Challenging the development of closure criteria to enhance the measurement of closure performance

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Abstract

Closure criteria are a tool used for measuring and demonstrating closure performance, and can be used to support the relinquishment of mining tenure. The standard of closure criteria throughout the industry is generally low and poorly developed closure criteria can result in the failure to meet closure objectives, resulting in delayed lease relinquishment, or unacceptable closure outcomes.

This paper presents a framework for the development of closure criteria which represents a logical process from the identification of the post closure issues, legal obligations and stakeholder engagement through to the development of a post mining land use vision, objectives, criteria and standards.

The development of closure criteria is ultimately guided by the post mining land use vision for a project. Closure aspects are elements that need to be considered for closure can be identified through risk assessment and analysis of operational data. For each aspect a closure objective, which outlines the intent of the closure program, should be developed. A number of closure criteria can then be established for each objective, providing the means for determining whether the objective has been met. Each closure criteria requires a standard to be developed which represents an agreed value that is measurable.

Common issues associated with the development of closure criteria are identified and alternative closure criteria for groundwater and vegetation are presented and discussed.

Introduction

The introduction of the "Guidelines for Preparing Mine Closure Plans" (the Guidelines) by the Department of Mineral and Petroleum (DMP) and Office of the Environmental Protection Agency (OEPA) in 2011, has resulted in an increasing focus on mine closure planning in recent times (DMP, OEPA, 2011). All new and existing projects operating under *The Mining Act 1978* are required to have a current and approved Mine Closure Plan (MCP) that meets the requirements of the Guidelines. In line with the Guidelines, projects are required to establish a framework to measure closure performance using robust measures such as closure objectives and criteria.

Poorly developed closure criteria can result in the failure to meet closure objectives, contributing to delayed lease relinquishment, or unacceptable closure outcomes. Only one project in Western Australia, the Bottle Creek Mine, has been successfully relinquished in response to a process that demonstrated that closure criteria had been met (Butler, 2011).

This paper presents a framework for developing effective closure criteria, identifies issues and mistakes commonly observed in their development and presents some specific examples of closure criteria for vegetation and water.

Framework for assessing mine closure performance

Mine Earth have established a framework (Figure 1) to aid the development of closure criteria, and to achieve a logical flow from the identification of the post mining land use through to the development of closure objectives, criteria and standards. The intent of this framework is to clearly state what will be achieved in relation to closure, how it will be achieved and how it will be measured. Stakeholder engagement underpins all steps in the framework and is integral to developing agreed objectives and criteria. The framework is described below.

1. Develop a knowledge base

Developing a knowledge base for the project will generally be undertaken as part of the mine closure planning process, and will involve the following:

- **Establishing project impacts**

  The first step in developing closure criteria should be to ascertain what impacts the project has had on the environment. Undertaking a risk assessment may contribute to identifying the key aspects for consideration.

- **Understand legal obligations**

  Identification of the legal obligations and commitments that are relevant to the project may have some bearing on the development of closure criteria. For example ministerial statements, tenement conditions and approvals conditions may include specific closure criteria that must be considered.

2. Determine post mining land use vision

The overarching vision for the project should describe the intent of the closure program in relation to long term outcomes. Consideration should be given to the previous land use, achievable outcomes, stakeholder expectations and risks.

3. Identify closure aspects

Aspects are the major elements that need to be considered for closure. Examples of typical closure aspects include surface water, surface stability, groundwater, geotechnical stability, infrastructure, fauna and vegetation.

4. Develop objectives

For each aspect an objective should be developed. The objective should describe the intent or the desired outcome in relation to each aspect Objectives should not provide a high level of detail and should be outcomes based.

5. Develop closure criteria

For each objective, closure criteria should be developed and should provide the means for determining whether the objective has been met.

6. Develop standards for each criterion

Standards are an agreed value that is measurable. Where possible, standards should be developed using site specific data and should be based on 'good science'. The use of random and arbitrary figures should be avoided when developing standards.

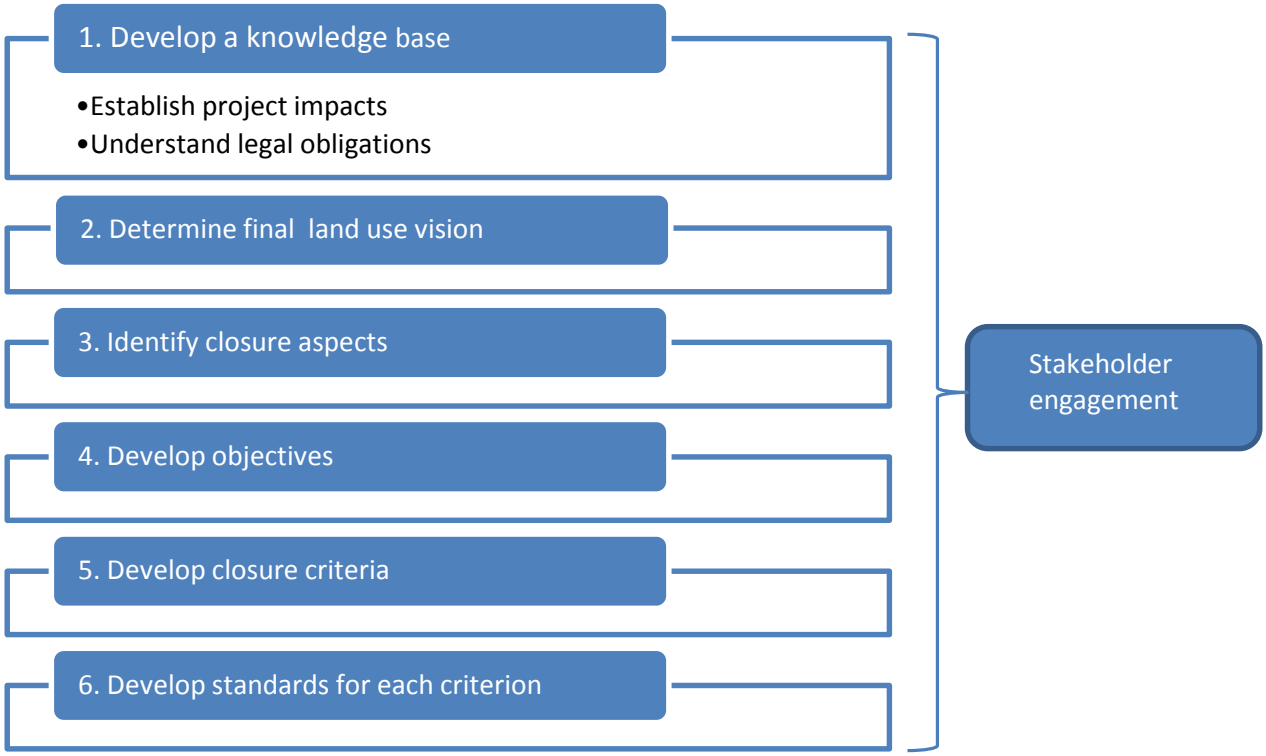

Figure 1 Framework for developing closure criteria

Common closure criteria issues

Developing effective closure criteria requires careful thought and consideration. There are a number of guidelines available which discuss the relevant components of effective closure criteria including OEPA (2006), ANZEMEC and Minerals Council of Australia (2000) and DMP/OEPA (2011). The current standard of closure criteria throughout the industry is generally low and some common issues associated with them include:

- They can be based on factors that are simply unachievable, and may be unnecessarily onerous or impractical.
- There has been a tendency to apply blanket criteria and guidelines with no consideration of project specific conditions.
- The timeframe for achieving them is not realistic.
- They can be imprecise and don't adequately describe the intent of the closure criteria.
- Terms such as *reasonable*, *significant*, *considerable* and *acceptable* have been used which add to the ambiguity of the closure criteria, particularly if not defined further.
- They can be immeasurable.
- They can be inflexible and not be able to be periodically updated as project knowledge increases.
- They can commit to using certain monitoring methods which may become redundant as monitoring techniques improve.
- They can be based on poor science and scientific methods are not considered in their development.
- They are not developed in consultation with stakeholders.
- They can be worded poorly.
- They may not relate to closure outcomes, but rather to the process of closure planning.
- They result in expensive and time consuming monitoring programs having to be conducted with little environmental benefit.

Specific examples

Closure criteria for aspects such as vegetation and groundwater can be poorly defined and worded. Some specific examples are described below along with more appropriate alternatives for closure criteria.

Vegetation criteria

Perennial plant diversity, perennial plant cover and weeds are the components of vegetation dynamics that are generally adopted as indicators of revegetation performance for closure criteria. Typically these components are compared to analogue or un-impacted sites with the aim of proving that a vegetation system is self-sustaining. Closure criteria for the vegetation components typically apply arbitrary figures which are to be met.

An example of a poorly defined vegetation criterion is: "*Species richness, floristic, vegetation cover and weed abundance in revegetation sites are all trending towards that measured in corresponding analogue sites*".

The issues associated with this criterion are:

- The criterion describes the intent of revegetation and is more of a closure objective.
- Suitable analogue sites would need to be identified at the project for comparison with revegetated areas, which often do not exist.
- Setting targets for plant cover and species richness for comparison with analogue sites is unrealistic, as substrate materials and profiles are considerably different, as are the time scales of their development.
- Comparing weed populations between analogue and revegetated areas may result in unachievable targets as disturbed sites will often be more susceptible to weed invasion (Australian Government, 2012). Also, the definition of what constitutes a "weed" needs to be considered, as this is typically not well defined (Pysek, Richardson, & Willaimson, 2004).
- The criterion does not define how close plant cover values in revegetated areas need to be to analogue sites to be acceptable.
- The use of the word "trending" is ambiguous and could be interpreted differently between stakeholders.

An alternative approach to developing vegetation objectives, criteria and standards is presented in Table 1. The premise behind these criteria is to use revegetation as a benchmark and base closure criteria on actual revegetation data rather than comparing values to analogue sites.

Table 1 Example of objectives, criteria and standards for vegetation.

Objective	Closure criteria	Standards (examples)
Establish a self-sustaining vegetation community on disturbed areas.	1. Revegetation is implemented in accordance with the approved rehabilitation plan.	Compliance with criteria
	2. Long lived perennial plant cover in revegetation has reached 70% of best achievable revegetation plant cover at the project within each specific revegetation zone.	Perennial plant cover in revegetation exceeds 50% on sloped areas and 70% on flat areas.
	3. Long lived perennial species richness in revegetation has reached 70% of best achievable revegetation plant diversity at the project within each specific revegetation zone.	Perennial plant species richness in revegetation exceeds three on sloped areas and four on flat areas.
	4. Representative taxa from nearby vegetation communities are included in the revegetation seed mix for specific areas.	Top four dominant taxa in each floristic community are used in revegetation seed mix.

	5. Weed cover is less than long lived perennial plant cover.	Perennial plant cover > weed cover

Justification for each of the vegetation criteria presented in Table 1 is provided below:

1. "*Revegetation is implemented in accordance with the approved rehabilitation plan.*"

This criterion indicates that rehabilitation and revegetation efforts have met an approved minimum standard.

2. & 3. "*Long lived perennial plant cover (or diversity) on revegetation has reached 70% of best achievable revegetation plant cover at the project within each specific revegetation zone.*"

The use of such criteria is useful for a number of reasons;

- It proposes that revegetation is consistent across the project.
- The performance of revegetation is ultimately linked to the substrate materials rather and age of rehabilitation.
- It recognizes that revegetation in different zones (i.e. waste dump tops and slopes, substrates and ages) performs differently.
- Standards for these criteria are calculated using actual site specific revegetation data and can evolve over time as revegetation practices improve or in response to changes in environmental conditions.

4. "*Representative taxa from nearby vegetation communities are included in the revegetation seed mix for specific areas."*

The criterion has been included to recognize that and attempt has been made to reconstruct pre-disturbance vegetation communities, but acknowledges that it may not be possible.

5. "*Weed cover is less than long lived perennial plant cover*."

This criterion accepts that it is inevitable that weeds will occur in the revegetated areas, but prescribes that they are not the dominant factor. The aim of this criterion is that the presence of weeds will not impact the ability of the revegetation to be self-sustaining. Further definition of this criterion may be required to define the type of weeds covered by the criterion. There may be an argument to remove "naturalized" weeds (Pysek, Richardson, & Willaimson, 2004) from consideration under this criterion.

Water criteria

Closure criteria related to surface water and groundwater typically relate to water quality. An example of a closure criterion used in a MCP for surface water and groundwater is "*Element concentrations in surface water drains, pit voids, and remaining groundwater bores is demonstrated to be within ANZECC stock water guidelines*."

There are several issues associated with this criterion:

- The criterion describes the intent of the water monitoring plan and is more of a closure objective.
- Impacts from surface water and groundwater issues are not linked to the potential impact they might have on receptors.

- The use of the ANZECC guidelines demonstrates a lack of site specific data. A number of parameters in natural groundwater and surface water systems within Western Australia regularly exceed the ANZECC stock water guidelines.
- Seasonal changes in water quality (Williams & Buckney, 1976) can be considerable and may result in this criterion only being able to be achieved at certain times of the year.
- This criterion was developed for a project with erratic rainfall, the majority of which occurs during cyclonic events. As such sampling surface water may be difficult because of accessibility and safety issues.
- The criterion indicates that water quality will be the same for groundwater and surface water, which is often not the case.
- Sampling of pit lakes after mine closure may present unacceptable safety concerns to the proponent.
- Little can be done after mine closure to rectify pit water quality if the criterion is not met.
- The criterion does not identify which water quality parameters are of concern and may result in testing for a larger suite of analytes than would otherwise be required. For example, ANZECC stock guidelines address cyanobacteria, pathogens and radioactive components which are not routinely tested in groundwater or surface water monitoring (ANZECC, 2000).
- There are different guideline values for different types of livestock and this is not addressed within this criterion (ANZECC, 2000).

It would be more effective to develop separate criteria for groundwater and surface water. In order to demonstrate this example objectives for surface water and groundwater are presented below. For the aspect of *surface water* an objective such as "*Uncontrolled surface water flows and impacts to surface water will be minimized*" may be appropriate in some cases (Table 2).

Three alternative criteria are presented for the surface water objective in Table 2. These criteria do not focus on surface water quality due to the difficulties of sampling and seasonal changes in water quality as described above. This will only be acceptable where no surface water quality concerns (e.g. a contamination or geochemical concerns) have been identified. Instead the focus is on the surface water drainage structures and ensuring that they are constructed and they operate as designed. The criteria also recognize that erosion will occur, but over time as the vegetation develops and the landform evolves, that the rate of change in erosion will reduce and the landform will stabilise.

Table 2 Examples of objectives, criteria and standards for surface water

Objective	Closure criteria	Standards (examples)
Uncontrolled surface water flows and impacts to surface water will be	Landforms have been constructed to meet approved design requirements.	Compliance with criteria.
	Surface water structures are operating as designed.	Compliance with criteria.

minimised.	Erosion levels on landforms stabilise.	The change in the proportion of erosion on the waste landform between years is less that 5%.

Groundwater objectives and criteria traditionally focus on groundwater quality and levels. This is not ideal as there are a number of factors which influence water quality and levels, over which the proponent will have little control (e.g. climatic factors and non-project related impacts). Rather than linking groundwater objectives to quality and levels, consideration should be given to using modelling tools to predict the potential for groundwater to impact receptors after closure, and focus the objective on limiting potential impacts to receptors. An objective such as "*The project will have no considerable adverse impact to groundwater receptors*" may be appropriate in some cases. Such an approach involves identifying all the potential groundwater receptors and modelling potential impacts to these receptors. Groundwater receptors may include borefields, springs or permanent water sources, and should be named in both the objective and criterion.

Table 3 Examples of objectives, criteria and standards for groundwater

Objective	Closure criteria	Standards (examples)
The Project will have no considerable adverse impacts to the XX spring..	No significant hydrogeological impact to the XX spring is predicted.	Confirm the predictions of the model through targeted and site specific monitoring.

Conclusion

Closure criteria are a critical tool in measuring and demonstrating closure performance to ensure that acceptable outcomes are achieved, and are the mechanism by which proponents will aim to relinquish mining tenure. Care and consideration should be used when developing closure criteria, and a number of factors should be kept in mind. Firstly project impacts, legal obligations and background data should be understood so that key closure risks can be readily defined. An overall land use vision should be developed and used to guide the development of the objectives and subsequent closure criteria. Stakeholder engagement should be conducted through all stages of the development of closure criteria to ensure that their expectations are taken into account. Standards should be developed to support the closure criteria, and should be quantifiable or auditable.

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