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A risk-based approach to closure planning

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Abstract

Indentifying and accounting for mine closure related risks ensures that a more realistic approach is adopted for closure planning. This approach acknowledges that risks exist, and moves away from the all too common tendency of adopting overly optimistic closure scenarios. By incorporating and costing risk, there is more accurate provisioning in balance sheets and a greater degree of cost-effective site divestment is achieved. The early identification of risks enables measures to be implemented during operations to eliminate or minimise them.

Risk-based closure planning formally assesses risks against a minimum closure case—the legal minimum base case. A risk profile is established for this minimum base case and risks are divided into those that can be tolerated and those that cannot—depending on the risk appetite of the organisation considering site closure.

For those risks that are considered unacceptable, risk controls or mitigation measures are identified that will either eliminate or reduce the risks to an acceptable level. These risk controls are then incorporated into, and become an integral part of, the Closure Plan.

The resulting Closure Plan is then defined by a legal requirement or by a control to a risk that is regarded as unacceptable. The scope of the Closure Plan is then a logical process that can be justified to all relevant stakeholders, be they community groups or the corporate finance group tasked with reviewing company expenditure on behalf of shareholders.

The risk-based closure planning also covers the development of detailed closure cost estimates, by including range analyses to cover uncertainties (or risks) over rates, quantities and schedules. These ranges, together with the costs of residual risks, are assessed in a probabilistic cost model to properly reflect the true cost of closure.

In summary, risk-based closure planning is a systematic methodology that incorporates a range of issues—environmental, social, financial and engineering. It evaluates so-called intangible risks, such as community concerns, reputation impacts and future environmental impacts and adopts a common financial measure for all costs and risks.

The approach provides a more realistic picture of liabilities, allows integration with ongoing mine planning, and can be applied to a single site or to a portfolio of sites.

1 Introduction

Successful closure is more than just good revegetation. It can be defined in terms of the following objectives:

- Cost-effective site divestment.
- Accurate provisioning in balance sheets.
- Minimised risks.
- Consideration of all stakeholders.
- Re-integration of the site into the community and the environment.

These objectives may sometimes be seen as contradictory, but by adopting a risk-based approach to closure planning they can be demonstrated as being complementary.

2 Approach

By incorporating formal risk assessment into the development of closure plans, a systematic methodology is adopted that incorporates a range of issues, including environmental, social, financial and engineering elements.

Importantly, the approach evaluates so-called intangible risks, such as:

- Community concerns.
- Reputation impacts.
- Future environmental impacts.

The methodology can be summarised by the graphic in Figure 1 and is consistent with the principles of risk management outlined in International Standards Organisation (2009) ISO 31000:2009 Risk Management—Principles and Guidelines.

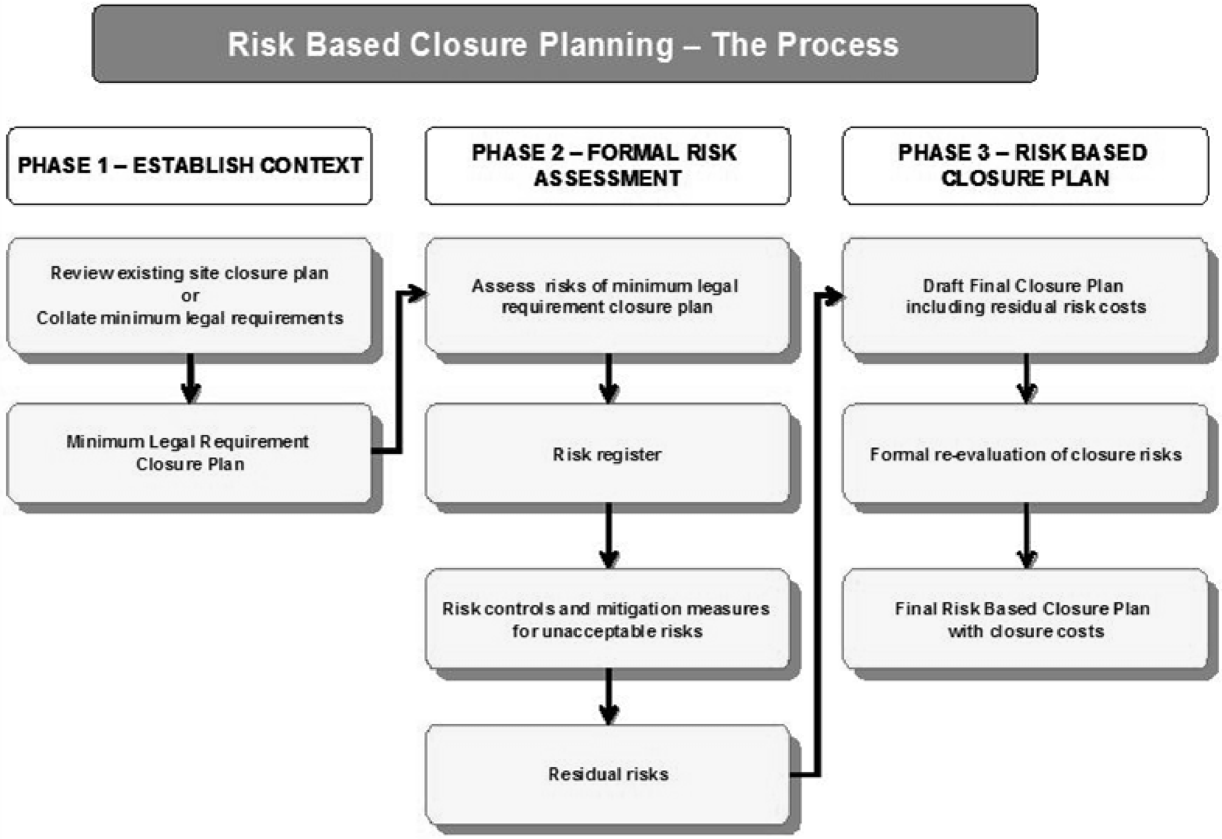

Figure 1 Risk-based closure planning process

2.1 Phase 1 – Establish context

The initial phase involves a review of any existing site closure plan or, if one does not exist, a collation of the minimum legal requirements that relate to site closure. This phase will comprise a review of corporate policies and industry obligations as well as previous company statements and commitments made in documents such as environmental impact assessments. It should also include a collation of other less formal commitments that have been made to stakeholders. A review of land tenure arrangements, as well as a collation of stakeholder lists should also be carried out at this stage.

From this review, a conceptual closure plan can be documented that specifies the minimum requirements for site closure.

2.2 Phase 2 – Formal risk assessment

Based on the conceptual closure plan the second phase is to conduct a formal risk assessment of this minimalist approach. Whilst this risk assessment could take a number of forms, it should be consistent with the risk management system normally adopted by the site. Typically the process would involve the following:

- Brainstorm risk issues.
- Identify risk events.
- Develop risk register.
- Analyse risks.
- Develop ranked risk register.

This will result in the identification of a range of closure risks. From the ranked risk register, a decision must be made as to which risks are unacceptable—this will be determined by the risk tolerance of the site and the parent organisation. For this minimalist plan, it is probable that many will be deemed unacceptable.

For those risks that are considered unacceptable, risk controls or mitigation measures will then need to be identified that will either eliminate or reduce the risks to an acceptable level. These risk controls are then incorporated into, and become an integral part of, the Closure Plan.

2.3 Phase 3 – Develop draft risk-based Closure Plan

The draft risk-based Closure Plan will be developed in a format consistent with standard industry practices, involving elements, such as:

- Documenting site setting.
  - Collation of baseline information, such as climate, geology, topography, biodiversity, water quality, etc.
- Stakeholder analysis—including local/regional community, government, partners, shareholders.
  - Document data on these stakeholders.
  - Delineate key issues, concerns and, most importantly, their expectations around closure.
- Post closure land uses.
- Definition of completion criteria.
- Closure execution phase activities, such as form of tailings dam cap, infrastructure demolition, waste rock dump closure, stakeholder engagement, etc.
- Post closure execution phase maintenance and monitoring programme.

The assumptions around post closure land uses will be influenced by the stakeholder analysis phase as well as by the risk controls that have been identified. For example, the risk assessment may identify unrealistic assumptions having previously been made about post closure use of the pit void (e.g. recreational uses–but the site is at a remote location and final water quality is expected to be acidic) resulting in controls that change that post closure use. Similarly, the closure execution phase activities will incorporate those controls that address unacceptable risks.

The draft Closure Plan will also document residual risks. These are the remaining risks that are considered tolerable after implementation, i.e. incorporation into the Closure Plan, of risk controls.

The resulting Closure Plan is then defined either by defined commitments (legal or otherwise) or by controls for risks that are regarded as unacceptable. This scope of the Closure Plan is then a logical process that can be justified to all relevant stakeholders, be they community groups or the corporate finance group tasked with reviewing company expenditure on behalf of shareholders.

2.4 Final Closure Plan

The final Closure Plan will be developed after a formal re-evaluation of the closure risks that will address questions such as:

- Have all risks been appropriately assessed?
- The closure risk register needs to be re-visited to ensure that there is agreement on its contents and ranking.
- Have they changed–especially stakeholder risks?
- During ongoing consultation new stakeholder groups might be identified or further community issues and conflicting expectations identified.
- Have new risks emerged with development of Closure Plan?
- For example, a risk control to address stakeholder concerns might determine that some buildings remain on site for community use instead of being demolished—yet this may entail new risks for the organisation if those buildings are not maintained in a safe manner into the future.

The Closure Plan also needs to be linked to the Life of Mine (LOM) plan—indeed it should form a fundamental component of mine planning. Changes to the LOM plan may instigate changes to the Closure Plan as well as generate new closure risks.

Changes to the draft Closure Plan may also be required after stakeholder feedback.

3 Closure costs

The accurate estimate of closure costs is a critical element of the closure planning process—either for budgeting purposes for those sites about to enter closure execution or for balance sheet provisioning, such as Asset Retirement Obligations, for those sites where closure is not imminent.

Risk-based closure planning allows for the development of realistic and detailed closure cost estimates by accounting for:

- Assumptions.
- Cost estimate uncertainties.
- Risk cost.

Assumptions are a common feature of many closure plans. They are, however, often not documented or they are hidden in qualifications contained in appendices—sometimes they are just lost during various iterations of closure plans over the years.

Cost estimate uncertainties over inputs such as rates, areas, quantities and schedules are often dealt with in by adopting a single cost item for each parameter. These can vary wildly—some estimates adopt conservative values—others are optimistic. Often a contingency item is included, for example 25%, which invariably under-estimates the potential cost variation and risks that might occur. The risk-based approach better models these uncertainties.

The costs of residual risks are also assessed in a probabilistic cost model. The consequences of these risks are estimated in financial terms, using range analyses as discussed above, with the likelihoods of occurrence modelled.

The approach is especially valuable if closure is well into the future and where there is not a lot of definition around closure. Significant uncertainty might exist, for example, over the final cover for the tailings dam with further research over a number of years needed to finalise design. By costing a design that the site thinks is likely and then adding additional cost elements such as thicker cap, capillary break, etc., based on the probability that they will be needed, a more representative cost estimate is obtained. Even when closure is imminent, significant uncertainty exists over material quantities and contractor rates. Whatever the stage of closure, whether it is tomorrow or decades away, the uncertainties in costs can be modelled by using range analyses, using Monte Carlo simulation, around key cost components and adopting likelihoods for other less certain cost elements.

4 Case study

The risk-based approach to closure planning has been applied to numerous sites around the world, across a range of mining and metals settings, where closure is many decades away and where closure is imminent. An example of one application is a gold mine in Australia. The name, specific locality and other identifying items have been withheld to preserve commercial confidentiality.

The mine is an underground operation with a number of historic open pits on the lease, but not in operation. There are a number of waste rock dumps, some active, others historic but not rehabilitated. Surface infrastructure comprises administration buildings, headframe, processing plants, sediment dams and roadways. The mine is located in a remote area. The nearest township is a small community heavily dependent on the mine for employment and to supply goods and services. The mine also provides funding to the community for a local health clinic.

The original closure cost estimate was A$ 28 million, based on the minimum legal requirements for closure, essentially involving removal of surface infrastructure, sealing of the shaft and an optimistic tailings dam cap of 0.4 m thickness of inert soil. Minimal works were proposed for waste rock dump rehabilitation. A number of closure options for the pits were discussed but not defined and were assumed to be cost neutral. It was also assumed that the cost of surface infrastructure demolition would be offset by scrap and equipment sales, and would therefore also be cost neutral. No allowance was made for stakeholder management or for offsetting the socio economic impacts in the local community of mine closure. No discussions had been held with the community or regulators around expectations for post closure land uses for the site. A contingency of 25% was added to the cost giving a total of A$ 35 million.

As part of the review of this cost estimate, a formal risk assessment was undertaken involving participants from the mine plus technical advisors. A range of risks was identified and categorised using a semi quantitative 5 × 5 risk matrix to rank risks. The graphical presentation of the ranked register of closure risks is presented in Figure 2. The identified risks ranged from the most severe—a more complex cover being required for the tailings dams—to the least severe—more work being required to rehabilitate exploration bores. After reviewing the risk profile and the existing closure plan, the closure team decided that risks below a risk ranking of 7 could be tolerated. All other risks needed controls to either reduce or eliminate them.

In addition to categorising the risks using the site's semi-quantitative risk ranking methodology, all risk consequences were evaluated in financial terms. That is, the cost of all the consequences, should they occur, was estimated using a range analysis approach and likelihoods (expressed in percentage terms) applied to the occurrence of the consequences and risk events.

For risks such as a more complex tailings cap, this was a conventional exercise of using estimates for the ranges in material quantities and ranges in rates for supply and emplacement. The so-called intangible risks, particularly social risks, were evaluated in terms of consequences to the company, such as negative reputation impacts, community outrage and being unable to relinquish the mine lease. The severity of these consequences was measured by their financial cost. For negative reputation impacts and community outrage, this comprised management costs to address community concerns, external advisory costs and delays to other projects being developed by the parent company elsewhere in the world. Figure 3 shows an extract of the risk register showing some social risks.

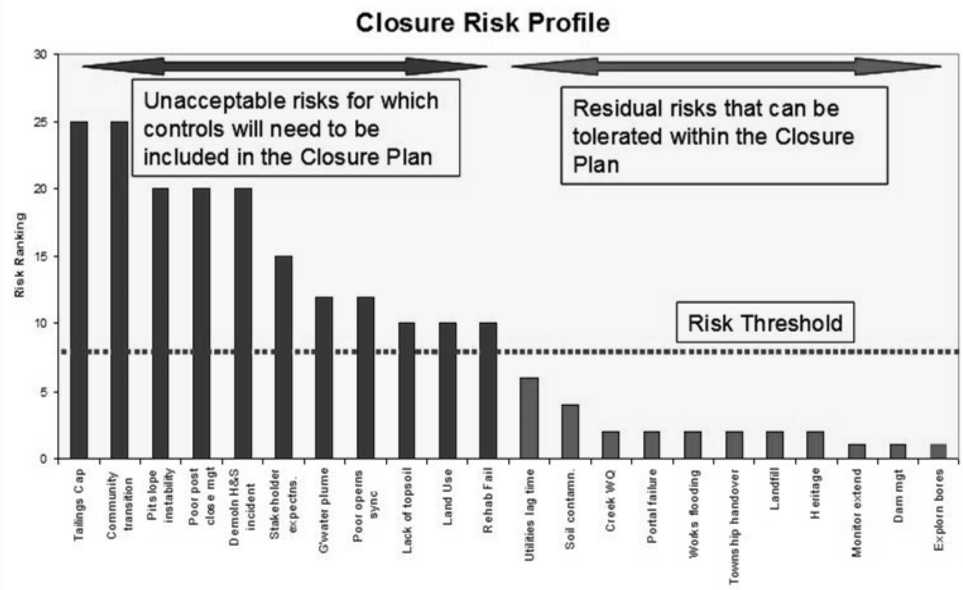

Figure 2 Mine site closure risk profile

Description	Consequence(s) - to Company	New Control Measures
Negative socio economic impacts due to site closure	Negative reputation impacts Additional severance costs	1. Integrate closure planning issues into CSI programmes 2. Provide support to development of local industry 3. Skills re-training 4. Relocate to other company sites 5. Involve local workforce in closure activities 6. Phased closure 7. Communications Stra
Do not meet post closure land use expectations of stakeholders	Negative reputation impacts Community outrage Rehabilitation re-work No land relinquishment	1. Community consultation programme 2. Include social team members into Closure Implementation Group
Unpredicted Stakeholder Expectations	Ongoing access maintenance Community water treatment Maintain shopping subsidies	1. Integrate closure planning issues into CSI programmes 2. Provide support to development of local industry 3. Skills re-training 4. Relocate to other company sites 5. Involve local workforce in closure activities 6. Phased closure
Closure of Health Clinic	Class action claim	Establish fund to run clinic & hand over to govt. to run prior to closure
Loss of community services (air charters, housing, etc)	Negative reputation impacts Community outrage No land relinquishment	1. Integrate closure planning issues into CSI programmes 2. Provide support to development of local industry 3. Phased closure 4. Communications Strategy
Deterioration of retained facilities post closure	1. Claims to repair/maintain 2. Negative reputation impact 3. Public fatality/injury	1. Do not retain facilities 2. Establish & fund management company post closure 3. Strict contract for handover
Description of risk event - this needs to be a specific event rather than a broad description of an issue. Frequency or probability of event occurring is assessed.	*Evaluation of all the possible consequences to the company* - described and quantified in $ terms. Probability of each consequence assessed assuming risk event occurs Analysis of each risk will provide a ranking (based on likelihood and consequence). Severity of the ranked risk will determine whether mitigation measures are required or whether the risk can be tolerated. Negative reputation impact is common consequence - Quantified in terms of, e.g.: 1. management time required to handle community discontent/outrage 2. increased charges from international financiers 3. approval delays to other company projects (local/international)	*Identified mitigation measures* - these are then incorporated into the final Closure Plan, including the cost to implement them Even after accounting for mitigation measures a residual risk is likely to remain. The risk cost of this residual risk must be included in the total closure cost.

Figure 3 Extract of risk register showing social risks

When the risk cost was modelled, it added substantially to the total closure costs, as demonstrated in Figure 4. Deciding on which cost to adopt is determined by the level of risk which the company is prepared to accept.

The graph shows that the CL80 cost estimate is A$ 234 million when the uncontrolled risks are included. This compares to the initial total closure estimate of A$ 35 million (including contingency)—with the modelling showing that there is still a 20% chance that A$ 234 million could be exceeded.

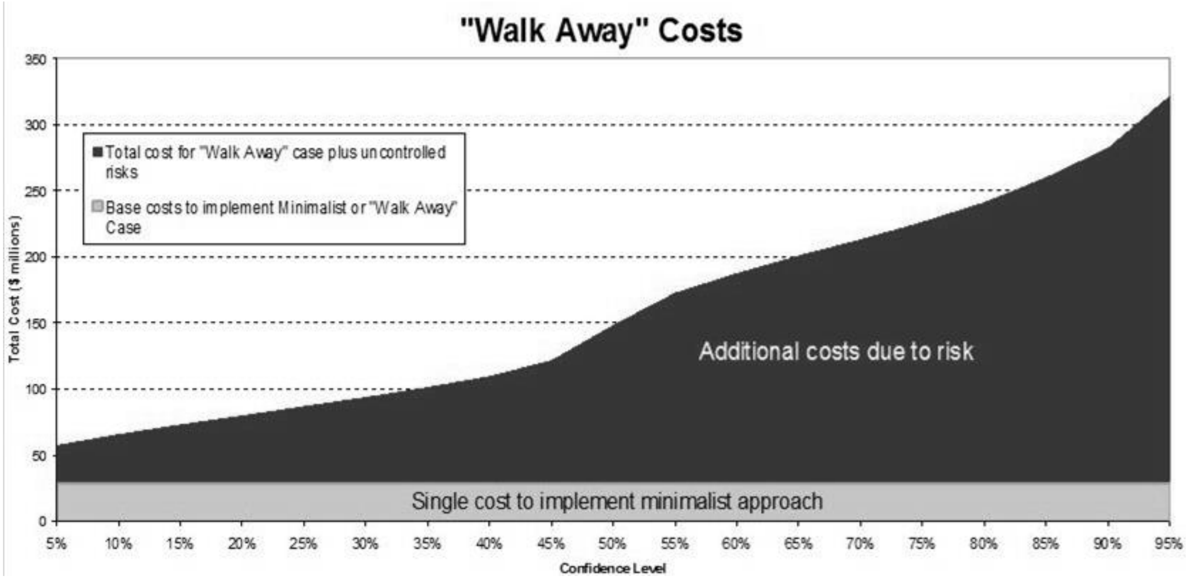

Figure 4 Costs for minimalist closure plus uncontrolled risks

The level of uncertainty that this presented to the company was unacceptable. Controls were identified to reduce the risks and therefore the uncertainty over cost.

The risk controls that were identified eliminated some, but mostly reduced the severity, of risks so that no unacceptable risks remained. This resulted in a substantially reduced total closure cost, with a CL80 estimate of A$ 112 million, as shown in Figure 5.

The probabilistic distribution for revised total closure costs is still greater than the initial site estimate because of the cost of including the following:

- Range analysis for cost components (rates, quantities, etc.).
- Risk controls.
- Residual risks.

While this process resulted in a significant increase in the estimate for total closure costs, it provided the following benefits to the site operations and the parent company:

- A more realistic closure cost estimate was developed compared to the very optimistic initial estimate made by the site.
- Earlier identification of realistic closure costs allowed for the adjustment of balance sheet provisions in a more timely and structured manner.
- The formal identification of closure risks enabled time for the site to implement control measures that would not have been available if these risks had been identified when closure was imminent.
- The formal risk process forced environmental and mine planning to staff to engage on better defining closure activities.

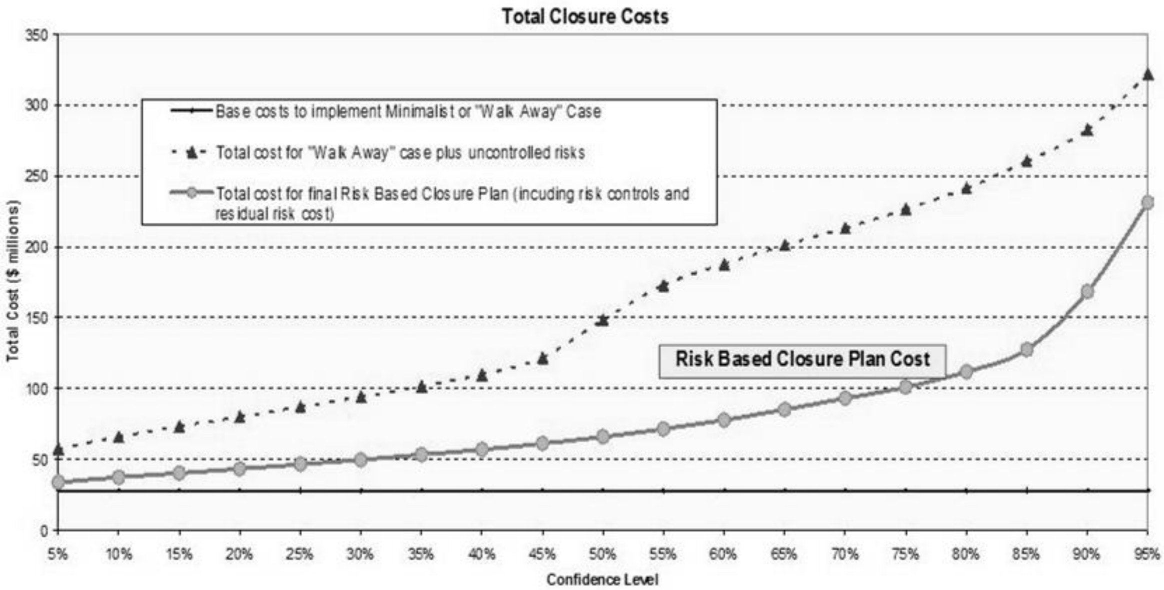

Figure 5 Probabilistic cost distribution of final closure plan

5 Portfolio management

The risk-based approach can be applied to a portfolio of sites. By combining risk identification, cost range analyses and probabilistic costing, realistic cost estimates can be developed even if costs for the portfolio are evaluated only at a high level. Figure 6 shows the outcome of a review of the closure costs for a portfolio of sites. The costs are shown at three levels of confidence (CL50, CL80 and CL95). The greater the spread of these costs, the greater will be the uncertainty that exists for a particular site. In this example, Site A has the greatest closure costs and a prudent manager might want to invest in further study to reduce the costs. However, the example also shows that Site D has significant uncertainties and that additional investment would be warranted to further evaluate and reduce the risks that are contributing to this uncertainty.

The benefits of this approach for multiple sites include:

- Allows for site ranking.
- Enables prioritisation of actions.
- Eliminates inconsistency of approach—particularly regarding assumptions made at a site level.
- Streamlines cash flows.

Because of these benefits corporate managers have a greater degree of confidence that their balance sheet provisions are more realistic and the chance of “sleeper” issues being missed is reduced.

Additionally complex technical issues, risks, community concerns and regulatory requirements can be assessed across the full range of sites to evaluate trends and enable actions to be initiated at a corporate level that might not be warranted when assessed as an isolated site issue.

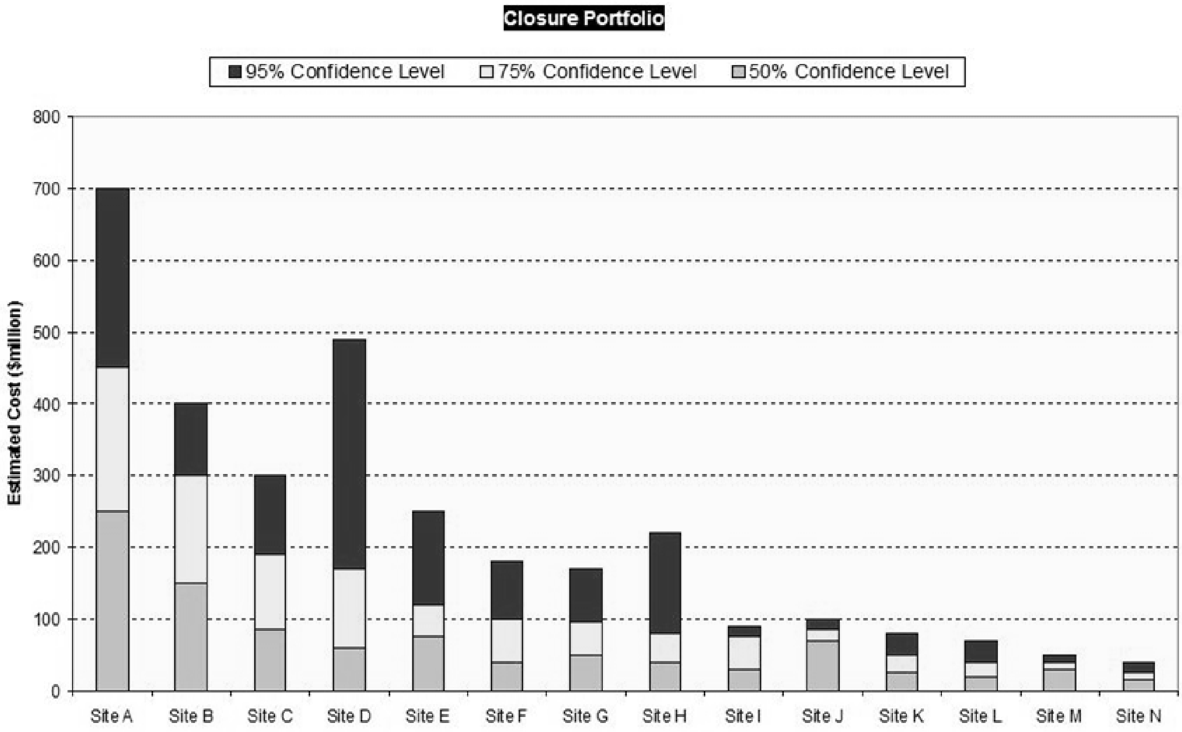

Figure 6 Closure portfolio

6 Conclusion

In summary, risk-based closure planning is a systematic methodology that incorporates a range of issues–environmental, social, financial and engineering. It evaluates so-called intangible risks, such as community concerns, reputation impacts and future environmental impacts and adopts a common financial measure for all costs and risks. It is not time limited and is applicable to both closure in the short- and long-term.

The responsible approach to effective risk-based closure planning achieves the following:

- Provides a more realistic picture of liabilities.
- Accounts for activities where large uncertainty exists.
- Allows integration with ongoing mine planning.
- Can be applied to a single site or to a portfolio of sites.
- Is a robust and transparent process.
- Provides defensible closure provisions for inclusion in company balance sheets.

Reference

International Standards Organisation (2009) (ISO 31000:2009) Risk management—Principles and guidelines, First edition, 15 November 2009.