could take over the bond or fund and have the work completed.

Some provinces in Canada and some states in the U.S. have provision for bonds to ensure the carrying out of reclamation plans for mines other

than uranium mines. But the amounts are small - usually in the order of a few thousand dollars per acre and aimed mainly at re-seeding and reclamation of disturbed areas. However the State of Idaho (1980) has regulations for mine tailings that require assured funding at realistic levels to cover the costs of abandonment. There, licences are issued for 2 year periods and have to be re-approved and re-issued every 2 years. Each time it applies for a renewal, the mining company must submit an abandonment plan

"detailed enough to provide the cost estimate required for bonding purposes" and it must post a bond or other acceptable financial guarantee in an amount sufficient to carry out the abandonment plan should it be necessary during the coming 2 year period. The amount of the bond is adjusted at each renewal to ensure that if it becomes necessary to implement the plans, sufficient funds will be available. This ensures that a mining company takes its obligation for satisfactory abandonment seriously, and sets aside the necessary funds. The costs are now tangible and part of the general operating costs. This should force the desired integration of planning for abandonment with the normal planning process and ensure that the abandonment plans are kept up to date. However, the mining company is relieved from having to make plans way into the future and must commit only sufficient funds to be able to safely abandon the tailings generated by the end of the current licence period. This seems a sensible approach and a suitable model for Canada.

PROPOSED CRITERIA

From the above general considerations the following criteria can be developed for tailings pond abandonment:

1. The plan should guarantee the permanent safe physical containment of the tailings with "permanent" taken as a period of the order of 10,000 years. This means that the dam should be able to pass the maximum probable flood and withstand the maximum credible earthquake.
2. The quality of water discharged from, or flowing past the tailings pond should continue to meet effluent water quality standards following abandonment.
3. The abandoned facilities should be maintenance-free.
4. If possible the plan should provide for the unimpeded passage of fish past the tailings pond, if this can be done without jeopardizing the safety of the dam.
5. At any particular stage the plan need only be conceptual, but it should be in sufficient detail to ensure its feasibility - both technical and financial.
6. If there are areas of unavoidable uncertainty because of inadequacies in presently available knowledge, then investigations should be undertaken as soon as possible to leave sufficient time for adjustments that may be necessary.
7. Licences should be issued for limited periods of the order of 2 years at a time.
8. Sufficient funding should be set aside or, be assured by a bond or other financial commitment to guarantee that should the mine close during the current licence period, the necessary resources will be available and dedicated to carrying out the abandonment plan.

The above are general rules which would likely have to be modified or adjusted to fit a particular situation. For example, it may be more economical to provide a capital fund, with the interest used to pay for periodic inspection and maintenance than to make a facility completely maintenance free; or in situations where the adverse effects from a tailings dam failure would be minor, less stringent design criteria for the dam may be appropriate. Careful judgement will be required in each situation. Nevertheless, the above are believed to provide a realistic set of guidelines to start from.

A CASE STUDY

In 1969, Cyprus Anvil opened a lead-zinc mine at Faro in the Yukon, by far the largest mine in the Territory. The tailings were deposited in a tailings pond located in the valley bottom alongside Rose Creek, the creek which originally occupied the valley. In the mid seventies, a new tailings dam was constructed across the valley, expanding the original tailings pond to take in the whole valley bottom; and Rose Creek, was now diverted through a channel along a bench above the valley bottom. This is a fairly typical arrangement as the valley bottom, being reasonably flat, allows storage at low cost and being at a low elevation allows gravity discharge of the tailings from mill to pond, a desirable feature from an operating point of view.

In the late seventies, as the pond begin to fill and the mine began a major expansion, plans were prepared for another larger cross valley dam downstream from the existing one and for an extension of the Rose Creek diversion channel past the new dam. The company applied to the Yukon Water Board for a water licence for the enlarged pond and the extended diversion channel. They were given permission to proceed with construction but a water licence was withheld until the company submitted a satisfactory abandonment plan. The company then appointed consultants to prepare the required abandonment plan. The consultants developed 3 alternative plans:

- (a) an arrangement similar to the existing tailings pond and diversion;
- (b) a "flow through" addition to the present main tailings dam to raise the water level in the tailings pond and diversion of Rose Creek back into the tailings pond;
- (c) removing the tailings from their present location and storing them in the abandoned open pit.

The consultants pointed out that alternative (c) would obviously be best from every point of view except cost, but it would be extremely expensive; alternative (b) would be acceptable and not so expensive; and alternative (a) would probably not be acceptable as they could not see how to ensure the integrity of the dam and the diversion without the regular maintenance that is available only as long as the mine is in operation or on temporary shutdown. They recommended alternative (b) which would involve an innovative flow-through dam to keep the tailings permanently submerged and be able to pass flood flows without erosion or deterioration of the dam. Keeping the tailings permanently submerged would inhibit the production of acid and the leaching of heavy metals into the effluent; and the dam was designed to withstand the maximum credible earthquake and to pass the maximum probable flood. This plan was estimated to cost about \$50 million (in 1982 dollars), with the bulk of the cost being incurred at the end of the active life of the mine.

The mining company endorsed the flow-through dam plan, did not appear to question its cost or press for a less costly scheme, and submitted it to the Yukon Water board as its proposed abandonment plan. The Board asked about the provision of funding to guarantee implementation, but the company vehemently opposed any form of bond or guaranteed funding on the grounds that such a requirement would be unprecedented for the mining industry and a severe extra burden for the company. Following a 2-day Public Hearing in Faro in March 1982, the Board issued a licence for a seven year period. Although the license imposed a number of technical requirements such as monitoring, it did not require the provision of bonds or funds to guarantee the financing of the abandonment plan. However the Board gave the company notice that some such guarantee would be required at the next licence renewal.

The mine has an estimated life of at least 25 to 30 years and at the public hearing, any suggestion that it might have to close down before the next century were dismissed as unthinkable. In the event, the mine had to close down along with all other major mines in the Yukon in the 1982-85 recession, emphasizing the uncertainties and the unpredictability associated with the mining industry. Now, in 1986, the mine is just being readied for re-opening, this time under new ownership.

CONCLUSION

Mine tailings ponds represent a potential long term hazard to the environment. Mining companies should be responsible for ensuring that when their tailings ponds are abandoned, they are left in a safe and satisfactory condition and will not require continuing maintenance by governments at a cost to the taxpayers. Regulatory authorities should require that abandonment plans be kept up to date and that funds for implementation be guaranteed. This can be done by requiring re-submission of plans for abandonment, funding guarantees and renewal of licences at relatively short intervals such as every 2 or 3 years. This should encourage the mining companies to integrate planning for abandonment with their normal mine planning activities, a process that should result in overall economies, and minimize any financial burden on the companies.

Acknowledgements

The help of Mr. H.F. McAlpine of the Department of Indian and Northern Affairs Whitehorse in formulating and discussing the above concepts is gratefully acknowledged.

References

Cluff Lake Board of Inquiry, 1978, "Final Report", Regina, Saskatchewan.

State of Idaho, Dept. of Water Resources, 1980, "Rules and Regulations for
Mine Tailings Impoundment Structures", Boise, Idaho.

U.S. Nuclear Regulatory Commission, 1980, "Final Generic Environmental
Impact Statement on Uranium Milling", Washington, D.C.