Case study - integrated planning to enhance closure outcomes for the Pardoo mine in Western Australia

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Abstract

The Pardoo Direct Shipping Ore Project is owned by Atlas Iron Limited and is located in the Pilbara region of Western Australia. Iron ore mining commenced in 2008 and ore reserves were depleted in early 2014. The Project is significant to Atlas as their first producing mine and they have committed to achieve a high standard for closure planning and implementation.

Closure planning commenced during the feasibility stage of the Project in 2008. Detailed closure planning was initiated during 2010 and included the use of gap analysis and risk assessment to identify closure opportunities and set planning priorities. A program of targeted investigations was then undertaken to resolve gaps and risks, and enable the development of a detailed mine closure plan. The detailed closure planning process was undertaken by a small, experienced, multidisciplinary team, which enabled Atlas to realise many financial and operational efficiencies.

Atlas will demonstrate closure performance using robust measures including closure objectives and criteria, to facilitate lease relinquishment in a planned and timely manner. Closure objectives and criteria have been developed in consultation with stakeholders.

The approach that Atlas has adopted will contribute to enhanced closure outcomes for the Project.
Introduction

The Pardoo DSO Project (the Project) is an iron ore mine which is owned and managed by Atlas Iron Limited (Atlas). The Project is located approximately 75 kilometres (km) east of Port Hedland in the Pilbara region of Western Australia (Figure 1). The Project consists of six deposits which were mined at a rate of approximately 3 million tonnes per annum (Mtpa). Mining commenced in December 2008 and ore reserves were depleted in January 2014. Ore processing ceased in March 2014.

Closure planning commenced during the feasibility stage of the Project with the development of a conceptual mine closure plan in 2008. Detailed closure planning was initiated during 2010 in response to Project commitments and Atlas’ aspiration to understand and manage closure risks and opportunities. The closure planning process that Atlas adopted aligns with the concept of progressive mine closure planning (Mackenzie et al., 2006; Mackenzie et al., 2008).

A detailed mine closure plan (DMCP) for the Project was developed collaboratively by internal stakeholders and specialists and through consultation with external stakeholders. The DMCP was submitted to the DMP and was subsequently approved in 2013. The DMCP was developed in accordance with the ‘Guidelines for Preparing Mine Closure Plans’ (DMP and OEPA, 2011). Closure works are currently being implemented at the Project in accordance with the approved DMCP.

The Project is significant to Atlas as their first producing mine and they have committed to achieve a high standard for closure planning and implementation. High standards have been achieved through innovative and integrated planning, open engagement of internal and external stakeholders, and through external peer review.

Project summary and setting

The Project is located in the Town of Port Hedland local government area. The dominant land use in the region includes pastoral and mining activities, Aboriginal Reserves, conservation areas and urban development. The population of Port Hedland is approximately 20,000 people and the main economic drivers in the region are commercial fishing and the minerals and energy industry (Town of Port Hedland, 2013). The Port Hedland port is the largest export tonnage port in Australia.

The Project tenements overlap the De Grey pastoral station leases and the De Grey River Water Reserve, which supplies scheme water to Port Hedland and is classified as a Priority 1 water reserve. The Project is also located approximately 10 km west of the De Grey River and 10 km east of the Leslie Saltfields which are both registered wetlands of national significance.

The climate of the region is arid tropical (Kendrick and Stanley, 2001) with hot summers and warm winters. Annual recorded rainfall fluctuates from year to year. A mean annual rainfall of 320 mm has been recorded at the Pardoo Station which lies 50 km east of the Project. Most rainfall occurs during the summer as a result of high intensity events related to cyclonic activity.

Mining was undertaken via conventional drill and blast, load and haul open pit mining methods from eleven pits (Bobby, Glenda, Alice East, Alice West, Alice Extension, Connie, South Limb, South Limb West, Chloe, Emma and Olivia) (Figure 2). Ore was crushed, screened and stockpiled onsite and then trucked using road trains to Port Hedland via the Great Northern Highway. Ore was shipped from the Utah Point bulk commodities berth at Port Hedland. Waste rock from the Project was stored in six waste rock dumps (WRDs) (Bobby/Glenda, Alice, South Limb, South Limb West, Chloe and Olivia/Emma).
Figure 1  Regional locality plan
Figure 2  Project layout
Closure investigations

Gap analysis and risk assessment were used to identify closure opportunities and set planning priorities. Targeted closure investigations were then undertaken to address gaps and risks, and the outcomes of which enabled the development of the DMCP. Closure investigations consisted of groundwater modelling, surface water drainage studies, soils assessments, landform design (including erosion modelling and geological mapping), and rehabilitation planning.

The detailed closure planning process was undertaken by a small, experienced, multidisciplinary team. It was through collaboration within the team and with other internal and external stakeholders that enabled Atlas to realise many financial and operational efficiencies.

Risk assessment

A series of mine closure risk assessment workshops were undertaken for the Project. The objectives of the risk assessment were to identify, rank and prioritise risks, to develop management options for risk events that could compromise closure objectives, and to assist with managing uncertainty. The risk assessment process aligned with the Australian and New Zealand Risk Management Standard (AS/NZ 31000:2009).

Three phases of mine closure were considered when undertaking the risk assessment including (i) pre-closure planning, (ii) closure implementation and (iii) post closure. Individual workshops were held to assess the risks associated with each phase and were attended by relevant stakeholders. As an example, four key risks from the phase three risk assessment are presented in Table 1.

Risk assessment outcomes were used to guide the development of closure plans for each relevant domain. Atlas will progressively review the phase three mine closure risk assessment throughout the post closure period, engaging relevant stakeholders where required.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Four key risks from the phase three risk assessment</th>
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<tbody>
<tr>
<td>Event</td>
<td>Cause</td>
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<tr>
<td>Poor revegetation outcomes.</td>
<td>Insufficient or hostile soil; Inappropriate or poor quality seed; Erosion; Excessive fire; Grazing pressure; Weeds; Poor climatic conditions.</td>
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<tr>
<td>Unauthorised access to open pits.</td>
<td>Abandonment bund failure; Bund not constructed according to guidelines.</td>
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<tr>
<td>Failure of engineered structures.</td>
<td>Landforms not constructed according to designs; Design criteria not suitable; Erosion; Specifications not achievable; Inadequate monitoring/maintenance.</td>
</tr>
<tr>
<td>Stakeholder expectations are not met.</td>
<td>Stakeholder engagement does not continue after mine closure.</td>
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</tbody>
</table>
Groundwater

A regional hydrogeological investigation was undertaken in 2012. The investigation assessed the potential for impacts on local receptors including a culturally sensitive pool (Muccangarra Pool) and water reserve (Bulgarene borefield). Increases in pit lake salinity and metal concentrations were predicted due to the formation of an evaporative sink. Flowpath analysis found it unlikely that the receptors will be influenced by pit lake seepage however, because seepage rates were generally low.

Surface water

Regional modelling of surface water flows during both 1:100 year average recurrence interval (ARI) and peak maximum flow (PMF) rainfall events were undertaken for the Project area. Modelling highlighted the potential impacts that these rainfall events could have on the constructed Project landforms. A number of management measures were implemented for each domain based on flooding predictions, including flood and flow protection (bunds and diversion structures) on and around WRDs, open pits and other disturbance areas.

Soils assessment

An assessment of the quality and inventory of stockpiled topsoil and potential subsoil resources was undertaken during 2012. The physical and chemical characteristics of topsoil stockpiles and subsoil resources were also assessed. Most stockpiled topsoils were suitable for use on flat areas and in some cases on lower/shallow slopes because of their erosive nature. The physical characteristics of subsoil resources were generally more favourable than stockpiled topsoil for use on WRD slopes, because they were less erosive.

A soil inventory revealed that there was going to be a deficit in terms of the volume of soil required for rehabilitation compared with the volume available in stockpile. It was found that harvesting of topsoil during abandonment bund clearing, and selective harvesting of subsoil was sufficient to mitigate this deficit during closure works.

Landform design

An investigation to develop an appropriate closure design for each WRD was undertaken. The investigation included slope erosion modelling, SIBERIA landform evolution modelling and a geological assessment of slope stability. The geological assessment found that the WRDs generally consisted of blocky and competent, high stability waste rock. There were some minor zones of medium and low stability rock that required rock armouring.

Both single and double batter landform designs were developed for Project WRDs and incorporated the following key design principles (Figure 3 and Figure 4):

- Minimise the potential for water flow onto WRD batters.
- Encourage surface water infiltration on WRD surfaces.
- Reprofile WRD batters to a concave shape, comparable to an eroded slope after 250 years of modelled erosion.
- Constrain slope lengths to less than 100 m.
- Limit vertical batter heights to 20 m, beyond which a mid-slope berm is recommended.
- Berms should accommodate peak maximum flows and should be level.
- Final batter surfaces should consist of suitably coarse and durable rock. Armouring rock will be placed where required.
- WRD surfaces will be sheeted with topsoil where available or subsoil.
- WRD surfaces will be cross-ripped on the contour.
- Spread area specific seed mix (native grass, shrub and tree species).
- Sediment control measures will be implemented around the perimeter of each WRD.
- Fencing will be installed where practicable to minimise grazing during vegetation establishment.

![Figure 3](image1.png)  
**Figure 3**  Single batter landform design

![Figure 4](image2.png)  
**Figure 4**  Double batter landform design
Rehabilitation planning

A detailed rehabilitation plan was developed to inform native seed procurement and management, topsoil reconciliation, surface treatments and revegetation. Domain specific native seed mixes were developed based on species represented in surrounding floristic communities and provenance seed was sourced where possible. Seed was treated to break dormancy and viability testing was undertaken for major seed batches. Contour ripping using survey support was undertaken and seed was applied at a rate of 10 kg/ha for WRDs and 6 kg/ha for all other disturbance areas.

Stakeholder consultation

Stakeholders often have a long term interest in an area beyond the operating phase of a mine. Atlas recognises the importance of consulting with stakeholders in relation to mine closure, to provide an avenue for effective participation in the closure process.

A closure consultation plan was developed and implemented, and consisted of a series of detailed meetings with relevant primary and internal stakeholders. Project stakeholders included Commonwealth and State government agencies, native title and traditional owner groups, pastoral lease holders, and other local/regional groups. Stakeholders were able to directly participate in the closure planning and decision making process.

Stakeholder meetings were scheduled in both Port Hedland and Perth to encourage attendance. Initial meetings provided background information and details of closure knowledge gaps to encourage stakeholders to contribute to the design of the closure investigations. Subsequent meetings were used to present the outcomes of the closure investigations and encourage stakeholders to contribute to investigation outcomes. Later meetings were used to encourage participation in developing closure objectives, closure criteria and the post-closure monitoring strategy.

In addition to the scheduled meetings, follow up meetings were held with individual stakeholders to discuss specific mine closure issues and requests. Atlas will consult with primary stakeholders on an ongoing basis.

Closure performance

Atlas will demonstrate closure performance using robust measures including closure objectives and criteria, with the aim to achieve lease relinquishment in a planned and timely manner. Post closure monitoring will be undertaken to measure performance and Atlas aims to meet all closure objectives and criteria ten years after the completion of closure works.

Atlas has developed a mine closure ‘vision’ to describe the intended future state of the Project area after mine closure. The mine closure vision is:

Rehabilitated areas will be safe and stable and the Project will have no significant impacts to Bulgarene borefield or Muccangarra Pool. Revegetation will be self-sustaining and will support limited pastoral land use over time. General access to the site will be limited and any residual infrastructure will be managed by a new owner.

The vision is supported by closure objectives which in line with the ANZMEC framework (ANZMEC/MCA, 2000) are site specific and cover a range of aspects. Closure objectives, criteria and standards have been developed for five aspects (i) safety, (ii) infrastructure, (iii) groundwater, (iv) vegetation and (v) surface water. The closure objectives for the Project are:

- Closed areas will be designed to deter access.
• Infrastructure will be removed or left in situ where agreed.
• The rehabilitation will support self-sustaining vegetation, which can be reasonably achieved.
• The Project will have no significant adverse impact to Bulgarene borefield and Muccangarra Pool.
• Uncontrolled surface water flows and impacts to surface water will be minimised.

Not all objectives apply to all Project domains. The closure objectives, criteria and standards have been developed in consultation with relevant industry specialists and representatives from relevant State government agencies.

Closure implementation

Closure works commenced at the Project during 2013 and the current phase of works will be completed during 2014. Closure works have been implemented in accordance with the approved DMCP. Some of the key learnings from the closure implementation process at the Project are outlined below:

1. Atlas integrated the outcomes from the mine closure planning phase into the operational phase of the Project which enabled efficiencies to be realised. Operational personnel were actively engaged in the planning process to help identify efficiencies mainly relating to the selection, segregation and strategic stockpiling of competent run-of-mine waste rock for various uses during closure works.

2. Closure works were commenced early and during the operating phase of the Project which resulted in efficiencies relating to management, logistical and technical support for closure implementation.

3. Contractor selection is critical to the success of the closure project. Closure works need to meet far more stringent specifications than bulk earth works in order to achieve adequate long term surface water management in arid environments with high intensity rainfall events. Many contractors claim to be rehabilitation specialists, but very few are capable of achieving the fine tolerances and standards associated with rehabilitation earthworks.

4. Closure work instructions are an important mechanism by which complex technical details are summarised into effective instructions that can be issued to contractors, supervisors and operators, so that conformance with closure designs and standards can be achieved and documented. Closure supervisors, contractors and operators underwent specific inductions to ensure that the appropriate specifications and standards were interpreted into the closure implementation phase.

5. Effective supervision is required to manage closure works to achieve the required outcome, including verification and signoff of the work instructions. Management of closure works involves an iterative process between the project managers, technical specialists, supervisory personnel and contractors to identify Project changes to which technical or operational responses need to be made.

Conclusions

The comprehensive and integrated strategy that Atlas adopted has contributed to enhanced closure outcomes for the Project. The small, experienced closure team enabled efficiencies to be realised, and targeted closure investigations were undertaken to develop a DMCP that was acceptable to regulators and other stakeholders. Operational activities were optimised to minimise closure costs and to enhance outcomes. This was achieved through collaboration of a multidisciplinary team which effectively balanced technical and physical aspects with the requirements and aspirations of internal and external stakeholders.

The detailed planning process and the closure implementation project have been informative for Atlas and have resulted in positive planning outcomes for their other projects.
References


