REHABILITATION AND CLOSURE 23

23.1 INTRODUCTION

Planning the closure of the expanded Olympic Dam operation and its associated infrastructure would be integrated into the current Olympic Dam Rehabilitation and Closure Mine Plan. Closure planning was started during the initial planning phase and would continue to be refined as results from research and monitoring programs become available, government regulations and stakeholder expectations change, and technology advances.

The timing of closure for the expanded operation at Olympic Dam is unknown, although it is likely that the operation would extend beyond the 40–year timeframe assessed for the Draft EIS. This chapter presents a proposed closure strategy to progressively rehabilitate and close the expanded Olympic Dam operation and its associated infrastructure should the operation require closure at 40 years. The same overriding principles would apply at a closure date beyond 40 years, should the operational life extend. The plan:

- identifies the objectives for progressively rehabilitating, decommissioning and closing the expanded operation
- defines the criteria that would be used to guide and assess the achievement of environmental objectives
- provides the potential post closure land uses and proposed rehabilitation and decommissioning practices for the major project components
- outlines future research and monitoring programs that may influence the conceptual closure plan.

23.2 ASSESSMENT METHODS

The conceptual rehabilitation and closure plan described in this chapter is based on:

- BHP Billiton Group's Closure Standard
- a risk assessment for closure undertaken for the Draft EIS (see Appendix C)
- the existing Olympic Dam Rehabilitation and Closure Plan
- a rehabilitation and closure study undertaken by Outback Ecology Pty Ltd (see Appendix T1 for details).

Rehabilitation practices in the arid zone were reviewed and discussed with regulatory authorities from South Australia, Western Australia, Queensland and New South Wales. The review included site-specific rehabilitation strategies as well as regulatory guidelines to ensure the approach proposed for Olympic Dam would meet applicable standards. The rehabilitation strategies of 22 mining operations in arid areas that generally receive rainfall of less than 350 mm a year and have evaporation rates of more than 2,000 mm a year were considered. A summary of the findings is presented in this chapter and details provided in Appendix T1.

23.3 EXISTING PLAN, STANDARDS AND GUIDELINES

The BHP Billiton Group Closure Standard requires all of its operations to have closure plans that are reviewed and updated regularly. The plans are required to identify, mitigate (where possible), estimate the cost of and manage the current and future health, safety, environment, community and business risks associated with closure. The BHP Billiton Group Closure Standard identifies the following principles for rehabilitation and closure:

- ensure that closure planning is incorporated into the design, construction and operation phases
- rehabilitate and stabilise disturbed areas as soon as reasonably practicable
- seek opportunities to reuse/recycle redundant assets during operations and on closure
- ensure that infrastructure is decommissioned in accordance with environmental, health and safety objectives.

The Olympic Dam operation's current rehabilitation and closure plan was updated recently to comply with the BHP Billiton Group Closure Standard. The updated plan ensures that the existing operation complies with statutory, corporate and site-specific policies, procedures and standards. It states the objectives of the closure plan, and estimates the cost of progressive rehabilitation, decommissioning and closure. The key elements of the plan are to:

- integrate closure planning with mine planning and budgeting
- identify and document the legal requirements and liabilities of mine closure
- identify the closure requirements and completion criteria for each component of the existing operation
- present a financial framework, including cost provisioning, for rehabilitation and closure of all aspects of the existing operation
- assure the BHP Billiton Group and external parties that closure planning and cost provisioning complies with company and government requirements
- present a framework for communication and stakeholder consultation, particularly in relation to technical issues relating to closure and land use objectives
- identify the need for further research to guide closure planning
- identify opportunities for progressive rehabilitation
- identify residual risks associated with closure of the mine
- present a framework for post closure monitoring, auditing and reporting.

In accordance with the existing Rehabilitation and Closure Plan and the United States *Sarbanes-Oxley Act 2002* (which established higher standards for corporate governance and financial auditing), BHP Billiton would make an accounting provision each year for the future rehabilitation and closure of the mine.

South Australian Government regulators are being consulted about the recently updated Olympic Dam Rehabilitation and Closure Plan for the existing operation. Guidelines and standards reviewed during the development of the updated plan included:

- PIRSA Guidelines for Preparation of a Mining Lease Proposal or Mining and Rehabilitation Program (PIRSA 2007)
- BHP Billiton Group's Closure Standard
- Australian minerals industry framework for sustainable development, particularly the 10 principles of 'Enduring Value' (MCA 2004)
- Australian Government Overview of Best Practice Environmental Management in Mining (DEH 2002)
- Australian and New Zealand Minerals and Energy Council Strategic Framework for Mine Closure (ANZMEC 2000)
- Western Australia Department of Minerals and Energy Guidelines for Mining in Arid Environments (DME 1996)
- Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (Australian Radiation Protection and Nuclear Safety Agency 2005).

23.4 REHABILITATION AND CLOSURE STRATEGY

23.4.1 BROAD OBJECTIVES

Although details of land use post closure would be determined at the appropriate time in the future, the broad objectives of the closure strategy are to:

- ensure that closure planning (including accountability and resourcing) is incorporated into the project development, construction and operation phases
- establish a base closure plan that can be reviewed and updated during the construction and operation phases
- provide information to relevant stakeholders for comment, and consider their views during rehabilitation and decommissioning planning.

Specific closure objectives are to:

- comply with applicable BHP Billiton Group, local, state, federal and international standards
- consult with and address stakeholder concerns
- rehabilitate operational areas to a condition that would support post-operational land uses as agreed with stakeholders
- leave operational areas in a state that poses minimal risk to the public, native fauna and livestock
- ensure public exposure to chemicals and radionuclides is within prescribed limits
- decommission assets soon after they become redundant
- stabilise and render safe the open pit and waste landforms, but leave as features within the landscape
- rehabilitate all other disturbed areas
- ensure the visual character of the site is consistent with the post-operational use, as agreed with stakeholders
- ensure rehabilitated sites and landforms are stable over the long term
- when possible, restore operational areas to a condition that has minimal off-site impact by controlling the release of pollutants to the air, land and groundwater
- rehabilitate operational areas using technically feasible and cost-effective methods that avoid ongoing post closure maintenance
- demonstrate that future risks and liabilities associated with post closure sites have been eliminated or are controlled to an acceptable level
- reuse assets and recycle materials recovered from decommissioned assets where reasonably possible.

23.4.2 STAKEHOLDER INVOLVEMENT

The involvement of stakeholders in developing responsibilities and agreed closure objectives and outcomes is a critical component of the rehabilitation and closure planning process. The process also ensures ongoing consultation and agreement in accordance with government and community expectations.

The key stakeholders with interests in some or all of the project components are likely to be:

- the Australian Government Department of the Environment, Water, Heritage and the Arts (DEWHA)
- the South Australian Environment Protection Authority (SAEPA)
- Primary Industries and Resources South Australia (PIRSA)
- the South Australian Department of Water, Land and Biodiversity Conservation (DWLBC)
- the South Australian Department for Transport, Energy and Infrastructure (DTEI)
- other State Government service providers (i.e. health, education, law enforcement)
- The Northern Territory Department of Natural Resources, Environment, The Arts and Sport (NRETAS)
- the South Australian Natural Resources Management (NRM) Board
- the Great Artesian Basin Consultative Committee
- the Pastoral Board
- Roxby Downs and Woomera Community Boards, and Andamooka Progress and Opal Miners Association
- Flinders and Outback Community Consultative Groups
- non Government Organisations (e.g. South Australian Conservation Council)
- Roxby Downs Council
- the communities of Roxby Downs, Woomera, Andamooka, Marree, William Creek, Port Augusta, Whyalla, Port Pirie and Darwin.
- pastoral communities
- Olympic Dam employees, contractors and suppliers
- Aboriginal groups
- the fishing industry
- Arid Recovery partners (the SA Department for Environment and Heritage, the University of Adelaide and the Friends of Arid Recovery).

Similar to the process followed for developing the current closure plan, stakeholders would be consulted regularly during the development of the Olympic Dam Rehabilitation and Closure Plan.

23.5 REHABILITATION AND CLOSURE CRITERIA

Closure criteria are based on the post-operational land use objectives following consultation with stakeholders. The progress and success of closure and rehabilitation can be assessed against these qualitative or quantitative measures.

The current rehabilitation and closure plan details the closure criteria for the existing operation. These criteria would be updated to include the expanded mine components when the detailed plan for the expanded mine is prepared.

Table 23.1 provides a summary of rehabilitation and closure objectives and the measures against which these objectives would be assessed.

23.6 DESIGN FOR CLOSURE

Mine closure was considered during the design of facilities for the proposed expansion (see Chapter 5, Description of the Proposed Expansion). Careful consideration was given to the layout and design of the mine components so that the risk of adverse environmental and social impacts after closure would be minimised. Examples of design considerations that would assist in improving closure outcomes are:

- designs that minimise the footprint of key project components by maximising the height of the TSF and RSF; placing the RSF, TSF and landfill in adjacent locations; and avoiding the need for additional tailings evaporation ponds
- incorporating appropriate safety factors in the designs of the TSF and RSF so that long-term physical stability is ensured
- careful planning of where potentially reactive rock material would be placed in the RSF to ensure that the risks associated with hazardous leachate, or exposure of reactive material were minimised.

23.7 PROJECT COMPONENTS AT YEAR 40

The Draft EIS assesses the proposed expansion to Year 40. It is therefore relevant to consider the status of project components at Year 40 as an interim stage prior to their final closure. A conceptual representation of the mine at Year 40 and after final closure is shown in Figure 23.1. Consistent with the closure strategy, numerous project components would have been progressively rehabilitated and closed by Year 40. The status of major project components at Year 40 would be as follows:

- the footprint of the open pit, RSF and TSF would be as shown in Figure 23.1
- the depth of the open pit would be about 1 km and a lake in the base of the pit would not yet have formed
- the RSF would have reached its design height, but the haul truck access passes would not yet have been re-contoured
- the TSF would have reached its design height and some cells would have been capped
- infrastructure associated with Roxby Downs, Hiltaba Village, the airport, rail spur and metallurgical plant would still be in place.

Table 23.1 Summary of closure objectives and performance measures

Aspect	Objective	Measure
Safety	Zero harm to members of the public	No preventable injuries or deaths occur
Landform stability	The waste landforms (RSF and TSF) remain stable over the long term Stability of rehabilitated sites is consistent with adjacent terrain Edges of the open pit are left in a stable condition	No exposure of hazardous materials occurs No evidence of subsidence around the edge of the open pit at closure
Groundwater	Minimise leachate entering the groundwater by covering the TSF and RSF with suitable non-reactive material Beneficial uses of groundwater and groundwater dependent ecosystems are protected	No mounding of groundwater above 80 m AHD Yet to be defined, but would be determined in the context of Schedule 2 of the Environment Protection (Water Quality) Policy 2003, and either an attenuation zone, or an amendment to the environmental value of the hyper saline groundwater body beneath Olympic Dam
Terrestrial ecology	Minimal risk of contaminated surface water harming fauna (particularly birds)	No adverse effects on fauna (particularly birds)
Soil contamination	Soil quality is compatible with final land uses after closure	Schedules B(4), B(5) and B(6) of the National Environment Protection (Assessment of Site Contamination) Measure 1999, relating to effects on human health, ecological receptors and groundwater, respectively
Visual amenity	Rehabilitated sites mimic regional terrain The open pit (which would not be filled) becomes a tourist attraction	None
Dust	Dust generation from the closed operation does not cause harm	Comply with OH&S dust limits Comply with NEPM limits for public exposure
Radiation	Exposure to gamma radiation, radionuclides in dust, and radon and its decay products do not cause harm to the public or biota	Comply with OH&S radiation limits (<1 mSv/a to members of the public) Radiation exposure is consistent with the as low as reasonably achievable (ALARA) principal
Rehabilitation	Rehabilitation of operational sites occurs progressively and results in landforms that are consistent with adjacent terrain or the final land use	Rehabilitation of sites occurs as soon as reasonably practical.

23.8 OUTLINE OF PROPOSED REHABILITATION AND CLOSURE STRATEGY

Revision of the current Olympic Dam Rehabilitation and Closure Plan to include the proposed expansion would begin once the expansion received approval and the detailed design phase of the project was completed.

This section outlines a conceptual strategy for achieving the rehabilitation and closure objectives identified in Table 23.1 for each of the main project components. This section focuses on the high-priority environmental issues.

23.8.1 OPEN PIT

The void created by the new open pit mine would remain as a permanent land feature. As discussed in Chapter 11, Surface Water, modelling of water into the pit suggests that a lake, about 100 m deep, would form in the pit about 100–200 years after closure if the works in the open pit finish at Year 40. The lake would ultimately reach a depth of about 350 m about 3,000 years after closure. The modelling suggests that there would be no risk of pit water flowing into and contaminating regional aquifers. The modelling also suggests the water in the pit lake would be near neutral (i.e. pH 7.8 eventually reducing to 7.3), be hyper-saline, and that a gypsum crust would eventually form over the surface of the lake (about 3,000 years after closure). The pit water would contain a variety of salts and a wide range of concentrations of metals (see Section 11.5.4 for details).

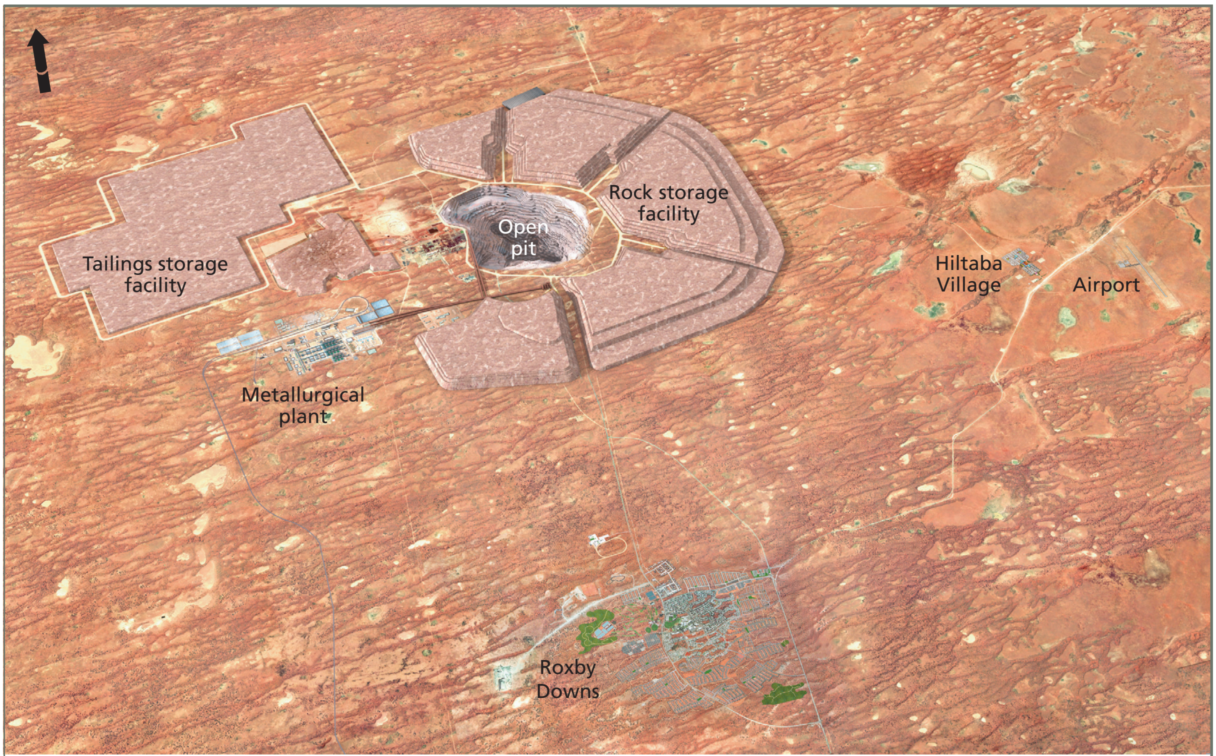
During the operation phase of the mine, the quality of water entering the pit would be monitored regularly so that the results of the pit hydrology and limnological modelling could be validated and/or further refined.

It is inevitable that the edges of the pit would gradually erode and subside. Although the stability of the pit edges after closure is considered to be low priority from an environmental perspective, it could affect public safety. Consequently, geotechnical studies would be conducted during the latter stages of operation to determine the potential for surface subsidence around the perimeter of the open pit.

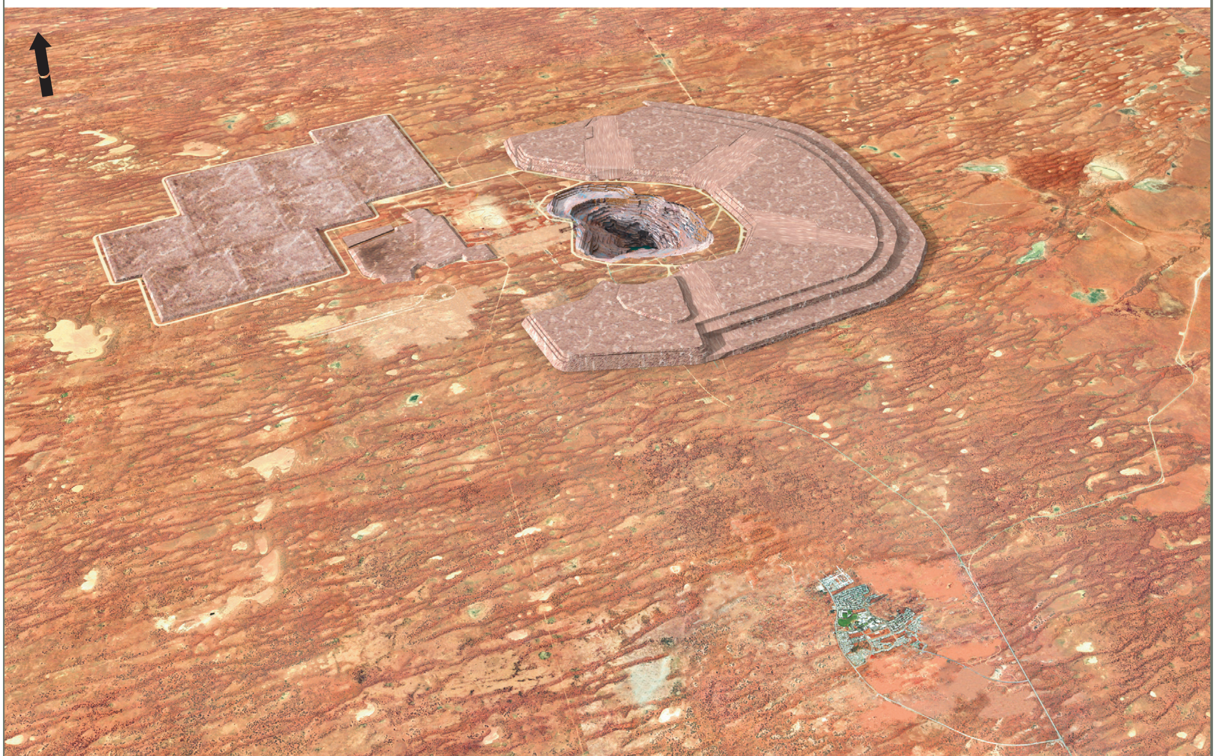
Potential post closure land use

The proposed options for how land would be used post closure include:

- vacant crown land, to which access by members of the public and livestock would be restricted
- a research and education site for geological, environmental and engineering disciplines
- a managed and regulated tourist attraction.



AT 40 YEARS



POST CLOSURE

Figure 23.1 Conceptual representation of the mine at 40 years and post closure

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It is expected that the South Australian Government would be responsible for the land, including, if relevant, the maintenance of viewing platforms and access to the pit by tourists, scientists and students.

Safety

The following measures would be adopted to reduce safety risk to the public:

- geotechnical studies would be conducted during the latter stages of the operation to determine the potential for surface subsidence around the perimeter of the open pit and to determine the safety exclusion zone
- based on these studies, an abandonment bund and/or fencing would be constructed around the perimeter of the pit outside the zone of potential pit-wall subsidence. This would restrict public access to the edge of the open pit. Access through the bund to a viewing platform would be provided if tourism was to be encouraged
- access roads and tracks in and around the open pit would be ripped to prevent or limit ease of use. One access track to the viewing platform would be maintained if it was decided that tourism was to be encouraged
- signs warning the public of exposure to radiation and possible subsidence would be erected around the edge of the open pit.

Wildlife

Wildlife, particularly birds, could be attracted to the lake within the open pit after closure. The lake is not expected to attract large numbers of birds, however, because the temperature within the pit would be high (up to 10 °C above ambient), and the pit lake is unlikely to support aquatic food. Although the quality of the pit water would be relatively poor (i.e. saline to eventually hyper-saline), the water quality model indicates that it would not be toxic to fauna (see Appendix J2).

23.8.2 ROCK STORAGE FACILITY

The RSF would remain as a permanent landform that would resemble natural mesas near Coober Pedy and Port Augusta (see Chapter 20, Visual Amenity).

Potential post closure land use

Potential uses of the RSF post closure include:

- vacant Crown land to which public and livestock access would be restricted
- a managed and regulated tourist attraction, which the public would be encouraged to visit
- further mining and processing, should metal prices reach levels that make it economically viable to recover the low grade ore stockpiled separately.

Stability

The long-term stability of the RSF is essential to ensure the reactive material is permanently contained within a benign outer layer. The following measures would be used to minimise the risk of erosion that may otherwise release reactive material into the environment (see Chapter 5, Description of the Proposed Expansion, for details):

- no reactive material would be stored under outer slopes
- outer slopes would be constructed using coarse material (Class C or D mine rock such as durable sandstone, quartzite and limestone) that would be resistant to erosion by run-off and wind
- the outermost slopes would be left at their constructed slope angles (30–37°) to minimise the length of slope that would be susceptible to erosion
- the upper surfaces would be covered with a coarse mulch layer that is stable and resilient over time and counters the erosive effects of wind and water. It can be conducive to plant colonisation through provision of germination niches and favourable microclimates.

Seepage

The RSF would be designed to minimise seepage to, and the impacts on, groundwater (see Chapter 12, Groundwater). This would be achieved by:

- using non-reactive rock (Class C or D mine rock) to construct the outermost walls and covers
- using traffic to compact layers, which would reduce the infiltration of rainfall into the top of the RSF and movement of water through the RSF and into the groundwater system below
- including a traffic compacted layer of non-reactive rock at the base of the RSF
- selectively placing mineralised mine rock (Class A or B material) within the RSF to enable potential seepage to be managed most efficiently.

Radon emanation

The RSF would be designed to ensure that radon emanation from the facility was consistent with the 'as low as reasonably achievable' (ALARA) principle (see Appendix S). This would be achieved by:

- selectively placing mineralised mine rock (Class A or B material) within the RSF to enable it to be most efficiently enclosed by suitable non-reactive material (Class C or D material)
- enhancing the long-term stability of the facility (as discussed above) to ensure that the protective outer layer was not eroded.

Safety

The following measures would be implemented at the RSF to reduce safety risk to the public post closure:

- access roads and tracks adjacent to the RSF would be ripped to prevent access
- signs warning the public of exposure to radiation and possible rock falls would be erected around the edge of the RSF.

Rehabilitation

The low, unpredictable rainfall at Olympic Dam is the overriding factor that would influence rehabilitation of the RSF. Local mesas that generally support little vegetation except in drainage lines around their bases (see Plate 20.9) provide a guide to the level of vegetation that may be expected on the RSF. In light of these limitations, the general rehabilitation strategy for the RSF would be:

- topsoil containing viable seeds of appropriate plants associated with the foot-slopes of rocky hills may be used at strategic locations (e.g. around the base of the RSF) to promote the natural regeneration of vegetation
- seeds of appropriate native (local) species would be spread at strategic locations to take advantage of rain events (see Appendix T2 for details of suitable species). A high proportion of hard or dormant seeds may be appropriate so that seeds could survive until favourable rainfall events. The choice of species would be influenced by soil properties such as pH, salinity, water retention and plant-available water (Jasper and Braimbridge 2006)
- the steep rocky slopes would be innately resistant to erosion and would not require revegetation to enhance stability
- establishing nodes of suitable native vegetation on 5–10% of the top of the RSF may provide a seed source that would enhance the creation of a self-sustaining system (see Appendix T2 for details of suitable species)
- at some locations, mechanical seeding would be the most appropriate technique for applying seed. Mechanical seeders may be mounted on a bulldozer with a multi-shank ripper box, enabling a one-pass operation that contour-rips, seeds and fertilises
- dominant local trees such as the Cypress-pine and Mulga may be established within depressions, drainage lines or gullies at the base of batter slopes.

23.8.3 MINING FACILITIES AND HAUL TRUCKS

Potential post closure use

Potential uses of the metallurgical plant post closure include research and education, tourism, and further mineral processing if the mining of ore from the RSF or TSF occur. If the plant is decommissioned, the site may revert to stock pasture or become vacant Crown land. A future use of at least some of the haul trucks, once decommissioned, may be as a tourist exhibit, possibly near the open pit.

Achieving closure objectives

The potential use of the metallurgical plant for research, as an educational facility or for tourism, would be investigated prior to closure. The inclusion of haul trucks as part of the tourist facility would be considered. If none of these were feasible, the facilities (including haul trucks) would be decommissioned and demolished. Reusing the assets and recycling redundant material would be a priority during decommissioning. Redundant material would either be removed from the site by rail (if benign) or buried on-site in an appropriate facility, i.e. within the RSF, TSF or landfill facilities.

Contaminated soils associated with process ponds and other work sites would be assessed and remediated as specified in the amended site contamination provisions (2007) of the *Environment Protection Act 1993*, the National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPC 1999), and other relevant legislation that addresses contamination.

All surfaces would be recontoured and deep ripped to facilitate natural revegetation.

23.8.4 TAILINGS STORAGE FACILITY

Potential post closure land use

The TSF would remain as a permanent land feature, resembling a low mesa to blend in with the surrounding landscape (see Chapter 20, Visual Amenity). Potential uses of the TSF post closure include:

- further mining, if metal prices reached levels that made extraction of the residual metals from the tailings economically viable
- vacant Crown land from which stock would be excluded.

Stability

Tailings are reactive and would, therefore, be indefinitely encapsulated within erosion resistant earthworks. Design measures to promote the long-term stability of the TSF would include (see Chapter 5, Description of the Proposed Expansion, for details):

- armouring the outermost rock on slopes and top surfaces with durable rock to protect the slopes from erosion (preferably limestone or durable sandstone/quartzite)
- leaving the outer embankments of the TSF at their angle of repose to minimise the length of slope that would be susceptible to erosion
- possibly providing specially armoured sections of the TSF wall, such as valley release structures, to accommodate run-off from extreme storm events
- covering the upper surfaces with a coarse mulch layer that is stable and resilient over time and counters the erosive effects of wind and water.

Seepage

Tailings associated with the proposed mine expansion would be expected to have similar properties to those currently produced at Olympic Dam. The tailings contain 70–80% of the radioactive material associated with the original ore. The tailings liquor is acidic and contains dissolved metals (including copper and uranium). Groundwater monitoring associated with the existing TSF has demonstrated that the calcareous clays and limestone beneath the facility neutralise the tailings seepage to a large extent, resulting in a large proportion of the metals precipitating and becoming immobile (see Chapter 12, Groundwater). Natural attenuation would continue to occur post closure.

Management measures adopted in the design of the TSF to minimise seepage are discussed in Chapters 5, Description of the Proposed Expansion; 12, Groundwater, and Appendix F1. The following measures would be adopted to minimise potential seepage into groundwater from the TSF post closure:

- tailings cells would be capped when they reached their target design height, and when it was safe for vehicles to access the TSF surface (i.e. when the tailings are sufficiently dry)
- rainfall infiltration into the tailings would be minimised by constructing a low permeability capping layer
- the most suitable cover would be defined by future test work.

Radon emanation

Monitoring radon and radon decay products on and adjacent to the existing TSF has shown that radon is dispersed and diluted by local air movement to very low levels within a short distance (WMC 2004). Similar dispersion and dilution of radon would be expected with the expanded TSF. Nevertheless, the following measures would be implemented to minimise radon emanation after closure:

- the surface of the TSF would be capped with sufficiently thick benign material (nominally 0.5 to 1.5 m, depending on the type material)
- the cap would be covered with a layer of coarse rocky material to ensure it resisted erosion by wind and water
- the details of the most suitable cap would be defined by future test work, when volumes of rock were available from the open pit.

Safety

The following measures would be implemented at the TSF to reduce safety risk to the public post closure:

- the facility would be capped with sufficiently thick benign material to minimise the potential exposure of the public to acidic liquor and radiation
- access roads and tracks adjacent to the TSF would be ripped to restrict access
- a fence would be constructed around the base of the TSF to prevent vehicle and stock access
- signs warning the public of exposure to radiation and possible rock falls would be erected around the edge of the TSF.

Dust

Dust emissions from the surface of the TSF would be minimised by an outer layer of rock armouring. The proposed cap for the TSF would probably consist of a low-permeability layer on top of the facility. This layer would be further defined through future test work. The cap would be covered with a layer of coarse rocky material to ensure it resisted erosion by wind and water. The surface would be similar to the natural gibber plains that are highly resistant to erosion.

Vegetation would not be established on the TSF surface to further minimise dust emissions because there is a possibility it would take up metals (see below for details).

Metal uptake by vegetation

After closure, vegetation growing on the TSF may take up metals, which would expose native fauna and stock to risk when grazing (SRK Consulting 2005). The degree of metal uptake depends on the extent of root penetration into the TSF surface, and the concentration of metals in the root zone of plants. This may be alleviated somewhat by high metal concentrations being accompanied by high salt concentrations, which would tend to discourage root growth and, as a consequence, restrict metal uptake (Golder Associates 2003; SRK Consulting 2005).

The risk of vegetation taking up metals would be minimised by discouraging vegetation regrowth on the TSF through creating a surface on the TSF that is not conducive to plant growth.

Rehabilitation

The early concept of rehabilitating the existing TSF at Olympic Dam was to establish a gibber-type tableland, with the surface covered in a grassland and chenopod-dominated shrubland and the walls covered with chenopod shrubland with occasional low woodland species (Kinhill 1997). As discussed above, subsequent studies have suggested that establishing vegetation on the TSF is inappropriate due to the potential for the vegetation to take up metals. It is more likely, therefore, that revegetation of the TSF surface would be discouraged.

A detailed rehabilitation plan for the TSF would be developed when the design of its cover had been completed. Conceptual designs are provided in Appendix F1, and include the following.

- the most appropriate form of rehabilitating the TSF would be investigated further during the operation phase when research trials and performance monitoring would occur. Suitable materials for use in rehabilitation would be defined and stockpiled, if necessary, as mining progressed.
- the TSF cells would be rehabilitated as each cell reached the end of its operational life. This would manage dust, surface water and radon emanation.

- final rehabilitation plans would be prepared during the lead-up to closure, as large quantities of mine rock would be available to construct the features required to manage environmental risks associated with closure.

23.8.5 ROXBY DOWNS, OLYMPIC DAM VILLAGE AND AIRPORT

Potential post closure use

The use of land post closure would be determined by consulting with relevant stakeholders, including the local government authority, the Roxby Downs and Andamooka communities and the South Australian Government. Olympic Dam Village and the existing airport would ultimately be covered by the RSF. The new airport would probably be wholly-owned by BHP Billiton, and post closure land use would be determined in consultation with the above stakeholders.

Roxby Downs and the new airport may be used as a regional centre for research, education, tourism and mining, or a combination of all of these. If the town and new airport were no longer viable, the land would be used for stock pasture or as vacant Crown land.

Achieving closure objectives

When Olympic Dam Village and the existing airport are decommissioned and relocated during the operation phase, reusing as much of the infrastructure as possible when developing the new Hiltaba Village, heavy industrial area and the new airport would be a high priority.

The potential use of Roxby Downs and the new airport would be investigated prior to closure of the mine. If the town was economically viable without the mine, much of the existing infrastructure within the town and the airport would continue to be used.

If the town was not economically viable after closure of the mine, however, the infrastructure owned by BHP Billiton, including components of the town and airport, would be decommissioned and removed. Reuse of the infrastructure wherever possible at other regional centres such as Andamooka, Woomera or Coober Pedy would be a priority. Surfaces would be re-contoured, deep ripped and revegetated.

23.8.6 HILTABA VILLAGE

Potential post closure land use

Hiltaba Village could be used for accommodation, research laboratories and as education and/or training facilities post closure. If decommissioned, however, the site would revert to pastoral use.

Achieving closure objectives

At mine closure, as much of the Hiltaba Village infrastructure as possible would be sold and reused and/or recycled in and around Roxby Downs, Andamooka and regional centres. All redundant material would either be removed from the site or buried at Olympic Dam in an appropriate facility. Surfaces would be re-contoured and deep ripped to facilitate natural revegetation.

23.8.7 DESALINATION PLANT

Potential post closure use

The desalination plant could continue to supply potable water to the Eyre Peninsula, the Upper Spencer Gulf region and other areas. As a modular construction method would be used, part of the desalination plant could be decommissioned if the demand for water was less than its full capacity. If it was fully decommissioned, the site would become available for other industrial uses if it remained zoned as industrial land.

Achieving closure objectives

At mine closure, alternative markets would be investigated for the water produced at the desalination plant. These may include Whyalla, Port Augusta and Port Pirie. If the desalination plant was partly or fully decommissioned, as much of the infrastructure as possible would be sold and/or reused. All redundant material would be removed from the site and disposed of at a licenced landfill site. If no further industrial use occurred, surfaces would be re-contoured and deep ripped to facilitate natural revegetation. Buried infrastructure, such as the intake and outfall pipelines, would remain in the ground or under the seabed.

23.8.8 WATER SUPPLY PIPELINES

Potential post closure use

The water supply pipelines include the existing pipes from the Great Artesian Basin (GAB) to Olympic Dam, and the proposed water supply pipeline from the Point Lowly desalination plant to Olympic Dam. The latter may continue to be used to supply water to regional centres in northern South Australia, but it is less likely that the lines from the GAB wellfields would continue to be used.

Decommissioned pipeline easements would revert to pastoral use.

Achieving closure objectives

Prior to mine closure, future use of the water pipelines would be investigated. If none was identified, the pipelines would be decommissioned. All above ground infrastructure would be removed and recycled, or removed to an appropriate landfill site. Buried infrastructure would remain in the ground.

23.8.9 WELLFIELDS

Potential post closure use

The Great Artesian Basin (GAB) and Motherwell wellfields include numerous groundwater wells and associated diesel pumps. Although some of the GAB wells may continue to be used to supply water for stock, it is less likely that any of the Motherwell wells would continue to be used as the water is very saline. Wells would be decommissioned in accordance with Department of Water, Land and Biodiversity Conservation (DWLBC) licence conditions.

Achieving closure objectives

Prior to mine closure, future use of the wellfields by local pastoralists or other mining ventures in the region would be investigated. If none was identified, the wells would be plugged with concrete and abandoned. All above ground infrastructure would be removed and recycled or removed to an appropriate landfill site. Buried infrastructure would remain in the ground.

23.8.10 ENERGY INFRASTRUCTURE

Potential post closure use

Post closure, the power station, gas supply pipeline and transmission lines could continue to supply electricity to industries and towns in northern South Australia, or could convey electricity (possibly even from future geothermal or solar sources) to the NEM. If decommissioned, the power station site and transmission line and gas pipeline easements would revert to existing land uses, which may include pastoral land use or conservation.

Achieving closure objectives

Before the mine closes, alternative uses for the power station, gas supply pipeline and transmission lines would be investigated. If none were identified, the infrastructure would be decommissioned. The power station and transmission line infrastructure would be dismantled and reused or recycled. All above ground infrastructure associated with the gas pipeline would be removed and recycled or disposed of in an appropriate landfill site. Buried infrastructure would remain in the ground. All infrastructure sites would be recontoured and access tracks ripped and revegetated.

23.8.11 RAIL LINE

Potential post closure use

The rail spur to Olympic Dam could continue to be used for goods/tourist transport to Roxby Downs and Woomera. If it was to be decommissioned, it would be one of the last infrastructure components removed as it would be used to transport other benign and redundant materials from the closed Olympic Dam operation. The rail easement would ultimately revert to pastoral land use.

Achieving closure objectives

Prior to mine closure, future use of the rail line would be investigated. If none was identified the rail line would be decommissioned, and all infrastructure removed and recycled or removed to an appropriate landfill site. The rail embankments would be ripped and revegetated.

23.8.12 PORT AND LANDING FACILITIES

Potential post closure use

The port facilities at Port Adelaide, Outer Harbor and the Port of Darwin would probably continue to be used as port facilities and/or as industrial sites by other commercial enterprises. Similarly, the landing facility may continue to be used as a landing for future mining or other enterprises in the region. Alternatively, the pier may be transferred to the South Australian Government for use by the public.

Achieving closure objectives

Prior to mine closure, future uses of the port and landing facilities would be investigated.

At the Port of Darwin, one important component of closure would be to investigate radionuclide contamination at the site, and take measures during rehabilitation, if necessary, to ensure that potential public exposure to radionuclides were within prescribed limits.

If no future uses for the port and landing facilities were identified, the facilities would be decommissioned. All infrastructure would be removed and recycled, or removed to an appropriate landfill site. The sites would be rehabilitated to a condition consistent with post-operational land uses, as agreed with stakeholders.

23.8.13 UNDERGROUND OPERATION

Potential post closure use

It is most likely that the open pit mine would extend beyond the 40–year life assessed in the Draft EIS and progressively mine out the underground operation.

Achieving closure objectives

Prior to mine closure, future uses for the underground facilities would be investigated. If none were identified, the underground facilities would be decommissioned. The existing Closure Plan for Olympic Dam describes in detail how the underground facilities would be decommissioned. The main elements of the plan are as follows:

- subsidence risks would be investigated and addressed, if deemed necessary, by backfilling high-risk shafts with cemented aggregate fill (CAF)
- all surface infrastructure would be removed and recycled, or removed to an appropriate landfill site
- all underground infrastructure would be removed if recyclable, or left in situ
- the Whenan shaft, portals and raise bores would be sealed with pre-cast concrete
- soil would be mounded over the concrete seals
- the site would be recontoured to reinstate natural contours and drainage lines, deep-ripped and allowed to naturally revegetate.

23.9 REHABILITATION AND CLOSURE PROCESSES

23.9.1 MATERIALS MANAGEMENT

Mine rock

The physical and geochemical properties of the rock materials that would be generated during the mining operations were characterised as part of mine planning. Cores were analysed in a comprehensive drilling program, and a mine plan that achieved the selective placement of Class A to D material was developed (see Chapter 5, Description of the Proposed Expansion).

The waste properties that determine rehabilitation strategies include acidity, salinity, sodicity, erodibility, particle size distribution, strength, water-holding capacity and hydraulic conductivity, acid-generating potential, and nutrient and metal availability (Jasper and Braimbridge 2006). Mine rock would be placed in the RSF according to:

- chemical toxicity (e.g. acid-formation, excess metal availability, salinity)
- susceptibility to erosion (e.g. particle size distribution, structural stability, sodicity)
- capacity to support plant growth (e.g. soil permeability, ability to retain water, nutrients).

The rehabilitation plans for the RSF and TSF would be updated as more information about the characteristics of the mine rock was gathered during the operation phase of the mine.

Topsoil and vegetation

A management plan would be prepared to guide the reuse of topsoil (including sand) and cleared vegetation at sites where revegetation was an appropriate rehabilitation objective.

Topsoil and cleared vegetation would be managed as follows:

- opportunities for topsoil and vegetation to be stripped and immediately respread on rehabilitated surfaces, or stockpiled as close as possible to the site where they would be respread, would be investigated as the mine plan was refined, and implemented where practicable
- vegetation would be spread over the surfaces of topsoil stockpiles to provide surface protection and a seed source. Regrowth of vegetation on stockpiles would be encouraged
- topsoil stockpiles (planned for reuse within 1–2 years) would be designed to harvest rainfall and encourage continued biological activity within the soil; as such they would be as low as possible (with a target height of about 1 m)
- harvested topsoil and vegetation would be reused as soon as possible after stockpiling
- where large volumes of topsoil have to be stockpiled, and reuse within 1–2 years is not feasible, stockpiles would be higher than 1 m to reduce the area of stockpiles to a practical size. Before reuse, such topsoil would require the addition of seed and fertiliser as some degree of soil sterilisation would inevitably have occurred during stockpiling.

23.9.2 REVEGETATION

Surface and soil preparation

The success of revegetation would be significantly enhanced if the soil surface was prepared appropriately, particularly in relation to water and nutrient harvesting, and the trapping of seed. Treatment of soil surfaces used to promote vegetation growth would include:

- the removal of soil compaction by ripping with winged ripping tynes, or cultivating with tyned instruments or scalloped discs on flatter areas with lighter, deeper soils
- respreading topsoil evenly over the disturbed area to a depth of 5–10 cm
- respreading cleared vegetation over disturbed surfaces.

Reconstruction of soil profiles

Reconstruction of appropriate soil profiles to support regrowth of native vegetation would be an important part of rehabilitation at some sites affected by the mine expansion. At sites where wastes hostile to plant growth may be covered, reconstruction of a soil profile would include topsoil (5–10 cm), and benign mine rock from the cover sequence, which would be used to form a growth medium to accommodate root growth and store water.

Seed and seedling stock

Large quantities of high quality native seed would be required to help rehabilitate particular mining and residential development sites. Suitable species would be those with seeds that could be collected in large quantities, were relatively straightforward to process and store, had defined treatments for dormancy release, and were recognised as coloniser species or generalists. Techniques for seed collection, treatment and storage are outlined in Appendix T1. A list of plant species that may be important in re-establishing vegetation on disturbed areas at Olympic Dam is included in Appendix T2.

BHP Billiton would work closely with suitable contractors to establish a seed collection, treatment and storage program to support rehabilitation initiatives at Olympic Dam. One aim of the program would be to ensure that contractors acquired and stored sufficient native seed during favourable seasons.

Large quantities of native tube stock would also be required to provide selected species for planting in high value areas such as Roxby Downs.

BHP Billiton would support the Australian Arid Lands Botanic Gardens at Port Augusta to manage the provision of both native seed and tube stock for rehabilitation and revegetation programs at Olympic Dam.

Revegetation techniques

In most cases, disturbed areas would be allowed to revegetate naturally, although in some areas direct intervention to promote revegetation would be needed. The methods used would include the following:

- mechanical seeders would be used to apply seed to large areas of freshly ripped material, with hand seeding for small areas
- tube stock may be used for vegetation establishment on a small scale in areas of high importance such as Roxby Downs, or where it was necessary to establish rare flora species that were difficult to establish from direct seeding
- fauna habitat would be created as appropriate in rehabilitated areas, using rocks or vegetation debris
- the presence of weeds at rehabilitated sites would be monitored by environmental staff or suitable contractors. If they were found, control measures would be implemented
- if grazing was adversely affecting revegetation, its impact on rehabilitation would be minimised by fencing rehabilitated areas temporarily.

23.9.3 CONTAMINATED LAND

Rehabilitation of contaminated land would be consistent with the National Environment Protection (Assessment of Site Contamination) Measure 1999. Accordingly, a tier based assessment of risks associated with contaminated land would be undertaken to screen potential risks to human health, ecological receptors and groundwater. The outcomes of the risk assessment would determine the most appropriate level and type of rehabilitation of contaminated sites. Rehabilitation approaches would be likely to include removal of contaminated soil to an appropriate treatment and disposal facility, *in situ* treatment, burying and capping on-site, encapsulating in an engineered cell, or do-nothing, depending on the assessed level of risk.

23.10 CLOSURE COSTS

Closure cost estimates for the major project components are being developed within the economic model for the mine expansion. Demolition costs were assumed to be a percentage of the capital construction costs (often 10%, but ranging from about 2% to 20% depending on the item).

In developing the closure costs, it was assumed that mine closure costs would be incurred for demolition and rehabilitation activities scheduled to commence immediately after mining stopped. Demolition and rehabilitation activities that take place throughout the mining operation (e.g. progressive tailing rehabilitation) were considered as an operational cost.

More detailed cost estimates would be developed as part of the Closure Plan that would be produced if the mine expansion was approved. The closure costs would be reviewed regularly during the life-of-mine.

BHP Billiton would make an accounting provision each year for the future rehabilitation and closure of the mine.

23.11 RISK ASSESSMENT FOR CLOSURE

Risks associated with closure were assessed according to the BHP Billiton Group Risk Management Standards. A risk register was developed, reviewed and validated (see Chapter 26, Hazard and Risk and Appendix C). The assessment identified controls and responsibilities to prevent or mitigate each risk event and produced a residual risk rating for each risk event. The level of each closure risk was considered to be acceptable.

The most significant post closure risk identified during the risk assessment was the failure (via erosion) of the RSF and TSF side walls and cover such that reactive material was carried by run-off into the surrounding environment. BHP Billiton would therefore investigate, design, build and maintain structures that would contain reactive material indefinitely and have the least likelihood of failure. The risk would be reduced by ensuring that rehabilitation of disturbed areas and waste landforms occurred progressively, thereby ensuring stability, and control of emissions to the air and land.

Risk assessment for closure would be an ongoing process during the operational life of the project.

23.12 MONITORING AND RESEARCH

The Olympic Dam Rehabilitation and Closure Plan is updated regularly to ensure that the proposed practices are consistent with the most up-to-date knowledge and technologies. All operations of the BHP Billiton Group are committed to continual improvement through an ongoing program of monitoring and research in closure technologies and leading practices.

The following sections outline the monitoring and research areas that would occur during the operation phase of the expanded Olympic Dam mine and provide additional information to help refine the rehabilitation and closure plan. The projects below would be incorporated into the Olympic Dam environmental management plans as discussed in Chapter 24, Environmental Management Framework.

23.12.1 PIT WATER QUALITY AND QUANTITY

The quantity and quality of water entering the pit during the operation phase of the mine would be monitored regularly. This data would enable the results of the modelling to be refined, resulting in refined predictions about the quantity and quality of pit water after the mine had been closed (see Chapter 11, Surface Water for details).

23.12.2 ROCK STORAGE FACILITY AND TAILINGS STORAGE FACILITY REHABILITATION TRIALS

During the first five to 10 years of the mine expansion, BHP Billiton would undertake trials to determine the optimal surface and slope designs for the waste landforms to ensure that:

- the landforms resisted erosion and reactive material remained enclosed permanently
- emission of radon gas to the atmosphere were consistent with the 'as low as reasonably achievable' (ALARA) principle (see Chapter 22, Health and Safety and Appendix S)
- infiltration and attenuation of contaminated leachate into the groundwater, or from the toe of the landforms, was minimised.

23.12.3 OPTIMISING REVEGETATION AND REHABILITATION

A revegetation research program would be developed as part of the overall rehabilitation plan for the Olympic Dam operation. It is anticipated that the research program would include investigating the suitability of particular species for specific revegetation purposes and soil treatment strategies to promote revegetation across the mining lease.

Areas of the SML, such as sections of the RSF outer walls, would be made available during the early years of the mine expansion to refine vegetation establishment techniques and quantify plant performance.

23.12.4 METAL UPTAKE BY VEGETATION

In the longer term, it is inevitable that vegetation would re-establish on the waste landforms, either naturally, or through active revegetation programs. The potential for uptake of metals by vegetation growing on the TSF is currently unknown because none of the existing facilities have been decommissioned and rehabilitated. Part of the landform surface trials discussed earlier would be to investigate the potential uptake of metals by vegetation growing on the landforms. A section of each of the trial landform surfaces would be revegetated with a range of endemic plant species, including deep-rooted woody shrubs. Controls would consist of the same plant species growing on identical surface material placed over benign rock. Metal levels within the plant leaves and fruit would be monitored over the course of the trial.

23.12.5 LONG-TERM MONITORING

Monitoring programs, using appropriate criteria or indicators, would be established during the operation phase of the mine to determine whether closure criteria had reached for sites that were being progressively rehabilitated. The monitoring program would include assessing:

- the stability of the RSF and TSF
- groundwater quality in the vicinity of the RSF and TSF
- dust and radon emissions from the RSF and TSF
- the performance of constructed surfaces in terms of water storage and deep percolation of incidental rainfall
- properties of the soil in relation to requirements for plant growth
- the structural attributes of the plant community
- the composition of the plant community
- selected indicators of ecosystem functioning.

The long life-of-mine at Olympic Dam provides the opportunity to monitor rehabilitated sites and assess the suitability and performance of rehabilitation techniques for sites such as the RSF and TSF. It is envisaged that ongoing monitoring of rehabilitation successes and failures at Olympic Dam would enable rehabilitation techniques to be refined and improved throughout the life-of-mine. It is assumed that, by the end of the mine's life, rehabilitation techniques would have been refined to such a point that achieving the closure criteria would be a routine occurrence. Post closure monitoring would therefore focus on assessing the achievement of the agreed closure criteria. In particular, monitoring of post mining impacts on beneficial uses of groundwater in the region would continue for an appropriate period to ensure that users of groundwater were protected from potential adverse effects.

Progress would be routinely audited and reported to government authorities in the annual environmental reports, as is currently the case.