Yandicoogina Junction South West and Oxbow Iron Ore Project

Public Environmental Review

September 2011

This document has been prepared by MWH and Equinox Environmental specifically for Rio Tinto in relation to this proposal for the purposes of assessment by the Office of the Environmental Protection Authority (OEPA).

This Public Environment Review document has been prepared by MWH and Equinox Environmental specifically for Rio Tinto. Rio Tinto has updated the document so that it can be assessed by the Office of the Environmental Protection Authority (OEPA).

Revision Schedule

Rev. No.	Date	Description	Prepared By	Reviewed By	Approved By
1.0	29/01/2009	Draft V1-11	DH	LB	LB
2.0	20/10/2010	Draft V12-19	DH	LB/RTIO Study Team	LB
3.0	22/03/2011	Draft V19-31	DH	LB/RTIO Study Team	JM
4.0	25/03/2011	Final Draft	DH	LB/FH, RTIO Study Team	JM
5.0	08/07/2011	Updated Final Draft	DH	LB, Matchpoint RTIO Study Team	JM
6.0	12/09/2011	Amended Final Draft	DH	LB, Matchpoint RTIO Study Team	JM

Invitation to make a submission on the Yandicoogina Junction South West and Oxbow Iron Ore Project Public Environmental Review

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal. Both electronic and hard copy submissions are most welcome.

Hamersley Iron Pty Ltd proposes to develop new iron ore mines at the Junction South West (JSW) and Oxbow deposits at Yandicoogina in the central Pilbara. Supplementing existing mines at the Junction Central (JC) and Junction South East (JSE) deposits, the new mines will contribute to an overall throughput of up to 60 million tonnes per annum of dry ore from the Yandicoogina operations. Existing infrastructure at Yandicoogina will be used to process and load the ore for transport to coastal port facilities.

In accordance with the *Environmental Protection Act 1986* (EP Act), a Public Environmental Review (PER) has been prepared which describes this proposal and its likely effects on the environment. The PER is available for a public review period of eight weeks from 10th October 2011 closing on 5th December 2011.

Comments from both government agencies and the public will help the EPA prepare an assessment report with recommendations to government.

Where to get copies of this document

Printed copies of this document may be obtained from:

Name:	Melinda Brand
Address:	Rio Tinto Iron Ore Central Park 152-158 St Georges Terrace, Perth, WA 6000 GPO Box A42, Perth, WA 6837
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Hard copies of the PER may be purchased at a cost of $10.00 per copy, or a CD-ROM version can be provided at no charge. Copies may also be obtained from http://www.riotintoironore.com/ENG/media

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Submissions will be treated as public documents unless they are provided and received in confidence, subject to the requirements of the *Freedom of Information Act 1992* (FOI Act). Submissions may be quoted in full or in part in the EPA's report.

Rio Tinto

Why not join a group?

Joining a group interested in making a submission on similar issues may be worthwhile, especially if you prefer not to write your own comments. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the PER or the specific proposal. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more environmentally acceptable.

When making comments on specific elements of the PER, please:

- clearly state your point of view
- indicate the source of your information or argument, if this is applicable
- suggest recommendations, safeguards or alternatives.

Points to keep in mind

Your submission will be easier to analyse if you consider the following:

- **make sure the issues are clear** when listing points. **A summary** of your submission is helpful
- **refer each point** to the appropriate section, chapter or recommendation in the PER
- if you discuss different sections of the PER, **keep them distinct and separate**. This will ensure there is no confusion about what section you are talking about
- **attach any factual information** you want to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name
- address
- date, and
- if you want your submission to be confidential. Please also include the reason why you want confidentiality.

Information in submissions will be deemed public information unless a request for confidentiality is made in writing and accepted by the EPA. A copy of each submission will be provided to Hamersley Iron Pty Ltd, as the proponent, but the identity of private individuals will remain confidential to the EPA.

The closing date for submissions is: 5th December 2011

The EPA prefers submissions to be made electronically using one of the following:

- the submission form on the EPA's website: www.epa.wa.gov.au/submissions.asp
- by email to submissions@epa.wa.gov.au

Alternatively, submissions can be

- **posted to** Chairman, Environmental Protection Authority, Locked Bag 33, CLOISTERS SQUARE WA 6850, Attention: Maree Heath (OEPA Assessment Officer), or
- **delivered to** the Environmental Protection Authority, Level 4, The Atrium, 168 St Georges Terrace, Perth, Attention: Maree Heath (OEPA Assessment Officer), or
- **faxed to** (08) 6467 5562, to the attention of Maree Heath (OEPA Assessment Officer).

If you have any questions on how to make a submission, please ring the EPA assessment officer, Maree Heath on (08) 6467 5410.

Executive Summary

Introduction

Hamersley Iron Pty Ltd (Hamersley) is proposing to develop new iron ore mines at the Junction South West (JSW) and Oxbow deposits at Yandicoogina (the project). Hamersley is a fully owned subsidiary of Rio Tinto Iron Ore (RTIO) and already operates mines at Yandicoogina which include the adjacent Junction Central (JC) and Junction South East (JSE) deposits. These deposits are expected to be fully mined by approximately 2015 and 2023, respectively. New mines at JSW and Oxbow will enable continuity of production from the overall Yandicoogina operation.

The project was referred to the Environmental Protection Authority (EPA) in January 2008 and received a Public Environmental Review (PER) level of assessment. This Environmental Review document has been prepared in accordance with the requirements of the *Environmental Protection Act 1986*, the approved Environmental Scoping Document (ESD) for the project and relevant EPA Position Statements and guidelines. It describes the project, the existing environment, and measures that will be taken to manage the likely environmental impacts.

The project

Global demand for iron ore remains strong and Western Australia is well placed to meet this demand. The Hamersley Yandicoogina operation has made a significant contribution to Western Australian iron ore exports over the past decade and is one of the State's largest iron ore producing mining projects. Developing the JSW and Oxbow deposits will sustain overall production from Yandicoogina, capitalising on infrastructure already in place to service the existing mining operation. The project will involve mining approximately 320 Mt of high grade ore from the JSW and Oxbow deposits.

Significant royalties and taxation payments will be generated by the project for both the State and Commonwealth governments. Traditional landowners will also benefit under the terms of the Yandicoogina Land Use Agreement. The existing workforce at Yandicoogina will be expanded and maintained, providing local and regional employment benefits.

The project will be managed by Pilbara Iron Pty Ltd on behalf of Hamersley. The following major components are included:

- **new open cut iron ore mines** to the west of the existing operations within the Channel Iron Deposit (CID) at the JSW and Oxbow locations (excluding the Marillana Creek section at JSW)
- **a dewatering system** for lowering the water table to enable mining of the ore deposits (note that the majority of the deposits are below the ambient water table)
- **a water management system** including on-site reuse of water abstracted from pit dewatering, and discharge of surplus volumes into creek systems. Discharge infrastructure servicing the JC and JSE Yandicoogina operations will be used and the pipeline infrastructure will be extended to service JSW and Oxbow

- **new temporary waste dumps**. Out-of-pit waste dumping will be used until in-pit waste dumping of mined areas can occur. Topsoil, subsoil stockpiles and haul roads are also required
- **flood protection structures** and minor stream diversion away from the pits and into Marillana Creek
- **redefinition of the Marillana Creek low flow channel** at JSW
- **diversion of a section of Phil's Creek** near the western edge of the JC pit
- **infrastructure** associated with drilling/blasting, loading and conveying of ore from the mine to the existing processing plants at JC
- **extension of power and communications infrastructure** from the existing JC operation, and
- **new dry crushing plants** at JSW and Oxbow. The crushed ore will be conveyed to the existing process plant at JC (which may be upgraded or modified, as appropriate).

An *overall project area* has been defined for the proposal; this covers existing Yandicoogina JC and JSE operations to take into account the shared services and infrastructure associated with the existing mining areas, and also enable new infrastructure tie-ins associated with the proposed JSW and Oxbow mines.

Only a portion of the overall project area will include new *disturbance areas* comprised of:

- **JSW disturbance area** - the JSW mine pits, water management system, ore handling and processing infrastructure, temporary waste dumps and flood protection structures
- **Oxbow disturbance area** - the Oxbow mine pit, water management system, ore handling and processing infrastructure, temporary waste dumps and flood protection structures, and
- **infrastructure tie-in disturbance areas** - with the existing JC and JSE facilities.

The overall project area will span the future integration of the Hamersley Yandicoogina operations. The maximum extent of ground disturbance for the new JSW, Oxbow and infrastructure tie-in areas is estimated to be 2,200 ha.

Stakeholder consultation

Hamersley initiated a Stakeholder Consultation Program for the project in 2008. Key government agencies that have been actively consulted during the preparation of the PER include:

- Office of the Environmental Protection Authority (OEPA)
- Department of Environment and Conservation (DEC)
- Department of Water (DoW), and
- Department of Mines and Petroleum (DMP).

The project was also referred to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) in December 2010 in accordance with the *Environment Protection and Biodiversity Conservation Act 1999*, and was determined to be a 'Controlled Action' for listed threatened species and communities under the Act.

Hamersley entered into the Yandicoogina Land Use Agreement (YLUA) with the Bunjima, Nyiyaparli and Innawonga people (the Traditional Owners) in March 1997. The agreement enabled access to the Yandicoogina deposits, so they could be developed for mining. Benefits established for Aboriginal stakeholders related to education, training, employment, business and community development. The YLUA is jointly managed by the Gumala Aboriginal Corporation (GAC) and Hamersley Iron, and has provided the basis for a highly effective and constructive relationship between Hamersley and Aboriginal stakeholders since its inception. The GAC and Traditional Owners have been consulted throughout the development of the project, and the existing YLUA will apply to the project.

BHP Billiton Iron Ore (BHPBIO) operates iron ore mines immediately west of the Hamersley Yandicoogina operations. BHPBIO has been consulted with respect to water use, closure and tenement boundary issues associated with their Yandicoogina mining operation and railway infrastructure. Neighbouring leaseholders, including Iron Ore Holdings and Brockman Resources, have also been consulted.

Non-government organisations, including the Conservation Council of Western Australia have also been consulted during the development of the project.

Key issues raised by the various stakeholders related to:

- **water management**, particularly discharge of surplus water generated by mine pit dewatering activities
- **cumulative hydrological impacts** from other mining activities in the area
- **impacts to Fortescue Marsh**
- **closure management**
- **vegetation disturbance**, particularity impacts on riparian vegetation and priority flora, and
- **disturbance of Aboriginal heritage values.**

Existing environment

The project is located in the central Pilbara region of Western Australia, approximately 90 km north-west of Newman and 300 km south-east of Dampier. This region experiences an arid tropical climate and has a history of pastoral land use.

The overall project area includes three main landforms: low stony hills, broad valleys and several major creek systems (Marillana Creek and Weeli Wolli Creek). Other significant tributaries to Marillana Creek, upstream from the Weeli Wolli confluence include Yandicoogina Creek and Phil's Creek.

The vegetation of the overall project area is correlated with topography and the broad units present include:

1. **low stony hills**: a scattered overstorey of *Eucalyptus* and *Acacia* species over moderately dense spinifex
2. **undulating low stony plains in the valleys (mosaic communities)**: eucalypts over sparse mixed shrubs and spinifex. Alluvial flats are dominated by *Acacia* communities over a moderately rich understorey of shrubs, herbs and tussock grasses
3. **minor drainage lines in the upper landscape**: similar to (1), and
4. **major creeklines**: woodlands and open forests of *Eucalyptus camaldulensis, E. victrix* and other tree species over mixed understorey of shrubs and grasslands.

The proposed and existing mines at Yandicoogina are situated along an extensive Channel Iron Deposit (CID), characterised by a continuous iron mineralisation along a palaeochannel. The palaeochannel is intersected by Marillana Creek at the JSW location and at several points further downstream. At the Oxbow location the CID is disjunct from the existing creek line. The JC and JSE mine pits are located to the east of the JSW deposits, and a rail load-out facility is located immediately south of the JSW deposits. Other nearby mining operations include the BHPBIO Yandi operation to the west and the Hope Downs 1 project (a joint venture between Hamersley and Hancock Resources) in the upstream reaches of the Weeli Wolli Creek, approximately 20 km to the south.

The environmental values of the overall project area and immediate surrounds have been comprehensively evaluated through a series of baseline studies, addressing factors identified in the project ESD (Table 1). These studies have built on a substantial body of knowledge gathered during the process of gaining past mining approvals. The studies meet EPA guidelines, and have considered environmental values in a local and regional context.

Environmental impacts and management

Pilbara Iron has extensive experience in developing and operating mines in the Yandicoogina locality. This experience, together with the application of Rio Tinto internal environmental standards, will help ensure that the project is managed in an environmentally sound manner.

The key potential environmental impacts of the project include:

- **impacts to the vegetation and aquatic ecology** of the Marillana and Weeli Wolli Creek systems due to additional discharge of pit dewatering water into these systems
- **loss of riparian vegetation** along the section of Marillana Creek adjacent to the proposed JSW mine pits, due to dewatering cones of depression and construction of surface water management structures
- **impacts to subterranean fauna** within and adjacent to the proposed mine pits
- **changes to aquifer properties** and groundwater chemistry from the post-mining landform, and
- **contributing** to greenhouse gas emissions from the Hamersley Yandicoogina Operations over the life of the project.

The potential impacts and proposed management actions to minimise these impacts, are discussed further in this section and in the main document.

Other impacts that have been considered in developing the project proposal include:

- dust emissions
- noise emissions
- waste handling and disposal, and
- weeds.

These factors can be readily managed using Pilbara Iron's standard operating practices and procedures, which have been successfully applied at the existing Hamersley Yandicoogina operations over the past decade.

Vegetation and flora

The vegetation and flora of the Yandicoogina locality has been comprehensively surveyed over multiple studies spanning a 16 year period. As a result, the composition and diversity of the vegetation in proposed disturbance areas is well characterised. Using this information, the local and regional significance of vegetation in the overall project area has been assessed. The identified vegetation associations are well represented in the central Pilbara region, and do not have elevated conservation significance in a regional context. Riparian vegetation in the overall project area is considered to have local conservation significance.

The project will result in the progressive removal and rehabilitation of up to 2,200 ha of native vegetation. There will be some disturbance to riparian vegetation along a section of Marillana Creek, near the JSW and Oxbow deposits. Groundwater drawdown will extend beyond the boundary of the mine pits during their operating life. This will locally reduce the availability of groundwater for tree species that rely on this water source, potentially causing drought stress and a decline in tree health. Surface water management structures, including a levee and a heavy vehicle creek crossing, will encroach into the Marillana Creek floodplain in the vicinity of the JSW deposits.

The discharge of surplus water from groundwater dewatering operations to the creek systems will contribute to prolonged saturation of sections of the Marillana and Weeli Wolli Creek systems, in addition to that caused by existing mining projects in the catchment. This activity may adversely affect the health of riparian vegetation in affected areas by stimulating plant recruitment, promoting weed invasion and exposing some areas of vegetation to waterlogging stress. Based on the groundwater monitoring records collected since 1974, the water balance and groundwater levels are anticipated to be largely reinstated when mining activities cease. The vegetation is expected to ultimately readjust to the naturally available water sources post-mining.

There is a risk that mining activities will contribute to the spread of weeds, however, this will be minimised through Pilbara Iron's weed control and hygiene procedures.

The project is not predicted to have any significant impact on regional flora and vegetation conservation values on the basis that:

- the vegetation types and flora species found within the project disturbance area also occur extensively outside the disturbance area
- the JSW and Oxbow disturbance areas do not contain significant populations of species with special conservation significance
- a range of control measures will be implemented to minimise impacts on flora and vegetation over the life of the project, in accordance with the Yandicoogina Environmental Management Program (Appendix B). The practices used at the existing Yandicoogina operations have been reviewed and updated for application to the proposed new mining areas at JSW and Oxbow, and
- disturbed areas will be rehabilitated with locally occurring native species when mining activities conclude. Where possible, such areas will be progressively rehabilitated during the operating life of the mines.

For these reasons, the project can be implemented so that the abundance, species diversity, geographic distribution and productivity of flora at species and ecosystem levels are maintained, ensuring that regional biological diversity is conserved.

Terrestrial, aquatic and subterranean fauna

The fauna and habitat values of the Yandicoogina locality have been comprehensively surveyed over multiple phases spanning a 16 year period. As a result, fauna species and assemblages are well characterised and assessed within a regional context. The habitat types occurring in the proposed disturbance areas are typical of the locality in respect to fauna biodiversity values. The overall project area does not support significant populations of species with restricted distributions or other special conservation values, although individuals of such species may use the area transiently or more regularly.

The project will result in the progressive loss and subsequent rehabilitation of terrestrial fauna habitat. This includes up to 2,200 ha of vegetation removal. Some permanent loss of subterranean fauna habitat is expected from mine pit development. Adjacent subterranean habitat will be modified by groundwater dewatering operations during the operational life of the project. The discharge of surplus water from groundwater dewatering operations may favour some fauna species and hinder others, resulting in shifts in the relative abundance of some species in riparian/aquatic habitats.

The project will address feral animal control in the Yandicoogina locality. This will benefit native fauna in areas beyond mining disturbance areas. A program of ongoing fauna surveys and monitoring will improve knowledge of fauna ecology in the region over the life of the project.

The project is not predicted to have any significant deleterious effect on regional habitat or fauna conservation values on the basis that:

Habitat

- the terrestrial habitat types found within the project disturbance area also occur extensively outside the area
- the project disturbance area does not include any permanent pools. Permanent pools act as refugia for aquatic fauna and have elevated conservation importance for aquatic fauna
- disturbed areas will be rehabilitated when mining activities end. Rehabilitation aims to reinstate the important terrestrial habitat values within disturbed areas, enabling the gradual recruitment of fauna species into rehabilitated areas, and
- although a portion of subterranean habitat will be permanently modified, sufficient habitat will be preserved so that subterranean fauna assemblages remain post-mining.

Fauna species

- no significant impacts on species with restricted distributions or other special conservation values are predicted
- changes to aquatic fauna assemblages are predicted from existing discharge activities, caused by the transition of the creek systems from ephemeral to a more permanent regime. The project will contribute further to this regime change. Although these changes may favour some species and hinder others, the effects are predicted to be transient, and
- a range of control measures will be implemented to minimise impacts on fauna over the life of the project, in accordance with the Yandicoogina Environmental Management Program (Appendix B). The practices used at the existing Yandicoogina operations have been reviewed and updated for application to the proposed new mining areas at JSW and Oxbow.

For these reasons the project can be implemented in a manner that maintains the abundance, species diversity, geographic distribution and productivity of terrestrial and subterranean fauna, thereby ensuring that regional biological diversity is conserved.

Surface water

The project will result in sections of Marillana Creek and its tributaries being modified. Depending on the final mine closure plan, some permanent changes may be made to the structural configuration of the creek system. These changes will be designed to preserve the functionality and behaviour of the creekline, and also water quality within Marillana Creek and Weeli Wolli Creek.

Major surface water management controls will include:

- modifying the Marillana Creek floodplain and low flow channel to provide flood protection for mine pits at JSW, as well as access across the creek between the JSW deposits
- temporary redirection of an 800 m section of Phil's Creek (a tributary of Marillana Creek that enters from the north between the JC pit and proposed JSW pits) and reinstatement of the drainage line as close to its original position as possible once this area has been mined, and
- surface water diversion structures for mine pit flood protection along the southern, eastern and/or western boundaries of the proposed Oxbow pit.

Flood protection and surface water diversion structures will be designed to maintain the integrity of the flow regime of Marillana Creek during the life of the project, within the existing flood margins. With appropriate management, temporary alterations to surface water flows will not adversely affect potential beneficial or environmental use of the water. The ecological values of the original creek alignment will be re-established post-mining, as far as practicable, by using a habitat reconstruction approach.

Surface water discharge outlets servicing the current Yandicoogina mining operations will be used for disposal of the dewatering surplus from the JSW and Oxbow mine pits, facilitated by overland pipeline connections. This water will contribute to a modified (persistent) flow regime downstream of the outlets, before infiltrating into the alluvial aquifer of the affected creeklines. Some of the existing operational discharge points may be relocated over time along Marillana Creek. The process of relocating the discharge points will be managed under discharge licence requirements for the existing Yandicoogina operations. However, these impacts have been assessed and taken into consideration in this environmental review.

The discharge of surplus water from the existing Yandicoogina operations and other mining projects in the catchment (BHPBIO and Hope Downs 1) has already resulted in localised impacts to the Marillana and Weeli Wolli Creek systems. These impacts are particularly apparent in the vicinity of the JSW deposits and mainly relate to:

- **the stimulation of vegetation growth** in areas provided with a continuous or semi-continuous water supply, and
- **a decline in vegetation canopy** linked to subsequent reductions in dewatering disposal volumes.

These responses are consistent with broad understanding of the way vegetation adjusts to changes in water availability. With appropriate management, the riparian vegetation is ultimately expected to return to a state similar to that before disturbance.

The project will contribute disposal volumes of up to 16 GL/yr, with an annual mean of about 10 GL/yr over the project life. These volumes are additional to the volumes discharged from the combined BHPBIO Yandi, Hamersley Yandi and Hope Downs 1 projects into the Marillana and Weeli Wolli Creek systems.

Analytical modelling techniques were used to assess the cumulative impact of the project. With an annual average maximum peak discharge of 22 GL/yr, the existing discharge footprint from all Yandicoogina operations extends up to 2.5 km downstream of the confluence of Marillana Creek and Weeli Wolli Creek. The discharge footprint is predicted to extend up to 13 km from the confluence, if existing projects collectively increase their dewatering rates to current licensed limits.

Historically, the discharge footprint from the Yandicoogina project has been confined to Marillana Creek, only reaching the confluence with Weeli Wolli Creek for short periods after intensive dewatering to merge with the discharge from the Hope Downs 1 project. Surface water modelling has indicated that the project could result in the overall discharge footprint extending an additional 4 km along the lower reaches of Weeli Wolli Creek (ie a total distance of up to 17 km from the Marillana Creek confluence).

The project is not predicted to have any lasting detrimental effects on surface water values on the basis that:

- by substantially maintaining the pre-disturbance surface water flow regime in Marillana Creek, modifications to the landscape and the presence of infrastructure are unlikely to significantly affect surface flows down gradient of the JSW and Oxbow mine pits
- the potential impact of an increased sediment load originating from the project disturbance area is unlikely to elevate the already naturally high background sediment load-levels observed in the local creek systems after large rainfall events
- as part of the existing operations at Yandicoogina, water quality monitoring has confirmed that surface water discharge does not result in significant water quality changes downstream of the operations. This is due to the inherent hydrological characteristics of the Marillana and Weeli Wolli Creek systems.

The analytical modelling of surface water discharge was peer reviewed by SKM in 2011 (Appendix A10) and supported the modelling predictions.

For these reasons, the project can be implemented in a way that protects water quality, preserves ecological water requirements, and maintains the human use and amenity values of the Marillana and Weeli Wolli Creek systems.

Groundwater

The groundwater in the vicinity of the JSW and Oxbow deposits varies in depth from 2 to 25 m below the ground surface. The depth to water table can fluctuate by up to 10 m in response to recharge events. The groundwater has low concentrations of dissolved major ions and is classified as fresh water of relatively good quality.

Mine pit dewatering is required to enable mining below the natural water table. This will result in a cone of depression in the water table in and around the mine pit during the mine life, extending beyond the CID aquifer into parts of the overlying and adjacent alluvial aquifer.

Potential impacts to groundwater systems during and post-mining have been assessed using the Yandicoogina numerical groundwater model developed by RTIO. This model has superseded earlier modelling and is based on an updated conceptual model of the Yandicoogina groundwater system. The model has been developed using historical data collected since the Yandicoogina operations commenced in 1998, along with extensive drilling and aquifer testing parameters. The model was calibrated using data from all existing production borefields and a selection of representative monitoring bores.

The majority of the groundwater extracted for mine pit dewatering purposes will ultimately be returned to the aquifer downstream of mining operations, through the action of surface water percolating beneath the Marillana and Weeli Wolli Creek beds. Water balance modelling has demonstrated that evaporation losses resulting from surface water disposal are relatively minor compared with the aquifer storage volumes and throughput volumes.

Flushing caused by cyclonic rainfall events in the Marillana Creek catchment is the main way that low salt concentrations are maintained in the CID aquifer. As a result, the potential for salt accumulation in the downstream aquifer is low. Water quality in the aquifer is unlikely to be affected by the proposed surface water disposal methods during the life of the project.

The long term functionality and behaviour of the CID aquifer post-mining depends on the approach taken for mine closure. Mining, backfilling and tailings disposal will result in permanent changes to the physical characteristics of the mined areas. However, the project can be implemented so that throughflow and water quality in the local aquifers are maintained. Mine closure designs will incorporate measures to protect the quality and quantity of groundwater post-mining.

Groundwater and Surface Water Management Plans for the project have been developed in consultation with DEC and DoW. These plans collectively address:

- **collection of reliable baseline groundwater data** for the mine and any associated borefield areas
- **collection of suitable baseline data** on the state and condition of ecosystems potentially affected by surface water discharge
- **monitoring parameters** for hydrological and ecosystem health change to ensure that changes and impacts are within acceptable limits, and
- **primary and contingent management and reporting actions** in the event that impacts are detected outside acceptable limits.

These management plans, along with the mine closure plan, will provide the basis for the protection of groundwater quantity and quality, for human use and ecosystem maintenance purposes.

Aboriginal heritage

Extensive archaeological and ethnographic surveys have been undertaken within the Yandicoogina locality, principally in association with mining activities in the area. Numerous Aboriginal archaeological sites have been recorded: including artefact scatters, quarries, rock shelters, engraving sites and scarred trees. These sites range from low to high archaeological and cultural significance.

A number of ethnographic sites have also been identified in the Yandicoogina locality, most significantly in connection with Marillana Creek and Weeli Wolli Creek. The creek systems are recognised to have important associations with camping, ceremonies and cultural activities. A heritage avoidance zone is currently demarcated around Weeli Wolli Creek, Marillana Creek and Phil's Creek.

Potential impacts to Aboriginal heritage values will be managed via the following provisions:

- **Hamersley will maintain an ongoing process of consultation** with the GAC for managing Aboriginal heritage sites and values in the overall project area
- **the project will be implemented** in accordance with the provisions of the YLUA, and
- **any disturbance to areas with heritage values will only be undertaken** in accordance with the provisions of the *Aboriginal Heritage Act 1972* (WA), and with the consent of the relevant Traditional Owners.

For these reasons, the project can be implemented in a manner that will not adversely affect the historical and cultural associations between Traditional Owners and the Yandicoogina environment.

Greenhouse gas emissions

Based on the emissions intensity of the existing operations at Yandicoogina, annual GHG emissions resulting from proposed mining at JSW and Oxbow will be around 100,000 tonnes $CO_{2\ \text{equiv.}}$ /yr over the life of the project. Systems used for metering and tracking energy consumption and greenhouse gas emissions at the existing Yandicoogina operations will be extended to include the project operations.

All RTIO operations have targets for increasing efficiency and for reducing energy consumption and the emission of greenhouse gases. The existing Yandicoogina project is subject to energy efficiency planning and implementation under the Commonwealth Government's *Energy Efficiency Opportunities Act 2006* legislative framework, as well as the Rio Tinto Environment Standard for Greenhouse Gas Emissions. These provisions will provide the basis for continuous improvement in energy efficiency for the project.

An evaluation of energy management and energy efficiency initiatives at the Yandicoogina operations was completed by RTIO in 2010. Examples of the types of energy efficiency opportunities that were identified include (but are not limited to):

- **improved efficiencies in mining** and ancillary systems, and infrastructure such as workforce accommodation facilities
- **increasing awareness** of energy efficiency and improving the efficiency of operating procedures
- **optimising mining and ore processing systems**, such as ore haulage and conveyance logistics, and
- **staged replacement of equipment** with more energy efficient units, according to asset management schedules.

For these reasons, the project can be implemented in a manner that reduces emissions per unit of product to 'as low as reasonably practicable', and is consistent with Commonwealth and State greenhouse gas strategies and programs.

Closure

The Rio Tinto Closure Standard details the mine closure policies and standards that apply to Rio Tinto mining operations globally.

The *Decommissioning and Rehabilitation Plan* for the existing operations at Yandicoogina has been updated to include the JSW and Oxbow iron ore mines. The updated plan will be progressively developed over the life of the project in consultation with regulatory agencies and other stakeholders,

An earlier version of the *Decommissioning and Rehabilitation Plan* was developed in 2003 and was endorsed by the Department of Environment[1] in 2005. Subsequently, the closure strategy in this earlier plan for the JC and JSE mines only, was seen to be unsuitable for meeting the closure objectives. The reasons include:

- strategies developed in the *Decommissioning and Rehabilitation Plan 2003* were based on old hydrogeological models that have now been superseded due to improved knowledge. The revised hydrogeological model suggests that these strategies may not be achievable
- the post-mining landform configuration in the 2003 plan would be compromised by a series of voids of varying depths, intersected by creeklines in several locations. Engineering such a landform that meets stability expectations is unlikely. Creeklines would be likely to collapse into the voids during the first period of heavy rainfall, causing adverse environmental outcomes, and
- the amount of backfill material needed for the final landform would greatly exceed the amount of mining waste available. Recent estimates indicate that almost all elevated land within Mining Lease ML274SA would need to be removed to provide the additional backfill needed. This would have significant environmental and cultural consequences that are potentially avoidable with alternative closure strategies.

Potential impacts of the complete backfill option include:

- **loss of hillside ecosystems** that would otherwise be unaffected by the mining operation
- **changes to surface drainage patterns**, with potentially significant implications for local and regional hydrology
- **additional disturbance** of places of cultural significance, such as rock shelters, and
- **additional greenhouse gas emissions** associated with excavating and transporting substantial volumes of backfill material.

Given these issues, the mine closure strategies were revised for the overall Yandicoogina operations. A new set of closure objectives has been developed and included in the current *Decommissioning and Rehabilitation Plan*.

[1] Now the Department of Environment and Conservation (DEC)

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Several alternative conceptual closure options have also been identified in the current *Decommissioning and Rehabilitation Plan,* including:

- **Option 1**: Retaining Junction Central and Oxbow pit voids
- **Option 2**: Creating a 'channel' landform, by reinstating the CID orebody zone as the primary flow path for Marillana Creek, and
- **Option 3**: Backfilling to ground level, involving extensive quarrying of surrounding hills.

Option 2 is currently the preferred option for meeting the mine closure objectives. All of the options are being assessed technically, economically and environmentally. These will inform a detailed closure study scheduled to be completed by early 2012, as a component of a broader program of closure studies and investigations to be completed during the operational life of the project.

The *Decommissioning and Rehabilitation Plan* will be finalised at least five years before the planned mine closure. Comprehensive closure completion criteria will be included as well as a program to monitor if closure objectives are being achieved. A 'walk away' solution will be included for the decommissioned JSW and Oxbow mine sites.

RTIO's systematic and inclusive process for mine closure will ensure that the EPA objectives are met when mining operations cease.

Environmental management framework

The project will be subject to the Pilbara Iron Health, Safety, Environmental and Quality Policy (Appendix A16). The proposed mines will be operated under the company ISO14001 accredited Environmental Management System (EMS), consistent with managing the existing Yandicoogina operations. The key elements of the EMS include:

- assessing environmental risk and legal requirements
- developing objectives and targets for improvement, training, operational control, communication, emergency response, corrective actions, audits and review
- using procedures for environmental protection during implementation and operation, and
- measuring and evaluating environmental performance.

A Construction Environmental Management Plan (CEMP) will be developed before mine development to ensure that environmental impacts are minimised during the construction phase.

The existing Yandicoogina Environmental Management Program (EMP) was reviewed and updated to span all (existing and proposed) Pilbara Iron mining operations at Yandicoogina (Appendix B). The EMP consists of a series of targeted environmental management plans, including those addressing the project environmental factors described in Table 2. These will be continuously reviewed and updated to address the environmental management requirements over the life of the project.

Conclusion

In summary, the key predicted environmental impacts of the project include:

- **progressive removal of up to 2,200 ha of native vegetation** and terrestrial fauna habitat over the life of the project. Based on extensive surveys, all vegetation communities and habitat types within the project disturbance area are widespread and well represented regionally. Unavoidable disturbance to some areas of locally significant riparian vegetation along Marillana Creek will occur. There are few flora of elevated conservation significance in the project disturbance area and where individual plants are identified they will be avoided, wherever possible.
- **unavoidable loss of individual animals** as a consequence of mining-related disturbance, potentially causing reductions in local populations of some species. Larger scale impacts to species populations are highly unlikely due to the wide distribution of affected species and habitat types (beyond the project disturbance area). Terrestrial fauna with special conservation significance are highly unlikely to be affected, as the project disturbance area does not include significant populations of these species or provide important habitat for them.
- **unavoidable loss of subterranean habitat** within the mine pits, and temporary modification to adjacent habitat areas from groundwater drawdown for mine pit dewatering. Based on extensive surveys for subterranean fauna across the Yandicoogina site, the project is not expected to affect the persistence of subterranean fauna assemblages.
- **modification of a section of Marillana Creek** near the JSW deposits from the installation of flood protection structures, a floodway creek crossing and dewatering effects on riparian vegetation. The terminus of Phil's Creek, near the western margin of the existing JC pit will require diversion and reinstatement. A range of measures will be used to minimise disruption to the flow regime of Marillana Creek and maintain downstream water quality. The ecological values of the affected creek sections will be re-established as far as practicable using a habitat reconstruction approach post mining.
- **up to 16 GL/yr of additional water discharged** to Marillana Creek due to mine dewatering operations at JSW and Oxbow (over and above existing discharge volumes within the catchment). This may contribute to changes in riparian vegetation, including stress and/or loss of riparian vegetation and changes in composition. In stream aquatic habitat/fauna populations in the lower reaches of Marillana Creek and a 10 to 17 km section of Weeli Wolli Creek downstream of the Marillana Creek confluence may also be affected. However, after discharge ceases, the creekline system is expected to recover and gradually return to a condition more closely resembling the pre-discharge condition.
- **drawdown of groundwater in the orebody aquifers** at JSW and Oxbow by approximately 60 m. The adjacent alluvial aquifer system will also be affected by the groundwater cone of depression, to a distance of ~2 km down gradient of the JSW pit boundary and ~1.5 km up gradient of the Oxbow pit boundary. At each location, groundwater levels in the orebody aquifers are likely to recover to their original levels post-mining.
- **a post-mining landscape** with stable landforms, rehabilitated vegetation and a flow regime in Marillana Creek which protects downstream water quality. The Yandicoogina *Decommissioning and Rehabilitation Plan* was recently updated to include the JSW and Oxbow mining areas. This plan provides the framework for more detailed closure planning over the project's operational life. A final *Decommissioning and Rehabilitation Plan* will be developed at least five years before planned mine closure. A detailed closure study addressing conceptual closure options is scheduled to be completed by early 2012
- **contribution towards greenhouse gas emissions** from the overall Yandicoogina operations in the order of 100,000 tonnes $CO_{2\ equiv.}$ /yr averaged over the life of the project. Energy management and efficiency initiatives at the current Yandicoogina operations have been evaluated, in accordance with the Commonwealth *Energy Efficiency Opportunities Act 2006*. The outcomes of this evaluation will also apply to the project.

A consolidated summary of the project's potential environmental impacts, proposed measures for managing these potential impacts and the predicted environmental outcome for each of the key factors assessed is provided in Table 3.

Costs and benefits

The JSW and Oxbow deposits are in close proximity to existing mine infrastructure, including ore processing plants and rail load facilities at JC. These deposits provide the most suitable option for ensuring continuity of production at Yandicoogina over the next 12 years.

Hamersley has undertaken a comprehensive assessment of potential environmental impacts associated with implementing the project. A range of mitigation and management strategies have been developed to ensure that unacceptable impacts will be avoided and EPA environmental protection objectives are met. To develop these strategies, Hamersley consulted extensively with regulatory agencies and other stakeholders and will continue to do so during the assessment process. The proposed environmental management approach builds upon existing systems being successfully implemented at the current Hamersley Yandicoogina operations.

On the basis of the findings of this Environmental Review, the project is considered to be environmentally acceptable if implemented in accordance with the proposed management measures.

Table 1 – Completed baseline studies and status of the existing environment

Environmental Factor/Aspect	Baseline Studies	Key Findings
Vegetation and flora	Vegetation and Flora Surveys of the Oxbow and Junction South West Deposits, near Yandicoogina (Biota 2010a; including 2011 addendum; Appendix A1) Yandicoogina Additional Vegetation Mapping (Biota 2011; Appendix A2)	The vegetation in the overall project area is typical of the central Pilbara region and does not contain any vegetation types or ecological communities with high regional conservation significance. Riparian vegetation along Marillana and Weeli Wolli Creeks is regarded as being locally significant, due to the relatively limited extent of this vegetation type compared with other locally occurring vegetation types and the ecological services that it provides. Portions of the overall project area have been surveyed in the past in association with the JC and JSE mine development projects. In the JSW disturbance area, 267 native vascular plant taxa from 114 genera belonging to 40 families were recorded. In the Oxbow disturbance area, 220 native plant taxa from 102 genera belonging to 38 families were recorded. In the remainder of the overall project area (not subject to historical surveys) a total of 75 vascular plant taxa from 37 genera belonging to 23 families were recorded. No significant populations of rare, threatened or otherwise significant plant species were recorded. One individual of the Declared Rare Flora (DRF) species *Lepidium catapycnon* was recorded in a recently burnt hilltop area south east of the Oxbow deposit. This species has also been found in historical surveys associated with the JC and JSE mines, within the overall project area. The Priority 4 species *Goodenia nuda* was recorded south of Marillana Creek in the eastern part of the JSW disturbance area (near the rail loop) and north-east of the existing JC pit. A Priority 3 species *Rostellularia adscendens* var. *latifolia* was recorded from historical surveys near JSW-C. The Yandicoogina locality has been subject to a long history of pastoral land use (since early 1900s) and nearly 20 years of mining activities. Much of the vegetation is in relatively good condition; however, the combined impacts of cattle grazing, weed introduction, infrastructure development and wildfires are evident in some areas. Fifteen weed species were recorded in the overall project area. These generally occurred at relatively low densities and in association with cattle activity or ground disturbance.

Environmental Factor/Aspect	Baseline Studies	Key Findings
Terrestrial and aquatic fauna	Yandicoogina Junction South West and Oxbow Fauna Survey (Biota 2010c; Appendix A3) Yandicoogina Targeted Northern Quoll Survey (Biota 2009; Appendix A4) Yandicoogina Expansion Northern Quoll Position Paper (Biota 2010d; Appendix A5) Cumulative Impacts of RTIO Mining on the Weeli Wolli Creek System (WRM 2010; Appendix A6) Yandicoogina JSW and Oxbow mine development – Aquatic Management Report (WRM 2011; Appendix A7)	The overall project area does not contain any terrestrial or aquatic fauna populations, or habitat types, with high regional conservation significance. Fauna surveys in the JSW and Oxbow disturbance areas and immediate surrounds yielded a total of 72 vertebrate fauna species, across 38 families: including 46 species of avifauna, 12 species of mammals and 14 species of herpetofauna. The mammal groups included six species of bats and two non-native species (the cow and donkey). This represents only a portion of the fauna assemblage of the wider locality, which from multiple historical surveys is estimated to comprise 301 species across 78 families; including 145 species of avifauna, 35 species of mammals and 121 species of herpetofauna . In addition to the baseline surveys, targeted surveys were undertaken for the Northern Quoll (*Dasyurus hallucatus*) over the wider Yandicoogina locality. This species is listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and Schedule 1 of the Western Australian *Wildlife Conservation (Specially Protected Fauna) Notice 2010*. It has a wide geographic range in the Pilbara region. Individual animals can range across large areas in response to disturbance events such as bushfires and the availability of prey species. No evidence was found in the surveys to suggest that a significant Northern Quoll population occurs within the overall project area, despite the Yandicoogina locality being one of the most intensively surveyed areas in the Pilbara for vertebrate fauna (over a 16 year period). Multiple sampling phases for aquatic fauna were completed in Marillana and Weeli Wolli Creeks during the period 2008 to 2010, resulting in detailed characterisation of fish and aquatic invertebrate assemblages within the creek systems. The majority of the fish and invertebrate species recorded in the surveys are widely distributed in the Pilbara and elsewhere. However, several hyporheic[2] amphipod species are known only from the Marillana/Weeli Wolli Creek system.

[2] A dynamic ecotone in stream systems, between the stream water above and groundwater below.

Environmental Factor/Aspect	Baseline Studies	Key Findings
Subterranean fauna	Yandicoogina Subterranean Fauna Assessment Phases 1 to 5 (Biota 2010e) including Yandicoogina Stygofauna Assessment 2010 Addendum; Appendix A8)	Subterranean fauna are of high conservation interest in Western Australia, due to the propensity for some species to have restricted distributions. Subterranean fauna are known to occur in the groundwater (stygofauna) and unsaturated stratigraphies (troglofauna) at Yandicoogina. Stygofauna populations at the Hamersley Yandicoogina operations have been monitored on a regular basis since 2003. Collectively, 68 bores were sampled for stygofauna across all seven phases, including 20 bores in the JSW and Oxbow disturbance areas in later phases. A total of 5,166 specimens consisting of 52 taxa were collected across the full extent of the survey, representing at least ten orders from seven invertebrate classes. Of the 52 taxa recorded, 32 were collected at multiple sampling locations and 20 were collected at four or more sampling locations. The majority of the sampled taxa are known from outside the Yandicoogina survey area. It is unlikely that any taxa would be confined to the Oxbow and JSW disturbance areas, given the extent of seasonal water movement through the Yandicoogina locality and the high level of connectivity across the valley alluvial substrates. Targeted surveys for troglofauna were completed in Q4 2009, with an additional survey completed in September 2010. A total of 58 sites (130 traps) were sampled in the JSW and Oxbow disturbance areas and surrounds (18 bores) and areas adjacent to Weeli Wolli Creek (40 bores). Site hydrogeological data were used to ascertain areas above the water table to target sampling areas. Out of 4,827 invertebrate fauna specimens recorded in the survey, only 16 specimens displayed troglomorphic characters. These included one schizomid, one pseudoscorpion, four Blattodea (cockroach) from two sites, ten polyxenid millipede species from six sites and a single pauropod specimen. In total, eight confirmed troglobitic specimens have been collected from Yandicoogina since 2008 (including by-catch from stygofauna sampling). The valley landforms are not considered to contain primary habitat for troglofauna, due to relatively shallow water tables and the likelihood of episodic saturation of the upper alluvium layers during cyclone events. Most of the potential CID habitat is below water table. The troglofauna specimens that have been collected are likely to have dispersed from source habitats in nearby higher elevation areas. These predominantly lie outside the project disturbance area.

Environmental Factor/Aspect	Baseline Studies	Key Findings
Surface water	Marillana Creek Regional Flow Balance and Catchment Hydrology (RTIO 2010c; Appendix A9) Review of RTIO Surplus Water Discharge Model (SKM 2011; Appendix A10)	Marillana and Weeli Wolli Creeks are both ephemeral and have catchment areas of 2,250 km^2 and 1,750 km^2, respectively above their confluence. Stream flow is largely dependent on rainfall and, in normal circumstances the creeks within the overall project area are dry for most of the year. Large stream flows are generally associated with rain bearing depressions or high intensity cyclonic rainfall that brings heavy rain over a large area of the catchments. All surface drainage in the overall project area eventually feeds into the upper Fortescue River system, north of the Hamersley Range. There is also a dense network of minor drainage lines formed by erosion from high intensity rainfall on the sparse vegetation cover and shallow soils adjacent to Marillana Creek. Discharge of the dewatering surplus into the Marillana Creek systems has occurred since the early 1990s (BHPBIO), and into the Weeli Wolli Creek system since 2007 (Hope Downs 1). In 2009, approximately 50 GL of surplus water from a potential 90 GL (licensed peak discharge limits) was discharged into Marillana and Weeli Wolli Creeks consisting of: • ~14 GL into Marillana Creek from the Hamersley Yandicoogina operations • ~5 GL into Marillana Creek from the BHPBIO Yandi operations, and • ~30 GL into Weeli Wolli Creek from Hope Downs 1 mining operations (approximately 20 km upstream from the Marillana Creek confluence). Discharge volumes from the JSW and Oxbow mine pit developments are predicted to contribute additional volumes of up to 16 GL/yr, with an annual mean of about 10 GL/yr over the project life. A baseline hydrological/hydraulic assessment was carried out to quantify the hydrological influence of surface discharge on Marillana and Weeli Wolli Creeks for various discharge scenarios. This assessment addressed the cumulative impacts of discharge from the Hamersley Yandicoogina, BHPBIO Yandi and Hope Downs 1 operations. The study predicted that under a maximum combined operations discharge rate of 106 GL/yr (allowing for maximum licensed increases across all contributing mining operations), the discharge footprint would extend another 4 km past the current peak maximum footprint, to approximately 17 km beyond the confluence of Marillana and Weeli Wolli Creeks. The northern extent of this footprint is 10 km south of a BHPBIO rail crossing of Weeli Wolli Creek, and approximately 25 km south of the southern edge of the Fortescue Marsh. Under a cumulative discharge scenario of 60 GL/yr, which is a more likely concurrent discharge peak from the various sites, the maximum discharge footprint would be 7 to 8 km beyond the confluence of Marillana and Weeli Wolli Creeks. The diversion of Phil's Creek will involve relocating the last 800 m of this creek so that ore can be extracted beneath the creek bed, in the eastern portion of the JSW deposits near the western margin of the JC pit. The drainage line will be reinstated as close to its original position as possible once this area has been mined.

Environmental Factor/Aspect	Baseline Studies	Key Findings
Groundwater	Yandicoogina Hydrogeological Field Program Report – Bore Installation, Test Pumping 2008/09 (RTIO 2010a; Appendix A11) Yandicoogina 2010 Regional Groundwater Modelling Report (RTIO 2011a; Appendix A12) Yandicoogina Water Balance; Pre and Post-mining Hydraulics and Hydrochemistry (RTIO 2010b; Appendix A13) Yandicoogina Model Review (URS 2011; Appendix A14)	Groundwater principally occurs in two aquifer systems of the Marillana Creek valley, namely the CID and flood-plain (alluvium) aquifer. Both aquifers are inter-connected and recharged from Marillana Creek. Water quality in the CID and alluvium aquifers is relatively fresh (predominantly <600 mg/L). Groundwater in the underlying basement rocks only occurs in secondary porosity associated with the weathered zone and within fractures in the bedrock, with lower hydraulic conductivities than the CID and floodplain alluvium. The depth to water table in the JSW and Oxbow disturbance areas can fluctuate considerably in response to cyclonic rainfall inputs. The water table in the CID ranges from 2 m where it intersects Marillana Creek, to a maximum of 25 m below ground level. The estimated range of throughflow from the CID is 1500 to 3000 m^3/day depending on the width of the CID channel. The Yandicoogina groundwater model incorporates a recently updated conceptual hydrogeological model, featuring permeable alluvium and weathered basement material adjacent to the CID. The key finding of this work is the critical importance of the proper application of cyclone and tropical storm-related creek flow events to the model, to recreate historically documented recharge to the aquifers of the region.
Aboriginal heritage surveys	Ongoing consultation with Traditional Owners Extensive archaeological and ethnographic surveys have been undertaken within the Yandicoogina locality since the early 1990s	Multiple archaeological and ethnographic surveys have been completed within the Yandicoogina locality since the early 1990s. These surveys have identified numerous Aboriginal archaeological sites, including artefact scatters, quarries, rock shelters, engraving sites and scarred trees. Sites range from low to high archaeological and cultural significance. A number of ethnographic sites have also been identified within the Yandicoogina locality, most significantly Weeli Wolli Creek and Marillana Creek. The creeks have important associations with camping, ceremonies and cultural activities.

Environmental Factor/Aspect	Baseline Studies	Key Findings
Mine closure	Yandicoogina Closure Study (RTIO 2011b; Appendix A15)	A *Decommissioning and Rehabilitation Plan* was developed for the Yandicoogina JC mining area in 1999, and revised in 2003. The revised plan was accepted by the Department of Environment[3] in March 2005. The *Decommissioning and Rehabilitation Plan* has been progressively updated by RTIO as the Yandicoogina operations have evolved. The plan was resubmitted to the OEPA in January 2011, in accordance with Ministerial Statement 695. This plan recognises the need for a life of mine approach to closure planning at Yandicoogina, and addresses closure issues across existing (JC and JSE), proposed (JSW and Oxbow) and projected future mining projects (Billiard) in the same palaeochannel. It also identifies that the closure strategy previously agreed with Government in 2005, is not suitable for meeting the closure objectives across the greater Yandicoogina mining area. A new set of closure objectives has been developed. The current *Decommissioning and Rehabilitation Plan* addresses: a closure vision and knowledge base, stakeholder consultation, landform reconstruction and rehabilitation, biodiversity and cultural heritage protection, development of completion criteria, monitoring, closure risk assessment and cost estimation processes. The following conceptual final landform options are also considered: • Option 1: Retention of Junction Central and Oxbow pit voids • Option 2: Creation of a ‘channel’ landform, involving the reinstatement of the CID orebody zone as the primary flow path for Marillana Creek, and • Option 3: Backfill to ground level, involving extensive quarrying of surrounding hills. Option 2 is currently the preferred option for meeting the revised closure objectives. A program of studies and investigations has been initiated by RTIO to evaluate all of the options in more detail. This will inform a detailed closure study, scheduled to be completed by early 2012.

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Table 2 – Components of the Yandicoogina Environmental Management Program (EMP) addressing key environmental factors associated with the project

Management Plan	Plan objectives	Key procedural components
Groundwater Management Plan	• Minimise the impacts of the proposal on key water parameters. • Maintain the quantity and quality of water so that existing and potential values, including ecosystem maintenance, are protected.	• model the short-term hydrogeological impacts. • establish baseline data on groundwater levels, quality and through-flow at the downstream boundary of Mining Lease 274SA and at appropriate locations along the CID aquifer. • monitor the groundwater levels, quality and through-flow at appropriate locations along the CID aquifer and along Weeli Wolli Creek during all phases of mining. • monitor the dewatering and discharge rates (both cumulative and direct). • reinject surplus dewatering water into the Billiard CID aquifer. • manage and minimise impacts on groundwater. • report management actions and monitoring results.
Surface Water Management Plan	• Minimise discharge into the creek systems to minimise impact to Weeli Wolli, Marillana and Yandicoogina Creeks. • Maintain flow paths and quantity in the creeks.	• minimise the volume of runoff impounded by structures. • maintain the flow paths, quantity and quality of water within Marillana, Yandicoogina and Weeli Wolli Creeks and the underlying aquifers to protect ecological systems that depend on surface and groundwater. • minimise the need for discharge. • maintain a 200 m mine pit buffer around Weeli Wolli, Marillana and Yandicoogina Creeks (with the exception of Marillana Creek in the vicinity of JSW pits). • report management actions and monitoring results.
Significant Species Management Plan	• Maintain the abundance, diversity, geographic distribution, conservation status and productivity of flora and fauna at species and ecosystem levels through avoiding or managing adverse impacts and improving knowledge.	• demarcate identified populations and/or individuals of flora and fauna, vegetation associations and habitat areas with conservation significance. • modify land clearing plans and evaluate alternative mine plans to minimise or avoid impacts on flora and fauna, vegetation associations and habitat areas with conservation significance. • minimise impacts where proposed mining activities are likely to impact on flora and fauna, vegetation associations and habitat areas with conservation significance. • monitor and record impacts on flora and fauna, vegetation associations and habitat areas with conservation significance. • implement appropriate contingency measures, where impacts on flora and fauna, vegetation associations and habitat areas with conservation significance are identified.
Riparian Management Plan	• Minimise impacts on riparian vegetation from dewatering and discharge of surplus dewatered water. • Maintain the abundance, diversity, geographic distribution, conservation status and productivity of flora and fauna species and ecosystem levels through avoiding or managing adverse impacts and improving knowledge.	• maintain the flow paths, quantity and quality of water within Marillana, Yandicoogina and Weeli Wolli Creeks and the underlying aquifers to protect ecological systems that depend on surface and groundwater. • monitor the effects of dewatering on riparian vegetation communities in areas where the water table is predicted to be lowered by at least 2 m (during and after mining) and implement remedial measures if impacts are detected. • manage and minimise potential impacts on riparian vegetation associated with dewatering and at discharge points. • evaluate alternative discharge locations and methodologies. • reinject surplus water from dewatering, into the Billiard CID aquifer, where feasible. • avoid disturbance and weed introduction to vegetation in creeklines, particularly vegetation which is currently in good or excellent condition. • maintain a riparian vegetation buffer of not less than 200 metres around Marillana, Yandicoogina and Weeli Wolli Creeks. The buffer is to protect riparian vegetation and the habitat of fauna associated with the creeks. The flood protection levees and a heavy vehicle road crossing at JSW are excluded from this buffer. Any encroachment will be designed to maintain the flow regime of Marillana Creek.
Subterranean Management Plan	• Maintain the abundance, diversity, geographic distribution, conservation status and productivity of subterranean fauna species and ecosystem levels by avoiding or managing adverse impacts and improving knowledge.	• avoid and/or manage impacts on subterranean fauna species, communities and their habitats where the long term survival of those species and communities may be at risk as a result of project operations. • establish additional data on the distribution of existing stygofauna species and communities, particularly the ostracod *Gomphodella* sp; and water mite *Recifella* sp., to demonstrate that there is no threat to these species. • take timely remedial action if additional data indicates that project operations may compromise the long-term survival of subterranean fauna species and/or communities. • report survey results and management actions.
Emissions Management Plan (dust, noise and greenhouse gases)	• Measure and minimise energy consumption and greenhouse gas emissions. • Control dust emissions. • Control noise emissions.	• comply with Commonwealth legislation for energy consumption and greenhouse gas emissions. • monitor noise and put mitigation controls in place. Comply with regulatory requirements. • monitor dust and put mitigation controls in place. Comply with regulatory requirements.

Management Plan	Plan objectives	Key procedural components

Decommissioning and Rehabilitation Plan	• Construct landforms that are stable, non-polluting and aesthetically compatible with the surrounding landscape.
	• Establish sustainable endemic vegetation communities consistent with the reconstructed landscape and surrounding vegetation.
	• Ensure that closure planning and rehabilitation are carried out in a coordinated, progressive manner. Integrate closure planning and rehabilitation with development planning, current best practice, and the agreed end land uses.
		The updated *Yandicoogina Decommissioning and Rehabilitation Plan* will be an evolving document over the life of the project. Subject to periodic internal and external review, the plan will respond to interim project outcomes. Consulting with regulatory agencies and other stakeholders will be an important part of this process.
		A final *Yandicoogina Decommissioning and Rehabilitation Pla*n will be developed at least five years before planned mine closure. Comprehensive closure completion criteria will be included as well as a program to monitor how the criteria are being achieved. A 'walk away' solution will be provided for the decommissioned mine site and address. The plan will include:
		• managing long term hydrogeological and hydrological impacts of mining the CID
		• modelling the long term hydrogeological impacts, using a landscape water balance approach
		• progressive rehabilitation of all disturbed areas to a standard suitable for the agreed end land use(s), including:
		  ◦ the characteristics of the pre-mining ecosystems within the project area (through research and baseline surveys)
		  ◦ the performance of previously rehabilitated areas within the mining lease
		  ◦ the performance of rehabilitation areas at Hamersley Iron's other operations in the Pilbara, and
		  ◦ best practice rehabilitation techniques used elsewhere in the mining industry.
		• monitoring rehabilitation to assess the performance of all rehabilitated areas against the completion criteria
		• reporting the rehabilitation and monitoring results
		• removing all infrastructure (unless otherwise agreed with the State Government), and
		• management strategies and/or contingency measures in the event that the closure strategy results in a significant environment impact.

Table 3 – Summary of the key environmental factors, potential impacts, proposed management and predicted outcomes

Environmental Factor	EPA Objective	Potential Impacts	Mitigation and Management Measures	Predicted Outcomes
Vegetation and Flora	To maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystem levels by avoiding or managing adverse impacts and improving knowledge.	• Up to 2,200 hectares of vegetation will be cleared. • Inundation from dewatering discharges has the potential to cause tree loss or health decline along sections of Marillana and Weeli Wolli Creeks. • Drawdown from dewatering activities has the potential to cause tree loss or health decline in the vicinity of JSW and Oxbow pits. • Increased risk of uncontrolled fires resulting from mining activities. Frequent fires can result in vegetation loss and altered vegetation community composition.	• Potential impacts to vegetation and flora will be addressed through the implementation of the *Yandicoogina Vegetation and Flora Management Plan*. • Vegetation values will be assessed prior to any ground disturbance. • Adhere strictly to RTIO ground disturbance permitting and procedures. • Monitor riparian vegetation health, with adaptive management responses linked to vegetation condition changes. • Implement dust suppression techniques, including watering of unsealed roads. • Minimise the risk of uncontrolled fires and maintain an on-site fire suppression capability. • Progressively rehabilitate disturbed areas with native vegetation. Collect and stockpile topsoil for use in rehabilitation post-mining.	After mitigation and management measures have been applied, the project is expected to result in the following vegetation and flora outcomes: • Progressive removal and rehabilitation of up to 2,200 ha of native vegetation over the life of the project. • Some disturbance to locally significant riparian vegetation due to groundwater drawdown near the proposed JSW and Oxbow mine pits. Modified flow regime in sections of the Marillana and Weeli Wolli Creek systems. • No significant impact on the regional conservation values of flora and vegetation. Vegetation units recorded from the proposed disturbance area occur extensively outside this area. • No threatened ecological communities (TECs), vegetation of high conservation significance or significant populations of rare plant species will be affected by the project. The project will not significantly affect the abundance, species diversity, geographic distribution and productivity of vegetation and flora at species and ecosystem level. The project will be consistent with maintaining regional biological diversity.
Terrestrial and Aquatic Fauna	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement of knowledge.	• Vegetation clearing for the mine pit and infrastructure will result in the loss of fauna habitat. This disturbance may lead to the loss or displacement of individual animals. • Vegetation clearing for the mine pit and infrastructure has the potential to contribute to the fragmentation and isolation of fauna populations. • Spills or leaks of contaminating materials may cause harm to individual animals or localised populations. • The movement of vehicles within the overall project area and on access roads has the potential to lead to the loss of individual animals from collisions. • Groundwater drawdown from dewatering and the surface discharge of excess water has the potential to alter the abundance and composition of vegetation. These changes to fauna habitat can lead to the loss or displacement of individual fauna species. • Indirect impacts from mining activities include the effects of pollution, noise, dust, the workforce, light emissions, and the introduction/spread of feral animals. • There may be an increased risk of fire due to blasting, heat from machinery and vehicles, and increased presence of human activity. Fire can result in the loss or alteration of habitat. • Potential population reduction due to predation by, or competition with, feral animals.	• Potential impacts to terrestrial and aquatic fauna will be addressed by implementing the *Yandicoogina Fauna Management Plan*. • Restricting vegetation clearing to designated areas. Clear the minimum area necessary for safe construction and operation of the project. • Protect uncleared habitat from encroachments and other disturbances. • Maintain natural drainage flows, wherever practicable, and prevent ponding of water. • Avoid disturbance of significant fauna, where possible. Include fauna protection specifications in all inductions, construction-related contracts and sub-contracts. • Contain potentially contaminating materials and activities within bunded areas, direct potentially contaminated flow to specifically designed ponds and ensure no liquid or solid waste is directed to sensitive areas. • Feral animal control in and adjacent to the overall project area. • Progressive rehabilitation of disturbed areas to re-establish fauna habitat. • Consider the habitat requirements of native fauna in rehabilitation plans and fauna monitoring in rehabilitated areas.	After mitigation and management measures have been applied, the project is expected to result in the following outcomes for terrestrial fauna: • The progressive loss and subsequent rehabilitation of terrestrial fauna habitat over the life of the project. • No significant impact on fauna habitat of high conservation significance is predicted, at a regional, state, national or international level. • No significant impact on fauna species of conservation significance is predicted, at a regional, state, national or international level. The project will not significantly affect the abundance, species diversity, geographic distribution and productivity of terrestrial fauna at species and ecosystem levels. The project will be consistent with maintaining regional biological diversity.

Environmental Factor	EPA Objective	Potential Impacts	Mitigation and Management Measures	Predicted Outcomes
Subterranean Fauna	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels by avoiding or managing adverse impacts and improving knowledge.	• Mine pit excavation will result in direct removal of stygofauna habitat. • Groundwater drawdown will reduce the extent of stygofauna habitat over the operational life of the mine. • Removing topsoil, overburden and ore could potentially modify underlying stygofauna habitat. • Surface water discharges, sealing of recharge areas and increased surface water runoff have the potential to modify underlying stygofauna habitat. • Loss and/or disturbance of stygofauna from dewatering and excavation. • Changes in surface water inputs and recharge can affect humidity levels with the subterranean habitat. Alterations to humidity levels may lead to changes in subterranean fauna distribution. • Spills or leaks of hydrocarbons, chemicals and wastewater may lead to surface and groundwater contamination. Contaminated surface and groundwater would degrade the subterranean habitat. • Vibration from blasting activities has the potential to cause changes to geological formations and may decrease the habitat available to troglofauna. • Reinjection of dewatering water may affect subterranean fauna habitat by introducing contaminants and/or altered water chemistry.	• Potential impacts to subterranean fauna will be addressed by implementing the *Yandicoogina Subterranean Fauna Management Plan*. • Regular stygofauna monitoring at the Hamersley Yandicoogina operations will be continued. • Hydrogeological modelling and monitoring will be used to assess potential impacts to stygofauna habitat over the operational life of the mine, and ensure that adequate amounts of habitat are preserved. • Adhere to operational controls to reduce hydrocarbon spills.	After mitigation and management measures have been applied, the project is expected to result in the following outcomes for subterranean fauna: • The project is unlikely to have a significant effect on stygofauna, as all the taxa recorded in the project disturbance area either occur, or are highly likely to occur, outside this area. • Troglofauna are unlikely to be significantly affected by the project, as the project disturbance area does not contain primary troglofauna habitat. • Reinjection of dewatering water into the Billiard South area is unlikely to affect any stygofauna that may occur in this area, as there is little difference in the water chemistry between the water abstracted from Southern JSE CID and the water in Billiard South CID. • Implementing the proposed management measures will adequately protect subterranean fauna and their habitat, and will ensure the EPA objective is fulfilled.
Surface Water	• To maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance, are protected. • To ensure that emissions do not adversely affect environmental values or the health, welfare, and amenity of people and land uses by meeting statutory requirements and acceptable standards.	Flows in several minor creeks within the mining area will be diverted, potentially increasing scouring and soil erosion. Surface discharges from mine dewatering will contribute to creating a persistent surface water expression (discharge footprint) in sections of Marillana and Weeli Wolli Creeks over the operational life of the project. The project is expected to extend the discharge footprint by up to 4 km over and above the predicted future discharge footprint from existing mining projects in the catchment. Potential impacts from the discharge footprint include: • Erosion and increased turbidity immediately downstream of the discharge point. • Increased turbidity and sedimentation of existing watercourses from surface runoff. • Disruption to natural flow lines caused by the development of mine pits, infrastructure and access roads. • Leaks or spills of hydrocarbons, chemicals and wastewater may lead to surface water contamination.	• Potential impacts to surface water will be addressed by implementing the *Yandicoogina Surface Water Management Plan.* • Diverted flow paths will be reinstated as close as possible to the pre-disturbance flow paths post-mining (subject to closure planning). • Erosion control mechanisms will be used to regulate surface water runoff, slow and disperse surface water flows. • Further investigate alternative water management options so that discharge volumes can be reduced. • Contain potentially contaminating materials and activities within bunded areas, • Direct potentially contaminated flow to specifically designed ponds and ensure no liquid or solid waste is directed to sensitive areas. • Continue ongoing sampling of aquatic fauna (fish, invertebrates, hyporheic fauna) and water quality so that areas impacted by mining activities can be detected and managed.	After mitigation and management measures have been applied, the project is expected to result in the following surface water outcomes: • Discharge volumes from the JSW and Oxbow mine pit developments are predicted to contribute additional volumes of up to 16 GL/yr^{-} into Marillana and Weeli Wolli Creeks, with an annual mean of about 10 GL/yr^{-} over the project life. • Discharge will create pools that will remain for several weeks or months and possibly years (particularly within Marillana Creek), depending on local rains, temperature and evaporation. • Appropriate engineering design, including installing sediment traps and energy dissipation structures will reduce flow velocities, minimise erosion and reduce unnaturally high sediment load contributing to natural waterways. • Realign minor creeks feeding into Marillana Creek. Reinstate flow regimes that largely emulate the pre-disturbance flow regime (subject to closure planning). Implementing the proposed management measures will protect surface water values and ensure that the EPA objective is fulfilled.

Environmental Factor	EPA Objective	Potential Impacts	Mitigation and Management Measures	Predicted Outcomes
Groundwater	To maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance, are protected. To ensure that emissions do not adversely affect environmental values or the health, welfare, and amenity of people and land uses by meeting statutory requirements and acceptable standards	Activities or aspects of the project that may affect groundwater values before mitigation efforts include: • dewatering, which will result in drawdown of the water table potentially affecting riparian vegetation. • excavations, which will intercept aquifers such as creek alluvium and cause localised declines of groundwater in aquifer from lateral leakage. Groundwater quality post-closure will be strongly influenced by the final landform. • hydrocarbon spills or leakages, which may contaminate groundwater quality.	Potential impacts to groundwater will be addressed by implementing the *Yandicoogina Groundwater Management Plan.* Key groundwater protection measures include: • taking water only from points licensed by the DoW. • regularly assessing potable water requirements and implementing opportunities to recycle. • developing and implementing a rotational bore maintenance schedule to minimise the potential for water to seep into the mine pit. • developing and continuing a water quality and depth to water table monitoring program and schedule, clearly specifying the relevant guideline levels and legal compliance requirements. • including regular monitoring of groundwater levels. • inducting staff on groundwater issues, particularly the risks of groundwater contamination and the proper storage and handling of fuel and chemicals and spill response procedures. • storing, handling and disposing of ablution effluent and waste in a safe manner, according to licence requirements. • installing appropriate bunding and hydrocarbon management at hydrocarbon storage facilities, re-fuelling locations, and stationary hydrocarbon usage areas. • constructing and using hydrocarbon treatment facilities at wash down and workshop areas. The use of hydrocarbons on-site will be managed in accordance with the *Yandicoogina Hydrocarbon Management Plan*.	After mitigation and management measures have been applied, the project is expected to result in the following groundwater outcomes: • dewatering the CID aquifer to approximately 465 mRL in the JSW pits and 475 mRL in the Oxbow pit. • no potential for the Fortescue Marsh to be affected as a result of dewatering. • disturbance to the CID aquifer caused by excavation and (partial) backfilling. • ongoing groundwater quality monitoring, and the use of management triggers to ensure actions are taken to protect water quality. • ongoing groundwater modelling to inform mine planning. Implementing the proposed management measures will protect groundwater systems and ensure that the EPA objective is fulfilled.
Aboriginal Heritage	To ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation.	• The project has the potential to impact heritage sites during earthworks/excavation. Sites may require clearance during construction and operation of the mine. • The project will result in changes to the landscape in disturbance areas, potentially impacting landscape values. Discharge of dewatering water into Marillana and Weeli Wolli Creeks will potentially affect the cultural heritage values associated with the creek systems. • Vegetation clearing for the mine pit and associated infrastructure may impact cultural heritage values.	Potential impacts to heritage values will be addressed by implementing the *Yandicoogina Cultural Heritage Management Plan.* • avoid disturbance to Aboriginal heritage sites, wherever possible. Where disturbance cannot be avoided, obtain section 16 and 18 approval to clear Aboriginal heritage sites under the *Aboriginal Heritage Act 1972.* • ongoing consultation with the GAC and relevant Bunjima, Nyiyaparli and Innawonga representatives regarding proposed works, cultural heritage values and Aboriginal sites within the proposal area. Consent from Traditional Owners will be sought before submitting section 16 or 18 applications under the *Aboriginal Heritage Act 1972*. • comply with existing and future section 16 and 18 conditions within the PER boundaries issued by the Department of Indigenous Affairs. • complete ethnographic and archaeological surveys in areas within the overall project area that have not been previously surveyed. • demarcate the location of known Aboriginal heritage sites on-site plans and within RTIO operational systems. • Stop work and contact the Department of Indigenous Affairs (DIA) and RTIO's Heritage Team where human remains or archaeological material are accidentally uncovered during the ground disturbance process.	Some heritage sites of moderate to low significance may be disturbed as a result of the project. Every effort will be made to minimise disturbance within the constraints of mine planning and operation. RTIO will consult closely with heritage stakeholders through the existing consultation frameworks and agreements established for the Yandicoogina operations (YLUA Heritage Protocols). The outcomes of consultation will inform mine planning and the design of activities so that potential impacts on heritage values will be kept to a minimum. The consent of stakeholders will be sought before making any formal submission to disturb sites under the *Aboriginal Heritage Act 1972.* These measures will ensure that the important heritage values in the Yandicoogina locality are preserved during and post-mining.

Environmental Factor	EPA Objective	Potential Impacts	Mitigation and Management Measures	Predicted Outcomes
Greenhouse Gas Emissions	Minimise greenhouse gas emissions in absolute terms and reduce emissions per unit of product to as low as reasonably practicable. Mitigate greenhouse gas emissions, taking into account Commonwealth and State greenhouse gas strategies and programs.	The project is predicted to contribute to the existing Hamersley Yandicoogina Operations greenhouse gas emission footprint by ~100,000 tonnes CO_{2equiv}. per annum, averaged over the life of the project.	Greenhouse gas emission will managed by implementing the *Yandicoogina Emissions Management Plan*. • Measure and report project related energy consumption and greenhouses gas emissions under the *Commonwealth National Greenhouse and Energy Reporting Act 2007* and the *Energy Efficiency Opportunities Act 2006.* • Set energy efficiency and emissions reduction targets and KPIs, subject to continuous assessment and review. • Extend the findings of the recently completed energy efficiency review of the existing Yandicoogina operations to this project. The review identifies energy efficiency and emissions reduction opportunities, and provides the basis for implementing selected options.	Greenhouse gas emissions are an unavoidable consequence of modern mining operations. However, they can be restricted by adopting best practice approaches in mine planning and operation. RTIO has systems in place for optimising the efficiency of energy use and minimising greenhouse gas emissions from Pilbara mining operations. As with the current Hamersley Yandicoogina operations, the project will be subject to the *Commonwealth Energy Efficiency Opportunities Act 2006*.
Rehabilitation and Closure	To ensure, as far as practicable, that rehabilitation achieves a stable and functioning landform which is consistent with the surrounding landscape and other environmental values.	Mining and establishing associated infrastructure will result in the loss of vegetation and habitat, the disturbance of soil profiles, landforms and drainage features, as well as lowering of the water table. Given the relatively low quantities of overburden and waste material, insufficient waste will be generated to completely backfill the JSW and Oxbow pits, unless additional backfill materials are externally sourced. The mine closure and rehabilitation approach will affect the degree to which environmental values are preserved or reinstated post-mining. The impacts of the project are in addition to those resulting from the existing JC and JSE operations. Landforms and landscape process, together with hydrological processes, are integrated across the overall operations. From a closure perspective it is essential that an integrated approach is developed across the entire Hamersley Yandicoogina operations.	A *Decommissioning and Rehabilitation Plan* has been completed for the overall Yandicoogina operations, updating an earlier version developed for the JC and JSE mines. This will provide the framework for more detailed planning to occur progressively over the operational life of the project. A final *Decommissioning and Rehabilitation Plan* will be developed at least five years prior to final closure of the mine site in consultation with stakeholders. The plan will address: • suitable end land uses and objectives for closure. • identify and evaluate closure options and determine preferred options. • establish completion criteria. • identify closure monitoring requirements. • determine cost estimates and fund allocation for closure. • define management measures to facilitate closure.	After mitigation and management measures have been applied, the project is expected to result in the following site rehabilitation and closure outcomes: • by considering closure early in the project, concepts can be fully integrated into short and long-term mine planning. As a result, acceptable and cost effective closure outcomes are expected to be achieved. The proposed mitigation and management strategies will ensure that closure is consistent with the EPA objective. • several alternative conceptual closure options have been identified, including a preferred option. These will be further assessed technically, economically and environmentally. This will form part of a broader program of closure studies and investigations to be completed during the operational life of the project. • regular and ongoing consultation with regulatory agencies and other stakeholders will be an important component of the closure planning process.

Contents

Figures

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Appendices

The following appendices are provided electronically on the CD accompanying this report:

1. Introduction

1.1. Overview

Hamersley Iron Pty Ltd (Hamersley) is proposing to develop new iron ore mines at the Junction South West (JSW) and Oxbow deposits at Yandicoogina (the project). The company already operates mines at the nearby Junction Central (JC) and Junction South East (JSE) deposits. These deposits are expected to be mined to their maximum extent by approximately 2015 and 2023, respectively. New mines at JSW and Oxbow will enable continuity of production from the overall Yandicoogina operation.

The project was referred to the Environmental Protection Authority (EPA) in January 2008 and received a Public Environmental Review (PER) level of assessment, under the provisions of the *Environmental Protection Act 1986* (EP Act). This Environmental Review document has been prepared to satisfy Section 6.3 of the *Environmental Impact Assessment (Part IV Division 1) Administrative Procedures* (EPA 2002a) and has been developed in accordance with the *Guidelines for Preparing a Public Environmental Review/Environmental Review and Management Programme* (EPA 2009a).

This Environmental Review document includes:

- a description of the project
- a summary of the important physical, biological and social factors of the existing environment
- a discussion of the extent of community and government stakeholder consultation
- an evaluation of potential impacts of the project on environmental factors
- management strategies and measures to ensure the protection of environmental factors and values at Yandicoogina, including a description of the Yandicoogina Environmental Management Program (EMP), and
- proposed environmental conditions for the project.

The EPA principles of environmental protection have been considered and addressed in developing the environmental management measures. This Environmental Review document demonstrates that the project can be implemented in an environmentally acceptable manner.

1.2. Proponent

The proponent for the project is Hamersley Iron Pty Ltd. The project is to be managed by Pilbara Iron Pty Ltd (Pilbara Iron) on behalf of Hamersley Iron, a wholly owned subsidiary of Rio Tinto Iron Ore (RTIO). The project Environmental Approvals Coordinator is:

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1.3. Location

The project site is located in the central Pilbara region of Western Australia, approximately 90 km north-west of Newman and 300 km south-east of Dampier (Figure 1-1). The JSW and Oxbow deposits are located immediately west of the existing JC mine (Figure 1-2). The JSE mine is located further to the east. The entire Yandicoogina mining operation is contained within ML274SA established under the *Iron Ore (Yandicoogina) Agreement Act 1996*.

1.4. Project context

The proposed and existing mines at Yandicoogina are situated along an extensive Channel Iron Deposit (CID), characterised by a continuous iron mineralisation along a palaeochannel. The total length of the CID is over 80 km. The main zone of the CID at Yandicoogina is approximately 500 m wide with a thickness of 45 to 50 m under approximately 10 m of overburden.

Hamersley's iron ore mining at Yandicoogina is subject to the *Iron Ore (Yandicoogina) Agreement Act 1996,* which came into effect on October 22, 1996. The current Yandicoogina JC and JSE iron ore mines are operated by Pilbara Iron on behalf of Hamersley. Mining at JC received approval from the Minister for the Environment on 24 May, 1996 (Ministerial Statements 417 and 523) and mining at JSE received approval from the Minister for the Environment on 22 October, 2005 (Ministerial Statement 695). Mining activities at JC and JSE commenced in 1998 and 2006, respectively. The JSE mine is a downstream extension of the CID mined at JC.

The proposal to develop deposits at JSW and Oxbow was referred to the EPA on 31 January, 2008. The EPA set a Public Environmental Review (PER) level of assessment with an eight week public review period. A draft Environmental Scoping Document (ESD) was originally submitted to the EPA on 17 October, 2008. In response to advice received on the draft an amended ESD was prepared and submitted to the EPA in April 2010. The amended ESD was approved by the EPA on 20 May, 2010. The amended ESD has provided the guiding framework for preparing this Environmental Review document.

1.5. Project rationale and benefits

Iron ore is now the largest individual mineral sector, by value, in Western Australia, accounting for 48% ($33.7 billion) of the value of Western Australian resources output in 2009/10 (DMP 2010a). Over the past ten years, the value of iron ore has increased by 28% per annum on average. The sector shipped record tonnages of iron ore in 2009/10, increasing by 25% to reach 396 Mt. Iron ore exports are presently an order of magnitude greater in value than other Western Australian mineral commodities such as gold, nickel and alumina.

Feasibility studies have indicated that there is sufficient global demand to warrant mining the JSW and Oxbow deposits. New mining projects are necessary to maintain ongoing benefits to the Western Australian economy from iron ore exports.

The project will enable mining at Yandicoogina to continue, as the existing mines at JC and JSE become depleted. Current projections show that the JC deposit will be mined to its maximum extent by approximately 2015. Production from JSE is expected to cease by approximately 2023.

The project will involve mining approximately 320 Mt of high grade ore. The JSW and Oxbow deposits are in close proximity to existing mine infrastructure, including ore processing plants and rail load-out facilities at JC. The advantages of scale, ore quality and existing infrastructure make the project a highly desirable option for continuing the success of the Western Australian iron ore industry, with consequent benefits for the wider economy.

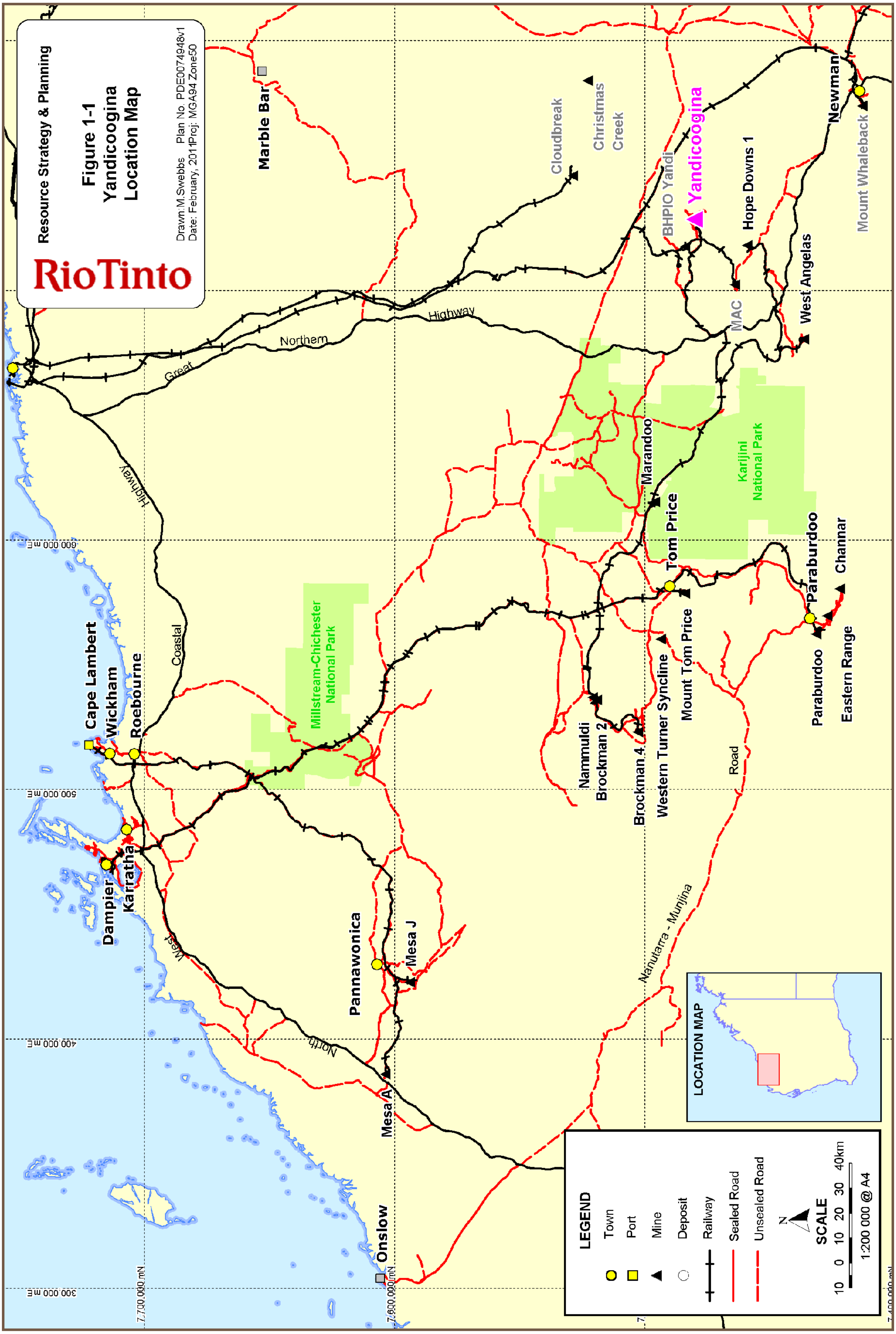
Implementing the project will generate significant royalties and taxation payments for the State and the Commonwealth governments. The Bunjima, Nyiyapali and Innawonga people (the Traditional Owners) will also benefit under the terms of the Yandicoogina Land Use Agreement (YLUA). The YLUA was the first major land use agreement to be signed in Australia, and provides the basis for delivering social and economic benefits to Aboriginal stakeholders.

The project enables an operational workforce to be maintained beyond the lifespan of the existing mines. New employment will be created during the mine construction phase, and the operating life of established mine and rail transportation infrastructure will be extended.

In connection with its existing and planned mining activities in the Pilbara, RTIO also contributes to a range of research activities addressing regionally relevant environmental impacts. Examples of these projects include research into:

- plant-water relationships in Pilbara vegetation, such as:
    - the occurrence and nature of groundwater dependence in different tree species
    - developing methods for measuring the effects of groundwater drawdown on vegetation, and
    - water use physiology of Mulga vegetation and strategies for maintaining surface flow regimes for Mulga conservation.
- the distribution and taxonomy of subterranean and short range endemic fauna, in collaboration with the WA Museum and in association with the Department of Environment and Conservation (DEC)
- predicting and managing water quality in pit voids, and
- the palaeoclimatic history of the Fortescue Marsh.

Key research collaborators in these projects include the University of Western Australia (UWA), DEC and the Western Australian Museum.



RioTinto
Resource Strategy & Planning
Figure 1-1
Yandicoogina
Location Map
Drawn: M.Swebbs Plan No. PDE0074948v1
Date: February, 2011 Proj: MGA94 Zone50
Marble Bar
Cloudbreak
Christmas Creek
BHPIO Yandi
Yandicoogina
Hope Downs 1
Newman
Mount Whaleback
MAC
West Angelas
Great
Northern
Highway
Marandoo
Karijini National Park
Tom Price
Paraburdoo
Channar
Mount Tom Price
Western Turner Syncline
Brockman 4
Nammuldi
Brockman 2
Paraburdoo
Eastern Range
Road
Nanutarra - Munjina
Cape Lambert
Wickham
Roebourne
Coastal
Highway
Millstream-Chichester National Park
Dampier
Karratha
West
Pannawonica
Mesa J
North
Mesa A
Onslow
LOCATION MAP
LEGEND
Town
Port
Mine
Deposit
Railway
Sealed Road
Unsealed Road
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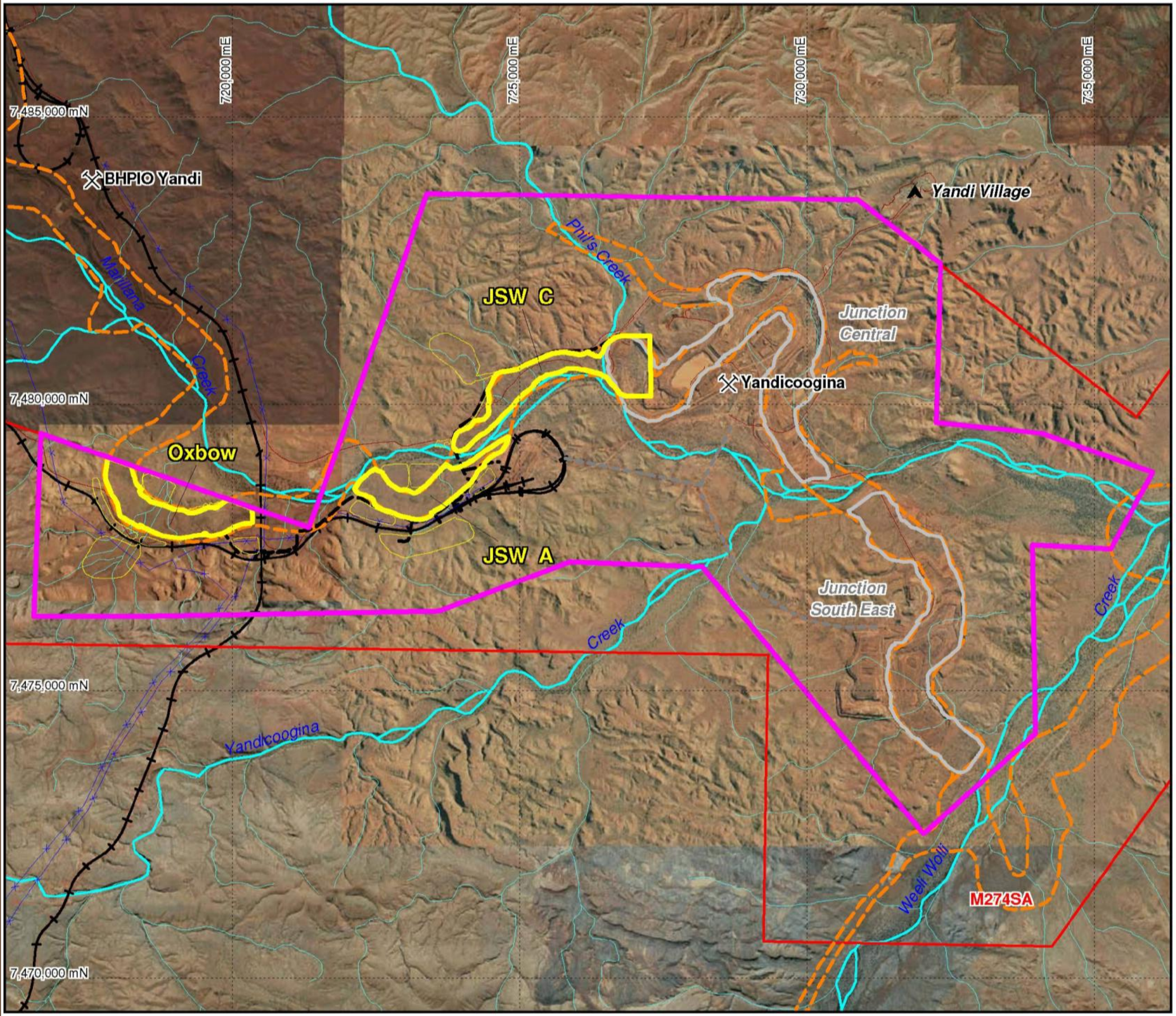

LEGEND

- Overall Project Area
- Hamersley Yandi Tenement (M274SA)
- JSW & Oxbow Conceptual Mine Pits
- Conceptual Waste Dumps & Topsoil Stockpiles
- Existing Yandi Operations
- CID Boundary
- Existing Ore Conveyer Systems
- Proposed Road
- Railway
- Powerline
- Road
- Major Creek
- Creek

N

SCALE

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RioTinto

Resource Strategy & Planning

Figure 1-2
Location of the
JSW & Oxbow Deposits
& Overall Project Area

Drawn: M.Swebbs
Date: Sept, 2011

Plan No. PDE0074948v6
Proj: MGA94 Zone50

1.6. Consideration of alternatives

1.6.1. Alternative deposits

In 2007, RTIO evaluated alternative nearby mining deposits in the Yandicoogina locality. Other deposits considered included the upstream sections of the CID and Billiard South locations.

The upstream deposits require further mining feasibility assessment. Developing these deposits would require significant new infrastructure to be constructed for ore extraction, processing and transport. The deposits are separated from the existing JC and JSE mine sites by the BHP Billiton Iron Ore (BHPBIO) Yandi operation. Consequently, these deposits are relatively less suited to providing a smooth transition to new production from the JC and JSE operations.

The Billiard South deposit is located on the eastern margin of the Weeli Wolli Creek, to the west of the JSE mine (Figure 1-2). Operating since 2007, the area includes an aquifer reinjection bore field servicing dewatering requirements from existing Hamersley mines. Mining of the Billiard South deposit was originally planned to be included in the project, but was subsequently excluded for the following reasons:

1. the aquifer reinjection bore field assessment has not been completed. Assessment includes possible relocation, replacement, and/or removal of the aquifer reinjection bore field
2. the Weeli Wolli Creek system receives surplus water discharge from multiple mining projects, including the Hope Downs 1 and BHPBIO Yandi mines, as well as the JC and JSE operations (Figure 1-2). The most appropriate mining process at Billiard South needs to be assessed further, to minimise and manage overall impacts on the creek system, and
3. more work is required to assess how the ore from Billiard South can be optimally interfaced with the processing capabilities at Yandicoogina.

1.6.2. Alternative mining methods and sequencing

In 2010, RTIO completed a high level evaluation of the optimal mine sequence for the Oxbow and JSW deposits. A range of environmental, economic, social and risk factors were assessed. The preferred sequence of mining was identified to be:

1. the JSW-C deposit (north of Marillana Creek); followed by
2. the JSW-A deposit (south of Marillana Creek); followed by
3. the Oxbow deposit.

An alternative mining sequence may be more appropriate (for example, developing the Oxbow deposit prior to the JSW deposits), however, this is subject to final engineering assessment and design. The final mining sequence will determine the timing and nature of infrastructure requirements including:

- haulage and overland conveyor systems to existing plants
- waste handling conveyor systems, and
- mineral waste stockpiling and pit backfilling sequence.

The final mining sequence will also affect the selection and implementation of mine closure options.

1.6.3. No development option

If the project does not proceed, the State of Western Australia would forego substantial economic benefits, including:

- viable iron ore deposits at Yandicoogina remaining undeveloped, and
- the decline and eventual end of production from the existing mines.

The ore quality within the project deposits will maintain product quality specifications from the overall Yandicoogina operations. The project will also prolong the use of the existing ore processing and transport infrastructure at Yandicoogina. This situation is not easily replicated at other locations in the Pilbara region, especially when taking the scale of the project into account.

The existing workforce at Yandicoogina will be reduced prematurely if the JSW and Oxbow deposits are not developed. Opportunities for supporting local communities and infrastructure would also be foregone.

Mining in the Yandicoogina locality started when BHP commenced operations in 1992. The environmental values of the locality have been well characterised. New mining at the JSW and Oxbow deposits will not significantly affect environmental factors over the existing mining operations, or impact high value environmental assets. Environmental management systems and controls developed for the existing Yandicoogina JC and JSE operations can be readily extended to the proposed new mining areas at JSW and Oxbow.

1.7. Environmental assessment process

1.7.1. Applicable legislation

Key environmental State and Commonwealth legislative and regulatory requirements relevant to the project are described in Table 1-1. The project was referred to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in December 2010. In February 2011, the project was determined to be a ‘Controlled Action’ for listed threatened species and communities. The project is being assessed by preliminary documentation under the EPBC Act process.

Table 1-1 – Applicable Environmental Legislation and Regulations

Legislation	Description of key aspects[4]
State Government WA Government	
Aboriginal Heritage Act 1972	Section 16 and 18 approval to disturb Aboriginal heritage sites that cannot be avoided.
Agricultural and Related Resources Protection Act 1976	Provisions for the control of declared plants and declared animals by land managers
Bush Fires Act 1954	Under s.27A of the Act, regulation of blasting and matters likely to cause bush fire danger.
Contaminated Sites Act 2003	Reporting and remediation of contaminated sites.
Dangerous Goods Safety Act 2004	Storage and use of explosives and other hazardous materials. Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007 and Dangerous Goods Safety (Explosives) Regulations 2007.
Environmental Protection Act 1986	Part IV approval of proposal. Part V Works Approval and Licensing for various proposal elements. Clearing of Native Vegetation Regulations 2004, Unauthorised Discharge Regulations 2004 and Controlled Waste Regulations 2007.
Health Act 1911	Construction and operation of wastewater treatment systems.
Iron Ore (Yandicoogina) Agreement Act 1996	Conditions relating to establishing and operating iron ore mining at Yandicoogina.
Land Administration Act 1997	Provides the legal framework for land access and land use activities on Crown land.
Main Roads Act 1930	Control of access areas – s.28A.
Mining Act 1978	Division 3 – Mining lease. Mining Regulations 1981.
Mines Safety and Inspection Act 1994	Obligations relating to the safety and welfare of the mine workforce. Mines Safety and Inspection Amendment Regulations 2009.
Occupational Safety and Health Act 1984	Part III of the Act sets out the duty of care requirements for employers and employees. Occupational Safety and Health Regulations 1996.
Rail Safety Act 2010	Owners and operators of railway must be accredited and comply with rail safety standards.
Rights in Water and Irrigation Act 1914	Licences required for taking or diverting of water in proclaimed areas. Permits required for infrastructure crossing watercourses and diversion of watercourses. Rights in Water and Irrigation Regulations 2000.
Waste Avoidance and Resource Recovery Act 2007	Provides for the development of a Waste Strategy for Western Australia and local government waste plans. Guidelines and standards relating to the siting, design, operation and post-closure management of landfills. Waste Avoidance and Resource Recovery Regulations 2008.
Wildlife Conservation Act 1950	Approval is required to take or disturb declared rare plants or animals which cannot be avoided.

[4] Including associated regulations

Legislation	Description of key aspects[4]
Commonwealth Government	
Environment Protection and Biodiversity Conservation Act 1999	If a proposal is considered to be a 'Controlled Action' under the EPBC Act, implementation requires approval from the Federal Minister for the Environment.
Energy Efficiency Opportunities Act 2006	Corporate entities with energy use greater than 0.5 PJ per year are required to assess their energy use and identify energy savings opportunities.
National Greenhouse and Energy Reporting Act 2007	Measurement and reporting of greenhouse gas emissions.
Native Title Act 1993	Consultative processes required with Native Title claimants.

1.7.2. Environmental approval process

Development proposals that are likely to have a significant effect on the environment are required be referred to the EPA under Section 38 of the EP Act. A decision will be made on whether or not they require assessment under the Act.

The Yandicoogina Junction South West and Oxbow Iron Ore Project proposal was referred to the EPA in 2008 and assessed in accordance with the *Environmental Impact Assessment Administrative Procedures 2002* (EPA 2002a). These procedures provide the following levels of assessment:

- Assessment on Referral Information (ARI):
    - typically applied to project proposals which raise one or a small number of significant environmental factors which can be readily managed, but where it is considered that environmental conditions under Part IV of the EP Act are required to ensure the proposal is implemented and managed in an environmentally acceptable manner.
- Environmental Protection Statement (EPS):
    - typically applied to project proposals of local interest that raise a number of significant environmental factors which can be readily managed, where it is considered that environmental conditions under Part IV of the EP Act are required to ensure the proposal is implemented and managed in an environmentally acceptable manner, and where in the judgement of the EPA, a formal public review period may be unnecessary because the proponent has adequately consulted with stakeholders.
- Public Environmental Review (PER):
    - typically applied to project proposals of local or regional significance that raise a number of significant environmental factors, some of which are considered complex and require detailed assessment to determine whether, and if so how, they can be managed. The EPA considers that such proposals should be subject to a formal public review period, and the setting of environmental conditions under Part IV of the Act to ensure they are implemented and managed in an environmentally acceptable manner.

- Environmental Review and Management Programme (ERMP):
  - typically applied to project proposals of State interest that raise a number of significant environmental issues, many of which are considered to be complex or of a strategic nature, and require substantial assessment to determine whether, and if so how, they can be managed in an acceptable manner. The EPA considers that such proposals should be subject to extensive public review.

- Proposal Unlikely to be Environmentally Acceptable (PUEA):
  - the proposed project cannot meet the EPA's environmental objectives.

The EPA assigned a **PER level of assessment** to the project, with an eight week public review period. The approval process for a PER level of assessment under the *Environmental Impact Assessment Administrative Procedures 2002* is outlined in Figure 1-3.

As part of the PER process, project proponents are required to prepare an Environmental Scoping Document (ESD). The ESD provides the terms of reference for preparing the project Environmental Review document. Hamersley prepared an ESD for the project that was endorsed by the EPA on 20 May, 2010 (Appendix C).

The ESD included the following elements that have guided the preparation of this Environmental Review document:

- **a summary description of the project**, including justification for the project and consideration of alternative options
- **a description of the biological, biophysical and social values** and functions of the existing environment at the Yandicoogina locality and an assessment of their importance
- **a description of potential environmental impacts** that could result from the project being implemented, their significance and potential management responses (including consideration of the impact of the existing mining operations at Yandicoogina)
- **proposed additional studies** to inform the assessment and management of particular potential environmental impacts
- **a description of previous and planned stakeholder consultation**, and
- **suggested project and assessment schedules.**

Following the public review period, the EPA will assess the environmental acceptability of the project and provide recommendations to the Minister for the Environment. The Minister will then decide whether to approve the project, and if so, under what legally binding conditions.

The assessment process is structured to enable environmental values to be protected during project design, implementation and post completion. This is facilitated through input from the EPA and other stakeholders. Once a decision has been made to assess a proposal, s41A of the EP Act specifies that it is an offence for any person to do anything to implement the proposal before Ministerial approval has been granted under s45 of the EP Act.

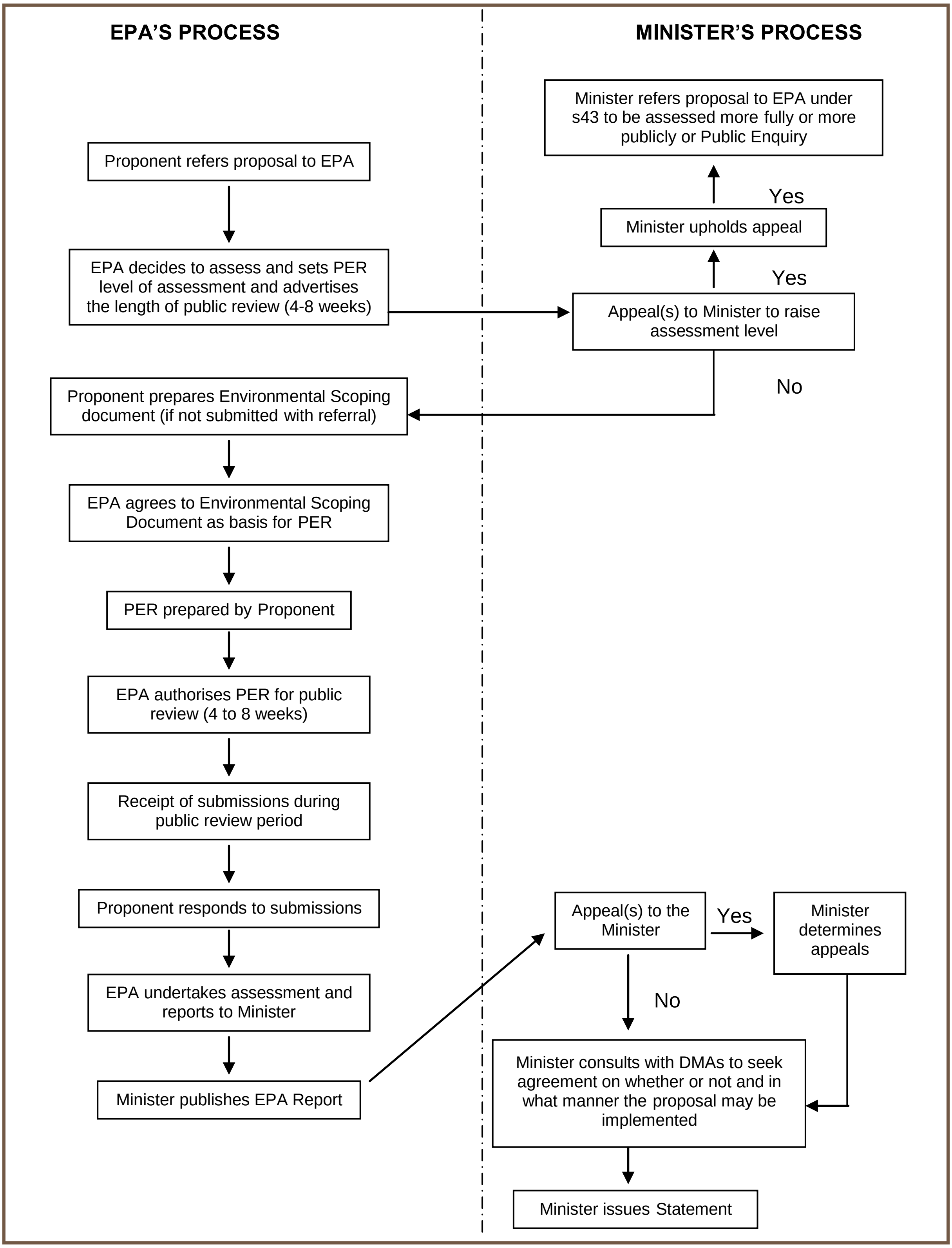


Figure 1-3 – The Public Environmental Review (PER) environmental approval process[5]

[5] In accordance with the *Environmental Impact Assessment Administrative Procedures 2002 (EPA 2002a)*

1.7.3. Strategies and policies

The following Australian government strategies and policies were considered during the preparation of this Environmental Review document:

- Western Australian
  - Western Australian Wetlands Conservation Policy 1997
  - State Water Quality Management Strategy 2001
  - Western Australian State Sustainability Strategy 2003
  - Western Australian Greenhouse Strategy 2004
  - State Water Plan 2007
  - Draft II Waste Strategy for Western Australia 2010
  - Pilbara Regional Water Plan 2010-2030

- Commonwealth
  - National Strategy for Ecologically Sustainable Development 1992
  - Intergovernmental Agreement on the Environment 1992
  - National Strategy for Conservation of Australia's Biological Diversity 1996
  - National Greenhouse Strategy 1998
  - Australia's Biodiversity Conservation Strategy 2010-2030 (2010)

- International Treaties
  - The Ramsar Convention on Wetlands of International Importance 1971
  - Convention on Biological Diversity 1992
  - United Nations Framework Convention on Climate Change & Kyoto Protocol 1997

1.7.4. Guidelines and standards

The following guidelines and standards were considered when preparing this Environmental Review document:

1.7.4.1. EPA guidance statements

- No. 6. Rehabilitation of Terrestrial Ecosystems. June 2006
- No. 8. Environmental Noise (Draft). May 2007
- No. 12. Minimising Greenhouse Gases. October 2002
- No. 14. Draft Road and Rail Transportation Noise. May 2000
- No. 18. Prevention of air quality impacts from land development sites. March 2000
- No. 20. Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia. May 2009
- No. 33. Environmental Guidance for Planning and Development. May 2008
- No. 41. Assessment of Aboriginal Heritage. April 2004
- No. 51 Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia. June 2004
- No. 54. Consideration of Subterranean Fauna in Groundwater and Caves during Environment Impact Assessment in Western Australia December 2003

- No. 54a. Sampling Methods and Survey Consideration for Subterranean Fauna in Western Australia (Draft). August 2007
- No. 55. Implementing Best Practice in Proposals Submitted to the Environmental Impact Assessment Process. December 2003
- No. 56. Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia. June 2004

1.7.4.2. Other guidelines considered during the preparation of this Environmental Review document included:

- *Guidelines for preparing Mine Closure Plans (DMP 2011)*
- *Pilbara Water in Mining Guideline* (DoW 2009)
- EPA Environmental Assessment Guideline No. 4 (Draft) *Towards outcome-based conditions* (EPA 2009b)
- ANZECC/ARMCANZ 2000 – Australian and New Zealand Guidelines for Fresh and Marine Water Quality

1.7.4.3. The following Australian standards were considered during the preparation of this Environmental Review document:

- AS/NZS 4801 – 2001 Occupational Health and Safety Management Systems – Specification with guidance for use
- AS/NZS 4804 – 2001 Occupational Health and Safety Management Systems – General guidelines on principles, systems and supporting techniques
- AS/NZS 4360 – 2004 Risk Management
- AS 1755 – 2000 Conveyors – Safety Requirements
- AS2187.2-2006 Explosives – Storage and Use – Use of Explosives
- ISO14001:2004 Environmental Management Systems

1.7.5. Principles of environmental protection

In 2003, the EP Act was amended to include the following five core environmental principles. These guide the EPA in carrying out its role and responsibilities (EPA 2004a):

- Precautionary principle
- Principle of intergenerational equity
- Principle of the conservation of biological diversity and ecological integrity
- Principles relating to improved valuation, pricing and incentive mechanisms, and
- Principle of waste minimisation.

These principles were taken into account when developing impact mitigation and management measures for the project (Table 1-2).

Table 1-2 – EPA principles of environmental protection considered in the JSW and Oxbow Iron Ore project Environmental Review

Principle	Relevant Yes/No	Consideration given in the PER	Section addressed in PER
1. Precautionary principle **Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.** **In the application of the precautionary principle, decisions should be guided by:** **(a) careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and** **(b) an assessment of the risk-weighted consequences of various options.**	Yes	A risk assessment of the potential environmental impacts of the project was undertaken as part of the project Environmental Scoping Document (ESD). This assessment included identifying potential environmental impacts arising from the project, and informed the design of the project by: • helping to frame the terms of reference for pre-mining site investigations (for example vegetation, flora and fauna surveys) • enabling environmental protection to be considered in the project planning phase, and • contributing to the development of the impact mitigation and management strategies that are described in this Environmental Review document.	Section 7
2. Intergenerational equity **The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.**	Yes	RTIO has developed a set of Sustainable Development Principles, which seek to ensure that a balance is achieved between economic, environmental and social aspects of the company's activities. These principles are consistent with the intent of the WA State Sustainability Strategy and Rio Tinto's 'The Way We Work' statement of business practice. The project is subject to these principles, for example: • measures to protect vegetation, flora and fauna values • water quality in the CID aquifer • the approach taken to ensure adequate mine site rehabilitation and closure • steps taken to minimise greenhouse gas emissions, and • land use agreements with Aboriginal stakeholders.	Section 8.4 Section 7

Principle	Relevant Yes/No	Consideration given in the PER	Section addressed in PER
3. Improved valuation, pricing and incentive mechanisms **a. Environmental factors should be included in the valuation of assets and services.** **b. The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement.** **c. The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any wastes.** **d. Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solutions and responses to environmental problems.**	Yes	The importance of improved valuation, pricing and incentive mechanisms is recognised. Hamersley has committed significant human and financial resources to ensure that an environmental management program for the project is well developed and implemented. The potential pollution impacts of the project have been identified, and management measures to minimise these impacts have been developed. Pollution will largely be addressed through a combination of minimisation and on-site treatment, resulting in minimal export of pollutants off site. Environmental goals will be pursued in the most cost effective way, using a combination of company resources and external expertise where appropriate. A comprehensive approach for mine rehabilitation and closure has been developed.	Sections 7.7, 7.8 and 7.9
4. Conservation of biological diversity and ecological integrity **Conservation of biological diversity and ecological integrity should be a fundamental consideration.**	Yes	Conservation of biological diversity and ecological integrity has been a key consideration in the design of the project, and is integral to project implementation. Biological investigations have been completed, and are continuing, within and adjacent to the project disturbance area. These investigations will identify any flora or fauna of conservation significance that require protection. Rehabilitation of the project area post-mining will be subject to clear objectives and completion criteria. Sustainable endemic vegetation communities will be established, consistent with reconstructed landforms and surrounding vegetation.	Sections 7.1, 7.2, 7.3, 7.4 and 7.5 Section 7.8
5. Waste minimisation **All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.**	Yes	The project includes measures to minimise the generation of waste and reuse and recycle waste materials, wherever possible.	Section 7.9

2. Project description

2.1. Development overview

The project involves developing new iron ore mines at JSW and Oxbow, which will sustain production from the overall Hamersley Yandicoogina operations. Ore produced by the new mines will be processed and transported using a combination of new and existing facilities:

- existing dry (crushing and screening) plant at JC
- new dry (and possibly secondary) crushing plants at JSW and Oxbow
- stockpiling, tertiary crushing and screening, reclamation and rail load-out facilities immediately south of the JSW deposit (Figure 1-2). This is referred to as the Loop Stockyard, and
- the Pilbara Iron Yandicoogina railway line.

A network of several overland conveyors connect the JC and JSE processing plants and the Loop Stockyard. A combination of road haulage and new overland conveyors will connect the proposed JSW and Oxbow mine pits to the existing Yandicoogina ore processing infrastructure.

Depending on mine sequencing and integrated production rates across the entire Yandicoogina operations, the capacity of the existing processing facilities will need to be upgraded to manage higher volumes. Any expansions that are required will be subject to separate environmental approvals processes.

The project includes the following major components:

- **new open cut iron ore mines** within the CID at the JSW and Oxbow locations (excluding the Marillana Creek section at JSW)
- **a dewatering system** to lower the water table so that the ore reserves can be mined
- **a water management system** including on-site reuse of abstracted groundwater and discharge of surplus volumes into creek systems. Current infrastructure servicing the existing Yandicoogina operations will be used for discharge and/or new discharge points will be established on Marillana Creek, downstream of existing operations
- **new mineral waste dumps**. Out-of-pit waste dumping will be used until in-pit waste backfilling of mined areas can occur. Topsoil, subsoil stockpiles and haul roads are also required
- **new Run of Mine (ROM) pads** at JSW and Oxbow
- **new roads** including light vehicle / heavy vehicle access and haul roads, and a floodway across Marillana Creek
- **flood protection bunding** within Marillana Creek and minor stream diversion away from the pits and into Marillana Creek
- **redefinition** of the Marillana Creek low flow channel at JSW
- **diversion of the Phil's Creek** terminus near the western edge of the JC pit

- **infrastructure** associated with drilling/blasting, loading and haulage/conveying ore from the mine to the existing processing plants at JC. Includes an overland conveyor, haul roads and a primary crushing (and screening) plant at JSW and Oxbow
- **extension of power and communications infrastructure** from the existing JC operation, and
- **other minor supporting infrastructure** such as administration buildings, maintenance workshop(s) and associated utilities and services.

2.2. Key characteristics

The project involves constructing three mine pits, two in the JSW deposit and one in the Oxbow deposit (Figure 2-1). Ancillary requirements include temporary surface waste rock dumps; supporting infrastructure for access; ore handling and conveyance; and utility connections. For operational purposes, the JSW deposit consists of a southern mining area (JSW-A) and a northern mining area (JSW-C), separated by the Marillana Creek floodplain. The key characteristics of the project are summarised in Table 2-1.

Surface drainage systems will need to be modified as part of the project. Phil's Creek is a tributary of Marillana Creek that dissects the JSW-C area near its eastern margin. This area will be mined by extending the existing JC pit to the west, so the Phil's Creek terminus will need to be diverted. Flood protection levees are needed along the northern margin of the JSW-A pit and the southern margin of JSW-C pit, which will encroach into the Marillana Creek floodplain.

The northern boundary of the Oxbow disturbance area is defined by the State Agreement Tenure boundary. Appropriate controls are required to prevent any encroachment onto the neighbouring tenement held by BHPBIO.

The project will use existing ore processing, post-processing conveying, rail load-out and workforce accommodation facilities associated with the JC and JSE mines. Some modifications will be needed to ensure a smooth connection with the new mines at JSW and Oxbow. Existing power, water supply and waste handling facilities will be extended to service the new mining areas. Some existing infrastructure, such as roads, will need to be realigned to accommodate proposed new infrastructure.

An *overall project area* has been defined for the proposal; this covers existing Yandicoogina JC and JSE operations to take into account the shared services and infrastructure associated with the existing mining areas, and also enable new infrastructure tie-ins associated with the proposed JSW and Oxbow mines (Figure 2-2).

Only a portion of the overall project area will include new *disturbance areas* comprised of:

- **JSW disturbance area -** the JSW mine pits, water management system, ore handling and processing infrastructure, temporary waste dumps and flood protection structures
- **Oxbow disturbance area -** the Oxbow mine pit, water management system, ore handling and processing infrastructure, temporary waste dumps and flood protection structures, and
- **infrastructure tie-in disturbance areas -** with the existing JC and JSE facilities.

The overall project area will span the future integration of the Hamersley Yandicoogina operations.

2.3. Ground disturbance

The project will result in up to 2,200 ha of new ground disturbance, within an envelope defined by the overall project area. The majority of the disturbance will occur within the JSW and Oxbow disturbance areas (Table 2-2). Additional disturbance will be required for infrastructure tie-ins with the existing mines.

While the majority of the predicted disturbance areas at JSW and Oxbow is known (including mine pit boundaries), the exact location of some ancillary infrastructure and tie-ins with the existing mines is dependent in final engineering design that is yet to be completed. The specifics of the infrastructure require flexibility in terms of siting once design is finalised. An approximate layout is indicated in Figure 2-1.

Other indirect disturbances include exposing phreatophytic riparian vegetation to groundwater drawdown along a ~9 km section of Marillana Creek in the vicinity of JSW, and modified flow regimes in downstream sections of Marillana and Weeli Wolli Creeks due to surplus water discharge.

A number of locations within the overall project area are designated as ground-disturbance avoidance zones (Figure 2-2). These include:

- known populations of Declared Rare Flora (DRF), and
- a 200 m buffer zone around the Marillana Creek line (excluding the JSW mining area, proposed infrastructure crossing points, and existing infrastructure crossing points).

Rio Tinto

Table 2-1 – Key characteristics of the Junction South West and Oxbow Iron Ore Project

Component	Proposal Characteristics	Detail
General	Project life	Approximately 12 years of mine operation (before closure).
	Production rate	55 Mt/a with the capacity to expand to ~60 Mt/a (combined total for the integrated Yandicoogina operations including JC, JSE, JSW and Oxbow mines).
	Ore deposit (Channel Iron Deposit)	JSW (excluding Marillana Creek section at JSW) and Oxbow. Total resource approximately 320 Mt.
	Timing	Construction in 2012, first throughput at JSW in 2013. First throughput at Oxbow in ~2017.
	JSW and Oxbow disturbance area	Approximately 2,200ha
Mine pits and mining	Pits and ore types	Three separate pit areas: JSW-A, JSW-C, and Oxbow. Combined pit disturbance area ~500 ha
	Stripping ratio (average)	~0.4:1 waste to ore.
	Waste rock disposal	Total waste: approximately 135 Mt/a. Waste rock will be used to backfill mine pits, with temporary storage in surface dumps.
Processing and residue	Residue storage	Existing waste fines cells in the JC pit void.
	Product transport	As per existing Yandicoogina operations ie by rail to Dampier Port and Cape Lambert, 300 km north-west of Yandicoogina.
	Plant design	• Develop primary (and possibly secondary) crushing and screening plants at JSW and Oxbow. • Convey ore from JSW and Oxbow back to existing processing facilities at Junction Central. • Option to develop a new secondary dry crushing plant at JC, or at JSW and Oxbow.
Dewatering	General dewatering	Dewatering to 465 mRL at JSW and 475 mRL at Oxbow. Peak dewatering at rates of ~14 GL/yr and ~8 GL/yr estimated for JSW and Oxbow, respectively.
	Water disposal	• Discharge into ephemeral creeks. • Re-use on-site. • Other options being investigated - including placement into disused mine voids and integration / sharing with other users.
Power	Supply and distribution	Power will be sourced from the Hamersley Iron power stations located at Dampier and Paraburdoo (as per existing Yandicoogina mines). New mines will be serviced by extending the existing on-site power distribution network.
Workforce	Workforce	Operational workforce: additional 200 personnel (~1,000 personnel for the integrated Yandicoogina operations including JC, JSE, JSW and Oxbow mines) Construction workforce: ~800 personnel.

Table 2-2 – Summary of ground disturbance and ancillary project area disturbance associated with the proposed JSW and Oxbow mining operations

Aspect	Proposal component	Relevant proposal activities	Extent of impact
Disturbance to vegetation	Mining areas	Clearing and earthworks to develop mine pits (up to 500 ha).	Up to 2,200 hectares of vegetation cleared.
	Waste dumps and stockpiles	Clearing and earthworks for waste rock stockpiles (up to 750 ha).	
	Dewatering and water disposal system	Installing bores, corridors and pipelines connecting to existing water disposal system (up to 150 ha).	
	Other: access roads, conveyor, infrastructure, accommodation camp, residue storage facility (if required)	Clearing and earthworks to develop roads and other infrastructure access paths (up to 600 ha).	
	Diversion levees and drains	Flood protection for the JSW and Oxbow pits (up to 200 ha).	
Groundwater drawdown	Drawdown cones of depression emanating from mine pits	Mine pit dewatering.	Up to 9 km of Marillana Creek near JSW will be subject to lowered water tables, based on modelling predictions.
Surface water discharge	Mining areas	The Marillana Creek channel will be narrowed and the low flow channel maintained within the existing flood-plain, at the JSW location. Local tributaries will be redirected around the mine pit areas through a combination of changed landscape topography and surface water diversion structures. An 800 m section near the terminus of Phil's Creek will be modified to enable mining in this area.	The Marillana Creek flow path at JSW will be controlled, with flow rates and speeds remaining within existing natural variance.
	Marillana and Weeli Wolli Creek systems	Surplus mine pit dewatering water from the JSW and Oxbow pits will be discharged to Marillana Creek.	Up to 12 km of Marillana Creek and 17 km of Weeli Wolli Creek (4 km more than the predicted cumulative peak discharge footprint of currently licensed mines) below the Marillana Creek confluence may be affected by a modified flow regime caused by cumulative disposal of surplus water into the creek systems.

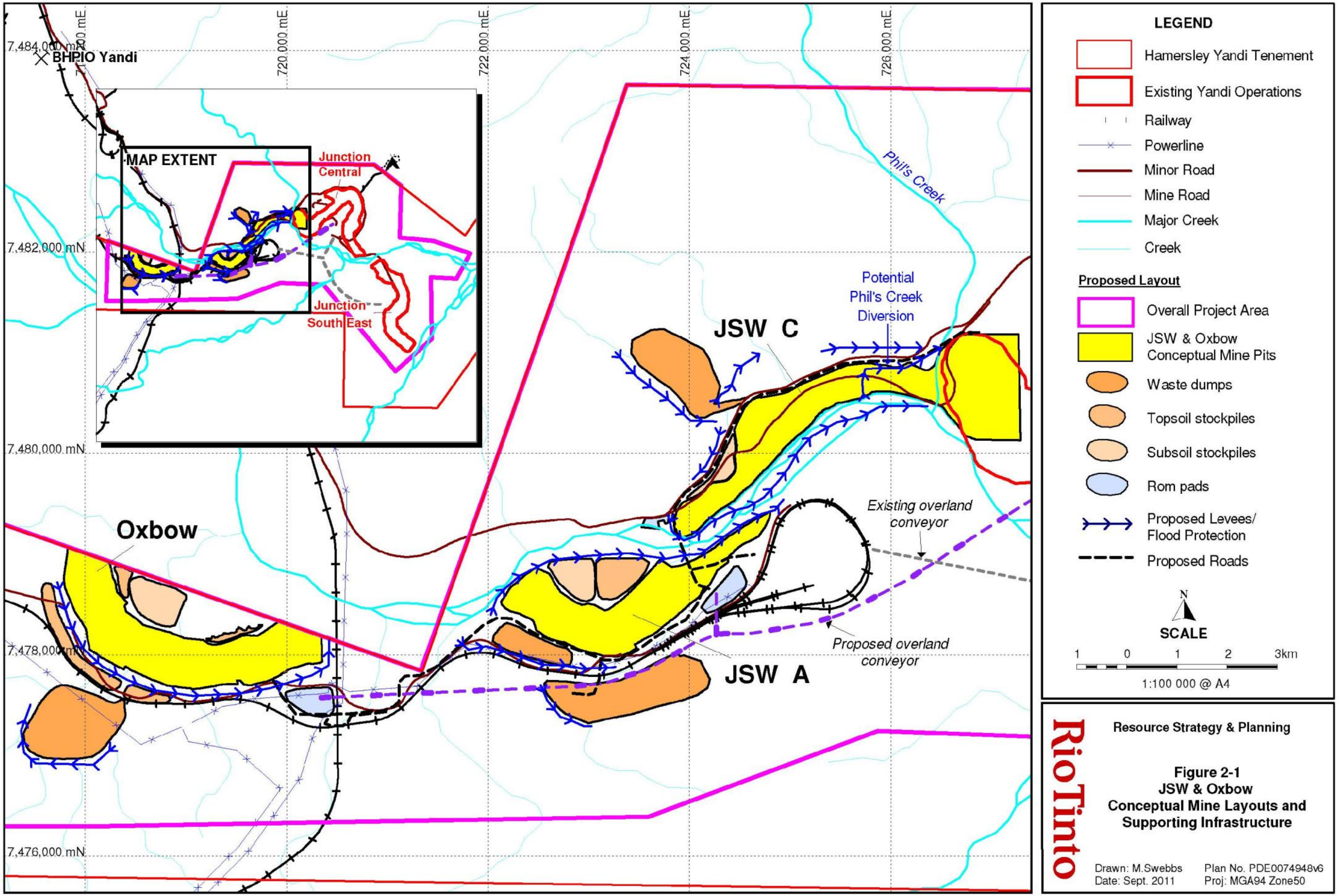
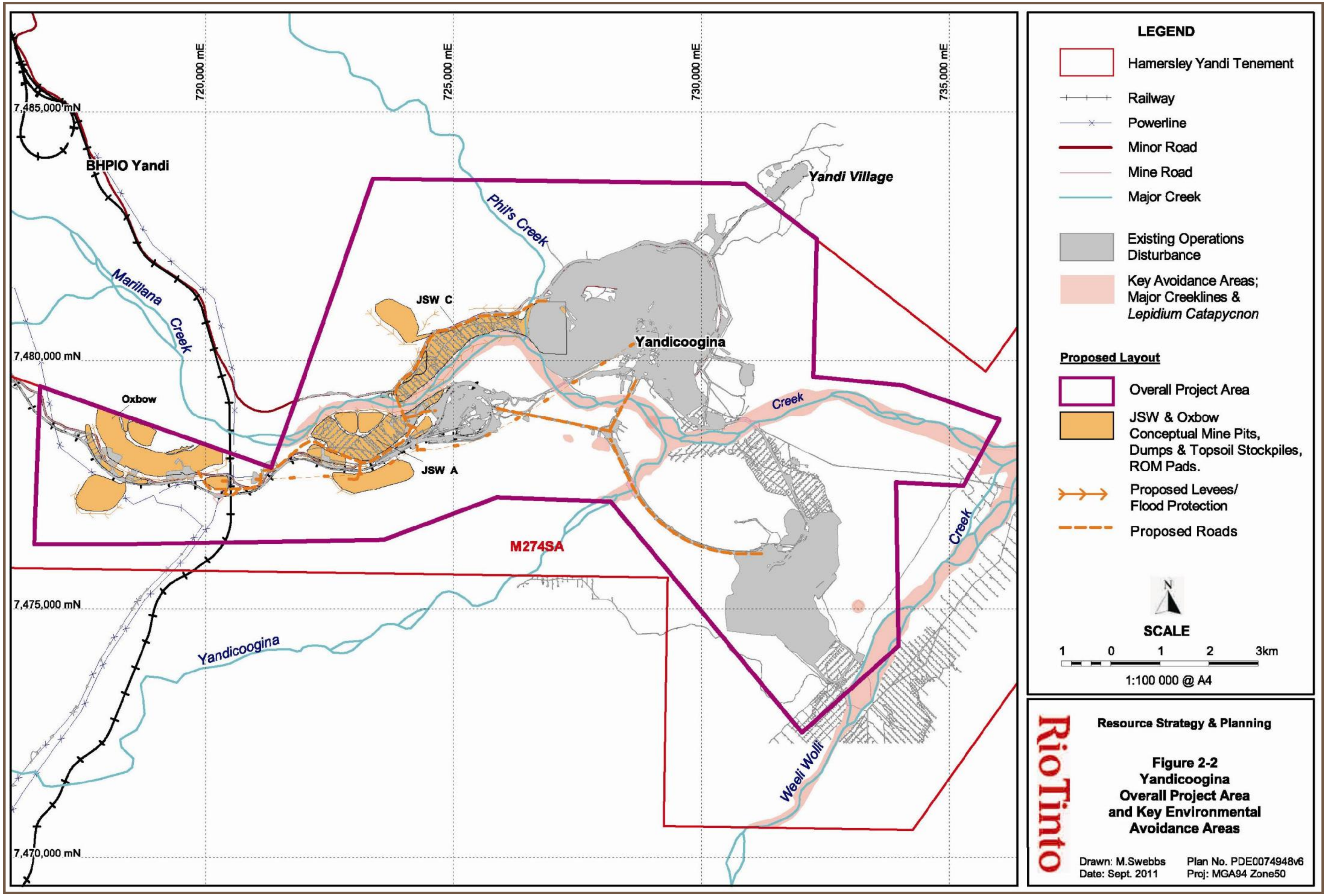
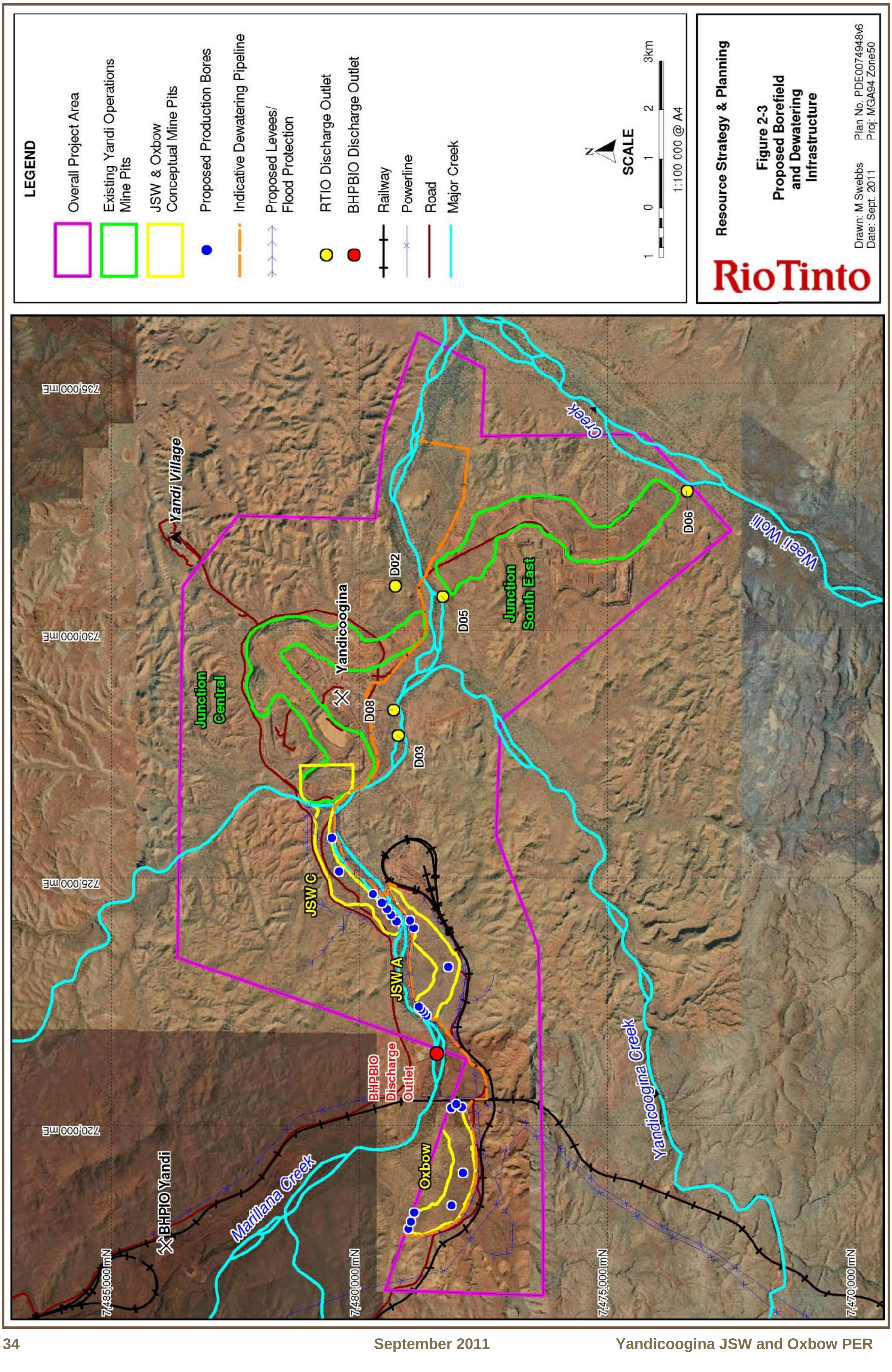


Figure 2-1
JSW & Oxbow
Conceptual Mine Layouts and Supporting Infrastructure



LEGEND
Hamersley Yandi Tenement
Railway
Powerline
Minor Road
Mine Road
Major Creek
Existing Operations Disturbance
Key Avoidance Areas; Major Creeklines & Lepidium Catapycnon
Proposed Layout
Overall Project Area
JSW & Oxbow Conceptual Mine Pits, Dumps & Topsoil Stockpiles, ROM Pads.
Proposed Levees/ Flood Protection
Proposed Roads
N
SCALE
1 0 1 2 3km
1:100 000 @ A4
Resource Strategy & Planning
Figure 2-2
Yandicoogina
Overall Project Area
and Key Environmental
Avoidance Areas
RioTinto
Drawn: M.Swebbs
Date: Sept. 2011
Plan No. PDE0074948v6
Proj: MGA94 Zone50
720,000 mE
725,000 mE
730,000 mE
735,000 mE
7,485,000 mN
7,480,000 mN
7,475,000 mN
7,470,000 mN
BHPIO Yandi
Yandi Village
Phil's Creek
Marillana Creek
JSW C
JSW A
Oxbow
Yandicoogina
Creek
M274SA
Yandicoogina
Weeli Wolli Creek


LEGEND
Overall Project Area
Existing Yandi Operations Mine Pits
JSW & Oxbow Conceptual Mine Pits
Proposed Production Bores
Indicative Dewatering Pipeline
Proposed Levees/ Flood Protection
RTIO Discharge Outlet
BHPBIO Discharge Outlet
Railway
Powerline
Road
Major Creek
N
SCALE
1 0 1 2 3km
1:100 000 @ A4
Resource Strategy & Planning
Figure 2-3
Proposed Borefield and Dewatering Infrastructure
Drawn: M.Swebbs
Date: Sept. 2011
Plan No. PDE0074948v6
Proj: MGA94 Zone50
RioTinto
735,000 mE
730,000 mE
725,000 mE
720,000 mE
7,485,000 mN
7,480,000 mN
7,475,000 mN
7,470,000 mN
Yandi Village
Junction Central
Yandicoogina
D02
D05
D06
D08
D03
Junction South East
Creek
Weeli Wolli
JSW C
JSW A
BHPBIO Discharge Outlet
Oxbow
BHPIO Yandi
Marillana Creek
Yandicoogina Creek

2.4. Vegetation clearing and topsoil removal

Vegetation and topsoil will be removed ahead of mining. Cleared vegetation will be stockpiled for later rehabilitation use.

The topsoil and underlying subsoil will be stored adjacent to the mine pits in separate stockpiles, before being placed onto rehabilitation areas. Topsoil is an important resource for rehabilitation as it contains a natural seed bank and, typically, has a substantial amount of organic material and nutrients. Topsoil layers in the Pilbara region are highly variable in thickness, ranging from very little soil development on rocky slopes to approximately 300 mm in wooded valley areas.

2.5. Mining

The proposed and existing mines are situated along an extensive Channel Iron Deposit (CID), characterised by relatively continuous iron mineralisation along a palaeochannel. The total length of the CID is over 80 km. The main zone of the CID at Yandicoogina is approximately 500 m wide with a thickness of 45 m to 50 m under about 10 m of overburden.

Mining will involve conventional drill, blast, load and haul methods, as currently used at the JC and JSE mines. For ore blending purposes, several faces within the mine pits will be worked simultaneously. The JSW operation will involve developing two mine pits: JSW-A and JSW-C, separated by Marillana Creek. A single mine pit will be developed at Oxbow.

The total quantity of extractable ore from all proposed pits is estimated to be ~320 Mt over the project life. The maximum depth of mining is expected to be approximately:

- JSW–A 470 mRL
- JSW-C 470 mRL, and
- Oxbow 480 mRL.

This equates to pit depths below the ground surface of 64 m, 62 m and 63 m, respectively.

Mining is proposed to start at JSW-C in 2013, JSW-A in 2015 and Oxbow in 2019. However, the sequence is still under review and may be altered depending on the finalised mine plan. The rate and sequence of mining will ultimately be dictated by ore blending requirements to meet product specification from the entire Yandicoogina operations (new and existing mines).

Overburden and waste will be used to progressively backfill depleted pits, where possible; although if the development sequence changes, temporary surface storage options may be used. Under the current mine plan, the indicative sequence of backfilling will be as follows:

- JSW-C to JC
- JSW-A to JSW-C
- Oxbow to JSW-A and return to Oxbow.

Mining is estimated to produce ~135 million tonnes of waste rock. Above ground stockpiles and mineral waste dumps have been provided for in the design. If they are required they will be located in close proximity to the mine pits. The quantity of material to be placed in temporary storage areas depends on the mining sequence.

A portion of the overburden from the initial mining area will be used as 'borrow material' for construction activities. As a result, the total area that would otherwise be disturbed during construction will be reduced.

2.6. Ore handling, processing and transport

The majority of the ore is expected to require dry processing. Raw ore from JSW and Oxbow will be dry crushed at crushing pads located near the mine pits. The crushed ore will then be transported to the existing dry plant at JC (and screened), by either overland conveyor or truck haulage, or a combination of both (truck haulage is likely in the initial stages of the project). This will require a Marillana Creek crossover point near the southern end of the JC pit adjacent to an existing road and conveyor and a crossover point in Phil's Creek near the eastern end of JC pit.

The transport of ore from Oxbow to the dry plant at JC will require a crossover point at the existing BHPBIO rail line. This crossover is subject to a Definitive Engineering Study, including preliminary geotechnical assessment. One of the main outcomes of this study will be to establish safe slope stability criteria for design purposes, addressing embankment concerns for existing and proposed new structures.

A number of crossover design options are being considered, all of which will have no structural impact on the existing BHPBIO rail infrastructure. The preferred option will be selected during design implementation, and will consider all safety, environmental and technical risks. BHPBIO has been consulted about this matter and further consultation will occur throughout the design process.

The existing capacity of the processing plants at JC (secondary and tertiary crushing and screening) with minor upgrades will accommodate all of the production from JSW and Oxbow. Any plant expansion requirements at JC will be subject to the provisions of the EP Act.

The existing waste fines cells at JC will be used for the disposal of waste generated by wet processing. Supernatant free water from the tailings storage facility is currently pumped to a 'turkeys nest' water storage pond located to the north east of the waste fine cells. As per existing operational practices, this reclaimed water will be used for dust suppression with any surplus discharged to the surface drainage system. An additional wet plant is being considered for JSE; however, this is subject to a separate environmental approvals process.

Processed ore will be conveyed from JC to the Loop Stockyard for rail loading and export. The existing capacity of the Loop Stockyard is expected to accommodate all of the production from JSW and Oxbow.

Under the current mine plan to optimise hauling distances it is anticipated that new dry plants will be required at JSW and Oxbow as stated above. However, provision for extension to the dry plant at JC or JSW-C has been made in this project proposal as a contingency option.

2.7. Dewatering and water disposal

The majority of the ore occurs below the water table, so dewatering is required to enable mining. Dewatering will need to commence about 12 months before mining activities start. Dewatering will be facilitated by vertical bore holes completed in a curtain or cluster arrangements within or adjacent to the mine pits (Figure 2-3). Permanent bores will be placed along the southern and western perimeter of the JSW-C pit. Permanent and sacrificial bores will be placed within and around the JSW-A and Oxbow pits. The sacrificial bores will be decommissioned and replaced as the pit advances over time. Pumping of residual groundwater from in-pit sumps will also be used when the mine pits reach final bench elevation.

An overland discharge pipeline to connect with discharge outfalls will be aligned along the inner margins of levees and existing roads where feasible.

A numerical groundwater model has been developed and calibrated to estimate dewatering rates and volumes from each mine pit. Peak abstraction rates at JSW and Oxbow are predicted to be ~14 GL/yr and ~8 GL/yr, respectively. The rate of dewatering will depend on the mining sequence (location and extent), the rate of vertical advance over time, and the discharge rate from BHPBIO outlet up gradient of JSW. Further discussion of the relationship between the project dewatering activities and the existing mining operations in the Marillana Creek catchment is described in Section 3.1.

Dewatering will be fully integrated with site water demand; however, a significant volume of surplus water will be generated over the life of the operations. Some of the groundwater extracted during dewatering (~30%) is expected to be used for dust control, camp usage and ore processing. The remainder will be discharged into the creek systems at controlled, release discharge points.

Based on modelling outputs, the annual discharge volumes are predicted to range from ~8 GL/yr to 16 GL/yr with an annual mean of ~10 GL/yr over the project life. Peak overall discharge will occur when, or if, all three pits are being dewatered at once.

RTIO has assessed the potential cumulative impact of water disposal from the project and existing mining projects in the catchment. The existing projects include the BHPBIO Yandi, Hamersley Yandicoogina and Hope Downs 1 operations. Hydrological modelling indicates that up to 12 km of Marillana Creek and 13 km of Weeli Wolli Creek (below the Marillana Creek confluence) could be affected by a modified flow regime (sustained low flow). This will be caused by each of the existing projects discharging at their current licensed limits.

Discharge from the JSW and Oxbow mine developments could extend this footprint by up to 4 km (ie corresponding with a total cumulative discharge footprint in Weeli Wolli Creek of up to 17 km below the Marillana Creek confluence). Given that it is unlikely that all projects will discharge maximum licensed discharge at once, the actual discharge footprint is anticipated to be significantly less. Observations to date indicate that discharge from the existing mining operations at Yandicoogina and Hope Downs 1 have created sustained low flow in Weeli Wolli Creek up to 8 km downstream of the Marillana Creek confluence.

Water discharge will occur using the existing Yandicoogina operations water disposal infrastructure and/or new discharge points in the lower reaches of Marillana Creek towards the Weeli Wolli Creek confluence, and possibly in the vicinity of Oxbow during the later stages of mining. The existing surface water discharge points are shown in Figure 3-20.

2.8. Surface water management

Developing the JSW and Oxbow deposits will result in localised disruptions to hydrological flow regimes. The following drainage management structures will be required to protect mine pits from accumulating water during large surface water flow events:

- **a surface water interception levee** along the southern edge of JSW-C, adjacent to Marillana Creek. This will encroach into the Marillana Creek floodplain in some areas
- **a surface water interception levee** along the northern edge of JSW-A, adjacent to Marillana Creek
- **maintaining a low flow channel** in Marillana Creek near the JSW pits, within the existing braided creek channel, and
- **a diversion levee and channel** along the southern and eastern and/or western edge of Oxbow.

These structures are shown in Figure 2-1 and will be designed to maintain flow volumes and flow speeds in Marillana Creek to prevent scouring during flooding events.

Phil's Creek is a tributary of Marillana Creek which separates JC and JSW-C, and flows over the deposit. The terminus of Phil's Creek will be modified; from the Yandicoogina mine access floodway to the confluence with Marillana Creek, so that mining is possible beneath the creek. This includes a creek section approximately 800 m long. A temporary or permanent diversion channel will be created, east or west of the existing channel. Options for reinstating the creek or using the flows to improve groundwater quality when mining ends are being investigated as part of the mine closure studies.

2.9. Water supply

Process water will be sourced from groundwater abstracted through the mine dewatering process. Potable water will be sourced from the borefields servicing the current Yandicoogina operations.

2.10. Power supply

Power supply will be derived from the existing distribution system at Yandicoogina, sourced from the Hamersley Iron power stations in Dampier and Paraburdoo. High voltage take-off facilities were upgraded for the Yandicoogina JSE project and additional infrastructure was installed to connect that power supply to the JSE site and plant. Power connections to JSW and Oxbow will be largely aligned with other infrastructure corridors (eg roads).

Back-up power supply will be provided by the existing on-site 10 MW diesel fired generator, currently servicing the JC and JSE operations. Between 2007 and 2009, this power station consumed 984 kL of diesel to generate 3,164 MWh of power.

2.11. Workforce and accommodation

The Hamersley Yandicoogina operation employs around 780 people for the existing JC and JSE operations. Personnel work on a fly-in/fly-out basis from Perth (WA) or from wherever personnel are recruited.

All operational personnel are housed at the permanent village, approximately 2.5 km north east of the JC mine site. The existing operational workforce at the JC and JSE mines will be increased by approximately 200 additional personnel to support the new mining operation. The existing accommodation village will be expanded to meet increased fly-in/fly-out workforce requirements.

An additional 800 personnel will be required for the construction phase. A temporary camp for ~800 people will be required for up 3 years. The existing decommissioned construction camp will be reinstated and expanded to accommodate the additional capacity.

The permanent village and construction camp are both part of the existing mining operation and they have been assessed under previous project approvals. However, an expansion to the existing facilities of ~400 double-storey rooms for construction and ~200 rooms for supporting operations will be required.

2.12. Wastewater treatment

Wastewater generated by the current Yandicoogina operations is treated using the existing licensed wastewater treatment plants at the JC mine site and south west of the accommodation village. These will continue to be used over the life of the project.

The JSW and Oxbow mining areas are not anticipated to need new wastewater treatment facilities. However, existing facilities will need to be expanded for construction and future operations. If any new facilities are required (to treat more than 10 m^3/day), then appropriate licenses under Part V of the EP Act will be obtained.

2.13. Mineral and non-mineral waste

Existing systems servicing the JC and JSE operations will be used to collect and recycle a number of waste streams including: hydrocarbon wastes (oil, drums, rags, filters etc.), tyres, batteries, scrap metal, printer cartridges, paper and cardboard, conveyor belting and computing equipment. These services will be extended to accommodate the JSW and Oxbow operations.

The licensed landfill facility servicing the JC and JSE operations will be used to dispose of putrescibles and inert materials, such as household waste, cardboard, furniture, fill, and demolition material. This facility is on the eastern side of the JC pit. Appropriate licenses under the EP Act will be obtained if any new landfill facilities are required.

Hazardous wastes will be collected and sent off-site for treatment by licensed contractors. An existing land farm bioremediation facility used to treat hydrocarbon contaminated soils, will continue to be operated over the project life. Contaminated soil is spread in a thin layer (300 mm) on an impermeable base. The soil is watered and tilled to stimulate aerobic microbial activity resulting in the degradation of hydrocarbon products into non-hazardous materials suitable for conventional disposal.

Asbestiform minerals are not known from the CID orebody, but can occur in surrounding lithologies. Any fibrous waste encountered during construction or mining of the JSW and Oxbow areas will be disposed of at the existing on-site facilities, in accordance with the current Yandicoogina Fibrous Mineral protocols and procedures.

2.14. Fuel

The existing fuel storage and handling facilities at Yandicoogina mine may be upgraded to service the project mining operations. These are likely to be supplemented by local refuelling facilities near the JSW and Oxbow pits.

2.15. Road access

Mine roads will be developed in and alongside the JSW and Oxbow pits. The roads will provide access to mining areas, soil and waste stockpiles and supporting infrastructure. The mine road network is expected to change to some extent during the life of the project, in accordance with the mine plan.

Based on the current mine plan, the primary heavy vehicle access road for JSW-C will be aligned with the northern perimeter of the mine pit. This road will cross Marillana Creek near the western end of the JSW-C deposit and connect with the proposed JSW ROM pad area. A floodway crossing will be constructed so that water can flow through culverts during small and medium-sized stream flows and run over the top of the floodway during large flooding events. The structure will be protected with rock armour to minimise flood damage and ensure that the crossing is operational once flood waters recede.

The primary access road for JSW-A will be situated between the southern edge of the mine pit and the existing railway line, and connect with the JSW ROM pad area to the east. This road will extend to the west to provide connection with the Oxbow mining area. At the Oxbow mine pit, an access road may extend along the southern extremity of the pit. A road crossing will also be required at the BHPBIO rail line for access to Oxbow. This is subject to a Detailed Engineering Study and a preferred option will be selected during design implementation. The preferred option will consider all safety, environmental and technical risks, and include further consultation with BHPBIO.

2.16. Timing

Construction activities and mine pit dewatering are scheduled to commence in 2012, subject to the project approval timeframe.

Mining at JSW is scheduled to start in 2013 and decrease after 2019. The Oxbow deposit is scheduled for mining in 2018 and will decrease after 2024.

3. Existing environment

3.1. Land use

3.1.1. Regional land use context

Yandicoogina lies within the Shire of East Pilbara. The main Pilbara regional centres are Newman, Tom Price, Paraburdoo, Roebourne, Karratha and Port Hedland. Newman, with a population of ~4,500, is the nearest significant population centre to the proposal area, located approximately 90 km to the south east. The 54 km Yandicoogina access road is 135 km north-west of Newman on the Great Northern Highway.

The principal land use in the region is pastoral cattle production. Hamersley's existing Yandicoogina mines are situated on Pastoral Lease L3114 984, which is currently held by a BHPBIO subsidiary and operated as Marillana Station (Figure 3-1). The JSW project area is also contained within Pastoral Lease L3114 984. The Oxbow project area extends onto Vacant Crown Land (VCL) to the south of the pastoral lease.

Marillana Station has a long history of cattle grazing and is still used for this purpose. Other regional land uses include the traditional use of land by Aboriginal groups, tourism, conservation and other mining operations.

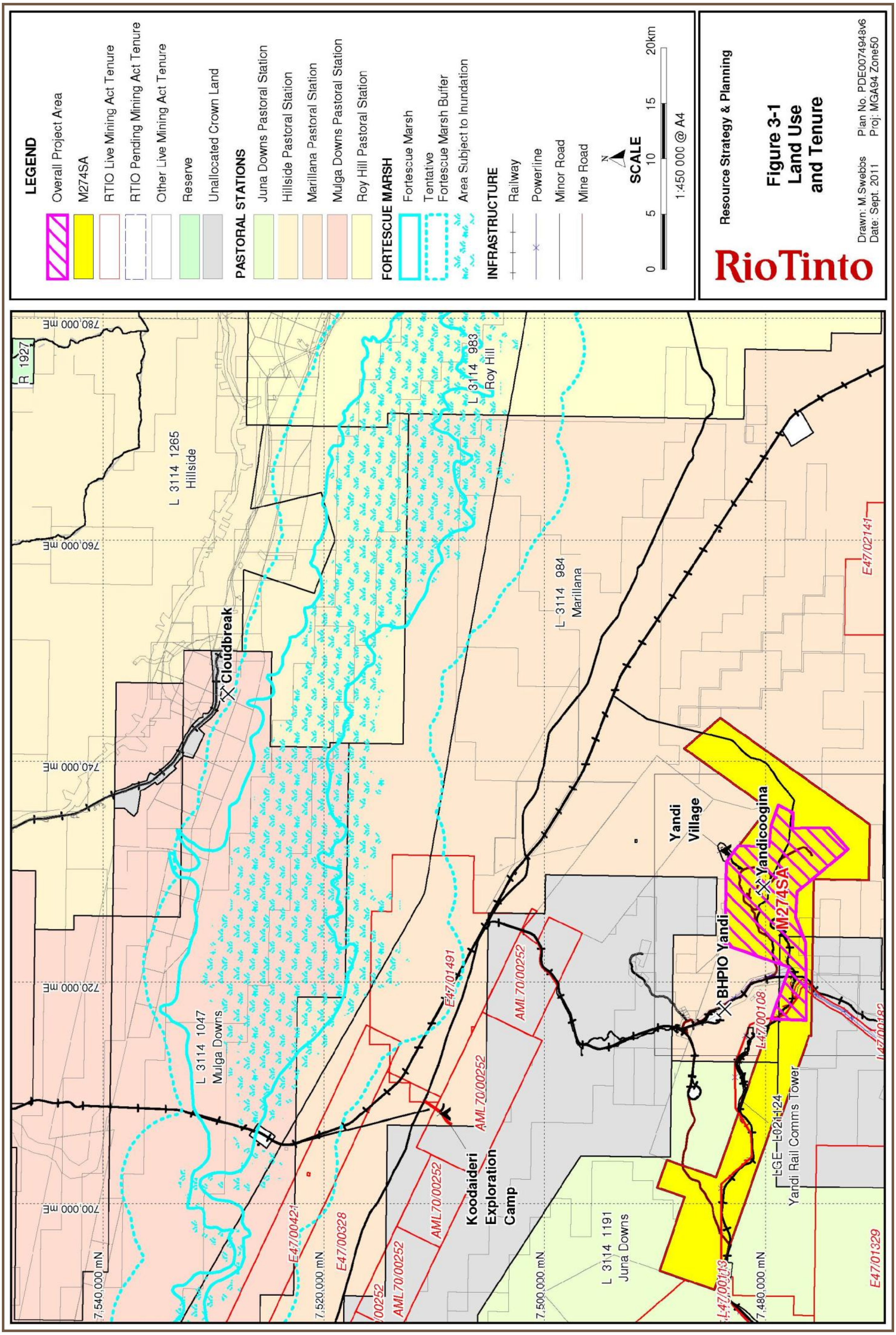
3.1.2. Local land use context

The Hamersley Yandicoogina Operations are located on Mining Lease ML274SA held by Hamersley (Figure 3-1). Pilbara Iron operates a railway corridor extending from the rail load-out facility near JSW in a west and then north westerly direction, ultimately connecting with RTIO port facilities at Cape Lambert. To the west of the Hamersley operations is ML270SA held by a BHPBIO subsidiary, which includes a working iron ore mining operation. BHPBIO operates a railway line and power transmission corridor which crosses ML274SA in a north south direction immediately east of Oxbow.

The JSW disturbance area is located immediately north of the existing rail load-out facility and Hamersley railway line. Marillana Creek separates JSW-A and JSW-C and also separates JSW-C from the rail load-out facility. The Hamersley railway line and power transmission corridor bounds the southern perimeter of JSW-A.

The Oxbow disturbance area is bounded by the Hamersley railway line to the south and the boundary of ML274SA to the north.

Photographic examples of the landscape within the JSW and Oxbow disturbance areas and surrounds are provided in Figure 3-2.



LEGEND
Overall Project Area
M274SA
RTIO Live Mining Act Tenure
RTIO Pending Mining Act Tenure
Other Live Mining Act Tenure
Reserve
Unallocated Crown Land
PASTORAL STATIONS
Juna Downs Pastoral Station
Hillside Pastoral Station
Marillana Pastoral Station
Mulga Downs Pastoral Station
Roy Hill Pastoral Station
FORTESCUE MARSH
Fortescue Marsh
Tentative Fortescue Marsh Buffer
Area Subject to Inundation
INFRASTRUCTURE
Railway
Powerline
Minor Road
Mine Road
N
SCALE
0 5 10 15 20km
1:450 000 @ A4
Resource Strategy & Planning
Figure 3-1
Land Use and Tenure
Drawn: M.Swebbs
Date: Sept. 2011
Plan No. PDE0074948v6
Proj: MGA94 Zone50
RioTinto
R 1927
L 3114 1265
Hillside
L 3114 983
Roy Hill
L 3114 984
Marillana
Cloudbreak
L 3114 1047
Mulga Downs
Yandi Village
Yandicoogina
M274SA
BHPIO Yandi
Koodaideri Exploration Camp
L 3114 1191
Juna Downs
Yandi Rail Comms Tower
LGE-L02i-124
E47/02141
E47/01491
E47/00421
E47/00328
E47/01329
AML70/00252
L47/00108
L47/00113
780,000 mE
760,000 mE
740,000 mE
720,000 mE
700,000 mE
7,540,000 mN
7,520,000 mN
7,500,000 mN
7,480,000 mN

JSW-A from southern boundary
(rail line access road in foreground)

Oxbow area from near the western end looking south east, showing the hills to the south (beyond railway line)

Marillana Creek in the area separating JSW-A and JSW-C

Marillana Creek adjacent to JSW-C

Figure 3-2 – Images of the JSW and Oxbow locations

Phil's Creek between the JC and proposed JSW- C pits

The Weeli Wolli Creek/ Marillana Creek confluence, characterised by a wide floodplain of Coolibah woodlands

Weeli Wolli Creek showing progression of the wetting front downstream of the confluence with Marillana Creek

Weeli Wolli Creek at the alluvial plain north of the project area, approximately 20 km from the Fortescue Marsh

Figure 3-2 cont… Images of the JSW and Oxbow locations

3.2. Conservation areas

The nearest major conservation reserves to the Yandicoogina locality include:

- **Karijini National Park** which lies approximately 70 km west of the proposal area, and
- **Millstream-Chichester National Park** which lies approximately 190 km north-west of the proposal area.

Weeli Wolli Creek ultimately drains into the Fortescue Marsh, which is approximately 40 km north of the confluence of Marillana and Weeli Wolli Creeks. The marsh area has important conservation values. Consequently, sections have been identified for conservation tenure following the renewal of Western Australian pastoral leases in 2015 (Figure 3-1). The EPA is preparing a Fortescue Marsh Management Strategy with assistance from the DEC and DoW, together with industry and Traditional Owner stakeholders. This Strategy will provide guidance for land use activities affecting the Fortescue Marsh by establishing an objective-based zoning framework.

DEC has identified the Fortescue Marsh on the Fortescue River, east of Mulga Downs on Marillana and Roy Hill Stations as a Priority Ecological Community (PEC Priority 1). The Weeli Wolli Spring riparian woodland and forest associations, approximately 15 km upstream of the Marillana and Weeli Wolli Creek confluence, have also been identified as a PEC (Priority 1). PECs are poorly understood ecological communities, which potentially have high conservation values and may be subject to threatening processes. They are classified as either priority 1, 2 or 3; ranked in order of priority for survey and/or definition of the community, and evaluation of conservation status.

3.3. Climate

The central Pilbara region experiences a semi-arid to arid climate. It is characterised by hot humid summers and relatively cooler, drier winters. Site records indicate that mean monthly maximum temperatures are typically 42°C to 45°C in December/January and reduce to 25°C to 28°C in June/July (Figure 3-3). Mean monthly minimum temperatures range from 20°C in December/January and reduce to 4°C in June/July.

Long-term, mean annual rainfall at the Yandicoogina locality is estimated to be approximately 400 mm, but is highly variable between years and over longer timescales. Annual potential evaporation is estimated to be 3,200 mm to 3,600 mm. On a monthly basis evaporation typically exceeds rainfall throughout the year.

The high variability in annual rainfall is largely a consequence of sporadic cyclonic and thunderstorm activity. Cyclonic rainfall can cause transient high volume runoff events. Site rainfall records for the period 1998 to 2007 provide an example of local rainfall variability (Figure 3-3). During this period, monthly rainfall ranged from 0 mm to 364 mm in December 1999. Long-term records from the Bureau of Meteorology Marillana weather station (Station Number 5009), located ~30 km north-east of the project area, indicate that higher than average rainfall has occurred since 1996 (Figure 3-4). This record indicates that approximately 85% of the annual rainfall occurs in summer months.

Easterly winds are prevalent throughout the year, with mean monthly wind speeds in the range of 10 to 14.5 km/hour Mean monthly wind speed in the summer months typically exceeds monthly wind speed in the winter months by 30 to 40%.

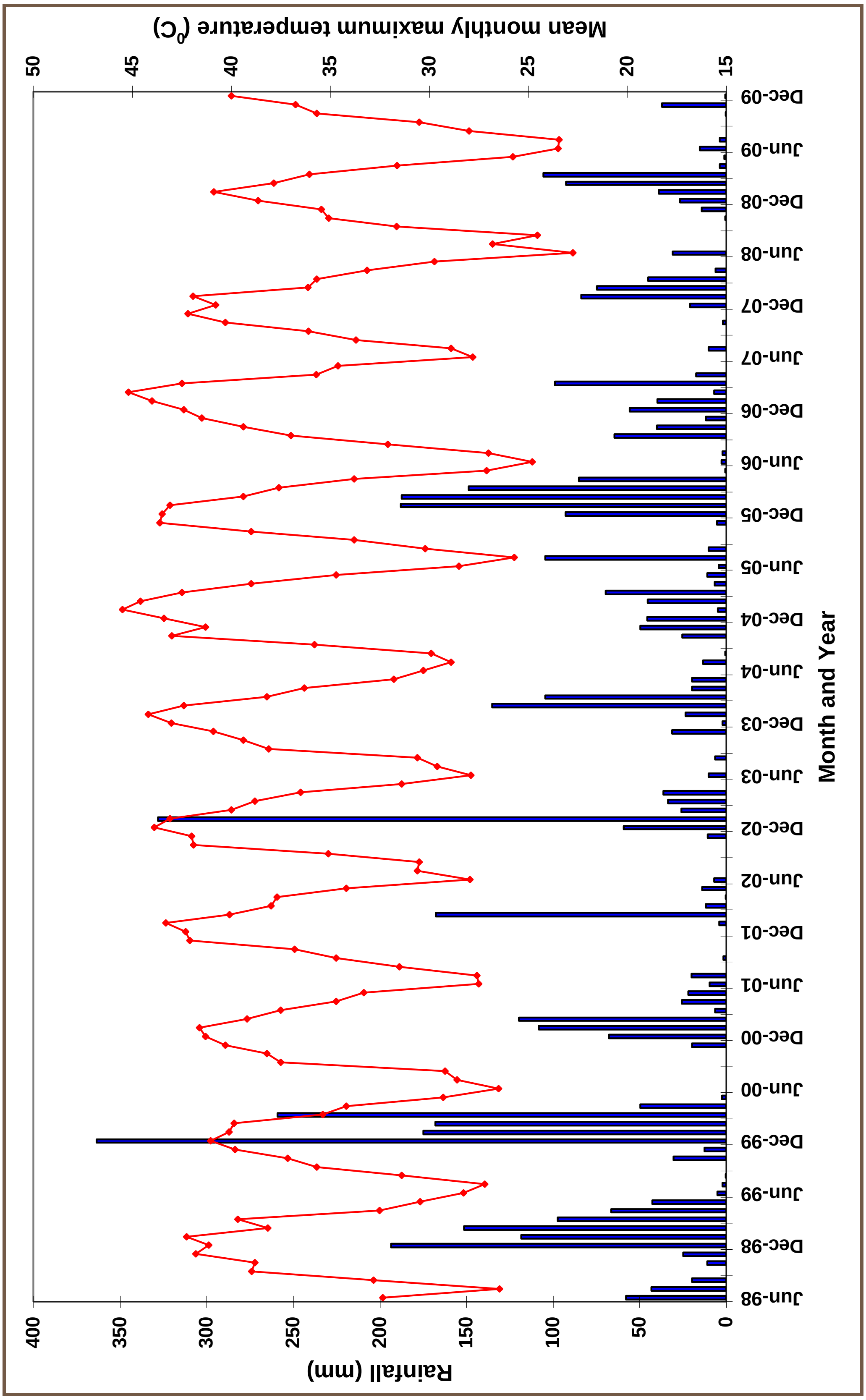


Figure 3-3 – Monthly rainfall and mean monthly maximum temperature recorded at the Hamersley Yandicoogina weather station - June 1998 to December 2009

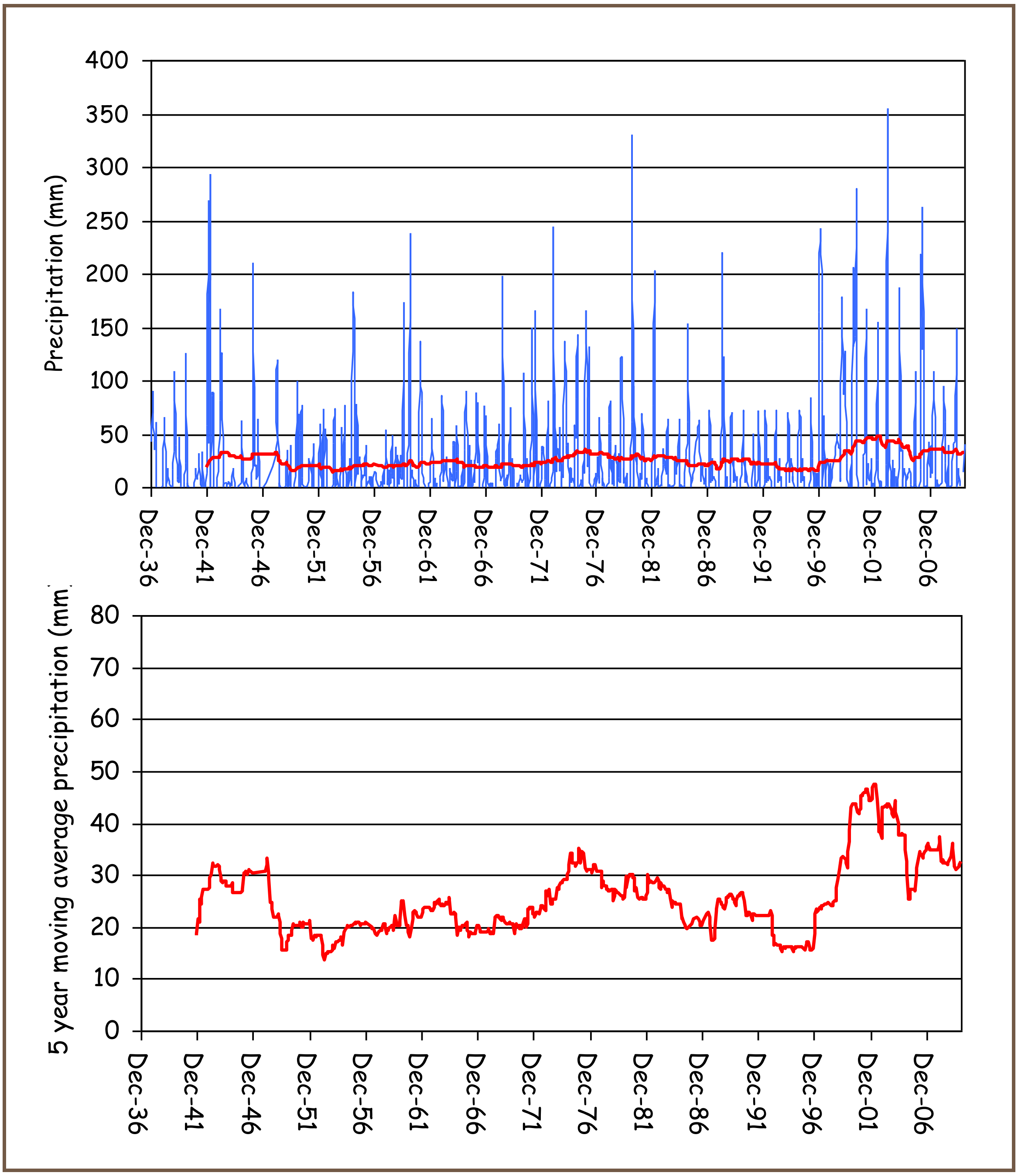


Figure 3-4 – Monthly rainfall recorded at the BOM Marillana weather station - 1936 to 2009. The five year moving average highlights the higher than average rainfall since 1996

3.4. Geology

The Yandicoogina area consists of Proterozoic basement rocks of the Weeli Wolli Formation, overlain by relatively thin Tertiary and Quaternary sediments. The basement rocks comprise Banded Iron Formation (BIF), chert, shale and volcanic rocks. The thin alluvium and colluvium cover consists of valley fill and drainage deposits, which are restricted to areas close to present drainages. These deposits include the CID, which has formed in the palaeochannel of the ancestral equivalents of the Marillana and Yandicoogina Creek systems. Figure 3-5 illustrates the Geological Survey Mapping of the area at 1:250 000 scale.

The Proterozoic basement rocks have been faulted and folded into a gently synclinal structure called the Yandicoogina Syncline, which controls the geomorphology and ultimately the location of the CID and present drainage system. Fractured, siliceous rocks underlie and enclose the CID and are hydraulically connected to the CID aquifer.

The CID was deposited during the Tertiary period some 65 million years ago. The deposits at JSW and Oxbow are approximately 300 m to 500 m wide and 45 m to 50 m thick. The CID is mostly below the water table and is overlain with unconsolidated alluvium/colluvium comprising BIF, chert, shale, minor dolerite and occasional CID clasts in a red-brown sandy to clay rich matrix. Alluvial cover in the project area varies in thickness from a thin veneer a few centimetres thick to 20 m or more across recent drainage lines, which in places have removed a significant thickness of the upper CID sequence.

The stratigraphy of the CID includes six main material types:

- **Eastern Clay Conglomerate / Laterite (ECC/LAT) -** mottled orange-brown and grey-white clays (after dolerite), BIF and ferricrete fragments.
- **Weathered Channel (WCH) -** partially lateritised upper surface of the CID, which is silicified and penetrated by clay filled solution pipes, but still retains recognisable CID texture. SiO_2 and Al_2O_3 are elevated at the expense of Fe in the weathering process. It has been postulated that the chemistry of the WCH was the same as the bulk of the GVU, but that meteoric waters have brought in alumina and silica in solution.
- **Goethite Vitreous Upper (GVU) -** the Upper Ore Zone, moderate in SiO_2 and low in Al_2O_3, is approximately 20 m thick. The GVU is slightly magnetic with confirmed presence of maghemite. This zone may have been above the palaeo-water table and is relatively unaffected by groundwater.
- **Goethite Vitreous Lower (GVL) -** the Lower Ore Zone, low in SiO_2 and moderate in Al_2O_3, and approximately 25 m thick. This zone may have been below the palaeo-water table and would have had similar chemistry to the GVU, but has since been altered by groundwater.
- **Limonite Goethite Channel (LGC) -** forms the footwall of the orebody. A clay-rich, leached, yellow, ochreous goethite (limonite) zone. It may contain lenses of material similar to the overlying GVL. The LGC is less competent than the main ore zone and as a result is more broken. Large cavities/voids are frequently encountered within this zone so the LGC is a target for dewatering bores and often yields high volumes of water.
- **Basal Conglomerate (BCC) -** the basal clastic facies of the channel that unconformably overlies the Weeli Wolli Formation. The unit may vary in thickness from a few centimetres up to 8 m and is generally only present in the centre of the channel.

Clay minerals typically occur in voids, fractures and other structures in the CID. Kaolinite is the dominant clay species. The overburden is a mixture of lateritic pisolite, poorly sorted angular to sub-rounded BIF, chert and dolomite gravels in a sandy matrix. Discontinuous kaolin clay bands and pods are common in the overburden and occur less frequently in the CID.

3.5. Landscape

3.5.1. Biogeographical regions

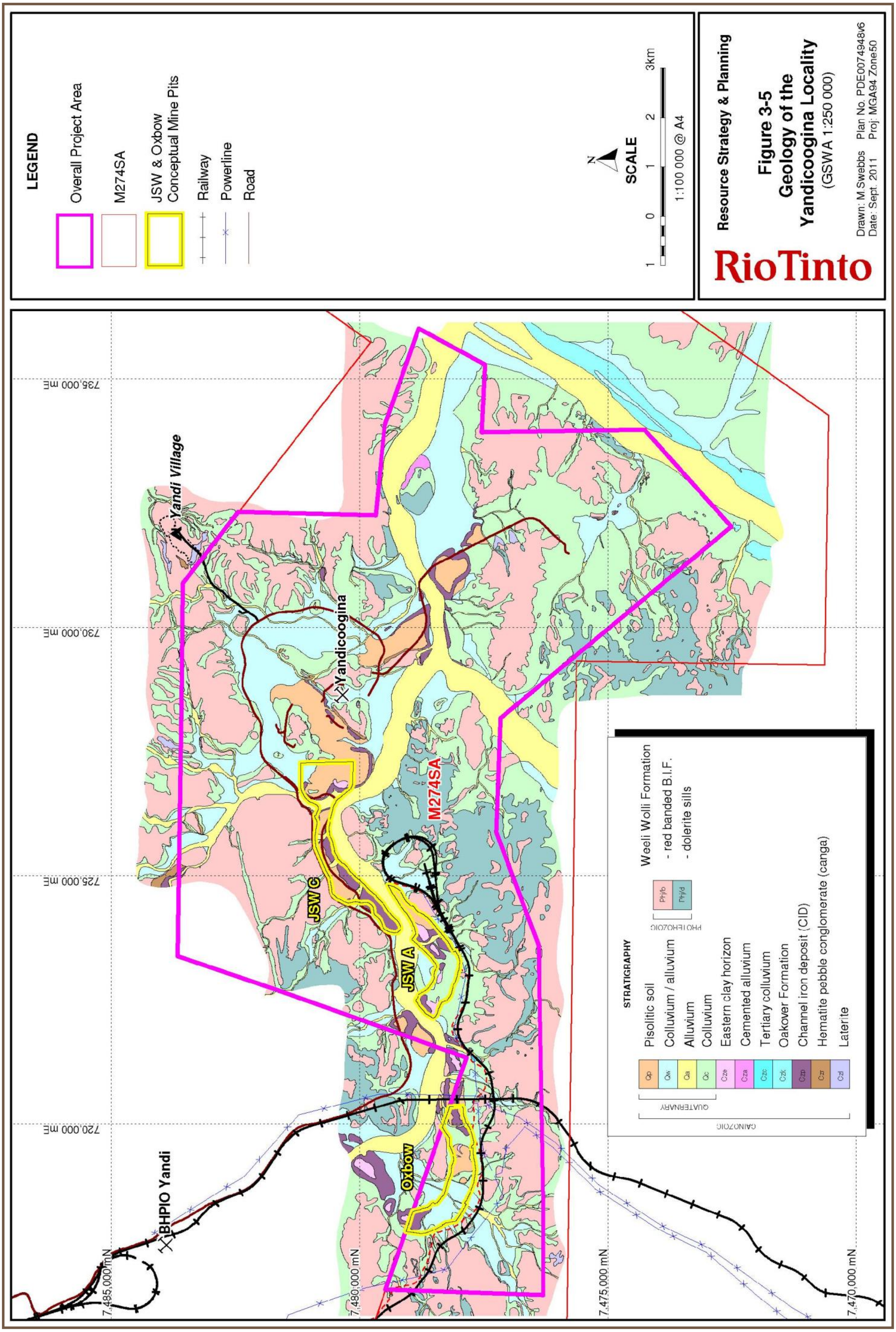
The Interim Biogeographic Regionalisation for Australia (IBRA) recognises 85 bioregions across Australia: defined on the basis of climate, geomorphology, landform, lithology, and characteristic flora and fauna attributes (Environment Australia 2000). The IBRA bioregions and sub-regions are the reporting unit for assessing the status of native ecosystems and their protection in the national reserve system. The IBRA regions are also used in the framework used by the Australian Government to monitor and evaluate natural resource management initiatives.

The project site is located near the eastern edge of the Hamersley sub-region, adjacent to the Fortescue Plains sub-region, of the Pilbara biogeographic region. The majority of the landscape within the project area is considered to typical of the Hamersley sub-region, while the creek systems have affinities with the Fortescue Plains sub-region. A description of the major characteristics of each IBRA sub-region is provided in Table 3-1.

Table 3-1 – Hamersley and Fortescue Plains sub-regions of the Pilbara Biogeographic Region

Pilbara Sub-region	Description
Hamersley	Mountainous area of Proterozoic ranges and plateaus of mulga woodland bunch grasses on fine textured soils and snappy gum over *Triodia brizoides* on skeletal soils.
Fortescue Plains	Alluvial plains and river frontages, salt marsh, mulga bunch grass and short grass communities on alluvial plains. River Gum woodlands fringe drainage lines. Northern limit of the *Acacia aneura* complex (Mulga).

(Source: Environment Australia 2000)


LEGEND
Overall Project Area
M274SA
JSW & Oxbow Conceptual Mine Pits
Railway
Powerline
Road
N
SCALE
1 0 1 2 3km
1:100 000 @ A4
Resource Strategy & Planning
Figure 3-5
Geology of the Yandicoogina Locality
(GSWA 1:250 000)
Drawn: M.Swebbs Plan No. PDE0074948v6
Date: Sept. 2011 Proj: MGA94 Zone50
RioTinto
735,000 mE
730,000 mE
725,000 mE
720,000 mE
7,485,000 mN
7,480,000 mN
7,475,000 mN
7,470,000 mN
Yandi Village
Yandicoogina
M274SA
JSW C
JSW A
Oxbow
BHPIO Yandi
STRATIGRAPHY
CAINOZOIC
QUATERNARY
Qp Pisolitic soil
Qw Colluvium / alluvium
Qa Alluvium
Qc Colluvium
Cze Eastern clay horizon
Cza Cemented alluvium
Czc Tertiary colluvium
Czk Oakover Formation
Czp Channel iron deposit (CID)
Czr Hematite pebble conglomerate (canga)
Czl Laterite
PROTEROZOIC
PHjb PHjd Weeli Wolli Formation
- red banded B.I.F.
- dolerite sills

3.5.2. Major landforms

The dominant landscape features of the Yandicoogina area are the ephemeral watercourses that locally drain to the north east and eventually into the Fortescue Marsh. The creeklines follow a surface gradient sloping downwards from west to east (~520 mRL at Oxbow to ~480 mRL near the Marillana Creek and Weeli Wolli Creek confluence). A row of small hills rising 800 to 900 mRL extend to the north west from JC, with a line of slightly higher hills (900 to 1 000 mRL) running in an east-west direction to the south of the current mining operations. An area less than one kilometre south of the CID at JSW/Oxbow rises over 600 mRL.

The surface topography has been shaped by alluvial processes with the existing streams winding between low lying mesas and hills. Three major landforms can be distinguished:

- **Low stony hills**: These areas generally consist of hills, ridges and breakaways supporting a scattered overstorey of small trees (*Eucalyptus* and *Acacia* species) over moderately dense Spinifex (*Triodia* species) hummock grassland
- **Valleys**: These areas consist of low stony plains in valleys supporting scattered overstorey of small trees (*Eucalyptus* and *Acacia* species) over sparse mixed shrubs and Spinifex (*Triodia* species). Alluvial flats are dominated by *Acacia* shrublands with a moderately rich understorey of shrubs, herbs and tussock grasses, and
- **Drainage lines**: These areas vary from small gullies in upper hills to more major creeklines. Minor drainage lines differ very little from the vegetation type surrounding them and are usually species poor. Major creeklines support *Eucalyptus* dominated woodlands and open forest over a mixed understorey of shrubs and grasses.

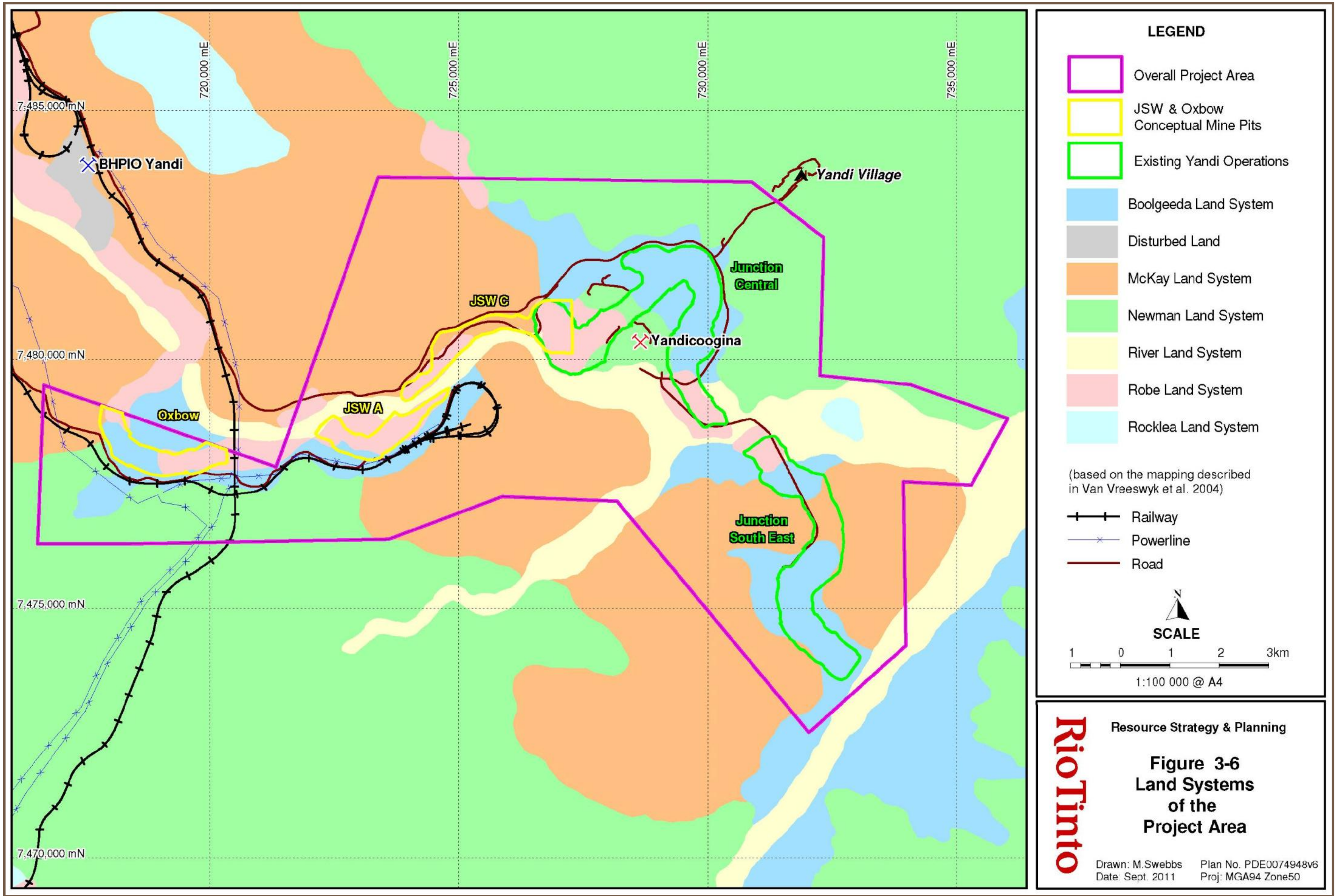
3.5.3. Land systems

The Pilbara region has been surveyed by the Western Australian Department of Agriculture and Food (DAFWA), for the purposes of land classification, mapping and resource evaluation. The region consists of 102 land systems; distinguished on the basis of topography, geology, soils and vegetation (Van Vreeswyk *et al.* 2004).

The project area coincides with the Boolgeeda, McKay, Newman, Robe and River land systems (Table 3-2; Figure 3-6). The River land system includes the major drainage lines (Marillana, Yandicoogina and Weeli Wolli Creeks). These land systems are all widely represented in the central Pilbara region.

Table 3-2 – Land systems occurring within and adjacent to the project area

Land System	Description
Boolgeeda	Stony lower slopes and plains derived from quaternary colluvium and situated below the surrounding hill systems. Major soil types include red loamy earths and red shallow loams. The vegetation is characterised by hard and soft spinifex grasslands and scattered Mulga (Acacia aneura and allied taxa) shrublands. This land system is extensive in the western half of the proposed Oxbow disturbance area and in the proposed JSW-A disturbance area.
McKay	Hills, ridges, plateaux remnants and breakaways of meta-sedimentary and sedimentary rocks. Major soil types include stony soils and red shallow loams. The vegetation is characterised by hard spinifex grasslands with isolated trees and shrubs. This land system dominates the low hills north and south east of the proposed mining areas.
Newman	Rugged jaspilite plateaux, ridges and mountains of varied geological origin. Major soil types include stony soils and red shallow loams. The vegetation is characterised by hard spinifex grasslands with isolated trees and shrubs. This land system is prevalent to the south of the proposed mining areas.
River	Major river channels and active floodplains formed from quaternary alluvium. Major soil types include red sands, loams and clays of varying depth. The vegetation is characterised by a mixture of hummock grasslands, shrublands and woodlands; including riverine fringing vegetation. This land system comprises much of the Marillana, Yandicoogina and Weeli Wolli Creek systems.
Robe	Low mesas and buttes derived from tertiary pisolitic limonite and laterite. Major soil types include stony soils, shallow gravels and loams. The vegetation is characterised by hard and soft spinifex grasslands with isolated trees and shrubs. This land system is common across the overall project area, adjacent to the Marillana Creek system.


LEGEND
Overall Project Area
JSW & Oxbow Conceptual Mine Pits
Existing Yandi Operations
Boolgeeda Land System
Disturbed Land
McKay Land System
Newman Land System
River Land System
Robe Land System
Rocklea Land System
(based on the mapping described in Van Vreeswyk et al. 2004)
Railway
Powerline
Road
N
SCALE
1 0 1 2 3km
1:100 000 @ A4
Resource Strategy & Planning
Figure 3-6
Land Systems of the Project Area
RioTinto
Drawn: M.Swebbs
Date: Sept. 2011
Plan No. PDE0074948v6
Proj: MGA94 Zone50
720,000 mE
725,000 mE
730,000 mE
735,000 mE
7,485,000 mN
7,480,000 mN
7,475,000 mN
7,470,000 mN
BHPIO Yandi
Yandi Village
Junction Central
Yandicoogina
JSW C
JSW A
Oxbow
Junction South East

3.6. Vegetation and flora

The proposal area is within the Fortescue Botanical District of the Eremaean Botanical Province, as defined by Beard (1975). The vegetation of the proposal area is typical of the Fortescue Botanical District. The vegetation units are widely distributed in the area and are not locally restricted (see Table 3-3).

Broadly, the vegetation types fall into the following groupings, based on landform/habitat type:

1. **Low stony hills**: scattered *Eucalyptus* and *Acacia* species over spinifex hummock grasslands (predominantly *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835) and *T. wiseana*).
2. **Lower-lying plains**: low open woodlands or scattered low trees of *Eucalyptus leucophloia* subsp. *leucophloia, E. gamophylla* and *Corymbia hamersleyana* over hummock grasslands dominated by the spinifex species *Triodia epactia/pungens* and *T.* sp. Shovelanna Hill (S. van Leeuwen 3835).
3. **Major creeklines**: woodlands and open forests of *Eucalyptus camaldulensis* and *E. victrix* over various understorey tree and tall shrub species, including *Acacia citrinoviridis*, *A. coriacea* subsp. *pendens, Melaleuca argentea* and *M. glomerata*, over an understorey of low shrubs, herbs, grasses and sedge species.
4. **Minor creeklines and flowlines**: scattered low trees of *Eucalyptus victrix* over a mixed shrubland of various creekline species and an open tussock grassland of *Eriachne tenuiculmis*.

3.6.1. Project area context

Historical disturbance

Vegetation disturbance in the overall project area has occurred as a result of historical mining activities at Yandicoogina. This includes disturbance in the JC project area approved under Ministerial Statements 417 and 523, and in the JSE project area approved under Ministerial Statement 695.

Vegetation changes have also been correlated with water management activities. Since the 1990s, dewatering of the CID orebody and discharges into Marillana Creek from the BHPBIO and Hamersley operations have contributed to some changes in creekline vegetation. Other factors, such as fire and climate, have also been implicated in these changes. Groundwater drawdown, in particular, has detrimentally affected the health of the phreatophytic species *Melaleuca argentea* in the vicinity of the JSW deposits.

Historical surveys

Numerous flora and vegetation surveys have been completed in the Yandicoogina locality, in connection with previous mining approvals and in advance of drilling programmes or construction projects (Biota 2010a; Appendix A1). These surveys have included broad-scale surveys of the Yandicoogina area and smaller scale surveys, particularly targeting rare flora. Key survey reports include:

- Southern Transport Corridor- Yandicoogina Junction Area (Mattiske and Associates 1995a)
- Northern Transport Corridor - Yandicoogina Junction Area (Mattiske and Associates 1995b)
- Yandicoogina Junction Area (Mattiske and Associates 1995c)
- Yandi Expansion Vegetation and Flora Survey (Biota 2004)
- A Flora and Vegetation Survey of the Billiard Deposit, near Yandi (Biota 2009).

All of the surveys considered significant flora taxa and included vegetation mapping, in accordance with Guidance Statement No. 51 (EPA 2004). All reports identified survey limitations, appraised existing information and considered regional and local context. The spatial extent of the survey effort is provided in Figure 3-7a.

Following vegetation surveys associated with the development of the JC deposit, Mattiske Consulting (1995a, b and c) identified that many of the vegetation communities in the Yandicoogina locality had been influenced by past activities and events, such as grazing and fire. These factors have acted to restrict certain components of those communities: for example, grazing by introduced species has led to the selective removal or reduction of some palatable understorey species along the main drainage lines and on the flats. Marillana Station has been subject to continuous grazing for several decades.

A number of flora species with conservation significance have been detected in the historical surveys (Table 3-3 and Figure 3-7b), including *Lepidium catapycnon,* which is listed Declared Rare Flora (DRF) under WA legislation and Vulnerable under the Commonwealth *EPBC Act*. A number of Priority species, as assigned by the DEC, have also been recorded in the wider Yandicoogina locality (Biota 2010a; Appendix A1). Priority species are those that appear to be rare or threatened, but for which there is insufficient information to properly evaluate their conservation significance at the present time (refer to Section 7.1 for additional discussion of the DEC classification system for Priority species).

3.6.2. Project area surveys

Additional vegetation surveys at Yandicoogina associated with the proposed JSW and Oxbow mining areas were completed to address the following objectives:

- achieve survey coverage consistent with a Level 2 survey methodology under EPA Guidance Statement No. 51 (EPA 2004b) in the proposed JSW and Oxbow disturbance areas, and
- achieve survey coverage consistent with a Level 1 survey methodology under EPA Guidance Statement No. 51 (EPA 2004b) in all other currently undisturbed areas within the overall project area.

The extent of the surveys therefore included all areas within the overall project area, excluding areas at JC and JSE already approved for disturbance in accordance with Ministerial Statements 417, 523 and 695.

The Level 1 survey coverage has informed the engineering design process for infrastructure tie-ins. Once detailed engineering designs have been completed, all tie-in areas required for disturbance will be surveyed using a Level 2 survey methodology.

3.6.2.1. Vegetation types

The proposed JSW and Oxbow disturbance areas and immediate surrounds were surveyed between 2007 and 2010 by Biota Environmental Sciences (Figure 3-7c and Figure 3-7d). The survey methodology involved a combination of linear foot traverses and 50 m x 50 m flora recording quadrats. Vegetation types were classified based on the height and estimated cover of dominant species using Aplin's (1979) modification of the vegetation classification of Specht (1970) to include a hummock grassland category. A summary of the survey effort is further described in Biota 2010a (Appendix A1).

Additional portions of the overall project area (outside the approved JC and JSE mining areas) had been surveyed prior to 2007 in association with the JC and JSE projects (Figure 3-7a). The remainder of the overall project area was surveyed in November/December 2010 (Biota 2011; Appendix A2). The 2010 survey included downstream sections of Weeli Wolli Creek within the maximum surface water discharge footprint.

Nineteen vegetation units were collectively identified within the JSW and Oxbow disturbance areas (Table 3-3). A further 13 vegetation units were identified in additional portions of the overall project area. Maps showing the distribution of these vegetation units in the project area are contained in Appendix A1 and also summarised in Figure 3-7 (b-e).

No vegetation units in the proposed JSW and Oxbow disturbance areas and immediate surrounds were identified as having regional conservation significance, based on interpretation of the survey data combined with the senior botanists' knowledge of the vegetation of the locality. This finding was consistent with the findings of historical surveys in the Yandicoogina project area associated with the JC and JSE projects. Similarly, rare flora searches associated with RTIO exploration work in the area have also detected any new species of conservation significance.

Two units were identified as having high local conservation significance (the major creekline supporting *Eucalyptus* and *Melaleuca* species, and the hills supporting the DRF species *Lepidium catapycnon*). Several vegetation units associated with minor creeklines and drainage were considered to be of moderate local conservation significance. The remainder of the vegetation units were assessed as having low conservation significance, on the basis that the units:

- are common and widely distributed beyond the JSW and Oxbow disturbance areas
- do not include unusual species or novel combinations of species
- do not provide key habitat for species with identified conservation significance, and
- occur within their contiguous distribution across the central Pilbara region (ie they are not outliers or occurring at range extremes).

The composition of the vegetation was considered to be consistent with historical surveys of nearby areas.

3.6.2.2. Vegetation condition

The vegetation types of the proposed JSW and Oxbow disturbance areas and immediate surrounds were generally in 'Very Good' to 'Excellent' condition (Biota 2010a; Appendix A1). The main signs of disturbance comprised grazing and trampling damage from cattle, which have contributed to extensive weed invasion through some areas.

Downstream riparian areas along Weeli Wolli Creek were assessed to be in 'Good' to 'Poor' condition, and were typified by scattered tall *E. victrix* trees over tall shrubs dominated by *Acacia* species with an understorey of the weed **Cenchrus ciliaris* (Buffel Grass) (Biota 2011; Appendix A2).

3.6.2.3. Flora

A total of 267 native vascular flora taxa from 114 genera belonging to 40 families were recorded in the JSW development area, while a total of 220 native vascular flora taxa from 102 genera belonging to 38 families were recorded in the Oxbow development area (Biota 2010a). Within additional areas surveyed in 2010 (encompassing the full extent of the overall project area), 75 vascular plant taxa from 37 genera belonging to 23 families were recorded (Biota 2011).

The species recorded were typical for the habitats in the locality. The total numbers of native species recorded were within the expected range (considering the size of the survey area and the locality) and are not considered to represent high species richness.

The plant families with the greatest number of native taxa in the Yandicoogina locality comprise the Asteraceae (daisy family), Amaranthaceae (mulla-mullas), Euphorbiaceae (spurges), Poaceae (grass family), Malvaceae (hibiscus family) and Fabaceae (peas, wattles and cassias). These families are predominant in the vegetation of the Pilbara, and usually have most representatives on flora lists from this region, due to their prominence in the Eremaean flora.

Rare flora

Extensive searches for rare flora have been conducted in the Yandicoogina project area. The four surveys conducted by Biota between 2007 and 2010 included targeted searches (for the DRF species *Lepidium catapycnon,* and any other flora of conservation significance). In addition, detailed quadrat sampling within the main vegetation types present was conducted. Rio Tinto has also conducted numerous smaller scale surveys, particularly targeting rare flora.

The species of listed significance recorded from the overall project area during the current surveys comprised:

- **One individual of the DRF species** *Lepidium catapycnon* was recorded on a recently burnt hilltop in the southeast of the Oxbow survey area (Figure 3-7d). This location is outside the proposed disturbance area. It has also been recorded to the south of the JSE deposit around Marillana Creek, the Loop Stockyard and existing conveyor areas, and near the JSE deposit.
- ***Goodenia nuda* (Priority 4)** was recorded south of Marillana Creek in the eastern part of the JSW disturbance area (near the rail loop) and north east of the JC pit.
- ***Rostellularia adscendens* var. *latifolia* (Priority 3)** was recorded from historical surveys on the southern margin of the proposed JSW-C pit. There is some debate as to whether this species is taxonomically distinct from *R. adscendens* var. *adscendens,* which has no Priority ranking (Malcolm Trudgen, M.E. Trudgen and Associates, pers. comm.).

Species with conservation significance likely to be impacted by the JSW and Oxbow development include:

- ***Lepidium catapycnon*** – three plants which occur within the existing JC operations footprint adjacent to the existing rail loop. The tie-in and location of the proposed JSW ROM pad is likely to impact these plants. Note that the *Lepidium catapycnon* in this area was previously approved for disturbance via a 'Licence to Take' under the *Wildlife Conservation Act 1950* during the construction of Junction Central mining operations.
- ***Rostellularia adscendens* var. *latifolia* (Priority 3)** – on the southern margin of the proposed JSW-C pit will be impacted.

Several other Priority species have previously been recorded from the wider locality (Biota 2010a), but none of these were recorded from the overall project area. It is considered unlikely that they occur in the proposed disturbance area. Priority flora records in relation to the JSW and Oxbow development from all surveys are depicted in Figure 3-7b – d.

An additional 33 taxa of conservation interest were identified from the overall project area, comprising species that are likely to be separate entities and are currently poorly collected and/or undescribed[6]. None of these are expected to represent DRF or Priority species and all are relatively common in the Pilbara bioregion (Malcolm Trudgen, M.E. Trudgen and Associates, pers. comm.).

3.6.3. Weeds

The following weed species have been recorded within the overall project area (Biota 2010a - Appendix A1 and Biota 2011 - Appendix A2):

- **Acetosa vesicaria* (Ruby Dock)
- **Argemone ochroleuca* subsp. ochroleuca (Mexican Poppy)
- **Bidens bipinnata* (Bipinnate Beggartick)
- **Cenchrus ciliaris* (Buffel Grass)
- **Citrullus colocynthis* (Colocynth)
- **Conyza bonariensis* (Flaxleaf Fleabane)
- **Flaveria trinervia* (Speedy Weed)
- **Malvastrum americanum* (Spiked Malvastrum)
- **Portulaca oleracea* (Purslane)
- **Setaria verticillata* (Whorled Pigeon Grass)
- **Sigesbeckia orientalis* (Indian Weed)
- **Sisymbrium orientale* (Indian Hedge Mustard)
- **Solanum nigrum* (Black Berry Nightshade)
- **Tribulus terrestris* (Caltrop)
- **Vachellia farnesiana* (Mimosa Bush).

These weed species generally occurred infrequently, with the exception of a number of Ruby Dock and Buffel Grass infestations associated with creeklines and areas disturbed by historical mining. Most of these species are common in the Pilbara bioregion. None are Declared Plants according to the *Agriculture and Related Resources Protection Act 1976*, however **Acetosa vesicaria* (Ruby Dock), **Argemone ochroleuca* subsp. *ochroleuca* (Mexican Poppy) and **Cenchrus ciliaris* (Buffel Grass) are considered to be serious environmental weeds.

Kapok (**Aerva javanica*) is another serious environmental weed known from the wider Yandicoogina locality. However, this species was not recorded in the JSW and Oxbow survey areas.

The existing mining operations at Yandicoogina are subject to a Weed Management Plan, which includes objectives, targets, management actions and monitoring requirements for the control of weeds in the mining lease area (ML274SA). The current plan addresses environmental approvals requirements contained in Condition 10 of Ministerial Statement 695.

Routine operational weed management activities include:

- **mapping and monitoring of target weed species** (Ruby Dock, Mexican Poppy and Kapok)
- **weed eradication programs** for target weed species, and
- **regular monitoring** of the effectiveness of weed control programs.

[6] There is a need for the taxonomic resolution of numerous plant groups in the Pilbara.

Table 3-3 – Vegetation units occurring in the project area

Vegetation Unit	JSW	Oxbow	Local conservation significance
Vegetation of major and minor creeklines (JSW and Oxbow disturbance areas)			
Eucalyptus camaldulensis, E. victrix woodland over *Melaleuca argentea, M. glomerata* low open woodland	✓	✓	High (due to locally restricted distribution along major creeklines)
Eucalyptus victrix scattered low trees over *Acacia tumida* var. *pilbarensis, Grevillea wickhamii* subsp. *hispidula, Rulingia luteiflora* tall shrubland over *Tephrosia rosea* low shrubland over *Cymbopogon procerus, Eriachne tenuiculmis* very open tussock grassland	✓	✓	Low
Eucalyptus victrix, E. camaldulensis scattered low trees over *Acacia tumida, Rulingia luteiflora* shrubland over *Tephrosia rosea* low open shrubland over *Eriachne tenuiculmis*, *Themeda triandra* open tussock grassland		✓	Mod
Vegetation of rocky hill slopes and crests (JSW and Oxbow disturbance areas)			
Corymbia hamersleyana scattered low trees over *Gossypium robinsonii, Rulingia luteiflora, Acacia tumida, Grevillea wickhamii* subsp. *hispidula* shrubland over *Themeda triandra*, *Cymbopogon ambiguus* open tussock grassland		✓	Low
Eucalyptus leucophloia subsp*. leucophloia* scattered low trees over *Acacia hilliana* low shrubland over *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835) hummock grassland		✓	Low
Eucalyptus leucophloia scattered low trees over *Grevillea wickhamii, Acacia dictyophleba* scattered tall shrubs over *Cassia pruinosa* scattered shrubs over *A. hilliana* scattered low shrubs over *Triodia* sp. Shovelanna Hill hummock grassland	✓		Low
Eucalyptus leucophloia subsp. l*eucophloia* scattered low trees over *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835), *T. wiseana* hummock grassland	✓	✓	Low
Eucalyptus leucophloia subsp. *leucophloia* scattered low trees over *Acacia inaequilatera*, *Grevillea wickhamii* subsp. *hispidula* tall open shrubland over *Acacia hilliana* low shrubland over *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835) hummock grassland		✓	Low
Eucalyptus leucophloia subsp*. leucophloia* scattered low trees over *Acacia inaequilatera* tall open shrubland over *Triodia wiseana* open hummock grassland		✓	Low
Eucalyptus leucophloia subsp. *leucophloia, Corymbia hamersleyana* low open woodland over *Acacia bivenosa* scattered shrubs over *Triodia wiseana* hummock grassland		✓	High (due to record of *Lepidium catapycnon*)

Vegetation Unit	JSW	Oxbow	Local conservation significance
Vegetation of plains (JSW and Oxbow disturbance areas)			
Corymbia hamersleyana low open woodland over *Hakea chordophylla*, *Grevillea wickhamii* tall open shrubland over *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835) open hummock grassland		✓	Low
Corymbia hamersleyana low open woodland over *Acacia pyrifolia* open shrubland over *Triodia pungens* scattered hummock grasses		✓	Low
Corymbia hamersleyana, *Eucalyptus gamophylla* low open woodland over *Hakea lorea*, *Acacia bivenosa*, *A. dictyophleba* tall shrubland over *Triodia pungens* open hummock grassland		✓	Low
Eucalyptus gamophylla low woodland over *A. tumida* var. *pilbarensis*, *A. elachantha* tall open shrubland over *Triodia pungens*, *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835) open hummock grassland		✓	Low
Eucalyptus leucophloia subsp. *leucophloia* scattered low trees over *Acacia pruinocarpa, Grevillea wickhamii* scattered tall shrubs over *Triodia epactia* hummock grassland	✓		Low
Eucalyptus leucophloia, *Acacia pruinocarpa* low woodland over *A. bivenosa* scattered shrubs over *Eremophila fraseri* scattered low shrubs over *Triodia wiseana*, *T. epactia* hummock grassland	✓	✓	Low
Eucalyptus leucophloia subsp. *leucophloia* scattered low trees over *Acacia pruinocarpa*, *Grevillea wickhamii* scattered tall shrubs over *Triodia epactia* hummock grassland		✓	Low
Grevillea wickhamii subsp. *hispidula*, *Hakea chordophylla* open shrubland over *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835) hummock grassland		✓	Low
Grevillea pyramidalis scattered tall shrubs over *Eremophila fraseri* open shrubland over *Ptilotus rotundifolius* scattered low shrubs over *Triodia epactia* hummock grassland	✓		Low
Additional vegetation units in the overall project area mapped in 2010 (including downstream Weeli Wolli Creek)			
Acacia aneura low open woodland over *A. pyrifolia* scattered shrubs over *Triodia wiseana* open hummock grassland			Low
Acacia pruinocarpa, A. citrinoviridis, A. inaequilatera, A. sclerosperma open shrubland over *Triodia brizoides* open hummock grassland			Low
Acacia pruinocarpa, A. synchronicia, A. inaequilatera tall open shrubland over *Triodia wiseana* hummock grassland			Low
Corymbia hamersleyana low woodland over *Hakea lorea* scattered tall shrubs over *Acacia arida, A. pyrifolia* open shrubland over *Triodia brizoides, T. pungens* very open hummock grassland and *Themeda triandra* scattered tussock grasses			Low
Corymbia hamersleyana scattered low trees over *Acacia pyrifolia, A. arida, Grevillea wickhamii* scattered shrubs over *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835) open hummock grassland			Low

Vegetation Unit	JSW	Oxbow	Local conservation significance
Corymbia hamersleyana scattered low trees over *Acacia pruinocarpa* tall shrubland over *Triodia pungens* open hummock grassland			Low
Corymbia hamersleyana scattered low trees over *Triodia wiseana* open hummock grassland			Low
Corymbia hamersleyana, Eucalyptus leucophloia scattered low trees over *Acacia pyrifolia* open shrubland over *Tephrosia rosea, A. adoxa* scattered low shrubs over *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835) open hummock grassland			Mod
Eucalyptus victrix scattered tall trees over *Acacia citrinoviridis, A. coriacea, Melaleuca glomerata* scattered tall shrubs over **Cenchrus ciliaris* scattered tussock grasses			Mod
Eucalyptus victrix scattered tall trees over *Acacia citrinoviridis* tall open shrubland over **Cenchrus ciliaris* closed tussock grassland			Mod
Eucalyptus victrix, Corymbia hamersleyana low open woodland over *Acacia pruinocarpa, A. inaequilatera, A. citrinoviridis* open shrubland over **Cenchrus ciliaris* open tussock grassland and *Triodia epactia* scattered hummock grasses			Mod
Eucalyptus victrix woodland over *Triodia pungens* open hummock grassland			Mod
Eucalyptus leucophloia, Corymbia hamersleyana low open woodland over Acacia ancistrocarpa, *A. bivenosa, A. tumida* var. *pilbarensis* tall open shrubland over *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835) open hummock grassland			Low

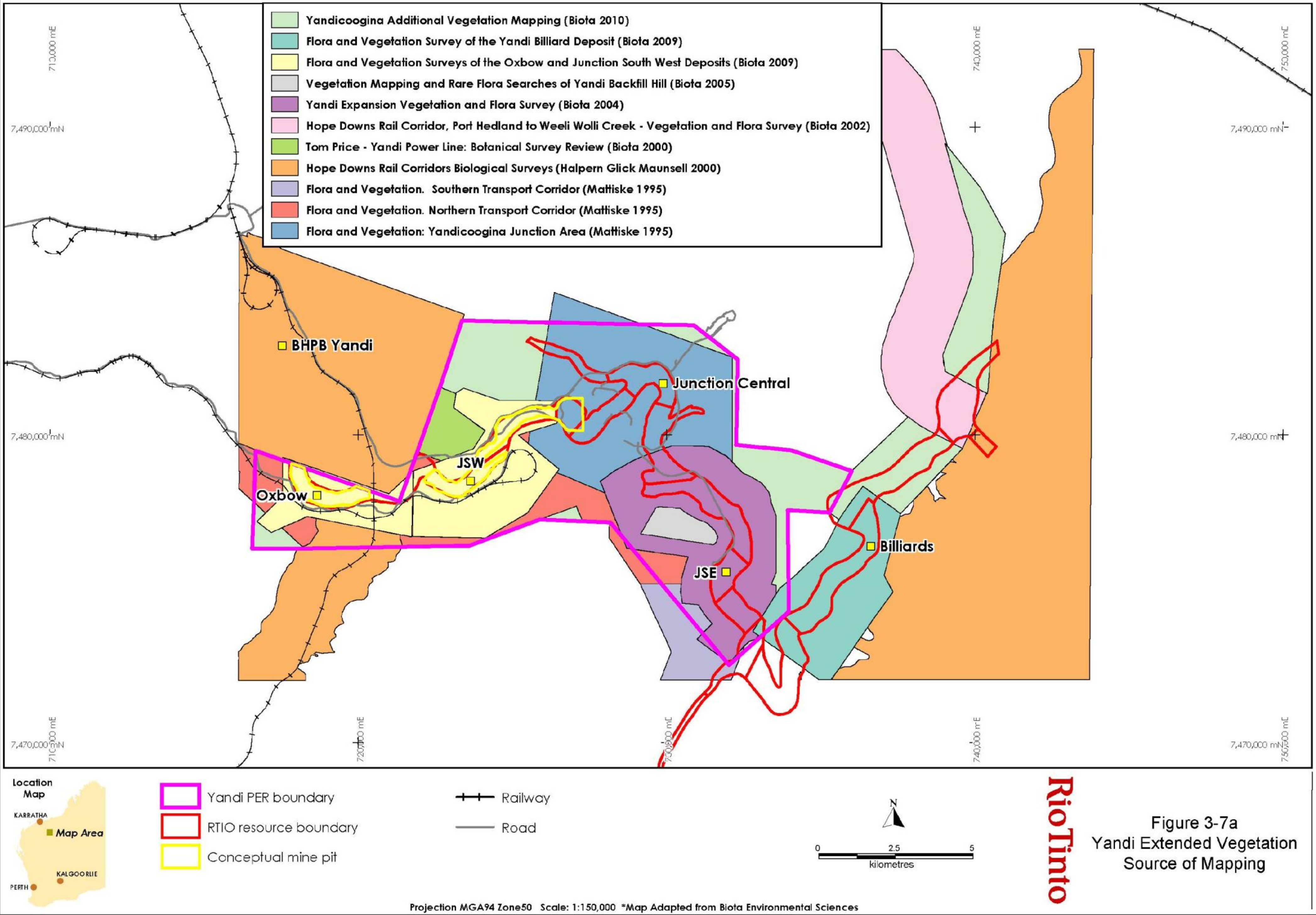
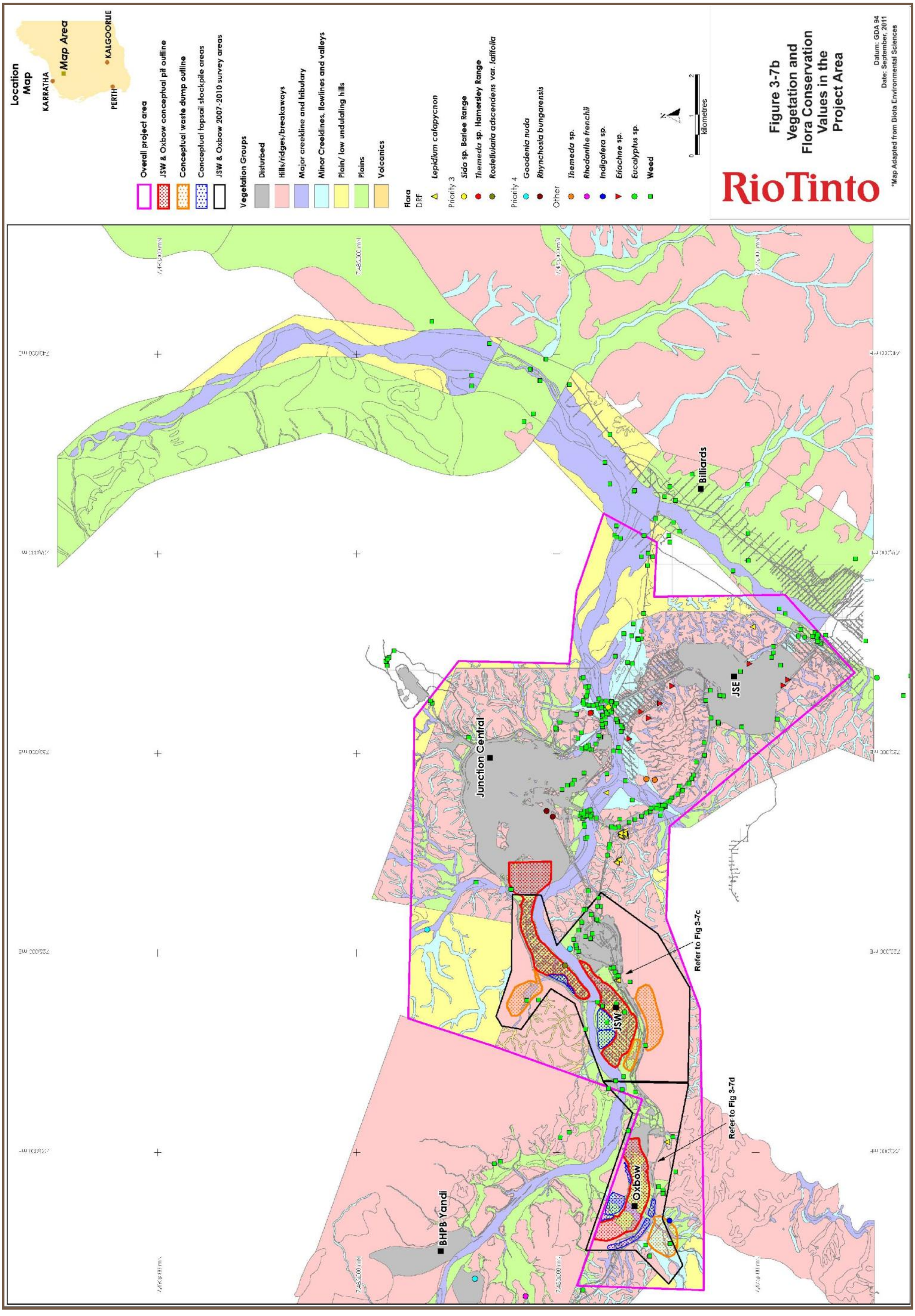


Figure 3-7a
Yandi Extended Vegetation
Source of Mapping


Location Map
KARRATHA
Map Area
KALGOORLIE
PERTH
Overall project area
JSW & Oxbow conceptual pit outline
Conceptual waste dump outline
Conceptual topsoil stockpile areas
JSW & Oxbow 2007-2010 survey areas
Vegetation Groups
Disturbed
Hills/ridges/breakaways
Major creekline and tributary
Minor Creeklines, flowlines and valleys
Plain/ low undulating hills
Plains
Volcanics
Flora
DRF
Lepidium catapycnon
Priority 3
Sida sp. Barlee Range
Themeda sp. Hamersley Range
Rostellularia adscendens var. latifolia
Priority 4
Goodenia nuda
Rhynchosia bungarensis
Other
Themeda sp.
Rhodanthe frenchii
Indigofera sp.
Eriachne sp.
Eucalyptus sp.
Weed
kilometres
Figure 3-7b
Vegetation and Flora Conservation Values in the Project Area
RioTinto
Datum: GDA 94
Date: September, 2011
*Map Adapted from Biota Environmental Sciences
Billiards
JSE
Junction Central
JSW
Oxbow
BHPB Yandi
Refer to Fig 3-7c
Refer to Fig 3-7d

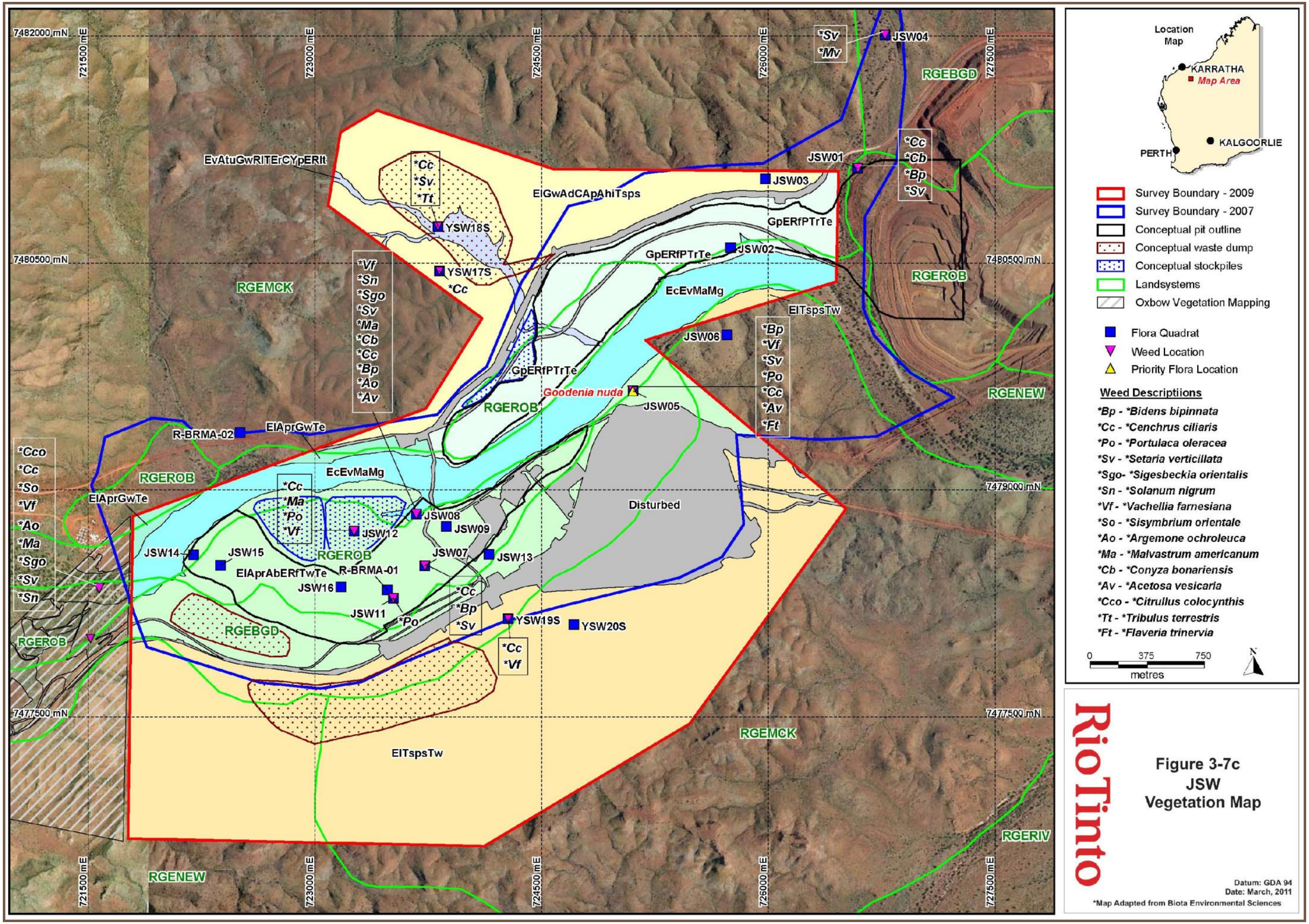


Figure 3-7c
JSW
Vegetation Map

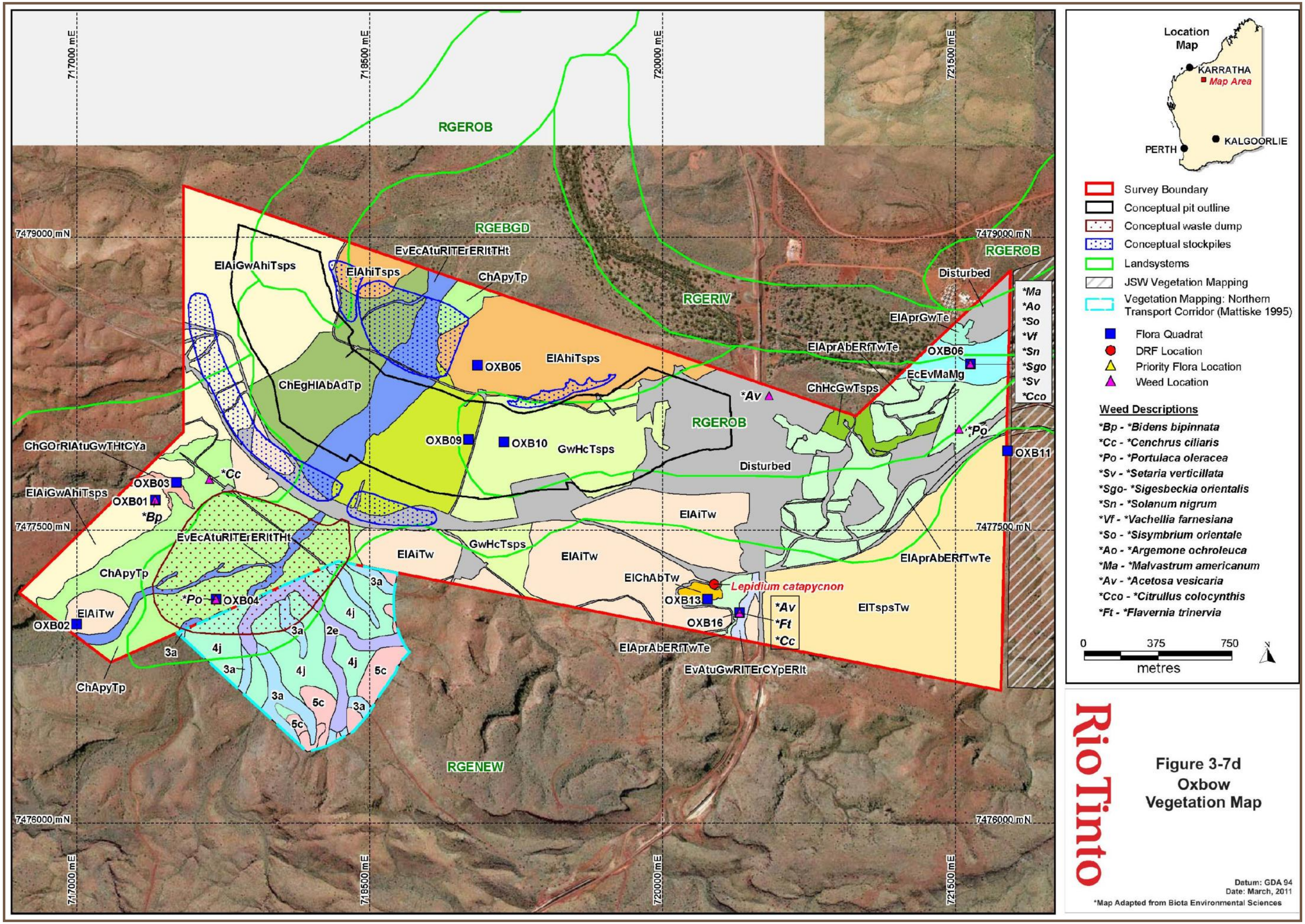


Figure 3-7d
Oxbow
Vegetation Map

Vegetation of Junction South West (Biota)

Vegetation of Major and Minor Creeklines

EcEvMaMg	*Eucalyptus camaldulensis, E. victrix* woodland over *Melaleuca argentea, M. glomerata* low open woodland
EvAtuGwRlTErCYpERlt	*Eucalyptus victrix* scattered low trees over *Acacia tumida* var. *pilbarensis, Grevillea wickhamii* subsp. *hispidula, Rulingia luteiflora* tall shrubland over *Tephrosia rosea* low shrubland over *Cymbopogon procerus, Eriachne tenuiculmis* very open tussock grassland

Vegetation of Plains, Low Plains and Undulating Plains

ElAprAbERfTwTe	*Eucalyptus leucophloia, Acacia pruinocarpa* low woodland over *Acacia bivenosa* scattered shrubs over *Eremophila fraseri* scattered low shrubs over *Triodia wiseana, Triodia epactia* hummock grassland.
GpERfPTrTe	*Grevillea pyramidalis* scattered tall shrubs over *Eremophila fraseri* open shrubland over *Ptilotus rotundifolius* scattered low shrubs over *Triodia epactia* hummock grassland.
ElAprGwTe	*Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Acacia pruionocarpa, Grevillea wickhamii* scattered tall shrubs over *Triodia epactia* hummock grassland

Vegetation of Rocky Hillslopes and Crests

ElGwAdCApAhiTsps	*Eucalyptus leucophloia* scattered low trees over *Grevillea wickhamii, Acacia dicteophleba* scattered tall shrubs over *Cassia pruinosa* scattered shrubs over *Acacia hilliana* scattered low shrubs over *Triodia* sp. Shovellana Hill hummock grassland.
ElTspsTw	*Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Triodia* sp. Shovellana Hill (S. van Leeuwen 3835) *T. wiseana* hummock grassland
Disturbed	Disturbed areas mostly cleared of native vegetation

RioTinto

Vegetation Community Types Descriptions for Junction South West Vegetation Map

Figure 3-7e

*Adapted from Biota Environmental Sciences

Vegetation of Oxbow (Biota)

Vegetation of Major and Minor Creeklines

EcEvMaMg	*Eucalyptus camaldulensis, E. victrix* woodland over *Melaleuca argentea, M. glomerata* low open woodland
EvAtuGwRlTErCYpERlt	*Eucalyptus victrix* scattered low trees over *Acacia tumida* var. *pilbarensis, Grevillea wickhamii* subsp. *hispidula, Rulingia luteiflora* tall shrubland over *Tephrosia rosea* low shrubland over *Cymbopogon procerus, Eriachne tenuiculmis* very open tussock grassland
EvEcAtuRlTErERltTHt	*Eucalyptus victrix, E. camaldulensis* scattered low trees over *Acacia tumida, Rulingia luteiflora* shrubland over *Tephrosia rosea* low open shrubland over *Eriachne tenuiculmis, Themeda triandra* open tussock grassland

Vegetation of Rocky Hill Slopes and Crests

ElAhiTsps	*Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Acacia hilliana* low shrubland over *Triodia* sp. Shovelana Hill (S. van Leeuwen 3835), hummock grassland.
ElTspsTw	*Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Triodia* sp. Shovelana Hill (S. van Leeuwen 3835),*T. wiseana* hummock grassland
ElAiGwAhiTsps	*Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Acacia inaequilatera, Grevillea wickhamii* subsp. *hispidula* tall open shrubland over *Acacia hilliana* low shrubland over *Triodia* sp. Shovelana Hill (S. van Leeuwen 3835) hummock grassland.
ElAiTw	*Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Acacia inaequilatera* tall open shrubland over *Triodia wiseana* open hummock grassland.
ElChAbTw	*Eucalyptus leucophloia* subsp. *leucophloia, Corymbia hamersleyana* low open woodland over *Acacia bivenosa* scattered shrubs over *Triodia wiseana* hummock grassland.
ChGOrRlAtuGwTHtCYa	*Corymbia hamersleyana* scattered low trees over *Gossypium robinsonii, Rulingia luteiflora, Acacia tumida, Grevillea wickhamii* subsp. *hispidula* shrubland over *Themeda triandra, Cymbopogon ambiguus* open tussock grassland.

Vegetation of Plains

ChHcGwTsps	*Corymbia hamersleyana* low open woodland over *Hakea chordophylla, Grevillea wickhamii* tall open shrubland over *Triodia* sp. Shovelana Hill (S. van Leeuwen 3835) open hummock grassland.
ChApyTp	*Corymbia hamersleyana* low open woodland over *Acacia pyrifolia* open shrubland over *Triodia pungens* scattered hummock grasses
EgAtuAeTpTsps	*Eucalyptus gamophylla* low woodland over *A. tumida* var. *pilbarensis, A. elachantha* tall open shrubland over *Triodia pungens, Triodia* sp. Shovelana Hill (S. van Leeuwen 3835) open hummock grassland
GwHcTsps	*Grevillea wickhamii* subsp. *hispidula, Hakea chordophylla* open shrubland over *Triodia* sp. Shovelana Hill (S. van Leeuwen 3835) hummock grassland

RioTinto

Vegetation Community Types Descriptions for Oxbow Vegetation Map

Figure 3-7e

*Adapted from Biota Environmental Sciences

Vegetation of Oxbow (Biota)

Vegetation of Plains

ChEgHlAbAdTp	*Corymbia hamersleyana*, *Eucalyptus gamophylla* low open woodland over *Hakea lorea*, *Acacia bivenosa*, *A. dictyophleba* tall shrubland over *Triodia pungens* open hummock grassland.
ElAprGwTe	*Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees over *Acacia pruinocarpa*, *Grevillea wickhamii* scattered tall shrubs over *Triodia epactia* hummock grassland
ElAprAbERfTwTe	*Eucalyptus leucophloia*, *Acacia pruinocarpa* low woodland over *Acacia bivenosa* scattered shrubs over *Triodia wiseana*, *Triodia epactia* hummock grassland
Disturbed	Disturbed aeas mostly cleared of native vegetation

Vegetation of Oxbow (Mattiske 1995)

2e	Woodland of Eucalyptus victrix
3a	Low Shrubland of mixed *Acacia* species
4j	Hummock Grassland of *Triodia pungens* - *Trioda* spp. with emergent *Eucalyptus xerothermica* and *Accacia* spp.
5c	Hummock Grassland of *Triodia basedowii* with occasional *Triodia wiseana* with emergent *Acacia* spp. and *Eucalyptus leucophloia*

RioTinto

Vegetation Community Types Descriptions for Oxbow Vegetation Map

Figure 3-7e

*Adapted from Biota Environmental Sciences

3.6.4. Riparian vegetation

Riparian vegetation along Marillana and Weeli Wolli Creeks is regarded as being locally significant, due to the relatively limited extent of this vegetation type compared with other locally occurring vegetation types and the ecological services that it provides. These services include:

- the provision of structural habitat elements, such as tree hollows
- protection of streambanks from erosion
- protection of water quality though sediment trapping and nutrient stripping, and
- transfer of subterranean water and nutrients to the surface environment by some of the dominant tree species.

To date, the Yandicoogina operations have maintained a 200 m buffer between the Marillana creekline and ground disturbance for mining activities, with the exception of discharge outfalls and one creek crossing.

3.6.4.1. Water availability and vegetation responses

Water is generally the limiting factor for plant growth in arid environments such as the Pilbara region. The regional environment is characterised by hot temperatures, high evaporative demand and infrequent and irregular rainfall. Much of the vegetation displays xeromorphic[7] adaptations: including the ability to regulate water loss from leaves, extract water from very dry soils and match reproductive strategies with wetter periods. Many species are ephemeral and persist in soil banks in between wetter periods.

The creekline systems often contain deeper soil types, with a greater capacity to store water in between rainfall events. This stored soil water can be used for plant growth. Some of the larger tree species have root systems that enable access to the deep profile, or in some cases, groundwater, either on an ongoing or transient basis. The most prominent of these in the Pilbara are *Eucalyptus camaldulensis* (River Red Gum) and *E. victrix* (Coolibah).

At a localised scale, areas of shallow groundwater that are accessible to species with shallower root systems can also occur. The paperbark species *Melaleuca argentea* (Silver Cadjeput) commonly occurs in these areas and is regarded as being dependent on groundwater to meet its ecological water requirements (Graham 2001; O'Grady *et al.* 2005).

Eucalyptus camaldulensis and *E. victrix* occur extensively along Marillana and Weeli Wolli Creeks in the project area. These species are known to use a range of mechanisms to regulate their water use in response to changes to water availability, such as:

- stomatal control (eg White *et al.* 2000)
- cell-wall elastic adjustment and osmotic adjustment (eg Lemcoff *et al.* 2002)
- leaf area equilibration (eg O'Grady *et al.* 2009)
- hydraulic architecture modification (eg O'Grady *et al.* 2009; Yunusa *et al.* 2010), and
- self thinning (eg Horner *et al.* 2009).

---

[7] Plant structural adaptations for survival in dry conditions

The potential impacts of enhanced or reduced water availability on riparian vegetation include:

- **tree growth responses** including altered biomass partitioning, canopy density, and flowering and seed production dynamics
- **modified recruitment** and senescence dynamics
- **altered root system** architecture in response to modified water table depth
- **increased leaf area** due to increasing water availability
- **canopy thinning** or tree death under conditions of prolonged waterlogging, and
- **changes in vegetation structure** and composition, including the spread of weeds.

Note that temporal gradients and time lags may have important effects on tree responses. For example, tree root systems may be able to adjust to gradual changes in water table depth, but be less able to adjust to rapid changes.

RTIO is considering a range of possible management interventions to minimise tree stress from artificially increased water availability (due to surplus water discharge) and then a return to more natural flow regimes. These include:

- **manage the timing of discharge** to more closely emulate the natural flow regime (episodic). Includes staged reductions in discharge volumes so that trees can adapt to the reinstated natural wetting regime, and
- **thinning treatments**, targeting artificially induced recruitment of samplings in areas where tree density significantly increases because of discharge water.

In the event that management triggers are breached, the DEC will be consulted to help determine the most appropriate management response. Riparian vegetation management issues are discussed more in Section 7.1.

3.6.4.2. Tree health monitoring

A riparian tree health monitoring program has been developed and implemented by RTIO at Yandicoogina over the past decade. The program includes remote sensing (multispectral imaging) and on-ground tree health monitoring.

The ground-based monitoring has included 11 monitoring locations along Marillana Creek and 22 locations along Weeli Wolli Creek. These have been measured on an annual basis since 2003, and on a quarterly basis since 2006. Foliage and crown cover has been assessed using digital photography methods. Sites, both within and outside the areas exposed to modified flow regimes from surplus water disposal, have been monitored (Figure 3-8).

Results of the riparian monitoring program, combined with ongoing observations and operational experience include:

- around 150 eucalypts have been monitored along Marillana Creek since 2003. In this time two trees on Marillana Creek and five trees on Weeli Wolli Creek have died or displayed a severe decline in health (ie total defoliation).
- no trigger levels identified in the *Yandicoogina Riparian Vegetation Management Plan* have been breached during this time.
- changes in crown and foliage cover through time have been recorded (Figure 3-9 and Figure 3-10). These changes are highly correlated with annual rainfall patterns.

- losses in foliage cover were recorded at site Y2 (western edge of JC pit) and sites Y3, Y4 and Y5 (JSW) between 2005 and 2006, downstream of the BHPBIO discharge point (Figure 3-9). In March 2010, foliage cover again declined at site Y5 by ~20%. These events are correlated with reduced water availability, attributed to natural climate variation. Reduced discharge volumes from the BHPBIO outlet and RTIO mine pit dewatering at JC potentially exacerbated this issue.
- at the remaining sites, foliage cover has fluctuated in response to climate, with no discernable changes detected from the dewatering regime (Figure 3-10).

Additional observations from the Yandicoogina site and elsewhere in the Pilbara region suggest that:

- over time, riparian areas that are subjected to artificial inundation, may show increased recruitment and stand leaf area index[8]. Note that increases in riparian vegetation density may also be exacerbated by increased creek flows and runoff during periods of above average annual rainfall.
- dewatering soil profiles beneath riparian vegetation has the potential to induce drought stress in overstorey *Eucalyptus* species.
- if water discharge suddenly stops, selective tree health may decline due to the immediate reduction in water availability. At a stand level, the leaf area index would be expected to adjust to conditions of less plant available water and, ultimately, establish a new dynamic equilibrium.

To date, the monitoring program has not detected significant differences in riparian vegetation response between areas affected by dewatering and surplus water discharge activities and unaffected areas. The magnitude of change in foliar canopy cover has been relatively small since the measurements started.

Since 1993, airborne multispectral imagery has been used intermittently (about every year) to monitor changes in vegetation condition in the lower Marillana Creek. Increases and decreases in Plant Cell Density (PCD) index[9] have been detected through time in various sections of the creek system. The patterns of PCD change provide evidence of increased density of riparian vegetation within sections of the creek system. This has been correlated with the prolonged release of surplus water. In most cases, the change in vegetation pattern is confined to areas adjacent to the discharge outlets and pools, associated with local depressions filled by discharged water.

Analysis of the remote sensing imagery between 2002 and 2008 has revealed that changes in the tree canopy cover, density and condition are dominated by impacts of fire and tree loss /damage caused by creek flooding (Specterra 2008). No significant correlations between exposure to dewatering discharge and vegetation health change have been detected using this method. Figure 3-11 and Figure 3-12 support this finding, and show how different creek sections have experienced net gains or net losses on a timescale of years.

The remote sensing data is consistent with results from on-ground monitoring, and has been successful in detecting natural disturbance events such as fires and cyclonic flooding. RTIO is actively seeking ways to improve the analytical methods used to distinguish between mining impacts and natural variability on riparian vegetation.

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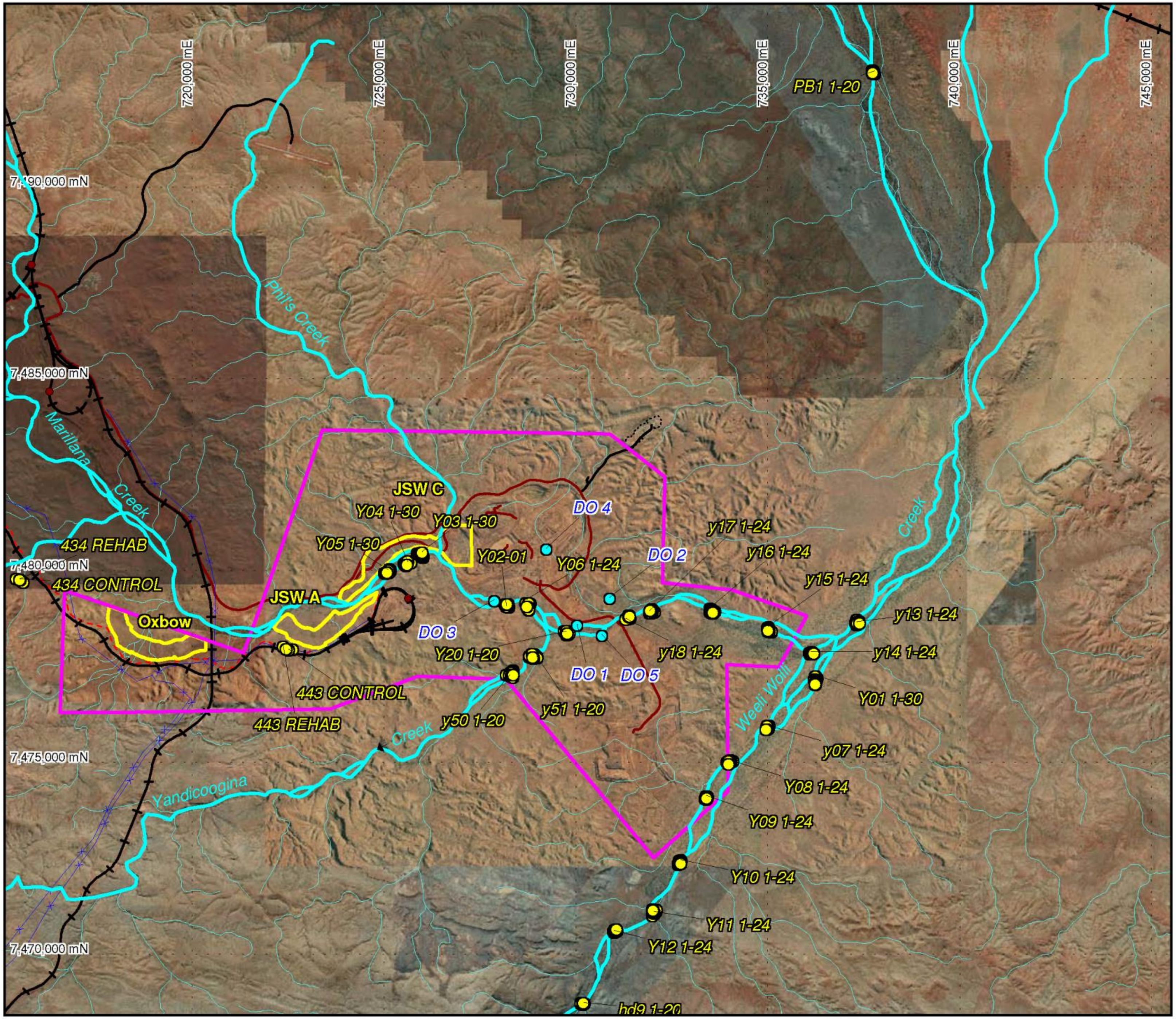
[8] Leaf Area Index is defined as the ratio of canopy leaf area to ground surface area beneath the projected canopy.

[9] PCD is an index based on the ratio of vegetation canopy reflectance in infrared and red wavelength bands.



LEGEND

Overall Project Area

JSW & Oxbow Conceptual Mine Pits

Tree Health Monitoring Sites

Discharge Points

Railway

Powerline

Minor Road

Mine Road

Rail Access Road

Town Road

N

SCALE

0 2.5 5km

1:150 000 @ A4

RioTinto

Resource Strategy & Planning

Figure 3-8
Tree Health Monitoring Sites at Yandicoogina

Drawn: M.Swebbs
Date: Sept. 2011

Plan No. PDE0074948v6
Proj: MGA94 Zone50

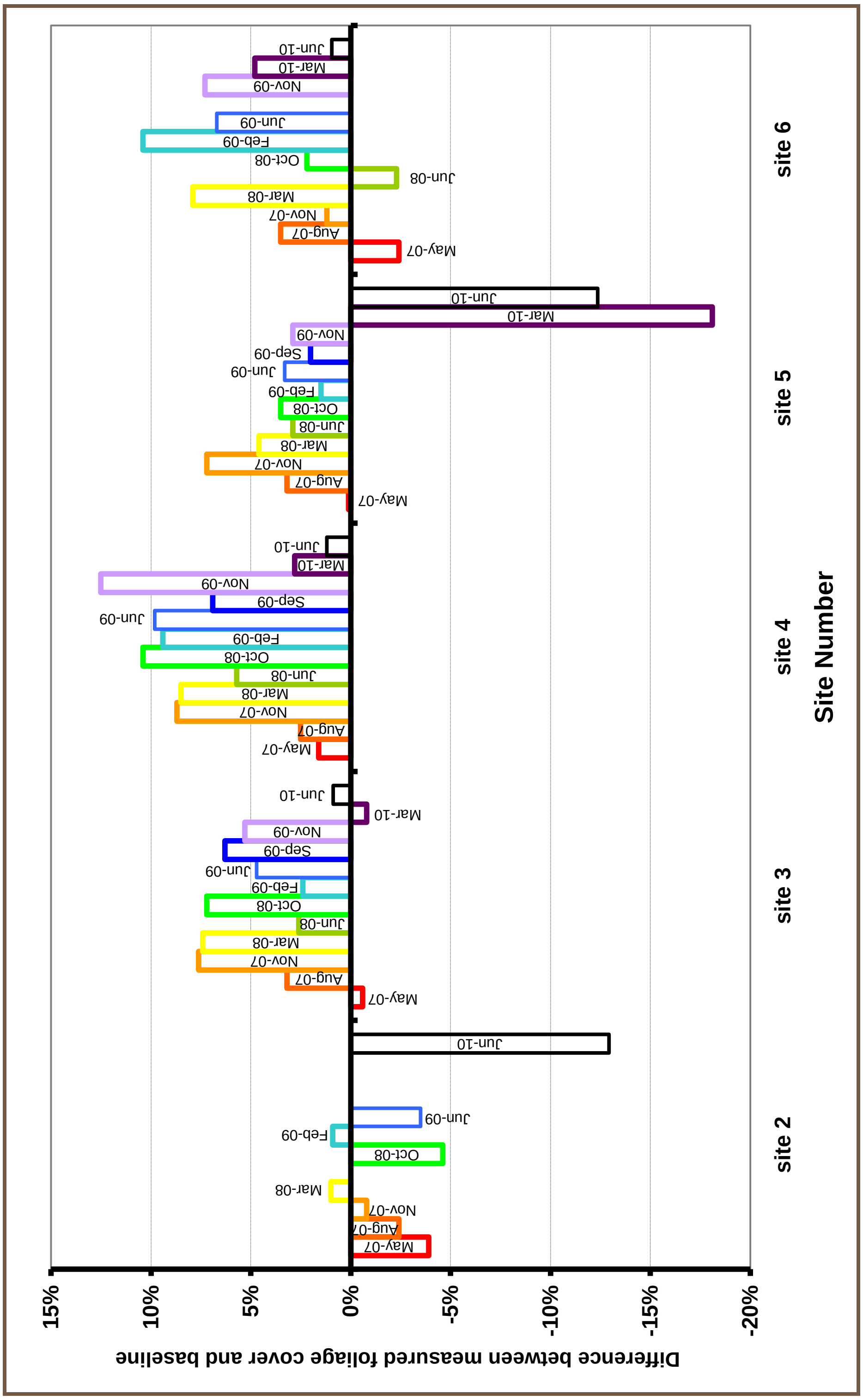


Figure 3-9 – Changes on foliage cover through time at monitoring sites in the vicinity of JSW measured using canopy photography[10]

[10] Using a baseline defined as the mean foliage cover of measurements made in October 2005, October 2006 and February 2007. The vertical axis displays units of foliage cover (leaf area expressed as a percentage of the vertically projected land surface area).

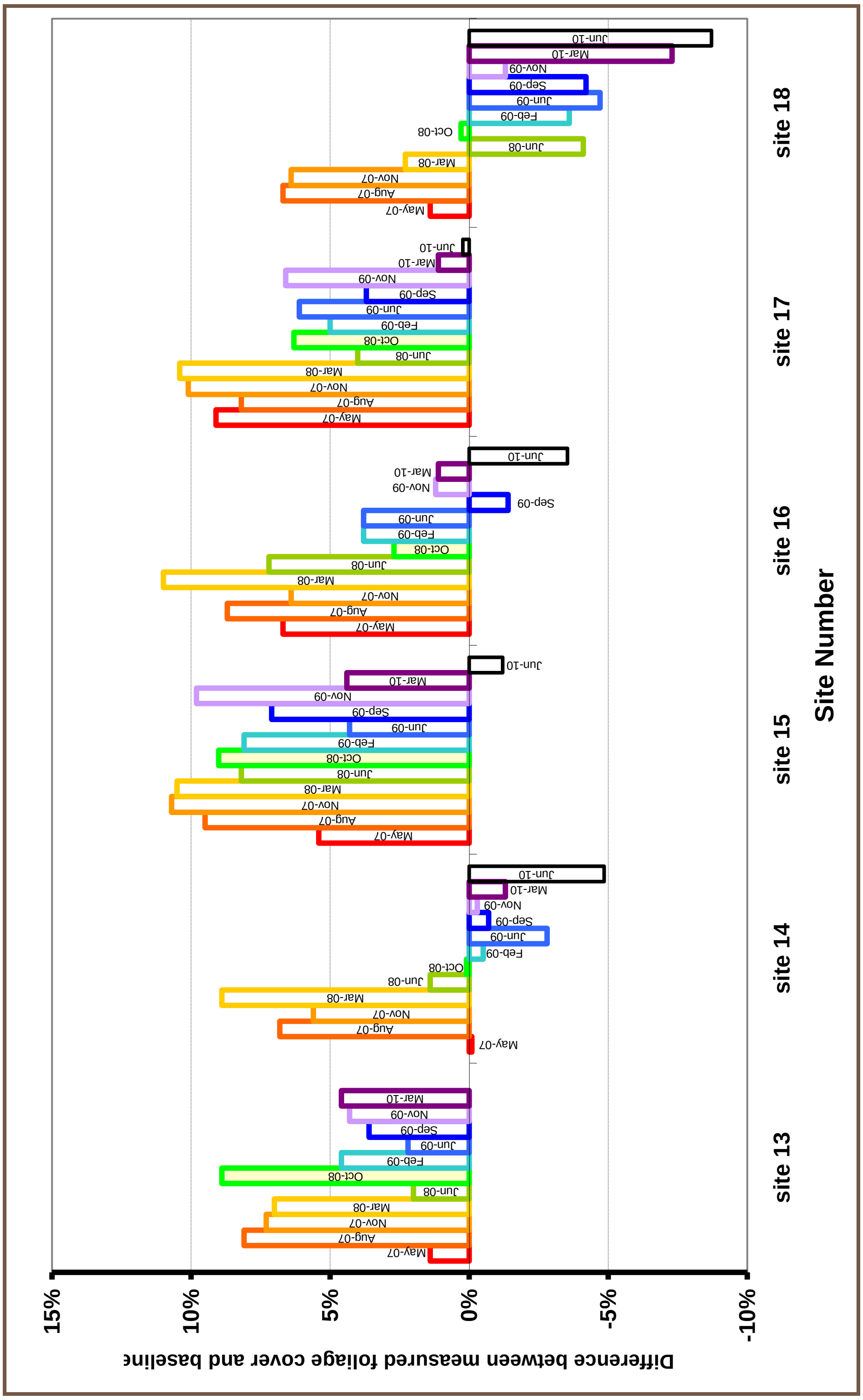
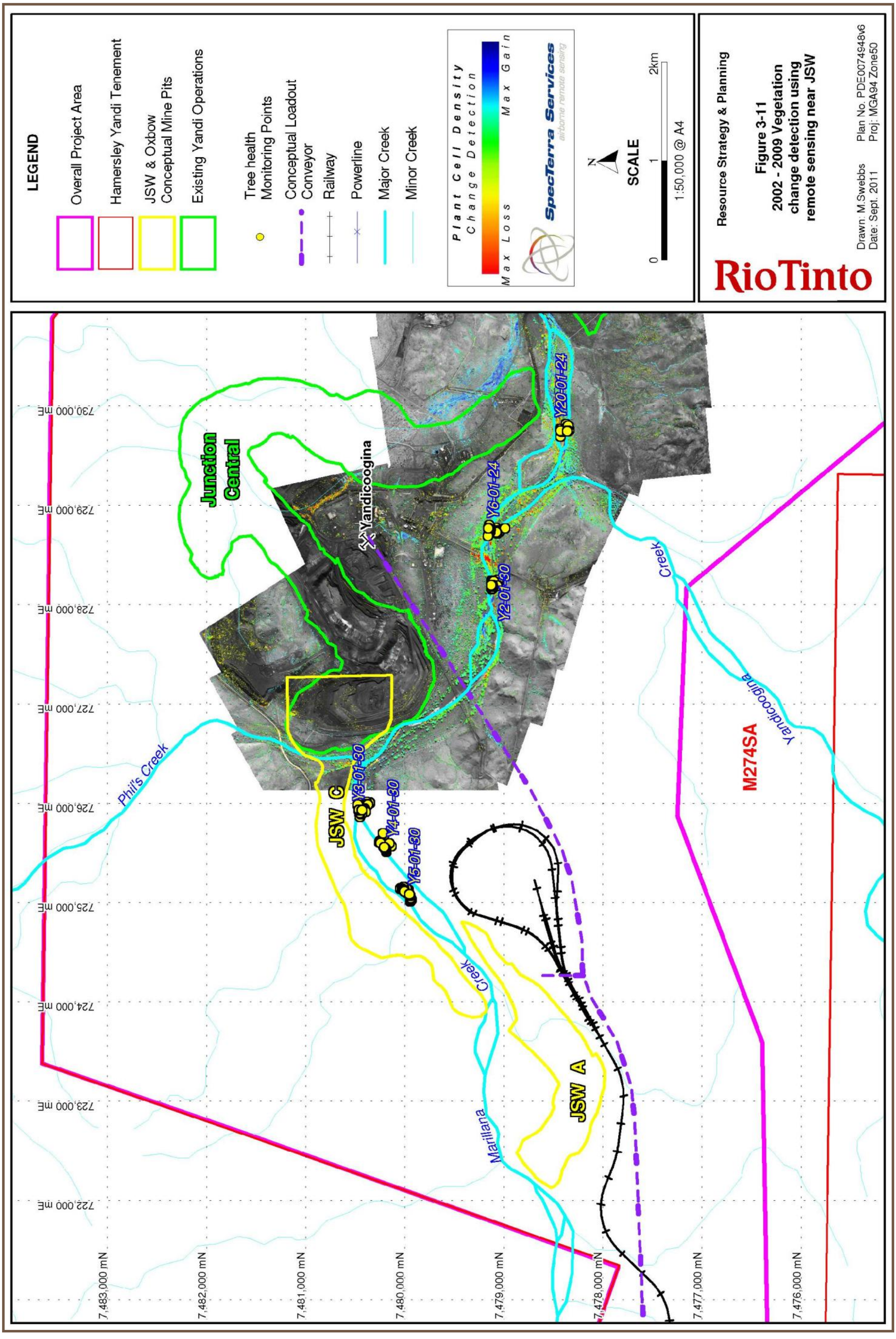
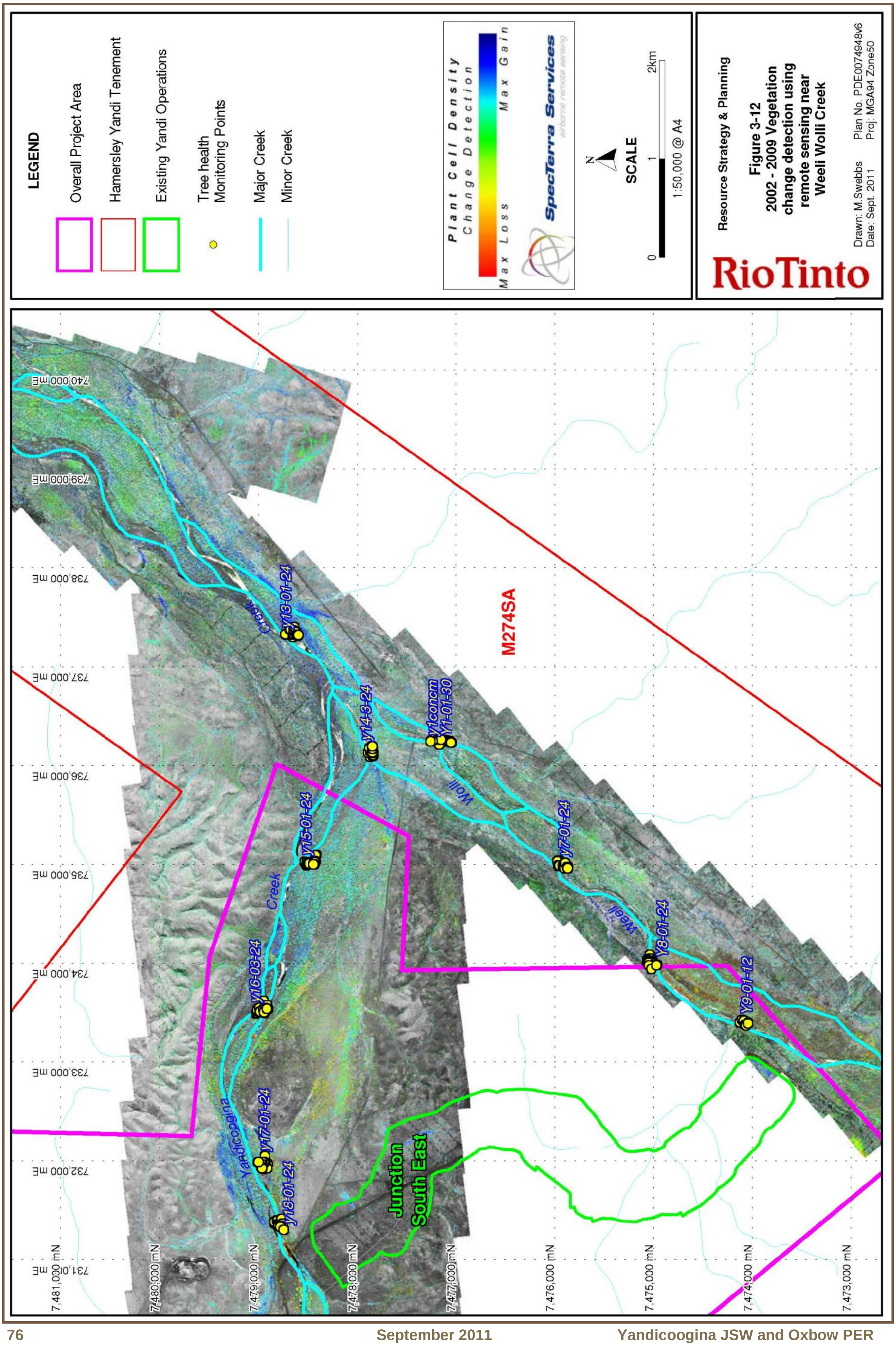


Figure 3-10 – Changes in foliage cover through time at monitoring sites in the lower Marillana Creek and nearby Weeli Wolli Creek measured using canopy photography [11]

[11] Using a baseline defined as the mean foliage cover of measurements made in October 2005, October 2006 and February 2007. The vertical axis displays units of foliage cover (leaf area expressed as a percentage of the vertically projected land surface area).


LEGEND
Overall Project Area
Hamersley Yandi Tenement
JSW & Oxbow Conceptual Mine Pits
Existing Yandi Operations
Tree health Monitoring Points
Conceptual Loadout Conveyor
Railway
Powerline
Major Creek
Minor Creek
Plant Cell Density Change Detection
Max Loss
Max Gain
SpecTerra Services
airborne remote sensing
SCALE
0
1
2km
1:50,000 @ A4
Resource Strategy & Planning
Figure 3-11
2002 - 2009 Vegetation change detection using remote sensing near JSW
Drawn: M.Swebbs
Date: Sept. 2011
Plan No. PDE0074948v6
Proj: MGA94 Zone50
RioTinto
Junction Central
Yandicoogina
JSW C
JSW A
M274SA
Phil's Creek
Marillana Creek
Yandicoogina Creek
Y20-01-24
Y6-01-24
Y2-01-30
Y3-01-30
Y4-01-30
Y5-01-30
722,000 mE
723,000 mE
724,000 mE
725,000 mE
726,000 mE
727,000 mE
728,000 mE
729,000 mE
730,000 mE
7,483,000 mN
7,482,000 mN
7,481,000 mN
7,480,000 mN
7,479,000 mN
7,478,000 mN
7,477,000 mN
7,476,000 mN


LEGEND
Overall Project Area
Hamersley Yandi Tenement
Existing Yandi Operations
Tree health Monitoring Points
Major Creek
Minor Creek
Plant Cell Density
Change Detection
Max Loss
Max Gain
SpecTerra Services
airborne remote sensing
N
SCALE
0
1
2km
1:50,000 @ A4
Resource Strategy & Planning
Figure 3-12
2002 - 2009 Vegetation change detection using remote sensing near Weeli Wolli Creek
Drawn: M.Swebbs
Date: Sept. 2011
Plan No. PDE0074948v6
Proj: MGA94 Zone50
RioTinto
M274SA
Junction South East
Y13-01-24
Y14-3-24
Y1concm
Y1-01-30
Y15-01-24
Y7-01-24
Y8-01-24
Y9-01-12
Y16-03-24
Y17-01-24
Y18-01-24
Weeli
Wolli
Creek
Yandicoogina
731,000 mE
732,000 mE
733,000 mE
734,000 mE
735,000 mE
736,000 mE
737,000 mE
738,000 mE
739,000 mE
740,000 mE
7,481,000 mN
7,480,000 mN
7,479,000 mN
7,478,000 mN
7,477,000 mN
7,476,000 mN
7,475,000 mN
7,474,000 mN
7,473,000 mN

3.7. Terrestrial fauna

The fauna of the central Pilbara is typified by arid-adapted vertebrates with generally extensive regional distributions. At the Yandicoogina locality, the major fauna habitat types correspond with the major landform and vegetation groups outlined in Sections 3.5 and 3.6.

3.7.1. Historical surveys

Since the 1990s, a large amount of fauna survey work has been undertaken in the Yandicoogina locality, mainly for previous mining approvals including Yandicoogina JC in 1995 and JSE in 2005 (Biota 2010c; Appendix A3). A review of this work in 2004 included the statement '*the region is one of the best collected in the State in terms of herpetofauna and mammals*' (Biota 2004b).

The key surveys that have been completed include:

- Yandicoogina (HI) biological survey (Ninox Wildlife Consulting 1995)
- BHPBIO Yandi Stage II biological survey (Ecologia 1995)
- Weeli Wolli Springs biological survey (Ecologia 1998)
- BHPBIO Marillana Creek biological surveys (summarised in Halpern Glick Maunsell 1999)
- BHPBIO Marillana Creek rare fauna survey (Bamford and Associates 2003)
- Western Rail Corridor survey from the Hope Downs mine to the vicinity of Coondewanna Flats (Halpern Glick Maunsell 2000)
- Eastern Rail Corridor survey from the Hope Downs mine to Weeli Wolli siding (Halpern Glick Maunsell 2000)
- Vertebrate fauna survey of the proposed Hope Downs rail corridor from Weeli Wolli Siding to Port Hedland (Biota 2002b)
- Yandicoogina Expansion Desktop Fauna Assessment and Targeted Invertebrate Survey (Biota 2004b),
- Vertebrate fauna survey of a proposed extension to the Hope Downs rail corridor through the Hamersley Range (Biota 2004c), and
- DEC Pilbara Biological Survey (eight sites of which were in the Yandicoogina locality).

Collectively, these surveys provide a comprehensive overview of the fauna assemblage present in the wider Yandicoogina locality, a subset of which would be expected to utilise the habitats of the overall project area. The locality assemblage comprises 301 species across 78 families (Appendix A3). The breakdown of native species amongst animal groups is summarised as follows:

- 35 mammal species (18 non-volant and 17 bat species)
- 145 avifauna species (80 passerine and 65 non-passerine species), and
- 121 herpetofauna species (114 reptile species and seven frog species).

An additional six introduced species have been recorded including the cow, donkey, house mouse, cat, rabbit and fox (Appendix A3).

3.7.2. Project area surveys

Project-related surveys in the JSW and Oxbow locations were completed by Biota Environmental Sciences in July 2008 (Figure 3-13 and Figure 3-14; Biota 2010c; Appendix A3). The surveys included the JSW and Oxbow disturbance areas and immediate surrounds.

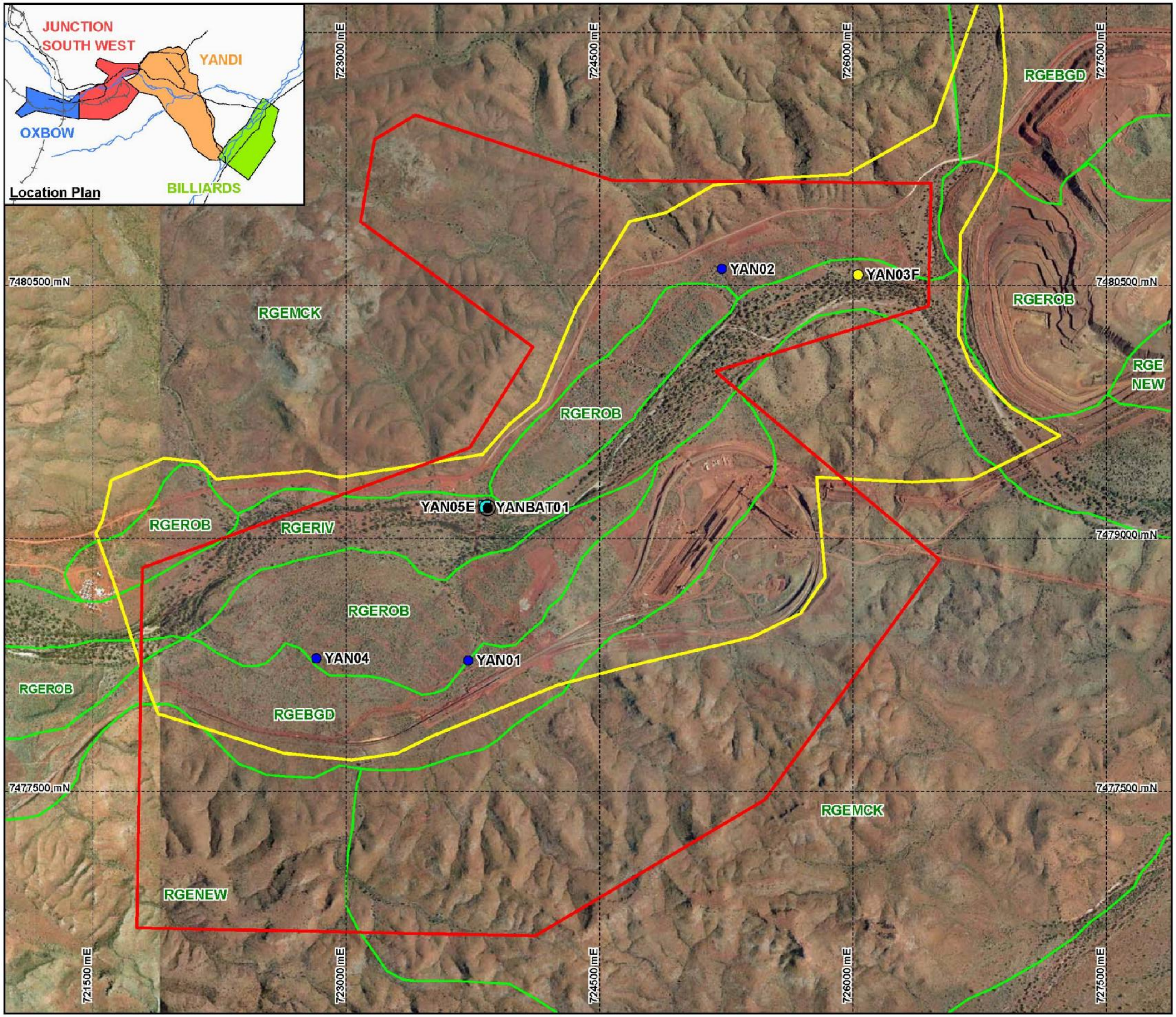
The surveys involved trapping techniques (pit-traps, funnel-traps and Elliot traps), systematic searches and opportunistic observations. The methodology used was consistent with EPA Position Statement No. 3 '*Terrestrial Biological Surveys as an Element of Biodiversity Protection*' (EPA 2002b) and Guidance Statement No. 56 '*Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia*' (EPA 2004c).

Four separate broad fauna habitat units were identified across the proposed JSW and Oxbow disturbance areas; defined on the basis of landform, vegetation structure and vegetation composition (Table 3-4). An additional habitat unit (Rocky breakaways and screes) was mapped as occurring within the overall project area but south of the proposed JSW and Oxbow disturbance areas. These habitats represent a small subset of the extent of similar habitats in the Pilbara and are widespread throughout the bioregion.

Table 3-4 – Habitat types in the proposed JSW and Oxbow disturbance areas

Landform	Vegetation and substrate	Area within survey area (ha)
Major drainage line	*Eucalyptus* spp. over *Acacia* spp. over mixed shrubs over *Triodia* spp. and tussock grasses on river gravel.	183
Drainage line	*Eucalyptus* spp. over Acacia spp. (some with *Grevillea wickhamii*) over *Triodia* spp. and grasses on stony loam.	73
Rocky hillslopes and crests	Scattered *Eucalyptus* spp., *Corymbia* spp. and *Acacia* spp. over *Triodia* on stony slope. Scattered *Eucalyptus* spp. and native grasses on scree slopes.	1055
Plain and valley floors	*Acacia* spp. and *Grevillea* sp. over *Triodia* spp. on stony loam.	639

The surveys yielded a total of 72 vertebrate fauna species, across 38 families: including 46 species of avifauna, 12 species of mammals and 14 species of herpetofauna. The mammal groups included six species of bats and two non-native species (the cow and donkey).



RioTinto

Figure 3-13
Junction South West
Fauna Survey Areas &
Fauna Trapping Sites

Datum: GDA 94
Date:March, 2011

*Map Adapted from Biota Environmental Sciences

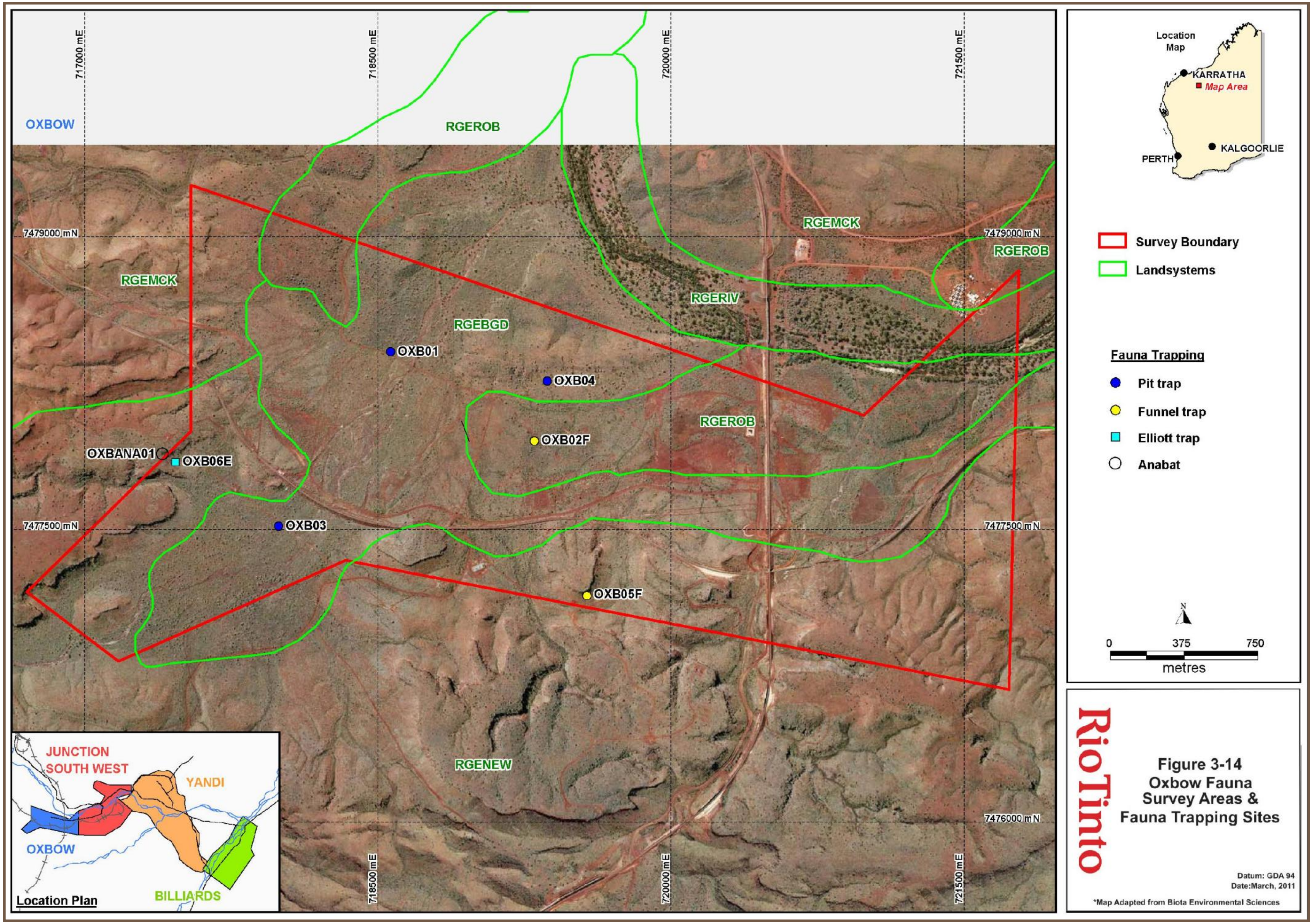


Figure 3-14
Oxbow Fauna
Survey Areas &
Fauna Trapping Sites

Assessment of Fauna assemblage

The recorded assemblage represented a typical subset of the vertebrate taxa that occur in the Yandicoogina locality. The lower species diversity in the 2008 survey (72 species compared to 147 in 2004) was largely due to the cool weather conditions during the survey. Cooler weather can hinder the activity of some species such as bats and reptiles.

Other survey limitations included:

- not all sections of the fauna survey area were ground-truthed or equally sampled for fauna due to accessibility constraints, and
- much of the JSW study area had been burnt just prior to the survey. As a result, the sampled fauna populations may not have been representative of the area prior to the impact of fire.

However, given the extensive history of fauna surveys in the Yandicoogina locality (Section 3.7.1), the adequacy of the project area surveys is not considered to be compromised by these limitations. In aggregate, the various previous surveys provide a comprehensive basis for describing the Yandicoogina locality fauna assemblage.

The absence from the disturbance area fauna of families and species in the broader locality assemblage can be attributed to a range of common factors, including survey weather conditions, local habitat disturbance, lack of suitable habitats for some species and normal patterns of seasonal variation in distributions (see discussion in Biota (2011c); Appendix A3).

Species of conservation significance

Four species of conservation significance were recorded in the JSW and Oxbow surveys, and an additional six species were assessed as having a reasonable likelihood of occurring in this area (Table 3-5). None of these species have a special reliance on the habitats within the project disturbance area. For each species, the requirement to undertake more intensive species specific surveys was evaluated on the basis of available habitat types, methodologies used in completed fauna surveys and the likelihood of species occurrence. The Northern Quoll was selected for additional survey effort, given recent Commonwealth focus on this species under the EPBC Act.

Table 3-5 – Species with conservation significance recorded or considered likely to occur in the Yandicoogina locality

Species	State Level	Federal Level	Distribution	Rationale for targeted survey
Species recorded in project area surveys (Biota 2010c; Appendix A3)				
***Merops ornatus* (Rainbow Bee-eater)**	N/A	Migratory	Widespread throughout much of Western Australia.	Sampled for as part of standard avifauna transects.
***Neochmia ruficauda subclarescens* (Star Finch)**	Priority 4	Vulnerable	Regarded as a Pilbara endemic. This species is typically confined to reed beds and adjacent vegetation communities along permanent waterways in the Pilbara.	Sampled for as part of standard avifauna transects
***Pseudomys chapmani* (Western Pebble-mound Mouse)**	Priority 4	N/A	Common to very common in suitable habitat with the Hamersley and Chichester sub-regions of the Pilbara.	Targeted by searching for mounds in suitable habitat, and Elliott trapping.
Possible short range endemic invertebrate species	N/A	N/A	Specimens lodged with WA museum.	Targeted sampling in suitable habitat.
Not recorded in project area surveys – but assessed as having a reasonable likelihood of occurrence				
***Liasis olivaceus barroni* (Pilbara Olive Python)**	Schedule 1 - Vulnerable	Vulnerable	Regarded as a Pilbara endemic, this subspecies has a known distribution that coincides roughly with the Pilbara bioregion.	Sampled as part of targeted searches, plus opportunistic sightings.
***Falco hypoleucos* (Grey Falcon)**	Priority 4	N/A	Widespread but rare throughout the arid zone of Australia.	Sampled for as part of standard avifauna transects.
***Falco peregrines* (Peregrine Falcon)**	Schedule 4	N/A	This species occurs across much of the Australian continent.	Sampled for as part of standard avifauna transects.
***Ramphotyphlops ganei* (Blind Snake)**	Priority 1	N/A	Insufficient data is known about the ecology of this species to determine whether it may occur within the habitats available within the study area.	Not specifically targeted, but pit trap lines would collect this species if present.
***Ardeotis australis* (Australian Bustard)**	Priority 4	N/A	This species occurs over much of Western Australia, with the exception of the more heavily wooded southern portions of the state.	Sampled for as part of standard avifauna transects, but more commonly sighted opportunistically.
***Burhinus grallarius* (Bush Stone-curlew)**	Priority 4	N/A	This species occurs across much of the Australian continent.	Sampled for as part of standard avifauna transects, but more commonly sighted opportunistically.

Species	State Level	Federal Level	Distribution	Rationale for targeted survey
Species known from the central Pilbara region but assessed as having a low likelihood of occurrence (on the basis of habitat and ecological preferences)				
Pezoporus occidentalis **(Night Parrot)**	Schedule 1 – Critically Endangered	Endangered	Night Parrots have been reported from every state on the Australia mainland. Most records come from hummock grasslands with Spinifex (*Triodia*), from areas dominated by samphire, or particularly, where these two habitats are side by side.	Unlikely to occur in the disturbance area (Biota 2010c), so not specifically targeted.
Dasyurus hallucatus **(Northern Quoll)**	Schedule 1 - Endangered	Endangered	Restricted to several disjunct areas across Northern Australia, including the northwest Kimberley and Pilbara regions of Western Australia.	Low probability of occurrence (Biota 2010c), but still the subject of a targeted trapping programme (Biota 2009), given recent Commonwealth focus on this species.
Macrotis lagotis **(Bilby)**	Schedule 1 - Vulnerable	Vulnerable	Confined to *Triodia* hummock grassland and *Acacia* scrub across parts of northern Australia.	Unlikely to occur in the disturbance area (Biota 2010c), so not specifically targeted.
Leggadina lakedownensis **(Short-tailed Mouse)**	Priority 4	N/A	This species is known to occur in the Pilbara and Kimberley regions of Western Australia.	Unlikely to occur in the disturbance area (Biota 2010c), so not specifically targeted.
Macroderma gigas **(Ghost Bat)**	Priority 4	N/A	Restricted to the tropical north of the Australian continent.	Potential foraging habitat, but no roost site opportunities within the disturbance area – not specifically targeted, but sampled as part of general bat survey methods.
Rhinonicteris aurantius **(Pilbara Orange Leaf-nosed Bat)**	Schedule 1 - Vulnerable	Vulnerable	Occurs in the Pilbara region of Western Australia, through the Kimberley and across the Top End into north-western Queensland.	Potential foraging habitat, but no roost site opportunities within the disturbance area – not specifically targeted, but sampled as part of general bat survey methods.

3.7.2.1. Surface water discharge footprint

The fauna values of downstream sections of Weeli Wolli Creek within the potential zone of surface water discharge from the Hamersley Yandicoogina operations were assessed using aerial photography and extrapolation of findings from the completed surveys (Biota 2010b). The habitat values of these areas were assessed to be unexceptional and well-represented elsewhere. On this basis, it is unlikely that terrestrial fauna will be significantly impacted by discharge activities associated with the project.

3.7.2.2. Targeted studies

A range of additional targeted fauna studies were undertaken on the basis that the taxa involved had not been specifically targeted in the general fauna surveys, but had some potential to occur in proposed disturbance areas.

Short Range Endemic (SRE) survey

In March 2010, an additional, targeted Short Range Endemic (SRE) survey was undertaken within the JSW and Oxbow fauna survey areas (Figure 3-13 and Figure 3-14; Biota 2010c; Appendix A3). The SRE survey used techniques consistent with EPA Guidance Statement No. 20 (EPA 2009c) and was targeted at a small number of specific groups that are known to potentially harbour SRE taxa.

No invertebrate groups of interest were recorded in the JSW area. Invertebrate species representing five groups were collected from the Oxbow area:

1. beetles (Coleoptera)
2. silverfish (Thysanura)
3. terrestrial snails (Gastropoda)
4. pseudoscorpions (Pseudoscorpionida), and
5. sac spiders (Trochanteriidae).

While the last three groups are known to potentially contain short-range endemic taxa, all of those collected during the survey have been collected elsewhere in the Pilbara Bioregion. Museum identifications are currently pending, but the morphotypes collected were typical of past collections from the locality. The disturbance area is considered to have a low risk of supporting short-range endemic species.

Survey for Northern Quoll

The Northern Quoll has a broad distribution in the Pilbara region, and is noted for its dynamic population ecology. Although uncommon in the Yandicoogina locality, the species is able to rapidly colonise suitable habitat areas under favourable conditions.

Given the potential occurrence of the Northern Quoll in the project areas, and its high importance for conservation at the State and National level, a targeted survey for this species was conducted within and adjacent to the project area in October 2009 (Biota 2009; Appendix A4). Conducted over a six night period, the survey involved placing 259 medium-sized Elliot traps in seven lines of up to 50 traps and a single line of 18 larger Elliot traps. Trapping sites were chosen to cover a range of habitats with the potential for the Northern Quoll, including drainage lines and breakaways. The survey did not detect any Northern Quolls or other evidence of their presence.

Northern Quoll position paper

In addition to the targeted survey for the Northern Quoll, the potential for the project to impact the species was further evaluated to support State and Commonwealth impact assessment processes (Biota 2010d; Appendix A5). Findings include:

- no Northern Quoll individuals have been recorded during historical Elliott trapping in the Yandicoogina locality, comprising more than 10,000 trap nights over the past 15 years
- a recent systematic and targeted Elliott trap effort over several phases failed to record the species, and
- systematic Elliott trap effort over several phases failed to record the Common Rock Rat (*Zyzomys argurus*), which is regarded as keystone prey species of the Northern Quoll.

The assessment concluded that there was no evidence to indicate a significant Northern Quoll population within the project area and wider Yandicoogina locality. The locality is one of the most intensively surveyed areas of the Pilbara region for vertebrate fauna.

3.7.3. Feral animals

Marillana Station produces beef cattle. The Station has access to ML274SA and cattle periodically graze in this area.

The current Yandicoogina operations maintain an ongoing feral cat trapping program using cage traps. From 2007 to 2009, thirteen cats were captured and euthanised.

3.8. Aquatic fauna

The Marillana and Weeli Wolli Creek systems provide habitat for a variety of vertebrate and invertebrate aquatic fauna. A subset of the invertebrate assemblage includes hyporheic species, which reside in the area below the streambed, where water percolates through spaces between the rocks and cobbles. The hyporheic zone is recognised as providing a range of important ecological functions, such as primary productivity and nutrient cycling (Boulton *et al.* 2010). However, its role in the ecology of intermittent creek systems in the Pilbara region is poorly understood.

3.8.1. Historical surveys

The Yandicoogina locality has been included in a number of wider scale aquatic fauna surveys, which have provided some initial baseline information on aquatic fauna composition and abundance within the project area. A downstream section of Marillana Creek was sampled for macroinvertebrates in 1998 as part of the First National Assessment of River Health (FNARH). This program included 550 sites in all of the major river systems of Western Australia (WRM 2011; Appendix A7). Additional surveys of the upper Fortescue River catchment were undertaken by Streamtec in 2002 and 2003 for BHHBIO. These surveys included a section of Marillana Creek, upstream from the project area and targeted water quality, riparian vegetation, aquatic macroinvertebrates, fish and other vertebrates.

3.8.2. Project area surveys

Multiple sampling phases for aquatic fauna were completed in Marillana and Weeli Wolli Creeks between 2008 and 2010 (WRM 2010; Appendix A6), in creek sections including and extending outside the project area. These surveys included 12 sampling sites on Marillana Creek, six of which were located in the vicinity of JSW and six downstream of the JC mine pit.

The aquatic fauna survey provided detailed characterisation of fish and aquatic invertebrate assemblages within the creek systems. The key findings from the 12 sampling sites on Marillana Creek included:

- 59 microinvertebrate taxa were recorded, comprised of Protista (Ciliophora and Rhizopoda), Rotifera (Bdelloidea and Monogonata), Cladocera (water fleas), Copepoda (Cyclopoida) and Ostracoda (seed shrimp). Different assemblages were recorded in different seasons. No species occurrences were restricted to the project area.
- 115 taxa of macroinvertebrate taxa were recorded, comprised of Cnidaria (freshwater hydra), Mollusca (freshwater snails), Oligochaeta (aquatic segmented worms), Crustacea (side swimmers), Acarina (water mites), Ephemeroptera (mayfly larvae), Odonata (dragonfly and damselfly larvae), Hemiptera (true aquatic bugs), Coleoptera (aquatic beetles), Diptera (two-winged fly larvae), Trichoptera (caddisfly larvae), and Lepidoptera (aquatic moth larvae).

Different assemblages were recorded in different seasons, with higher species richness in the 'dry' season:

- three species of fish were recorded, including spangled perch, western rainbowfish and Hyrtl's tandan, all of which are common and widespread outside the project area.
- a number of hyporheic taxa were recorded, including several known only from the Marillana and Weeli Wolli Creek systems (four species of stygal amphipod). Higher species richness occurred during the wet season. No species occurrences were restricted to the overall project area.

No species occurrences were restricted to the project area.

The overall project area and immediate surrounds do not include any permanent pools acting as refugia for aquatic fauna. As a result, there is no elevated conservation importance for aquatic fauna in the project disturbance area. The nearest permanent pools occur at Flat Rocks (~25 km upstream from Oxbow in Marillana Creek, west of the BHPBIO mining operations) and at Weeli Wolli Spring (~15 km upstream of the confluence of Marillana and Weeli Wolli Creeks).

3.8.3. History of mining disturbance

After three years of surveys and monitoring, there is no evidence to suggest that the long-term survival of any aquatic fauna taxa has been placed at risk due to existing mining operations at Yandicoogina. However, modified habitats due to dewatering and surface water discharge activities are likely to have influenced species assemblages. Some species are advantaged and others disadvantaged by impacts to the hydrological regime, depending on their life history strategies (WRM 2011; Appendix A7). Data on aquatic fauna assemblages collected in the recent surveys can be used to compare current results with future monitoring and assessment outcomes.

3.9. Subterranean fauna

Subterranean fauna are animals that inhabit underground habitats and include:

- **stygofauna** - obligate, groundwater dwelling aquatic fauna, and
- **troglofauna** - obligate, subterranean dwelling fauna occurring in the unsaturated profile above the water table.

Most subterranean fauna in Western Australia are invertebrates. Many species have affinities with tropical fauna lineages, and are considered to have descended into subterranean environments during the aridification of Australia during the late Miocene epoch (Humphreys 2001).

Stygofauna and troglofauna are known to occur in a range of habitats in the Pilbara region. At least 150 species of stygofauna have been recorded in the region, belonging to 77 families and 39 genera (Eberhard *et al.* 2005). It is estimated than an additional 500–550 taxa remain undescribed (Eberhard *et al.* 2009).

Species of subterranean fauna can potentially have restricted distributions, based on their evolutionary history and specialised habitat requirements. Factors limiting species dispersal in the Pilbara region include poor connectivity between dispersed hydrologic basins, geological formations, variability in groundwater chemistry, and localised structural and textural differences in host lithologies.

3.9.1. Subterranean fauna surveys

3.9.1.1. Stygofauna

Preliminary sampling for stygofauna in the Yandicoogina locality was undertaken by Hamersley in 1998 and 1999. The area was also sampled as part of the broader DEC Pilbara stygofauna survey (2002-2007); however, the relevant results of this survey remain unpublished.

More extensive stygofauna surveys were completed to support environmental impact assessments for the Yandicoogina JC and JSE projects, including ongoing biannual sampling in accordance with project compliance requirements. Seven phases of sampling have been completed over seven years (November 2003 - November 2010). The findings of these surveys were recently collated and reviewed (Biota 2010e; Appendix A8). The sampling work was consistent with *EPA Guidance Statement 54 (EPA 2003) and Draft Guidance Statement 54a (EPA 2007a)*. These surveys span the greater Yandicoogina operational area, from the Oxbow deposits to downstream of the Marillana Creek and Weeli Wolli Creek confluence.

Collectively, 68 bores were sampled for stygofauna across all seven phases, including 20 bores in JSW and Oxbow project areas in later phases (Figure 3-16). A total of 5,166 specimens consisting of 52 taxa, were collected across the full extent of the survey, representing at least ten orders from seven invertebrate classes. The proportional representation of the collected taxa amongst orders is shown in Figure 3-15. Of the 52 taxa recorded, 32 were collected at multiple sampling locations and 20 were collected at four or more sampling locations.

The majority of the sampled taxa were previously known from outside the Yandicoogina survey area. However, 15 new (undescribed) taxa were recorded. These are currently known only from the Yandicoogina area. Based on patterns of distribution for stygofauna in the Pilbara more generally, this finding is likely to be an artefact of the boundaries of the sampling program rather than true reflection of the geographic distribution of these taxa (Biota 2010e; Appendix A8). The 2010 sampling program also supports this finding, with both *Gomphodella* sp. 'yandi' and *Recifella* sp.1 taxa, previously thought to be significant due to their restricted distribution within the Marillana Creek system, now also sampled within Weeli Wolli Creek.

3.9.1.2. Troglofauna

Historical surveys associated with earlier mining approvals did not target troglofauna. However, three troglobiotic taxa were detected during the stygofauna sampling phases. These included single specimens of the orders Schizomida, Araneae and Psuedoscorpiones.

Targeted surveys for troglofauna were completed in Q4 2009, with an additional survey completed in September 2010. A total of 58 sites (130 traps) were sampled in the JSW and Oxbow project areas (18 bores) and areas adjacent to the Weeli Wolli Creek line (40 bores) (Figure 3-16). Site hydrogeological data was used to identify target sampling areas above the water table. Out of 4,827 invertebrate fauna specimens recorded, only 16 specimens displayed troglomorphic characters. These included one schizomid, one pseudoscorpion, four Blattodea (cockroach) from two sites, ten polyxenid millipede species from six sites and a single pauropod specimen. In total, eight confirmed troglobitic specimens have been collected from Yandicoogina since 2008 (including by-catch from stygofauna sampling).

All of the troglofauna records were found in areas adjacent to the Weeli Wolli Creek south east of the JSE mine pit, with the exception of a pseudoscorpion, a schizomid and a cockroach specimen which were collected from the JSW project area (Biota 2010e; Appendix A8). This is likely to be an artefact of the artificially lowered water table from the adjacent Phil's Creek borefield, as this area was largely below the standing water table prior to mine dewatering activities associated with the existing mines.

At the JSW and Oxbow locations, the water table varies from 2 to 25 m below the land surface. The majority of the alluvium deposits within the project area are subject to seasonal inundation/flooding. These characteristics suggest that the project disturbance area does not provide core habitat for troglofauna. Elsewhere in the Pilbara, it is uncommon for troglobitic fauna to be abundant in low-lying alluvium and colluvium deposits (Biota 2010e; Appendix A8).

3.9.2. History of mining disturbance

After five years of surveys and monitoring, there is no evidence to suggest that the long-term survival of any stygobitic taxa has been placed at risk due to existing mining operations at Yandicoogina.

Based on geological drilling information, the greater Marillana and Weeli Wolli Creek systems are believed to provide contiguous habitat for stygofauna (Biota 2010e; Appendix A8). This would provide a mechanism for the recolonisation of areas disturbed by mining activities.

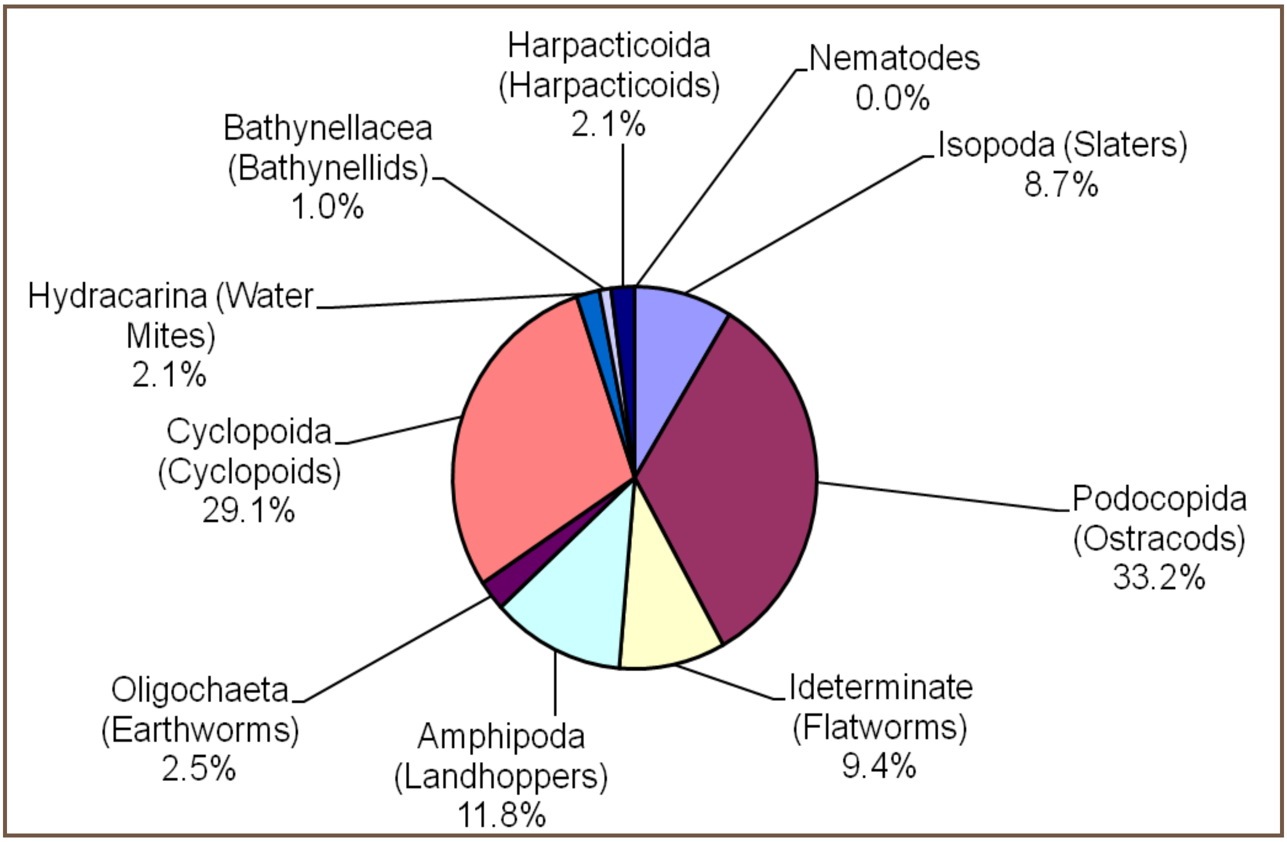
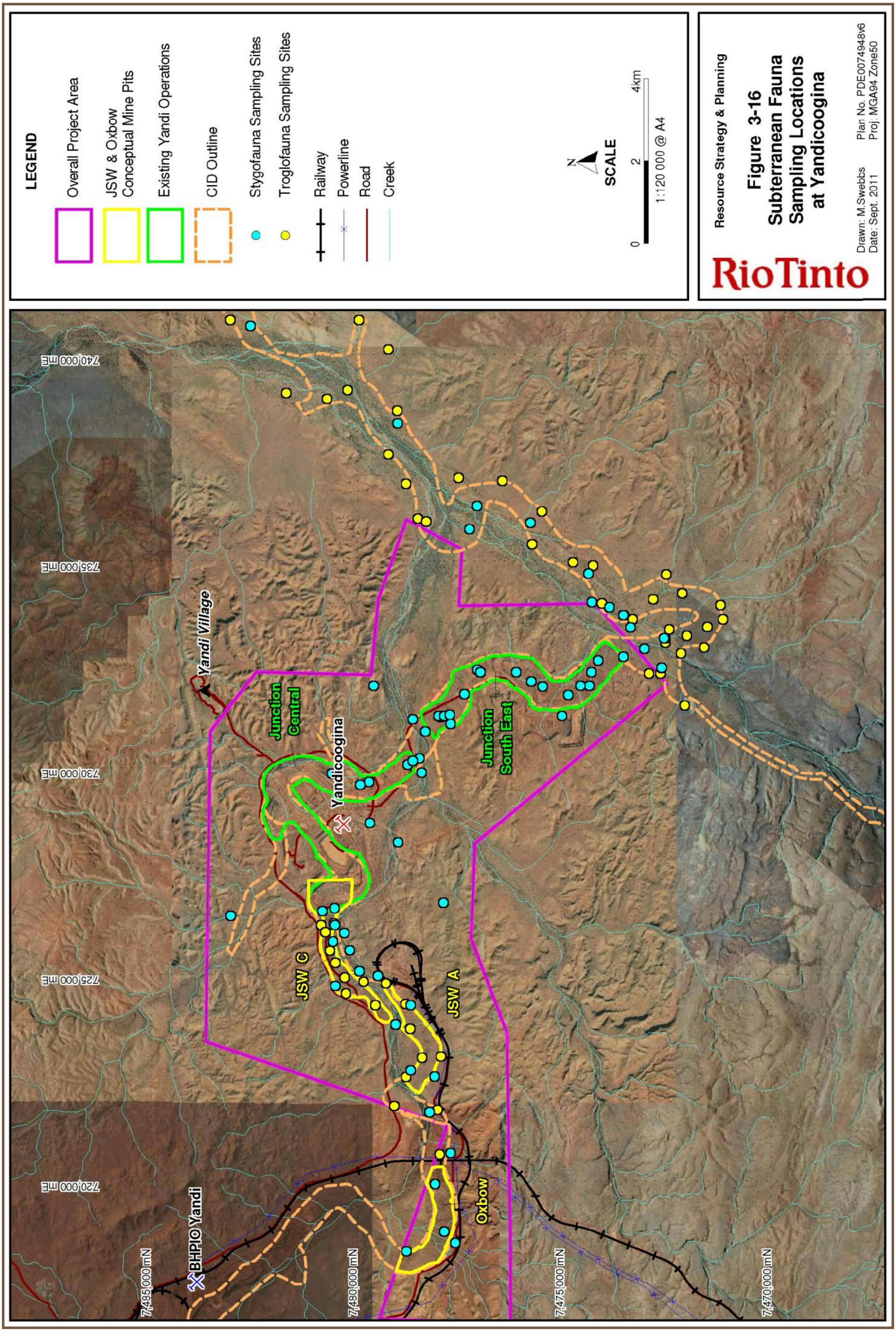


Figure 3-15 – Proportional representation of stygobitic taxa collected at Yandicoogina by taxonomic order between 2003 and 2010


LEGEND
Overall Project Area
JSW & Oxbow Conceptual Mine Pits
Existing Yandi Operations
CID Outline
Stygofauna Sampling Sites
Troglofauna Sampling Sites
Railway
Powerline
Road
Creek
N
SCALE
0 2 4km
1:120 000 @ A4
Resource Strategy & Planning
Figure 3-16
Subterranean Fauna Sampling Locations at Yandicoogina
Drawn: M.Swebbs
Date: Sept. 2011
Plan No. PDE0074948v6
Proj: MGA94 Zone50
RioTinto
Yandi Village
Junction Central
Yandicoogina
Junction South East
JSW C
JSW A
Oxbow
BHPIO Yandi
720 000 mE
725 000 mE
730 000 mE
735 000 mE
740 000 mE
7,485 000 mN
7,480 000 mN
7,475 000 mN
7,470 000 mN

3.10. Surface water

3.10.1. Hydrological setting

The topography of the central Pilbara region generally supports well-defined surface catchments. The Marillana Creek catchment occupies 2,230 km^2 and extends west from Yandicoogina to within about 20 km of the Great Northern Highway (Figure 3-17). The project area is located near the downstream end of the catchment.

Marillana Creek is the dominant drainage feature in the project area. It enters from the west near the Oxbow deposit and drains in a predominantly easterly direction into the Weeli Wolli Creek system, downstream of the current Yandicoogina mine operations. Two major tributaries, Phil's Creek and Yandicoogina Creek, drain into Marillana Creek within ML274SA. Weeli Wolli Creek ultimately discharges into the Fortescue Marshes, located approximately 40 km to the north of Yandicoogina. The creekline becomes increasingly braided and ill-defined as it approaches the Marsh. Marillana Creek is estimated to contribute approximately 50% of the flow into the Fortescue Marshes from the overall Weeli Wolli Creek system (Aquaterra 2001).

Large flows in Marillana Creek are correlated with rain bearing depressions or high intensity cyclonic events, which bring heavy rain over a large area of the catchment. Peak flow generally occurs within 24 hours; however, flow recession is such that minor stream flow can continue for days after the peak has passed. Retention basins in the upper catchment, such as the Munjina Claypan, can sustain flows into the dry season in some years. The claypan is an internally draining basin with an area of approximately 274 km^2. It acts to reduce peak discharges for lower rainfall events (up to 1 in 10 year ARI) and delay the time to the peak of runoff. In the lower catchment, including the project area, major flow events can cause transient water table rises in the alluvium of several metres. The lateral extent of these flows defines a greater creekline floodplain, within which preferred pathways transmit smaller flow events. The floodplain is well defined at its boundaries and ranges from 200 m to 350 m wide in the vicinity of JSW.

Marillana Creek contains one flow gauging station at Flat Rocks (WRC number 708001), approximately 27 km west of the current RTIO Yandicoogina mine operation, and upstream of the BHPBIO operations. Daily flow data for the gauging station is available from August 1967 to the present, with occasional missing data. Seven rainfall events (five cyclones and two other events) occurred between 1971 and 2003, producing flows greater than 100 m^3/s at the Flat Rocks gauging station, with the highest flow recorded at 839 m^3s (Tropical Cyclone 'Joan' in December 1975). This equates to a water level of approximately four metres at the gauging station. Estimated natural peak flow volumes near Oxbow, at the western edge of the project area, are 70 m^3/s for a two year ARI event and greater than 2,000 m^3/s for a 100 year ARI[12] flood (RTIO 2008).

The JSW project area is located immediately upstream of the existing JC mine. The JSW-A and JSW-C deposits are separated by the Marillana Creek 100 year ARI floodplain, with sections underlying Marillana Creek. Phil's Creek drains to the east of the JSW-C, near the western end of the JC pit. The morphology of Marillana Creek at JSW is dynamic, with large flood events capable of redefining preferred pathway flow lines within the floodplain.

The Oxbow project area is located to the south west of Marillana Creek where it enters ML274SA. It contains a dense network of largely minor drainage lines, formed by erosion from high intensity rainfall over the sparse vegetation cover and shallow soils. A single larger drainage line crosses through the centre of the proposed Oxbow pit.

[12] Average return interval (years)

3.10.2. History of mining disturbance

3.10.2.1. Discharge volumes

Before mining commenced in the Yandicoogina locality in the early 1990s, stream flow in Marillana Creek was intermittent and largely dependent on rainfall. From 1975 to 2008, the annual number of flow days ranged between 10 and 365 (with a mean of 212) at the Flat Rocks gauging station. Continual flow at this location was recorded between 2000 and 2004, mainly due to saturated catchment conditions from abnormally high rainfall in 2000 (970 mm recorded at Flat Rock station) and the influence of the Munjina Claypan.

Discharge of surplus water from the BHPBIO Yandi mine operation into Marillana Creek began in May 1991. In 1998, RTIO started releasing surplus water into Marillana Creek and by December 2006 the combined operations were discharging at an average rate of 34 ML/day. Release of surplus water directly into Weeli Wolli Creek began in 2007, with expansion of the JSE mine and development of the Hope Downs 1 operation, approximately 20 km up gradient of Yandicoogina. In 2009, approximately 50 GL of surplus water was discharged into Marillana and Weeli Wolli Creeks, consisting of:

- ~14 GL into Marillana Creek from the Hamersley Yandicoogina operations
- ~5 GL into Marillana Creek from the BHPBIO Yandicoogina operations, and
- ~30 GL into Weeli Wolli Creek from Hope Downs 1 mining operations (~20 km upstream from the Marillana Creek confluence).

A more detailed description of the Yandicoogina operations water balance and discharge volumes is provided in Section 5.

The combined discharges of the various mining projects in the catchment have resulted in continuous stream flow and saturated creek bed conditions in the downstream sections of the Marillana and Weeli Wolli Creek systems. Since 2008, the surface water discharge footprint, defined as the extent of surface water expression, has extended to up to ~8 km below the confluence of the Marillana and Weeli Wolli Creeks. The surface wetting front fluctuates over a distance of several kilometres, depending on climatic conditions and surplus water discharge rates (refer to Figure 3-18).

Long term records of water level monitoring in downstream sections of the Weeli Wolli Creek indicate strong correlations between rainfall and water table fluctuations. Monitoring records at Bore 99YJWB01, 6 km downstream of the confluence, show no discernable correlation between water table levels and surface water disposal activities before 2007 (Figure 3-19). After 2007, a trend of higher water table levels may be associated with the onset of surface water disposal from the Hope Downs 1 mine site, although the levels are still within the boundaries of natural variability.

Sub-catchment areas in the vicinity of the Hamersley and BHPBIO operations have been modified by the construction of diversion structures, mini-pits and haul/access road crossings. This has resulted in changes to the direction and pattern of surface flows, with an overall reduction in flow contributions to Marillana Creek compared with the pre-disturbance regime. Hydrological modelling undertaken by RTIO indicates that the existing operations at JC and JSE have caused only minor reductions in flow contributions to Marillana Creek; in the order of 1% of the pre-disturbance flow volumes.

Mining at the JSW and Oxbow locations will require additional flow diversion infrastructure along sections of Marillana Creek, which will further reduce inflows to Marillana Creek during the operational life of the mines.

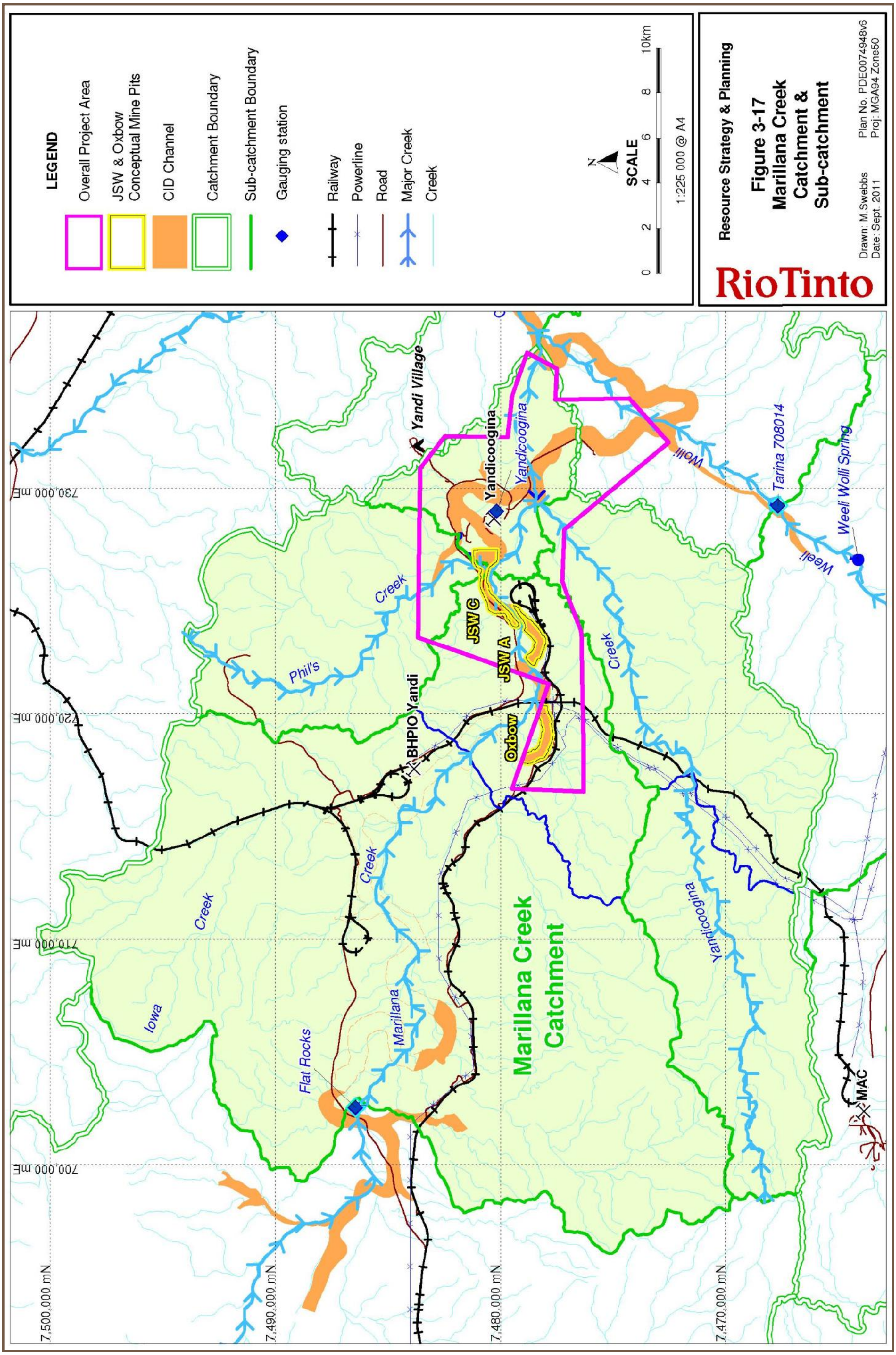
3.10.2.2.Surface discharge water quality

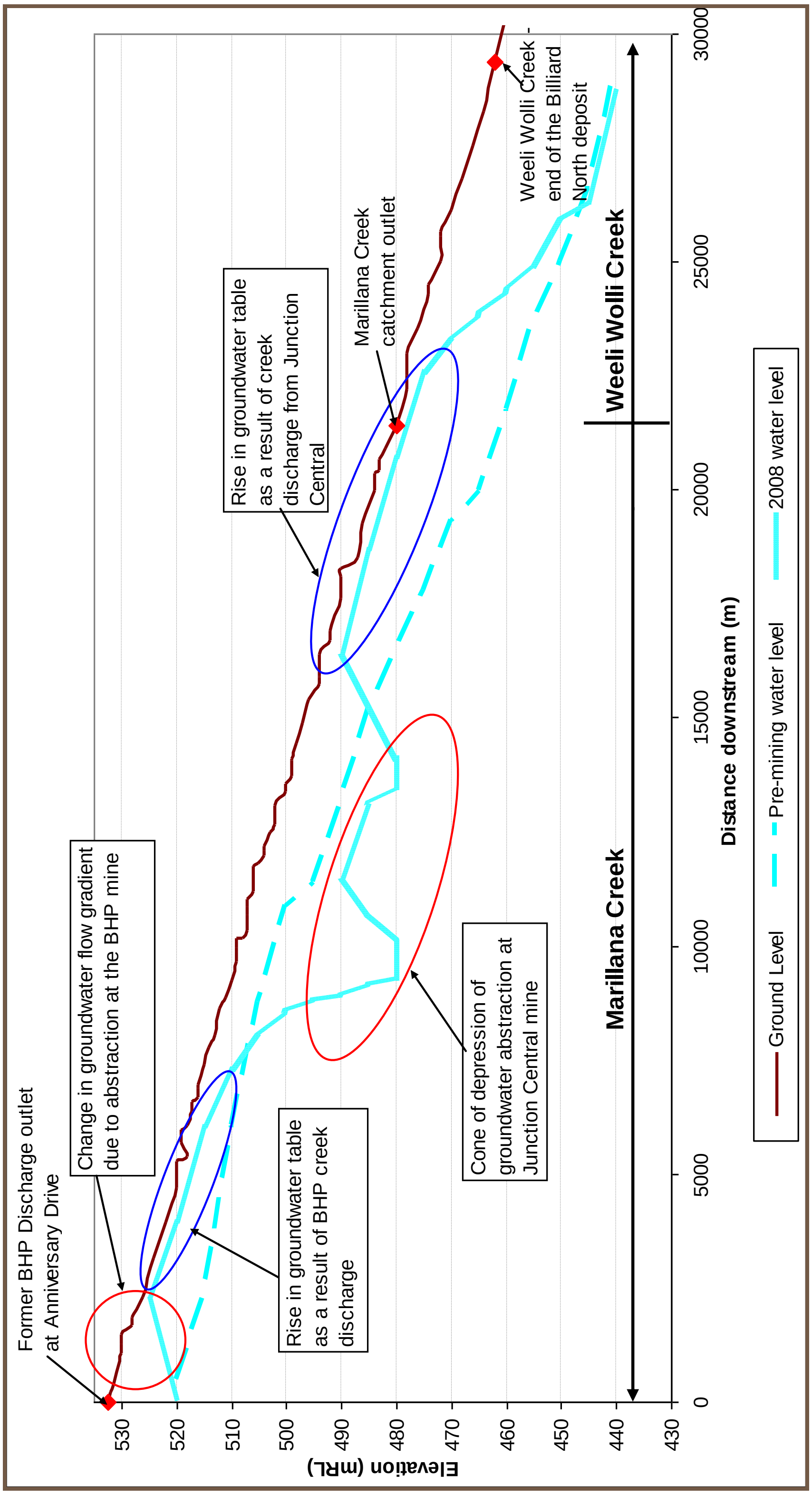
Pilbara Iron monitors the water quality of mine pit dewatering discharges from the Hamersley Yandicoogina operations on a regular basis (Table 3-6). The monitoring program also includes all discharge outlets and selected points along inundated sections of Marillana Creek (alluvium). The current configuration of monitoring points is shown in Figure 3-20. Note that BHPBIO originally released surplus water into Marillana Creek at the discharge outlet at Anniversary Drive, ~2 km up gradient of the Oxbow deposit. This outlet was relocated in May 2007 and is now positioned 500 m downstream from the BHPBIO railway bridge.

Discharge water quality requirements under the current Yandicoogina Operating Licence (L7340/1997/9) include:

- pH in the range 6.0 to 8.5
- concentration of total dissolved solids (TDS) not greater than 1500 mg/L
- concentration of total suspended solids (TSS) not greater than 80 mg/L
- concentration of total recoverable hydrocarbons (TRH) not greater than 5 mg/L.

Since monitoring started in 1998, the discharge water has ranged from pH 6.8 to 9.6 and the concentration of TDS has ranged from 370 to 780 mg/L.


LEGEND
Overall Project Area
JSW & Oxbow Conceptual Mine Pits
CID Channel
Catchment Boundary
Sub-catchment Boundary
Gauging station
Railway
Powerline
Road
Major Creek
Creek
N
SCALE
0 2 4 6 8 10km
1:225 000 @ A4
Resource Strategy & Planning
Figure 3-17
Marillana Creek Catchment & Sub-catchment
Drawn: M.Swebbs
Date: Sept. 2011
Plan No. PDE0074948v6
Proj: MGA94 Zone50
RioTinto
Yandi Village
Yandicoogina
Yandicoogina
Wolli
Tarina 708014
Weeli Wolli Spring
Weeli
Creek
Phil's
JSW C
JSW A
BHPIO Yandi
Oxbow
Creek
Creek
Creek
Yandicoogina
Iowa
Creek
Marillana
Flat Rocks
Marillana Creek Catchment
MAC
730,000 mE
720,000 mE
710,000 mE
700,000 mE
7,500,000 mN
7,490,000 mN
7,480,000 mN
7,470,000 mN



** The cross section extends from the former BHPBIO discharge outlet along Marillana Creek to downstream of the confluence with Weeli Wolli Creek.

Figure 3-18 – A comparison of pre-mining and 2008 groundwater level along Marillana and Weeli Wolli Creeks at Yandicoogina The cross section extends from the former BHPBIO discharge outlet along Marillana Creek to downstream of the confluence with Weeli Wolli Creek

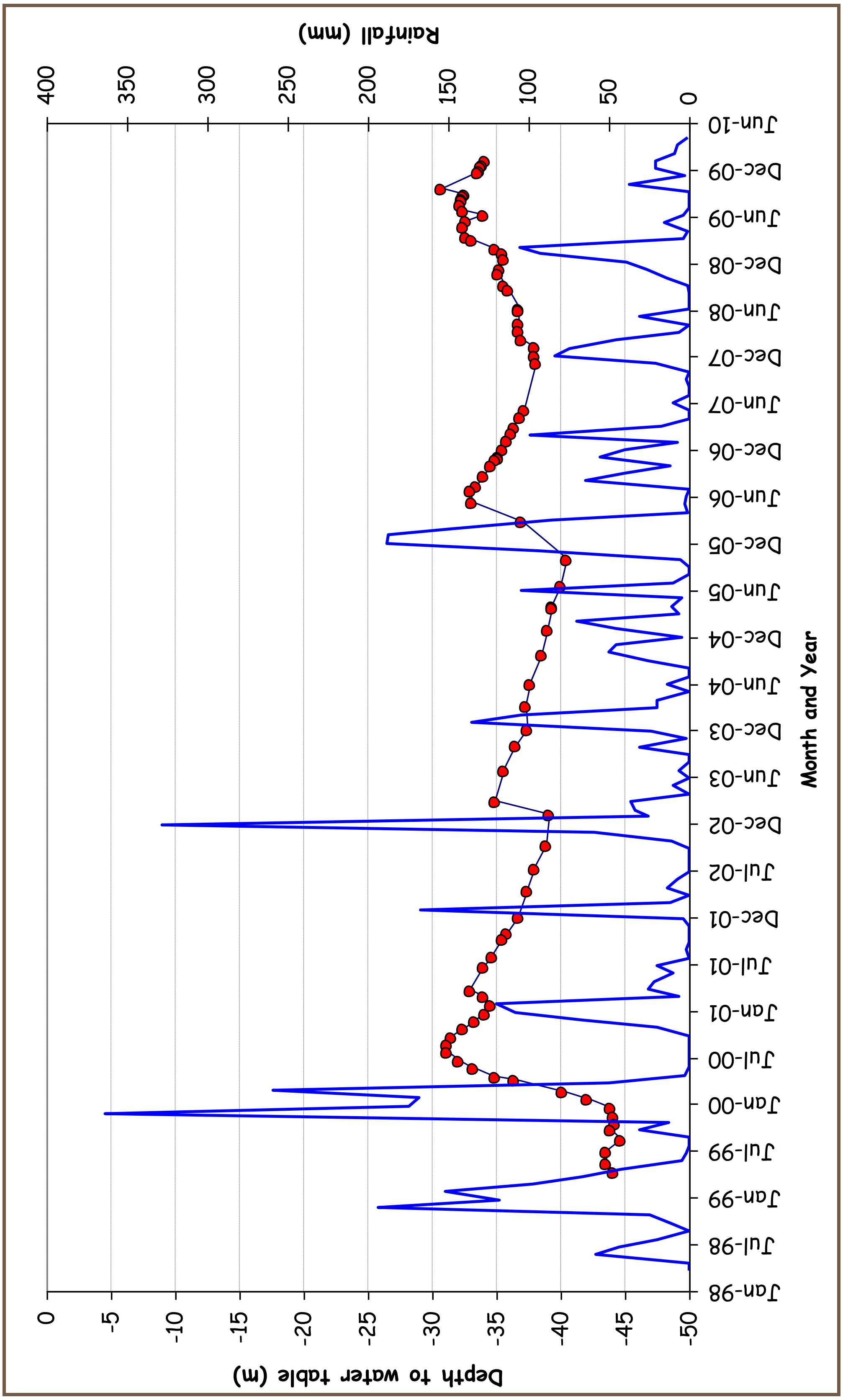


Figure 3-19 – Time series groundwater level measurements at Bore Number 99YJWB01, 6 km from the Marillana Creek and Weeli Wolli Creek confluence

Table 3-6 – Yandicoogina discharge water monitoring schedule

Monitoring points	Sampling frequency	Parameters measured
Discharge outlets (All)	Quarterly	pH, EC, total dissolved solids, total suspended solids.
	6-Monthly	pH, EC, total dissolved solids, total suspended solids, aluminium (Al), calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), sulphates (SO_4), lead (Pb), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), zinc (Zn), arsenic (As), cadmium (Cd) and chromium (Cr).
Discharge outlet DO8 (receives water from the waste fines facility water return system at JC)	Quarterly	pH, EC, total dissolved solids, total suspended solids, aluminium (Al), calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), sulphates (SO_4), lead (Pb), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), zinc (Zn), arsenic (As), cadmium (Cd), chromium (Cr), nitrate (NO_3), total phosphorus (TP) and total recoverable hydrocarbons (TRH).
Marillana Creek alluvium	6-Monthly	pH, EC, total dissolved solids, total suspended solids, aluminium (Al), calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), sulphates (SO_4), lead (Pb), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), zinc (Zn), arsenic (As), cadmium (Cd), chromium (Cr), nitrate (NO_3) and total phosphorus (TP).

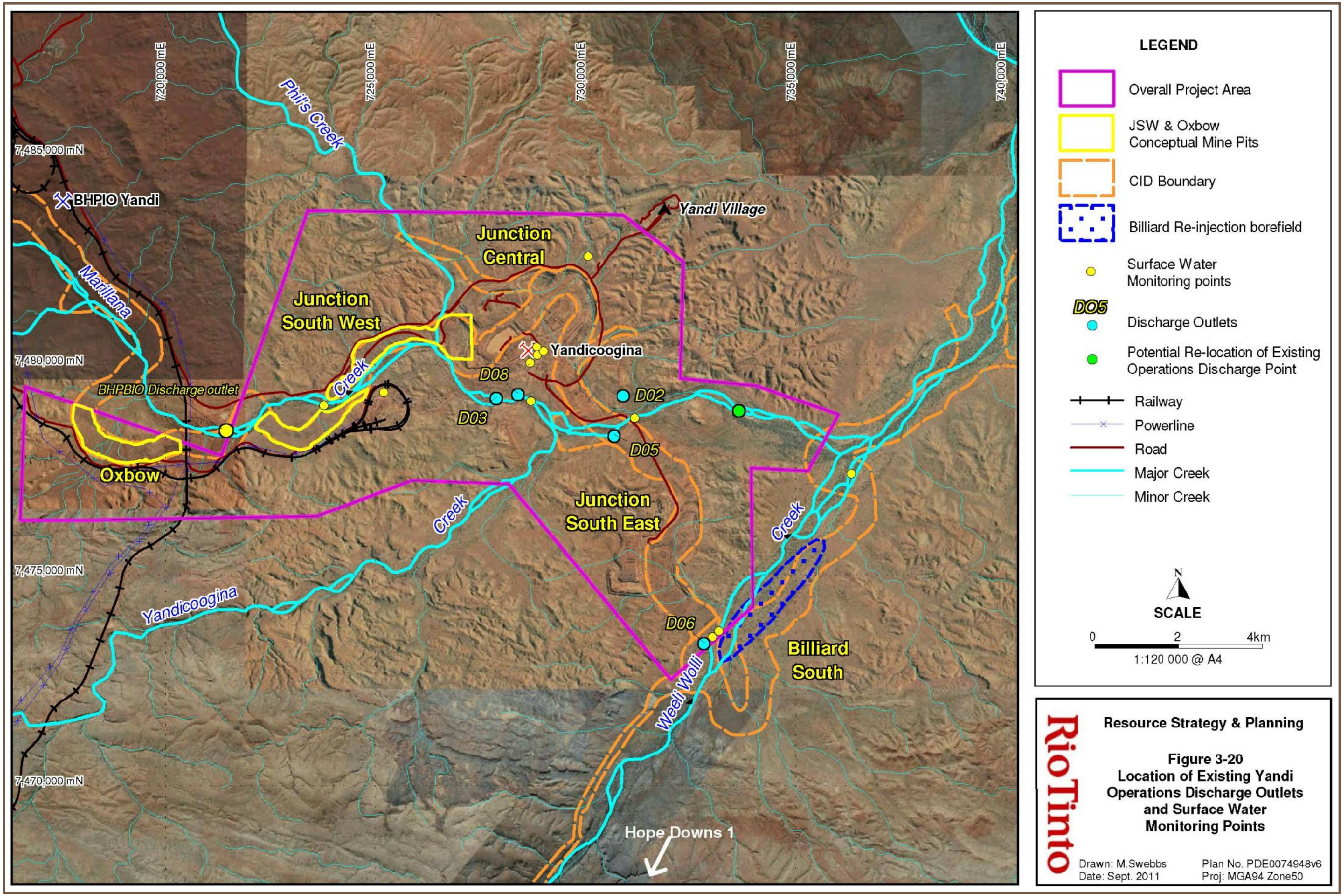


Figure 3-20
Location of Existing Yandi Operations Discharge Outlets and Surface Water Monitoring Points

Rio Tinto

3.11. Groundwater

3.11.1. Hydrogeological setting

The Yandicoogina iron ore deposits infill the dissected palaeo-river valley of the Marillana-Yandicoogina Creek system to form the CID. The main CID extends some 80 km on a north west-south east axis and adjacent to the current alignment of Marillana Creek (Figure 3-21). The CID is approximately 300 to 500 m wide and bounded at depth (a maximum of about 110 m) by relatively less permeable basement rocks of the Weeli Wolli Formation (RTIO 2010a; Appendix A11). The CID aquifer is characterised by a relatively high water yield associated with secondary porosity.

The CID is overlain and flanked by alluvium and unconsolidated materials, which are also relatively transmissive and variably connected with the CID aquifer. The combined width of the CID and alluvium aquifers range from 1,000 to 2,000 m. The overall groundwater system is bounded by low transmissivity parent rocks. The depth of the CID channel diminishes towards the flanks of the floodplain.

The natural depth to groundwater at the Yandicoogina operations varies from 2 m to 25 m below the surface, with the groundwater flow direction to the east and south east at the Oxbow and JSW locations, and to the north east near Weeli Wolli Creek.

Periods of above average rainfall cause disequilibrium between recharge and discharge; resulting in elevated groundwater levels, steepening of hydraulic gradients and increased aquifer throughflow and discharge. Periods of rainfall deficit result in less recharge, lowered water levels, a flattening of hydraulic gradients, reduced throughflow and decreased discharge. The rise and fall of the water table acts to maintain the natural balance between recharge and discharge.

3.11.1.1. The Floodplain aquifer

The floodplain aquifer consists of three geological units that exhibit strong hydraulic connection, described as follows:

1. **Creek Bed Alluvium**: consists of coarse creek bed colluviums and alluvium underlying Weeli Wolli Creek. It is considered to be the conduit for recharge to the CID aquifer primarily from surface flow, generated immediately following rainfall events. Discharge of surplus water from mine dewatering operations to Weeli Wolli Creek has also resulted in greater recharge within the creek bed alluvium. This unit is incised within and discharges to the Floodplain unit.
2. **Floodplain**: consists of floodplain sediments that unconformably overlie the insitu weathered basement and lie adjacent to the CID. This unit comprises mixtures of poorly sorted gravels, sand, silt and clay.
3. **Insitu Weathered Basement**: consists of heavily fractured and weathered (saprolitic profile) insitu Weeli Wolli Formation. This unit comprises weathered banded iron formation, chert, shale, dolerite and clay.

Transmissivity is variable within the Floodplain aquifer. Groundwater moves freely within the coarser less clayey sediments, but flow may slow within the underlying clayey sections of the weathered basement material. The coarse river gravels of the upper alluvium of the creek bed are highly permeable and, in locations of reasonable thickness, have the ability to transmit and store large volumes of groundwater.

3.11.1.2. The CID aquifer

The CID aquifer is a relatively narrow meandering palaeochannel imbedded in the basement, comprising mainly Weeli Wolli Formation. The development of solution features has largely superseded the primary porosity of the interstitial pore space.

The CID is rapidly recharged by seepage from the overlying and adjacent Floodplain alluvium. Long-term observations indicate water levels can rise by up to 10 m in the CID aquifer through creek flow, triggered by intense rainfall events. Historically, such recharge events have been infrequent as dictated by rainfall patterns. More recently the alluvial and CID aquifers have been subject to constant recharge due to surface water discharge to Marillana Creek from mining operations. Discharge from the CID occurs by aquifer throughflow to the south-east.

3.11.1.3. Basement aquifer

The basement is a fractured rock aquifer consisting of inter-bedded banded iron formation, banded chert, shale and dolerite. It underlies and surrounds the alluvial/in situ weathered aquifer. Aquifer permeability is largely dependent on the development of structural features. Groundwater in the basement rocks only occurs in secondary porosity associated with the weathered zone and within fractures in the bedrock, with lower hydraulic conductivities than both the CID and the Floodplain aquifers.

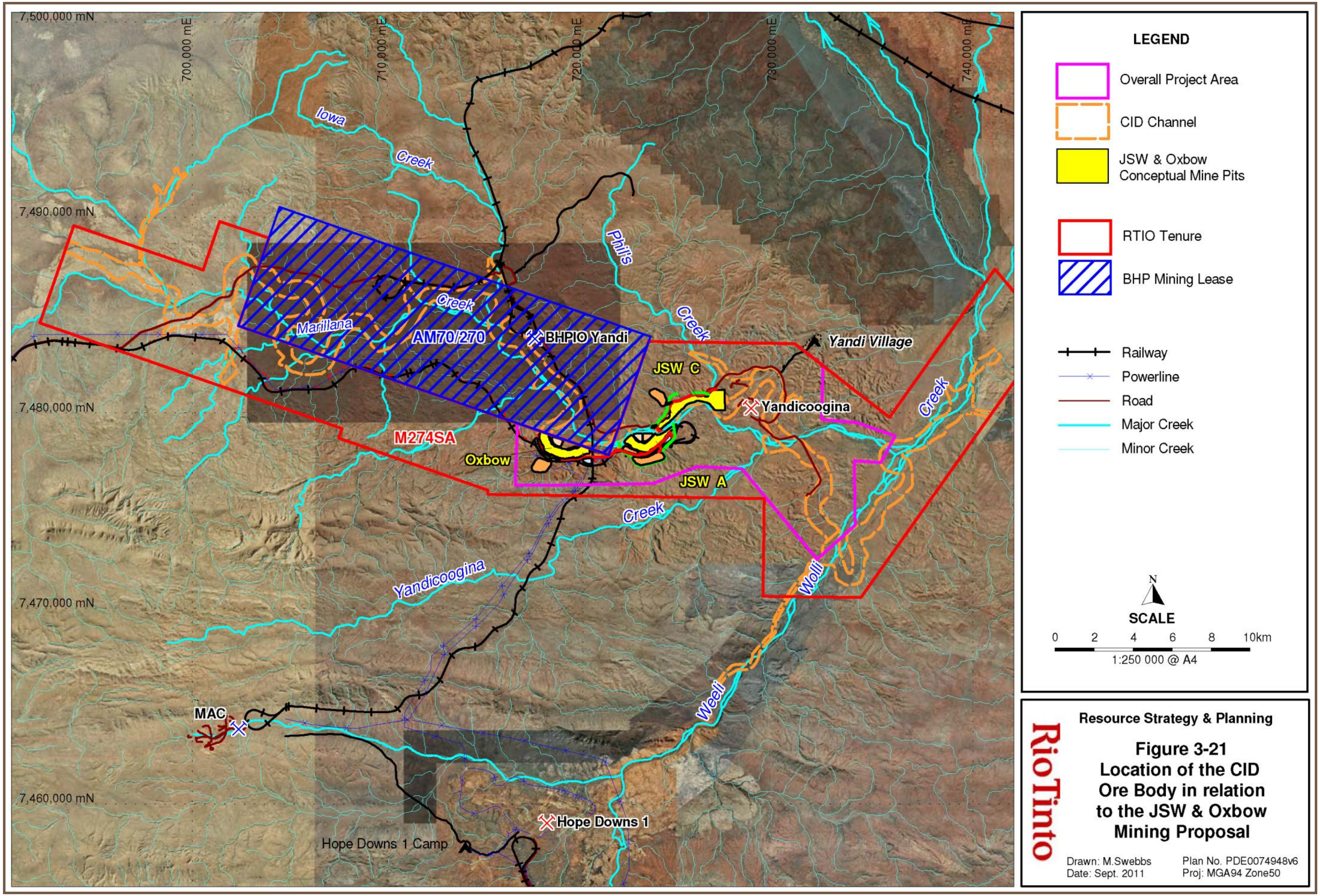
3.11.2. Groundwater levels

3.11.2.1. Junction South West

Groundwater levels underlying the JSW area have been measured intermittently since 1974. A more detailed hydrogeological investigation of the JSW deposit was undertaken by Hamersley in 2008, consisting of drilling and installing seven production bores and 22 monitoring bores.

The measured groundwater levels (AHD) in late 2008 were ~520 mRL at the western end of the JSW-A deposit and ~482 mRL at the eastern margin of the JSW-C deposit. The difference in water level across the overall JSW area is due to:

- **saturation of the CID/alluvial aquifer** from continuous surface water flow entering Marillana Creek from the west, resulting from the upstream BHPBIO water discharge outlet, and
- **continuous dewatering of the JC deposit** as mining advances, creating a cone of drawdown in groundwater levels, extending into the eastern end of the JSW area.



RioTinto

Resource Strategy & Planning

Figure 3-21
Location of the CID Ore Body in relation to the JSW & Oxbow Mining Proposal

Drawn: M.Swebbs
Date: Sept. 2011

Plan No. PDE0074948v6
Proj: MGA94 Zone50

3.11.2.2. Oxbow

Groundwater levels underlying the Oxbow area have been measured intermittently since 1974. A hydrogeological investigation of the Oxbow deposit was undertaken by Hamersley in 2008, consisting of the drilling and installing one production bore and seven monitoring bores. Measured groundwater levels (AHD) were 518 mRL at the western end of the Oxbow deposit and 516 mRL at the eastern end near the BHPBIO rail line, equating to a hydraulic gradient of approximately 0.001.

3.11.3. Groundwater quality

Groundwater in the CID at Yandicoogina is fresh (TDS ranging from 150 to 600 mg/L) and meets drinking water standards for inorganic chemicals. The groundwater in the alluvial aquifer contains higher TDS concentrations than the CID aquifer, with TDS values of up to 1290 mg/L. The groundwater from both of these aquifers is dominated by bicarbonate (HCO_3) anions. Sodium (Na) constitutes a higher portion of the major cations, followed by calcium (Ca) and magnesium (Mg). Chloride (Cl) concentration ranges from 15 mg/L, for the relatively fresh groundwater in the CID, to a maximum of 280 mg/L in the alluvium.

On average, the chloride concentration in the CID aquifer is 30% lower than that in the alluvium aquifer. This difference is attributed to the processes of direct evaporation and evapotranspiration by native vegetation along Marillana Creek, which acts to concentrate salts in the upper profile.

3.11.4. History of mining disturbance

3.11.4.1. Water levels

Dewatering requirements at the Hamersley Yandicoogina operations have increased since 1998, as mining rates and depth of mining have progressed. Dewatering volumes abstracted in 2009 from the JC and JSE pits equated to ~25 GL. This included all borefield and sump pumping across the combined operations. The dewatering volume greatly exceeded on-site water demand. Further discussion of current and projected dewatering volumes from the combined Yandicoogina operations is provided in Section 5.

Discharge from mining operations since the early 1990s has created continuous creek flow in sections of Marillana Creek at Yandicoogina. Significant additional leakage into the CID aquifer has resulted, relative to the pre-disturbance condition, particularly at locations where Marillana Creek crosses or flows adjacent to the CID. Increased gradient between surface water in Marillana Creek and depressed groundwater levels in the CID aquifer near the mine pits has also increased the rate of leakage into the CID aquifer.

Reinjection of surplus water from the JSE operation into the CID aquifer of the Billiard South deposit began in 2006. In conjunction with surplus water discharge from the Hope Downs 1 mine, this reinjection has resulted in groundwater mounding within the CID at the southern end of the JSE mine. A groundwater divide has formed in the location of the reinjection borefield, so that water flows from the mound both to the southwest towards the JSE pit, and to the northeast, down gradient in the CID aquifer beneath the Weeli Wolli Creek floodplain.

Groundwater levels and gradients at the Oxbow location have fluctuated historically in response to mining activities. Discharge from the BHPBIO project began in 1992, at an outlet on Marillana Creek two kilometres up gradient from the Oxbow deposit. Water levels rose by approximately 12 m in the Oxbow CID aquifer. In 2007, the original discharge outlet was relocated 1.2 km down gradient of the Oxbow deposit, where Marillana Creek crosses the palaeochannel east of the BHPBIO railway line. The water table subsequently reduced to levels more comparable with pre-disturbance conditions.

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Groundwater levels and abstraction rates at the Hamersley Yandicoogina operations are monitored by Pilbara Iron on a regular basis (Table 3-7). The monitoring program also includes all production bores and selected monitoring bores. The current configuration of groundwater level monitoring points is shown in Figure 3-22.

3.11.4.2. Water quality

Groundwater quality at the Hamersley Yandicoogina operations is monitored by Pilbara Iron on a regular basis, in accordance with the Yandicoogina Groundwater Operating Strategy (GWOS) (Table 3-7). The current configuration of groundwater water quality monitoring points is shown in Figure 3-22.

Table 3-7 – Yandicoogina groundwater monitoring schedule

Monitoring points	Sampling frequency	Parameters measured
Production bores	Monthly	pH, EC, temperature, run hours, cumulative flow, instantaneous rate flow, water level elevation
	Annually	pH, EC, total dissolved solids, calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), chloride (Cl), carbonates (CO_3), bicarbonates (HCO_3), sulphates (SO_4) and nitrate (NO_3)
Monitoring bores	Monthly	Water levels
	Annually	pH, EC, total dissolved solids, calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), chloride (Cl), carbonates (CO_3), bicarbonates (HCO_3), sulphates (SO_4) and nitrate (NO_3)

No significant water quality changes have been detected in the CID aquifer since the start of routine water quality monitoring at Yandicoogina. The monitoring records suggest aquifer water quality is subject to complex interactions between the following processes:

- increased leakage from the Marillana Creek system into the CID aquifer, caused by saturation of the creek bed from surface water discharge activities. This creates large hydraulic head differences between the saturated creek bed and dewatered mine pits.
- mixing of water from the CID aquifer with water from the alluvial aquifer (which has higher TDS concentrations), as a result of percolation of the discharge water from the creek bed and laterally derived inflow from the alluvial aquifer into the CID aquifer near drawdown areas.
- evaporative concentration of salts in the permanent surface water bodies within the creek systems.
- throughflow within the CID aquifer.

The following example illustrates how these processes can interact to affect water quality. Drawdown of the water table at the JC mine since 1998 has created a cone of depression up gradient towards JSW deposit. A higher head difference between the water level in the alluvium and the adjacent CID aquifer has resulted, with a higher rate of leakage. The increased leakage rate from the relatively more saline alluvial aquifer has resulted in an increase in salinity in the CID aquifer in the vicinity of JC. However, this has been moderated by an influx of recharge from the saturated Marillana Creek upstream, from low salinity BHPBIO discharge water sourced from the upstream CID.

3.11.5. Yandicoogina hydrogeological model

There have been various hydrogeological investigations in the Yandicoogina locality since 1978. Early conceptualisations of the groundwater system postulated that the CID was incised into the basement Weeli Wolli Formation and overlain by a thin veneer of transmissive alluvial sediments. The surrounding basement was regarded as being impermeable, except in localised areas resulting from fractures. Recharge was thought to occur principally from creek systems where they intersected the vertical projection of the palaeochannel.

The conceptual model has been progressively developed over the past decade, based on information obtained from drilling and test pumping. It is now recognised that a far more extensive zone of alluvium and transmissive weathered basement surrounds the CID (RTIO 2010a; Appendix A11). These materials can accept much greater rates of recharge than previously thought and transmit this to the CID aquifer. As a consequence, the early hydrogeological models under-predicted the dewatering volumes required to enable below water table mining. The current conceptualisation is shown in Figure 3-23.

The updated conceptual model has been further supported by geophysical surveys of the Billiard CID, adjacent to Weeli Wolli Creek, downstream from the Marillana Creek confluence (RTIO 2011a; Appendix A12). These surveys have detected up to 40 m of unconsolidated material overlying the basement beyond the flanks of the CID aquifer. The volume of the CID is smaller than these adjacent transmissive materials.

The hydraulic connection between the CID and alluvium/weathered basement aquifers has been more accurately determined in recent studies undertaken by RTIO (details in Appendix A11 and Appendix A13). A regional-scale numerical groundwater model has been developed and used to estimate the life of mine dewatering volumes needed to achieve dry mining conditions at JSW and Oxbow.

The numerical groundwater model can predict peak dewatering rates and develop optimal bore field configurations and designs, for a range of operational scenarios. Key assumptions underpinning the base case model include:

- rainfall records for the last 20 years are a suitable analogue for the next 20 years
- in the absence of information relating to BHPBIO’s dewatering activities upstream of the Oxbow pit, throughflow in the CID will be equivalent to pre-mining throughflow, and
- the mean annual BHPBIO discharge to Marillana Creek is 5 GL/yr and is uniformly distributed throughout the year.

Given these assumptions, combined dewatering volumes for JSW and Oxbow are predicted to peak at 22 GL/yr, with an average dewatering volume of 13 GL/yr, over the operational life of the JSW and Oxbow mines. Dewatering scenarios, including greater and lesser rates of discharge by BHPBIO, indicate that dewatering volumes for JSW and Oxbow will vary linearly with BHPBIO’s discharge, after an initial volume of water in storage has been removed from each pit (RTIO 2011a; Appendix A12). A more detailed discussion of the modelling outputs is provided in Section 5.

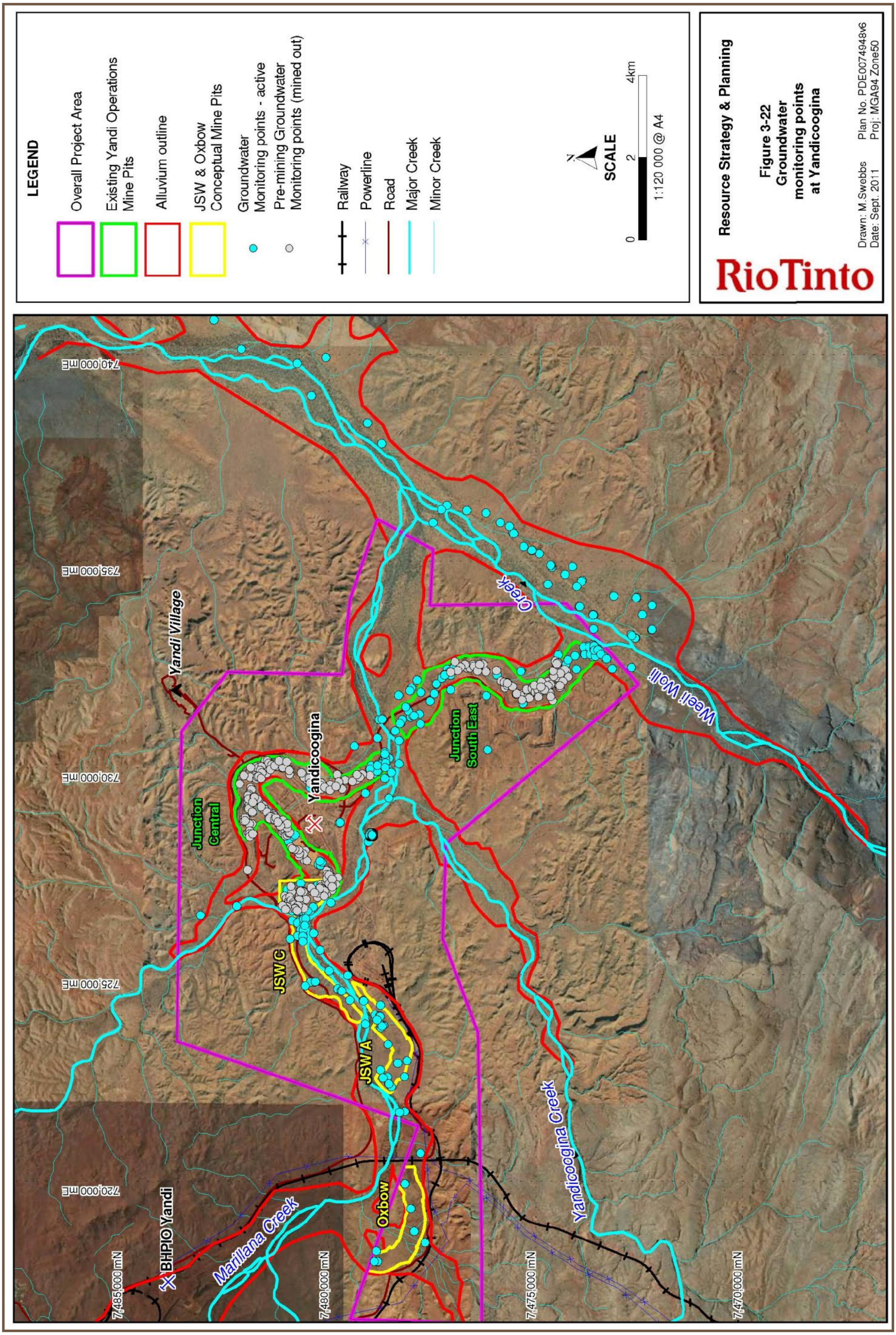
Additional insights into protecting aquifer water quality have been gained from geochemical studies. Geochemical modelling of groundwater suggests that evapotranspiration of infiltrated rainfall in the unsaturated zone, followed by carbonate minerals dissolution and clay minerals hydrolysis, can accurately predict the measured major ion compositions in groundwater of both CID and alluvium/in situ weather aquifers (RTIO 2010b; Appendix A13).

The key findings of this work include:

- **the rate of leakage from the creek to the CID aquifer increases** when the relative head difference between surface water and groundwater is changed due to mining activities. This includes dewatering of the aquifers and saturation of creek beds due to surface discharge
- **leakage of surface water in Marillana Creek** to the underlying aquifers accounts for approximately 80% of the total discharge from the creek in the vicinity of the Hamersley Yandicoogina operations. The remainder is lost to evapotranspiration
- **chloride (Cl) dilution patterns in the CID aquifer**, derived from 10 years of records, suggest that the groundwater system along the Weeli Wolli Creek is dominated by vertical flow (recharge) rather than horizontal flow (CID throughflow). There is a clear trend of lower Cl concentrations moving down gradient in Marillana and Weeli Wolli Creeks, suggesting that groundwater is being diluted by fresh recharge.

The applicability of the numerical groundwater model and the key findings described above were supported by an independent peer review completed by URS in December 2010. Based on recommendations of the peer review, the report was updated to include additional descriptive information on the model inputs and model assumptions. No changes were required to the modelling outputs generated by RTIO.

In summary, the updated groundwater system conceptual model has important implications for the dewatering of proposed and existing pits. The direct contribution of Marillana Creek surface water to the CID, combined with the relatively large storage capacity of the alluvium surrounding the CID, mean that drawdown in the CID aquifer during dewatering will result in considerable leakage from the saturated alluvium and creek bed. The over-riding influence of recharge from major rainfall events is likely to prevent the accumulation of salts in the CID aquifer downstream of mining.



LEGEND
Overall Project Area
Existing Yandi Operations Mine Pits
Alluvium outline
JSW & Oxbow Conceptual Mine Pits
Groundwater Monitoring points - active
Pre-mining Groundwater Monitoring points (mined out)
Railway
Powerline
Road
Major Creek
Minor Creek
N
SCALE
0
2
4km
1:120 000 @ A4
Resource Strategy & Planning
Figure 3-22
Groundwater monitoring points at Yandicoogina
Drawn: M.Swebbs
Date: Sept. 2011
Plan No. PDE0074948v6
Proj: MGA94 Zone50
RioTinto
740,000 mE
735,000 mE
730,000 mE
725,000 mE
720,000 mE
7,485,000 mN
7,480,000 mN
7,475,000 mN
7,470,000 mN
Yandi Village
Yandicoogina
Junction Central
Junction South East
Weeli Wolli
Creek
JSW C
JSW A
Oxbow
BHPIO Yandi
Marillana Creek
Yandicoogina Creek

RioTinto

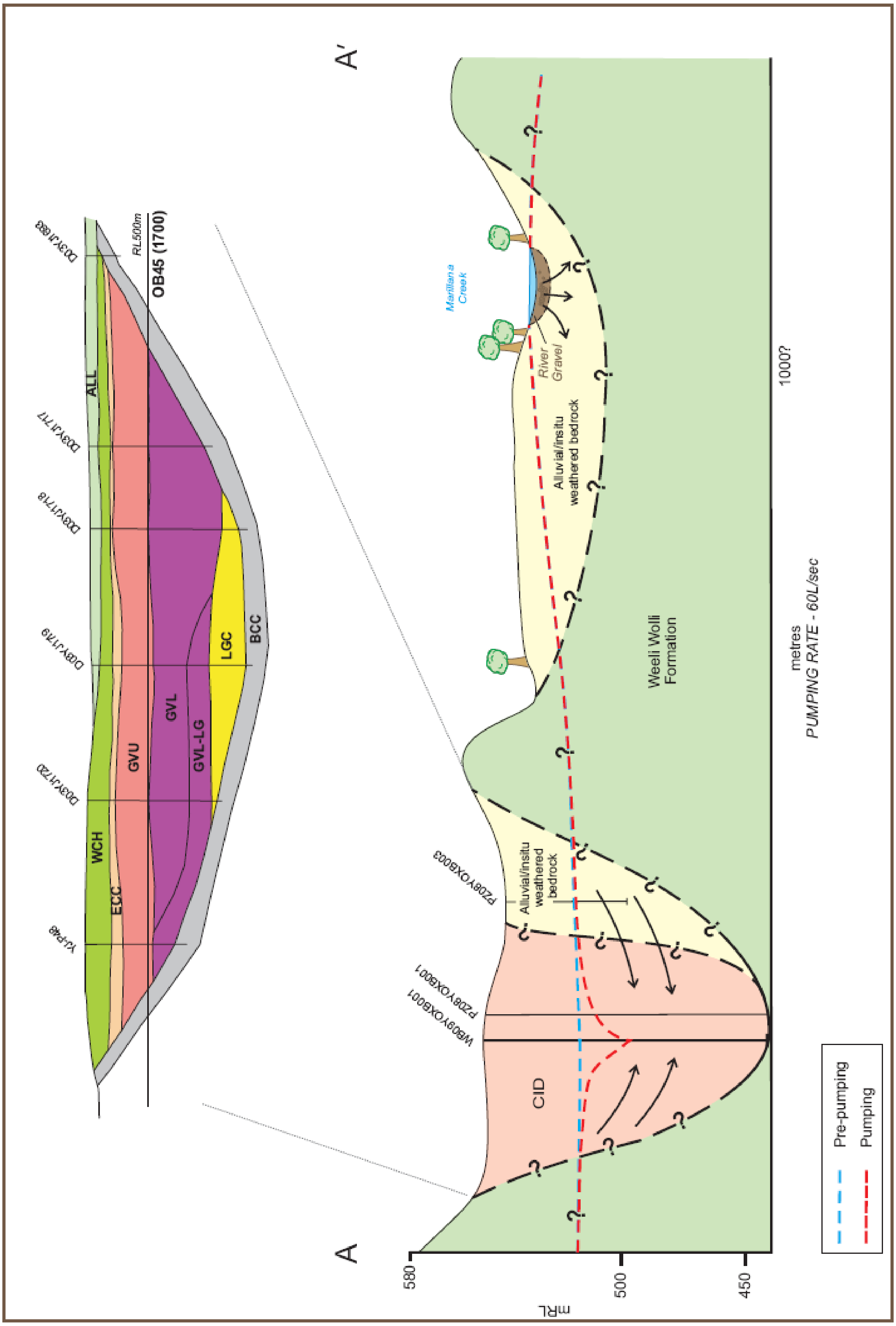


Figure 3-23 – The updated conceptual model for the CID aquifer, showing the relative extent of the surrounding transmissive alluvium/in situ weathered bed rock material in the floodplain

3.12. Aboriginal heritage

Three native title claims exist over the Yandicoogina area. These are Innawonga Bunjima WC96_061, Nyiyaparli WC05_006 and Martu Idja Banyjima WC98_062. Gumala Aboriginal Corporation (GAC) is the representative body for these claimant groups in relation to the Hamersley Iron's Yandicoogina mining lease area (AM70/00274). In March 1997, Hamersley Iron entered into the Yandicoogina Land Use Agreement (YLUA) with the Aboriginal parties, which enabled tenure to be granted for the Yandicoogina Project. The agreement provides benefits to the Aboriginal parties over 20 years for education, training, employment, business and community development. The YLUA is jointly managed by Gumala Aboriginal Corporation and Hamersley Iron.

3.12.1. Archaeological and ethnographic sites

Extensive archaeological and ethnographic surveys have been undertaken within the Yandicoogina locality (eg Quartermaine 1993, 1995, 1996; Hammond 1997; Archae-Aus 2001, 2003a & b; 2005, 2010a and b; O'Conner and Brunton 1995; MacDonald 2003; Day 2004; Ethnosciences 2010; MacDonald and Coldrick 2010). The spatial extent of these surveys is shown in Figure 3-24.

Collectively, these surveys have identified numerous Aboriginal archaeological sites within the Yandicoogina locality including: artefact scatters, quarries, rock shelters, engraving sites and scarred trees. These sites range from low to high archaeological and cultural significance. Possible burial sites (high significance) have also been identified within the area.

A number of ethnographic sites have been identified within the Hamersley Yandicoogina mining lease area, most significantly Weeli Wolli Creek and Marillana Creek. Significant creeks within the area have been identified as having important associations with camping, ceremonies and cultural activities. A heritage exclusion zone has been identified around Weeli Wolli Creek, Marillana Creek and Phil's Creek for the purposes of the existing mining operations. The Native Title claimants have requested that no ground disturbance work be undertaken in the creeks without prior consultation and agreement.

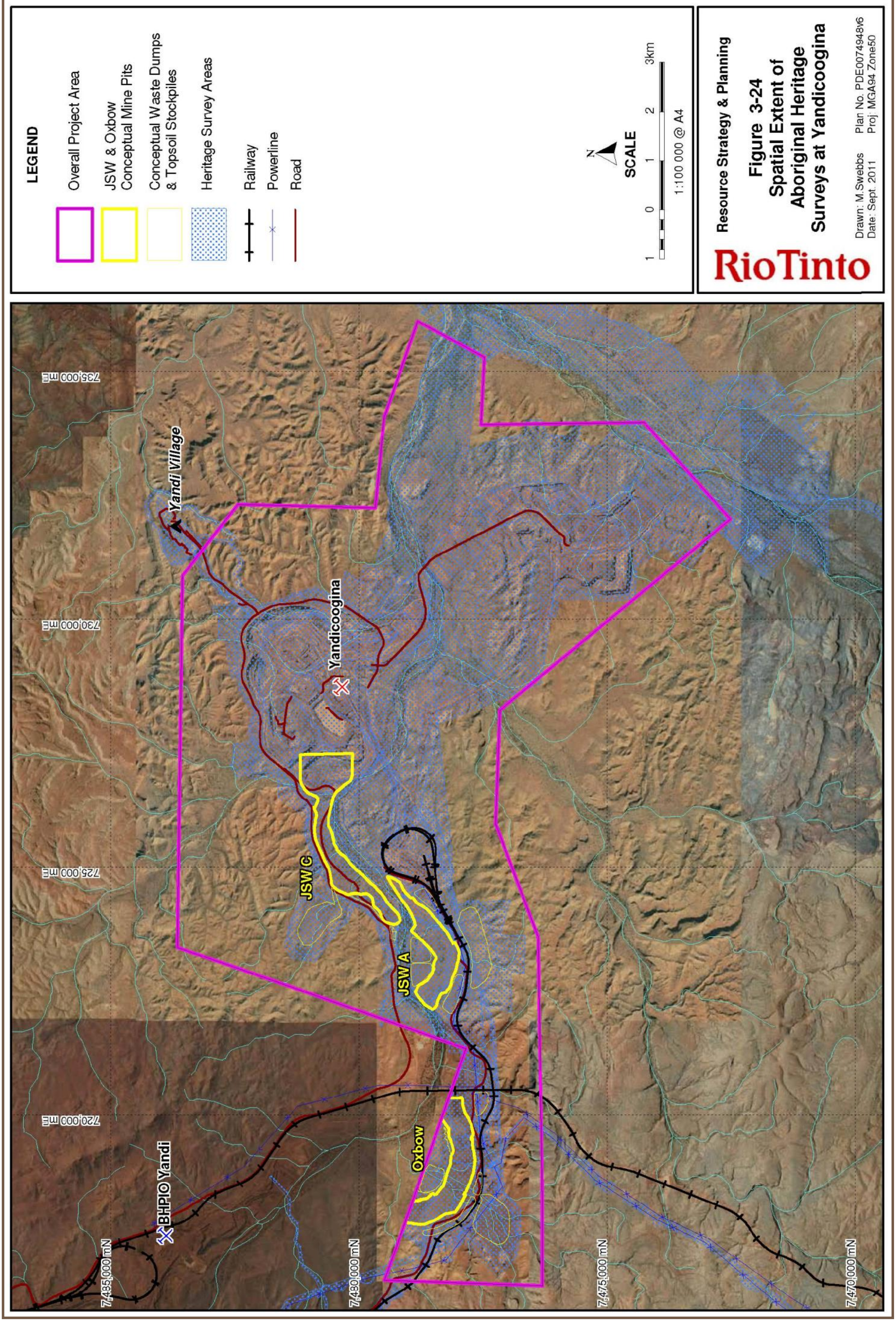


Figure 3-24
Spatial Extent of Aboriginal Heritage Surveys at Yandicoogina

4. Environmental impact assessment approach

4.1. Assessment process

Hamersley has developed a process for assessing the environmental impact of proposed mining operations in the Pilbara region of Western Australia. This process has been followed for the proposed Yandicoogina JSW and Oxbow Iron Ore project.

The process is based on experience gained from other similar proposals and the requirements of the EP Act and relevant guidelines. It includes:

1. preparing a preliminary project scope
2. identifying the environmental factors and values within the project area and their potential to be affected by aspects of the project (within a risk management assessment framework)
3. referring the project proposal to the EPA, under Part IV of the *Environmental Protection Act 1986* (EP Act)
4. consulting with stakeholders on an ongoing basis throughout the project development and assessment process
5. identifying the need for additional surveys and investigations of key environmental factors, and completing these, where necessary. Continuously review and refine this need during the assessment process, in response to interim survey/investigation results and input from regulators and stakeholders
6. defining the scope of the project in greater detail, and characterising potential environmental impacts. This includes developing and refining project design options for minimising impacts
7. preparing and submitting an Environmental Scoping Document (ESD) in accordance with the provisions of the EP Act and associated regulations. The ESD provides an agreed framework for evaluating the potential environmental impacts of the project
8. formulating environmental impact management and mitigation measures
9. determining the likely extent and significance of potential environmental impacts when management and mitigation measures have been implemented, and
10. preparing and submitting an Environmental Review document for public review and subsequent EPA assessment.

These steps provide a systematic and robust process for identifying and evaluating significant environmental impacts associated with mining development proposals. By following this process appropriate impact mitigation and management measures can be developed, ensuring that mining activities are compatible with environmental protection objectives.

4.2. Assessment of environmental factors

Scoping of relevant environmental factors was completed as part of the Yandicoogina JSW and Oxbow Iron Ore project Environmental Scoping Document (ESD). The ESD was prepared in accordance with the *Environmental Impact Assessment Administrative Procedures 2002* (EPA 2002a) and the *Guide to Preparing an Environmental Scoping Document* (EPA 2007b).

The scoping process included identifying environmental factors and completing an environmental risk assessment to outline key aspects and impacts associated with the project. The following potential environmental impacts were identified as being significant:

- **impacts to the vegetation health** and composition of the Marillana and Weeli Wolli Creek systems, resulting from additional discharge of water from pit dewatering into these systems (ie additional to existing operations)
- **loss of groundwater dependant riparian vegetation** along the section of Marillana Creek within and adjacent to JSW-C, due to mining excavation and dewatering cones of depression in this creek section
- **localised impacts to subterranean fauna** within and adjacent to the proposed mine pits, due to groundwater drawdown and excavation
- **changes to aquifer properties and groundwater chemistry** from the post-mining landform, including partially backfilled pit voids, and
- **greenhouse gas emissions,** due to the scale of the mining operations proposed. Based on the emissions intensity of the existing operations at Yandicoogina, annual GHG emissions from the proposed Yandicoogina operations will be ~100,000 tonnes CO_2 equiv. /yr over the life of the project.

A series of investigations to understand these factors and predict potential impacts from the project were then developed (Table 4-1). These investigations provided the basis for the significance of the potential environmental impacts for each factor to be evaluated.

A range of additional factors were identified as not requiring detailed investigation. These included:

- dust emissions
- noise emissions
- light emissions
- waste handling and disposal, and
- weeds.

These factors can be readily managed using Pilbara Iron's standard operating practices and procedures, which have been successfully applied at the existing Yandicoogina operations over the past decade.

Table 4-1 – Environmental factors identified in the Yandicoogina JSW and Oxbow Iron Ore project scoping document

Category	Environmental Factor	Potential significance of environmental impacts (if not managed)	Additional studies required to support the project environmental review
Biophysical	Vegetation and flora	High – the clearing footprint will include up to 2,200 ha of native vegetation.	Vegetation and flora surveys of the project area and surrounds.
	Terrestrial fauna	High – the clearing footprint will include up to 2,200 ha of native vegetation.	Terrestrial fauna surveys of the project area and surrounds.
	Subterranean fauna	High – proportion of the primary alluvium habitat will be removed by mining and adjacent profiles will be affected by dewatering. The zone of drawdown will run the length of the CID in the project area.	Subterranean fauna surveys of the project area and surrounds.
	Groundwater	High – modification of aquifer throughflow characteristics and water quality.	Hydro-geological modelling and impact assessment related to aquifer properties. Studies to support the design and implementation of mine closure.
	Surface water	High – localised modification of surface drainage and discharge of surplus water from mine pit dewatering operations.	Hydrological modelling and impact assessment related to natural surface water drainage. Hydrological modelling and impact assessment related to surface water discharge into the Marillana and Weeli Wolli Creek systems.
Pollution management	Air quality - dust	Low - the current Yandicoogina operations are subject to effective dust control measures.	Review of existing dust control measures at Yandicoogina.
	Greenhouse gases	Med – the project is expected to result in annual emissions of ~100,000 tonnes $C0_{2\ equiv}$. per annum.	Energy efficiency opportunities (2010 assessment for the existing Yandicoogina operations in accordance with the Commonwealth *Energy Efficiency Opportunities Act 2006*) A range of opportunities were identified for existing operations.
	Solid and liquid waste	Low – the existing licensed waste handling and disposal facilities servicing the current Yandicoogina operations are available.	Review of the capacity of the existing waste handling facilities, and options for increasing this capacity if required to service the JSW and Oxbow mining operations.
	Noise and vibration	Low - the current Yandicoogina operations are subject to effective noise and vibration control measures.	Review of existing noise and vibration control measures at Yandicoogina.
	Mineral waste	Low – The project deposits have a low risk of Acid Rock Drainage (ARD) and mobilisation of metallic elements.	Geochemical analysis of mine pit lithologies.
Social surrounds	Aboriginal heritage	High – the Yandicoogina locality is known to contain multiple sites of Aboriginal heritage significance.	Aboriginal heritage surveys, including consultation with relevant Aboriginal groups.
	European heritage	Low – no sites of recorded heritage significance occur.	None required.
	Visual impacts	Low – the area is remote from population centres.	Consider visual impacts in mine closure planning.
Other	Economic and social impacts	Low.	The remote location of the project obviates the potential for significant economic social impacts.

4.3. Environmental studies

RTIO has conducted a number of environmental studies as part of the environmental impact assessment process for the project and in line with the project ESD (Table 4-2). These studies, as well as other supporting studies and documentation (eg relating to existing operations at Yandicoogina) are referenced as appropriate throughout this Environmental Review document. They are included in the document appendices. Where relevant, these studies were undertaken using commonly accepted methodology and in accordance with relevant EPA Guidance Statements.

4.4. Environmental management plans

The existing mining operations at JC and JSE are subject to comprehensive environmental management plans, prepared and implemented according to Ministerial Approvals conditions applied to these projects. Collectively, these plans make up the Yandicoogina Environmental Management Program (EMP) and include:

- Yandicoogina Groundwater Management Plan
- Yandicoogina Surface Water Management Plan
- Yandicoogina Vegetation and Flora Management Plan
- Yandicoogina Fauna Management Plan
- Yandicoogina Significant Species Management Plan
- Yandicoogina Riparian Management Plan
- Yandicoogina Subterranean Fauna Management
- Yandicoogina Weed Management Plan
- Yandicoogina Aboriginal Heritage Management Plan
- Yandicoogina Waste Management Plan
- Yandicoogina Hydrocarbon Management Plan
- Yandicoogina Emissions Management Plan
- Yandicoogina Fire Management Plan
- Yandicoogina Contaminated Sites Management Plan, and
- Yandicoogina Decommissioning and Rehabilitation Plan.

The Yandicoogina EMP (Appendix B) has been reviewed and updated to apply for the proposed mining at JSW and Oxbow. Various management plans for the separate Yandicoogina deposits (JC and JSE) have been consolidated into a single management program that can be applied consistently across the overall Yandicoogina operations. The objectives and major components of the updated management plans are described in Table 4-3. More details on the updated environmental management plans are provided in Section 7.

Table 4-2 – Studies and investigations supporting the Environmental Review document

Environmental factor/aspect	Baseline studies	Appendix No.
Vegetation and flora	Vegetation and Flora Surveys of the Oxbow and Junction South West Deposits, near Yandicoogina (Biota 2010a) Yandicoogina Additional Vegetation Mapping (Biota 2011)	A1 A2
Terrestrial and aquatic fauna	Yandicoogina Junction South West and Oxbow Fauna Survey (Biota 2010c) Yandicoogina Targeted Northern Quoll Survey (Biota 2009) Yandicoogina Expansion Northern Quoll Position Paper (Biota 2010e) Cumulative Impacts of RTIO Mining on the Weeli Wolli Creek System (WRM 2010) Yandicoogina JSW and Oxbow Mine Development – Aquatic Management Report (WRM 2011)	A3 A4 A5 A6 A7
Subterranean fauna	Yandicoogina Subterranean Fauna Assessment Phases 1 to 5 (Biota 2010e), including Yandicoogina Stygofauna Assessment: 2010 Addendum	A8
Surface water	Marillana Creek Regional Flow Balance and Catchment Hydrology (RTIO 2010c) Review of RTIO Surplus Water Discharge Model (SKM 2011)	A9 A10
Groundwater	Yandicoogina Hydrogeological Field Program Report - Bore Installation, Test Pumping 2008/09 (RTIO 2010a) Yandicoogina 2010 Regional Groundwater Modelling report (RTIO 2011a) Yandicoogina Water Balance; Pre and Post-mining Hydraulics and Hydrochemistry (RTIO 2010b) Yandicoogina Model Review (URS 2011)	A11 A12 A13 A14
Aboriginal heritage surveys[13]	Ongoing consultation with relevant Traditional Owners. Extensive archaeological and ethnographic surveys have been undertaken within the Yandicoogina locality since the early 1990s	N/A
Mine closure	Yandicoogina Closure Study Report (RTIO 2011b)	A15

[13] The Yandicoogina surveys submitted to DIA are not available for public viewing.

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Table 4-3 – Components of the Yandicoogina Environmental Management Program (EMP)

Management Plan	Key objectives	Key procedural components[14]
Groundwater Management Plan	• Use improved models to predict impacts to groundwater systems, under a variety of possible dewatering and surface water discharge scenarios. • Monitor aquifers to enable impacts to be detected. • Manage and minimise impacts to groundwater and ecosystems associated with dewatering and discharge of groundwater. • Evaluate water use and alternative management options for the purposes of minimising discharge to creek systems.	• modelling of short term hydrogeological impacts • establish baseline data on groundwater levels, quality and through-flow at the downstream boundary of Mining Lease 274SA and at appropriate locations along the CID aquifer • monitor the groundwater levels, quality and through-flow at appropriate locations along the CID aquifer and along Weeli Wolli Creek during all phases of mining • monitor the dewatering and discharge rates (both cumulative and direct) • reinjection of surplus water from dewatering into the Billiard CID aquifer where feasible • manage and minimise impacts on groundwater • report on the management actions and monitoring results.
Surface Water Management Plan	• Minimise discharge into the creek systems to minimise impacts to Weeli Wolli, Marillana and Yandicoogina Creeks. • Maintain flow paths and flow regimes in the creeks. • Maintain water quality in the creeks. • Evaluate alternative discharge locations and methodologies. • Manage runoff from operational areas to minimise impacts to creek systems.	• maintain the flow paths, quantity and quality of water within Marillana, Yandicoogina and Weeli Wolli Creeks to protect ecosystems and maintain ecological water requirements • regulate discharge to creek systems and evaluate alternative discharge locations and methodologies (eg to achieve ecological mimicry) • minimise the volume of runoff from operational areas and treat runoff to remove contaminants • prevent erosion.
Vegetation and Flora Management Plan	• Ensure that clearing meets approval requirements. • Minimise the clearing of vegetation/habitat within the overall project area. • Avoid species and ecological communities with conservation significance, wherever practicable.	• pre-disturbance vegetation surveys • planning processes for minimising vegetation clearing requirements • ground disturbance prescriptions related to vegetation clearing.
Fauna Management Plan	• Protect native fauna. • Avoid species and ecological communities with conservation significance, wherever practicable. • Protect uncleared habitat from threats and disturbance. • Minimise the effect of feral animals on native terrestrial fauna.	• pre-disturbance fauna surveys • operating prescriptions for minimising harm to fauna • native fauna encounter procedures • feral animal control measures.

[14] Excluding generic components (eg workforce training, documentation and reporting aspects *etc*)

Management Plan	Key objectives	Key procedural components[14]
Significant Species Management Plan	• Maintain the abundance, diversity, geographic distribution, conservation status and productivity of flora and fauna species and ecosystem levels by avoiding or managing adverse impacts and improving knowledge.	• demarcate identified populations of species of flora and fauna of conservation significance and/or areas of their habitat • modify land clearing plans and evaluate alternative mine plans to minimise or avoid impacts on significant species • monitor and record impacts on conservation significant, identified species of flora and fauna, vegetation associations and habitat areas • implement appropriate contingency measures where impacts on significant species and/or areas of their habitat are identified.
Riparian Management Plan	• Monitor riparian ecosystems. • Minimise impacts on riparian vegetation from dewatering and discharge of surplus dewatered water. • Minimise impacts on riparian fauna and habitat.	• monitor the effects of dewatering and injection on riparian vegetation communities and implement remedial measures if adverse impacts are detected • monitor erosion and sedimentation in riparian systems and implement remedial measures if adverse impacts are detected • monitor weed populations in riparian systems and implement remedial measures if adverse impacts are detected • maintain a riparian vegetation buffer of not less than 200 m around Marillana, Yandicoogina and Weeli Wolli Creeks to protect riparian vegetation and the habitat for fauna associated with the creeks, excluding intrusion into this buffer associated with flood protection levees and heavy vehicle road crossing points (near JSW and JC mining areas). Any encroachment will be designed to maintain the flow regime of Marillana Creek.
Subterranean Fauna Management Plan	• Preserve subterranean fauna habitat during mining operations. • Ensure the persistence of subterranean fauna assemblages during and post-mining.	• use modelling techniques to predict the extent of impacts on subterranean fauna habitat • monitor subterranean fauna assemblages • establish additional data on the distribution of existing stygofauna species and communities, particularly the ostracod *Gomphodella* sp; and water mite *Recifella* sp., to demonstrate that there is no threat to these species • take timely remedial action if monitoring data indicates that project operations may compromise the long–term survival of subterranean fauna species and/or communities.
Weed Management Plan	• Minimise the spread of weed species. • Prevent the introduction of new weeds. • Control and/or eradicate both noxious and environmental weeds in the project area.	• identify and map the distribution of target weed species in the operational area • implement weed hygiene and containment procedures • control and eradicate target weeds • monitor the success of weed control.

Management Plan	Key objectives	Key procedural components[14]
Aboriginal Heritage Management Plan	• Maintain ongoing consultation and relationships with Aboriginal heritage stakeholders. • Identify and protect Aboriginal heritage sites and values. • Provide education and information on heritage management required at Yandicoogina.	• ensure ongoing consultation processes • complete pre-disturbance heritage surveys • manage and develop mitigation measures for known Aboriginal heritage sites • develop planning processes to minimise disturbance to heritage sites or values • provide ground disturbance prescriptions to protect Aboriginal heritage (in accordance with the *Aboriginal Heritage Act 1972*) • develop a database and register of Aboriginal heritage sites.
Waste Management Plan	• Ensure that all waste is disposed of in a manner that does not have unacceptable impacts on the environment. • Minimise the volume of non-process wastes generated by adopting practicable waste reduction strategies.	Develop and use: • waste minimisation strategies and procedures • mineral waste management procedures • wastewater management procedures • recycling initiatives • safe waste handling and disposal • landfill operation • hazardous waste management procedures.
Hydrocarbon Management Plan	• Ensure that all hydrocarbons are transported, handled, stored and disposed of in a manner that minimises contamination of the environment.	• use hydrocarbon handling procedures, including hydrocarbon waste streams • use guidelines for operation of hydrocarbon storage facilities • establish spill response and decontamination procedures.
Emissions Management Plan (dust, noise and greenhouse gases)	• Measure and minimise energy consumption and greenhouse gas emissions. • Control dust emissions. • Control noise emissions.	• comply with Commonwealth legislation for energy consumption and greenhouse gas emissions • use noise monitoring and mitigation controls, comply with regulatory requirements • monitor dust and use mitigation controls, comply with regulatory requirements.
Fire Management Plan	• Prevent the outbreak of fires caused by the operation. • Ensure that any fires from the operation or bushfires are contained and controlled so that any damage to the environment and existing facilities or property is minimised.	• establish procedures for preventing uncontrolled fires • maintain on-site fire suppression capability, including trained workforce and fire fighting equipment.
Contaminated Sites Management Plan	• Ensure that contaminated sites do not pose a risk of harm to human health or environmental value.	• identify and register potential contaminated sites • characterise contaminated sites, including identifying and prioritising risks and impacts • develop and use contaminated site management plans and operational procedures.

Management Plan	Key objectives	Key procedural components[14]
Decommissioning and Rehabilitation Plan	• Construct final landforms that are stable, non-polluting and aesthetically compatible with the surrounding landscape. • Establish sustainable endemic vegetation communities consistent with the reconstructed landscape and surrounding vegetation. • Ensure that closure planning and rehabilitation are carried out in a coordinated progressive manner and are integrated with development planning, consistent with current best practice, and the agreed land uses.	The *Decommissioning and Rehabilitation Plan* will be progressively developed over the life of the project. The final plan will include comprehensive closure completion criteria and a monitoring program so progress can be assessed. It will provide a 'walk away' solution for the decommissioned mine site and address: • development of appropriate closure completion criteria • management of long-term hydrogeological/hydrological impacts of mining the CID • modelling the long-term hydrogeological impacts, using a landscape water balance approach • progressive rehabilitation of all disturbed areas to a standard suitable for the agreed end land use(s) • monitoring of rehabilitation to assess the performance of all rehabilitated areas against the completion criteria • reporting on the rehabilitation and monitoring results • removal of all infrastructure (unless otherwise agreed with the State Government) • management strategies and/or contingency measures in the event that operational experience and/or monitoring identify any significant environment impact as a result of the implemented closure strategy • regular consultation with regulatory agencies and other stakeholders.

5. Surplus water management

Water management associated with mining at JSW and Oxbow is strongly influenced by other mining activities in the greater Weeli Wolli Creek catchment. Since mining started at the Hamersley Yandicoogina operations in 1998, substantial volumes of surplus water from mine pit dewatering have been discharged into the Marillana Creek system. This is in addition to the surplus water volumes discharged by BHPBIO into upstream sections of Marillana Creek since 1992. It is estimated that up to 80% of the BHPBIO discharge volume leaks into the CID aquifer and is subsequently intercepted by the JC dewatering infrastructure, with the balance removed via evapotranspiration.

In 2007, the Hope Downs 1 operations began discharging surplus water into Weeli Wolli Creek upstream of Yandicoogina, which has created a discharge footprint which now interfaces with the JSE operations and the Billiard South injection borefield. A proportion of this discharge leaks into the JSE pit and is recirculated by the JSE dewatering infrastructure.

The combined surface water disposal activities of each operation have the potential to cause cumulative impacts to the Marillana and Weeli Wolli Creek systems. Cumulative impacts can arise where operation level impacts act synergistically, cause indirect impacts or combine to exacerbate impacts spatially and/or through time. It was recognised in the project environmental scoping process that the potential for cumulative impacts required further investigation, and that alternative management strategies for the JSW and Oxbow water surplus could potentially deliver improved environmental outcomes.

Several alternative surplus water management options have been identified and evaluated to determine the potential to cause environmental impacts, including:

- Reuse on-site
- Transfer to meet other demand
- Aquifer recharge via pit voids
- Reinjection into aquifers
- Storage and evaporation
- Seasonal storage and release of water, and
- Continuous release of water.

5.1. Site water management

Dewatering of the JC and JSE CID ore bodies is currently facilitated by five dewatering borefields (Phil's Creek Cutback, Marillana, Northern JSE, Sacrificial JSE and Southern JSE), consisting of a total of 27 production bores. Sixth and seventh borefields (Waterstand and Central JSE) consisted of nine production bores, but were removed entirely by mine progression in 2009. The Ridge North and Marillana replacement borefield have recently been drilled which will add an additional nine bores.

The abstraction volumes from each borefield are currently managed as follows:

- **Phil's Creek Borefield** supplies JC operations and the mine camp with potable water and feeds raw water to the plant before discharging to Marillana Creek via Discharge Outlet 3 (DO3)
- **Marillana Borefield** discharges to Marillana Creek via Discharge Outlet 2 (DO2)
- **Northern JSE Borefield** discharges to Marillana Creek via Discharge Outlet 5b (DO5b)
- **Two bores from the JSE Sacrificial Borefield** discharge to Marillana Creek via Discharge Outlet 5a (DO5a) while a third discharges to a collecting tank which transfers the water to the Billiard Reinjection Borefield and Discharge Outlet 6 (DO6) and the JSE turkeys nest which feeds raw water to the plant and potable water for the JSE facilities
- **JSE Southern Borefield** supplies water to a collecting tank which transfers the water to the Billiard Reinjection Borefield and Discharge Outlet 6 (DO6) and the JSE turkey's nest which feeds raw water to the plant and potable water for the JSE facilities.

The location of the borefields and corresponding discharge points is shown in Figure 3-20 (Section 3.10). The water cycle at Yandicoogina is conceptualised in Figure 5-1 and Figure 5-2, including naturally occurring processes and those caused by mining activities. The existing water management system at Yandicoogina is inefficient due to infiltration (leakage) of discharge and reinjection volumes towards dewatered mine voids, followed by recirculation of water through the JC and JSE dewatering infrastructure. This problem is a consequence of the location of the BHPBIO and Hamersley discharge points along Marillana Creek; recharge from Weeli Wolli Creek attributable to Hope Downs 1; and artificial recharge to the CID aquifer from the Billiard South Reinjection Borefield.

The BHPBIO operations have historically discharged up to 13.5 GL/yr to Marillana Creek upstream of, and within, the JSW area. The peak discharge volumes occurred in 2000. BHPBIO has approval to increase the discharge volume to 15 GL/yr under existing approvals for expanded mining in the upstream CID deposits. Infiltration of RTIO Hope Downs 1 discharge volumes from Weeli Wolli Creek to the CID upstream of the Marillana Creek confluence adds approximately 6 GL/yr to dewatering volumes at the JSE pit.

The pumping requirements associated with the double handling of these volumes contribute to higher operational costs and energy consumption, with associated greenhouse gas emissions. RTIO is currently evaluating alternative surface water discharge configurations that can reduce the double handling of water and deliver net environmental benefits.

5.2. Water balance

The components of the water balance for the current and proposed Hamersley Yandicoogina operations are shown in Table 5-1, and explained in the following sections. The water balance was modelled over the projected operational life of the JSW and Oxbow mine pits (2011 to 2022; RTIO 2011a - Appendix A12).

The water balance specifically accounts for volumes captured and/or transported via pumping and pipeline infrastructure to predict water volumes and assess potential management strategies. Leakage volumes resulting from both BHPBIO and Hope Downs 1 discharge are accounted for in the JC and JSW, and JSE dewatering volumes and evaporation/evapotranspiration losses are assumed to have occurred outside the bounds of the water balance.

Two water balance scenarios for the 2011 to 2022 water balance projections have been considered, based on discharge into Marillana Creek from the BHPBIO Yandi operations:

- current long-term average discharge from BHPBIO operations of approximately 5 GL/yr into Marillana Creek, resulting in infiltration (leakage) to the JC/JSW dewatering infrastructure of approximately 4.1 GL/yr, and evapotranspiration of approximately 1 GL/yr; and
- an assumed worst-case scenario, whereby BHPBIO increases their discharge to the licensed limit of 15 GL/yr into Marillana Creek, resulting in infiltration (leakage) to the JC/JSW dewatering infrastructure of approximately 14 GL/yr (numerical hydrogeological modelling shows that evapotranspiration remains approximately the same in both scenarios).

The modelled range of dewatering and surplus water volumes under these scenarios are shown in Table 5-1

Table 5-1 – Yandicoogina projected mine site water balance 2011 to 2022

Component	Volume (GL/yr)
Dewatering	
Dewatering - Junction Central[15]	9.8 to 14.1
Dewatering - Junction South East[16]	13.6 to 17.0
Dewatering - Junction South West and Oxbow[17]	10.0 to 21.3
Water use and surplus disposal	
Plant and Operational Use	5.1 to 5.9
Reinjection at Billiard South	4.3
Existing surface discharge from Junction Central and Junction South East	14.3 to 21.1
Additional surface discharge attributable to Junction South West and Oxbow	10.0 to 21.3
Total Yandicoogina surplus for surface discharge (all pits)	24.6 to 38.1

[15] Includes leakage from BHPBIO discharge into Marillana Creek up to when dewatering of the JSW deposits commence.
[16] It is assumed that JSE dewatering volumes also include leakage of Hope Downs 1 discharge and recirculation of volumes from Billiard South Reinjection Borefield.
[17] Includes leakage from BHPBIO discharge into Marillana Creek.

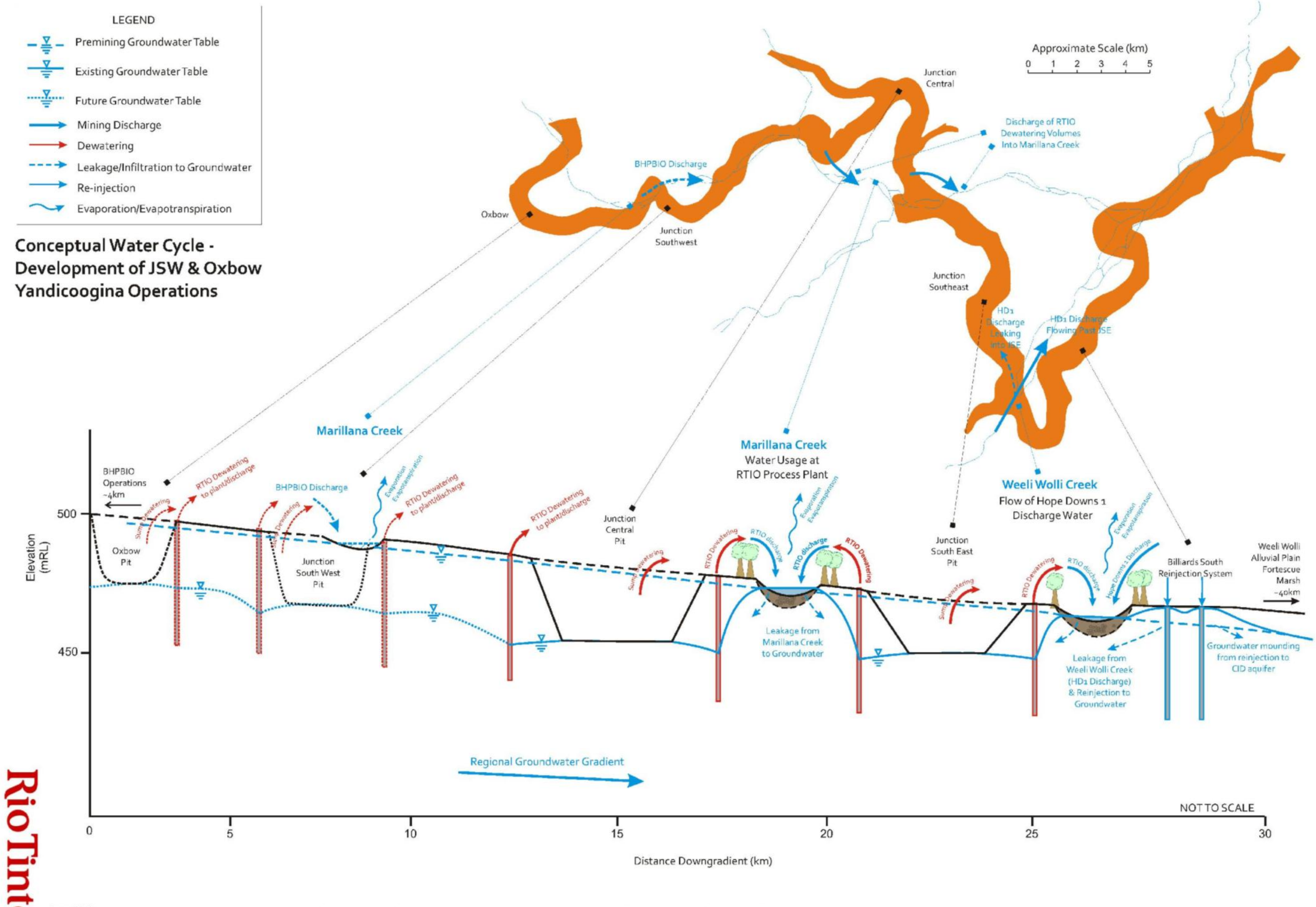

Figure 5-1 Conceptual mine site water cycle at the Hamersley Yandicoogina Operations (current operations)

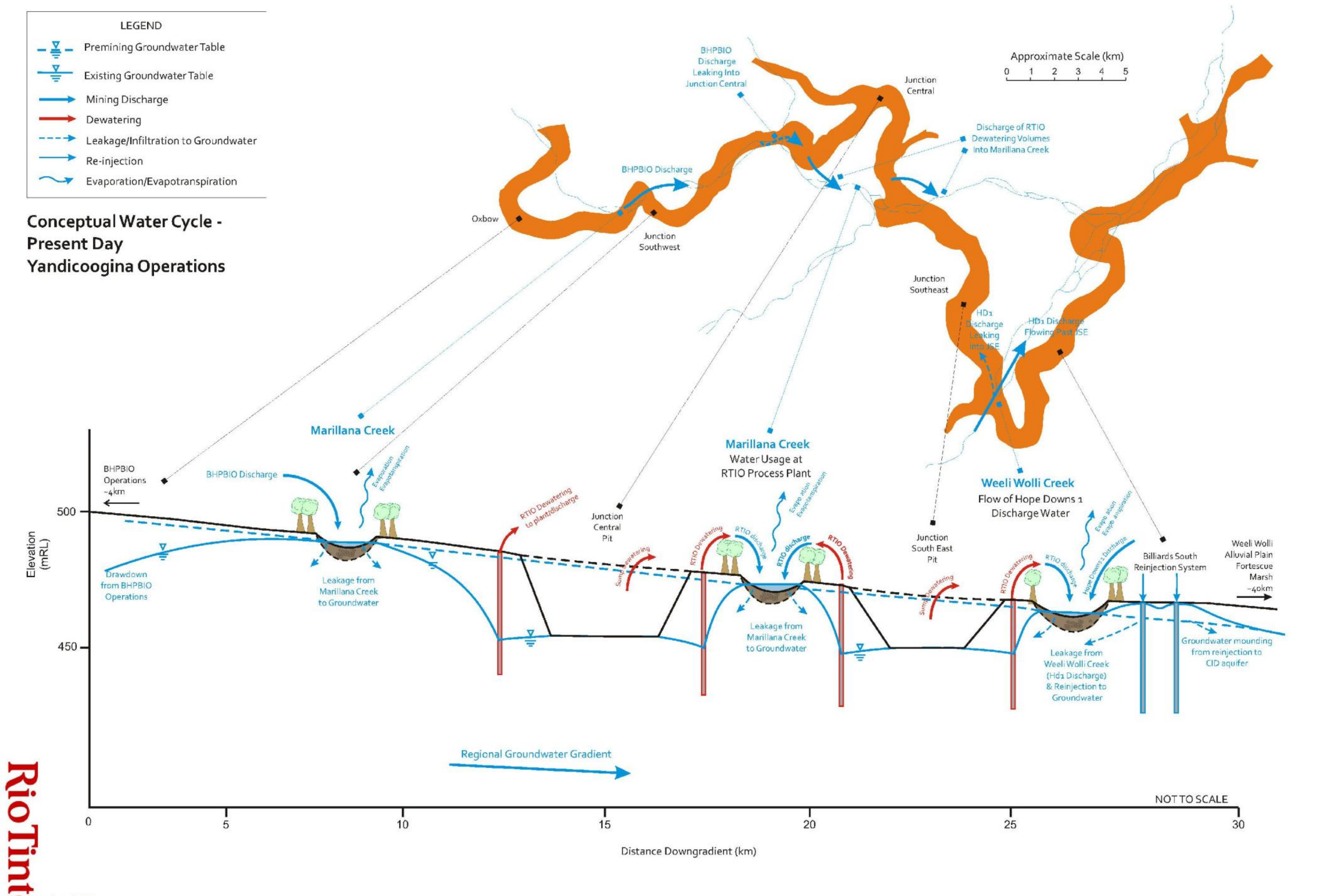

Figure 5-2 Conceptual mine site water cycle at the Hamersley Yandicoogina Operations (including JSW and Oxbow mine pits)

RioTinto

5.2.1. Assumptions and limitations

The results of numerical groundwater models developed by RTIO provide the inputs for the water balance (RTIO 2011a; Appendix A12). Both water balance and the numerical model depend on a number of assumptions, including:

- **Evapotranspiration of BHPBIO discharge volumes is limited to 1 GL/yr.** The remaining volumes are assumed to all infiltrate and be captured by the JSW/JC dewatering infrastructure. In each of the water balance scenarios, BHPBIO discharge remains constant at either 5.1 GL/yr or 15 GL/yr.
- **Input to the Yandicoogina hydrogeological model domain** from discharge of Hope Downs 1 (HD1) surplus water is assumed to be 30 GL/yr. This is assumed to represent the licensed discharge limit of 40.15 GL/yr from HD1, less infiltration and evapotranspiration losses in Weeli Wolli Creek between Hope Downs 1 and Yandicoogina JSE. Dewatering infrastructure at JSE is assumed to capture 27% of the 30 GL/yr that enters the model domain. The remaining 73% flows past JSE down Weeli Wolli. HD1 discharge volumes and subsequent leakage into JSE do not change over the life of the water balance model.
- **There is assumed to be minimal recirculation** from reinjection at the Billiard South borefield, as it is assumed that reinjection in bores RB001 and RB002 has ceased, minimising the potential for recirculation within the CID aquifer.
- **Reinjection is assumed to continue for the life of the water balance model** at the mean 2008/2009 reinjection rates of 4.27 GL/yr.
- **Operational and plant water usage** is as per RTIO forecast plant demands.
- **Rainfall and creekflow events for the previous 20 years** (1990 to 2010) have been used as an analogue for rainfall and creekflow volumes for the life of the model.
- **The models do not take into account the removal of material** from currently mined pits, the construction of the waste fine cells at JC in 2005 and any subsequent new waste fine cells, backfilling of pits that may occur in the future, or dewatering activities carried out by BHPBIO upgradient of the Oxbow deposit.
- **With the exception of water from Hope Downs 1**, there is assumed to be no other leakage and recirculation of volumes discharged by RTIO into Marillana and Weeli Wolli Creeks.
- **The RTIO hydrogeological model has been used** to predict dewatering volumes from JC and JSE, assuming that these voids remain dry for the life of the Yandicoogina mining operations.
- **The dewatering volumes for JSW** assume that the order of pit development is:
  i. JSW-C (commencing 2013)
  ii. JSW-A (commencing 2015)
  iii. Oxbow (commencing 2017).

5.2.2. Supply

The water supply inputs included in the water balance were based on the results of the RTIO numerical groundwater modelling outputs, including predicted dewatering volumes from the Yandicoogina mining operations. Dewatering volumes for the JSW and Oxbow deposits may vary slightly according to the sequence in which the deposits are mined.

5.2.3. Operational demand

Operational and plant demand includes all water used at site for ore processing, dust suppression, and other miscellaneous uses. Ore production rates at Yandicoogina reached 52 Mt/a in 2007, when mining was commissioned at JSE. Since 2007, plant and operational water demand has increased from 3.8 GL/yr to a maximum of 7.7 GL/yr, equivalent to an increase of 18% to 34% of abstraction volumes. Under the current mine plan, the Yandicoogina operations will continue to use the existing processing plant at JC and JSE to maintain output of 52 Mt/a of ore as the JSW and Oxbow deposits are developed. Ongoing plant and operational demand is forecast to be approximately 6 GL/yr.

5.2.4. Billiard South reinjection scheme

Hamersley implemented an additional method of water management in late 2006 by installing and commissioning the Billiard South reinjection borefield. Part of the dewatering volume from JSE is reinjected back into the CID aquifer using up to seven injection bores. Reinjection started at 0.5 GL/month. During 2007, the total reinjection was 4.4 GL.

Reinjection rates have been steadily reducing since the scheme was commissioned, such that the reinjection volume during 2009 totalled 2.7 GL. Average reinjection rates of ~0.07 GL/month were achieved during the latter half of 2009, as the system was taken offline during the commissioning of upgrades to the JSE Southern Borefield. Reinjection rates are expected to return to the average 2008/09 reinjection rate of 4.3 GL/yr, or 0.36 GL/month following the recent reconfiguration of the reinjection system. However, reinjection rates depend heavily on the ongoing integrity of the reinjection bores which are subject to clogging and require regular shutdown and maintenance periods.

5.2.5. Surplus volumes

Surplus water is the remaining dewatering volumes unable to be reinjected or used on-site for operational or plant requirements. Management of surplus water volumes is required due to the large volumes generated by dewatering of the CID deposit and the limited range of on-site uses available. With the exception of the Billiard South Reinjection Borefield, surplus water from Yandicoogina has historically been discharged using surface outfalls feeding into Marillana Creek.

The projected water volumes surplus to operational requirements and reinjection capacity for the overall Yandicoogina operations have been estimated over the project life. The water balance and resulting surplus water volumes are discussed as follows:

5.2.5.1. Water Balance Scenario: BHPBIO discharge 5 GL/yr

Under this scenario, leakage into the CID aquifer from BHPBIO discharge is~4.1 GL/yr. Life of mine dewatering volumes from the Hamersley Yandicoogina operations peak at 38.1 GL/yr during 2018. Total discharge volumes into Marillana and Weeli Wolli Creeks, including an assumed 30 GL/yr input to the Yandicoogina area resulting from discharge from Hope Downs 1, reaches a maximum of 53.4 GL/yr in 2018. This is equivalent to a 14 GL/yr increase on current total discharge volumes from all sources.

The time series water balance under this scenario is depicted graphically in Figure 5-3.

5.2.5.2. *Water Balance Scenario: BHPBIO discharge 15 GL/yr*

Where BHPBIO discharges 15 GL/yr, leakage into the CID aquifer is ~14.1 GL/yr. Life of mine dewatering volumes from the Hamersley Yandicoogina operations peak at 55 GL/yr during 2018. Total discharge volumes into Marillana and Weeli Wolli Creeks, including an assumed 30 GL/yr input to the Yandicoogina area resulting from discharge from Hope Downs 1, reaches a maximum of 63 GL/yr in 2018. This is equivalent to a 23 GL/yr increase on current total discharge volumes from all sources.

The time series water balance under this scenario is depicted graphically in Figure 5-4.

5.3. Surplus water management options

In accordance with the project ESD, Hamersley has undertaken an assessment of options for managing the reuse and disposal of water generated from the mine pit dewatering process. This assessment was based on the list of water management options as outlined in the EPA response to the ESD, and within the Pilbara Water in Mining Guidelines (DoW 2009), as follows:

- Reuse on-site
- Transfer to meet other demand
- Aquifer recharge via pit voids
- Reinjection into aquifers
- Storage and evaporation
- Seasonal storage and release of water, and
- Continuous release of water.

5.3.1. Reuse on-site

This option refers to using abstracted groundwater for operational purposes at the Hamersley Yandicoogina mine site. Water needed for the current and proposed Yandicoogina operations includes:

- **dust suppression** – regularly applying water to unsealed roads and other disturbed surfaces that could generate dust. The amount of water required for dust suppression depends on the area that needs treatment, evaporation rates and traffic levels
- **ore processing** – product screening and the separation of impurities in wet processing circuit
- **expansion projects construction water supply** – for use in site works, dust suppression, exploration drilling and other construction uses
- **potable water for human consumption and septic purposes** – on-site and in the accommodation village.

Water reuse activities associated with developing the JSW and Oxbow mines will be integrated with those of the existing operations.

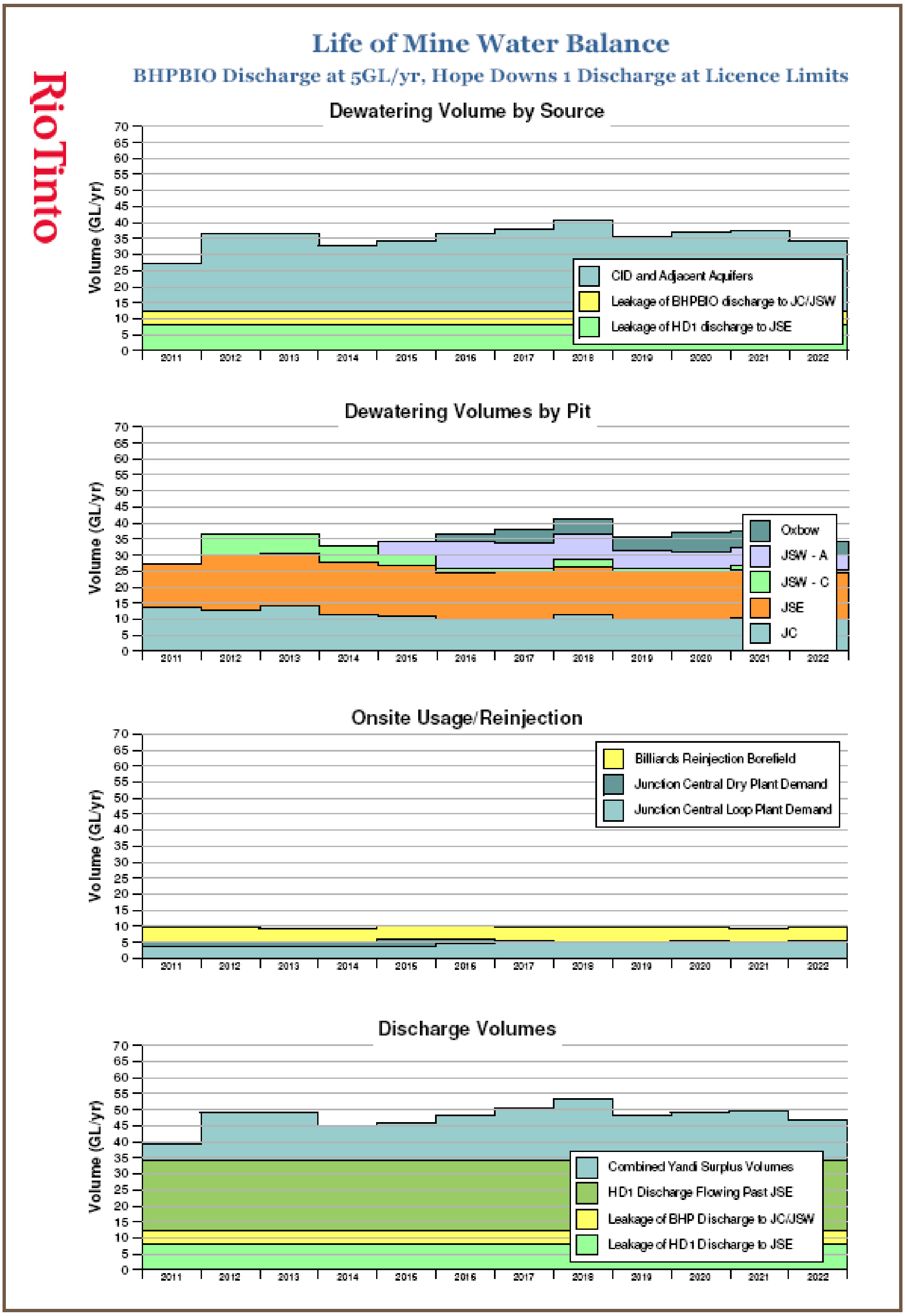

Figure 5-3 – Hamersley Yandicoogina life of mine water balance – Scenario 1 BHPBIO discharge 5 GL/yr

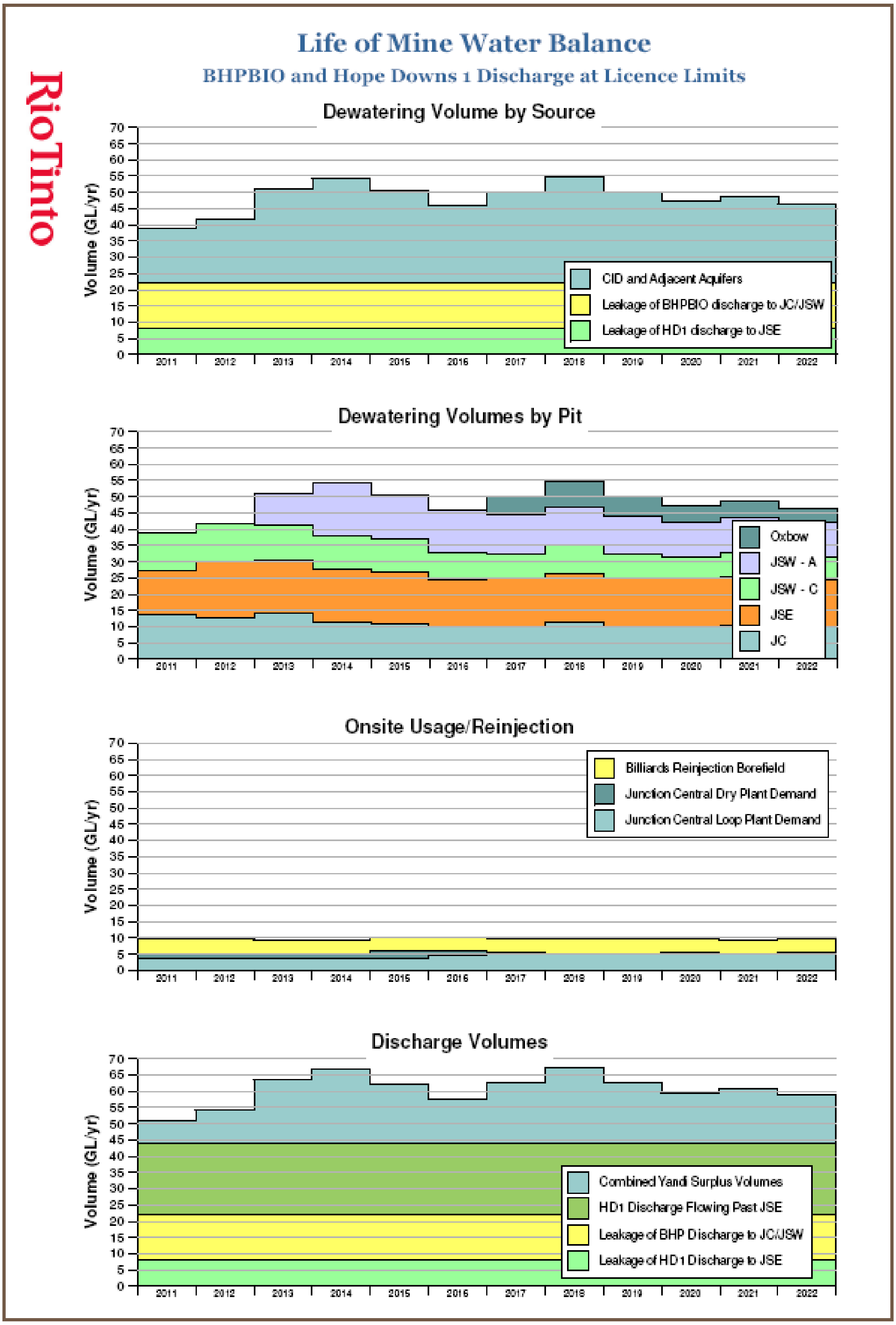

Figure 5-4 – Hamersley Yandicoogina life of mine water balance – Scenario 2 BHPBIO discharge 15 GL/yr

Water for operations and dust suppression at the existing JC and JSE operations is supplied completely by groundwater from mine pit dewatering. In 2009, operations and dust suppression used 34% of the total dewatering volume abstracted. Water is also recovered by decant from the waste fines cell at the JC pit and is recycled into the wet plant or used for dust suppression.

Potable water supply is currently sourced from a borefield located in the CID near the terminus of Phil's Creek. This borefield will need to be relocated to a suitably determined location when Phil's Creek is diverted, as it will also be used for potable water for the proposed JSW and Oxbow mine developments.

There is no scope to sensibly increase on-site water use without compromising water use efficiency objectives. All of RTIO's mining operations are subject to water efficiency targets which aim to reduce the volume of water consumed per unit of shipped ore product. It is proposed that the Yandicoogina operations will continue to use the existing processing plant at JC and JSE to maintain output of 52 Mt/a of ore as the JSW and Oxbow deposits are developed. Ongoing plant and operational demand is therefore forecast to remain consistent with recent (2007 to 2009) usage.

5.3.2. Transfer to meet other demand

This option refers to the transfer of water to other RTIO mine sites, other industrial users or public water supplies.

There are a number of future projects, both Rio Tinto and others, that could make use of surplus water from Yandicoogina and which will remain in consideration. However these need to be considered on a case-by-case basis and whilst the potential for transfer exists, project alignment, security of supply and other factors, such as those outlined below need to be taken into consideration.

Transferring dewatering volumes beyond the boundaries of ML274SA is constrained by a number of factors, including:

- **the *Iron Ore (Yandicoogina) Agreement Act 1996* does not expressly enable** the sale of water to third parties. The inclusion of enabling provisions within the Act would require detailed assessment, followed by parliamentary approval. The implications of an amendment of this type may extend beyond the Yandicoogina project
- **a significant water demand,** or infrastructure to connect to a public water supply, does not currently exist within a practical distance from the Yandicoogina locality
- **mine dewatering supply is transient and variable in quantity**, which is likely to increase the prospect of a mismatch between supply and downstream demand. Given the lack of existing infrastructure to transfer water in the central Pilbara, only a limited number of supply and demand scenarios would enable the recovery of the extensive capital investment required to install new, large-scale water transfer infrastructure
- **large scale transfer of water to meet a non-RTIO demand exposes RTIO** to legal liabilities. Security of demand is equally as important as security of supply and considerable legal liabilities may exist for both parties if supply or demand is interrupted
- **the development of new projects with a water demand** (for example irrigated agriculture projects) within a viable distance from Yandicoogina would require additional tenure, Traditional Owner agreement and extensive project development and feasibility assessments, in addition to environmental and other government approvals. It is unlikely that a significant new project could be developed in time to enable synchronisation with the projected water surplus at Yandicoogina.

5.3.3. Aquifer recharge via pit voids

This option refers to the use of existing pit voids to store and passively discharge water back into the CID aquifer.

Pit void options at Yandicoogina include those at JC and JSE. The JSE pit void is not scheduled to be mined out until ~2025, so will not become available for bulk water storage in a timeframe compatible with the continuity of the Yandicoogina operations. The JC pit is due to close in 2013, and could potentially be converted into a large-scale water storage facility at this time. However, the predicted dewatering volumes from the remaining Yandicoogina operations (JSE, JSW, and Oxbow) will rapidly surpass the storage capacity of the JC pit void, necessitating periodic discharge to the creek systems.

Inundation of the JC pit void would also establish a constant hydraulic head with significant steepening of hydraulic gradients towards adjacent dewatered pit voids. This would promote leakage and require extensive double handling of water volumes from adjacent pit voids, unless suitably engineered cut off walls could be established to reduce leakage.

The use of the JC pit for water storage is further complicated by the existence of tailings storage cells in sections of the pit, which have been established in association with existing ore processing infrastructure. Water storage would need to be integrated with the functionality of the tailings storage areas.

There appears to be greatest potential for the JC pit void to be converted into temporary storage vessel, which would enable the staged release of water on a periodic basis. This option is further discussed in Section 5.3.6.

5.3.4. Reinjection into aquifers

Using borefield infrastructure to deliver surplus water back into aquifer systems was also considered. The potential benefits of this system:

- reduced surface water discharge footprint
- eliminating the potential for evaporative concentration of salts and other solutes before water re-entry into groundwater systems
- storing water for possible future use.

The rate at which water can be supplied into aquifer layers is a function of head differentials and aquifer properties at the point of injection. The utility of this option is highly case specific and strongly influenced by spatially and temporally variable aquifer characteristics. The incised landscape at Yandicoogina constrains the spatial extent of local groundwater systems. These systems receive large flow volumes from up-gradient catchment areas. In combination, these factors limit the potential for injection of significant volumes of surplus water generated by mine pit dewatering activities.

Hamersley has operated an aquifer reinjection project at the Billiard South location since late 2006. The project had the objective of reducing the surface discharge into Weeli Wolli Creek from the JSE dewatering operations and operationally testing injection methods for surplus water disposal. The initial results were promising, and RTIO received industry wide recognition for establishing the project. However, ongoing monitoring identified that a significant proportion of the reinjected water was being recirculated and that injection rates were highly variable between individual bores.

Over the life of the project the majority of the bores have not performed at design capacity. This outcome is attributable to the limited storage capacity in the CID aquifer from inherently shallow water tables at the Billiard South location. A lack of storage prevents the development of temporary groundwater mounding, which could otherwise dissipate accumulated injection volumes over longer time periods, as dictated by aquifer transmissivity characteristics. The effectiveness of the reinjection borefield has been further compromised by discharge water from the Hope Downs 1 dewatering operations, which began recharging the CID aquifer by infiltration through the overlying sediments in Weeli Wolli Creek in early 2007.

Without local aquifer reinjection site options, it is possible that water could be piped to more suitable locations further afield before reinjection. A solution like this would be subject to a range of regulatory and physical constraints, and would also create environmental impacts, including:

- **tenement issues -** from a hydrogeological perspective the best location for reinjection in the greater Weeli Wolli Creek catchment is the Weeli Wolli alluvial plain, ~15 km north of the Yandicoogina operations. However, this location is subject to non-RTIO tenure arrangements and is close to the Brockman Resources Marillana project. Any pipeline servicing this area would need to traverse tenements held by Iron Ore Holdings and BHPBIO
- **deep water table -** the Weeli Wolli alluvial plain, creek proper and the associated ecosystem occupies a broad area with a relatively deep water table (~30 m below surface). The depth to water table and relatively high porosity of the alluvium means that the system is able to absorb large, infrequent flood flow events that occur in the Weeli Wolli catchment. Water reinjection in this area would reduce the buffering capacity of the unsaturated alluvium, potentially increasing the size and frequency of surface water flows discharging directly into the environmentally sensitive Fortescue Marsh further downstream. This type of hydrologic modification could result in undesirable ecosystem changes in the Marsh
- **vegetation and fauna disturbance -** installing a pipeline to transfer surplus water to the reinjection site would require additional vegetation disturbance and potentially interfere with fauna movements and surface water flow regimes. Creating a new borefield would also result in disturbance
- **an exploration campaign to search for other sites** with the potential to receive significant reinjection volumes would in itself cause a variety of environmental impacts, and be subject to various regulatory requirements for vegetation disturbance, heritage protection, access and tenure arrangements, exploration drilling and test pumping. It is unlikely that this task could be carried out within a timeframe that is aligned with the JSW and Oxbow mine developments.

Given these issues, there is no potential to significantly increase reinjection volumes in the project area. Developing reinjection facilities further afield is environmentally sub-optimal, particularly given the additional disturbance that would be required.

5.3.5. Surface storage and evaporation

Constructing large-scale, shallow surface ponds to enable water to evaporate into the atmosphere was also considered.

Although intuitively appealing, this option is subject to a variety of physical and technical constraints. Research by the CSIRO Centre for Complex Systems Science shows that surface area storage facilities have low evaporation efficiencies, even under the arid climatic regime experienced in the Pilbara region (pers. comm. Dr. John Finnigan, CSIRO). Evaporation rates are often negligible outside of areas immediately adjacent to the upwind dam wall, as the lens of air directly over the water body quickly approaches saturation and so cannot readily accept any additional moisture.

The need for shallow storage volumes to improve evaporation rates necessitates large dam surface areas. An above ground storage and evaporation facility dam with sufficient capacity to safely accommodate operational dewatering volumes, plus cyclonic rainfall volumes, would exceed the available land area at Yandicoogina. Preliminary estimates for a dam 2 m deep and with sufficient volume to accommodate and evaporate 20 GL over a one year period, show that the dam would need to cover between 1,200 and 1,600 ha.

Dam construction at Yandicoogina would be associated with a range of environmental impacts including:

- extensive land area disturbance
- modification of subterranean habitats beneath and adjacent to the dam
- modification to surface water flows
- greenhouse gas emission associated with dam construction, with the potential to significantly increase the emission intensity of the overall operations, and
- substantive additional land rehabilitation and mine closure requirements.

Based on this preliminary assessment, RTIO considers that construction of an above ground storage and evaporation dam is not viable at Yandicoogina on technical, economic and environmental grounds.

5.3.6. Seasonal storage and release of water

Large-scale water storage coupled with periodic (discontinuous) discharge of large water volumes to adjacent creek systems was considered.

A seasonal storage and release management regime at Yandicoogina could potentially be achieved by converting the mined out JC pit void as a water storage facility. In conceptual terms, the void would be filled with water during the dry season (April to November) and drained during the wet season (December to March) by pumping and discharging to an area downstream of the Yandicoogina mines. The optimal discharge area needs to be investigated further, but could include sections of Marillana Creek, Weeli Wolli Creek or an area of alluvial floodplain adjacent to Weeli Wolli Creek in the Billiard North deposit. The discharge regime would be designed to mimic flows from natural seasonal rainfall and runoff, reducing, and possibly eliminating, the need for year round discharge.

Based on preliminary estimates, the JC pit void could store 35 to 70 GL. The total volume available is subject to the integration of water storage with mineral waste storage from the JSW pit and waste fines storage from the existing wet processing plant. The area of the overall pit potentially available for water storage extends from the Hairpin to Waterstand pits. It is conceivable that the pit could be engineered to enable complete storage of annual surplus water volumes generated by the Hamersley (existing and proposed) and BHPBIO operations. The JC dam could also be a source of water for processing operations and future supply to off site users.

Converting the JC pit void into a surplus water disposal vessel (the JC dam) is a complex engineering challenge and subject to considerable technical uncertainties. A number of additional investigations would be necessary to fully evaluate the viability of this option (Table 5-2). RTIO will investigate this option further as a potential component of the site water management strategy following the closure of the JC pit after 2013. These investigations will be integrated with concurrent mine closure planning.

5.3.7. Continuous release of water

This option refers to direct discharge of surplus water to the nearby creek systems, on a mostly continuous basis as dictated by groundwater abstraction rates. The majority of surplus water volumes generated by the existing Yandicoogina operations are managed in this way.

Water balance studies at Yandicoogina have shown that ~20% of the surplus water currently discharged into Marillana and Weeli Wolli Creeks is taken up by evaporation and evapotranspiration. The remaining 80% readily infiltrates and percolates back to the CID and alluvial aquifers down gradient of the mining operations (RTIO 2010b; Appendix A13).

Surplus dewatering volumes from RTIO Yandicoogina and BHPBIO Yandi operations have been continuously discharged into Marillana Creek since 1996 and 1992, respectively. More recently, large volumes have been released into the Weeli Wolli Creek upstream of the Marillana Creek confluence by the Hope Downs 1 project. Concerns over release of surplus water volumes in the creek systems relate to the following potential environmental impacts on the receiving environment:

- Surface water quality
- Groundwater quality
- Riparian vegetation
- Aquatic fauna assemblages
- Weeds
- Feral animals.

Trigger levels established in the original *Yandicoogina Riparian Vegetation Management Plan* and Hope Downs 1 Water Management Plan have not been exceeded due to mining related impacts. Further information on the monitoring program and historical impacts is contained in Section 3.10.

Table 5-2 – Additional studies required to assess the feasibility of converting the Junction Central pit void into a surplus water storage vessel

Factor requiring assessment	Description
Leakage management	It is recognised that filling the JC dam, being located in the CID, will provide an elevated hydraulic head promoting infiltration of water into the JSE or future JSW pits. Prior to filling with water, the south east wall of the JC dam may need to be engineered to reduce flow through the wall into the JSE pit by installing a barrier.
Assessment of required infrastructure upgrades and modifications	The following modifications to the current dewatering infrastructure may be required: • The current borefield and pit sump pumps may have insufficient head to pump water at adequate flows to the JC dam. Additional header pumps, tanks and control systems may be required to ensure that the current and future dewatering systems are supported. • The existing water discharge infrastructure would require modification to include large dirty water type pumps, large diameter piping and water dissipation structures in at the disposal area. • The BHPBIO discharge structure is located to the west of the proposed JSW pits in Marillana Creek. Discharge from the pipe will require redirection into a sump and booster pump arrangement for piping to the JC dam. The objective is to reduce water inflow to the JSW area. • All of the JC pumping and discharge systems will require additional electric power and control systems capable of being directed from the Operations Centre in Perth.
Geotechnical assessment	A stability assessment of the walls of the open pit and land bridges associated with Marillana Creek and Phil's Creek will be required to ensure they are stable during the life of the operation of the JC dam. This assessment needs to consider modes of failure and any remedial measures to ensure stability.
Waste Fine Cells assessment and design	The proximity of water dam to the waste fine cells will require the JC dam to be hydraulically sealed from the waste fine cells. Additionally the waste fine cells are required to drain to allow consolidation of the tailings. Failure to drain will decrease the density of the tailings and could lead to additional volume for waste fines being required. Sufficient waste fines storage capacity is required to accommodate variable rates of wet processing, which will ultimately be determined based on ore product specifications.
Assessment of required earthworks	Earthworks will be required in the vicinity of the dam for flood control, access to pumps and pipelines and a spillway.
Hydrological, hydrogeological and hydrochemical assessment	Assessment of these factors will be required to inform the design of the various pumping systems, flood control, and maintenance of water quality within the dam and CID aquifer.
Mechanical engineering assessment and design	The pumps, pipelines and associated control systems will require engineering design. The discharge point will require an energy dissipation structure to prevent erosion.
Electrical engineering assessment and design	Electrical power will be required to be supplied to the pumps and control systems.
Civil engineering assessment and design	Foundation design for all equipment and facilities around the dam will be required.
Closure design	The JC water dam will be required to be closed at the end of its operating life.

5.4. Comparative assessment of surplus water management options

This section describes an evaluation of the various surplus water management options described in Section 5.3, with respect to their comparative potential to impact on environmental values at Yandicoogina. The purpose of the evaluation was to identify management options for project dewatering volumes having the lowest potential for adverse environmental impact.

5.4.1. Comparative assessment criteria

Assessment criteria for evaluating surplus water management options were developed based on policy, environmental and operational considerations (Table 5-3). Key policy documents considered when developing the assessment criteria included:

- Pilbara Regional Water Plan 2010-2030, and
- Draft Pilbara Water in Mining Guideline.

The assessment criteria provided a high level framework for comparing the relative environmental merits of the different surplus water management options (Table 5-4). Key issues for particular management options were identified, suitable for inclusion in more detailed feasibility assessments.

5.4.1.1. Pilbara Regional Water Plan 2010-2030

The criteria for assessing the options are consistent with the objectives of the *Pilbara Regional Water Plan 2010-2030* (DoW 2010), including:

- ensuring security of water supply for the current and future needs of all water users
- ensuring water use is balanced to meet environmental, social, cultural and economic values
- ensuring that impacts, including cumulative impacts, are managed to protect the long term health of waterways, aquifers, wetlands, springs, floodplains and estuaries. In doing so the following principles require consideration:
    - the healthy, natural and functioning state of high-value assets which remain in near pristine condition need to be maintained.
    - the impacts of mining, pastoral, recreational and tourism activity on water-dependent values need to be minimised through best practice water use.
    - ecological objectives and targets for water-dependent values that are likely to be affected by development, need to be set in advance, impacts monitored and management actions reviewed if necessary,
    - ecological objectives and targets for the rehabilitation of water-dependent values at the end of the life of the development need to be set in advance.
- integrating land-use, infrastructure and natural resource management planning with water planning
- recognising and protecting Aboriginal and other heritage values associated with water
- ensuring the quantity and quality of water used is appropriate for the purpose for which the water is being used, and
- supporting high-value use by industry and agriculture, with the least adverse impact.

The *Pilbara Regional Water Plan 2010-2030* recognises that the Aboriginal people of the Pilbara have a strong connection to water and have important custodial links with the region's water resources. Significant social and cultural constraints may apply to human induced movement of water within the region. The Plan also recognises that the practicality of water supply (for example from mine dewatering sources) is strongly affected by supply security and water transfer logistics. The following statements are included, applying directly to the Hamersley Yandicoogina operations:

'…for inland towns and mines with more water than they require, the policy focus is to optimise water use to minimise environmental impacts'

'…it is essential that water management issues are planned for early in the mining development process and that all mining players adopt best practice water use'

'The quality and quantity of water potentially being discharged may vary greatly from the quality and quantity of water in local waterways and because of this, mine operators are required to ensure that appropriate measures are taken to minimise long term pollution or degradation of any receiving water bodies'.

The plan also recognises the need for energy to be conserved and greenhouse gas emissions to be minimised in water management planning and implementation.

5.4.1.2. Draft Pilbara Water in Mining Guideline

The criteria used to assess the options are consistent with the mine water management objectives of the *Draft Pilbara Water in Mining Guideline* (DoW 2009). These objectives include:

- ensuring that all possible water sources are considered when planning water supply for mining operations
- planning for and managing the effects of the highly variable climate
- ensuring that high quality water is used only in situations where it is essential or where no other suitable water source is available
- ensuring that mining activity does not adversely affect the quality and quantity of drinking water supplies
- minimising the adverse effects of the abstraction and release of water on environmental, social and cultural values
- optimising the use of surplus water on-site to reduce the effects of releases to the environment
- maximising water use efficiency at the ports and water-deficit sites to reduce the need for water to be abstracted from the environment
- using a monitoring and evaluation process to adaptively manage the effects of abstractions and releases on the water regime both at mining sites and in the catchment in general
- ensuring that water management planning considers the mine void after the mining operations cease
- ensuring that the cumulative effects of individual mining operations are considered and managed
- maximising cooperation in water management activities between mining operations, to reduce the impact on the environment, and
- developing and maintaining positive relationships between stakeholders so that information needed to properly manage water resources is shared.

Table 5-3 – Assessment criteria used to compare and evaluate different surplus water management options

Criterion	Description and rationale

Environmental factors with the potential to be directly and indirectly impacted	Environmental factors include those contained in the EPA checklist of environmental factors contained in EPA Guidance Statement No. 33 (EPA 2008). There are three classes of factors including:
	• Biophysical factors
	    • conservation areas
	    • vegetation and flora
	    • fauna (terrestrial, subterranean, aquatic and marine)
	    • wetlands
	    • waterways
	    • public drinking water sources
	    • groundwater
	    • soils and land
	    • landscape and landforms
	    • coastal areas
	    • marine areas
	    • biophysical processes that may affect human health, safety and amenity or the environment
	• Pollution management factors
	    • greenhouse gas emissions
	    • air quality
	    • water management
	    • noise and vibration
	    • light
	    • radiation and electromagnetic fields
	    • contaminated sites
	    • waste management
	• Social surroundings factors
	    • culture and heritage
	    • visual amenity
	    • recreation
	    • risk to public from 'hazardous industrial plant.'
	The assessment process distinguished between the potential for direct and indirect impacts on these environmental factors. Direct impacts were defined as effects caused by actions associated with the option and occurring at the same time and place. Indirect impacts were defined as effects caused by actions associated with the option that occur later in time or farther removed in distance, but are still reasonably foreseeable.
	Consideration of these factors is consistent with the *Pilbara Regional Water Plan 2010-2030* and *Draft Pilbara Water in Mining Guideline*.

Criterion	Description and rationale
Extent of ground disturbance	The extent of ground disturbance associated with each option was qualitatively assessed as being ‘minor’ or ‘significant’. Generally, larger disturbance footprints have a greater probability of affecting environmental factors such as threatened species and communities, heritage values and natural drainage systems. Significant linear infrastructure requirements (defined as linear infrastructure extending beyond the boundaries of Mining Lease ML274SA) were also identified.
Net loss of water from local ecosystem	The net loss of water from the Yandicoogina CID aquifer associated with each option was qualitatively assessed as being ‘minor’ or ‘significant’, based on the proportion of dewatering volumes that would be expected to be returned to the aquifer system after abstraction and handling. Consideration of water being returned to the local environment is consistent with the *Pilbara Regional Water Plan 2010-2030* and *Environmental Water Provisions Policy for Western Australia - Statewide Policy No. 5*.
Operational considerations	Operational considerations with the potential to significantly affect the feasibility or practicality of each option were assessed. Sub-components of this criterion included: • the need to enter into legal or commercial arrangements with third parties • to the need to access land outside tenements held by RTIO or its subsidiaries • timeframes required to undertake feasibility assessments • obvious major risk factors with the potential to undermine the effectiveness of the option • closure and decommissioning considerations. Including this criterion was considered to be important for option validation purposes. Note: projected cost and technical difficulty were not included as operational considerations for the purposes of this assessment. These items were considered ‘not appropriate’ for comparing the environmental merits of each option, even though they are commercially important considerations.

5.4.2. Options evaluation

Table 5-4 – Evaluation of surplus water management options against assessment criteria

Surplus water management option	Assessment criteria			
	Environmental factors with the potential to be significantly impacted (directly and indirectly)	Extent of ground disturbance	Net loss of water from local ecosystem	Operational considerations
Transfer to meet other demand	**Direct** Vegetation and flora Landscape and landforms Culture and heritage Significant additional greenhouse gas emissions (water transfer infrastructure and end use) **Indirect** Terrestrial fauna (movements) Subterranean fauna (surface disturbance) Visual amenity (linear infrastructure)	Significant Linear infrastructure requirement	Significant	Supply arrangements with third parties Land access to non RTIO tenure required Supply and/or demand shortfall risks
Aquifer recharge via pit voids	**Direct** Groundwater Landscape and landform **Indirect** Terrestrial fauna (movements; artificial water source)	Minor	Minor	Long pre-implementation timeframe – the conversion of pit void into storage vessel will require multiple technical feasibility assessments
Reinjection into aquifers	**Direct** Vegetation and flora Subterranean fauna Landscape and landforms Culture and heritage Groundwater Significant additional greenhouse gas emissions (linear infrastructure construction, borefield construction and operation) Visual amenity (linear infrastructure) **Indirect** Terrestrial fauna (movements)	Significant Linear infrastructure requirement [18]	Minor	Land access to non RTIO tenure required Risk that receiving aquifer does not accept injection volumes

[18] On the basis that local injection site options are not available

Surplus water management option	Assessment criteria			
	Environmental factors with the potential to be significantly impacted (directly and indirectly)	Extent of ground disturbance	Net loss of water from local ecosystem	Operational considerations
Surface storage and evaporation	**Direct** Vegetation and flora Subterranean fauna Landscape and landforms Culture and heritage Visual amenity Significant additional greenhouse gas emissions (dam construction) **Indirect** Terrestrial fauna (movements) Groundwater	Significant	Significant	Large land area required to dispose of projected dewatering volumes Substantial closure and decommissioning requirements
Seasonal storage and release of water	**Direct** Vegetation and flora (riparian) Subterranean fauna Watercourses Groundwater **Indirect** Culture and heritage	Minor (assuming the use of existing pit voids)	Minor	Long pre-implementation timeframe – the conversion of pit void for water storage purposes will require multiple technical feasibility assessments
Continuous release of water	**Direct** Vegetation and flora (riparian) Watercourses **Indirect** Groundwater Culture and heritage Fauna (artificial water source)	Minor	Minor	Minimal closure and decommissioning requirements Potential for cumulative impacts on creek systems due to combined effects of multiple water disposal activities in the catchment

5.4.3. Preferred option

The evaluated surplus water management options were ranked on the basis of their relative potential environmental impacts. Based on currently available knowledge, the ranking from *most* to *least* preferable was:

1. Continuous release of water
2. Seasonal storage and release of water
3. Aquifer recharge via pit voids
4. Reinjection into aquifers
5. Transfer to meet other demand
6. Surface storage and evaporation.

The analysis showed that the *continuous release of water* has several important advantages over alternative options. It does not require significant new ground disturbance and minimises water losses to the atmosphere or other external sinks (ie local ecosystem loss). The potential impacts are largely confined to riparian areas with known biological characteristics, and can be considered to be disruptive rather than destructive to riparian ecosystems.

Riparian vegetation monitoring associated with historical surplus water discharge activities at Yandicoogina has not detected highly significant vegetation health decline of the dominant riparian tree species in over six years of assessment. The monitoring findings to date, provide a level of confidence that the impacts associated with surplus water disposal are unlikely to result in the removal of key ecosystem functions or the ability of the ecosystem to recover post-mining.

Continuous release of water can potentially result in cumulative impacts, due to interactions with water disposal volumes from other mining projects in the catchment. However, RTIO's hydrological modelling (Appendix A9), peer reviewed by SKM (Appendix A10), has shown that these interactions are predominantly linearly additive under a wide range of discharge and climate scenarios. This finding provides confidence that the impacts will be contained to downstream sections of the Weeli Wolli Creek, with low probability of affecting downstream conservation assets such as the Fortescue Marsh.

Converting the JC pit void to include a water storage function could potentially enable option two (seasonal storage and release of water) and option three (aquifer recharge via pit voids), or some combination of the two to be developed as part of an alternative water management strategy. RTIO is completing feasibility assessments of these options, which could provide contingency management measures if riparian vegetation monitoring shows a significant and continuous decline in vegetation health when the project is implemented. This approach is consistent with the *Yandicoogina Riparian Management Plan*.

6. Stakeholder consultation

6.1. Key stakeholders

Substantial stakeholder consultation and public review of mining activities at Yandicoogina has occurred historically, as part of environmental approval processes for the existing JC and JSE operations. Since mining started at Yandicoogina, Hamersley Iron has sought to keep relevant stakeholders up-to-date with studies relating to future mining in the area. Consultation relating to the JSW and Oxbow mining project has been complementary to this existing process.

The following stakeholders have been consulted during the preparation of this Environmental Review document:

6.1.1. Government Agencies

- Office of the Environmental Protection Authority (OEPA)
- Department of Environment and Conservation (DEC) Pilbara Regional Office
- Department of Environment and Conservation (DEC) Kensington Office - Environmental Management Branch and Science Division
- Department of Water (DoW), and
- Department of Mines and Petroleum (DMP).

6.1.2. Non-Government Organisations

- Conservation Council
- Gumala Aboriginal Corporation, including Traditional Owners
- BHP Billiton Iron Ore (BHPBIO), including Marillana Station
- Iron Ore Holdings (IOH), and
- Brockman Resources.

6.2. Consultation process

Consultation activities for the project commenced in 2007, and a number of discussions and meetings have been held with key stakeholders from this time. A site visit with representatives from key regulatory agencies occurred in August 2008. Comments on the project Environmental Scoping Document (ESD) were provided by the EPA, Department of Environment and Conservation, Department of Water, Department of Indigenous Affairs and the Department of Industry and Resources[19].

Stakeholder contributions have been considered during project design and when preparing this Environmental Review document (Table 6-1).

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[19] The Department of Industry and Resources (DOIR) has since been restructured to establish the Department of Mines and Petroleum and the Department of State Development

6.3. Stakeholder comments and proponent responses

Issues raised by stakeholders have been addressed throughout the Public Environmental Review process. A summary of the issues raised and Hamersley Iron's responses, as the proponent, are provided in Table 6-2.

The key issues identified by stakeholders over consultation process so far, include:

- water management, particularly discharge
- cumulative hydrological impacts from other mining activities in the area
- impacts to Fortescue Marsh
- closure management
- vegetation disturbance, particularity riparian vegetation and any impacts on priority flora, and
- disturbance of Aboriginal heritage values.

6.4. Ongoing consultation

Ongoing consultation activities will occur throughout the PER assessment process, including meetings with stakeholders, public meetings and informal information sessions when environmental documentation is released for public comment. Table 6-3 shows the proposed consultation program in the future.

Table 6-1 – Completed stakeholder consultation undertaken for the JSW and Oxbow project proposal

Date	Stakeholder	Purpose
18/12/2007	EPA Services Unit	To introduce and provide an overview of the project.
25/03/2008	Gumala Aboriginal Corporation	To provide an overview of the project (as part of an update on the overall Yandicoogina operation).
07/04/2008	Department of Water	To discuss water management considerations associated with the project, including cumulative impacts of existing and proposed mining operations affecting the Weeli Wolli Creek catchment. Options for integrating groundwater extraction licences across the Yandicoogina operations were also discussed.
26/08/2008	Department of Environment and Conservation Department of Water	Site visit and discussion of the Yandicoogina JSW and Oxbow mining project.
03/09/2008	Gumala Aboriginal Corporation	Status update of the project (as part of an update on the overall Yandicoogina operation).
12/12/2008	Department of Environment and Conservation	Project update and discussion of scoping document and requirements.
10/03/2009	Department of Environment and Conservation	Review of proposed Yandicoogina dewatering, including discussions on the cumulative impacts with Hope Downs 1.
17/04/2009	Conservation Council	Briefing on the Yandicoogina JSW and Oxbow Project.
08/09/2009	Brockman Resources	Discussion about the potential opportunities for water sharing.
10/11/2009	Department of Environment and Conservation	A status update on the project and discussions on closure (as part of a larger RTIO project update).
24/11/2009	BHPBIO	Initial discussions on the need to share information within the Marillana - Weeli Wolli Catchment.
03/12/2009	Gumala Aboriginal Corporation	Status update of the project (as part of an update on the overall Yandicoogina operation).
07/12/2009	Department of Environment and Conservation	Provided an update on the status of the project, including the PER submission timeline and discussed key issues relating to water management and mine closure.
23/02/2010	Department of Environment and Conservation	Provided a status update on the project and discussed closure (as part of a larger RTIO project update).
23-24/03/2010	Gumala Aboriginal Corporation	Status update of the project (as part of an update on the overall Yandicoogina operation). Yandicoogina Closure workshop – to discuss key closure values and objectives with Traditional Owners and proposed closure landform options.
19/04/2010	Gumala Aboriginal Corporation	Initial ethnographic consultation on the proposed impacts and mitigation of heritage sites located within the JSW, JSE Oxbow pit expansion area. Section 16 and S18 requests to clear sites were discussed.
29/4/2010	EPA Board	EPA Board Presentation of Yandicoogina JSW and Oxbow Environmental Scoping Document.

Date	Stakeholder	Purpose
28/05/2010	Department of Environment and Conservation Department of Water	To provide an update on the status of the project including: • the outcomes of vegetation health monitoring at Yandicoogina since 2003 • possible water management options and approaches • mine closure options and approaches.
17/06/2010	BHPBIO	Provide an update on the Yandicoogina PER and timing. Discussion of the Yandicoogina Closure Strategy, dewatering, and BHPBIO construction camp.
14/07/2010	Department of Environment and Conservation	Discussed Yandicoogina JSW and Oxbow Environmental Management Plans. Management plans consolidated with Yandicoogina Operations EMP, and removed overlaps between management plans.
15/07/2010	Department of Water	Update of Yandicoogina JSW and Oxbow Project. Update on current hydrogeology knowledge and water disposal options.
13/08/2010	BHPBIO	Provided an overview of the Yandicoogina Junction South West and Oxbow PER submission and discussed issues relating to potential interaction with BHPBIO activities in the development proposal.
02/08/2010 to 4/08/2010	Gumala Aboriginal Corporation	Ethnographic consultation on the proposed impacts and mitigation of heritage sites located within the JSW and Oxbow pit expansion areas.
19/08/2010	Gumala Aboriginal Corporation	Presentation of Yandicoogina Closure options to Gumala Lore and Culture Meeting.
14/09/2010	Gumala Aboriginal Corporation	Consultation and discussion on proposed changes to Marillana Creek due to the JSW and Oxbow expansion.
9/11/2010	Department of Environment and Conservation Regional Branch (Karratha)	Update on the status of the project, including the PER submission timeline and discussion of key issues relating to water management and mine closure. Discussion of management plans and updates to existing operational management plans.
22/11/2010	Department of Environment and Conservation (EMB)	Update on the Yandicoogina JSW and Oxbow project: including updated closure proposal for Yandicoogina life of mine, project disturbance areas, and Weeli Wolli Creek ecological monitoring.
24/11/2010	Department of Water	Presentation of the Yandicoogina JSW and Oxbow project latest updates, including discussion of interface with exiting Yandicoogina operations for water management.
7/12/2010	Department of Mines and Petroleum	Presentation of Yandicoogina JSW and Oxbow project and discussion of proposed closure considerations for the entire Yandicoogina Operations (life of mine closure) in light of DMP draft Closure Guidelines released in 2010.
1/03/2011	Gumala Aboriginal Corporation	Field presentation of overall Yandicoogina Sustaining project and contexting of project with existing operations. Discussed predicted Environmental Impacts of proposed project focusing on: drawdown impacts along Marillana Creek; surface water discharge into Marillana and Weeli Wolli Creek; Phil's Creek diversion; flood protection structures at JSW and Oxbow; diversion levee around JSW and encroachment into Marillana Creek; haul road crossing in Marillana Creek; and closure
28/07/2011	Department of Environment and Conservation (EMB)	General update on the Yandicoogina JSW and Oxbow project: including updated closure proposal for Yandicoogina life of mine
12/08/2011	Gumala Aboriginal Corporation (Board) (Perth)	Update on the Yandicoogina JSW and Oxbow project: including updated closure proposal for Yandicoogina life of mine
25/08/2011	Dept of Water – Regional and Perth Branch (Yandicoogina site)	Field tour of Yandicoogina JSW and Oxbow proposal including presentation and discussion of key project aspects, key predicted environmental impacts, management measures, and closure.

Table 6-2 – Key topics raised during stakeholder consultation regarding the JSW and Oxbow project proposal

Stakeholder	Topic raised	Hamersley Iron response
Government agencies		
EPA Board	Concerned about the amount of discharge from the project and if the discharge water will reach Fortescue Marsh.	The discharge volumes for the project have been calculated, together with the modelled resultant surface water footprint. This calculation considers cumulative impacts from BHPBIO and HD1 dewatering. These predictions indicate that mining water discharge will extend a maximum of 17 km from the Marillana Creek confluence and will not reach Fortescue Marsh. Refer to Sections 5 and 7.4.
	Water quality of discharge water and how it may be impacted.	Water quality will be monitored and managed throughout the life of the project and upon closure, as per the Yandicoogina Surface Water and Groundwater Management Plans. Discharge water quality from existing Yandicoogina operations is not discernibly different from naturally occurring groundwater. An ARD assessment has also been undertaken by RTIO which demonstrates that no acid-forming risks exist for the proposed operations.
	Cumulative impacts.	The impacts of dewatering from other mining operations in the vicinity have been taken into consideration and factored into the surface water modelling in Marillana Creek and Weeli Wolli Creek. The resultant impacts on sensitive environmental receptors have also been considered.
	Total project footprint and associated GHG emissions.	The total project footprint is estimated to be ~2,200 ha of new vegetation clearing. The project GHG emissions are estimated to be in the order of 100,000 tonnes $_{CO2\ equiv.}$ /yr over the life of the project.
EPA Service Unit	Cumulative impacts of the project required to be assessed.	The impacts of dewatering from other mining operations in the vicinity have been considered and factored into the surface water modelling in Marillana Creek and Weeli Wolli Creek, along with impacts on sensitive environmental receptors.
	Reinjection borefield and how this might be impacted by the new operations.	The existing reinjection borefield is proposed to remain in operation during the development of the new deposits. The ability of the reinjection borefield to achieve its intended purpose is compromised by discharge from HD1 in Weeli Wolli Creek.
	Queried if Hope Downs 4 water would also be discharged into Weeli Wolli Creek.	Hope Downs 4 water is not proposed for discharge into Weeli Wolli Creek.
	Investigations of pit lake contamination by metalliferous leachates, if pit lakes are to be retained.	Hydrogeological and closure studies are currently in progress. These studies will address the hydrogeological and hydrological aspects associated with the proposed final closure landforms. These studies will also include leachate testing for PAFs and other metalliferous substances. No issues associated with metalliferous leachates are associated with the proposal.

Stakeholder	Topic raised	Hamersley Iron response
DMP	Status of closure modelling and updated *Yandicoogina Decommissioning and Rehabilitation Plan* in relation to the DMP draft Mine Closure Guidelines released in 2010. Queried modelling requirements to support conceptual closure options. Feedback was sought from DoW/ DEC/ EPA on closure options. Queried if there were any metalliferous leachates of concern. Closure objectives need to be focused on non-polluting and stable landforms.	The updated *Yandicoogina Decommissioning and Rehabilitation Plan* incorporates life of mine (LoM) closure, including current operations and future proposals in line with the Draft Mine Closure Guidelines 2010. Detailed hydrogeological studies to support the Yandicoogina LoM closure options are currently in progress. These studies will address the hydrogeological and hydrological aspects associated with the proposed final closure landforms. Dedicated closure mine planning is in progress to support the mine closure options to ensure stable landforms and that hydrogeological and hydrological objectives are met. No issues associated with metalliferous leachates are anticipated, based on project geochemical assessments.
DEC (Perth and Regional Branches)	Water management – predominantly discharge and how far the footprint will extend along the creek systems. Consideration needs to be given to the hierarchy of surplus water disposal options. Cumulative impacts from other mining activities in the area. Requested Hope Downs 1 dewatering scenarios be included in the modelling. Potential impacts to the Fortescue Marsh require evaluation. Closure management – current LoM closure planning for Yandicoogina. Impacts to riparian vegetation and any impacts on priority flora.	A review of discharge mitigation options was investigated following the outcomes of the surface water modelling. The current proposal for managing surplus dewatering volumes is discharge into Marillana and Weeli Wolli Creeks. Alternate discharge options are still being considered as back-up mitigation measures including: seasonal storage and discharge, water sharing, and reinjection. These options are discussed in Section 5. The discharge footprint has been calculated for the project and takes into consideration cumulative impacts from other mining activities in the catchment, including BHPBIO and HD1.Under maximal licensed discharge for current and proposed mines, hydrological modelling indicates that surplus discharge water from all mining operations could extend ~17 km from the Marillana Creek confluence and will not reach Fortescue Marsh. RTIO is involved with the Fortescue Marsh Strategy being directed by the EPA, and is aware and actively involved in addressing the issues of concern by key stakeholders. The current LoM closure proposal, previously agreed with government, has been reviewed in light of the updated hydrogeological modelling; reinterpreted geology and hydrogeology; and lack of available material to backfill to above water table. The OEPA have been consulted about mine closure planning at Yandicoogina. Proposed final landform options and potential environmental impacts have been discussed. The project will potentially impact ~9 km of riparian vegetation along Marillana Creek from groundwater drawdown, exposing riparian vegetation to an altered hydrological regime from surplus water along a (cumulative) ≤17 km section from the Marillana Creek confluence. Projected water disposal from the proposed JSW and Oxbow mines is estimated to account for ~4 km of this discharge footprint.

Stakeholder	Topic raised	Hamersley Iron response
DoW	Cumulative impacts from dewatering and how will they be managed.	The discharge footprint has been calculated for the project and considers cumulative impacts from other mining activities in the catchment, including BHPBIO and HD1. Under maximal licensed discharge for current and proposed mines, hydrological modelling indicates that surplus discharge water from all mining operations could extend ~17 km from the Marillana Creek confluence and will not reach Fortescue Marsh. Management strategies are discussed in this Environmental Review document.
	Water disposal options.	Options for managing surplus water production at Yandicoogina have been evaluated for their potential environmental impacts. The DoW water disposal hierarchy was taken into account as well as the high level feasibility of the various options identified. *Discharge into the creeklines* was considered to be the preferred option based on the level of impact predicted. However, alternate mitigation strategies such as seasonal storage and discharge are also being investigated. These are discussed in more detail in Section 5.
	Closure modelling needs to be updated in order to assess closure options.	The hydrogeological understanding of groundwater systems at Yandicoogina has recently been updated. Based on this work, subsequent updated modelling, and additional stakeholder consultation, several new conceptual mine closure options have been developed to supersede earlier proposals. More detailed evaluation of these conceptual options is in progress (refer Section 7.8).
Non-government organisations		
Gumala	Proposal impacts on Marillana Creek – vegetation and physical disturbance.	Ongoing consultation will be undertaken to discuss the surface water management and engineering designs. Options for Traditional Owner employment opportunities to monitor Marillana and Weeli Wolli Creeklines will be investigated.
	Closure planning workshop. Options for final closure landforms discussed. Current closure option (backfilling to 490RL) already agreed by government stakeholders is unlikely to be feasible.	The final closure option will depend on agreement of final closure objectives by key government; non-government and Traditional Owner stakeholders. As a result of improved knowledge, several new conceptual mine closure options are being developed to potentially supersede earlier proposals. More detailed evaluation of these conceptual options is in progress. Ongoing consultation will be required to evaluate these options.

Stakeholder	Topic raised	Hamersley Iron response
Conservation Council	Dewatering management and options for excess water use.	Options for managing surplus water production at Yandicoogina have been evaluated for their potential environmental impacts. The DoW water disposal hierarchy has been considered, along with the high level feasibility of the various options. *Discharge into the creeklines* was considered to be the preferred option. However, alternate mitigation strategies, such as seasonal storage and discharge are also being investigated. These are discussed in more detail in Section 5.
	Cumulative impacts from other mining operations in the catchment.	The impacts from other mining operations in the catchment have been considered and factored into the surface water modelling in the Marillana and Weeli Wolli Creeks. There are no significant impacts on sensitive environmental receptors.
	Extent of discharge footprint in relation to Fortescue Marsh.	The modelled extent of the surface water discharge is predicted to extend up to 17 km from the Marillana Creek confluence, some 20 km south of the Fortescue Marsh.
Industry		
BHPBIO	Discussions with BHPBIO on the impacts of the proposed JSW – Oxbow Mining operations on their BHPBIO Yandi operations, including: water management; closure; crossing of MAC rail line to access Oxbow; proximity of proposed operations to BHPBIO disused construction camp.	Ongoing consultation is continuing regarding the following matters: • timing of Yandicoogina JSW/Oxbow project • mine closure • sharing groundwater modelling and hydrogeological data • cumulative impacts from dewatering, and • results of noise and vibration modelling and potential impacts on the BHPBIO camp (near JSW).
IOH	IOH proposal and interactions with Yandicoogina Operations.	Initial discussions regarding the interaction of the proposed agreement with upcoming JSW and Oxbow operations. Discussions have not progressed.
Brockman Resources	Preliminary discussions regarding water sharing.	Additional discussions will be undertaken about water management.

Table 6-3 – Proposed ongoing consultation program for the JSW and Oxbow project proposal

Tool	Possible activities	Timing
Awareness/ information campaign	Proposal briefing note or presentation distributed to stakeholders.	At start of consultation program and ongoing, as required
	Proposal will be available for viewing or downloading from the RTIO website.	When environmental assessment documentation (PER) is released for public comment
	Stakeholder meetings/briefings.	Ongoing, and as required
Stakeholder sessions	Proposal follow-up meetings/briefings, including feedback to stakeholders on how their input has affected proposal decisions. Site visit with key government stakeholders.	Prior to finalising PER
Ongoing feedback to stakeholders	Proposal follow-up meetings/briefings.	Ongoing

The following stakeholders will be included in the consultation program outlined in Table 6-3:

- Office of the Environmental Protection Authority
- Department of Environment and Conservation (Perth and Regional offices)
- Department of Water (Perth and Regional Offices)
- Department of State Development
- Department of Minerals and Petroleum / Department of State Development
- Department of Industry and Resources
- Shire of East Pilbara
- BHPBIO – including Marillana Pastoral managers
- IOH
- Brockman Resources
- Gumala Aboriginal Corporation.

7. Environmental management measures

This section describes measures that will be used to mitigate or manage the environmental impacts of the project, to ensure that the environmental values of the project area and surrounds are protected during project implementation. The following information is provided for each relevant environmental factor:

- environmental management objectives
- applicable standards and guidelines
- potential impacts
- management measures, and
- the predicted outcome after management measures are implemented.

A set of consolidated environmental management commitments for the project has been proposed, addressing all significant environmental factors (refer to Section 8.7).

7.1. Flora and vegetation

7.1.1. Management objective

In most circumstances, including this assessment, the EPA applies the following management objective for the protection of vegetation and flora:

To maintain the abundance, species diversity, geographic distribution and productivity of flora and fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

7.1.2. Applicable standards and guidelines

7.1.2.1. Legislation

The preservation and conservation of flora is covered primarily by the following Western Australian legislation:

- *Wildlife Conservation Act 1950*; and
- *Conservation and Land Management Act 1984*.

The Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) also provides legislative protection for species listed under Schedule 1 of this Act. In 1974, Australia became a signatory to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). As a result, an official list of endangered species was prepared and is regularly updated. This listing is administered through the EPBC Act. Many of the species listed under the EPBC Act are also listed under State biodiversity protection legislation, however, exceptions do occur.

In Western Australia, rare or endangered plant species subject to protection under the *Wildlife Conservation Act 1950* are listed in the Wildlife Conservation (Rare Flora) Notice 2010. These species are referred to as Declared Rare Flora (DRF).

The Department of Environment and Conservation also maintains a list of priority conservation species, which do not meet the criteria for listing as DRF under the *Wildlife Conservation Act 1950,* but are considered to be threatened or poorly known. This provides a mechanism for recognising species which:

- are suspected to be threatened but whose distribution is poorly understood, or
- are not threatened, but are rare and in need of ongoing monitoring, or
- depend on ongoing management intervention to prevent them from becoming threatened.

There are four priority rankings which reflect different levels of knowledge relating to species or taxa[20] conservation significance (Table 7-1). Generally, it is expected that impacts from mining developments should be managed to protect priority listed flora, so that they do not meet the criteria for listing DRF under the *Wildlife Conservation Act 1950*. Vegetation types that include priority flora are generally regarded as having a higher level of conservation significance.

As described in EPA Guidance Statement No. 51 (EPA 2004b), a number of other attributes may also contribute to the conservation significance of particular taxa including:

- fulfilment of a keystone role in a particular habitat for threatened species, or supporting large populations of threatened species which represent a significant proportion of the local regional population of these species
- relic status
- anomalous features that indicate a potential new discovery
- being representative of the spatial range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range)
- the presence of restricted subspecies, varieties, or naturally occurring hybrids
- local endemism/a restricted distribution, or
- being poorly reserved.

[20] Taxa is an abbreviated term for taxonomic groupings of plants within the classification hierarchy of the *International Code of Botanical Nomenclature*. It has a wider application than the species classification, and can include intraspecies classifications such as subspecies, varieties, hybrids or plants that are yet to be formally described.

Table 7-1 – Priority flora categories used in Western Australia (Atkins 2008)

Category	Description
P1: Priority One - Poorly Known	Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, eg road verges, urban areas, farmland, active mineral leases, etc, or the plants are under threat, eg from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.
P2: Priority Two - Poorly Known	Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (ie not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.
P3: Priority Three - Poorly Known	Taxa which are known from several populations, at least some of which are not believed to be under immediate threat (ie not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in need of further survey.
P4: Priority Four - Rare	Taxa which are considered to have been adequately surveyed and which, whilst being rare in Australia, are not currently threatened by any identifiable factors. These taxa require monitoring every 5 to 10 years.

It is also possible for particular assemblages of plants to have conservation significance at the vegetation community level[21], independent of the conservation status of individual species within the community. The Western Australian *Environmental Protection Act 1986* and *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* provide an indirect legislative basis for the protection of Threatened Ecological Communities (TECs), defined as naturally occurring biological assemblages or groups of plants and/or animals (or other living things such as microbes) that occur in a particular type of habitat. TECs in Western Australia are categorised as Presumed Totally Destroyed (PD), Critically Endangered (CR), Endangered (EN) or Vulnerable (VU) by the Western Australian Threatened Ecological Communities Scientific Advisory Committee.

DEC maintains a list of priority ecological communities (PECs) that do not meet criteria for classification of TECs, generally due to insufficient knowledge being available to enable a classification (DEC 2009). Ecological communities that do not meet criteria for classification as TECs, or that are not adequately defined, are classified under Priorities 1, 2 and 3. These three categories are ranked in order of priority for survey and/or definition of the community, and evaluation of conservation status, so that their declaration as threatened ecological communities can be considered.

Ecological communities that are adequately known, and are rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Ecological communities that depend on conservation interventions are placed in Priority 5.

[21] Community is a general term applied to any grouping of populations of different organisms found living together in a particular environment.

EPA Guidance Statement No. 51 (EPA 2004b) also identifies other vegetation community attributes that can contribute to the conservation status of vegetation including:

- scarcity
- unusual species
- novel combinations of species
- a role as a refuge
- a role as a key habitat for threatened species or large populations representing a significant proportion of the local to regional total population of a species
- being representative of the range of a unit (particularly, a good local and/or regional example of a unit in 'prime' habitat, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range), or
- having a restricted distribution.

EPA Position Statement No. 2: Environmental Protection of Native Vegetation in Western Australia

EPA Position Statement No. 2 (EPA 2000) provides an overview of the EPA position on the clearing of native vegetation in Western Australia. Principles and related objectives and actions have been adopted from national strategies for this Position Statement. The EPA will consider the following principles when considering impacts on vegetation:

- comparison of proposal scenarios, or options, to evaluate the relative level of protection of biodiversity at the species and ecosystems levels between options, and demonstration that all reasonable steps have been taken to avoid disturbing native vegetation
- the risks to threatened species are considered to be acceptable, and the proposal will not cause any known species of plant or animal to become extinct
- no association or community of indigenous plants or animals will cease to exist as a result of the proposal
- there is a comprehensive, adequate and secure representation of scarce or endangered habitats within and/or in areas biologically comparable to the proposal area protected in secure reserves
- if the proposal is large (in the order of 10 to 100 ha or more, depending on where in the State) the proposal area itself should include a comprehensive and adequate network of conservation areas and linking corridors whose integrity and biodiversity are secure and protected
- the on-site and off-site impacts of the proposal are identified and the proponent demonstrates that these impacts can be managed.

EPA Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection

EPA Position Statement No. 3 (EPA 2002b) discusses the principles the EPA would apply when assessing proposals that may have an effect on biodiversity values in Western Australia. The outcomes sought by this Position Statement are intended to:

- promote and encourage all proponents and their consultants to focus their attention on the significance of biodiversity and, the need to develop and implement best practice in terrestrial biological surveys, and
- enable greater certainty for proponents in the environmental impact assessment process by defining the principles the EPA will use when assessing proposals that may have an effect on biodiversity values.

EPA Guidance Statement No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia

EPA Guidance Statement No. 51 (EPA 2004b) provides guidance on standards and protocols for terrestrial flora and vegetation surveys, particularly those undertaken for the Environmental Impact Assessment of proposals. Factors contributing to the conservation significance of vegetation and flora are described. Two broad categories of survey are identified to support vegetation impact assessments:

- **Level 1 surveys**: designed to gather background information on the target area, verify the accuracy of the background information using field reconnaissance and broadly delineating vegetation units and flora species within the target area, and
- **Level 2 surveys**: designed to enhance the level of knowledge at the locality scale and the context at the local scale, involving multiple site visits and structured survey methodologies (achieving adequate coverage and replication to meet specific survey objectives).

7.1.3. Potential impacts

Land clearing is the main type of vegetation disturbance associated with the project. Additional vegetation disturbance could result from:

- **groundwater drawdow**n from mine pit dewatering, affecting the health of riparian vegetation along the Marillana creekline near JSW
- **discharge of surplus water** from mine pit dewatering into Marillana Creek, affecting riparian vegetation along the Marillana and Weeli Wolli Creek systems
- **the introduction and spread of weeds**, and
- **increased risk of uncontrolled fire**, from mining-related ignition sources or increased fuel loads from weed infestations.

Vegetation surveys of the project area and surrounds commissioned by RTIO have enabled potential impacts on flora and vegetation within the project disturbance area to be comprehensively assessed (Appendices A1 and A2). Overall, the vegetation is unexceptional with respect to biodiversity values and regional conservation significance (Section 3.6). The project is unlikely to result in any significant or irreversible impacts to vegetation and flora values in accordance with EPA objectives. However, locally significant areas of riparian vegetation will be affected. There is scope to reduce the likelihood and extent of the potential impacts on vegetation using appropriate management controls.

7.1.3.1. Clearing

Vegetation clearing is an unavoidable component of mine development. The project will require up to 2,200 ha of native vegetation to be cleared to enable the JSW and Oxbow mine pits, waste dumps, ore conveyors, haul roads and associated infrastructure to be developed. The final location of these elements is still to be finalised as part of detailed mine planning and engineering studies. Clearing will predominantly occur in the proposed JSW and Oxbow disturbance areas (Figure 2-2). Any additional clearing required for infrastructure tie-ins with the existing JC and JSE mines will be contained within the overall project area shown in Figure 2-2.

Ground-disturbance avoidance zones generally include known populations of the DRF species Lepidium catapycnon, and a 200 m buffer zone around the Marillana Creek line (refer to Section 2.3). As such clearing activities will largely avoid areas of riparian vegetation. Minor clearing of riparian vegetation will be required for infrastructure across Marillana Creek including construction of an overland conveyor and/or heavy haulage road to the JC plant and a 70 m wide floodway crossing at JSW for heavy vehicles. This is necessary to enable haul trucks access to the ROM pad from JSW-C. The floodway will include drainage culverts to minimise backwater and rock armouring to prevent scour. One Lepidium catapycnon population, consisting of 3 plants near the rail loop, is in the clearing footprint. This population has previously had an approved 'Licence to Take' authorised by the DEC during construction of the existing JC operations. A population of *Rostellularia adscendens* var. *latifolia* (Priority 3) located on the southern margin of the proposed JSW-C pit is also in the proposed clearing footprint.

The proposed disturbance areas are described in Table 2-2 with a preliminary summary of vegetation types impacted in Table 7-2. This breakdown is based on current designs and does not include all infrastructure requirements, such as borrow pits.

7.1.3.2. Groundwater drawdown

Groundwater drawdown beneath stands of riparian vegetation is an unavoidable consequence of mine pit dewatering, which is necessary to access the CID ore at JSW and Oxbow. The extent of groundwater drawdown beyond the mine pit boundaries was predicted using the RTIO Yandicoogina numerical groundwater model (Figure 7-1). This model is discussed in greater detail in Section 3.11.

The majority of plant species in the project area do not depend on groundwater to meet their water use requirements. These species rely principally on rainfall and are highly unlikely to be affected by lowered water tables. The exceptions include the riparian species *Melaleuca argentea* and, possibly, *Eucalyptus camaldulensis,* which are thought to depend on groundwater in the Pilbara (Appendix A1). *Eucalyptus victrix* also occurs in riparian areas but is considered to be less reliant on groundwater.

These riparian tree species are predicted to be exposed to drought stress along the section of Marillana Creek subjected to groundwater drawdown. The extent of drought stress experienced by individual trees is likely to vary depending on site heterogeneity, tree root architecture, climatic conditions and other biotic factors (eg leaf herbivory). Individual trees are likely to exhibit different responses, ranging from no significant change in health to tree death in extreme cases.

Table 7-2 – Preliminary summary of vegetation disturbance by type within the proposed JSW and Oxbow pit areas and associated infrastructure

Terrain Type	Terrain Type Area (ha)	Vegetation type	Veg. Code Area (ha)
JSW and Oxbow Pits			
Disturbed	36	Disturbed	36
Hills/Ridges/Breakaways	87	5d	5
		5j	2
		5k	4
		5l	46
		ElAhiTsps	2
		ElAiGwAhiTsps	28
Major Creekline and Tributary	24	2a	4
		2c	3
		2d	5
		EcEvMaMg	2
		EvAtuGwRlTErCYpERlt	1
		EvEcAtuRlTErERltTHt	9
Minor Creeklines, Flowlines and Valleys	2	3a	2
Plains	286	4a	7
		ChEgHlAbAdTp	20
		EgAtuAeTpTsps	21
		ElAprAbERfTwTe	101
		GpERfPTrTe	99
		GwHcTsps	38
Additional disturbance areas to be determined (based on final pit design)	65	To be determined	
Sub-total	**500**		
Other disturbance (waste dumps/infrastructure etc)			
Disturbed	11	Disturbed	11
Hills/Ridges/Breakaways	122	ElAhiTsps	7
		ElAiGwAhiTsps	44
		ElAiTw	12
		ElTspsTw	59
Major Creekline and Tributary	26.5	2e	3
		EcEvMaMg	0.5
		EvAtuGwRlTErCYpERlt	11
		EvEcAtuRlTErERltTHt	12
Minor Creeklines, Flowlines and Valleys	40	3a	1
		ChApyTp	39

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Terrain Type	Terrain Type Area (ha)	Vegetation type	Veg. Code Area (ha)
Plains	82	4j	7
		ChEgHlAbAdTp	8
		EgAtuAeTpTsps	3
		ElAprAbERfTwTe	56
		ElAprGwTe	1
		GpERfPTrTe	6
		GwHcTsps	1
Additional disturbance areas to be determined (waste dumps, borrow pits, haul roads etc)	1420	To be determined	
Sub-total	**1700**		
Total	**2,200 ha**		

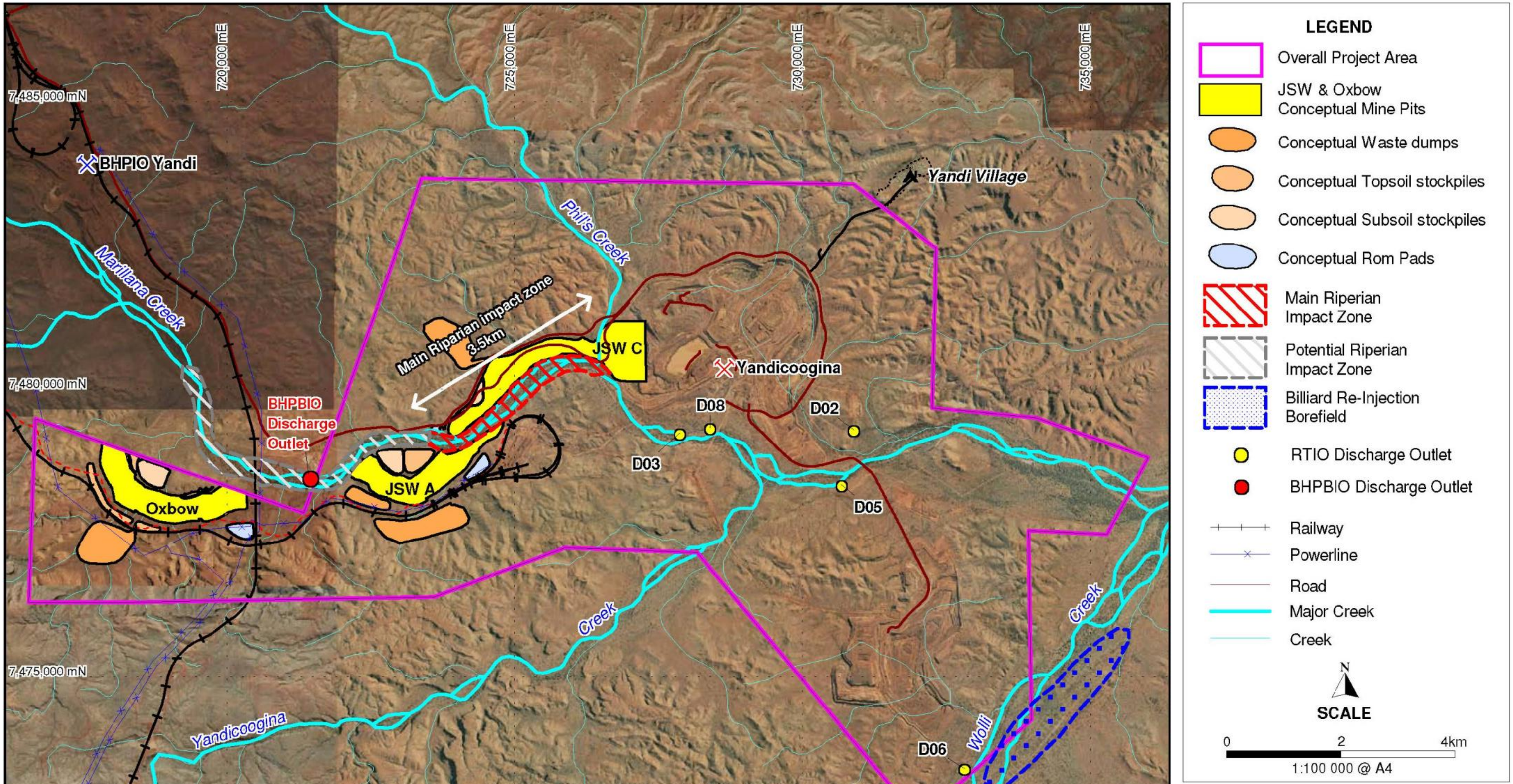

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Figure 7-1
Riparian Vegetation exposure to groundwater drawdown near the proposed JSW pit

Drawn: M.Swebbs
Date: Sept. 2011

Plan No. PDE0074948v6
Proj: MGA94 Zone50

7.1.3.3. Surface water discharge

Surface water discharge will contribute to, and extend, the saturated zone within the Marillana and Weeli Wolli Creek systems created by the existing mining operations. Taking into account the cumulative effects of all mining projects in the catchment, the extent of the surface water discharge footprint was predicted using RTIO hydrological models (Figure 7-2). Further discussion of the modelling techniques is provided in Appendices A9 and A10.

Experience from the existing Yandicoogina operations suggests that prolonged surface water discharge could potentially affect the health and composition of riparian vegetation by:

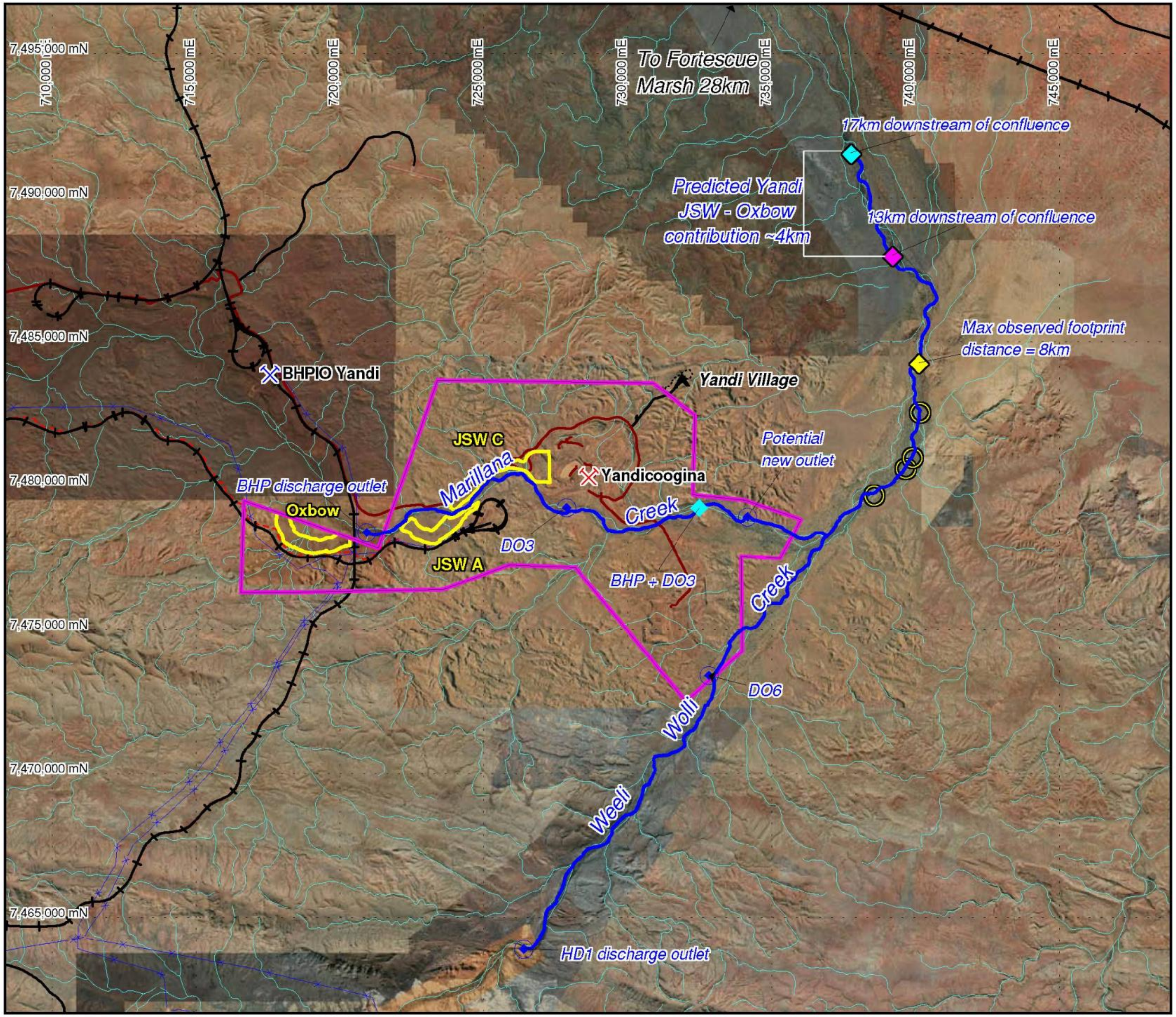
- artificially increased recruitment of riparian vegetation
- enhanced potential for weed invasion
- increasing the leaf area index and standing biomass of vegetation exposed to higher water availability
- sustaining vegetation that would otherwise be impacted by groundwater drawdown or drought conditions
- increasing exposure to water-logging stress in areas of prolonged soil profile saturation, causing tree health decline or death
- drought stress in individual plants (particularly saplings) unable to readjust to the withdrawal of artificial water supplies following the cessation of discharge, and
- changes in vegetation structure and composition including the introduction of weeds. This could contribute to increased fuel loads in the riparian vegetation.

Marillana Creek, near JSW and Oxbow, has been influenced by the combined effect of climatic conditions, fire and dewatering activities of BHPBIO since the early 1990s[22]. Periods of low rainfall have corresponded with reduced discharge by BHPBIO exacerbating the drought stress experienced by the trees. A wide range of responses have been observed between individual trees, potentially related to variability in microtopography and edaphic factors.

While a decline in tree health has been observed in some individuals; the effect of duration, severity and rate of change of flooding and drying cycles on tree health remains poorly understood. The effect of prolonged water-logging on tree root systems could be of particular importance. Water-logging may kill roots in the saturated layers, promoting a shallow root architecture which prevents trees from accessing deeper waters sources if the upper soil profile subsequently dries out (Adams *et al.* 2005). Tree species differ in their ability to withstand drought and water-logging stressors. Different age classes within a species may also respond differently: for example mature trees with established root systems are potentially more vulnerable to inundation than younger trees with a greater ability to modify their root morphology.

The major riparian tree species growing in the project area are *Eucalyptus camaldulensis, E. victrix,* and to a lesser extent *Melaleuca argentea*. Both of the Eucalypt species can withstand large fluctuations in groundwater depth, if these fluctuations occur over long enough time periods to enable physiological and morphological adaptations to occur (Adams *et al.* 2005). *Melaleuca argentea* tends to have a shallow root system and relies more on permanent near surface water sources associated with shallow water tables. It has a high tolerance to water-logging.

[22] Further discussion of historical impacts to the creek systems is provided in Section 3.10



LEGEND

- Overall Project Area
- JSW & Oxbow Conceptual Mine Pits
- Averaged observed wetting fronts
- Discharge Outlets proposed to be maintained

Discharge Scenarios:

- Maximum observed wetting front
- Maximum licence limits-predicted wetting front
- Additional Yandi JSW-Oxbow predicted wetting front

- Railway
- Powerline
- Minor Road
- Mine Road
- Major Creek
- Creek

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Figure 7-2
Surface Water Discharge in the Marillana and Weeli Wolli Creek Systems

Drawn: M.Swebbs
Date: Sept. 2011

Plan No. PDE0074948v6
Proj: MGA94 Zone50

Riparian environments in the Pilbara region are adapted to wide fluctuations in water availability, with catastrophic events, such as cyclones and wildfires common in the region. When surplus water discharge activities cease, the vegetation can be expected to gradually readjust to ambient water sources. Over time, it is reasonable to expect that the riparian vegetation will return to a state comparable with the pre-disturbance condition.

7.1.3.4. Weeds, dust and fire

Vehicle and earth movements can potentially introduce and/or spread weeds. The level of risk is influenced by weed species distributions, weed reproductive strategies, weather conditions and vehicle hygiene practices. Weed infestations are not severe at Yandicoogina; however, several invasive species - notably, Ruby Dock, Mexican Poppy and Buffel Grass - have been detected in vegetation surveys.

The potential for uncontrolled fires could increase due to vehicle movements and hot work associated with mining activities, like welding and grinding. The hot and dry conditions in the Pilbara increase vegetation fire risk, however, fuel loads in most of the Yandicoogina locality are generally low and accumulate slowly. The risk of accidental fires is largely avoidable by separating ignition sources from fuel loads, as per current RTIO operational procedures.

7.1.4. Management measures (non-riparian vegetation)

The impacts of clearing and other forms of vegetation disturbance can be reduced through appropriate project planning and implementation. It is useful to distinguish between riparian and non-riparian vegetation for management purposes, given that these vegetation categories will be exposed to a range of differing impacts as discussed in Section 7.1.3.

Management strategies to protect non-riparian vegetation are summarised below and described further in Table 7-3.

7.1.4.1. Clearing

RTIO has well established ground disturbance procedural requirements for its Pilbara mining operations. These are administered by a company Approvals Coordination Officer (ACO). The following items are required before any ground is disturbed:

- **a flora survey** for priority species and declared rare flora (100% cover)
- **a heritage survey**, both archaeological and ethnographic (100% cover)
- **an internal review** of the proposed work to ensure that the appropriate environmental approvals have been obtained
- **obtaining legal title to the tenure** or some other legal right to access the ground to carry out the proposed work, and
- **appropriate governmental approval** to disturb vegetation, including Part IV approvals or native vegetation clearing permits, as per the *Environmental Protection Act 1986*.

RTIO has received industry awards for its environmental data storage and approvals request management systems. GPS linked digital information systems are used to guide field personnel so that they avoid environmentally sensitive areas[23]. These systems also enable disturbance activities to be spatially recorded in real time and are used to monitor land rehabilitation activities.

[23] 2010 Golden Gecko 'Certificate of Merit' award

Wherever practicable, existing disturbed areas will be used for mine infrastructure development in preference to clearing native vegetation. Progressive vegetation rehabilitation will be undertaken in disturbed areas in accordance with mine plan requirements, using local native species.

Areas nominated for infrastructure tie-ins with the existing JC and JSE mines will be subject to Level 2 category surveys prior to any disturbance. If significant vegetation values are identified in these areas they will be preserved through appropriate engineering design.

Approval for any disturbance to DRF will be sought under the *Wildlife Conservation Act 1950*.

7.1.4.2. Weeds

The existing *Yandicoogina Iron Ore Mine Operation Weed Management Plan* has been updated to include the proposed JSW and Oxbow operations. This Management Plan includes provisions for:

- **mapping and monitoring** the occurrence and distribution of weed species in and adjacent to mining disturbance areas
- **preventing the introduction and spread of weed species**, including hygiene, staff training and monitoring procedures, and
- **weed containment and control activities**, including prioritising weed species to be controlled, based on their invasive potential or threat to environmental values, and selecting and using appropriate treatment methods.

The Plan specifies weed control objectives and targets and performance indicators. Weed species have been prioritised for control based on how invasive they are and how well they can be contained and/or controlled. An annual summary of weed management activities is included in the Yandicoogina operations Annual Environmental Report. The Plan will be reviewed and updated every three years.

7.1.4.3. Dust

The project will be subject to the *Yandicoogina Emissions Management Plan*. This Management Plan includes details on monitoring and preventing dust emissions, mainly by minimising the area of dust producing surfaces and preventing dust lift off by repeatedly applying water to frequently used roads.

7.1.4.4. Fire

The project will be subject to the *Yandicoogina Fire Management Plan*. This Management Plan specifies operational procedures for minimising fire risk. In accordance with the Plan, the Yandicoogina operation maintains fire suppression capability on-site, including a trained workforce and a combination of light and heavy duty fire fighting vehicles and isolated water supplies.

7.1.5. Management measure (riparian vegetation)

Management strategies to protect riparian vegetation are summarised below and described further in Table 7-4.

7.1.5.1. Mine dewatering and surface water disposal

Tree health will continue to be monitored at established monitoring points (Figure 3-8), using the remote sensing and digital cover photography techniques developed for this purpose.

These are described in Section 3.6.4. Additional monitoring sites will be established by RTIO at ~2 km intervals, in downstream sections of Weeli Wolli Creek, up to a distance of 18 km from the Marillana Creek confluence.

The existing *Yandicoogina Riparian Vegetation Management Plan* has been updated to include the proposed JSW and Oxbow operations. This updated Plan includes provisions for:

- **maintaining the flow paths**, quantity and quality of water within Marillana, Yandicoogina and Weeli Wolli Creeks and the underlying aquifers. The aim is to protect the ecological systems that depend on surface water and groundwater
- **monitoring the effects of dewatering** on riparian vegetation communities in areas where the water table is predicted to be lowered by at least two metres (during and after mining), and to implement remedial measures if impacts are detected
- **managing and minimising potential impacts** on riparian vegetation associated with dewatering and at the discharge points
- **maintaining creekline discharge** south of JC to offset the dewatering impact of the JSE Ridge North borefield, as per existing management procedures
- **avoiding disturbance and the introduction of weeds** to vegetation in creeklines, particularly vegetation which is currently in good or excellent condition
- **maintaining a riparian vegetation buffer** of not less than 200 m around Marillana, Yandicoogina and Weeli Wolli Creeks. The aim is to protect riparian vegetation and fauna habitat associated with the creeks. Flood protection levees and a heavy vehicle road crossing at JSW will encroach on this buffer, however, designs will ensure the flow regime of Marillana Creek is maintained.

The *Yandicoogina Riparian Vegetation Management Plan* specifies riparian vegetation management objectives, targets and performance indicators. An annual summary of riparian vegetation health monitoring is included in the Yandicoogina operations Annual Environmental Report. The Plan will be reviewed and updated every three years. The review will consider if science and technology advances can be used to assess vegetation health, for example using remote sensing technologies.

It is possible that the existing discharge points (Figure 3-20) may be relocated further downstream on Marillana Creek. This may reduce the inefficiencies associated with recirculation of abstracted groundwater from the movement of borefields adjacent to the mine pits (refer Figure 5-1 and Figure 5-2). The effects of moving the discharge points on the surface water discharge footprint have been incorporated within the discharge modelling scenarios (Figure 7-2).

7.1.5.2. Weeds

Riparian areas will be subject to the provisions of the *Yandicoogina Iron Ore Mine Operation Weed Management Plan* (as per non-riparian areas).

Weed distribution mapping has been undertaken along the length of the predicted surplus water discharge footprint prior to the commencement of project dewatering activities, as a component of vegetation surveys in this area (Biota 2011; Appendix A2). This mapping will develop a baseline so that the effect of discharge on weed distributions can be assessed over the life of the project.

7.1.5.3. Dust

Roads and vehicle movements near riparian areas, including creek crossings, will be subject to the *Yandicoogina Emissions Management Plan*. This Management Plan includes provisions for monitoring and preventing dust emissions. Minimising the area of dust producing surfaces is a priority, along with preventing dust lift off by repeatedly applying water to frequently used roads.

7.1.6. Predicted outcome

After applying mitigation and management measures, the following flora and vegetation outcomes are expected:

- **clearing of up to 2,200 ha of vegetation**, including vegetation types without distinctive conservation values that are widely distributed beyond the project area
- **drawdown impacts on riparian tree species** in the vicinity of the JSW and Oxbow pits, along a 9 km section of Marillana Creek. Tree health is expected to decline, potentially resulting in some tree deaths within a 3.5 km zone, as shown in Figure 7-1. The vegetation in this area has been modified by historical mining activities since the early 1990s
- **no impact on the conservation status of DRF or priority listed flora**. Disturbance to individual plants may occur, subject to the provision of the *Wildlife Conservation Act 1950*
- **no loss or disturbance to any TECs** or upland vegetation communities with regional conservation significance;
- **effective monitoring, containment and control of weed species**
- **ongoing monitoring of riparian vegetation** on Marillana and Weeli Wolli Creeks, and
- **effective control of dust emissions** and prevention of accidental fires in vegetation.

Hamersley will investigate the impact of groundwater drawdown on phreatophytic tree species in Marillana Creek near the JSW and Oxbow deposits to ascertain tree responses to different exposure levels to drawdown, taking into consideration the climate regime and other environmental variables.

Implementing the project will not result in significant impacts on flora or vegetation conservation values, and is consistent with the EPA objective for flora and vegetation protection.

Table 7-3 – Potential impacts on non-riparian flora and vegetation after applying the proposed management controls in the *Yandicoogina Vegetation and Flora Management Plan*

Type of impact to flora and vegetation values	Description of potential impacts	Significance of potential impact	Proposed management strategies and controls	Predicted outcome
Removal of flora or vegetation communities with conservation significance	**Vegetation** The project will require clearing of up to 2,200 ha of native vegetation. Extensive surveys of the proposal area show that there are no occurrences of TECs or PECs within the project disturbance area. The vegetation does not include any components with high regional significance. The riparian vegetation in the Marillana Creekline, dominated by *Eucalyptus camaldulensis and/or E. victrix woodland*, is regarded as having local conservation significance.	Proposed vegetation clearing will not affect the regional conservation status of vegetation types occurring within the JSW and Oxbow disturbance areas or overall project area.	All infrastructure tie-in areas will be subject to Level 2 category vegetation surveys prior to any disturbance (if not already surveyed to this level). If significant vegetation values are identified in these areas they will be preserved through appropriate engineering design The project will be subject to the provisions of the *Yandicoogina Vegetation and Flora Management Plan.* • rehabilitation completion criteria will be developed to preserve vegetation values (biodiversity, structural and functional attributes, land use attributes) post-mining. • undertaking progressive rehabilitation of disturbed areas with endemic native species. Disturbance areas, such as selected mine pit areas, waste dumps, access roads and infrastructure corridors, will be landscaped, including replacing topsoil, and revegetated with native species.	No change in the conservation status of vegetation communities with conservation significance. When mining concludes, a proportion of the mine pit areas may remain as unvegetated pit voids; subject to finalising the mine closure plan (refer Section 7.8).
Removal of flora or vegetation communities with conservation significance	**Flora** Based on extensive surveys of the proposal area, one DRF and EPBC Act listed species (*Lepidium catapycnon*) has been recorded adjacent to the project disturbance area. Three Individuals of this species occur within areas proposed for clearing. The P4 species *Goodenia nuda* has been recorded adjacent to the proposed JSW pit area and north-east of the JC pit. An additional five priority species have been recorded in the greater Yandicoogina locality (Figure 3-7 b-d). Based on their known habitat preferences, they could potentially occur within areas proposed for clearing.	All identified flora with conservation significance occur at multiple locations outside the Yandicoogina locality. Although clearing could possibly result in the removal of individual plants, the project will not significantly affect the conservation status of any of these species. ~135 ha of locally significant vegetation (riparian vegetation types), is within the overall project area, with ~35 ha within the proposed clearing footprint.	The project will be subject to the provisions of the *Yandicoogina Vegetation and Flora Management Plan*. • restricting clearing to the extent allowed within the mining area. • minimising the clearing footprint from project outset by using existing disturbed areas, wherever practicable, planning and marking clearing areas, and obtaining internal ground disturbance authorisation for all areas to be cleared, in accordance with the Pilbara Iron Approvals Request System. • completing pre-disturbance surveys to collect baseline data for rehabilitation, and identifying any species and vegetation communities with conservation significance. • avoiding species and vegetation communities with conservation significance, wherever practicable.	No change in the conservation status of plant taxa with conservation significance.
The introduction and/or spread of weed species, resulting from vehicle and earth movements	Fifteen weed species have been detected in or adjacent to the project disturbance area. These include some species that are known to be highly invasive and difficult to control, such as Ruby Dock, Mexican Poppy and Buffel Grass. Weed species can displace native flora with conservation significance, if not adequately managed. Weeds can also hinder rehabilitation by hindering native plant species to become established. Some weed species, such as Buffel Grass, accumulate high fuel loads relative to native species, resulting in increased fire hazard. Weed species also have the potential to accumulate in drainage lines and interfere with natural drainage patterns. Mining activities could spread weed propagules (eg seeds) or facilitate weed infestations as a consequence of ground disturbance. New species could be introduced to the project area on contaminated vehicles or equipment. As a result, mining activities could contribute to new or expanded weed infestations within the project disturbance and adjacent areas.	The project disturbance area already includes a range of weed species and is subject to cattle grazing, which can promote the spread of weed species. Note that the Marillana Station supports a pastoral cattle production enterprise. Cattle are another potential weed vector, due to their mobility and propensity to disturb soil and vegetation.	The *Yandicoogina Iron Ore Mine Weed Management Plan* will provide the basis for effectively monitoring, containing and controlling weed species. The occurrence of weeds in the project area has been relatively well documented in biological surveys and as part of current operations. Control systems are in place for problematic weed species.	Weeds within the project area will be continuously monitored and controlled over the life of the project. This will prevent a significant worsening of weed burdens (number of weed species and their extent) in the project area as a result of mining activities over the life of the project.

Type of impact to flora and vegetation values	Description of potential impacts	Significance of potential impact	Proposed management strategies and controls	Predicted outcome

An increase in the potential for uncontrolled fires from project related ignition sources	Developing and operating mine sites involves activities that have the potential to ignite fires in vegetation. For example:
	• heavy vehicle operation and maintenance
	• storage and handling of explosive or flammable materials
	• blasting, and
	• electrical power supply and distribution.
	Altered fire regimes may favour the establishment of weeds and prevent the regeneration of native vegetation, particularly fire sensitive species such as Mulga.
		Mining activities will introduce a range of potential ignition sources for wildfires.	The project will be subject to the provisions of the *Yandicoogina Fire Management Plan*.
			The risk of accidental fires will be minimised using a variety of preventative controls including:
			• implementing fire education, control and mitigation measures
			• creating and maintaining firebreaks around infrastructure and work areas
			• maintaining the operational capacity to undertake fire suppression activities during the life of the project, including:
			  • a bushfire response plan as part of site emergency procedures
			  • training a number of mine personnel in fire suppression, to FESA standards
			  • heavy duty (x2) and light attack (x4) fire fighting vehicles maintained on-site
			  • isolated water supply (2 x 30,000 L capacity) water trucks for fire suppression.
				An effective fire incident response and suppression capacity will be maintained, to ensure that accidental fires are substantially avoided; quickly detected and suppressed if they do occur.

Table 7-4 – Potential impacts to riparian flora and vegetation after applying proposed management controls in the *Yandicoogina Riparian Vegetation Management Plan*

Type of impact to flora and vegetation values	Description of potential impacts	Significance of potential impact	Proposed management strategies and controls	Predicted outcome
Reduced water availability for groundwater dependant species in the Marillana Creek system, in areas affected by mine pit dewatering	Groundwater dependent vegetation in a 9 km section of Marillana Creek at JSW (mainly within a 3.5 km section close to the mine pits) is expected to be affected by lowered water tables due to mine pit dewatering. The estimated extent of groundwater drawdown at the JSW and Oxbow pits has been predicted using modelling techniques (Figure 7-1). Based on vegetation surveys, this section includes the groundwater dependant species *Melaleuca argentea* (Silver Cadjeput), and, to a lesser extent, *Eucalyptus camaldulensis* (River Red Gum) and *Eucalyptus victrix* (Coolibah). These species will be exposed to increased drought stress, which in extreme cases could result in the death of individual trees.	The riparian vegetation has local conservation significance.	The project will be subject to the provisions of the *Yandicoogina Riparian Vegetation Management Plan*. • continue the RTIO program of monitoring tree health along Marillana and Weeli Wolli Creeks • complete ongoing studies into plant/water relations and the responses to modified eco-hydrology.	Groundwater dependent vegetation in a 9 km section of Marillana Creek at JSW is expected to be affected by lowered water tables from mine pit dewatering. This will cause exposure to drought stress, and in extreme cases could result in the death of individual trees.
Altered vegetation structure and composition in the Marillana and Weeli Wolli Creek systems, in areas influenced by the discharge of surplus water from mine pit dewatering activities	Surplus water discharge will expose riparian vegetation to increased water availability and, in some cases, waterlogging. Vegetation recruitment could be enhanced, and some vegetation could become artificially reliant on disposal water. Weed species could potentially be favoured by the modified hydrological regime. The extent of the surface water discharge wetting front has been predicted using hydrological modelling (Figure 7-2). If discharge is maximised under the current licensed limits (BHPBIO Yandi, HD1 and Hamersley Yandicoogina -Feb 2011), the wetting front could extend up to 4 km down Weeli Wolli Creek, over and above the discharge wetting front from existing mining projects in the catchment (up to 13 km). Vegetation within the area predicted to be affected by the surface water discharge wetting front has been assessed (Biota 2011; Appendix A2). The vegetation does not include any species or communities with elevated conservation significance. However, the riparian vegetation is considered to have local conservation significance.	The discharge of surplus water into Marillana Creek will contribute to cumulative impacts on riparian ecosystems caused by multiple mining projects in the catchment. The Yandicoogina project will only incrementally increase the disturbance footprint caused by existing, approved projects. Long term tree health monitoring by RTIO suggests that impacts to riparian tree species are likely to be minimal, however, prolonged inundation could cause waterlogging stress, and in extreme cases, could result in the death of individual trees.	The project will be subject to the provisions of the *Yandicoogina Riparian Vegetation Management Plan.* • continue the RTIO tree health monitoring program along Marillana and Weeli Wolli Creeks. • selective thinning of saplings in the event that significant recruitment is artificially induced due to increased water availability in riparian areas, to emulate tree densities in control areas, in consultation with the DEC. • reduce dewatering gradually and monitor responses, to enable vegetation to adapt root systems to available water sources. • conduct ongoing studies into plant/water relations and the responses to modified eco-hydrology.	Over the operational life of the JSW and Oxbow mines, the project may contribute to cumulative modifications to the structure and composition of riparian vegetation. This is will be along a 12 km section of Marillana Creek, and up to 17 km of Weeli Wolli Creek downstream from the Marillana Creek confluence. When discharge activities cease, the vegetation can be expected to gradually readjust to ambient water sources. Over time, it is reasonable to expect that the riparian vegetation will return to a state comparable with the pre-disturbance condition.
The introduction and/or spread of weed species, in areas influenced by the discharge of surplus water from mine pit dewatering activities	Fifteen weed species have been detected in or adjacent to the project disturbance area. These include some species that are known to be highly invasive and difficult to control, such as Ruby Dock, Mexican Poppy and Buffel Grass. Weed species can displace native flora with conservation significance, if not adequately managed. Weeds can also hinder rehabilitation by hindering native plant species to become established. Some weed species, such as Buffel Grass, accumulate high fuel loads relative to native species, resulting in increased fire hazard. Weed species also have the potential to accumulate in drainage lines and interfere with natural drainage patterns. Mining activities could spread weed propagules (eg seeds) or facilitate weed infestations from ground disturbance. New species could be introduced to the project area on contaminated vehicles or equipment. As a result, mining activities could contribute to new or expanded weed infestations within the project disturbance and adjacent areas.	The project disturbance area already includes a range of weed species and is subject to cattle grazing, which can promote the spread of weed species. Note that Marillana Station supports a pastoral cattle production enterprise. Cattle are another potential weed vector, due to their mobility and propensity to disturb soil and vegetation.	The *Yandicoogina Weed Management Plan* will provide the basis for effectively monitoring, containing and controlling weed species. The occurrence of weeds in the project area has been relatively well documented in biological surveys and as part of current operations. Control systems are in place for problematic weed species.	Weeds within the project area will be continuously monitored and controlled, over the life of the project. This will prevent a significant worsening of weed burdens in the project area (number of weed species and their extent) resulting from mining activities over the life of the project.
Localised vegetation smothering from uncontrolled dust emissions	Without preventative measures, dust can accumulate on the foliage of vegetation adjacent to dust source areas. This could potentially hinder leaf transpiration and photosynthesis, resulting in vegetation health decline.	Uncontrolled dust emissions could cause smothering of vegetation adjacent to roads, waste dumps, stockpiles and other disturbance areas.	Minimise and monitor dust emissions in accordance with the *Yandicoogina Emissions Management Plan*. Refer to Section 7.9 for more details on dust mitigation actions.	No significant impacts to vegetation from dust emissions.

7.2. Terrestrial fauna

7.2.1. Management objective

In most circumstances, including this assessment, the EPA applies the following management objectives to protect terrestrial fauna:

To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement of knowledge.

To maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance, are protected.

To maintain biological diversity that represents the different plants, animals and microorganisms, the genes they contain and the ecosystems they form, at the levels of genetic diversity, species diversity and ecosystem diversity.

7.2.2. Applicable standards and guidelines

EPA Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection

EPA Position Statement No. 3 (EPA 2002b) discusses the principles the EPA applies when assessing proposals that may have an effect on biodiversity values in Western Australia.

EPA Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia

EPA Guidance Statement No. 56 (EPA 2004c), provides guidance on standards and protocols for terrestrial fauna surveys, particularly those undertaken for the Environmental Impact Assessment of proposals.

EPA Guidance Statement No. 20: Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia

EPA Guidance Statement No. 20 (EPA 2009c) provides guidance on standards and protocols for surveys for SRE fauna, particularly those undertaken for the Environmental Impact Assessment of proposals.

7.2.2.1. Legislation

The preservation and conservation of terrestrial fauna is mainly covered by the following Western Australian legislation:

- Wildlife Conservation Act 1950 (WA); and
- Conservation and Land Management Act 1984 (WA).

The Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* also provides legislative protection for species listed under Schedule 1 of this Act. In 1974, Australia became a signatory to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). As a result, an official list of endangered species was prepared and is regularly updated. This listing is administered through the EPBC Act. The current list differs from the various State lists; however, the majority of listed species are common to both.

In Western Australia, rare or endangered animal species subject to protection under the *Wildlife Conservation Act 1950* are listed in the Wildlife Conservation (Specially Protected Fauna) Notice 2010. The DEC also maintains a list of priority conservation species which do not meet the criteria for listing under the *Wildlife Conservation Act 1950*. For example, due to lack of information or because they are not currently threatened, but which:

- may be suspected to be threatened, or
- are not threatened, but are rare and in need of ongoing monitoring, or
- depend on ongoing management intervention to prevent them from becoming threatened.

Potential impacts to these priority listed species are expected to be managed so that the species do not meet the criteria for listing under the *Wildlife Conservation Act 1950*.

7.2.2.2. International agreements

Australia is party to the Japan-Australia (JAMBA), China-Australia (CAMBA) and Republic of Korea-Australia (ROKAMBA) Migratory Bird Agreements. Most of the birds listed in these agreements are associated with saline wetlands or coastal shorelines and have little relevance to the project area; however, some migratory birds not associated with water are also listed on these international treaties.

Australia is party to various global biodiversity protection conventions including:

- Convention on Biological Diversity
- Convention on Migratory Species of Wild Animals, and
- Ramsar Convention on Wetlands.

7.2.3. Potential impacts

The project has the potential to cause the following impacts to terrestrial fauna:

- **habitat removal and fragmentation** due to vegetation clearing. The habitat types within the clearing footprint are common in a local and regional context and the impact of this loss on fauna species will be minimal
- **increased water availability**, causing persistent surface water ponding in downstream riparian areas and changes in vegetation composition, potentially resulting in:
    - increased habitat heterogeneity and carrying capacity for macroinvertebrates and benefits to other aquatic fauna that are favoured by saturated conditions
    - enhanced breeding opportunities for terrestrial and aquatic fauna
    - disadvantages to aquatic fauna that rely on both wet and dry conditions characteristic of the existing ephemeral regime
- **decreased water availability** when dewatering discharge ceases, potentially causing adjustments in fauna populations that have acclimatised to the increased water availability during the project dewatering phase
- **habitat contamination** from spills and leaks in localised areas associated with refuelling, vehicle operation and vehicle maintenance

- **death or injury of individual animals** from vehicle movements (ie collisions) and the operation of other mining equipment
- **disruption to animals** resulting from dust, noise and light emissions
- **encouraging increased feral animal numbers** in the Yandicoogina locality, resulting in heightened threat to native species. Feral animals are known to be attracted to mining camps where food waste is not appropriately managed, and may benefit from more persistent water sources created by surplus water discharge activities.

Fauna surveys commissioned by RTIO in the project area and surrounds have enabled the impacts on fauna values to be comprehensively assessed (Table 7-5). In broad terms, the habitat types in the project area are unexceptional with respect to biodiversity values, habitat values and regional conservation significance (refer to Section 3.7). The project is unlikely to result in any significant or irreversible impacts to environmental values associated with terrestrial fauna. Using appropriate management controls, the likelihood and extent of the potential impacts can be reduced even further.

7.2.4. Management measures

The impacts of clearing and other mining related disturbance can be reduced through appropriate project planning and implementation. Management strategies to address the potential impacts identified in Section 7.2.3 are briefly summarised below and described further in Table 7-5. The *Yandicoogina Fauna Management Plan* will provide the operational framework for implementing fauna protection and management measures.

7.2.4.1. Clearing

Wherever practicable, existing disturbed areas will be used for developing mine infrastructure in preference to clearing native vegetation. Staged clearing of vegetation will be designed to allow for the progressive movement of fauna into areas outside the proposed disturbance areas. RTIO has well established ground disturbance procedural requirements for its Pilbara mining operations (refer Section 7.1.4). Areas to remain uncleared will be protected from disturbance by controlling access and maintaining buffers between these areas and operational activities.

Progressive vegetation rehabilitation will be undertaken in disturbed areas, in accordance with mine plan requirements, using local native species. Reinstating habitat elements will be a specific component of rehabilitation activities. Habitat rehabilitation completion criteria will be developed as the basis for preserving fauna habitat values post-mining. Topsoil, log debris and leaf litter gathered during clearing operations will be appropriately stored and redistributed on rehabilitated areas.

7.2.4.2. Riparian habitat protection

A riparian vegetation buffer of not less than 200 metres around Marillana, Yandicoogina and Weeli Wolli Creeks will protect riparian vegetation and the habitat for fauna associated with the creeks (excluding the JSW mining area, proposed infrastructure crossing points, and existing infrastructure crossing points). The buffer will be in accordance with the *Yandicoogina Riparian Vegetation Management Plan*. The proposed encroachments into riparian areas will be designed to maintain the flow regime of Marillana Creek to protect riparian habitat and fauna associated with the creeks.

Monitoring aquatic fauna assemblages will continue in the Marillana and Weeli Wolli Creek systems, based on the existing RTIO monitoring program.

7.2.4.3. Spills and leaks

The storage, handling and disposal of hydrocarbons and related substances at the current Yandicoogina operations are managed in accordance with the *Yandicoogina Hydrocarbon Management Plan*. This Plan includes procedures relating to the detection and cleanup of spills and leaks. These operational requirements will also apply to the JSW and Oxbow mining operations.

7.2.4.4. Vehicle movements

Vehicle speed limits will be imposed to minimise the potential for fauna collisions. Education and training programs about protecting native fauna will be provided to the mine workforce. This will be part of current staff induction procedures.

7.2.4.5. Feral animals

Feral are monitored and controlled as part of the current Yandicoogina operations. These activities will continue and be extended to the project area.

Appropriate food hygiene and municipal waste disposal procedures will be followed to minimise attracting feral animals to mining areas.

7.2.5. Predicted outcome

The project disturbance area does not include any habitat areas with high conservation significance. The overall project area may contain individual animals belonging to species with conservation significance, which could be disturbed by mining and related activities. However, none of these species are restricted to the area, and all are distributed broadly across the Pilbara region.

A range of management measures will be used to protect fauna and their habitat outside the clearing footprint. This includes maintaining ground-disturbance avoidance zones around riparian areas. Rehabilitation procedures will include specific habitat reinstatement components.

Implementing the project will not cause a change in the conservation status of any of fauna species with conservation significance. The project is consistent with the EPA objective for fauna protection.

Table 7-5 – Potential impacts to terrestrial fauna following the application of proposed management controls

Type of impact to terrestrial values	Description of potential impacts	Significance of potential impact	Proposed management strategies and controls	Predicted outcome
Habitat removal through vegetation clearing.	**Habitat** The project will require up to 2,200 ha of native vegetation to be cleared. Based on extensive surveys of the proposal area, the habitat types within the project clearing footprint are well represented in the central Pilbara. The habitat does not have special significance for rare and endangered fauna species.	The proposed vegetation clearing will not affect the regional conservation status of habitat types occurring within the project area.	The project will be subject to the provisions of the *Yandicoogina Fauna Management Plan* • develop rehabilitation completion criteria for preserving vegetation values (biodiversity, structural and functional attributes, land use attributes) post-mining • undertake progressive rehabilitation of disturbed areas with endemic native species. Disturbance areas, such as selected mine pit areas, waste dumps, access roads and infrastructure corridors will be landscaped, including replacing topsoil and revegetated with native species • maintain a riparian vegetation buffer of not less than 200 metres around Marillana, Yandicoogina and Weeli Wolli Creeks to protect the riparian habitat of fauna associated with the creeks (excluding intrusion into this buffer associated with flood protection levees and a heavy vehicle road crossing at JSW	No loss of habitat with regional conservation significance. Disturbed areas will largely be rehabilitated with native vegetation post-mining. At the conclusion of mining, a proportion of the mine pit areas may remain as pit voids; subject to finalising the mine closure plan (refer Section 7.8).
	Rare fauna Based on extensive surveys of the proposal area, two declared rare terrestrial fauna species have been recorded in the Yandicoogina locality. These are the Northern Quoll and the Pilbara Olive Python.	The Northern Quoll and the Pilbara Olive Python occur at multiple locations outside the Yandicoogina locality. The project disturbance area does not include habitat of special importance for the ecological requirements of these species. Although it is possible that individual animals could be disturbed, implementing the project will not significantly affect the conservation status of these species.		No change in the conservation status of fauna with conservation significance.
Habitat modification due to surface water discharge activities.	The discharge of surplus water from mine pit dewatering to the Marillana and Weeli Wolli Creek systems will contribute to and extend the permanent creek flow already occurring as a result of current mining activities. Changes in the structure and composition of the riparian habitat could result within the extent of the discharge influence. Stopping dewatering discharge may contribute to further changes.	The section of riparian habitat affected by the proposal has been assessed as having no significant conservation values for fauna species with conservation significance. When discharge activities stop, the riparian ecosystem is expected to gradually readjust to a more intermittent flooding regime to resemble the pre-disturbance condition.	The project will be subject to the provisions of the *Yandicoogina Riparian Vegetation Management Plan* • continue the RTIO tree health monitoring program along Marillana and Weeli Wolli Creeks • continue the RTIO aquatic fauna monitoring program along Marillana and Weeli Wolli Creeks • selectively thin saplings, if there is significant artificial recruitment from increased water being available in riparian areas. Emulate tree densities in control areas, in consultation with the DEC.	In a section of Marillana and Weeli Wolli Creek systems, extending up to 17 km, riparian habitat will be subject to increased and more persistent surface water expression. Changes to habitat from structural vegetation changes may result.
Habitat contamination from spills, leaks and discharge.	Mining activities will involve the storage, transport and use of fuels, lubricants and other substances with the potential to harm fauna. Without adequate controls in place, fauna could become exposed these substances.	The proposal area does not contain rare or restricted habitat types and terrestrial fauna species. Under most circumstances, the effect of spills, leaks and discharges would be localised and would not threaten the conservation status of fauna species.	The project will be subject to the provisions of the *Yandicoogina Hydrocarbon Management Plan* • fuels, lubricants and other contaminating substances will be subject to a range of controls to prevent their entry to the environment. Additional information on management controls is provided in Sections 7.4 and 7.5.	Proposed management controls will ensure that the risk of environmental contamination is minimised, and that any contamination that does occur is rapidly detected, contained and mitigated. Any impacts on fauna will be minimal and not change the conservation status of fauna with conservation significance.
Death or injury of individual animals due to vehicle movements and other mining activities.	Fauna species will be exposed to the risk of colliding with mining vehicles and equipment. Vehicle movement corridors could interfere with localised fauna movement patterns.	Experience at Yandicoogina suggests that fauna collisions are likely to be uncommon and have minimal impact on the persistence of the local fauna assemblage.	• speed limits will be enforced on all roads within the project area to reduce the risk of impact with fauna • vehicle 'no-entry' sites will be designated and communicated to project personnel • all animal strikes by vehicles will be recorded and documented	The proposed management controls will ensure that the risk of animal strikes is minimised, as far as practicable. Any impacts to fauna will be minimal and not affect species conservation status.
Disruption to animals resulting from dust, noise and light emissions.	Dust, noise and light emissions can degrade the quality of fauna habitat adjacent to mining operations. Species such as bats can be drawn to light sources, increasing the risk of vehicle strikes.	Experience at Yandicoogina suggests that disruption to fauna resulting from dust, noise and light emissions is likely to have minimal impact on the persistence of the local fauna assemblage.	The project will be subject to the provisions of the *Yandicoogina Emissions Management Plan*. • effective dust, noise and light emissions controls are in place at the current Yandicoogina operations, which will be extended to include project activities.	Any impacts on fauna will be minimal and not change the conservation status of fauna with conservation significance.

Type of impact to terrestrial values	Description of potential impacts	Significance of potential impact	Proposed management strategies and controls	Predicted outcome
Increased feral animal numbers in the Yandicoogina locality, resulting in heightened threat to native species.	Feral animals can be attracted to mining areas where they have access to food scraps and other wastes.	The attraction of feral carnivores to the area (eg cats) could create locally increased predation pressure on native fauna. An influx of feral species could create increased competition with native species for resources such as space, water and food.	The existing feral cat trapping program associated with the JC and JSE operation will be extended to include the project area. Other feral species will be monitored and controlled, where necessary.	Monitoring and control programs will be implemented to prevent an increase in the abundance of feral animals.
An increase in the potential for uncontrolled fires from project related ignition sources.	Developing and operating mine sites involves activities with the potential to ignite fires in vegetation. Examples include: • heavy vehicle operation and maintenance • storage and handling of explosive or flammable materials • blasting • electrical power supply and distribution. Uncontrolled fires could result in animal mortalities and modified or reduced habitat.	Mining activities will introduce a range of potential ignition sources for wildfires.	The project will be subject to the provisions of the *Yandicoogina Fire Management Plan*. The risk of accidental fires will be minimised using a variety of preventative controls, including. • implementing fire education, control and mitigation measures • creating and maintaining firebreaks around infrastructure and work areas • maintaining an operational capacity to undertake fire suppression activities during the life of the project, including: • a bushfire response plan as part on on-site emergency procedures • training a number of personnel in fire suppression, to FESA standards; • heavy duty (x2) and light attack (x4) fire fighting vehicles maintained on-site • isolated water supply (2 x 30,000 L capacity) water trucks available for fire suppression.	An effective fire incident response and suppression capacity will be maintained, to ensure that accidental fires are substantially avoided; quickly detected and suppressed, if they do occur.

7.3. Subterranean fauna

7.3.1. Management objective

In most circumstances, including this assessment, the EPA applies the following management objectives to protect subterranean fauna:

To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement of knowledge.

To maintain biological diversity that represents the different plants, animals and microorganisms, the genes they contain and the ecosystems they form, at the levels of genetic diversity, species diversity and ecosystem diversity.

7.3.2. Applicable standards and guidelines

EPA Guidance Statement No. 54 Sampling of subterranean fauna in groundwater and caves and Draft Guidance Statement No. 54a

EPA Guidance Statement No. 54 (EPA 2003) provides guidance on the information the EPA will consider when assessing proposals where subterranean fauna is a relevant factor.

The draft EPA Guidance Statement No. 54a (EPA 2007a) has been developed as a technical appendix to EPA Guidance Statement No. 54. It provides guidance on sampling for subterranean fauna, including sampling effort, sampling design and ongoing monitoring.

7.3.2.1. Legislation

The protection and conservation of subterranean fauna is subject to the same legislation as described in Section 7.2.2 for terrestrial fauna.

7.3.3. Potential impacts

Activities or aspects of the project with the potential to affect subterranean fauna populations include:

- **direct loss of subterranean fauna habitat** from the excavation of ore and overburden material
- **a temporary loss of stygofauna habitat** within the groundwater drawdown cones of depression beyond the mine pits, for the duration of the dewatering phase of the project
- **altered subsurface habitats** due to modifications to the surface environment, including:
    - **increased sediment loads** due to runoff from surface operations, resulting in reduced habitat space in strata above the water table
    - **changes to groundwater recharge or discharge regimes** due to sealing of surface areas from roads/infrastructure.
- **groundwater pollution** - eg chemical pollutants spills, unlined landfills and direct discharge of waste or different quality water into streams or aquifers
- **groundwater systems becoming saline** following mine closure, if the post-mining landscape is not designed to prevent salt accumulation in pit voids.

The Yandicoogina locality has been subjected to extensive subterranean fauna surveys over multiple phases since 2003. As a result the potential impacts on subterranean fauna values within the project area are clearly defined. The majority of the sampled subterranean taxa have been recorded in reference sites outside of the drawdown footprint of the Hamersley Yandicoogina operations (including the project area).

Only fifteen undescribed taxa have been found in areas expected to be influenced by dewatering activities. This finding can be attributed to the limited extent of sampling in the alluvial aquifer to date. Given the level of connectivity along the alluvial substrate, as well as the significant seasonal water movement through the project area, especially during cyclonic activity, short-range endemism stygofauna at the JSW and Oxbow locations is unlikely (Appendix A8).

Mine pit excavation is unlikely to significantly affect the diversity and persistence of subterranean fauna in the Yandicoogina locality for the following reasons:

- **the zone of contiguous subterranean fauna habitat** in the CID and adjacent alluvial sediments is extensive beyond the mine pits
- **all of the obligate subterranean taxa recorded at Yandicoogina** have been recorded in reference sites outside of the footprint of the mine pits, based on the results of multiple sampling phases.

Impacts on subterranean habitat will extend beyond the boundaries of the mine pits due to groundwater drawdown required for mine pit dewatering. Hydrogeological modelling has been used to assess the spatial and temporal extent of groundwater drawdown over the project life. The modelling has taken into account the dewatering activities of the proposed and existing Yandicoogina operations. The modelling outputs were cross referenced against mapped subterranean fauna species distributions and geological cross sections to indicate the extent of habitat reduction on particular species and assemblages of species. The findings of this assessment were:

- although groundwater drawdown will be extensive over the life of the project, **significant volumes of saturated habitat for stygofauna will be preserved** adjacent to each mine pit. This includes habitat within the alluvial materials and CID. The water table will be drawn down to approximately 3 metres below the proposed pit floor, which will leave the lower sections of the CID and basal conglomerate saturated. Although considered secondary habitat for stygofauna, these units have a higher percentage of cavities than the overlying stratigraphies, which would potentially create more suitable refuge within the CID stratigraphies.
- **stretches of alluvials will remain intact** along sections of Marillana Creek throughout the life of the project. Considered to be primary habitat for stygofauna, the alluvials also remain in connection with CID, which is regarded as secondary or refuge habitat for stygofauna (Appendix A8)
- the lateral extent of **mine pit dewatering cones of depression will be minimised** by overlapping the drawdown cones between individual bores, within the constraints of maintaining bore efficiency.
- **the extent of groundwater drawdown around each pit will be temporally offset**, due to the staged sequence of mining. The total volume of habitat affected will vary through time during the life of the project and will be significantly less than the combined spatial dewatering footprint from all mine pits. This will provide the opportunity for stygofauna to migrate out of profiles affected by dewatering over various phases throughout the life of the project. The stratigraphy of the Marillana and Weeli Wolli aquifer shows no distinguishing differences or geological features to suggest that the stygofauna habitat is not continuous between the two creek systems (Figure 7-3).

Modifying surface conditions, including sealing surface areas for infrastructure (eg hard stand areas, haul roads and mineral waste stockpiles) will affect surface water infiltration and recharge to groundwater. However, the impact is considered to be negligible due to the size of the catchment for Marillana Creek (less than 1% of the 2,230 km^2 catchment area disturbed). This may in turn affect sediment fluxes to the alluvials of the subterranean environment, potentially detracting from the suitability of the subterranean habitat for some species. The ecological needs of obligate subterranean taxa are not understood well enough to assess how modified recharge regimes will impact species assemblages or individual species. However, the extent of this type of disturbance will be limited in relation to the size of the subterranean habitat zone in the Yandicoogina locality.

The project area is not considered to contain primary habitat for troglofauna. This is mainly due to the high volume of water flow and creek bed morphology changes within the alluvials during cyclonic events. The majority (90%) of the subterranean CID habitat occurs below the water table. The small percentage of CID above water table is unlikely to be of a suitable thickness (nominally <10 m) to support core troglofauna habitat (refer to Section 3.9).

Dewatering from the existing Yandicoogina operations has lowered the water table and increased the volume of unsaturated CID habitat in the immediate area around the operating bore fields. This may have created temporary habitat which could be suitable for troglofauna. The taxa that have been collected in project area surveys are likely to have migrated from upslope areas, which support more extensive troglofauna species populations. As a result, lowered groundwater levels are not expected to detrimentally effect troglofauna populations in the vicinity of the JSW and Oxbow pits.

Evidence from elsewhere in the Pilbara region suggests that troglofauna habitat quality is correlated with relatively high (and constant) humidity. Another key criterion for troglofauna habitat is the presence of cavities or void spaces. Groundwater drawdown may result in the drying out of the soil profile in localised areas directly above the water table (as the zone of capillary rise falls with the declining water table). However, infiltration from rainfall and surface flow in overlying drainage lines is considered to have an overriding influence on profile humidity.

Since one of the key habitat requirements for troglofauna is the presence of void spaces and given the nature of the high flows that occur within the alluvials during storm events and cyclonic activity (and inundation for days/weeks), combined with the resultant sediment loads, the lowering of the water table is not considered a significant influence in the alluvial strata. In bedrock, the impact of dewatering has little effect on the humidity of the system. Constant humidity has been recorded in open cave systems. Humidity levels measured by RTIO in Mesa A remain at ~90% with no groundwater to influence the system.

Rio Tinto

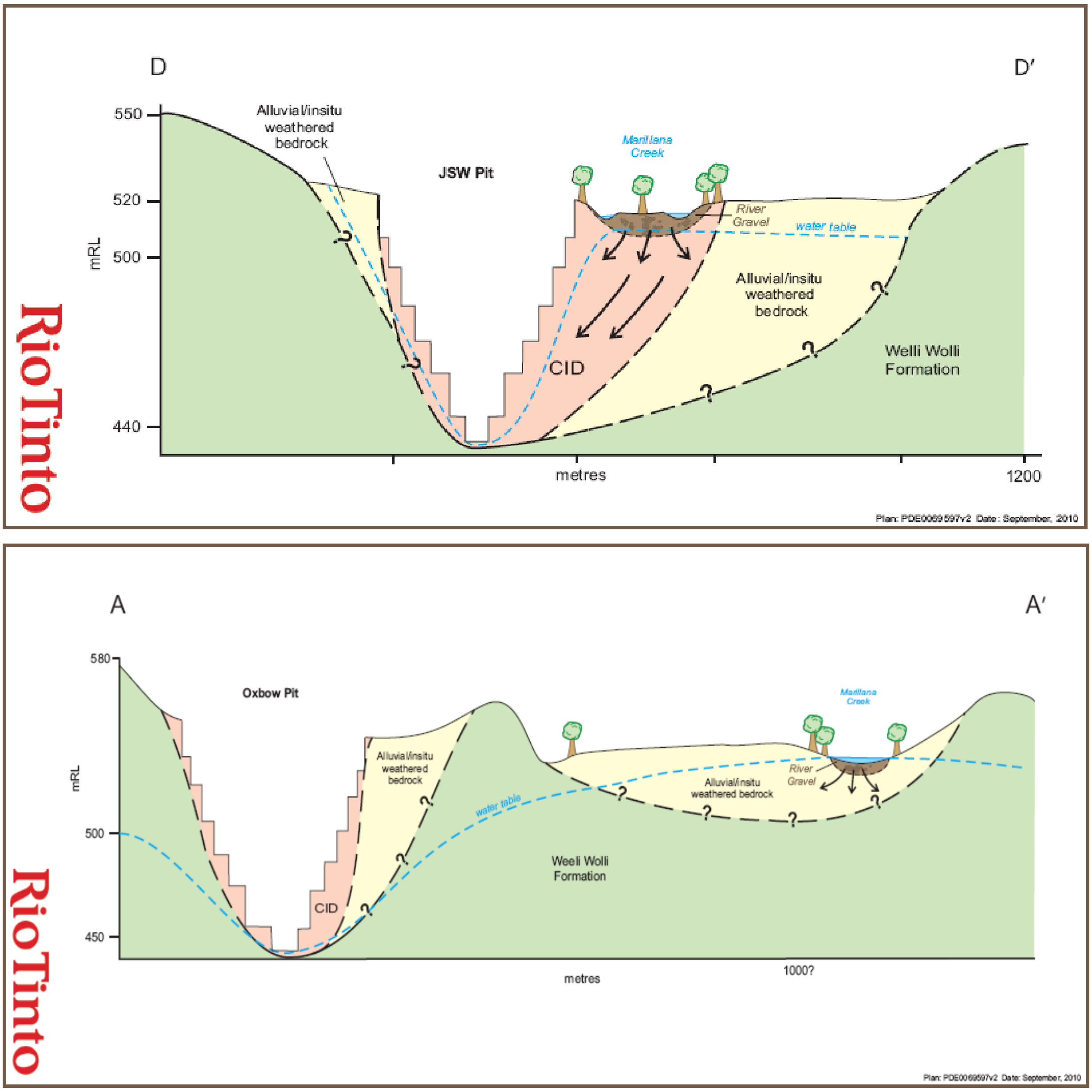

Figure 7-3 – Schematic cross sections of the JSW and Oxbow locations showing the influence of groundwater drawdown on subterranean habitat

The groundwater in the project area has relatively low levels of TDS. TDS in the floodplain aquifer (up to 1 300 mg/L) tend to be slightly higher than the CID aquifer (up to 600 mg/L). This can be attributed to salt concentration from vegetation evapotranspiration in the upper regolith. Groundwater brought to the surface through mine dewatering activities could be exposed to the evaporative concentration of salts. Similar processes could occur in groundwater systems exposed to evaporation in below water table pit voids. If reintroduced into aquifer systems these salt loads could increase overall salinity levels in aquifers, which could potentially affect some subterranean fauna species. In both cases, prolonged exposure of large volumes (relative to the size of the groundwater systems) would be necessary to significantly increase aquifer salinity levels.

Operational experience and hydrogeological modelling suggests that there is a low risk of significantly increasing salinity in aquifers from the proposed dewatering and surface water disposal activities during the mine life. This is due to the size of the aquifers at Yandicoogina and the rate of aquifer recharge and throughflow. Current groundwater sampling has not indicated any discernable changes in water quality throughout the current mining operations. Ongoing protection of groundwater quality post-mining is a major consideration for mine closure and is further discussed in Section 7.8.

7.3.4. Management measures

The design of the mine pit dewatering system for the JSW and Oxbow pits will consider preserving and protecting adequate subterranean fauna habitat in the Yandicoogina locality. This focus will enable subterranean fauna species and assemblages to persist during and after project implementation. Additional management strategies to address the potential impacts identified in Section 7.3.3 are summarised below and described further in Table 7-6. The *Yandicoogina Subterranean Fauna Management Plan* will provide the operational framework for implementing subterranean fauna protection and management measures.

The extent of groundwater drawdown beyond the current and proposed mine pits at Yandicoogina will fluctuate through time, according to the sequence of mining across the overall operations. Over the operational mine life, staged dewatering will enable significant areas to be preserved across the Yandicoogina locality (Appendix A8). The impact of groundwater drawdown will be partially offset by dewatering discharge points into Marillana Creek, which will help maintain saturation of the alluvial strata. A discharge point is planned to be maintained in the area of Marillana Creek to the south of JC to help maintain saturated conditions in aquifers beneath the downstream Marillana Creek section (refer to Figure 3-20 for existing DO3 discharge location).

7.3.4.1. Modified infiltration and recharge regime

Localised impacts to infiltration will be minimised by incorporating drainage design features to maintain the existing drainage patterns, as far as practicable (Section 7.4). Sediment traps and other design features will be used to prevent the movement of sediment from disturbance areas into natural watercourses and the subterranean environment. These measures will help minimise potential impacts to the immediate vicinity of surface disturbance areas.

7.3.4.2. Groundwater pollution

The storage, handling and disposal of hydrocarbons and related substances at the current Yandicoogina operations are managed in accordance with the *Yandicoogina Hydrocarbon Management Plan*. This Plan includes procedures for detecting and cleaning up spills and leaks. These operational requirements will also apply to the JSW and Oxbow mining operations.

Measures to protect groundwater from pollution are also provided in Section 7.5.

7.3.4.3. Subterranean fauna monitoring program

A framework for monitoring subterranean fauna populations is provided in the *Yandicoogina Subterranean Fauna Management Plan*. This includes improving knowledge on the distribution of existing stygofauna species and communities in the Yandicoogina locality, particularly the ostracod *Gomphodella* sp. and water mite *Recifella* sp. which are regarded as having conservation significance.

The current subterranean fauna monitoring program will be maintained and augmented with new monitoring bores and drill holes in the project area. Groundwater levels will also be routinely measured and recorded to validate the predicted extent of groundwater drawdown in the project area. Additional measures to monitor and protect groundwater quality are discussed in Section 7.5.

7.3.5. Predicted outcome

After applying management and mitigation measures, the following outcomes for subterranean fauna are expected:

- **loss of some subterranean fauna and habitat** due to ore access and extraction, and additional temporary loss of stygofauna habitat in groundwater drawdown areas beyond the mine pits. The predicted loss of habitat is relatively small compared to the amount of habitat available for subterranean fauna in the Yandicoogina locality. Most subterranean species (except one) are known to occur extensively outside the project area. As such, their conservation status will not be affected by the project
- **negligible impact on troglofauna habitat or fauna assemblages**, given that the project area contains suboptimal unsaturated subterranean habitat and is sparsely populated with troglofauna
- **areas exposed to modified infiltration and runoff regimes will be restricted** relative to the amount of available habitat for subterranean fauna
- **areas exposed to groundwater contamination risk will be restricted** (eg from hydrocarbons or salinisation), relative to the amount of available habitat for subterranean fauna.

Minimal change to the diversity and long term persistence of subterranean fauna and their associated habitat is predicted at Yandicoogina. This is supported by multiple phases of subterranean fauna surveying and assessment. Subterranean fauna will continue to be monitored both inside and outside the project disturbance area to detect trends in species diversity and abundance.

Implementing the project will not cause a change in the conservation status of subterranean fauna taxa with conservation significance, and is consistent with the EPA objective for fauna protection.

Table 7-6 – Potential impacts to subterranean fauna after applying proposed management controls

Type of impact to subterranean fauna	Description of potential impacts	Significance of potential impact	Proposed management strategies and controls	Predicted outcome
Reduced habitat for subterranean fauna caused by excavation.	Excavating of ore and removing overburden material at JSW and Oxbow will remove CID habitat above and below the water table.	The mine pits occupy only a portion of the available habitat for stygofauna in the project areas, which includes the alluvium and weathered basement profiles outside the CID.	Mine pit excavation in the CID is unavoidable.	A proportion of the subterranean fauna habitat in the Yandicoogina CID will be removed by mining. However, the volume removed is not expected to significantly impact stygofauna assemblages and species persistence.
Temporary reduction in the extent of the saturated zone available for stygofauna.	During the operating life of the mine pits (dewatering regime) stygofauna habitat will be reduced within the groundwater drawdown cones of depression around the mine pits.	• the modelled extent of drawdown will extend beyond the CID into the adjacent alluvial sediments and weathered basement profiles. • the extent of groundwater drawdown around each pit will be temporally offset, due to the staged sequence of mining. The total volume of habitat affected at points in time during the project will be significantly less than the combined spatial dewatering footprint from all mine pits. Stygofauna will have the opportunity to migrate out of profiles affected by dewatering over the life of the project. • groundwater drawdown impacts will be partially offset by dewatering discharge points into Marillana Creek, which will help maintain saturation of the alluvial strata (considered to be primary stygofauna habitat). A discharge point is planned in the area of Marillana Creek to the south of JC. Discharge into the downstream area to the east of JC which forms the confluence with Weeli Wolli Creek is also planned.	Mine pit dewatering cones of depression are unavoidable, but will be designed to minimise the lateral extent of groundwater drawdown. This will be achieved by overlapping the drawdown cones between individual bores, within the constraints of maintaining bore efficiency.	A proportion of the stygofauna fauna habitat in the Yandicoogina CID will be dewatered during mining. However, the volume affected is not expected to significantly impact stygofauna assemblages and species persistence
Altered subsurface habitats due to modifications to the surface environment	Modified sediment loads from runoff due to surface operations could reduce the suitability of habitat for subterranean fauna. The habitat space in karstic or fractured strata may be reduced. Modified nutrient fluxes could also affect subterranean ecosystems. However, nutrient dynamics in these systems are poorly understood. Changes to groundwater recharge or discharge regimes due to sealing of surface areas.	These types of impacts would be restricted to areas of ground disturbance outside the mine pit boundaries. The total area that could potentially be affected is small relative to the surface area overlying the extent of subterranean fauna habitat in the project area.	The project will be subject to the provisions of the *Yandicoogina Surface Water Management Plan*. • suspended sediment in runoff from developed or disturbed areas will be reduced to natural levels through sediment traps or other design features before being released into natural drainage lines.	The extent of subterranean fauna habitat subject to overlying ground disturbance is small relative to the available subterranean habitat. These disturbances are not expected to significantly impact stygofauna assemblages and species persistence.
Groundwater pollution	Potential sources of groundwater pollution includes spills and leaks of fuels, oils and lubricants, leachates from waste disposal areas and direct discharge of waste or different quality water into streams or aquifers.	The project will not involve the large scale transport, storage and handling of high quantities of potential contaminants relative to the size of the subterranean habitat zone. Pollution risk is restricted to localised areas.	The project will be subject to the provisions of the *Yandicoogina Groundwater Management Plan, Yandicoogina Hydrocarbon Management Plan* and *Yandicoogina Waste Management Plan* • hydrocarbons and other potential chemical contaminants will be transported, handled and stored in designated areas in accordance with RTIO operational procedures and controls. • hydrocarbon traps will be used to treat stormwater that might contain hydrocarbons. • waste will be disposed in licensed waste disposal facilities servicing the existing Yandicoogina operations. • any spills and leaks will be contained and managed in accordance with RTIO operational procedures and controls.	Potential groundwater contaminants will be identified, managed and contained to prevent groundwater contamination in accordance with operational procedures developed for the existing Yandicoogina operations. The risk of pollutants being transported into subterranean habitats is considered to be low and restricted to localised areas.
Salinisation of groundwater systems	If post-mining landforms include permanent or persistent surface water expressions, salts concentrated by evaporation in these water bodies could migrate into underlying aquifers.	Water quality in the Yandicoogina groundwater systems is primarily controlled by episodic, high volume recharge events. These dilute salt loads and maintain relatively high water quality within the aquifers.	The project will be subject to the provisions of the *Yandicoogina Groundwater Management Plan* Preventing excessive salt accumulating in the CID and alluvial aquifers will be addressed in mine closure plans - refer to Section 7.8.	Hydrogeological investigations indicate a low potential for salt to accumulate in the Yandicoogina groundwater systems, using the proposed dewatering and surface water discharge regime over the operational life of the project. Mine closure options addressing the maintenance of groundwater quality at Yandicoogina post-mining are at an advanced stage of detailed feasibility assessment.

7.4. Surface water

7.4.1. Management objective

In most circumstances, including this assessment, the EPA applies the following management objectives for protecting surface water, including water quality and the ecology that surface water supports:

To maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance, are protected.

To ensure that emissions do not adversely affect environmental values or the health, welfare or amenity of people and land uses by meeting statutory requirements and acceptable standards.

7.4.2. Applicable standards and guidelines

7.4.2.1. Legislation

The *Rights in Water and Irrigation Act 1914* (RIWI Act) makes provision for regulating, managing, using and protecting water resources, for irrigation schemes and related purposes. Permits to interfere with bed and banks of a watercourse are issued by the DoW under the RIWI Act. A process is provided to identify the impacts of modifying watercourses, as well as developing suitable management strategies to address these impacts. Mining leases granted under the *Mining Act 1978*, and relevant State Agreement Acts, also provide the right to interfere with the bed and banks of watercourses within lease areas; as long as such activities are not related to the taking of water.

Stormwater management, surface water discharges and potentially polluting activities are managed under an environmental licence issued under Part V of the EP Act. The discharge of mine dewatering volumes is also managed under the EP Act.

7.4.2.2. Environmental Water Provisions Policy for Western Australia

The *Environmental Water Provisions Policy for Western Australia - Statewide Policy No. 5* describes the approach to be followed by the DoW[24] in determining how water will be provided to protect ecological values when allocating the rights to use water in Western Australia. (WRC 2000). The primary objective of the policy is:

…to provide for the protection of water dependent ecosystems while allowing for the management of water resources for their sustainable use and development to meet the needs of current and future users.

7.4.2.3. Pilbara regional water plan

Regional water plans are being developed throughout Western Australia in accordance with the *State Water Plan* 2007 and *National Water Initiative (NWI)* signed by Western Australia in 2006. The NWI is an agreement between the Commonwealth and State and territory governments that recognises the importance of using Australia's water productively and efficiently and protecting the health of surface water and groundwater systems.

[24] Formerly the Water and Rivers Commission (WRC)

The Pilbara regional water plan, published in June 2010 (DoW 2010), provides strategic direction for managing and developing the Pilbara region's water resources in a sustainable manner. The aim is to ensure water resources maintain and enhance the region's natural environment, cultural and spiritual values, quality of life and economic development.

7.4.2.4. Water resource strategies and guidelines

In 2000, the Water and Rivers Commission (now the DoW) and Department of Minerals and Energy (now the DMP) developed a series of Water Quality Protection Guidelines for mining and mineral processing. These guidelines address a range of issues including installation of mine site groundwater monitoring wells, water quality and managing mine site stormwater.

The Government of Western Australia developed the State Water Quality Management Strategy in 2001 with the objective "to achieve sustainable use of the Nation's water resources by protecting and enhancing their quality while maintaining economic and social development."

In 2009, the DoW released the *Pilbara Water in Mining Guideline* (DoW 2009). The guideline includes a series of water management objectives relating to mining projects in the Pilbara, and provides advice on water management and information for the water licence assessment process. The guideline is structured around five stages in project development and implementation:

- Stage A – Preliminary consultation
- Stage B – Scoping the water management task
- Stage C – Preparation and assessment of a water management plan
- Stage D – Preparation and assessment of an operating strategy
- Stage E – Construction and operation.

The existing JC and JSE mines at Yandicoogina are operated in a manner that is consistent with the guideline.

A series of guidelines on national water quality management have also been released by the Natural Resource Management Ministerial Council (NRMMC), in collaboration with the National Health and Medical Research Council (NHMRC) and, on some aspects, the Australian Health Ministers' Conference. These guidelines address a range of issues including policies and processes for water quality management, water quality benchmarks, groundwater management, diffuse and point sources, guidelines for sewerage systems, effluent management and water recycling.

7.4.2.5. ANZECC/ARMCANZ Guidelines

In 1996, the Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ) developed the *National Principles for the Provision of Water for Ecosystems* (ANZECC/ARMCANZ 1996). These national principles aim to improve how water resources are allocated and managed, and incorporate the environment's water needs in the water allocation process. The overriding goal is to provide water for the environment to sustain and, where necessary, restore the ecological processes and biodiversity of water-dependent ecosystems.

A set of water quality guidelines for protecting marine and freshwater ecosystems has also been released (ANZECC/ARMCANZ 2000). The guidelines provide a comprehensive list of recommended low-risk trigger values for physical and chemical stressors in water bodies, broken down into five geographical regions across Australia and New Zealand. The guidelines and their application to mining are discussed in detail in Batley *et al.* (2003).

7.4.2.6. RTIO Pilbara Surface Water Management Strategy

The *RTIO Pilbara Surface Water Management Strategy* is based on Rio Tinto corporate environmental management standards and provides a framework for preventing adverse impacts on the natural function and environmental value of watercourses, water quality and sheet flow downstream from the mine area. Measures for minimising the disruption to natural flows are included as well as preventing erosion and contamination of surface and groundwater. Integrating natural and constructed drainage into the pit is covered, along with infrastructure and building design to minimise the impact of uncontrolled surface water movement on mine safety and mine production.

Key components of the RTIO Pilbara Surface Water Management Strategy include:

- surface water management plans
- annual flood risk assessments
- wet season drainage management plans
- mine design reviews for minimising in-pit flooding and downstream impacts
- five year mine plan impact reviews
- floodplain assessments
- baseline hydrology assessments to define natural creek conditions. These are used to help define the impacts of discharge of surplus mine water into creek systems.

7.4.3. Potential impacts

Activities or aspects of the project that have the potential to affect surface water systems in the project area, include:

- **surface water diversion** and creek crossing structures
- **discharge of surplus water volumes** into the Marillana and Weeli Wolli Creek systems, and
- **contaminating surface water systems** with sediments and other pollutants.

Note that impacts to ecosystems, including vegetation, flora and fauna are discussed in previous sections.

7.4.3.1. Surface water diversion and creek crossing structures

The project needs to modify the natural drainage systems in the vicinity of the JSW deposit, including:

- **a levee along a section of Marillana Creek** adjacent to the JSW-C pit to protect the JSW mine area from flooding
- **a levee along the northern margin of the JSW-A pit** to provide flood protection

- **a heavy vehicle creek crossing structure** across Marillana Creek at JSW to provide access between the JSW-C pit and JSW-A pit and ROM pad. During mining of JSW-C, this may need to be relocated to access the pit and ROM pads as the mine pit progresses. The existing light vehicle creek crossing may also need to be relocated, pending the final mine plan. Culverts at the heavy vehicle creek crossing point will be designed to direct low flow volumes away from the southern margin of the JSW-C mining area into natural low flow channels on the southern boundary of the floodplain
- **diverting the terminus of Phil's Creek** near the eastern margin of the JSW-C pit, to provide mining access to ore in this area and protect the pit from flooding. The flow will be re-routed to merge at natural velocities upstream or downstream of the current confluence with Marillana Creek, depending on the mine progression
- **diverting surface flows** from drainage to the north of JSW-C
- **diverting surface flows** from drainage to the south of JSW-A
- **diverting surface flows** from drainage to the south (east and/or west) of the Oxbow pit around the pit perimeter, into the Marillana Creek floodplain.

Flood protection levee structures for the JSW-C pit will be constructed adjacent to the northern edge of the Marillana Creek floodplain. Additional flood protection levee structures will need to be constructed to the north of JSW-A pit on the southern side of the Marillana Creek floodplain. These levees will encroach into the creekline floodplain, and will be designed to withstand 100 year annual recurrence interval (ARI) flooding events; with additional freeboard above the 100 year flood level which may reduce the impact of larger flood events.

As a result, the width of the Marillana Creek floodplain will be reduced to ~150 m in some sections, however, the low-flow line will be maintained. Although this could potentially increase flow velocities within the floodplain, with the associated risks of accelerated erosion and sediment suspension, the velocities will remain within the natural range of flow velocities identified upstream of the diversion. Downstream riparian habitat could potentially be affected by increased sediment loads.

The heavy vehicle creek crossing is required to enable ore haulage from JSW-C to the new JSW ROM pad, immediately west of the Rail Loop circuit. This structure will need to be sufficiently wide (~70 m) and robust to provide safe carriage for loaded ore trucks. A system of culverts will facilitate throughflow during small and medium sized stream flows (5 year ARI or lower), with overtopping in large flooding events.

The crossing could potentially cause erosion and sedimentation of the Marillana Creek floodplain. If not appropriately designed, it could also cause prolonged upstream impoundment of water, and increase downstream flow velocities leading to increased scour and downstream sedimentation. Upstream riparian areas could be exposed to prolonged flooding, whilst downstream riparian habitat could be affected by increased erosion or increased sediment loads. Crossings that are destroyed by floods could also pollute the creek system through the release of stray culverts, road base and other road construction materials into downstream areas.

Marillana Creek at the JSW-C location is a braided system of channels within a floodplain 200 m to 350 m wide. The location of these flow paths is dynamic and periodically modified by flooding events. Currently, the major preferential flow line is near the northern margin of the floodplain. The culverts at the Marillana Creek heavy vehicle crossing will direct flows into an alternative natural channel along the southern margin of the floodplain. This will move infiltration from BHPBIO discharge away from the pit edge and associated flood infrastructure, to ensure safe and effective operation of the JSW diversion levee near the northern margin. Given the dynamic nature of the floodplain, this intervention will not affect its hydrological or ecological functionality.

The terminus of Phil's Creek includes a creek section extending ~800 m above the confluence with Marillana Creek. Flows entering this area from the north will be redirected into a drainage structure using a system of berms and levees. This system will also intercept and redirect runoff from minor tributaries, where they are intercepted along the northern margin of the JSW-C pit. The ore immediately adjacent to, and below the terminus of Phil's Creek, will be mined via a western extension of the existing JC pit.

Modifying the creek terminus includes removing riparian habitat. Appropriate design will ensure flows returned to Marillana Creek at high velocities are managed, minimising erosion and sediment being deposited downstream of the new confluence. Energy dissipation structures will be required at the confluence with the Marillana Creek floodplain to emulate natural flow velocities and minimise erosion at this location.

Post-mining drainage designs at JSW-C will be addressed as a component of mine closure planning. Options being considered include:

- **reinstating the original Phil's Creek drainage path** by backfilling and constructing a new channel
- **constructing a new channel for Phil's Creek** either east of west of the existing creek, or
- **alternative surface water redirection** compatible with the post-mining landform and mine closure objectives.

A significant, unnamed drainage line entering Marillana Creek bisects the Oxbow mining area. Flow conditions upstream of the Oxbow deposit have been modified by the Hamersley railway line. To prevent flooding of the Oxbow pit, a system of levees and channels will be required along the southern, eastern and western perimeters of the pit to divert flows away from the active mine areas into existing or engineered drainage lines. Flows will be returned to Marillana Creek, east and west of the existing confluence.

Flows diverted to natural drainage lines west of the deposit will enter Marillana Creek within the BHPBIO mining tenement. The modified flow regime may affect riparian vegetation currently receiving runoff from the unnamed drainage line (reduced water inputs) and near the new confluences created by redirected flows (increased water inputs). Without appropriately designed flow management, these changes in the flow regime could result in accelerated erosion and sediment suspension. Downstream riparian habitat and water quality could be affected by increased sediment loads.

The design of post-mining landforms will be affected by the various proposed modifications to surface water drainage patterns in the project area. These are being evaluated as part of mine closure planning (Section 7.8). When mining ends, the principal elements of the Marillana Creek flow regime, peak flow and total volumes, sediment loads and water quality will need to be maintained to minimise long term effects on downstream areas.

7.4.3.2. Discharge to creek systems

The project will contribute up to 16 GL/yr of additional discharge from the combined Hamersley Yandicoogina operations, with a projected mean of ~10 GL/yr over the operational life of the project. Dewatering borefields will be connected by new surface pipelines to discharge outlets in Marillana Creek used by the JC operations.

Surplus water discharge from this project and existing Hamersley Yandicoogina operations will supplement discharge volumes from the BHPBIO and HD1 operations, which dispose into the Marillana and Weeli Wolli Creek systems, respectively (see Section 5). Based on peer reviewed hydrological modelling, the collective disposal volumes from these projects will combine linearly to form a creek bed saturation front in the Weeli Wolli Creek, north of the Marillana Creek confluence (Appendices A9 and A10).

Excluding disposal volumes from the project, the discharge footprint is predicted to extend to up to 13 km downstream from the confluence due to the combined effects of BHPBIO, existing Hamersley Yandicoogina and HD 1. With disposal volumes of up to 16 GL/yr from the JSW and Oxbow project, the saturation front is predicted to extend up to 4 km further downstream in the Weeli Wolli Creek (Figure 7-2).

Additional hydrological modelling has been undertaken to evaluate the behaviour of the Marillana Creek system during flooding events. This work suggests that the zone of saturated creek bed created by the project and existing mines will have negligible influence on flow rates, flood levels and flood extent in the Marillana and Weeli Wolli Creek systems during large events. This is mainly due to the orders of magnitude difference in the discharge to large flood peak volume flow rates.

Sustained discharge volumes from the project may impact the creek systems in the following ways:

- **altered vegetation composition** along Marillana and Weeli Wolli Creeks due to increased volumes of water available within the creek alluvial system (refer to Section 7.1)
- **increase in the number/ size of permanent or persistent pools,** with resulting impacts on fauna species. Includes artificial pools sustained by discharge (refer to Section 7.2)
- **increased frequency of small flood events** due to sustained creek bed saturation may accelerate erosion and sediment movement
- **changes to bank morphology** as a result of sustained saturated bank material and changes to vegetation densities and distributions. May alter erosion and sediment movement patterns, influencing the geomorphology of the creek bed, and
- **modified water chemistry**, including changes to salinity and pH.

Natural baseflow duration is two months, on average, in Weeli Wolli Creek compared to eight months, on average, in Marillana Creek. Note that Marillana Creek is also known to have experienced longer periods with continuous flow. These differences suggest that the Weeli Wolli Creek system may have a higher vulnerability to more persistent flow regimes than Marillana Creek.

7.4.3.3. Contaminants

Surface water contamination could occur from unmanaged waste disposal, spills/leaks and runoff from mine infrastructure areas and general land disturbance. Potential contaminants include:

- **hydrocarbon risk areas** such as vehicle maintenance workshops and refuelling facilities
- **detergents** used in wash down areas, and
- **increased total dissolved solids** and total suspended solids generated by runoff over disturbed land.

Contaminants may reduce the water quality.

7.4.4. Management measures

Strategies to manage surface water diversions and creek crossing structures, discharge to creek systems and contaminants are summarised below and described in Table 7-7. The *Yandicoogina Surface Water Management Plan* will provide the operational framework for implementing surface water protection and management measures.

7.4.4.1. Surface water diversion and creek crossing structures

The development of the JSW and Oxbow deposits require the modification of local minor and major tributaries to Marillana Creek, including Phil's Creek, as well as modification to the Marillana Creek floodplain. Named creeks and major tributaries will be managed in accordance with the *Surface Water Management Plan*.

All major tributaries will be diverted around the pits. Levees and channels will be used to constrict and control the flow of water. Criteria to be implemented to minimise the impact to the downstream environment include:

- **rock armouring of channels and levees** where flow velocities are likely to induce scour within the diversion. This will minimise sediment contribution to the downstream environment
- **velocity dissipation structures** to reduce the velocity of diverted flows prior to convergence with the natural flow lines. These structures will be designed to mimic natural flow conditions, minimising erosion and resulting sedimentation within Marillana Creek. Design features to dissipate energy and reduce flow velocity may include the use of vertical tee, concrete head/thrust walls, gabions, rock beaching/armouring (rip-rap) and rock edging laid on geofabric
- **using protection to minimise scour** in the diversion channels, levees and creek crossings within Marillana Creek floodplain. In accordance with Austroads waterway design standards (refer to www.austroads.com.au), this will minimise the potential for sedimentation and downstream erosion
- **roads designed for flood events.** The road crossings over Marillana Creek floodplain will be designed for small flood events of five year ARI or smaller. Culverts will be used under the crossing for small flood events and inlet/outlet culvert and embankment protection will be suitable for large flood events. This will minimise impact on the peak flow volumes of larger flood events, ensuring downstream floodplains are naturally activated. Damage to the crossing will also be minimised, reducing the amount of debris released to the creek and any additional disturbance to the creek
- **crossing design over Marillana Creek to minimise upstream impoundment** of minor flows. This will minimise inundation impacts upstream from the crossing
- **progressively use alternate, existing braided channels** within the Marillana Creek floodplain to receive the Marillana Creek low flow water. This will minimise disturbance to the creek ecosystem by mimicking a natural migration of the Marillana Creek low flow channel.

Local drainage and minor tributaries will be modified as a result of mine and associated activities. These modifications will be managed via the site Environmental Management Plan. Management activities include, but are not limited to:

- **maintaining local drainage systems** wherever practicable by avoiding drainage features and using design measures, such as culverts, to maintain flow and minimise the impact on downstream communities, and
- **localised diversion of surface water flows**, where practicable, around infrastructure and into downstream drainage lines when disruption to local drainage is unavoidable. The aim is to minimise impoundment.

7.4.4.2. Discharge to creek systems

Continuous discharge of surplus groundwater into ephemeral creeks will alter local hydrological regimes. These changes may be temporary (minor) or significant, depending on the condition of the creeklines, and will influence the level of impact to riparian systems, habitat and biodiversity. Risks will be managed using the *Groundwater, Surface Water, and Riparian Vegetation Management* plans. Key management actions include:

- **minimising changes to the existing creek bed morphology and ecology**, by restricting discharge to the lesser of the carrying capacity of the creek(s) or peak flow volume generated by a one in two year ARI flood event
- **designing discharge outlets** to incorporate appropriate protection features to minimise erosion and scouring, so that flow conditions will be similar to those produced during natural flood events, and
- **regularly monitor the chemical characteristics** of the groundwater to ensure that the quality of the discharge water remains similar to natural surface waters. Based on measured groundwater quality, discharge water will be fresh with total dissolved solids ranging between 370 and 780 mg/L, with pH between 6.8 and 9.6.

7.4.4.3. Contaminants

The risk of hydrocarbon spills and resulting contamination will be minimised by managing, monitoring and implementing contingency measures as part of the *Hydrocarbon Management Plan* contained in the EMP. These activities include:

- **appropriate bunding** and hydrocarbon management will be implemented at hydrocarbon storage facilities, re-fuelling locations, and stationary hydrocarbon usage areas to prevent flood waters and runoff entering and leaving the area
- **using hydrocarbon treatment facilities** at wash down and workshop areas to minimise potential release of hydrocarbons to the environment. Any soil contaminated by accidental spills will be removed to treatment areas that are not affected by flooding risk
- **monitoring water quality parameters** for off-site discharge, as per existing schedules, to identify contamination
- **minimising vegetation clearing**, as far as practicable, and progressively rehabilitating cleared areas, to minimise erosion and downstream turbidity from disturbed areas
- **constructing site drainage which directs flows** from disturbed areas to sedimentation traps (or suitable alternative) to minimise turbidity prior to discharge off-site

- **incorporating water management features in the design** of mine infrastructure in disturbed areas, such as pit areas, waste dumps and haul roads. The aim is to minimise the release of sediment laden runoff and potential hydrocarbons to the environment
- **using in-pit sumps to manage storm runoff within the pits**. The location and capacity of the sumps will be determined progressively. Existing operational flood risk assessments and procedures for preparing for the wet season will be used to minimise unnecessary water movement in active mine areas. Sumps may also be used for abstracting groundwater during phases of rapid pit advancement and/or towards the end of the mine life, when standard bores are not positioned or are unable to cope with the rapid rates of dewatering. The sumps may also be used if groundwater levels rapidly recover following an emergency shutdown, power outage to the dewatering bores or after a large flood/recharge event. The water will be removed via sump pumps and managed via the on-site drainage management measures.

7.4.5. Predicted outcome

After mitigation and management measures have been applied, the following surface water outcomes are expected:

- **maintaining pre-disturbance flow paths upstream and downstream** from the mining areas, wherever practicable, by designing surface water diversion structures appropriately. Surface water diversion structures are needed to protect mine pits from runoff events.
- **minimising impacts to Marillana Creek** during construction and operation by implementing management measures and rehabilitation in line with the CEMP
- **unlikely to significantly affect surface flows down gradient of the Proposal area**. The proposed design and management measures will minimise impact on surface water flows and changes in topography, particularly from infrastructure
- **increased sediment load from the project area is unlikely to elevate** the already naturally high background sediment load-levels observed in creek systems in the locality after rainfall
- **disturbance** of up to 5 km of Marillana Creek, 1 km of Phil's Creek and 3 km of the Oxbow tributary due to flood protection and management activities
- **exposure of up to 4 km of vegetation and aquatic fauna** communities to modified flow regimes in a downstream section of the lower Weeli Wolli Creek. This is in addition to the 13 km creek section below the Marillana Creek confluence that is already potentially exposed to cumulative discharge from current, approved mining activities in the catchment
- **maintaining the quality and quantity of surface water** downstream of the project area. Water discharged from operational areas will meet ANZECC/ARMCANZ (2000) guidelines for hydrocarbon content. Given the management measures to be implemented, it is unlikely that hydrocarbon spills represent a significant environmental risk
- **ecosystem expected to return to a similar state post-discharge**. In Marillana Creek, away from the reaches impacted by groundwater drawdown, the ecosystem is considered to be sufficiently resilient to recover from any changes resulting from discharge. When discharge activities stop, the ecosystem is expected to return to a similar community structure and composition to the existing system.
- **no affects to the ecological values of the Fortescue Marsh** from the discharge.

The section of Weeli Wolli Creek potentially affected by discharge is considered to be sufficiently resilient to recover from any changes due to the discharge. It is expected to return to an ecosystem with a similar community structure and composition to the existing system, when discharge ceases.

In Marillana Creek, the cumulative impact of drawdown, combined with ceasing discharge activities, is likely to have a significant impact on portions of the riparian ecosystem. Impacts could include vegetation stress leading to death and loss of habitat. Some sections of Marillana Creek within the groundwater cone of depression are not expected to passively return to pre-mining conditions. These areas will be a focus for rehabilitation, in accordance with the Decommissioning and Rehabilitation program.

Table 7-7 – Potential impacts to surface water after applying proposed management controls, in the *Yandicoogina Surface Water Management Plan*

Type of impact to surface water values	Description of potential impacts	Significance of potential impact	Proposed management strategies and controls	Predicted outcome
Levees and channels	Erosion near the confluence of water diversion structures and the Marillana Creek floodplain, and potentially further downstream if flow velocities are increased significantly above pre-disturbance levels.	Erosion impacts would initially be localised, but without intervention, could extent further downstream. Erosion of banks could undermine riparian vegetation. The physical structure of the natural creek systems is dynamic and modified naturally during cyclonic events. Erosion could increase the natural rate of erosion.	Levees and channels will be designed to include energy dissipation structures and rock armouring, where necessary, to provide controlled entry of flows into natural watercourses. Levees and channels will be regularly inspected and maintained, enabling the start of erosion to be detected and rectified.	Significant erosion associated with levees and channels will be prevented with appropriate design and maintenance.
	Sedimentation of downstream sections of Marillana Creek and floodplain	Without careful management, construction activities in or near riparian areas have the potential to release significant sediment loads. Downstream riparian habitat could be affected by increased sediment loads.	Erosion during construction will be managed using the CEMP. Ground disturbance will be minimised to prevent potential increases in erosion and downstream sedimentation.	Releasing and transporting significant sediment associated with construction will be minimised.
	Failure of structures causing riparian zone pollution with debris or inundation of non-riparian areas.	Levees that are destroyed by floods would release spoil, rock and other construction materials into the creek system. These materials could damage other downstream structures and vegetation. Foreign materials (eg rocks) could be difficult to recover.	Levees and channels will be designed to withstand infrequent large events, which have a low probability of occurring over the operational life of the project. However, all structures within floodplains are potentially vulnerable to extreme events.	Levees and channels within the floodplain will be designed to withstand a 1 in 100 year ARI event. There is a low probability of events of this magnitude occurring over the life of the project. Levees and channels outside the floodplain will be designed to an appropriate recurrence interval relative to the life of the structure (~20% annual exceedance probability or lower).
Creek crossings	Localised flow restriction creates waterlogging. Compaction of the alluvial material from construction and frequent, heavy traffic could disrupt water movement through the creekbed alluvial, forcing water to the surface upstream of the crossing. Surface flow may be impounded upstream of crossing. Areas immediately upstream could be exposed to waterlogging causing a decline in vegetation health.	Upstream waterlogging would be locally confined. The duration of waterlogging depends on climatic conditions, but is likely to be transient in the Pilbara environment. Riparian species such as *Eucalyptus camaldulensis* have some tolerance to waterlogging, and would not be expected to be detrimentally effected by relatively short duration waterlogging events.	Creek crossing structures will use culvert systems to facilitate surface water flow. Creek crossings will be placed preferentially at locations of natural flow restriction, to minimise changes to the hydrological regime. Vegetation health will be monitored in areas upstream and downstream of creek crossings.	The exposure of upstream areas to prolonged waterlogging following flood events will be spatially and temporarily restricted. Impacts on riparian vegetation health are predicted to be minimal.
	Localised flow restriction creates high velocity flows, leading to downstream erosion and increased sedimentation.	Flow conveyed through the culverts at the creek crossing can create flow velocities above natural conditions at the inlet and outlet to the culvert. The high velocities can scour, leading to increased erosion and/or sedimentation downstream.	Inlet and outlet controls will be designed into the crossing to prevent scour.	Inlet and outlet controls will prevent high flow velocities from restricted flows over or through the creek crossing structures from scouring the upstream and downstream creek bed or banks.
	Erosion and sedimentation of downstream sections of Marillana Creek and floodplain.	Without careful management, construction activities in or near riparian areas have the potential to release significant sediment loads. Downstream riparian habitat could be affected by increased sediment loads.	Erosion during construction will be managed using the CEMP. Ground disturbance will be minimised to prevent potential increases in erosion and downstream sedimentation.	Releasing and transporting significant sediment associated with construction will be minimised.
	Failure of structures causing riparian zone pollution with debris.	Crossings that are destroyed by floods would release stray culverts, road base and other road construction materials into the creek system. These materials could damage other downstream structures and vegetation. Foreign materials (eg culverts) could be difficult to recover.	Creek crossings will be designed to withstand infrequent large events, which have a low probability of occurring over the operational life of the project. However, all structures within floodplains are potentially vulnerable to extreme events.	Creek crossings constructed using foreign materials will be designed to withstand a 1 in 100 year ARI event. There is a low probability of events of this magnitude occurring over the life of the project.

Type of impact to surface water values	Description of potential impacts	Significance of potential impact	Proposed management strategies and controls	Predicted outcome
Discharge of surplus water volumes into the Marillana and Weeli Wolli Creek systems	Erosion at discharge outlets.	Erosion impacts would initially be localised, but could extend further downstream without intervention. Erosion channels could increase natural erosion rates and modify creek morphology.	Discharge outlets have been designed to include flow reduction structures and rock armouring, where necessary, to provide controlled entry of flows into natural watercourses. Outlets will be regularly inspected and maintained, enabling the start of any erosion to be detected and rectified.	Significant erosion associated with discharge will be prevented by using appropriate design and maintenance.
	Sedimentation of downstream sections of Marillana Creek and floodplain	Sediment could be released due to the collapse of creek banks from sustained saturation, or as a result of naturally high local flow velocities, accelerating natural erosion processes. Sediment could also be released as a result of poor discharge release practice, leading to scour around the discharge outlet. Downstream riparian habitat could be affected by increased sediment loads.	Discharge outlets have been designed to include flow reduction structures and rock armouring, where necessary, to provide controlled entry of flows into natural watercourses.	Significant sediment liberation and transport associated discharge will be minimised.
	Spread of weeds into downstream areas	Managing these potential impacts by following the *Yandicoogina Vegetation and Flora Management Plan* and *Yandicoogina Weed Management Plan*.		
	Altered health and composition of riparian vegetation			
	Altered aquatic fauna assemblages	Managing these potential impacts by following the *Yandicoogina Fauna Management Plan.*		
Contamination of surface water systems with other pollutants	Transporting contaminants via stormwater from disturbance areas into areas downstream of mining areas (eg hydrocarbons).	Contaminants could potentially accumulate in areas such as refuelling facilities.	• This aspect of the project will be subject to the provisions of the *Yandicoogina Hydrocarbon Management Plan* and *Yandicoogina Waste Management Plan* • Hydrocarbons and other potential chemical contaminants will be transported, handled and stored in designated areas in accordance with RTIO operational procedures and controls. • Hydrocarbon traps will also be used to treat stormwater with the potential to contain hydrocarbons.	
	Spills and leaks of contaminating substances needed for mining activities could enter drainage systems. For example: fuels, oils, lubricants, leachates from waste disposal areas and direct discharge of waste or low quality water into streams or aquifers.	The project will not involve the large scale transport, storage and handling of large quantities of potential contaminants. If spills and leaks occurred, they would involve small absolute quantities and be restricted to localised areas.	• This aspect of the project will be subject to the provisions of the *Yandicoogina Hydrocarbon Management Plan* and *Yandicoogina Waste Management Plan* • Hydrocarbons and other potential chemical contaminants will be transported, handled and stored in designated areas in accordance with RTIO operational procedures and controls. • Hydrocarbon traps will also be used to treat stormwater with the potential to contain hydrocarbons. • Waste will be disposed in licensed waste disposal facilities servicing the existing Yandicoogina operations. If any spills and leaks are detected, these will be contained and managed in accordance with RTIO operational procedures and controls.	Potential surface water contaminants will be identified, managed and contained to prevent surface water contamination. Operational procedures developed for the existing Yandicoogina operations will continue to be followed. The risk of pollution entering the creek systems with these controls in place, is low.

7.5. Groundwater

7.5.1. Management objective

In most circumstances, including this assessment, the EPA applies the following management objectives to protect groundwater:

To maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance, are protected.

To ensure that alterations to groundwater flows and quality do not have an adverse impact on beneficial or environmental uses of the water and that the integrity, functions and environmental values of watercourses are maintained.

7.5.2. Applicable standards and guidelines

7.5.2.1. Legislation

The *Rights in Water and Irrigation Act 1914* (RIWI Act) makes provision for regulating, managing, using and protecting water resources for irrigation schemes and related purposes. Licences issued under the RIWI Act by the DoW are required for works associated with groundwater abstraction, including for mine dewatering purposes. Groundwater abstraction licences specify the maximum abstraction rate from aquifers and includes conditions for monitoring.

Potentially groundwater polluting activities are managed under environmental harm and pollution control provisions of the EP Act and licences are issued under Part V of the EP Act. The discharge of mine dewater is also managed under the EP Act.

7.5.2.2. Environmental Water Provisions Policy for Western Australia

The Environmental Water Provisions Policy for Western Australia - Statewide Policy No. 5 describes the approach the DoW[25] will follow when allocating the rights to use water in Western Australia, including how ecological values will be protected (WRC 2000). The primary objective of the policy is:

...to provide for the protection of water dependent ecosystems while allowing for the management of water resources for their sustainable use and development to meet the needs of current and future users.

7.5.2.3. Pilbara regional water plan

Regional water plans are being developed throughout Western Australia in accordance with the *State Water Plan* (DPC 2007) and *National Water Initiative* (NWI) signed by Western Australia in 2006. The NWI is an agreement between the Australian and state and territory governments that recognises the importance of increasing the productivity and efficiency of Australia's water use and protecting the health of surface water and groundwater systems.

The *Pilbara Regional Water Plan* was published in June 2010 (DoW 2010). This plan provides strategic direction for managing and developing the Pilbara region's water resources in a sustainable manner. The aim is to maintain and enhance the region's natural environment, cultural and spiritual values, quality of life and economic development.

[25] Formerly the Water and Rivers Commission (WRC)

7.5.2.4. *Water resource strategies and guidelines*

The Government of Western Australia developed the *State Water Quality Management Strategy* in 2001, with the objective 'to achieve sustainable use of the Nation's water resources by protecting and enhancing their quality while maintaining economic and social development'.

The *State Water Quality Management Strategy 2001* requires that a Water Conservation Plan be developed before a water allocation licence is issued or renewed. The Water Conservation Plan must outline water efficiency objectives and timeframes. Licence conditions require implementing the Water Conservation Plan to an agreed schedule.

In 2000, the Water and Rivers Commission (now the DoW) and Department of Minerals and Energy (now the DMP) developed a series of *Water Quality Protection Guidelines* for mining and mineral processing. These guidelines address a range of issues including installing mine site groundwater monitoring wells, monitoring mine site water quality and managing mine site stormwater.

In 2009, the DoW released the *Pilbara Water in Mining Guideline*. The guideline includes a series of water management objectives relating to mining projects in the Pilbara, and provides advice on water management and information required as part of the water licence assessment process. The guideline is structured around five stages in project development and implementation:

- Stage A – Preliminary consultation
- Stage B – Scoping the water management task
- Stage C – Preparation and assessment of a water management plan
- Stage D – Preparation and assessment of an operating strategy
- Stage E – Construction and operation.

The existing JC and JSE mines at Yandicoogina are operated in a manner that is consistent with the guideline.

7.5.3. Potential impacts

Activities or aspects of the project with the potential to affect groundwater systems in the project area include:

- **mine pit dewatering** resulting in a drawdown zone extending beyond the mine pit boundaries into the alluvial aquifer. The drawdown will reduce the groundwater resource for phreatophytic vegetation along a section of Marillana Creek and reduce the extent of saturated habitat for obligate groundwater dependent fauna (stygofauna)
- **mine pit excavations**, which will alter the hydraulic properties of the CID aquifer and may cause localised declines in adjacent water tables due to lateral leakage into the pits. The excavations will result in the removal of habitat for obligate groundwater dependent fauna (stygofauna), and
- **contamination of groundwater**, for example from hydrocarbon spills/leakages or the evaporative concentration of salts in pit lakes or discharge water.

Managing potential impacts from the discharge of surplus volumes from mine pit dewatering is discussed in Section 7.4. Managing potential impacts from changes in subterranean fauna habitat caused by groundwater drawdown is discussed in Section 7.3. Protecting groundwater post mine closure is addressed in Section 7.8.

7.5.3.1. Dewatering

With most of the high grade ore occurring below the current water table, dewatering of the CID aquifer is required to enable mining at JSW and Oxbow. Dewatering involves pumping groundwater using multiple abstraction bores located within and adjacent to the mine pit boundaries. In-pit dewatering from multiple sumps will remove groundwater seepage from the lower sections of the CID aquifer, before deeper benches are mined. Hamersley will obtain dewatering licences under the RIWI Act before any dewatering activities start.

Based on the current mine plan, the maximum depth of dewatering within the mine pits will be approximately 470 mRL at JSW-A, 465 mRL at JSW-C and 475 mRL at Oxbow. These levels equate to a maximum groundwater drawdown depth of ~60 m below the pre-mining water levels. Dewatering will create cones of groundwater depression which extend laterally and become progressively less pronounced as they get further from the abstraction bores. The size of these zones will extend some distance beyond the boundary of the mine pits, and vary over the life of the project in accordance with the depth of dewatering.

The Yandicoogina regional numerical groundwater model was used to quantitatively predict the extent of drawdown adjacent to the JSW-A, JSW-C and Oxbow pits through time (Appendix A12). This model was peer reviewed by URS, which supported that the modelling undertaken by RTIO was appropriate and in accordance with relevant groundwater modelling guidelines (Appendix A14). The model accounted for existing dewatering activities associated with the JC and JSE pits. Regional impacts of dewatering will be constrained by the low permeability of the surrounding bedrock lithologies.

Looking at the overall Yandicoogina operations (existing and proposed), water level changes in the CID due to mining activities extend up to 12 km downstream from JC. Monitoring records collected since 1998 (some records date back to 1974), from further downstream, show no discernible effect of mining activities on water tables (eg Figure 3-19). However, correlations between water levels and climate are evident at these locations.

The modelling investigations and operational experience indicate that groundwater levels respond rapidly to changes in the water budget at Yandicoogina, highlighting the connection between various aquifers and creek systems. These changes include natural and human induced processes.

7.5.3.2. Mine pit excavations

Mining of the CID ore at JSW-A and C and Oxbow will result in part of the CID aquifer and sections of the adjacent alluvial aquifer being excavated. The removal of part of the alluvial aquifer may reduce flows downstream from the excavated pits.

Leakage from the alluvial aquifer into the excavated pits may reduce the availability of groundwater to riparian vegetation and to stygofauna in the alluvial material downstream of the excavation. The high permeability of the alluvial aquifer, combined with recharge from rainfall events and flow from surface water discharge outlets, is expected to minimise these impacts.

The changed landform post-closure has the potential to decrease throughflow in the CID aquifer, which could result in increased aquifer salinity.

7.5.3.3. Groundwater contamination

Unmanaged waste disposal, spills/leaks and runoff from mine infrastructure areas and general land disturbance, specifically closure, could result in groundwater contamination. Potential contaminants include:

- **hydrocarbon risk areas** such as vehicle maintenance workshops and refuelling facilities
- **increased total dissolved solids** / salinity caused by evapotranspiration of pit lakes upon closure.

Contaminants may reduce the groundwater quality, which may subsequently impact surface water.

7.5.4. Management measures

Management strategies to address the potential impacts identified in Section 7.5.3 are summarised below and described in Table 7-8. The *Yandicoogina Groundwater Management Plan* will provide the operational framework for implementing groundwater protection and management measures.

7.5.4.1. Dewatering

Borefield optimisation will minimise the lateral extent of drawdown by using a series of 'cluster' borefields, located up gradient and down gradient or adjacent to the active mining area. The cones of groundwater depression created by each bore will interface to concentrate the effect of dewatering in the CID orebody in the active mining areas and also minimise the dewatering discharge volumes.

Dewatering volumes will significantly exceed operational water requirements. RTIO has undertaken an evaluation of surplus water management options to minimise the environmental impacts of surplus water disposal. A detailed discussion of this assessment is provided in Section 5.1.

Aquifers will be monitored on an ongoing basis so impacts to water levels and chemistry can be detected. Monitoring includes using flow meters, groundwater level monitoring, and groundwater quality testing.

The dewatering borefield design will be informed by the Yandicoogina numerical groundwater model (Appendix A12). This model will continue to be reviewed and updated over the life of the project, in response to mine planning and new information collected from the Yandicoogina bore network monitoring program. This includes model calibration and validation exercises using the operational monitoring bore network and additional geochemical mass balance investigations.

7.5.4.2. Mine pit excavations

Excavation from the JSW-A, JSW-C and Oxbow pits will prevent throughflow in the CID aquifer during the operational life of these pits. Mine pit dewatering will intercept incoming flows and ultimately return a large proportion of these flows to downstream aquifer following infiltration through the creek beds. Losses will principally be due to evaporation and operational water use. The magnitude of downstream changes caused by mining will be substantially diminished by episodic cyclonic rainfall events, which through recharge, will replenish water stores and maintain low salinity levels in the aquifer.

The behaviour of the mined aquifer post-mining depends on the final mine closure plan. Further discussion of issues relating to groundwater quality is provided in Section 7.8.

7.5.4.3. Groundwater contamination

The risk of potential hydrocarbon spills and resulting contamination will be minimised by managing, monitoring and using contingency measures as part of the *Yandicoogina Hydrocarbon Management Plan*. These activities include:

- **appropriate bunding and hydrocarbon management** at hydrocarbon storage facilities, re-fuelling locations, and stationary hydrocarbon usage areas to prevent floodwaters and runoff entering and leaving the area;
- **hydrocarbon treatment facilities** used at wash down and workshop areas to minimise potential release of hydrocarbons to the environment
- **monitoring water quality parameters** to identify contamination as per the project Operating Licence and Groundwater Abstraction Licence issued under Part V of the EP Act, and reported through the *Yandicoogina Groundwater Operating Strategy* (GWOS)
- **designing mine infrastructure in disturbed areas to minimise** the release of potential hydrocarbons to the environment. Includes incorporating water management features in the design of pit areas, waste dumps and haul roads, and
- **regularly monitor** pipelines, reinjection bores and infrastructure associated with water transport for potential leaks and ruptures. Also test water quality.

7.5.4.4. Monitoring

The *Yandicoogina Groundwater Management Plan* provides for comprehensive groundwater monitoring across the overall Yandicoogina operations. Monitoring will also be regulated via the project Operating Licence and the GWOS. The monitoring program will include:

- **collecting baseline groundwater data** (groundwater quality and quantity) for the mine and any associated borefield areas. This will supplement ongoing monitoring associated with the current Yandicoogina operations (refer Section 3.11)
- **monitoring the dewatering and discharge volumes** from the discharge sites to ensure pH, TDS and hydrocarbons are within acceptable limits (refer Section 3.11)
- **monitoring aquifer water quality** at multiple points within the CID aquifer across the project area, to ensure that ecosystem health changes and impacts are within acceptable limits, and
- **implementing primary and contingent management and reporting actions** in the event that impacts are detected outside acceptable limits, in accordance with the GWOS and riparian vegetation health monitoring program.

7.5.5. Predicted outcome

The following groundwater outcomes are expected after applying mitigation and management measures:

- **dewatering of the CID aquifer** to the maximum depth of 470 mRL at JSW-A, 465 mRL at JSW-C and 475 mRL at Oxbow
- **groundwater drawdown** in areas surrounding the JSW-A, JSW-C and Oxbow pits
- **removing and permanently modifying CID aquifer** characteristics within the JSW-A, JSW-C and Oxbow pits
- **minor changes in water volumes and water quality** in downstream groundwater systems during the operational life of the project. These changes are expected to be transient and ecologically insignificant due to the overwhelming effect of cyclonic recharge events to control water volumes and quality in the local groundwater system.

Mine pit dewatering will create a zone of lowered water tables extending beyond the mine pit boundaries. This will reduce the volume of saturated subterranean habitat and potentially make groundwater unavailable to phreatophytic vegetation in localised areas over the operational life of the project. These impacts and their management are further discussed in Section 7.3 and Section 7.1.

Long term water quality in the local groundwater system will be influenced by the final mine closure plan. Management considerations for post-closure groundwater protection are further discussed in Section 7.8.

Implementing the project will not result in significant impacts on groundwater conservation values, and is consistent with the EPA objective for groundwater protection.

Table 7-8 – Potential impacts to groundwater after applying proposed management controls, as per the *Yandicoogina Groundwater Management Plan*

Type of impact to groundwater values	Description of potential impacts	Significance of potential impact	Proposed management strategies and controls	Predicted outcome
Dewatering	A drawdown zone will be created which extends beyond the mine pit boundaries into the alluvial aquifer. The drawdown will reduce the groundwater resource for riparian vegetation along a section of Marillana Creek and reduce the extent of saturated habitat for obligate groundwater dependent fauna (stygofauna).	Riparian vegetation protection measures for the project are in the *Yandicoogina Riparian Vegetation Management Plan* and discussed further in Section 7.1. Stygofauna protection measures for the project are in the *Yandicoogina Subterranean Fauna Management Plan* and discussed further in Section 7.3.		Refer to Section 7.1 (vegetation and flora) and Section 7.3 (subterranean fauna).
Mine pit excavations	The hydraulic properties of the CID aquifer will be altered due to removing the overburden and CID orebody in the mine pits, and backfilling the pits with mineral waste.	Upstream flows entering the CID aquifer in the project area will be intercepted and abstracted by dewatering borefields. The majority of these abstraction volumes will be returned to the downstream aquifer. Some losses will occur from the local groundwater system due to operational water use and evaporation before the infiltration and percolation of surplus water discharge volumes. Based on modelling studies and operational experience, any changes to groundwater quality are expected to be transient and ecologically insignificant. Cyclonic recharge events have an overwhelming effect in controlling water volumes and water quality in the local groundwater system.	The *Yandicoogina Mine Closure Plan* will address final landform designs relating to mine pits to protect groundwater quality in the longer term. Aquifer water quality will be monitored at multiple points within the CID aquifer across the project area and downstream, as part of ongoing monitoring for the overall Yandicoogina operations.	Removal and permanent modification of CID aquifer characteristics within the JSW-A, JSW-C and Oxbow pits will occur. This will cause minimal changes to water volumes and water quality in downstream groundwater systems during the operational life of the project. Post-closure landform designs will ensure that groundwater quantity and quality is protected in the longer term.
Groundwater contamination	Increased salinity of the local groundwater systems	Salt accumulation would reduce the quality of groundwater for beneficial or environmental uses. The accumulation of salts in local groundwater systems would change the ecological utility of these systems for subterranean biota assemblages. Based on modelling studies and operational experience, any changes to groundwater quality are expected to be transient and ecologically insignificant. Cyclonic recharge events have an overwhelming effect in controlling water volumes and water quality in the local groundwater system.	The *Yandicoogina Groundwater Management Plan* includes management controls to ensure the protection of water quality. Aquifer water quality will be monitored at multiple points within the CID aquifer across the project area and downstream, as part of ongoing monitoring for the overall Yandicoogina operations. The *Yandicoogina Mine Closure Plan* will address the protection of groundwater quality in the longer term.	The project is not expected to result in significant accumulation of salts in the local groundwater system.
Groundwater contamination	Spills and leaks of contaminating substances needed for mining could enter groundwater systems. Eg fuels, oils, lubricants, leachates from waste disposal areas and direct discharge of waste or low quality water percolating into aquifers.	The project will not involve the large scale transport, storage and handling of large quantities of potential contaminants. If they occurred, spills and leaks would involve small absolute quantities and be restricted to localised areas.	This aspect of the project will be subject to the provisions of the *Yandicoogina Hydrocarbon Management Plan* and *Yandicoogina Waste Management Plan*. • hydrocarbons and other potential chemical contaminants will be transported, handled and stored in designated areas, in accordance with RTIO operational procedures and controls. • hydrocarbon traps will also be used to treat stormwater with the potential to contain hydrocarbons, preventing transport into groundwater systems. • waste will be disposed in licensed waste disposal facilities servicing the existing Yandicoogina operations. • any spills and leaks will be contained and managed in accordance with RTIO operational procedures and controls.	Potential groundwater contaminants will be identified, managed and contained in order to prevent surface water contamination, in accordance with operational procedures developed for the existing Yandicoogina operations. With these controls in place, the risk of pollution entering the groundwater systems is low.

7.6. Aboriginal heritage

7.6.1. Management objective

In most circumstances, including this assessment, the EPA applies the following management objective for protecting Aboriginal heritage:

To ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation.

7.6.2. Applicable standards and guidelines

EPA Guidance Statement No. 41

EPA Guidance Statement No. 41 (EPA 2004d) provides guidance on the process for assessing Aboriginal heritage as an environmental factor.

The EPA expects proponents to:

- report on the likelihood of the presence of matters of heritage significance to Aboriginal people, and
- determine whether the proposed changes to the biophysical environment will result in an impact to these matters of heritage significance to Aboriginal people.

Based on this information, the EPA will determine whether Aboriginal heritage is a relevant environmental factor to the proposal. Where Aboriginal heritage is determined to be a relevant factor, the EPA expects the proponent to properly consider how the proposal can minimise any impact to heritage values.

EPA Guidance Statement No. 41 (EPA 2004d) details actions that apply to Aboriginal heritage, including:

- **consulting with Department of Indigenous Affairs** staff and conducting desktop review of sites
- **undertaking an Aboriginal heritage archaeological and ethnographic survey** in consultation with relevant Aboriginal representatives
- **informing relevant Aboriginal people** of the proposal and conducting appropriate consultation, and
- **demonstrating that any concerns raised** by the Aboriginal people have been considered in the environmental management of the project and that this is made known to the relevant Aboriginal people.

7.6.2.1. Legislation

The *Aboriginal Heritage Act 1972* is administered by the Minister for Indigenous Affairs and recognises, protects and preserves Aboriginal sites in Western Australia. It is an offence under s.17 of the *Aboriginal Heritage Act 1972* to excavate, destroy, damage, conceal, or in any way alter an Aboriginal site (DIA 2009).

A land owner can apply for consent under s.18 (2) of the *Aboriginal Heritage Act 1972,* if they wish to use their land in a way which is likely to breach s.17 concerning any Aboriginal sites which might be on the land. Consent has the effect of removing the criminality from any breach of s.17 which occurs on the land.

If a proposal is referred under the EP Act, the Minister for Indigenous Affairs cannot make a decision under s.18 (3) of the *Aboriginal Heritage Act 1972* that could cause or allow the proposal to be implemented, until:

- the EPA has notified the Minister that it is not going to assess the proposal and the appeals process has been finalised, or
- the Minister for Environment has served a statement on the Minister permitting the decision to be made.

7.6.3. Potential impacts

Aboriginal heritage sites could potentially be disturbed by proposed activities such as clearing, dewatering, excavation and surface water discharge, although it is Rio Tinto's policy to avoid heritage sites, wherever practicable. Section 18 approvals under the *Aboriginal Heritage Act 1972* will be required where disturbance to heritage sites cannot be avoided. All potential secondary impacts to heritage sites and cultural values are also considered prior to any works approvals being granted (eg relating to dust, blasting, and subsidence). These are often site and works specific, and as such mitigation measures may vary.

The major risks to Aboriginal heritage are related to the disturbance of archaeological or ethnographic sites and impacts on the heritage values of sites and places. Management strategies are in place to ensure comprehensive surveys are undertaken by archaeologists, anthropologists and Traditional Owners across all areas of proposed ground disturbance, and the sites are protected and managed appropriately.

7.6.4. Management measures

Management strategies to address the potential impacts identified in Section 7.6.3 are briefly summarised below and further described in Table 7-9. RTIO has well developed practices and procedures for protecting Aboriginal heritage sites including the *RTIO Cultural Heritage Management Standard* and *RTIO Iron Ore Heritage Policy*. An overarching *Cultural Heritage Management Plan* (CHMP) is currently being developed for the Yandicoogina project area, which includes the proposed new mines at JSW and Oxbow. RTIO also adheres to environmental legislation with relevance for managing potential impacts on heritage values (such as dust monitoring outlined in Section 7.9.2), together with RTIO's internal environmental and health compliance policies and procedures.

Previous heritage reports within the overall project area have been collated to create a map of areas that have been surveyed (Figure 3-24). Additional surveys of proposed new disturbance areas are currently being undertaken in conjunction with the relevant Native Title claim groups represented by the Gumala Aboriginal Corporation (GAC) (Innawonga Bunjima WC96_061, Nyiyaparli WC05_006 and Martu Idja Banyjima WC98_062). The location of known Aboriginal heritage sites will be marked on all planning documents and site plans. Where agreed with GAC, heritage sites within high risk areas will be fenced. RTIO will also ensure site specific management recommendations are followed by all workers.

RTIO will also consult with GAC regarding proposed works and Aboriginal sites likely impacted within the project area, prior to submitting a Section 18 application to DIA. Section 18 approval from the DIA (and Section 16, where required), will be sought and granted prior to any disturbance of an Aboriginal heritage site, in accordance with the *Aboriginal Heritage Act 1972* (WA).

RTIO is currently undertaking a program to ensure heritage awareness is raised for all workers on site. Work will stop immediately and the Department of Indigenous Affairs (DIA) and RTIO's Heritage team will be contacted where human remains or archaeological material are accidentally uncovered during any ground disturbing activity.

7.6.5. Predicted outcome

After mitigation and management measures have been applied, the following outcomes for Aboriginal heritage values are expected:

- **direct disturbance of some archaeological sites will be undertaken**, mostly of low archaeological significance. Any disturbance will be in accordance with the provisions of the *Aboriginal Heritage Act 1972* (WA) and will have the consent of the relevant Traditional Owners
- **some effect on the cultural values of Marillana, Phil's and Weeli Wolli Creeks.** This is associated with the environmental significance of the creek system to Traditional Owners. However, no known ethnographic sites are likely to be affected, and
- **no expected detrimental effect on water quality** as a result of discharge of excess water to local drainage line(s) (if chosen). However, such discharge will alter the duration that water is present in the watercourse(s) and this may have some perceived effect on cultural values.

RTIO will maintain ongoing consultation with Aboriginal stakeholders over the life of the project, in accordance with processes established for the existing Hamersley Yandicoogina operations. Implementing the proposed management measures should ensure that the EPA objective for the protection of Aboriginal heritage is fulfilled.

Table 7-9 – Potential impacts to Aboriginal heritage values after applying proposed management controls

Type of impact to Aboriginal heritage values	Description of potential impacts	Proposed management strategies and controls	Predicted outcome
Disturbance of known heritage site	Clearing of heritage site through earthworks Impact on heritage site via surface water inundation Impact to cultural values from dewatering and discharge activities	Surveying of heritage sites prior to construction. Include heritage values in the induction program for all site personnel (including contractors). Establish and maintain a register of sites of Aboriginal significance within the site, including spatial records of site locations. Flag and/or fence the boundaries of Aboriginal sites in the vicinity of construction or operation areas. Maintain regular ongoing communication with representatives of relevant Aboriginal groups Obtain Section 18 clearances under the *Aboriginal Heritage Act 1972 (WA),* where it is not possible to avoid impacting sites.	Direct disturbance of some archaeological sites, mostly of low archaeological significance. Any disturbance will be undertaken in accordance with the provisions of the *Aboriginal Heritage Act 1972* (WA) and the consent of the relevant Traditional Owners. Some effect on the cultural values of Marillana, Phil's and Weeli Wolli Creeks as associated with environmental significance of the creek system to Traditional Owners, however, no known ethnographic sites are likely to be affected. No detrimental effect on water quality as a result of discharge of excess water to local drainage line(s). Discharge will result in more persistent flows and surface water expression in sections of the creek systems over the life of the project. This may affect the cultural values of these creek sections.
Detect suspected Aboriginal heritage site(s) (previously unrecorded)		Disturbance areas will be surveyed prior to ground disturbance activities. Any heritage sites will be recorded and their values assessed in consultation with the Traditional Owners.	Project area surveys and consultation with relevant Aboriginal stakeholders will enable previously unrecorded sites to be detected and appropriately managed.
		Project employees will undertake cultural awareness training in accordance with standard RTIO procedures. Aboriginal heritage will be included in the site induction program for all project personnel (including contractors). Maintain regular ongoing communication with Aboriginal stakeholders. Implement management protection actions in the event that a suspected heritage site is discovered.	A management and mitigation plan, including education of operations and construction workers, will be implemented to raise awareness of heritage protection issues across the project workforce. This will ensure minimal indirect and direct impacts to heritage values in the project area.

7.7. Greenhouse gases

7.7.1. Management objective

In most circumstances, including this assessment, the EPA applies the following management objectives to minimise greenhouse gas emissions:

Minimise greenhouse gas emissions in absolute terms and reduce emissions per unit of product to as low as reasonably practicable.

Mitigate greenhouse gas emissions, mindful of Commonwealth and State greenhouse gas strategies and programs.

7.7.2. Applicable standards and guidelines

EPA Guidance Statement No. 12: Minimising Greenhouse Gas Emissions

EPA Guidance Statement No. 12 (EPA 2002c) provides guidance on minimising greenhouse gas emissions from significant new or expanding operations.

The EPA will expect proponents to:

- apply best practice measures to maximise energy efficiency and minimise emissions
- undertake comprehensive analysis to identify and implement appropriate offsets
- undertake an ongoing program to monitor and report emissions and periodically assess opportunities to further reduce greenhouse gas emissions over time.

7.7.2.1. Legislation

The Commonwealth *National Greenhouse and Energy Reporting Act 2007* (NGERS Act) has created a framework under which corporations are required to report their annual energy production, energy production and greenhouse gas emissions. The NGERS Act is administered by the Department of Climate Change and Energy Efficiency (DCCEE).

The NGERS Act is triggered where prescribed emissions or energy consumption thresholds are exceeded for facilities and/or controlling corporations. From 2010/11, onwards, the reporting thresholds for activities generating greenhouse gas emissions under the Act are 25,000 tonnes $CO_{2equiv.}$/yr for a single facility and 50,000 $CO_{2equiv.}$ /yr tonnes for corporations.

The Commonwealth *Energy Efficiency Opportunities Act 2006* (EEO Act) has created a framework under which corporations with high energy consumption are required to identify, evaluate and report publicly on cost effective energy savings opportunities. The EEO Act is administered by the Department of Resources, Energy and Tourism (DRET). Corporations with annual emissions greater than 0.5 PJ are subject to the EEO Act.

7.7.2.2. Rio Tinto Standards

All Rio Tinto business units that contribute significantly to total GHG emissions and energy use have the objective of achieving continuous improvement in GHG emissions reductions. This applies to planning and operational activities, and provides the basis for establishing systems for measuring GHG emission and identifying emissions reductions opportunities.

7.7.3. Potential impacts

Greenhouse gas emissions are an unavoidable consequence of modern mining operations. Activities or aspects of the project that will directly result in the emission of greenhouse gases include:

- **fuel usage** by vehicles, mobile plant and equipment used for extracting and transporting ore and waste
- **explosives** used for blasting
- **electrical energy usage** by processing plants and conveyors, sourced from external facilities
- **land clearing** (a source) and **revegetation** (a sink), and
- **decomposition** of waste (landfill).

The emissions intensity of the mining operation at Yandicoogina is relatively low compared with other iron ore projects in the Pilbara region, in the order of 3 to 5 kg $CO_{2equiv.}$ per tonne of mined product (excluding rail and port shipment). This is partly attributable to the low amount of overburden and properties of the ore. Based on this figure, annual GHG emissions from the proposed Yandicoogina Operations (JSW and Oxbow) will be in the order of 100,000 tonnes $CO_{2equiv.}$/yr over the life of the project.

7.7.4. Management measures

All existing Hamersley operations have targets for reducing energy consumption, increasing energy use efficiency and limiting the emission of greenhouse gases. These targets will apply to the project after the first full year of production. From an emission perspective, the project will benefit from the ability to connect with and utilise existing infrastructure, including ore processing facilities, the rail network, and power and water distribution networks.

The current Hamersley Yandicoogina operations are registered under the NGERS Act and EEO Act, as a component of Rio Tinto's national operations. Systems and methods are in place for assessing and reporting energy consumption and greenhouse gas emissions from the current operations. These will be extended to apply to the project.

Reporting under the NGERS Act will address:

- the consumption of energy (principally diesel and electricity)
- Scope 1 (direct) greenhouse gas emissions (principally from diesel combustion), and
- Scope 2 (indirect) emissions (principally associated with imported electricity).

Reporting under the EEO Act will address energy consumption and identify and assess opportunities for energy efficiency. An evaluation of energy management and energy efficiency initiatives at the Yandicoogina operations was completed by RTIO in 2010. Examples of the types of energy efficiency opportunities that were identified include (but are not limited to):

- **improved efficiencies in mining and ancillary systems**, and infrastructure such as workforce accommodation facilities
- **programs to increase awareness of energy efficiency** and improve the efficiency of operating procedures

- **optimising mining and ore processing systems**, such as ore haulage and conveyance logistics, and
- **staged replacement of equipment** with more energy efficient units, in accordance with asset management schedules.

The collective requirements of RTIO standards, the NGERS Act and EEO Act will contribute towards achieving best practice in greenhouse gas emissions reductions over the life of the project.

7.7.5. Predicted outcome

The project will contribute towards GHG emissions from the Yandicoogina operations in the order of 100,000 tonnes $CO_{2equiv.}$/yr over the life of the project. GHG emission will be measured on an annual basis in accordance with NGERS Act.

Energy efficiency and emission reduction strategies are aimed at improving the emissions intensity levels achieved historically. RTIO will monitor state and national developments for greenhouse gas emissions, and adopt a proactive approach for responding to carbon price signals or new compliance requirements that may arise.

The project can be implemented in a manner that ensures that the EPA objectives for greenhouse gas emissions are fulfilled, and is consistent with Commonwealth and State greenhouse gas strategies and programs.

7.8. Closure and rehabilitation

7.8.1. Management objective

In most circumstances, including this assessment, the EPA applies the following objectives when assessing proposals that have a closure component:

To ensure, as far as practicable, that rehabilitation achieves a stable and functioning landform that is consistent with the surrounding landscape and other environmental values.

To maintain the abundance, diversity, geographic distribution and productivity of flora and fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement of knowledge.

7.8.2. Applicable standards and guidelines

EPA Guidance Statement No. 6: Rehabilitation of Terrestrial Ecosystems

EPA Guidance Statement No. 6 (EPA 2006) provides guidance on the rehabilitation of terrestrial ecosystems following disturbance. The Guidance Statement states that the key aims of rehabilitation are to:

- **ensure the long term stability** of soils, landforms and hydrology required for the sustainability of sites, and
- **partially or fully repair the capacity of ecosystems** to provide habitats for biota and services for people.

Actions relevant to rehabilitation planning and design include developing relevant rehabilitation objectives, in consultation with stakeholders, as well as developing clear targets for rehabilitation. These targets must be effectively monitored and audited to confirm the objectives are achieved.

Recommended objectives for rehabilitation include (EPA 2006):

- provide safe, stable and resilient landforms and soils
- provide appropriate hydrology
- provide suitable visual amenity
- retain heritage values
- be suitable for agreed land uses
- include resilient and self-sustaining vegetation comprised of local provenance species
- reach agreed numeric targets for vegetation recovery
- comprise habitats capable of supporting all types of biodiversity.

7.8.2.1. Mine closure strategies and guidelines

Regulatory agencies and industry bodies have established guidelines (industry best practice) to assist mining companies achieve acceptable standards of mine closure and rehabilitation. While there are no legislative requirements to adhere to these guidelines, their use can be considered to represent industry best practice. Hamersley Iron subscribes to the intent and advice of such guidelines. Collectively, these guidelines address planning, risk assessment, stakeholder consultation, implementation, monitoring, reviewing and the reporting aspects of mine closure.

Applicable mine closure guidelines include:

- Environmental Notes on Mining – Waste Rock Dumps (DoIR 2009)
- Planning for Integrated Mine Closure: Toolkit (ICMM 2008)
- Mine Void Water Resource Issues in Western Australia (Johnson and Wright 2003)
- Strategic Framework for Mine Closure (ANZMEC & MCA 2000)
- Mine Closure Guidelines for Mineral Operations in Western Australia (Chamber of Minerals and Energy 2000)
- Enduring Value – The Australian Minerals Industry Framework for Sustainable Development (MCA 2004)
- Best Practice Environmental Management in Mining Series (Environment Australia 1998)
- Guidelines for preparing Mine Closure Plans (DMP 2011).

7.8.2.2. Rio Tinto policies and standards

The Rio Tinto group has established policies and standards addressing mine closure, some of which may go beyond legislative and statutory requirements. All operations must adhere to these policies and standards.

The *Rio Tinto Corporate Environmental Policy* outlines specific directions and management commitments for environmental management. The Policy incorporates the aim of leaving areas in a condition as close as practicable to their original condition and preventing pollution. To fulfil these aims, it is necessary to minimise land disturbance and waste generation, continually update disturbance and closure plans, and undertake progressive rehabilitation.

The *Rio Tinto Closure Standard* is the key document that directs the development and implementation of closure activities at Rio Tinto operations, from project inception. The specific intent of the Standard is:

To ensure that Rio Tinto managed activities are left in a condition which minimises adverse impacts on the human and natural environment.

The Standard provides a framework for establishing an overall vision and objectives for closure, selecting appropriate measures to meet the objectives, and defining closure performance targets. It includes the need to develop a project level *Closure Management Plan*, which includes:

- a detailed description of closure and post-closure mitigation programmes
- a description of specific technical solutions related to infrastructure and facilities for the preferred closure option
- ongoing consultation process related to the preferred closure option
- an employee information, communication and consultation framework
- identification and assessment of risks and uncertainties associated with the preferred closure option
- a detailed communication plan
- an agreed process and time scale for post-closure management and monitoring, and
- a program for socio-economic mitigation, where required.

Through implementing the Standard, RTIO seeks to influence the design, development, operation and closure of all its operations. This ensures post-closure outcomes are optimised for social, environmental and economic development needs and expectations.

In addition to the Closure Standard, there are a number of other company environmental standards that have direct or indirect implications for closure including:

- RTIO Decommissioning Strategy
- RTIO Rehabilitation Handbook
- RTIO Final Landform Guidelines
- RTIO Soil Management Procedure, and
- RTIO Contaminated Sites Management Plan.

These standards outline the minimum level of compliance for all operations and are regularly audited.

7.8.2.3. Existing operations

The existing JC and JSE operations at Yandicoogina are subject to mine closure obligations under Ministerial Statements 523 and 695, respectively. Closure plans must be developed, updated and submitted to the Western Australian Government on a five yearly basis.

A *Decommissioning and Rehabilitation Plan* was developed for the Yandicoogina JC mining area in 1999, and revised in 2003. The revised plan was accepted by the Department of Environment[26] in March 2005. The plan was developed in consultation with Government agencies, and included the following agreed closure objectives:

- **maintain water quality** within limits suitable for stock watering downstream (as measured at Waterloo Bore)
- **limit the extent and intensity of drawdown impacts** on creek and phreatophytic vegetation to within 1 to 2 km of the mine pits, and
- **limit the potential for saline development** of in-pit water to <15,000 mg/L.

The agreed closure strategy involved backfilling mine pits to an average height of 490 mRL. This strategy was affirmed when approvals to mine the JSE deposit were being sought.

The *Decommissioning and Rehabilitation Plan* has been progressively updated by RTIO as the Yandicoogina operations have evolved, and was resubmitted to the OEPA in January 2011, in accordance with Ministerial Statement 695. This plan recognises the need for a life of mine approach to closure planning at Yandicoogina, and addresses closure issues across existing (JC and JSE), proposed (JSW and Oxbow) and projected future mining projects (Billiard) in the same palaeochannel.

[26] Now the Department of Environment and Conservation (DEC)

The current closure plan identifies that the closure strategy previously agreed with Government in 2005 is not suitable for meeting the closure objectives across the greater Yandicoogina mining area, for the following reasons:

- The strategies developed in the *Decommissioning and Rehabilitation Plan 2003* were based on old hydrogeological models that have now been superseded (refer to Section 3.11). The current hydrogeological model suggests that alternative strategies for protecting hydrological and ecosystem functions post-mining are warranted.
- The post-mining landform configuration under the *Decommissioning and Rehabilitation Plan 2003* was envisaged to consist of a series of voids of varying depths intersected by creeklines in several locations. It is unlikely that engineering a landform of this type is possible, particularly one that meets stability expectations across the overall life of mine (LoM) of the Hamersley Yandicoogina operations. There is a high risk that creeklines would collapse into the voids during the first period of heavy rainfall, causing adverse environmental outcomes.
- The volume of backfill material required to create the final LoM landform would greatly exceed the volume of mining waste available. Recent estimates indicate that the additional backfill volumes required would require almost all elevated land within Mining Lease ML274SA to be removed. This would have significant environmental and cultural consequences that are potentially avoidable with alternative closure strategies. Potential impacts include:
    - loss of hillside ecosystems that would otherwise be unaffected by the mining operation
    - changes to surface drainage patterns, with potentially significant implications for local and regional hydrology
    - additional disturbance of places of cultural significance, such as rock shelters
    - additional greenhouse gas emissions associated with the excavation and transport of substantial volumes of backfill material.

Given these findings, an updated set of closure objectives has been proposed (Table 7-10). Based on these objectives, the following conceptual closure options have been identified for more detailed evaluation (Appendix A15) and are further discussed in Section 7.8.4:

- Option 1: Retain Junction Central and Oxbow pit voids
- Option 2: Create a ‘channel’ landform
- Option 3: Backfill to ground level.

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Table 7-10 – Proposed Hamersley Yandicoogina operations closure objectives

No.	Objective
1	Working with Indigenous communities and other stakeholders to preserve, protect and manage the cultural heritage values of the area
2	Considering the implications of closure on local communities when developing and implementing closure strategies
3	Negotiating completion criteria with Government stakeholders, and working towards achieving those goals
4	Returning the area to landforms that are safe, stable and compatible with the surrounding environment
5	Working towards achieving environmental outcomes that are compatible with the surrounding environment
6	Working with employees and stakeholders to identify and manage ongoing employment and other opportunities
7	Achieve closure objectives in a cost effective manner
8	The water in any pit voids should be able to support natural ecosystems
9	Environmental values of Fortescue Marsh should not be compromised
10	Closure strategies should be complimentary to those employed at the BHPBIO Yandi mine
11	Final landforms should be designed and constructed so as to withstand erosive forces associated with floodwaters

7.8.3. Potential impacts

Mining and establishing associated infrastructure will result in the loss of vegetation and habitat, disturb soil profiles, landforms and drainage features, and lower the water table. Given the relatively low quantities of overburden and waste material, insufficient waste will be generated to completely backfill the JSW and Oxbow pits, unless additional materials are externally sourced. The approach taken for mine closure and rehabilitation will affect the degree to which environmental values associated with each of these factors are preserved or reinstated post-mining.

The impacts created by the project will be in addition to those from the existing JC and JSE operations. Landforms and landscape processes (eg hydrological processes associated with Marillana Creek) are integrated across the overall Hamersley Yandicoogina operations. The way the overall mine plan is implemented (eg timing and sequence of mining) will influence the feasibility of options for reconstructing the landscape post-mining. Closure planning needs to be integrated across the overall Hamersley Yandicoogina operations and interface closely with the ongoing mine planning process.

7.8.3.1. Post-mining land use

The values and constraints of the surrounding physical and biological environment need to be considered when selecting appropriate land use options for the project area post-mining. Heritage requirements and agreements with native title claimants, and other socio-economic aspects of the project must also be taken into account.

When mining concludes, RTIO anticipates that the project area could be used for pastoral livestock production or conservation purposes. This will be contingent on management decisions made by the pastoral lease holder (BHPBIO). These or other land use activities would be compromised if:

- post-mining landforms are unstable and/or unsafe for access by humans, livestock and native fauna
- post-mining surface water drainage systems interfere with area accessibility and vegetation re-establishment, and
- the native vegetation is not adequately rehabilitated.

7.8.3.2. Groundwater and surface water

Dewatering, mining and surface water diversion associated with the project will affect:

- the integrity and functional behaviour of the CID aquifer, including throughflow and water quality
- surface flow regimes including flow paths, flow volumes, flooding extent and erosion processes, and
- modified water availability for riparian, aquatic and subterranean ecosystems, as a consequence of the above.

Groundwater modelling studies indicate that aquifer recharge and throughflow are important processes for maintaining water quality (principally low salinity) in the Yandicoogina locality. The choice of post-closure landform will strongly influence the way surface and groundwater inputs are redistributed within, and released from, the project area. This in turn will influence aquifer water quality and riparian environments within the project area and to some extent, downstream. There is a risk that inappropriate landform design could result in aquifer salinisation and ecosystem degradation.

7.8.3.3. Vegetation

Areas subject to ground disturbance will be revegetated post-mining, using locally occurring native species. The design of the final landform will influence its suitability for establishing vegetation and its long term persistence. Key factors include:

- **providing stable landforms** with infiltration and runoff characteristics that support vegetation being established and ongoing ecological functioning. In particular, growth, reproduction and vegetation succession
- **soil profiles with adequate water holding capacity** and physiochemical characteristics to enable plant root system development and access to water and nutrients
- **minimising exposure to conditions hostile to vegetation**, for example extremes of soil pH and exposure to toxic metal ions.

Inappropriate landform construction may affect the rehabilitated area’s ability to support native vegetation and meet revegetation completion criteria. Poorly designed and/or poorly implemented revegetation could also result in suboptimal vegetation reestablishment, including enhancing undesirable weed species. Topsoil handling and storage practices are important for maintaining seed viability and enhancing rehabilitation success.

7.8.3.4. Terrestrial fauna

The final landform will be gradually recolonised by native fauna. The ability of fauna to use the area will be influenced by landform components and configurations, with some species being favoured and others disadvantaged. Inappropriately constructed habitat could lead to poor habitat use or favour undesirable species, such as feral animals.

7.8.3.5. Subterranean fauna

Mining activities will result in the removal of subterranean habitat. The design of the post-mining landform will influence the amount of habitat retained in the project area, for the persistence of stygofauna assemblages post-mining. Factors that could detract from reinstating suitable habitat (Appendix A8) include:

- lack of void spaces due to incorrect substrate backfill
- lack of void space within the alluvials due to silt and sediment runoff from surrounding habitat
- the production of standing water which can stagnate or become saline
- nutrient enrichment from the surface, reducing water quality due to lack of buffering vegetation, and
- changes in hydrology throughout the system.

7.8.3.6. Aboriginal heritage

The post-mining landform will affect the accessibility of heritage sites and the ability of the Traditional Owners to use the project area for cultural and amenity purposes. These uses require safe and stable landforms that are suitably integrated with the wider landscape and environment.

7.8.4. Management measures

A mine closure approach will be adopted that includes the following elements:

- **ongoing updating and refining** of the Yandicoogina *Decommissioning and Rehabilitation Plan* in accordance with Ministerial Statements 523 and 695. This plan applies to the overall Yandicoogina operations and will take into account new knowledge, including the revised conceptual hydrogeological model. The plan will continue to be reviewed on a five yearly basis
- **a detailed closure study**, scheduled for completion by early 2012, addressing conceptual closure options identified in the current closure plan
- **targeted studies and investigations** assessing the technical and economic feasibility of conceptual mine closure options
- developing a final ***Decommissioning and Rehabilitation Plan*** approximately 5 years prior to mine closure.

All of these activities will occur within the closure planning framework applied to the overall Hamersley Yandicoogina operations.

7.8.4.1. Decommissioning and Rehabilitation Plan

Rio Tinto has a standard protocol for developing conceptual closure studies, which applies to the company's mining operations globally. Conceptual closure studies are prepared when a site has not yet started operating, or if a site is more than 30 years from closure. These are strategic documents, which provide the framework for more detailed planning to occur progressively over a project's operational life. The RTIO conceptual closure planning process is described in Figure 7-4.

The current *Decommissioning and Rehabilitation Plan* (Appendix A15) includes the conceptual closure study for the Hamersley Yandicoogina operations. This plan addresses closure requirements for the JC, JSE, JSW and Oxbow iron ore mines. A summary of the major components of the plan is provided in Table 7-11. More details on decommissioning, decontamination and rehabilitation addressed by the updated plan, include:

7.8.4.2. Decommissioning measures

Pilbara Iron will maintain a detailed inventory of project facilities requiring decommissioning (decommissioning units) during the life of the project. This will provide the basis for tracking decommissioning requirements and scheduling decommissioning activities.

The general aims for infrastructure decommissioning include:

- **demolition/removal of all above ground structures**. Structures more than 1 m below final ground level may be left *in situ* if they pose no long term threat to the environment
- **removal/burial of all concrete slabs**, footings and retaining walls
- **removal of services**, including water lines, power lines and communications, unless approved for further use. Services more than 1 m below final ground level may be left *in situ* if they pose no long term threat to the environment
- **removal of all culverts**, including those along rail corridor, to reinstate natural drainage contours or, where required, integrate into final landform design
- **permanently capping bores** no longer required and removal of all associated infrastructure. Piping greater than 1 m deep to remain *in situ*
- **draining of ponds** and removal and disposal of any liners
- **removal of all services and infrastructure** associated with the wastewater treatment plants, rail line and rail loop, including rails, sleepers, ballast and signalling equipment
- **removal of decking and piers of the bridges**, if the bridges require removal. Steelwork and other re-usable items will be salvaged
- **removal of all bitumen surfaces** within the site. The main access road up to the main gate will remain
- **removal and dismantling of decontaminated storage tanks**
- **initial and ongoing mine planning** to ensure location and design of infrastructure, including camps, dewatering infrastructure and processing facilities, minimise potential post-closure impacts.

Decommissioning requirements for the project area will depend on the final intended land use and agreed mine closure objectives. Some infrastructure components, such as sealed roads and rail lines, may be retained to assist future developments in the vicinity of the project area, provided relevant stakeholders agree.

7.8.4.3. Decontamination measures

Any areas of contaminated land within the project area will be identified, remediated and managed by RTIO leading up to and/or following mine closure, in accordance with the *RTIO Contaminated Sites Management Plan*. Land will be left in a condition that does not present a risk for the identified future land use.

Pilbara Iron maintains a contaminated sites register for the existing operations at Yandicoogina, in accordance with the requirements of the *Contaminated Sites Act 2003*. This register will be expanded to include project operations, where required. The register will be maintained throughout the life of the project. It will be used to help develop the final *Decommissioning and Rehabilitation Plan* so that any contaminated sites can be identified and cleaned up.

The remediation of contaminated areas will typically occur during project operations; however, depending on the nature and location of the contamination, this may not be possible in all cases.

7.8.4.4. Rehabilitation measures

Rehabilitation will be implemented progressively over the life of the project. The rehabilitation approach will be consistent with RTIO standards and protocols and addresses the following items:

- **Recovery and stockpiling of cleared vegetation and topsoil** before mining, to be used later on rehabilitation areas. Careful management of topsoil and reuse of vegetative material is an important factor in successful rehabilitation, particularly in arid environments such as the Pilbara. Topsoil is valuable as it has a high nutrient content and contains most of the viable seed and vegetative material relative to other sections of the soil profile. It typically has a higher water holding capacity, suitable structural properties and, contains mycorrhizal fungi that facilitate plant growth.
- **Constructing stable landforms**. Design elements will be included to prevent surface subsidence and protect against erosion under long term project climatic conditions.
- **Re-spreading topsoil** and deep ripping of soil surfaces.
- **Progressive seeding** using appropriate seed sources to maintain the genetic integrity of local vegetation. A species list will be included in the site rehabilitation plan, which will be continuously refined based on rehabilitation monitoring results and stakeholder consultation. Particular species suited to specific rehabilitation landforms, for example rocky slopes, flat plains and low lying areas, may be targeted.
- **Monitoring how well plants are being established.** Developing ecosystem processes that are consistent with the anticipated end land use and can be compared with existing vegetation at adjacent controlled sites. Monitoring is necessary to clearly demonstrate successful closure has been achieved, or to provide an early indication of when problems may arise and intervention is required. In many cases, post-closure monitoring will be a continuation of monitoring programs established during operations, appropriately adjusted to reflect the closed status of the mines. Specific closure measures and schedules will be determined during the development of the monitoring plan. Monitoring activities are expected to include:
    - landform stability and erosion monitoring on reconstructed landforms examining surface drainage patterns, erosion gullying, rilling, loss of surface material and factors affecting surface stability and revegetation

   - revegetation monitoring measuring specific parameters to gauge success of re-establishing plants, compared with natural analogue sites, and identifying required remedial actions to establish sustainable native vegetation communities, and

- monitoring surface and groundwater and measuring against closure targets and predicted changes.

The rehabilitation measures will be reviewed regularly based on knowledge obtained from trials, operational experience in the Pilbara region, performance of completed rehabilitation activities and site-specific information on material characterisation and performance.

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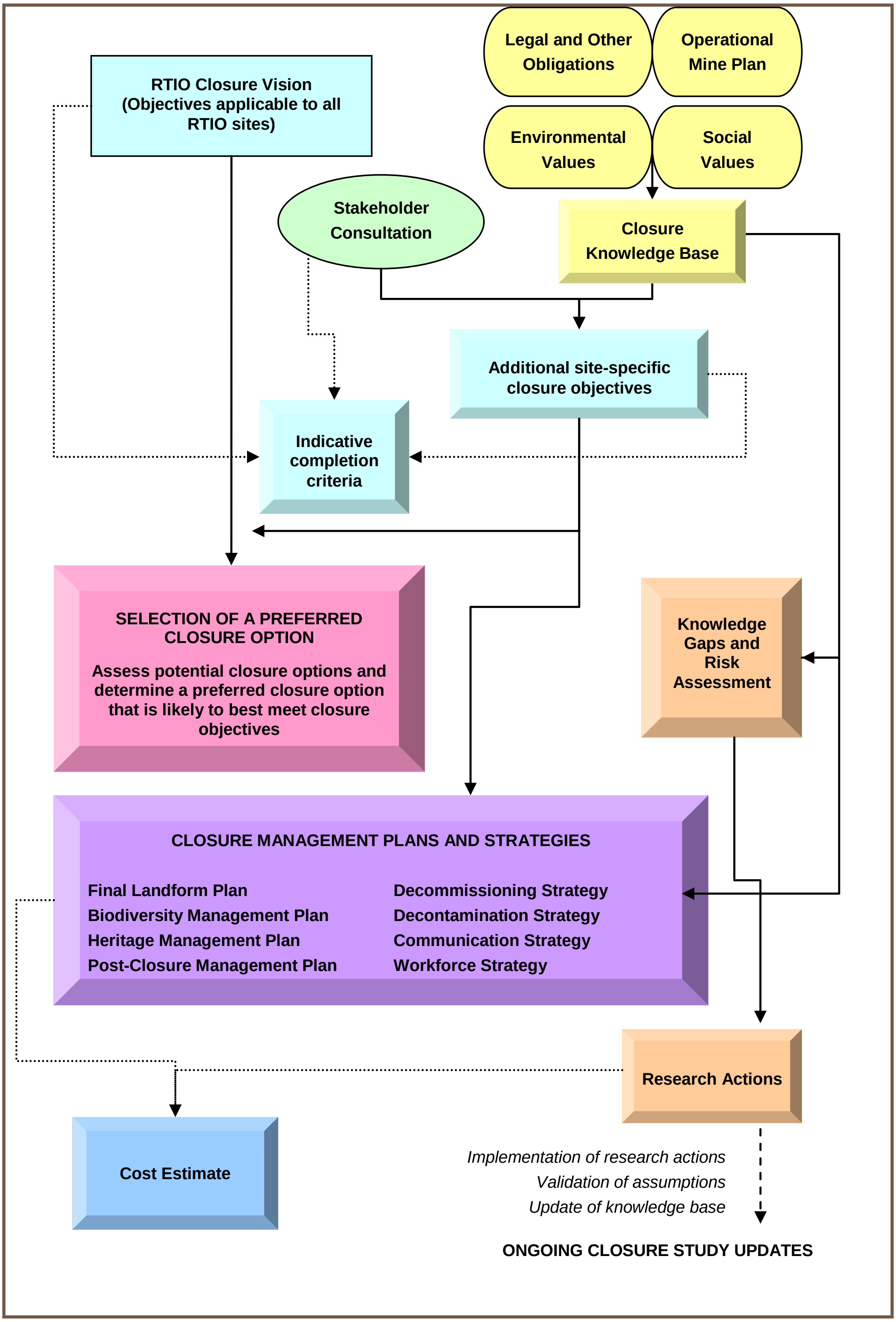

Figure 7-4 – Conceptual closure planning process flowchart

7.8.4.5. High level options assessment

The current *Decommissioning and Rehabilitation Plan* (Appendix A15) has identified the following conceptual final landform options for further assessment:

Option 1: Retaining Junction Central and Oxbow pit voids

This option involves no backfilling in the JC and Oxbow pits, and backfilling the remaining pits to ground level. Preliminary estimates suggest that sufficient mineral waste will be generated by the overall operations, so that no additional backfill material will need to be sourced from adjacent (non-mining) areas. Other opportunities include using the JC void for the storage and the controlled release of surplus water volumes from mine pit dewatering, and logistical efficiency due to the Oxbow pit being the final pit in the currently projected mining sequence.

Option 2: Creating a 'Channel' landform, by reinstating the CID orebody zone as the primary flow path for Marillana Creek

This option involves excavating material between individual pits so that they form one continuous pit ('channel') from Oxbow in the west, to Billiard North in the east. Backfill material would then be used to landscape the channel so that it is narrower and shallower than the original void, with gentler slopes. A void would be retained to below water table level, and standing water would be present near the terminus of Marillana Creek post-closure. This configuration was assessed because:

- the final landform could be constructed using only waste material, avoiding the need to quarry additional backfill material
- natural flushing of the channel could be expected during periods of heavy rainfall, minimising the potential for pit water salinisation
- the orebody represents the ancient watercourse flow path and reinstituting a channel in such an alignment would be similar to an historic local landscape - notwithstanding that the configuration is a big departure from the current landscape
- generating a permanent surface water body creates the potential for biodiversity enhancement, and
- the connection of mine pits to create a channel may enable additional ore to be accessed, providing revenue to help underwrite closure costs.

Option 2 has been identified as the preferred option for the following reasons (Appendix A15):

- it provides greater opportunity for biodiversity enhancement compared with other options due to the creation of a permanent water source, and retention of elevated areas
- whilst local flow will be radically altered (the creeklines will be moved), it is the option considered most likely to lead to positive regional water flow outcomes, and
- there is potential to offset closure costs with additional revenue generated from the mining of additional ore.

Option 3: Backfilling to ground level, with extensive quarrying of surrounding hills

This option involves a technically simpler and lower risk final landform. However, it requires extensive, additional ground disturbance and would substantially modify the surrounding landscape, including interrupting natural surface water flows into Marillana and Weeli Wolli Creeks. Backfilling to ground level requires a significant volume of quarried backfill material, including the surrounding hills, than the previously approved partial backfill strategy, and would create a significant disturbance footprint.

Other options

Other options, or combinations of options, may still be considered, pending the findings of more detailed feasibility assessments of the aforementioned options. Note that the additional options of 'do nothing' and 'backfilling to ~490 mRL' were also assessed, but were not considered to be viable.

7.8.4.6. Additional studies and investigations

Key closure related issues requiring more detailed investigation include the maintenance of water quality in the long term, functionality of the Marillana Creek, and final landform stability (given the high water flows associated with cyclonic events). A range of studies and investigations are required to address these issues and enable the development of more detailed closure designs. These include:

- **mine planning and scheduling**, to ensure that the development of final landform configurations can be achieved without compromising ongoing production volumes and grades
- **more detailed technical, economic and environmental assessment** of selected closure options, for example addressing landform reconstruction and rehabilitation methods. In the case of the preferred 'channel' landform option, the design of flow maintenance structures (including materials requirements) is a priority for further evaluation in the near term. Physical attributes of the waste material (eg stability and erodibility) are also being investigated
- **developing closure groundwater and surface water models** to support options assessment and landform design options. Groundwater modelling to date indicates that aquifer recharge and throughflow are important processes for maintaining water quality (principally low salinity) in the Yandicoogina locality. Consideration of the project area water balance and dynamic flooding cycles will be essential components of the final landform design process
- **heritage surveys within the potential span of closure activities**, with ongoing consultation with heritage stakeholders, to identify cultural heritage implications, and
- **consulting with BHPBIO** to determine compatibility with closure strategies at the adjacent, and upstream BHPBIO Yandi mine. The need for an integrated approach for mine closure in the Marillana Creek system is recognised.

A program of studies and investigations addressing these items has been initiated by RTIO. Additional details are provided in Appendix A15.

7.8.4.7. *Final Decommissioning and Rehabilitation Plan*

Closure planning is a dynamic process. Regular reviews and development are required throughout the life of the operation, taking into account changes in legal obligations, corporate requirements, community expectations and changes in technical knowledge. The updated *Yandicoogina Decommissioning and Rehabilitation Plan* will be an evolving document, responding to interim project outcomes and subject to periodic internal and external review. Consultation with regulatory agencies and other stakeholders will be an important part of this process.

The *Yandicoogina Decommissioning and Rehabilitation Plan* will be finalised at least five years before planned mine closure. This plan will include comprehensive closure completion criteria and a monitoring program so progress towards achieving goals is assessed. A 'walk away' solution for the decommissioned mine site will be included. The plan will address:

- finalisation of appropriate closure completion criteria
- management of long term hydrogeological and hydrological impacts of mining the CID
- modelling the long term hydrogeological impacts, using a landscape water balance approach
- progressive rehabilitation of all disturbed areas to a standard suitable for the agreed end land use(s), incorporating:
    - the characteristics of the pre-mining ecosystems within the project area (through research and baseline surveys)
    - the performance of previously rehabilitated areas within the mining lease
    - the performance of rehabilitation areas at Hamersley Iron's other operations in the Pilbara
    - best practice rehabilitation techniques used elsewhere in the mining industry.
- monitoring rehabilitation to assess the performance of all rehabilitated areas against the completion criteria
- reporting the rehabilitation and monitoring results
- removal of all infrastructure, unless otherwise agreed with the State government, and
- management strategies and/or contingency measures to manage any significant environment impact as a result of the implemented closure strategy.

7.8.5. Predicted outcome

RTIO has established policies and standards addressing mine closure, encapsulated in the company *Closure Standard*. A conceptual closure plan for the integrated Hamersley Yandicoogina operations has been completed (Appendix A15). Three conceptual closure options have been identified, with the 'channel' landform preferred based on current assessments. A program of studies and investigations has been initiated by RTIO to evaluate these options in more detail. These will inform a detailed closure study scheduled to be completed by early 2012.

The current *Decommissioning and Rehabilitation Plan* for the Hamersley Yandicoogina operations will be progressively developed over the life of the project in consultation with regulatory agencies and other stakeholders. This plan will be finalised at least five years before planned mine closure.

The systematic and inclusive process adopted by RTIO for mine closure will ensure that the EPA objectives for project closure will be met when mining operations conclude.

Table 7-11 – Major components of the current *Yandicoogina Decommissioning and Rehabilitation Plan*

Component	Description
Closure vision	The closure vision at Yandicoogina is to: • minimise the company's post-closure impact on the natural environment by returning the land to a state compatible with regional ethnographic and ecological values, and preserving local biodiversity • remediate the area to end-states that are safe and stable • work with Indigenous and non-Indigenous communities and other stakeholders towards a stable future for the region, independent of Rio Tinto's active management, activities and involvement, that contributes to a stable community consistent with the majority of the stakeholders' expectations • work with Indigenous communities towards preserving, protecting and managing the region's cultural heritage • facilitate the post-operational option that is negotiated with stakeholders, which reflects the management capacity of State and Local government • work with employees to identify and manage opportunities from the ceasing operations and closure.
Closure knowledge base	The knowledge base addresses: • the current operations and surrounding land use • assessment of legal obligations • the background environment • social aspects including matters relating to Aboriginal stakeholders.
Stakeholder consultation	The plan provides the basis for ongoing consultation with government and community stakeholders to continually assess post-closure land use objectives and expectations.
Closure objectives	A revised set of closure objectives has been developed (refer to Table 7-10).
Assessment of closure options	The following closure options have been identified for more detailed evaluation: • Option 1: Retaining Junction Central and Oxbow pit voids • Option 2: Creating of a 'channel' landform • Option 3: Backfilling to ground level. Option 2 is currently the preferred option for meeting the revised closure objectives. A program of studies and investigations has been initiated by RTIO to evaluate all of the options in more detail; which will inform a detailed closure study scheduled to be completed by early 2012.
Final landform plan	Describes how RTIO intends to achieve the conceptual final landform configuration, by addressing the following factors: • constructing post-mining landforms in accordance with RTIO standards and protocols (RTIO Landform Design Guidelines, SCARD Management Plan and Rehabilitation Handbook) • proposed additional final landform studies • progressive rehabilitation.
Biodiversity management plan	Describes how RTIO intends to achieve positive biodiversity outcomes upon closure, by addressing the following factors: • protecting the Fortescue Marsh • protecting rare flora and fauna • protecting stygofauna • revegetating, including managing topsoil, seeds and water quality.

Component	Description
Cultural heritage management plan	Describes objectives and targets for heritage management, management strategies, and accountabilities for heritage management.
Monitoring	The monitoring program will be finalised during development of a final *Decommissioning and Rehabilitation Plan* as the site approaches closure. This program could be expected to include the following components: • erosion monitoring • vegetation monitoring • fauna surveys (terrestrial, subterranean and aquatic) • water quality monitoring • contaminated sites assessment • ecology function study • hydrology/hydrogeology study • heritage surveys.
Indicative completion criteria	Draft generic completion criteria are still in the development phase. RTIO expects to commence stakeholder consultation on these in 2011, with site specific indicative completion criteria to follow.
Research actions	A consolidated list of proposed research actions to support mine closure is provided, including an indicative implementation schedule.
Risk assessment	Critical risks associated with mine closure at Yandicoogina include: • currently unidentified heritage issues • developing saline pit lakes • issues associated with integrating closure planning and future development approvals • issues relating to formulating new mine closure strategies, which supersede strategies previously approved by government
Cost estimation	A description of the general process used to develop the closure cost estimate. Note that closure cost assumptions and calculations are contained in separate commercial-in-confidence reports.

7.9. Other factors

Some environmental factors were identified in the project *Environmental Scoping Document* as requiring a less detailed assessment than other factors. These include:

- waste
- dust
- noise and vibration
- hazardous materials
- visual amenity.

These factors are either subject to controls under other legislation, existing environmental management procedures associated with current Yandicoogina operations, or have low level of applicability to the project.

7.9.1. Waste

7.9.1.1. Management objective

The EPA applies the following broad management objectives for waste management:

Maintain the integrity, ecological function and values of the environment

Ensure that emissions do not adversely affect the health, welfare and amenity of people and land uses.

7.9.1.2. Background

The EPA recommends that wastes are managed according to the following hierarchy of preference (EPA 2004a):

1. avoidance
2. reuse
3. recycling
4. recovery of energy
5. treatment
6. containment
7. disposal.

Waste management is controlled through licence conditions and addressed provisions contained in the *Yandicoogina Operations EMP*. These have been reviewed and revised, where relevant, to incorporate waste management for this project:

- *Yandicoogina Waste Management Plan*
- *RTIO Waste Management Treatment, Storage and Disposal Guidelines* – which outlines the relevant disposal procedures, accountabilities and contacts as part of the Hamersley Iron Environmental Management System (EMS)
- *Rio Tinto Environmental Standard: Non Mineral Waste Management* – which addresses minimising waste generation and the safe handling, treatment and disposal of all generated wastes at Rio Tinto sites
- *Rio Tinto Environmental Standard: Mineral Waste Management* – which addresses environmentally safe and effective management of mining and process wastes generated or handled at Rio Tinto sites.

7.9.1.3. Impacts and management

Wastes generated by project activities will be similar in composition to those already generated at the existing JC and JSE operations. The project will result in increased volumes of the following waste types:

- mineral waste, predominantly overburden material including clays, alluvium and weathered channel horizon, and CID fines from the wet processing facility at JC
- domestic solid and liquid wastes
- food scraps from the accommodation village and construction camp
- scrap metal and drums
- rubber products, such as conveyor belt sections, tyres

- batteries
- waste oils and lubricants
- wash down water
- residue from wet processing, if required.

Existing systems servicing the JC and JSE operations will be used for collecting and recycling a number of waste streams including: hydrocarbon wastes (oil, drums, rags, filters etc), tyres, batteries, scrap metal, printer cartridges, paper and cardboard, conveyor belting and computing equipment. Recycling of village accommodation wastes including cans, bottles, paper, cardboard and plastic will also be continued. This latter initiative was awarded the 2009 Golden Gecko excellence award in environmental management.

The licensed landfill facility servicing the JC and JSE operations will be used for the disposal of putrescibles and inert materials, such as household waste, non recyclable cardboard, furniture, fill, and demolition material. Hazardous waste types will be collected and sent off-site for treatment by licensed contractors.

Domestic sewage is currently handled through licensed sewage treatment plants servicing the existing mine sites and accommodation village. Any new sewage treatment facilities required in the future will be appropriately licensed under the EP Act (if treating volumes greater than 10 $m^{3/}$day).

Additional details on waste management measures are included in the *Yandicoogina Waste Management Plan* (Appendix B). Related waste management measures will be included in the project CEMP.

7.9.1.4. Geochemistry of mineral waste rock

Asbestiform minerals

The asbestiform mineral Crocidolite (blue asbestos) is known to sometimes occur in the Weeli Wolli Banded Iron Formation, and has historically been detected in the hills to the north of the existing Yandicoogina operations. Exploration and resource drilling in and near the JSW and Oxbow deposits has not intercepted any fibrous mineral. The CID formation is considered to have a low risk of containing such material. This is due in part to its absence from the existing JC and JSE orebodies, and also because silicate minerals are replaced by goethite during the mineralisation process. However, in the event that fibrous material is intercepted, Pilbara Iron will manage the material according to internal plans and industry requirements and guidelines.

Construction activities within the rail loop and the proposed overland conveyor are likely to encounter existing operations fibrous waste storage, and potentially cut through formations known to host fibrous minerals.

Any fibrous waste encountered during mining of the JSW and Oxbow area will be disposed of at the existing on-site facilities, in accordance with the current Yandicoogina Fibrous Mineral protocols and procedures.

Acid Rock Drainage

An assessment of acid rock drainage (ARD) at the JSW and Oxbow deposits was undertaken by RTIO in 2007. The deposits were assessed to have a low risk of ARD, based on geochemical interpretation and analytical testing of drillhole samples.

In line with the *Rio Tinto Mineral Waste Management* standard, sampling was designed to provide adequate spatial and volumetric representation to span geological variability within and adjacent to the orebodies. All tested samples from the JSW and Oxbow deposits returned total sulfur values less than 0.1%. This finding is consistent with historical assessments undertaken by RTIO at the JC and JSE deposits.

Leachates

Mineral waste (overburden) and ore from all lithologies at JSW and Oxbow have been geochemically characterised, in line with the *RTIO Mineral Waste Management Plan*. More than 27,000 samples from across the deposits were assessed:

- determination of chemical enrichment relative to median crustal abundance, based on the Geochemical Abundance Index (GAI)[27], for the following elements: Al, As, Ba, Ca, Cl, Co, Cr, Cu, Fe, Pb, Mg, Mn, Ni, P, K, S, Si, Na, Sn, Sr, Ti, V, Zn and Zr. An element is considered enriched when the GAI > 3.
- preliminary assessment of element mobility, based on liquid extracts (1 part solid: 2 parts deionised water).

The materials contained in the JSW and Oxbow deposits consist predominantly of iron oxides, silica and alumina. Other elements that can be enriched include arsenic and tin. A detailed geochemical risk assessment for the project was completed using data within the drillhole database, in accordance with RTIO protocols. Groundwater contamination with arsenic is considered to be unlikely, based on historical groundwater assessments at the Hamersley Yandicoogina operations and experience from similar deposits in the Pilbara. Tin is similarly unlikely to mobilise into the groundwater and cause any environmental concern.

Selenium, a non-metallic chalcogen, has also been identified by the EPA as an element of concern in some Pilbara iron ore lithologies. Compared with background materials, selenium does not occur at elevated concentrations in the JSW and Oxbow deposits. Gardiner (2003) reported dissolved selenium concentrations of up to 2.94 µg/L in pre-mining groundwater measurements within the Yandicoogina CID aquifer. These concentrations are below the ANZECC/ARMCANZ Guidelines (ANZECC/ARMCANZ 2000) for selenium trigger levels in freshwater aquatic ecosystems (trigger value <5 µg/L for protection of 99% of species).

Iron mineralogies are often associated with low mobility of metalliferous and other elements. Iron oxy-hydroxides have high sorption capacities for arsenic and selenium (Zhang *et al.* 2004; Rovira *et al.* 2008), and consequently these materials have been used around the world for treating water enriched in these elements (via adsorption to the hydrated iron hydroxide surface).

The overall risk posed by selenium release to the surface environment from mineral wastes is likely to be negligible. The oxidation state of the iron-rich lithologies would prevent major chemical change from mining and storage activities (Watkins 2011).

RTIO is undertaking additional physical characterisation of Yandicoogina waste materials in association with mine closure planning. This includes leaching and erodibility tests for representative waste types. This first phase of this work is scheduled to be completed by late 2012. The results of this test work will inform ongoing mine closure planning at the Yandicoogina operations.

[27] The GAI relates the actual concentration with median crustal abundance on an adjusted log 2 scale (Bowen, 1979)

7.9.1.5. Predicted outcome

Mineral waste

The project will increase the volume of wastes generated by the entire Yandicoogina operation. The composition of the wastes will be similar to the existing operations and JC and JSE. The proposed mine pits does not contain significant amounts of asbestiform minerals or potential acid forming materials. The geochemical characteristics of the mineral waste do not predispose this material to the formation of metallic leachate contaminants.

The following management measures will be used to address the risk of environmental contamination from mineral waste during the implementation of the project:

- implementing the *Yandicoogina Waste Management Plan*
- ongoing surface water and groundwater monitoring to detect any increase in concentrations of metalliferous contaminants
- adhering to the *RTIO Mineral Waste Management Plan*
- adhering to the *Yandicoogina Fibrous Mineral* protocols and procedures.

Implementing these measures should ensure that the EPA objectives for waste management are fulfilled.

Non mineral waste

Non mineral waste will be subject to the provisions of the *Yandicoogina Waste Management Plan*. Existing licensed landfill and sewage treatment facilities will be used to treat and dispose of non mineral wastes. If required, any new or expanded facilities will be appropriately licensed under Part V of the EP Act.

Implementing these measures should ensure that the EPA objectives for waste management are fulfilled.

7.9.2. Dust

7.9.2.1. Management objective

The EPA applies the following management objective for managing air quality, including dust emissions:

To ensure that emissions to air do not adversely affect environmental values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.

7.9.2.2. Background

Dust is generated by mechanical disturbances such as blasting, vegetation clearing, earthmoving and road traffic on unsealed surfaces. Dust may also be generated through transport and handling of ore and waste, including during processing and rail transport. In dry, windy conditions, particles can lift from open or disturbed areas, resulting in visible dust emissions. In the assessment of environmental impacts, dust is more conventionally referred to as ‘particulates’ or ‘airborne particulates’.

The generation of dust from the project depends on:

- the frequency at which a dust generating activity takes place
- meteorological conditions, such as wind speed
- moisture content of the dust source
- composition of dust, including particle size distribution, particle density
- the condition of the dust source.

7.9.2.3. Impacts and management

Background dust levels at Yandicoogina are high relative to urban areas in the south west of Western Australia. Located in an arid region, dust lift off occurs from sparsely vegetated landscapes.

Dust is not a significant environmental issue at the existing JC and JSE operations owing to the remote location of the site, and absence of sensitive environmental receptors. At the JC and JSE operations, the principal risks of dust and the drivers for dust control are safety and health for the workforce.

Aspects of the project that may potentially result in generating dust/particulates impacts include:

- physical disturbance of the land surface during construction of infrastructure and mining (removal of vegetation, blasting, excavations)
- primary and secondary crushing of ore
- haulage and light traffic on unsealed roads
- conveying and transfer of ore, and
- blasting.

The Pilbara Iron Yandicoogina operation is required to be consistent with *Rio Tinto Environmental Standard: Air Quality Control;* which provides a systematic process for identifying and minimising air pollutant emissions and their potential impacts. In accordance with this standard, generating dust within the project area will be controlled by implementing the following management measures:

- **using equipment enclosures, water sprays and dust extraction** at the crushing, stockyard and rail loadout facilities
- **using equipment enclosures**, and dust extraction at the dry screening facility
- **clearing work areas only as they are required**
- **minimising exposed surfaces** by progressively rehabilitating disturbed areas no longer in use
- **applying water sprays to reduce dust** and maintaining ore moisture content when mining ore above water table
- **applying water**, or appropriate suppressants to haul roads, working surfaces and stockpiles as required. Recycled water may be used, where appropriate
- **operating scrapers** to remove excess material from plant conveyor belts
- **implementing speed limits** to minimise dust being generation from roads
- **scheduling blasting activities to coincide with favourable weather** conditions, wherever possible, and
- **sealing selected high usage roads,** such as access roads, servicing mining operations.

These measures will be included in the project CEMP and the *Yandicoogina Emissions Management Plan* (Appendix B). In addition, the *Cleaner Air Management Plan (CAMP)* has been developed to provide a consistent approach for managing dust generated by Rio Tinto Iron Ore (WA) Operations. The aim is to achieve the Cleaner Air Program Objective to:

Control dust and manage risks relating to health, safety, environment, community, financial impacts as well as the legislative requirements and government relations.

Potential dust emissions from processing facilities may be subject to controls imposed through an environmental licence required for such prescribed premises, in accordance with Part V of the EP Act.

7.9.2.4. Predicted outcome

Existing RTIO procedures and practices used at Yandicoogina are effective in preventing significant dust emissions. The proposed operations at JSW and Oxbow will be subject to these procedures and practices.

7.9.3. Noise and vibration

7.9.3.1. Management objective

The EPA applies the following management objective related to noise:

To protect the amenity of nearby residents from noise impacts resulting from the activities associated with the proposal by ensuring the noise levels meet statutory requirements and acceptable standards.

7.9.3.2. Background

Unmanaged noise and vibration emissions from mining activities can cause a nuisance to nearby residents and mine workers. The current Yandicoogina operations at JC and JSE are subject to the *Environmental Protection (Noise) Regulations 1997*, environmental licence conditions and relevant health and safety regulations.

7.9.3.3. Impacts and management

The main components of the project that generate noise will include blasting and excavation at the new mine pits, ore processing and vehicle and rail movements. The main source of ground vibration from the project will be associated with blasting.

The proposed JSW and Oxbow operations are remote from most significant noise-sensitive receptors, with the exception of the BHPBIO Marillana construction camp (~500 m). This camp is currently unoccupied. Consultation with BHPBIO is ongoing about the intent to mine JSW and the potential noise and vibration impacts.

The following noise mitigation measures should help further reduce the potential for noise impacts:

- using ‘smart’ reversing alarms
- selecting and locating conveyor start-up alarms so that they reduce noise impacts, and
- restricting blasting to daylight hours.

These measures will be included in the *CEMP* and *Yandicoogina Emissions Management Plan* (Appendix B).

7.9.3.4. Predicted outcome

Existing RTIO procedures and practices used at Yandicoogina are effective in preventing significant noise and vibration related impacts. The proposed operations at JSW and Oxbow will be subject to these procedures and practices.

7.9.4. Hazardous materials

7.9.4.1. Management objective

The EPA applies the following broad management objectives to waste management. They also apply to hazardous waste management:

Maintain the integrity, ecological function and values of the environment

Ensure that emissions do not adversely affect the health, welfare and amenity of people and land uses.

7.9.4.2. Background

Hazardous materials include substances which, by their characteristics, pose a threat or risk to public health, safety or the environment. Examples of hazardous characteristics include toxicity, infectious agents, carcinogenic, explosive, flammable and/or corrosive.

Hazardous substances used at mining operations in Western Australia are regulated under the *Mines Safety and Inspection Amendment Regulations 2009*. Many hazardous substances are also classified as dangerous goods, which are subject to the *Dangerous Goods Safety Act 2004* and subsidiary legislation.

Hazardous waste generally needs to be disposed of at specialist hazardous waste treatment centres which are licensed under the EP Act.

7.9.4.3. Impacts and management

Hazardous substances will be managed in accordance with the Yandicoogina Hydrocarbon Sites Management Plan and Yandicoogina Contaminated Sites Management Plan.

A range of hazardous materials are required for the operation of the JSW and Oxbow operations, including hydrocarbons and explosives. A lubricant and fuelling facility will be constructed adjacent to the JSW and Oxbow mine pits, similar to JSE mine with two large (110,000 L) diesel tanks, two oil tanks (10 kL each) and a waste oil storage tank (10 kL). The diesel tanks will be connected to the Yandicoogina JC fuel facility by an above ground pipeline which will cross the Yandicoogina Creek, or will be imported with trucks.

Bunding for hydrocarbon storage areas will be constructed in accordance with relevant Australian standards. Runoff from areas that may be contaminated with hydrocarbons will not enter natural drainage channels without prior treatment.

The existing licensed explosive storage facilities for the JC operation will be used to store explosive required for the JSW and Oxbow mining operations.

7.9.4.4. Predicted outcome

The hazardous materials storage, management and disposal procedures and practices used at the existing Yandicoogina operations will also service the proposed JSW and Oxbow mining operations. Legislation and regulations governing hazardous materials and dangerous goods will be adhered to during the life of the project.

7.9.5. Visual amenity

7.9.5.1. Background

The EPA applies the following management objective to visual amenity:

To ensure that aesthetic values are considered and measures are adopted to reduce visual impacts on the landscape as low as reasonably practicable

7.9.5.2. Impacts and management

The proposal area is distant from major population centres, communities, significant tourist attractions or public access routes. The project will augment existing mining operations and use existing processing and ore transport infrastructure. Implementing the project will not result in a significant change to visual amenity as the area.

However, maintaining aesthetic values is an important consideration for mine closure. Creating suitable final landforms and maintaining ecological water requirements for vegetation are key factors. Additional information on mine closure requirements is contained in Section 7.8.

7.9.5.3. Predicted outcome

Visual amenity will be considered as part of developing the mine closure plan.

8. Environmental management framework and commitments

8.1. Overview

Hamersley is a member of the Rio Tinto Group, which has extensive experience in managing the development, operation and environmental compliance of iron ore mining projects similar to this proposal. This experience, along with stakeholder consultation, has been used to define the potential environmental impacts from this project, and the proposed mitigation and management measures. Stakeholders who have been engaged include government agencies, non-government organisations and Traditional Owners. A systematic process has been adopted, which improves the likelihood that all significant environmental impacts have been identified, investigated and mitigated, as far as practicable. As a result, there is greater certainty in achieving desirable environmental outcomes.

Hamersley will manage environmental impacts through:

- **complying** with proposed environmental approval conditions
- **maintaining** an Environmental Management System (EMS) and business systems
- **preparing and implementing** a *Construction Environmental Management Plan* (CEMP) and updating the existing *Yandicoogina Operations Environmental Management Plan* (Operational EMP) for the project (Appendix B)
- **regularly reviewing** the performance of the EMS, CEMP, Operational EMP and management plans that address specific environmental factors
- **measuring** energy use and greenhouse gas emissions, and continually seeking opportunities to reduce emissions
- **improving** the efficiency of using natural resources
- **continually updating** plans for ground disturbance and closure, progressively rehabilitating disturbed land and measuring success
- **training** staff and contractors in environmental requirements and considerations of their work
- **seeking** stakeholder views and ensuring they are respected and considered
- **reporting regularly** to stakeholders on performance, and
- **aligning** with the Rio Tinto Iron Ore Health, Safety, Environment and Quality Policy (HSEQ Policy).

8.2. Environmental policy

The Rio Tinto Group aims to conduct business in an efficient and environmentally responsible manner that meets the expectations of shareholders, regulatory authorities and the community. The Rio Tinto Group also recognises that environmental responsibilities go beyond those required under statutory regulations and include social obligations, leadership in sustainable development and minimising environmental impacts.

Hamersley will operate under *Rio Tinto's Iron Ore Health, Safety, Environment and Quality Policy* (HSEQ Policy) which was signed in July 2009 by the company's executive management (Appendix A16). The HSEQ Policy is the guiding document for environmental management and provides context and direction for continuous improvement. The HSEQ Policy states that all members of Rio Tinto's Iron Ore group will:

- relentlessly work towards achieving our **goal of zero harm** while preventing property damage, process loss and business interruption
- strive for consistency in **product quality**
- demand **visible leadership**, with clear accountabilities, that encourages effective employee, contractor and supplier participation to achieve our goals and recognise the business value of good HSEQ performance
- **strengthen the capability** of employees and contractors to recognise and control the potential impact of their activities
- build from **a foundation of compliance** with applicable laws, Rio Tinto Standards and Policies, and our HSEQ Management System, including our voluntary commitments
- implement systems to **identify, control and monitor HSEQ risks** in development, construction and operational areas
- ensure our **risk-based objectives, targets and actions are set**, reviewed and integrated into business planning and decision-making processes
- **provide and develop adequate resources** and expertise to manage our HSEQ performance
- closely **monitor market and customer needs** to identify and act upon opportunities for improvement and to satisfy customer requirements
- strive to implement the best available practices and technology to **deliver HSEQ excellence**, minimise impacts to land, make a positive contribution to biodiversity and improve our efficiency in water and energy use
- be **active contributors to the climate change solution** and ensure the effective implementation of our climate change work programs
- ensure service and technical support to our suppliers and customers is **responsive, fair, courteous and timely**
- **positively contribute to local communities** in the areas of health, safety and environment to provide a lasting benefit, and
- **report regularly** to all stakeholders on our performance and seek their feedback.

8.3. Environmental management system

Rio Tinto Iron Ore operates under an EMS, based on the globally recognised International Organisation for Standardisation (ISO) 14001 framework. ISO14001 is a continuous improvement model, which includes the following key elements:

- systematic assessment of environmental risk and legal requirements
- systematic development of objectives and targets for improvement
- training
- operational control
- communication

- emergency response
- corrective actions, and
- audits and review.

All existing iron ore operations managed by the Rio Tinto were certified to ISO14001 in 2003 and recertified in 2006, after successfully demonstrating commitment to continual improvement. Operations are subject to regular external independent surveillance audits.

The project will be operated in accordance with the updated Yandicoogina Operations EMP (Appendix B), implemented under the EMS and certified to ISO14001.

8.4. Sustainability

The project will be undertaken in accordance with the *Rio Tinto Iron Ore Sustainable Development Principles*, to assist in achieving sustainable development outcomes. These principles are consistent with the intent of the WA State Sustainability Strategy and the Rio Tinto *'The Way We Work'* statement of business practice.

Policies detailed in *'The Way We Work'* state that Rio Tinto businesses, projects, operations and products should contribute constructively to the global transition to sustainable development. This will be achieved by helping satisfy global and community needs and aspirations, whether economic, social or environmental. Sustainable development considerations have been made an integral part of business planning, decision-making processes and operations.

The Rio Tinto Iron Ore Sustainable Development Principles guiding principles include:

8.4.1. Environmental

- Optimise management of water resources
- Minimise disturbance of land and water bodies
- Minimise harm to flora, fauna and ecosystems
- Minimise dust and greenhouse gas emissions.

8.4.2. Social

- Health and safety as a priority
- Equal employment opportunities
- Community relations and support
- Respect for heritage.

8.4.3. Economic

- Optimise long term economic value.

8.5. Summary of likely environmental control instruments

Hamersley has identified the regulatory controls that will ensure that environmental values are protected during project implementation (Table 8-1).

The key controls include, but are not limited to:

- environmental conditions in any Statement issued by the Minister for the Environment allowing the project to be implemented
- conditions of DEC Vegetation Clearing Permits
- conditions of DEC Works Approval(s) (under Part V of the EP Act) for construction of works on prescribed premises (ore processing, landfill and sewage facility)
- conditions of DEC Licence(s) (under Part V of the EP Act) for the operation of activities on prescribed premises (mine dewatering and discharge of excess water, ore processing, landfill, sewage facility), and
- conditions of the Licences and Permits for activities relating to the abstraction of groundwater and disturbance to river bed and banks (under the RIWI Act).

As part of the project, management controls will be implemented to ensure key environmental factors are managed as per this Environmental Review. Other relevant measures and/or actions are also contained within the following documents:

- Construction Environmental Management Plan (CEMP)
- Yandicoogina Operational Environmental Management Plan (EMP) (Appendix B)
- Yandicoogina Closure Study report (Appendix A15).

8.5.1. Project design and feasibility assessment

From the initial stages of planning and design, Hamersley is committed to proactive management and initiatives to reduce the environmental footprint of the project. Minimising the project footprint will ensure there are minor, insignificant changes to the exact location of infrastructure. Any vegetation clearing will be managed so that the extent of direct disturbance is minimised, as much as possible. As well as benefiting the environment, this approach also minimises economic costs at the start, during operation and at closure.

The costs of environmental management, including rehabilitation and closure costs, have been accounted for in the feasibility assessment of the project. This ensures that Hamersley can commit to undertaking the required environmental remediation and rehabilitation works to return the affected land to an agreed land use, once mining operations are completed.

Table 8-1 – Statutory and environmental management controls for the Yandicoogina JSW and Oxbow Iron Ore Project

Factor	Topic	Proposed Statement Conditions	CEMP/ Operational EMP	Works Approval (Part V EP Act)	Other legislation and regulations
Key environmental factors					
Groundwater	Extent of groundwater drawdown	✓	✓		✓
	Groundwater quality		✓	✓	
Surface water	Discharge of surplus water	✓	✓	✓	
	Surface water quality	✓	✓	✓	
	Realignment of low flow line in Marillana Creek	✓	✓		✓
Vegetation and flora	Extent of clearing	✓	✓		
	DRF		✓		✓
	Weeds		✓		✓
	Fire		✓		✓
Terrestrial fauna	Habitat removal /impact		✓		
	SRES/Priority Fauna		✓		✓
	Feral animals		✓		✓
Subterranean fauna	Groundwater drawdown		✓		
	Direct habitat removal		✓		
Aboriginal heritage	Heritage sites		✓		✓
Greenhouse gases			✓		✓
Closure	Closure, decommissioning and rehabilitation	✓	✓		✓
Other environmental factors					
Noise and vibration			✓	✓	
Dust			✓	✓	
Waste			✓	✓	✓

8.5.2. Construction Environmental Management Plan

During the construction phase, the environmental aspects of the project will be managed in accordance with a *Construction Environmental Management Plan* (CEMP). The CEMP will provide the framework for ensuring that the project complies with environmental obligations, including internal objectives, legislation, regulations, and relevant project approval conditions.

8.5.3. Operational Environmental Management Plan

Environmental impacts from operating the proposed mines will be managed through the *Yandicoogina EMP* (Appendix B). The Operational EMP will provide the framework for ensuring that the project complies with environmental obligations, including internal objectives, legislation, regulations, and relevant project approval conditions.

The EMP will be subject to a process of regular review and revision, where appropriate.

8.5.4. Closure planning

Potential long term/permanent impacts of the project will be avoided, minimised and mitigated by implementing design initiatives, the EMP, and at closure, the *Decommissioning and Rehabilitation Plan*. This plan will be an evolving document, developed in close consultation with regulatory agencies and other stakeholders, over the life of the project. A final *Decommissioning and Rehabilitation Plan* will be developed at least five years before mine closure, and will be designed to meet EPA objectives and provide a 'walk away' closure solution.

8.6. Reporting

The environmental performance of the project from commencement to closure will be documented in annual environmental reports, as required. Regular closure and rehabilitation assessment reports will also be completed.

8.7. Proposed environmental conditions

The project will be implemented so that the resulting environmental effects will be as anticipated and described in the Environmental Review document.

The environmental footprint of the project, as described in Table 2-2 is anticipated to form the basis of Schedule 1 of any Statement issued by the Minister for the Environment. Hamersley Iron has developed 'Proposed Environmental Conditions' for consideration by the Minister to be incorporated into any Statement issued (Table 8-2).Hamersley has also developed environmental trigger values for managing the discharge of excess water, for possible inclusion in Schedule 2 of any Statement issued by the Minister (Table 8-3). The proposed project environmental conditions have been designed to complement other regulatory controls that are likely to be applied under legislation (refer to Table 8-3). Conditions for managing specific environmental factors have not been proposed if the environmental impact can, or is, adequately addressed by other environmental control instruments (Section 7), including the Yandicoogina EMP (Appendix B).

The proposed project environmental conditions are outcome-based and suitable for internal and external auditing.

Table 8-2 – Proposed environmental conditions for the Yandicoogina JSW and Oxbow Iron Ore Project

Condition No.	Proposed Condition
Proposal implementation	
1-1	The Proponent shall implement the Proposal subject to the conditions of this statement and within the footprint defined in Schedule 1 of this statement.
Proponent nomination and contact details	
2-1	The Proponent, nominated by the Minister for the Environment under section 38(6) or 38(7) of the *Environmental Protection Act 1986* (WA), is responsible for the implementation of the Proposal.
2-2	The Proponent shall notify the Chief Executive Officer (CEO) of the Department of Environment and Conservation (DEC) of any change of the name and address of the Proponent for the serving of notices or other correspondence within 30 days of such change.
Time limit of authorisation	
3-1	The authorisation to implement the Proposal provided for in this statement shall lapse and be void within five years after the date of this statement if the Proposal to which this statement relates is not substantially commenced.
3-2	The Proponent shall provide the CEO of the DEC with written evidence which demonstrates that the Proposal has substantially commenced, on or before the expiration of five years from the date of this statement.
Compliance and performance review, monitoring and reporting	
4-1	The Proponent shall submit to the CEO of the DEC, a Performance Review Program at least 12 months prior to the first Performance Review Program report required by Condition 4-2. The Performance Review Program shall include: • a definition of the intent and the scope of the monitoring program • specification of the compliance requirements of the Proposal • specification of the parameters to be measured and appropriate units • an outline of monitoring methods including specification of the frequency of the monitoring, and • an outline of the recording and reporting requirements including details of the Annual Environmental Report described in Condition 4-2. The program will be updated as required to account for changes in monitoring requirements throughout the Proposal, including those following the implementation of the *Decommissioning and Rehabilitation Management Plan* as described in Condition 8-1 to 8-4. Significant changes to the program shall be reported to the CEO of the DEC in the Annual Environment Report as required in Condition 4-2.
4-2	At the conclusion of the first year following the commencement of construction, and on an annual basis thereafter, the Proponent shall submit to the CEO of the DEC, an Annual Environmental Report to report on the performance of the Proposal in accordance with the Performance Review Program as described in Condition 4-1. The Annual Environmental Report shall address: • an outline of the status of the Proposal • calibration requirements and records and assumptions made • monitoring results • details of any instances of non-compliance or exceeding targets and the measures taken to avoid recurrence • trends in monitoring results • achievement (or otherwise) of outcomes predicted in the PER, the success (or otherwise) of mitigation measures in achieving these outcomes • proposed or implemented changes to mitigation measures to ensure desired outcomes are achieved, and • progress, results and modification to the Performance Review Program.

Condition No.	Proposed Condition
4-3	The Proponent shall inform the CEO of the DEC of any instances of non-compliance as soon as practicable.
Diversion of minor creeks	
5-1	The proponent shall implement the project to ensure that diverted flows are managed to ensure that diverted flows associated with minor creeks are directed into Marillana Creek • designed to prevent erosion and related disturbance to Marillana Creek • minimise impacts to riparian vegetation • maintain water quality to ANZECC guidelines (based on natural background water quality).
Re-alignment of the low flow channel in Marillana Creek at JSW	
6-1	The realignment of the low-flow line in Marillana Creek shall meet final design criteria, based on a calibrated hydraulic model for the system, which will include: • minimum 150 m base width high flow channel • maintenance of low flow channel • inclusion of velocity control features • channel embankments built for minimum 1 in 100 year ARI flood event • provision for flood levees to prevent diversion of water from Marillana Creek into mine voids for flood events exceeding the 1 in 100 year flows.
Discharge of excess water to watercourses	
7-1	The Proponent shall implement the Proposal so that the extent of surface water or sub-surface flows from discharge of excess water alone does not enter Fortescue Marsh.
7-2	If any Level 1 discharge impact trigger criterion prescribed in Schedule 2 is exceeded, the Proponent shall: 1. Investigate cause to determine if the trigger was met as a result of discharge of excess water. 2. Undertake appropriate remedial action as required. 3. Investigate whether there is a need to implement alternative discharge management options to avoid a Level 2 trigger being exceeded and prepare for this possibility. 4. Review and revise discharge procedures as per adaptive surface water management plan as required.
7-3	If any Level 2 discharge impact trigger criterion prescribed in Schedule 2 are exceeded, the Proponent shall: 1. Notify the CEO of DEC immediately. 2. Investigate cause(s) and assess residual risk to creekline ecology (and if relevant, that of the Fortescue Marsh). 4. Develop and implement course of action to best mitigate impact as required which may include increasing channel stability and vegetation cover (eg revegetation, fencing). 5. Provide the CEO of DEC with details of mitigation and management being undertaken and details of residual risk. 6. Revise procedures as required to prevent recurrence.
Rehabilitation and Closure	
8-1	The Proponent shall submit a Progressive Rehabilitation Schedule to the CEO of the DEC, prepared in consultation with the Department of Environment and Conservation within twelve months of the commencement of mining and at five yearly intervals thereafter. The rehabilitation schedule shall address: • the sequence and timing for areas to be rehabilitated • conceptual rehabilitation objectives and targets for each area, and • Review and revision of the current decommissioning and rehabilitation plan for the existing

Condition No.	Proposed Condition
	Yandicoogina operations to incorporate JSW and Oxbow mines.
8-2	The Proponent shall conduct rehabilitation progressively as areas become available, in accordance with the rehabilitation schedule required by Condition 8-1.
8-3	The Proponent shall monitor the performance of rehabilitation against rehabilitation targets required by Condition 8-1, based on annual monitoring and report results in the Annual Environmental Report, as required by Condition 4-2.
8-4	A final Closure Plan will be developed in consultation with key stakeholders and submitted to the CEO of the DEC at least two years before the planned date of closure. The Closure Plan shall address: • a review and revision of the current decommissioning and rehabilitation plan to incorporate the JSW and Oxbow mines into an overall closure planning framework for the overall Yandicoogina operations • detailed measures to be implemented as part of closure • the schedule and timing of closure activities • agreed completion criteria for closure • closure monitoring requirements, and • management measures to facilitate closure.

Table 8-3 – Proposed Schedule 2: Management criteria for discharge to creek systems

Level	Trigger
1	Extent of permanent surface water flow exceeds that predicted in modelling by greater than 10% (with the exception of flow events from seasonal rainfall events) Or Water quality parameters of discharge do not meet ANZECC water quality criteria, taking into consideration natural background water quality and environmental values of the receiving environment Or Loss of 25% foliage cover not explainable by natural events and not seen at the reference site(s)
2	Discharge is resulting in erosion and altered geomorphology where changes to beds and banks is determined to be affecting creekline vegetation and ecology Or Loss of 40% foliage cover not explainable by natural events and not seen at the reference site(s)

9. Conclusion

This Environmental Review document provides:

- a description of the key components of the project
- a summary of the important physical, biological and social factors of the existing environment
- a discussion of the extent of community and government stakeholder consultation
- an evaluation of potential impacts of the project on environmental factors, and
- strategies and measures to ensure environmental factors and values are protected and managed to an appropriate level, in accordance with industry best practice.

9.1. Residual environmental impacts

The project is anticipated to result in the following environmental impacts once mitigation and management measures are applied:

- progressive removal of up to 2,200 ha of native vegetation and terrestrial fauna habitat over the life of the project. Based on extensive surveys, **all vegetation communities and habitat types within the project area are widespread and well represented regionally**. Unavoidable disturbance to some areas of locally significant riparian vegetation along Marillana Creek will occur. Minimal flora with conservation significance occurs in the project area, and where individual plants are identified, they will be avoided wherever possible.
- unavoidable loss of individual animals due to mining related disturbance, potentially causing reductions in local populations of some species. However, **larger scale impacts to species populations are highly unlikely** due to the wide distribution of affected species and habitat types beyond the project disturbance area. **Terrestrial fauna with elevated conservation significance are highly unlikely to be affected -** the project area does not include significant populations of these species and is not an important habitat for them.
- groundwater drawdown for mine pit dewatering resulting in unavoidable loss of subterranean habitat in the mine pits, and temporary modification to adjacent habitat areas. However, based on extensive surveys for subterranean fauna across the Yandicoogina site, the project is **not expected to affect the persistence of subterranean fauna assemblages**.
- modification of a section of Marillana Creek near the JSW deposits due to installing flood protection structures, a creek crossing and dewatering effects on riparian vegetation. The terminus of Phil's Creek near the western margin of the existing JC pit will need to be diverted and reinstated. **A range of measures will be used to minimise disruption to the flow regime** of Marillana Creek and maintain downstream water quality. The ecological values of the affected creek sections will be re-established as far as practicable using a habitat reconstruction approach, post-mining.

- up to 16 GL/yr of additional water will be discharged to Marillana Creek from mine dewatering operations at JSW and Oxbow, in addition to existing discharge volumes within the catchment. This may contribute to changes in riparian vegetation, including stress and/or loss of riparian vegetation and changes in composition. Stream aquatic habitat/fauna populations in the lower reaches of Marillana Creek and in a 10 km to 17 km section of Weeli Wolli Creek downstream of the Marillana Creek confluence may also be affected. However, when discharge ceases, the **creekline system would be expected to recover** and gradually return to a condition more closely resembling the pre-discharge condition.
- drawdown of groundwater by ~60 m in the orebody aquifers at JSW and Oxbow. The adjacent alluvial aquifer system will also be affected by the groundwater cone of depression, to a distance of ~2 km down gradient of the JSW pit boundary and ~1.5 km up gradient of the Oxbow pit boundary. At each location, **groundwater levels in the orebody aquifers are likely to recover** to their original level, post-mining.
- a post-mining landscape characterised by **stabilised landforms, rehabilitated vegetation and a flow regime in Marillana Creek which protects downstream water quality**. The current *Decommissioning and Rehabilitation Plan* provides the framework for progressively more detailed planning to occur over the project's operational life. A final *Decommissioning and Rehabilitation Plan* will be developed at least five years before planned mine closure.
- greenhouse gas emissions from the overall Yandicoogina operations in the order of **100,000 tonnes $CO_{2\ equiv.}$ /yr averaged over the life of the project**. An evaluation of energy management and energy efficiency initiatives at the Yandicoogina operations has been implemented by RTIO, in accordance with the Commonwealth *Energy Efficiency Opportunities Act 2006*. The outcomes of this evaluation will be extended to the project.

9.2. Environmental management framework

The project will be subject to the *Rio Tinto Iron Ore Health, Safety, Environment and Quality Policy* (Appendix A16). The proposed mines will be operated under the company ISO14001 accredited *Environmental Management System* (EMS), consistent with the management of the exiting Yandicoogina operations. The key elements of the EMS include:

- assessing environmental risk and legal requirements
- developing objectives and targets for improvement, training, operational control, communication, emergency response, corrective actions, audits and review
- implementation and operational procedures for environmental protection, and
- measuring and evaluating environmental performance.

To ensure that environmental impacts are minimised during the construction phase, a *Construction Environmental Management Plan* will be developed before mine development starts.

As a component of developing the project, the existing *Yandicoogina Environmental Management Program* (EMP) was reviewed and updated to span all (existing and proposed) Pilbara Iron mining operations at Yandicoogina. The updated EMP consists of a series of targeted environmental management plans (Appendix B). These will be subject to a process of ongoing review and revision, to ensure that environmental values are protected over the life of the project.

9.3. Environmental costs and benefits

The JSW and Oxbow deposits are in close proximity to existing mine infrastructure, including ore processing plants and rail load facilities at JC. These deposits provide the most suitable option for sustaining production at Yandicoogina over the next 10 to 15 years.

9.4. Project environmental acceptability

Hamersley has undertaken a comprehensive assessment of potential environmental impacts associated with implementing the project. A range of mitigation and management strategies have been developed to ensure that unacceptable impacts will be avoided and EPA environmental protection objectives are met. Hamersley has undertaken extensive consultation with regulatory agencies and other stakeholders to develop these strategies and will continue to do so during the assessment process. This approach builds on existing systems used successfully for the current Yandicoogina operations.

On the basis of the findings of the Environmental Review, the project is considered to be environmentally acceptable if implemented in accordance with the proposed and existing management measures.

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11. Glossary

Term	Definition
Abstraction/dewatering	Removal of groundwater from aquifer system
Alluvial	Materials transported and deposited by the action of rivers or streams, in recent geological times
Aquifer	A permeable rock formation which stores and transmits groundwater
Asbestiform	Having a fibre-like crystal form similar to that of asbestos minerals eg chrysolite or crocidolite
Banded Iron Formation	Tabular rock body usually consisting of alternating bands of quartz and iron rich minerals
Borefield	Series of holes that are drilled into an aquifer for the purpose of withdrawing water
Bund	An earth, rock or concrete wall constructed to prevent the inflow or outflow of liquids
Catchment	Surface area from which runoff flows to a river or any other collecting reservoir
Confluence	Joining of two or more drainage systems
Copepod	Any small aquatic crustacean of the Class Copepoda
Cut-to-fill	Where material from cuts is used in areas needing fill – resulting in flat terrain for infrastructure
Dendritic	Type of drainage pattern which has fanning-out appearance
Ephemeral	Water course that flows on only a few occasions in a year
Detrital	Material derived from the weathering of pre-existing rocks
Fines	That portion of iron ore product that is sized less than 6 mm
Goethite	An iron mineral consisting of oxides and hydroxides or iron
Hydrogeology	The geology of groundwater
Hydraulic gradient	Slope of the water table over distance. Change is static head per unit of distance in a given direction
Hyporheic zone	A transitional ecological zone between the surface stream and groundwater
Impermeable	Material that does not allow a particular substance to pass through it
Lump	That portion of iron ore product that is sized greater than 6 mm
Mineralisation	The outcome of the introduction of valuable elements into rock material
Overburden	Soil and rock overlying a mineral deposit that must be removed before the deposit can be mined
Palaeochannel	Ancient and currently inactive river channel systems that have been filled by younger sediments
Permeability	The extent to which fluids can pass through rock

Term	Definition
Potable water	Fresh and marginal water generally considered suitable for human consumption
Putrescible	Waste material that has potential to rot, such as food matter
Recharge	The process where water penetrates soil to a temporary or permanently saturated zone
Regolith	A widespread layer of soil, weathered materials and transported sediments above fresh bedrock
Riverine	Habitat around large drainage lines
Stratigraphic	Formation, composition and occurrence of stratified rocks
Storativity	Volume of water an aquifer can release from or takes into storage per unit surface area
Stripping ratio	The ratio of overburden to ore mined
Stygofauna	Invertebrates (mostly) that are adapted to inhabiting subterranean aquatic environments
Syncline	A large scale geological fold structure where the centre of the fold is lower than the exposed eroded edges
Tailings	Material remaining after the processing of ground/crushed ore
Through-flow	Amount of water that passes through a given area
Thrust	A reverse fault of low angle, with older strata displaced horizontally over newer
Transmissivity	Rate of water can be transmitted through material
Void	An open structure or pit that remains after ore has been removed by mining
Water table	Top surface of the groundwater, whether above or below ground level
Xeromorphic	Plant structural adaptations for survival in dry conditions

12. Acronyms

Term	Definition
ANZECC	Australian and New Zealand Environment and Conservation Council
ARI	Annual Recurrence Interval
ARMCANZ	Agricultural and Resource Management Council of Australia and New Zealand
BCC	Basal Conglomerate
BHPBIO	BHP Billiton Iron Ore
BIF	Banded Iron Formation
CAMBA	China-Australia Migratory Bird Agreements
CAMP	Cleaner Air Management Plan
CEO	Chief Executive Officer
CEMP	Construction Environmental Management Plan
CID	Channel Iron Deposit
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMP	Closure Management Plan
CR	Critically Endangered
DAFWA	Western Australian Department of Agriculture and Food
DCCEE	Department of Climate Change and Energy Efficiency
DEC	Department of Environment and Conservation
DIA	Department of Indigenous Affairs
DO	Discharge Outlet
DoW	Department of Water
DMP	Department of Mines and Petroleum
DRET	Department of Resources, Energy and Tourism
DRF	Declared Rare Flora
DSEWPC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities
ECC	Eastern Clay Conglomerate
EEO Act	Commonwealth Energy Efficiency Opportunities Act 2006
EMP	Environmental Management Program
EMS	Environmental Management System
EN	Endangered

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Term	Definition
EPA	Environmental Protection Authority
EP Act	Environmental Protection Act 1986
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPS	Environmental Protection Statement
ERMP	Environmental Review and Management Program
ESD	Environmental Scoping Document
FNARH	First National Assessment of River Health
FOI Act	Freedom of Information Act 1992
GAC	Gumala Aboriginal Corporation
GHG	Greenhouse Gas
GWOS	Yandicoogina Groundwater Operating Strategy
GVL	Goethite Vitreous Lower
GVU	Goethite Vitreous Upper
HD1	Hope Downs 1
HI	Hamersley Iron
IBRA	Interim Biogeographic Regionalisation for Australia
IOH	Iron Ore Holdings
ISO	International Organisation for Standardisation
JAMBA	Japan-Australia) Migratory Bird Agreements
JC	Junction Central
JSE	Junction South East
JSW	Junction South West
LAT	Laterite
LGC	Limonite Goethite Channel
LoM	Life of Mine
NGERS Act	National Greenhouse and Energy Reporting Act 2007
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
NWI	National Water Initiative
OEPA	Office of the Environmental Protection Authority
PCD	Plant Cell Density
PEC	Priority Ecological Community
PER	Public Environmental Review
PD	Presumed Totally Destroyed
PUEA	Proposal Unlikely to be Environmentally Acceptable

Term	Definition
RIWI Act	Rights in Water and Irrigation Act 1914
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreements
ROM	Run of Mine
RTIO	Rio Tinto Iron Ore
SRE	Short Range Endemic
TDS	Total Dissolved Solids
TEC	Threatened Ecological Community
TRH	Total Recoverable Solids
TSS	Total Suspended Solids
YLUA	Yandicoogina Land Use Agreement
UWA	University of Western Australia
VCL	Vacant Crown Land
VU	Vulnerable
WCH	Weathered Channel
WRC	Water and Rivers Commission

13. Appendices

The following appendices are provided electronically on the CD accompanying this report:

Appendix A1	Vegetation and Flora Surveys of the Oxbow and Junction South West Deposits, near Yandicoogina (including 2011 addendum)
Appendix A2	Yandicoogina Additional Vegetation Mapping
Appendix A3	Yandicoogina Junction South West and Oxbow Fauna Survey
Appendix A4	Yandicoogina Targeted Northern Quoll Survey
Appendix A5	Yandicoogina Expansion Northern Quoll Position Paper
Appendix A6	Cumulative Impacts of RTIO Mining on the Weeli Wolli Creek System – Dry 08 and Wet 09 Sampling Final Report
Appendix A7	Yandicoogina: JSW and Oxbow Mine Development – Aquatic Management Final Report
Appendix A8	Yandicoogina Subterranean Fauna Assessment Phases 1 to 5, including Yandicoogina Stygofauna Assessment: 2010 Addendum
Appendix A9	Marillana Creek Regional Flow Balance and Catchment Hydrology
Appendix A10	Review of RTIO Surplus Water Discharge Model
Appendix A11	Yandicoogina Hydrogeological Field Program Report - Bore Installation, Test Pumping 2008/09
Appendix A12	Yandicoogina 2010 Regional Groundwater Modelling Report
Appendix A13	Yandicoogina Water Balance; Pre and Post-mining Hydraulics and Hydrochemistry
Appendix A14	Yandicoogina Model Review
Appendix A15	Yandicoogina Closure Study Report
Appendix A16	Rio Tinto Iron Ore Health, Safety, Environment and Quality Policy
Appendix B	Yandicoogina Iron Ore Operations Environmental Management Program
Appendix C	Yandicoogina JSW and Oxbow Iron Ore Project Environmental Scoping Document
Appendix D	Yandicoogina Extended Vegetation Codes and descriptions
Appendix E	RTIO disclaimer/waiver for PER appendices