

TOTAL RESOURCES MANAGEMENT IN MINE PLANNING

by

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Abstract. Historically, mines have been planned and operated with a single-resource, single-use approach in which the target mineral was the only resource of value and its extraction was the only use for the land. The Total Resources Management (TRM) approach views mining as just one in a succession of uses and the mine site as an assemblage of resources that are managed to support both mining and post-mining objectives. TRM starts with inventorying and evaluating all site attributes and determining what value (resource potential) each has. TRM supports life-cycle mine planning by identifying those resources that can have market value on their own, reduce capital or operating costs, abate environmental impacts, or facilitate reclamation. Because site resources are characterized early, soon after the ore body is proven, the mine plan can both take advantage of site resources and include measures for their management. TRM then becomes part of the mine plan, contributing revenues or saving costs in the total operation.

Additional Key Words: life-cycle planning, site resources, reclamation

Introduction

When the average person, who is unfamiliar with mining, is asked what he thinks about the mining industry, the expectable response is that mining destroys the land, damages the environment, and leaves a legacy of devastation. While environmental activists and some politicians have done much to promote this perception of mining, the industry itself carries substantial blame. Historically, the industry did not understand or consider impacts of its actions on the environment of the mine or surrounding area.

The modern industry is different, in part because of regulatory requirements and liability concerns, but also because more thoughtful industry managers now realize that they have to be stewards of the land that they mine. Stewardship comes with a price, but it also includes opportunities to reduce costs and utilize all resources of a mine site, not just the target mineral. It means planning, operating, and reclaiming using a life-cycle approach that considers all resources of the site. Total Resource Management, or TRM, is an empirically-based approach to mine planning that allows management to optimize its use

of site resources while also minimizing long-term impacts and liabilities.

What are Site Resources?

Site resources are attributes of a site that either exist at the time that the target mineral is selected for development or that are generated during target-mineral production. They are tangible; site resources can be described in measurable terms such as area, weight or volume, market value, etc.. Each such attribute has actual or potential economic, environmental, recreational or cultural value that can be translated into monetary terms for purposes of evaluation and decision-making. The value of an attribute and, therefore, whether or not the attribute is actually a site resource, is determined on a case-by-case basis for each site. Examples of site resources include:

- *Target mineral* - the mineral of primary economic value, at which extraction is directed
- *Other rock and mineral material* - value as construction material or industrial raw material
- *Soil* - value as growth medium, construction material, raw material for manufacturing
- *Vegetation* - value as wildlife habitat, livestock feed, fuel, mulch, raw materials for manufacturing
- *Wildlife* - value as recreational pursuit, commercial attraction, food source
- *Ground water and surface water* - value as water supply and wildlife habitat
- *Historical features* - value as records of cultural activities, recreational use, commercial attraction

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- *Recreational features* - value as commercial attractions or sites for leisure activity

This list is not all-inclusive, and not all of the listed resources necessarily exist on every site.

What is Total Resources Management?

Total Resources Management (TRM) is an approach that makes site resources and environmental attributes critical components of life-cycle planning. It differs from traditional approaches in the following ways:

- ◆ *Planning and management of site resources are integral parts of the entire project*, not add-ons or after-thoughts. They start with feasibility assessments and carry through design, construction, operations, and reclamation.
- ◆ *All resources within the site are managed for economic value*, not just the target mineral. Types and quantities of such resources, which may include production waste materials or byproducts, are evaluated during project planning for possible use either directly on site or as commodities for sale off site. These resources are credited with their economic values when project costs are estimated.
- ◆ *Project layout, facility design, and operations and reclamation planning are performed from a life-cycle perspective*. Each part of the life cycle is planned and conducted to support the other parts. For example, mine layout and mill design take into consideration the eventual reclamation of those units, and concurrent reclamation is planned to facilitate ongoing operations wherever possible.
- ◆ *Realizing multiple benefits from costs is a goal in all elements of development and management*. For every cost that must be incurred for a specific purpose, additional benefits are sought. Every waste is viewed as a potentially useful byproduct, and each material that must be moved is handled only once wherever possible.
- ◆ *Public information and involvement during site planning and development are used to counteract rumor and distrust in the community*. A community relations strategy, developed early in project planning, provides communication between the project and the public that is essential to the success of any project that impacts community values. The public is more likely to support a mine operation that uses site resources wisely and considers community interests.

TRM views environmental issues and resource extraction issues as interdependent, and they should be treated as inseparable in life-cycle planning and management. The term "site resources" embodies this concept. When all resources of a site are managed as parts of a larger whole, their interactions are almost automatically considered and the collective benefits from these resources can be maximized.

Fundamentals of the TRM Approach

TRM has the same basic objectives as any other business planning and management approach, to maximize profit and to minimize risk. These basic objectives become specific and quantified for a particular project; a profitability target and limits for risk exposure set for one project that may be quite different for another project.

TRM Strategies and Principles

TRM employs four strategies implemented through specific planning and management principles:

1. Establish standards for project performance (quantify profit goals and risk limits)
 - Identify desired production, economic, social and environmental goals and maintain focus on them throughout the planning process.
 - Determine acceptable limits of risk.
2. Plan and manage site resources for the life of the project and beyond (take the long-term view)
 - Apply the life-cycle perspective in which project development, operations, and closure are a continuum.
 - Consider post-mining land use in project planning.
3. Demonstrate environmental stewardship (reduce liability, improve community and regulatory support)
 - Manage all processes, both natural and man-made, to avoid unintentional impacts.
 - Plan proactively, instead of responding reactively, to deal with problems and uncertainties.
 - Create appropriate mechanisms for community and regulatory agency involvement at all stages of the project.
 - Minimize land disturbance and consumptive use of non-renewable resources.

- Maintain separation between potential contaminants and transport media.
4. Maximize the return on each cost unit (improve cost efficiency)
- Inventory and evaluate all site materials, whether naturally occurring or byproducts, as potential resources that could have monetary value.
 - Minimize the number of times any material is handled.

Implementing the TRM Approach

The steps in TRM planning will vary in detail with each project. The general TRM approach is illustrated on Figure 1, "The TRM Approach to Life-Cycle Planning of Mining Projects" and Figure 2, "The TRM Decision Process in Life-Cycle Mine Planning". In Figure 1 the traditional elements of mine planning are shown in simple, one-line blocks, and the TRM elements are shown in shadowed blocks. In Figure 2 these TRM elements are described in a set of five steps.

Figure 1
THE TRM APPROACH TO LIFE-CYCLE PLANNING OF MINING PROJECTS

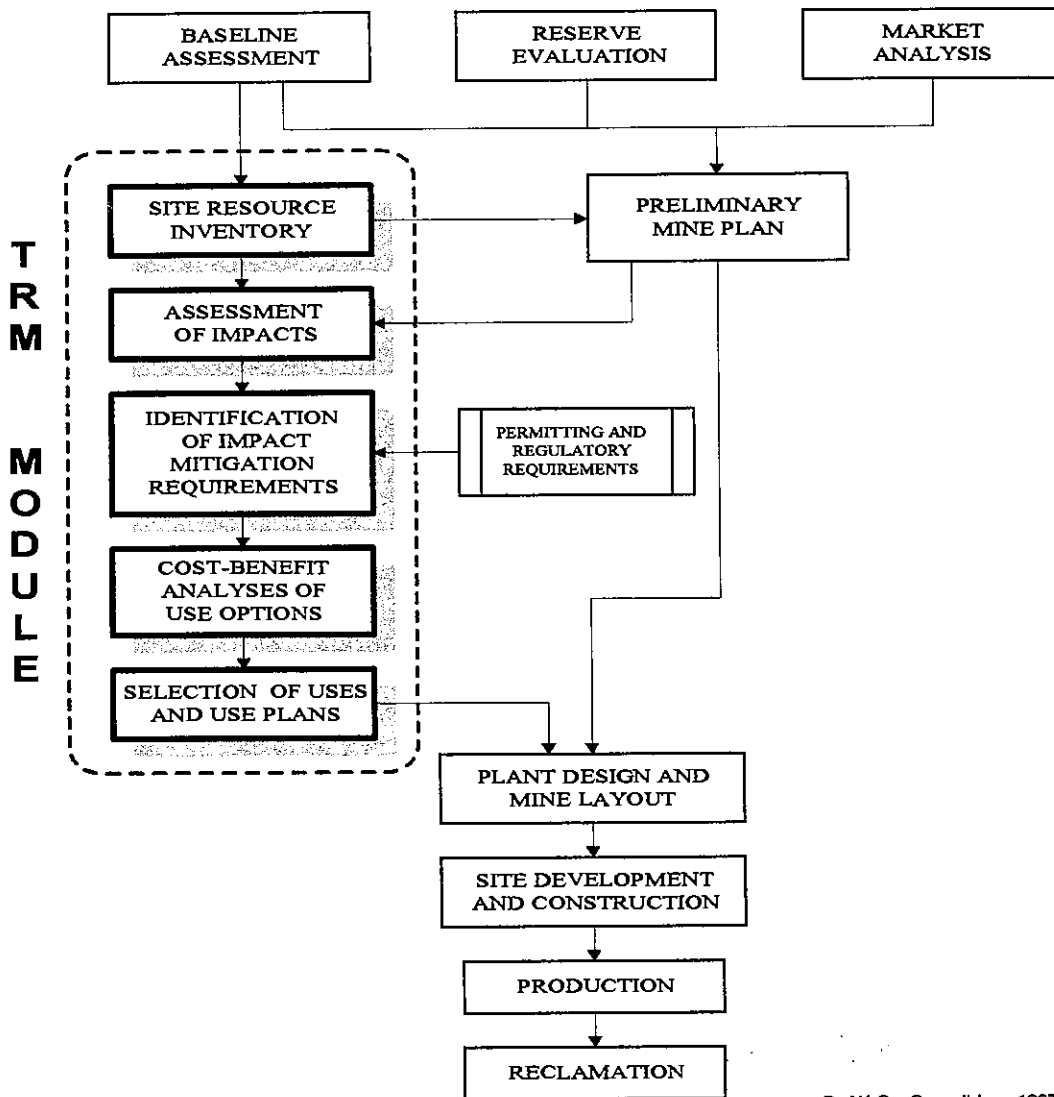
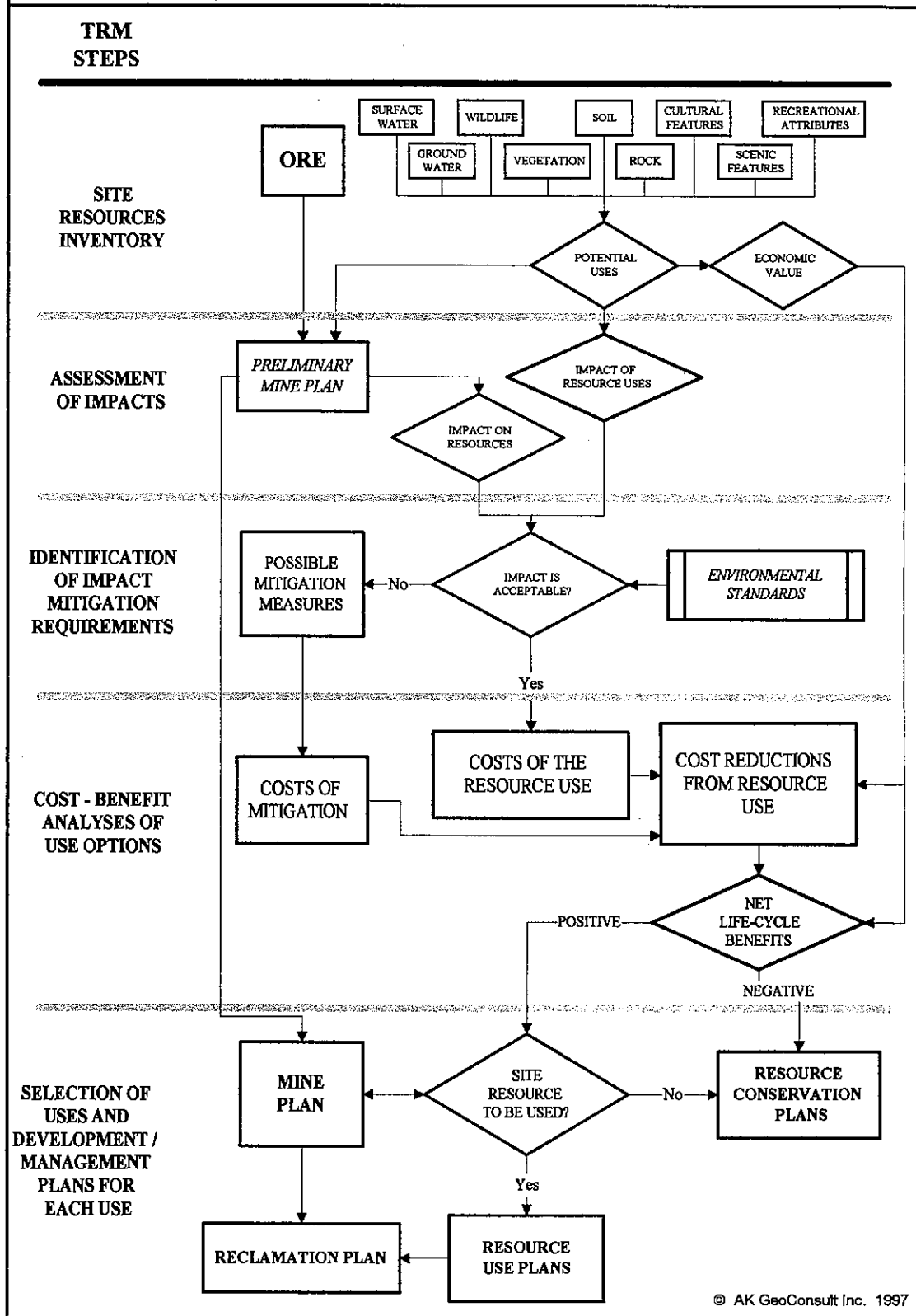


Figure 2
THE TRM DECISION PROCESS IN LIFE-CYCLE MINE PLANNING



Step 1 - Site Resources Inventory

As soon as the decision is made to develop the mine, an inventory of site resources is prepared. This inventory can be based entirely on the baseline assessment if it was sufficiently comprehensive and detailed. If not, additional site investigations will be needed.

The inventory identifies the site resources, quantifies them as appropriate, and identifies their potential uses and economic values. Potential uses can include both on-site and off-site uses. Off-site uses usually involve natural materials that have some commercial value and can be sold to generate revenue. On-site uses will usually involve some application that reduces other costs or mitigates some impact of the mining operation.

Step 2 - Assessment of Impacts

Two distinctly different types of impacts are assessed in this step. The first type is impact on site resources directly due to mining. This includes such impacts as loss of wildlife habitat and degradation of ground water quality. Impacts on resources are the traditional focus of environmental assessments and regulatory attention, and we tend to think of this type of impact automatically when the subject arises.

The second type is impact of resource use. These impacts are not directly caused by mining but by the utilization of the site resource either in support of mining or independent of mining. An example of a site resource that is used to support mining is limestone on the site that is quarried to supply rock to riprap diversion channels or to neutralize acidic raffinate. Independently of the mining operation, that same limestone could be sold off-site for cement production or aggregate. In these examples, the use of limestone in support of mining offsets some costs of mine development, operations, and reclamation; the sale for off-site use offsets no mining costs but generates revenue. Both types of use have quantifiable value to the mining company, but the values will probably be different. The impacts of these limestone uses will be very similar in nature (i.e., both involve impacts of quarrying) but may be very different in magnitude.

In the real world it is often difficult to neatly categorize impacts in the assessment process. Lines between impact types and causes tend to be blurry more often than sharp. Consider the common scenario of ground water in an open pit. The first type of impact - what the open pit operation does to the water - comes to mind immediately. But the second type of impact may be at least as important to the mining company in its planning

process - that water may be a resource necessary for milling operations. In dewatering the pit to mine the ore, there may be more water produced than needed for operations, giving the company a marketable resource to sell to nearby water users. In this case, all variations of resource impacts come into play for the same resource, and the assessment of impacts becomes complicated. Dewatering the mine will lower the local water table but produce valuable water for productive use. Water quality may be degraded within the mill circuit, but treatment prior to release may produce potable water where there had been none. The outcome of these assessments could carry substantial weight in the company's mine planning and permitting efforts.

Step 3 - Identification of Impact Mitigation Requirements

Once the impacts have been assessed, the next step is to determine what, if any, mitigation is necessary. Admittedly, there are many circumstances in which an impact is certain to occur, but the level of impact cannot be assessed with much certainty before the fact. In such cases, we must rely on the best predictive tools and empirical knowledge available to make an educated guess about how much impact to expect, then cover the uncertainty with appropriate contingency. If the sum of uncertainty plus contingency is too large, the mine may never be developed - but mining never has been a venture for the faint of heart.

If the expected impact will fall within acceptable limits, determined by environmental standards, then no mitigation is included in the mine plan. Otherwise, possible mitigation measures are identified and evaluated for both technical feasibility and cost.

Step 4 - Cost-Benefit Analyses of Use Options

Through steps 1-3, the technical feasibility issues of resource uses were evaluated to determine what uses were possible and what impacts would be associated with those uses. Step 4 deals with the bottom line - the costs and the economic benefits of the resource uses.

The costs of resource use can be grouped into two categories - direct costs of resource use and costs of mitigation of use impacts. Direct costs of resource use include the costs of production, handling, and application or sale of the resource. In the example of the limestone resource, direct costs of resource use include site clearing, quarrying, loading and hauling, and either sales or on-site application. Mitigation costs are those required to implement remedial measures to satisfy environmental

requirements such as dust suppression, quarry reclamation, and topsoil salvaging and replacement.

The balance sheet for cost-benefit analysis should show a net benefit from site resource use. The credit side of the sheet includes the revenue from sale of the resource and the costs savings realized from using the site resource instead of some other material obtained off site. The debit side includes costs of mitigation, direct cost of the use, and any associated costs such as additional financial surety. For on-site uses, the cost savings minus the sum of mitigation and direct costs of resource use gives the overall reduction in capital and operating costs for the mine related to site resource use. Add to this the revenue to be realized from any off-site sales of site resources. The sum of the off-site sales (economic value) plus cost reductions is the net life-cycle benefit of site resource use. In most cases this sum must be positive for the resource use to be justified.

There will be some situations in which the balance sheet for a particular use, evaluated by itself, may show a net negative benefit. It is important to make sure that all benefits of the resource use are identified and included in the evaluation so that full credit for all capital, operating and reclamation costs for the life of the mine are considered. In some cases a site resource can become available for use as a consequence of necessary mining activities. For example, water that must be removed to make ore accessible is made available as a consequence of the necessary dewatering of the ore body. The cost of pumping the water out of the ground is chargeable to mining, but the revenues from water sales or value of on-site use can be credited as a cost reduction from resource use.

The maximum net benefit from each resource use is certainly important, but it is the aggregate net life-cycle benefit of all evaluated resource uses that must be positive. This is the reason why every disturbance to be caused by mining should be examined for the resources that might be made available by the disturbance so that such resources can be used to their fullest potential at the lowest possible cost.

Step 5 - Selection of Uses and Development/ Management Plans for Each Use

The cost-benefit analyses will show which site resource uses have positive and negative net life-cycle benefits. The uses that would have negative benefits are not used, and even site resources with net positive benefits may not be used if there are regulatory or legal obstacles.

Resources not selected for use are managed through resource conservation plans (RCPs). Such plans may be very simple, just one part of the mine plan of operations or site management plan. Other RCPs may be more complex, including measures for the conservation of many site resources. These plans need not be more complicated than the measures actually needed to conserve the resource.

If the net benefit of a resource use is positive and the resource is selected for use, its use is integrated into and coordinated with the mine plan. The details of resource development and use are described in resource use plans (RUPs) that become parts of the plan of operations. RUPs are prepared as separate documents so that they can also be incorporated as appendices and references in permit applications, environmental compliance documents, and reclamation plans.

Although no regulatory requirement may exist for RCPs or RUPs, they are worth the time and expense of their preparation. They provide company and mine management with a clear and complete picture of what resources the site contains in addition to the target mineral and how those resources will be used to the economic advantage of the company. These plans also demonstrate that the mining company has informed itself about the total site and has not taken a myopic view that sees the site one-dimensionally. Perhaps most importantly in the long term, these plans show that the mining company recognizes and has made a commitment to its responsibility of stewardship of the site during its tenure there.

Conclusion

TRM is the result of lessons learned from the experience of mining past and present. As such, it avoids or minimizes old mistakes or costly decisions by anticipating, during planning, what could become problems or unproductive costs at some later date. Because environmental costs are the fastest growing of all and produce no revenue, they are the primary focus of TRM. TRM provides a tool for planning and managing environmental and other site resources that works directly on a project's bottom line.