An Approach to Evaluating the Contributions of Sub-Aqueous Tailings Management to Sustainable Development

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ABSTRACT

Sub-aqueous tailings management in manmade or natural water bodies is typically undertaken to halt the oxidation of tailings and thereby preventing the release of metals as a result of acid or neutral drainage. Water provides an effective oxygen barrier for the tailings. This typically results in a compelling environmental argument in favor of this approach to tailings management. This paper proposes a broader approach to the consideration of sub-aqueous tailings management. It sets out to evaluate whether the contributions of sub-aqueous tailings management to sustainable development can be considered as net positive or negative. The Seven Questions to Sustainability, which originated from the North American Regional Process of the Mining, Minerals and Sustainable Development project, will be used as a basis for this evaluation. The seven components that will be considered are: engagement, people, environment, economy, traditional and non-market activities, institutional arrangements and governance, and synthesis and continuous improvement.

Key Words: Engagement, environmental, governance, non-market economy, continuous improvement

Introduction

Sub-aqueous deposition of tailings is a tailings management option that can be available to mine project planners, depending on project location. Sub-aqueous deposition can be in manmade lakes/tailings storage facilities, natural lakes and the ocean. Widely different ranges of parameters and considerations are considered for each option. Sub-aqueous management of tailings in a manmade lake requires a climate and site hydrology that will constantly recharge the lake and maintain the water cover in perpetuity. Natural lakes occur in wetter climates such as in large parts of Canada. Tailings deposition in natural lakes and the ocean is only an option if the mine is located near such water bodies.

Selection of a site-specific tailings management option requires careful consideration of many site and terrain, material, environmental, economic and socio-economic measures (Van Zyl, 2009). There is a danger that evaluations that are narrowly focused, for example based on cost or environmental aspects only, can result in regulatory and civil society resistance thereby delaying the approval process. This paper explores the concept of a much broader evaluation to establish whether the tailings management at a mining project has a net positive or negative contribution to sustainable development. Such an evaluation can provide mining companies, their stakeholders and decision-makers with a much broader decision-making framework.

The proposed basis for this evaluation is the task undertaken by the North American Regional Process of the Mining, Minerals and Sustainable Development (MMSD) project (IIED 2002 and IISD 2002). The methodology developed in the report “Seven Questions to Sustainability: Evaluating The Contributions of Mining Projects to Sustainable Development” is proposed as the basis of a more comprehensive method of evaluating projects.

While the proposed approach can be used for evaluating the contributions of sub-aqueous tailings management in manmade lakes, natural lakes and the ocean, this paper will more narrowly focus on sub-aqueous tailings management in natural lakes.

The following section of the paper provides some comments on approaching the concept of mining and sustainable development, plus the outcomes of previous work focused on large volume mine waste. It also reviews some ideas that have been proposed for the inclusion of sustainable development concepts in acidic drainage considerations (www.gardguide.com). The subsequent section summarizes the Seven Questions approach to Sustainability and this is followed by a discussion of the approach.

Mining and Sustainable Development

The mining industry has made considerable advances in the implementation of sustainable development concepts in its corporate planning and operations. It is now a broad topic of conversation in the industry. Terms such as sustainable development, sustainability and even sustainable mining (which for some is an oxymoron) are often used interchangeably without carefully identifying their meaning or implications. This paper will use the accepted terminology of: the contributions that mining, a project or part of a project, makes to sustainable development. It is meant to include considerations of environmental, economic, societal and governance aspects in a multi-generational context. All aspects of the mine and associated facilities must be evaluated over the full mine life-cycle.

A topic evaluated as part of the MMSD Project dealt with Large Volume Waste. A paraphrased summary of the recommendations resulting from this study is provided in Tables A - 1 to A - 3 in the Attachment (note that two recommendations associated with abandoned mines have not been included) (Van Zyl *et al*. 2002). These recommendations are still valid and while mining companies, governments and NGO's have implemented some of them, they are not consistently applied in the international industry. While some of the recommendations may not seem directly focused on sub-aqueous tailings management they are all included for completeness. These recommendations are part of the broader discussion associated with the contributions that appropriate tailings management make to sustainable development.

This paper is especially focused on developing guidance with respect to the recommendation in Table A - 2 dealing with trade-offs, as copied here:

> Many technological trade-offs are necessary in the development of a mine. Some of these balances specifically concern the mine, such as site layout and mine closure. It must be recognized that many such evaluations of competing considerations are made when a mine is developed. It is recommended that a system of logical steps be developed to make these trade-offs such that all aspects of sustainable development are addressed. This methodology must result in a balancing of the sustainable development factors.

By using the Seven Questions (described below) the paper suggests a logical process for making and documenting trade-off decisions, while balancing the sustainable development factors.

Chapter 10 of the Global Acid Rock Drainage Guide (GARD Guide) (www.gardguide.com) provides guidance on acid rock drainage communication and consulting. It provides excellent guidance with respect to the engagement of communities of interest as it relates to acidic drainage. Engagement is one of the seven questions discussed below and the recommendations of Chapter 10 of the GARD Guide can also form part of the engagement process for sub-aqueous tailings management planning and implementation.

More recently Franks, et al (2011) suggested seven sustainable development principles for the disposal of mining and mineral processing wastes. Table A – 4 provides a list of these principles. It is interesting to note that there are overlaps between the MMSD recommendations, the Seven Questions and these suggested principles.

Seven Questions to Sustainability

A more comprehensive approach to measuring the contributions of mining to sustainable development was developed as part of the North American process of MMSD and the report entitled "Seven Questions

to Sustainability: How to Assess the Contribution of Mining and Minerals Activities", available on line (IISD 2002). While the report contains a more comprehensive discussion on mining and sustainable development it recommends an approach to implementing the Seven Questions.
The seven questions are related to the following topics:

- Engagement
- People
- Environment
- Economy
- Traditional and non-market activities
- Institutional arrangements and governance
- Synthesis and continuous learning

In applying the Seven Questions it is proposed that a table be compiled that contains the following columns for each question and sub-element: the question (goal), ideal answer to the question (objectives), i.e. answering the question in the positive plus sub-elements to the topic, example indicators and example metrics (IISD 2002). Tables 1 to 7 provide a summary for each of the questions taken from IISD (2002). The first row in each table provides the question, the second row the sub-elements for the question and the third row provides example indicators proposed in the report.

The following paragraphs provide short descriptions of the seven questions, however because of their brevity these descriptions do not reflect the richness of their context. The reader is encouraged to review the referenced IISD document.

Engagement (Table 1) focuses on the processes committed to communities of interest; emphasis is on identifying all the affected communities as well as their understanding and participation in these processes. The considerations are similar to those listed in Table A - 2. The sub-elements and example indicators cover a wide range of expectations and activities.

The topic of people (Table 2) considers the well-being of people associated with the project and suggests a maintenance or improvement of their well-being as a result of the project, during and after operations. A large number of sub-elements are included, reflecting the importance of including a broad range of people-related aspects in every project.

Environment (Table 3) emphasizes the maintenance or strengthening (improvement) of biophysical system integrity during and after the project as it is closely related to the well-being of people. The sub-elements and indicators are familiar to the mining environmental community

Table 4 provides the question and associated components for economy. The focus is on the economical health of the project and its contributions to the local and regional economies. It is critical to have projects that are economically successful, as they will have the capacity to contribute to the sustainable development of a community and a region during and after operations.

Traditional and non-market activities are considered in Table 5. These activities usually refer to indigenous communities, however it also refers to the volunteer activities of mining personnel.

Table 6 addresses the institutional arrangements and governance aspects. These refer not only to the regulatory processes of governments but also to the governance aspects of the company, i.e. does the company have a strong sustainable development policy that is backed by upper management.

Table 7 summarizes the aspects of synthesis and continuous learning. It specifically addresses the evaluation of reasonable approaches to include all alternatives for a project. This question also addresses the commitment to ongoing review and continuous improvement.

Table 1. Sub-elements and example indicators for Question 1

Q.1 Engagement. Are processes of engagement committed to, designed, and implemented that:

- ensure all affected communities of interest (including vulnerable or disadvantaged sub-populations by reason of, for example, minority status, gender, ethnicity, or poverty) have the opportunity to participate in the decisions that influence their own future; and
- are understood, agreed upon by implicated communities of interest and consistent with the legal, institutional, and cultural characteristics of the community and country where the project is located?

Engagement processes	Dispute resolution mechanism	Reporting and verification	Adequate resources	Informed and voluntary consent
Stakeholder mapping, design agreed upon engagement strategy	Establish dispute resolution mechanisms	Put systems in place	Make sure that adequate resources are available and that there is satisfaction with level of support	Level of support of local communities and those implicated in the project

Table 2. Sub-elements and example indicators for Question 2

Q.2 People. Will the project/operation lead directly or indirectly to maintenance of people's well being (preferably an improvement):

- during the life of the project or operation?
- post-closure?

Individuals		Communities				
Population health and safety	Worker health and safety	Social and cultural integrity	Full social and cultural costs, benefits and risks	Distribution of costs, benefits, risks and responsibilities	Community organizational capacity, infrastructure resiliency and dependency	Responsibilities and sureties
Baseline studies of population health	Baseline studies of worker health	Existence of community and regional visions in development and land use, sense of satisfaction that by interests that integrity will be maintained or improved	Consider this for the full mine life-cycle	Mechanisms in place to identify and assess these collaboratively designed with community, indigenous people and government	Presence of organizational structure that links community to project related decision-making, training facilities, basic infrastructure local educational and skills level, access to expertise	Financial assurance in place to address non-performance by company

Table 3. Sub-elements and example indicators for Question 3

Q.3 Environment. Will the project/operation lead directly or indirectly, to the maintenance or strengthening of the integrity of biophysical systems so that they can continue in post closure to provide the needed support for the well-being of people and other life forms?				
Ecosystem function, resilience and self-organizing capacity	Ecological entitlement	Full ecosystem costs, benefits and risks	Responsibilities and sureties	Environmental stress and action to ensure ecosystem integrity
Baseline studies completed, monitoring systems in place, projected effects of project on indicator species, projected long-term well-being	Degree of confidence of stakeholders	Full cost accounting tools are used to assess the implications of the project, satisfaction that all of the sub-elements have been identified for the full	Financial assurance and mechanisms in place	Materials inputs/flows, recycling, waste management, surface water, groundwater, ARD and metal leaching, soils, rapid landscape change, air

Table 4. Sub-elements and example indicators for Question 4

Q.4 Economy. Is the financial health of the project/operation assured and will the project or operation contribute (through planning, evaluation, decision-making and action) to the long-term viability of the local and regional economy in ways that will help ensure sufficiency for all and provide specific opportunities for the less advantaged?				
Project or operational economics	Operational efficiencies	Economic contributions	Community /regional economies	Government and broader society economies
Positive project economics as per feasibility study, economic targets are met as project proceeds	Mining efficiency, refining efficiency	To the local, regional, national and international economies	Positive project economics as per feasibility study, economic targets are met as project proceeds	Net financial gain for government and targets are met

Table 5. Sub-elements and example indicators for Question 5

Q.5 Traditional and Non-Market Activities. Will the project/operation contribute to the long-term viability of traditional and non-market activities in the implicated community and region?	
Activity/use levels	Traditional/cultural attributes
Baseline studies of traditional and non-market activities and dependency levels on traditional and non-market activities	Use of indigenous language and sub-elements of Question 2

Table 6. Sub-elements and example indicators for Question 6

Q.6 Institutional Arrangements and Governance. Are the institutional arrangements and systems of governance in place to provide a reasonable degree of confidence that the capacity to address project or operation consequences will continue to exist through the full life-cycle including post closure?			
Efficiency and effectiveness in the mix of legislative rules, voluntary programs, market incentives, and unspoken cultural norms	Capacity to address operational consequences	Bridging to post closure conditions	Overall confidence that commitments made will be fulfilled
Satisfaction of stakeholders with the mix	Capacity of community support infrastructure to meet the needs of residents and workers, monitoring and enforcement programs are in place and with adequate resources	Existence of community-based non-mining economic and social development initiatives	Level of funding to cover rehabilitation/reclamation costs during operations and at closure

Table 7. Sub-elements and example indicators for Question 7

Q.7 Synthesis and Continuous Learning. Has an overall evaluation been made and is a system in place for periodic evaluation based on:

- Consideration of all reasonable alternative configurations and designs at the project level (including the no-go option in the initial evaluation)
- Consideration of all reasonable alternatives at the overarching strategic level for supplying the commodity and the services it provides for meeting society's needs
- A synthesis of all the factors raised in this list of questions, leading to an overall judgment that the contribution to people and ecosystems will be net positive over the long term?

Project level alternatives	Strategic level alternatives	Overall synthesis	Continuous learning and improvement
All key alternatives have been considered including access, transportation, energy supply, water supply, local infrastructure, tailings and effluent management, mineral processing options, etc.	Strategic level review has been undertaken that confirms project need	Synthesis has been undertaken	Mechanisms and resources are in place to periodically repeat the overall sustainability assessment and to report the results publicly

Applying the Seven Questions to Sub-Aqueous Tailings Management

The Seven Questions to Sustainability was developed "to guide the assessment of whether or not a project or operation's net contribution to sustainability is positive over the long term" (IISD 2002). Applying it to sub-aqueous tailings management in natural lakes necessarily narrows the focus. It is difficult to fully address the question related to economy. Tailings management is a "cost center" and does not generate revenue. However, the evaluation must include a rigorous analysis of the tailings management costs. If any specific tailings management method results in cost savings over time, then it contributes positively to the overall economy of a project.

In applying the seven questions to evaluating the contributions to sustainable development three separate steps are proposed. The first step is a planning or conceptual stage to "scope" the issues and identify for each question the aspects specifically related to natural lake sub-aqueous tailings management. This is followed by a quantitative evaluation of indicators and metrics. The final stage in the evaluation is the integration of all results into a final assessment of the contributions to sustainable development.

The rest of this section will provide guidance on all three aspects. All mines are different and therefore all projects must be evaluated using site-specific information. Discussion in this section provides broad guidance that must be refined and expanded at the site-specific level.

Planning or conceptual stage

This sub-section provides bulleted lists of items that can be included for each of the seven questions during the planning and conceptual stages of sub-aqueous tailings management projects. These lists are not exhaustive but are meant to provide an introduction to site-specific planning and implementation.

Q.1 Engagement:

- Stakeholder identification – the stakeholders associated with sub-aqueous tailings management may include groups or individuals with specific interests in regional water bodies, aquatic organisms, etc. Other groups may have specific emotional or spiritual relationships with a specific water body. All communities of interest must be identified for the project engagement activities.
- Engagement processes must include specific consideration of the sensitivities related to water bodies.
- Identify what resources may be required to allow engagement participation by communities of interest. Resource adequacy must be addressed early in the process.

Q.2 People:

- Develop a list of the aspects of life-cycle financial and social/cultural costs of site-specific sub-aqueous tailings management.
- Identify the aspects of long-term water quality and aquatic organisms that may affect the post-closure availability of the water body to local communities.

Q.3 Environment:

- Identify what water quality and aquatic aspects may be affected during the operational life of the mine.
- Identify what long-term water quality and aquatic aspects post-closure may be affected.
- Identify aspects of full ecosystem costs, benefits and risks.
- Identify components of sureties and long-term environmental responsibilities of the mining company, government and communities.

Q.4 Economy:

- Identify the full life-cycle cost components of site-specific sub-aqueous tailings management.

Q.5 Traditional and Non-Market Activities:

- Identify the users of the water body.
- Identify the traditional/cultural significance of the water body.

Q.6 Institutional Arrangements and Governance:

- Identify the regulatory framework for sub-aqueous tailings management.
- Identify the capacity of the company to address operational and long-term consequences.

Q.7 Synthesis and Continuous Learning:

- Identify the tailings management options for the mine other than sub-aqueous management.
- Identify the components for evaluation of the various tailings management options.
- Identify the components of continuous learning and improvement needed from the company, government and the stakeholders.

Quantitative evaluation of indicators and metrics

This sub-section provides guidance on the evaluations and metrics that could be considered for each of the questions during the evaluations process of sub-aqueous tailings management.

Q.1 Engagement:

- Active engagement with stakeholders to move along the path of establishing a social license (Thompson and Boutilier, 2011)
- Adequate resources must be available to the communities of interest to participate in the engagement process, both from a financial and informational aspect.

Q.2 People:

- Evaluate life-cycle financial and social/cultural costs of site-specific sub-aqueous tailings management through interactions with local communities of interests and scientific and engineering experts.

Q.3 Environment:

- Obtain baseline water quality data and aquatic resource information.
- Understand how water quality and aquatic aspects may be affected during the operational life of the mine.
- Understand how long-term water quality and aquatic aspects post-closure may be affected.
- Evaluate the full ecosystem costs, benefits and risks.
- Evaluate the value of sureties and long-term environmental responsibilities of the mining company, government and communities.

Q.4 Economy:

- Evaluate the full life-cycle cost components of site-specific sub-aqueous tailings management.

Q.5 Traditional and Non-Market Activities:

- Evaluate and understand the benefits to users of the water body.
- Evaluate and understand the value of traditional/cultural significance of the water body.

Q.6 Institutional Arrangements and Governance:

- Perform a gap analysis of the regulatory framework for sub-aqueous tailings management to identify aspects that may not be covered by present regulations and which are important for the integrity of the biophysical system.

- Evaluate the level of commitment that will be needed from the company to address operational and long-term consequences.

Q.7 Synthesis and Continuous Learning:

- Perform a complete evaluation of tailings management options.
- Develop a management plan for continuous learning and improvement.

Integration of the assessment

The final step in the evaluation is to integrate the outcomes of the evaluation for each of the questions to obtain an assessment of whether or not site-specific sub-aqueous tailings management will result in a positive net contribution to sustainability over the long term. This is clearly not a simple task and should not be left to a small group of company engineers and managers to perform. One approach is that this should take the form of a carefully designed multistakeholder process where there is fair representation of the communities of interest. The process has to be transparent and easy to understand by all participants.

The ideal outcome of the multistakeholder process is a clear indication of the preferences of the various groups. Success of such a process is highly dependent on the facilitation of the discussions and their documentation.

It is recommended that decision-makers use the outcome of the multistakeholder process in their final analysis of and decision on the future of the project. Having a well-balanced evaluation of the contributions that a project makes to sustainable development through a multistakeholder process will support the decision-makers commitment to a project.

Recent Guidance from Environment Canada for Evaluation of Mine Waste Disposal Alternatives

In September 2011, Environment Canada issued a guidance document for the assessment of alternatives for mine waste disposal to provide an outcome that will help to expedite the natural lake alternative and its licensing if it is the selected option (Environment Canada, 2011). This requires that an alternatives assessment be objective and rigorous, including all aspects of each alternative throughout the project life cycle. It is recommended that the assessment addresses environmental, technical and socio-economic aspects. Many of the topics related to the seven questions are mentioned but there is not a detailed analysis of all of them.

The process proposed by Environment Canada is similar to a Multiple Accounts Analysis and includes seven steps:

- Identify candidate alternatives
- Pre-screening assessment
- Alternative characterization
- Multiple accounts ledger
- Value-based decision process
- Sensitivity analysis
- Document results

In the alternative characterization step, four categories are suggested: environmental characterization, technical characterization, project economic characterization and socio-economic characterization. The Seven Questions approach proposed in this paper provides a broader sustainable development characterization. Furthermore value scales and weighting of indicators are proposed as the approach to arrive at a final ranking.

Closing Comments

This paper set out to identify the actions required in the management of large volume mine waste to make a positive contribution to sustainable development. The Seven Questions to Sustainability is proposed as a framework to develop an integrated evaluation of natural lake sub-aqueous tailings management. It is proposed that using this broad framework will allow a more comprehensive approach to making these decisions. Full implementation of the Seven Questions to Sustainability framework for the decision-making process will require a broad range of data collection and analyses, or in some cases a re-organization of data already available. The obvious difference is that the evaluation is not narrowly focused on a few measures such as water quality and cost. It should consist of a multistakeholder process that is transparent and must consider the full mine life cycle.

Recent guidance from Environment Canada further addresses the alternatives assessment for mine waste disposal. The proposed approach is more rigorous and strives to address a wide range of topics. However, it does not include all the measures necessary to address the contributions (positive and negative) of a mine waste management system to sustainable development.

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Acronyms

MMSD Mining, Minerals and Sustainable Development

Attachment

Table A - 1. Summary of Recommendations from MMSD Large Volume Waste Study – Best Practices and Guidelines; Industry, NGO's and Government; Large Volume Waste Management

Best practices and guidelines:
Best Practice Guidance – To improve the management of large volume waste and mine closure it would be advantageous to develop a 'Best Management Process' supported by Guidelines for technical and design frameworks.
International Guidelines – It is recommended that international guidelines be developed through the application of best management process by multi-stakeholder workshops.
Industry, NGO's and Government:
Industry Management/Corporate Culture –A corporate culture change is necessary in most cases to allow recognition of environmental and social accomplishments of site managers to the same level of importance as meeting production targets.
Relationships – Relationships between the industry and the NGO community as it relates to large volume waste and other mining issues is at a low point. It is recognized that both these groups do not speak with a single voice, however it is important that progress be made in developing a dialogue that can be mutually agreed upon.
NGO responsibilities – While it is clear that there are differences in the behaviour and culture of members of both the industry, NGO and other communities of interest, it is essential that peer pressure, or other approaches, be used to encourage better practices in each of the communities. For example, the 'mining industry' does not necessarily speak out when poor management at a mine of one of their community results in a spill. Similarly NGOs should speak out when inaccurate claims which conflict with their knowledge and understanding are made by other NGOs.
Government responsibilities – Governments have clear responsibilities to promulgate and implement regulatory frameworks for large volume waste, mine closure and abandoned mines. They also have the responsibility for having a staff with a high level of technical knowledge and capacity to review permits and enforce the regulations. Government responsibilities also include defining outcomes and assessing the attainment of those outcomes.
Large Volume Waste Management:
Good Baseline Data – It is necessary that comprehensive baseline studies be undertaken at new mines so that statistically valid information can be obtained for the evaluation of the site conditions before any development as well as the potential impacts of the proposed actions.
Stewardship of Tailings Facilities – Guidelines of good stewardship on the design, construction, management and closure of tailings storage facilities should be established. These should include scope and treatment of baseline data, method of recording the history of construction and operation and an ongoing safety evaluation programme and a closure plan. Continuity of management and independent review process should also be addressed in these guidelines.
Riverine Disposal – There should be a clear commitment by industry to eschew this practice for any future projects. At ongoing projects it is recommended that site specific risk assessments and mitigations be implemented to advance their contribution to sustainable development.
Marine Disposal – A programme of independent research should be implemented to assess the potential risks of marine disposal and in particular deep-sea disposal. This programme will pay specific attention to baseline studies at the proposed deep-sea disposal sites and will develop ongoing monitoring during and after operations.
Acid Drainage – Acid drainage is the most significant water quality issue that the mining industry, governments and society must deal with. There are a number of past and ongoing national and international research programs to address the issues of characterization, modelling and evaluation and mitigation. While significant strides have been made in all these areas, much additional work is required to provide cost-effective long-term solutions. It is recommended that public and corporate funds be made available for further research and development in this area.

Table A - 2. Summary of Recommendations from MMSD Large Volume Waste Study – Engagement and Decisions

Engagement and Decisions:
Public Engagement/Participation – The first task with respect to public engagement and participation is to identify the interested parties associated with a specific project so that effective engagement can be established. Engagement of the neighbouring communities (and other stakeholders as appropriate) should start during the exploration phase for a project and must continue throughout development, operations and closure. In most cases it will be necessary to build capacity amongst the stakeholders, this may take the form of financial assistance and other approaches. Companies must be transparent in all their interactions with the stakeholders.
Decision-making – Decision-making should be done with involvement of the community and regulatory agencies at all stages of the project. The qualitative values of the stakeholders should be considered in the decision-making processes. Risk assessment approaches can also be used in making these decisions. The 'no-mine' alternative should always be on the table. It is recommended that the decision-making processes at all stages of mining should be investigated through a multistakeholder process.
Peer Review and Validation – Many different analyses and models are prepared during environmental impact assessments, mine development, operations and closure. It is essential that analyses and models used for permit approvals be peer reviewed and validated. The funding and technical support for this review could come from individual projects or companies.
Information availability and accessibility – It is important that information about a project be available and accessible to all interested parties. Governments must make sure that public information is widely distributed; it is also to the advantage of the mining company if this can be accomplished. Apart from making the information available it may also be necessary to provide for the capacity to interpret and understand the information; governments and companies can help to make the expertise available to help with this task.
Trade-offs – Many technological trade-offs are necessary in the development of a mine. Some of these balances specifically concern the mine, such as site layout and mine closure. It must be recognized that many such evaluations of competing considerations are made when a mine is developed. It is recommended that a system of logical steps be developed to make these trade-offs such that all aspects of sustainable development are addressed. This methodology must result in a balancing of the sustainable development factors.

Table A - 3. Summary of Recommendations from MMSD Large Volume Waste Study – Mine Closure

Mine Closure:
Closure Plans – Closure plans should include site closure issues as well as economic, social and employee matters. Closure objectives and plans should be developed in close partnership with the communities who might be affected by closure as well as the regulatory authority. This means that options for closure plans are provided upfront to all involved in the decision-making process and these plans should include the costs. Input from the communities should be sought about future economic development options following the completion of mining, specifically the diversification of the local economies. Completion criteria are an important part of any closure plan as no mine can be considered closed (or 'completed') until all stakeholders have agreed that the required outcomes have been attained. These criteria could be defined at the EIA stage and mine performance could be measured against them throughout operations.
Closure Cost Calculations – Closure cost calculations must be based on appropriate closure technology and estimated according to the cost of *implementing* rehabilitation and socio- economic closure measures rather than just according to re-vegetation costs only. Closure plans and cost estimates must be reviewed regularly during the mine life so that the ultimate plans and costs are as realistic as possible.
Financial Surety – Financial surety regulations should be established in all countries where mining takes place. These should be implemented so that society is protected from large rehabilitation costs in the case of bankruptcies. The amount of the surety should be based on a realistic closure plan for the site.
Post-Closure Environmental Monitoring and Management – Ongoing environmental monitoring during the post-closure period is a very important consideration at all mine sites. For example, there may be ongoing water management and treatment activities for a number of years following closure, in some cases in perpetuity. As a result, it is important that the mining company develops a plan for ongoing monitoring and reporting to regulatory agencies and other stakeholders. Sufficient funds must be committed for this, which may require long-term financial surety to remain in place.
Post-Closure Socio-Economic Management- Just as it is necessary to monitor and manage environmental aspects after mine closure, similarly it is necessary to manage socio-economic conditions. During the closure planning clear steps must be developed for mitigating, as far as possible, the socio-economic impacts of mine closure. It is important to monitor the success of these activities and to provide extra support where necessary. It is recommended that the industry work closely with government in establishing this.
Discounted Cash Flow (DCF) analysis for mining projects. – The outcome of a DCF analysis is not sensitive to projected expenditures in 20 or more years; it therefore does not provide a complete picture of the effects of long-term costs and benefits for mines. It is recommended that multiple economic models be used to consider the long-term costs and benefits for a mine, including undiscounted cash flow analysis.
Accounting Practices – Acceptable accounting practices in some countries require that all environmental liabilities, including closure costs, be reported and included in the annual financial statements of publicly traded corporations. It is recommended that all companies include all liabilities in annual financial statements. It is also recommended that a review be made of accounting procedures to make sure that this issue is addressed adequately by the annual reporting.

Table A – 4 Seven Sustainable Development Principles for the Disposal of Mining and Mineral Processing Wastes (Franks, et al, 2011)

Principle 1. Mining and mineral processing wastes should be managed, such that it remains physically, geographically, chemically and radiologically stable.
Principle 2. Mining and mineral processing wastes that interact with the environment should be inert, i.e., equivalent (in form, concentration, location, volume, time and rate) to material and chemicals already within the same ecosystem.
Principle 3. Mining and mineral processing wastes that are not inert should be isolated, be as inert as practicable, and in a form that is compatible with the adopted waste management technique and the sensitivity of the ecosystem and social context.
Principle 4. Mining and mineral processing wastes should be contained, i.e., geographically bounded, exhibit a minimal footprint in a location of acceptably low ecological and social values and be in physical and chemical forms, given local conditions, that limits interaction with the surrounding environment.
Principle 5. Mining and mineral processing wastes should be managed in a manner consistent with the environmental and social conditions of each location. The determination of acceptability of the disposal technique should include the views of stakeholders.
Principle 6. Mining and mineral processing wastes should be managed to minimize active post-closure management, inputs (such as water and energy) and the volume of wastes generated per volume of an extracted ore.
Principle 7. Mining, mineral processing and waste management technologies, which offer improved environmental and social performance and a smaller surface footprint, should be preferentially adopted. Opportunities for re-use of waste material should be pursued when practicable.