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SMART closure objectives and criteria: a benchmark recipe for success

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Abstract

Mine closure planning and execution should follow a cradle-to-cradle approach, with closure considerations embedded in mine planning processes from the outset. This integration must address physical, biophysical and social dimensions to ensure defensible closure outcomes and sustainable post-mining land uses. Industry frameworks such as the International Council on Mining and Metals (ICMM) Good Practice Guideline and International Finance Corporation (IFC) Standards provide the foundation for integrated mine closure planning and support the development of site-specific closure objectives and criteria.

Well-defined closure objectives and criteria – guided by SMART principles (specific, measurable, achievable, relevant and timely) and informed by operational experience, technical studies and field trials – are central to estimating closure liabilities accurately and ensuring appropriate financial provisioning. These elements form the basis of a dynamic integrated mine closure plan that enables responsible relinquishment and supports long-term environmental and socio-economic resilience. Establishing these elements provides a robust basis for a dynamic integrated mine closure plan that enables responsible relinquishment and supports a sustainable environmental and socio-economic legacy at the life of mine and beyond.

Building on industry best practices and real-world application, this paper highlights the pathway to successful closure through the development of risk-based success and closure criteria aligned with clearly defined closure objectives. Results from various African mining operations' case studies demonstrate how multidisciplinary teams refine these criteria over time using tools such as benchmarking, closure risk assessments, rehabilitation trials, closure criteria effectiveness reviews and gap analyses. This iterative, evidence-based approach ensures that closure strategies (physical, biophysical and social) remain realistic, feasible and responsive to evolving site conditions throughout the operational mining life cycle, which ultimately ensures the most realistic closure liabilities.

Keywords: *site-specific closure objectives, integrated closure planning, sustainable legacy, rehabilitation and closure criteria, risk-based approach, success criteria, socio-economic closure, industry best practice, criteria benchmarking*

1 Introduction

Mine closure is no longer an end-of-life technical activity; it is an integrated, life of mine process that must be designed, resourced and governed from project inception to relinquishment. International guidance increasingly frames closure as a cradle-to-cradle planning discipline in which physical landform stability, biophysical recovery and social transition are addressed together to achieve defensible outcomes and viable post-mining land uses (International Finance Corporation [IFC] 2007; International Council on Mining and Metals [ICMM] 2025). In practice, the quality of closure planning is tested by the clarity of its closure vision, objectives and the measurable criteria used to demonstrate achievement and reduce residual risk to acceptable levels (Krause & Snyman 2014).

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A benchmark 'recipe' for developing SMART (Specific, Measurable, Achievable, Relevant, Timely) closure objectives and associated success and closure criteria, drawing on industry best practice and operational lessons from African mining contexts, has been identified as a critical step within the integrated closure planning process. This recipe synthesises elements from integrated closure planning frameworks (Fleury & Parsons 2006; Coetzer & Erasmus 2024; International Council on Mining and Metals 2025), corporate systems used to standardise closure decision-making and liability estimation (Grant & Lacy 2016; Anglo American 2019) and governance perspectives relevant to Africa's development agenda (African Union 2009; African Union Commission et al. 2012). The intent is to provide practitioners with a concise structure for defining, testing and iteratively improving closure criteria so that closure liabilities are realistic and closure outcomes are demonstrably achievable.

2 What is integrated closure planning?

2.1 Introduction and background

Integrated closure planning is the coordinated, multidisciplinary process of incorporating closure requirements into mine planning, design, operations and stakeholder engagement across the entire project life cycle (Fleury & Parsons 2006; Coetzer & Erasmus 2024; International Council on Mining and Metals 2025). It aligns technical closure design (e.g. landforms, water management, infrastructure decommissioning) with environmental performance, social transition planning and financial provisioning so that closure is progressively implemented rather than deferred to the end of mining.

Consistent with the focus of this article, integrated closure planning is only effective when it is translated into a practical management system through SMART closure objectives and associated rehabilitation, closure and success criteria that can be implemented, monitored and signed off with defensible evidence. Accordingly, the sections that follow move from the integrated planning concept to the 'recipe' elements: Section 3 defines the main criteria types and how they relate to closure objectives and verification evidence, and Section 4 summarises African case study lessons on how teams refine criteria over time and what this means for stabilising closure liabilities and improving relinquishment readiness.

The core practical features include:

- early definition of a closure vision and post-mining land use, informed by stakeholders
- integration with impact assessment and permitting pathways
- a risk-based evaluation of closure options and residual risks
- progressive rehabilitation and field trials to reduce uncertainty
- a financial model that translates defined scope and standards into credible closure liability estimates and provisions (van Zyl et al. 2012; Slingerland & Wilson 2015; Morrison-Saunders et al. 2016; International Council on Mining and Metals 2025).

Figure 1 illustrates a simplified overview of the iterative process of integrated closure planning throughout the life of an operation. Governance frameworks and standards (e.g. IFC performance expectations and corporate systems) provide consistency, while periodic reviews ensure plans remain responsive to changing operational, environmental and social conditions (International Finance Corporation 2007; World Bank Group 2021).

Figure 1 Integrated closure planning process

2.2 Operationalising integrated closure planning through SMART objectives and criteria

In practice, the effectiveness of integrated closure planning depends on whether high-level closure intent is translated into work that can be executed and verified. A useful discipline for doing this is 'SMART working', which frames closure objectives and their linked criteria so they are sufficiently specific (clear feature, boundary and intended outcome), measurable (auditable thresholds and methods), achievable (feasible within site constraints and available resources), relevant (focused on material residual risks and agreed post-mining land use) and timely (aligned to planning cycles and the duration of evidence needed for sign-off). Applied well, SMART working converts closure commitments from narrative statements into accountable work packages, monitoring plans and decision points, which in turn reduces ambiguity at closure and improves the traceability of liability estimates.

Within a rehabilitation and closure context, SMART working typically results in criteria that specify the closure feature (e.g. a waste rock dump, tailings facility, open pit, haul road or community and social transition commitment), the verification method (e.g. as-built survey, inspection protocol, monitoring records) and the evidence timeframe (e.g. performance demonstrated over one or more wet seasons). For example, instead of stating that a landform will be 'stable', a criterion can define a survey-based slope requirement and an erosion performance requirement (including geochemical stability) over an agreed monitoring period; instead of stating that water impacts will be 'acceptable', criteria can define site-specific trigger levels and a duration of compliant monitoring. Keeping these criteria concise and auditable supports consistent multidisciplinary implementation and creates a defensible line of sight from closure objectives to monitoring evidence and sign-off requirements.

In practical terms, integrated closure planning is strengthened when sites:

- define closure governance clearly (roles, decision rights and review cadence) and embed closure requirements into life of mine planning and budgets
- maintain an integrated closure plan that links closure objectives, closure criteria and success criteria to designs, schedules, monitoring and costs
- use structured reviews (including closure risk assessment, gap analyses and criteria effectiveness reviews) to refine criteria and update liabilities as evidence improves (Grant & Lacy 2016, Anglo American 2019; Santos et al. 2025).

2.3 Regulatory closure requirements: international and African context

While terminology and legal instruments differ by jurisdiction and country, statutory closure regimes internationally tend to require the same core elements: documented closure plans approved through a permitting pathway; progressive implementation of rehabilitation and decommissioning; monitoring to demonstrate performance; and a defined administrative process for completion, sign-off and, where available, relinquishment or transfer of long-term responsibilities (World Bank Group 2021; International Council on Mining and Metals 2025). In parallel, global lender and investor expectations (e.g. the IFC Performance Standards and the World Bank Group EHS Guidelines) often influence closure requirements through project finance covenants and environmental and social governance (ESG) assurance, reinforcing the need for early planning, stakeholder engagement and demonstrable reduction of residual environmental and social risks over time (International Finance Corporation 2007; World Bank Group 2021). Practically, these requirements create a line of sight from approvals and commitments (e.g. environmental impact assessment (EIA)/ environmental and social impact assessment (ESIA) conditions and management plans) to a site's closure objectives and measurable criteria, because regulators and financiers need auditable evidence that agreed outcomes have been achieved (Morrison-Saunders et al. 2016; Coetzer & Erasmus 2024; International Council on Mining and Metals 2025).

Within an African context, closure requirements are typically embedded across mining, environmental, water and land legislation and implemented through licence/permit conditions, ESIA approval commitments and (in many jurisdictions) financial assurance instruments (Morrison-Saunders et al. 2016; World Bank Group 2021). Although the detail varies across countries and commodities, common closure-related regulatory expectations include:

- an approved closure and rehabilitation plan that is updated periodically and aligned with the approved life of mine changes
- concurrent rehabilitation and verification of works against defined standards
- provision for closure and post-closure costs (financial provisioning) that is commensurate with the defined scope and residual risk
- transparent engagement with affected stakeholders on post-mining land use and socio-economic transition
- evidence packages to support completion decisions (e.g. as-built records, monitoring datasets and inspection sign-off) (van Zyl 2012; World Bank Group 2021).

Because many sites operate under evolving regulatory capacity and overlapping approvals, a practical way to maintain compliance and relinquishment readiness is to translate all closure-related legal and permit obligations into a single, auditable criteria register (rehabilitation, closure and success criteria), linked to monitoring methods, timeframes and accountable sign-off roles (Morrison-Saunders et al. 2016; Coetzer & Erasmus 2024; International Council on Mining and Metals 2025). This same traceability also strengthens closure liability estimation by tying costed work packages and contingencies directly to defined legal standards, verification timeframes and aftercare obligations (van Zyl et al. 2012).

3 Closure and success criteria

International good practice treats closure planning as an ongoing life of mine process in which the intended post-mining land use (or land use capability) is translated into a closure vision, closure objectives and measurable criteria that can be implemented, monitored and ultimately signed off (International Finance Corporation 2007; Slingerland & Wilson 2015; World Bank Group 2021; International Council on Mining and Metals 2025). Within this context, rehabilitation criteria, closure criteria and success criteria are complementary tools for defining 'what will be done', 'to what standard' and 'how achievement will be demonstrated'. Clear definitions and traceability between these elements are essential to avoid subjective sign-off, reduce residual risk and support credible liability estimation and financial provisioning.

Good practice requires a clear line of sight (Figure 2) from post-operational land use → closure objectives → closure criteria → success criteria → monitoring evidence (Slingerland & Wilson 2015; World Bank Group 2021; International Council on Mining and Metals 2025). This traceability is also where closure planning connects to permitting and impact assessment: closure commitments made in the EIA process should be converted into measurable criteria and embedded in the integrated closure plan, with responsibilities, timeframes and verification methods defined (Morrison-Saunders et al. 2016; Coetzer & Erasmus 2024). Where long-term performance is uncertain, criteria should explicitly require trials, progressive rehabilitation and periodic review so that standards are refined as site knowledge improves (Grant & Lacy 2016).

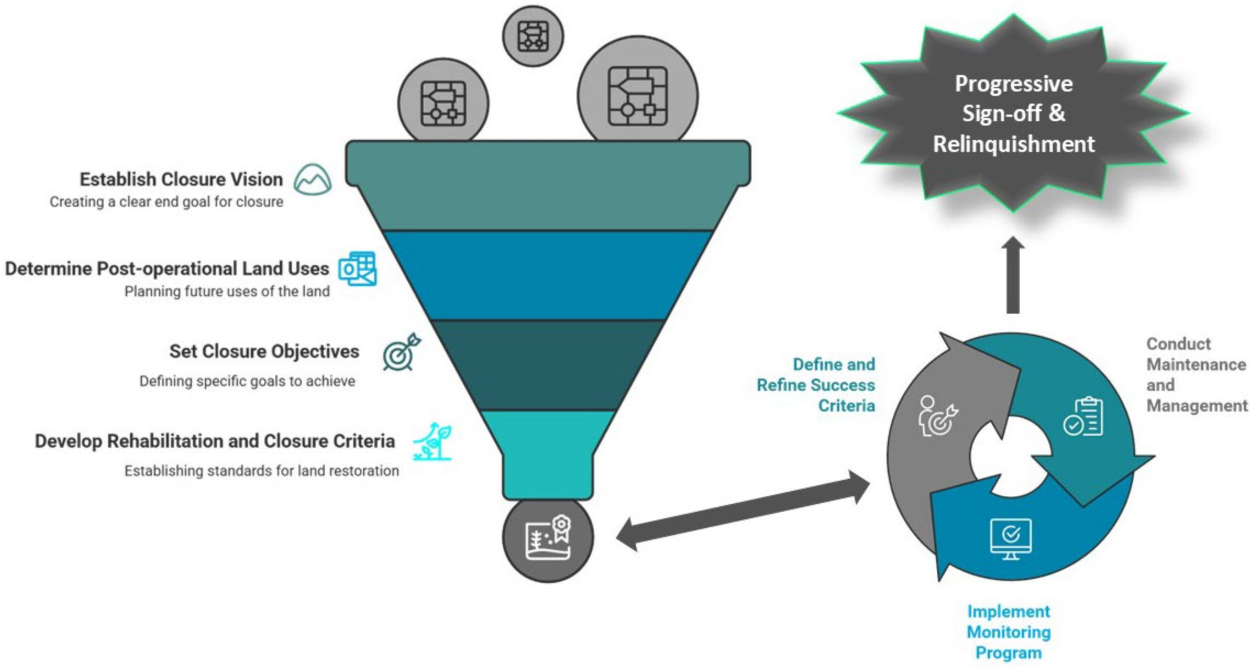

Figure 2 Relationship between closure vision, post-mining land uses, closure criteria, success criteria and monitoring program

Where closure and success criteria are poorly defined, the burden of residual risk is often shifted to regulators and communities after mining ceases, a systemic weakness highlighted in analyses of mine closure accountability frameworks (Krause & Snyman 2014). Although terminology varies across organisations and regulators, leading guidance (World Bank Group 2021; International Council on Mining and Metals 2025) consistently distinguishes between rehabilitation criteria, closure criteria and success criteria, which together define the standards for implementation and the evidence required for sign-off, as outlined below:

- **Rehabilitation criteria** define the measurable standards used to plan, implement and track progressive rehabilitation during operations (e.g. landform shaping, topsoil placement, revegetation, erosion controls). They confirm that rehabilitation actions are executed to an agreed specification and are performing as intended in the short to medium term (International Council on Mining and Metals 2025).

- **Closure criteria** translate closure objectives into auditable requirements that define the scope and standard of closure works across physical, biophysical and socio-economic domains (e.g. decommissioning standards, long-term drainage controls, residual risk controls and handover requirements). In practice, closure criteria are a primary input to closure work packages and closure cost estimates because they specify what must be delivered (van Zyl et al. 2012; Coetzer & Erasmus 2024; International Council on Mining and Metals 2025).
- **Success criteria** define the performance outcomes and evidence thresholds used to demonstrate that closure criteria have achieved the closure objectives and that residual risks are acceptable for sign-off and, where applicable, relinquishment. They are typically monitored over an agreed timeframe and are linked to verification methods, responsibilities, and decision points (International Finance Corporation 2007; World Bank Group 2021).

In practical application, criteria are strongest when written in a way that is unambiguous and auditable. A simple best-practice checklist is to ensure each criterion states (World Bank Group 2021; Coetzer & Erasmus 2024; International Council on Mining and Metals 2025):

- the feature or outcome (what)
- the measurable threshold (how much/how well)
- the method and data source (how measured)
- the timeframe (when/for how long)
- the accountable role and sign-off rule (who decides).

This structure supports consistent implementation across disciplines, reduces subjectivity at sign-off and creates a defensible basis for closure scope definition and financial provisioning (van Zyl et al. 2012).

4 Current integrated mine closure planning within an African context

Currently, mine closure and rehabilitation policies, principles and legislation are less well established in Africa compared to countries like Australia and Canada, with the key focus for mining being more oriented towards improving governance mechanisms related to attracting investment and associated opportunities for harnessing resource development (African Union 2009; Morrison-Saunders et al. 2016). Case study findings across African mining operations consistently indicate that the quality of closure objectives and criteria is the main determinant of whether integrated closure planning functions as a practical management system or remains a compliance document. Where objectives were clear and criteria measurable, closure requirements could be embedded into routine mine planning (design, scheduling, budgeting and monitoring), enabling progressive rehabilitation and earlier risk reduction. Where objectives and criteria were vague, closure decisions became reactive, interdisciplinary assumptions diverged, and closure costs and provisions were less stable over time (van Zyl et al. 2012; Grant & Lacy 2016; Coetzer & Erasmus 2024; International Council on Mining and Metals 2025).

Four practical findings explain why criteria are so important in African contexts:

1. Driving technical integration: criteria translate closure intent into design specifications and performance tests (e.g. stability, drainage function, water quality, revegetation trajectories), supporting optimisation and reducing late-stage redesign (Slingerland & Wilson 2015; International Council on Mining and Metals 2025).
2. Strengthening governance: criteria create objective ‘pass/fail’ evidence requirements for multidisciplinary review and sign-off, reducing dependence on individual judgement (Anglo American 2019).

3. Stabilising closure liabilities: because criteria define scope and standard, they directly drive closure liability estimates; unclear criteria lead to inconsistent work packages and higher contingencies, while clear criteria improve traceability and auditability (van Zyl et al. 2012; Coetzer & Erasmus 2024).
4. Improving stakeholder alignment: criteria make closure commitments explicit and measurable, which is particularly important where closure planning must support broader development objectives (African Union 2009; African Union Commission, African Development Bank, and United Nations Economic Commission for Africa 2012).

These findings reinforce a consistent message: effective closure outcomes are built by first defining clear, site-specific closure objectives and then operationalising them through measurable criteria. In practice, this requires teams to:

- validate post-mining land use and SMART closure objectives with stakeholders
- maintain an integrated criteria register linking rehabilitation, closure and success criteria to risks, work packages, monitoring plans and costs
- apply periodic criteria effectiveness reviews and gap analyses so that lessons from rehabilitation trials, operational changes and benchmarking are systematically incorporated and closure plans are progressively improved over time (Grant & Lacy 2016; Anglo American 2019; Santos et al. 2025).

The country examples that follow illustrate how these principles are applied in practice, demonstrating how SMART closure objectives and well-defined criteria are used to manage risk, guide decision-making and stabilise closure liabilities across different African regulatory and operational contexts.

4.1 South Africa

Integrated mine closure planning within South Africa is well advanced, with sound legislative drivers and sophisticated regulations specifically applicable to all mining operations. For example, closure planning at two diamond mines in South Africa are being practically implemented by adhering to closure objectives, specifically by operational management of waste rock with closure in mind by avoiding double-handling of waste rock material being used for rehabilitation purposes. Waste rock material received from underground workings is placed where it will be ultimately used (either for buttressing of the tailings facilities or infill of erosion gullies), rather than being dumped on the waste rock dump. By adapting operational SMART working, progressive rehabilitation is possible and will positively influence the closure liability in the long term. This example demonstrates how clearly defined SMART closure objectives, embedded directly into operational waste management decisions, enable progressive rehabilitation that reduces double-handling, lowers long-term closure liability and improves life of mine closure readiness.

4.2 Botswana

Various open pit diamond and copper mines in Botswana have site-specific risks where rehabilitation and closure criteria need to be tailored to the site conditions and differ from other operations. Although Botswana has high-level legislation for closure and rehabilitation, there are currently no detailed regulations and legislation in place, and international best practice (IBP) – together with company guidelines – is being followed. For example, by conducting stakeholder alignment on end land use with both internal and external stakeholders from early on in the life of mine and throughout operations, these outcomes already accurately inform and improve both the closure and success criteria for the mining operations. Therefore the end land use commitments are not only pre-mining conditions or only grazing, but a more true reflection of the current needs and expectations of the stakeholders. This case illustrates how early stakeholder-aligned closure objectives translate into more relevant, site-specific closure and success criteria, strengthening governance confidence and alignment of closure outcomes with actual post-mining land-use expectations.

4.3 Zimbabwe

A platinum mining operation in Zimbabwe also has unique challenges related to developing and refining the site-specific closure objectives, and rehabilitation and closure criteria. For example, as with most tailings facilities, a variety of closure-related risks require constant operational management such as the contamination of groundwater resources. By developing a detailed hydrogeological model for the tailings facilities, trigger-based corrective actions have been built into the closure objectives and criteria to accurately track and manage the contamination plume. This keeps the criteria accurate and traceable to the identified risk and maintains continuity through life of mine changes and leads to improved closure governance decisions. This example shows how risk-based SMART closure objectives, supported by measurable trigger-based criteria and monitoring, turn complex hydrogeological risks into auditable decision rules that improve governance continuity and defensibility over the life of mine.

4.4 Lesotho

In Lesotho, there is limited legislation guiding mine closure planning and therefore IBP is being followed. A diamond mine in Lesotho at 3,200 m above mean sea level has unique challenges. A specific aims is to conduct progressive rehabilitation on an annual basis across the site where possible to reduce the life of mine closure liability. From the first conceptual closure plan and closure criteria defined and developed in 2010, a comprehensive set of rehabilitation and closure criteria have been refined annually based on the site-specific conditions as well as outcomes of long-term rehabilitation trials being conducted on site. These trials focus on measuring and documenting the outcomes of different growth media, levels and severity of erosion as well as the preferred angle of reshaping through land function analysis studies. These outcomes directly influence and refine both the rehabilitation and closure criteria, provide completion evidence and ultimately increase the level of accuracy of the closure liability estimates. This case demonstrates the value of iteratively refining SMART rehabilitation and closure criteria through rehabilitation field trials, where performance-based evidence directly improves criteria realism, sign-off confidence and the accuracy of long-term closure liability estimates.

4.5 Tanzania

The mine closure and rehabilitation framework in Tanzania aligns well with IBP as articulated by the ICMM, particularly in its requirement that mine closure planning be initiated before operations commence and updated throughout the life of mine – a core ICMM principle for integrated closure planning. Similar to ICMM guidance, Tanzania's *2019 Mine Closure Guidelines* require early definition of closure objectives, performance criteria, progressive rehabilitation, and full life of mine closure costing, rather than treating closure as an end of project activity (Ministry of Minerals 2019). This early-stage, SMART-oriented planning materially improves the accuracy and credibility of closure liability estimates, as disturbance footprints, closure methods, scheduling and third-party execution assumptions are incorporated in the mine closure and rehabilitation plan from the outset and refined over time. In practice, this reduces uncertainty, limits late-stage cost escalation, and improves the alignment between financial provisioning and actual closure risk – consistent with ICMM's emphasis on defensible, auditable closure liabilities that are integrated into operational decision-making. This example highlights how early definition of SMART closure objectives and measurable criteria at the pre-operations stage materially reduces uncertainty in closure scope, scheduling, and costing, resulting in more credible life of mine closure liabilities.

5 Conclusion

This paper demonstrates that effective mine closure outcomes are best achieved when closure is treated as a core design function of mining, rather than a terminal obligation. Aligning regulatory requirements and site practices with IBP frameworks such as the ICMM and IFC enables closure objectives and criteria to be defined early, technically grounded, and progressively refined through the life of mine. The application of SMART closure objectives – developed prior to operations and continually validated through operational data, trials and risk-based reviews – significantly improves the accuracy and defensibility of closure liability estimates and associated financial provisions. Evidence from African case studies confirms that an integrated, multidisciplinary and iterative approach reduces uncertainty, avoids late-stage cost escalation and supports credible relinquishment. Ultimately, embedding closure planning from cradle to closure strengthens environmental performance, underpins socio-economic transition and delivers a sustainable post-mining legacy consistent with international good practice.

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