

SUSTAINABLE | ENGAGED | SIGNIFICANT | SMART | RESPONSIBLE | RELEVANT



## A SUSTAINABLE ENVIRONMENT

Our Resources, Our Industry, Our Environment



THE CHAMBER OF  
MINERALS AND ENERGY  
OF WESTERN AUSTRALIA INC.



**THE CHAMBER OF  
MINERALS AND ENERGY  
OF WESTERN AUSTRALIA INC**

## GOLDEN GECKO AWARDS FOR ENVIRONMENTAL EXCELLENCE

Some of the case studies featured in this publication have been awarded the Department of Industry and Resources (DoIR) Golden Gecko Awards for Excellence in the Minerals and Petroleum Industries. DoIR instigated the awards to recognise excellence and leadership and to acknowledge the outstanding contribution recipients have made to balance environmental responsibility with the successful development of Western Australia's resources.

A Golden Gecko Award symbolises company or individual commitment to go far beyond basic compliance with regulations, and provides public and industry recognition for their efforts. By recognising these advances and innovations in environmental practice by the minerals and petroleum industries, the Department seeks to encourage continuous improvement throughout the industry and to develop and maintain community confidence in the compatibility of mining and environmental management. The awards also provide an opportunity to pass knowledge on to others, helping improve environmental management across the industry.



*The Chamber of Minerals and Energy of WA would like to thank Newcrest Mining Limited, Robe River Iron Associates and Wesfarmers Premier Coal Limited for supplying the photographs that appear on the front cover.*

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### Case Study Locations in Western Australia



# FOREWORD



It is with great pleasure that The Chamber of Minerals and Energy of WA (CME) presents 'A Sustainable Environment'; a showcase of environmental excellence and commitment in the resources industry.

The resources industry contributes significantly to the Western Australian economy with over a quarter of the State's income coming from minerals and energy production. This contribution to the economy and way of life in Western Australia is well known. What many people may not realise is the contribution that the industry makes to the environment. The industry has led the way in addressing environmental issues and has been proactive in improving its performance over the years through involvement in research and the development of innovative practices. The industry takes its obligation to protect the environment seriously and is justifiably proud of the standard achieved. The case studies presented here are just some of a great many examples of the industry's commitment to the environment.

When mining commenced in Western Australia over 100 years ago, the overall awareness of environmental issues was not like today. It did not take long however for industry to realise the impact their operations were having on the environment and subsequently many companies adopted responsible environmental management. The industry today now employs more environmental specialists than any other industry and spends significant amounts of money on environmental management and research.

You may have heard of 'sustainability'. The concept has been adopted by many organisations, including several government departments. As defined by the Brundlandt Commission, sustainability is '*Development that meets the needs of the present without compromising the ability of future generations to meet their own needs...*'

To give this context within the resources industry, the International Council of Mining and Metals states that, '*investments should be financially profitable, technically appropriate, environmentally sound and socially responsible*'.

The industry has been proactive in addressing the Sustainability Agenda. It has recognised that sustainable development is about more than environmental protection and in essence involves a proactive cultural change in the corporate decision making process.

Whilst this publication was developed to highlight environmental excellence in the industry, it is a mark of the commitment to sustainability that community and economic issues are integral to the case studies presented.

I hope 'A Sustainable Environment' provides an insight into how the resources industry is managing the environment.

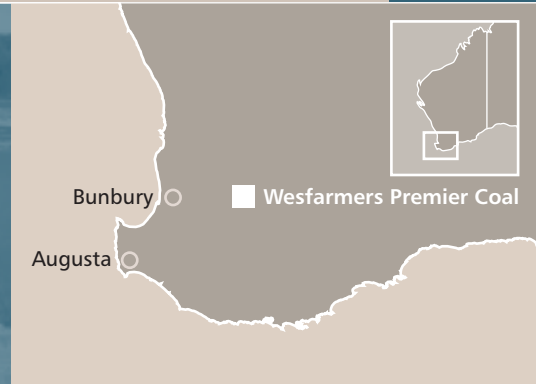
Yours Sincerely

**Tim Shanahan**  
**Chief Executive**  
**The Chamber of Minerals and Energy of Western Australia Inc**



## WESFARMERS PREMIER COAL

# Creating a Sustainable Lake Environment



Recreation lakes, sports facilities and research centres are all part of an innovative and imaginative rehabilitation strategy adopted by Wesfarmers Premier Coal.

Since the closure of two major open cut and three underground mines in the mid 1990's, Premier Coal was faced with developing a closure plan. What was developed is changing the common perception that abandoned mine sites are liabilities. After proper rehabilitation, a landscape should exist, not only to house indigenous flora and fauna, but provide real and exciting opportunities for the local community.

Wesfarmers Premier Coal runs its operations just outside of Collie in Western Australia's South West. The company has mined coal in the Collie Basin for over 50 years and currently produces up to four million tonnes per year from its Premier Mine for the supply of energy and electricity to the Western Australian community.

## Re-creating a Lake Environment

The closure of two open cut mines in the 1990's left several major voids, the biggest being Western No. 5B. When full, it will have a surface area of 100 hectares. During rehabilitation, Premier Coal has the challenge of creating a stable landform with self-sustaining indigenous vegetation, that is safe for the public.

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Big voids can take a long time to fill naturally with water. It is estimated that Western No. 5B would take 100 years to fill and with that comes the potential for acid generation due to oxidation of pyrite from the coal-bearing sediments. The Australian Coal Association Research Program (ACARP) has recently completed a three-year, one-million-dollar investigation at Collie into the source and treatment of acidity in mining voids. In a follow-up research program, Premier Coal, ACARP and Curtin University have now begun to trial an aquaculture

facility next to the smaller, 40-hectare Western No. 5H void, which has recently been rehabilitated. It is a polyculture system containing silverperch and freshwater crayfish.

Research is focusing on production technology and the safety of food that is produced. Technologies developed in the prior ACARP investigation have been applied and extended to combat void water acidity problems for cultured species. Water is pumped from the void into a fluidised bed limestone treatment system followed by 'sweetening' in an organic carbon/macrophyte pond before entering the aquaculture dams. Community groups have been getting involved in the aquaculture project with the Collie TAFE using the aquafarm as a teaching facility and the University basing postgraduate degree projects on the site.

Premier Coal is spending more than \$13 million dollars to rehabilitate its abandoned mine sites. The basic requirements for void rehabilitation safety include bunding, which limits further uses. Instead, Premier's voids are being shaped to an angle of 10 degrees until five metres below the final surface water level. Although wetlands are constructed where possible, by shaping the voids instead of bunding, additional valuable shallows are created that will provide a habitat for aquatic life, potential aquaculture opportunities, and safe access for public recreational activities. The Western No. 5B void features an island sanctuary which will act as a surface area for waterfowl to breed away from the possible threat of feral animals such as cats and foxes.



Premier has engineered a rapid fill program, which means that the void would be filled in five years, instead of the 100 years it would take naturally. Modelling showed that diverting peak flow in winter from the Collie River South Branch into WO-5B would have no effect on downstream users or on river water levels. This diversion of peak flow has raised the water levels in the void by 30 metres over two years. As the void is being filled faster, the potential for acid generation is minimised. Rapid rehabilitation of the surrounding land also reduces the environmental impacts of acid generation and erosion. This is done by careful shaping of the landform, then capping with two metres of inert material followed by topsoil prior to installation of contour drains. The revegetation program applies direct seeding, fertilising and deep ripping in one pass. The rapid fill and rehabilitation programs at WO-5B mean that the void will be a useable asset for the community a lot sooner. The final lake can provide a base for a wide range of public recreational activities such as camping, picnicking, watersports, hiking, biking and four wheel driving as well as providing a conservation resource and commercial opportunities for accommodation and aquaculture.

An abandoned mine site does not only consist of voids. Premier Coal has also been innovative in applying 'value-adding' solutions for rehabilitating other sites. Closure of the underground mines left valuable infrastructure including buildings, water and electricity supplies. More importantly, the remaining network of bitumen roads and haulroads attracted a transformation into what is now known as the 'South West Motor Sports and Training Complex'.

The complex is already operational, providing a venue for youth driver training, advanced training for bus and truck drivers, driver training for essential services including high speed pursuit training for police, and production car testing. The site also accommodates recreational motor sports including drag racing,

*Premier has engineered a rapid fill program, which means that the void would be filled in five years, instead of the 100 years it would take naturally.*



rallying and motorkhanas. This particular recycling of a mine site is considered a much preferable outcome for the environment and the community.

Plans are now underway for the development of a world-class research Centre for Sustainable Mine Lakes based in Collie. With over a dozen mine lakes in varying states of development, Collie is a prime location for such a centre of research. A consortium across the community including, Premier Coal, Griffin Coal, ACARP, Sons of Gwalia, the Shire of Collie, the Coal Miner's Welfare Board, and the four major Western Australian universities will be providing the financial support for the Centre. Government backing through the Centre of Excellence Program or equivalent is also expected. Groups from Curtin University, Murdoch University, The University of Western Australia and Edith Cowan Universities will come together to form a research team that will address a range of issues relevant to mine closure and the resulting mine lake developments. The research centre will be located at the Collie South West College of TAFE.

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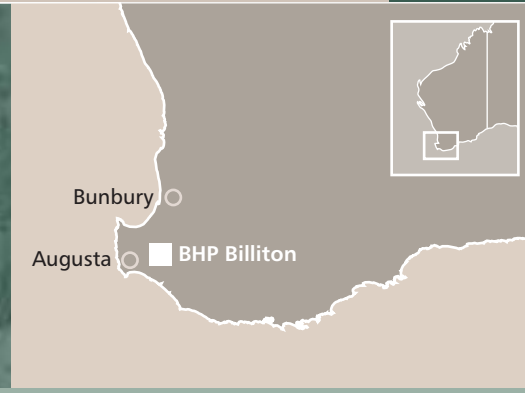
The centre will target research into void rehabilitation and water quality amelioration while developing predictive tools for long-term quality determination. This is vital for end-use planning and it is expected that research outcomes will be applicable globally. In addition, several end-use options that can assist sustainable rehabilitation or conservation outcomes will also be explored including aquaculture and horticulture. Where possible, linkages will be developed with other community focussed projects. For example, the Plants for People Cooperative Research Centre proposal which is looking at a sustainable development project focussed on preservation of Aboriginal Heritage and the development of Indigenous Business Enterprises in Horticulture, Tourism and Cultural Heritage Activities. To this end, horticultural proposals at Collie will include research into Boronia cultivation in wetlands produced during rehabilitation.





BHP BILLITON

# Bringing Back Beenup



The resources industry sees community consultation as an essential part of doing business today.

Increasing environmental awareness in recent years has created new opportunities for the industry in meeting the high environmental standards now expected by society. Many companies understand the need for a supportive community in the areas in which they operate.

When BHP Billiton decided to establish a mine in the area of Beenup, 17km north east of Augusta in Western Australia's South West, one of the company's first priorities was to form a community consultation group. The creation of such a group was especially important in the case of Beenup, given the mine's location between the Scott and Blackwood Rivers, and the strong community and environmental sentiment. When unexpected technical difficulties led to the closure of the mine in 1999, community involvement was particularly sought to put in place an innovative rehabilitation and revegetation program in an effort to take Beenup to a new revitalised state.



*Environmental representatives inspecting the Beenup Declared Rare Flora Translocation Project.*

## Beenup Consultative Group

It was early in the process that BHP Billiton distributed invitations to the main community groups in the area in recognition of the fact that there may be many community issues generated by the development of the mine. The result was the establishment of the Beenup Consultative Group (BCG), formed to act as a communication channel between the local Augusta-Margaret River community and the company.

BCG's wide membership comprised of representatives from the Shire Council, Molloy Island and East Augusta residents, neighbouring landholders, farmers, the fishing industry and the business sector including BHP Billiton.

The initial purpose of the group was to gain information about the operation, circulate it and obtain feedback from the wider community for the company to take into account. However, the subsequent active and influential role of the group, particularly in the rehabilitation of the mine site, has set new standards for industry-community relationships in the resources industry.

Members of the group became very involved and have demonstrated their commitment to this unique interactive partnership. They contributed many hours to understanding the range of complex environmental issues and possible solutions relating to the life of the mine. Some members have been involved since its inception – a total of 14 years.

The broader community was engaged through public meetings, site tours, public presentations of independent audit findings and through notices and inserts in the local press. Audit reports and other important documents were also made available at the Shire offices and local libraries.

Information sharing between various government departments including the Department of Environmental Protection, Water and Rivers Commission, Department of Conservation and Land Management, and the former Department of Resource Development and Department of Minerals and Energy (now the amalgamated Department of Industry and Resources) was a key aspect of the community consultation process.

*When unexpected technical difficulties led to the closure of the mine in 1999, community involvement was particularly sought to put in place an innovative rehabilitation and revegetation program in an effort to take Beenup to a new revitalised state.*

BCG has played an active and influential role during the operations of the Beenup mine site. Since BHP Billiton made the decision to close the mine in 1999, the group has continued to be a strong voice of the community, providing valuable input to the rehabilitation program currently being undertaken at the site.



## Developing a Rehabilitation Plan

BHP Billiton and the Augusta-Margaret River community, represented by BCG, were faced with the closure and rehabilitation of a major mine site with significant environmental challenges.

A total of 336 hectares of land had been disturbed by the mining operations and there was considerable concern in the community about the future of the site.

BHP Billiton undertook an extensive assessment of the site and presented several rehabilitation options to Government, the Shire Council and BCG for consideration. The group reviewed these options and communicated them to the broader community. They assisted in developing a rehabilitation plan and played an integral part in its progressive improvement, such as the inclusion of additional areas of native vegetation on the site. A final rehabilitation plan was agreed to and approved by Government in November 1999.

## Meeting the Challenges

The mine site is being rehabilitated as a self-sustaining eco-system of native vegetation, permanent and seasonal wetlands, and pasture. Current monitoring indicates there is evidence that this is already occurring and the wetland system is already supporting a wide variety of macro-invertebrates.

BHP Billiton has committed the resources necessary to implement the rehabilitation plan. The company will remain responsible for the site and the ongoing monitoring program until the agreed rehabilitation objectives have been met.

### **An Innovative Management of Pyrite**

One of the key challenges and indeed one which the rehabilitation plan was shaped to overcome was the management of pyrite. During trial mining in 1992, a naturally occurring sulphide mineral called pyrite was found during excavation. This mineral if exposed to the air for an excessive amount of time has the potential to oxidise and form acid.

The issue of how this challenge was going to be managed and monitored became an important area of discussion for the consultative group during meetings, workshops and consultations with government department representatives.

BHP Billiton, with the assistance of the group, found an innovative solution. Firstly it was decided that lime sand would be used to neutralise the acid. Secondly, as the problem exists when the pyrite is exposed to air for excessive amounts of time, the material would be permanently saturated by the creation of a permanent body of water where the former dredge pond was located. The tailings ponds, used during operations, have been similarly transformed to become wetlands which manage pyrite effectively.

The rehabilitation of the dredge pond and tailing ponds was completed in 2003 with revegetation and monitoring to continue as required.

### **Restoring the Vegetation**

The Kings Park Botanic Gardens and Parks have been commissioned as part of a joint research project to assist in the rehabilitation of the local flora and fauna.

This innovative revegetation program has involved seed germination trials and the trans location of at least four declared rare flora from local ironstone communities to the site.

### **Mine Surface Water**

The potential impact of the release of excess mine surface water and the successful reinstatement of mine surface water flow through to the adjacent Blackwood River was identified early on as a priority issue in the community consultation process.

Liaison with government authorities and the community through BCG led to the reinstatement of surface water flow being monitored in real-time and with maximum public transparency via the Internet.



*BHP Billiton worked with a neighbouring dairy farmer to develop an irrigation system to dispose of excess mine water.*

Irrigation of neighbouring pastures was chosen as the preferred method of water release, using the centre pivot irrigation method, to irrigate 210 hectares of land. This increased the number of cows able to graze in the area from 400 to 1,000. This successful use of excess water from the mine site for irrigation of a local dairy farm has shown the potential the area may have for sustainable intensive agricultural production.

### **Contribution to the Community**

The operation and subsequent closure and rehabilitation of Beenup have provided the local community with employment opportunities and other economic benefits. Infrastructure developed for the mine, such as power and roads, remains and can facilitate the development of future industries in the region.

An adjacent parcel of approximately 153 hectares of undisturbed remnant vegetation has been donated to the State, which will see the land managed as a conservation reserve.

Through the operational, closure and rehabilitation phases of Beenup, considerable knowledge has been gained about the treatment and management of pyrite and acid soils.



*The rehabilitated storage dam is hydro-mulched to control dust.*

This knowledge has been transferred to the farming community to assist in their management of 'sour' soil in the area.

BHP Billiton are working with Government, external consultants and the Beenup Consultative Group to develop completion criteria for this project, focusing on understanding key eco-system processes as a measure of restoration success.

The rehabilitated mine site from the ongoing development to closure has the potential to act as a location for flora and fauna research, environmental education and eco-tourism.



*A chain of ephemeral wetlands is being developed at Beenup.*

# Real Estate and Mining? The Joshua Brook Development



Mineral sands miner Iluka Resources has transformed a disused mine site into a unique real estate development – writing a new chapter in the diverse history of land use in the South West.

Picture this. Walk and cycle trails uncurl through native bush and spill onto the water's edge. Wild ducks shuffle through the reeds. The frogs start singing. Kangaroos pick lazily at tufts of grass. The sun's watercolour dance across the lake marks the end of the day.

This is Joshua Brook – a rural subdivision just 20 minutes drive from the city of Bunbury.

The sales pitch is appealing. So it takes some imagination to see this picture as it was not too many years ago, when it was one of the most productive mineral sands mines in Western Australia. The Joshua Brook development has captured the history of the South West region in distinct chapters.

The story begins with an ancient coastline stretching in a south-westerly direction to Busselton. The shore captured and held the heavy mineral sands for millions of years.

The foresters came for the hardwood timber and many towns were built to serve dozens of timber mills. In 1871, a 30 kilometre rail line to cart timber through the Yoganup district to Lockeville, near Busselton, was the first railroad in Western Australia. And the farmers also came, planting many different crops and running sheep, cattle and horses. Over time, farming activities became more specialised and the area has become best known for its dairy industry.

About 50 years ago the ancient coastline revealed her long held treasure. A group of local business people formed Westralian Oil, with the intent of exploring for oil. Instead they found a rich vein of mineral sands.

The company switched its mining plans. A mineral sands processing plant was built in Capel and bulk product was shipped through the Bunbury port. Through several name and ownership changes, the business continues operating as Iluka Resources.



The Yoganup North deposit – part of the wider Yoganup deposit – was mined from 1986 to provide feedstock for a new synthetic rutile plant at Capel. Mining finished in 1997. As mining neared its end, Iluka’s mine planning and rehabilitation departments considered different options to rehabilitate the site. Already large tracts of mined areas had been returned to pasture or forest but the Joshua Brook land offered something different.

The area of land that Iluka owned and was looking to rehabilitate was inside the town planning boundary for the expansion of the Boyanup townsite. In talks with the Shire of Capel, it was agreed that this area would soon become a rural-residential area, subdivided into small holdings.

*This is Joshua Brook – a rural subdivision just 20 minutes drive from the city of Bunbury. The sales pitch is appealing. So it takes some imagination to see this picture as it was not too many years ago, when it was one of the most productive mineral sands mines in Western Australia.*



“It did not need rezoning and the idea of developing a land release offered a challenge to Iluka to demonstrate that mining areas could be rehabilitated to a different land use,” said Ian Watson, Rehabilitation Superintendent for Iluka Resources.

Management agreed and the planning and development work for a rural-residential subdivision began.

The proposal was advertised in local newspapers and a number of nearby landowners made submissions about how the development should proceed. Public meetings were held and local residents were asked to comment on the future of the area. Iluka responded by giving community representatives direct involvement in the planning stage through the formation of a community liaison group.

“We encouraged the company to increase the size of the lots, especially those lots that were furthest from the township,” said committee member and nearby landowner Martin Pardo. “We also suggested that the lot layout and road design be changed to protect some areas of forest that had not been mined. I understand that the company must get a commercial return from this development but Iluka has been very receptive to our ideas and it has been a fantastic working relationship.”

Two large mining pits, not suitable for development as residential lots, have been re-shaped and revegetated into two lakes. These picturesque lakes have become centrepieces for large park areas and can be used for public recreation.

The lakes also collect drainage from the subdivision. A series of walk and cycle trails connect the lakes to the residential lots.

Some of the timber and steel structures used in the mining operations were saved from the scrapheap to build public facilities.

For example a bird hide on the shore of one of the lakes has been created to encourage people to observe native birds

that visit the area. A gazebo and seating in picnic areas have also been built for the enjoyment of the local residents and any tourists that may come to the area.

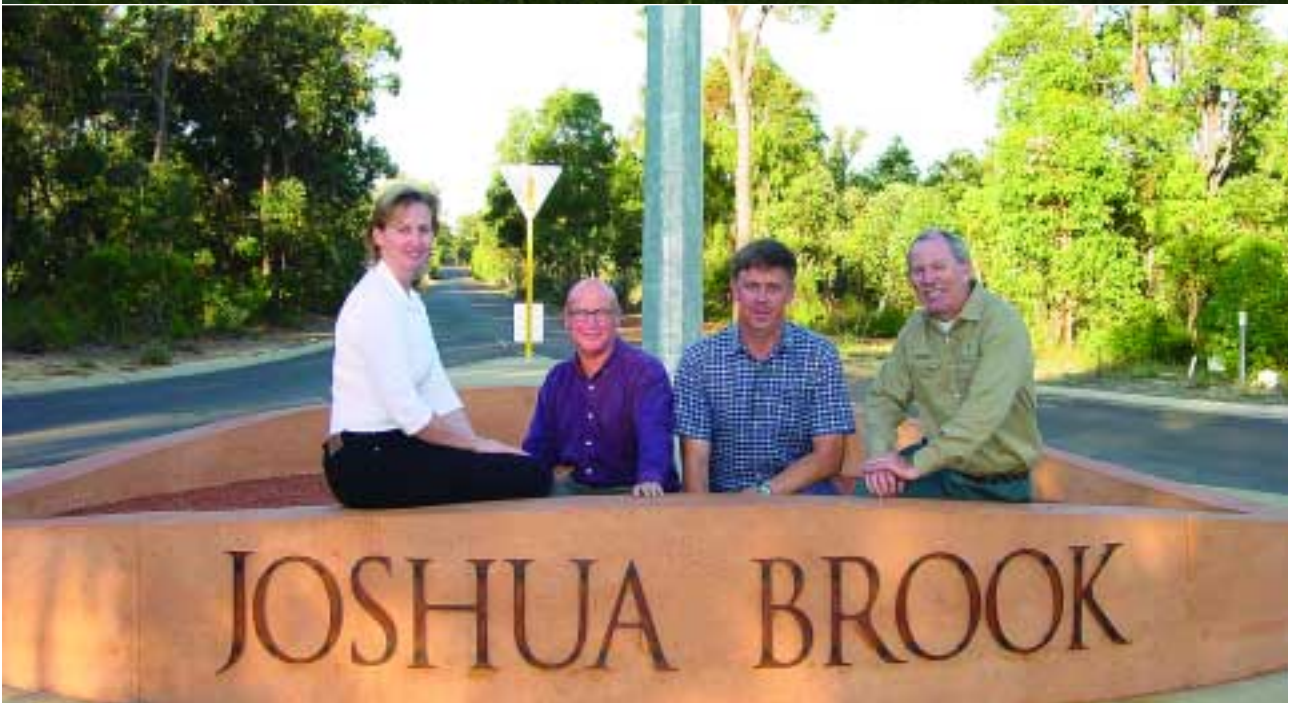
Public barbecues are next on the list. Local artist Russell Sheridan, who has his studio nearby and has produced many public artworks for the region, used a tree cleared for one of the roads to build a large bench in the shape of a dog. The dog is in place and a crocodile is soon to follow.

Another piece of public artwork has been installed at the entry to the subdivision.

This development has firmly embraced the triple bottom line principles of sustainability – yielding economic return in harmony with the enhancement of environmental and social values.

Market reaction has been very positive. All lots are serviced by sealed roads, scheme water and underground power. The first new house in the subdivision is under construction.

Only one lot remains to be sold in the first stage, and work is now underway on developing a second release. Some of the lots that will become available in later stages of the subdivision will provide views of the Bunbury city skyline and coastline.



*This development has firmly embraced the triple bottom line principles of sustainability – yielding economic return in harmony with the enhancement of environmental and social values.*



The community liaison group continues to be actively involved in the design of each stage. As new landowners come into the area, they are invited to be a part of the continuing design process.

The transition from farming to mining and now to real estate has been a process of co-operation and compromise; the management of social and environmental issues has been a constant companion.

When mining was underway, Iluka was able to work with nearby landowners to avoid any unnecessary disruption to farming activities and lifestyle. And when the mining finished, Iluka faced a different set of challenges.

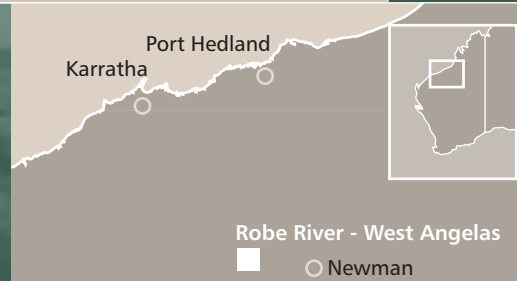
“When we first started this real estate project we could find no similar developments to guide us,” said Russell Harvie, Manager Community Relations and Land Management. “There was no blueprint to follow and we’ve relied on help from the community group to develop the plan from scratch. We have also had good support from other neighbours, the Boyanup community and the local authority. I believe we have achieved a very good result, and it is a positive demonstration of some innovative thinking in post-mining rehabilitation.”

The next chapter in the history of Joshua Brook – and indeed in much of the history of the South West – has begun.



**ROBE RIVER IRON ASSOCIATES**

# Southern Spur - Construction of a Low Impact Railway



Robe River Iron Associates (Robe) was awarded a Certificate of Merit in the 2003 Golden Gecko Awards in recognition of excellence in environmental management throughout the detailed planning, construction and associated rehabilitation of the West Angelas Southern Spur Rail Project.

The construction of the West Angelas Southern Spur Railway, through an area of difficult terrain and high environmental value, was carried out to an exceptionally high standard and sets a new benchmark for the construction of low-impact railways.

Robe’s approach involved detailed planning, tight procedural controls, open communication and cooperation with contractor companies and government agencies. This ensured the protection of significant vegetation association and priority species along the selected route.

The Southern Spur Rail is a 49 kilometre rail line which connects Robe River’s West Angelas iron ore mine, one of the Pilbara’s newest iron ore mines, to Hamersley Iron’s main railway.

Robe River is a dynamic mining joint venture widely regarded as one of the world’s most cost effective, consistent and reliable suppliers of iron ore. Robe River is committed to minimising the impact of its operations through responsible environmental management and performance.

## The Southern Spur Rail Project

The Southern Spur section of the West Angelas Rail was built in a unique and environmentally sensitive landscape, running through the Coondewanna Flats.

The project involved numerous companies, including Robe as the client, North Major Projects as the project manager, ecologia as environmental consultants, Fluor Australia as the main contractor for detailed planning, engineering, procurement and construction management and Henry Walker Eltin for earthworks and drainage construction. The number of organisations involved created a challenge in that there needed to be extremely good communication throughout the extensive project.

There were also significant environmental challenges posed and these were successfully managed in all stages of the project from planning, approval, letting of contracts and construction.

	<b>Coondewanna West</b>	<b>Mt Robinson</b>
Length (km)	42.5	52.4
Rail formation area (ha)	61	81.7
Total impact area (ha)	163.7	257.4
Number of vegetation associations directly impacted	21	14
Number of vegetation associations unique to section	29	14
Aboriginal custodians preference	Preferred	Significant concern
Greenhouse gas emissions (CO2 tonnes for 25 year period)	101,302	124,899
Visual amenity impact from tourist lookout	Low	High



## Nature of the Challenge

### Rail Route Selection

During the original planning of the West Angelas project and the rail projects, two routes were considered for the last section of the rail into the mine site. These were known as the Coondewanna West route and the Mt Robinson route.

A study into the two routes found that the Coondewanna West Route had significant advantages over the Mt Robinson route (see table). Whilst the Coondewanna West route was the most appropriate because of the lower overall land disturbance due to shorter distance, lower estimated greenhouse gas emissions for railing iron ore and a reduced impact on Aboriginal heritage sites, the potential impact on priority flora species in the area was of concern.

Robe developed a detailed management plan which outlined how the impact on this priority species could be reduced and submitted this to the EPA. The Coondewanna West rail route was finally approved subject to the on-going involvement of the Department of Conservation and Land Management (CALM) prior to ground-disturbing activities and the project strictly adhering to the plans submitted.

### Priority Flora Species Protection

The plan identified that the Coondawanna Flats region is made up of tussock grassland and Mulga scrub. Good examples of the grasslands found in the Coondawanna region are relatively

rare as they are usually affected by pastoral activities or feral animal invasion.

Significant flora was also identified, including *oleara fluvealis*, which is known to exist in three areas within the project. *Oleara fluvealis* is a shrub of around 0.5 metres in height that has blue, purple, white or yellow flowers from April to May.

When priority flora was located close to the construction corridor, to prevent any disturbance to the plant, it was mapped by a botanist and tagged for clear identification. The drainage area of the plant was fenced off from the construction corridor, with an additional three to five metre buffer. This approach, taken to minimise the area of disturbance, resulted in reducing the width of the corridor from 200 metres to approximately 40 metres.



*Priority flora sites along rail corridor were fenced and tagged with pink flagging for clear identification.*



*This image, which was taken in August 2001, shows the workshop area and one of the borrow pits used for the rail construction.*



*This image, which was taken in March 2003, shows the same area after one year of rehabilitation work.*

This measure ensured the protection of the oleara fluvealis species from construction activities and no disturbance was made to this priority species. The potentially adverse impact on another rare flora species was also avoided.

#### **Minimising Environmental Impact During Construction**

As well as the priority flora species protection, care was taken to minimise the overall environmental impact within the construction corridor (the area of greatest disturbance), both during construction and for the long term operation of the railway.

This involved taking steps to minimise impact on areas through careful selection and management, progressively rehabilitating areas that had been cleared and managing the potential impacts to drainage to minimise the effect of water flows on the surrounding flora.

#### **Selecting and Minimising Impact on Land**

A detailed survey of the route for the railway and of 'borrow pit' areas was undertaken which included extensive heritage and environmental surveys of the planned areas.

Borrow pits were used to provide fill for the infrastructure such as roads and railways. There was close consultation and cooperation with CALM for the selection of the borrow pit locations. The location of each pit was determined after looking at the way in which the surface water flows as well as attempting to follow natural topography and considering the appearance of the area after it had been excavated and rehabilitated. Robe had planned to create 24 borrow pits, however because the use of each active borrow pit was maximised, it resulted in only 16 being created, a significant saving not only in cost but in minimising land disturbance.

Boundaries for construction of the railway and the borrow pits were marked and the areas containing priority flora or Aboriginal heritage archaeological sites were fenced to physically ensure there was no disturbance. The boundaries and fencing of important areas helped to ensure that all activities relating to

the construction of the railway were kept within restricted areas and therefore disturbance was kept to a minimum.

Of the available construction corridor area, only around 20 per cent was actually cleared for the project. Activities were maintained well within the corridor limits, with the widest area cleared being only 50 metres. However most sections were only 25 metres wide. Further, approximately 25 per cent of the cleared area has now been rehabilitated.

#### **Progressive Rehabilitation**

The implementation of progressive rehabilitation along the rail line and borrow pit areas reduced impacts.

Existing roads and other areas that were no longer being used were rehabilitated, this included some pre-existing tracks and fence lines which were realigned due to the rail project. Of the areas that remained every effort was made to maximise their use. For example, instead of clearing more land for a second workshop the old culvert manufacture and laydown area was used.

Borrow pits were progressively rehabilitated by first backfilling with all available excess material and shaped to match the original surface topography as closely as possible. Due to a higher degree of success in rehabilitation of plants using the first few metres of soil (topsoil), efforts were made to preserve existing topsoil. All excess topsoil and vegetation from under the railway embankment was hauled to the borrow pits and this, including material retained from the borrow pits, was re-spread over the borrow pit areas.

#### **Potential Impacts on Drainage**

The interruption of sheet wash water flows, due to construction, and subsequent impact on the vegetation because of the changed water flow pattern was of concern.

To counter the problem Robe conducted extensive planning, taking into consideration current and expected rain events. This involved constructing sufficient culverts that allowed for

drainage under the railway. This prevented the development of surface or sheet flow shadows downstream, or excessive pooling on the upstream side. As a result more culverts were installed than what was typical industry practice to ensure sufficient drainage.

The access road across the Coondewanna Flats was raised, also to enable culverts to be built under the road. This reduced impacts on water sheet flows (and potential impacts on Mulga) on Coondewanna Flats.

Drainage issues have arisen in other rail construction projects in the Pilbara. In the early 1990's these issues were not well understood, but since then our awareness and methods for dealing with drainage have improved. The West Angelas Southern Spur Rail has set world's best practice for minimising the impact on natural drainage patterns from rail construction.

**Community Awareness and Participation**

The project manager held community information sessions on behalf of Robe in Wickham and Newman. These sessions, together with community information bulletins provided information about the Southern Spur, and gave local residents an opportunity to discuss aspects of the project.

Consultation with local aboriginal groups continued throughout the project, specifically in relation to the changes to the rail project, involvement with the heritage surveys and amendments to the Native Title agreement to facilitate the changes to the rail

project. Several on-site meetings were held with representatives of the local aboriginal communities to address heritage issues and ensure that disturbance could be minimised. The rail route was re-aligned to avoid a significant Aboriginal heritage site, which remained undisturbed by the project. To avoid this site completely, the track alignment was shifted 50 metres, which resulted in six kilometres of the route being modified. Other heritage sites identified were fenced off for protection.

**Learning for the Future**

The Southern Spur Rail Project has set a new industry benchmark for the construction of a low impact railway.

As a result of the project, Robe identified several key outcomes that can be applied to future infrastructure development in the Pilbara and elsewhere. Such learning experiences are fundamental in the continual improvement of rehabilitation programs and environmental performance. For Robe, these areas included the importance of preserving topsoil for use in progressive rehabilitation, effective water management, planning for minimal disturbance and reviewing environmental performance.

The measures taken to minimise impact on the surrounding environment at the Southern Spur Rail Project were in excess of the regulatory requirements that have applied to previous rail constructions in the Pilbara and have paved the way for future developments.



*The Southern Spur Rail Project has set a new industry benchmark for the construction of a low-impact railway.*

# Sustainability in Practice



The production of silicon has provided some environmental challenges for Simcoa, a silicon smelter based in Kemerton, just outside of Bunbury in the State's South West region.

The success of Simcoa's operations has often relied on forming strong economic and consultative partnerships with fellow industries and communities in the South West.

This case study highlights the importance of establishing strong relationships in creating a sustainable future for industry and therefore the communities it supports. Simcoa exemplifies the way in which unique partnerships can work to ensure that there is the most efficient use of our resources in a diverse region of our State.

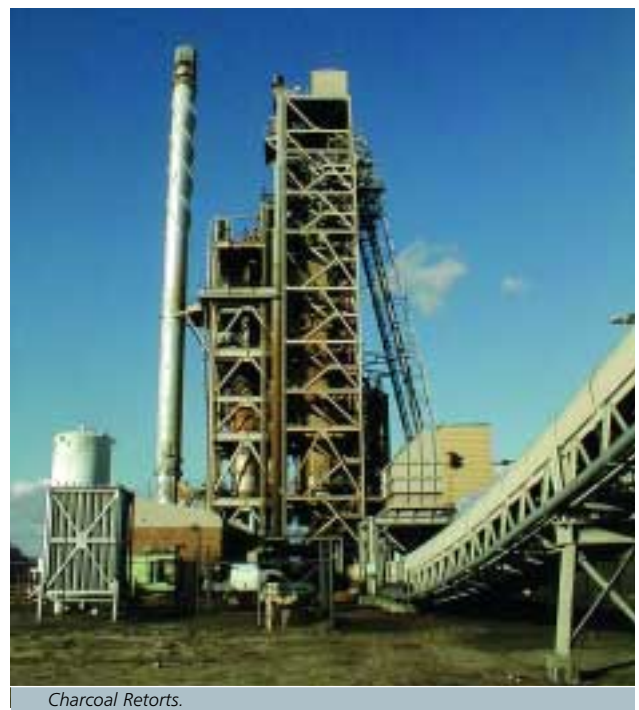
Simcoa's operation requires high purity, highly reactive and cost effective forms of carbon for the reduction of quartz to silicon. Generally low ash coal is used in Europe and the US, whereas charcoal is used in Brazil. There are no suitable coal deposits in Australia but the availability of low grade jarrah

logs, as a by-product of the timber industry in the South West of Western Australia, was seen as a unique opportunity. As a resource this material was even more attractive due to the extraordinarily low ash content of the jarrah as well as the fact that the jarrah residues are unsuitable for other applications such as chip for paper production.

The silicon smelter commenced operation in 1990 using jarrah chip as flux in the furnaces and jarrah block for charcoal production. Of this material all of the chip and up to a quarter of the block required was sourced as sawmill residues with the remainder of the block being produced from both green and dry char logs, ie logs not considered to be economically millable for sawn timber. The concept was that as a part of any logging operation there is always going to be a proportion of logs generated in the process that are not 'saw grade'. Also in most logging areas there were many dry logs left on the ground or



27 MVA Submerged Arc Silicon Furnace.



Charcoal Retorts.

on landings, from previous logging campaigns, which were not of millable grade. It was these categories of log which were to be the basis of timber supply to Simcoa.

During the last decade there has been increasing concern expressed by the community that the process of residue log supply to Simcoa was being abused. It was often felt that instead of Simcoa just receiving residue logs unavoidably generated as a by-product of a sustainable forest management process, the need to supply logs to Simcoa had become a driver in the logging program.

In 2000, Simcoa first met with representatives of the conservation movement, not only in their offices but also in the forest. Simcoa wanted to listen to their concerns first hand and to jointly develop a strategy to move forward in terms of a sustainable future, both for the native jarrah forest and for Simcoa.

*Simcoa wanted to listen to their concerns first hand and to jointly develop a strategy to move forward in terms of a sustainable future, both for the native jarrah forest and for Simcoa.*

It was quickly agreed that the prime concern was not the dry char grade logs, which obviously were not being felled in order to supply Simcoa, but rather the green char grade logs. In the case of the green char logs it was often claimed that they came from trees which would not have been felled if it were not for Simcoa. At Simcoa there is a strong empathy with the need to preserve old growth forest, although a complication was the



*Simcoa's Smelter Building.*

wide range of definitions as to what actually constitutes old growth. As a starting point Simcoa immediately agreed to stop receiving logs from areas defined by the Department of Conservation and Land Management as being old growth (this agreement predated the 2001 State election, following which logging of old growth was halted anyway). They then looked at mechanisms for ensuring that no green logs supplied came from old growth trees and that trees were not being felled specifically for Simcoa.

After extended discussions and the consideration of a range of proposals, all these ideas ended up as being too complex and so a decision was taken to just stop taking delivery of any green logs. This solved all the key issues as to whether old growth trees or in fact any trees were being felled in order to supply Simcoa. Simcoa then needed to find alternative reductants to ensure their own sustainability.

The company implemented a number of solutions. Contact was made with all sawmilling operations in the South West and it was found that sawmills were still burning significant quantities of mill residues. Simcoa had not used much of this material in the past because of concerns regarding bark or contamination with other timber species. By modifying some of their own practices at Simcoa they were able to accept all of this material thereby reducing their dependency upon logs.

In the past there had been a reluctance to use other timber species apart from jarrah, due partially to a concern with respect to higher ash levels and partially related to a perception that the physical properties of the charcoal may be inferior. The first problem proved manageable through the careful blending of other species such as pine with the jarrah and the second problem was found to be no more than a perception. The use of other species has nevertheless remained





*Alcoa mine site clearing residue heap, ready for processing to alternative uses such as mulch or charcoal.*

limited due to competition for these from the paper pulp and particle board markets.

In parallel to this process it was apparent nevertheless that there is still a large volume of wood which is a by-product of the harvesting of first and second grade sawlogs. Estimates tabled in the Draft Forest Management Plan (July 2002) suggest that whilst much of the focus has been on the significantly reduced cutting of first and second grade saw log in future, there will still be a very large quantity of lower grade log generated. This material is only utilised to a limited extent at present.

Obviously if a proportion of this material could be used for value adding, there is the potential to partially offset the impact of the reduced first and second grade log allocation on both the sawmills looking to stay in operation and the downstream timber processing industry. Utilising this material would also not have any further negative impact in terms of the native jarrah forest. To facilitate this more efficient utilisation of the forest resource, Simcoa was able to obtain agreement with the Forest Products Commission (FPC) for green char logs from the Simcoa log allocation to be delivered directly to sawmills for value adding. To assist the financial viability of this project Simcoa essentially agreed to purchase the residues from the milling process. This has made it viable for the mills to process low grade logs to recover sawn timber. Obtaining economic recovery levels from low grade logs is difficult for mills designed only to process high grade logs but several mills have been successfully processing char grade logs to achieve recovery levels in excess of 20 per cent (in some cases in excess of 30 per cent) as sawn product.

As a result of changes in the forestry industry the situation has changed again for Simcoa. With many mills taking packages

and shutting down, the availability of sawmill residues has been halved. The harvesting of a much reduced area of forest has also meant reduced availability and higher cost (longer haulage distances) of dry char log.

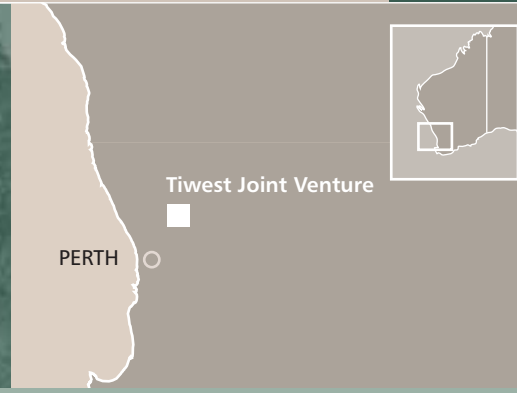
It has therefore been necessary for Simcoa to identify an alternative long term source of reductant. Simcoa is using increasing volumes of plantation timber (particularly pine) but this is not economically sustainable. In this environment however, another option came to their attention. On the Alcoa mine sites in the South West, the FPC undertakes a harvesting operation, prior to mining, to remove any useful timber. Once the timber harvesting has been completed the FPC issues Alcoa with a release which authorises them to dispose of any remaining wood waste on site and to commence mining. Much of this remaining material is stumps, roots, the tops of trees and broken wood. It is primarily jarrah but mixed with other species. The quantity of wood waste available should be more than enough to meet Simcoa's needs and Alcoa is committed to finding an environmentally sustainable alternative solution to burning this waste. The challenge has been to identify a means of converting this material to a form viable for use by Simcoa.

Conventional timber processing technologies are designed to handle logs and other equipment available locally, such as tub grinders, will only result in a mulch product. A search was undertaken internationally for suitable equipment and after reviews of several options, plant from a manufacturer in Denmark was deemed to best meet the needs of Simcoa.

This project is now entering its final stage of finalising agreements between Simcoa, Alcoa, FPC and a processing contractor. The economics are tight, as even though the material as waste has little or no inherent value, the processing and transport cost will mean that the cost is comparable to the use of sawmill residues.

The project will ensure Simcoa's future sustainability without dependence upon either logs from the native forest or resorting to imported low ash coal. This will mean the increased protection of the native forests and a reduction of greenhouse emissions. The partnership will resolve the dilemma faced by mine sites in the area with respect to disposing of forest residues as well as ensuring a sustainable future for Simcoa. By conducting an open dialogue and working together with a diverse range of parties, Simcoa has demonstrated the possibilities of integrating an industry with the needs and considerations of its unique location.

# Restoring the Environment One Wetland at a Time



One of the most critical challenges faced by the inhabitants of the Swan Coastal Plain today is the loss of approximately 80 per cent of the Plain's original wetland areas.

The remaining wetlands are now restricted to isolated pockets within an ever-expanding metropolitan area. Their very existence continues to be threatened by high nutrient levels due to run-off from agricultural and urban lands, urban development and changes to the management of water levels.

Wetlands serve many purposes and are considered one of the most productive natural systems in the world. They serve as 'pit-stops' for migratory birds, and provide valuable habitat for insects, amphibians, reptiles, birds, fish, and mammals. Wetland eco-systems such as the Ellen Brook Brockman Catchment, where Tiwest Joint Venture's Chandala operations are located, are critical components in the health of the earth's freshwater eco-systems and serve as natural filters, allowing sediments and toxins to be filtered and settled from the water before reaching the Swan River.



*Wetland eco-systems such as the Ellen Brook Brockman Catchment, where Tiwest Joint Venture's Chandala operations are located, are critical components in the health of the earth's freshwater eco-systems and serve as natural filters, allowing sediments and toxins to be filtered and settled from the water before reaching the Swan River.*

Tiwest Joint Venture's dry mill and synthetic rutile plant, located in Western Australia's Mid West region, are part of Australia's first fully integrated titanium minerals operation. This involves mining rutile and processing it to create titanium minerals and a titanium dioxide pigment. Titanium dioxide pigment is a substance used as a whitening agent in a wide range of consumer goods including, paints, plastics, paper, toiletries manufacturing and colour enhancing dyes. Another mineral derived from rutile is zircon which is used in the ceramics manufacturing industry to make tiles, sanitary ware and TV screens.

### **The Borrow Pit Wetland**

Since 1998, Tiwest has undertaken works to either create or enhance existing wetlands on its Chandala property, which falls within the sensitive Ellen Brook Brockman Catchment. The Catchment constitutes additional challenges for environmental control but also presents many opportunities for wetland restoration.

Prior to Tiwest's arrival, the land at Chandala had been highly degraded as a result of former cattle grazing activities. The company has taken the view that it should not be assumed that the land should be returned to this pre-operational state. Subsequently, much of the 341 hectare site is being rehabilitated through revegetation of the degraded area. In order to be truly consistent with sustainability principles, the emphasis during rehabilitation is to turn the land into an economic, social and environmental asset that meets the needs and desires of the local community.

The largest undertaking for Tiwest so far has been the ongoing development and rehabilitation of a wetland area called the Borrow Pit Wetland. The wetland was created when Tiwest's processing plants were constructed. An elevated sand pad was created for the plant using material excavated from an area on the northern end of the property. The extraction of sand created a large pit that went below the water table and which carries water all year round. This pit became known as the Borrow Pit Wetland.



The ultimate goal is to create a self-regulating system of native wetland plants and other organisms to reproduce, as closely as possible, a natural eco-system. The first step in this process is the utilisation of existing topography and hydrology to establish self-sustaining seasonal or permanent wetlands. The wetland project has many objectives that are consistent with an overall goal of preserving and enhancing the natural environment while simultaneously embracing a catchment management principle of retaining rather than conveying runoff and nutrients.

Considering that reconstruction of the wetland began in 1998, the Borrow Pit site has made remarkable improvements in habitat diversity and biodiversity in the area and goes some small way towards replacing one of the many wetlands lost from the Swan Coastal Plain.

At the time of writing this article, the Borrow Pit Wetland at Chandala was being further expanded. This project encompasses vegetation management, construction of slow-moving flow paths designed to cleanse water affected by nutrient-rich runoff and control of exotic plants and feral animals.

*The ultimate goal is to create a self-regulating system of native wetland plants and other organisms to reproduce, as closely as possible, a natural eco-system.*

### Community Involvement and Ownership

The Borrow Pit Wetland project is a fine example of how the care of wetlands can unite communities, raise community pride and instil a sense of ownership and respect for the natural environment.

School and university groups have been a common sight at Chandala, some student visitors have helped to create wildlife sanctuaries and others have learnt about wetland diversity. The wetland has provided a welcoming environment for students of all ages, where education has, to a large extent, come through



hands-on activities. Throughout 2003, students from the University of Western Australia have been gathering crucial scientific data at Chandala to establish minimum conditions to facilitate effective management of the Borrow Pit Wetland.

In every environmental and community initiative, Tiwest explores opportunities for partnerships with local community and environmental groups. Tiwest provided a refurbished farmhouse, located on the Chandala property, on a rent-free basis for exclusive use by Landcare Centre coordinators of the Ellen Brook Brockman Catchment Group.

One of the most recent Landcare projects, undertaken in conjunction with the catchment group, was the construction of a 'mini demonstration wetland' on land adjacent to the Centre, in June 2003. The 'mini demonstration wetland' will serve such multiple purposes as establishing an educational resource for students and teachers and showcase positive, solution-oriented and responsible environmental practices for land owners and community groups, interested in undertaking similar projects in a simple and cost-effective manner.

On a sunny Saturday in July 2003, Tiwest held its annual Tree Planting Day on the land adjacent to the Landcare Centre. In total, over 7,000 seedlings were planted, including River Gums and Melaleucas along the banks of a local creek and rushes and sedges around the new demonstration wetland.

While expansion plans for the Borrow Pit Wetland take shape on the ground, Tiwest will continue its program of community tree planting days, support for a local school nursery, and wetland rehabilitation projects in conjunction with local schools and Landcare organisations.

The development of Tiwest's Borrow Pit Wetland will continue over many years to come. It is broadly envisaged that the area will continue to be a place where the community comes together to celebrate and nurture biological diversity and environmental awareness.

Whilst the final plan for the post-closure use of the site is yet to be determined, the wetlands undoubtedly provide a focus of community energy and vision, a place of learning and a quiet place to simply sit and find solace in nature. What is certain is that the experience gained through Tiwest's wetland development and management program, such as the one under way at Chandala, will become crucial to the preservation of these important wetlands of the Swan Coastal Plain in the years to come.



## BODDINGTON GOLD MINE

# Helping the Hotham

PERTH

■ Boddington Gold Mine



The Hotham River is a scenic backdrop to the town of Boddington and is one of the attractions of the town.

Adding value back to the river contributes to improved ecological condition of the flora and fauna, which in turn provides improved amenity to the local community and visitors. In partnership with the local community, the Boddington Gold Mine (BGM) is actively involved in restoration and ongoing monitoring of the local Hotham River.

Boddington Gold Mine is located in the South West of Western Australia, within the catchment of Thirty-four Mile Brook, a tributary of the Hotham River. The mine is managed on behalf of the Boddington Gold Mine Joint Venture by BGM Management Company Pty Ltd. At present BGM is in a care and maintenance phase awaiting a decision on a large expansion of the mine.

### Boddington River Action Group

The Boddington River Action Group is a community group drawing upon resources from mining, government and community to make a positive contribution towards the health of the Hotham River.

The group was founded through the efforts of a number of organisations including Boddington Gold Mine, the Waters and Rivers Commission, the Hotham Catchment Community Landcare Coordinator (CLC), the Friends of Reserves Boddington (Inc), Shire of Boddington and local community members, with a common interest of improving the Hotham River and its surrounding environment. This group provides support and resources through funding, in-kind assistance, technical support and co-ordination of fieldwork.



*The Thirty-four Mile Brook - a tributary of the Hotham River.*

### Boddington Fish Ladder Project

A major initiative undertaken through Boddington River Action Group has been the development of a fish ladder (see photograph below) adjacent to the Lions Weir. The ladder is one of only three in Western Australia.

The Lions Weir was constructed across the Hotham River at Boddington in the early 1980s. The construction of the weir formed a barrier for the upstream passage of fish species. This has resulted in large numbers of native fish becoming concentrated downstream of the weir, making them vulnerable to predation and affecting seasonal migration.

The Hotham River is known to have four of Western Australia's eight endemic freshwater fishes. These are the western minnow,

western pygmy perch, nightfish and freshwater cobbler. One species of estuarine fish (the Swan River goby) and two introduced species (the mosquitofish and red-fin perch) also make their home in the area.

With support from members of the local community, including a local business, Boddington Earthmoving and the Boddington Shire Council, a fishway (fish ladder) was designed and built, with rock supplied by BGM.

A community information sign, to be placed near the Lions Weir, has been designed and includes photographs and descriptions of fish species expected to make use of the fish ladder.



The Boddington Fish Ladder adjacent to the Lions Weir. (above), Western Minnow, Nightfish and Western Pygmy Perch (below, left to right).

The National Heritage Trust and the Peel Harvey Catchment Council have provided funding for the project as in time it will contribute to improving the whole river system. Sampling conducted by the Murdoch University in September 2003, found 474 western minnow and 13 nightfish utilising the fish ladder, within a two hour period.

### **Restoring the Banks of the Hotham River**

A planting day that aimed to revegetate the banks of the Hotham River was organised in August 2002. This successful project was coordinated by the Hotham Catchment CLC, with funding provided by the National Heritage Trust.

As the banks are adjacent to farmland the first step was to fence off the area to prevent livestock from entering.

The planting day involved several people from the local community including children and staff from Boddington District High School, Boddington River Action Group members, the Friends of Reserves Boddington (Inc), the Hotham Catchment CLC and staff from Boddington Gold Mine. Hundreds of shrubs and trees endemic to the Boddington area were planted.

The students have recently returned to the riverbank to remove the protective bags and stakes from the plants, which provided a 'mini-greenhouse', and protection from predation. BGM has also participated through BRAG in transplanting native reeds along the lower banks of the Hotham River in Boddington.

*Community involvement in planting days not only helps to restore the Hotham River, but also raises awareness and educates local community members and school children about local environmental issues such as the significance of restoring riverbanks.*

Community involvement in planting days not only helps to restore the Hotham River, but also raises awareness and educates local community members and school children about local environmental issues such as the significance of restoring riverbanks.

The riverbank restoration was established as a site to demonstrate appropriate management and river restoration techniques. These techniques can be replicated elsewhere in the catchment, are cost effective and provide education, tourism and other beneficial uses for public visiting the river, as well as providing ecological improvements.



*Revegetated banks of the Hotham River in Boddington (left). The Hotham River (top right). Tullis Bridge on the Hotham River (bottom right).*

## Local Water Monitoring

Boddington Gold Mine also records water monitoring results collected by groups such as the Friends of the Reserves Boddington (Inc). With centralised management of the results, a more complete picture of water quality in the district can be collated and maintained into the future.

Sampling is conducted at different locations along the Hotham River and local tributaries. These results are updated regularly and displayed on the BGM website ([www.bgm.com.au](http://www.bgm.com.au)). This enables local catchment groups and individuals to access this data at any time. In addition to its regional water monitoring program of the Hotham River and its tributaries, BGM also monitors groundwater in the town of Boddington for pH, conductivity and depth of water. These results are regularly forwarded to the Boddington Shire.



*The groundwater monitoring bore pump used to collect bore samples at BGM (above). Boddington Gold Mine's stall at the Boddington Rodeo Arts and Crafts Exhibition (below).*

## Education

During 2001, the BGM environmental team provided a presentation to local community members on water quality measures, entitled 'What's in the Hotham'. Topics of discussion included water quality parameters, water quality history, flow rates and flora and fauna of the Hotham River.

In November 2003, BGM was involved in promoting the 'water' theme at the annual Boddington Rodeo Arts and Crafts Exhibition. The exhibition included local artists and crafts people displaying work that captures the theme of water. BGM's stall with the Friends of the Reserves Boddington (Inc.) presented many aspects relating to the water theme including historical Hotham River flow rates, rainfall and salinity changes over time.

By working with the community through the Boddington River Action Group and other groups, Boddington Gold Mine is 'Helping the Hotham' to improve both its ecological and community values.

# What do Kings Park and Mining have in Common?



PERTH Kings Park Botanic Parks & Gardens

## Kings Park Scientist Solves the Riddle of Spinifex Restoration

Few people realise that Spinifex, an icon of Australia's outback and desert areas may be difficult to regenerate by artificial means. Kings Park scientists solved the mystery for spinifexes growing at Argyle Diamond Mine in the Kimberley region of Western Australia which previously could not be returned to post-mined sites.

*As a result of the research Argyle can now develop restoration programs to enable the reinstatement of Spinifex following mining operations.*

Seed of Spinifex grasses, which cover almost a quarter of the continent, have a very short harvest window and require a special period of ripening (about one year following release from the parent plant) before they may be germinated. Germination may be further enhanced by smoke and heat treatments to the seed, no doubt copying the action of Spinifex in the wild where germination typically follows fire.

Using DNA fingerprinting methods the research program also found that seed should be collected within a 30 kilometre radius of the restoration zone to retain the local genetic diversity in spinifexes at the Argyle site.

As a result of the research Argyle can now develop restoration programs to enable the reinstatement of Spinifex following mining operations.



### Plant Detectives at Work

Alcoa World Alumina operate one of the largest bauxite mines in Australia in the jarrah forest near Perth. The company needed to ensure that their restoration programs would only use seed taken from plants with known genetic similarity to the plants removed during the mining operation.

To answer this question, the DNA fingerprinting scientists from Kings Park were brought in to develop the world's first genetic analysis for restoration of a comprehensive range of species used in mining rehabilitation.

The study found that by extracting DNA from just a single leaf, it was possible to precisely measure the genetic composition of plants from small shrubs and herbs to mighty forest trees such as jarrah. The study went on to describe the genetic diversity for many jarrah forest species leading to precise measures of the 'genetic catchment' for seed collection programs.

The outcomes of this ongoing study have meant that Alcoa will be able to focus seed collection efforts, prior to mining, to plant populations that will more precisely replicate the genetic composition – leading to considerable savings in their seed programs and guarantee more environmentally sustainable restoration.

*To answer this question, the DNA fingerprinting scientists from Kings Park were brought in to develop the world's first genetic analysis for restoration of a comprehensive range of species used in mining rehabilitation.*



## Seeds for the Future

Seeds are the major source of plants used in restoration following mining. In fact, it was recently estimated that 70 to 80 per cent of all seed collected in Australia is used for mine site rehabilitation. Correctly storing seeds so they maintain their initial quality for as long as possible is vital to maximising the number of germinants achieved in a seed broadcast program and for ensuring the long-term conservation of valuable species.

Scientists at Kings Park are developing optimal storage methods for seeds used by Iluka Resources in their restoration programs. The project is focused on investigating the impacts of temperature and seed water content on longevity. Both of these factors have a major influence on the viability of stored seeds. As an example, at a given temperature storage life can as much as double with just a one per cent decrease in seed water content.

Conventional wisdom suggests that the colder and drier the seeds are stored, the longer their storage life. However, recent studies at Kings Park have demonstrated that over a relatively short period (two to three years) some species lose viability more quickly when stored at -18°C (the temperature of a domestic freezer and an internationally recommended storage procedure) than when stored at temperatures above 0°C. Therefore, a particular focus of the project is to ensure that seeds of native species are able to survive the combined stresses of drying and storage at freezing temperatures.

The outcomes of this study will ensure that Iluka Resources are able to secure a source of high quality propagules for conservation and future restoration activities.

*Scientists at Kings Park are developing optimal storage methods for seeds used by Iluka Resources in their restoration programs. The project is focused on investigating the impacts of temperature and seed water content on longevity.*

## When is Enough, Enough?

While industry, landowners, government agencies and landcare organisations have been restoring vegetation to degraded sites for numerous decades, the establishment of completion criteria for restoration is in its infancy. Completion criteria are a set of quantitative measures which when met demonstrate that a particular system has been restored. Completion criteria are required in the resources industry to allow companies to demonstrate satisfactory restoration so that environmental bonds can be recovered. Since 1999 Kings Park scientists have been researching vegetation completion criteria for post-mined sites in the Goldfields region of Western Australia with the Cawse and Murrin-Murrin nickel mines.

Restoration requires a set of specific objectives and this may be achieved through comparison with reference (analogue) or undisturbed sites. Completion criteria are based upon measures (eg. plant density and foliage cover) attained from surveys in



healthy native communities analogous to that to be restored. A necessary first step in the evaluation process therefore is to ensure the systems being compared have been adequately sampled.

Not all species are equally important in determining the nature of their community, relatively few exert a major influence on the environment and the extent to which a species impacts on habitat function may be closely related to its contribution to total plant biomass. Eco-system properties will be determined by the characters of dominant species and will be comparatively unaffected by changes in abundance of less prominent species. To establish a functioning community, restoration may focus on revegetation of functional groups or clusters of local species rather than the return of complete diversity. Utilising various dominance indicators the scientists at Kings Park have established that typically less than 50 per cent of the species recorded at individual study sites contributed in excess of 75 per cent and as much as 95 per cent of total plant biomass.

This research is still in progress. Outcomes to date include:

- establishment of a procedure to determine an appropriate sampling regime for native taxa
- provision of benchmark data from natural vegetation communities in the goldfield region
- provision of a scientifically robust system to identify key components of the flora which may then become the focus for restoration

*To establish a functioning community, restoration may focus on revegetation of functional groups or clusters of local species rather than the return of complete diversity.*



CME hopes 'A Sustainable Environment' has provided you with a better understanding of the contribution the resources industry is making to the Sustainability Agenda. This sample of innovative and interesting solutions to often complex issues are by no means isolated examples. Many other examples are available; this is demonstrated by the increasing quality of the entries to the annual Golden Gecko Awards that are presented for environmental excellence in the resources industry by the Department of Industry and Resources.

Look out for the next edition which will showcase many more leading edge examples of environmental excellence.

Together the industry, with the support of the Western Australian community, will continue to grow and continue its objective of contributing to all pillars of sustainability – through the economy, in social and community issues and environment excellence. It is with this goal in mind that the industry seeks to achieve 'A Sustainable Environment'.

For more information or for additional copies of this publication please contact CME.

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SUSTAINABLE | ENGAGED | SIGNIFICANT | SMART | RESPONSIBLE | RELEVANT

