AUSTRALIAN ZIRCONIA LTD

(A wholly owned subsidiary of Alkane Resources Ltd)

Dubbo Zirconia Project

Aquatic Ecology Assessment

Prepared by

Alison Hunt & Associates

September 2013

Specialist Consultant Studies Compendium
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Aquatic Ecology Assessment

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RW CORKERY & CO. PTY. LIMITED

AUSTRALIAN ZIRCONIA LTD

Dubbo Zirconia Project

Aquatic Ecology

Final

September 2013

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TERRESTRIAL | MARINE | AQUATIC

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SUMMARY

Alison Hunt & Associates Pty Ltd was commissioned by RW Corkery & Co Pty Limited, on behalf of Australian Zirconia Limited (AZL), to undertake an assessment of aquatic ecology for the proposed development of the Dubbo Zirconia Project (DZP), which would be located at Toongi, approximately 25 km south of Dubbo in Central West NSW. The DZP has been deemed to be a State Significant Development (SSD) in accordance with Schedule 1(5) of the *State Environmental Planning Policy (SEPP) State and Regional Development* and requires the preparation of an Environmental Impact Statement (EIS) to accompany an application made under Part 4 Division 4.1 of the NSW *Environmental Planning & Assessment Act 1979* (EP&A Act). The DZP was deemed a Controlled Action under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on the basis of potential impacts on threatened terrestrial species (4 January 2013). To meet the requirements for assessment as SSD, the potential impacts of the proposed DZP on aquatic ecology have been considered within the framework for assessment under Part 4 Division 4.1 of the EP&A Act, NSW *Fisheries Management Act 1993* (FM Act), NSW *Threatened Species Conservation Act 1995* (TSC Act) and the Commonwealth EPBC Act.

The area of investigation for this assessment, focusses on the DZP Site and potentially affected aquatic environments is located within the Dubbo City local government area in Central West NSW, approximately 25 km south of Dubbo and to the east of Obley Road, Toongi. It falls within the Central West Catchment Management Area and includes the Castlereagh, Bogan and Macquarie River valleys. The DZP Site is located within the *Slopes Zone* of the Macquarie River valley, downstream of the Burrendong Dam and upstream of Dubbo. Major tributaries of the Macquarie River within the area include Little River (which receives flow from a minor first order stream known as Cockabroo Creek) and Wambangalang Creek (which receives flow from Paddys Creek and Meadows Creek within the affected catchment).

The DZP would comprise a small scale open cut mine supplying approximately 1 million tonne (Mt) of ore containing rare metals (zirconium and niobium) and rare earth elements to a processing plant annually (19.5 Mt of ore over a period of up to 20 years). The proposal also incorporates an upgrade and reactivation of the Toongi to Dubbo Section of the Dubbo-Molong Rail Line. AZL also proposes to construct a pipeline to deliver compressed natural gas from the Central West Pipeline within the Toongi-Dubbo Rail Line and Natural Gas Pipeline Corridor; construction of a water pipeline to deliver up to 4.05 gigalitres of water from the Macquarie River to the processing plant, and upgrades of the public road network.

Methods

Aquatic ecology investigations included a review of available literature and databases to assist with the identification of the aquatic ecological values of the DZP site and locality; a scoping assessment (7 - 8 February 2012) to allow development of a detailed methodology; field surveys (19 – 23 February 2012) to ascertain the current condition and the presence or likely presence of threatened or protected species within the DZP Site and study area; an impact assessment to determine the likely effects of the proposal on the aquatic ecology of the site with particular reference to threatened species, populations and / or ecological communities; and preparation of recommendations to ameliorate and mitigate impacts which may be associated with the construction and operation of the DZP.

Existing Aquatic Environment

The DZP Site is set within an agricultural landscape that has been altered and farmed for over 150 years. Native vegetation has been cleared with pockets of woodland remaining in non-arable areas. Groundcover is dominated by agricultural grasses and other weeds and crops. Bare soil is common in cropping areas and areas where erosion has removed topsoil. Sheep, cattle and horses are grazed within the area. Macrophytes are largely absent across the DZP Site and study area with only small occurrences of such species as Common Reed (*Phragmites australis*) and *Juncus usitatus*. As a consequence of the alteration of the landscape, there have been substantial changes to the catchments and waterways.

A series of minor watercourses radiate out from the high point of the DZP Site near the ore body and all watercourses within the DZP Site drain to the Macquarie River via three catchments, Wambangalang Creek, Cockabroo Creek and Watercourse A catchments. All of the watercourses across the DZP Site, study area and locality have been substantially altered and are suffering impacts due to upstream and adjacent land use practices including roads, clearing, weed invasion, alteration of flows, cropping, erosion, sedimentation and salinisation. Modified Riparian, Channel and Environmental Inventory (RCE) scores reflected the general low to moderate health of these waterways. Groundwater investigations concluded that the creek systems to the west and south of the DZP Site rely on groundwater discharge to support their ecosystems, but there are no other known groundwater dependant ecosystems within the groundwater flow system associated with the DZP Site.

Water quality in the study area was poor with conductivity being above (1,501 - 4,500 µS/cm) *Australian and New Zealand Environment and Conservation Council* (ANZECC 2000) trigger values (350 µS/cm) at the majority of sites. Levels of dissolved oxygen were also below acceptable levels at 50% of sites and pH was marginally outside acceptable norms at 30% of sites.

Although the development of the DZP would be undertaken across aquatic ecosystems that are stressed and degraded, the watercourses still provide habitat for aquatic biota. Habitat values are not uniformly spread across the area but instead are in general linked to stream order, with the larger watercourses, such as Macquarie River and Little River providing the more consistent and complex habitat in an otherwise degraded landscape. This includes habitat for threatened species, populations and endangered ecological communities such as the *Aquatic Ecological Community in the Natural Drainage System of the Lowland Catchment of the Darling River*. Aquatic habitat in the lower order streams, such as Wambangalang Creek, Cockabroo Creek, Hyandra Creek and Paddys Creek is more patchily distributed due in part to their ephemeral low flow regimes. In these lower order streams, pools provide important refuge habitat for aquatic biota during times of low flow, especially for sedentary species adapted to saline and turbid conditions such as the Eel-tailed Catfish, and consequently should also be afforded protection.

Seven aquatic fauna species were recorded during the surveys: Four of these species are native (Eastern Snake-necked Turtle (*Chelodina longicollis*) Common Yabby (*Cherax destructor*), *Western Carp Gudgeon* (*Hypseleotris klunzingeri*) and Eel-tailed Catfish (*Tandanus tandanus*)) and three are non-native invasive fish species (Goldfish (*Carassius auratus),* Common Carp (*Cyprinus carpio)* and Eastern Gambusia (*Gambusia holbrooki))*. All but one of the native fauna species recorded are considered relatively common within the Central West CMA although almost all native fish species are considered to have some potential for local extinction due to the alteration and removal of habitat, low water quality and competition from invasive species. The once common Eel-tailed Catfish (*Tandanus*

tandanus) recorded at Site C in Wambangalang Creek is part of the *Eel-tailed Catfish in the Murray / Darling Basin Endangered Population* listed under the NSW FM Act.

Potential Impacts

In the absence of mitigation measures the development and operation of the DZP has the potential to impact directly and indirectly on the aquatic ecosystems across the DZP Site and study area, including a range of matters of conservation significance, including alternation of natural flows due to the removal of headwaters and changes to the upper catchment; obstruction of fish passage due to instream structures; mobilisation of sediment resulting in habitat degradation during construction; changes in water quality; entrainment and impingement of aquatic organisms at the off-take site at Macquarie River; disturbance of the Eel-tailed Catfish habitat at Toongi; removal and disturbance of Lowland Darling River aquatic ecological community; and cumulative impacts. Consequently a range of management and mitigation measures would be incorporated into the development and operation of the DZP.

Matters of National Environmental Significance listed under the EPBC Act which may be relevant to the DZP include, Macquarie Marshes Nature Reserve which is a Ramsar Site and two species of freshwater fish, Trout Cod (*Maccullochella macquariensis*) and Murray Cod (*Maccullochella peelii peelii*). The DZP would not impact the Macquarie Marsh Nature Reserve as it is approximately 200 km north-west of the site. Both the Trout Cod and Murray Cod are known from the Macquarie River and have greater potential to be impacted by this proposal if unmitigated. However, it was concluded that it is unlikely that the DZP would impact any local or regional population of these species as they are unlikely to occur across the DZP Site and hence direct impacts are not anticipated. Impacts at the off-take site of water extraction from the Macquarie River would be avoided through the use of pump extraction screen technology reducing the likelihood of entrainment or injury of larvae or juveniles. In addition, stringent on-site management measures would mitigate against potential impacts through implementation of Construction and Operational Environmental Control Plans.

Matters listed under the FM Act which have the potential to be affected by the DZP include one Endangered Ecological Community, two endangered populations and four threatened species and these are discussed below. Aquatic communities of the Macquarie River, Little River, Wambangalang Creek, Cockabroo Creeks including the DZP Site, DZP study area and locality all support the EEC *Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River* as these are natural creeks and rivers of the Darling River system below 500 m AHD (approximately 280 – 350 m AHD) and are all downstream of the Burrendong Dam. The DZP is unlikely to significantly impact this EEC within the local catchment as flows would not substantially change from current levels, woody debris removed during construction would be restored and riparian areas would be rehabilitated as part of the biodiversity offsets for this project.

The Western NSW population of the Olive Perchlet, *Ambassis agassizii,* is known from the Central West CMA. It is considered unlikely that this species would occur in the watercourses of the DZP Site as these are generally ephemeral headwaters and / or highly degraded creeks suffering from many of the recognised threats for this species. It is more likely that this species may occur within the wider study area and locality and hence no impacts are anticipated.

Tandanus tandanus – Eel-tailed Catfish in the Murray / Darling Basin, an endangered population, was recorded within the Wambangalang Creek at Site C where the disused railway line crosses the creek via a trestle bridge. This site consists of a number of still, turbid pools up to 1.5 m in depth some with large snags. This species may also be present in other sections of the creek with suitable habitat (e.g. deep

pools and snags) as well as the Macquarie and Little Rivers. In the absence of mitigation measures, the Eel-tailed Catfish in the Murray / Darling Basin has the potential to be impacted by this proposal during demolition of the existing wooden rail bridge and the construction of a new bridge which crosses Wambangalang Creek 50 m downstream of the recorded occurrence of the Eel-tailed Catfish. Stringent environmental management of the upgrade of the wooden rail bridge across Wambangalang Creek would be implemented to assist with the protection of the Toongi population of the Eel-tailed Catfish during construction. With these management and mitigation measures in place it is considered that this population could be adequately protected to such an extent that this project would be unlikely to significantly impact this endangered population.

Trout Cod (*Maccullochella macquariensis*), Purple Spotted Gudgeon (*Mogurnda adspersa*), Silver Perch (*Bidyanus bidyanus*) and River Snail (*Notopala sublineata*) are all listed as threatened under the FM Act and all are known from the CMA. It is considered unlikely that the DZP would impact any local or regional population of any of these species as they are unlikely to occur across the DZP Site, and any potential off-site impacts would be managed and mitigated with stringent on-site management measures.

There are no aquatic communities, populations or species listed under the TSC Act which have the potential to be impacted by this proposal.

The footprint of the proposed DZP Site has undergone iterative changes to reduce impacts on aquatic biodiversity. Where impacts are inevitable, a range of mitigation measures have been proposed which would reduce potential impacts and protect aquatic biota. Statutory assessments undertaken for species, populations and communities listed under the EPBC Act, TSC Act and FM Act concluded that with the implementation of the range of proposed mitigation measures proposed that it is unlikely that there would be significant impacts on aquatic matters listed under the EPBC Act or FM Act.

Specific Recommendations

- Minimise the clearing of native vegetation and other groundcovers;
- Implement an Erosion and Sedimentation Control Plan to minimise opportunities for mobilised sediments to reach drainage lines and watercourses;
- Design and construction of all new and upgraded watercourse crossings in accordance with *Guidelines and Policies for Aquatic Habitat Management and Fish Conservation* (NSW Fisheries 1999) and *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull & Witheridge 2003);
- Development of an adaptive management plan for protection and conservation of the Endangered Population of the Eel-tailed Catfish at Toongi;
- Ensure that appropriate screening and pump technology be used at the off-take site for water abstraction from the Macquarie River to minimise impacts on aquatic biota; and
- Include rehabilitation and restoration of instream habitats as a part of the biodiversity offsets package for the DZP.

GLOSSARY & ACRONYMS

Glossary & Acronyms	
asl	Above sea level
AHD	Australian Height Datum
AUSRIVAS	Australian River Assessment System
AZL	Australian Zirconia Limited
BOM	Bureau of Meteorology
cm	Centimetres
CMA	Catchment Management Authority
CNG	Compressed natural gas
^{o}C	Degrees Celsius
DEC	Department of Environment and Conservation (NSW Government Department succeeded by the DECC)
DECC	Department of Environment and Climate Change (NSW Government Department succeeded by the DECCW)
DECCW	Department of Environment, Climate Change and Water (NSW Government Department succeeded by OEH and EPA)
DEH	Department of the Environment and Heritage (Commonwealth Government Department succeeded by the DEWHA)
DEWHA	Department of Environment, Water, Heritage and the Arts (Commonwealth Government Department succeeded by SEWPaC)
DGRs	Director-General's requirements
DPI	NSW Department of Primary Industries
DZP	Dubbo Zirconia Project
E	Endangered
Ecological community	An assemblage of species occupying a particular area.
EEC	Endangered ecological community
EIS	Environmental Impact Statement
Endangered	Used in reference to a species, population or ecological community, specified

Glossary & Acronyms

species	in the *Threatened Species Conservation Act 1995*, *Fisheries Management Act 1994* or *Environment Protection and Biodiversity Conservation Act 1999* that is in danger of becoming extinct if threats continue, or its numbers are reduced to a critical level, or its habitat is reduced.
Environment	The aggregate of all conditions that influence the life of a species, including natural, social, cultural, built and spatial elements.
EPA	Environment Protection Authority
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*
ESD	Ecologically sustainable development
ETL	Electricity transmission line
Exotic species	A species occurring in an area outside its historically known natural range as a result of intentional or accidental dispersal by human.
Floodplain	The flat area usually toward the lower end of a river system where periodic flooding has deposited river-borne materials.
Flora	The entire plant life of a site or region.
FM Act	NSW *Fisheries Management Act 1994*
FNARH	First National Assessment of River Health
Fragmentation	The division of natural areas by vegetation clearance for human land use, isolating the remnants and the species within them and limiting genetic flow.
GDE	Groundwater Dependent Ecosystem
GIS	geographic information system
GL	Gigalitres
GPS	Global positional system
km	Kilometre
KTP	Key threatening processes listed under the FM Act or EPBC Act
kV	Kilo volts
LGA	Local Government Area
LRSF	Liquid Residue Storage Facility
m	Metre

Glossary & Acronyms

ML	Mega litre
mg/L	Milligrams per litre
mm	Millimetres
Mt	Million tonne
NES	National Environmental Significance
µS/cm	Micro Siemens per centimetre
Native	Species that are native to (i.e. occur naturally) in a region.
Native vegetation	Any local indigenous plant community containing throughout its growth the complement of native species and habitats normally associated with that vegetation type or having the potential to develop these characteristics. It includes vegetation with these characteristics that has been regenerated with human assistance following disturbance. It excludes plantations and vegetation that has been established for commercial purposes.
Noxious	Undesirable, troublesome, difficult to control or eradicate. Listed under the NW Act.
NPWS	NSW National Parks and Wildlife Service
NSW	New South Wales
NTU	Nephelometric Turbidity Units
NW Act	*Noxious Weeds Act 1993*
OEH	Office of Environment and Heritage
Population	A group of individuals of the same species, forming a breeding unit and sharing a habitat.
RCE	A modified Riparian, Channel and Environmental Inventory (RCE) (Chessman *et al*. 1997)
REE	Rare earth elements
Riparian	Situated on or within a riverbank.
ROM	Run-of-Mine
RWC	RW Corkery & Co Pty Limited
SEPP	State Environmental Protection Policy
SEWPaC	Department of Sustainability, Environment, Water, Population and Communities

Glossary & Acronyms

SRSF	Solid Residue Storage Facility
Species	A group of organisms that is biologically capable of breeding and producing fertile offspring with each other but not with members of other species.
Species diversity	A measure of the number of individuals and their relative abundance in an area.
Threatened	Refers to a species, population or ecological community specified in the *Threatened Species Conservation Act 1995, Fisheries Management Act 1994* or *Environment Protection and Biodiversity Conservation Act 1999* that is either endangered, vulnerable, or presumed extinct.
TSC Act	NSW *Threatened Species Conservation Act 1995*.
TSR	Travelling stock reserve
V	Vulnerable
Weed	Any plant that is not cultivated deliberately by humans but that grows entirely or predominantly in situations disturbed by humans.
WRE	Waste rock emplacement

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1 INTRODUCTION

1.1 Background

Alison Hunt & Associates Pty Ltd was commissioned by RW Corkery & Co Pty Limited (RWC) on behalf of Australian Zirconia Limited (AZL) to undertake an assessment of the aquatic ecology for the proposed development of the Dubbo Zirconia Project (DZP), which would be located at Toongi, approximately 25 km south of Dubbo in Central West NSW (**Figure 1**). The DZP would comprise a small scale open cut mine supplying approximately 1 million tonne (Mt) of ore containing rare metals (zirconium and niobium) and rare earth elements (REEs) (including hafnium and tantalum) to a processing plant annually (19.5 Mt of ore over a period of up to 20 years). The land on which the proposed open cut, processing plant and associated facilities for the management of waste generated by these activities is collectively referred to as the DZP Site.

The DZP has been deemed to be a State Significant Development (SSD) in accordance with Schedule 1(5) of the *State Environmental Planning Policy (SEPP) State and Regional Development* and requires the preparation of an Environmental Impact Statement (EIS) to accompany an application made under Part 4 Division 4.1 of the NSW *Environmental Planning & Assessment Act 1979* (EP&A Act). The Director-General's requirements (DGRs) for the DZP, including appended assessment requirements of consulted government agencies, were issued on 4 May 2012 (Attachment A). The DZP was deemed a Controlled Action under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on the basis of potential impacts on threatened terrestrial species (4 January 2013). The Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) has indicated that assessment of the DZP will be undertaken bi-laterally with the NSW State Significant Development assessment process being undertaken by NSW Department of Planning & Infrastructure. Supplementary DGRs were issued for the DZP, reflecting the assessment requirements of SEWPaC on 1 March 2013.

To meet the requirements for assessment as SSD, the potential impacts of the proposed Project on aquatic ecology have been considered within the framework for assessment under Part 4 Division 4.1 of the EP&A Act, NSW *Fisheries Management Act 1993* (FM Act), NSW *Threatened Species Conservation Act 1995* (TSC Act) and the Commonwealth EPBC Act.

1.2 Project Location

The 2,864 ha area of investigation for this assessment focusses on the DZP Site and potentially affected aquatic environments within the Dubbo City local government area (LGA) in Central West NSW, approximately 25 km south of Dubbo to the east of Obley Road, Toongi (**Figure 1**). The city of Dubbo is a major regional centre with a population of over 40,000. Irrigation agriculture, dryland cropping and grazing of cattle and sheep are all established land uses within the region.

The DZP investigation area of falls within the Central West Catchment Management Area (CMA) and includes the Castlereagh, Bogan and Macquarie River valleys. The DZP investigation area is located within the ‘Slopes Zone’ of the Macquarie River valley, downstream of the Burrendong Dam and upstream of Dubbo. Major tributaries of the Macquarie River within the area include, Little River (which receives flow from a minor first order stream known as Cockabroo Creek) and Wambangalang Creek (which receives flow from Paddys Creek and Meadows Creek within the affected catchment).

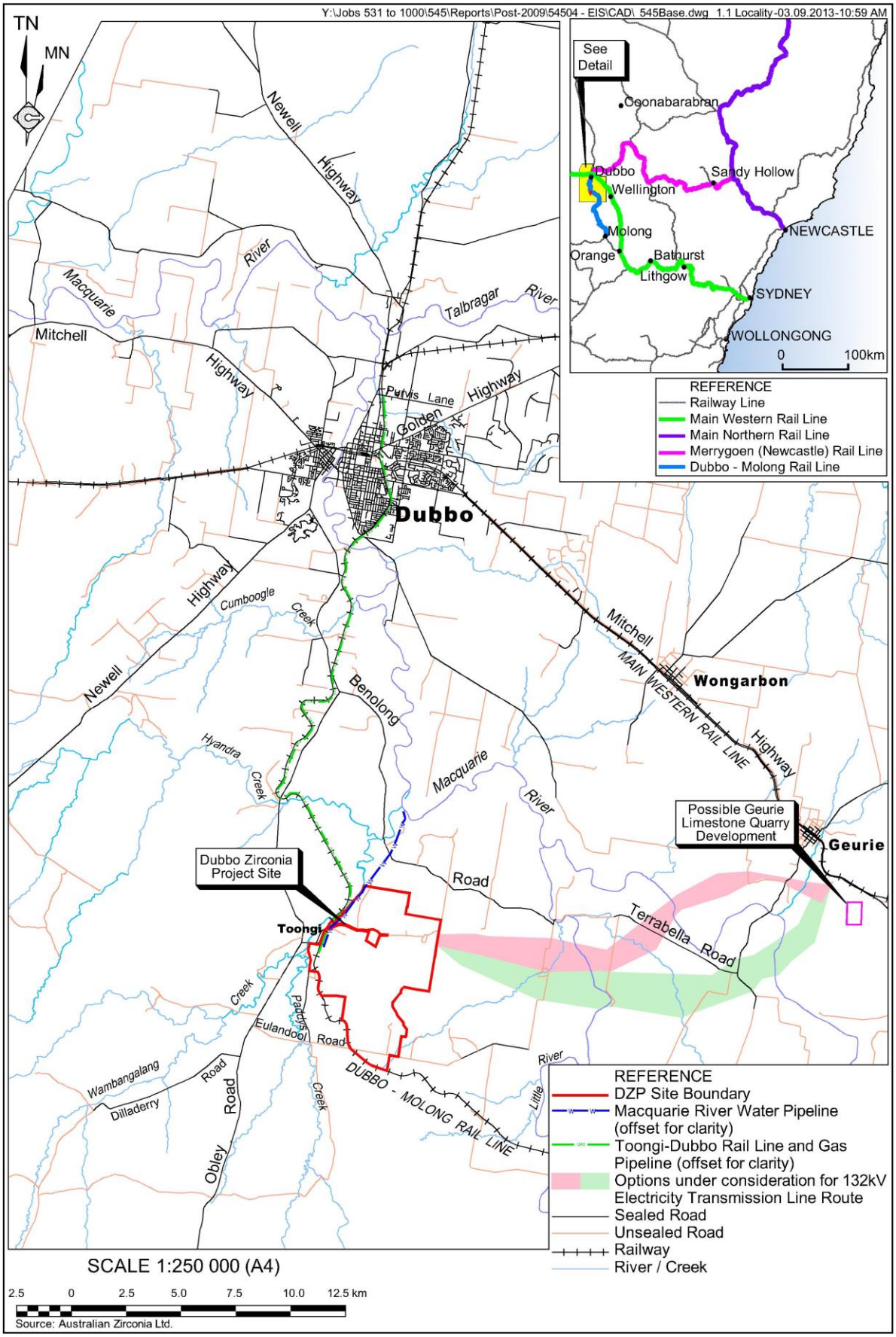


Figure 1 Location of Dubbo Zirconia Project

1.3 Project Description

In addition to the operations on the DZP Site, the DZP would also incorporate the following three component areas (see **Figure 2**).

- Upgrade and reactivation of the Toongi to Dubbo Section of the Dubbo-Molong Rail Line. AZL also proposes to construct a pipeline to deliver compressed natural gas (CNG) from the Central West Pipeline operated by APA Group within the 'Toongi-Dubbo Rail Line and Natural Gas Pipeline Corridor';
- Construction of a water pipeline to deliver up to 4.05 gigalitres (GL) of water from the Macquarie River to the processing plant (referred to hereafter as the Macquarie River Water Pipeline); and
- Upgrades, including minor realignment, creek crossing upgrade and pavement strengthening, of the public road network (Toongi Road and Obley Road).

The following provides an overview of the activities to be undertaken within each of these areas.

1.3.1 DZP Site Operations

The following provides an overview of principal components and activities to be undertaken on the DZP Site (and illustrated on **Figure 2**).

- Extraction of approximately 19.5 Mt of ore at a maximum rate of 1.1 Mt per year from a shallow open cut developed to a maximum depth of 32 m (355 m Australian Height Datum (AHD)) (remaining above the groundwater table). At the proposed rate of mining, the open cut design proposed would provide for a mine life of 20 to 22 years;
- Extraction and placement of approximately 3.5 Mt of waste rock (weathered material or rock containing insufficient grades of rare metals or REEs for processing) within a small waste rock emplacement (WRE) to the southwest of the open cut;
- Haulage of ore to a Run-of-Mine (ROM) Pad for crushing and grinding;
- Processing of the crushed and ground ore by:
    - Sulphation roast of ore and leaching to dissolve sulphated metals; and
    - Solvent extraction, precipitation, thickening, washing and drying of the various rare metal and REE products.

  The sulphuric acid required as part of the sulphation process would be manufactured within the DZP processing plant from imported raw sulphur;
- Construction and operation of a rail siding from the Toongi-Dubbo Rail Line and a Rail Container Laydown and Storage Area for the unloading and temporary storage of reagents and loading of products for despatch.

  Other reagents would be transported to the DZP Site via the public road network, with sections of Obley Road and Toongi Road to be upgraded to accommodate the proposed increase in heavy vehicle traffic;
- Mixing of solid residues produced by the processing of the ore with crushed and washed limestone and transportation via conveyor to a Solid Residue Storage Facility (SRSF);

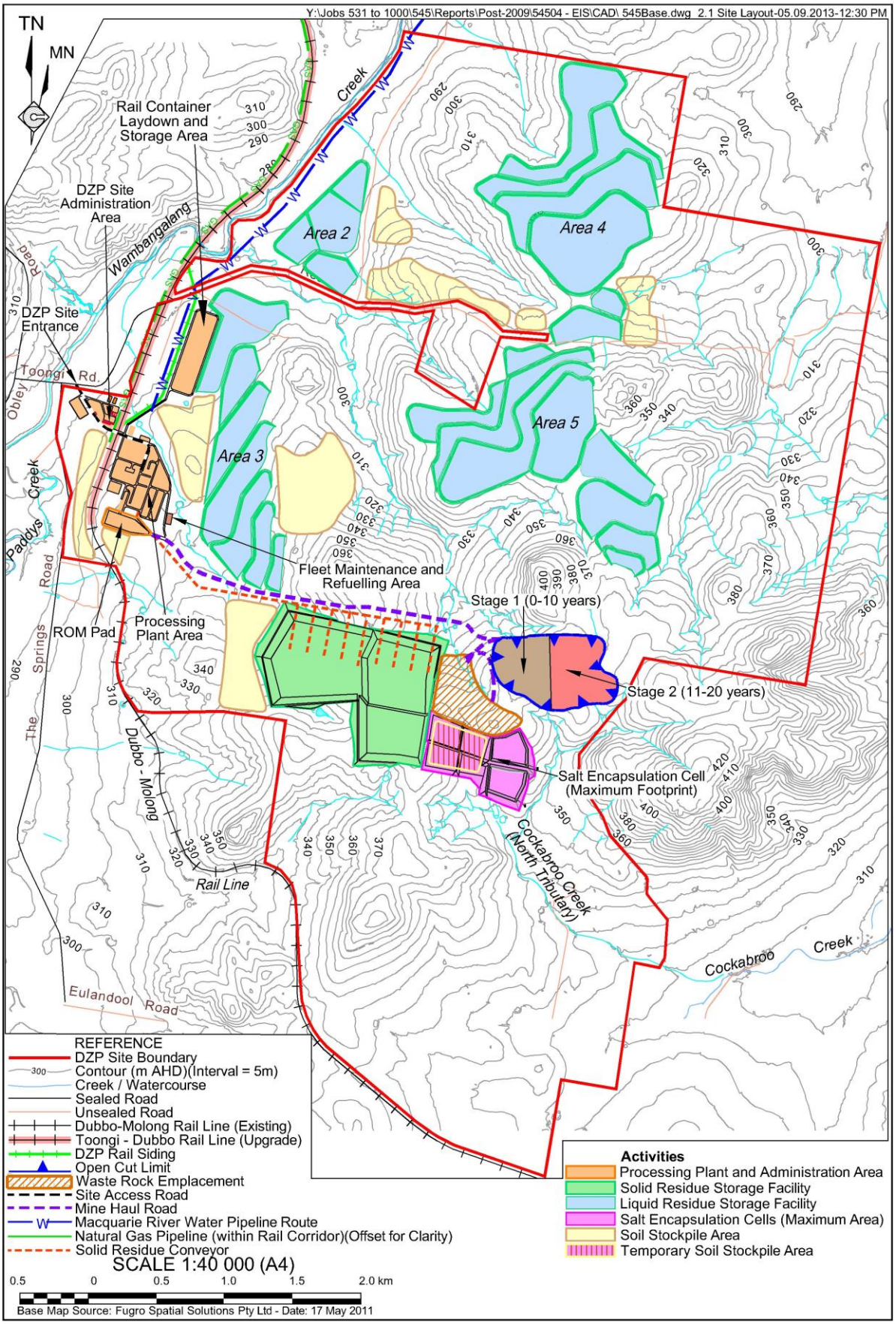


Figure 2 DZP Site Layout

- Pumping of water used in the processing operations, which cannot be recycled, to a Liquid Residue Storage Facility (LRSF), comprising a series of terraced and lined crystallisation cells;
- Recovery and disposal of an estimated 6.7Mt of salt which would accumulate within the LSRF within a series of Salt Encapsulation Cells adjoining the WRE and SRSF; and
- Other ancillary activities including equipment maintenance, clearing and stripping of the areas to be disturbed and rehabilitation activities.

The maximum development footprint on the DZP Site would be approximately 807.7ha (see **Figure 2**). Component areas of disturbance are as follows:

- Open Cut Mine – 40.3 ha;
- Waste Rock Emplacement Area – 20.4 ha;
- ROM Pad – 4.2 ha;
- Processing Plant and DZP Site Administration Area (incorporating the processing plant and associated reagent storage areas, rail siding and container laydown areas and site offices and administration complex) – 43.3 ha;
- Solid Residue Storage Facility – 102.8 ha;
- Liquid Residue Storage Facilities (Evaporation Ponds) – 425.4 ha;
- Salt Encapsulation Cell – up to 34.6 ha;
- Soil Stockpile Areas – up to 129.4 ha; and
- Internal Haul Roads – 7.3 ha.

The ore body to be mined is a roughly elliptical stock in shape with outcrop dimension of 600 m x 400 m. Exploration completed by AZL has identified the ore body extends below a thin veneer of soil and recent sediments to be approximately 900 m (east-west) x 500 m (north-south) (surface area of 36ha) and appears to be a near vertical body of indeterminate depth.

1.3.2 Toongi-Dubbo Rail Line and Gas Pipeline Corridor

The processing operations require significant volumes of chemical reagents and other raw materials. While significant volumes of these reagents and materials would be delivered by road, the Applicant has identified the upgrade and use of the Toongi to Dubbo section of the currently disused Dubbo-Molong Rail Line as an opportunity to reduce the volume of traffic on the public road network.

Figure 3 provides the proposed alignment of the Toongi-Dubbo Rail Line, the key features of which are as follows:

- Upgrade of the Toongi to Dubbo section of the Dubbo-Molong Rail Line to a Class 1 track (92 t gross/ 67 t pay load capacity);
- Replacement or upgrade of steel bridges, culvert structures, and timber bridges; and
- Reinstatement, civil works and installation back to the required standard at each of the 26 level crossings. Of these, seven are major crossings (of local roads), four of which occur in Dubbo (Wingewarra Street, Cobra Street, Boundary Road and Macquarie Street) and three (Cumboogle, Glengerra and Toongi) between the Macquarie River and the proposed DZP Rail Siding.

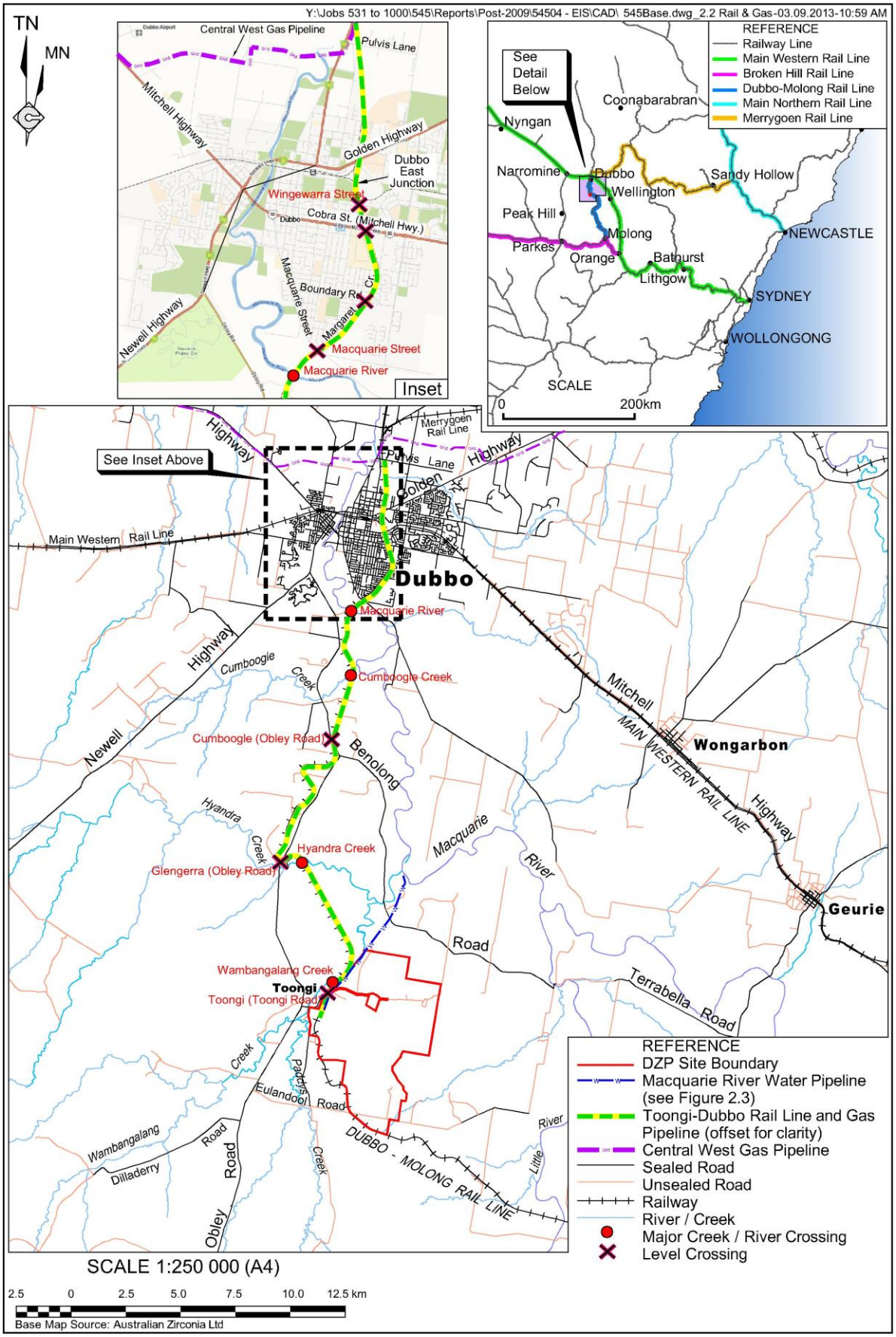


Figure 3 Toongi – Dubbo Rail Line and Gas Pipeline Corridor

Figure 3 also identifies the proposed natural gas pipeline between the Central West Pipeline (of APA Group) at Purvis Lane, Dubbo, and the DZP Site which would deliver up to 970 TJ/year of natural gas for the heating of various circuits within the processing plant.

1.3.3 Macquarie River Water Pipeline

Processing operations would require up to 4.05 GL of water annually which would be sourced (partially or completely) from the Macquarie River (under licence) and transferred to the DZP Site by water pipeline.

Figure 4 provides the proposed alignment of the Macquarie River Water Pipeline, the key features of which are as follows:

- A pumping station which incorporates a dual water inlet, wet well and vertical mounted axial flow pump configuration; and
- A 400 mm to 450 mm diameter HDPE pipeline within an embedded trench.

The easement to be created for the Macquarie River Water Pipeline Corridor would be approximately 15.2 ha (20 m x 7.6 km), although the actual area of disturbance within this corridor would be much less. An area of up to 50 m x 50 m (0.25 ha) would be disturbed on the river frontage of the "Mia Mia" property to allow for the construction of the pumping station for water from the Macquarie River. A small section of the river channel (5 m x 10 m) would require temporary damming to allow for a horizontal bore hole to be drilled for the installation of the intake pipe from the river to the wet wells.

1.3.4 Public Road Network

Significant quantities of the processing reagents and other raw materials would be delivered by road, via the Newell Highway, Obley Road and Toongi Road. To accommodate the proposed heavy vehicle traffic associated with this transport, the alignment and pavement depth of the two roads would be improved in several locations, with a number of creek crossings, rail level crossings and intersections to be upgraded. **Figure 5** provides the locations of these works.

A more detailed description of the Proposal is provided by Section 2 of the EIS, of which this assessment forms Part 7 of the accompanying *Specialist Consultant Studies Compendium*.

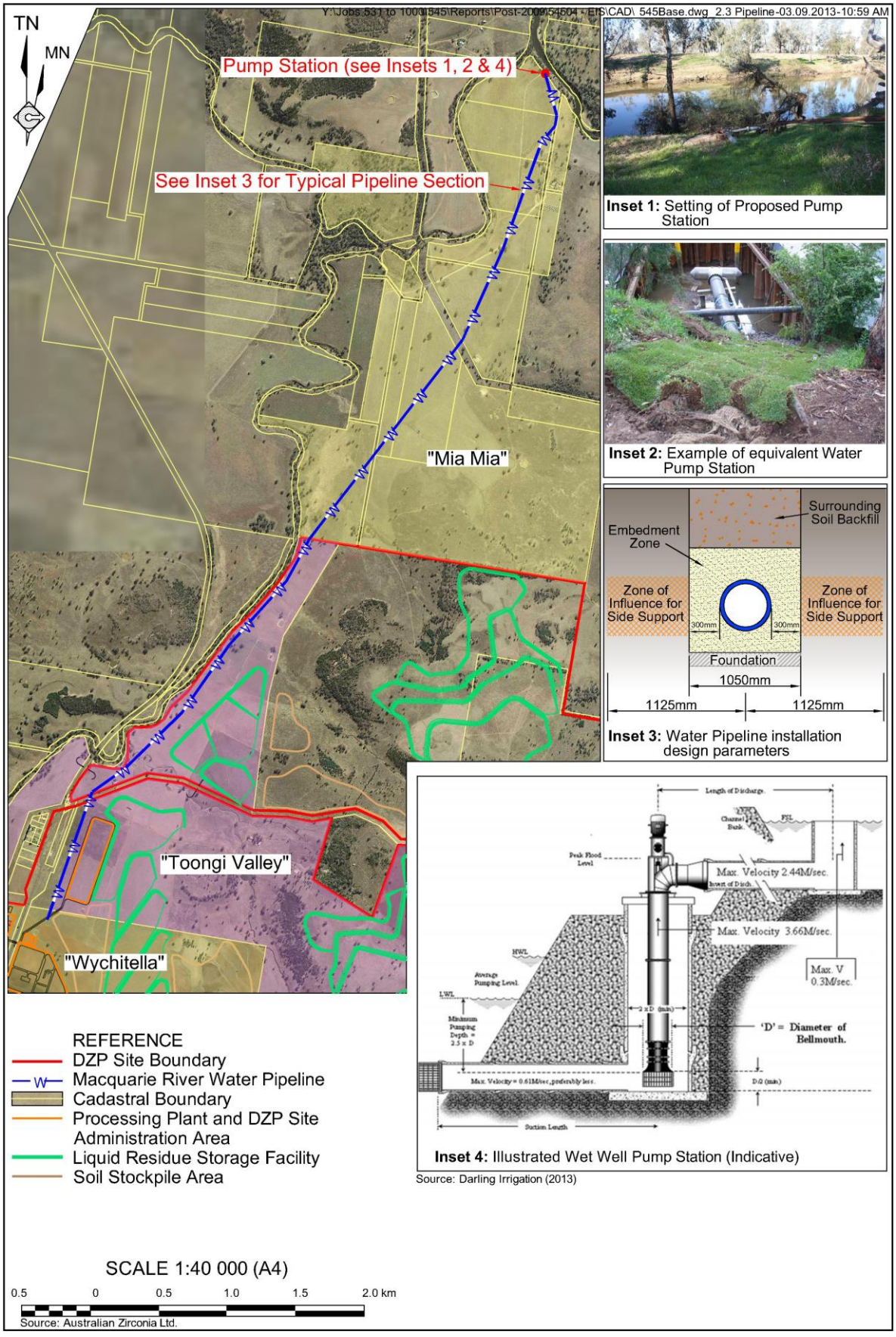


Figure 4 Macquarie River Water Pipeline and Pump Station

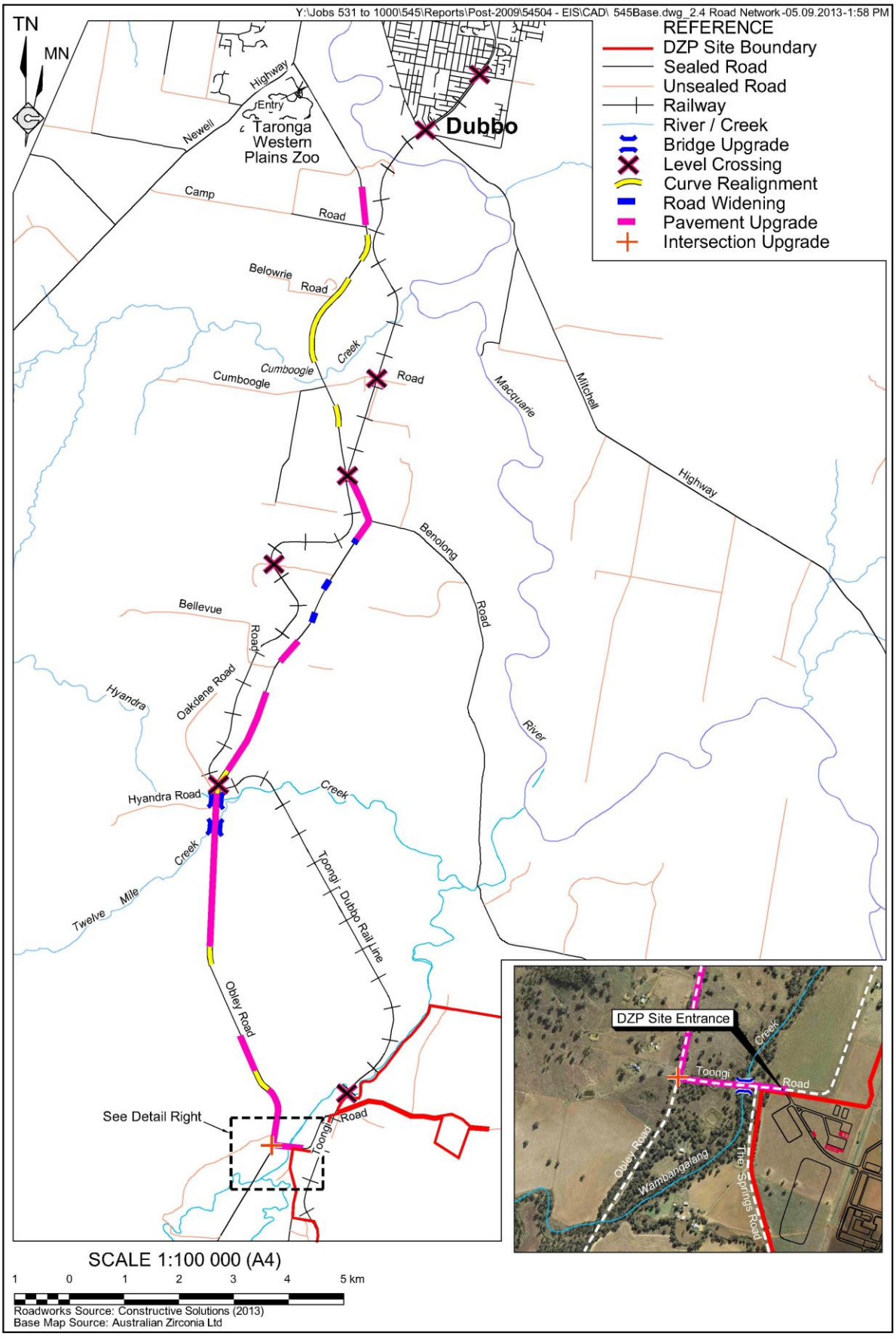


Figure 5 Public Road Network Upgrades

1.4 Assessment Area

Terminology used to describe the assessment area for the aquatic ecology investigations are as follows:

- The DZP investigation area shown in **Figure 1** (area bounded by red), which includes the areas that have the potential to be directly impacted. This area is referred to in this report as the *DZP Site*;
- The *DZP study area* (refer **Figure 6**) which includes adjacent off-site assessment areas, including Wambangalang Creek upstream of the DZP Site (Site A), Wambangalang Creek downstream of the DZP Site (Site H), Hyandra Creek to the north-west of the DZP Site (Site F) and Cockabroo Creek (Site I), Little River (Site J) and Macquarie River downstream of the DZP Site. These areas were included in investigations to provide a broader view and baseline information on the status of aquatic ecosystems in the area; and
- The catchments and area covered by the Central West CMA, referred to as the *locality*.

2 LEGISLATIVE FRAMEWORK

A number of legislative requirements in relation to the biodiversity of the DZP study area are relevant to the DZP and those of particular relevance are outlined below.

2.1 Commonwealth Legislation

2.1.1 Environment Protection and Biodiversity Conservation Act 1999

The DZP was deemed a Controlled Action under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on the basis of potential impacts on threatened terrestrial species (4 January 2013).

The primary objective of the EPBC Act is *to provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance*. Environmental approvals under the EPBC Act may be required for:

- An *action* that is likely to have a significant impact on Matters of National Environmental Significance (known as *NES matters*) including:
    - World Heritage Areas;
    - National Heritage Places;
    - Ramsar wetlands of international importance;
    - Nationally listed threatened species and ecological communities;
    - Listed migratory species;
    - Nuclear actions;
    - Commonwealth marine areas; and
    - Commonwealth heritage places.
- Actions taken on Commonwealth land that are likely to have a significant impact on the environment;
- Actions that are likely to have a significant impact on the environment of Commonwealth land, even if the action is taken outside Commonwealth land; and
- Any action taken by a Commonwealth agency that is likely to have a significant impact on the environment.

An *action* is considered to include a project, development, undertaking, activity or series of activities.

Of potential relevance to this proposal are matters of NES which may include nationally listed threatened aquatic species. The potential impacts of this proposal on matters of NES have been assessed using the Significant Impact Criteria detailed in the *EPBC Act Policy Statement 1.1 – Significant Impact Guidelines: Matters of National Environmental Significance* (DEH 2006).

2.2 State Legislation

2.2.1 Environmental Planning and Assessment Act 1979

The DZP was determined to be State Significant Development (SSD) in accordance with Schedule 1(5) of the *State Environmental Planning Policy (SEPP) State and Regional Development* and hence requires the preparation of an Environmental Impact Statement (EIS) to accompany an application made under Part 4 Division 4.1 of the EP&A Act.

As required under Part 4 Division 4.1 of the EP&A Act the Director-General of the Department of Planning and Infrastructure (DP&I) has provided project specific environmental assessment requirements. The assessment must adequately address these Director-General's requirements (DGRs) in order to be considered for approval by the Minister. The DGRs for the DZP were issued on 4 May 2012, with supplementary DGRs issued on 1 March 2013 following the determination of the DZP as a Controlled Action by SEWPaC and therefore requiring an approval under the EPBC Act (Appendix A). These have been addressed though an assessment of the potential impacts of the DZP on aquatic species, populations and ecological communities listed under Schedules 1, 1A and 2 of the TSC Act. This assessment is therefore to be undertaken in accordance with *Threatened Species Assessment Guidelines: the Assessment of Significance* (DECC 2007).

DGRs relevant to the aquatic ecological assessment for the DZP are shown in **Table 1** along with the section of the document where these are addressed.

Table 1 Director-General's requirements relevant to the aquatic assessment for the DZP

Type	Requirement	Addressed in Section
General	A description of the existing environment, using sufficient baseline data	Section 4
	An assessment of the potential impacts of the Project, including any cumulative impacts, taking into consideration any relevant guidelines, policies, plans and statutory provisions	Section 6
	A description of the measures that would be implemented to avoid, minimise and if necessary, offset the potential impacts of the Project, including detailed contingency plans for managing any significant risks to the environment	Section 7
Biodiversity	Measures taken to avoid, reduce or mitigate impacts on biodiversity	Section 7
	A detailed assessment of potential impacts of the development on aquatic threatened species or populations and their habitats, endangered ecological communities and groundwater dependent ecosystems	Section 6
	A comprehensive offset strategy to ensure the development maintains or improves the terrestrial and aquatic biodiversity values of the region in the medium to long term	Section 8.2

2.2.2 Threatened Species Conservation Act 1995

The objectives of the TSC Act are:

- To conserve biological diversity and promote ecologically sustainable development;
- To prevent the extinction and promote the recovery of threatened species, populations and ecological communities;
- To protect the critical habitat of those threatened species, populations and ecological communities that are endangered;
- To eliminate or manage certain processes that threaten the survival or evolutionary development of threatened species, populations and ecological communities;
- To ensure that the impact of any action affecting threatened species, populations and ecological communities is properly assessed; and
- To encourage the conservation of threatened species, populations and ecological communities by the adoption of measures involving co-operative management.

The TSC Act provides for the identification, classification and priority conservation actions, of the State listed species, populations and ecological communities that need to be considered under the EP&A Act. It also provides for the identification of critical habitat as well as key threatening processes that are most likely to jeopardise the survival of those species, populations and ecological communities.

2.2.3 Fisheries Management Act 1994

The FM Act aims *to conserve, develop and share the fishery resources of the State for the benefit of present and future generations* and, in particular, to:

- Conserve fish stocks and key fish habitats;
- Conserve threatened species, populations and ecological communities of fish and marine vegetation;
- Promote ecologically sustainable development, including the conservation of biological diversity, and, consistently with those objectives;
- Promote viable commercial fishing and aquaculture industries;
- Promote quality recreational fishing opportunities;
- Appropriately share fisheries resources between the users of those resources; and
- Provide social and economic benefits for the wider community of New South Wales.

To meet these objectives, Part 7 of the FM Act outlines legislative provisions to protect fish habitat and Part 7A outlines provisions to conserve threatened species of fish and marine vegetation and their habitat.

Definition of "fish"

Under the FM Act, fish means "marine, estuarine or freshwater fish or other aquatic animal life at any stage of their life history (whether alive or dead)" and includes:

- oysters and other aquatic molluscs;
- crustaceans;
- echinoderms; and
- beachworms and other aquatic polychaetes.

The definition also includes any part of a fish, but does not include whales, other mammals, reptiles, birds, amphibians or other things excluded from the definition by the regulations.

NSW DPI's jurisdiction

NSW Department of Primary Industry (DPI) has jurisdiction over all fish and marine vegetation in State waters. This includes permanent and intermittent freshwater areas and *water land* below the highest astronomical tide in tidal areas, extending to three nautical miles offshore (or beyond where other legislative powers of the State apply). *Water land* is defined under the FM Act as land submerged by water, whether permanently or intermittently or whether forming an artificial or natural body of water and includes wetlands and any other land prescribed by the regulations as water land.

Development approvals

Under the *integrated development* provisions of the EP&A Act, DPI is an approval body for local development that requires one or more of the following permits under the FM Act:

- Section 144 - aquaculture permit , i.e. cultivating fish or marine venation for sale / commercial purposes;
- Section 201 - permit to carry out works of dredging or reclamation, i.e. any excavation within or filling of water land;
- Section 205 - permit to harm (cut, remove, damage, destroy, shade) marine vegetation (mangroves, seagrass and seaweeds); and
- Section 219 - permit to obstruct the free passage of fish.

Development activities requiring a DPI permit

Issues associated with the development of the DZP that may require one of the permits listed above include:

- Bridges, culverts, causeways (both piped and unpiped) or other road crossing of waterways (temporary or permanent) which require placing material on the bed of the waterway (i.e. reclamation) and/or which may obstruct the free passage of fish;
- Dams, weirs, floodgates or levee banks (i.e. obstruction of fish passage);
- Channelisation, relocation or realignment of waterways; and
- Installation of pipelines across a waterway involving dredging or reclamation.

2.2.4 Threatened Species Legislation Amendment Act 1994

The *Threatened Species Legislation Amendment Act 1994* (TSLA Act) builds on the earlier legislation's mechanisms for conserving threatened species, populations and ecological communities and their habitats. Parallel amendments have also been made to the *Fisheries Management Act 1994*. The key areas of reform are:

- In urban and coastal areas, integration of biodiversity values into better strategic land-use planning, changes to the development assessment process and accreditation of flora and fauna consultants;
- In rural areas, threatened species conservation embedded within native vegetation protection to deliver a simpler and more supportive system of conservation incentives for landholders;
- Listing of threatened species maintained as a scientific process, with enhanced transparency;
- Transparent prioritisation of actions for recovery and threat abatement;
- Upgraded enforcement and compliance provisions; and
- Expert advisory councils to advise the Minister for the Environment on social, economic and biodiversity implications.

2.3 Policies and Guidelines

There are a number of policies and guidelines relevant to the development of the DZP.

2.3.1 Part 3A Draft Guidelines for Threatened Species Assessment

The NSW Part 3A (referring to the repealed Part 3A of the EP&A Act which is now provided for in Part 4 Division 4.1) *Draft Guidelines for Threatened Species Assessment* (DEC and DPI 2005) provides information to enable decision makers to ensure that developments:

- Maintain or improve biodiversity values;
- Conserve biological diversity values and promote ecologically sustainable development (ESD);
- Protect areas of high conservation value;
- Prevent the extinction of threatened species;
- Protect the long term viability of local populations of a species, population or ecological community; and
- Protect aspects of the environment that are matters of national environmental significance.

Whilst this project is being assessed under Part 4 Division 4.1 of the EP&A Act, NSW DPI - Fisheries has specifically requested that (Appendix A: DGRs):

Assessment of the impacts should include initial 'Seven-Part Test's

Consequently, Assessments of Significance (Seven-Part Tests) have been undertaken using *Threatened Species Assessment Guidelines: The Assessment of Significance* (DECC 2007) instead of *Draft Guidelines for Threatened Species Assessment* (DEC and DPI 2005) used for Part 4 Division 4.1 as these do not include Assessments of Significance as required by NSW DPI - Fisheries.

2.3.2 Commonwealth Department of Industry, Tourism and Resources Biodiversity Management Handbook

The Commonwealth Department of Industry, Tourism and Resources (DITR) Biodiversity Management Handbook (DITR 2007) provides guidance for all stages of a mine's life from exploration, feasibility, design, construction, operation and closure. It outlines the key principles and procedures for assessing biodiversity values including:

- Identifying primary, secondary or cumulative impacts on biodiversity values;
- Minimising and managing these impacts;
- Restoring conservation values; and
- Managing conservation values on a sustainable basis.

2.3.3 Threatened Species Assessment Guidelines

The threatened species impact assessment is conducted under the FM Act and TSC Act for NSW listed species, populations and ecological communities. The Assessment of Significance under section 5A of the EP&A Act is used to ensure that the consideration is transparent for threatened species, populations and ecological communities, and their habitats (Threatened Species Assessment Guidelines: The Assessment of Significance, DECC 2007).

The Threatened Species Assessment Guidelines provides assistance with interpreting and applying the factors of assessment. The aim of the guidelines is to help ensure that a consistent and systematic approach is taken when determining whether an action, development or activity is likely to significantly affect threatened species, populations or ecological communities, or their habitats either directly or indirectly.

NSW DPI (Fisheries) has specifically requested the use of these guidelines in the preparation of this document (**Appendix A**: DGRs).

2.3.4 EPBC Act Policy Statement 1.2: Significant Impact Guidelines

The *EPBC Act Policy 1.2: Significant Impact Guidelines* (DEH 2006) provides assistance in determining if an action should be referred to SEWPaC for a decision by the Australian Government Environment Minister on whether assessment and approval is required under the EPBC Act.

2.3.5 NSW DPI Policy and Guidelines for Aquatic Habitat Management and Fish Conservation

DPI's *Policy and Guidelines for Aquatic Habitat Management and Fish Conservation* (NSW Fisheries 1999) aims to improve the conservation and management of aquatic habitats in NSW. General policies for the conservation of fish, marine vegetation and aquatic habitats included in these guidelines are:

- Assessment of fish and their aquatic habitats in all development and planning procedures, using a precautionary approach;
- Aquatic habitats must be protected when the habitat is important to maintain biodiversity at the ecosystem, species or genetic levels or is required to maintain harvestable fish populations;

- Habitats of protected or threatened fish must be afforded special protection;
- Protected areas and critical fish habitats should be given priority consideration;
- Terrestrial areas adjoining freshwater, estuarine and coastal habitats should be carefully managed in order to minimise land-use impacts on these aquatic habitats. As a precautionary approach, foreshore buffer zones at least 50 m (and up to 100 m) wide should be established and maintained, with their natural features and vegetation preserved;
- Pollution of waterways should be avoided;
- Free passage should be maintained for migratory fish species. Unlicensed barriers should be removed or fish passage facilities installed;
- Alien, exotic or introduced fish species should not be released into any waterway without the approval of NSW Fisheries;
- Environmental compensation needs to be integrated into the planning process;
- Degraded aquatic habitats should be rehabilitated, wherever possible, to repair past environmental damage; and
- Environmental monitoring is needed to determine if the assessment of the environmental impacts of a development were accurate.

2.3.6 Survey Guidelines for Australia's Threatened Fish

SEWPaC (2011) has developed survey guidelines for Australia's threatened fish that are listed as threatened under the EPBC Act (SEWPaC 2011). This document aims to provide a set of methods to be used to ensure consistency across Australia.

2.3.7 Aquatic Habitat Management & Fish Conservation1999 Update

This policy and guideline has been prepared by NSW Fisheries in order to improve the conservation and management of aquatic habitats in NSW. It is targeted at local and state government authorities, proponents of developments and their advisors, and individuals or organisations concerned with the planning and management of our aquatic resources, including conservation organisations.

2.3.8 Groundwater Dependent Ecosystems Policy

The Groundwater Dependent Ecosystems Policy (DLWC 2002) was developed to *manage the State's groundwater resources so that they can sustain environmental, social and economic uses for the people of NSW*. The policy aims to encourage the ecologically sustainable management of the State's groundwater resources, so as to:

- Slow and halt, or reverse any degradation of groundwater resources;
- Ensure sustainability of groundwater dependent ecosystems;
- Maintain the full range of beneficial uses of these resources; and
- Maximise economic benefit to the region, state and nation.

3 METHODS

3.1 Introduction

This assessment has been undertaken to describe the aquatic biodiversity values of the DZP Site and study area in order to establish the potential impacts likely to be associated with the DZP. These matters were considered within the framework for assessment under Part 4, Division 4.1 of the EP&A Act, the FM Act, TSC Act and EPBC Act, and with reference to the *Threatened Species Assessment Guidelines: The Assessment of Significance* (DECC 2007) as requested by NSW DPI – Fisheries (**Appendix A**: DGRs) and *EPBC Act Policy Statement 1.1 – Significant Impact Guidelines: Matters of National Environmental Significance* (DEH 2006).

The following tasks were undertaken:

- A review of available literature and databases to assist with the identification of the values of the DZP Site and locality, especially in relation to threatened aquatic species, populations and endangered ecological communities (EEC), and groundwater dependent ecosystems (GDEs);
- A scoping assessment of the DZP Site and local setting to allow development of a detailed methodology;
- Field surveys to ascertain the current condition and the presence or likely presence of threatened or protected species within the DZP Site and study area;
- An impact assessment to determine the likely effects of the proposal on the aquatic ecology of the site with particular reference to threatened species, populations and / or ecological communities; and
- Preparation of recommendations to ameliorate and mitigate impacts which may be associated with the construction and operation of the DZP.

3.2 Literature Review

A review of the available literature and database records pertaining to the DZP and locality (i.e. Central West CMA) was undertaken. The full list of reference materials is provided in Section 9 and those of particular relevance are listed below:

- The NSW Department of Primary Industries - Fisheries *What is Currently Listed?* Online resource (accessed February 2012 & February 2013);
- Office of Environment and Heritage (OEH): Threatened species database records (OEH; accessed February 2012 & February 2013);
- SEWPaC Online protected matters search tool for Matters of National Environmental Significance (SEWPaC; accessed February 2012 & February 2013);
- SEWPaC Survey guidelines for Australia's threatened fish. Guidelines for detecting fish listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999. Available from: http://www.envrionment.gov.au (2011);
- RW Corkery & Co. Pty. Limited: Project Overview and Preliminary Environmental Assessment for the Dubbo Zirconia Project New South Wales. Prepared for Australian Zirconia Ltd (March 2012);

- Australian Zirconia Ltd: Dubbo Zirconia Project. Conceptual Project Development Plan. EL 5548, MLA 183 (Orange) (October 2011);
- EPA Guidance Statements No. 54 and 54A for the survey and assessment of subterranean fauna in Western Australia (EPA 2003, 2007);
- Department of Land & Water Conservation. NSW State Groundwater Dependant Ecosystem Policy (April 2002); and
- Golder Associates Pty Ltd Draft Hydrogeological and Hydrological Investigations and Environmental Impacts Dubbo Zirconia Project, Dubbo, New South Wales. Prepared for Australian Zirconia Ltd (April 2002).

3.3 Scoping Assessment

A scoping assessment was undertaken during 7 - 8 February 2012, to assist with the development of a detailed methodology and to maximise the outcomes of field surveys. A preliminary investigation into the condition of watercourses, habitat available and adjacent land use was used to identify those threatened species, population and communities for which there was likely to be suitable habitat. Identification of sampling sites for targeted surveys and the implementation of condition assessment methodology was also carried out.

3.4 Site Selection

- A total of 22 sites were evaluated with ten of these sites being selected for more detailed assessment. Survey sites were selected based on position in landscape with upstream, direct impact area and downstream being included, potential for impact, water levels and habitat available. The location of each of these survey sites is shown in **Figure 6** and details of each site are provided in **Table 2**. Photographs are provided in **Appendix B**.

3.5 Field Surveys

A four day field assessment was undertaken during 19 – 23 February 2012. The tasks carried out during this assessment are detailed below.

3.5.1 Aquatic Habitat Assessment

Aquatic habitat assessments were undertaken for all survey sites to identify habitat types, the quality of habitat, the overall health of the watercourse and the potential for these areas to provide habitat for species, populations and communities listed under the FM Act, TSC Act and EPBC Act. A modified Riparian, Channel and Environmental Inventory (RCE) (Chessman *et al*. 1997) was used to provide a standardised descriptor of the aquatic habitat. Descriptors, categories and values recorded at each site are detailed in **Appendix C**. The RCE score for each site was calculated by summing the scores for each descriptor. A maximum RCE score of 52 indicates a stream with few obvious alterations from natural conditions while the lowest RCE score of 13 indicates a heavily impacted stream which retains very few natural features.

Table 2 Survey site locations in relation to the DZP Site

Site	Watercourse	Northing / Easting	Location
A	Wambangalang Creek, Obley Road	648507 / 6408344	Off-site Upstream 550 m west of Soil Stockpile Area 650 m west of Processing Plant & Administration Area
B	Farm Dam and Watercourse B	651329 / 6409049	On-site 200 m west of Liquid Residue Storage Facility 350 m east of Soil Stockpile Area
C	Wambangalang Creek, Toongi	650219 / 6409996	On-site 50 m upstream of railway upgrade area 140 m north of Processing Plant & Administration Area 250 m north-west of Liquid Residue Storage Facility
D	Unnamed tributary of Cockabroo Creek	652581 / 6405382	On-site 50 m west of Soil Stockpile Area 100 m south of Salt Encapsulation Cell
E	Paddys Creek	649128 / 6408289	Off-site 100 m west of Processing Plant & Administration Area.
F	Hyandra Creek, Obley Road	647860 / 6415344	Off-site 6.4 km north-west of Processing Plant and Administration Area.
G	Ugothery Farm dam (Watercourse A)	654223 / 6488437	On-site Direct impact area Site of Liquid Residue Storage Facility
H	Wambangalang Creek, Benolong Bridge	652713 / 6413807	Off-site Downstream 6.4 km north-west of Processing Plant & Administration Area.
I	Cockabroo Creek, Nuberingerie Road	660135 / 6407694	Off-site Downstream 6.5 km east of Open Cut Mine
J	Little River, Terrabella Road	660374 / 6409981	Off-site Downstream 7 km north-east of Open Cut Mine

Notes: Distances are approximate and are linear distances to DZP Site and infrastructure. Northings and eastings: WGS 84, UTM.

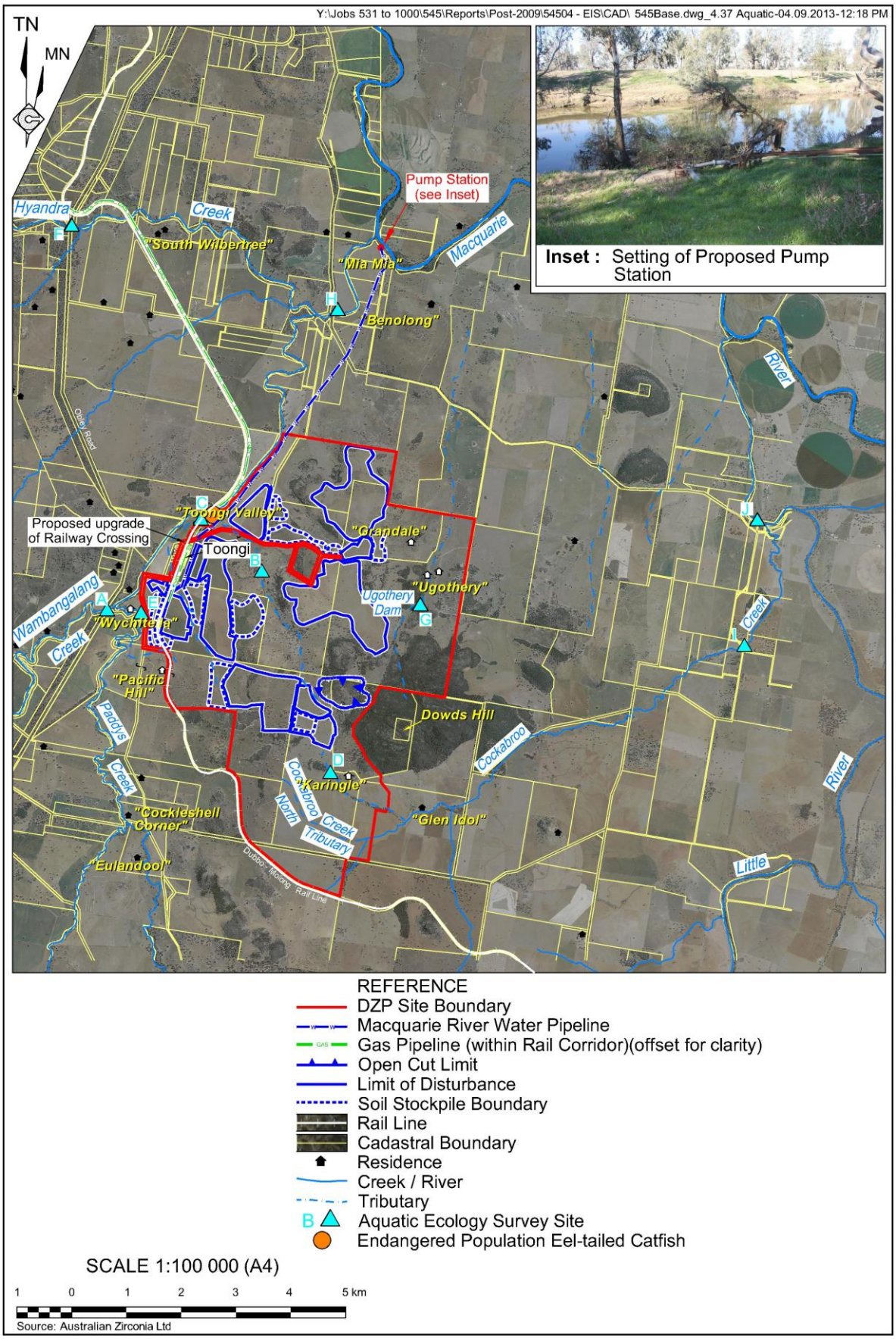


Figure 6 DZP aquatic survey site locations

An objective of the FM Act is to 'conserve key fish habitats'. The policy definition of Key Fish Habitat includes *Intermittently flowing rivers and creeks that retain water in a series of disconnected pools after flow ceases including those where the flow is modified by upstream dam(s), up to the top of the natural bank regardless of whether the channel has been physically modified*. To determine if any of the waterways within the DZP Site and study area were considered to be Key Fish Habitat, NSW DPI Key Fish Habitats – Dubbo LGA were examined (http://www.dpi.nsw.gov.au/fisheries/habitat/protecting-habitats).

3.5.2 Field Water Quality

A YEO-KAL YK611 hand held, multi-probe water quality meter was used to record *in situ* water quality at each site. Parameters measured include pH, turbidity (NTU), conductivity (µS / cm), temperature (°C) and dissolved oxygen (% saturation and mg / L). Sampling was undertaken following procedures outlined in:

1. AS/NZS 6557.1:1998 Water Quality-Sampling-Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples;
2. AS/NZS 5667.6:1998 Water Quality-Sampling-Guidance on sampling of rivers and streams. Provides detailed guidance on the design of sampling programs, sampling techniques and the handling and preservation of samples from rivers and streams; and
3. Australian Guidelines for Water Quality Monitoring and Reporting (2000).

The water quality data were analysed against parameters set out in the Australian and New Zealand Marine and Fresh Water Quality Guidelines (ANZECC 2000).

3.5.3 Macrophyte and Emergent Vegetation

At each survey site the emergent vegetation and macrophytes were recorded. The emergent vegetation and macrophyte surveys were undertaken to record species abundance and richness. The surveys were quantitative, using five metre wide 25 m long transects, which provided stratified mapping of communities.

3.5.4 Targeted Threatened Species Surveys

A review of literature and liaison with Mr Dave Ward, NSW DPI Fisheries (pers. comm. February 2012), determined the suite of threatened communities, populations and species (including those listed under the FM Act, TSC Act and EPBC Act) to be targeted during the surveys. In addition, Mr Matt Hansen, a local fishing identity, was consulted in regard to species known from the area, preferred local habitat types and recent fish sightings and captures. Overall, the suite of communities, populations and species targeted during the surveys undertaken during 19 – 23 February 2012, was based on:

- Species known from the Central West CMA locality;
- Anecdotal records across the DZP study area; and
- Potential suitable habitat across the DZP Site and DZP study area.

Endangered Ecology Community (EEC)

Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River

Endangered Population

Tandanus tandanus – Eel tailed Catfish in the Murray/Darling Basin as an endangered population

Species

- Trout Cod (*Maccullochella macquariensis*);
- Murray Cod (*Maccullochella peelii*);
- Silver Perch (*Bidyanus bidyanus*);
- Purple Spotted Gudgeon (*Mogurnda adspersa*);
- Olive Perchlet (*Ambassis agassizii*); and
- River Snail (*Notopala sublineata*).

Given that the cod and perch species are known to occur within the Macquarie and Little Rivers (records and anecdotal evidence) and that suitable habitat exists in both of these waterways, active sampling for these species was not undertaken and instead areas of suitable habitat were noted. However, there is little known of the distribution and occurrence of the smaller fish species (Olive Perchlet and Purple Spotted Gudgeon) as they are not actively fished. These species may also have the potential to be present within the upper reaches of the smaller and intermittently flowing waterways upstream from the Macquarie and Little Rivers and therefore have the potential to be directly and / or indirectly affected by the DZP. Consequently, active sampling resources were directed towards these species although techniques employed were also suitable for detecting juveniles of both the cod and perch species.

Where appropriate, surveys were undertaken in line with the *Survey Guidelines for Australia's Threatened Fish* (SEWPaC 2011). In addition, direction was sought from Mr Dave Ward, NSW DPI Fisheries (pers. comm., February 2012) and advice was sought from Mr Leighton Llewellyn (pers. comm., February 2012) for additional information regarding survey techniques for the Purple Spotted Gudgeon and species with the potential to be present within the locality.

A range of survey techniques was used to sample aquatic fauna species at the ten survey sites to increase the probability of sampling a wider range of species and size classes.

The type and dimensions of traps and nets used during these surveys included:

- Single wing fyke net with a central wing (8 m x 1.2 m) attached to the first supporting hoop (diameter = 0.65 m) with a stretched mesh size of 10 mm;
- Dual wing fyke net with two wings (each 2.5 m x 1.2 m) attached to the first supporting hoop (diameter = 0.64 m) with a stretched mesh size of 10 mm;
- Opera House Traps (0.65 m x 0.48 m x 0.22 with a stretched mesh size of 10 mm);
- Seine net measuring 5 m with a mesh size of 5 mm; and
- Bait traps that have a funnelled opening at each end (0.22 m x 0.22 m x 0.4m, with a stretched mesh size of 2 mm).

Timed active searches for snails and other notable invertebrates were undertaken at each of the survey sites. Dead branches and rocks were overturned and macrophytes and emergent vegetation were also searched for the presence of invertebrate fauna.

Techniques used at each of the sites are detailed in **Table 3**.

Table 3 Fauna survey techniques employed at each of the ten sampling sites

Technique	Site									
	A	B	C	D	E	F	G	H	I	J
Bait trap	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Opera House trap	✓	✓	✓	✓			✓	✓	✓	
Fyke net		✓	✓					✓		
Seine net								✓		✓
Active searches	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

All surveys were carried out in accordance with Scientific Collection Permit No. P12/0002-1.0.

Specific methodology for each of the trapping methods is provided below.

Fyke Nets
A single wing fyke net or a dual wing fyke net was deployed at sites with suitable habitat. The fyke nets were positioned to ensure sampling of a diversity of structural habitat (open water, amongst or against vegetation and woody material). The cod-end of each net was set with the cod-end on one bank with the wing attached to the opposite bank, wherever possible. The cod-end was suspended out of the water to avoid the mortality of captured air breathing vertebrates.

Bait and Opera House Traps
Bait traps were used to sample fish and invertebrates amongst woody debris, dense vegetation, steep banks and deep waters. At each site a number of bait traps were deployed. Some were baited (with a variety of baits: dried dog food, sardines, bread) and others were deployed without bait. The traps were placed in the waterway close to vegetation or submerged snags.

Seine Net
Where possible a 5 m seine net was used to sample small mid-water and benthic fish species. Each seine trawl was standardised to 5 m transects with a number of multiple replicates sampled to target a number of habitat types.

To minimise the stress caused to fauna captured during surveys all animals caught were immediately collected using a small ‘enviro’ dip net and placed in aerated holding tanks if identification could not be made immediately. The fish were identified to species, enumerated, measured and immediately returned to the areas where they were captured.

All noxious species were euthanased in clove-oil water and removed from the site.

3.6 Classification of Watercourses

Strahler stream order and Industry & Investment (I&I NSW) classifications were used to broadly categorise watercourses within the DZP Site and study area. The attributes of each of these methods are detailed below.

- Strahler stream ordering provides a measure of complexity and the potential for fish habitat. 1st order streams are often the least complex due to their position at the headwaters, 2nd order streams are where the two flow paths of 1st order join and so on to 4th order streams which are generally very large and permanent waterways; and
- Industry & Investment (I&I NSW) class system describes the characteristics of each waterway class (**Table 4**).

Table 4 I&I NSW classification of fish habitat in NSW waterways

Classification	Characteristics of Waterway Type
Class 1 – Major fish habitat	Major permanently or intermittently flowing waterway (e.g. river or major creek); habitat of a threatened fish species or 'critical habitat'
Class 2 – Moderate fish habitat	Named permanent or intermittent stream, creek or waterway with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Marine or freshwater aquatic vegetation is present. Known fish habitat and / or fish observed inhabiting the area.
Class 3 – Minimal fish habitat	Named or unnamed waterway with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna (e.g. fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or recognised aquatic habitats.
Class 4 – Unlikely fish habitat	Named or unnamed waterway with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free standing water or pools after rain events (e.g. dry gullies or shallow floodplain depressions with no permanent aquatic flora present).

3.7 Weather

The region has received higher than average rainfall since 2011, after a number of years of drought. Rainfall and temperature during the surveys are shown in **Table 5**.

Table 5 Climatic conditions during DZP Site surveys

Parameter	February 2012				
	19	**20**	**21**	**22**	**23**
Temperature (°C)	32.1	26.7	27.8	27.3	30.6
Rainfall (mm)	7.6	3.2	4.6	0	0
Moon Phase	Waxing Crescent				New Moon
Source: Weather Station No. 065070, Dubbo Airport AWS, http://www.bom.gov.au/					

3.8 Limitations

3.8.1 General Limitations

The study design, survey effort and timing of surveys optimised the potential for species to be recorded during a relatively limited survey period. It is not possible to record every species that may be resident or transitory across a site as generally some species may be inactive, dormant or have cryptic habits, or some may be nomadic or migratory in nature. Consequently, it is likely that not all species, either resident or transitory, would have been recorded during the study period. Given the limitations associated with ecological surveys, these studies instead aimed to provide an overall assessment of the ecological values of the DZP Site and study area with particular emphasis on threatened species. For those species of conservation significance that were not detected but with the potential to occur, an assessment of the likelihood of occurrence was based on the presence of suitable habitat.

3.8.2 Mapping Data Limitations

Spatial co-ordinates for features, habitats or species, recorded in the field were captured using a Garmin Etrex Legend Global Positioning System (GPS) and transferred to MapInfo and / or ArcGIS Geographic Information Systems (GIS) programs. The accuracy of GPS readings varies depending on the number of signals obtained by the GPS unit from satellites. Where possible, GPS points were only taken when the accuracy was < 10 m. Consequently, important limitations to the mapping of ecological data exists and these should be given due consideration when interpreting data.

4 RESULTS

4.1 Environmental Setting

4.1.1 Climate

The study area is located in an area that experiences semi-arid climatic conditions where hot summers and cold winters prevail, with average rainfall of 580 mm per year (Dubbo Airport AWS; Bureau of Meteorology (BOM) 2012). Rainfall is generally highest in spring and summer (**Table 6**). Summer temperatures are highest in January with a mean temperature of 33°C, and July recorded the lowest daytime temperature of 15.4°C (Dubbo Airport AWS; BOM 2012).

Table 6 DZP meteorological station rainfall from March 2001 to June 2011

Rainfall	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Ave. Monthly (mm)	38.5	58.7	35.9	29.4	26.9	48.6	39.0	29.1	38.1	41.3	66.9	77.6	497
Max. Monthly (mm)	86.6	133.6	96.6	62.0	72.6	96.2	88.2	102.2	102.6	86.8	162.4	157.8	919.4
Min. Monthly (mm)	9.6	19.0	8.4	0.6	0.6	6.4	7.4	3.8	1.0	0.6	11.4	23.8	179.6
Note: Meteorological station: Wychitella Homestead. Ann. = annual, Ave. = average, Max. = maximum, Min = minimum, mm = millimetre													

4.1.2 Central West Region

The DZP Site is located within the Central West region and Central West CMA. This region includes the Castlereagh, Bogan and Macquarie River valleys. The catchment covers an area of 92,000 km^2, from the central tablelands around Oberon, Bathurst and Rylstone to the western plains around Nyngan and Coonamble. It is flanked by the Barwon and Darling catchments to the north and west, Lachlan to the south and the Sydney / Shoalhaven Basin to the east (DECCW 2010).

The Castlereagh River is approximately 541 km in length and rises in rugged broken country in the Warrumbungle Range to an elevation of approximately 850 m. The Castlereagh River flows through Timor Dam and then into the Broadsheet Lagoon on its way to joining the Macquarie River. The Macquarie River is some 626 km in length and is formed by the joining of the Campbells and Fish Rivers, which drain a high plateau centred near Oberon with a general elevation of 950 m above sea level (asl). The river flows northward through steep gorges in the Hill End area and is impounded by Burrendong Dam upstream of Wellington. The Cudgegong River rises in the sandstone tableland country east of Rylstone, is impounded by Windamere Dam upstream of Mudgee, and then flows through Mudgee and Gulgong before flowing into Lake Burrendong. Windamere Dam (113 km south-east of the DZP Site) on the Cudgegong River, upstream of Mudgee, has a capacity of 368,000

megalitres (ML) and Burrendong Dam (56 km south-east of the DZP Site), at the junction of the Macquarie and Cudgegong Rivers, has a capacity of 1,189,000 ML and is upstream of Wellington.

Downstream of Burrendong Dam, the Macquarie River continues to flow in a north-west direction through Wellington, past the DZP Site and to Dubbo, and is joined by several major tributaries from the eastern and western parts of the catchment. At Narromine the river heads north and commences a complex system of anabranches and effluent creeks that connect the Macquarie, Darling and Bogan Rivers. The Macquarie Marshes are located toward the end of the catchment, although the Macquarie River does emerge from the wetlands before being joined by the Castlereagh River and then flowing into the Barwon River near Brewarrina. The Bogan River is some 617 km in length and rises in the Harvey Ranges between Parkes and Peak Hill. It flows north-west through a broad, flat landscape through Nyngan to join the Darling River near Bourke (DECCW 2010).

The Macquarie Marshes (approximately 210 km northwest of the DZP Site) is one of the largest remaining inland semi-permanent wetlands in south-eastern Australia. It is recognised as an area of international importance for waterbird breeding and was listed as a Ramsar site in 1986.

There are a number of weirs along the Macquarie River: Dubbo, Narromine, Gin Gin and Warren. The regulated section of the Macquarie extends from Burrendong Dam to Pillicawarrina in the Marshes and takes in Bulgeraga Creek, Duck Creek and Gunningbar Creek. Other water sources in the catchment where the flow is augmented include the Ewenmar system, the lower Bogan River, Marra and Crooked Creeks, Marthaguy Creek and the lower Macquarie River. River regulation and water extraction has had substantial effects on flow.

The weirs in the Macquarie River at Dubbo include the North Dubbo Weir and the South Dubbo Weir. North Dubbo Weir is located north of the central business district (CBD) and approximately 1.1 km downstream of the Serisier Bridge. The South Dubbo weir is upstream of the CBD and was constructed around 1941 to provide a more secure water supply for Dubbo (Dubbo City Council 2012).

A reduction in water quality has occurred in almost all streams throughout the catchment. There are increasing trends for the catchment in chemical contamination (nutrients and pesticides), temperature, bacteria levels, heavy metals, turbidity, salinity and pH. Due to the nature of the Macquarie River, most salt generated in the uplands and slopes is deposited back into the landscape through irrigation or floodplain entrapment or it is deposited in the wetlands and effluent systems of the western areas.

Groundwater exists in underground aquifers and is an important source of water for many towns, agriculture and industry within the catchment. Groundwater also helps maintain base flow for streams, rivers and wetlands, as well as plants and animals in and around them. Risks to the groundwater in the catchment are through bore water use and contamination. In some parts of the catchment, water extraction exceeds recharge, resulting in lower groundwater levels and pressure. Some groundwater levels rise when natural systems of plants are removed, or as a result of irrigation. This can bring salts in the water table to the surface and lead to salinity. There are polluted aquifers in urban and rural areas. This may be from land use practices, streams or rivers which are linked to groundwater, or chemical spills which can travel down through the soil into groundwater (Central West CMA 2012).

The State of the Riverine Environment (DECCW 2010) found that the overall fish condition in the Central West region was very poor. Of the individual catchment zones within the Central West region, the Bogan River lowlands was in poor condition, the Macquarie River lowlands, slopes and uplands

were in very poor condition and the Bogan slopes, Macquarie highlands and all zones in the Castlereagh catchment were in extremely poor condition. In addition, the proportion of the fish assemblage that is native versus introduced was poor in the Macquarie slopes and Bogan lowlands, very poor on the Bogan and Castlereagh slopes and in the Macquarie and Castlereagh uplands and Macquarie highlands, and extremely poor in the Macquarie and Castlereagh lowlands. Nonetheless, 24 fish species are known from the Central West CMA (Goldney *et al*. 2007) and these are listed in **Table 7** along with their status.

Table 7 Fish species known from the Central West Catchment Management Authority

Scientific Name	Common Name	Status
Ambassis agassizii	Olive Perchlet	E-FM
Bidyanus bidyanus	Silver Perch	V-FM
Carassius auratus	Goldfish	Introduced
Craterocephalus stercusmuscar	Flyspecked Hardyhead	Native
Cyprinus carpio	Common Carp	Noxious Class 3
Gadopsis marmoratus	River Blackfish	Native
Galaxias olidus	Mountain Galaxias	Native
Gambusia holbrooki	Eastern Gambusia	Noxious Class 1
Hypseleotris klunzingeri	Western Carp Gudgeon	Native
Leiopotherapon unicolor	Spangled Perch	Native
Maccullochella macquariensis	Trout Cod	E-FM, E-EPBC
Maccullochella peelii	Murray Cod	V-EPBC
Macquaria ambigua	Golden Perch	Native
Macquaria australasica	Macquarie Perch	V-FM, E-EPBC
Melanotaenia fluviatilis	Crimson-spotted Rainbowfish	Native
Nannoperca australis	Southern Pygmy Perch	V-FM
Nematalosa erebi	Bony Herring	Native
Oncorhynchus mykiss	Rainbow Trout	Introduced
Perca fluviatilis	Redfin Perch	Noxious Class 1
Philypnodon grandiceps	Flathead Gudgeon	Native
Retropinna semoni	Australian Smelt	Native
Salmo trutta	Brown Trout	Introduced
Salvelinus fontinalis	Brook Trout	Introduced
Tandanus tandanus	Freshwater Catfish	EP-FM

Note: FM = NSW *Fisheries Management Act 1994*, EPBC Act = Commonwealth *Environment Protection and Biodiversity Conservation Act 1999,* E = Endangered, V = Vulnerable, EP = Endangered Population, Noxious Class = Listed Noxious Fish under the FM Act, Introduced = not native to the area.

Little River is a major tributary of the Macquarie River between Burrendong Dam and Dubbo and is an important source of water during winter when water is sourced from the dam for irrigation (Little River Landcare Group Inc. 2001a&b). Cockabroo Creek flows into Little River approximately 6 km north-east of the DZP Site and Little River joins the Macquarie River around 7 km north of the DZP Site. Little River is considered to be one of the best stocked rivers for native fish in NSW. NSW DPI Fisheries has classified it as in *good condition* from a habitat aspect (compared with streams in the Upper New England area). Carp are present in Little River but it also supports good stocks of cod, River Blackfish, and Silver and Golden Perch. Trout cod are also thought to be found here. The numbers of carp present in Little River is reasonably low compared to other rivers in the surrounding area (Little River Landcare Group Inc. 2001a&b).

Pressures on the aquatic ecosystems of the catchment (DECCW 2010) were identified as:

- Competition for resources from introduced fish species: The lowlands of the Macquarie Valley is under greatest pressure from alien fish (ranking of 15 out of 100), followed by the uplands (29 out of 100), then highlands (31 out of 100), followed by the slopes exhibiting the lowest pressure with a score of 42 out of 100;
- Alteration of natural temperature patterns through cold water releases from water storages. Releases from Burrendong Dam, upstream of the DZP Site, are known to reduce the water temperature downstream of the dam for around 400 km;
- Artificial barriers have a major impact on fish passage and aquatic habitat condition;
- Agricultural and urban development including polluted runoff from agricultural, industrial and domestic sources;
- Loss of native vegetation through clearing of riparian zones, clearing of the broader catchment, de-snagging of instream channels and the decline of natural replenishment of instream wood;
- Aquatic and riparian weeds changing the local habitat, flow regimes and out-competing native macrophytes,
- Alteration of natural flow patterns through development, channelisation and dams; and
- Climate change resulting in a decline in biota that is unable to adjust to environmental changes, and alteration of life cycle cues.

4.1.3 Local Catchments

The Toongi Catchment is prone to significant salinity (Smithson 2001) with the surface water described as moderately saline to brackish. Surface and groundwater flows appear to be controlled by basement geology. Surface water salinities average 2,000 to 3,000 µS/cm but can be over 6,000 µS/cm. Groundwater salinities range from 160 µS/cm at discharging springs to over 6,000 µS/cm, with a general increase in salinity downslope in the catchment. Smithson (2001) identified trends in groundwater levels during the 1990s indicating that they were rising at an average of 24 cm/year. Smithson (2001) infers there is interaction between surface and groundwater in this catchment, as the two have similar salinities.

A series of minor watercourses radiate out from the high point near the ore body and all watercourses within the DZP Site drain to the Macquarie River via three catchments (SEEC 2013) (**Figure 7**). The catchment areas and the subcatchment areas (i.e. catchment area within the DZP Site) are detailed in **Table 8**.

Table 8 Catchment Areas

Catchment	Area (ha)		Percentage of Surface Water Study Area
	Total Catchment	Subcatchment DZP Site	
Wambangalang Creek (including Paddys Creek and Meadows Creek)	36,880	1,613	56
Cockabroo Creek	4,260	590	21
Watercourse A (Unnamed tributary of the Macquarie River)	5,820	660	23
Source: RWC 2013			

1. Wambangalang Creek Catchment (including Paddys Creek and Meadows Creek)

Wambangalang Creek drains north-northeast before joining the Macquarie River approximately 7 km north of the DZP Site. The catchment drains an area of approximately 36,880 ha which represents approximately 1.9% of the Macquarie River catchment. The DZP Site subcatchment of 1,613 ha is located in the lower 10% of the catchment (near the confluence point with the Macquarie River). Major creeks draining into Wambangalang Creek include Belowrie, Glennie and Tanners Creeks from the upper western side of the catchment. The Emmagool and Meadows Creeks drain the upper central section of the catchment, and Paddys Creek and Springs Creek drain the upper south-eastern area of the catchment. Approximately 314 ha of the DZP Site actually drains into Paddy's Creek just upstream of its confluence with Wambangalang Creek.

All flows are ephemeral but may have some degree of subsurface flow through unconsolidated alluvium which itself is recharged by rainfall, as well as sub-surface flows emanating from local recharge zones of the volcanic trachyte formations. Topography at the head of the catchment is steep to undulating with granite tors, pavements and rocky outcrops occurring especially near the rim of the catchment. Igneous intrusions (e.g. Turtle Hill) form high hills and knolls which can have steep slopes and rocky outcrops. These rise significantly above the surrounding land. The DZP Site is located in the lower catchment where the slopes are undulating to gentle, although elevations of approximately 400 m occur over the western section of the DZP Site along the catchment boundary with Cockabroo Creek. Elevations within the catchment range from 275 m to 620 m, a rise of 345 m. The Toongi ore body is located within the Wambangalang Creek catchment and forms a low irregular topographic rise with common semi-continuous rock pavements on the south and east side of the body and steeper outcrops of boulders on the north and west side of the body.

2. Cockabroo Creek Catchment

The Cockabroo Creek Catchment of 4,260 ha drains to the east before joining the Little River approximately 4 km east of the DZP Site. Approximately 660 ha of the Cockabroo Creek catchment occurs across the DZP Site where it drains surface flows off a local high point, Dowds Hill, and other rockier and subsequently more densely vegetated areas within the local setting. On the DZP Site, the elevation of the catchment falls from approximately 440 m on Dowds Hill to approximately 300 m within Cockabroo Creek. The Cockabroo Creek Catchment provides the most elevated and steepest terrain across the DZP Site.

3. Watercourse A Catchment

A section of the DZP Site with a catchment area of 796 ha which occurs predominantly on the 'Ugothery' property, flows via several ephemeral channels directly into the Macquarie River which is located approximately 7 km to the north. While the Watercourse A catchment is surrounded by several isolated hills up to 385 m in height, the elevation is generally below 320 m.

4.2 Aquatic Habitat Across the Study Area

4.2.1 Watercourse Classification

Watercourses within the DZP Site and study area range from Strahler 1st order streams at the headwaters of Cockabroo Creek, Watercourse A and Wambangalang Creek Catchments to the Macquarie River, which is classified as a 4th order stream with Class 1 Major Fish Habitat (**Table 9**). While the Macquarie River is known to provide habitat for a range of fish species, some of which are listed as threatened under State and Commonwealth legislation, headwaters of the catchments are unlikely to provide consistent fish habitat due to their undefined channels and lack of water. However, headwaters are considered to be important sites for processing of organic matter and nutrient cycling and are thought to contribute to the maintenance of the health of whole river networks (various authors cited in Clarke *et al*. 2008). The headwaters of the Wambangalang Creek, Cockabroo Creek and Watercourse A Catchments within the DZP study area originate largely in cleared or semi-cleared areas which support grasses, bare soil and rock.

Table 9 Classification of watercourse across the DZP Site and study area

Watercourse	I&I NSW Waterway Classification
Macquarie River	Class 1 – Major fish habitat
Little River	Class 1 – Major fish habitat Class 2 – Moderate fish habitat
Wambangalang Creek	Class 1 – Major fish habitat Class 2 – Moderate fish habitat
Hyandra Creek	Class 2 – Moderate fish habitat
Cockabroo Creek	Class 3 – Minimal fish habitat
Paddys Creek	Class 3 – Minimal fish habitat
Headwaters	Class 4 – Unlikely fish habitat

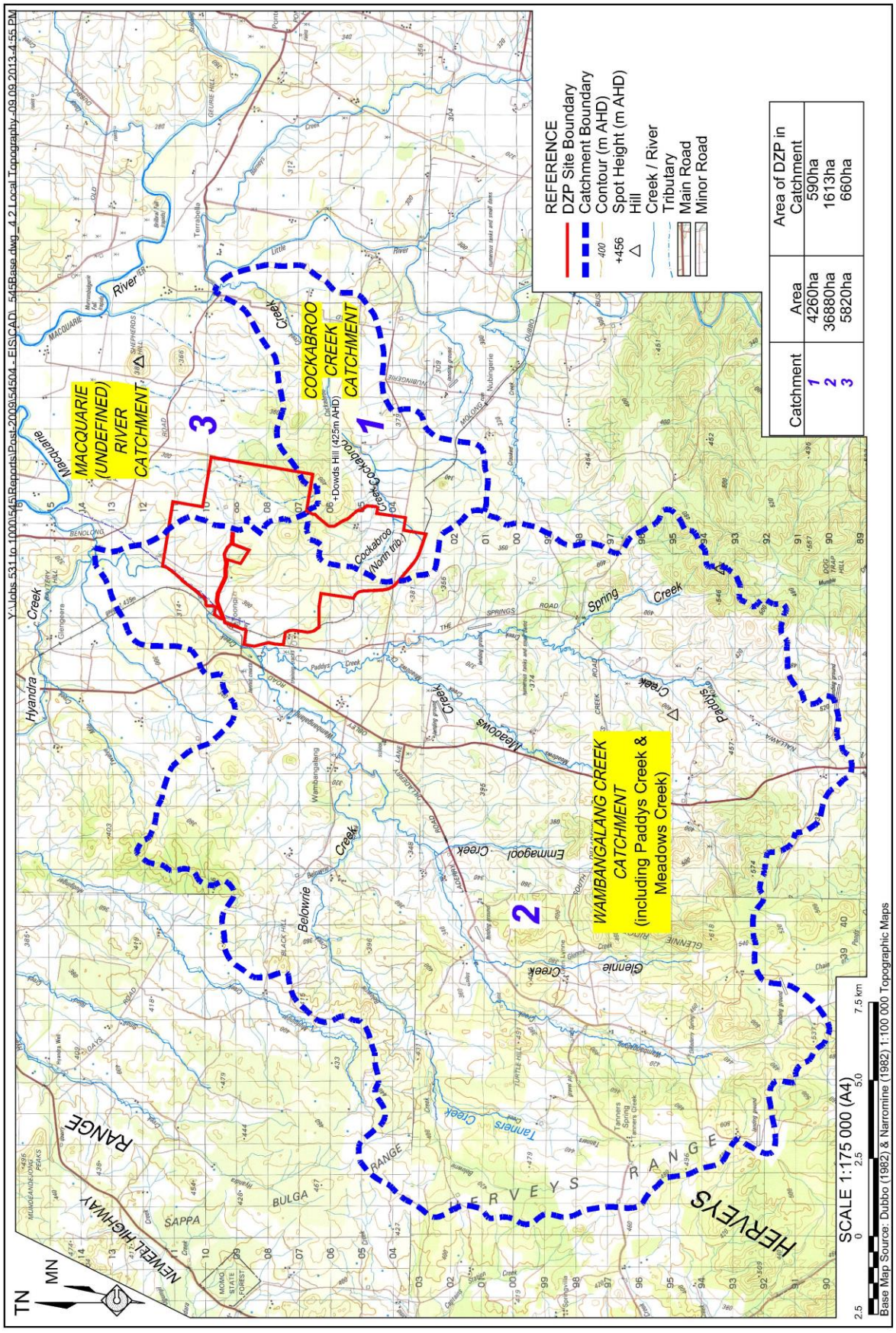


Figure 7 DZP mine site boundaries, catchments, dams and stream orders

4.2.2 Aquatic Habitats

The DZP Site is set within an agricultural landscape that has been altered and farmed for over 150 years. Native vegetation has been cleared with pockets of woodland remaining in non-arable areas, such as on rocky outcrops, and occasionally in very narrow strips along riparian corridors, road reserves and travelling stock reserves. Groundcover is dominated by agricultural grasses and other weeds and crops. Bare soil is common in cropping areas and in areas where erosion has removed topsoil. Sheep, cattle and horses are grazed within the area. Macrophytes are largely absent across the DZP Site and study area with only small occurrences of such species as, Common Reed (*Phragmites australis*) and *Juncus usitatus*. Such alteration of the landscape has resulted in substantial changes to the catchments and waterways.

In general, all of the smaller waterways (i.e. Paddys Creek, Wambangalang Creek, Cockabroo Creek) have been substantially altered and are suffering impacts due to upstream and adjacent land use practices including roads, clearing, weed invasion, alteration of flows, cropping, erosion, sedimentation and salinisation. Such factors have greatly reduced the overall health of these waterways. Modified Riparian, Channel and Environmental Inventory (RCE) (Chessman *et al*. 1997) (**Table 10**) scores reflected this low health as values were, in general, low (e.g. Site E – Paddys Creek and Site B – Watercourse B), suggesting that these would provide poor to moderate aquatic habitat, (e.g. Site F - Hyandra Creek) which would still represent reasonable aquatic habitat even though it is stressed and degraded (**Appendix C** shows full assessment).

Table 10 Modified RCE scores for waterways across the DZP Site and study area

Site	Waterway	Modified RCE Score
A	Wambangalang Creek (Obley Road)	26
B	Watercourse B tributary of Wambangalang Creek	19
C	Wambangalang Creek (Toongi)	26
D	Unnamed tributary of Cockabroo Creek	23
E	Paddys Creek	21
F	Hyandra Creek	33
G	Watercourse A Ugothery Dam	29
H	Wambangalang Creek (Benolong Road)	25
I	Cockabroo Creek (Nuberingerie Road)	22
J	Little River (Terrabella Road)	24

Note: RCE scores after Chessman *et al*. 1997. Scores range from 53 (high quality aquatic habitat) to 13 (lowest quality aquatic habitat).

Although the Dubbo region has been experiencing good rainfall events, all of the smaller watercourses and creeks were dry at the time of assessment, except for:

- Site B – Watercourse B whose headwaters drain the north-western side of the ore body into a large shallow dam and eventually into Wambangalang Creek; and
- Site D – which is a part of the Cockabroo Creek Catchment.

Cockabroo Creek was dry across the DZP study area, but pools of water were present downstream of Nubingerie Road. Wambangalang Creek was not flowing but pools were evident upstream, within and downstream of the DZP Site to its confluence with Little River. Paddys Creek also consisted of small pools while Hyandra Creek was flowing slightly at the Obley Road bridge. The Little River had low flows while the Macquarie River had high water levels and moderate flows.

According to NSW DPI Key Fish Habitats for the Dubbo LGA all named watercourses across the DZP Site and DZP study area are considered to be Key Fish Habitat, including Macquarie River, Little River, Cockabroo Creek, Paddys Creek, Wambangalang Creek and Hyandra Creek.

A detailed description is provided below in Table 11 for each of the ten survey sites targeted during the field surveys. These survey sites are broadly indicative of the watercourses across the DZP Site and study area. Photos of the sites are provided in **Appendix B**.

4.3 Field Water Quality

The apparent low health of the watercourses in the study area is reflected in the water quality measurements at the ten survey sites (Table 12) (refer to Figure 6 for locations of survey sites) and appear to be fairly consistent over time (Golder Associates Pty Ltd 2002 & SEEC 2013). Water temperatures ranged from low to high 20^{o}C and varied with size of pool sampled and time of day, with higher temperatures recorded during afternoons and in small pools. Turbidity was within limits at all sites except for *Site D – Unnamed tributary of Wambangalang Creek* where turbidity was double the upper limit at 52 NTU. Dissolved Oxygen (% saturation DO) was well outside acceptable levels at *Site A – Wambangalang Creek, Obley Road* with only 27% DO. This site also massively exceeded trigger levels for conductivity (see below).

The majority of sites were above the trigger values of 350 µS/cm for conductivity (ANZECC 2000). Values ranged from 1,501 - 4,500 µS/cm indicating extremely high levels of salinity (**Graph 1**). The highest reading of 4,500 µS/cm was recorded at *Site A – Obley Road*. SEEC (2012) also recorded extremely high levels of salinity (i.e. 3,031 µS/cm) at this site on 2 February 2012. These high values of electrical conductivity are most likely related to dryland salinity. Dryland salinity is a consequence of a rise in the water table due to clearing of native vegetation and agricultural practices in an area where the water table is shallow (Smithson 2001).

Three survey sites recorded substantially lower levels of conductivity and these were: *Site D – Unnamed tributary of Cockabroo Creek, Site G – Ugothery Dam (Watercourse A)* and *Site I – Cockabroo Creek at Nubingerie Road*. Both Site D and G are relatively high up in the catchment and hence surface water runoff is still quite fresh (Golder Associates Pty Ltd 2002).

Table 11 Descriptions of the ten survey sites across the DZP Site and study area

Landscape Position	Adjacent Land use	Aquatic Habitat	Instream and Riparian Vegetation	Bank Stability	Fauna Recorded	Overall Water Quality	RCE Score	DPI Class-ification
Site A – Wambangalang Creek, Obley Road								
Upstream of DZP Site. 2 km south Toongi Road turnoff. Single span steel girder bridge.	Road, road reserve, TSR, agriculture	Gravel substrate. Pools. No flow. Some snags. Common Reed instream and along banks.	Mostly cleared. Scattered River Red Gum. Groundcover agricultural grasses and weeds.	Erosion evident especially downstream with vertical sandy walls. Roots of trees exposed.	Common Yabby, Eastern Gambusia*	Very high salinity and low dissolved oxygen.	26	2
Site B – Watercourse B tributary Of Wambangalang Creek								
Site of Residue Storage Facility and headwater of unnamed tributary of Wambangalang Creek adjacent to ore body.	Agriculture – grazing and some cropping.	Large shallow dam fed by drainage line (up to 2 m deep in sections) which drains from the north-western side of ore body. Largely devoid of snags. Silt substrate.	Agricultural grasses and weeds to top of bank. Adjacent floodplain supports Yellow Box (*Eucalyptus melliodora*) as paddock trees.	Highly erodible. Substantial erosion along the length of the drainage line.	Common Yabby, Eastern Gambusia*, Eastern Snake-necked Turtle	High salinity and high turbidity.	19	4

Landscape Position	Adjacent Land use	Aquatic Habitat	Instream and Riparian Vegetation	Bank Stability	Fauna Recorded	Overall Water Quality	RCE Score	DPI Class-ification
Site C – Wambangalang Creek, Railway Crossing								
Railway upgrade area approximately 140 m north-west of Processing Plant and Administration Area.	Agriculture – grazing and some cropping.	Series of pools separated by sand banks. Some pools large. Up to 1 m deep. Gravel / sand substrate. Snags present.	Common Reed present. Agricultural grasses and weeds to top of bank. Occasional River Red Gum (*Eucalyptus camaldulensis*) scattered along banks.	Highly erodible. Substantial erosion along drainage lines feeding into creek.	**Eel-tailed Catfish**, Common Yabby, Eastern Gambusia*, Eastern Snake-necked Turtle	High Salinity	26	1
Site D – Unnamed tributary of Cockabroo Creek								
Site of evaporation pond. Downstream of ore body and approximately 100 m west of the Processing Plant and Administration Area.	Agriculture – grazing and some cropping.	Runs below rocky outcrop of Cypress Pine. Cleared paddocks. Instream vegetation consists of *Juncus usitatus*. Frog spawn was noted amongst the dense tufts.	Agricultural grasses and weeds to top of bank.	Appears moderately stable.	Common Yabby	Freshwater, high turbidity	23	4

Landscape Position	Adjacent Land use	Aquatic Habitat	Instream and Riparian Vegetation	Bank Stability	Fauna Recorded	Overall Water Quality	RCE Score	DPI Class-ification
Site E – Paddys Creek								
Upstream of DZP Site although 100 m west of the Processing Plant and Administration Area.	Agriculture – Intensive cultivation.	Creek is a series of small shallow pools. Small snags occur occasionally. Gravel / sand substrate with some small sections of bank undercutting.	Bare soils and agricultural grasses and weeds to top of bank.	Channel deeply eroded in sections.	Common Yabby, Eastern Gambusia*, Goldfish*	High salinity, low dissolved oxygen.	21	3
Site F – Hyandra Creek, Obley Road								
Sampling site located where Obley Road crosses Hyandra Creek approximately 6.5 km north-west of the DZP Site.	Agriculture – TSR and grazing.	Deep (approx. 1.5 m) pooled area under bridge with a small riffle area downstream. Large snags are present. Substrate is predominately gravel with cobble and pebbles also present at riffles. Common Reed occurs in patches. Mayfly larvae very common.	Agricultural grasses and weeds grow to top of bank with scattered occurrences of River Red Gum.	Appears stable	Common Yabby, Eastern Gambusia*	High salinity	33	2
Site G – Watercourse A Ugothery farm dam								

Landscape Position	Adjacent Land use	Aquatic Habitat	Instream and Riparian Vegetation	Bank Stability	Fauna Recorded	Overall Water Quality	RCE Score	DPI Class-ification
Direct impact area. Located just north-east of main ore body. Occurs within the impact footprint of the LRSF–Area 4.	Agriculture – grazing.	Dam formed near to the headwaters and downstream (north) of the ore body. Waterbody shallow (< 1 m) except at the southern end where water flows into the dam. The dam occasionally dries up. Water spills over the earthen dam wall to the creek below which is currently dry. Overall shading of the dam is low.	Agricultural grasses and weeds grow right to top of bank with scattered remnant / regrowth Eucalypts around the dam.	Low flow regime. Appears stable.	Common Yabby	Freshwater	29	3
Site H – Wambangalang Creek, Benolong Road								
Downstream and offsite of DZP Site.	Agriculture – grazing.	Broad creek with sandy / gravelly substrate with around 30% detritus cover. No macrophytes present. Oily film present across water surface likely from runoff from bridge and road.	Cleared up to creek. Occasional old River Red Gum some with large buttressed roots which are visible due to erosion.	Visible bank erosion.	Common Yabby, Eastern Gambusia*, Eastern Snake-necked Turtle, Western Carp Gudgeon	High salinity	25	1
Site I – Cockabroo Creek, Nuberingerie Road								

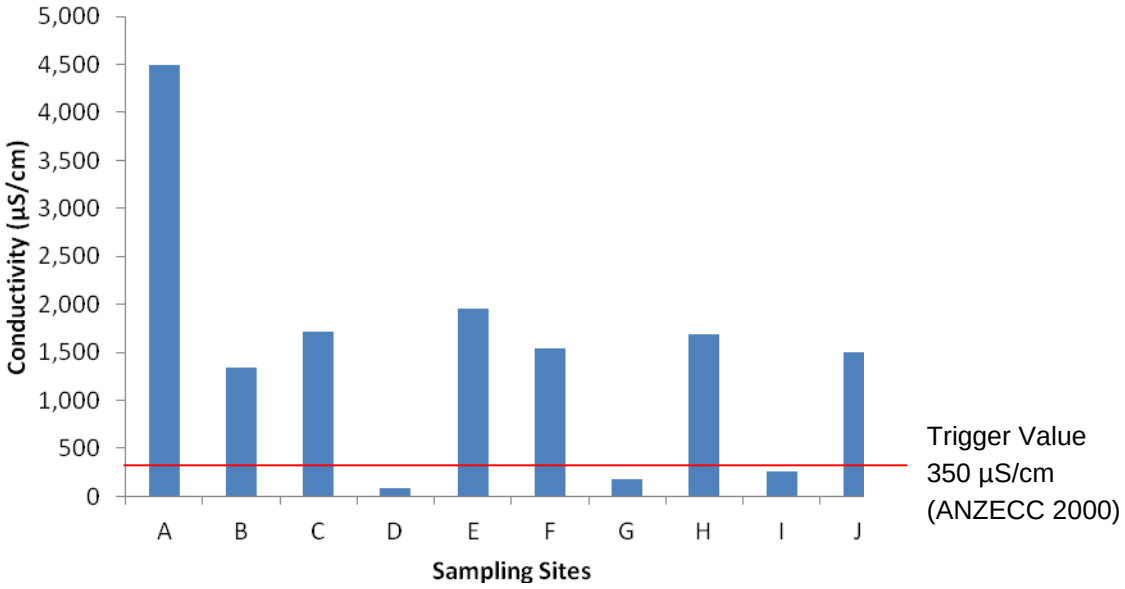
Landscape Position	Adjacent Land use	Aquatic Habitat	Instream and Riparian Vegetation	Bank Stability	Fauna Recorded	Overall Water Quality	RCE Score	DPI Class-ification
6.5 km downstream of mining area where Nuberingerie Road crosses Cockabroo Creek.	Agriculture – grazing and some cropping.	Pools sampled were the first pools in Cockabroo Creek system closest to DZP Site. Pools separated by sandbars. Shallow (< 1 m deep).	Cleared to creek edge. Occasional Acacia sp. and Eucalypt sp. scattered nearby. Some *Juncus usitatus* along banks.	Visible bank erosion especially around road.	Common Yabby	Very low salinity	22	3
Site J – Little River, Terrabella Road								
Offsite, downstream and approximately 7 km north-east of the DZP Site. Sampled near trestle bridge which crosses Little River at Terrabella Road.	Agriculture – grazing and some cropping.	A number of deep pools around and near to the bridge were present. Snags scattered along stream. Substrate gravel / sand.	Cleared to creek edge. Occasional Acacia sp. and Eucalypt sp. scattered nearby.	Visible bank erosion especially downstream.	Common Yabby, Western Carp Gudgeon, Common Carp*	High salinity	24	1
Notes: TSR = Travelling stock route; Fauna Recorded: * = introduced species, **Bold** = indicates endangered population; RCE Score = Modified riparian, channel and environmental inventory (after Chessman *et al*. 1997)								

Table 12 Field water quality measurements at the ten sampling sites

Parameter	Units	ANZECC 2000	Sampling Sites									
		Trigger Values	A	B	C	D	E	F	G	H	I	J
Temperature	^{o}C		21.2	23.8	24.3	21.3	21.6	23.15	26.3	28.6	25.3	21.2
Conductivity	µS/cm	350	**4,500**	**1,335**	**1,718**	88	**1,955**	**1,542**	184	**1,694**	265	**1,501**
Turbidity	NTU	<2 or >25	11.2	24	15.8	**52**	8.5	13.2	3.8	10	24.1	6.8
Dissolved Oxygen	% Sat	<60 or >120	**27**	85	**56**	**26**	**31**	**59**	96	110	65	71
pH		<6.5 or >8	7.38	**8.74**	7.87	6.66	7.86	7.66	**8.15**	7.8	7.4	**8.04**

Notes: Sampled 17 February 2012, using a YEO-KAL YK611 hand held meter. **Bold** & shading = readings exceeding trigger values.

Graph 1 Conductivity values for ten samples across the DZP study area



4.4 Aquatic Fauna Recorded

Seven aquatic fauna species were recorded during the surveys (**Table 13**). Four of these species are native and three are non-native invasive fish species. All but one of the native fauna species recorded are considered relatively common within the Central West CMA although almost all native fish species are considered to have some potential of local extinction due to the alteration / removal of habitat, water quality and invasive species. The once common Eel-tailed Catfish (*Tandanus tandanus*) recorded at Site C is part of the *Eel-tailed Catfish in the Murray / Darling Basin Endangered Population* listed under the NSW FM Act. The distribution has markedly declined over recent years. A similar suite of species were recorded in the Talbragar River catchment and the Cudgegong River catchment approximately 70 km north-east of the DZP Site.

Descriptions of each of the species recorded are provided below.

Goldfish (*Carassius auratus*)
Introduced to Australia as an aquarium fish, this species now survives in still and sluggish water and can tolerate relatively high temperatures and low oxygen levels. A single juvenile (40 mm in length) was trapped in Paddys Creek at Site E. Despite being related to Carp, little is known of the impacts of this species on native fish in terms of competition for resources. Goldfish can be a food source for some predatory freshwater fish such as the Murray Cod (DPI Fisheries 2012c).

Eastern Snake-necked Turtle (*Chelodina longicollis*)
This common turtle occurs across Victoria, the majority of NSW, eastern South Australia and South-east Queensland (Australian Museum 2011). It is known to inhabit freshwater ponds, lakes and streams and to have a diverse diet of amphibians and other aquatic vertebrates and invertebrates (Parker 1999). This species was recorded at Site B (Watercourse B), Site C on Wambangalang Creek and Site H on Hyandra Creek.

Table 13 Aquatic fauna species recorded at the ten sites

Scientific Name	Common Name	A	B	C	D	E	F	G	H	I	J
*Carassius auratus****	Goldfish					✓					
Chelodina longicollis	Eastern Snake-necked Turtle		✓	✓					✓		
Cherax destructor	Common Yabby	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cyprinus carpio *[3]	Common Carp										✓
Gambusia holbrooki *[1]	Eastern Gambusia	✓	✓	✓		✓	✓		✓		
Hypseleotris klunzingeri	Western Carp Gudgeon								✓		✓
Tandanus tandanus	**Eel-tailed Catfish**			✓							

Note: **Bold** = Endangered Population. Listed Noxious Fish under the FM Act: 1 = Class 1, 3 = Class 3, * = non-native species.

Common Yabby (*Cherax destructor*)

The Common Yabby was the most commonly recorded species with adult and juveniles being recorded at all ten survey sites. This species is especially hardy and can survive years of drought by burrowing, later emerging during wet periods to feed, breed and migrate. It has been recorded in a wide range of habitats including lakes, swamps, billabongs, farm dams, irrigation canals and bore drains (mainly still, warm waters) and also in slow, muddy rivers and creeks. It can also tolerate a wide range of water temperatures and water quality (NSW DPI Fisheries 2012d).

Common Carp (*Cyprinus carpio*)

Carp is listed as a *Class 3 Noxious Fish* in NSW. This highly adaptable species is normally found in still or slowly flowing waters at low altitudes and brackish lower reaches of some rivers and coastal lakes. Carp are omnivorous, and their diet varies depending on food availability. They consume a range of small food items such as molluscs, crustaceans, insect larvae and seeds. These food items are sucked up (along with mud and water) from the bottom and filtered out using the gill rakers. Carp are known to have major impacts on watercourses including a reduction of water quality through an increase in turbidity, erosion, impacts on invertebrates and aquatic plants, all resulting in the continual decline of native fish numbers (DPI Fisheries 2012e). A control plan has been developed to manage this species and its impacts on watercourses (Industry & Investment NSW 2010).

Eastern Gambusia (*Gambusia holbrooki*)

It is likely that the Eastern Gambusia would find suitable habitat at all ten sites although it was only recorded at six of the sites. The sites at which it was not recorded were *Site D – spring fed stream, Site G – Ugothery dam (Watercourse A), Site I – Cockabroo Creek* and *Site J – Little River*. This species was introduced into Australia in the 1920s. Their preferred habitat niche is still and slowly flowing waters, such as wetlands and backwaters, predominantly occupying the upper water column and littoral zone. Their broad omnivorous diet includes detritus, aquatic and terrestrial invertebrates, eggs and larvae of fish and amphibians (Macdonald & Tonkin 2008). Such adaptability makes it an aggressive and voracious predator able to live in a wide range of habitats (NSW Scientific Committee 1999). The

Eastern Minnow is linked to the decline of a number of fish and amphibian species due to the breadth of its preferred habitat (Goldney *et al.* 2007). Predation by this species is listed as a Key Threatening Processes under the NSW TSC Act.

Western Carp Gudgeon (*Hypseleotris klunzingeri*)

The Western Carp Gudgeon was trapped at Wambangalang Creek at Site H and the Little River at Site J. This small fish is a common species and widespread throughout the tributaries of the Murray – Darling. They are most common in slow flowing rivers and streams or the still waters of lakes, billabongs and dams, among aquatic vegetation. This species consumes a range of prey, including caddisflies, odonates, shrimps and detritus with the bulk of their diet volume consisting of chironomids and zooplankton (Balcombe & Humphries 2006). They are also considered an important forage fish for other larger native species such as the Murray Cod, Golden Perch, Macquarie Perch and Catfish (North Central CMA & Waterwatch North Central (Undated).

Eel-tailed Catfish (*Tandanus tandanus*)

The Eel-tailed Catfish was recorded in Wambangalang Creek at Site C where the disused railway line crosses the creek via a trestle bridge. This site consisted of a number of still, turbid pools up to 1.5 m in depth with some containing large snags. The seven individuals caught at Site C ranged from 140 - 400 mm with the largest weighing upwards of approximately 2.5 kg. Given that this species does not migrate and that individuals caught exhibited a range of sizes it would suggest that this population has reproduced successfully in recent years.

Further information for this population is provided in Section 5.3.2.

4.5 Noxious Aquatic Species

4.5.1 Noxious Aquatic Fauna

Fauna species listed as Noxious under the FM Act are organised into categories depending on the perceived threat they pose to the aquatic environment. These categories have different management mechanisms (**Table 14**). Those species recorded in this study as Noxious included:

- Common Carp Class 3; and
- Eastern Gambusia Class 1.

The Goldfish, an introduced species, was also recorded but this species is not listed as Noxious.

Redfin Perch (*Perca fluviatilis*) is also known to occur within the Little River catchment (Little River Landcare Group Inc. 2001a&b) and this species is listed as a Class 1 Noxious fish species.

Table 14 Summary of rules and exemptions for noxious fish in NSW.

Class	Possession			Sale	Destruction Required	Management
	Aquarium	Garden Pond	Farm Dam			
1	No	No	No	No	Yes	Strategies developed for rapid response to any outbreaks.
2	Yes	No	No.	No	Yes (conditional) Destruction of fish is not required if kept in fully contained aquarium.	Control / eradication where possible.
3	Yes	Yes	Yes	Yes	No	Eradication and awareness campaign to discourage possession and sale.

4.5.2 Noxious Aquatic Flora

Water Lettuce (*Pistia stratiotes*) is an introduced aquatic plant species. It is free-floating and can quickly cover an entire body of water. It has been listed as Noxious under the *Noxious Weeds Act 1993* (NW Act) and is considered a Class 1 weed within the Dubbo City Council area. Under the NW Act a Class 1 weed *must be eradicated from the land and the land must be kept free of the plant*. There are concerns that recent floods in Queensland and northern NSW could spread this species into the Darling River system. However, this aquatic weed was not recorded across the DZP Site.

4.6 Groundwater Dependent Ecosystems

Groundwater Dependent Ecosystems (GDEs) have the potential to be impacted by groundwater drawdown, changes to water flows and changes to groundwater composition. GDEs are a diverse and important component of biological diversity and include ecosystems that use groundwater as part of their survival strategies, and can potentially include wetlands, vegetation, mound springs, river base flows, cave ecosystems, playa lakes and saline discharges, springs, mangroves, river pools, billabongs and hanging swamps and near-shore marine ecosystems.

The level of groundwater dependence of ecosystems can range from complete to partial reliance on groundwater. The degree and nature of groundwater dependence will influence the extent to which they are affected by changes to the groundwater system, both in quality and quantity. Ecological processes in groundwater dependent ecosystems are threatened by the regular extraction of groundwater and changes in land use or management. Species and communities that require permanently wet conditions, particularly in arid, semi-arid or seasonally dry conditions are more likely to be groundwater dependent than those tolerant of a regular cycle of wetting and drying.

Groundwater investigations for the DZP (EES 2013) found that:

The GDE map (after BOM 2012) shows that, in the vicinity of the site, Paddy's Creek to the west is listed as having a *high potential for groundwater interaction*. Groundwater interaction refers to a surface water system that is *reliant on surface expression of groundwater*.

Wambangalang Creek to the north of Obley Road and Cockabroo Creek to the north of Eulandool Road are both listed as having a *moderate potential for groundwater interaction*. There is no vegetation in the vicinity of the DZP Site listed as being reliant on subsurface groundwater, and no subterranean GDEs (caves or aquifers). Based on these findings, it can be concluded that the creek systems to the west and south of the DZP Site rely on groundwater discharge to support their ecosystems, but there are no other known GDEs within the DZP Site groundwater flow system.

5 CONSERVATION SIGNIFICANCE

A number of features of conservation significance occur, or have the potential to occur, across the locality, study area and DZP Site, and these are outlined below and detailed in **Appendix D**.

5.1 Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

Matters of NES listed under the EPBC Act which may be relevant to the DZP include:

5.1.1 Wetlands of International Significance (Ramsar Sites)

Macquarie Marshes Nature Reserve is located in central northern NSW, around 200 km north-west of Dubbo. The Macquarie Marshes are one of the largest remaining inland semi-permanent wetlands in south-eastern Australia and are of international importance as a major waterbird breeding area and as an important refuge for a large number of other wildlife species. The Macquarie Marshes were listed as a Ramsar Site in 1986. The Macquarie River passes through the Macquarie Marshes.

The DZP would not directly impact the Macquarie Marshes and its distance from the DZP site makes indirect impacts unlikely. Specific detail on the potential impacts of the DZP on the Macquarie Marshes was supplied to SEWPaC on referral of the DZP. SEWPaC confirmed that the DZP is unlikely to impact on this Matter of NES

5.1.2 Communities

There are no aquatic ecological communities listed under the EPBC Act with the potential to occur within the locality.

5.1.3 Populations

There are no aquatic populations listed under the EPBC Act with the potential to occur within the locality.

5.1.4 Species

Predictive modelling indicates that two species of freshwater fish listed under the EPBC Act have the potential to occur within the locality of the DZP, and these are the Trout Cod (*Maccullochella macquariensis*) and Murray Cod (*Maccullochella peelii peelii*). Both of these species are known from the Macquarie River.

Trout Cod (*Maccullochella macquariensis*) is listed as Endangered under the FM Act and EPBC Act. It is known from the Central West CMA and there are records in the Macquarie River and anecdotal records from Little River (Little River Landcare Group Inc. 2001a&b). The Trout Cod is a large, elongated, deep-bodied fish that is very similar in appearance to the Murray Cod. It is endemic to the southern Murray-Darling river system, including the Murrumbidgee and Murray Rivers, and the Macquarie River in central NSW. This species has been restocked into the Murrumbidgee and Macquarie Rivers over the last decade. Trout Cod are often found close to cover and in relatively fast currents, especially in fairly deep water close to the bank, and often congregate around snags. They tend to remain at the one site and to have small home ranges. They are carnivores, preying mainly on other fishes as well as crustaceans and aquatic insects.

Given its propensity for relatively fast currents and fairy deep water, it is unlikely that this species would be present across the DZP Site due to lack of habitat and therefore the potential for direct impacts on this species is very unlikely. However, habitat for this species is present within the DZP study area and CMA locality

Murray Cod (*Maccullochella peelii peelii)* is listed as Vulnerable under the EPBC Act. It is the largest freshwater fish found in Australia and is a long-lived predatory species that is highly territorial and aggressive. It occurs naturally in the watercourses of the Murray–Darling Basin in a wide range of warm water habitats that range from clear, rocky streams to slow flowing turbid rivers and billabongs up to 5 m deep. Murray Cod are generally found in areas sheltered by rocks, wood or overhanging banks, with wood debris being an essential habitat feature used for sheltering from currents. This species is mostly found in the major rivers and larger tributaries. Whilst Murray Cod are known from the Macquarie River and anecdotal reports suggest its presence in the Little River, it is unlikely that any of the smaller tributaries would regularly provide habitat for this species.

5.2 NSW *Threatened Species Conservation Act 1995*

A search of the NSW BioNet Atlas of the NSW Wildlife database identified no aquatic threatened species, populations or communities listed under the TSC Act that might be present within the DZP Site or study area.

5.3 NSW *Fisheries Management Act 1994*

Matters listed under the FM Act which have the potential to be affected by the DZP include one Endangered Ecological Community, two endangered populations and four threatened species and these are discussed in the following sections.

5.3.1 Communities

Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River *(Darling River EEC).* This community is listed as an Endangered Ecological Community under the FM Act and is known to occur within the region.

The Darling River EEC includes all native fish and aquatic invertebrates within all natural creeks, rivers, streams and associated lagoons, billabongs, lakes, anabranches, flow diversions to anabranches and the floodplains of the Darling River within NSW up to 500 m AHD, and includes the Macquarie River downstream from the Burrendong Dam and its tributaries. Excluded are man-made / artificial canals, water distribution and drainage works, farm dams and off-stream reservoirs (NSW DPI Fisheries 2007, Fisheries Scientific Committee 2010a). This EEC is characterised by meandering channels and a variety of habitats that form an integral part of the river system, including deep channels and pools, wetlands, gravel beds and floodplains. The complex river morphology provides a multitude of aquatic habitats that play a critical role in the life cycles of the species comprising the community. In its natural state, many of the water-bodies in this area are characterised by variable and unpredictable patterns of high and low flows and many of the species have adaptations in their life history which reflect this unpredictable nature (NSW DPI Fisheries 2007).

Aquatic communities of the Macquarie River, Little River, Wambangalang Creek, Cockabroo Creeks including the DZP Site, DZP study area and locality all support this EEC as:

- These are natural creeks and rivers of the Darling River system;
- The DZP Site and study area occupies altitudes below 500 m AHD (approximately 280 – 350 m AHD);
- The Macquarie River within the study area and its tributaries (i.e. Little River, Wambangalang Creek, Cockabroo Creek) are all downstream of the Burrendong Dam;
- A number of species which characterise this community were recorded in these watercourses; and
- These watercourses provide habitat for a larger range of aquatic animal species than was recorded during these surveys.

5.3.2 Endangered Populations

There are two populations listed as Endangered under the FM Act which are known from the Central West CMA and these are described below.

Western NSW population of the Olive Perchlet, *Ambassis agassizii* is known from the Central West CMA. This once widespread species has suffered a serious decline and is now found only at a few sites in the Darling River drainage upstream of Bourke where it inhabits rivers, creeks, ponds and swamps. The most recent records of this species are from the Bogan River (1995, 2002), Dumaresq River (2003, 2004, 2005), Lachlan River (2008) and Mole River (2008) (NSW DPI Fishing and Aquaculture, Records Viewer 2012b, accessed July 2012).

They are usually found in slow-flowing or still waters, often near overhanging vegetation or amongst logs, dead branches and boulders. They often congregate around suitable shelter (e.g. large woody debris (snags) and vegetation) during the day but disperse during the night to feed on micro-crustaceans and insects, including larvae (Fisheries Scientific Committee 2009, McNeil *et al*. 2008).

There are a number of recognised threats to the ongoing survival of this species including:

- Predation by introduced fish such as Gambusia and Redfin Perch;
- Habitat degradation, including the removal of vegetation, logs and large woody debris (snags);
- Rapid fluctuations in water levels as a result of river regulation, leading to negative impacts on reproduction and recruitment; and
- Spawning failures due to cold water releases from dams.

It is considered unlikely that this species would occur in the watercourses of the DZP Site as these are generally ephemeral headwaters and / or highly degraded creeks suffering from many of the recognised threats for this species. It is more likely that this species may occur within the wider study area and locality.

***Tandanus tandanus* – Eel-tailed Catfish in the Murray / Darling Basin** was recorded within the Wambangalang Creek at Site C where the disused railway line crosses the creek via a trestle bridge. This site consisted of a number of still, turbid pools up to 1.5 m in depth with some containing large snags. This species may also be present in other sections of the creek with suitable habitat (e.g. deep pools and snags) as well as the Macquarie and Little Rivers.

This species is naturally distributed throughout the Murray-Darling Basin and in the eastern drainages of NSW north of Newcastle. *Tandanus tandanus* is non-migratory and lives in a wide range of habitats including rivers, creeks, lakes, billabongs and lagoons, and although it inhabits flowing streams, it prefers sluggish or still waters. It can be found in clear to turbid waters, and over substrates ranging from mud to gravel and rock. This species is a carnivore that feeds on crustaceans (mainly yabbies and shrimp), molluscs, aquatic insects and small fish. It is a benthic species that lives, feeds and breeds near the bottom. The Eel-tailed Catfish can grow up to 900 mm and 6.8 kg although individuals over 2 kg are uncommon (Fisheries Scientific Committee 2008). It is rare in natural riverine habitats but can be found in farm dams throughout inland NSW and southern Queensland. Moderate remnant populations occur in the Macquarie catchment upstream of Warren, the Castlereagh catchment upstream of Mendooran, the Namoi catchment upstream of Wee Waa, the Gwydir catchment upstream of Moree and the Border Rivers catchment upstream of Goondiwindi. Eel-tailed Catfish numbers in the Murray-Darling Basin have declined due to a range of impacts including competition from invasive species, habitat degradation, cold water pollution and fishing pressures, and are now virtually absent from the Murray, Murrumbidgee and Lachlan catchments.

5.3.3 Threatened Species

Four aquatic species listed under the FM Act are known from the Central West CMA or have the potential to occur within the study area.

Trout Cod (*Maccullochella macquariensis*) is listed as Endangered under the FM Act and EPBC Act. It is known from the Central West CMA and there are records from the Macquarie River (both upstream and downstream of the DZP Site (NSW DPI Fishing and Aquaculture, Records Viewer 2012b, accessed July 2012)) and anecdotal records from Little River (Little River Landcare Group Inc. 2001a&b). The Trout Cod is a large, elongated, deep-bodied fish that is very similar in appearance to the Murray Cod. It is endemic to the southern Murray-Darling river system, including the Murrumbidgee and Murray Rivers, and the Macquarie River in central NSW. This species has been restocked into the Murrumbidgee and Macquarie Rivers over the last decade. Trout Cod are often found close to cover and in relatively fast currents, especially in fairly deep water close to the bank, and often congregate around snags. They tend to remain at the one site and to have small home ranges. They are carnivores, preying mainly on other fishes as well as crustaceans and aquatic insects.

Given its propensity for relatively fast currents and fairly deep water, it is unlikely that this species would be present across the DZP Site due to lack of habitat and therefore the potential for direct impacts on this species is unlikely.

Purple Spotted Gudgeon (*Mogurnda adspersa*) is listed as Endangered under the FM Act. It was once common and widely distributed throughout south-eastern Australia (Faulks *et al.* 2008) but is now extremely rare in inland NSW, having been recorded from this area only once since 1983. They are generally found in slow-moving or still waters (Boxall *et al*. 2002) of rivers, creeks and billabongs, often amongst weeds, rocks or large snags (Llewellyn 2006). The only known naturally occurring population in the Central West is 47 km south-east of the DZP Site in a small tributary that flows into the Macquarie River downstream from the Burrendong dam wall. The Wuuluman Creek site is approximately 1 km upstream from the creeks confluence with the Macquarie River. The pools are free from other fish species. Carp and redfin have been known to swim upstream during floods as far as the site, but do not survive when water levels drop. The aquatic habitat quality is good with abundant cumbungi and aquatic macrophytes. *In-situ* rocks are abundant and water depth was over 2 m when inspected. This pool is persistent and has reportedly never dried (David Ward, pers. comm. February 2012).

Recognised threats to the ongoing survival of this species include:

- Predation by introduced fish such as Gambusia and Redfin Perch;
- Habitat degradation, particularly the loss of aquatic plants; and
- Fluctuations in water levels as a result of river regulation, leading to negative impacts on reproduction and recruitment.

There is potential habitat present in Macquarie and Little Rivers and some very marginal habitat in sections of Wambangalang Creek. However, this species is extremely vulnerable to competition from Eastern Gambusia which occurs throughout the DZP Site and study area, making it less likely that a population of this species would occur.

Silver Perch (*Bidyanus bidyanus*) is listed as Vulnerable under the FM Act. This once widespread and abundant species is now confined to the Murray-Darling river system. Silver Perch are thought to prefer fast-flowing, open waters, especially where there are rapids and races, however they will also inhabit warm, sluggish water with cover provided by large woody debris and reeds (NSW DPI Fisheries 2005). This species is known from the Central West CMA (Goldney *et al*. 2007) with a number of records from the Macquarie River, downstream of the DZP Site (NSW DPI Fishing and Aquaculture, Records Viewer 2012b, accessed July 2012).

There are some pockets of potential habitat for this species in the Little River, Wambangalang Creek and Hyandra Creek.

River Snail (*Notopala sublineata*) is listed as Endangered under the FM Act. The river snail once occurred in flowing rivers throughout the Murray-Darling system, where it was found along the banks attached to logs and rocks or crawling in the mud. Although now virtually extinct throughout its natural range, some populations have been recorded as surviving in artificial habitats (irrigation pipelines) in the Murray-Darling system (Fisheries Scientific Committee 2010b).

This species is unlikely to be present across the DZP Site and study area due to the substantial changes to aquatic habitat in this area.

6 IMPACT ASSESSMENT

6.1 Potential Impacts Associated with the DZP Construction and Operation

The footprint of the DZP has been designed to avoid where possible direct and indirect impacts to the aquatic ecology, and especially those areas of conservation significance. Nonetheless, there is the potential for a number of impacts as a consequence of construction and operation of the DZP. The key components of the development of the DZP and potential for impacts are shown in **Table 15**.

Table 15 Potential impacts associated with construction and operation of the DZP

Component	Potential Impact	
	Direct	Indirect
Open cut mining area	Alteration of natural flows due to removal of headwaters and changes to the upper catchment.	Mobilisation of sediment resulting in habitat degradation during construction. Changes in water quality. Noise and vibration.
Processing plant and administration area		Increase runoff due to increase in hard surface areas. Mobilisation of sediment resulting in habitat degradation during construction. Changes in water quality. Noise and vibration.
Liquid residue storage facility	Alteration of natural flows due to removal of headwaters and changes to the upper catchment.	Mobilisation of sediment resulting in habitat degradation. Potential for leakage into groundwater and downstream systems.
Solid residue storage facility	Alteration of natural flows due to removal of headwaters and changes to the upper catchment.	Mobilisation of sediment resulting in habitat degradation during construction. Changes in water quality.
Soil stockpile areas	Alteration of natural flows due to removal of headwaters and changes to the upper catchment.	Mobilisation of sediment resulting in habitat degradation during construction. Changes in water quality.
Salt encapsulation cells	Alteration of natural flows due to removal of headwaters and changes to the upper catchment.	Mobilisation of sediment resulting in habitat degradation during construction. Potential for leakage into groundwater and downstream systems.
Waste rock emplacement	Alteration of natural flows due to removal of headwaters and changes to the upper catchment.	Mobilisation of sediment resulting in habitat degradation during construction. Changes in water quality.
Site access road	Instream structures related to infrastructure obstructing fish passage	Mobilisation of sediment resulting in habitat degradation during construction. Changes in water quality.

Component	Potential Impact	
	Direct	**Indirect**
Mine haul road	Instream structures related to road obstructing fish passage.	Mobilisation of sediment resulting in habitat degradation during construction. Changes in water quality.
Rail line upgrade and rail siding	Instream structures related to the rail line upgrade obstructing fish passage. Removal and disturbance of Freshwater Catfish habitat at Toongi. Removal and disturbance of Lowland Darling River aquatic ecological community.	Mobilisation of sediment resulting in habitat degradation during construction. Changes in water quality.
Macquarie River water abstraction and pipeline	Instream structures related to pipeline obstructing fish passage. Entrainment and impingement of fish, fish larvae and eggs of native fish species at abstraction site. Removal and disturbance of Lowland Darling River aquatic ecological community.	Mobilisation of sediment resulting in habitat degradation during construction. Changes in water quality.
Natural gas pipeline	Instream structures related to pipeline obstructing fish passage. Removal and disturbance of Lowland Darling River aquatic ecological community.	Mobilisation of sediment resulting in habitat degradation during construction. Changes in water quality. Noise and vibration.

6.2 Potential Impacts

6.2.1 Alteration of natural flows due to removal of headwaters and changes to the upper catchment

Mining of the ore body and construction and operation of the liquid and solid residue storage facilities, soil stockpile areas, salt encapsulation cell and waste rock emplacement all have the potential to alter the upper reaches of tributaries of the Wambangalang Creek, Cockabroo Creek and Macquarie River catchments through removal of catchment area and headwaters and changed flow patterns and volumes. Changes to flow regimes can alter abundance and distribution of aquatic fauna and flora as:

- Flow is an important determinant of physical habitat in streams;
- Flows maintain natural patterns of connectivity (both longitudinally and laterally) that are essential to the viability of populations of aquatic species;
- Life history strategies of aquatic species have evolved in response to natural flows; and
- Changes to flows patterns have been shown to facilitate the invasion of exotic and introduced species.

The mean annual runoff from the 2,864 ha of the DZP Site is estimated to be 1,775 ML / year. Water balance modelling for the DZP indicates that the proposed liquid and solid residue storage facilities, Salt Encapsulation Cells, bunded processing areas and the Open Cut represent a loss of approximately 640 ha from local stream catchments and so this represents a mean annual runoff loss of approximately 453 ML / year (SEEC, 2013). The estimated loss from each catchment and the overall reduction in flows within the catchment are shown in **Table 16**.

Table 16 Estimated loss of surface water runoff and percentage of existing flows

Catchment	Estimated Loss (ML)	Estimated Reduction in Flow (%)
Wambangalang Creek	338	1.3
Watercourse A	95	20
Cockabroo Creek	20	5
Source: SEEC 2013		

Along with a reduction of surface water affecting flow regimes the removal of headwaters from systems can potentially impact the health of whole river networks as these are considered to be important sites for processing of organic matter and nutrient cycling (various authors cited in Clarke *et al*. 2008). Consequently, there is the potential that the DZP would potentially impact the health of river networks within the locality.

6.2.2 Obstruction of fish passage due to instream structures

The construction and operation of the DZP has the potential to obstruct movement of aquatic biota as a consequence of the construction of road and rail crossings and laying of pipelines. The disruption of movement patterns along streams can effectively isolate populations resulting in their gradual decline and in some cases local extinction.

Whilst the majority of the existing road and rail crossings of watercourses are adequate for the purposes of operation of the DZP, a number would require upgrading to meet the required specifications, including all of the timber bridges associated with the rail line.

All new structures across watercourses would be designed and constructed in line with the *Guidelines and Policies for Aquatic Habitat Management and Fish Conservation* (NSW Fisheries 1999) and *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull & Witheridge 2003).

In addition, the proposed water pipeline and natural gas pipeline would cross several ephemeral drainage lines which flow into Wambangalang Creek. The pipeline would be installed across these drainage lines by trench excavation during periods of no flow within the channels and in accordance with *Controlled Activities on Waterfront Land Guidelines 2012* for laying pipes and cables in watercourses on waterfront land. This would have few impacts on aquatic ecology as long as the trenched areas are protected from erosion and reinstated with vegetation to prevent erosion and downstream impacts. Alternatively, the pipelines would be installed by directional drilling (under-boring) methods or possibly hung below the rail line for larger bridge crossings such as that of the Macquarie River. Trenching

across ephemeral drainage lines and directional drilling would have few impacts on aquatic ecology as long as the trenched and bored areas are protected from erosion and reinstated with vegetation to prevent erosion and downstream impacts. Hanging of the pipeline below bridges would have few impacts.

6.2.3 Mobilisation of sediment resulting in habitat degradation during construction

The DZP involves significant earthworks and this has the potential to mobilise sediments into watercourses. In the absence of mitigation measures the movement of sediments into watercourses could occur due to the following factors:

- Site establishment and preparation works involving vegetation clearing, soil stripping and soil stockpiling;
- Airborne dust from construction works may enter watercourses;
- Compaction of surfaces in construction areas may reduce infiltration of surface waters resulting in sediment being present in runoff;
- Road and rail upgrade and construction;
- Laying of the water and natural gas pipelines;
- Construction of temporary coffer dams on Macquarie River for the installation of the take-off pipe for water abstraction and Wambangalang Creek for the reconstruction of the Toongi rail bridge; and
- Overflow from sedimentation ponds.

The mobilisation of sediments into watercourses can result in the:

- Smothering of vegetation and an increase in light attenuation which can decrease the productivity of instream vegetation and increase mortality;
- An increase in nutrients which can cause eutrophication;
- Infill of habitat refugia and smothering of spawning habitat; and
- Decrease in growth rates and mortality as suspended particles can obstruct gills and feeding structures of fish.

In addition, it is known that suspended sediments can travel many kilometres downstream of impact sites and hence the Macquarie River catchment could be at risk (Wheeler *et al*. 2005).

6.2.4 Changes in water quality

Construction and operational activities across the DZP Site have the potential to reduce water quality through contamination of watercourses as a consequence of runoff of contaminants from the site during construction and operation. In the absence of mitigation measures the contamination of watercourses could occur through:

- Contamination from hazardous reagents used in the mining process;
- Pollutants from heavy machinery and construction equipment including lubricants, oils, fuels and heavy metals associated with tyres and brake linings;
- Uncontrolled surface water runoff from the Soil Stockpile Areas;

- Leakage from Liquid Residue Storage Facilities and Salt Encapsulation Cell; and
- Sewage and grey water spills.

In the absence of mitigation measures, contamination could result in changes to the assemblages and mortality of aquatic plants and fauna within watercourses downstream of the DZP Site, including the Macquarie River and through infiltration into groundwater aquifers.

6.2.5 Entrainment and impingement of aquatic organisms & water abstraction

Processing of the ore would require up to 4,050 ML of water per year. A significant proportion of this annual water requirement would be obtained under licence in accordance with the *Water Sharing Plan for the Macquarie and Cudgegong Regulated Rivers Water Source 2003.* The water would be abstracted from the Macquarie River at the existing *Mia Mia* property river pumping location (**Plate 1**).

Plate 1 Abstraction point on the Macquarie River

Source: RWC 2012

There is the potential for impacts as a consequence of water abstraction and these include:

- Entrainment and loss of eggs, larvae, and juvenile fish (including threatened species) extracted via the pump and pipeline system;
- Mechanical damage and fish mortality from pumps; ·
- Impacts on refuge pools, key fish habitats and threatened species habitat due to extraction during low flows; and
- Alterations to the existing hydrology within the Macquarie River as a result of extraction.

The entrainment of propagules, larvae and juvenile fish through the intake mechanisms can cause mechanical injury and death and whilst it is recognised that some individuals do manage to survive and form viable populations in off-river canals and impoundments, fish and invertebrates are still lost from natural river populations (Baumgartner *et al.* 2009) and this may alter the population structure of species. Similarly, pumps can also impact species and populations through mechanical damage and

fish mortality (Blackley 2003). A study on the Namoi River (Baumgartner *et al.* 2009) showed that native fish that were entrained included Golden Perch (*Macquaria ambigua*), Murray Cod (*Maccullochella peelii peelii*), Murray Rainbowfish (*Melanotaenia fluviatilis*), Bony Herring (*Nematolosa erebi*), Carp Gudgeon, Catfish and species of Australian Smelt as well as the introduced Goldfish and Carp. Many of these species are likely to occur at least on occasion within this reach of the Macquarie River. This study also showed that there was considerable variation in the rates of death and injury among species and that significantly more small fish (<50 mm) were injured or killed than large fish (>200 mm). If unmitigated the extraction of water for use in the DZP could impact on the native fish and invertebrate population of the river.

Extraction of water during times of low flow can alter the capacity for key habitat areas to maintain adequate water levels which can provide refuge during times of drying. Habitat refuges provide important habitat for fish species in an otherwise drying environment and these can be altered in low flow situations if water is extracted from the reach in which they occur. If extraction of water continued during times of low flow then this could impact on a species ability to persist. However, the volume of water available for extraction for the DZP under licence from the Macquarie River would vary each year (largely dependent on flows within the river) and other sources of water would be accessed during times of low flow.

Alterations to the existing hydrology of the Macquarie River could occur as a consequence of water abstraction. These activities can alter the temporal flows associated with normal hydrological cycles that respond to seasonal rains and drying patterns. Such changes can impact on the persistence and dispersal of fauna and flora within these ecosystems as these have evolved life histories primarily in direct response to these predictable hydrological fluctuations. When flow regimes are altered this can lead to recruitment failure and loss of biodiversity of native species (Bunn & Arthington 2002).

6.2.6 Disturbance of Eel-tailed Catfish habitat at Toongi

The recorded Eel-tailed Catfish and habitat at Toongi occurs within a relatively deep pool (approximately 1.5 m) 50 m upstream from the wooden rail bridge which crosses Wambangalang Creek. It is possible that there are other occurrences of this endangered population within the study area. Freshwater fish are susceptible to changes in the hydrology of watercourses which can result in reduced levels of biodiversity, although the Eel-tailed Catfish appears to be adapted to increased levels of salinity and turbidity. The location of the recorded population 50 m upstream from the wooden rail bridge proposed for replacement would provide some protection for this population. However, mitigation measures to protect this species and habitat would be required to limit the potential for the DZP to impact on this endangered population of Eel-tailed Catfish.

6.2.7 Removal and disturbance of Lowland Darling River aquatic ecological community

This endangered ecological community is present along all watercourses in the study area up to 500 m AHD (excluding dams and artificial drainages). There are a number of recognised threats to this EEC:

- Modification of natural river flows as a result of river regulation (dams, weirs);
- Altered floodplain and wetland inundation as a result of instream structures;
- Spawning failures resulting from cold water releases from dams;
- Degradation of the riparian zone through clearing of native vegetation and stock access, leading to loss of shelter and increased sedimentation;

- Removal of snags;
- The presence of introduced fish species;
- Agricultural practices such as irrigation runoff, clearing, grazing and the use of fertilisers and pesticides; and
- Overfishing.

This community is susceptible to changes in the hydrology of the catchments in the study area and hence the DZP could impact on this community unless mitigation measures are applied. Impacts on this community can be far reaching as several components of this EEC (e.g. macroinvertebrates and terrestrial insects) provide important resources in the aquatic food chain.

6.2.8 Groundwater Dependant Ecosystems

Negligible changes in groundwater levels are expected to occur throughout the life of the DZP and after mine closure, although there are expected to be minor to moderate increases in groundwater levels beneath and within the solid and liquid residue storage facilities, waste rock enclosures and salt encapsulation cells. The local increase in groundwater levels are predicted to be in the order of several metres (up to a maximum of approximately 20 m) with some discharge expected in incised gullies and creeks draining the high ground (Environmental Earth Sciences 2013).

Groundwater investigations (Environmental Earth Sciences 2013) concluded that there will be no drawdown of groundwater levels and no anticipated impacts on groundwater resources in the DZP Site or study area due to the following reasons:

- The open cut is not proposed to extend to below the water table; and
- There are no plans to source groundwater from the DZP Site or study area for use in the DZP.

6.3 Key Threatening Processes

Key threatening processes (KTP) listed under the FM Act and TSC Act that are relevant to the DZP include:

- **The introduction of fish to fresh waters within a river catchment outside their natural range (FM Act). Predation by *Gambusia holbrooki* Girard, 1859 (plague minnow or mosquito fish) (TSC Act).** Fish such as Carp, Eastern Gambusia, Goldfish, and Redfin Perch, introduced to waters outside their natural range can impact on native biota in a number of ways, including predation, competition for resources, habitat degradation and by the spread of diseases. Eastern Gambusia, Carp, Goldfish and Redfin Perch are all present across the DZP Site, study area and locality.

  Several threatened species are known to be affected by this threatening process. However, the construction and operation of the DZP is unlikely to inadvertently spread introduced fish as water would not be transferred between watercourses.

- **Removal of large woody debris from New South Wales rivers and streams (FM Act).** Woody debris within streams provides important feeding and breeding habitat for aquatic species and can slow water flows. The removal of woody debris is a particular threat to Murray Cod, Trout Cod, Olive Perchlet, the Eel-tailed Catfish endangered population and the Lowland Darling River aquatic ecological community.

  To minimise any potential impacts on these and other species, any woody debris encountered within streams during construction of the DZP would be relocated within the stream adjacent to the construction area, wherever possible.

- **Degradation of native riparian vegetation along New South Wales water courses (FM Act).** Loss of native riparian vegetation is a threat to aquatic biodiversity. The majority of water courses with the DZP Site are severely degraded through previous clearing of the riparian vegetation and agricultural practices.

  Further removal of vegetation along the banks of these watercourses would be minimised and the rehabilitation and restoration of riparian areas would be included as part of the biodiversity offset strategy developed for the DZP, including the conservation and enhancement of the vegetation of several drainage lines within the Wambangalang Creek, Cockabroo Creek and Macquarie River catchments

- **Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams (FM Act)**. **Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands (TSC Act).** Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands is recognised as a major factor contributing to loss of biological diversity and ecological function in aquatic ecosystems, including floodplains. These processes can be affected by extraction of water which reduces flows, leading to a lower distribution of organic matter on which invertebrates and vertebrates depend, riparian zone degradation where changes to flows increases erosion, leading to sedimentation impacts upon aquatic communities, deeper and more permanent standing water which permits the establishment and spread of exotic species and changes to the physical, chemical and biological conditions of rivers and streams which alters biota.

  The construction and operation of the DZP has the potential to obstruct and / or alter movement of aquatic fauna and flora as a consequence of the construction of road and rail crossings and laying of pipelines, and to change the hydrology of the study area through water abstraction. Whilst some of these changes and alteration would be temporary (e.g. construction of a coffer dam for installation of the intake pipe from the Macquarie River) other changes would be permanent with the upgrade of road and rail crossings. Therefore, all watercourse crossings would be constructed in accordance with design principles outlined in the *Guidelines and Policies for Aquatic Habitat Management and Fish Conservation* (NSW Fisheries 1999) and *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull & Witheridge 2003), minimising the potential for impacts across the DZP Site.

6.4 Connectivity

Construction of instream structures, such as watercourse crossings, can disrupt movement of species and plant and animal propagules by creating physical barriers. This can result in the isolation of populations which may become prone to extinction events over time. The construction of fish-friendly watercourse crossings assists with ensuring that individuals and populations do not become physically or genetically isolated by allowing renewal of populations through movement of individuals and ensuring

genetic exchange. The natural flow regime of the Macquarie River system has been heavily disrupted by the construction of weirs and the extraction of water, as has much of the Central West catchment. The Macquarie River is regulated along the reach extending from Lake Burrendong (south-east of Wellington) to Pillicawarrina in the Macquarie Marshes. Along this reach there are a number of weirs, including those located at Dubbo, Narromine, Gin Gin and Warren. In the upper Macquarie River catchment, above Burrendong Dam, there are a number of other storages including Windamere Dam, Winburndale Dam, Oberon Dam, Ben Chifley Dam, Suma Park Dam and Spring Creek Dam. Consequently seasonal patterns have been altered and flow variability has been reduced resulting in fewer large floods and long periods between inundations in the Macquarie Marshes (Central West CMA 2007).

The DZP is unlikely to substantially contribute to the further disruption of connectivity within the study area and locality as all creek crossings would be constructed in accordance with design principles outlined in the *Guidelines and Policies for Aquatic Habitat Management and Fish Conservation* (NSW Fisheries 1999) and *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull & Witheridge 2003) which would assist with maintaining the existing connectivity and improving connectivity in some instances.

Floodplains are known to provide many benefits to fish assemblages, especially during inundation events when these areas become important places for the movement and growth of larvae, juveniles and adult fish (Balcombe *et al*. 2007). During inundation, floodplains also provide spawning sites for native species, provide extensive areas for zooplankton and insect populations to develop, and provide interaction with rivers to supply nutrients, debris and organic material back into the main channels (DPI Undated Online resource). Substantial disruption to the floodplains of the Central West CMA has occurred as a consequence of agricultural practices, urbanisation and industrial development across the area. The floodplain has hence become highly fragmented with fewer opportunities for dispersal of fish, invertebrates, larvae and propagules. The disruption to the floodplain through mining for the DZP would be relatively minor given that the ore body is located off the floodplain at approximately 350 m elevation and that associated infrastructure (e.g. storage facilities and Liquid Residue Storage Facility) have been located off the floodplain.

6.5 Cumulative Impacts

Cumulative impacts are those that add to the transformation of the ecological values of a site or locality and generally occur when habitat is removed or altered and / or the natural hydrology of the area is altered through an accumulation and interaction of impacts from past, present and future proposals. They can vary in intensity, and spatially and temporally, and can be both positive and negative (Franks *et al*. 2010). There are no local industrial facilities within the DZP Site and study area as the current predominant land use is dryland cropping and some mixed grazing. Hence, local cumulative impacts would be minor. However, there are existing disturbances within the Central West CMA and the potential impacts from the DZP may combine with those to lower the values of aquatic biodiversity with the CMA area. To offset the potential for cumulative impacts, a number of mechanisms are proposed which are aimed at improving the health of aquatic resources within the locality, including the biodiversity offsets and rehabilitation efforts, which will add to the conservation network within the wider region.

6.6 Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

An assessment of the likely impacts of the proposal on matters of NES relevant to the aquatic ecology has been undertaken using the Significant Impact Criteria detailed in the *EPBC Act Policy Statement 1.1 – Significant Impact Guidelines: Matters of National Environmental Significance* (DEH 2006). The matters addressed include:

- Trout Cod (*Maccullochella macquariensis*); and
- Murray Cod (*Maccullochella peelii peelii*).

Details of these assessments are provided at **Appendix E**.

These assessments concluded that it is unlikely that the DZP would impact any local or regional population of these species as:

- These species are unlikely to occur across the DZP Site and are therefore unlikely to be directly affected by this proposal;
- The DZP is unlikely to result in the removal of any potential habitat for these species;
- Measures to avoid entrainment of larvae or juveniles through the use of pump extraction screen technology for water extraction from the Macquarie River would be used; and
- Any potential off-site impacts would be managed and mitigated with stringent on-site management measures through implementation of Construction and Operational Environmental Control Plans.

6.7 NSW *Environmental Planning and Assessment Act 1979*

An assessment of the impacts of this proposal on species, populations and ecological communities listed under the FM Act was undertaken in accordance with the *Threatened Species Assessment Guidelines: The Assessment of Significance* (DECC 2007). The Assessment of Significance for each of the EEC, populations and species are addressed in **Appendix F** and the findings are summarised below:

6.7.1 Endangered Ecological Community

Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River
The DZP is unlikely to significantly impact this EEC within the local catchment, as flows would not substantially change from current levels, woody debris removed during construction would be restored and riparian areas would be rehabilitated as part of the biodiversity offset strategies for the DZP.

6.7.2 Endangered Populations

Western NSW population of the Olive Perchlet, *Ambassis agassizii*
It is unlikely that the DZP would impact any local or regional population of Olive Perchlet as this species is unlikely to occur across the DZP Site and any potential off-site impacts would be managed and mitigated with stringent on-site management measures.

***Tandanus tandanus* – Eel-tailed Catfish in the Murray / Darling Basin**

In the absence of mitigation measures, the Eel-tailed Catfish in the Murray / Darling Basin has the potential to be impacted by the DZP during demolition of the existing wooden rail bridge and the construction of a new bridge which crosses Wambangalang Creek 50 m downstream of the recorded occurrence of the Eel-tailed Catfish. Stringent environmental management of the upgrade of the wooden rail bridge across Wambangalang Creek would be implemented to assist with the protection of the Toongi population of the Eel-tailed Catfish during construction. With these management and mitigation measures in place it is considered that this population could be adequately protected to such an extent that the DZP would be unlikely to significantly impact this endangered population.

6.7.3 Species

Trout Cod

It is unlikely that the DZP would impact any local or regional population of Trout Cod as this species is unlikely to occur across the DZP Site and any potential off-site impacts would be managed and mitigated with stringent on-site management measures.

Purple Spotted Gudgeon

It is unlikely that the DZP would impact any local or regional population of the Purple Spotted Gudgeon as this species is unlikely to occur across the DZP Site and any potential off-site impacts would be managed and mitigated with stringent on-site management measures.

Silver Perch

It is unlikely that the DZP would impact any local or regional population of the Silver Perch as this species is unlikely to occur across the DZP Site and any potential off-site impacts would be managed and mitigated with stringent on-site management measures.

7 MANAGEMENT & MITIGATION

In the absence of mitigation measures the construction and operation of the DZP has the potential to impact directly and indirectly on the aquatic ecosystems across the DZP Site and study area, including a range of matters of conservation significance. Consequently, a range of management and mitigation measures would be incorporated into the construction and operation of the DZP and these are outlined in the following sections.

7.1 Goals

Effective measures would be established with the aim of achieving the following goals:

- Minimisation of impacts on biodiversity values of the proposed DZP Site; and
- Protection of biodiversity values across the study area and locality.

7.2 General Principles

The goals would be achieved through implementation of the following general principles:

- Avoidance of impacts;
- Reduction of impacts where avoidance is not possible; and
- Mitigation measures.

7.3 Potential Impacts

The main issues relating to impacts on the aquatic ecology of the DZP Site, study area and locality include:

- Alteration of natural surface flows;
- Removal and disturbance of riparian vegetation;
- Disturbance of Eel-tailed Catfish habitat at Toongi;
- Obstruction of fish passage due to instream structures;
- Removal of large woody debris from streams;
- Mobilisation of sediment;
- Changes to water quality;
- Entrainment and impingement of aquatic organisms; and
- Water abstraction.

The avoidance, mitigation and management actions that address each of these potential impacts are described below.

7.3.1 Alteration of Natural Surface Flows

Iterative refinement of the footprint of the DZP has been undertaken to minimise the direct impact on upper catchment areas through removal of headwaters and changes to the upper catchment and

floodplain across the DZP Site. Changes to the footprint have included the reduction in the size and number of storage areas and alteration of the shape of Liquid Residue Storage Facility.

Some disturbance and removal of upper catchment areas is unavoidable. These disturbances have been minimised to such an extent that Wambangalang Creek, which would experience the most substantial alteration to flows from surface water run-off, would only experience an approximate 1% reduction in flow (SEEC 2013) which is unlikely to cause noticeable declines in aquatic habitat.

7.3.2 Removal and Disturbance of Riparian Vegetation

The DZP footprint has been designed with due regard to the retention of floodplain areas and riparian vegetation and this has reduced the potential for impacts. In particular, the location of components such as the solid and liquid residue storage facilities were chosen to remain at least than 200m from the Wambangalang Creek and 50m from other major drainage lines through the DZP Site, thereby avoiding remnant riparian vegetation. However, unavoidable loss of some riparian vegetation would occur within this already heavily impacted and degraded area.

Management measures to protect riparian areas from off-site impacts would include an Erosion and Sedimentation Plan prepared for construction and operation of the DZP to protect areas in the catchment from an increase in sediment loads as a consequence of erosion. This should include the provision for minimising clearing of vegetation across the DZP Site and the appropriate location of silt fences and sediment traps.

The benefits of riparian tree cover have been shown to include improved water quality and in-channel habitat and to have positive effects on macroinvertebrate assemblages, all of which benefit fish populations especially during climate extremes (Thomson *et al*. 2012). Consequently the rehabilitation and restoration of riparian areas should be included as part of the biodiversity offsets developed for the DZP. Notably, the proposed biodiversity offset strategy for the DZP includes the conservation and enhancement of the vegetation of several drainage lines within the Wambangalang Creek, Cockabroo Creek and Macquarie River catchments.

7.3.3 Disturbance of Eel-tailed Catfish habitat at Toongi

A population of the Eel-tailed Catfish has the potential to be impacted during the upgrade of the railway line which may require the renewal of the trestle bridge at Toongi, and due to the potential disturbance of Wambangalang Creek. Whilst the downstream location of the bridge relative to the recorded site of the Eel-tailed Catfish would minimise the potential for impacts, this population of *Tandanus tandanus* is non-migratory, largely preferring to remain and breed within its current habitat, so protection of its habitat is important.

Reconstruction of the bridge across Wambangalang Creek should be undertaken in such a manner as to not to impact upstream habitat or change the current habitat regime supporting *Tandanus tandanus*. The design principles outlined in the *Guidelines and Policies for Aquatic Habitat Management and Fish Conservation* (NSW Fisheries 1999) and *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull & Witheridge 2003) should be incorporated into the design of the bridge. During construction of the new bridge or restoration of the old bridge, flows should be maintained within the creek which reflects the conditions at the time of construction.

An adaptive management plan specific to the Eel-tailed Catfish population should be prepared prior to construction or operation of the bridge and DZP. Whilst protection should be the main focus of this plan it should also include activities which would improve aquatic habitat for this species.

7.3.4 Obstruction of fish passage due to instream structures

The construction of road crossings, railway bridges and pipelines could disrupt the movement of aquatic biota through providing physical barriers to movement. All upgraded or new instream structures should meet the design principles outlined in the *Guidelines and Policies for Aquatic Habitat Management and Fish Conservation* (NSW Fisheries 1999) and *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull & Witheridge 2003). These measures would include the provision of crossing structures which are appropriate for the type and size of watercourse and in the majority of cases improve the connectivity along watercourses over the current conditions. Importantly, fish passage should be maintained throughout the construction phase.

7.3.5 Removal of Large Woody Debris from Streams

The removal of woody debris from watercourses reduces the extent and quality of habitat available to aquatic biota. Large woody debris encountered at an area of construction should be temporarily relocated until construction is completed and then re-instated along the bank or within the watercourse as close as possible to its original position.

Installation of additional large woody debris along banks and within watercourses should be considered as part of a biodiversity offset package developed for the DZP. Such techniques have been used with the broader catchment area to increase habitat diversity for aquatic biota. **Plate 2** shows re-snagging operations near Pilchers Reserve, Macquarie River.

Plate 2 Re-snagging of the Macquarie River near Pilchers Reserve

7.3.6 Mobilisation of Sediment

The mobilisation of sediment can result in turbidity, changes to water chemistry, smothering of vegetation and other substrates which result in changes to the suite of species that are currently supported. Implementation of an Erosion and Sediment Control Plan should include measures to limit clearing of vegetation and measures to reduce the opportunities for sediment to reach watercourses. Monitoring of water quality should be incorporated into the Erosion and Sediment Control Plan. As a part of this monitoring, suspended particulate matter and turbidity should be monitored as these are correlated with suspended sediment loads and can be used as indicators of physical stress on aquatic biota. Values set out in ANZECC (2000) for the protection of aquatic ecosystems should be used as triggers for implementation of mitigating management responses.

7.3.7 Changes to Water Quality

Changes to water quality may result from leakage from the liquid or solid residue storage facilities, overflow from the liquid residue storage facility and / or spillage of chemical and fuels used on the DZP Site. A Construction and Operational Management Plan should be prepared which deals specifically with these issues and the mitigating management responses should leakage or spills be detected across the DZP Site.

7.3.8 Entrainment and Impingement of Aquatic Organisms

The entrainment of propagules, larvae and juvenile and adult fish can cause mechanical injury and death resulting in fish and invertebrates being lost from natural river populations (Baumgartner *et al.* 2009). Laboratory studies have shown that the presence of an intake screen significantly reduced entrainment in Silver Perch and Golden Perch and in some cases reducing mortality from over 90% (unscreened) to less than 2% (when screened) (Boys *et al*. 2013). Approach velocities were also shown to be crucial. Velocities (measured 8 cm in front of the screen) of up to 0.4 m / s effectively reduced entrainment, with very little injury or mortality resulting from incidental screen contacts or impingement. Both Perch species also used visual cues to negotiate the screen face, thereby increasing their ability to avoid contact at higher velocities. In the absence of these visual cues, positive rheotactic behaviour was enhanced and fish mostly avoided approaching the screen (Boys *et al*. 2013).

To mitigate against entrainment of aquatic biota the intake system would be fitted with a Johnson Screen with a maximum 2 mm mesh size and ideally have an approach velocity no greater than 0.4 m / s. The screen should be placed parallel, or at a slight angle to the direction of flow, to assist fish that come into contact with the screen to brush gently against the screen and continue on downstream. A pump which gradually ramps-up and down to and from operating levels will also assist with protection of biota.

7.3.9 Water abstraction

Approximately 2.5 GL / year of water would be sourced from the Macquarie River for processing of the ore. This water would be obtained under licence(s) obtained in accordance with the *Water Sharing Plan for the Macquarie and Cudgegong Regulated Rivers Water Source*, and hence there would be no water abstraction at times of low flow thereby protecting the biota of the Macquarie River from impacts associated with abstraction during periods of low flow. A Water Supply Strategy is being developed for the DZP to assist with meeting the requirements of NSW DPI Office of Water.

7.3.10 Threatened Species, Populations and Communities

The potential impacts on matters listed under the EPBC Act, FM Act and TSC Act would be managed and mitigated through implementation of the above measures. Specific management and mitigation measures should be developed to address the likely impacts on the *Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River* and the Eel-tailed Catfish population at Toongi.

8 CONCLUSIONS

8.1 General

Streams, creeks and drainage lines within the boundaries of the DZP Site, across the study area and locality have been degraded through clearing, agriculture and water abstraction over many years. These impacts have resulted in:

- Changes in water quality from erosion and sedimentation, increased inputs of nutrients and increased salinisation of the study area;
- Clearing of vegetation and instream snags, which has resulted in the simplification of habitat structure as instream vegetation and overhanging vegetation has largely been removed and weeds have become established; and
- Changes to drainage patterns through the construction of farm dams, bridges and causeways, which has disrupted dispersal patterns.

Although the development of the DZP would be undertaken across aquatic ecosystems that are stressed and degraded, the watercourses still provide habitat for aquatic biota. Habitat values are not uniformly spread across the area but instead are in general linked to stream order, with the larger watercourses, such as Macquarie River and Little River providing the more consistent and complex habitat in an otherwise degraded landscape. This includes habitat for threatened species, populations and endangered ecological communities such as the Aquatic Ecological Community in the Natural Drainage System of the Lowland Catchment of the Darling River. Aquatic habitat in the lower order streams, such as Wambangalang Creek, Cockabroo Creek, Hyandra Creek and Paddys Creek is more patchily distributed due in part to their ephemeral low flow regimes. In these lower order streams, pools provide important refuge habitat for aquatic biota during times of low flow, especially for sedentary species adapted to saline and turbid conditions such as the Eel-tailed Catfish, and consequently should also be afforded protection.

The footprint of the proposed DZP has undergone iterative changes to reduce impacts on aquatic biodiversity. Where impacts are inevitable, a range of mitigation measures have been proposed which would reduce potential impacts and protect aquatic biota. Statutory assessments undertaken for species, populations and communities listed under the EPBC Act, TSC Act and FM Act concluded that with the implementation of the range of proposed mitigation measures proposed that it is unlikely that there would be significant impacts on matters listed under the EPBC Act, FM Act or TSC Act.

8.2 Specific Considerations

Specific consideration should be given to the following issues during construction and operation of the DZP:

- Minimise the clearing of native vegetation and other groundcovers;
- Implement an Erosion and Sedimentation Control Plan to minimise opportunities for mobilised sediments to reach drainage lines and watercourses;
- Design and construction of all new and upgraded watercourse crossings in accordance with *Guidelines and Policies for Aquatic Habitat Management and Fish Conservation* (NSW Fisheries 1999) and *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull & Witheridge 2003);

- Development of an adaptive management plan for protection and conservation of the Endangered Population of the Eel-tailed Catfish at Toongi;
- Ensure that appropriate screening and pump technology be used at the off-take site for water abstraction from the Macquarie River to minimise impacts on aquatic biota; and
- Include rehabilitation and restoration of instream habitats as a part of the biodiversity offset strategy for the DZP.

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