20.0 Rehabilitation and Closure

20.1 Rehabilitation Objectives

The main objectives of the MRM rehabilitation program are to:

- Plan the placement of materials in a strategic manner to facilitate progressive rehabilitation and to minimise material handling costs.
- Conduct studies that will enable effective techniques to be implemented when carrying out rehabilitation.
- Carry out rehabilitation works that will, at the completion of the mining project, result in a stable, vegetated landscape having minimal impact on the surrounding environment.
- Carry out construction and rehabilitation works that will, at the completion of the mining project, result in stable stream channels having minimal impact on the surrounding environment.

The rehabilitation strategy will remain flexible and will be amended as new rehabilitation techniques emerge and as environmental investigations progress, or when MRM's Mine Management Plan is modified (refer Section 20.3.3). This will ensure the most appropriate technology is utilised as and when it becomes available. The rehabilitation of disturbed areas will be carried out progressively throughout the life of the mining project, consistent with operational requirements.

20.2 Rehabilitation Strategy

MRM maintains a strategy to ensure that rehabilitation will be sustainable and, where operationally practicable, undertakes ongoing rehabilitation and contaminated site remediation. Estimates of costs to remediate contaminated land and to close the operation have been made. Financial provision for rehabilitation and closure is reviewed on an annual basis.

To achieved the objectives above, MRM has established:

- An Unplanned and Life of Mine Completion Plan (LOM);
- Rehabilitation requirements, plans and timelines which are annually reviewed;
- Security and decommissioning life of mine costs which are calculated annually;
- Rehabilitation accrual which is annually reviewed;
- Post-mining land use objectives which are reviewed annually; and
- Rehabilitation trials to develop the site rehabilitation requirements and potential success of any rehabilitation programs.

20.2.1 Exploration and Surface Drilling

MRM continues to refine the knowledge of the resource and to develop the long-term viability of the operation. A key component of that strategy is surface drilling and exploration. Approximately 500 exploration holes remain above the ore-body and surrounds.

When exploration or surface drilling, MRM personnel adhere to Northern Territory legislative requirements as well as the mine's own Surface Drilling (Exploration) Procedure. Key components of the procedure are discussed below.

Capping and Plugging of Exploration Holes

Upon completion, all drill holes are permanently closed. They are either plugged with concrete or back filled using drill chips or concrete. The holes are then filled with dirt and mounded at the surface to prevent water ingress. The surface is then stabilised to minimise erosion.

Construction and Rehabilitation of Drill Pads, Sumps and Benches

The following are requirements for the construction and rehabilitation of drill pads, sumps and benches:

- The top layer of soil is separately removed from all sites and stockpiled for later re-spreading over the sites during rehabilitation operations.
- Drill pads, sumps and benches are constructed with a minimum of disturbance to the environment and rehabilitated in such a way as to promote revegetation and prevent erosion.
- Drill sumps are lined if they are to contain contaminated water so that seepage and erosion is prevented. If the drill material is placed into the sump it is covered with at least 0.5 m of inert material and then topsoiled.
- An MRM environmental representative visits all sites prior to rehabilitation to determine the requirements.
- All waste, including sample bags and drill cuttings, are removed and disposed of according to the site's waste management procedures.

Clearing and Rehabilitation of Gridlines and Tracks

The following strategies are applied to the clearing and rehabilitation of gridlines and tracks:

- Land clearance and disturbance is kept to a minimum at all times and undertaken as close to the construction period as possible.
- Wherever possible, clearing is undertaken by a front-end loader or a grader rather than a bulldozer.
- Clearing must be authorised by the environmental representative.
- A plan is developed for tracks prior to clearing to avoid environmentally and/or culturally sensitive areas.

- Topsoil is not removed unless authorised. Where topsoil is removed, it is stored and replaced at the time of rehabilitation.
- At the time of rehabilitation, if the surface of the grid line or track has become compacted or degraded or in areas where the topsoil has been substantially disturbed, the grid line is scarified or contour ripped to promote revegetation.

20.2.2 Progressive Rehabilitation

Mine Site

Progressive rehabilitation will be undertaken during the life of the mine as operations permit. Most opportunities for this will be at the overburden emplacement facility and the tailings storage facility. Details of the operational strategies for these facilities are given in Sections 7.2 and 7.4 respectively and closure strategies are outlined in Section 20.3.7.

Bing Bong Port Facility

The construction of the navigation channel and swing basin at Bing Bong resulted in marine spoil being placed on shore immediately to the south of the port infrastructure (Figure 3.2). The bulk of the spoil emplacement area lies outside Mineral Lease ML1126 and a Non-Pastoral Land Use Permit is in place for the management of the area.

The primary aims for rehabilitation of the spoil material are as follows:

- To accelerate the leaching of salt through the profile to enable establishment of vegetation.
- Achieve a stable revegetated landform.
- To encourage the process of natural revegetation on fine spoil material.

From initial rehabilitation trials, MRM has determined that the preferred method of rehabilitation is to internally drain the area to create ponds to increase infiltration and leaching of salts. This method has proved to be successful and 29 ha of dredge spoil areas have been rehabilitated since 1998. A further 63 ha has been classified as remnant vegetation, stable natural regeneration or fines spoil revegetation. These areas are stable and are revegetating successfully and do not require further disturbance with rehabilitation earthworks.

20.2.3 Revegetation Strategy

Development of revegetation strategies has been an ongoing component of MRM's rehabilitation activities. Various types of revegetation are required depending on the nature of the soil profiles to be covered. Extensive revegetation work has already been undertaken at the dredge spoil emplacement area at Bing Bong.

The soil profiles to be used in the rehabilitation program for the open cut operation will vary according to the underlying materials. A relatively simple soil profile will be used to support vegetation on weathered non-acid generating materials but a more complex profile will be required on contaminated sites such as the tailings storage facility or acid generating waste rock. In some locations, a rock mulch cover will be used in which case a vegetation cover may not be possible.

Vegetation trails will be undertaken to identify the most appropriate revegetation programs. The trials will be based on site experience to date and will include consideration of a variety of soil covers, fertiliser requirements, vegetation species and management techniques. A selection of native species and locally proven pasture species will be investigated. The following characteristics will be considered during the investigations:

- seed viability and plant vigour;
- establishment success;
- nutrient and water requirements;
- fire tolerance;
- growth rate;
- tolerance to noxious weeds or disturbed soils;
- ability to self propagate; and
- erosion protection
- potential as stock feed value, native fauna refuge and food source, and for local Aboriginal uses.

A major revegetation program is proposed for the realigned drainage channels. Details of this program are given in Section 13.2.2.

20.3 Mine Closure

20.3.1 Closure Policy

MRM Closure Policy is outlined as follows:

- “Progressively rehabilitate areas no longer required for efficient operation using the most practical methods.
- Communicate with our employees, the community, regulators and other stakeholders in relation to environmental and heritage (and associated cultural and social) issues.
- Operations are to maintain a strategy to ensure that rehabilitation will be sustainable and, where operationally practicable, carry out ongoing rehabilitation and contaminated site remediation. Each site is to develop a regularly reviewed life of operation rehabilitation and decommissioning plan that

includes estimates of costs to a) remediate contaminated land and b) close the operation. Financial provision for rehabilitation and closure is to be made and be recalculated on an annual basis."

In addition to its own corporate policy, MRM has adopted the Australian Minerals Industry Code for Environmental Management. This code states the following regarding rehabilitation and decommissioning:

- "Ensuring decommissioned sites are rehabilitated and left in a safe and stable condition, after taking into account beneficial uses of the site and surrounding land.
- Incorporate rehabilitation and decommissioning options in the conceptual design of operations at the feasibility stage.
- Develop clearly defined rehabilitation plans, monitor and review rehabilitation performance and progressively refine such plans.
- Determine and account for rehabilitation and decommissioning costs and periodically review their adequacy during the life of the operation.
- Establish a program of progressive rehabilitation commensurate with the nature of the operation and the rate of disturbance.
- Periodically review the rehabilitation and decommissioning strategies over the life of the operation to incorporate changing legislative requirements, public expectations and environmental and cultural heritage information.
- Address issues and programs related to long-term responsibility for land management in the final decommissioning plan."

20.3.2 Life of Mine Completion Plan

An Un-Planned and Life of Mine Completion Plan (LOM) (MRM, 2004) has been developed by MRM. This plan provides the costs and strategies associated with mine closure. It will continue to be developed with operational development and stakeholder consultation. In 2004, the plan's costs were reviewed and some modifications made, however the principles and costs have remained generally aligned to those that were originally developed.

The plan has been used to set long-term post-mining objectives for the MRM leases which can be incorporated into the operational mining phase to ensure that the best post-mining outcome can be achieved economically. The plan details options available for post-mining land use and the relevant financial requirements.

It also identifies the categories of disturbance and rehabilitation methods to be adopted for these categories, as presented in Table 20.1. Full details of the rehabilitation proposed are discussed in Section 20.3.7.

Table 20.1

LOM Disturbance Categories and Summary of Rehabilitation Methods

Category	Description	Rehabilitation Method
Decline and Vent Rises	Underground portals and surface structures associated with shafts for underground operations	Declines will be sealed with inert waste rock and the entrance and surrounds to the decline bunded. Vent raises will be removed and backfilled according to DBIRD specifications. Vent shafts are located in paddocks and therefore will be overlain with 100 mm of topsoil.
Underground workings and associated infrastructure	Underground workings	Part of the workings will be backfilled with overburden and the remainder will be left to fill with groundwater. All underground infrastructure that is not able to be recovered on a cost neutral basis will be buried *in situ*.
Contaminated Hardstand	E.g. Surface waste rock	Infrastructure is removed and areas with significant contaminated material, such as the processing area, secondary crusher area and workshops will be cleaned up by surface scraping of contaminant (and disposed of underground) and covered with 500 mm of inert material.
Uncontaminated Hardstand	E.g. Mill laydown area	An average of 200 mm of ungraded material placed over the surface. Areas, which are considered to be susceptible to erosion, will have 200 mm of rock material placed over the top. After infrastructure is removed, the areas are to be ripped, fertilised and seeded routinely. Some minor profiling may be required to improve stability (drainage).
Concrete or Bitumen Hardstand		Concrete pads will be evaluated to determine if there is potential for post mining use. Concrete to be decommissioned will either be removed or cracked and covered with 500 mm of ungraded material.
Chemical Contaminated Sites	E.g. Hydrocarbon storages	Contaminated sites will be covered with 500 mm of ungraded material. 200 mm of rock will be placed over ungraded material in areas susceptible to erosion. Vegetation will be established using routine established methods.
Roads	Sealed and unsealed roads	Roads will remain only at the request of the post-mining landowner. Roads around the tailings dam and mine site hardstand areas will remain and be compacted to provide a permanent firebreak. Bitumen roads around the camp and main road will be covered if not required.
Above Ground Infrastructure	E.g. Plant and administration buildings	All above ground structures (except the airport) will be dismantled and removed if there is no other post mining land use determined. The underlying ground will be assessed, remediated and rehabilitated as required.
Tailings Storage Facility	E.g. Cell 1 and water storage pond	The TSF will be rehabilitated according to the methods, which makes it the most stable over the long term, as this is the highest post-mining environmental risk. Measures to trial the differing potential scenarios will be undertaken throughout the mine life. The surface will be re-profiled and covered by a capillary layer and low permeability covering, then topsoiled and re-seeded.
Overburden Emplacement Facility		The OEF will be re-profiled, capped, topsoiled and revegetated.
Other Infrastructure	E.g. Power station and accommodation camp	Other infrastructure will be decommissioned and removed in consultation with government and other stakeholders.

20.3.3 Closure Criteria

Closure criteria for the site are aimed at reaching long-term stability of the site and the minimisation of off-site impacts. The completion criteria have been derived from MRM commitments, the generic set of closure criteria developed by the Department of Business Industry and Resource Development (DBIRD) as guidelines for the mining industry in the Northern Territory, and the approved MRM Bing Bong Relinquishment Strategy Report.

The Mine Close Out Criteria (DME, 2000) will be used to determine the success of the site's rehabilitation. They have been used as the basis for environmental and mine planning strategies outlined in MRM's Mining Management Plan. This plan aims to ensure that the site is left in a condition that reflects government and community expectations. This will be ascertained with the following specified criteria:

- Compatibility with agreed post-mining land use;
- Physical safety;
- Low risk to biota;
- Stability;
- Rubbish cleanup;
- Revegetated or otherwise improved;
- Visual amenity;
- Heritage and archaeological sites;
- Physical environmental sustainability; and
- Socio-economic sustainability.

MRM has developed indicators to measure progress in achieving the completion criteria for their existing operations in the LOM (MRM, 2004). These indicators will be modified to incorporate the application of the completion criteria to the open cut operations. Once this process has been undertaken, the modified plan will be submitted to DBIRD.

The above closure criteria are aimed at reaching long-term stability of the site and minimise off-site impact. A report on the progression towards mine closure criteria will be issued to stakeholders each year subsequent to decommissioning and a final report in year eight after rehabilitation completion.

The DBIRD Closure Criteria and the methods MRM proposes to adopt to demonstrate satisfaction of the criteria are presented in Table 20.2.

Table 20.2

DBIRD Closure Criteria and Corresponding Methods to Achieve Compliance

Compatibility with Agreed Post-Mining Land Use	
Criteria	**MRM Proposed Methods to Achieve Compliance**
Stable landform of native vegetation.	
	• Monitoring trends of vegetation structure, richness and cover via aerial photographic data and fieldwork. • Improving or stabilised plant cover will indicate whether a stable revegetated land surface has been achieved.
Criteria Physical Safety	
Excavations and subsidence to be rendered safe.	• Inspection to demonstrate all excavations are complete. • Geotechnical stability report. • Risk assessment will include subsidence however it is not expected. • Shafts rehabilitated in a safe and stable manner.
All drill holes, shafts, open cuts and other openings to be securely capped, filled or otherwise made safe.	• Inspection and expense records. • Drill sites capped will be mapped.
Access of people and livestock to be restricted as appropriate to site conditions.	• Agreed roads will remain and be maintained by the post mining landowner. All other roads will be rehabilitated. • Tailings dam, the open pit and Barney Hill hardstand areas will be fenced and a permanent fire break established. • Livestock may graze all other mine site areas depending on the owner. • Underground entrances will be sealed permanently as approved.
Low Risk to Biota	
The quality of water leaving the site should be such as to cause no significant deterioration of water quality to the downstream beneficial use(s) or water quality objectives of the receiving waters declared under Section 73 of the *Water Act 1992.*	• Surface water will be monitored until relinquishment (8 years proposed). • Contaminated areas will have capillary layer and erosion resistant material placed over the top. • Trials will be undertaken to confirm capillary layer, surface cover material and revegetation requirements. • No contaminated areas will be left uncovered. • A risk assessment will incorporate this facet. • Sediment traps will be utilised to reduced off-site suspended solids where appropriate.
Production of groundwater should be minimised, and trends should indicate improvement.	• Water quality will not be declining and will be within specified guidelines (long-term results). • An approved monitoring program for mine relinquishment will be implemented.
Production of polluted surface water (e.g. metals, acid or caustic runoff from pits, stockpiles, waste rock or tailings) should be minimised, and trends should indicate improvement.	• Water quality will not be declining and within specified guidelines (long-term results). • An approved monitoring program for mine relinquishment will be implemented. • All sources will be covered with an appropriate amount of mitigating capillary layer and erosion reducing material and revegetated.

Compatibility with Agreed Post-Mining Land Use	
Criteria	**MRM Proposed Methods to Achieve Compliance**
Continuing active intervention should not be required for site water management.	• Ongoing site water management is not required. • Groundwater contamination will not impact on the potential post-mining land use and will pose no risk to biota following rehabilitation.
Residual toxic material should be removed or contained; mobilisation of toxicants in general should be prevented, and in the case of acid rock drainage, minimised and controlled.	• ROM material will be disposed of underground, placed in the tailings storage facility or buried in the Test Pit. Other contaminated material will be either picked up and disposed or covered. • The rubbish tips will be covered and revegetated.
All sources of radioactivity should be decontaminated, removed or encapsulated such that levels of radioactivity on site conform to contemporary criteria.	Radioactive measuring equipment will be disposed off-site in an approved manner.
Stability	
All disturbed areas should be stabilised, including the construction of stable landforms.	• A stable landform will be characterised by the lack of erosion and presence of vegetative cover. These features will be measured via visual interpretation and ground data. • The data should indicate that vegetation cover is either stable or increasing.
Drainage should be consistent with post-mining land use (re-establishment of natural drainage patterns where appropriate).	The existing drainage supports the post mining land use of establishment of native vegetation and stable.
Erosion by wind and water should be at least comparable with background levels of the area.	• Local deposition gauges are used to detect dust emissions. • Visual appraisal will be used to determine areas of excessive water erosion. • Where identified, rock will be placed to mitigate water forces.
Storage's left *in situ* should be stable (providing an adequate margin of safety which is dependent on material stored) against floods, erosion and subsidence.	Flood, erosion and subsidence will be risk assessed (independent panel) and modelled. These results will be reported and an acceptable risk level agreed.
Rubbish Cleanup	
Facilities and equipment to be removed unless they are to remain for an agreed future use.	This criterion is core to the other closure elements. Consultation of closure criteria and practices will be undertaken during the mine life and at closure.
No rubbish should remain at the surface, or at risk of being exposed through erosion.	• Domestic and industrial rubbish has been disposed and buried on the site. Rehabilitation works will continue to ensure that this rubbish remains buried. • All drill sumps rehabilitated and rubbish and cuttings removed or buried. • All holes capped. • Disturbance stabilised, including that from exploration will be stabilised (water management structures implemented if required)

Compatibility with Agreed Post-Mining Land Use	
Criteria	**MRM Proposed Methods to Achieve Compliance**
Revegetated or Otherwise Improved	
Salts will not rise through the profile to the surface on tailings or contaminated hardstand areas.	• Annual profile sampling will be conducted to determine the extent of leaching through the profile over time in rehabilitated areas. • The data should show that a balance of salt level within the capillary layer has occurred on rehabilitated areas and that salt levels do not impact plant establishment by decreasing cover. • Trials will be established to confirm this and the subsequent establishment techniques.
The establishment of a revegetated, stable landform.	Visual interpretation will be used to indicate the status of vegetation cover and how it has changed over time. This criterion will be met if the results demonstrate that vegetation has stabilised over five consecutive seasons.
Vegetation should be able to survive the local fire regime.	• Native species known for their fire tolerance will continue to be used in seed mixtures. • Permanent firebreaks will be established.
The introduction and spread of weeds and pests should be prevented and an active program in place to minimise their presence.	Weeds species are not used in revegetation. MRM has a Weed Management Plan to manage weeds during the management of the leases. The post mining landowner will be responsible for weed management once the lease has been relinquished.
Visual Amenity	
Long-term visual impact should be minimised by creating acceptable landforms, preferably compatible with adjacent landscape.	Visual impact will be minimised through the establishment of vegetation on the disturbed areas as indicated by visual interpretation of ortho-photos and ground monitoring data.
Heritage and Archaeological Sites	
Condition of heritage and archaeological sites should meet requirements of relevant authorities.	• No archaeological sites exist on the disturbed areas. Traditional owners will be consulted in the decommissioning plan where there will be opportunity to discuss post mining management of identified sites. • Historical sites will be determined in consultation with stakeholders and will largely reflect the finalised post mining land use.

20.3.4 Closure Commitments

The NT Government has issued guidelines which relate to security derivation and mine closure planning in the *Mining Management Act (2001)* and the Mining Management Plan Advisory Note. Whilst this is not consistent with the *McArthur River Project Agreement Ratification Act 1993* (with amendments), the *Mining Management Act* has been used as the basis for security determination. Bonds for the McArthur River and Bing Bong leases have been lodged with the NT Government. Both of these bonds are for the life of the project.

MRM has made a number of commitments to site closure in its Mining Management Plan. Relevant closure commitments include the following:

- MRM has lodged a guarantee with the NT Government as security for compliance with its rehabilitation obligations pursuant to the *Mining Management Act* and its lease conditions.
- Prior to decommissioning, a complete rehabilitation plan will be submitted to the NT Government for the tailings storage facility.
- Life of mine rehabilitation costs and associated decommissioning activities will be reviewed annually.
- The goal for rehabilitation is to return all disturbed areas to stable landforms to minimise off-site deleterious effects. The fundamental aims may therefore be summarised as follows:
  - the surface of the rehabilitated ground is to be stabilised against the forces of erosion and the rehabilitated landform is to be non-polluting to contiguous properties; and
  - vegetation is to be capable of recovering from natural disturbance, such as drought and fire, and man-made disturbances (such as grazing) likely to occur for a selected land use sufficiently quickly, such that the land is not prone to erosion.
- Topsoil is to be salvaged in all areas which are to be disturbed and which contain suitable topsoil (nominally 10 to 15 cm).
- Revegetation of topsoil stockpiles will be undertaken manually if not naturally attained.
- Trials during the mine life will be undertaken as required to investigate landform options, soil cover options, vegetation options, and rock mulch options.
- A selection of suitable native species and proven pasture species will be trialed during the life of the operation. A range of species aspects and post-mining use aspects will be considered for the final species seed list.
- Advanced trials will be designed after the initial vegetation screening process. They will include managed plant successions, irrigation for plant establishment, land preparation and seeding techniques, and mulch covers.
- Soil erosion will be measured by visual assessments with identified poor areas remediated prior to the following wet season. A regular photographic record will be maintained over time.

- Revegetation assessment will be conducted using transects for six years after establishment. Success will be determined through plant population estimations of plantings and topsoil germination. Growth rates and biomass surveys will be undertaken.
- The decommissioning strategy for inert sites will be relatively similar to surrounding areas. The areas will be made safe by:
  - the dismantling and removal of all structures and equipment;
  - the removal of infrastructure and unused equipment;
  - the disposal of rubbish or hazardous wastes at approved sites;
  - closing or burial of adit opening and exposed shafts;
  - removing or closing access roads and tracks; and
  - the retention of water storages which may be useful for cattle grazing.
- The inert sites will be levelled off, deep ripped and seeded with native species or pastures. A topsoil cover of 100 mm may be required in areas where there is no existing topsoil.
- The Bing Bong site will be decommissioned in a similar manner to inert sites at the mine by removing all plant and equipment and rehabilitating all disturbed areas.
- The dredge channel at Bing Bong will be left untouched as benthic biota will recolonise the area (channel beacons will be removed).

20.3.5 Final Land Use

Due to the long timeframe for the closure of the operation, agreements with relevant stakeholders regarding the final land use for the site are not yet in place. In the years leading up to closure, stakeholders will be consulted as to their desires and requirements for the MRM leases. The best post-mining land use can thus be determined after full consultation with the community and Government.

The site has a long history of mining activity associated with it. Numerous exploration activities were conducted over the area in the 1960s and since then the extent of mining infrastructure and activities has gradually increased.

The area's predominant pre-mining land use was low intensity cattle grazing, utilising native grasses and woody shrubs.

The primary post-mining land use for the site will be to stabilise and make safe all areas. Secondary values will be promoted after stability and safety are ensured and include promotion of ecological values and enhancement of local economic sustainable development industries such as grazing land and tourism.

Given the nature of the surrounding land uses, it is likely that the dominant post-mining land use for the will be grazing land. To enhance pastoral values, ponds will remain in place to provide stock water. A grazing post-mining land use strategy is a conservative one given the resource value that grazing will provide. It should be noted that the return of mining-impacted areas to grazing is insignificant in terms of grazing contribution in the context of the local industry. The McArthur River Station is 8,000 km^2 in area and the total area to be disturbed by the mine will be 45 km^2.

Other potential land uses under consideration for part of the site include:

- Airforce use of the camp and airport.
- Tourist park focusing on the McArthur and Glyde Rivers and/or mine history.
- Wildlife sanctuary.

20.3.6 Security

The costs of an unplanned closure are used in the estimation of security as required by the *Mining Management Act 2001*. Security estimations are presented to the Department of Business Industry and Resource Development (DBIRD) annually in the Mining Management Plan. Under this arrangement, security is currently held with DBIRD for use in the event of project failure. The security is based on the costs of implementing the environmental requirements to achieve satisfactory closure criteria.

The security provided to DBIRD is determined on a performance-based system which includes consideration of the rate at which environmental management strategies are implemented and which demonstrate a reduced environmental risk of the operation.

20.3.7 Closure Strategy - Mine

The closure strategy aims to have a sustainable post-mining land use that does not require continual post-mining management beyond that which would be expected of surrounding land. Weed management, fire prevention management, and fence maintenance are accepted as ongoing post-mining management requirements.

The primary post-closure risk for the mine site is unstable contaminated areas that may lead to significant off-site impacts, particularly from tailings or overburden disposal or contaminated hardstand areas. For this reason, the rehabilitation strategy for these areas focuses on minimising instability. These areas will be covered with inert material that will not necessarily facilitate vegetation regrowth similar to that of the surrounding landscape. It is not proposed to rehabilitate such areas to resemble surrounding areas.

The closure strategies to apply to each of the project areas are discussed below.

Decline and Vent Rises

The conveyor and vehicle declines will be sealed with inert waste rock and the entrance and surrounds to the decline bunded to DBIRD specifications. The conveyor and vehicle declines will be erosion resistant, requiring the placement of large rocks on the outer layer. Vent raises will be removed and backfilled according to DBIRD specifications. Vent shafts will be overlain with 100 mm of topsoil.

Underground and Associated Infrastructure

Currently, there are over 200 km of underground workings to a depth of 450 m. All underground infrastructure will be buried *in situ* unless an item can be reclaimed cost neutral. It is likely the elements of the conveyor systems and pumps will be saleable items at the completion of the underground operations. Potentially hazardous substances in the underground will be cleaned up and costs allocated to the general cleanup in the first year following closure.

Open Pit and New River/Creek Channels

The following are closure scenarios considered for the open pit void:

1. Do nothing and let the pit fill naturally from groundwater inflows and direct rainfall. No surface water inflow will occur to the pit from the McArthur River.
2. Breach the flood protection bund temporarily and allow the McArthur River to flow along its original alignment and through the pit until the pit is full. Then re-establish the bund permanently and divert the river to the realignment channel.
3. Breach the flood protection bund permanently and allow the McArthur River to flow along its original alignment and through the pit.
4. Maintain the McArthur River in the new river channel but breach enough of the flood protection bund to allow flood flows that overtop the river channel to enter the pit. This is likely to occur in floods with a peak discharge greater than about 400 m^3/s, which have an Average Recurrence Interval (ARI) of about two years.

Water Balance Modelling

Water balance modelling was undertaken to estimate the steady-state water levels in the pit for each of the above closure scenarios (Appendix G).

In Scenario 1, groundwater, rainfall and TSF seepage are the pit inflows while water losses will be caused by evaporation. Without evaporation, the pit would slowly fill to the regional groundwater level (approximately 20 m below the pit rim). However evaporation rates exceed groundwater inflows and water in the pit will eventually stabilise with about 74 Giga Litres (GL) of water (pit capacity is 83 GL) at about 24 m below the rim of the pit (i.e. 196 m deep). Modelling indicates that it is likely to take some 70 years for water levels to stabilise. An advantage of this scenario is that the pit will never overflow as a result of seepage inflow and direct rainfall alone. A disadvantage is that water quality in the pit will continuously decline as a result of concentration of contaminants by evaporation. Should the flood protection bunds around the pit fail, the pit could be filled with river water and consequently the poor quality pit water, mixed with the stream flow, could be released to the environment.

In Scenarios 2 and 3, the pit fills rapidly with river water, probably within 1-2 years. The volume of the pit (83 GL) is significantly less than average annual stream flows in the McArthur River (595 GL) and the median flow (380 GL), so rapid filling of the pit is likely.

In Scenario 2, once stream flow is excluded from the pit, the water level falls slowly to stabilise at around the level of the regional groundwater table (20 m below the pit rim) with a the pit containing 74 GL . The quality of water in the pit will subsequently deteriorate as contaminants will concentrate as a result of evaporation. In addition, there is a risk that the bund could fail in which case the contaminated water could flow down the McArthur River as for Scenario 1.

In Scenario 3, once the pit is full, it will remain close to full and regular flushing will ensure the quality of water in the pit is similar to the quality of the river water. Stream flow into the pit will always be substantially greater than evaporation over the dry winter season, so the pit water level will only drop a short distance over winter and the pit will be quickly refilled during the first flows of the next wet season. Seepage inflows will be negligible with this scenario because the water level is typically above the regional water table level. Seepage outflows are predicted to be small relative to stream flows. Any concentration by evaporation of salts and metals in the pit over the winter dry season is likely to be relatively small due to the high volumes of stream inflows, and will be flushed in the following summer.

A potential disadvantage with Scenario 3 is that coarse sediment is likely to settle in the pit and the downstream transfer of coarse sediment may decrease. Downstream ecology may rely on nutrients or habitat that is influenced by the movement of coarse sediment (i.e. bed load) during floods. The pit will also reduce the low flows downstream during the tail of the wet season or as a result of winter rainfall events which may impact on any downstream ecosystems that rely on these flows.

The pit is not likely to fill quickly with sediment with Scenario 3. Assuming bed load settles in the pit and average annual flows and average pit, the pit will fill at about 2.85 m per year. Accordingly, to completely fill the pit will take 77 years.

Scenario 3 also suffers from the disadvantage that the riverine ecosystem that will have developed along the realigned river will be lost once the river returns to its original channel. Meanwhile the ecosystem along the original channel will have changed during the mining project from a riverine environment to a more terrestrial one. Returning the river will result in yet a further change to this ecosystem.

In Scenario 4, where only floods greater than a 2-year ARI enter the pit, there is more variation in pit water levels than with Scenario 3, but the pit still remains close to full. Even the reduced inflows from the McArthur River are still considerably larger than evaporation or seepage outflows from the pit. The main advantage of this scenario over Scenario 3 is that most low flows, including bed load, can continue to move through the realigned river channel to support downstream ecosystems. While some sediment will be collected in the pit during floods, it is not likely to be as much as with Scenario 3, so impacts on the downstream environment are likely to be less. Furthermore, Scenario 4 will not result in the loss of the riverine ecosystem that will have developed along the realigned section of the river during the life of the open cut mining operations.

Scenario 4 will also enable flood flows from Barney and Surprise Creeks to enter the pit while still enabling their bed load sediment and small flows to bypass the pit and continue downstream in a manner similar to that proposed for the McArthur River.

On this basis Scenario 4 is preferred.

Water Quality - Mass Balance Modelling

Mass balance modelling was undertaken to investigate the water quality in the final void. This model was used to assess the temporal changes in the concentration of specific compounds, taking into account mixing water from different sources (e.g. rainfall, groundwater inflow, TSF seepage etc.). As the model is a mass balance model it only takes into account the processes of mixing, dilution and concentration. It does not simulate any chemical reactions that may occur due to the mixing of these different waters.

Sulfate was selected as the key indicator parameter as it is relatively non-reactive and is generally stable when waters of variable pH levels are mixed. Similar trends can be expected with other salts and metals dissolved in the water.

A major determinant of the final concentration of sulfate in the pit water is the amount of sulfate that will leach from potentially acid forming material in the pit wall. Modelling was undertaken for sulfate leaching concentrations of 5,000 mg/L (best case), 12,000 mg/L (average case) and 20,000 mg/L (worst case).

Under Scenario 1, modelling indicated that the sulfate concentrations will increase steadily as a consequence of the processes of groundwater inflow and evaporation. Model results (worst case) indicate that 33 years after closure, the average sulfate concentrations are likely to be 4,750 mg/L. This is significantly higher than typical existing maximum surface water concentrations which are about 100 mg/L. Although the pit is unlikely to ever overflow, Scenario 1 is not considered to be an acceptable option as there is always a risk of failure of the flood protection bund and flood waters entering the pit and flushing low quality pit water to the environment.

Under Scenario 2, once the pit has been filled with river water, the water quality will concentrate gradually over time as per Scenario 1. However, the buffering capacity of the river water used to fill the open pit would result in a reduced sulfate concentration in the final void water, when compared to Scenario 1. Based on application of a best-fit regression to the modelled data (worst case), it is likely that the average sulfate concentration in the open pit after 33 years would be 1,700 mg/L which is still significantly higher than typical existing maximum surface water concentrations (about 100 mg/L). As for Scenario 1, should the flood protection bunds around the pit fail, the pit could be filled with river water and consequently the poor quality pit water could be released to the environment.

Under Scenarios 3 and 4, sulfate concentrations in the open pit are buffered by regular (Scenario 3) or occasional (Scenario 4) inflows of river water. In general, the model indicates that sulfate concentrations would remain close to the sulfate concentrations in the river water. The buffering effect of the river water becomes apparent after several months (Scenario 3) or years (Scenario 4), as the water quality in the final void is essentially the same for both scenarios.

Table 20.3 summarises the sulfate concentrations in the void predicted by the mass balance model after 33 years.

Table 20.3

Predicted Sulfate Concentrations (mg/L)

McArthur River	Scenario 1			Scenario 2			Scenario 3			Scenario 4		
	Best Case	Average Case	Worst Case	Best Case	Average Case	Worst Case	Best Case	Average Case	Worst Case	Best Case	Average Case	Worst Case
100	2,800	3,700	4,750	1,100	1,400	1,700	110	110	110	160	170	180

Water Quality – Geochemical Equilibrium Modelling

Geochemical equilibrium modelling was undertaken to assess the effect of the chemical reactions (in terms of precipitation and dissolution) that may take place when water from different sources (i.e. river water, rainwater, pitwall leachate, groundwater, TSF seepage) is mixed in the final void. Such chemical reactions cannot be included in the mass balance model discussed above.

The geochemical equilibrium model was applied to each of the four scenarios. As the model does not allow for the time-dependent assessment possible with the mass balance model, pre-determined mixing ratios for each of the inflow/outflow components were used.

Table 20.4 summarises the modelled water quality of the final void under each of the four scenarios assuming the worst case leachate results from the potentially acid forming material that will be exposed on the surface of the pit wall.

Table 20.4

Modelled Final Void Water Quality (Worst Case)

Parameter	River Water[1]	Scenario 1	Scenario 2	Scenario 3	Scenario 4
pH	8.20	5.04	8.14	8.20	8.19
Concentration (mg/L)					
Calcium	48.7	166.3	55	48.7	48.7
Cadmium	0.00006	0.006	0.000	0.000	0.000
Chloride	15.3	126.5	24.8	15.5	16.8
Copper	0.001	0.008	0.001	0.001	0.001
Iron	<20	22.8	10.6	10.0	9.9
Potassium	4.2	34.8	6.2	4.2	4.4
Magnesium	47	373.4	65.5	47.0	47.5
Sodium	10.6	138.5	21.6	10.9	12.4
Lead	0.00055	0.025	0.002	0.001	0.001
Zinc	0.0104	10.9	0.600	0.010	0.011

[1] Monitoring location SW7 (April 2003)

The geochemical equilibrium model also calculated the saturation index for several minerals that could potentially precipitate from the mixed water. If the saturation index is greater than zero, the mineral could precipitate. If the SI is less than zero, the mineral remains dissolved and will not precipitate. Based on the modelled saturation indices, the following minerals could precipitate:

- $Fe(OH)_3$
- Goethite
- Hematite

In addition, the model predicts that jarosite would precipitate under Scenario 1 but would remain in solution under Scenarios 2, 3 and 4.

As can be seen from Tables 20.3 and 20.4, the modelling has shown that Scenario 4 which is the preferred scenario on the basis of the water balance modelling is also preferred on the basis of the water quality modelling. For Scenario 4 there is little difference between the predicted water quality in the pit and the background water quality of the river.

Tailings Storage Facility

At the completion of mining activities, the tailings storage facility (TSF) will be decommissioned. This will include:

- Re-profiling the surface to ensure incident rainfall runs off rather than seeps into the tailings.
- Placement of a capillary layer over the re-profiled surface to limit the capillary rise of salts into the cover layer.
- Placement of a low permeability cover over the capillary layer to prevent the oxidation of tailings, minimise the potential for seepage into the tailings, and stabilise the surface.
- Placement of a topsoil layer on the surface of the TSF to provide a medium for vegetation growth.

The effect of this rehabilitation strategy will be to eliminate as far as possible additional water input into the tailings. In this way the head of water available to influence the seepage will be limited to what is in the tailings and will reduce over time as the seepage water is removed by the recovery bores.

Modelling was undertaken to assess the time over which the recovery bores would need to operate after the TSF is rehabilitated, until sufficient seepage water is removed so that no further surface expressions of seepage would occur. If the recovery bores are turned off immediately after completion of mining, surface expressions of the ongoing seepage of the water retained within the tailings would appear downgradient of the perimeter embankment after approximately five years. Modelling has indicated that the recovery bores may need to be operated for a period of 30 years or longer after mining has ceased to avoid surface expression of the seepage. Seepage extracted by the recovery bores will be discharged to the final void. The effect of this discharge has been included in the final void water quality modeling described above.

Details of the TSF rehabilitation and decommissioning are given in Section 7.4.

Overburden Emplacement Facility

The top of the overburden emplacement facility (OEF) will be rehabilitated with a low permeability cover, topsoiled and revegetated.

The velocity and flow path of surface runoff from the top of the OEF will be limited by the use of shallow surface undulations. This surface profiling will allow rainfall from small rain events to be captured and utilised to sustain vegetation. The majority of surface runoff from larger storm events will be allowed to spill over the shallow surface undulations and be directed towards a series of rock-lined drainage chutes located down the sides of the OEF. Surface runoff will be prevented from escaping over the top edge of the OEF and diverted to the drainage chutes using surface topography and perimeter bunds.

Should the outer batters be constructed with coarse-graded, hard, durable rock, the outer batter design may be built without the need for rock chutes. In this case surface water could be shed by sheet flow rather than by concentrating it in the rock chutes. The intermediate berms would be designed with a minimum forward slope of 1 in 50 to avoid concentrating the sheet flow.

Drainage from the OEF will discharge into a sediment pond at natural surface level to limit the release of sediment to the downstream environment. The sedimentation ponds will be sized to provide 500 m^3 of sediment capacity for every hectare of contributing catchment. This will provide sufficient capacity to capture the equivalent of 50 mm erosion depth from the catchment surfaces.

Further details of the OEF design are given in Section 7.2.4.

Vegetation establishment on the outer berms will improve the overall aesthetics of the OEF and will also reduce post-rehabilitation maintenance costs by encouraging “self-healing” of any minor erosion. Any significant erosion areas at the OEF will be identified through a post-rehabilitation monitoring program and repairs carried out, as required.

Hardstand Areas

Hardstand areas include the accommodation village, stores, electrical and metallurgical laydown, and borrow pits. After the infrastructure has been removed, these areas are to be ripped, fertilised and seeded. Some minor profiling may be required to improve surface water drainage. If any of these areas have been contaminated, they will be treated as discussed below.

Chemical Contaminated Sites

These sites are those that have been contaminated during the life of the mine. Potential contaminants include tailings, pyritic material, ore, hydrocarbons, reagents or other chemicals. These sites are noted in the mine’s Contaminated Sites Register.

Contaminated sites will be covered with 500 mm of ungraded material. 200mm of rock will be placed over ungraded material in areas susceptible to erosion. Vegetation will be established using routine established methods.

Roads

There are many roads used for access around the mine site and at Bing Bong.

Roads will remain only at the request of the post-mining landowner. This will be agreed at a time closer to planned closure. However, for the purposes of financial calculations, it will be assumed that most roads will be removed, with some remaining for post-mining requirements. Some roads are likely to remain and be compacted to provide a permanent firebreak. Bitumen roads around the camp and main road will be covered.

Underground Workings and Associated Infrastructure

Voids in the underground workings will be either filled with overburden and/or left to fill up with groundwater. This water may contain residual contaminants particularly hydrocarbons which will float to the surface. This will be monitored in the groundwater bores and in the underground workings post-mining. A bore will be drilled to enable this water to be sampled once the entrance to the underground portal is sealed. Associated infrastructure that cannot be recovered at a cost neutral basis will be buried *in situ.*

Above Ground Mining Infrastructure

Above ground infrastructure includes the plant, administration buildings, stores areas, workshop facilities and any other facilities above ground.

All above ground structures will be dismantled and removed if there is no other post-mining land use determined. The underlying ground will be assessed, remediated and rehabilitated as described above for chemical contaminated sites.

Allowances have been made for clean up and covering of minor contamination around the process plant, fuel storage, workshop areas and concentrate shed.

Power Station

The power station is not owned by MRM and will be the responsibility of the power contractor who operates it. The power station will be decommissioned according to the post-mining land use. The power station is readily transportable and is likely to be relocated at the end of the mining activity unless there is a post-mining use for the power. In this case, one or more of the turbines could remain.

Pipeline Corridor

NT Gas owns the gas pipeline and corridor. The pipeline will be decommissioned as approved by the NT Government. This usually takes the form of filling the pipeline with concrete. If there is potential for future utilisation of the line, it will be filled with nitrogen for preservation.

Accommodation Village

All transportable buildings and equipment will be sold and removed and the area rehabilitated. Remaining structures will be dismantled and buried. Concrete will be broken up and buried. Hardstand and disturbed areas will be ripped, fertilised and seeded.

Fences

All fences that are not required for post-mining land uses will be removed. Those that remain are likely to be used for pastoralist activities or to exclude stock from the key rehabilitation areas of the tailings dam or from the pit. The post-mining landowner will be required to maintain these fences.

Airstrip

The fuel storage area and small building associated with the airstrip will be decommissioned and removed, and the area rehabilitated. It has been assumed that there will be a post-mine use for the airstrip and this will not be rehabilitated conventionally. This assumption is based on the current interest in the facility, although any agreement will be secured in the future. The fuel storage tank is owned by Shell and it will be the responsibility of Shell to remove their infrastructure.

Borefields

Borefields will remain in place to facilitate the post-mining pastoral land use.

20.3.8 Closure Strategy - Bing Bong

The Bing Bong port facility may be of value for uses such as tourism, local town use, Government (Navy), or commercial activities (cattle/fishing). For the purposes of current calculations, it is assumed that the area will be decommissioned to the same criteria as the mine site, however, it is unlikely that all infrastructure will have no post-mining value.

All above ground infrastructure will be removed and transported off-site to be disposed of or sold. This includes the sheds, offices, and the village.

The topography will be altered post-mining. All areas will be drained through the Bing Bong site runoff pond as much as possible. The depression where the shed was located will form an additional sediment trap. The front areas of the conveyors will drain towards the ocean through the battered and stabilised wharf area.

Roads will remain only at the request of the post-mining landowner. This will be agreed at a time closer to planned closure. However, for the purposes of financial calculations, it has been assumed that the access road will be maintained as there will be access desired by local peoples for recreational purposes such as fishing and for use as a boat ramp. Sealed and unsealed roads will be rehabilitated as per the mine site closure strategy (Section 20.3.4).

Contaminated material will be cleaned out of the site runoff pond which will remain as the site catchment and discharge point. This will collect contaminants and sediments from erosion. The discharge will be allowed at the southern wall to reduce the volume contained. It is not intended that this pond be used for post-mining pastoralist use as cattle are not grazed in the area. If required, the pond will be cleaned out during the first three years after the area is rehabilitated.

The wharf concrete area will be broken into rubble (where not contaminated) and levelled back to a safe and erosion resistant angle. Additional rubble can be obtained from other uncontaminated concrete and hardstand areas. This may provide a suitable boat ramp site if required. Water from the front of the current conveyor area will flow directly into the ocean down a purpose-built spoon drain.

Contaminated soil will be picked up and disposed of at the mine. The area will be ripped and seeded with native species, which will enhance the native flora and fauna values of the area. This seed mix will be determined at least five years prior to mining cessation.

Other surface areas that are disturbed and not used for roads or hardstand will only require ripping, fertilising and revegetation.

The dredge channel will be left as is. Additional rehabilitation will destroy the potential post mining port values of the site and create additional unnecessary disturbance. Tests will be undertaken to determine if there is any residual contamination. Where any significant residual contamination is found, it will be dredged and disposed of appropriately.

20.3.9 Post Operational Closure Requirements

Closure Personnel

A closure project manager and administrative assistant would be employed from six months prior to closure to six months after closure. The remainder of the team would be employed for one to two years after closure and are likely to be recruited from existing personnel or contractors. The exception is the caretaker/handyman who will be required for a minimum period of eight years after closure. A total of 11 personnel would be required in the first year of decommissioning, 5 in the second and then the caretaker and consultants for the remaining 5 years. Any management requirements beyond 5 years (e.g. tailings storage facility) would be staffed as necessary.

Monitoring and Caretaking

Following mine closure, an eight-year monitoring program (water, dust and rehabilitation) will be conducted, plus progress monitoring and reporting on meeting completion criteria. It is assumed that the closure monitoring for security and life of mine is equivalent. The need for any ongoing monitoring will be reassessed at the end of the eight years.

20.3.10 Final Site Relinquishment

Closure criteria are aimed at reaching long-term stability of the site and the minimisation of off-site impacts. Reports on progress towards mine closure criteria will be issued to stakeholders annually and a summary report in year eight.

20.4 Environmental Management Plans

Draft rehabilitation and mine closure environmental management plans for the open cut project are given in Section 22.4.