



Government of **Western Australia**  
Department of **Mines, Industry Regulation and Safety**

# Rehabilitation Showcase

December 2020





The department wishes to thank all contributors who provided content to the Rehabilitation Showcase.

Cover image courtesy of Atlas Iron, Pardoo.





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# Foreword



Western Australia's resources sector is the backbone of the State's economy and it will continue to play a significant role for decades to come. The McGowan Government recognises how important it is to balance environmental responsibility with the successful development of Western Australia's mineral and petroleum resources.

The pace of change in our resources sector is gaining speed thanks to technologies that are now commonplace, but would have seemed farfetched 10 years ago. In line with this, rehabilitation techniques are constantly evolving and being updated to improve the quality of rehabilitation post-resource development.

This book showcases new technologies, innovative thinking, and conservation strategies that underpin the safe and responsible development of Western Australia's vast resources.

Hon Bill Johnston MLA  
Minister for Mines and Petroleum; Energy; Industrial Relations



# Message from the Director General



The Department of Mines, Industry Regulation and Safety (DMIRS) plays a unique role in supporting a safe, fair and responsible future for the Western Australian community, industry and resources sector. It is a role we take very seriously in our efforts to ensure responsible development, build trust with our stakeholders, deliver exemplary regulatory practice and reform, and protect the community.

DMIRS is responsible for regulating Western Australia's largest industry sector, playing a critical role in building the State's economy, while ensuring its resources are developed in a sustainable and responsible manner.

This showcase of innovative rehabilitation techniques, technologies and outcomes provides a platform to demonstrate in part, the medium to longer term outcomes and benefits being realised from the resources sector here in Western Australia.

The rehabilitation summaries also align with the principles of the department's Golden Gecko Award, which recognises environmental outcomes and innovation in environmental management, and provide a further opportunity to share experiences between government, industry and the community on rehabilitation success.

David Smith  
Director General  
Department of Mines, Industry Regulation and Safety

Company Name: South32 Worsley Alumina  
Site Name: Boddington Bauxite Mine  
Image: Courtesy of South32 Worsley Alumina





**5 Years**

# Rehabilitation of State Forest

## Rehabilitation Summary

Rehabilitation of state forest areas at the South32 Worsley Alumina Boddington Bauxite Mine has developed and progressed over the past 40 years through a partnership between Worsley Alumina and the Department of Biodiversity, Conservation and Attractions (DBCA).

Working together, South32 and DBCA have developed rehabilitation methods to support the end goal of a stable, sustainable ecosystem that has similar characteristics to the surrounding eastern and northern jarrah forest. This included ongoing research, updates and continuous improvement to the practices and process of undertaking rehabilitation at Worsley Alumina.

Post-closure, the areas will be used for a variety of end land uses. Goals for rehabilitation of the State forest are quite broad and include recreation, conservation, timber production, landscape and water stability, while ensuring minimal impact on undisturbed areas.



**10 Years**



**17 Years**

Company Name: Atlas Iron  
Site Name: Pardoo  
Image: Courtesy of Atlas Iron





# Rehabilitation at Pardoo Mine Site



## Rehabilitation Summary

Detailed closure planning at the Pardoo iron ore mine started in 2010 in response to Atlas Iron's aspiration to understand and manage closure risks and opportunities. The project was significant to Atlas Iron as its first producing mine and they committed to achieving a high standard of rehabilitation through integrated planning and an external peer review of the scope and outcomes of closure investigations; and the development of a comprehensive plan to manage quality during implementation of rehabilitation.

Since 2016, at completion of rehabilitation works, rehabilitation monitoring has been conducted annually on the waste rock landforms and includes vegetation monitoring to assess plant cover, species richness and weed cover; monitoring of landform scale erosion stability and drainage control; and opportunistic fauna observations.

Plant growth on all waste rock landforms has been excellent, with plant cover values and species richness recorded on rehabilitation sites falling within the range of values recorded at the natural analogue sites.

The performance of all key waste rock landform drainage controls is determined by analysing Unmanned Aerial Vehicle survey data. All drainage controls are performing in accordance with their design and no potential failure points have been observed.

Company Name: Buru Energy  
Site Name: Canning Basin  
Image: Courtesy of Buru Energy





# Seismic Line Rehabilitation

## Rehabilitation Summary

The clearing technique used during the seismic surveys (raised-blade scraping) removes vegetation at or above the soil surface, minimising disturbance to the seed and root stock and assisting rehabilitation.

Buru Energy has formally monitored the rehabilitation of seismic lines across the Canning Basin since 2013. Rehabilitation monitoring is undertaken to determine the effectiveness of passive rehabilitation for vegetation recovery on the seismic lines (i.e. no intervention required to encourage rehabilitation).

Buru Energy's rehabilitation monitoring has demonstrated that raised-blade scraping minimises disturbance, which allows the vegetation to naturally regenerate. The monitoring has demonstrated that the vegetation typically becomes comparable to the neighbouring vegetation in less than five years.



Operator Name: David Woodiwiss and Paul Simmonds  
Image: Courtesy of David Woodiwiss and Paul Simmonds





# Prospecting Rehabilitation

## Rehabilitation Summary

This is an example of progressive rehabilitation of scrape-and-detect activities. Significant vegetation has been avoided and retained during disturbance activities. Following the completion of the prospecting activities, topsoil and stockpiled vegetation have been re-spread with most areas scarified. Over a short period of time, vegetation has begun to take hold and the beginnings of a rehabilitated vegetation community are emerging. As can be seen in the photo, by leaving the large significant vegetation in place, the vegetation community will soon represent something close to the original condition.

Company Name: Iluka Resources  
Site Name: Eneabba Mineral Sands  
Image: Courtesy of Iluka Resources





# Flora Restorer: Revegetation of a Diverse Ecosystem

## Rehabilitation Summary

Seedling emergence is notoriously low in mining rehabilitation. This project focused on designing, building and commissioning new equipment for seeding, imprinting and stabilising sandy topsoil for the revegetation of a diverse ecosystem after mining.

At Iluka Resources' Eneabba mineral sands mine in the Mid West of Western Australia, eightfold more seedlings emerged under ideal nursery conditions than seed broadcast in the field. Unlocking this potential in broadcast seed has been critical to establishing plant density and species diversity of restored Kwongan shrubland vegetation.

Rehabilitation practice at Eneabba in 2018 sought to incorporate seed burial, imprinting and spraying of bitumen emulsion. To do so, Iluka designed and built a rehabilitation trailer, named "Flora Restorer", that spreads fertiliser, scarifies uneven and rocky soil, air-seeds the diverse size and shape seed mix, imprints and thereby buries the seed, and sprays the surface with bitumen emulsion in one pass.

Given the flexibility and functional control designed into this equipment, Iluka will continue experimenting with the different aspects of the seeding process (seed burial, imprinting and bitumen emulsion) to understand and improve on each process and its individual influence on seedling emergence in rehabilitation.



Company Name: Tronox Mining  
Site Name: Gwindinup North  
Image: Courtesy of Tronox Mining Australia Pty Ltd.



**Pasture rehabilitation**



**Wetland rehabilitation**



# Biodiverse Wetland and Pastures

## Rehabilitation Summary

Cristal Mining, now Tronox Mining, created a biodiverse wetland within the rehabilitation at the Gwindinup North mineral sands mine. The rehabilitation project, undertaken between 2012–2017 won the revegetation Industry Association of Western Australia (RIAWA) Award for Excellence in Rehabilitation in 2018.

The key to the creation of a successful wetland ecology was installation of a semi-impermeable clay lens constructed within post-mining soil profile to hold water in the wetland during summer.

Clay that was extracted during ore processing was stored onsite in drying dams to be available for construction of the clay lens in the wetland area.

A careful balance had to be designed to ensure there was enough water in the wetland to support riparian ecology while not impacting downstream users of surface and ground water.

The final land use has been successfully achieved as have the closure objectives. It is considered that the post-mining land use is a higher beneficial use than the pre-mining uses. Any water flows entering the wetland are slowed down, sediments drop, vegetation flourishes and water quality will improve.

A monoculture of blue gums has been replaced with floristically and structurally diverse native vegetation. A productive pasture and healthy native vegetation co-exist.

Company Name: BHP  
Site Name: Yarrie Iron Ore Mine  
Image: Courtesy of BHP





# Rehabilitation and Ghost Bat Cave Installation

## Rehabilitation Summary

BHP undertook rehabilitation of the Cattle Gorge ore body, part of the Yarrie group of iron ore mines, in 2016–17.

This work involved materials characterisation and long-term evolutionary modelling. Material movement optimisation was undertaken and rock armour applied in defined areas to ensure slope stability in key slope locations. More than 100 hectares has been rehabilitated with local provenance seeds.

In addition, BHP installed a second, larger, more complex artificial bat cave as part of its ongoing closure works across Yarrie iron ore projects. The artificial bat caves have evolved into multi-faceted, multi-compartmented, terracotta-coloured structures made from pigmented concrete to reduce light shine. Commonly called “bat motels” they are designed to accommodate multiple significant Pilbara bat species (i.e. Pilbara Leaf Nosed Bat), allowing each to coexist due to the inherent nested design. BHP won a Golden Gecko in 2018 for the Chasing Ghosts - Understanding Ghost Bat Ecology in the Pilbara project.

The Cattle Gorge rehabilitation project has created stable slopes, fauna habitats and the reintroduction of a diverse array of local flora. The project has blended into the surrounding natural Pilbara palette of colours.

Company Name: Hanson Construction Materials and Kings Park Botanic Gardens  
Site Name: Banksia Woodlands  
Image: Courtesy of Hanson Construction Materials





# Banksia Woodlands Restoration

## Rehabilitation Summary

The Banksia Woodlands represent an important part of the rich fabric of biodiversity in Australia's South West region. Close proximity to the sprawling Perth metropolitan region has seen 60 per cent of woodland lost in areas with many of the remnants under increasing threat from processes associated with fragmentation. Integrating future planning with restoration knowledge from scientists and management practitioners is critical to successfully manage and conserve these nationally important woodlands.

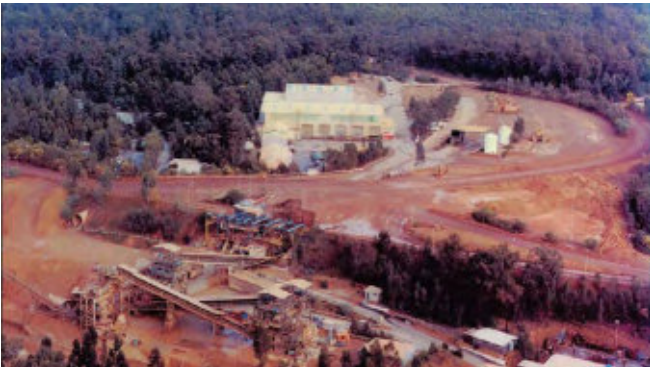
Using two decades of research, the publication *Banksia Woodlands – A Restoration Guide for the Swan Coastal Plain*, winner of the 2017 Golden Gecko Award, documents the new standard for mine site rehabilitation of Banksia Woodlands and is actively sharing the knowledge within the industry and broader community.

*Banksia Woodlands – A Restoration Guide for the Swan Coastal Plain*, developed by Hanson Construction Materials and Kings Park Botanic Gardens, highlights how long-term industry-scientific partnerships driven by a mutual vision can deliver world-class restoration solutions.

The results from the research partnership championed by Hanson Construction Materials and King Park Botanic Gardens are now contributing to restoration practices worldwide in new applications of techniques and technologies developed in WA.

Company Name: Alcoa of Australia  
Site Name: Jarrahdale  
Image: Courtesy of Alcoa of Australia





# Mine Closure in the Jarrah Forest

## Rehabilitation Summary

The Jarrahdale Mine was Alcoa's first operation in Western Australia. Over a 35-year period up to 1998, 168 million tonnes of bauxite were mined from a total area of 4,090 hectares.

At the time operations ceased, Alcoa set itself the challenge of a benchmark in mine closure. Key aspects of the closure were:

- consultation with government and the community regarding the closure plan and future land uses;
- removal of all obsolete infrastructure including removal of a mine water supply dam;
- recycling of materials where possible and removal of all contaminated materials;
- rehabilitation of all disturbed areas to agreed completion criteria; and
- review and remediation of older rehabilitation areas and the development of long-term management plans to allow sign off with the State Government.

A Certificate of Acceptance for 975 ha of rehabilitation at Jarrahdale Mine, the first for a significant area of mining rehabilitation in Australia at that time, was issued in November 2005. In 2007, Alcoa was recognised for its efforts in the successful closure of Jarrahdale Mine with a Golden Gecko Award for Environmental Excellence.

Company Name: Tronox Mining  
Site Name: Ludlow  
Image: Courtesy of Tronox Mining





# Tuart Woodland Ecosystem

## Rehabilitation Summary

Following mineral sands mining in State Forest in south west WA from 2004 to 2007, Bemax and Cristal Mining (now Tronox Mining) re-established a 110-hectare Tuart Woodland Ecosystem. Rehabilitation has achieved the proposed future land use, being the conservation of biological, physical, cultural and landscape values.

Weeds and the regeneration of Tuart trees identified during project approvals were the key challenges that were overcome to create an ecosystem progressing well towards, or meeting, completion criteria.

Prior to mining, the site was assessed as degraded, heavily weed infested with absent native understorey and various pine plantations. Positively, there were also many Tuart trees throughout the lease.

Tronox Mining developed a rehabilitation strategy to improve the ecosystem of the area post mining. A large part of this was to re-establish a biodiverse system with healthy groundcover, mid storey and canopy layers and to introduce new Tuart trees.

Some innovations undertaken during rehabilitation included retention of mature Tuart trees, and regeneration of Tuart seedlings using ash beds from stockpiled, cleared vegetation.

Operator Name: G. Morgan Amalgamated Prospectors and Leaseholders Association member  
Image: Courtesy of G. Morgan





# Prospecting Rehabilitation

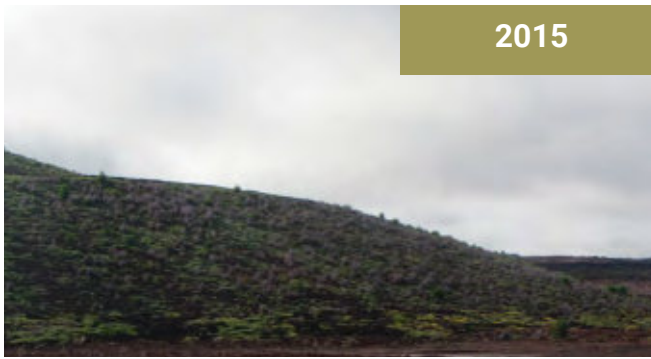
## Rehabilitation Summary

This is an example of progressive rehabilitation of scrape-and-detect activities in the Goldfields region.

Following the completion of prospecting activities, the operator has respread topsoil and scarified the ground surface, creating grooves that assist the capture of seeds and water, which in turn facilitates the regrowth of native vegetation. Long after the prospecting is completed, this area will begin to resemble the natural surrounding vegetation, reminding us why it is important to get the rehabilitation done well at the start, and letting nature do the rest. This regrowth photograph was taken three years after completion of the works on Ora Banda Mining's tenement at Siberia.

Company Name: Karara Mining Limited  
Site Name: Mungada Iron Ore  
Image: Courtesy of Karara Mining Limited





2015

# Terapod Waste Landform



2016

## Rehabilitation Summary

The Terapod waste landform was constructed as part of Karara Mining Limited's Mungada Iron Ore Project. Earthworks for the rehabilitation of the waste landform commenced in early 2014 and the final seeding component was undertaken in June 2014.

During rehabilitation, the slope of dump was battered to 17 degrees, and topsoil and rock/gravel, including banded ironstone formation (BIF) salvaged from the original landform surface were blended in a 1:2 mix. The BIF material, intended to protect the surface from erosion, was selected to be less than 300mm in diameter with a median diameter of 75 to 100mm. This blended material was spread over the sloping surfaces of the dump to a depth of no greater than 300mm. The final surface was cross ripped with a multi-tyne bulldozer to create furrows approximately one metre apart. These actions were intended to slow the movement of water down slope and reduce erosion. Seeding of the slopes was undertaken with seed sourced from surrounding plant communities. A total of 18 species were sown at a seeding rate of 1.5kg/ha. Nursery seedlings were planted for species known to have poor germination results or are difficult to collect.



2019

Rehabilitation of this waste rock landform has exceeded the benchmark of 70 per cent species diversity of reference sites. The average species counts in monitoring quadrats on the waste dump for 2019 were 16 species per quadrat compared to an average of 13 species in the reference sites. The waste rock landform has good native species recruitment in non-seeded areas (top flat area of the dump), and good soil stability and minimal erosion achieved where the rock/soil blend was as per the design.

Company Name: Roy Hill Holdings Pty Ltd  
Site Name: Roy Hill Project  
Image: Courtesy of Roy Hill Holdings Pty Ltd





# Rail Rehabilitation Success

## Rehabilitation Summary

Roy Hill Holdings Pty Ltd's independently owned and operated railway is a 344km standard-gauge, single-line, heavy-haul railway built to transport iron ore from the Roy Hill Mine to the dedicated Port stockyard facility in the Boodarie Industrial Estate south of Port Hedland.

Construction commenced in 2013 and progressive rehabilitation began along the rail corridor in 2014 with the majority completed by mid-2016. Approximately 7300 hectares were required to be disturbed during the railway's construction phase. To date, more than 2500ha of temporary disturbance areas, including borrow pits, spoil dumps, bridge areas, turkey's nest dams, laydowns and rail camps along the 344km rail line corridor have been rehabilitated. The success of rehabilitation has resulted in relinquishment of rehabilitation monitoring requirements under the Ministerial Statement for 430ha of land in 2018.

Rehabilitation activities included landform reshaping, re-establishment of drainage patterns and fauna habitat return.

Company Name: Rio Tinto  
Site Name: Channar  
Image: Courtesy of Rio Tinto





# Channar 84E5 Waste Rock Landform Rehabilitation

## Rehabilitation Summary

The Channar 84E5 waste dump was completed in 2011. The rehabilitation earthworks were completed by a joint venture indigenous contracting company over six months.

The waste dump had been tipped in a single tip face some 60–80 metres high. The rehabilitation design work was significant and required about 2 million cubic metres of material to be reshaped and moved into a tiered lift design to achieve a safe and stable design to meet long-term rehabilitation requirements.

The project used laser scanning survey controls and ensured the specifications of the final surfaces were in conformance tolerances. This has ensured the landform is able to cope with significant rainfall events.

Due to the topography of the Channar operations being located in steep hillsides, there is a shortage of available topsoil and the project was completed without topsoil application.

This project has demonstrated that it is possible to achieve successful revegetation outcomes without topsoil application. A number of key species are present in the rehabilitation and after nine years of monitoring its progress, it is a project that Rio Tinto's business and rehabilitation team are proud of.



Company Name: Mount Gibson Mining  
Site Name: Talling Peak  
Image: Courtesy of Mount Gibson Mining





# Drone Sampling and Rehabilitation Progress Modelling

## Rehabilitation Summary

Mount Gibson Mining relinquished and surrendered three tenements at Talling Peak in July 2016. A Rehabilitation Report was subsequently submitted to the department in February 2019 as a case for relinquishment of the remaining five tenements at Talling Peak. As part of landscape modelling, a custom-built drone was utilised to collect surface water samples from one of the pit lake surfaces. This technique was a finalist in the Safety and Innovations Awards for 2016 and 2017.

Empirical ecological data collected from Talling Peak mine was used to develop a mathematical model consistent with Eagleson's optimality theory of dynamic equilibrium. This work was published by Steedman et al (2019) in the AusIMM proceedings. The work makes clear forecasts about rates of recovery and its trajectory through time for the revegetation parameters, plant richness and density.

Company Name: BHP  
Site Name: Mount Whaleback  
Image: Courtesy of BHP





# Stable Landform Design and Construction

## Rehabilitation Summary

During 2016, BHP initiated a rehabilitation project encompassing more than 2km of Mt Whaleback, W40 waste rock dump. The design aimed to achieve maximum slope stability within a very limited footprint.

Extensive waste rock investigation, characterisation and modelling were completed to understand the proposed designed landforms performance over timeframes out to 1000 years in the future. Designs that met or exceeded criteria are subjected to optimisation analysis. The best of these designs undertook a further 3D evolutionary modelling run to highlight any points or mechanisms that would lead to erosion or failure and the final design selected from this group moved on to construction.

BHP identified suitable materials within the current run of mine for the capping layer, scheduling the movement of these materials. Integral to the construction is the use of digital elevation control to maximise efficiency and work within design limits.

## Department of Mines, Industry Regulation and Safety

Mineral House, 100 Plain Street, East Perth,  
Western Australia 6004

Telephone: 1300 136 237  
National Relay Service: 13 36 77

[online@dmirs.wa.gov.au](mailto:online@dmirs.wa.gov.au) |  [dmirs\\_wa](https://twitter.com/dmirs_wa) | [www.dmirs.wa.gov.au](http://www.dmirs.wa.gov.au)

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