

RATIONAL SELECTION OF POST-MINING LAND USE¹

by

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Abstract: The right post-mining land use (PMLU) can minimize reclamation and surety costs, shorten the term of post-closure liability, and in some cases even produce revenue for the mine operator. Rather than an afterthought, the selection of PMLUs should be a deliberate process that takes into account a variety of factors. These factors can be grouped into four categories - environmental impacts and mitigation, land management, public interest, and feasibility. For existing mines that were planned without a PMLU, environmental impacts and mitigation may set limits on the PMLUs that can be implemented. Similarly, management policies for public lands usually limit the possible PMLUs. For new mines on private land, or on public land with forward-thinking management policies, a methodology for rational selection of PMLU can be used to include all four categories of factors. This methodology can be used also for existing mines or mines with public land policy constraints, but with fewer options and less latitude for economic feasibility evaluations. The selection process follows a sequence of screening steps that include site resource evaluation and options identification, feasibility evaluation, impact assessment, and cost/ benefit analysis. The process can be very detailed and rigorous for large mines but can be simplified for smaller, less complex mine sites. In any case, the rational selection process uses an objective methodology that produces a defensible, documented PMLU decision.

Additional Key Words: environmental impacts, land management, site resources, reclamation

Introduction

Mining has been going on for thousands of years, but only since the 19th century has it involved large land areas or substantially impacted surrounding lands. The value of mined land used to be defined solely in terms of the mineral values; once the minerals were extracted, the land's value was gone, or so it seemed. Only in the second half of this century has the post-mining value and use of land drawn any meaningful attention. Now every mining state in the U.S. has some form of requirement for measures to protect or reclaim mined lands to some level of productivity, but many such requirements are centered around a prescribed set of conditions that reclamation must

achieve, regardless of PMLU, rather than selecting appropriate PMLUs first and then determining the reclamation measures needed to create or enable the selected PMLU. Part of the reason that reclamation is not more often based on PMLUs is that a rational methodology for PMLU selection has been lacking. This paper describes a rational method for PMLU selection that uses site-specific factors and defensible logic.

The Role of Post-mining Land Use in Mine Planning and Reclamation

In the not-too-distant past, the question "What will the land be used for after mining?" would have drawn predictable responses like "I don't know" and "Who cares!" That was when mining companies could walk away from an unreclaimed mine site without a care. Now the company must satisfy reclamation requirements before its permit is terminated and its bond released. The company knows that it will have to perform reclamation, but it still might not know or care what the PMLU will be if it is expected only to satisfy some arbitrary reclamation criteria.

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Who should care? The company, the regulatory agencies, and the public should care. They all should care because a mine site planned to subsequently achieve or enable the right PMLU(s) can be more economically and successfully reclaimed for uses that fit the site and the community. By contrast, measures prescribed to restore pre-mining conditions (e.g.; approximate original contours) do not consider how the reclaimed land can or should be used. The prescriptive approach to mine planning and reclamation makes the PMLU subservient to reclamation instead of reclamation serving the needs of the PMLU.

To illustrate the proper relationship between reclamation and PMLU, consider a common reclamation requirement - restoring approximately original contours. This requirement is based on the premise that land forms that existed before mining should (and can) be restored. However, the overburden and interburden materials are not the same as they were; they've been substantially altered by excavation and weathering. These materials may not be able to maintain stable slopes if put back to original contours, making flatter slopes necessary. In addition, years of mining will certainly change the local demographics and economy, making a return to past community values impossible or inappropriate. What is needed instead is rational selection of PMLUs that fit the impacted site and community, taking into account the irreversible changes that mining has caused. If PMLUs are selected with this perspective in mind, the reclamation measures can then be tailored to achieve PMLU requirements.

Not all changes caused by mining are negative; some may be very beneficial. PMLUs can be selected to take advantage of some mining-induced changes. Old quarries south of Chicago now serve the metropolitan area as storm water reservoirs of the Tunnel and Reservoir Plan (T.A.R.P.) to hold runoff until it can be treated (Kuhn, 1978). Some coal mine highwalls in New Mexico have been left in place to provide critical raptor habitat (Garland, 1997). A mountain ridge will be removed by surface mining near a large western city, making the post-mining flat surface worth more after mining than before because it is ideally located for residential development (Silverman, 1996). In each of these cases some thought was given to the beneficial potential of mined land forms, and reclamation was planned around the selected PMLU.

Mining should be viewed as one use in a succession of uses of a particular piece of land. In

planning new mines, a life-cycle plan should include potential PMLUs and the reclamation measures appropriate for those uses most likely to be implemented. For existing mines that were not planned with a life-cycle approach, PMLUs are still important in determining how the mine can be managed through closure to minimize impacts and facilitate PMLU-focused reclamation.

The Need for PMLU Selection Methodology

If the PMLU is to be the basis for reclamation planning, then the PMLU must be selected with a rationale that takes into account all relevant characteristics of the mine site, the mine vicinity, regulatory and environmental requirements, and the economic and social community. The mine operator has much at stake in the selection of the PMLU(s), specifically:

- actual cost of reclamation
- value of residual site assets used in the PMLU
- other financial liability, including financial assurance, for reclamation
- environmental liability, including compliance requirements in state and federal rules and active or passive damage assessments by the Natural Resources Trustee
- public support or opposition, including potential for citizen suits, where applicable

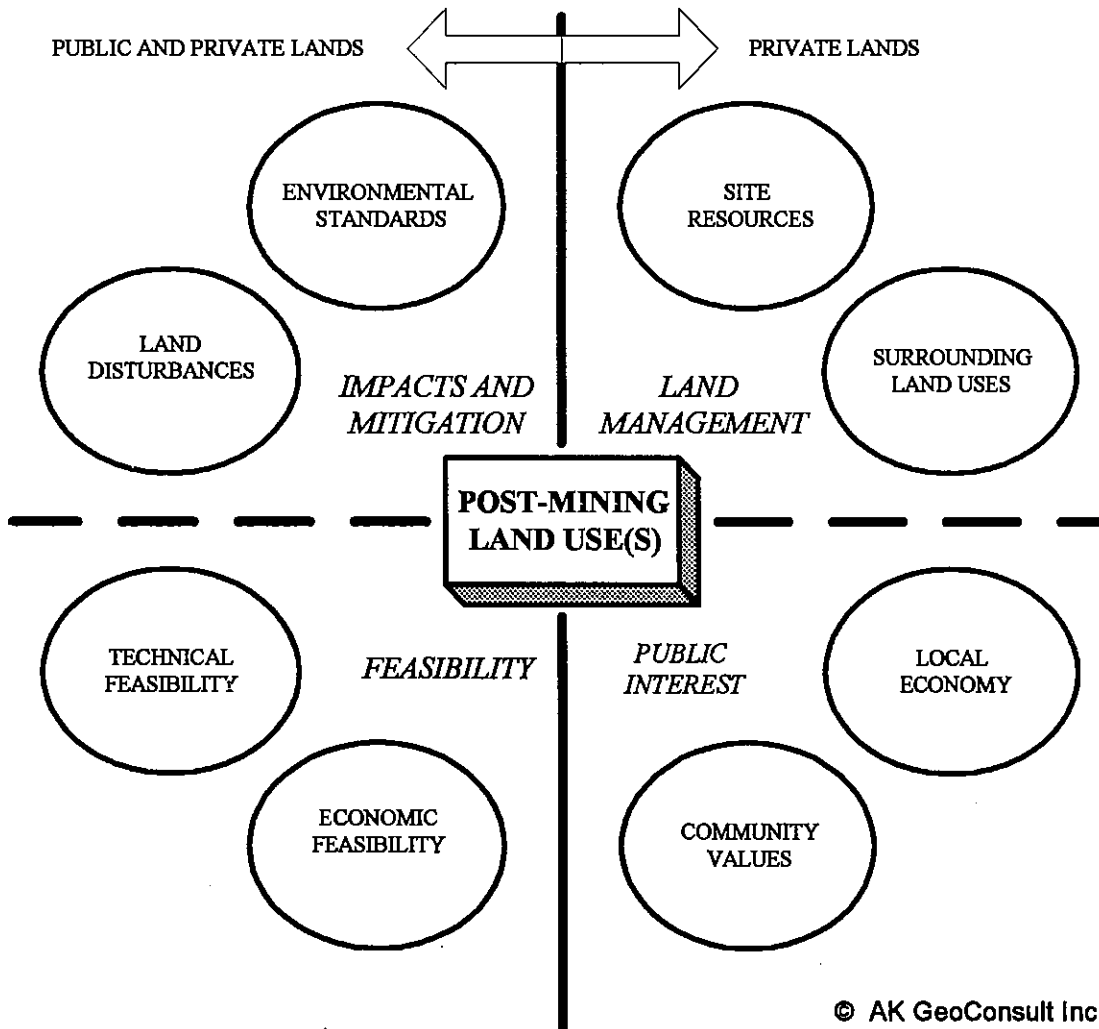
Considering all that could be at risk, the mine operator needs to select PMLUs carefully, not as an afterthought to mine or reclamation planning. It is not enough to simply pick the pre-mining land use or the apparently easiest-to-implement use, because in fact these may not be feasible or may entail more cost or more residual liability than other uses. Rational PMLU selection requires that all factors affecting the selection be identified and evaluated through a systematic selection process.

Factors in PMLU Selection

Selection of a PMLU involves a number of factors, illustrated in Figure 1, that can be grouped into four categories:

- feasibility
- environmental impacts and mitigation
- land management
- public interest

Figure 1
FACTORS IN SELECTION OF POST-MINING LAND USE(S)



The specific factors in each of these categories, as well as the importance of each, will vary from site to site. However, the four categories are listed above in the most likely order of importance. The importance of the categories also differs between public land and private lands, the former usually presenting fewer options in land management and public interest factors than the latter.

Feasibility

In PMLU selection there are two types of feasibility factors - technical and economic.

The two are clearly different but, in the context of PMLU selection, they are often inseparable.

Technical Feasibility. In the most simplistic terms, if the means exist to implement a PMLU, then it is technically feasible. The line separating feasible from unfeasible is often not a sharp one, especially when the measures being considered lack precedent or carry substantial uncertainty. In cases where considerable doubt exists, the PMLU should be classified as technically not feasible because the PMLU by definition needs to be achievable through the implementation of specific measures.

Economic Feasibility. Where technical feasibility is usually based on objective criteria, economic feasibility includes both objective and subjective criteria; i.e., costs and returns. The objective criteria relate to the costs of the measures needed to implement the PMLU. The subjectivity involves the perception of value, or the return achieved for the money spent, and this perception will be different for an environmental regulator than for a mining company CFO. When coupled with risk or uncertainty of technical feasibility, the economic feasibility issues can become very complex.

There is no simple, one-size-fits-all approach to evaluating the economic feasibility of all potential PMLUs. The task is relatively straightforward for PMLUs with predictable revenue-generating potential, such as converting a mine pit into a municipal landfill. In this case, the costs of the conversion and landfill operation and closure can be compared quantitatively to the predictable revenues. The PMLU is economically feasible if the revenues minus costs yield an acceptable net return on investment. However, if that same mine pit is converted to a PMLU that lacks an economically quantified return, such as wildlife habitat, the benefits realized from the costs are largely subjective. To the extent possible some economic value should be applied to each potential PMLU so that they can be compared to each other in quantified terms.

Technical and economic feasibility can become confused if an old adage is applied - throw enough money at a problem, and anything is possible. Unless a PMLU has inherent and necessary experimental elements, it should never require measures that push the state of technology or involve costs that have negligible benefit. In fact, an important difference between reclamation based on rational PMLUs and that based on prescriptive measures is that PMLU-based reclamation has a specific functional objective. Only those measures required to meet that objective are employed.

Environmental Impacts and Mitigation

PMLUs should satisfy applicable environmental standards and limit land disturbances. Meeting environmental standards is usually mandatory, while limiting land disturbance is good practice even if not mandatory.

Environmental Standards. The selection of a PMLU may be limited by environmental standards or

mitigation requirements that can be satisfied only by taking specific measures. These measures may drive the PMLU decision either toward or away from a particular PMLU. For example, standards that require preservation of wetlands, even those created by mining, may rule out other PMLUs for that land such as agriculture. On the other hand, those wetlands might serve environmental mitigation purposes by continuing to remove heavy metals from mine drainage, making their incorporation into the PMLU not only mandatory but desirable.

In some jurisdictions there may be categorical requirements to mitigate mining-created impacts. Standards for protection of water resources are in place at federal and state levels everywhere in the U.S. These standards will generally take priority over reclamation-specific standards. Therefore, the options for PMLU selection may be limited to those that will provide, or at least not compromise, the mandated protections.

Land Disturbances. In the context of this discussion, land disturbance includes all disturbances to vegetation, land forms, and earth materials; consequently, even land surfaces with only impacted vegetation are disturbed.

The types, sizes and shapes of land disturbances are the most obvious impacts of mining and, therefore, the most commonly used indices for mitigation of impacts. A PMLU should be selected in part for its ability to either mitigate land disturbances or turn them to productive use. Some of the largest land disturbances caused by mining in the U.S. are due to open pit copper mining, most of which have been operating for many decades. Backfilling was never considered when these mines started operating, and the logistics and costs of backfilling in the future would be overwhelming. Mitigating land disturbance on this scale is the main challenge in reclamation of these mines. The most rational approach is to develop a PMLU that can take advantage of the sizes and shapes of these disturbances.

In identifying a PMLU that mitigates or utilizes land disturbance, the biggest obstacle to getting started is old mind sets. For some, the thought of doing anything with major land disturbances, either reclamation or conversion to a PMLU, triggers an immediate and determined resistance to considering the possibilities, usually because the mere idea conjures up images of out-of-control costs and corporate bankruptcy. The process stops there unless

that reflexive response can be overcome by some deliberate and creative thinking. The key is to look at the disturbance as a composite of assets as well as liabilities. The assets may not be apparent at first, but if the site is viewed from the perspective of potential PMLUs, then possibilities can emerge. Once the process gets started, PMLU selection seeks to offset liabilities with assets and costs with potential returns.

Land Management

Land management factors in PMLU selection obviously have to start by taking into account the ownership of the surface and mineral estates. If ownership of the surface or both is private, the land management factors must reflect the wishes of the surface owner, and these might override all other factors except environmental standards. If the surface is owned by the state or federal government, then the policies or regulations of the managing agency will set some limits for PMLU selection. Recognizing the caveat of any such limitations, the land management factors in PMLU selection involve site resources and surrounding land uses.

Site Resources. Historically, miners have had a singular focus on the target mineral, and other attributes of the mine site were only coincidental. Recently, environmental and economic drivers have forced the mining industry to consider other site resources that may be impacted by mining. Total resource management approaches to mine planning and operation have been proposed to maximize the benefits of such resources to the mine operator (Kuhn 1998).

Site resources are any attributes that have value. This value need not be monetary only; it can be cultural, aesthetic, or environmental as well. Some resources of a mine site other than the target mineral will be disturbed no matter how carefully mining is done. If a post-mining use for the disturbance can be found, the disturbance becomes an attribute.

With some creative mine or reclamation planning, a PMLU can be selected to either make productive use of the disturbance or to mitigate it. For example, waste rock at an open pit mine was piled up in large dumps that sat untouched for decades. Oxidation of sulfides accelerated the breakdown of already highly weathered and broken rock, producing kaolinitic clays. The weathered rock/clay material with its substantial acid neutralizing potential became

a valuable source of structural fill in an area generally poor in this construction material (Kuhn, 1996).

Surrounding Land Uses. One of the favorite themes of environmental activists is that mined lands should be returned to their pre-mining condition and use. In reality, neither of these goals is usually achievable or desirable. It is hard to find a place in the U.S. where land uses are exactly the same today as they were a generation or two ago, whether or not mining has occurred there. This is the result of rapidly changing demographics as well as changes in technology and public policies.

A PMLU is much more likely to be accepted and to succeed if it is consistent with present uses of the surrounding land. Some of those uses may have developed as a direct result of the mine and, therefore, be untenable after the mine closes. Therefore, it is necessary to consider only those surrounding uses that have viability independent of the mine. On federal or state lands, the surrounding land uses might, in fact, dictate the PMLU of the mine site.

Public Interest

Land management and public interest factors are often inseparable, but for this discussion land management addresses the mined land and public interest addresses the mining-impacted community. When the well-being of that community is recognized by the mining company and supported in its PMLU selection, the backing of the community can be a powerful voice in obtaining regulatory approvals of mining and reclamation plans.

Local Economy. Both altruistic and self-serving issues are involved in selecting a PMLU that is supportive of the local economy. When mining-related sales and wages disappear from the economy, mining communities have historically gone through hard times. The legacy remains for many years, a fact that has been used by anti-mining activists to oppose new mining anywhere. So a PMLU that can provide employment and revenues in place of those from mining is good for both the community and the mining industry.

The most obvious PMLUs that could replace mining's economic role are those that take advantage of the same labor skills and infrastructure that supported mining. These will tend to be oriented toward heavy construction, manufacturing, and materials handling and transportation. Selection need

not be limited to these, of course, but the transitions in the local economy are eased by PMLUs that minimize the need for retraining or new investment. For those local economies that enjoy a broad base, the loss of mining jobs and revenues may be relatively insignificant, leaving little concern for the economic potential of a PMLU.

Community Values. When jobs are scarce and money is tight, these concerns become central to community values. However, other elements that characterize a community are not tied to economics. The cultural makeup of a community can create an atmosphere that can tip the scale for or against mining, driving or obstructing the mine at every step it takes. A PMLU that is part of a well-prepared life-cycle mine plan takes into account the history of the community, its ethnic and cultural heritage, and impacts that a mine would have on the local sensitivities.

Although there may be no easy fit of a mining operation with the community values, the difference in whether a mine is accepted could be the mining company's willingness to make the PMLU fit the community. The key to this is community involvement. This does not mean that the company turns over decision authority; it means that lines of communication are established with community leaders so that all points of view are heard and problems are given a mechanism for resolution short of litigation.

The PMLU Selection Process

The foregoing discussion shows that many factors bear on the selection of a PMLU, making the process of choosing a PMLU more than a rote exercise. To give all relevant factors their appropriate roles, the selection process should follow a rational methodology that:

- characterizes the site resources and their values
- identifies PMLU options
- evaluates the feasibility of each option
- assesses the impacts of each option
- analyzes the cost versus benefits of each option
- provides objective ranking for selection

The methodology should provide mechanisms for screening options so that only those options that satisfy the acceptance criteria of one step are taken through the next step. A six-step process that employs

this methodology is illustrated in Figure 2 and described below.

Step 1 - Site Resource Evaluation

In this first step the objective is to identify and evaluate all attributes of the site, and of the surrounding area where appropriate, that can have value after mining. To the extent possible the evaluation should be in one scale of measurement, monetary value, to make subsequent comparisons between options more objective. Assigning monetary values to some site resources will be difficult, in many cases requiring subjective judgment to assign dollar values to features such as scenic views or historic structures. The value assigned to any such resource may be open to criticism, but if a rationale for assigning values is carefully developed and documented, there will at least be a common point of reference for further discussion and refinement of the evaluation.

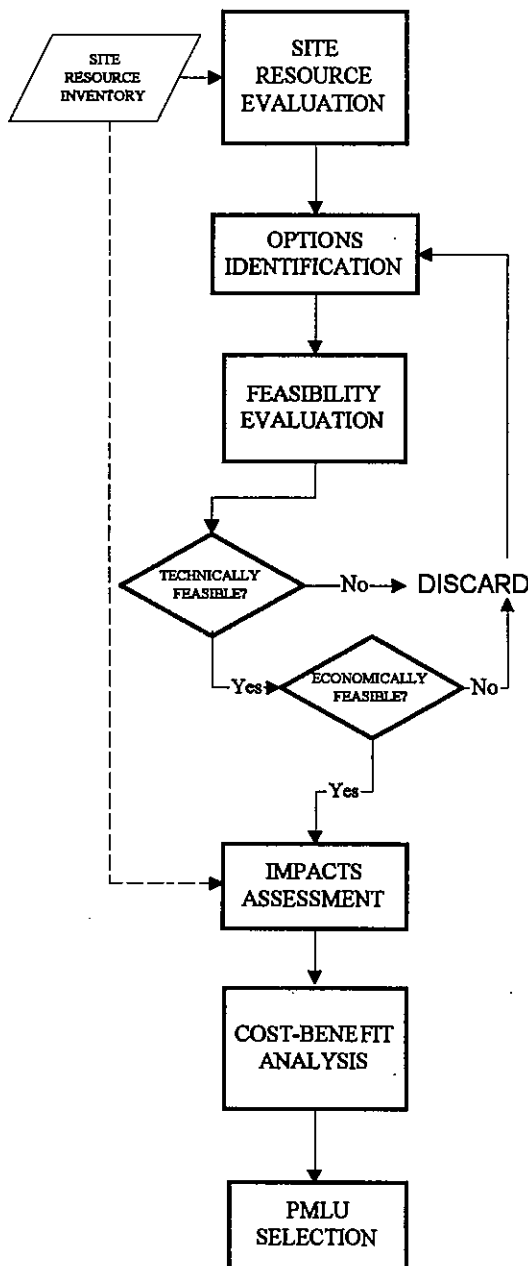
It is important to keep in mind the potential value of all site resources, not just the natural resources. Mine facilities, waste materials, and byproducts should always be evaluated as potential resources; the cost of evaluating them is very small compared to the returns that they might yield.

Step 2 - Identification of Options

With site resources identified and values assigned, the next step is to develop a list of as many options as possible. For this the only limit is imagination and creativity; no idea should be discarded at this point unless it is clearly not reasonable.

This is the appropriate time for inclusion of input from the community and, for public lands, from the managing agency. The latter may have statutory or regulatory requirements for PMLUs that would make some options not possible. The community may have incomplete understanding or unrealistic wishes, but its different perspectives may produce good ideas that the mining company might not have considered. Furthermore, the community's involvement in the process at this point can foster an important supportive relationship in the approval and success of appropriate PMLUs.

Figure 2
PMLU SELECTION PROCESS



Step 3 - Evaluation of Feasibility

From step two, a list of options is developed that can include the full range of possibly reasonable options. In step 3, the first screening takes place to pare the list down according to technical feasibility.

Technical feasibility is evaluated on several levels. The first and most obvious addresses whether

the technology exists to implement the option. If so, then the next level is the uncertainty involved in the option; i.e., how much information is needed versus how much is, or can be, known that is critical to the implementation of the option. Finally, feasibility should address the physical compatibility of the option, or how well does the option fit the setting.

To objectively evaluate and compare the feasibility of options for which the needed technology exists, a numerical ranking system should be used. The author's own preferred system assigns a rank of 1 to 5 for uncertainties, with 1 being most uncertain, and 1 to 10 for physical compatibility, 10 being most compatible. The total score is the product of the two numbers, giving a range of possible scores from 1 to 50.

Economic feasibility is evaluated only for those options that have acceptable scores on technical feasibility. Economic feasibility must be based on two criteria, the estimated cost of the option and the potential revenue that the PMLU can produce for the mining company. The feasibility of spending \$1M for a PMLU on a mine site that covers 1000 acres and produced \$200M in profit is clear, but not so for the same \$1M spent on a 100 acre site that produced \$2M profit *unless* the PMLU can produce enough revenue to the mining company for it to recover that \$1M cost. Note that the mining company need not retain the mine property to realize the necessary financial return; it can recoup that investment through sale of the property worth at least \$1M more than without the PMLU.

From the options that are scored for feasibility, only a few will be retained into the next step of the selection process. The cutoff might be a certain minimum score or perhaps the top five, but the scores of the feasibility-ranked options will usually leave little doubt about which options deserve further evaluation.

Step 4 - Assessment of Impacts

In step 4 the options surviving step 3 are subjected to assessment of their potential impacts. These include negative impacts such as:

- degradation of air, water, or habitat
- depletion of site resources
- land disturbances in addition to those from mining

as well as positive impacts such as:

- mitigation of mining-related negative impacts
- protection or conservation of site resources
- improvements to ambient air, water, or habitat quality
- new revenues for the local economy

This step requires that impacts be not only identified but also quantified as much as possible. Every discipline involved in the assessments has models that are used routinely for these predictions, but each model has associated with it some uncertainty. The level of uncertainty must be recognized in the assessments, and the conclusions drawn from the models should contain the necessary caveats to express the uncertainty.

The assessment of impacts provide the basis for screening the feasible options to eliminate those that would have excessive negative impacts. A ranking system similar to that used for technical feasibility can be used in some cases, but normally the combination of negative and positive impacts will result in either findings of obvious unacceptability or clear advantages of some options over others based on their relative impacts.

Step 5 - Cost-Benefit Analysis

The options that are preferred based on their expected impacts are subjected to cost-benefit analysis in step 5. This step takes the cumulative results of the previous steps and makes monetary comparisons based costs to implement the PMLU options versus the financial benefits expected from the options. Costs to implement an option are derived from both the economic feasibility evaluation and from more detailed definition of work developed in this step. Benefits are based on the impact assessments of step 4, from which positive impacts are evaluated for their economic benefits in this step.

In the cost-benefit analyses the role of subjective judgment is still present, and reasonable people can and will disagree on how the subjectivity is translated into monetary terms. Nevertheless, the same logic described for this issue in step 1 applies here and elsewhere in the selection process where subjective judgments must be made. The rationale for the judgments and their conversion to quantitative terms should be clearly documented so that the evaluator's logic is a matter of record rather than speculation.

The result of this step should be a ranking of the remaining PMLU options according to their financial merits.

Step 6 - PMLU Selection

If steps 1 through 5 are followed carefully, step 6 is simply a declaration of results of the process. At this point one to a few options should remain, all of which are virtually certain to be achievable technically. These should be clearly differentiated with respect to their impacts, and the best of these should then be the one that has the most favorable benefit-to-cost ratio. The process will usually produce one PMLU choice that objectively stands out as the best. In some cases where a mine site has several distinctively different areas, one clearly preferable choice for each area will usually be produced.

Conclusion

Planning and implementation of the right PMLU is good for business and good for the land. If the PMLU is treated as unimportant, opportunities for cost savings and even post-mining revenues might be lost. A rational approach to PMLU selection allows the mine operator to identify the post-mining assets of its site and to turn them to the best use. Although there will always be some difference of opinion about what is "best use", the methodology described here leads to objective PMLU selection that is documented and defensible.

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