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FOREWORD

Protecting the environment is a priority for all members of our society. Governments have a key role in setting environmental standards and ensuring that individuals and organisations meet them. Increasingly, however, governments, industry and community organisations are working as partners to protect our environment for present and future generations.

Representatives of the minerals industry in Australia and Environment Australia, (the environment arm of the Federal Government), are working together to collect and present information on a variety of topics that illustrate and explain best practice environmental management in Australia's minerals industry. This publication is one of a series of booklets aimed at assisting all sectors of the minerals industry to protect the environment and to reduce the impacts of minerals production by following the principles of ecologically sustainable development. It should be of value to practitioners involved in exploration and planning through to supply chain and minerals processing.

These publications also provide information that allows the general community to gain a better appreciation of the environmental management practices applied by the minerals industry.

Our best practice booklets include examples of current best practice in environmental management in mining from some of the leaders in the Australian industry. They emphasise practical, cost-effective approaches to protecting the environment that exceed the requirements set by regulation. Case studies are provided to encourage better environmental performance in Australia and internationally. These case studies demonstrate how best practice can be applied in diverse environments across Australia, while allowing flexibility for specific sites.

The concept of best practice is simply the best way of working sustainably at a given site. The booklets integrate environmental issues and community concerns through all phases of mineral production, providing:

- Basic principles, guidance and advice;
- Case studies from leading Australian companies; and
- Useful references and checklists.

We encourage mine managers and environmental officers to take up the challenge to continually improve environmental performance and management of our global resources and to apply the principles outlined in these booklets.

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Contents

1. INTRODUCTION

Mine decommissioning and closure is the process of shutting down a mining operation with the broad objective of leaving the area in a safe and stable condition that is consistent with the surrounding physical and social environment and does not need ongoing maintenance. The mine area may also be suitable for alternative, post-mining land uses depending on site-specific circumstances.

The purpose of this booklet is to provide an overview of the principles of mine decommissioning illustrated by case studies representing current best practice in Australia. A *Strategic Framework for Mine Closure* (ANZMEC/MCA 2000,) was jointly produced by the Australian and New Zealand Minerals and Energy Council (ANZMEC)[1] and Minerals Council of Australia (MCA)[2] in 2000. The Strategic Framework is the culmination of an extensive partnership between Government and the mining industry. It is therefore appropriate that this Booklet is closely referenced to the Strategic Framework and builds on the concepts presented within.

This Booklet is also complemented by other booklets in the Best Practice Environmental Management in Mining Series particularly *Landform Design for Rehabilitation* (Environment Australia 1998) and *Rehabilitation and Revegetation* (Environment Australia 1998) (all BPEM booklets can be accessed from http://www.ea.gov.au/industry/sustainable/mining/).

2. OVERVIEW OF BEST PRACTICE MINE DECOMMISSIONING

Why is Mine Decommissioning Important and what are its Objectives?

Mine decommissioning usually occurs at a point in the life of an operation where the economic recovery of minerals has ceased. However, the overall mine decommissioning process should be integrated with the overall mine operation planning process. In other words, the mine should be designed and operated with a continual focus on closure outcomes. While new orebodies and mineral resources are constantly being discovered through exploration, the reserves contained in any particular deposit on which a project is based are finite.

Factors contributing to cessation of mining activities include:

- depletion of mineable reserves;
- changes in market conditions;
- financial viability of the company; or
- even adverse environmental or political conditions.

In some cases mining may only be suspended for a period of time and the project is placed under care and maintenance. In circumstances where it is clear that economic or other limits of the operations have been reached, decommissioning and final closure is required.

Mine decommissioning ultimately determines what is left behind as a benefit or legacy for future generations. If decommissioning and closure are not undertaken in a planned and effective manner, chances are that the site will continue to be hazardous and a source of pollution for many years to come. The overall objective of mine closure is to prevent or minimise adverse long-term environmental (physical, social and economic) impacts, and to create a stable landform suitable for some agreed subsequent land use.

There are no standard formulae that can be applied to determine decommissioning and closure outcomes, as each operation are unique in terms of potential long-term effects on the environment and communities. Appropriate mine decommissioning outcomes need to be determined on a site-specific basis taking into account the nature of the project in the context of regional factors such as climate, land capability, landform, water resources and ongoing land uses.

The following factors are important when considering decommissioning options:

- public safety hazards and risks
- ecological compatibility
- potential as ongoing source of pollution
- community expectations
- future land use and resource demands
- aesthetics

What are the Benefits of Effective Mine Decommissioning?

Planning for and progressively implementing effective mine decommissioning can produce significant benefits both during and at the end of operations. These benefits include:

- continually reduces liabilities by optimising rehabilitation works undertaken during the productive phase of mining operations rather than deferring costs to the end of the project;
- provides a basis for estimating rehabilitation costs prior to final closure so that sufficient financial and material resources can be set aside;
- tests rehabilitation designs and/or processes in a site specific fashion and allows for scrutiny of the outcomes, with feedback during the active mine life;
- reduces double-handling of waste materials and topsoil;
- reduces area of land disturbance through use of smaller waste landforms and mining paths, and in some circumstances progressive backfilling;
- identifies areas of high risk as priorities for ongoing research and/or remediation;
- facilitates the direct involvement of operations personnel in achieving mine rehabilitation outcomes;
- facilitates the involvement of key stakeholders (especially local communities) in setting priorities for mine rehabilitation;
- reduces ongoing responsibilities for the site and facilitates timely relinquishment of tenements and bond recovery; and
- eases impacts on local communities that may be economically reliant on mine operations.

How have community attitudes changed in relation to historical decommissioning practices in Australia?

Governments and the community in general have ever-changing expectations for mine decommissioning mainly relating to the potential for public health, safety and environmental hazards to result in future liabilities for the state.

Historically mine decommissioning practices in Australia have been highly variable often depending on the age of the operations and proximity to population centres. Little planned decommissioning work was undertaken more than 30 years ago largely due to insufficient regulatory controls and only minor awareness within the industry of the costs and benefits relating to decommissioning.

Environmental problems at operations where well planned decommissioning was not undertaken has become apparent at many sites around the country. Some of the most notorious examples include; Rum Jungle in the Northern Territory, Captains Flat in New South Wales, Mt. Lyell in Tasmania and Mt. Morgan in Queensland. Impacts associated with these operations were mainly due to acid rock drainage (ARD). However, many other abandoned and active mine sites also presented serious environmental and safety issues such as dust, erosion, and subsequent sedimentation in waterways, unstable landforms, and visual impacts. A stark example of this is the long abandoned Wittenoom asbestos mine where unstabilised tailings continue to pose a threat to public health.

Through most of the 1970's and early 1980's much of the focus for mine decommissioning was on rehabilitation. During this time, a number of national and international forums began to focus on the issue of "Sustainable Development" based on the concept of meeting the needs and aspirations of the present, without compromising the ability to meet those of the future . The debate was also broadened through such forums with the closer involvement of various non-government organisations and community representatives. The Australian mining industry was also influenced by revelations in the USA and Canadian mining industry of the massive liabilities associated with some "Superfund" sites.

Realisation of decommissioning as an integral part of mine planning and operations management became more prominent through the 1990's and is common practice in most current operations. However, there are still many legacies of past practices that will need to be dealt with in coming years.

What is the Legal Framework for Mine Decommissioning in Australia?

Mining activities in Australia are mainly regulated by State and Territory governments. The Commonwealth Government only becomes involved in an activity where there are deemed to be matters of national significance or Commonwealth land is involved.

The system applied in most States basically involves environmental impact assessment prior to the commencement of an operation. Conditions are imposed as an outcome of the assessment process for protecting the environment. These conditions usually require that a Decommissioning or Closure plan be developed at some stage of the operations. In the past, such plans were only required "prior to decommissioning". More recently, many of these plans are required to be submitted within 1 – 2 years of commencing operations and in some cases prior to commencing operations. Bonds or other forms of financial securities are also applied in most circumstances to provide government with money at call should conditions not be met and the mine not satisfactorily decommissioned.

The general approach to developing decommissioning plans allows for site specific factors to be taken into account. This approach also recognises that the plans will evolve throughout the life of the mine to accommodate changes in the project and increased knowledge and understanding of the local environmental conditions.

The Australian approach differs from some overseas "command and control" type regulatory frameworks where more prescriptive decommissioning outcomes are imposed at the time of initial project approval. While the Australian approach allows for more flexible outcomes, it also requires greater commitment by the company to provide sufficient resources, undertake necessary studies and implement the plans. Greater diligence is also required on the part of regulators to monitor the progress of the decommissioning works and ensure acceptable outcomes are achieved.

What is meant by Mine Decommissioning in Various Situations?

A number of terms are associated with mine decommissioning or closure depending on particular circumstances. The following definitions are based on those presented in the *Strategic Framework for Mine Closure* (ANZMEC/MCA 2000).

- Mine Decommissioning – the process that begins near, or at, the cessation of mineral production. This term is often used interchangeably with Mine Closure.

- Mine Closure – a whole of mine life process which typically culminates in tenement relinquishment. Closure includes decommissioning and rehabilitation.
- Rehabilitation (Reclamation) – the return of the disturbed land to a stable, productive and self-sustaining condition, taking into account beneficial uses of the site and surrounding land.
- Temporary Closure (Care and Maintenance) – phase following temporary cessation of operations when infrastructure remains intact and the site continues to be managed.
- Abandoned Site – an area formerly used for mining and mineral processing, where closure is incomplete and for which a titleholder still exists.
- Orphan Site – an abandoned mine for which a responsible party no longer exists or can be located.
- Inactive Site – a mining or mineral processing area which is currently not being operated but is still held under some form of title. Frequently such sites are referred to as being under care and maintenance.

Labouchere Mine – Western Australia: Waste landform prior to seeding.

Labouchere Mine – Western Australia: Waste landform 4 years later.
Photos courtesy Outback Ecology

3. BEST PRACTICE MINE DECOMMISSIONING PRINCIPLES

The following sections discuss "Best Practice" mine decommissioning objectives and principles as outlined in the Strategic Framework for Mine Closure (ANZMEC/MCA 2000).

3.1 STAKEHOLDER ENGAGEMENT

Objective – To enable all stakeholders to have their interests considered during the mine closure planning process.

Stakeholder engagement stands out as one of these most fundamental principles for effective mine decommissioning. Stakeholders include individuals, government agencies, community groups or others that are affected by or have an interest in the mine closure.

Mining is generally a transient activity, which is often responsible for substantial changes in both the community and the environment in which it operates. Stakeholders' interests often precede the mining operation and remain long after mining ceases. These interests often relate to alternative ongoing land uses, retention of infrastructure for public use and the maintenance of sustainable non-mining based communities. In some circumstances, stakeholders' livelihoods may be directly or indirectly dependent on the mine. Mine closures can cause significant social concerns, particularly in local communities where the mine may be the major commercial activity (WMI, 1994).

It is therefore essential that these interests be considered in all aspects of decommissioning planning and implementation. This is most effective when there is early involvement of key stakeholders in the operational planning and continuing liaison throughout the life of the project. Engaging stakeholders in meaningful dialogue is not just a matter of holding a public meeting to present the company's pre-determined Decommissioning Plan. It is a two-way exchange where all participants feel that their input is valued and will be given serious consideration in the process of developing and implementing the Plan.

Working closely through community consultative committees during operations will assist in the development of measures to offset the inevitable changes that will occur at closure. Similarly, there needs to be direct stakeholder involvement during the decommissioning works phase through a range of initiatives such as community forums and site inspections.

Principles for stakeholder engagement in mine decommissioning can be defined as follows (ANZMEC/MCA 2000):

- **Identification** of stakeholders and interested parties is an important part of the mine closure process.
- **Effective consultation** is an inclusive process, which encompasses all parties and should occur throughout the life of the mine.
- A **targeted communication strategy** should reflect the needs of stakeholder groups and interested parties.
- **Adequate resources** should be allocated to ensure the effectiveness of the consultation process.

- Wherever practical, **work with communities** to manage the potential impact of mine closure.

Effective engagement with relevant stakeholders will assist with:

- developing realistic employee, community, and regulatory expectations;
- establishing a satisfactory post-closure land use;
- understanding internal and external stakeholder issues;
- enabling stakeholders to participate in the process;
- enabling stakeholders to prepare for closure;
- minimising dependency on the company; and
- avoiding costly surprises.

Two case studies in this Booklet present examples of how Best Practice principles are applied to stakeholder consultation. These are:

- Case Study 1 – Community Consultation for Premature Mine Closure – Beenup Titanium Minerals Mine. This case study illustrates the value of community input to determining mine decommissioning options.
- Case Study 2 – Community Transition Strategy for Mine Closure – Pasminco Broken Hill Mine.

3.2 PLANNING

Objective – To ensure the process of closure occurs in an orderly, cost effective and timely manner with the allocation of adequate resources.

Planning also emerged as a fundamental part of Best Practice mine decommissioning. In all things we do, there is a simple rule known as the "Peter the Sixth Principle". That is, "Prior Planning and Preparation Prevents Poor Performance". All too often, mine decommissioning is only considered when closure is imminent. At this stage, cash flows are dwindling and unstable mined areas often exist with little resources available to undertake the required works.

Best Practice decommissioning planning starts at the pre-mine approvals stage as a conceptual closure plan outlining broad outcomes for mine closure. The conceptual plan should be an integral part of assessing project viability so that adequate provision can be made during operations to achieve an outcome that is both cost effective and meets community standards.

As the project develops, more detailed plans are prepared to ensure the greatest efficiencies are achieved through progressive rehabilitation – "Close as You Go". The decommissioning planning process should be ongoing throughout the life of a mining operation to accommodate changes as a result of factors such as: future developments; ongoing (post-mining) land use options; rehabilitation success as determined by monitoring; areas rehabilitated and signed-off; and changes in industry practice and available technology. A systems approach assists in integrating decommissioning planning with day to day management activities.

Principles for mine decommissioning planning are defined as follows (ANZMEC/MCA 2000):

- Mine closure should be **integral** to the whole of mine life plan;
- A **risk-based approach** to planning should reduce both cost and uncertainty;
- **Closure planning** is required to ensure that closure is technically, economically and socially feasible;

- **Closure plans** should be developed to reflect the status of the project or operation; and
- The dynamic nature of closure planning requires **regular and critical review** to reflect changing circumstances.

The process of mine decommissioning planning is further discussed in Section 4.

Case Study 3 presents a Systems Approach to Progressive Mine Closure adopted at the Placer Granny Smith Gold Mine.

3.3 FINANCIAL PROVISIONS

Objective – To ensure that the cost of closure is adequately represented in company accounts and that the community is not left with a liability.

Financial provisioning is crucial to Best Practice mine decommissioning. It is a mechanism to ensure that there are sufficient funds available to close an operation and that closure costs do not become a burden in later years of the mine life when revenues could be diminishing. Mine decommissioning is a costly exercise involving the removal of plant and infrastructure, rehabilitating all remaining disturbed areas, and monitoring and maintaining the area for a period into the future. While progressive rehabilitation assists in keeping liabilities to a minimum, the nature of most operations dictates that much of the disturbed areas are active until the cessation of mining and processing. Progressive rehabilitation can also assist in minimising bonds or security deposits required by governments.

Closure provisions should also reflect the real value of closure (Chamber of Minerals and Energy of WA, 1999). This is important as costs associated with closure can contribute significantly to overall project costs and hence the bottom line. In some extreme cases unforseen costs associated with decommissioning can far exceed any financial gains achieved over the life of a project, hence the need for closure planning during the mine life.

While adequate financial provisioning by the company represents "best practice", most governments now require bonds to be lodged for mining operations in order to protect the public's interests and minimise ongoing liabilities. Financial institutions may also seek to include mine decommissioning costs and potential ongoing liabilities for due diligence on project finance and under terms for guarantees on unconditional performance bonds.

Closure planning puts the company in a position to understand its potential costs early in the mine life. Financial provisioning can commence at the conceptual closure planning stage but may be highly inaccurate, as it is difficult to predict the course of mine development. However, the initial cost estimate exercise helps a company to focus on the areas of decommissioning where there is the greatest uncertainty in the outcomes. This enables priorities to be set for further work and research studies to be undertaken to better define required outcomes and hence costs over the life of the operations.

Decommissioning cost estimates must be regularly reviewed to account for project changes including; new developments, progressive rehabilitation, new approaches, changing social expectations and inflation.

Principles for financial provisions in mine decommissioning are defined as follows (ANZMEC/MCA 2000):

- A **cost estimate** for closure should be developed from the closure plan;
- Closure costs should be **reviewed regularly** to reflect changing circumstances;
- The **financial provision** for closure should reflect the real cost;
- **Accepted accounting standards** should be the basis for the financial provision; and
- **Adequate securities** should protect the community from closure liabilities.

3.4 IMPLEMENTATION

Objective – To ensure that there is clear accountability, and adequate resources, for implementation of the closure plan.

Implementation of the decommissioning plan is the Best Practice principle that ultimately determines the success of the planned approach. This involves commitment and accountability at all levels of operations management.

Mine management must assign a high priority to decommissioning to ensure that the plan does not remain "on the shelf" and that ongoing decommissioning works are undertaken as part of day-to-day operations. In this regard, the decommissioning plan should be a regular agenda item at routine mine management meetings, and tasks assigned to various levels of management.

The successful implementation of a decommissioning plan also relies on having sufficient physical and human sources available. Dedicated staff need to be made accountable for monitoring and reporting progress as they implement the plan against well defined performance criteria. Communication with, and the involvement of, all employees is also fundamental to effectively implementing the plan.

A "close-as-you-go" philosophy is important in implementing a mine decommissioning plan. Some mining operations are developed in such a way that the disturbance moves from one area to the next and mining landforms are progressively constructed. This creates opportunities to rehabilitate and decommission areas as they become available. Mine decommissioning earthworks can be scheduled to coincide with mining operations using the same equipment.

"Close As You Go"
During the life of your operation,
"you can show"
your stakeholders
"what you will leave behind after you go"
(Lacy 2000)

Principles for implementing mine decommissioning plans are defined as follows (ANZMEC/MCA 2000):

- The **accountability** for resourcing and implementing the closure plan should be clearly identified;
- **Adequate resources** must be provided to assure conformance with the closure plan;
- The **on-going management** and monitoring requirements after closure should be assessed and adequately provided for;
- A closure **business plan** including a schedule of actions, responsibilities, resources, and timeframes should provide the basis for implementing the closure plan; and
- The **implementation** of the closure plan should reflect the status of the operation.

Case Study 4 – Mine Closure Management Team – Forestania Nickel Operations looks at the management functions necessary to close a series of open cut and underground nickel mines.

3.5 STANDARDS AND CLOSURE CRITERIA

Objective – To establish a set of indicators that will demonstrate the successful completion of the closure process.

Standards and completion criteria are the focal point for mine decommissioning. Best Practice standards and completion criteria are those that are clearly understood and agreed by the company, the regulators and other stakeholders. Relevant standards for mine decommissioning ideally need to be developed on a site specific basis based on the nature of the operation and the environment in which it operates. However, this approach also needs to be underpinned by generic regulatory standards to provide the community with a degree of confidence that minimum acceptable outcomes will be achieved. Companies should seek to apply the same standards universally, exceeding local standards if they are below the standards the company applies in their home country.

Standards and completion criteria must be finely balanced between flexibility to allow changes in circumstances whilst being specific enough to provide certainty through measurable outcomes. Broad objectives for mine decommissioning are often set in the context of a generic outcome such as: "to prevent or minimise adverse long-term environmental impacts, and to create a self-sustaining ecosystem based on an agreed set of land use objectives". Overly prescriptive, uniform standards may restrict options for decommissioning that represent the best closure outcomes for one operation but may be totally inappropriate for another. Effective consultation between a mining company, the community and regulatory authorities is the best means of developing standards that are both appropriate and achievable. This also ensures that there is broad agreement for both the ongoing land use objectives and the basis for measuring the achievement of the objectives (ANZMEC/MCA 2000).

More specific completion criteria need to be developed through the life of an operation as an agreed set of environmental indicators, which upon being met will demonstrate successful rehabilitation of a site. These should be developed and refined as the operational aspects and characteristics become better understood through operating experience, focussed research studies and community consultation. Where possible, appropriate standards should provide benchmarks against which performance can be measured.

Principles for developing standards for mine decommissioning are defined as follows (ANZMEC/MCA 2000):

- **Legislation** should provide a broad regulatory framework for the closure process;
- It is in the interest of all stakeholders to develop **standards** that are both acceptable and achievable and transparent;
- **Completion criteria** are specific to the mine being closed, and should reflect its unique set of environmental, social and economic circumstances;
- An agreed set of **indicators** is required to demonstrate successful rehabilitation of a site; and
- **Targeted research** will assist both government and industry in making better and more informed decisions.

Case Study 5 – Mine Closure Through New Project Over Historical Mining Area - Junction Reefs Gold Project is an example of closure issues featuring prominently in gaining approval for a new mining operation within an area previously disturbed by over a century of mining activity.

Case Study 6 – Decommissioning Planning for Project Approval at the Marillana Creek Iron Ore Mine provides a Best Practice example of how appropriate closure standards can be developed through undertaking studies aimed a gaining a clearer understanding of potential long-term effects.

3.6 MINING TITLE RELINQUISHMENT

Objective – To reach a point where the company has met agreed completion criteria to the satisfaction of the responsible authority.

Enhancing pit water quality ensures that the water and surrounds are not a source of ongoing pollution or instability. Photo courtesy Outback Ecology

Best Practice relinquishment occurs at the point, or points, in time when the company has achieved all agreed standards and completion criteria for mine decommissioning. All parties should be satisfied that the site is no longer a danger to public health and safety, is not a source of ongoing pollution or instability and allows a productive use of the land similar to its original use or an acceptable alternative. In some instances, such as where land has previously been used for agriculture, the mining company should aim to relinquish land that is in a better condition, environmentally, than it was prior to the commencement of mining.

In Australia, most mining operations are conducted under a form of mining tenement that can coexist with other forms of land titles. For example, many mining operations are conducted on private freehold land, pastoral leases and reserves. At the end of an operation, it is usually the intention of the company to relinquish its title over the land where responsibility for the decommissioned site reverts to the government or landholder.

Relinquishment may be a staged process as progressive completion criteria and/or benchmarks are achieved. A sufficient period of time should have elapsed to demonstrate the stability of the site. For revegetated areas, this may require verification that the vegetation has reached, or is trending towards, a self-sustaining status. Potential impacts on groundwater may also take several years of monitoring to establish or refute.

In some circumstances the company may be required to retain some ongoing liability under broad environmental or civil laws for specific aspects of the operation for an indefinite period of time (eg contaminated sites).

It is important that a responsible authority is identified and held accountable to make the final decision on accepting closure. The responsible authority will make a judgement on the achievement of the agreed completion criteria after consultation with other involved regulatory agencies, including the future land manager (ANZMEC/MCA 2000). This applies to both financial securities and tenure over the mining area.

Principles for relinquishing a company's interests in a mining property can be defined as follows (ANZMEC/MCA 2000):

- A **responsible authority** should be identified and held accountable to make the final decision on accepting closure;
- Once the completion criteria have been met, the company may **relinquish** their tenement without further obligations; and
- **Records** of the history of a closed site should be preserved to facilitate future land use planning.

Two case studies are presented relating to Best Practice relinquishment principles as follows:

- Case Study 7 – Abandoned Minesite Requiring Decommissioning by Government Agency – Agricola Gold Mine.
- Case Study 8 – Closure of Open Cut Mining Operations Using Ecosystem Function Analysis to Show Ecosystem Development and Demonstrate Closure – Paddy's Flat Gold Mine.

4. PLANNING FOR DECOMMISSIONING

Planning for decommissioning depends largely on the current status of the operations. Ideally, proper planning for closure should come during the feasibility study, design and approval stage of the mine development. However, this is not always possible for operations that have been developed prior to recognising the need for decommissioning planning. As a general rule, the longer an operation has been underway, the more limited the options and resources are for decommissioning.

The following diagram, originally developed by the Chamber of Minerals of Western Australia, provides a suggested structure for the planning process, and an indication of the elements that may contribute at each stage. The structure may be used as a guide and adapted where necessary to suit specific site or regulatory requirements.

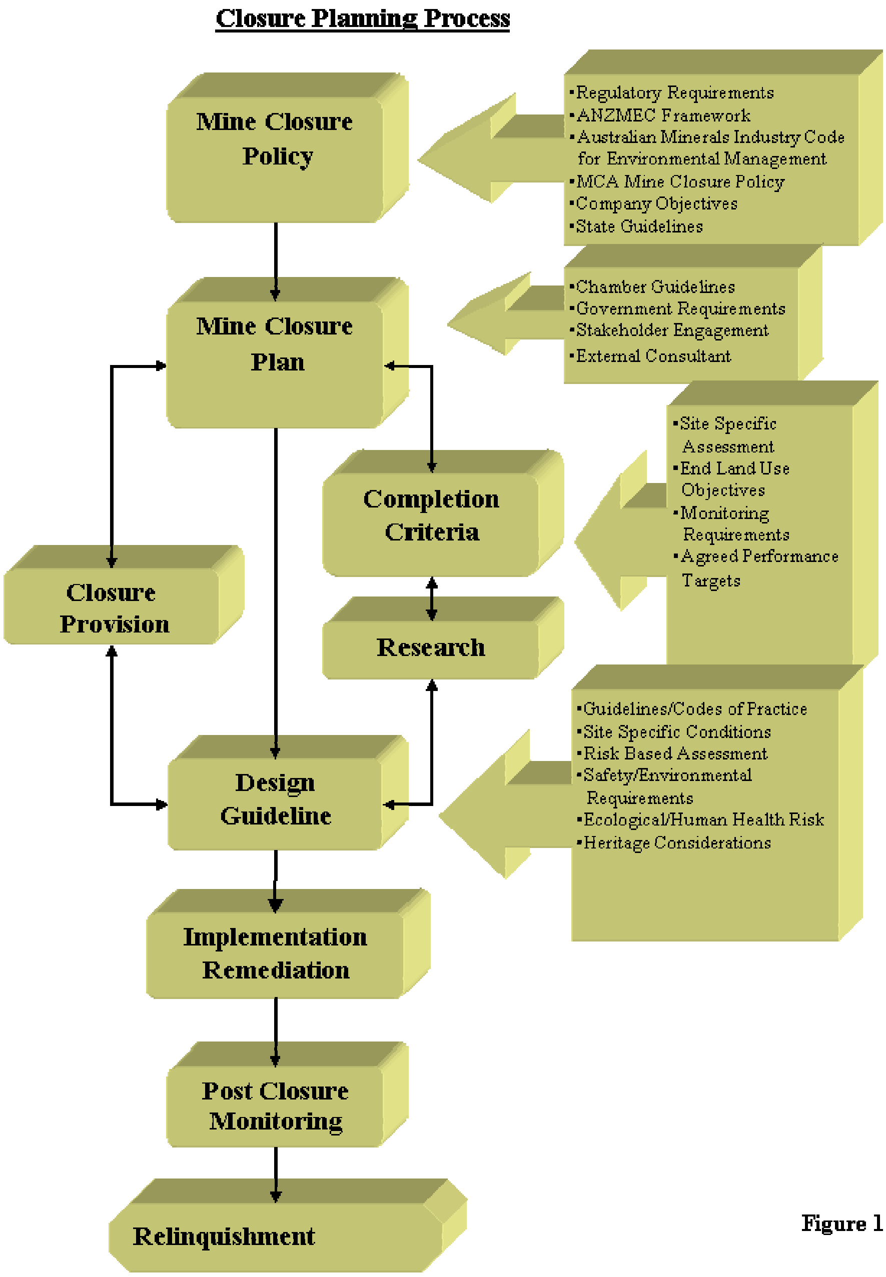


Figure 1

(Adapted from Chamber of Minerals and Energy of Western Australia, 1999)

4.1 MINE CLOSURE POLICY

The process of mine decommissioning planning progresses through a series of steps starting with developing a policy that is appropriate for the operation. The development of a mine closure policy is necessary to provide a framework for closure planning and may reflect industry approaches and trends, both nationally and internationally, as well as regulatory requirements, corporate objectives and community aspirations. The mine closure policy should be developed in the context of the company's overall Environmental Policy. The policy needs to clearly state the organisation's intentions in relation to closure planning and provide a framework for actions and setting objectives (Chamber of Minerals and Energy of WA, 1999). The mine closure policy should also be made available to the public.

Industry and government in Australia, which may assist in formulating a closure policy, have recently developed a number of policy frameworks. These include:

- ANZMEC / MCA. 2000, *Strategic Framework for Mine Closure*, ISR 2000/155, ISBN 0 642 72138 6, Australia;
- Chamber of Minerals and Energy of Western Australia, 1999, *Mine Closure Guideline for Minerals Operations in Western Australia*, ISBN 1875449973, Australia;
- Queensland Mining Council, 2001, *Guidelines for Mine Closure Planning in Queensland*, ISBN 0 9578701 0 8; and
- Northern Territory Department of Mines and Energy, 1997, *Mine Close Out Criteria: Life of Mine Planning Objectives.*

4.2 MINE CLOSURE PLAN

The form of a mine closure plan is usually dependent on the stage of an operation at the time the plan is being developed. In the case of a new proposed operation, a conceptual closure plan is appropriate which sets out broad objectives and indicative cost estimates. On the other hand, a closure plan being developed for an operating site needs to be much more detailed and include closure costs determined through operational experience. Closure planning options for abandoned sites are often more limited depending on funds available for rehabilitation. Opportunities also exist for present and future project operators to rectify the problems and effects of abandoned sites by integrating these areas in their closure plans.

The mine planning process should cover the following aspects:

- Integration;
- Cost Estimations and Financial Provisioning
- Risk-based Approach;
- Closure Plans;
- Closure Feasibility; and
- Regular and Critical Review.

Integration

Closure should be integral to the whole of mine life plan.

Mine closure should not be an "end of mine life process" but should be integral to "whole of mine life" if it is to be successful. Planning for closure should commence at the pre-feasibility phase of an operation. In this way, future constraints on, and costs of, mine closure can be minimised, post-mining land use options can be maximised and innovative strategies have the greatest chance of being realised (ANZMEC/MCA 2000).

Decommissioning and closure plans are often developed as part of the initial financial planning process and updated periodically through out the life of the operation. Table 4.1 provides example of the planning schedule used by the Homestake Mining Company (Allan, 2000).

Table 4.1Mine Closure Planning Schedule

Project Stage	Type of Plan / Estimate	Estimate Basis	Estimate Reliability
Initial mine planning (proforma)	Order of Magnitude	Experience	Variable
Prior to mine construction	Bonding	Permitting requirements	Variable
One year following mine startup	Preliminary	Preliminary engineering takeoffs and experience	Plus or minus 30%
Ten years prior the scheduled shutdown	Budgetary	Detailed engineering takeoffs	Plus or minus 25%
Five years prior to scheduled shutdown	Control	Quoted costs for major elements and detailed engineering takeoffs	Plus or minus 15%
Annually after preliminary	Updates	Variable	Plus or minus 30% to 15%

Case Study 6 provides an example of decommissioning planning being an integral part of the project approval process for the BHP Billiton Marillana Creek iron ore mine in Western Australia.

Financial Provisioning

Preliminary Cost Estimates

Estimating costs for decommissioning at the early stages of mine planning and development is often imprecise as the real costs associated removing infrastructure and rehabilitating post-mining landforms are not known. These costs are dependent on a range of site and operational specific factors including; isolation, machinery rates, difficulties in materials handling, geochemical and physical characteristics of waste materials, final land use and completion criteria. The degree of variability in costs is often related to the level of certainty in achieving the required outcome. It is therefore important to adopt a risk-based approach that identifies areas of uncertainty thereby reducing the high variability in estimated costs.

There is, however, sufficient industry experience in developing indicative unit costs that can be applied to a mining situation to generate rough estimates. The following tables provide examples of some indicative costs for a typical gold operation in the arid zone.

Table 4.2 Indicative Earthwork Costs		
Area	**Activity**	**Unit Cost**
Hardstand areas	Profiling	$400 – 500/ha
	Surface scraped	$2500 – 3000/ha
	Minor ripping (no seed)	$300 – 400/ha
	Hydrocarbon contaminated soil excavation	$1000 – 5000/storage bund
Roads	Edges graded (minor unsealed roads)	$50 – 80/km
	Surface scraped (major sealed or capped roads)	$2500 – 3000/ha
Tracks	Edges graded	$50 – 80/km
	Minor ripping (no seed)	$300 – 400/ha
Pits Safety bund construction	$15 – 30/linear m	
Waste landforms	Battering / contour / profiling work (highly variable depending material and slope)	$5000 – 20,000/ha
	Rock armouring and drainage control structures (eg rock drains)	$40,000 – 50,000/hectare
	Oxide material placement and spreading (<0.5m)	$7000 – 8000/ha
Tailings storage facilities	Capping with 1m material	$25,000 – 40,000/ha
Leach pads	Reshaping and capping	$20,000 – 40,000/ha

Table 4.3 Indicative Topsoil Spreading, Ripping and Seeding Costs

Activity	Unit Cost
Topsoil spreading	$2000 – 3000/ha
Ripping and seeding	$1000 – 2000/ha
Manual seeding only	$500 – 1000/ha
Mobilisation / demobilisation	$1000 – 3000/time

Table 4.4 Infrastructure Demolition and Removal/Disposal	
Item Description	**$ Cost/Unit ***
Primary crusher	$40,000 – 60,000/unit
SAG mill	$50,000 – 80,000/unit
Ball mill	$40,000 – 60,000/unit
Tankage CIP/thickeners etc	$10 – 20/m^3
Conveyors	$30 – 50/linear m
Power poles/lines	$2000 – 3000/km
Poly pipe 100/400 mm	$2000 – 3000/km
Transportable units	$2000 – 3000/unit
Fuel storage tank	$5,000 – 30,000/tank
Elution Circuit	$20,000 – 30,000/unit
Gold Room	$20,000 – 30,000/unit
Water storage tanks	$2000 – $5,000/tank
Cyclone mesh fence	$2 – 5/linear m
Light industrial buildings (includes concrete floor)	$60 – 80/m^2
Heavy industrial buildings (includes concrete floor)	$80 – 100m^2
Concrete slabs and footings	$40 – 60/ m^2
Wash-down bay	$2000 – 3000/bay

* Assumes no resale value – dismantle and dispose.

Detailed Operational Cost Estimations

More detailed cost estimates can be developed during the operational phase of a project as actual site specific conditions such as waste material characteristics and earthmoving costs etc are known. An effective means of calculating the cost of decommissioning various aspects of the operation is to develop a series of spreadsheets. This approach also allows for periodic updating of cost estimates to accommodate changes in operations and unit costs. Figure 4.5 provides a conceptual example of such a spreadsheet.

Figure 4.5 Conceptual Decommissioning Cost Spreadsheet											
Site / Facility											
				Machine A		Machine B					
Activity Description	**Personnel Units**	**Personnel Rates**	**Total Personnel Costs**	**Days**	**Cost/Day**	**Days**	**Cost/Day**	**Total Machinery Costs**	**Rehabilitation Materials Cost (Seed, Fence)**	**Total Activity**	**Risk Factor**
rip haul road											
construct abandonment bund											
remove buildings											
batter waste landform											
rip waste landform											
seed waste landform											
Site Sub-total											
Contingency 10%											
Management & Monitoring 10%											
Total Site Decommissioning Cost											

Contingency Provision

In addition to direct cost estimates for earthworks, revegetation and fixed plant decommissioning, a contingency allowance for general cleaning-up and removal of minor, unaccounted, infrastructure etc. for various sites must also be included. An approach that is being applied to many closure cost estimations throughout the mining industry is to include a general contingency as a percentage of overall costs. The percentage figures used typically range from 10% to 25% depending on the nature of the disturbances and uncertainty associated with estimating the extent of work required.

Management and Monitoring Costs

Provisions also need to be made to cover management and monitoring costs over and above normal salaries for key personnel during operations. This is largely to cover management personnel costs after operations cease and specialist staff and/or consultants required to supervise infrastructure removal/rehabilitation and monitoring. This contingency would also include initiatives such as relinquishment audits for closed areas.

Similar to general contingency provisions, the approach being adopted by a number of operations is to include management and monitoring provisions as a percentage of overall costs. The percentage figures used for management and monitoring typically range from 10% to 25% depending on a range of site specific factors.

Risk-Based Approach

A risk-based approach to planning should reduce both cost and uncertainty (ANZMEC/MCA 2000).

Current trends in closure planning involve technical review and analysis of risk and cost benefit in both engineering and environmental terms. Strategic planning for mine decommissioning and closure needs to consider all available options in the context of operational and financial constraints and taking into account statutory government requirements and community expectations. Sometimes the most obvious solutions in the short-term may result in significant future liabilities. For example, pushing the out-slope of a cyanide dump leach beyond the facility liner, to achieve a more stable slope angle, may result in persistent seepage of leachate to the groundwater.

The advantages of a risk-based approach to closure planning lie in the quantification of subjective factors and the analysis of uncertainty related to both design performance and cost (Morrey, 1999). Many of the variables that contribute to risk relate to specialised engineering and scientific principles, and it takes more than just the project engineer's or the environmental manager's or consultant's interpretation of a situation to adequately assess potential risks. An effective risk assessment must take into account environmental, engineering, financial, legal and community aspects of a project with the direct involvement of the project specialists covering these areas.

A systematic, risk-based, approach can by applied to define appropriate objectives and develop cost effective decommissioning strategies at various stages of the project. Such an approach would initially involve a qualitative risk analysis integrating all aspects of the project including: financial, legal, engineering, environmental and community issues. More complex issues identified through the risk analysis may require further quantitative risk assessment to compare various closure options based on relative costs and benefits over the life of a project.

Varying levels of risk are associated with different aspects of the mine closure where rehabilitation outcomes are uncertain. Table 4.6 provides an example of a qualitative risk assessment matrix where indicative risk factors are shown as a function of the potential significance of resultant impacts and level of certainty regarding effectiveness and/or acceptability of rehabilitation measures.

Figure 4.6 Risk Matrix

	Potential Significance of Resultant Impact			
Level of Certainty Regarding Effectiveness and/or Acceptability of Rehab Measure	• negligible pollution potential • long term stability with no ongoing management	• low pollution potential • some short-term easily managed instability • long term stability	• significant pollution potential • short to medium term instability requiring substantial ongoing management • long term stability	• high pollution potential • medium to long term instability • extensive ongoing management
High	1	2	2	3
Medium	1	2	3	4
Low	2	3	4	5

Risk Scale: 1 – Negligible Risk, 2 – Low Risk, 3 – Significant Risk, 4 – High Risk, 5 – Very High Risk

It should be noted that closure costs associated with low risk factors are likely to be more accurate (ie ±25 – 30%) than those associated with high risk factors (ie ±30 – 40%). Costs associated with very high risk factors could be highly inaccurate (±100%). Unfortunately the high risk areas usually coincide with the aspects which represent the greatest potential costs. It is therefore particularly important that a high priority be given to high risk areas to determine the most effective and practicable means of closure that are acceptable to government and the community.

Environmental risk assessment is a powerful tool that can be applied for many aspects of environmental management. The Best Practice Environmental Management in Mining series includes a booklet on Environmental Risk Management, which provides practical approaches, supported by case studies, on risk assessment.

Closure Plans

Closure plans should be developed to reflect the status of the project or operation (ANZMEC/MCA 2000).

At least two types of closure plan will be required through the life of a mine:

- a **Conceptual Closure Plan** for use during exploration, feasibility and up to project commitment; and
- a **Closure Plan** for use during construction, operation and post-operation.

Conceptual Closure Plan

A conceptual closure plan identifies the key objectives for mine closure to guide project development and design. It should include broad land use objectives and indicative closure costs.

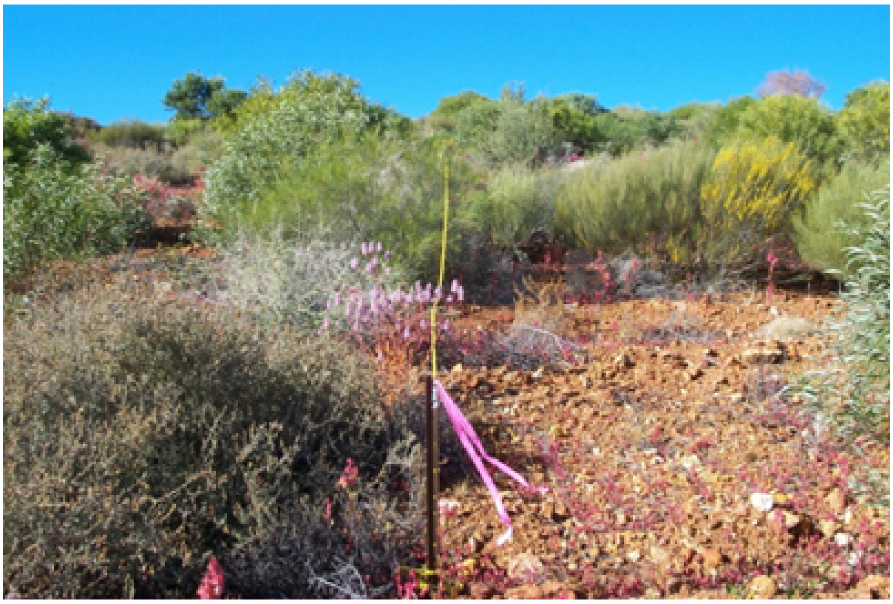
During the construction phase, the Conceptual Closure Plan should evolve into the first Closure Plan, and post-mining land use objectives should be refined at this time. This does not preclude land use objectives being varied during the mine life to reflect changes in both knowledge and technology (ANZMEC/MCA 2000).

Closure Plan

Closure planning includes a commitment to progressive rehabilitation and detailed plan development and implementation. Closure plans often evolve through a project life-cycle with the primary focus being dependent on the stage of operations.

In the early stages of mine development the primary focus may be on rehabilitation planning to develop appropriate techniques for achieving objectives outlined in the conceptual closure plan. This usually involves undertaking active research and trials in conjunction with progressive rehabilitation aimed at confirming or modifying completion criteria or demonstrating if they can be met. It also assists in minimising ongoing contamination and reducing final costs. Progressive rehabilitation allows best use of available personnel and equipment and should assist in minimising required security deposits.

At a later stage in the operation, the focus of the closure plan shifts to more comprehensive decommissioning planning. This often occurs a few years before closure when an endpoint is in sight. At this point, the decommissioning plan should detail the demolition and removal or burial of all structures not required for other uses; removal, remediation or encapsulation of contaminated materials; and completion of outstanding rehabilitation. Specialised personnel and equipment may also be required such as: process plant decommissioning and demolition engineers, geotechnical engineers, rehabilitation specialists, cranes, large flatbed equipment transports and so on.



Waste landform rehabilitation monitoring - 7 years in Western Australia arid zone. Photo courtesy Outback Ecology

After the decommissioning works have been undertaken, whether progressive or final, the main focus of the closure plan is monitoring and maintenance. The monitoring programme should be designed to demonstrate that the completion criteria have been met. This period should also plan for remedial action where monitoring demonstrates completion criteria are unlikely to be met. If progressive rehabilitation has been successful, with stabilisation and revegetation meeting completion criteria this last phase of closure may be shortened. It is, however, unlikely to be less than 5 years in duration (ANZMEC/MCA 2000).

Closure Feasibility

Closure planning is required to ensure that closure is technically, economically, environmentally and socially feasible (adapted from ANZMEC/MCA 2000).

Being able to successfully close a mine is critical to project approval. It is necessary to ensure that closure is technically, economically, environmentally and socially feasible without incurring long-term liabilities. The Conceptual Closure Plan should address preliminary land use objectives and should be an integral component of final project design (ANZMEC/MCA 2000).

Case Study 5 - Mine Closure Through New Project Over Historical Mining Area - Junction Reefs Gold Project is an example of closure issues featuring prominently in gaining approval for a new mining operation within an area previously disturbed by over a century of mining activity.

Regular and Critical Review

The dynamic nature of closure planning requires regular and critical review to reflect changing circumstances (ANZMEC/MCA 2000).

The Closure Plan should be modified as a result of any operational change, new regulations or new technology, and should be comprehensively reviewed on a regular and pre-determined cycle (eg. every 3 to 5 years). It should always remain flexible enough to cope with unexpected events. Figure 4.2 shows the various steps in a typical Closure Plan review process.

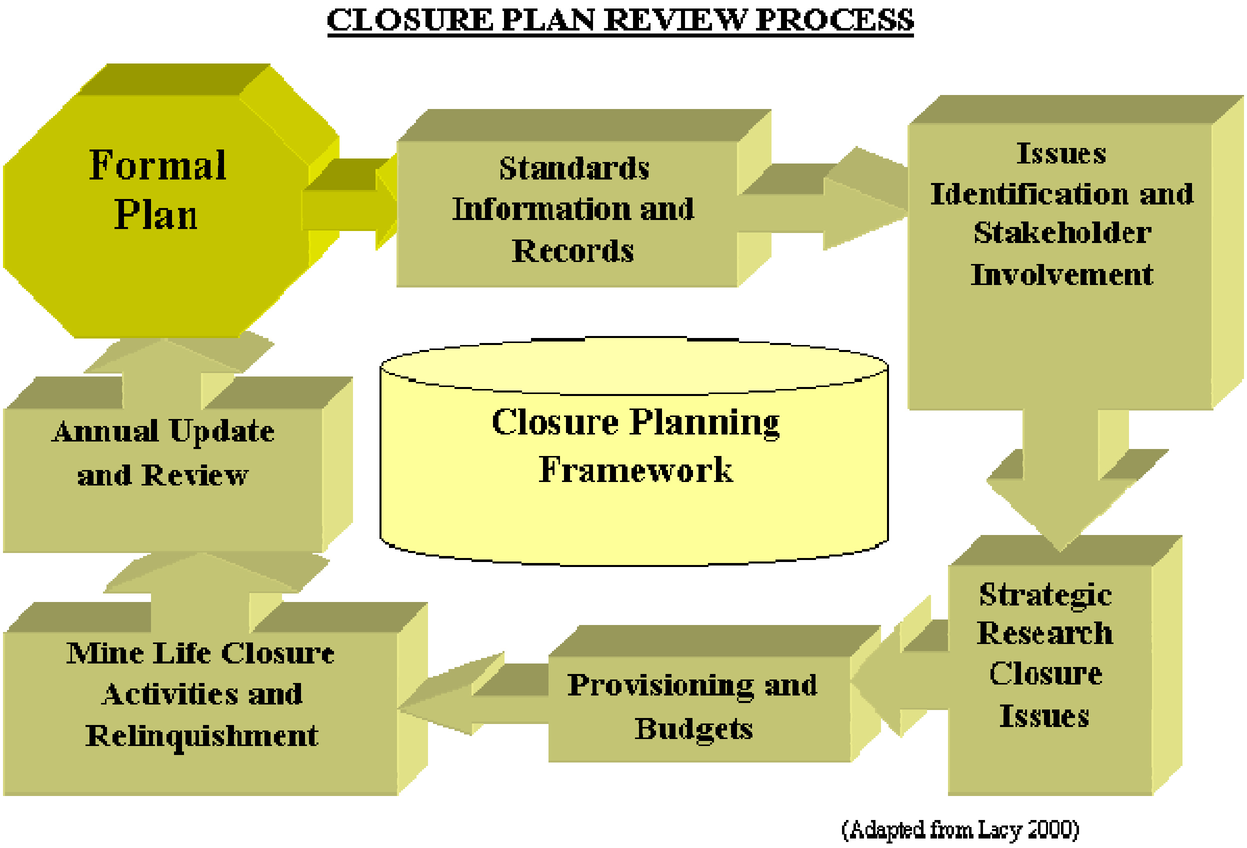


Figure 4.2

5. SOME SPECIFIC ISSUES FOR DECOMMISSIONING

5.1 ISSUES AND CONSEQUENCES

The decommissioning process must cover all aspects of the operations in a site specific manner. The following series of tables outline various issues and consequences associated with closure aspects of a project. Options and techniques for managing these closure issues are also indicated.

Table 5.1 Underground Voids and Shafts

Issues and Consequences	Options and Techniques
Stope Failure or Void Collapse • Surface subsidence	• Backfill upper levels with waste rock or paste (during operation)
Planned Surface Subsidence • Surface water impacts	• Integrate subsided landform • River diversion
Acid Rock Drainage and Hydrocarbon Pollution • Adverse groundwater quality	• Recover water table (flooding of UG) • Treat and replace acidic water. Sulphide reducing bacteria • Segregate known aquifers (operational) • Cement and seal adits
Public Safety • Human injury or death	• Prevent access into underground workings by backfilling decline to portal then place engineered cement cap (plug) over portal and all surface entrances (ie escapeways, vent rises)
Fauna • Injury or death • Loss of habitat	• Fauna survey • Creation of habitat (eg. Bats) • Prevent access (see above)
Post-mining Land Uses	• Research • Tourism • Waste disposal • Bio-reactors (methane production) • Water supply

Table 5.2 Open Cut Pits

Issues and Consequences	Options and Techniques
Acid Drainage and Leachate Production From Exposed Walls. • Poor groundwater quality	• Backfill above predicted recovered groundwater level • Maintain water quality during mining • Treat water (lime etc) • Seal potential ARD generating surfaces • Refill pit with water (eg stream diversion and/or groundwater recovery)
Void Stability • Slumping	• Bench highwall and reshape low wall to a stable slope angle. • Batter or blast high wall to safe and stable angle

• Wall failures	• Backfill to support internal walls
Public and Fauna Safety • Injury or death	• Hostile materials may need immediate covering eg. possible spontaneous combustion • Barrier to discourage human access • Abandonment bunds of competent rock (where possible) and located outside of area of wall instability • Fencing and signage
Aesthetics • High visual impact • Industry reputation • Negative public reaction	• Revegetate void surroundings • Screening • Create wetlands • Backfill or collapse and revegetate berms.
Post-mining Land Use	• Stakeholder engagement to determine possible uses • Aquaculture • Recreational facilities • Educational areas • Water storage • Domestic and/or hazardous waste disposal

Table 5.3 Tailings Storage Facilities

Issues and Consequences	Options and Techniques
Erosion and Structural Instability • Overtopping from floodwaters • High phreatic (water table) surfaces • Piping of materials during seepage • Sedimentation • Surface flooding erosion of batters	• Geotechnical review/risk assessment on closure • Integrity from construction phase • High quality operational management • Rock armouring • Buttressing • Drainage control • Erosion resistant cover • Integration of cover into surrounding environment
Acid Rock Drainage • Internal and external instability • Water impacts • Acid soil • Toxic to biotic systems • Gas and thermal emissions • Cover deterioration and failure	• Geochemical characterisation and selective discharge • Cover and capping research studies and design to reduce water and oxygen reactions • Identification of cover material source and availability • Monitoring of cover performance and integrity • Capture and release systems • Use as waste backfill in open pits or underground • Neutralisation (eg lime) and treatment (sulphide reducing bacteria) • Segregation / isolation / encapsulation • Passive leachate management and treatment
Dust • Visual impact • Offsite pollution effects • Flora and fauna	• Surface capping to prevent wind erosion (eg. rough cover, rock mulching) • Wet cover / wetlands • Revegetation • Wind breaks • Hydromulch
Groundwater • Aquifer contamination • Limitation of beneficial use • Recharge impact • Localised mounding	• Reduce hydraulic head by water shedding • Integrate capture release systems • Utilise evapotranspiration • Cap and cover with capillary break • Drainage diversions • Neutralisation and detoxification of tails seepage

	• Wetland filtration
Aesthetics • High visual impact • Industry reputation • Negative public reaction	• Revegetated • Effective landform and cover design. • Stakeholder engagement
Public and Fauna Safety • Injury or death	• Effective landform and cover design • Restrict access
Long-term Viability of Rehabilitation	• Stock and feral animal control • Monitoring

Table 5.4 Waste Rock Landforms

Issues and Consequences	Options and Techniques
Erosion / Instability • Safety • Sedimentation • Slope/piping failure	• Signage and isolation bunding • Revegetation/rehabilitation • Landform design appropriate to materials used • Surface water management (stream diversion etc)
Surface Water • Sediment loading • Contaminated water • Visual impacts • Interruption of water courses.	• Placement of erosion control measures • Drainage control • Erosion resistant outer covers • Material characterisation • Wetland filters • Containment • Revegetation
Groundwater • Aquifer contamination • Limitation of beneficial use • Recharge impact • Localised mounding	• Waste characterisation including geochemistry • Selective placement of covers and caps • Location relative to landform and substrate • Hydrogeology studies prior to placement
Acid Rock Drainage • Internal and external instability • Water impacts • Acid soil • Toxic to biotic systems • Gas and thermal emissions • Cover deterioration and failure	• Geochemical characterisation & waste selection placement • Cover and capping research studies and design to reduce water and oxygen reactions • Identification of cover material sources and availability • Monitoring of cover performance and integrity Capture and release systems • Use as waste backfill in open pits or underground • Neutralisation (eg lime) and treatment (sulphide reducing bacteria) • Segregation / isolation / encapsulation • Passive leachate management and treatment
Dust • Visual impact • Offsite pollution effects • Flora and fauna	• Surface Capping to prevent wind erosion (eg. rough cover, rock mulching) • Wet cover/ wetlands • Revegetation • Wind breaks • Hydromulch
Aesthetics • High visual impact • Industry reputation	• Stakeholder engagement • Effective landform and cover design • Modelled to compliment surrounding landforms

• Negative public reaction	• Revegetated
Post-mining Land Use • Loss of economic benefit	• Stakeholder engagement to determine uses • Tourism • Farming/horticulture • Recreation • Stored resource

Table 5.5 Treatment Plant, Office Buildings and Maintenance Facilities

Issues and Consequences	Options and Techniques
Salt, Heavy Metals And Hydrocarbons. • Contaminated soil • Contaminated water	• Removal • Bioremediation • Treatment • Isolation and encapsulation
Buildings/Infrastructure • Safety • Pollution	• Stakeholder benefits • Asset register • Tourist facility • Re-sell
Services	• Recycling • Asset register
Concrete • Soil pollution	• Removal/Bury • Recycling
Drainage • Contaminated runoff	• Reinstate/modification, divert • Sediment traps
Pre/Post-mining Heritage	• Stakeholder engagement • Tourism
Compaction • Restricted revegetation	• Deep ripping

Table 5.6 Mine Townships

Issues and Consequences	Options and Techniques
Social Dislocation • Unemployment	• Stakeholder consultation • Councilling/retraining/placement • Relocation
Regional Economic loss • Small business collapse	• Stakeholder consultation • Seed capital alternative new industry • Long term stakeholder involvement • Provide sustainable industry
Social Services	• Stakeholder engagement • Support alternative options
Townsite infrastructure/buildings	• Stakeholder engagement • Sale • Removal • Asset transfer

Table 5.7 Water Storage Dams

Issues and Consequences	Options and Techniques
Altered Ecosystems • Catchment impact	• Fence • Breach wall

• Flora and fauna impact	• Rehabilitate • Restore natural drainage
Process Water Dams • Contaminated water/Soil	• Remove water and dredge through plant (operational) • Rehabilitate
Siltation	• Draining system
Downstream Shadow • Vegetation loss • Soil degradation	• Draining system
Long-term Stability • Wall failure	• Geotechnical review and risk assessment
Water quality • Salinity • Nutrients	• Through flow system • Catchment management
Safety • Injury or Death	• Restrict access (fencing)
Post-mining Land Use	• Recreation • Irrigation • Water supply • Asset transfer • Stakeholder benefit

Table 5.8 Service Infrastructure

Issues and Consequences	Options and Techniques
Above Ground Services (eg. Powerlines, Roads, Railways, Airstrips, Borefields, Ports) • Soil contamination • Drainage obstruction • Vegetation loss	• Stakeholder engagement • Removal of infrastructure • Rehabilitate • Reinstate drainage • Asset transfer
Below Ground Services (eg. Electrical Cable, Piping) • May be exposed during rehabilitation	• Remain buried depending on depth • Remove and salvage • Rehabilitate
Vent Rises/Escape Ways and Service Tunnels. • Injury or death	• Backfill and cap with engineered concrete structure • Waste disposal

5.2 GENERATING ALTERNATIVE OBJECTIVES FOR DECOMMISSIONING

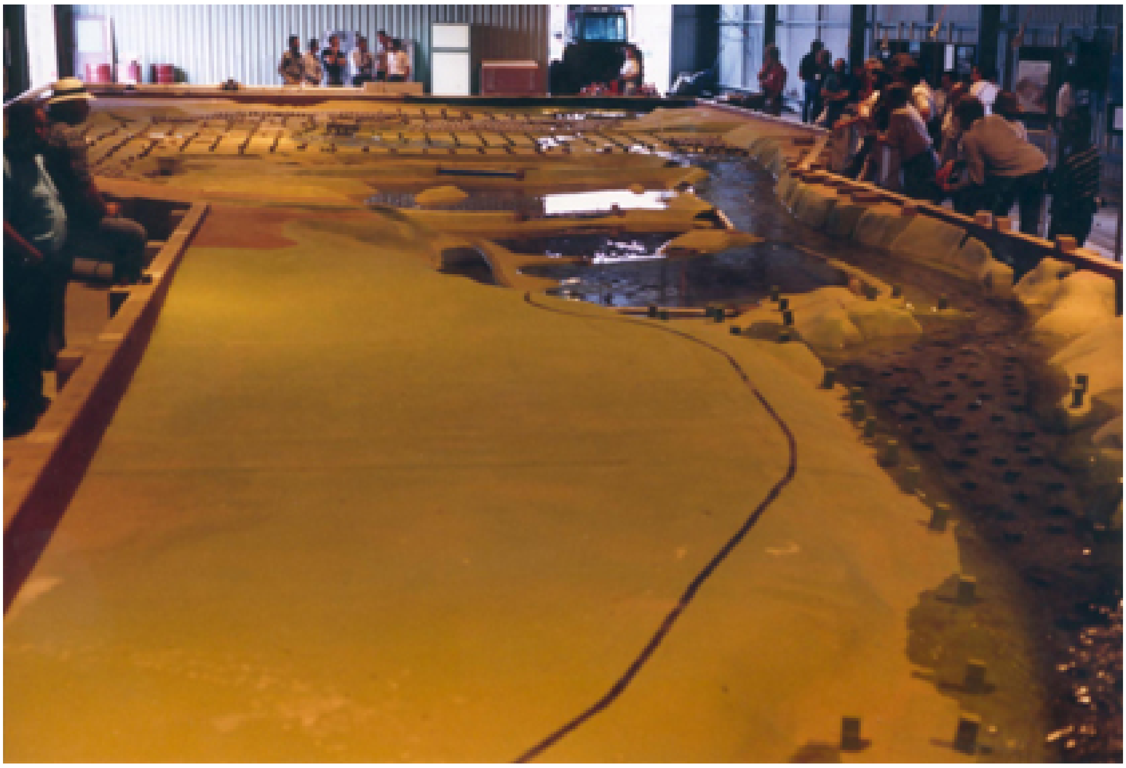
A wide range of options is available for mine decommissioning objectives. Whilst it is important that the decommissioned site is compatible with the surrounding environment and land uses, there are many innovative outcomes that can be achieved. There are examples around Australia and internationally where rehabilitated mine sites have become wetlands, water storage dams, tourist sites, golf courses, fish farms, water ski and windsurfing parks, motor sport complexes, rowing courses and even amphitheatres. In fact the site for the 2000 Olympic rowing events were rehabilitated gravel pits near Penrith, NSW as illustrated by this series of photographs.

Generating post-mining land use options firstly needs to consider factors such as climate, topography, soils and adjoining land use. Consultation on the specific issues of post-mining land use with neighbours, local authorities, special interest groups is also a fundamental part of the process. Each site should be assessed as to its post decommissioning use. Sustainability is an important factor and the ongoing use should continue to be beneficial to the local community and the environment, and does not become a liability.

In some cases options for ongoing land use will be limited due to economic, legal and technical constraints. For example, where deep voids remain with a surrounding zone of instability, it would not be appropriate to consider options that would attract people into the area. The first priority must always be to protect the environment and public health and safety by using safe and responsible closure practices.

Engaging stakeholders in deciding decommissioning options assists in focussing on long term economic and social sustainability of communities associated with the mine.

Penrith Gravel Pit Rehabilitation in Progress (October 1990)



Physical Scale Surface Water Model for Penrith Lakes Development (October 1990)

Previously Rehabilitated Penrith Gravel Pits (October 1990)

6. THE DECOMMISSIONING PROCESS

6.1 AN OVERVIEW OF THE SYSTEMS APPROACH TO MINE CLOSURE

Recent approaches to closure planning involve the sequential development of a series of different "Closure Plans" for mine planning, operational and decommissioning phases of a project. Such an approach is advocated by the Strategic Framework (2000), various regulatory authorities globally and many financial institutions. However, this approach has also led to some operations relying on Conceptual Plans that were initially developed to achieve financial and regulatory approvals, rather than a "live on the ground" applicable Closure/Decommissioning Plan.

Once a project is underway the operational management, with the pressure of the day-to-day matters, can be lured into a false sense of security in relation to the closure issue. That is, "we have a mine decommissioning plan, it was developed in order to gain regulatory and financial approval". As a consequence the operational management may fail to develop and implement an updated decommissioning plan.

This is a completely understandable scenario, as mining is a mercurial and taxing process where change is constant, management is commonly under pressure, and issues of production tend to take precedence. The word "closure" also has negative connotations with the some miners and stakeholders, and may therefore be ignored until late in the resource life.

As the operation develops and matures it may be vastly different from that described in the project-planning phase, and as a result the conceptual closure plan can be largely irrelevant to the actual operating project. For example, it is quite common for mining reserves to increase significantly from start-up reserves and/or production rates to be increased. Such circumstances have significant implications for mine decommissioning planning as either the overall area of disturbance may be increased or the disturbance is occurring a more rapid rate.

This can ultimately lead to a situation where the operation reaches the point of closure with no effective plan in place. The operation is then vulnerable as the following points may be overlooked in whatever closure work is undertaken:

- statutory conditions and commitments relating to closure;
- technical challenges that have developed during operations, that may effect closure;
- cost liabilities and other implications for the parent company, cash reserves, shareholders, financing and the bottom line;
- closure promises made to stakeholders that may not be able to be kept;
- a vision of how the closed site will look, and
- cost saving opportunities associated with the planned and final placement of waste materials.

This scenario can be avoided by ensuring that a mining operation approaches mine decommissioning and closure on a **systematic basis** from the very beginning of the operation. As with Environmental Management Systems, mine closure planning must be a dynamic process including regular review and updating.

ROM Pad and Rill Tower, before rehabilitation (left) and after rehabilitation (right).
Photo courtesy Outback Ecology

The systems approach is most effective when it is driven from the top of the organisation with the close involvement of all levels of management. The Company Directors have the ultimate responsibility to ensure that the commitment for mine decommissioning is honoured. The Chief Executive Officer in turn should compel the Mine Manager to initiate, endorse and provision the development of a Mine Closure System. All relevant managerial staff should be involved in the development of the system and progressively carrying out the defined tasks. Early demarcation ensures boundaries for areas of the operation are clearly determined and responsibilities are apparent to managers.

Effective implementation of a Mine Closure System requires:

- support from the company board or mine owners;
- commitment from the operation management, particularly the senior manager;
- an accepted closure systems framework;
- involvement of stakeholders;
- adequate resources (financial and human) to implement;
- managers and champions in charge of the system at the site level;
- regular system audit and actioning of outstanding items;
- regular reporting to the board from mine managers;
- ongoing commitment to funding for closure options research;
- acceptance by the regulators; and
- monitoring to ensure long term viability.

In today's educated world shareholders and owners of the operation also need to know that a closure system or plan is in place, and know that this plan is being appropriately resourced and implemented. As a result of the systematic closure process the company will find that all liabilities, complexities and unknowns are out in the open, and can be accounted for during the mine life. Having the human and financial resources directed to the "close as you go principal" while the operation is active assists this. The Directors of mining companies are expected, as a normal part of their fiduciary duties, to report on the environmental management system as being in place and working on an annual basis. It can be easily demonstrated through having a Closure System or Progressive Rehabilitation System in place at the operations that shareholders are protected from these often unseen and unaccounted liabilities as a result of unplanned closure.

The company can assure that adequate provisions for closure are retained through regular and systematic reviews. This can be done by auditing the actual progress of rehabilitation works and/or areas disturbed against the current plan on a periodical basis and revising the System, including costs estimates, accordingly. This will also lead to a better understanding of whether or not the value of performance sureties or bonds are a true representation of the cost of closure. Strategies can then be developed for minimising capital locked-up through sureties by progressive recovery as work is completed. For example, the principle focus of closure works could be focused on an operation's satellite mines, resulting in active early closure work and reduced liabilities.

If a systematic closure plan is in place and a Sudden or Temporary Closure (ANZMEC 2000) occurs, the operation will be well placed to respond without panic. The systematic closure work conducted to that point would have brought the operation forward on a yearly basis toward the inevitable day when its finite resources have been exhausted.

Case Study 3 provides an example of applying a systems approach to mine decommissioning at an advanced stage of operations at the Granny Smith gold mine in Western Australia.

Case Study 4 looks at the management functions necessary to close a series of open cut and underground nickel mines owned by Outokumpu Mining Australia.

6.2 IMPLEMENTING AND DEVELOPING CLOSURE PLANS FOR SUDDEN UNPLANNED OR TEMPORARY CLOSURE

Unfortunately, sudden unplanned or temporary closures still occur in the mining industry. These events are often due to changing economic, technical and political circumstances and are most often unforeseen. This can result in many closures being poorly managed, with considerable environmental consequences and legacies worldwide.

Temporary closures often occur while projects are re-evaluated, awaiting changes in market conditions or offered for sale. In such circumstances, it is important to ensure that all aspects of the operations are stabilised and will not result in pollution or a public health and safety hazard. There must also be contingency plans and adequate resources available to implement these plans in the event that mining does not resume and closure becomes permanent.

Unplanned closures are not cost effective and often result in sub-standard rehabilitation outcomes, as works are remedial rather than integrated with mine planning. Substandard, unmanaged mine closures continue to damage the mining industry's reputation. The decommissioned mine determines what we leave behind as a legacy for future generations. If decommissioning and closure is not undertaken in a planned and effective manner, the mine may be hazardous and a potential source of pollution for many years to come.

On the other hand, a properly decommissioned project, a site that remains safe and stable, is less likely to attract negative comment and to become a social legacy.

In order to protect the public's interests and minimise ongoing liabilities, most governments now require bonds to be lodged for mining operations. While the industry is not always comfortable with the level of bonds applied, there is a general acceptance that they are here to stay as long as there continues to be unacceptable closures.

Government agencies have been required to undertake mine decommissioning in circumstances where companies have not met their obligations and either forfeited bonds or walked away unsecured.

Case Study 7 on the Agricola gold mine in Queensland provides an example of an abandoned minesite requiring decommissioning by government agency.

7. PASSIVE CARE STAGE

At the end of the active decommissioning stage when infrastructure is removed, earthworks are completed and ecosystems are becoming established, decommissioning moves to a passive care stage for a period of time until it is demonstrated that completion criteria are achieved. This is usually the responsibility of the mining company and involves ongoing monitoring and remedial maintenance.

7.1 POST-DECOMMISSIONING MONITORING

The post-decommissioning monitoring programme should be similar to monitoring undertaken during the progressive rehabilitation but "scaled back" to focus on those aspects of the site that either relate to a potential ongoing pollution hazard or provide an indicator for how well the rehabilitation is progressing. An indicative post-decommissioning sampling and monitoring programme is provided in Table 7.1 below.

Table 7.1 Indicative Post-Decommissioning Monitoring Programme

Area	Parameter	Sampling / Monitoring Approach*
Waste Rock Landforms	• Erosion • Vegetation Establishment • Biotic Activity • Dust • ARD	• Visual, photographic, sediment loading in runoff, EFA* • Transects, density, cover, diversity, EFA, photographic, regeneration • Ants, pollinators, vertebrate fauna return, EFA • Deposition dust gauges, high volume samplers Runoff/seepage water quality, lysimeters
Tailings Storage Facility	• Seepage • Erosion • Vegetation Establishment • Dust	• Monitoring bores • Visual, photographic, sediment loading in runoff, EFA • Transects, density, cover, diversity, EFA, photographic, regeneration • Deposition dust gauges, high volume samplers
Process Plant Site	• Vegetation Establishment • Dust	• Transects, density, cover, diversity, EFA, photographic, regeneration • Deposition dust gauges, high Volume Samplers
Roads / Hardstand / Infrastructure Areas	• Vegetation Establishment • Dust	• Transects, density, cover, diversity, EFA, photographic, regeneration • Deposition dust gauges, high volume samplers
Underground Workings	• Subsidence • Shaft/vent bore capping	• Visual, photographic, periodic survey
Open Pit	• Pit wall stability • Abandonment bund • Pit water quality	• Visual, photographic, periodic survey • Visual, photographic • pH, TDS, metals etc
Adjacent and Downstream Areas	• Dust • Surface water quality	• Deposition dust gauges, high volume samplers • pH, TDS, metals, nutrients etc

* Monitoring techniques include – EFA (Ecological Function Analysis) and TDS (Total Dissolved Solids)

Case Study 8 looks at the closure of the Paddy's Flat open cut gold mine in Western Australia using Ecosystem Function Analysis (EFA) to show ecosystem development and demonstrate closure.

7.2 RELINQUISHMENT

Relinquishment should occur at the point, or points, in time when the company has achieved agreed outcomes for mine decommissioning. It is therefore very important that completion criteria are clearly defined.

The site should not endanger public health and safety, should alleviate or eliminate environmental damage, and allow a productive use of the land similar to its original use or an acceptable alternative. A site requiring active maintenance is unlikely to be acceptable to government agencies. Release of securities and bonds may be progressive, and reflect the progress of rehabilitation (ANZMEC/MCA 2000).

It is important that a responsible authority is identified and held accountable to make the final decision on accepting closure. The responsible authority will make a judgement on the achievement of the agreed completion criteria after consultation with other involved regulatory agencies, including the future landowner or manager (ANZMEC/MCA 2000).

8. CONCLUSIONS

Planned mine decommissioning is still at an early stage of development in Australia. While there are many good examples of progressive rehabilitation and final closure of older mine sites, there are few examples of mine closure planning being applied from conception through to the end of the mine life. This is largely due to the timeframe of most mining operations and the relatively recent development of integrated mine closure planning.

Best Practice Mine Decommissioning is a whole of mine life process involving:

- Stakeholder Engagement;
- Planning;
- Financial Provision;
- Implementation;
- Standards and Completion Criteria; and
- Mining Title Relinquishment.

All of these elements must be fully integrated with day-to-day operations management and assigned a high priority by all levels of management. Stakeholder engagement has emerged as a fundamental element in many of the projects reviewed. The key to developing appropriate outcomes that are ultimately acceptable to the community and the regulators is to build open and honest relationships over the life of the operation.

Plans and associated financial provisions must be updated on a regular basis taking into account changes in the project, results of monitoring, new approaches to decommissioning and a wide range of other factors that may change over the life of an operation. It is therefore important that standards and completion criteria are finely balanced between flexibility to allow changes in circumstances whilst being specific enough to provide certainty through measurable outcomes. They must also be developed based on a site-specific basis and realistic to what can be achieved.

At the end of the day, when the company has met its obligations and closed the operation in a way that represents "Best Practice Mine Decommissioning", there must be the reward of being able to walk away with little or no liabilities remaining.

REFERENCES AND FURTHER READING

- Allan, R., 2000, *A Systematic Approach to Closure of Five Sites*, Proceedings "Planning for Mine Closure – An Operator's Guide", Australian Centre for Geomechanics Seminar No. 2009, Perth.
- ANZMEC / MCA. 2000, *Strategic Framework for Mine Closure*, ISR 2000/155, ISBN 0 642 72138 6, Australia.
- BHP Titanium Minerals Pty Ltd, 1999, *Rehabilitation Plan – Beenup Mine Closure*, BHP, WA.
- BHP Minerals, 2000, *Annual Environmental Report – 1 July 1999 – 30 June 2000*, BHP, WA.
- Boisvert, M., and McKinney, J., 2000, *Forrestania Nickel Mines Closure*, Proceedings "Planning for Mine Closure – An Operator's Guide", Australian Centre for Geomechanics Seminar No. 2009, Perth.
- Chamber of Minerals and Energy of Western Australia, 1999, *Mine Closure Guideline for Minerals Operations in Western Australia*, ISBN 1875449973, Perth,).
- CSIRO, 1998,*Applied Resource Ecology – Ecological Indicators of Minesite Rehabilitation Success*.
- Ellis, C., 2001, *A Partnership in Transition – A Strategy for Mine Closure at Pasminco Broken Hill Mine*, In 'Proceedings of 26th Annual Mineral Council of Australia Environmental Workshop', Canberra, ACT.
- Environment Australia, 1998, *Best Practice Environmental Management in Mining – Landform Design for Rehabilitation*, Commonwealth of Australia, ISBN 0 642 54546 4 of series 0 642 19418 1.
- Environment Australia, 1998, *Best Practice Environmental Management in Mining – Rehabilitation and Revegetation*, Commonwealth of Australia, ISBN 0 642 546203 of series 0 642 19418 1.
- Environment Australia, 1995, *Best Practice Environmental Management in Mining – Community Consultation and Involvement*, Commonwealth of Australia, ISBN 0 642 194211 of series 0 642 19418 1.
- Environment Australia, 1998, *Best Practice Environmental Management in Mining – Environmental Risk Management*, Commonwealth of Australia, ISBN 0 642 54546 4 of the series 0 642 19418 1.
- Hamblin, A., 1998, *Environmental Indicators for National State of Environment Reporting – The Land. Australia: State of the Environment*. Environmental Indicator Reports, Department of the Environment. Canberra.
- Hick, P. & Ong, C., 1999, *The role of remote sensing for measuring mining impact on the Australian arid environment and the link to ecological function*. In "Proceedings of the Second AMEEF Innovation Conference 'On the Threshold: Research into Practice'". Fremantle, WA. pp.116-124.
- Lacy, H., 1997, *Environmental Management Of Goldmining Operations In Proximity To A Townsite In The Arid Rangelands Of Western Australia. Dominion Gold Operations, Meekatharra*. 1989-1996. In 'Proceedings of 26th Annual Mineral Council of Australia Environmental Workshop', Canberra, ACT.
- Lacy, H., 2000, *Planning the Process of Closure "Close As You Go"*, Proceedings "Planning for Mine Closure – An Operator's Guide", Australian Centre for Geomechanics Seminar No. 2009, Perth.

- Lacy, H., Lee, K. & Payne,C., 2001, *Applications of Ecosystem Function Analysis (EFA): Proving Ecosystem Function*. Proceedings "Indicators of Ecosystem Rehabilitation Success" Workshop – Centre for Land Rehabilitation. UWA. Perth
- Minerals Council of Australia, 1997, *Proceedings of 26th Annual Environmental Workshop*, Canberra, ACT.
- Morrey, D.R., 1999, *Principles of Economic Mine Closure, Reclamation and Cost Management, M.H. Wong et al.* (eds). Lewis, New York
- Mudder, T. & Harvey K., 1998, *Closure Concepts*, Mining Environmental Management, November 1998.
- Northern Territory Department of Mines and Energy, 1997, *Mine Close Out Criteria: Life of Mine Planning Objectives.*
- Payne C., Boisvert, M., & Lacy, H., 2000 *Ecosystem Function Analysis of Rehabilitation on the Waste Landforms at the Meekatharra Gold Operations.* Internal Report Homestake Gold of Australia. Outback Ecology Services, South Perth WA.
- Placer, 2000, *Granny Smith Mine Sustainability Report 2000*, Placer Dome Asia Pacific, placerdome.com.
- Price, G., 2000, *BHP Beenup Closure – Case Study 4*, Proceedings "Planning for Mine Closure – An Operator's Guide", Australian Centre for Geomechanics Seminar No. 2009, Perth.
- Queensland Mining Council, 2001, *Guidelines for Mine Closure Planning in Queensland*, ISBN 0 9578701 0 8.
- Savory, R., 1999, *Turning a Negative into a Positive – Rehabilitation of the Abandoned Agricola Gold Mine, Kenilworth, Queensland*, In 'Proceedings, 24th Annual Mineral Council of Australia Environmental Workshop', Canberra, ACT.
- Tatzenko, S., 2000, *Strategic Framework for Mine Closure*, In 'Proceedings, 25th Annual Mineral Council of Australia Environmental Workshop', Canberra, ACT.
- Tongway, D., Hindley, N., Ludwig, J., Kearns, A. & Barnett, G. (1997). *Early indicators of ecosystem rehabilitation on selected minesites.* In 'Proceedings, 22nd Annual Minerals Council of Australia Environmental Workshop', Canberra, ACT, pp. 494-505.
- Tongway, D., 1999, *Assessing Rehabilitation Success – A Training Course to Understand, Assess and Monitor the Success of Mine Rehabilitation Using Ecosystem Function Analysis Indicators.* CSIRO, Canberra.
- Watson, J., 2001, *Mine Closure Planning at Pasminco Broken Hill Mine*, In 'Proceedings of 26th Annual Mineral Council of Australia Environmental Workshop', Canberra, ACT.
- WMI (Whitehorse Mining Initiative), 1994, *Environment Issues Group*, Final Report, October 1994. (as referenced in ANZMEC/MCA 2000).

WEBSITES AND FURTHER READING ON GENERAL MINING & ENVIRONMENTAL ISSUES, POLICIES, PROGRAMS & TECHNIQUES

Best Practice Environmental Management in Mining – booklets, training kits, environmental management tools and resources – http://www.ea.gov.au/industry/sustainable/mining/

Environment Australia – http://www.erin.gov.au/

Australian Greenhouse Office (AGO) – http://www.greenhouse.gov.au/

AGO Funding Programs – http://www.greenhouse.gov.au/ago/funding/index.html

Office of the Renewable Energy Regulator – http://www.orer.gov.au/

Minerals Council of Australia – www.minerals.org.au/

Australasian Institute of Mining and Metallurgy – www.ausimm.com.au/

Australian Mineral Foundation – http://www.amf.com.au/amf/

Australian Minerals and Energy Environment Foundation – www.ameef.com.au/

Australian Petroleum Production and Exploration Association – http://www.appea.com.au/

Australian Centre for Minesite Environmental Research – http://www.acmer.com.au/

CADDET (International Energy Efficiency Database) – http://caddet-ee.org/

Cooperative Research Centre for Mining Technology and Equipment – www.cmte.org.au/

Energy Efficiency Best Practice Website – http://www.isr.gov.au/resources/netenergy/domestic/bpp/index.html

Department of Industry, Tourism and Resources – http://www.industry.gov.au/

Sustainable Energy Development Agency – www.seda.nsw.gov.au

Sustainable Energy Industry Association – www.seia.com.au

Julius Kruttschnitt Mineral Research Centre – www.jkmrc.uq.edu.au

McIntosh Engineering Ltd (USA) – Rules of Thumb for the Mining Industry http://www.mcintoshengineering.com/Hard%20Rock%20Handbook/rulesofthumb.htm#view

Mining and Management Article – http://www.wspc.com.sg/profiles/anncat/anncat/jnlarticle/mrev9n2/S0950609800000184.pdf

Motor Solutions Online – http://www.industry.gov.au/motors/

General information on Australia's policies, strategies and actions on ESD – http://www.ea.gov.au/esd/index.html

Information on programs and initiatives by Australia's Federal Government for sustainability in industry – http://www.ea.gov.au/industry/index.html

Links to publications and Australian government web pages on ESD – http://www.ea.gov.au/esd/publications/index.html

Information on environmental management techniques has been published by government departments and industry associations. Some useful references are:

- Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland, 1995. Department of Minerals and Energy. Brisbane, Queensland. ISBN 0724252606;
- Guidelines for Mining in Arid Environments, 1996. Department of Minerals and Energy, Perth, Western Australia. ISBN 0730978028;
- Mine Rehabilitation – a Handbook for the Coal Mining Industry, 1995. New South Wales Minerals Council, Sydney NSW. ISBN 0949337625; and
- Environmental Management in the Australian Minerals and Energy Industries, Principles and Practices. Mulligan DR (editor) 1996. University of New South Wales Press/Australian Minerals and Environment Foundation. Sydney NSW. ISBN 0868403830.

International resources for BPEM are accessible through the internet pages of the United Nations Environment Programme (UNEP) – http://www.mineralresourcesforum.org/tutorial.htm

Major international initiatives to promote sustainability in mining are being pursued through:

- The Global Mining Initiative – http://www.globalmining.com/index.asp ; and
- The Mining, Minerals and Sustainable Development Project – http://www.iied.org/mmsd/

The Australian report prepared for the MMSD Project is available at – http://www.ameef.com.au/mmsd/pdfs/report/ozreport.pdf

WEBSITES ON AUSTRALIAN ENVIRONMENTAL AWARD SCHEMES

AMEEF Environmental Excellence Awards – http://www.ameef.com.au/awards/awd_abt.html

Banksia Awards – www.banksiafdn.com/awardabout.html

Northern Territory Government – http://www.dme.nt.gov.au/dmemain/awards/2001/Awards_categories.htm#environmgt

New South Wales Government – http://www.minerals.nsw.gov.au/minfacts/11.htm

Tasmanian Government – http://www.dpiwe.tas.gov.au/env/env_awards/awards2001.html

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[1]ANZMEC (now Ministerial Council on Mineral and Petroleum Resources (MCMPR) consists of the Commonwealth Minister for Industry, Science and Resources, State and Territory Ministers with responsibility for minerals and energy and the New Zealand Minister for Energy.

[2]MCA represents companies involved in mineral exploration, mining and processing. Its activities are funded entirely by its member companies which, between them, produce about 90 percent of Australia's mineral output. http://www.minerals.org.au/

[3]Definition of Sustainable Development from Brundtland Report as published in The World Commission on Environment and Development, Our Common Future, Oxford, New York, OUP, (1987)

[4]The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund, was enacted by Congress on December 11, 1980. This law created a tax on the chemical and petroleum industries and provided broad Federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. Over five years, $1.6 billion was collected and the tax went to a trust fund for cleaning up abandoned or uncontrolled hazardous waste sites.
http://www.epa.gov/superfund/index.htm

[5]National significance is defined in the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* as: World Heritage properties; Ramsar wetlands of international significance; nationally listed threatened species and ecological communities; listed migratory species; Commonwealth marine areas; and nuclear actions (including uranium mining).

CASE STUDY 1

BEENUP TITANIUM MINERALS MINE, WESTERN AUSTRALIA - BHP BILLITON - COMMUNITY CONSULTATION FOR PREMATURE MINE CLOSURE

The Beenup minesite is located in the South-West of Western Australia, approximately 17km north east of Augusta and 4km north east of the confluence of the Blackwood and Scott Rivers, on the Scott Coastal Plain. Land use within the Scott Coastal Plain area primarily consists of pasture production for beef and dairy, silviculture (blue-gum plantations) and some horticulture (vegetables).

Mining operations at Beenup commenced in January 1997 using an electrically powered dredge to feed ore to a floating wet plant using gravity concentration to separate heavy minerals from sand and clay. The heavy mineral concentrate was transferred to the dry mill at Beenup where ilmenite and zircon product was separated from the concentrate. Final product was trucked to Bunbury Port for export.

Difficulties were encountered during mining with the high clay content of the orebody. Predicted settling and consolidation rates of the fine clays returned to the dredge pond were not achieved. There was also a significant pyrite burden associated with the orebody. Extensive studies of the technical problems associated with the consolidation of the clay fines were unable to identify an economically viable alternative to rectify this problem and allow mining plant to reach satisfactory levels of production. Closure was subsequently announced on the 26th February 1999.

At the time of closure, a total area of 335 hectares of land had been disturbed. The majority of this being associated with the dredge pond and above ground storage facilities.

Following the closure announcement, BHP Billiton commenced preparation of a detailed minesite Rehabilitation Plan for consideration by the Western Australian Government.

One of the initial steps undertaken in the development of the Rehabilitation Plan was to develop an overall closure philosophy. BHP Billiton saw itself as a temporary resident (and obviously was) compared with the permanency of the local community and therefore, saw the community as critical to the project success. This placed significant importance on the community viewpoint. To this end, BHP Billiton set out to develop a flexible plan, which fostered continuous improvement. This enabled community input to the plan throughout the planning and implementation process.

The community consultation program for the rehabilitation project commenced when the closure was first announced in February 1999. The announcement was accompanied by briefings for the Augusta-Margaret River Shire Council, Beenup Consultative Group, employees, local media, Government departments and other stakeholders.

BHP Billiton was fortunate to have an active community consultative group in place at the time of the mine closure. Membership of the Beenup Consultative Group is comprised of Shire representatives, landowners, business and conservation group representatives.

The Beenup Consultative Group played a significant role in the selection of rehabilitation options. In addition, the group provided a communication channel for Government to obtain feedback on aspects of the plan.

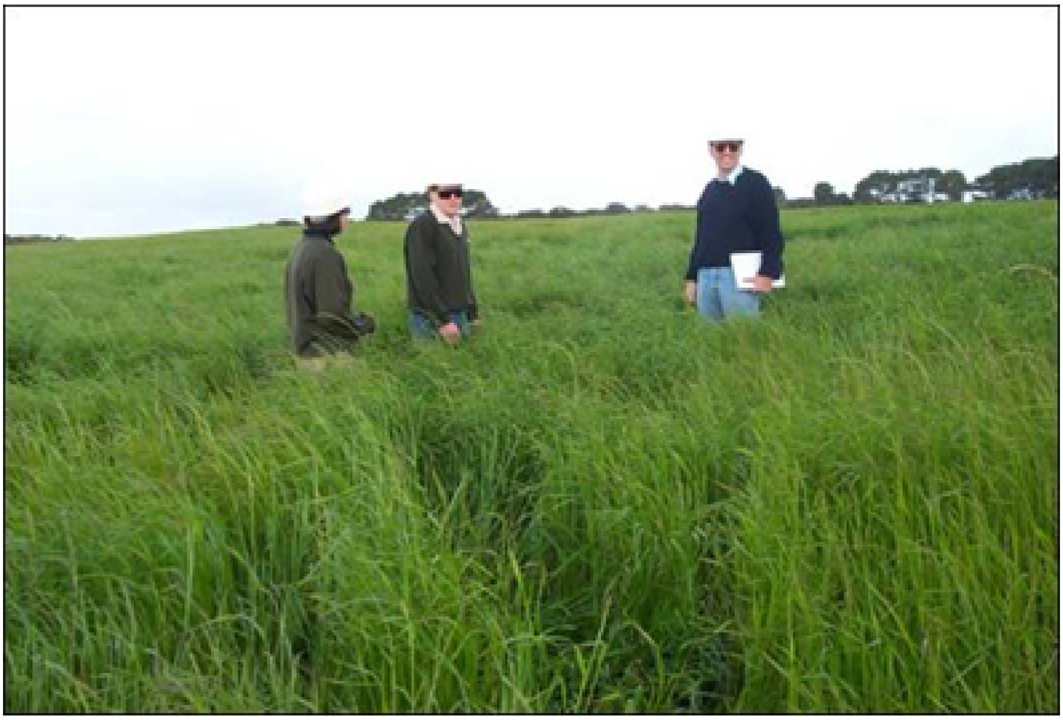
As the first step to developing the Rehabilitation Plan, BHP Billiton identified a number of concepts for the long-term future of the site. All concepts involved common elements, which included:

- decommissioning and removing plant and equipment;
- retaining all mined materials on site in the dredge pond and a rehabilitated storage area;
- ensuring effective pyrite management;
- re-contouring and revegetating the land;
- ongoing monitoring of soil and water conditions; and
- effective maintenance, where required.

These options were discussed with the Beenup Consultative Group leading to the preparation of a public discussion document. The document was widely circulated throughout the community including publication of some sections in the principal local newspapers.

As an outcome of this initial consultation, a preferred concept was selected which included backfilling the dredge pond area with mined material creating wetlands surrounded by native vegetation and pasture. Selection of this concept provided a direction for the development of the detailed Rehabilitation Plan.

To assist the community consideration of a preferred concept, BHP Billiton prepared visual impressions of preferred options.



Pasture Regrowth on Rehabilitated Bulk Sample Area
©Outback Ecology

The consultative process involved the community and Government department representatives to identify key issues to be addressed by the Rehabilitation Plan.

These issues included:

- Management and quality control of water to be released from the site;
- Permanent security and management of acid soils;
- Long term monitoring to identify any impact on ground or surface water;
- Effective long term rehabilitation of the Mine Development Storage Areas;
- Impact of rehabilitation on the area's hydrological regime;
- Plans for the rehabilitation of trial mine areas; and
- Landscaping and land use of the area.

Based on input from the early consultation process, BHP Billiton prepared a detailed Rehabilitation Plan for consideration by the Western Australian Government. The Plan, which included provision for ongoing monitoring following completion of rehabilitation, was approved by the Department of Environmental Protection in November 1999 following public review.

The formal public review process identified the need for an independent review of the rehabilitation design concept for the Mine Development Storage Area. The Department of Environmental Protection commissioned the Director of the Australian Centre for Geomechanics to complete this review and the findings were reported to a meeting of the Beenup Consultative Group.

Beenup Wetland Rehabilitation

Briefings, meetings and informal liaison with the Beenup Consultative Group, Government agencies and other stakeholders continued throughout the rehabilitation planning and implementation phases.

Formal meetings and site inspections were held with the Beenup Consultative Group to review the progress of the implementation of the mine rehabilitation activities, including earthworks, irrigation, the overall project schedule and progress of the development of the more specific Mine Development Storage Area Rehabilitation Plan.

It was not all clear sailing for the Group. On one such occasion individual views differed over sourcing lime-sand for the rehabilitation project. This led to dissatisfaction within some represented parties on the Group and in the local community. In cases such as this, the Company reviewed alternatives and endeavoured to identify the cause of individual concerns to enable measures to be employed to address the issue and alleviate concerns.

An independent community audit on the progress against the Rehabilitation Plan was also conducted based on a protocol developed by the Beenup Consultative Group. The audit and review concept facilitated continuous improvement and enabled the local community the opportunity to ensure the ongoing implementation of the Rehabilitation Plan remained aligned with community expectations.

Beenup Titanium Minerals Mine – Cessation of Mining

Beenup Titanium Minerals Mine – Visual Impression of Wetland Option

CASE STUDY 2

BROKEN HILL BASE METALS MINE, NEW SOUTH WALES - PASMINCO BROKEN HILL MINE - COMMUNITY TRANSITION STRATEGY FOR MINE CLOSURE

Broken Hill is located in the far west of New South Wales, 1170km west of Sydney. Mining and the city of Broken Hill have been synonymous for more than 118 years and many of Australia's leading resource companies will find their roots here.

In its glory days, fifteen companies stretched along the famous Line of Lode, which at its peak directly employed 6500 people. In the last thirty years, mining-based employment has tumbled from 43 percent of the Broken Hill workforce, to less than 10 percent. In 2001, the remaining Pasminco operations employed 450.

Pasminco Broken Hill – South Operations in Relation to Townsite

In 1996, Pasminco Broken Hill was aware that the end of the mine life was approaching, with an expectation that the mineable resource would soon be depleted to the extent that further mining would not be profitable or practical.

Acknowledging the company's role as the only remaining major mining operation, Pasminco worked in partnership with the local community to effect the final, and most difficult, stage of the transition process – to an economy which can survive in the inevitable absence of mining.

Development and implementation of the Pasminco Broken Hill Mine Transition Strategy was aimed at positioning the site ahead of legislation. The strategy is compatible with the ANZMEC/MCA '*Strategic Framework for Mine Closure*', but in many ways exceeds the framework in:

- the extended timeframe for strategy development and implementation;
- extended community participation in the decision making process;
- support of employee pathways in people management; and
- guiding asset disposal toward opportunities which allow post mining land use to create an asset or benefit for the community.

At the start of the Transition Strategy process in 1997, Pasminco was operating aged infrastructure spanning seven kilometres down the spine of the city. The local community often considered 'the mine' as the 4th tier of government and depended upon 'the company' for sponsorship of almost every aspect of community life – sport, recreation, education, health, and charities. At this time, any suggestion of eventual mine closure in 10-12 years met with wide-spread denial.

Benchmarking and research provided little assistance as there were no examples of how inter-twining issues of this degree and complexity had been dealt with previously, successfully or otherwise.

In March 1998, Pasminco convened a forum of community leaders to discuss the challenges ahead and to provide input to the development of a response strategy. The forum welcomed the initiative and asked Pasminco for three critical contributions to the development of an over-arching Transition Strategy, which would guide the period to mine closure. The community asked for:

- a timeline for planning – when was mine closure likely to occur?
- an assessment of the projected socio-economic impacts of eventual mine closure – where and how would the impacts be felt; and
- assistance to build a Community Foundation that could support non-mining employment initiatives.

Throughout the next twelve months, the company commissioned an independent analysis of projected mine life which concluded that the Broken Hill community could expect to lose its only remaining major mine operation in approximately 2005/06. With the concurrence of city leaders, these findings were released to the community in February 1999.

While predicting the loss of the city's leading commercial enterprise had significant implications for the community, the realisation of the inevitable mine closure also had impacts for the mine site in terms of change management, staff morale and an ensuing loss of professional expertise. However, the company had committed to open and forthright communications at the initial community forum and so prepared to minimise the impacts of closure (both on and off the site) in partnership with the community.

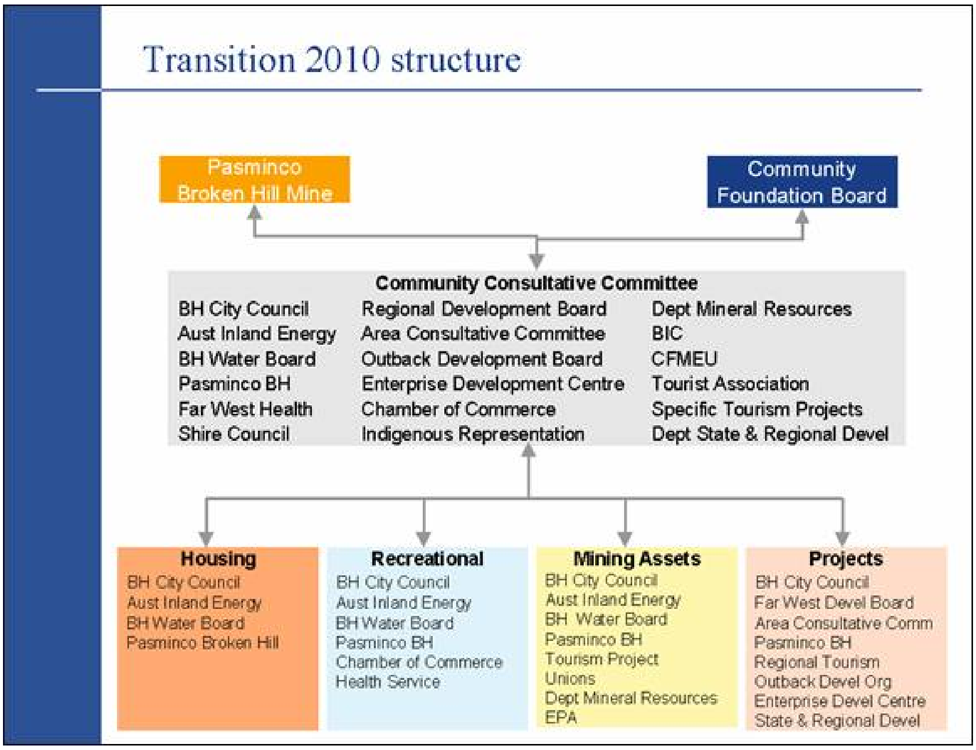
Pasminco commissioned an independent socio-economic analysis of the existing relationship between community and mine. The analysis revealed that Pasminco Broken Hill Mine annually contributed $60 million after tax to Broken Hill, equivalent to a quarter of the total income of the city and two thirds of the commercial economic base.

The study also considered a range of other Pasminco-owned assets, including heritage mining structures and mine equipment, along with significant community recreation facilities, sporting grounds, a pre-school and 1% of the local housing stock, much of it heritage-listed.

Chloride Street – Broken Hill

Impacts of mine closure were also identified in terms of a significant reduction in payments to utilities such as water and electricity, coupled with a projected significant loss in income for the Broken Hill City Council from rates and charges. In a 'do-nothing' situation, Broken Hill residents would be faced with either a significant loss in services or large fee increases to pay for them.

With assistance from Pasminco and all three tiers of government, members of the initial community leaders forum went on to form Transition 2010, an incorporated economic development organisation.



Structure of Community Consultative Committee – Transition 2010(Ellis 2001)

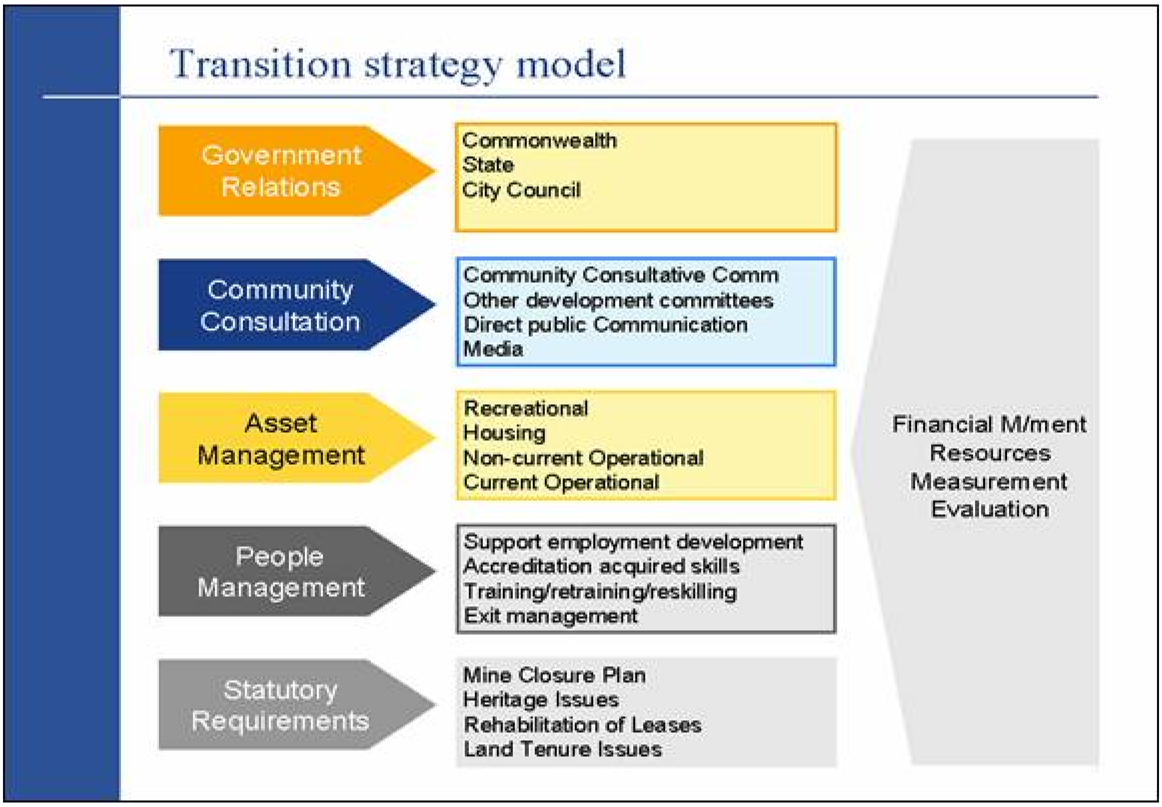
The broad based committee has a charter to attract new investors to the region, support existing business to survive mine closure and work with Pasminco in the role of community consultative committee. This has also provided a valuable consultation forum as the site moves to transfer non-core assets in a way that benefits, rather than burdens, the local community.

By late 2001, Transition 2010 assisted in attracting more than $3million in new business investment to the region, which has led to the creation of more than 30 sustainable jobs.

As a further response to the initial community forum, Pasminco Broken Hill Mine contributed $500,000 to kick-start a Broken Hill Community Foundation and committed an additional $125,000 to assist with start-up administration during the initial five year establishment phase. A marketing campaign is seeking to build on the company's initial contribution to support employment initiatives recommended by Transition 2010 and other social or educational development projects submitted by the community.

The NSW Government also provided $500,000 to Transition 2010 for employment generating projects and the Federal Government contributed $275,000 in administration and marketing support. Broken Hill City Council contributed to both Transition 2010 and the Community Foundation in terms of administration support and also contributed to specific projects.

The Pasminco Broken Hill Mine Transition Strategy comprises five distinct sub-strategies as illustrated by the following model.



Transition Strategy Structure (Ellis 2001)

While Pasminco was a key player in initiating a community response, the company has also been active in developing a broad strategy to guide its activities. The Transition Strategy was managed by a Project Team involving Public Affairs, Environment, Commercial Services, Engineering and Human Resources personnel to ensure the development and incremental implementation of the strategy occurs in an orderly, cost effective and timely manner.

Due to the complexity and dynamic nature of the strategy, coupled with substantive linkages between the various functions, clear accountabilities are critical to successful progress. Regular review of progress within and between the functions will facilitate the flexibility required as the strategy evolves.

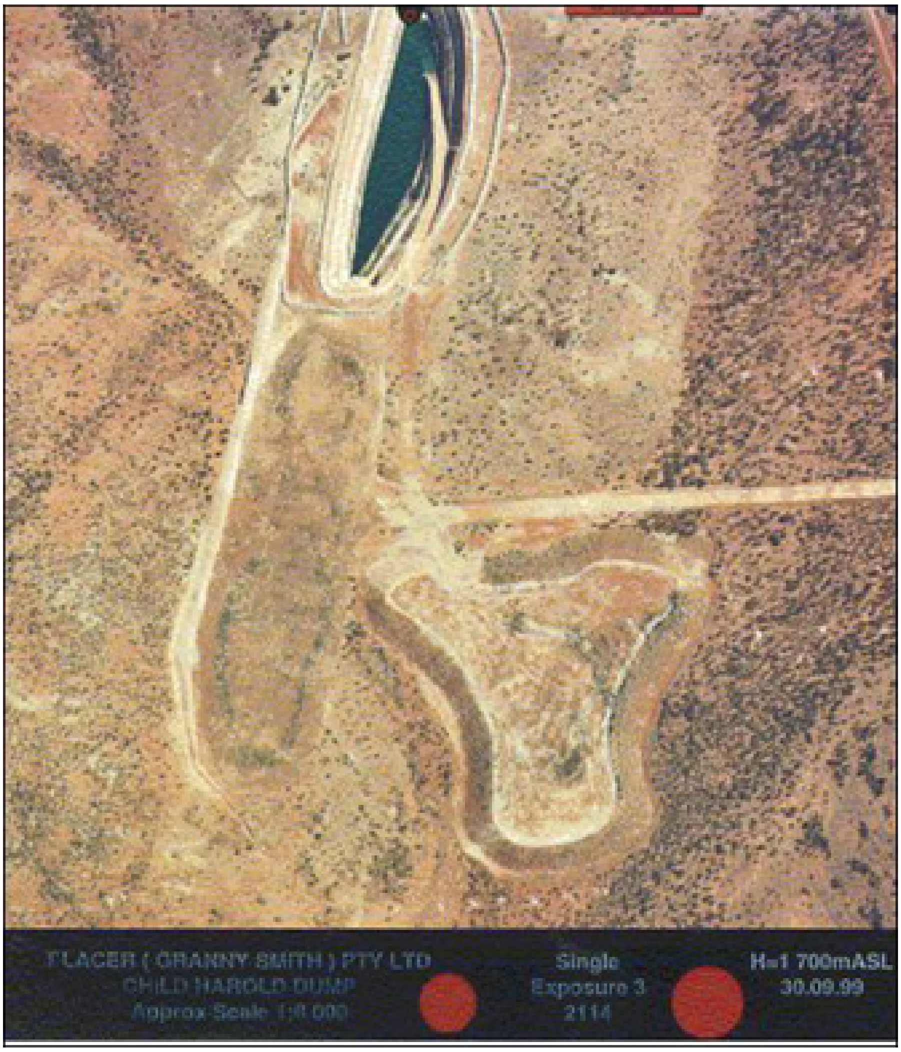
As the products of this government-community-industry partnership continue to emerge, Broken Hill will increasingly move toward its goal of a vibrant economic and social future.

CASE STUDY 3

GRANNY SMITH GOLD MINE, WESTERN AUSTRALIA - PLACER GRANNY SMITH - SYSTEMS APPROACH TO PROGRESSIVE MINE CLOSURE

The Granny Smith gold mine, located 23 kilometres south of Laverton, Western Australia, started production in February 1990. The Granny Smith mine is owned through a joint venture between Placer Dome Asia Pacific Ltd (60%) and AurionGold Limited (40%). Placer (Granny Smith) Pty Ltd is the manager and is a wholly owned subsidiary of Placer Dome Asia Pacific Ltd.

The Granny Smith operation was founded on three discontinuous deposits (Granny, Goanna and Windich). Five satellite deposits (Childe Harold, Phoenix, Keringal, Jubilee and Sunrise) have since been discovered and mined. The Keringal satellite deposit was mined as two open pits (Holland and Belgium). The Wallaby deposit is currently being developed with an expected 10-20 year mine life.



Backfilled Pit and Landform Blending into the Country

Granny Smith completed a comprehensive closure plan of processing plant, mining areas, all associated infrastructure and accommodation facilities in 2000. This plan, known as the Granny Smith Progressive Decommissioning System (GSPDS), adopts a systems approach aimed at facilitating progressive mine rehabilitation over the life of the operation and to return rehabilitated landforms to functioning ecosystems in the shortest possible time. The decommissioning system was developed using the broad objectives and principles outlined in the ANZMEC and MCA Strategic Framework for Mine Closure.

Rehabilitated Karingal Area
© Outback Ecology

The GSPDS is intended to provide the following:

- framework for ongoing planning and management of various project areas;
- reference tool to assist in the costing of both ongoing operations and conceptual development options;
- reference tool for day-to-day operations in rehabilitation planning;
- basis for documentation to meet statutory obligations re: decommissioning and closure; and
- system for recovering performance bonds as areas are progressively rehabilitated.

The first step in the process of developing the GSPDS was to establish a series of primary objectives to be achieved in planning for long term rehabilitation of the current and future minesites. These objectives are summarised as follows:

- the final post-mining landforms to be safe, stable, durable and non-polluting;
- landforms and disturbed areas are to be designed to integrate into the surrounding ecosystems on closure;

- the post-mining landforms must be compatible with and as resilient as possible to the impacts, uses and effects likely to occur within the local ecosystems;
- a policy of progressive rehabilitation will be maintained, and will ensure that only a small amount of rehabilitation will be outstanding across the project areas when mining is finished;
- the intent in planning, engineering, operating and closing the respective project areas to align with the objectives of with the joint venture partners' respective corporate Environmental and Sustainability policies;
- stakeholders' expectations will be taken into account in setting priorities for mine rehabilitation outcomes;
- the GSPDS is to have clear objectives and be integrated into the general mine planning and provisioning process; and
- the GSPDS will be actively implemented and regularly reviewed and updated.

The next step in the process of developing the GSPDS involved the compilation of a detailed compliance, commitment and conditions register as a baseline for determining minimum completion requirements and to allow for strategic variations of commitments and conditions to better reflect the situation on the ground.

Once the completion requirements were defined, a comprehensive site audit was undertaken to identify specific tasks to be undertaken to achieve the required outcomes.

The GSPDS consists of a series of individual modules for each of the individual project areas. The modules are set out as follows:

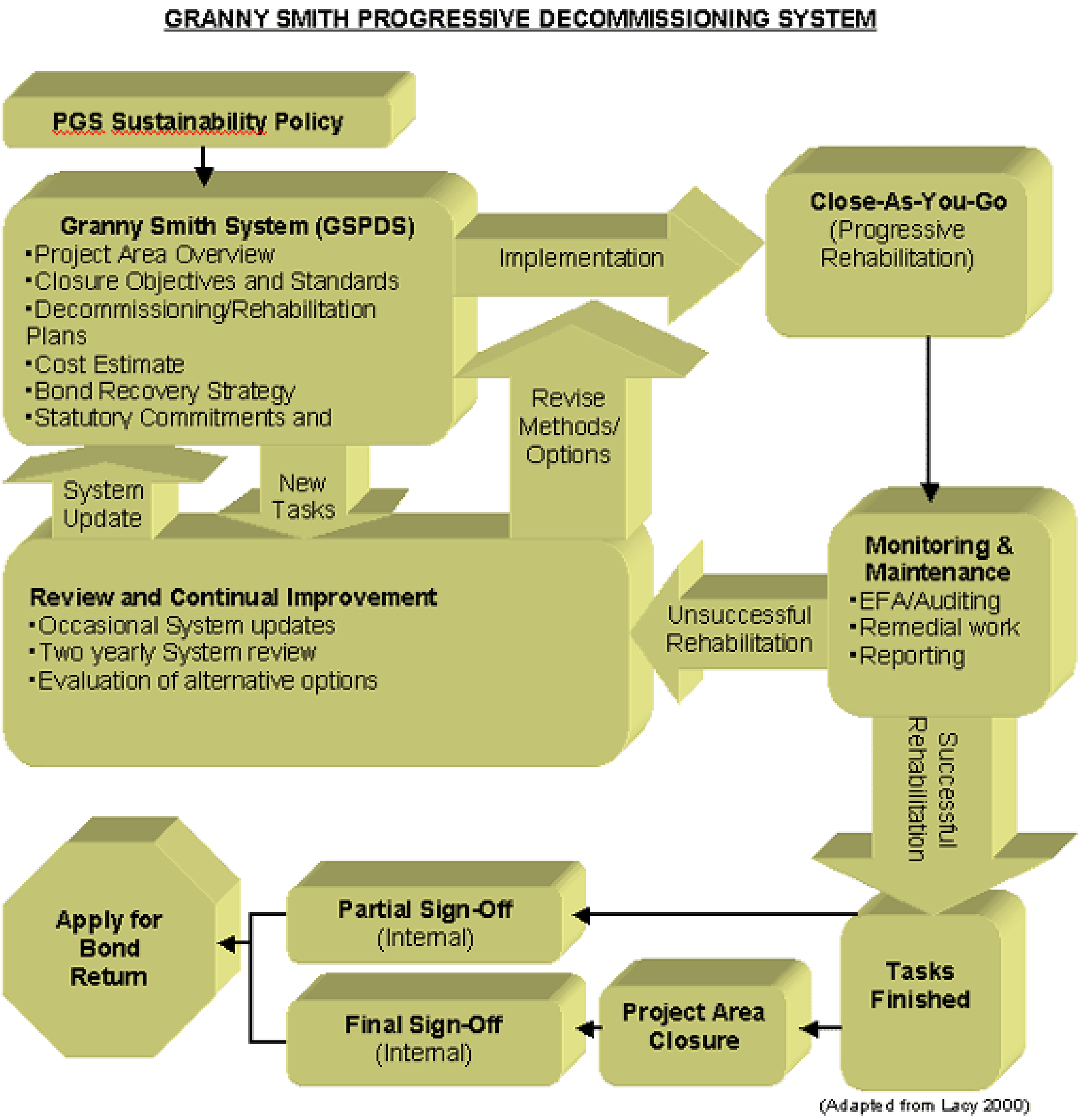
- Brief Overview of Project Area – description of recent and historical operational activities, location, infrastructure inventory and issues identified through stakeholder consultation;
- Rehabilitation Objectives and Standards – summary of relevant statutory commitments, standards and guidelines, applying to individual project areas;
- Decommissioning/Rehabilitation Plan – a series of rehabilitation and decommissioning task sheets are presented for each of the mine project areas – these task sheets provide an inventory of sites and identify specific tasks to be undertaken in order to meet rehabilitation criteria and aerial reference photographs for each project area are included to identify specific features that relate to individual tasks;
- Closure Cost Estimate – cost tables for individual project units based on known rehabilitation and earthwork costs including, unit rates for machinery, post-mining monitoring and contingencies for remediation;
- Bond Recovery Strategy – outlines approach for progressive recovery of performance bonds; and
- Statutory Commitments and Conditions – series of tables summarising relevant statutory conditions and commitments applied to Mining Act tenements covering each respective project area.

The GSPDS is a dynamic system and is designed to be updated on a regular basis to accommodate changes in the operations and completion of tasks identified in the system. Other factors taken into account when updating the GSPDS include; future developments, ongoing (post-mining) land use options; rehabilitation success as determined by monitoring, areas rehabilitated and signed-off; industry practice and available technology; and costs and benefits of a range of decommissioning/closure options.

The development and implementation of the GSPDS has produced the following benefits for the Granny Smith gold mine operations:

- a reduction in liabilities associated with mine closure;
- forming a basis for the progressive recovery of performance bonds;
- identifying areas of high risk as priorities for ongoing research and/or remediation;
- maximising rehabilitation undertaken during the productive phase of mining operations;
- facilitating the direct involvement of operations personnel in achieving mine rehabilitation outcomes; and
- facilitating the involvement of key stakeholders in setting priorities for mine rehabilitation.

The following flow diagram illustrates the systems approach featured in the GSPDS.



CASE STUDY 4 - FORESTANIA NICKEL OPERATIONS, WESTERN AUSTRALIA - OUTOKUMPU MINING AUSTRALIA - THE MINE CLOSURE MANAGEMENT TEAM

This brief case study looks at the management functions necessary to close a series of open cut and underground nickel mines owned by Outokumpu Mining Australia (OMA). The Forrestania operations are located in the Yilgarn Mineral Field of Western Australia. (Boisvert and McKinney, 2000).

Planning for closure commenced at the beginning of 1998, when it became apparent that the resource was becoming unviable. Consultants were commissioned to assist closure planning and identify important issues that needed research. Early site visits from the consultant assisted OMA in outlining the major closure issues that needed to be addressed in order for closure to be sustainable.

Exploration hole capping and rehabilitation also commenced during this period. Monthly closure planning meetings were initiated and attended by senior representatives of all departments of the operation. Formal minutes were kept of these meetings. Early in the process closure objectives were formulated, issues discussed and tasks delegated. Decisions made during the closure meeting process were relayed to Outokumpu Head Office in Finland, to ensure closure decisions were congruent with company policy and best practice. This process advanced to the stage of fortnightly and then weekly meetings. During this planning stage, updates in relation to the principal environmental issues were sent to regulatory agencies.

During the initial planning meetings a Closure Team was selected from existing mine employees who were to be responsible for completing the decommissioning and rehabilitation work. This consisted of Resident Manager, Mill Superintendent, Underground Managers, Mine Foremen, Maintenance Foremen, Administration Manager, Environmental Staff and the Environmental Consultant. People were selected based on specific skills required to manage the rehabilitation plan, operate machinery, run services, provide closure expertise and run the camp.

Aims and targets for the rehabilitation team were based on the Mine Site Tenement Specific Information Sheets, which focussed primarily on completion of individual tasks. More specific closure objectives were developed in the Decommissioning and Closure Report. This report was produced for submission initially to Outokumpu Head Office, and then on approval to the regulatory authorities.

The key to the successful closure was the early initiation of regular closure planning meetings with representatives from all mine departments. Intensifying the frequency and rate with which this group met, and moving the decision- making process into high gear as the last reserves of mineral were milled. By the time the mills had stopped producing nickel much of the closure works were underway, and over the following years 1999-2000 the appointed closure team concluded all work to a high standard.

Rehabilitated Forestania Nickel Minesite
© Outback Ecology

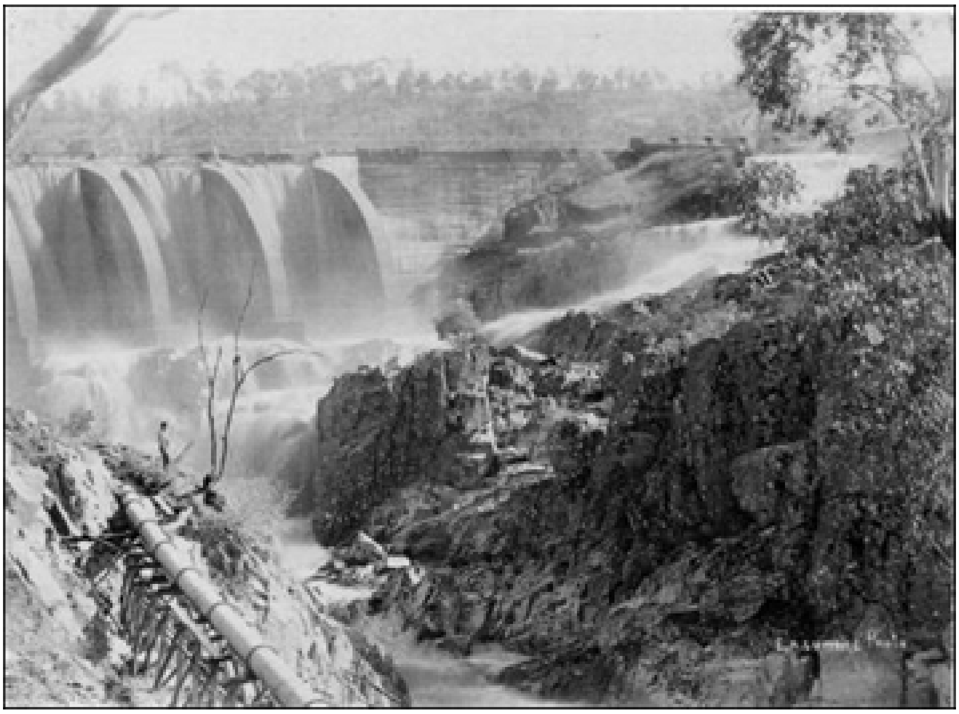
CASE STUDY 5 - JUNCTION REEFS GOLD PROJECT, NEW SOUTH WALES - CLIMAX MINING LIMITED - MINE CLOSURE THROUGH NEW PROJECT OVER HISTORICAL MINING AREA

The Junction Reefs Gold Project is located in the Central Tablelands of New South Wales (NSW), Australia, approximately 270km west of Sydney. The project is located on undulating cleared grazing land in a cereal cropping, vineyards and sheep and cattle grazing region. The project site is bisected by the Belubula River with spectacular steep sided rocky ravines. The Cadia Gold mine is 12km to the north and the now defunct Browns Creek underground gold mine 15km to the east.

Gold was discovered in the Belubula River 13km downstream of Junction Reefs in the early 1870s and was traced to the Junction Reefs area where hard rock mining soon commenced. From 1886, a number of companies mined the gold bearing ore by open cut, and room and pillar stoping methods in three ore-bodies now known as Sheahan-Grants, Frenchmans and Cornishmens. Mining virtually ceased in 1938 with only mining of the odd underground remnant and sporadic open pitting continuing until 1954. Between 1954 and 1978, there was then very little activity until Cyprus Minerals Australia Company commenced in 1978. Climax Mining Ltd became a JV partner in 1984 and managed the development.

The land containing the prospective deposits adjacent to the Belubula River was gazetted as Crown Land Reserved for Mining Purposes at the turn of last century. However, due to lack of exploration and development during the 1960's and early 1970's it was re-gazetted in 1978 as a Recreation Reserve managed by the Canobolas Region Parkland Trust (CRPT). This reserve was leased for grazing and used for public recreation (fishing, swimming, camping and bush walking) with an estimated 2,000-3,000 annual person visitation rate, mainly on weekends during summer and school holidays.

The site also contains many mining relics, recognised for many years as reflecting the changes in technology and treatment of gold bearing ores. One of the most imposing features is the Belubula Dam, an arched buttress dam constructed of concrete and bricks in 1897. Water was piped from the dam to drive pelton wheels which powered crushers and later an electric generator. The Heritage Council of NSW placed an Interim Conservation Order over the Belubula Dam and relics at the Frenchmans and Cornishmens site. This effectively prevented Climax applying for a Mining Lease over the Frenchmans and Cornishmens deposits at the time application was made for the Sheahan-Grants deposit, so development of the project was subject of a two stage permitting process.



Historical Belubula Dam

In mid-1985, Climax commenced a feasibility study and baseline monitoring for an open pit based on the Sheahan-Grants orebody which contained a reserve of 1.4 million tonnes. Fieldwork for the Environmental Impact Study (EIS) included archaeological, flora, fauna, noise, stream and tailings sediments, and water quality surveys.

The EIS was lodged with the Blayney Council in November 1986, who issued Development Consent, subject to 30 conditions, in February 1987. The Mining Lease was subsequently granted, subject to 148 conditions by the Minister for Mineral Resources, in May 1987 prior to mine construction. Pollution Control Approval, subject to 44 conditions, was granted by the State Pollution Control Commission in November 1987, six weeks before the mine was commissioned. The first gold was poured in January 1988.

The initial rehabilitation objectives for the mine site were to:

- Ensure progressive rehabilitation;
- Undertake a soil conservation management program on all disturbed areas where topsoil was to be removed and carefully stockpiled for later use. Climax proposed to work closely with the State Soil Conservation Service;
- Ensure resulting long-term stable, low maintenance landforms; and
- Leave as much land as possible suitable for grazing purposes; the then long-term objective of the CRPT.

Whilst these appeared to be realistic and viable objectives, the final outcome would be significantly different.

Initially proposed closure outcomes for Stage 1 are summarised in the following table.

Proposed Closure Outcomes

Area / Facility	Closure Outcome
Open pit	Partially backfilled in the upper and lower sections, the deeper section allowed to fill with water above river level, and with access to steep sections limited by fencing and bund walls.
Waste Dump	Topsoil cover placed on the berms and top surface for future grazing.
Tailings Dam	Allowed to dry, covered by 0.5m weathered waste rock then topsoiled, fertilised and sown with pasture.
Heritage Tailings Dam site adjacent to the Belubula River	Contoured for camping and picnicking.
Process Plant Area	Cleared of all buildings and plant, and ripped, fertilised and seeded for grazing.
Access Roads no longer required	Removed, ripped, fertilised and seeded.

A significant bond was imposed by the Department of Mineral Resources (DMR) to cover rehabilitation costs in the event that Climax failed to fulfil its obligations.

The first phase of the Junction Reefs Gold Project operated under a Mining, Rehabilitation and Environmental Management Plan (MREMP). The MREMP was a dynamic process allowing operational changes to mine production, employment and rehabilitation to be proposed, discussed, approved and implemented through the annual reporting process without recourse to the EIS process. An MREMP annual meeting was held to allow all parties to comment and make suggestions on Climax plans. The meeting was designed to be inclusive, involving all relevant State and Municipal Authorities as well as the CRPT.

Following commissioning of Stage 1, Climax commenced work on establishing ore reserves at the Frenchmans, Cornishmens and Glendale prospects and gathering background data for a further EIS for the Stage 2 development. In March 1988, a series of investigations was launched to overcome concerns about the heritage value of the relics associated with the Frenchmans and Cornishmens mines and the Belubula Dam. Based on the findings of these investigations, Climax was able to negotiate a significant reduction in the size of the Interim Conservation Order and the Permanent Conservation Order excluding the Frenchmans and Cornishmens orebodies.

In an effort to overcome continued objections to Stage 2 by the CRPT, Climax devised an open pit mining schedule involving backfilling of both Frenchmans and Cornishmens open pits and a low profile waste dump sympathetic with existing landforms. This planning resulted in:

- Significant reduction in waste rehandling that would otherwise have been required to satisfactorily rehabilitate the site; and
- Safer final landforms than would otherwise have been possible.

To further enhance the 2nd stage, Climax proposed to substantially backfill with tailings in the Sheahan-Grants open pit, reducing the public safety risks. A consultation program was undertaken prior to lodging the EIS with the Blayney Council for public review in September 1990. This program included:

- a Planning Focus seminar to present the proposal to nine State and one Municipal Government authorities in November 1989;

- a Public Forum involving approximately 100 residents from the surrounding district in August 1990; and
- a presentation to the Orange Environment Group (OEG).

Despite ongoing objections to the project the Blayney Council approved the mine in December 1990. The OEG then lodged an objection in the Land and Environment Court which had potential to delay commencement indefinitely. After a period of negotiations a Deed of Agreement was signed between Climax, the OEG and CRPT in March 1991, and contained the following conditions:

- Climax would construct a road to the alternative area of the Recreation Reserve and equip it with toilet and camping facilities;
- Refill the Frenchmans open pit to above river flood height; and
- Establish a Climax-CRPT working group and hold regular meetings to review management and rehabilitation aspects.

Climax would also provide funding for:

- Consultants to assist in development of a final land use plan for the Reserve;
- Specialist revegetation advice;
- A study on restoration of the Belubula Dam by an independent Conservation Engineer; and
- A special purpose trust to assist in ongoing rehabilitation maintenance and upkeep of the Reserve.

Backfilling Frenchmans Open Pit

Rehabilitated Frenchmans Open Pit

Climax reviewed potential land use alternatives as part of environmental assessment for 2nd stage of the project. The CRPT preference for licensed grazing on the Recreation Reserve was found not to be economically sustainable and would contribute to degradation throughout the Recreation Reserve.

To assess revegetation potential, Climax employed a consultant botanist to review the existing works, provide ongoing rehabilitation supervision and advice, resulting in further negotiations with the CRPT.

The rehabilitation objectives for the mine were amended to:

- Re-establishment of a eucalypt woodland with a native grassy understorey;
- Provide a suitable habitat for native wildlife (marsupials, birds and reptiles);
- The establishment of a local seed source which, in the future, could provide seed for local farmers and landcare groups;
- Provide a field study area for education; and
- Enhance the recreational amenity of the Reserve.

The last ore was mined in August 1995 and the process plant decommissioning in November 1995. All plant, equipment and buildings, other than the administration office (retained for rehabilitation purposes) were auctioned in early 1996 and the site cleared by mid 1996.

Process water contaminated with cyanide was returned to the main tailings dam after closure where it was gradually evaporated from the tailings dam surface.

The earthworks described in the EIS for were implemented as planned, although there were some minor and major exceptions, namely:

- Two designed berms were omitted from the partial backfilling of the Cornishmens open pit as they were determined to be unstable;
- Sheahan-Grants open pit was backfilled to higher level and the surrounding steep batters were generally removed resulting in a much safer and much more aesthetic landform;

- The in-pit and main tailings dams were not covered with a layer of oxidised waste. A layer of hard rock waste was placed on the tailings providing a capillary break preventing salts rising to the overlying oxidised waste and/or soil layers. So great was the need for hard rock waste, that the already rehabilitated main waste-dump had to be uncovered and re-mined! In a sense, this was a bonus as it allowed much flatter slopes to be formed and these were more in keeping with the surrounding topography; and
- The process water recovery dam downstream of the main tailings dam was converted into a wetland using local native species. The wetland vegetation was designed to assist in the attenuation of salinity and cyanide levels in ground water seepage from the rehabilitated tailings dam.

Placement of Main Tailings Dam Cover

Rehabilitated Main Tailings Dam

At the project site, highly oxidised waste (overburden) was preferentially used instead of topsoil as the oxidised waste has similar chemical and physical properties to the topsoil but without organic carbon and seeds of weedy species. Local native species were used almost exclusively on the mine as they are better adapted to the local conditions, especially climatic variations and low nutrient soils. The local native species require no long-term nutrient additions or irrigation. Local native shrub and tree seed was collected and native grass mulch harvested from the mine site, cemeteries, roadsides and farms within a 20km radius of the mine. Establishment of native grasses and direct seeding of other species were trialled and results applied on the mine rehabilitation areas. Direct seeding has been very successful with many species growing faster than nursery tube stock planting. The knowledge gained has also been very useful for local landholders in grazing management and reducing farm environmental problems such as dry land salinity and erosion.

During the project constant and comprehensive monitoring of the following environmental parameters was undertaken:

- Water from all streams analysed on a regular basis (monthly/quarterly);
- Water from boreholes around each tailings dam monitored on a quarterly basis;
- Dust and noise monitoring on a regular basis (quarterly/six monthly) until monitoring became unnecessary;
- Stream biota and sediment;
- Vegetation cover;
- Establishment rates of native grass, herb and shrub species; and
- Tree growth rates.

The location, timing of monitoring and parameters analysed were discussed at each annual MREMP meeting and adjusted by agreement. Water monitoring continued during the decommissioning and final earthworks. The need for regular water monitoring has diminished post decommissioning, but continues at seepage points and sites where any contamination of groundwater may occur. This monitoring will continue until all parties are satisfied.

With revegetation complete in many areas and well underway elsewhere, regular flora and fauna monitoring is undertaken to determine re-establishment rates and identify areas requiring further attention.

Climax personnel have become actively involved in the re-establishment of the natural riparian ecosystems of the Belubula River. Introduced willow trees, known for contributing to the degradation of waterways, have been removed and replaced by local native species. Climax has been awarded Gold and Silver Rivercare Awards by the NSW State Government. The heritage listed Belubula Dam has been restored and a large silt island abutting the wall removed, thus preventing public access to the steep wall.

The Junction Reefs Gold Mine successfully operated in a sensitive riverine environment in a popular recreation reserve. The style and quality of the mining, earthworks and revegetation throughout the mine life has accommodated changing public and Government expectations. Climax strived for better rehabilitation methods, actively supported and encouraged by the MREMP review process.

CASE STUDY 6 - MARILLANA CREEK IRON ORE MINE, WESTERN AUSTRALIA - BHP BILLITON - DECOMMISSIONING PLANNING FOR PROJECT APPROVAL

The Marillana Creek iron ore mine is located approximately 90km north west of the Newman township in the Pilbara region of Western Australia. The Marillana Creek mine is one of numerous BHP Billiton operations in the Pilbara supplying iron ore to export facilities at Port Hedland by railway.

Mining commenced at Marillana Creek in 1991 following an environmental impact assessment by the Western Australian Environmental Protection Authority (EPA) and the formulation of the *Iron Ore (Marillana Creek) Agreement Act, 1991*. This original approval was limited to the Eastern 2 pit at a mining rate to 5 million dry tonnes per annum (Mdtpa). Subsequent proposals to increase production and develop new pits have been submitted to and approved by the Western Australian Government in response to increasing demand for the Marillana Creek ore and the development of the Hot Briquetted Iron (HBI) Plant at Port Hedland. Production is currently from three pits with a limit on tonnage of 30 million tonnes per annum.

Marillana Creek Iron Ore Mine – Ore Handling Facilities

In 1995, BHP Billiton submitted a proposal to develop the Central 1&2 pit and to establish the infrastructure required to service the total resource on the lease over the projected 30 – 50 year mine life. Progressive development of future deposits was also covered by this proposal. The environmental aspects of the proposal were subject to further formal assessment by the EPA and approval was granted in February 1996. A condition of the approval required that a Decommissioning Plan be prepared for existing operations in a form that could be updated to cover the development of future deposits.

A Decommissioning Plan was subsequently prepared in support of a proposal to develop the Central 5 deposit in 1998. This plan covered the proposed new development and all existing mining operations and infrastructure including:

- Eastern 2, Central 1&2, Central 5 pits and associated overburden storage areas;
- two ore handling and rail load out facilities;
- haul roads associated with all pits;
- dewatering borefields and associated pipelines;
- rail spurs associated with the two ore handling plants;
- power generating equipment; and
- accommodation village.

While the Decommissioning Plan covers all environmental aspects of the mine development, the key long-term issues relate to potential impacts on the Marillana Creek aquifer system. The iron ore deposits form part of a continuous channel iron deposit (CID) which extends over 80km in length. The Marillana Creek lease covers approximately 27km of this with reserves both up and downstream of the current operations. The orebody infills Tertiary age palaeochannels of the ancient Marillana Creek. The CID is the predominant aquifer and approximately 60% of the orebody lies below the water table. As a result, extensive dewatering is necessary to lower the water table to recover the iron ore.

Marillana Creek Near Iron Ore Mine

Dewatering Discharge to Marillana Creek Downstream of Mining Operation

Dewatering will be discontinued at the cessation of operations and aquifer inflows will allow the water table to partially recover in the mined out pits. A number of alternatives have therefore been evaluated for decommissioning the mine pits. The main objectives of these evaluations were to:

- produce landforms that maintain long-term stability;
- minimise the regional effects of mining and removal of the aquifer;
- develop practical, long-term management plans for other issues inter-related to the closure process; and
- maximise operational and cost efficiencies.

A number of options for closure ranging across three basic scenarios were evaluated:

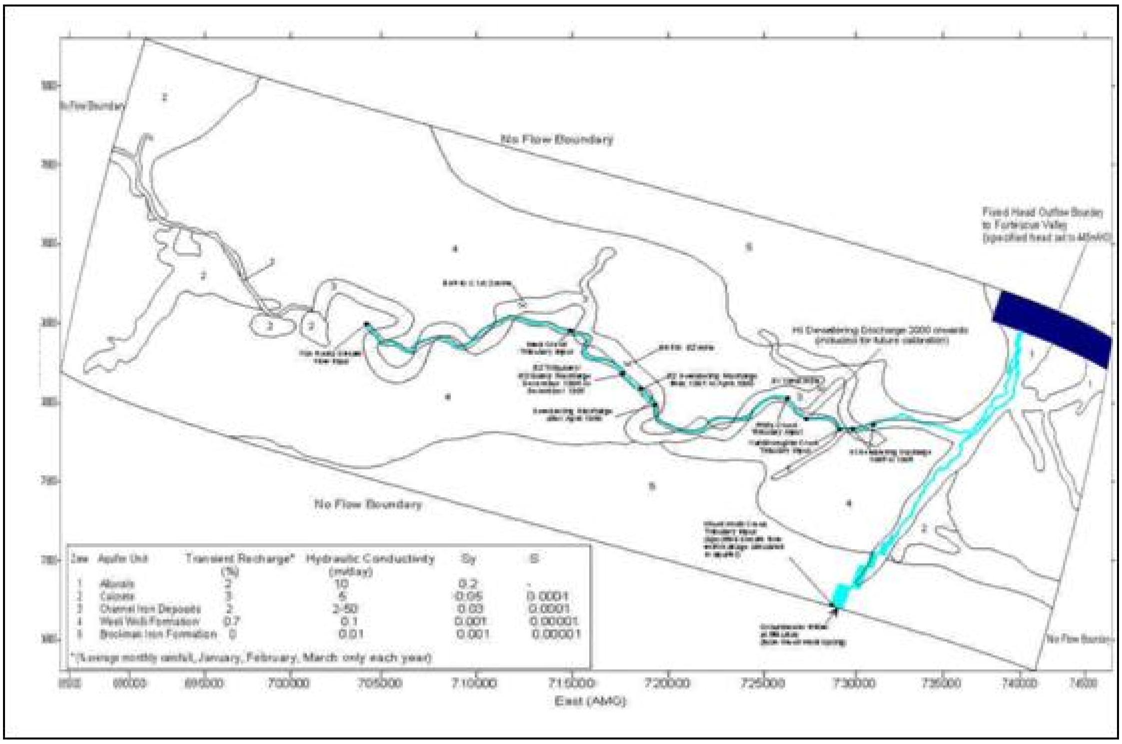
- complete infilling of the mine pits to the water table;
- no infilling of the mine pits; and
- partial infilling of the mine pits.

The option of complete infilling was not considered to be achievable as the overall overburden to ore ratio is less than 0.5:1. Consequently, there is also insufficient overburden material available to fill the pits to the pre-mining water table. In addition, the initial development of these pits required out-of-pit overburden storages which further reduces the material available for infilling. Double-handling of this material would have significant cost implications.

The second option of no infilling was ruled out as it would result in significantly increased land disturbance, increased environmental issues, require more out-of-pit overburden storage and result in less favourable economics.

The third option of partially infilling the pits was selected as it will result in less out-of-pit storage, greatly minimising land disturbance, and providing economic benefits through greater operational efficiency. With careful design and sequencing of future mining operations, with direct infilling, it may be feasible to decrease adverse environmental effect as more pits are developed.

A comprehensive groundwater model incorporating state of the art surface – groundwater interaction features has been developed to simulate the hydrogeological impact of decommissioned pits. The model has been used for planning dewatering as well as evaluating closure options and will continue to be used to assess the impacts associated with future pit development. The model will also be used to evaluate alternative options for the placement of infill to minimise environmental impacts.



Marillana Creek Model Features

CASE STUDY 7 - AGRICOLA GOLD MINE, KENILWORTH, QUEENSLAND - QUEENSLAND DEPARTMENT OF MINES AND ENERGY - ABANDONED MINESITE REQUIRING DECOMMISSIONING BY GOVERNMENT AGENCY

The Agricola gold mine is located near the town of Kenilworth (pop 370) approximately 100km north west of Brisbane. Kenilworth lies on a tourist route through the Sunshine Coast hinterland, in picturesque dairy, farming and forestry country. The minesite is located in the Conondale National Park on a steep, heavily forested mountain ridge, approximately 600m above sea level. This area was previously State Forest.

Open pit mining and cyanide treatment of the ore commenced at Agricola in 1987. In the early stages of development the company encountered technical problems relating to instability of the pit walls. The western pit wall finally collapsed in December 1988 bringing mining activities to an abrupt halt. The company went into liquidation and all plant and equipment was sold off and removed from site.

A disturbed area of approximately 16 hectares remained, including the open pit, tailings storage facility (TSF), waste rock landform and process plant areas with concrete slabs. The waste rock also included significant quantities of pyritic shales and signs of Acid Rock Drainage were evident. No rehabilitation had been undertaken.

The local community initially supported the development on the basis of employment and business opportunities. However, incidents related to the operations, including a spill of cyanide while in transit near a residential area and the eventual failure of the project soon turned the support to disillusionment. As no security deposit had been paid, the Queensland Department of Minerals and Energy (DME) accepted responsibility for the site.

In April 1991, DME detoxified the cyanide solution in the TSF and pumped the treated water into the open pit. The TSF was capped and several monitoring bores were installed. Natural revegetation of the site was occurring only slowly due to the acidic, salty nature of the exposed surface material.

No further rehabilitation was undertaken over the next four years. This inactivity was very frustrating to the local community group, Conondale Range Committee, who periodically expressed their outrage in a monthly newsletter. The unrehabilitated site was also a concern to the Department of Primary Industries (Forestry), who were responsible for the well being of visitors to the camping grounds immediately downstream of the mine.

The *"Agricola Gold Mine Rehabilitation Consultative Committee"* was formed to facilitate stakeholder involvement in the decommissioning process. The Committee consisted of; Conondale Range Committee (community conservation group), Department of Environment, Department of Primary Industries, University of Queensland (Centre of Mined Land Rehabilitation) and the Department of Mines and

Energy (project supervision). However, as further work was delayed due to lack of funds and relationships between stakeholders on the Committee were strained.

A rehabilitation plan was commissioned by DME in 1995 and funding for the estimated rehabilitation cost of $850,000 was approved.

The incorporation of the Agricola minesite into the Conondale National Park considerably raised the political profile of the rehabilitation program. The goals of the rehabilitation program were two-fold:

- to minimise adverse environmental impacts of past mining activities; and
- to create a vegetated landform compatible with the conservation and recreational values of the surrounding National Park.

The initial approach to developing a decommissioning program involved preparing the following Environmental Impact and Aspects Register to indicate priorities for the program.

Environmental Impact and Aspects Register		
ASPECT	**ENVIRONMENTAL IMPACTS**	**SIGNIFICANCE*(1-5)**
Whole Site • Disturbance (approx. 16 ha)	• Destruction of sclerophyll and rainforest ecosystems • Steep, unsafe mine faces • Siltation of Booloumba Creek • Ingress of weeds	5 3 4 1
Pit 2 and Palm Pond • Acid water (pH 5.5-6.0) • Copper contamination (up to 8mg/L)	• Downstream water quality	3 5
Waste Rock Landform • Acidic Salty Surface • Seepage of copper (up to 50mg/L)	• Restricted germination • Downstream water quality	5 5
The planned rehabilitation works • Chemical treatment of pit waters • Earth moving • Revegetation • Numerous subcontractors	• Downstream water quality • Risk of an accident enroute through one of the tourist camping areas	4 5

*Significance: 1 – low & 5 – high

An important part of implementing the rehabilitation plan was to build cooperation and confidence within the stakeholder Rehabilitation Committee. This was achieved through ensuring that all stakeholders were kept fully informed, by delegating responsibilities for technical decision making and by ensuring that appreciation was shown to all concerned for a job well done.

Objectives and targets were established to manage the rehabilitation program as follows.

Decommissioning Objectives and Targets	
OBJECTIVE	**TARGET**
Reduce effects of acid drainage	• Treat Pit 2 waters with hydrated lime to precipitate copper • Back-fill Palm Pond and Pit 2 with waste rock and agricultural lime • Cap Pit 2 with compacted clay • Reverse the slope on the waste rock benches to accelerate shedding of storm water
Reshape the unstable faces	• Bulldoze the eastern pit wall of Pit 2 • Modify unnatural buttresses, where possible
Minimise siltation	• Install diversion drains • Install silt traps
Improve germination and seedling establishment	• Spread agricultural lime • Spread topsoil (limited area) • Spread organic mulch
Revegetation with native species	• Hydroseed all accessible areas • Plant seedlings in all flat areas
Encourage the return of small mammals and reptiles to the site	• Placement of piles of "critter rocks" in open areas
Preclusion and control of weeds	• Wash down all earthmoving machinery prior to coming to site • Selective up-rooting and spraying
Preclusion of *Phytophthera*	• Wash down all earthmoving machinery prior to coming to site
Preclusion of cane toads	• Kill all toads around the organic mulch supply stockpile area at Eumundi

The decommissioning project was undertaken over a 15 month period and was highly successful from a number of perspectives. Project outcomes are summarised as follows:

Revegetation – Tree establishment has been variable depending on the nature of the substrate. The thickest and healthiest growth is in a broad band across the upper edge of the waste rock landform which received topsoil dressing. Many trees grew to over 5 metres within two and a half years of completing the rehabilitation work. The poorest growth was on a small, acidic waste rock batter that was inaccessible to lime spreading vehicles.

Water Quality – Apart from localised deposition of silt in the bed of Booloumba Creek, the rehabilitation works caused no apparent deleterious effects on downstream water quality. The levels of copper and changes in pH associated with the release of pit waters had little detectable effect on indicator invertebrates used in the monitoring program. Water quality monitoring will continue for at least 6 years following the completion of rehabilitation works.

Community Relations – Once rehabilitation work started there was an improvement in attitude from the community in general and for the Conondale Range Committee and Forestry Rangers in particular.

Safety – No accidents were recorded during the 15 month rehabilitation program involving more than 600 person-visits to the site.

Agricola Before Rehabilitation - 1995
Pit 2 (left), TSF (foreground), crusher foundation (right)

Agricola Rehabilitation - 1996
Landform work on steep north/east faces

Agricola Rehabilitation - 2001

CASE STUDY 8 - PADDY'S FLAT GOLD MINE – MEEKATHARRA - HOMESTAKE GOLD OF AUSTRALIA - CLOSURE OF OPEN CUT MINING OPERATIONS USING ECOSYSTEM FUNCTION ANALYSIS (EFA) TO SHOW ECOSYSTEM DEVELOPMENT AND DEMONSTRATE CLOSURE

The small goldfields town of Meekatharra is situated in the arid interior of north west WA, some 700 km to the North – East of Perth and 450 km inland from the west coast. The area, initially pastoral, was extensively mined from the turn of the 20th century. Various companies developed deep shafts operations, which were mined until no longer viable, prior to the Second World War. Between 1950 and 1980, most of the area was subjected to intermittent mining on a very small scale. Areas of the town common were polluted by tailings and general rubbish generated by the historic operations and the town itself. Gold mining operations recommenced in 1980 with the development of the first carbon leach – low-grade operations in Australia. A succession of owners continued to mine the leases in the area until 1995.

Rehabilitation commenced in 1987, and continued via a progressive process until the Paddy's Flat Mill was decommissioned and removed in 1995. The mine management teams had to face many challenges in this time, particularly the construction and rehabilitation of large landforms as a result of the open pit mining within and surrounding the town's boundaries. The aim was to achieve a green-belt buffer zone, with recreational and aesthetic values for the town of Meekatharra (Lacy, 1997).

By mid 1996 the disturbed areas of approximately 1,300 ha (waste landforms, pits, bunds, lay down areas, roads, plant sites and tailings storage areas), was, in the most part, rehabilitated by Dominion Mining. Remaining at the site were workshops, processing areas and plant, approximately 260 hectares of tailings storages and other areas of disturbance. Plutonic Resources purchased most of these assets in 1996. Homestake then purchased Plutonic Resources in 1998 and found that they had to rapidly develop closure plan and protocols for this site along with 4 other closed mines. The programme and closure works completed over these 5 mines was of such a high standard that Homestake was presented with a Golden Gecko award for a Systematic Approach to Mine Closure by the WA State Government in 2001.

Lukes Waste Landform- Lower Batter Topsoiling
© Outback Ecology

Lukes Waste Landform – Five Years Later
© Outback Ecology

The progressive closure protocol that Homestake utilises has five main components: planning, auditing, accruals, reclamation and monitoring. All these processes are considered equally important but this case study is focused on monitoring using Ecosystem Function Analysis (EFA) at the Paddys Flat Mine. Detail of the other processes and lessons learnt in relation to closure can be gleaned from Allan (2000).

An environmental monitoring system must contain the minimum set of key indicators that will provide rigorous data, describing major trends in ecosystems.

Monitoring systems must:

- Comprise the minimum set of key indicators, that when monitored properly, will provide rigorous data, describing major trends in the ecosystem;
- Describe the condition of all major elements in the ecosystem;
- Indicate the extent of pressures exerted on the ecosystem; and
- Monitor the responses to changes in condition.

Hamblin, 1998; CSIRO, 1998; Tongway, 1999, in Lacy, et al. 2001).

Homestake spent some time looking at the options in relation to monitoring and completion criteria and chose to use EFA monitoring throughout its WA operations. Information from the EFA monitoring is presented in the sites Annual Environmental Report and assists Homestake Gold to evaluate rehabilitation success, raises issues outstanding that need to be addressed by way of remedial work and assists in performance bond reduction.

EFA is a field-monitoring tool used to assess the functional status of natural and rehabilitated ecosystems. This method was developed by members of CSIRO in Australia and incorporates three modules, which are:

- **Landscape Function Analysis (LFA) measures** - soil surface characteristics, soil stability, infiltration and nutrient cycling;
- **Vegetation Dynamics measures** - plant cover (width and breadth), density and diversity; and
- **Habitat Complexity measures** - the complexity of the habitat for a wide range of vertebrate fauna, tree cover, shrub cover, ground cover, litter cover and free water availability.

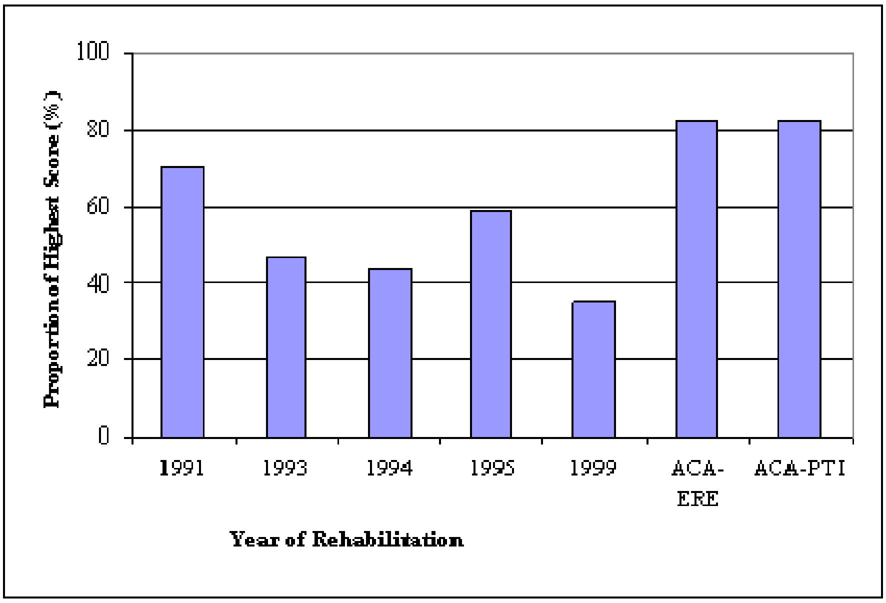
EFA has successfully been used for the assessment of rangelands, tropical grasslands and rehabilitated mine sites. The flexibility of the method and the fact that it focuses on key processes of ecosystem function, contribute to the success of EFA.

There are many factors that need to be considered when measuring ecosystem function. Most ecological researchers agree that "criteria based on a narrow set of vegetation indices or single parameters, have generally been found to be inadequate, and a combination of attributes at both the landscape level and specific ecosystem properties are necessary" (Hick & Ong, 1999). This is where EFA excels.

A Case Study Landform at Meekatharra the "Halcyon" landform

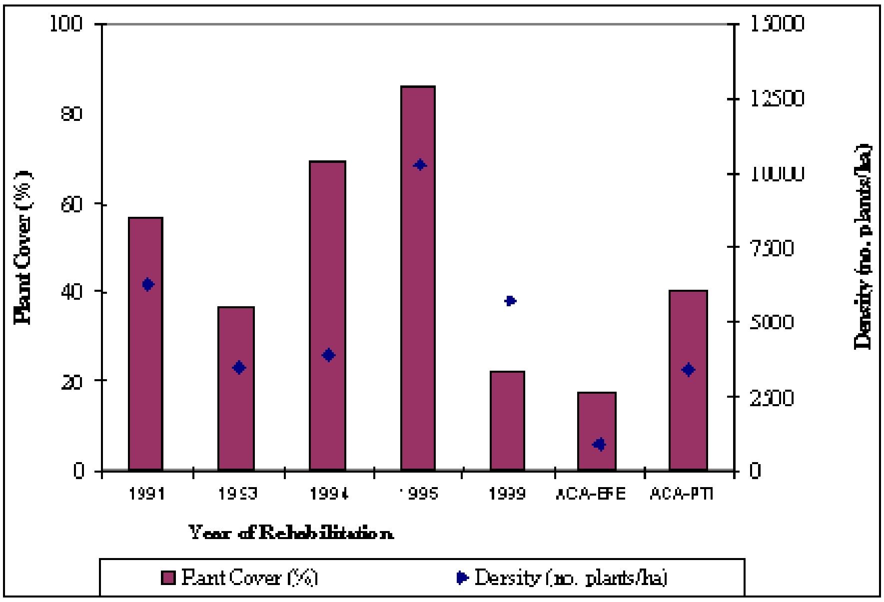
This large 40 metre high landform (approx 100 ha) to the east of Meekatharra has been developed and rehabilitated over 8 years, and has inadvertently caused a reduction in winter frosts due to its effects on cold winter easterly winds. Age comparisons are possible for the rehabilitation on this landform as indicated below.

Stability ranged from 48% in the 1999 rehabilitation to 53% in the 1991 and 1993 areas, slightly lower than in the analogue (control) sites. Infiltration indices ranging from 28% in the 1999 area to 36% in the oldest rehabilitation area. Nutrient cycling indices ranged from 15% in the 1999 area to 20% in the 1994 and 1991 rehabilitation. All indices show a gradual change toward those of the analogue sites on the left side of the graph.



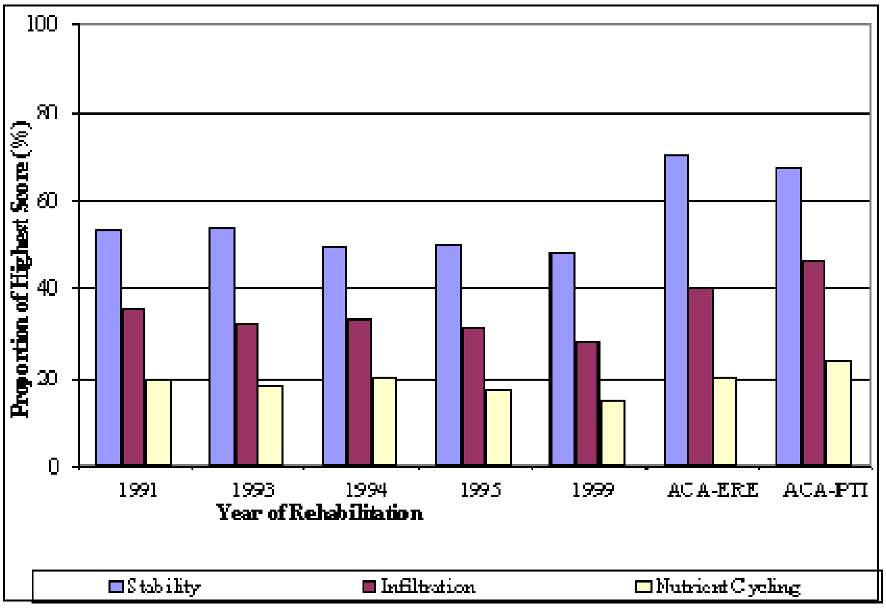
Landscape condition for the 1991, 1993, 1994, 1995 and 1999 rehabilitation on the Halcyon waste landform, in comparison to the analogue sites.

Plant cover ranged from 22 to 86% in the rehabilitation with the lower cover reported in the 1999 area. Once the rehabilitation had reached five years of age values often surpassed those of the analogue sites.



Plant cover and density for the 1991, 1993, 1994, 1995 and 1999 rehabilitation on the Halcyon waste landform, in comparison to the analogue sites.

The habitat complexity indices ranged from 35% to 70%, becoming progressively higher in the older rehabilitation. The high complexity indices were increased in the 1991 area were attributed mainly to the presence of larger Acacia tree species providing nesting and shelter sites for fauna.



Habitat complexity for the 1991, 1993, 1994, 1995 and 1999 rehabilitation on the Halcyon waste landform, in comparison to the analogue sites.

In summary, Homestake's monitoring found that rehabilitation success was evident on the Halcyon landform as it was at many of the Meekatharra waste landforms, whereby all measured values were high in comparison to the analogue sites reflecting excellent ecosystem development. In general, plant cover and density was higher than in the analogue sites throughout most years of rehabilitation. Important upper storey species were present on a number of landforms and are serving to increase the habitat complexity index by providing potential shelter and nesting sites in the rehabilitation. Plant diversity was also generally high on the landforms in comparison to the analogue sites, increasing the complexity of the landform ecosystems.

The monitoring methodology provided a comprehensive comparison with that of nearby ‘analogue’ sites resulting in the Department of Minerals and Energy, in this case the principal stakeholder, progressively releasing Homestake from their rehabilitation commitments under the performance bond system.