Environmental Issues in Decommissioning Mining and Petroleum Operations

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SUMMARY

The key to minimising cleanup costs after mining and petroleum operations cease is to plan for decommissioning from the earliest conceptual stage of the project. Plans should include progressive rehabilitation, and ensure the use of sound practices for environmental protection throughout the life of the operation. Many of the practices and techniques used by the mining and petroleum industries for environmental

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management and rehabilitation are now well-tried and proven. In response to the sometimes high cost of employing "standard" rehabilitation methods, some mines are employing innovative rehabilitation practices, and the mining industry is supporting considerable research into minesite rehabilitation and environment protection, in an attempt to achieve even higher standards. However, issues such as land contamination and final voids tend to be the focus of disputation at the decommissioning stage.

INTRODUCTION

The National Strategy for Ecologically Sustainable Development[1] (NSESD) is setting the agenda for environmental impact assessment and environmental management of all developments in Australia, including mining and petroleum developments. The NSESD established the challenge for the mining industry as being to efficiently manage the mineral resources of the nation in accordance with the principles of Ecologically Sustainable development (ESD), and set as objectives:

1. to ensure sound environmental practices;
2. to provide appropriate community returns; and
3. to improve community consultation and information.

The strategies set by the NSESD include:

1. treating environmental management, rehabilitation and closure as an integral part of the planning of mines;
2. providing incentives for improved environmental performance;
3. improving environmental monitoring; and
4. improving community consultation and information.

Governments have responded by refining the requirements of Environmental Impact Assessment (EIA) processes, clarifying rehabilitation objectives, and, in some cases, providing incentives for improved environmental management through discounts to security bonds. Mining and energy companies and industry associations have developed their own Environmental Codes of Practice and Guidelines, which are very comprehensive, and when implemented with a strong commitment from well-trained field teams and contractors, result in effective environment protection, and sound rehabilitation. There is also an increasing trend, amongst the larger companies at least, to develop and implement Environmental Management Systems (EMS), as part of a structured approach to managing its environmental affairs, and to ensure due-diligence. Many community groups, including environmental groups, are also entering into the "partnership" spirit fostered by the NSESD, by working on consultative committees and advisory bodies.

However, community perceptions of poor performance in environmental

1. Commonwealth of Australia, *National Strategy for Ecologically Sustainable Development* (December 1992).

management and rehabilitation by mining and petroleum companies persist, even though they are not always valid. They are fuelled by media reports of abandoned mines and mine pollution, and a lack of interest by the media in reporting "good news" mining and environmental stories. These community perceptions and the occasional conflicts that arise between the mining industry, landowners and environmental groups help to shape government policy, legislation and the conditions attached to approvals.

The key to minimising clean-up costs after the operation ceases, and to providing for effective final rehabilitation, is to plan for decommissioning from the earliest conceptual stage of the project. Plans should include progressive rehabilitation, and ensure the use of sound practices for environmental protection throughout the life of the operation. Many of the practices and techniques used by the mining and petroleum industries for environmental management and rehabilitation are now well-tried and proven. In response to the sometimes high cost of employing "standard" rehabilitation methods, some mines are employing innovative rehabilitation practices, and the mining industry is supporting considerable research into minesite rehabilitation and environment protection, in an attempt to achieve even higher standards.

The practices employed during progressive rehabilitation and operational environmental protection are designed to ensure that decommissioning and final rehabilitation can be achieved effectively, and with minimal additional cost at the end of operation's life. However, issues such as land contamination and final voids tend to be the focus of disputation at the decommissioning stage.

In Australia, there are no recognised completion criteria defining successful rehabilitation. This sometimes leads to great debate between the holders of mining and petroleum tenements, regulators and landowners. However, it is generally agreed between the mining industry and regulatory agencies that success criteria should be defined and agreed by both parties on a site-specific basis prior to work commencing. Success criteria most often nominated include aspects of safety, stability, revegetation and water quality protection.

The successful final rehabilitation and decommissioning of any mineral and petroleum development is most often a result of good environmental and rehabilitation planning. This planning should commence at the earliest concept stage, and continue throughout the life of the operation to the decommissioning stage. Monitoring, for perhaps years after decommissioning, is essential to verify the success of rehabilitation, and to initiate the maintenance of any failed areas as early as possible.

This paper discusses environmental issues in the decommissioning of mining and petroleum developments, based mostly on the experience of the author with Sinclair Knight Merz, and for ten years previously as Manager of the Environmental Branches of the Departments of Minerals and Energy in Victoria and Queensland.

The paper gives an overview of the legal requirements that are common

to most Australian jurisdictions, and discusses some of the environmental protection and rehabilitation practices used on most mines. The paper then focuses on the situation in Queensland, where legislation and policy has provided incentives for improved environmental performance and rehabilitation of mines, and where some innovative rehabilitation practices are being trialed. Recent developments in Queensland's environmental protection legislation concerning mining and petroleum developments are also discussed. In particular, the recent announcement of a Queensland Environmental Protection Policy (EPP) for the mining and petroleum industries is discussed. The EPP could become the benchmark for the regulation of these industries in Australia.

COMMUNITY PERCEPTIONS OF MINING AND ENVIRONMENT

Community perceptions of poor performance in environmental management and rehabilitation persist, even though they are not always valid. They are fuelled by media reports of abandoned mines and mine pollution, and a lack of interest by the media in reporting "good news" mining and environmental stories. For instance, most of the media have recently covered the situation concerning BHP's OK Tedi mine and North Ltd's Parkes mine, but what can you recall in the electronic and print media of the Environmental Excellence Awards given to the mining and petroleum industries by AMEEF, or those given by the New South Wales and Queensland governments? The considerable achievements of the industry in environmental management and rehabilitation are almost entirely ignored by the media.

In a discussion paper on mining and ESD produced by the Australian Conservation Foundation, Burton et al[2] found that, although rehabilitation efforts by the mining industry had improved in recent years, the lack of uniformity of standards for rehabilitation and the failure of governments to enforce the standards had contributed to inadequate rehabilitation. They considered the major limitations of current rehabilitation practices to be:

1. long-term seepage from mines and tailings dams;
2. establishing a plant cover; and
3. ensuring that rare as well as common species return to rehabilitated areas.

Some landowners consider that rehabilitation is inadequate. Often, mineral exploration, petroleum prospecting, the construction of gas collection facilities, and pipeline developments occur while the landowner remains in occupancy of the land. Complaints from the landowner to the authorities can occur, especially if the company fails to maintain effective

2. B Burton, P Kinrade, N Amos, M Giese and M Kockenburger, *Mining and Ecologically Sustainable Development - A Discussion Paper* (Australian Conservation Foundation, May 1994).

and regular communication with the landowner. The complaints are usually in respect of the perceived poor treatment and rehabilitation of roads, tracks, fences, creek crossings, water quality issues affecting stock and domestic supplies, and the introduction and spread of weeds.

These perceptions and the occasional conflicts that arise between the mining industry, landowners and environmental groups help to shape the conditions attached to approvals, government policy, and legislation concerning mining and environmental issues.

THE REGULATORY FRAMEWORK

National overview

Legislative control over the on-shore environmental impacts of mineral and petroleum exploration and development is vested in the State and Territory governments. Commonwealth law is applicable to extensive off-shore areas, and administered in co-operation with the States. The Commonwealth *Environment Protection (Impact of Proposals) Act* 1974 can trigger the involvement of the Commonwealth government in environmental matters when export permits, foreign investment or Commonwealth land is involved. When both the Commonwealth and State governments are required to issue approvals, the operator has to comply with both Commonwealth and State legislation concerning environmental impact assessment and environment protection.

Australia is a signatory to many international agreements and conventions concerned with environmental protection. Compliance with these requirements is given effect through Commonwealth legislation and the administrative arrangements between the Commonwealth and the States. Agreements such as RAMSAR (covering wetlands) can impact upon mineral and petroleum developments.

In all States, the principal mining and petroleum tenures cover:

1. exploration or prospecting (usually permits, authorities or licences);
2. retention of prospective development areas, by providing an "intermediate" tenure between exploration and development (usually retention leases or mineral development licences); and
3. development, involving mining or petroleum production (usually leases or licences).

Mineral exploration and mining

There are many requirements of the regulatory framework that are common to all States, concerning mine decommissioning and rehabilitation. These requirements are typically given statutory force in the relevant legislation, or form part of the conditions of the tenures and approvals that are required prior to commencing work. The main features and

requirements common to all States are to:

1. plan and integrate environment protection and rehabilitation in all planning;
2. minimise disturbance;
3. minimise and manage all wastes;
4. prevent pollution from the area;
5. progressively and finally rehabilitate disturbed land;
6. conduct environmental monitoring;
7. make disturbed areas safe;
8. remove unwanted obstructions;
9. prevent land contamination, and provide for the remediation and registration of contaminated land; and
10. deposit a rehabilitation security bond with the regulatory agencies, which can be forfeited to correct a failure by the operator to rehabilitate the site.

Petroleum

As with mineral exploration and mining, the environmental management requirements for petroleum exploration, development, production and abandonment are imposed through environmental protection legislation and/or the conditions of the tenure. Typical environment protection requirements of the petroleum legislation in all States incudes provision for the explorer or operator to:

1. prevent or control oil and saline water spillages;
2. control the release of water used in the hydrotesting of pipelines;
3. plug holes, and rehabilitate wells and other disturbed areas;
4. progressively rehabilitate areas disturbed by pipeline construction;
5. prevent the removal or damage of Aboriginal artefacts;
6. protect flora and fauna;
7. prevent the spread of weeds; and
8. comply with any EIA report and/or the Australian Petroleum and Production Exploration Association's[3] Code of Environmental Practice.

Enforcement

In addition, the relevant legislation usually provides for a compliance monitoring and enforcement regime to ensure that exploration, mining and petroleum activities comply with the statutory requirements for environment protection and rehabilitation.

These regimes typically provide for:

1. inspections by the regulatory agencies;
2. the issuing of infringement notice;,
3. orders to take remedial action, or cease work;
4. notices to "show cause";

3. Australian Petroleum and Production Exploration Association, 1991.

5. prosecution;
6. penalties; and
7. cancellation of tenure and approvals.

The Allens Arthur Robinson Group[4] has provided a review of the legal considerations in operating and rehabilitating a mine in each Australian State and Territory, as well as the federal legislation affecting mine owners and operators. They provide a useful guide to the relevant legislation in each jurisdiction.

Environmental impact assessment processes

Minimising environmental impacts by improved environmental planning is a central theme of ESD. Careful planning and a commitment to environment protection is now an essential element of mineral and petroleum resource developments, and life-of-mine environmental planning to take account of progressive and final rehabilitation from the establishment to the decommissioning of a mine is gaining prominence.[5]

In Australia, legislative frameworks are being improved to ensure that EIA processes meet the principles of ESD. The Commonwealth EIA process has been the subject of considerable review,[6] with a view to strengthening the provisions of the *Environment Protection (Impact of Proposals) Act*. In Queensland, Australia's second largest mining State, the EIA process for mining has also been refined recently,[7] and the key elements are now enshrined in legislation.

The key changes to EIA processes include:

1. increased accountability for mine developers and governments, achieved through publicly available assessment reports;
2. increased opportunities for public participation, involving the early provision of information and consultation with stakeholders; and
3. greater transparency and certainty about the process for all stakeholders, achieved by having a clearly defined process from the outset, and conducting the process to agreed timeframes.

A Queensland focus

The *Mineral Resources Act* 1989 (Qld) (MRA) and the *Environmental Protection Act* 1995 (Qld) (EPA) are the principal regulatory controls over the environmental effects of mining. The EPA and *Petroleum Act* 1921 (Qld) principally regulate the environmental requirements of the petroleum

4. Allens Arthur Robinson Group, *Mines and the Environment*, July 1995.
5. Queensland Department of Minerals and Energy, *Draft Environmental Impact Assessment Process for Mining in Queensland*, October 1995.
6. Environmental Protection Agency, *Review of the Commonwealth Environmental Impact Assessment Process*, Discussion Paper, 1994.
7. D Welsh, "Environmental Impact Assessment Process for Mining in Queensalnd", Proceedings of the 19th Australian Mining Industry Council Environmental Workshop, Karratha, October 1994.

industry. The EPA has replaced the previous *Clean Waters Act*, *Clean Air Act* and *Noise Abatement Act*.

The tenures issued under the MRA are Exploration Permits (EPs), Mineral Development Licences (MDLs) and Mining Leases (MLs). Authorities to Prospect (ATPs), Petroleum Leases (PLs) and Pipeline Licences (PIPs) are issued under the *Petroleum Act*, which has been under review for five years.

Queensland has arguably the most comprehensive environmental impact assessment process for mineral exploration and mining. The Queensland Department of Minerals and Energy[8] describes a life-of-mine process that extends from the earliest concept to decommissioning and final rehabilitation. To support the system, various environmental management policies, Codes of Practice and technical guidelines have been developed covering exploration, planning and mining.

Mineral exploration

The activities conducted under Exploration Permits and Mineral Development Licences in Queensland are regulated by an Interim Policy on Environmental Management.[9] The objectives of the policy are for:

1. activities to be planned to minimise the environmental impact;
2. rehabilitation to maximise the potential for returning a stable landform; and for
3. activities to take account of all relevant government policy, including regional and local environmental planning processes and requirements such as integrated catchment management plans and landcare strategies.

The interim policy establishes a Code of Practice for managing the environmental impacts of most activities, with an additional Environmental Management Plan for activities that cannot comply with the Code. It is a condition of all exploration permits and mineral development licences that the holder complies with the Code of Practice. The rehabilitation aspects of the Code of Practice apply to all areas that will not be subject to ongoing exploration or development. Amongst other things, the Code requires:

1. disturbance to be kept to a minimum, and not to exceed 500m^2 at any one location;
2. costeans to be backfilled upon completion of use;
3. disturbed land to be reshaped to be similar to surrounding undisturbed land;
4. pits to be backfilled if there is a potential for acid mine drainage;
5. collection and disposal of spilled oils, fuels, drilling chemicals, radioactive materials and industrial refuse;
6. the recycling of oils and greases;

8. Queensland Department of Minerals and Energy, *Interim Environmental Management Policy for Activities on Exploration Permits and Mineral Development Licences* (July 1995); *Interim Environmental Management Policy for Activities Under Petroleum Tenures* (July 1995).
9. Ibid.

7. the collection and use of topsoil from disturbed areas;
8. revegetation using species consistent with the surrounding area;
9. the remediation of contaminated land;
10. the avoidance of importing weeds;
11. the prevention of nuisance noise and light; and
12. record keeping to demonstrate compliance.

A Final Rehabilitation Report (FRR) is required prior to the surrender of the tenure. An Audit Report must accompany the FRR, and must address compliance with the Code of Practice or commitments made in the Environmental Management Plan.

Mining

The Environmental Management Policy for Mining[10] clarifies the objectives for environmental management and rehabilitation as being to:

1. create a landform with land use capability similar to that prior to disturbance;
2. create stable, self sustaining post-mine landforms, where the maintenance requirements are consistent with the post mine land use; and to
3. preserve downstream water quality.

The MRA requires that an Environmental Management Overview Strategy (EMOS) must be submitted with the application for a mining lease The EMOS must contain life-of-mine environmental management strategies to achieve the objectives of the policy (above). During the operation of the mine, an audited Plan of Operations provides in detail, regular updates on how the mine is to achieve its commitments.

When surrendering a tenement it is necessary to lodge a FRR. Amongst other things, the FRR must contain:

1. reference to EMOS commitments, indicating how each of these commitments has been met;
2. a statement on the final rehabilitation and the requirements for any ongoing maintenance and management; and
3. a Site Assessment Report describing land contamination of the lease area.

The FRR must be submitted with an Environmental Audit Report indicating whether mining has been carried out in accordance with the approved EMOS. Hence there is a clear link between the commitments concerning rehabilitation that were made by the applicant for the mining lease in the mine planning stage, and the final rehabilitation after decommissioning. It is a "life-of-mine" rehabilitation monitoring and assessment process.

In addition to the MRA (under which, rehabilitation includes remediation of contaminated land), the *Petroleum Act* and EPA, the *Contaminated Land Act* 1991 (Qld) prohibits land contamination and

10. Queensland Department of Minerals and Energy, *Environmental Management Policy for Mining*, June 1992.

imposes requirements about the identification, assessment, registration and remediation of contaminated land. This Act does not apply to land that is the subject of a mining tenement under the MRA, but it does apply when the mining tenure is surrendered, and to former mine sites.

Incentives for good performance

In Queensland, the MRA requires that an application for a mining lease must be accompanied by an EMOS, which must contain strategies for protecting and managing the environment, and for the progressive and final rehabilitation. Two months prior to commencing mining, and for periods of up to five years afterwards, a Plan of Operations must be submitted. The Plan identifies the area disturbed and the cost to rehabilitate this area to the standards identified in the EMOS. This cost is the basis of the security bond. The Plan also contains an environmental performance category rating from 1-6, with category 1 being the best performers and category 6 for lesser performers and new mines. Discounts of up to 75 per cent on security bonds are available for good performance, based on the performance category criteria.[11] The Queensland mining industry has responded to the performance category incentive by rapidly accelerating the rate of rehabilitation on Queensland's coal mines.[12]

Legislation is now beginning to reflect the need for EMS. The *Environmental Protection (Interim) Regulations* 1995 lists 85 categories of "environmentally relevant activities" (ERAs). All of these ERAs require either a licence or approval. Licences carry an annual fee. Some mines may have to obtain up to 30 licences, but a single licence can be issued covering multiple ERAs if the operator develops and implements an Integrated Environmental Management System (IEMS). If a mine has an EMS, and holds a single licence, it pays a single licence fee, which can result in a substantial cost saving.

Petroleum

The activities conducted under petroleum tenures in Queensland are regulated by an interim policy on environmental management.[13] The objectives of the policy are identical to the objectives for mineral exploration (above). The policy establishes a Code of Practice (Environmental Management for Petroleum Tenures). The requirements of the Code are similar to those of the Code of Practice for mineral exploration (above). For activities that cannot comply with the Code, the Interim Policy provides for an Environmental Management Plan to be submitted to the Department of Mines and Energy. The Plan must be approved by he Minister before the activities commence. A FRR and an Environmental Audit is required prior to surrendering the whole or part of

11. Ibid.
12. D Welsh, D Garlipp, R Hinz and N Gillespie, "Coal Mines on Target with Environmental Planning" (1994) (Feb) *Queensland Government Mining Journal.*
13. Queensland Department of Minerals and Energy, op cit n 8.

the tenure.

EPP for mining and petroleum

In 1994, the Queensland Criminal Justice Commission (CJC) heard evidence of improper disposal of liquid wastes in south-east Queensland and further evidence regarding mining issues. The CJC report called for a further investigation of the environmental impacts of mining.[14] State Cabinet proposed that subordinate legislation under the EPA would address the requirements of the CJC recommendations.

It has recently been announced in Queensland that an EPP is to be developed for the mining and petroleum industries. The EPP will be subordinate legislation under the EPA. The EPP will establish the regulatory framework that will control the environmental impact of mining and petroleum activities.

The EPP must be developed through two rounds of public consultation. A Consultative Committee and Working Group consisting of government, industry and environmental group representatives has already been involved in the production of a discussion paper on the EPP.[15] The public consultation process will involve a review of the approval and regulatory regimes concerning mining and petroleum developments, and their effects on the environment.

The Discussion Paper on the EPP lists a number of possible objectives for the EPP. Amongst these, and of relevance to the topic of this paper are to:

1. maximise industry adoption of best practice environmental management;
2. protect environmentally sensitive areas;
3. maximise compliance;
4. ensure satisfactory rehabilitation; and
5. identify and rehabilitate abandoned mine sites that present an unacceptable hazard.

There is a statutory requirement under the EPA to assess the performance of the programs to be established in the EPP. The possible assessment program could include:

1. industry, government and community surveys;
2. measures against specified performance criteria;
3. measures against national industry performance;
4. community consultation, including the establishment of a "round-table" forum of key stakeholders to advise government.

The Queensland EPP for the mining and petroleum industries could become the benchmark for the regulation of these industries in Australia.

14. Queensland government, *A Discussion Paper on the Environmental Protection Policy for the Mining and Petroleum Industries*, 1996.
15. Ibid.

MINERAL EXPLORATION AND MINING PRACTICES

Mining is considered a temporary land use, and rehabilitation objectives consistent with the future land use of the area are generally required by the regulatory authorities. Most States require mined land to be returned to a safe, stable, non-eroding and non-polluting condition.

Environmental impacts from mineral exploration and mining

It is generally accepted that the possible adverse environmental impacts from mining[16] include:

1. threats to the safety of the public, stock, and native animals;
2. unacceptable visual impacts or nuisance from abandoned buildings, derelict equipment, odours and smoke from spontaneous combustion of reject coal and tailings, and scarred landscapes;
3. a reduced capacity of the land for other beneficial uses;
4. geotechnical and erosional instability;
5. land contamination;
6. air and water pollution; and
7. loss of habitats.

With the increased emphasis on consultation and public participation, mining proposals are being subject to increasing scrutiny. Mine planning documents prepared as part of the EIA process or in response to lease conditions must ensure that all the potential issues are identified and addressed. It is generally accepted that the issues to be addressed as part of the mine planning process include the impacts on:

1. post mine land use, progressive and final rehabilitation, landform stability, prevention and management of land contamination, and life-of-mine estimates of the volume and character of waste rock;
2. water quality; including the prevention of acid and toxic leachate, and the protection of downstream surface and groundwater uses;
3. air quality and noise; including dust, and especially potentially hazardous dust from tailings dams, emissions and odours from mineral processing, and noise and vibration from blasting;
4. conservation values; involving the preservation of rare, vulnerable or threatened flora and fauna; and
5. cultural, heritage and social values, involving, in Australia, the potential impacts on Aboriginal people, relics of European heritage and the potential disruption of people and communities.

Rehabilitation standards and completion criteria

One of the more contentious issues regularly debated between the

16. Queensland Department of Mines and Energy, op cit n 8.

mining industry and regulatory authorities concerns rehabilitation completion criteria. Largely in response to the NSESD process, governments have attempted to clarify rehabilitation objectives and standards, and provide additional guidance on best environmental practice. Australian and New Zealand Minerals and Energy Council (ANZMEC)[17] considered the minimum requirements for operating mines should include:

1. the return of an agreed post-mine land use;
2. monitoring in accordance with Australian Standards;
3. life-of-mine waste management planning; and
4. making decommissioned sites safe and stable.

In addition, an excellent series on "Best Practice Environmental Management in Mining" has been produced by the Commonwealth Environment Protection Agency with input from the mining industry.[18]

In Queensland, the rehabilitation completion criteria must be related to the objectives of minesite rehabilitation, which are to:

1. return an agreed post-mine land use;
2. provide stable landforms; and
3. preserve downstream water quality.

Welsh et al[19] reported that the State's coal mines had committed in their EMOSs to completion criteria such as:

1. the return of specified land uses, usually native ecosystem or grazing;
2. establishing self-sustaining vegetation, with a productivity > 80 per cent of the surrounding area;
3. specified tree cover, tree density and species richness, and the number and diversity of understorey species;
4. providing stable soil profiles;
5. limits on erosion rates, and on the depths of rills and gullies;
6. no seepage of toxic leachate;
7. colonising rehabilitated areas with native flora and fauna;
8. various water quality standards relating to surface runoff from rehabilitated areas;
9. competent drainage structures; and
10. maintenance requirements consistent with surrounding land.

Tacey and Treloar[20] suggest some generic issues for rehabilitation objectives and completion criteria, including:

1. physical issues; such as visual amenity, erodibility and land capability;
2. biological issues; such as species composition, vegetation density, vegetation cover, fauna abundance and composition, and percentage weeds,

17. ANZMEC, *Baseline Environmental Guidelines for New and Existing Mines*, Report No 95.02, March 1995.
18. Environmental Protection Agency, *Best Practice Environmental Management in Mining*, June 1995.
19. Welsh et al, op cit n 12.
20. W Tacey and J Treloar, "What Do We Want Competition Criteria to Achieve?", Proceedings of the 19th Australian Mining Industry Council Environmental Workshop, Karratha, October 1994.

3. water quality issues; and
4. safety.

However, the rehabilitation process can take decades to achieve these outcomes, and mining companies often require the return of rehabilitation bonds prior to confirmation that the standards have been achieved. To address this issue, a mine may nominate completion criteria as a series of milestones. Achieving the milestone criteria is evidence that the rehabilitation process is trending toward success.

General decommissioning and rehabilitation strategies

The type of mining and the characteristics of the mineral deposit affect the extent and nature of land disturbance. Underground mines cause relatively minor surface disturbance, and rehabilitation is limited to tailings and surface infrastructure, and relatively small amounts of reject material and waste rock. Surface mining destroys the existing vegetation, changes the soil profile, and the creation of substantial waste rock dumps, pits and voids can have deleterious impacts on the stability of the land.

Effective final rehabilitation and decommissioning requires the operator to plan for mine closure from the outset, and to have regard for the physical, biological and social aspects of the environment. The general principles of mine decommissioning[21] involve:

1. removal from the site of any buildings, structures, materials and equipment; and especially any potentially hazardous substances;
2. treatment of any potentially hazardous materials by chemical or biological means, incineration or fixing in solids by cementation;
3. containment, by collection and storage in the smallest possible area, encapsulation, capping, submersion or burial, including returning materials underground; and
4. final rehabilitation, with the objectives of ensuring minimum on-going risks to human health and safety, and the environment.

Standard rehabilitation practices

Most mines in Australia now use procedures that have become standard practice for minesite rehabilitation. These include:[22]

1. the preparation of a rehabilitation plan, addressing progressive and final rehabilitation, and nominating the objective post-mine land use;
2. the collection and immediate use or stockpiling of topsoil or growth media;
3. the characterisation of wastes, and the identification and selective handling of any potentially acid-forming wastes;
4. the reshaping of land to achieve the desired level of stability, having regard for the compatibility of the landform with surrounding land;

21. Queensland Department of Minerals and Energy, op cit n 8.
22. Australian Mining Industry Council, *Mine Rehabilitation Handbook*, 1990.

5. the use of temporary or permanent soil conservation measures to limit the effects of soil erosion;
6. the revegetation of the mined area, generally using direct seeding techniques, to a condition consistent with the nominated land use;
7. the control of weeds and pests;
8. the removal of unwanted buildings and structures; and
9. rehabilitation monitoring and maintenance.

Innovative rehabilitation practices

In response to the sometimes high cost of employing "standard" rehabilitation methods, some mines are employing innovative rehabilitation practices. In many cases, these practices are "trialed" over relatively small areas. Often, a "fallback" method is identified to the regulatory authorities. The "fallback" method would have to be used if the innovative approach failed. In Queensland, innovative practices include:

1. ponded and terraced landform designs;
2. various mulching techniques to stabilise slopes;
3. the use of sewage sludge on waste rock to provide organic material and nutrients for rehabilitation;
4. the use of bactericides to alleviate acid mine drainage;
5. soil amelioration techniques, including the use of reject coal;
6. strips of waste rock and topsoil over tailings to provide revegetation and wind breaks to limit fugitive dust emissions, and to initiate the soil-forming processes over the tailings;
7. using final voids and pits as an integral part of wetland fauna habitat, or for waste disposal where appropriate;
8. wetlands to polish mine drainage; and
9. codisposal of tailings and coarse reject materials.

Practices for special issues in decommissioning and final rehabilitation

The practices outlined above and employed during progressive rehabilitation and operational environmental protection are designed to ensure that decommissioning and final rehabilitation can be achieved effectively and with the minimum of cost remaining at the end of the operation's life. However, issues such as land contamination and final voids tend to be the focus of disputation at the decommissioning stage.

Final voids

It is generally accepted that final voids and pits should be left safe, stable and not a hazard to the public. Most mines leave one or more voids after mining because either:

1. the cost of refilling the voids is usually prohibitive;
2. there is insufficient material remaining to refill the voids; or

3. they provide a beneficial post-mine use.

Voids and their catchment can be engineered to minimise overflow, and maintain the best possible water quality. An effective environmental risk assessment is recommended to identify the long-term environmental management needs. Safety issues concerning voids can be addressed by:

1. trenching and bunding around the perimeter;
2. closing off access;
3. filling shaft, adits and tunnels;
4. erecting warnings; and
5. covering potentially toxic or dangerous substances.

Contaminated land

It is not always possible to remove all contaminants after mining and petroleum development has ceased. In such cases, there is a potential for a residual liability to attach to the operator for on-going maintenance of leachate and other contaminant control systems, for any future clean-up due to the failure of the systems, and for the potential loss of value of the site.

Most State mining and/or environmental protection legislation contains provisions for the clean up of contaminated and waste disposal sites.[23] These appear to be mostly aimed at providing powers to regulate the clean up of potential contaminated areas such as tailings dams and waste rock dumps.

It is generally recommended that the potential for land contamination be addressed as early as possible in the exploration and planning phases, and during operation. Some form of risk assessment should be included in the planning and operational phases. The risk assessment should address:[24]

1. hazard identification; involving consideration of all existing and potential hazards, having regard for exiting and planned activities;
2. hazard characterisation; involving a site environmental audit, and considering causes and effects of the hazard, its distribution in the environment, and the likely media affected (soil, water, air et cetera);
3. environmental exposure pathways; being inhalation, ingestion, dermal contact, or through eating affected plants and animals;
4. exposure risk; involving the toxicity of the contaminant, and its cumulative and synergistic effects;
5. risk characterisation; involving the rating of the significance of the hazard, and the risks to the environment;
6. risk comparison; using techniques to evaluate the risks compared with background levels, and weighing the risks against perceived benefits; and
7. risk management; involving the planning, implementation and monitoring of controls and contingency plans.

Contaminated land strategies should be developed concerning:

1. avoidance; involving the construction of impervious lined dams and

23. Allens Arthur Robinson Group, op cit n 4.
24. Queensland Department of Minerals and Energy, op cit n 8.

piping to avoid spillages;
2. minimisation; involving bundling around fuel and chemical storage areas, locating landfills where leakage of leachate will have minimal potential to affect groundwater;
3. identification; involving regular inspections of tanks, pipes and fittings, dams, ponds and lagoons;
4. assessment; including sampling soil, surface water and groundwater for contaminants;
5. management; involving isolating the contaminated area, or changing the land use; and
6. remediation; involving on-site treatment to destroy contaminants, or removal of the contaminant.

Minesite rehabilitation research

The mining industry has recognised the need to further improve the standards of minesite rehabilitation, and has funded major commitments to rehabilitation research, especially in:
1. landform design parameters for erosion control (angle and length of slope);
2. soil management and soil substitutes;
3. rehabilitation of tailings;
4. the reconstruction of native ecosystems;
5. co-disposal of mine wastes; and
6. the rehabilitation of final voids and pits.

Environmental and rehabilitation monitoring

Whichever practices are chosen, a long-term program of rehabilitation monitoring and maintenance is essential to ensure that any failed areas are identified, and remedial action is taken quickly. The objective of environmental monitoring at mines has focused on demonstrating compliance with the mine lease or licence conditions. On most mines, monitoring typically includes:
1. the area and rate of rehabilitated mined land;
2. revegetation, usually grass, tree and shrub establishment;
3. vegetation productivity;
4. the return of specific flora and native fauna;
5. erosion rates and gully stabilisation;
6. water quality, including groundwater; and
7. dust, noise and vibration.

Environmental monitoring on mines during the past 10 years has shown an increasing trends toward:
1. the standardardisation of methods, and the use of Australian or equivalent standards;
2. automated systems for the collection of water quality and weather data;

3. the inclusion of biological parameters, especially in water quality monitoring;
4. remote sensing and the use of Geographic Information Systems for rehabilitation monitoring, recording and reporting; and
5. systematic environmental auditing.

Codes of practice and technical guidelines

Many States have Codes of Practice covering either exploration, mining or both.[25] In addition, mining and petroleum companies and industry associations have developed their own Codes of Practice and guidelines.[26] The former Australian Mining Industry Council produced the highly-regarded *Mine Rehabilitation Handbook*.[27] These guidelines are very comprehensive, and when implemented with a strong commitment from well-trained field teams and contractors, result in effective environment protection, and sound rehabilitation.

Recently, the Minerals Council of Australia released a consultation draft Code of Practice for Environmental Management of the minerals industry.[28] Consultations on the draft are being conducted with a range of stakeholders and interest groups. Recognising the need for life-of-mine environmental protection strategies, the draft Code provides strategies designed to guide environmental management from exploration, through design and construction to mining, minerals processing, rehabilitation and decommissioning. The draft Code embodies a set of principles aimed at achieving environmental best practice. Key principles of the draft Code include:

1. recognising environmental management as a key corporate priority, and integrating environmental management systems into all aspects of the life of the operations; and
2. ensuring that decommissioned sites are left in a safe and stable condition, and take account of the beneficial uses of the surrounding land.

With respect to decommissioning, the draft Code suggests:

1. incorporating decommissioning strategies at the conceptual design and feasibility stage;
2. making provision for rehabilitation and decommissioning costs; and
3. developing rehabilitation criteria, and monitoring rehabilitation performance.

Most State Mining Councils also have Codes of Conduct or Practice covering miner-landholder relations, which have resulted from extensive

25. Victorian Department of Manufacturing and Industry Development, *Code of Practice for Mineral Exploration*, 1992; "Mineral Exploration Code of Practice" (1995) 3 (June) *Industry Safety and Mines*, Queensland Department of Minerals and Energy, op cit n 8.
26. Santos Ltd, *Code of Environmental Practice*, April 1991.
27. Australian Mining Industry Council, op cit n 22.
28. Minerals Council of Australia, *Draft Code of Practice for Environmental Management*, March 1996.

processes of consultation between these two major land user groups. In some cases, these Codes have achieved ministerial approval, and been incorporated into the conditions of tenure.[29]

The Queensland Department of Mines and Energy has published 36 Technical Guidelines.[30] The guidelines stress the importance of mine planning from the earliest exploration stages, through feasibility and design stages, and encourage mine developers to:

1. incorporate environmental safeguards in the project while the greatest range of options exists;
2. determine the significant issues, and immediately commence baseline environmental studies to address the issues; and
3. develop life-of-mine environment protection, and progressive and final rehabilitation measures.

PETROLEUM EXPLORATION AND PRODUCTION PRACTICES

The principles applying to environment protection for petroleum developments are very similar to those for mineral exploration and mining. These principles are embodied in the Australian Petroleum Exploration Association's 1991 *Code of Environmental Practice - Onshore and Offshore.* This Code is highly regarded by the regulatory agencies, and is often referred to in the conditions of tenure. Most petroleum companies adhere to the APEA code as a supplement to the conditions of the environmental approval. Other company-specific Codes are mostly based on the same principles.[31] The Codes propose ways to avoid or minimise damage from petroleum exploration, development and abandonment, which again follow similar principles to the recommended ways for the rehabilitation of mineral exploration and mining sites.

The APEA Code is extensive, and includes these requirements:

1. for exploration, involving access routes, seismic lines and drilling:
   (a) the need for planning to avoid damage, expedite repairs, minimise the removal of vegetation, and maintain natural drainage patterns;
   (b) the need to avoid the transmission of weeds; and
   (c) the special needs to avoid the contamination of groundwaters, the containment of drilling muds and liquids, and the avoidance of Aboriginal sites and artefacts;
2. for development and production, involving surface facilities and pipelines:
   (a) the need to operate and maintain equipment in accordance with

29. Queensland Department of Minerals and Energy, op cit n 8.
30. Queensland Department of Minerals and Energy, *Technical Guidelines for Environmental Management of Exploration and Mining in Queensland,* January 1995.
31. Santos Ltd, op cit n 26.

Australian or similar Standards, so as to avoid oil and gas losses, minimise the clearance of vegetation, and have minimal impact on wildlife habitat; and

(b) contingency planning covering failures, and special provisions for crossing other pipelines, railways, roads and creeks;

3. for well abandonment:
   (a) planning and compliance issues; especially the need to plug wells, remove equipment, clean up litter and other wastes, and the rehabilitation of roads and tracks; and
   (b) the removal of the wellhead for offshore developments, to prevent possible damage to fishing and trawling equipment.

Some special requirements concerning environment protection for offshore activities include:

1. the preparation of a detailed oil spill contingency plan;
2. customs and quarantine requirements covering plant and animal diseases;
3. the visual checking of the sea bed to detect and remove debris;
4. the avoidance of broad-spectrum biocides and algacides; and
5. discharge of ballast according to regulations and international agreements.

The Code generally stresses the importance of consultation with government and non-government stakeholders, including landowners, and the need to keep employees and contractors aware of environmental issues, and trained to deal with routine and emergency situations.

CONCLUSIONS

Governments, industry and community groups are responding to the requirements of the NSESD and applying the principles of ESD to mining and petroleum developments. While community perceptions of poor performance in environmental management and rehabilitation persist, they are not are not always valid. The industry will therefore continue to be a focus of scrutiny for environmental and landowner groups. The industry is responding with Codes for Environmental Management and a greater commitment to consultation, planning, sensitive development practices, progressive rehabilitation, monitoring and research. The trend to develop and implement Environmental Management Systems should see compliance and environmental management further improve with the adoption of industry best practices.