MCA - Appendix A

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An industry report commissioned
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Mine rehabilitation in the Australian minerals industry

INDUSTRY REPORT

Minerals Council of Australia

Mine rehabilitation in the Australian minerals industry

Prepared by **Andrew Mattiske.**

Andrew Mattiske is a consultant to the mining industry who specialises in regulatory approvals, legislative compliance, community relations, safety and environmental management systems. He has an honours degree in Chemical Engineering and has worked for more than 20 years in mining and smelting operations in Australia & the Netherlands.

The Minerals Council of Australia is the peak national body representing Australia's exploration, mining and minerals processing industry, nationally and internationally, in its contribution to sustainable economic, and social development.

This publication is part of the overall program of the MCA, as endorsed by its Board of Directors, but does not necessarily reflect the views of individual members of the Board.

It is intended to showcase leading practice examples of mine rehabilitation within the minerals industry. The case studies displayed have been undertaken by suitably qualified environmental professionals in adherence to normal professional standards.

Minerals Council of Australia
Level 3, 44 Sydney Ave, Forrest ACT 2603
(PO Box 4497, Kingston ACT Australia 2604)
P. + 61 2 6233 0600 | F. + 61 2 6233 0699
www.minerals.org.au | info@minerals.org.au

Cover photograph courtesy of Downer EDI.

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Introduction

The ability to successfully rehabilitate mined areas is fundamental to the industry's social licence to operate and a foundation for demonstrating the industry's commitment to operating responsibly.

During development and operation, mines bring significant benefits to regional areas through economic development, capacity building and infrastructure. However, mining operations are finite in nature and mining is only one of many alternative land uses over time.

The Australian minerals industry recognises its responsibility as a temporary custodian of land to contribute to sustainable land use outcomes. It is the industry's goal that previously mined land is available for future economic activity, conservation or community use.

The industry's approach to land rehabilitation has improved significantly over past decades. This evolution has been driven by sustained investment in land rehabilitation techniques, evolving corporate values, community expectations and government regulation. While much progress has been made, the industry is continuing its efforts to improve rehabilitation methods to ensure mining's compatibility with current and future land uses.

Responsible environmental management over the life of a mining operation is essential for successful rehabilitation. Companies are careful to avoid disturbing land unnecessarily and to minimise the footprint of operations. This reduces the scale and complexity of rehabilitation requirements, and lowers the cost to companies. Furthermore, rehabilitation is undertaken not only at the end of a mine's life, but progressively during the mining process. This enables companies to meet rehabilitation obligations and minimise risk over the life of the operation.

The purpose of this booklet is to showcase examples of rehabilitation which demonstrate high standards of environmental stewardship. It also highlights innovative approaches employed by the industry to overcome technical challenges and achieve high quality environmental outcomes.

Industry commitment to mine rehabilitation and closure

The Australian minerals industry is committed to contributing to sustainable development outcomes, as evidenced by the widespread adoption of internationally recognised frameworks. Minerals Council of Australia member companies are signatories to *Enduring Value – The Australian Minerals Industry Framework for Sustainable Development*. *Enduring Value* provides guidance for the implementation of the 10 Sustainable Development Principles developed by the International Council on Mining and Metals (ICMM) (Appendix 1).

Key elements within the ICMM Principles and *Enduring Value* framework relate to mine closure and rehabilitation and provide guidance for the responsible decommissioning of mining operations.

The Minerals Council of Australia has also developed a Land Stewardship Policy (Appendix 2) which describes a vision and the key elements required to achieve sustainable land management throughout the mining life cycle, from exploration to relinquishment.

Government oversight

Mine closure planning and progressive rehabilitation are integrated into regulatory approval processes in all Australian jurisdictions. Environmental and planning legislation for mineral extraction requires mine operators to develop and update closure plans throughout the life of a mine, and closed sites cannot be relinquished until approval obligations, including closure criteria, have been met. All Australian jurisdictions also require some form of financial surety to be in place prior to granting of a mining approval/lease. This is used to fund the rehabilitation of mine sites in the event that a company defaults on its approved closure and decommissioning plans obligations.

Community engagement

Engagement with landholders, local communities and other stakeholders is essential in the development, implementation and review of mine closure and rehabilitation strategies. Community input is an essential step in developing final land use objectives for closed mines.

There have been many examples of final land use objectives changing over time as better alternatives become apparent. These can differ from those developed during the initial planning and approval process. This evolution highlights the importance of ongoing stakeholder engagement in rehabilitation and closure planning throughout the life of mine. This also ensures stakeholder expectations remain aligned with closure objectives.

Mine life cycle

Closure and rehabilitation are planned and considered across all stages of mine development and operation, from design to closure. Decisions made from the start of a project can significantly impact the success of rehabilitation programs and final closure and relinquishment.

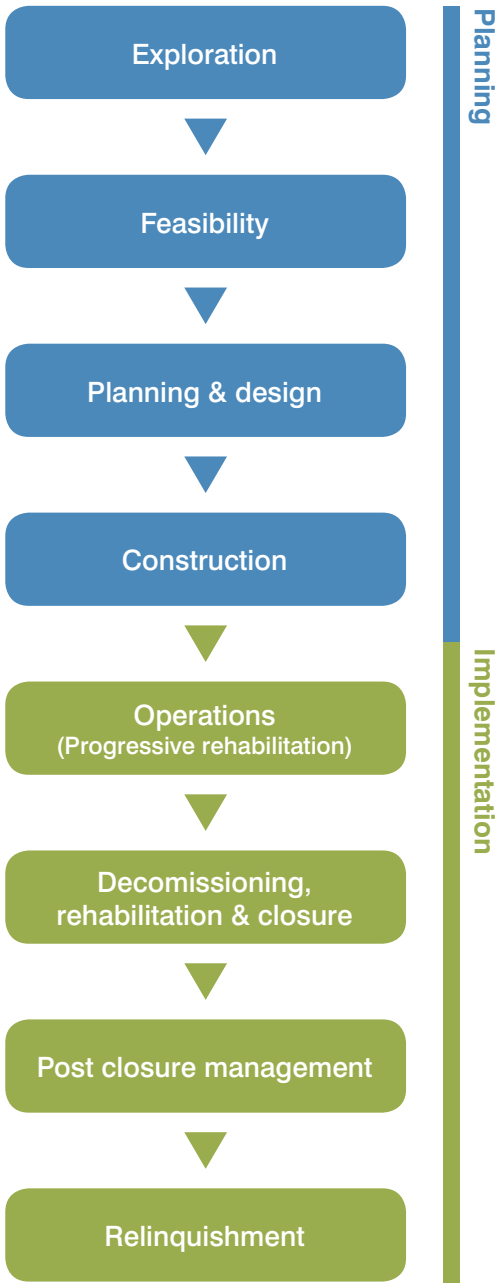
Using a series of case studies, this document explores what is being achieved at a number of mining operations in the areas of progressive rehabilitation during operations, through to final rehabilitation and closure.

Leading practice case studies

The case studies highlight the success of Australian mining companies in rehabilitating mined land for agricultural use or sustainable ecosystems. The examples demonstrate industry investment and innovation in land rehabilitation and illustrate results that meet or exceed a company's regulatory obligations.

All case studies have been developed by professionals with significant expertise in measuring and assessing the effectiveness of rehabilitation, and highlight where leading scientific methods have been used to optimise rehabilitation outcomes.

Mine life cycle



1 Alluvial land rehabilitation

Coal & Allied Mine

Post rehabilitation, during the lucerne cropping trial

Coal & Allied's rehabilitation of alluvial lands in the Hunter Valley is the first trial of its kind in New South Wales to demonstrate that alluvial land used for mining can be rehabilitated to match the crop production levels of nearby farms.

After three years of consecutive production, hay yields were above the district average and landform settlement had reached equilibrium.

The land was tendered out for commercial cropping in 2013 and is being used to grow crops such as Lucerne and Triticale (a hybrid of wheat and rye used in cereals).

Alluvial land rehabilitation / Coal & Allied Mine

Rehabilitated alluvial land supports successful commercial cropping

Background

The Coal & Allied Mine is located in the Upper Hunter Valley Region. Alluvial land is land along rivers where sediment has built up, producing rich fertile soils. This project has been ground-breaking, because mining in New South Wales generally occurs on lower classes of land suitable only for grazing, or unsuitable for agriculture.

As a condition of the development consent to mine the 165 hectares of farming land, Coal & Allied was required to reinstate 65 hectares of the land to Class 1 and 2 lands suitable for irrigated agriculture. The remaining area was rehabilitated to support dry-land farming. In order to demonstrate that the land had been restored as required, Coal & Allied was required to produce Lucerne hay with a productivity yield equivalent to the average crop productivity yields for the Upper Hunter Region for three consecutive years.

Planning and rehabilitation

Planning for rehabilitation began in 1990 before mining commenced. Mapping of the soil profile was carried out and topsoil and subsoil stockpiled separately. By 2003, backfilling of the eastern section of the alluvial land was complete and rehabilitation commenced.

The stockpiled subsoil and topsoil were replaced to a depth of 1.5 metres to accommodate crops with deep roots like Lucerne.

Cropping trial results

By 2007 the trial area demonstrated hay production yields above the district average for three consecutive years, as demonstrated in Table 1.

Table 1 **Crop yields for stage 1 and 2 and the district (2003-2007)**

Year	Stage 1 tonnes of hay per hectare	Stage 2 tonnes of hay per hectare	District average
2003-04	11.7*	Not sown	Not available
2004-05	15.9	18.4	14.8
2005-06	14.8	15.6	14.9
2006-07	Compliant	8.72	7.6

** Shortened harvest season due to crop establishment*

Farmer Peter Nichols, Coal & Allied's Bill Baxter and Farmer Warehouse's Kyle Roper inspect yield, and below, a triticale crop.

Courtesy Singleton Argus

Challenges

Consolidation and settlement of the backfilled land was anticipated, and the area was regularly surveyed to confirm this. An assessment of these results indicates that the rate of settlement has reached equilibrium. To confirm this, in 2011 soil test pits were excavated through the area and revealed that there has been no loss in the depth of subsoil and topsoil.

Ongoing results

In 2010, Coal & Allied carried out a competitive tender process for commercial cropping of the land. The tender attracted five submissions and was awarded to Jerry's Plains farmer Peter Nichols. The ability to attract graziers to compete for the right to commercially crop the land highlighted community confidence in the results of the trial.

In June 2013 Peter began preparation for planting a crop on the land, including cultivation and spraying. In July 2013 a crop of Triticale was planted on the land, the first commercial crop since the productivity trial ended in 2007. Triticale is a hybrid of wheat and rye and is used in cereals. The crop was progressing well until it was hit by late frost in October 2013. Instead of being harvested for grain the crop was baled and used for fodder. Another crop of Triticale was planted in 2014 and subsequent crops are likely to include Lucerne.

Conclusion

The Coal & Allied experience has provided new knowledge on the rehabilitation of higher classes of agricultural land. The land will continue to be farmed and monitored and will ultimately be a valuable asset to relinquish at the end of the mine life.

Summary

Pre-mining land use	Agriculture (cropping)
Post mining land use	Agriculture (cropping)
Change in land use values	Aim to replicate pre-mining productive farmland
Key success factors	Detailed planning completed prior to mining with careful mapping of the soil profile
Further information	www.riotintocoalaustralia.com.au info@rtca.riotinto.com.au

2 Ginkgo Mineral Sands
Cristal Mining

Rehabilitation work at the Ginkgo minerals sands mine in south western New South Wales demonstrates the re-establishment of a semi-arid native vegetation ecosystem in an extremely challenging environment.

Native flora species cover once bare soil and many native lizards and birds have resettled in the area.

Successful rehabilitation works demonstrate an understanding of the delicate landscape, which required innovative techniques to return it to a diverse and functioning ecosystem.

Native species resettle after rehabilitation works at Ginkgo mine

Background

Cristal Mining Australia is part of Cristal Global, a supplier of high quality titanium-based products.

The Ginkgo mineral sands mine is located in the Murray Basin approximately 85 kilometres north of Mildura. Mining operations are primarily carried out on lightly grazed native vegetation. Topsoil which varies from 0.7 – 1 metre in depth is removed by tractors with scoops and placed directly on prepared rehabilitation areas or stockpiled separately. Overburden is removed by excavators and dump trucks. Timber vegetation is cleared and stockpiled for re-use as fauna habitat and to stabilise sloping landforms.

The mine is located in a semi-arid area with around 270 millimetres of annual rainfall, and incurs baking summer temperatures in excess of 40 degrees Celsius, high winds particularly in autumn and sub-zero temperatures in winter. The company approached the project with a great deal of care, particularly due to the fragile nature of overburden materials, which is prone to erosion and tunnelling which hinder stability and regrowth of vegetation.

Planning and rehabilitation

Cristal Mining engaged an industry specialist in erosion modelling and landform design to assist in drawing up a rehabilitation plan to establish landforms that were able to withstand the severe weather events which can occur in the region.

Planning for the rehabilitation work started well before the first tonne of soil was removed for mining. Progressive rehabilitation of the site began in 2007, only two years after the mine commenced operations. Trials were designed to investigate and understand the most effective seed mixes, appropriate site preparation techniques, and optimal depths for reestablished soil profiles. The Cristal Mining team collected native seeds, topsoil and timber along the mine path and surrounding areas and stored them for use after the completion of mining in the area.

Rehabilitation profiles were designed and constructed to correct the gradient of the land to minimise the risk of erosion. The timber and topsoil that were previously removed from the site were replaced over the land to create a growth medium and protective microclimate for the seedlings to establish. Where possible, larger trees that

Ginkgo Mineral Sands / Cristal Mining

Harvesting biological soil crusts as part of a study into the role of lichen and mosses in the establishment of vegetation.

had been cut down during clearing were placed standing up to provide fauna habitat, and were even used to host nest boxes. The effort resulted in an impressive transformation into a landscape where native vegetation thrived.

Challenges

Revegetation work at Ginkgo was tested when a rain event caused severe flooding in the area in February 2011. Two-hundred millimetres of rain fell in one day after the region had endured a heat wave, a crippling drought, bush fires and a plague of locusts. Remarkably, these severe climate events did not hamper the revegetation work completed at Ginkgo, and no significant erosion was apparent after the storms and flooding had subsided

As is relatively common in this part of the country, the Ginkgo mine site is continually frequented by feral goats. The goats can destroy native vegetation, cause erosion and are generally very detrimental to rehabilitation efforts. Every month, Cristal teams up with a local landholder to muster goats on the mining lease, where they are rounded up and sold for export.

Innovation

Seed collection is an important component of the rehabilitation program, and due to the irregular plant seeding events in the area, seed needs to be collected up to 500 kilometres from the mine site.

The sporadic nature and general lack of rainfall makes it difficult for trees to survive and thrive in the first two years. Given these difficulties, the company focussed on planting smaller stands of tube stock which can be manageably watered in the dry climate to aid their establishment. The company has also partnered with Federation University to undertake a PhD study to refine techniques to successfully and more efficiently grow trees in the area.

The Company has initiated studies to understand the role of biocrust in the establishment of vegetation. Biocrust, or biological soil crusts, are primarily lichen and mosses that establish on the landscape surface, and is known to aid in the retention of moisture from rainfall. Greater understanding of its role and the means of promoting the growth of these organisms on revegetated land may be an important part of the jigsaw in learning how to revegetate land in a very harsh, arid climate.

Community members from the Dareton Men's Shed have contributed to environmental efforts at Ginkgo by building specially designed bat and bird boxes to provide habitat for animals as they return to the rehabilitated land.

The company has also implemented an innovative program to count ants, the abundance of which is an important measure of ecosystem development.

This mind boggling task can involve tallying up to 50,000 ants in an individual area. Ants are an important colonising species in that they are not only an important food source in the food chain, but also assist in the germination of plants.

Monitoring

Cristal Mining has established a vast number of monitoring sites to measure the success and progress of the rehabilitated areas including:

- Observations on erosion type and severity
- Assessment of ground conditions
- Vegetation species composition, cover and height.

Annual fauna surveys to date on the Ginkgo overburden area 3 (OB3) rehabilitation have shown counts twice as high when compared to the surrounding remnant vegetation control sites.

Outcomes

Today, native flora species including Belah, Mallee, Black Bluebush, Old Man Saltbush, and Pearl Bluebush cover the once bare soil. Many of the flora species have re-established themselves from the stored topsoil, and this complements the seeding and replanting efforts. Many species of native lizards and birds have resettled in the area to create their homes.

Conclusion

The rehabilitation work at the Ginkgo mine demonstrates a commitment to understanding the landscape and developing innovative techniques to return it to a diverse and functioning ecosystem.

While the aim of the restoration work is to ultimately return the land to the government and landholders as native vegetation suitable for light grazing under existing grazing licences, there is still some work to do in confirming relinquishment criteria and defining a process whereby the land might be handed back to the original land managers.

Summary

Pre-mining land use	Light grazing on native vegetation
Post mining land use	Light grazing on native vegetation
Change in land use values	Aims to replicate pre-mining native ecosystem suitable for light grazing. Trees slow to re-establish
Key success factors	Developing innovative techniques to re-establish semi-arid native vegetation ecosystem
Further information	www.cristalmining.com cristalmining@cristal.com

3 Commodore Coal Mine

InterGen / Downer Mining

Commodore coal mine rehabilitation program is an example of a mature mine revegetation program on agricultural land.

Around 250 hectares of land has to date been rehabilitated and is being maintained and monitored to demonstrate the land is stable and productive.

Located on the Darling Downs in southern Queensland, the mine has successfully used the innovative Ecosystem Function Analysis methodology developed by the CSIRO to assess the success of rehabilitation works. Resilience of the rehabilitated pasture has also been scientifically measured through the use of slashing and fire trials.

Commodore Coal Mine / InterGen / Downer Mining

Commodore coal mine is an example of successful agricultural land rehabilitation

Background

Millmerran Power is an 850 Megawatt power station near the town of Millmerran on the Darling Downs in southern Queensland, about 180 kilometres southwest of Brisbane. Coal for the power station comes from the adjacent open-cut Commodore mine. Global power generation firm InterGen owns the land on which the mine and power station are located, and contracting company Downer Mining has responsibility for mine planning, mining and rehabilitation of previously mined areas.

The environmental authority requires the land be reinstated for agricultural use. Revegetation consists of pasture grass species as well as 10-20 per cent of seasonal cover crop such as oats and barley.

Planning and rehabilitation

A key factor contributing to the successful progressive rehabilitation of the site is the management of topsoil. Topsoil is carefully stripped and segregated, seeded with pasture grasses and stockpiled. Care is taken to minimise compaction of soil stockpiles and manage weeds. More recently, mine planning logistics have been developed to enable topsoil to be stripped from new mining areas and directly placed as rehabilitation cover on previously mined land.

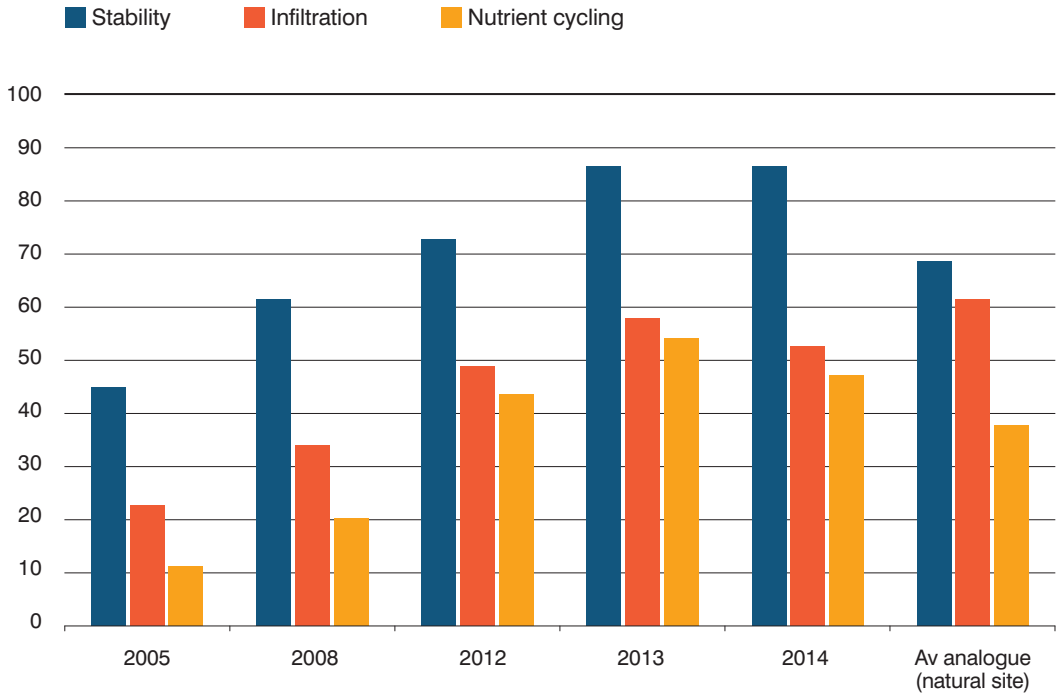
Other aspects of the continual improvement of the rehabilitation methodology include incorporating ash from the power station at the base of the void, which is subsequently covered with eight metres of overburden.

Innovation

The Commodore mine has successfully used the Ecosystem Function Analysis (EFA) methodology developed by the CSIRO to quantitatively assess the success of rehabilitation works. Landscape Function Analysis (LFA) and Vegetation Dynamics are used as key performance indicators, which are compared to analogue undisturbed control sites that have been monitored over a number of years. Simple field indicators such as landscape stability, water infiltration and nutrient cycling are regularly monitored along transect lines and analysed.

Chart 1 shows the improvement at one rehabilitation site across key indicators over time in comparison with control sites (analogues).

Chart 1 **Changes through time in indices from transect CD 1**



One of the key objectives of the rehabilitation program has been to stabilise the landform such that surface water run-off achieves water quality criteria to enable discharge into local waterways. Water quality in the receiving creeks needs to be protected, and initial rehabilitation works required all surface water run-off to be captured and stored on the mining lease.

Over time Downer Mining has worked closely with the Queensland Department of Environment and Heritage Protection to ensure appropriate water quality parameters have been established and monitored to demonstrate protection of the local waterways. As the rehabilitated areas have matured, surface water quality has improved such that the water can be released off site which enables run-off to feed the natural waterways as it did prior to mining.

Outcomes

Downer Mining has conducted a number of trials to demonstrate that the established rehabilitation work is both resilient and sustainable and that the vegetation will regenerate and remain productive after natural events such as fire or disturbance such as grazing.

While the ultimate goal of the rehabilitation works is to return the land to pasture to support cattle grazing, there is concern that introduction of stock onto the land in the early stages of regeneration may result in some degree of erosion and therefore compromise the important goal of protecting surface run-off water quality. Therefore grazing on the land is not currently considered a priority, but may be trialled at a later stage.

Conclusion

Downer and InterGen consider the rehabilitation work completed to date demonstrates a sustainable and productive landscape and achieves the rehabilitation requirements prescribed in the original mining approval issued to the site. The companies are continuing to work with the Queensland government to achieve final sign off on the rehabilitation program.


Surface water quality has improved such that it can be released off site, enabling run-off to feed the natural waterways as it did prior to mining.

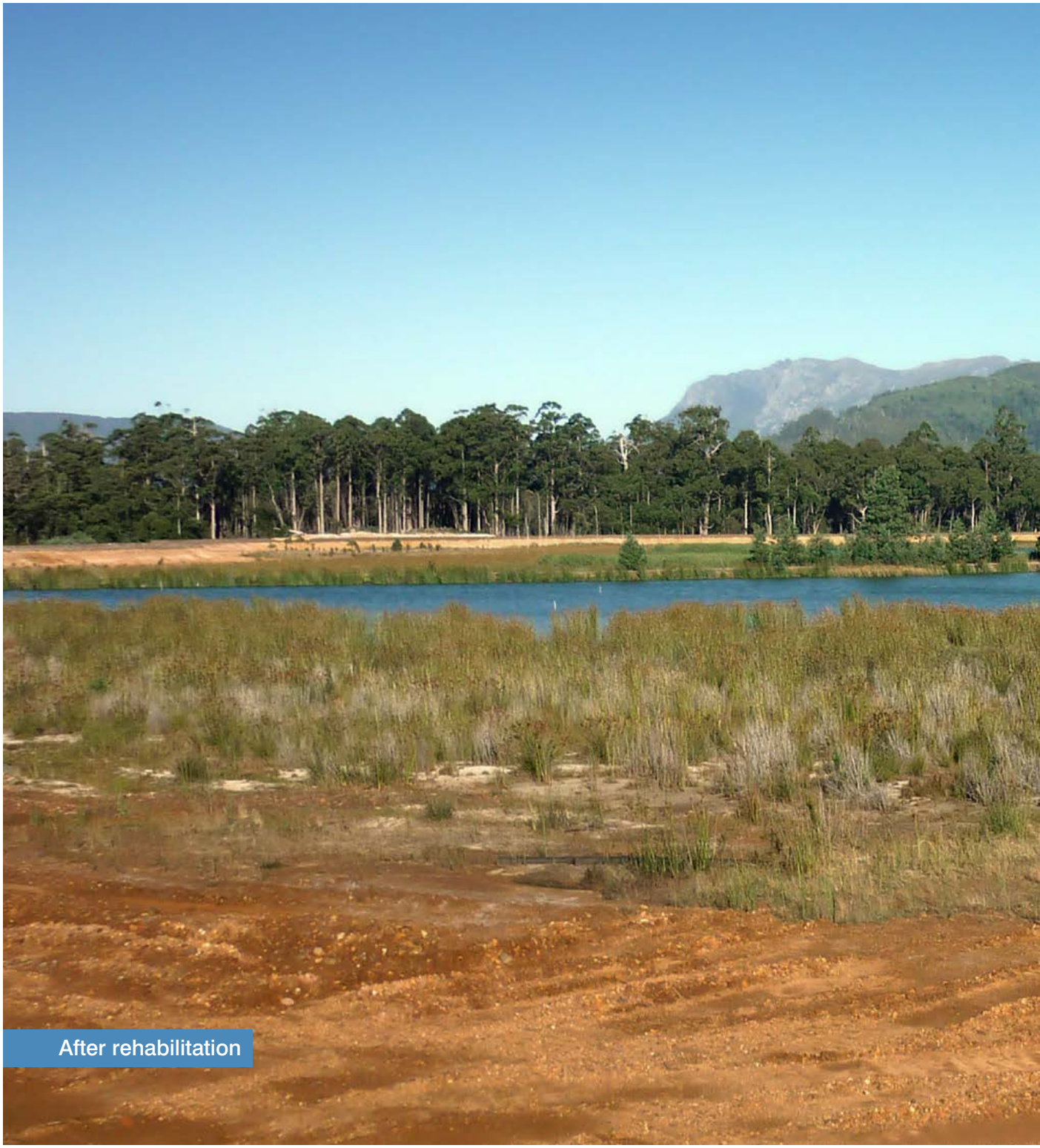
Commodore Coal Mine / InterGen / Downer Mining

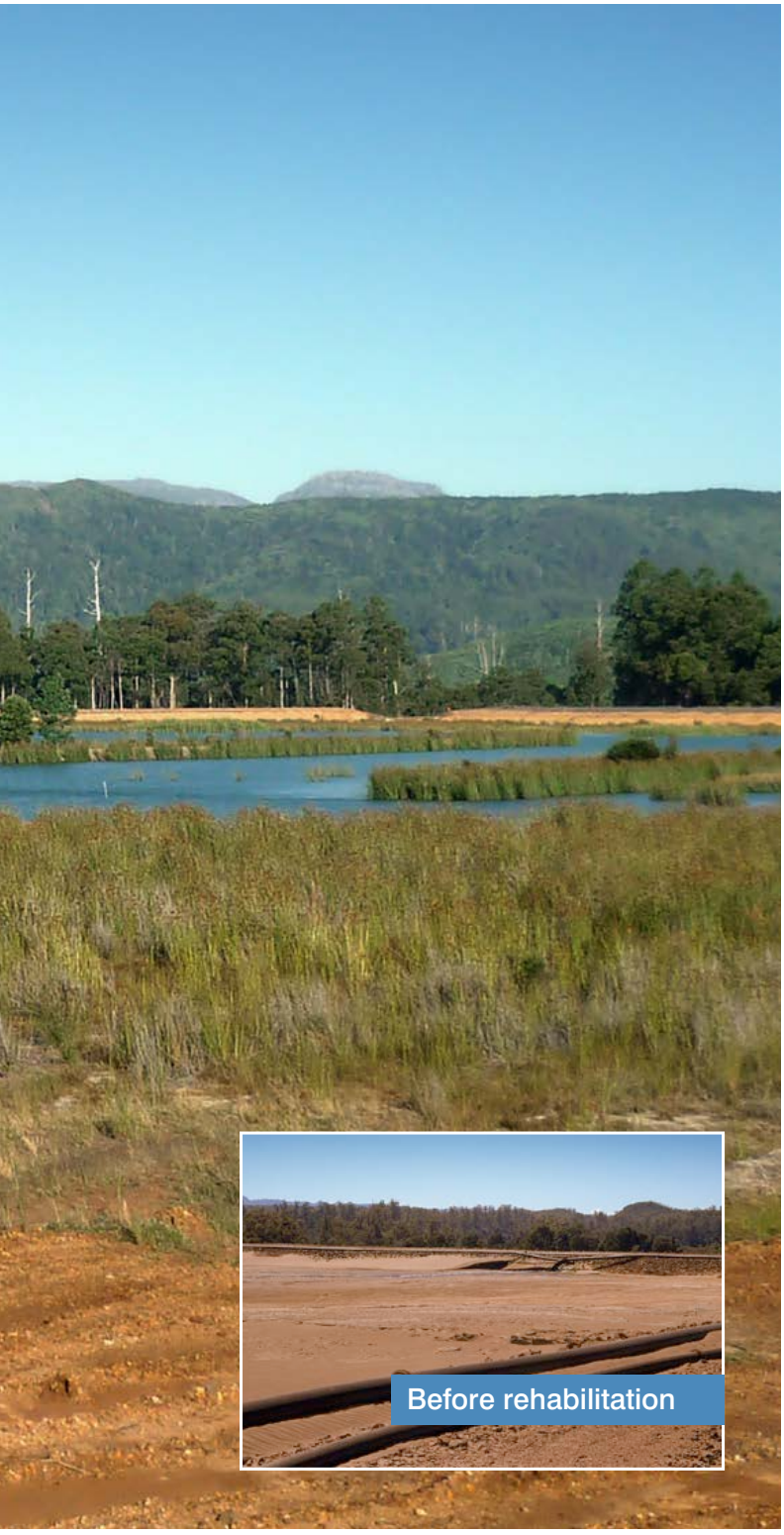
Summary

Pre-mining land use	Grazing pasture
Post-mining land use	Grazing pasture
Change in land use values	Resilient pasture established, with grazing trials expected to be undertaken after further maturing of the rehabilitated area
Key success factors	Extensive consultation to deliver a rehabilitation strategy accepted by stakeholders
Further information	www.downergroup.com info@downeredimining.com

4 Renison Bell Tin Mine

Bluestone Mines Tasmania





Rehabilitation of the Renison Bell tin mine tailings storage facility (TSF) in western Tasmania is an example of the application of good science and commitment to solve environmental challenges.

Two tailings storage facilities at Renison, first used in 1968, had a history of discharging elevated levels of dissolved metals, sulphate and acidity, which posed a risk to water quality in the adjacent Lake Pieman.

Innovative geochemical studies carried out with assistance from CSIRO revealed a way to create a cap which excludes oxygen and neutralises water within the TSF. Once implemented surface water quality rapidly improved and acceptable environmental discharge standards were achieved.

Renison Bell Tin Mine / Bluestone Mines Tasmania

Innovative approach to tailings storage resolves long-running challenge

Background

The Renison Bell mineral deposit in Tasmania has been mined since 1890. The mine has been under the ownership of Bluestone Mines since 2004 and currently produces approximately 7,000 tonnes per annum of tin metal.

Challenges

Tailings comprise a slurry of water and fine sediment particles, and are produced as a by-product of minerals processing following the recovery of valuable minerals from the ore. It is conventional to dispose of the product within a purpose built TSF. Some tailings, such as those at Renison, can oxidise in the presence of moisture and oxygen over time to produce dilute but environmentally damaging acid, commonly referred to as acid mine drainage.

Two TSFs were constructed and first used at Renison in 1968. Seepage from the TSFs and rainfall collecting on the surface of the TSFs contained elevated levels of dissolved metals, resulting in acidic discharge to Lake Pieman, a highly valued trout fishing and eco-tourism destination set among cool temperate rainforest.

Planning and rehabilitation

Since 1992, a closure plan for the Renison TSFs has been in place, an objective of which is to protect water quality in Lake Pieman. It was determined that the Renison mine TSF should be constructed and operated in such a way that upon closure, it acted to passively neutralise or treat acidic waters prior to release to the environment.

Innovation

In a research partnership with the CSIRO, Renison began covering the TSFs with a non-acid forming material to exclude oxygen. A discrete component of the tailings stream, known as cassiterite flotation tailings, was identified as being a suitable capping material which was able to be separated during mineral processing and spread as a slurry across the top of the tailing beaches. Grasses and rushes were then planted on the covered beaches. The system was then allowed to develop naturally into a wetland.

Surface water quality rapidly responded to the improved management of the TSF, with sulphate levels in runoff falling from around 1,500 milligrams per litre in 2002 (before covering of the sulphide beaches was completed), to an average of

The development of the wetlands began in 2003 following three years of research with the CSIRO. By 2014, water birds had inhabited the wetlands.

The cassiterite flotation tailing cover across the tailings at the start of the TSF rehabilitation in 1992.

70 milligrams per litre in 2006, and remained around this level until 2013. There were similar decreases in acidity and metals levels.

The effect took longer to manifest in the seepage waters, but has been more pronounced. By 2014 acidity levels had fallen by 90 per cent compared to 1994 levels, achieving a standard which was acceptable for discharge to the environment.

Monitoring

Water quality discharging from the TSFs is closely monitored, and Bluestone has worked closely with the Tasmania Environment Protection Authority to develop its strategy for managing closure and discharge from the TSFs and ensure appropriate environmental standards continue to be achieved.

Next steps

The rehabilitation of the two original TSFs at Renison was initially considered as final rehabilitation for closure. However, as is often the case in an industry as dynamic as mining, the rehabilitated TSFs have recently been identified as being geotechnically suitable for expansion to sustain mining activities for an additional four years.

Re-use of the original TSFs has enabled Renison to significantly reduce its footprint (area of disturbance), the future cost in managing tailings, and minimise the size of the next TSF planned for the site.

Conclusion

The rehabilitation work completed to date provides the company and government regulators with a high level of confidence that closure can be carried out in a practical and effective manner that will achieve prescribed environmental criteria and protect water quality in Lake Pieman.

Summary

Pre-mining land use	Water catchment, native vegetation
Post mining land use	Water catchment, native vegetation
Change in land use values	Tailings storage facility retained as a water body in the Lake Pieman water catchment
Key success factors	Research and development studies to understand chemistry and adapt process to improve outcomes
Further information	Bluestone Mines Tasmania Joint Venture Pty Ltd enquiries@bluestonetin.com.au

5 Liddell Coal Operations

Glencore

Liddell open-cut coal mine has achieved high quality rehabilitation of grazing pasture, demonstrating mined land can be returned to productive and sustainable farming.

The successful grazing trials revealed cattle on the rehabilitated land grew faster and averaged an extra 79 kilograms over cattle on neighbouring pasture. At the abattoir, the extra weight and condition of the cattle grazed on rehabilitated land returned approximately 25 per cent higher price, or $220 per head.

While trial results are not yet conclusive, there are indications the grazing of cattle on rehabilitated land at the Liddell coal mine is commercially viable and may well provide superior pasture compared to surrounding unmined paddocks.

Cattle grazing trials on rehabilitated land deliver strong results at market

Background

Liddell Coal Operations is an open-cut mine located at Ravensworth, approximately 25 kilometres north-west of Singleton in the Upper Hunter Valley of New South Wales. The mine is operated and managed by Liddell Coal Operations Pty Limited, on behalf of a joint venture between Glencore and Mitsui Matsushima Australia. It has been in continuous operation, using open cut and underground mining methods since the 1950s.

Planning and rehabilitation

The upper and central Hunter Valley has been largely cleared of native vegetation, primarily for agriculture as well as other land uses including mining, power generation and urban development.

The nominated end land use for the Liddell operation is primarily grazing. However, because of the long history of clearing and degradation of the floristic diversity and fauna habitat in the central Hunter Valley, there is a strong commitment to rehabilitating the land with viable woodland as well as pasture land suitable for grazing.

The mine's rehabilitation management strategy has been designed to progressively achieve prescribed mine closure objectives.

The rehabilitation strategy aims to emulate the pre-mining grazing areas, ensure the landscape is compatible with adjoining lands, enhance local and regional ecological linkages and provide for a sustainable land use option.

Cattle grazing trials

Grazing of cattle on rehabilitated mining land in the Upper Hunter has occurred in various forms since the 1980s, but was generally small scale and not well documented. Commensurate with the nominated end land use of primarily grazing, and in response to feedback from various stakeholders, Glencore commenced a grazing trial at Liddell mine in late 2012. The aim of the trial was to demonstrate that previously mined land can be

Liddell Coal Operations / Glencore

rehabilitated to sustainable and productive grazing land, at least equivalent to its pre-mining capacity.

The grazing trial was designed to compare a rehabilitated grazing site to an adjoining unmined (control) grazing site using a range of soil, vegetation and livestock parameters. The trial also sought to refine criteria used by Glencore for restoration of grazing land.

The trial has been overseen by a local agronomist and the selected rehabilitated paddocks range from 3 to greater than 10 years since sowing. For the first phase of the trial, 60 Chambray steers were randomly drafted into rehabilitation or control paddocks in December 2012 at stocking rates slightly above the district average.

The rehabilitation and control sites are each 70 hectares in size, with two paddocks in each treatment to allow for rotation of cattle and spelling of paddocks.

Every 2 to 4 months the cattle were weighed and pasture condition monitored which coincided with rotations through paddocks. At point of sale, blood tests were repeated as per the baseline, commercial returns were assessed and feedback was received from the point of sale.

Soil samples were collected at depths of 0 to 10 centimetres at each representative site. The soil monitoring data showed a degree of variability in the results, but generally indicated a good capacity to sustainably support productive pasture species.

Table 1 **Carcass comparisons**

Average per steer	Natural pasture	Rehabilitated pasture	Difference
Carcass weight (kg dressed)	309 kg	342.7 kg	+33.7 kg
Fat depth (mm P8)	2.6 mm	3.0 mm	+0.4 mm
$ per kilogram dressed	$2.96	$3.42	+$0.46
$per head	$958.05	$1,177.65	+$216.60
$ per 30 head in each treatment	**$28,741.50**	**$35,329.50**	**+$6,588**

Table 2 **Cattle weights**

Average weight & gain (kg/day)	Unmined pasture	Rehabilitated pasture
17 December 2012	418 kg	406 kg
30 April 2013	480 kg (0.5 kg/day)	510 kg (0.8 kg/day)
2 August 2013	447 kg (-0.4 kg/day)	485 kg (-0.3 kg/day)
26 November 2013	463 kg (0.1 kg/day)	512 kg (0.2 kg/day)
23 January 2014	517 kg (0.9 kg/day)	566 kg (0.9 kg/day)
26 March 2014	541 kg (0.39 kg/day)	597 kg (0.5 kg/day)
30 April 2014	577 kg (1.0 kg/day)	638 kg (1.2 kg/day)
3 June 2014	597 kg (0.57 kg/day)	662 kg (0.63 kg/day)
Total weight gain (533 days)	**177 kg (0.3 kg/day)**	**256 kg (0.6 kg/day)**

Importantly, the first phase of the trial achieved one of the primary objectives which was to maintain average ground cover levels above 70 per cent throughout the trial to minimise the potential for erosion.

Pasture samples collected across the trial areas showed that compared to the natural pasture rehabilitated paddocks had superior feed quality when considering the range of species present. Testing of water quality in stock dams confirmed the water was of suitable quality for grazing cattle.

At the abattoir, the extra weight and condition of the cattle grazed on rehabilitated land returned approximately 25 per cent higher price, or $220 per head. All carcasses met meat industry standards in relation to quality, pH, fat, ossification, etc.

Conclusion

Overall the trial indicated that the grazing of cattle on rehabilitated land at the Liddell coal mine is commercially viable and may well provide superior pasture compared to surrounding unmined paddocks. However, while the trial results are very encouraging, they are not yet conclusive. The trial is ongoing and a second load of cattle entered the trial in late 2014. This will allow further monitoring and analysis of results over a range of seasonal conditions to fully understand the trends with respect to cattle weights, soils and pastures. The impressive results to date should provide the local community with a degree of confidence that cattle grazing on rehabilitated mining land can be carried out in a productive and sustainable manner.

Summary

Pre-mining land use	Grazing pasture (cattle)
Post mining land use	Grazing pasture (cattle) and native woodland
Change in land use values	From native pasture grasses to introduced pasture grasses for sustainable, higher productivity grazing
Key success factors	Scientific approach to measuring grazing productivity and characterising soils and pasture composition
Further information	www.glencore.com.au sustainability@glencore.com.au

6 Huntly and Willowdale Mines
Alcoa

After rehabilitation

Alcoa mines and rehabilitates approximately 600 hectares each year at its Huntly and Willowdale bauxite mining operations in the Darling Range in Western Australia.

A key objective of Alcoa's rehabilitation program is to restore 100 per cent of the plant species that existed in the pre-mined jarrah forest 15 months after rehabilitation is complete, an objective well above government requirements.

Alcoa has established its own nursery and has developed innovative techniques over many years to ensure the successful rehabilitation of the land and maximise the number of species re-established.

Huntly and Willowdale Mines / Alcoa

Marrinup nursery behind success of large-scale jarrah forest revegetation

Background

Alcoa's Western Australian bauxite mining operations are located within jarrah forest on the Darling Range, approximately 100 kilometres south of Perth. Extraction of bauxite in the Darling Range Plateau commenced in 1963. The Huntly and Willowdale mines currently produce about 34 million tonnes of bauxite per year.

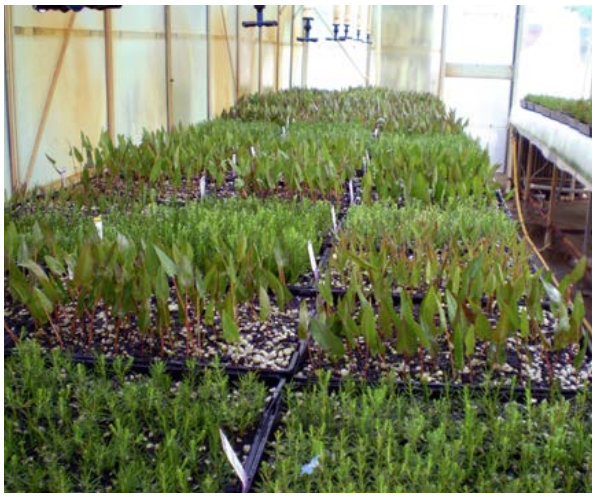
Planning and Rehabilitation

The rehabilitation process has been developed, researched and continuously improved over the past 35 years. Rehabilitation processes have been fully integrated into mining operations and start at the mine planning stage where significant vegetation, fauna and heritage sites are identified.

A key environmental objective of the program is to restore 100 per cent of the plant species richness to the rehabilitated areas compared to the pre-mined jarrah forest, 15 months after rehabilitation is complete. This goal was first achieved in 2001 when over 101 per cent of botanical species were returned to the rehabilitated areas. Rehabilitation which involved planting in the 2006-07 season resulted in the highest return of botanical richness to date, over 108 per cent. The result means that on average there are more species found in an equivalent area of rehabilitation, compared with the existing unmined forest.

Innovation

Alcoa has developed a number of innovative techniques over many years to ensure the successful rehabilitation of the land and to maximise the number of species re-established. In addition to returning fresh topsoil, specially treated seeds are broadcast and nursery-grown plants from seeds, cuttings and tissue culture are planted.



Marrinup nursery

Alcoa's Marrinup nursery provides seeds and plants for the rehabilitation of mined areas. In addition, the nursery carries out seed viability and germination testing, and grows 'recalcitrant' plant species (defined below) for other mining companies.

The nursery includes a tissue culture (or micro-propagation) laboratory solely for the purpose of restoring a high diversity of plant species in previously mined areas. These unique facilities are world class.

Applied seed

Each year Alcoa spreads over five tonnes of native seed onto mine rehabilitation areas. All of the seed is collected within approximately 20 kilometres of where it is used to ensure that the same genetic diversity that was present before mining is reinstated.

Some species require heating or smoke treatment to germinate. Furthermore, the timing of seeding has also been found to be important in the establishment of plants from applied seed. Contrary to conventional practices, laboratory and field trials identified benefits of sowing seed in the summer ahead of autumn rains and immediately onto the tilled soil. This improves seed burial and germination rates.

Alcoa uses a computer controlled air seeding machine attached to a ripping bulldozer, spreading seeds of various species directly onto freshly ripped ground, which results in superior germination rates.

Recalcitrant species

Many of the dominant jarrah forest understorey plant species do not produce viable seeds. If they do produce seeds, they are difficult to collect or do not readily germinate. As a result, some of these species would be under-represented in rehabilitated areas compared with the forest vegetation as they do not readily establish from the natural seed in the topsoil that is returned or from applied seed.

These difficult plants are known as recalcitrant species, and they often play an important role in the jarrah forest ecosystem. For example, common dry land sedges are a favourite food source for kangaroos in the rehabilitated areas. They also re-sprout quickly and vigorously after disturbances such as fire, and hence give the forest resilience to such disturbances. Several processes are used to overcome the difficulty of germinating recalcitrant species, including the use of cuttings, tissue culture propagation and direct planting of seedlings.

Cuttings

Approximately 50,000 plants are grown from cuttings each year at the company's Marrinup nursery. Fresh shoot material is taken from wild populations in spring each year (with appropriate collecting permits) to have plants ready for planting the following winter. The best shoots for cuttings are from plants that are re-sprouting after being burnt, so collections are made from recent control burns or wildfire areas.

Tissue culture/micro propagation

Tissue culture or micro propagation is the most difficult and expensive method of propagating recalcitrant or difficult plant species for mine rehabilitation. This method is used when other methods such as seeds or cuttings fail. Instead of seed, these ancient species grow and spread by sending out vegetative shoots.

Huntly and Willowdale Mines / Alcoa

These vegetative adaptations are ideally suited to recovering from fires, grazing and drought, which are regular occurrences in the natural jarrah forest. However it does make them difficult to return to mined areas. Approximately 100,000 plants are grown from tissue culture each year for planting into rehabilitated mined areas.

Seedlings

For some jarrah forest plant species, seed does germinate but is difficult to collect and only small amounts can be obtained. It is more efficient to use this seed to produce seedlings in the nursery and plant them out rather than simply use the seed in the broadcast seed mix where the number of successful seedlings will be much lower.

Approximately 50,000 plants are grown from seed and planted each year in rehabilitated areas.

Fauna habitat

Increasing the number of fauna habitats in the rehabilitation area results in more animals recolonising. Alcoa has adopted an internal standard of one constructed habitat per hectare.

A long term fauna monitoring program was developed in 1991 to standardise Alcoa's fauna-related monitoring and research activities. Results to date have shown that most fauna species return to rehabilitated areas once the appropriate habitat has developed.

Monitoring

To assess progress, the following criteria were developed for rehabilitated areas at nine months:

- A minimum of 600 eucalypt stems per hectare
- A minimum of 150 marri stems per hectare
- A maximum of 2,500 eucalypt stems per hectare (with the exception of haul roads and pits less than 2 hectares)
- A minimum legume density of 0.5 plants per square metre
- Less than 50 declared perennial weed plants per hectare
- No large erosion gullies.

In addition, when the rehabilitated areas are 15 months old, intensive counts of plant species are carried out in randomly located monitoring plots. Fifteen months is the second spring after the completion of rehabilitation and by this age the plants are large enough to be identified and many species are flowering at this time of the year. It is also after the first summer dry period and seedlings that have survived the first summer are likely to persist.

The purpose of this monitoring is to determine the species richness of the rehabilitated areas and compare this to species richness counts in the unmined forest. Alcoa's internal target for species richness in the rehabilitated areas is to establish the same number of species as in the unmined forest plots, which is a value of 100 per cent on average over all pits (above the government's requirement of 60 per cent). Higher species richness is achieved through optimum topsoil return, seeding and the propagation and planting of recalcitrant plants.

Each year some of the 15 month old monitoring plots are retained as permanent long term monitoring plots. There are now more than 900 permanently marked plots covering a wide range of rehabilitation ages and unmined forest areas.

Conclusion

The ability to restore a piece of altered land relies heavily on a good understanding of the area's ecology. Alcoa's environmental team has worked in collaboration with local universities, government agencies and private researchers to understand the forest ecosystems and to ensure rehabilitation is successful.

Summary

Pre-mining land use	Native jarrah forest
Post mining land use	Native jarrah forest
Change in land use values	Aims to replicate native jarrah forest ecosystem
Key success factors	Achieving species richness with significant work in propogating and rehabilitating recalcitrant species
Further information	www.alcoa.com/australia alcoaofaustralia@alcoa.com.au

7 Westside Coal Mine

Glencore

Rehabilitation of the Westside open cut coal mine near Lake Macquarie in New South Wales was completed in April 2012, just two months after mining operations ceased.

The land has been successfully returned to high quality native vegetation and is home to a diverse range of flora and fauna.

Recent monitoring found seven threatened species on the rehabilitated site, including grey-headed flying fox, masked owl, greater broad-nosed bat, little bentwing bat, powerful owl and squirrel glider.

Westside demonstrates a well planned and executed mine closure strategy

Background

The Westside mine site, located near Lake Macquarie in New South Wales, operated as an open cut coal mine from 1992 until 2012. It is managed by Oceanic Coal Australia Limited (OCAL), and is owned by Glencore.

Planning

The closure plan for the mine divided the site into a number of different rehabilitation domains with different completion criteria developed for each area and included a void which has been retained as a permanent lake. The management plan also takes into account a number of nearby native vegetation voluntary conservation lands which enhance the ecology of the general area.

Rehabilitation

Surface preparation and revegetation

Extensive surface preparation activities for rehabilitated areas commenced as soon as possible following the completion of mining activities. This followed a program of progressive rehabilitation across the life of the mine. These included the following:

- Spoils and topsoils were characterised to determine the need for soil ameliorants (e.g. gypsum, lime, fertiliser etc.) and their application rate
- Topsoils or suitable alternatives were spread across areas to be rehabilitated
- Erosion control measures (e.g. catch drains, sediment dams, silt fences, mulches, etc.) were constructed to minimise soil loss
- Structures such as tree hollows, logs and other woody debris were incorporated into the final landform to improve the habitat value of rehabilitated areas
- Habitat structures, including nest boxes, were installed where practical.

Revegetation comprised native vegetation communities that are characteristic of the local environment and landform type.

Westside Coal Mine / Glencore

Void (open cut pit) management

The mine closure plan included retaining the void associated with the open cut mining. A final void management plan was developed to describe geotechnical aspects of the void design to manage slope stability, minimise safety hazards, identify water licensing requirements and describe ongoing environmental monitoring requirements.

The void is being allowed to fill with water, fed by rainfall run-off and groundwater. Modelling has indicated it will take 17 years to fill the void (to year 2029) at which time it will commence discharging into an adjacent creek with water quality similar to background levels. A long term monitoring program has been designed to confirm modelling results.

Monitoring

Soils and vegetation

Rigorous rehabilitation monitoring programs have been in place at the Westside mine for many years. These include flora, fauna and Ecosystem Function Analysis (EFA), all of which are used to assess the success of the rehabilitation program and to identify opportunities to improve ecological management of the site.

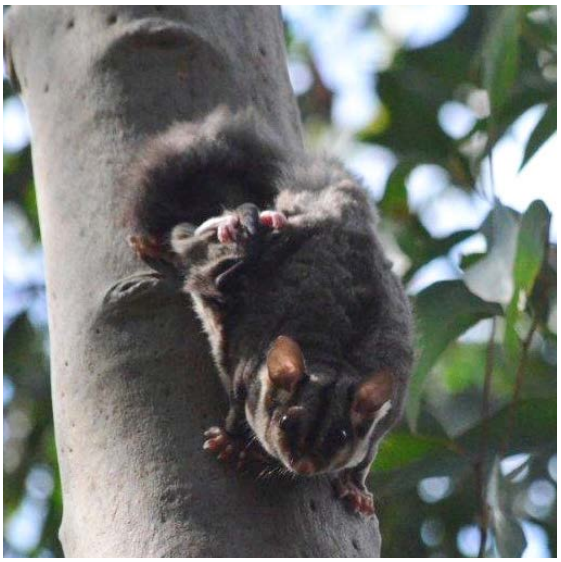
The rehabilitated areas have also been assessed annually to develop detailed records of the progress of the rehabilitation works which include:

- Revegetation germination rates
- Presence of second generation seedlings
- Plant/tree health and the presence of treeless areas
- Invasive weeds and feral animals and the need for control
- Fire management
- Success or failure of remedial management.

In sufficiently mature areas (3+ years) monitoring of the floristic and structural composition of rehabilitated land has been undertaken using standard methods employed by New South Wales government agencies. Most effort is spent on examining groundcover, which supports the majority of species.

Three analogue (natural) reference sites are simultaneously assessed to provide baseline information regarding regional vegetation structure and floristics. Monitoring of reference sites allows for a comparison of flora species, abundance and structure to establish whether the rehabilitation has achieved the stated objectives, taking into account seasonal changes and different flora responses from year to year.

Rehabilitation assessment uses Landscape Functional Analysis (LFA), an innovative tool developed by the CSIRO. LFA uses visual assessment techniques to monitor the health of landscape components, which can be repeated over time to measure changes to the quality of the landscape in comparison to remnant vegetation



Fauna habitat

A fauna habitat assessment of the rehabilitated area is carried out by qualified fauna ecologists at least every three years. This information is used to determine progress against habitat targets

Fauna monitoring indicated good recolonization in the rehabilitated areas, with 69 different fauna species identified in a 2012 survey.

Several types of fauna surveys are carried out to monitor the number of species present in the rehabilitated area. These include:

- Diurnal (daytime) bird, reptile and amphibian surveys
- Spotlighting surveys for nocturnal birds, mammals, reptiles and amphibians
- Call playback survey, targeting threatened species of koala, squirrel glider, masked owl, sooty owl and powerful owl
- Micro-bat echolocation survey.

Outcomes

Post mining, the land has been successfully returned to high quality native vegetation and is home to a diverse range of flora and fauna. The site currently supports second generation tree seedlings and flora species such as spotted gum, swamp paperbark, red mahogany and black she-oak. Recent monitoring found seven threatened species on the rehabilitated site, including grey-headed flying fox, masked owl, greater broad-nosed bat, little bentwing bat, powerful owl and squirrel glider.

Relinquishment

Relinquishment of the Westside mining leases will be undertaken after the successful closure of the remaining adjacent OCAL operations. However, it is the intention of OCAL to seek formal endorsement of the success of rehabilitation as it becomes established.

Conclusion

The Westside Mine closure plan has been carefully implemented with a clear goal of achieving relinquishment in a staged manner, once sustainable vegetation has been established and agreed closure criteria have been met. OCAL has used sophisticated and innovative monitoring methods to ensure objectives are being met and have employed a proactive management approach to optimise ecological outcomes for the site.

Summary

Pre-mining land use	Native vegetation
Post mining land use	Native vegetation with permanent lake
Change in land use values	Land returned to pre-mining land use with the inclusion of a water storage dam
Key success factors	Development of specific detailed closure criteria which have been used to refine rehabilitation strategy
Further information	www.glencore.com.au sustainability@glencore.com.au

8 Pilbara rehabilitation

BHP Billiton Iron Ore

After rehabilitation

BHP Billiton Iron Ore's innovative seed management program has boosted successful revegation rates in the Pilbara's arid climate. To date, around 2,500 hectares has been rehabilitated and revegetated.

The project involves leading practice seed science, including collection and handling methods, and a detailed inventory of seed viability and seed germination characteristics to promote the best use of seeds for rehabilitation.

Outcomes from the project are being put into practice at BHP Billiton Western Australian Iron Ore sites including Mt Whaleback, Jimblebar, Yandi, Yarrie and Mt Goldsworthy.

Pilbara rehabilitation / BHP Billiton Iron Ore

A commitment to rehabilitation is sowing the seeds for success in the Pilbara

Background

BHP's mine, rail and port operations occupy more than 19,000 hectares of the Pilbara region of Western Australia. Mine rehabilitation in the Pilbara faces a wide range of challenges, not least of which is its arid climate and rainfall patterns which are characterised by isolated thunderstorms or cyclones during the summer months.

Another serious constraint is that certain species seed only once every few years, which hinders annual revegetation works.

The dramatic fluctuations in rainfall in the Pilbara mean that traditional revegetation methods, such as using nursery seedlings are unlikely to succeed.

The innovative 'Sowing the Seeds for Success' program focuses on the use of seed to revegetate land. To date, around 2,500 hectares of land has been successfully rehabilitated across BHP Billiton sites in the Pilbara.

Innovation

At the heart of the program is the need to better understand and best use available seed. Findings from research partnerships with the Botanic Gardens and Parks Authority (BGPA) and the University of Western Australia (UWA) supplement ongoing field activities.

Over the past five years, the program has led to significant improvements in all facets of seed management, including identifying seed requirements, availability, viability, collection, storage, treatment, germination, and species knowledge that informs rehabilitation programs.

The Pilbara Seed Atlas

BHP Billiton has developed the Pilbara Seed Atlas, a set of guidelines for the efficient use of seeds in rehabilitation programs. The seed atlas includes a seed-use manual and plant identification guide, with species-specific findings for over 80 plant species.

The project, completed in 2014, involved extensive and detailed studies by researchers from the Science Directorate of the BGPA and BHP Billiton employees into native Pilbara species.

The seed atlas complements the Sowing the Seeds for Success program. Not only is the seed atlas a comprehensive field guide for seed identification and the collection of local species, it will be an essential resource to drive improved rehabilitation outcomes. The seed atlas will also be made publicly available which will benefit environmental management practices across the whole of the Pilbara region.

Rehabilitation seed mix and right, a temperature controlled seed store at the Mt Whaleback mine near Newman, Western Australia.

More than 70 per cent of species contained in the seed atlas are difficult to propagate. While much progress has been made to understand these problems, overcoming them will require further research into seed management and the development of species-specific treatments.

The Restoration Seed Bank Initiative

The Restoration Seed Bank Initiative commenced in mid-2013. It is a five-year research partnership between BHP, the BGPA, and UWA. The initiative, which uses the findings from the seed atlas, is focused on resolving key seed propagation challenges such as dormancy and germination.

The initiative is also focused on the development of seed enablement technologies, new approaches to topsoil management and alternative growth media to overcome limitations to seedling establishment and plant growth.

> “To date, around 2,500 hectares of land has been successfully rehabilitated across BHP Billiton sites in the Pilbara.”

Summary

Pre-mining land use	Native vegetation
Post mining land use	Native vegetation
Change in land use values	Aim to replicate pre-mining native vegetation
Key success factors	Extensive research and development to improve storage, treatment and germination of seed
Further information	www.bhpbilliton.com info@bhpbilliton.com.au

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Appendix 1 ICMM Sustainable development principles

International Council on Mining and Metals

10 Sustainable Development Principles

1/ Implement and maintain ethical business practices and sound systems of corporate governance.

2/ Integrate sustainable development considerations within the corporate decision-making process.

3/ Uphold fundamental human rights and respect cultures, customs and values in dealings with employees and others who are affected by our activities.

4/ Implement risk management strategies based on valid data and sound science.

5/ Seek continual improvement of our health and safety performance.

6/ Seek continual improvement of our environmental performance.

7/ Contribute to conservation of biodiversity and integrated approaches to land use planning.

8/ Facilitate and encourage responsible product design, use, re-use, recycling and disposal of our products.

9/ Contribute to the social, economic and institutional development of the communities in which we operate.

10/ Implement effective and transparent engagement, communication and independently verified reporting arrangements with our stakeholders.

Appendix 2 Minerals Council of Australia Land Stewardship Policy

Minerals Council of Australia

Land Stewardship Policy

Access to land is fundamental for minerals development. The Australian minerals industry recognises that access to land is earned by demonstrating responsible land stewardship throughout the mining life cycle. While mining is a temporary land use, the minerals industry acknowledges its responsibility to contribute towards sustainable land use outcomes.

Accordingly, the Australian minerals industry has adopted the following vision to deliver sustainable land use outcomes:

> **Australian mining companies will be recognised as responsible stewards of the land by delivering balanced economic, cultural, social and environmental outcomes throughout the mining life cycle.**

The minerals industry can be a significant land manager at a regional level and non-operational land managed by the industry can be significantly larger than the mining footprint. This land may be managed under existing or alternative land uses.

The minerals industry recognises that while some previously mined areas are rehabilitated to pre-existing condition or better, other mined areas result in substantial transformation of the landscape. It is the minerals industry's goal to ensure that this land is available for subsequent economic activities, conservation or community use.

The Minerals Council of Australia advocates the application of the following principles to achieve the minerals industry vision[1]:

Land use planning and access

- Sustainable land use outcomes can only be delivered through recognition and integration of the multiple values within the landscape (conservation, economic, social and cultural) with the aim of maximising these values
- Land use planning should be strategic, regionally focussed and facilitate sustainable land use outcomes for the benefit of current and future generations.
- Land use planning should be based on sound science and account for both negative and positive cumulative effects.
- Mining, conservation, agriculture and other land uses can be complementary as sequential or neighbouring activities. The minerals industry endorses the application of leading practice which can enhance the integration and co-existence of these activities.
- The rights, knowledge and interests of traditional owners, existing land holders and the community should be recognised and respected in integrated land use planning processes.
- Mine and exploration planning activities should engage appropriately with stakeholders, including the surrounding community, on an ongoing basis and consider changing circumstances.
- Government planning decisions that impact land access and land use arrangements should be transparent, evidence based, and consider the social, economic, environmental and cultural implications of developing or sterilising mineral resources.

Appendix 2 continued

Land use compatibility

- It is recognised that in some cases, mining or exploration activities may not be compatible when balanced with the surrounding values (conservation, economic, social or cultural). Industry recognises that while regulators may make decisions that development may not proceed, these decisions should be founded in a transparent and science based process.
- Changes in land use values, mining practices or technology may provide for future compatibility for minerals development. Any restrictions on land access should allow for future re-evaluation.
- Exploration and mining should not be undertaken in World Heritage properties. Mining operations which already exist within World Heritage properties, and existing and future operations adjacent to such areas, should ensure activities do not adversely impact on their listed values.

Land management

- Mining activities will aim to minimise disturbance, and provide for ongoing progressive rehabilitation, directed at achieving an agreed final land use that is both stable and self-sustaining.
- The industry will apply the 'avoid-minimise mitigate' approach to managing land values. In some circumstances, offsets may be used to compensate for significant residual loss of these values.
- Both operational and non-operational land should be managed responsibly considering adjacent and future land uses.

Future land use

- The post-mining land use should be considered at the mine design stage and defined through an ongoing consultation process with regulators and relevant stakeholders.
- Closure design should aim to facilitate beneficial post-mining land use, this may include future economic activity, conservation or social use.

[1] Note: This Land Stewardship Policy should be read in conjunction with the MCA Biodiversity Offsets Policy, MCA Water Policy and the ICMM Position Statement on Mining and Protected Areas (http://www.minerals.org.au)

Minerals Council of Australia
Level 3, 44 Sydney Ave, Forrest ACT 2603
(PO Box 4497, Kingston ACT Australia 2604)
P. + 61 2 6233 0600 | F. + 61 2 6233 0699
www.minerals.org.au | info@minerals.org.au

INDUSTRY REPORT