Overview of Best Practice Environmental Management in Mining

Environment Australia  
Best Practice Environmental Management in Mining  
Commonwealth of Australia, August 2002  
ISBN 0 642 48797 9 of the series 0 642 19418 1

6.0 The Booklets on Best Practice Environmental Management in Mining

Mining, exploration and energy extraction are carried out in many different geographic regions in Australia, including the surrounding seas and oceans. Differences in climate, topography, soils, flora, fauna and land use, mining techniques and commodities being extracted lead to differences in the possible impacts of exploration and mining and the environmental management and rehabilitation techniques required to minimise and repair these impacts.

The booklets provide personnel responsible for environmental issues, irrespective of the mine's location, with the information they need to achieve good environmental performance, minimise conflicts with other land users, maintain ecological values in surrounding areas and restore or enhance the land use capability of the areas affected by their activities. They cover planning, monitoring, management systems and technical issues. The information is also valuable for staff at other levels and in other areas of the mining company hierarchy to improve their understanding of environmental issues and to build a sense of responsibility amongst all mine staff. Members of stakeholder representative groups, regulatory authorities, and students of mining and environment subjects will also find the booklets a valuable resource to improve environmental awareness, understanding of various principles and technologies, and the capacities of leading practitioners to significantly reduce the level of environmental impact from mining.

All the booklets include illustrated case studies which demonstrate the application of a wide range of best practice techniques to address different environmental issues across many different mine type, commodity, geographic and environmental settings. The booklets offer references for further information and some contain short guides on the steps to be taken to achieve best practice on the specialised topic.

A checklist is also available for each booklet topic. The checklists are aimed at assisting small to medium scale mining enterprises with limited access to environmental expertise to identify the steps to be taken in order to conform to best practice behaviour. The checklists may also be used as prompts for designing simple audit protocols for each specialised topic, which can be used by internal and external auditors, and by regulators.

The following brief descriptions for each of the booklets available at July 2002 summarise the topics covered, the contents of each booklet, and key recommendations.

6.1 Mine Planning for Environment Protection  
(View booklet)

Planning is the key to identifying and minimising the environmental impacts of mining. This booklet examines one crucial part of the process -- how mine planning for environmental protection can help in developing projects that meet community expectations for minimal environmental impacts. It outlines the considerations that shape mining methods and the design of environmental safeguards. These considerations include: air, water and noise quality; vibration; transport; biological resources; social and economic factors; visual impacts; surrounding land uses; and heritage places and artefacts.

Each mineral deposit is unique and so planning needs to take into account the detailed nature of the resource to be mined. The nature and sensitivity of the surrounding environment must be understood through baseline monitoring and data collection in order to provide environmental constraints for mine planning. Community expectations must be garnered through constructive dialogue with the community and representative bodies. A sound information base will allow appropriate and sensitive options to be developed, which will include the rate and direction of mining, alternative process designs, optimal facility layout, and the location of supporting services and infrastructure. It is critical that the mine is built as planned and approved during the government assessment process, staff are trained to provide adequate skills to properly implement the plan, and that environmental monitoring and auditing are undertaken throughout mine life to check on the adequacy of performance and to implement improvements where necessary.

6.2 Environmental Impact Assessment  
(view booklet)

This booklet describes the background to and purposes of environmental impact assessment (EIA). It briefly covers the legislative requirements within Australia and the key components of EIA. The relationship between EIA and environmental management plans, monitoring, and environmental management systems are discussed.

EIA is a central part of the project approval process for mining in Australia, and has evolved since the 1970s to become a comprehensive and
detailed integral part of project development and design. EIA is the best way of predicting potential impacts and identifying early on in the planning process effective and efficient ways of mitigating them. EIA also provides a sound basis upon which to devise special regulatory requirements, design appropriate Environmental Management Systems, plan the environmental monitoring regime, and identify focal issues for environmental auditing and reporting.

An EIA should contain an introduction to the project's proponents; the location, environment and a background to the project and its objectives; a comprehensive and detailed description of the environment before development commences, including the physical, biological and social aspects which the project is most likely to effect; a detailed description of the project at each stage of development and operation (ie. site preparation, construction, operation, proposed expansions, decommissioning, rehabilitation and site closure); identification of issues relating to possible physical, ecological, land use, social, infrastructure, heritage or other issues; a description of how the identified impacts will be managed and the levels of protection to be provided; an evaluation of alternative approaches to development (eg lower mining rate, milling infrastructure remote from mine, different waste disposal options, local or remote housing of mine staff ); consideration of the "no development" option to enable appreciation of the consequences of the project not going ahead; a description of the proposed assessment, monitoring and review procedures; and a list of the commitments made by the proponents to minimise the environmental impacts of the proposal.

6.3 Community Consultation and Involvement (view booklet)

The expectations and needs of communities affected by mining proposals are considered in this booklet. The processes for preparing for the consultation process are discussed in detail and the key community consultation techniques described. A community-centred, rather than a project-centred approach to community consultation and involvement is preferred.

There are no shortcuts to developing effective community consultation programs. Gaining local support involves convincing all the community's sub-groups that their interests will not be overlooked or prejudiced. It helps to: start consultation very early; clearly demonstrate the integration of social, economic and environmental aspects of the project; emphasise tangible benefits to the local community (eg jobs, skills training) and make sure these happen; be always visible and accessible to openly discuss issues; be aware of changing concerns and interests in the community over time and address these directly through direct consultation; and maintain a flexible approach to consultation and ongoing modification to project design over the life of the mine.

6.4 Environmental Management Systems (view booklet)

This booklet outlines the role and key components of an environmental management system (EMS) as a key tool to use in achieving the company's environmental objectives and targets. It explains how to operate and implement an EMS within a company's daily operations, from exploration to mine closure. An EMS is a structured approach to managing the environmental aspects of a project so that nothing is overlooked; tasks are done and checked; provision is made for changes, and response procedures established for emergencies. It avoids a haphazard process of site-based, narrowly focussed and non-integrated responses to individual environmental challenges. EMS is a major contributor to demonstrating due diligence.

The components of a comprehensive EMS for a mine site include: organisational commitment; corporate environmental policy; EIA; community consultation and involvement; objectives and targets; environmental management program; documentation and records; operational and emergency procedures; responsibility and reporting structure; training, awareness and competence; audit systems for environmental impact, regulatory compliance and environmental performance; and emission and performance monitoring and measurement.

6.5 Environmental Risk Management (view booklet)

Environmental impact is unavoidable in mining – decisions are constantly being made, with action or inaction, which affect the likelihood of negative impacts from foreseen or unforeseen events on the mine site or from the effects of external forces. Assessing these changes should include risk management. Environmental Risk Management (ERM) is defined and the key principles described. ERM methods and practice are discussed, including scoping of the risk analysis to be undertaken; the elements of risk analysis and the differences between quantitative and qualitative approaches; assessment of risk; and the different methods of risk treatment or management. Different forms of EMS are described as they are appropriately applied in the different stages of mine life. For example in the pre-mining stage, careful and considerate mine planning and concept development, and thorough environmental impact assessment, are very influential and effective tools in reducing risk and the potential for major financial outlays through the remainder of the mine's life (eg by avoiding or minimising exposure to costs of modifying systems, rectifying impacts or paying fines).

Key points made in this booklet are that some level of risk is unavoidable, but it can be significantly reduced if an integrated approach to ERM is taken. ERM helps to ensure that environmental risk is contained to acceptable levels, and ideally it should be applied to all aspects of a mining operation in a structured process to ensure that all relevant issues are addressed. Criteria and objectives for risk assessment should be established early on and an open mind maintained in respect of the assumptions that are always made because of limited knowledge – information and experience gained during operations, such as the results of environmental monitoring, should be fed into the risk assessment process to identify emerging problems as soon as possible and progressively reduce risk levels with time. As ERM encompasses the entire mine project, multiple skills are needed and sufficient resources must be made available to do the job effectively. The results of the risk analysis must be communicated effectively and risk management recommendations implemented promptly for the ERM process to succeed.

6.6 Cleaner Production (view booklet)

Cleaner production is a concept that encompasses many of the operational practicalities of best environmental practice on a mine site. It is aimed at maximising resource usage and operational efficiency, not only during production of the mineral commodity at the mine, but also in its fabrication, use and ultimate disposal (eg as copper wiring and tubing in a refrigerator). The concept also extends to minimising waste disposal and rehabilitation requirements, and its application is linked to continuous improvement in environmental and economic performance.
This booklet describes how cleaner production requires a change in attitudes, acceptance of responsibility for environmental management, and on-going evaluation and, where appropriate, upgrading of technological options. Cleaner production looks to identify, remediate, minimise or remove an environmental problem before it happens; it looks for "end of pipe solutions" instead of allowing the problem to continue and addressing it by applying an "end of pipe" solution. In other words, it is an integrated and preventative approach to minimising environmental risk, rather than a curative approach. It involves good housekeeping throughout the mine site, and ongoing procedures to identify opportunities for further improvement. The benefits of cleaner production can include less waste, recovery of valuable by-products, improved environmental performance, increased resource productivity, better efficiency, reduced energy consumption and an overall reduction in costs.

6.7 Planning a Workforce Environmental Awareness Training Program (view booklet)

A workforce environmental awareness training program is important in achieving an enduring and improving environmental culture amongst all staff. The booklet explains how corporate commitment is critical to a successful program. It also provides a framework that managers can use in planning a workforce environmental awareness training program and shows how its effectiveness can be evaluated. Key components of building a culture of environmental awareness and concern in the workplace are good communication with all staff; encouragement and motivation for workers to change their views on and levels of commitment to environmental protection; strong, clear and continued leadership; encouraging team approaches to address environmental issues; clear understanding of the issues to be addressed and building of sufficient skills amongst staff to ensure that staff have the knowledge and competencies to take appropriate measures when needed; appropriate recognition to staff and teams for good work; and empowerment through delegation to allow workers to become responsible directly for their own actions. Such measures lead to higher morale, lower staff turnover, employees taking more responsibility and displaying initiatives in environmental protection, and overall improved environmental performance.

6.8 Onshore Minerals and Petroleum Exploration (view booklet)

This booklet discusses the potential environmental impacts that can arise at the different stages of exploration, and management of those impacts. Impacts can be minimised through participation of stakeholders, personnel training, and selection, use and timing of appropriate equipment. Best practice in exploration starts with pre-exploration planning and continues until exploration is completed. Any exploration program should ensure proper communication to stakeholders about the program of work and its outcomes; protection of the environment outside the exploration area; minimisation of disturbance and contamination within the explored area; and restoration of all impacted areas at the end of the program. Effective and practical techniques to minimise impacts and restore the area at the end of exploration are discussed in the booklet.

6.9 Water Management (view booklet)

Water is integral to virtually all mining activities and typically the prime medium, besides air, that can carry pollutants into the wider environment. Consequently, sound water management is fundamental for most mining operations to achieve environmental best practice. As mine planning is commonly based on limited data it is important to validate initial predictions as soon as possible in the operational phase and adjust the water management system to minimise the risk of environmental impact. A mine's water management system (WMS) must account for site-specific physical, chemical and climatic characteristics as well as mine process factors. As water features in most operational aspects, total company commitment to integrated water management is critical. Periodic risk/consequence assessments will check WMS effectiveness and allow changes to reduce the risk of system failures and environmental impacts, and also help to "fine tune" rehabilitation planning to achieve desirable post-mining land use objectives.

The booklet describes the hydrological cycle; the physical and process elements of a WMS; outlines how a best practice water management plan can be devised and developed; and examines the different water management issues which pertain at different stages during the life of a mine.

6.10 Tailings Containment (view booklet)

All aspects of planning, designing, constructing, operating and monitoring tailings disposal facilities are covered in this booklet. Factors to consider in selecting the site and choosing between the various disposal options for tailings are explained, and monitoring and control methods to minimise environmental impacts are discussed.

Tailings storages can cause a number of short and long term environmental problems if not well designed, constructed and managed. The problems relate to contamination of surface and ground waters, dam safety and stability, dust, visual impact, reclamation and restoration of the area, and long term maintenance, stewardship and mitigation of contamination.

The booklet describes the objectives for tailings storage; site suitability; different tailings containment designs; and operating and monitoring approaches and techniques.

6.11 Energy Efficiency (view booklet)

Energy is critical for all mining activities to continue their operations. Energy is a major operating cost and usually requires substantial capital investment. Energy generation and consumption are also known to be a significant contributors to greenhouse gas emissions; and performance in this area is seen as a key indicator of the environmental credentials of industries in general and individual companies. Voluntary and mandatory targets are being set by many jurisdictions and the move to tax greenhouse gas emissions in many countries adds extra incentive to improve performance and efficiency.
The booklet explores opportunities to directly reduce costs through reduction in energy consumption and improvements in efficiency, and to reduce emissions related to energy use. Management approaches are examined for providing leadership through building awareness, measuring energy use, identifying opportunity for improvement, and reporting outcomes. Methods of increasing the efficiency of energy use are applicable across all activities in the minerals sector and are discussed for exploration, excavation, ventilation and dust extraction, water management, transport, crushing milling and processing, and general site services. Particular attention is given to the sources of greenhouse gas emissions and how these can be reduced, including the application of alternative products and processes.

6.12 Atmospheric (Non Dust) Emissions (view booklet)

Most of the techniques involved in ore processing are sources of non-dust emissions to the atmosphere, such as radioactive gases and particles from uranium ore and mineral sands processing; odorous gases during ore concentration employing sodium ethyl xanthate; acid gases from roasting of sulphide ores; and hydrogen sulphide and other acid gases when bricks are heated in kilns or aluminium is reduced.

The booklet discusses what clean air is, describes the common pollutants, and summarises the Australian regulatory controls and standards. Different control techniques are described for capturing pollution and treating pollutants using adsorption, absorption, incineration, and sulphuric acid plants. Atmospheric dispersion of pollutants is also discussed, including the influences of terrain, meteorology, buildings, and convection, and the effectiveness of stacks to reduce impacts. Modelling and assessment of odour are briefly described.

Key elements of best practice in managing atmospheric pollution are to use technology which reduces generation of gaseous emissions and which eliminates gaseous waste streams through recycling. Emissions should be treated to reduce them as far as practicable. All pollutants must be identified and appropriate technologies selected to control them effectively. Care must be taken in designing stacks to suit local meteorological, topographic and built environment conditions, and to take account of gas cleaning technologies that reduce the temperature of emissions inside the stack. Fugitive emissions should be captured by hoods systems. Odour monitoring is important to provide fast warning of emissions problems, as dispersion models may not provide information quickly enough to allow speedy response to emission levels which may give rise to health concerns or complaints from workers and the community.

6.13 Dust Control (view booklet)

Dust is unavoidable for almost all forms of mining – it is one of the most visible, invasive and potentially irritating impacts and commonly causes more concern than is warranted from neighbouring communities. However, many dusts do contain potentially hazardous metals and certain types and size ranges of dust are known to have associated health impacts. It can also affect flora and fauna and poses a health risk to mine workers. Dust control must therefore be part of a mine environmental management plan.

The booklet describes the origin of dust in mining, the characteristics of dust from different operations, and the health risks it poses. As dust transport and deposition on sensitive recipients are influenced by many operational, climatic and topographic variables, the importance, type and application of dust modelling and prediction are described. Methods to control dust can be incorporated at the mine planning stage. Knowledge must
be acquired during the operational phase to understand how dust is generated and how it can be most effectively controlled. An understanding of dust emission sources and use of on-line monitoring technology can be used to provide real-time dust data for input to active dust management through adjustments to mine operations and dust suppression such as watering and sealing of surfaces, or delay of blasting under adverse weather conditions.

6.14 Noise, Vibration and Airblast Control (view booklet)

Noise, vibration and airblast are unavoidable in many types of mining and constitute significant threats to worker health and safety if not well managed. Noise and vibration require particular management at projects close to communities, where they can give rise to concerns for public health, safety, and damage to private and public buildings and other infrastructure. The mine planning stage should recognise the potential for adverse impacts, and layout, infrastructure and systems designed to mitigate possible impacts. The extent of noise, vibration and airblast should be quantified during the environmental impact assessment stage and predictions made of the levels likely at potentially sensitive locations, such as the nearest dwellings, school or public place. A management plan should be prepared in consultation with the local community, including specific measures to minimise emission levels. Ongoing monitoring during construction and operation will provide information for assessment of performance against objectives, and data for effective auditing throughout the life of the mine.

The booklet looks at the sources of noise, vibration and airblast, describes why they are of concern and need to be understood and managed; characterises what they comprise; gives examples of the effects they can cause; and sets out a three-stage approach to their management (impact assessment, management plan, monitoring and auditing).

6.15 Hazardous Materials Management, Storage and Disposal (view booklet)

Hazardous materials include any substance that may pose a hazard to human health or the environment when improperly treated, stored or disposed of. Most mining and mineral processing facilities use and generate hazardous materials. Approaches to minimising risk from these substances include: identifying and properly preparing materials, and compiling inventories of all hazardous materials including waste products; characterising the potential environmental hazards associated with them; documenting methods for transport, storage, handling and use; identifying options for disposal and long term storage, preparing contingency plans and emergency response plans; and training of all managers, workers and contractors who deal with or handle hazardous substances.

The booklet defines hazardous materials and describes why they must be properly managed. It also lists many of the materials and wastes associated with mining, under the categories of exploration activities, process chemicals, service materials, process wastes, radioactive materials, and other waste streams. Principles of best practice materials management are set out, and the need is stressed for comprehensive management plans and systems for all stages and areas where hazardous substances are involved. Finally, suggestions are made for review and auditing of systems for the management of hazardous materials.

6.16 Cyanide Management (view booklet)

The economic viability of many gold mines is dependent upon the efficiency of cyanide as a solvent. However, cyanide use brings with it the risk of health impacts to workers, the public and the environment if cyanide chemistry, handling, containment and disposal are not properly understood and practiced. This booklet includes a chemical overview of cyanide during gold extraction, recycling and disposal, and describes how health and environmental risk can be minimised. As cyanide exists in many different forms and may undergo many different transformations, an understanding of the chemistry is important in developing best practice approaches to its management. Management principles include: using the minimum amount required to recover metals; disposal techniques which eliminate the potential for impacts; and monitoring of all operations, discharges and the environment to detect and deal with any escape of cyanide and any resultant impacts.

Integrated management of cyanide should include: a cyanide management plan, which must be integrated with the water management plan; training for all staff and contractors; clear documentation of responsibilities and authority, and defined lines of communication in respect of cyanide management; development and promulgation of safe procedures for cyanide handling including transport, storage, containment, use and disposal; identification and implementation of appropriate methods for reusing, recycling and disposal of residual cyanide; regular cyanide audits and revision of the cyanide management plan where appropriate; a cyanide occupational and natural environment monitoring program and sampling, analysis and reporting protocol; and cyanide emergency procedures and emergency practice sessions.

Best practice cyanide management will lead to benefits such as better relationships with the public and regulatory agencies, improved economic and environmental performance, reduced risks and liabilities, and easier access to capital and potentially lower insurance costs.
Nomenclature, stability and toxicity of some important cyanide species in gold mining tailings. The booklets contain technical information relevant to each topic such as chemical characteristics, nomenclature, equations, flowcharts, standards and regulatory requirements. This is one of many tables in the Cyanide Management booklet that sets out information critical to understanding why and how best practice techniques must be applied.

6.17 Managing Sulphidic Mine Wastes and Acid Drainage [view booklet]

Excavation and breaking of rock containing sulphidic minerals will accelerate the production of acid drainage, which at mines typically occurs as runoff or seepages from waste rock piles, tailings impoundments, coal reject piles, mine dewatering, or from flooded pits or underground workings. The financial impacts of acid drainage are considerable: the cost of remediating acid-generating materials in Canada is estimated at around $C 3 billion, and the annual management cost to the mining industry in Australia is about $A 60 million (Harries 1997).

Best practice environmental management must directly address the potential risks and effects of acid drainage by: characterising mine waste for its acid-producing potential; using site-specific analysis to determine the levels of environmental risk; implementing mine design and mine management practices to avoid or minimise the risks; designing monitoring programs which will provide early identification of any impact on the environmental values at risk; mine planning and closure strategies which minimise the potential for off-site impacts; and ensuring the long term effectiveness of the acid drainage management strategies developed for the site.

The booklet illustrates the importance of control of acid drainage by describing several mine sites where major environmental damage has resulted from uncontrolled or poorly controlled acid drainage. Techniques are described for predicting and identifying the potential for acid drainage. Different approaches are described for reducing the generation of acid from sulphidic materials, i.e. by reducing oxygen and water access, isolation, blending and by bacterial inhibition. Different strategies are described to treat acid waters by neutralisation, and with passive constructed and natural (i.e. wetlands) systems. Concepts and some techniques for monitoring are briefly outlined.
The booklets contain guidance in the form of flow charts for managers and practitioners such as this step-by-step guide to evaluating acid mine drainage potential from the Managing Sulphidic Mine Wastes and Acid Drainage booklet.

6.18 Environmental Monitoring and Performance (view booklet)

This booklet looks at the objectives of monitoring programs for air, water, dust, flora and fauna and community impact, including the selection of indicators, measurement methods, data collection and analysis, and reporting of monitoring data. The linkages between environmental monitoring and performance, and environmental auditing and EIS predictions are explained.

The environmental monitoring program collects and interprets the information necessary to determine whether the environmental management plan and related systems are being applied effectively, and whether the environmental objectives set by the company, regulator and community are being properly met. The booklet describes the principles for design of a monitoring program, and how these can be implemented for different monitoring targets such as water, land, biota, air, noise, processing systems, waste, and people and the community. Methods for data collection, evaluation and presentation are also discussed, and comments made on the cost of implementation. Clearly a quality monitoring program is critical to inform the company, the regulatory authorities and the community on the level of environmental protection being achieved. Proper interpretation will provide the information necessary to enable early changes to the mining operation if unacceptable impacts are indicated or predicted, and will form the basis of credible technical reporting, occurring.

6.19 Environmental Auditing (view booklet)
Environmental auditing is an essential management tool to measure overall performance objectively and to develop action plans for ongoing improvement in the effectiveness and efficiency of environmental protection. An audit program will help demonstrate due diligence in the event of confrontations with stakeholders, or prosecution. Environmental audits must not be one-off events but should be repeated at regular intervals to provide periodic assessments of the effectiveness of environmental management systems. Whilst internal auditors can undertake them, independent audits are usually needed for the results to be credible to regulators and stakeholders. The benefits of environmental auditing include identification and management of risk; lower probability of non-compliance; preferred access to lending institutions; lower insurance premiums for environmental risk; and improved public image.

Environmental audit is a voluntary activity in Australia but it is commonly demanded by stakeholder groups, and by codes of practice or standards adopted by many operators. It is common for regulators to undertake inspections in the form of environmental audits, and in some instances these may be undertaken jointly with stakeholder groups to improve transfer of information and mutual trust.

There are many different types of environmental audit that reflect the level of sophistication of a company's environmental management plan and systems; and the purpose and objectives for the audit. Internal or external auditors may conduct audits. The type of audit depends on the focus of the audit exercise, which may be compliance against regulations, legislation, and licences; or environmental outcomes; or a specific technical part of the overall operation; or related to assessing a company's financial, insurance, or product liabilities. The different audit types are explained and examples given. Guidance is provided on how to select auditors, choose the right type of audit, develop protocols, prepare for the audit, and conduct the on-site audit procedures. The importance is stressed of communicating the results of the audit and of implementing audit recommendations effectively and promptly. An effective cycle of audit planning, execution and implementation of recommendations is a major contributor to the key sustainable development principle of continuous improvement.

6.20 Contaminated Sites (view booklet)

Contamination is an ever-present risk in mining because of the materials involved – mineralised rock, tailings, process chemicals, lubricants, fuels and other solid and liquid materials are all potential contaminants. Best practice starts with minimising the potential for contamination of land by designing systems to reduce the potential for releases to the environment including waste minimisation and management strategies and operating procedures. The management of contaminated land needs to be an integral part of the environmental management system and auditing procedures.

The booklet recommends a risk-based approach rather than one based on concentration levels, as this allows for the use of innovative and cost-effective strategies to manage contaminated land. While overall mine and mine systems design should minimise the potential for contamination and provide adequate safeguards in the event of failure, it is also important that mine staff are able to react quickly, appropriately and confidently to deal with any contamination event. Assessment of contamination prevention and control measures in regular environmental audits will allow improvements to be made to effectively manage the likelihood of and impacts from contamination over the life of the mine and through its various stages of operation and management.

The booklet describes why contamination at mines is a problem, discusses the issue of liability, and summarises current regulatory requirements placed on Australian mines. The different mining processes which can lead to contamination are described, at the exploration and trial mining stage; during construction; during the operational phase through processing/extraction, tailings storage, handling of waste chemicals, consumables and equipment; and in the context of management procedures and human behaviour. Approaches to reducing the risk of contamination in all of these settings is discussed in terms of technological, operational and management solutions. The nature of mining means that it is very difficult to avoid some level of contamination from occurring, and so the booklet also discusses various approaches to assessing contamination and how contaminated land can be remediated. Heavy contamination may place restrictions on future use of the area, which may have serious consequences for discharge of liabilities at mine closure.

6.21 Landform Design for Rehabilitation (view booklet)

Best practice demands that mining is a temporary user of land and that the land should be returned to some beneficial use for the community after mine closure. Landform design is critical to achieving this objective. Traditional mining activity either left the land with no shaping, or left any shaping until the end when the size of the problem and low cash flows generally resulted in a minimalist program of landscaping works. This approach also often meant that the best options for placement of contaminated or other hazardous materials such as rock with acid-forming potential to reduce long-term risk were no longer available.

This booklet demonstrates how mine planning can integrate ongoing landform reshaping works throughout the operational phase at minimal cost so that the prospects of achieving desirable post-mining land use objectives to the satisfaction of regulators and the community are maximised. This booklet should be read in tandem with the Rehabilitation and Revegetation booklet to determine how climate, soil, local topography, management requirements and the like are best factored in to the landform design.

The value of the land, its proximity to larger communities, and its natural attributes (such as slope, rainfall, fertility ), and the type of mine, will dictate sensible and achievable post-mining land use options and thus the most appropriate objectives for landform design. The booklet includes an example of how different outcomes are warranted for a coal mine in a relatively well populated area with a viable pastoral cattle industry, in contrast to a low grade and high-throughput gold mine in a remote and arid environment where there is little commercial land use.

Planning aspects for landform design are discussed, and design parameters described to produce a landform compatible with the surrounding natural landscape (ie hydrology, drainage channel types and density, slopes, and relationship between landform and land use). Survey methods, land use options and design considerations are discussed for in-pit spoil and waste rock, and for other materials, including the use of computer-assisted planning and design tools. In many circumstances it may be economically impractical to fill in voids, and so alternatives to use of voids in the post-mining landscape are discussed and their safety aspects considered. Water control is an important post-mining management issue, and techniques are described for water control, and minimising erosion.
Rehabilitation and Revegetation (view booklet)

Rehabilitation is an essential part of achieving ecologically sustainable development in mining. It cannot be considered only towards the end of mine life; to be effective it must be part of an integrated management plan right from the mine planning stage, and must incorporate research and trials to improve the probability of success and acceptance by regulators and the community.

Rehabilitation can take different forms – for example in mining areas close to towns where a range of land use options such as playing fields, industrial development, housing, water recreation and parkland is potentially appropriate. In more remote areas, restoration into natural rangelands may be the only option. In many parts of remote Australia, agriculture is commonly marginally viable because of low rainfall and fragile and low-fertility soils and the levels of soil or pasture improvement are very low. Therefore mine rehabilitation commonly takes a form of ecosystem restoration. Mining organisations and research institutions have developed expertise to re-establish floral and faunal species that will develop into communities with similar biodiversity to undisturbed systems.

The booklet emphasises the rehabilitation of natural ecosystems, particularly the re-establishment of native flora. Topics covered include rehabilitation objectives; land clearing, soil handling, storage and replacement; landform design and erosion control earthworks; species selection, seed collection and treatment, and application techniques; the use of fertilizers and soil amendments; nutrient building and cycling; maintenance; and monitoring and measuring revegetation and rehabilitation success.

Mine Decommissioning (view booklet)

Mine decommissioning and closure is the process of shutting down an operation so that the area is left in a safe and stable condition, which is consistent with the surrounding environment, and does not need ongoing maintenance.

Decommissioning 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, the site may 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 impacts, and to create the agreed beneficial land use objectives.

There are no standard formulae that can be applied, as each operation and its situation is unique. Appropriate mine decommissioning outcomes need to be determined on a site-specific basis taking into account climate, land capability, land form, water resources, ongoing land use and the risks associated with alternatives. Factors important in considering decommissioning options include: public safety hazards and risks; ecological compatibility; potential for ongoing pollution; community expectations; future land use and resource demands; and aesthetics.

The benefits from best practice mine decommissioning include: reduction of liabilities; sufficient financial and material resources set aside for final closure requirements; rehabilitation designs and/or processes tested for their suitability for the specific site; less double-handling of waste materials and topsoil; less land disturbed; identification of areas of high risk as priorities for ongoing research and/or remediation; realistic estimation of rehabilitation costs; potential to progressively recover performance bonds; and reduced impacts on local communities that may be economically reliant on mine operations.