Adani Mining Pty Ltd

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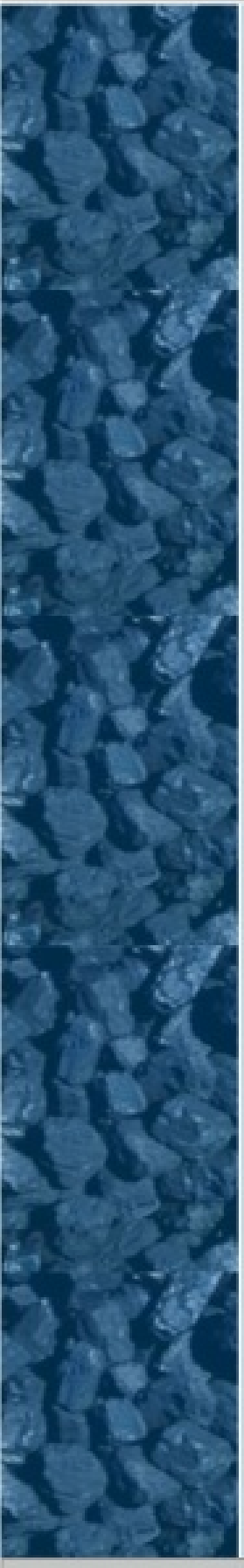

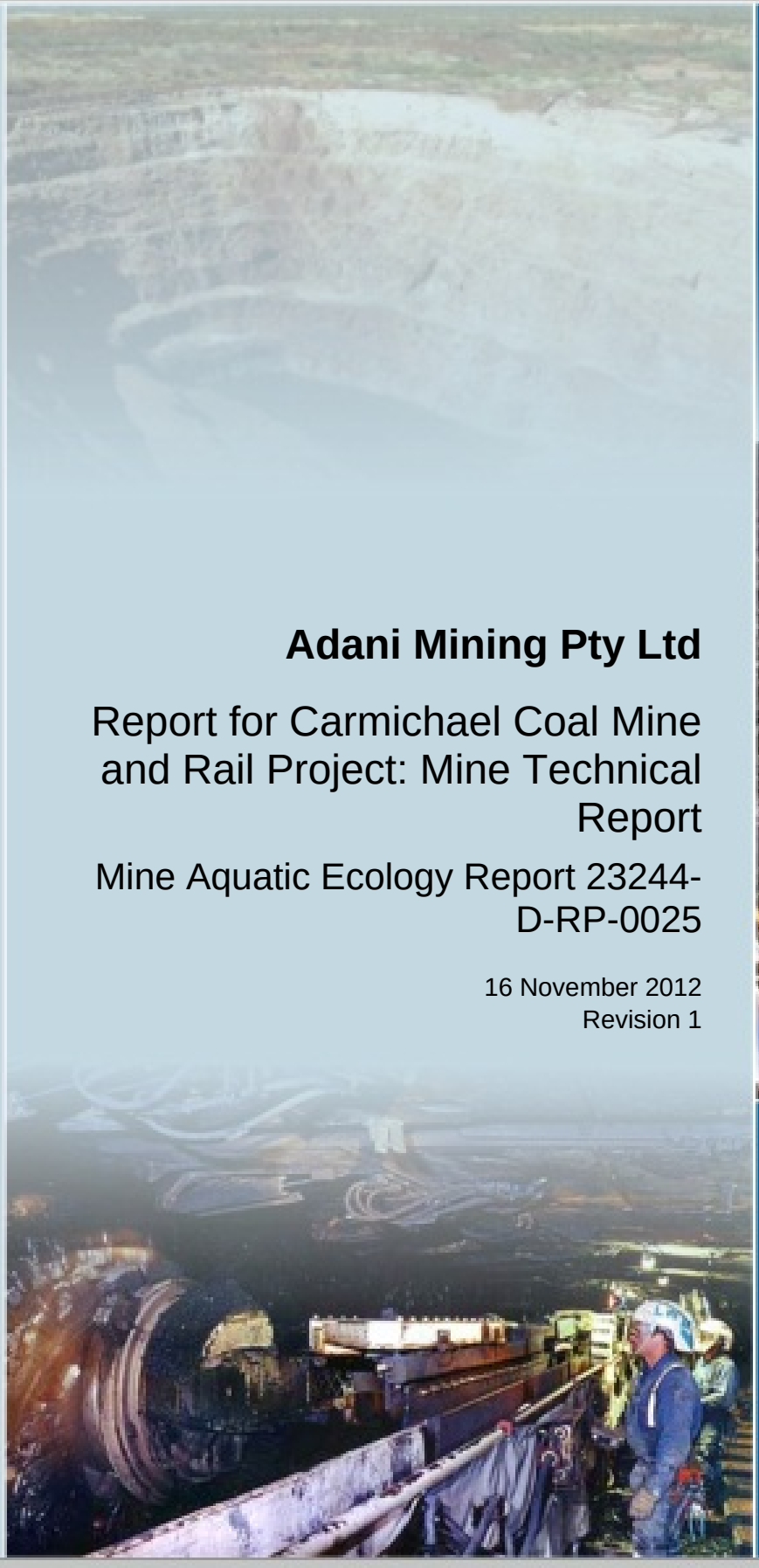

Adani Mining Pty Ltd

Report for Carmichael Coal Mine and Rail Project: Mine Technical Report

Mine Aquatic Ecology Report 23244-D-RP-0025

16 November 2012
Revision 1

GHD

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The services undertaken by GHD in connection with preparing the Report were limited to those specifically detailed in Section 1 of the Report and did not include GHD undertaking testing at some parts of the site.

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- *reliance on the Report by a third party, or use of this Report other than for the Purpose.*

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Abbreviations and Glossary

Project Specific Terminology	
Abbreviation	**Term**
the EIS	Carmichael Coal Mine and Rail Project Environmental Impact Statement
the Proponent	Adani Mining Pty Ltd
the Project	Carmichael Coal Mine and Rail Project
Generic Terminology	
Abbreviation	**Term**
ACA	Aquatic Conservation Assessment
ANZECC	Australian and New Zealand Environment and Conservation Council
AquaBAMM	Aquatic Biodiversity Assessment Mapping Method
AusRivAS	Australian River Assessment System
BOM	Bureau of Meteorology
cm	Centimetre
DEEDI	Former Department of Employment, Economic Development and Innovation (Qld)
DEHP	Department of Environment and Heritage Protection
DERM	Former Department of Environment and Resource Management (Qld)
EIS	Environmental impact statement
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPC	Exploration Permit for Coal
EPT	Ephemeroptera, Plecoptera, Trichoptera
GBR	Great Barrier Reef
GDE	Groundwater Dependant Ecosystem
GPT	Gross Pollutant Trap
Ha	Hectares
HES	High Ecological Significance
hrs	Hours
km	Kilometre
m	Metre

Generic Terminology	
Abbreviation	**Term**
mm	Millimetre
MIA	Mine Infrastructure Area
Matters of NES	Matters of National Environmental Significance
N/A	Not applicable
NC Act	*Nature Conservation Act 1992*
Nov	November
NRM	Natural Resource Management
RE	Regional Ecosystem
SDPWO Act	*State Development and Public Works Organisation Act 1971*
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
SPP	State Planning Policy
TOR	terms of reference
WPA	Wetland Protection Area
WQO	Water Quality Objectives

Executive Summary

The Carmichael Coal Mine and Rail Project in central Queensland comprises a proposed coal mine on Exploration Permit for Coal (EPC) 1690 and EPC 1080 and offsite workers accommodation village, permanent airport, heavy industrial area and offsite water infrastructure. The mine will consist of both open cut and underground mining areas, and associated infrastructure.

This report focuses on the environmental assessment of aquatic ecology of the proposed mine site, workers accommodation village and airport (hereafter, the 'Study Area') and offsite water infrastructure, the associated potential impacts, and the identification of control measures to manage potential impacts.

The Study Area (approximately 45,400 ha) is predominantly located on the Moray Downs cattle station, approximately 160 kilometres (km) north-west of Clermont. At full operation, the mine is expected to produce 60 million tonnes per annum (Mtpa) of thermal coal for export via the proposed rail route described in Volume 3 Section 2.

The offsite water infrastructure comprises a combination of storage dams on North Creek and Obungeena Creek, groundwater bores, in-stream extraction on the Belyando River and North Creek and water treatment.

A combined desktop and field assessment was undertaken to describe the existing aquatic ecological values of the Study Area. Seasonal field assessments of surface water ecosystems were conducted in November 2010, May 2011, November 2011 and June 2012 to identify the existing aquatic ecological values of the Study Area and to supplement and ground truth the information obtained from the desktop assessment. Aquatic flora and fauna surveys incorporated assessment of a total of 26 sites that represent the aquatic habitats within the Study Area and associated mine village and airport. Spatial variation based on the assessment of these sites was determined. Assessments undertaken included a combination of habitat assessments, fish and crustacean sampling, aquatic flora assessments and macroinvertebrate sampling. Field assessments of subterranean aquatic ecosystems were conducted in October 2011 and August 2012 to determine if stygofauna were present in groundwater.

The key findings from this assessment include:

- The main riverine feature of the Study Area is the Carmichael River, which flows through the Study Area and joins the Belyando River almost 20 km downstream of the Study Area. The river is located high in the Burdekin River catchment and seasonality in rainfall restricts flows to the wetter months, November to March. Flow of the Carmichael River varies annually with the intensity of wet season conditions. Evidence of very high flooding flows was noted however these extreme events are not necessarily expected to occur consistently each year. Many streams and drainage channels within the catchment dry entirely during the winter months (June/July) when rainfall is typically lower than the summer months around December and January. Larger rivers sustain only pools or low flows during the drier, winter periods.
- Doongmabulla Springs is located approximately 10 km west of the site and is DSEWPaC threatened ecological community. .

- Aquatic habitats across the Study Area vary in size and geomorphology. They can be grouped into five broad water body types: lacustrine, palustrine, riverine, drainage lines and gilgais (DERM, 2010b). Within the Study Area these habitats are represented as follows:
  - Lacustrine habitats are most commonly damned watercourses located north of the Moray Carmichael Road. Other examples of this habitat include farm dams associated with bore water supply
  - Palustrine habitats are represented by dams in the Study Area. Compared with the lacustrine habitat, palustrine habitats have a greater presence of macrophytes or trees and shrubs (greater than 30 per cent cover).
  - Riverine habitats are represented at the Carmichael River and reaches of Cabbage Tree Creek. There are a number of drainage lines that have established stream banks and a formed channel, however, these drainage lines provide limited long term aquatic habitat. The Carmichael River (5th order stream) represents the largest watercourse within the Study Area and maintains aquatic habitat throughout the year, even if in isolated pools. Cabbage Tree Creek also provides permanent aquatic habitat for flora and fauna.
  - Drainage lines within the Study Area display loose sandy substrate with adjacent geology being much more compact than the bed. They provide a pathway for runoff during high downpours, as observed during field surveys, and do not accommodate long term flows or isolated permanent of semi-permanent pools.
  - Gilgais are distributed across the Study Area, however they are not necessarily related to the location of waterways. The gilgais observed to have water at the time of survey were shallow, narrow (no greater than four metres wide) and the water is not expected to be sustained throughout the dry season.
- Field assessments within the Study Area detected a low diversity of aquatic flora and fauna species in the surveyed habitats.
- Stygofauna species were detected at two locations within EPC 1690.
- No conservation significant species or communities were observed within the Study Area nor are any expected to occur based on habitat requirements.
- Supporting technical reports identified a relationship between the ground and surface water environments at the Carmichael River, especially during the drier months. These reports identify the potential impacts the Project may have on the water supply for the nearby springs.

An assessment considering the aquatic ecology values of the Study Area and the proposed activities of the Project identified the following potential impacts:

- Loss of habitat and aquatic fauna mortality within the footprint of both the construction and operation components.
- Indirect degradation of aquatic habitats and riparian zones as a result of clearing of land.
- Degradation of aquatic habitats as a result of the introduction or spread of pest and/or weed species
- Changes in topography and alteration of catchment flows as a result of mining excavation and infilling, as well as the potential for subsidence associated with underground mining.

- Alteration of the groundwater regime and water quality both within and outside of the mine operation areas as a result of excavation.
- Change to the availability and suitability of surface water aquatic habitats as a result of changes in the relationship between ground and surface water environments or water extraction.

The Project EIS provides discussion on a number of other environmental fields relevant to this assessment of the aquatic ecology values of the Study Area. In particular the following technical reports should be read in conjunction with this assessment:

- Volume 2, Chapter 6 Water Resources
- Volume 4, Appendix N1 Mine Terrestrial Ecology Report
- Volume 4, Appendix N2 Doongmabulla Springs Existing Environment Report
- Volume 4, Appendix O2 Stygofauna Survey Report
- Volume 4, Appendix P1 Mine Hydrology Report
- Volume 4, Appendix Q Mine Water Quality Report
- Volume 4, Appendix R Mine Hydrogeology Report

Most of the potential impacts to aquatic ecology values associated with the construction, operation and decommissioning of the Project can be managed or mitigated using a combination of engineering and construction management solutions. Adaptive management mechanisms and environmental monitoring will be required to allow for corrective actions to be implemented if required. Management and monitoring requirements will be embedded into the Construction and Operation Management Plans for the Project.

Impacts associated with a change in the relationship between surface and groundwater environments have the potential to substantially reduce the availability of aquatic habitats during dry periods when rainfall does not provide volumes to sustain isolated pools in the Carmichael River.

Groundwater modelling suggests there will be a water table drawdown of up to between 20 to 50 m in the vicinity of the Carmichael River under the post closure scenario and that groundwater discharges to local water courses, predominantly the Carmichael River, will be reduced by up to 1,000 m^3/d or 7 per cent of pre-development discharge during the operational phase. Further details regarding the groundwater modelling are reported in the Volume 4 Appendix R Mine Hydrogeology Report.

The groundwater model predicted maximum drawdown impacts to the Doongmabulla springs range from <0.05 to 0.12 m after 40-70 years at the two closest springs to the proposed mining area, i.e. the Little Moses spring to the north and the Doongmabulla Spring to the east. Model results also predict maximum drawdowns at the Mellaluka Springs of between 0.7 and 0.8 m. This may occur within and outside the Study Area (e.g. at Mellaluka Springs and to a lesser extent the Doongmabulla Springs).

1. Introduction

1.1 Project Overview

Adani Mining Pty Ltd (Adani) is proposing to develop a 60 million tonne (product) per annum (Mtpa) thermal coal mine in the north Galilee Basin approximately 160 kilometres (km) north-west of the town of Clermont, Central Queensland. All coal will be transported via a privately owned rail line connecting to the existing QR National rail infrastructure, and shipped through coal terminal facilities at the Port of Abbot Point and the Port of Hay Point (Dudgeon Point expansion). The Carmichael Coal Mine and Rail Project (the Project) will have an operating life of approximately 90 years.

The Project comprises of two major components:

- The Project (Mine): a greenfield coal mine over EPC1690 and the eastern portion of EPC1080, which includes both open cut and underground mining, on mine infrastructure and associated mine processing facilities (the Mine) and the Mine (offsite) infrastructure including:
  - A workers accommodation village and associated facilities
  - A permanent airport site
  - Water supply infrastructure
- The Project (Rail): a greenfield rail line connecting the Mine to the existing Goonyella and Newlands rail systems to provide for the export of coal via the Port of Hay Point (Dudgeon Point expansion) and the Port of Abbot Point, respectively; including:
  - Rail (west): a 120 km dual gauge portion from the Mine site running west to east to Diamond Creek
  - Rail (east): a 69 km narrow gauge portion running east from Diamond Creek connecting to the Goonyella rail system south of Moranbah

The Project has been declared a 'significant project' under the *State Development and Public Works Organisation Act 1971* (SDPWO Act) and as such, an Environmental Impact Statement (EIS) is required for the Project. The Project is also a 'controlled action' and requires assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Project EIS has been developed with the objective of avoiding or mitigating all potential adverse impacts to environmental, social and economic values and enhancing positive impacts. Detailed descriptions of the Project are provided in Volume 2 Section 2 Project Description (Mine) and Volume 3 Section 2 Project Description (Rail). Figure 1-1 shows the Project location.

LEGEND

- Town
- Major Port
- Other Rail Network
- Goonyella System
- Newlands System
- State Road
- Local Road
- Watercourse
- Local Government Area
- Project (Rail)
- Rail (West)
- Rail (East)
- Project (Mine)
- Mine (Offsite)

1:2,000,000 (at A4)

0 10 20 30 40 50

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision L
Date 28-08-2012

Project Location

Figure: 1-1

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Data Source: © Commonwealth of Australia (Geoscience Australia): Town, Railways, Watercourses (2007); DERM: LGA, (2011), Hillshade (2009); DMR: State Roads (2008); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011); Adani: Alignment Opt9 Rev3 (2012). Created by: BW, JVC

1.2 Report Scope

This aquatic ecology assessment addresses the terms of reference for the Project (Mine) component of the Carmichael Coal Mine and Rail Project Environmental Impact Statement (May 2011). Table 1-1 provides a cross reference with the Project terms of reference; full details are provided in Appendix A.

Table 1-1 Terms of Reference Cross Reference

Terms of Reference Section	Report Section
3.3.4 Aquatic Ecology	
Describe the aquatic flora and fauna occurring in the areas affected by the proposal, noting the patterns and distribution in the waterways (e.g. rivers, streams, creeks and other bodies of water) and any associated wetlands	Section 2.3
Describe the aquatic flora and fauna species occurring in the waterways and wetland, including near-threatened or threatened species. Describe the habitat requirements and sensitivity of aquatic species in the project areas.	Section 2.3, 3.1, 3.3.1, 3.4 Amphibians and water birds are described in Volume 4 Appendix N1 Mine Terrestrial Ecology Report
Describe any Ramsar wetlands in terms of proximity to the proposal and likelihood of impacts	Section 3.2.2
Describe the aquatic and benthic substrate	Section 2.2
Describe habitat upstream and downstream of the project or potentially impacted due to currents in associated lacustrine and aquatic environments	Section 2.2
Identify all types of groundwater-dependent ecosystems occurring within and outside the project area and potentially impacted by project activities.	Section 2.2.2 and See Volume 2 Section 5.4
Include a description to Order or Family taxonomic rank of the presence and nature of stygofauna occurring in groundwater likely to be affected by the project. Sampling and survey methods should be in accordance with the best practice guideline currently published by the Western Australian Environmental Protection Authority.	Section 2.3
Describe aquatic substrate and stream type, including the locations and extent of any permanent and semi-permanent water holes or streams potentially affected by the mine and its operations and location.	Section 2.2
Describe the significance of national, state or regional wetlands including wetlands of international importance, and their values and importance for aquatic flora and fauna species.	Section 3.2, 3.3
A map is to be included which identifies aquatic ecosystems in the project area and at the regional scale.	Figure 2-1, Figure 3-1, Figure 3-2 Figure 3-3

Terms of Reference Section	Report Section
Discuss the potential permanent and temporary impacts of the project on the aquatic ecosystems and describe proposed measures to avoid, minimise or mitigate actions, including: ◗ Stream diversions, crossing facilities, stockpiled material and other restrictions to free movement of aquatic fauna ◗ Measures to facilitate fish movement through water crossings ◗ Offsets and alternatives ◗ Monitoring of aquatic ecology health, productivity and biodiversity in areas upstream and downstream of the project area	Section 4, 5, 6
Address any actions of the project or likely impacts that require an authority under the relevant legislation including the NC Act and/or the Fisheries Act 1994.	Section 1.5, 4, 5 and Volume 4 – Appendix D – Project Approvals and Planning Assessment
Outline how these measures will be implemented in the overall EMP for the project.	Section 4, 5 and Volume 2 Section 13

The scope of this report considers impacts to aquatic flora, fauna and habitats. This report discusses all fish, turtles and other aquatic reptiles, aquatic mammals (in particular the platypus), aquatic invertebrates and aquatic flora. All amphibians and bird species, including water birds and migratory birds are discussed in the Volume 4 Appendix N1 Mine Terrestrial Ecology Report.

An assessment of subterranean ecosystems and stygofauna has been undertaken and summarised in this report. A complete technical report of the stygofauna assessment is contained in Volume 4 Appendix O2 Stygofauna Survey.

This report should be read in conjunction with:

- Volume 4 Appendix N1 Mine Terrestrial Ecology Report, which assesses the terrestrial flora and fauna ecological values of the Study Area.
- Volume 4 Appendix O2 Stygofauna Survey which includes the assessment of the subterranean ecosystems and stygofauna of the Study Area.
- Volume 4 Appendix P1 Mine Hydrology Report, which assesses the surface water flows of the Study Area.
- Volume 4 Appendix Q Mine Water Quality Report, which assesses the surface water quality environmental of the Study Area.
- Volume 4 Appendix R Mine Hydrogeology Report, which includes the assessment of the groundwater environments of the Study Area.

As some technical aspects overlap between reports, cross referencing has been provided within this document where appropriate to avoid repetition.

1.3 Assessment Scope

This ecological assessment addresses the final terms of reference (ToR) for the mine component of the Carmichael Coal Mine and Rail Project Environmental Impact Statement (May 2011).

A combination of desktop assessments and field studies were undertaken to describe the existing aquatic ecology values of the Study Area. Desktop studies provided information on water bodies, sensitive aquatic environments, aquatic species and communities within and/or of relevance to the Study Area. Field studies allowed for desktop-derived information to be ground-truthed and supplemented, thereby providing information on the existing aquatic ecology values of the Study Area. Surveys particularly sought to document the occurrence of conservation significant values, including:

- Wetlands of state, national and international significance
- Protected areas
- Flora and fauna species listed as critically endangered, endangered or vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- Flora and fauna species listed as endangered, vulnerable, near threatened or special least concern under the Queensland *Nature Conservation Act 1992* (NC Act) and its regulations, namely the *Nature Conservation (Wildlife) Regulation 2006*
- Priority flora and vertebrate fauna species identified in the *Burdekin Natural Resource Management (NRM) Region Back on Track Actions for Biodiversity* report (Queensland Department of Environment and Resource Management (DERM), 2010a)
- Groundwater dependant ecosystems

In characterising the aquatic ecology values of the Study Area, potential impacts arising from construction and operation of the proposed mine were identified. Mitigation measures and management actions seeking to avoid/minimise/manage the risk associated with identified impacts to the ecological values of the Study Area were developed. These aspects are reported herein.

1.4 Study Area

The Study Area for this assessment has evolved as a result of development of the Project during the study period. The progress of the extent of the Study Area can be defined by:

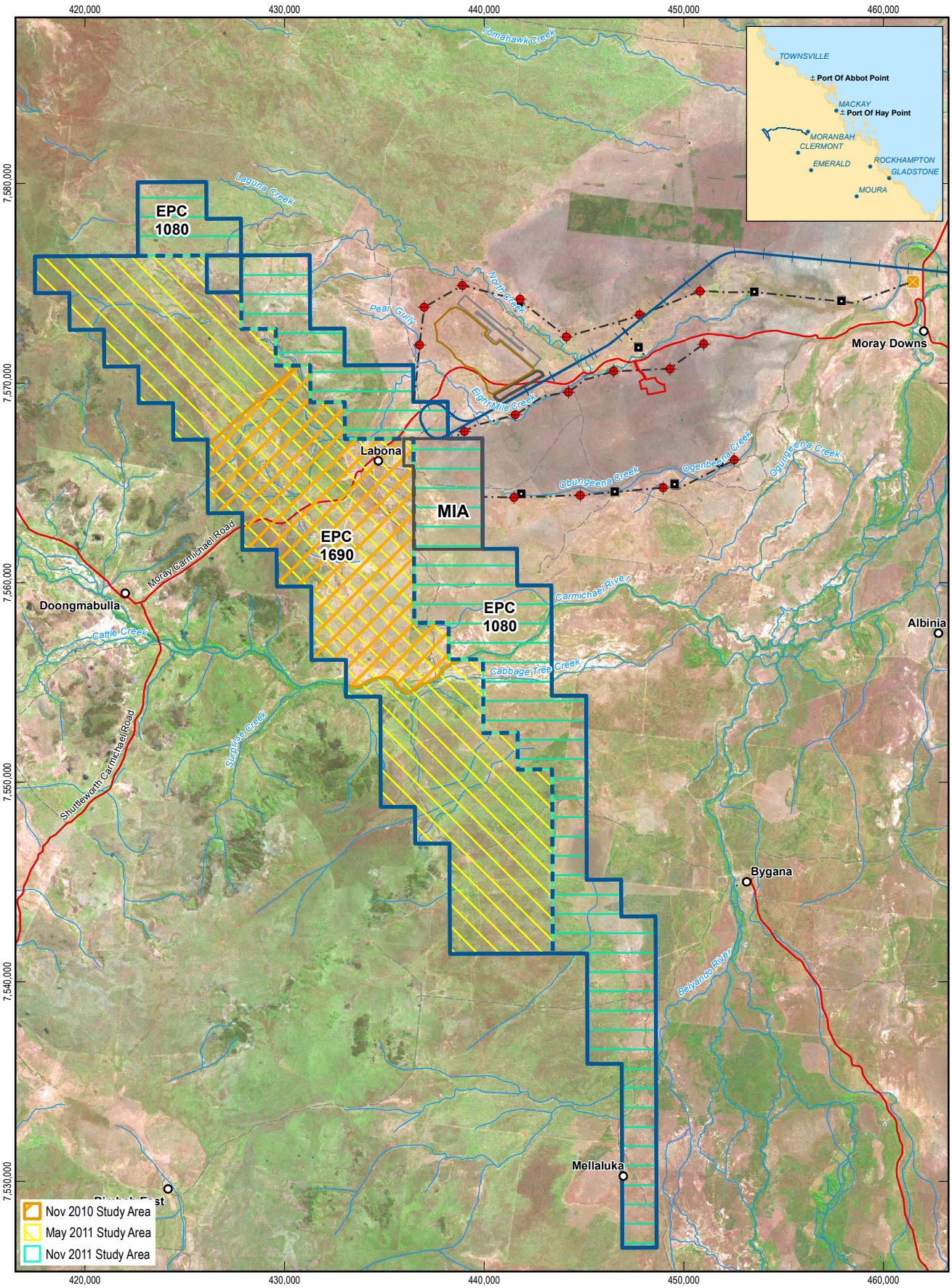
1. Phase one – at the inception of the assessment the middle third of EPC 1690 was the focus. Consequently the survey undertaken prior to/at the onset of the wet season (November 2010) targeted this area.
2. Phase two – expanded the assessment to include all of EPC 1690 whereby phase one assessment area was revisited and additional areas were assessed immediately after the wet season (May 2011) to provide an assessment of temporal variability.
3. Phase three – expanded the assessment to include EPC 1080 (directly adjacent to EPC 1690) and the Mine (offsite) infrastructure with the survey undertaken prior to the wet season (November 2011).

The mine offsite infrastructure is a parcel of land bounded as far west as the Moray Downs property boundary and the eastern edge of mining lease exploration area EPC 1080. The site encompasses

water supply options for pumping of water from North Creek and the Belyando River, in-stream extractions and pumping of local groundwater reserves.

The collective areas studied across the three phases of the Project are shown in Figure 1-2, are referred to in combination as the Study Area. The total Study Area encompasses approximately 45,400 hectares (ha) of predominantly grazing land. See Section 1.6 for discussion regarding the approach to the assessment to account for a change in study extent.

For contextualisation of the values described for the Study Area, ecological values of the surrounding local and regional environment were characterised through desktop studies.



LEGEND

- Homestead
- Local Road
- Track
- Watercourse
- Rail (West)
- Mine (Onsite)
- Mine Infrastructure Area
- Mine (Offsite)
- Borehole
- Storage Site (Instream)
- Storage Facility (Offstream)
- Pipeline Network
- Airport Location
- Rail Siding
- Industrial Area
- Workers Accommodation Village

1:275,000 (at A4)

0 2 4 6 8 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

Aquatic Ecology Study Area

Job Number 41-25215
Revision E
Date 30-08-2012

Figure: 1-2

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Data Source: DERM: Elevation (2011); GHD: Aquatic Ecology Study Area (2010, 2011); © Copyright Commonwealth of Australia - Geoscience Australia: Road, Homestead, Watercourse (2007); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011).Created by: BW.

1.5 Relevant Legislation

1.5.1 Overview

A detailed description of legislation, policies and regulations applicable to the Carmichael Coal Mine and Rail Project is provided in Volume 4 Appendix D Project Approvals and Planning Assessment. Outlined below is an overview of the key regulatory instruments of relevance to the aquatic ecology assessment.

1.5.2 Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the Commonwealth's principal piece of environmental protection legislation. It provides a national framework for the protection of the Australian environment and its unique biodiversity. Specifically, the EPBC Act aims to protect the environment by reducing significant impacts to matters of national environmental significance (matters of NES).

In addition to endowing protection on Australia's environment, the EPBC Act provides a systematic framework for assessment and approval of actions potentially impacting matters of NES. The Project was referred to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) on 18 November 2010 (EPBC 2010/5736). It was declared a 'controlled action' requiring assessment and approval under the EPBC Act on 6 January 2011. The controlling provisions for the Project (i.e. those matters of NES which the Project (mine and rail) is likely to have a significant impact on) include:

- World Heritage properties (section 12 & 15A)
- National Heritage places (section 15B & 15C)
- Wetlands (Ramsar) (section 16 & 17B)
- Listed threatened species and communities (sections 18 & 18a)
- Listed migratory species (section 20 & 20A)
- Great Barrier Reef Marine Park (section 24B & 24C)

These matters of NES may directly or indirectly relate to aquatic ecology environmental values within the Study Area. The Burdekin River catchment drains to the east coast of Queensland where the Great Barrier Reef marine Park is located. Similarly, this assessment considers the presence of wetlands of international importance and listed aquatic species. In the event matters of NES are considered relevant to the Project, an assessment of significance of potential impacts will be required. Volume 1 Section 11 details the impacts to matters of NES, including aquatic ecosystems and species.

1.5.3 State Development and Public Works Organisation Act 1974

On 26 November 2010 the Project was declared a 'significant project' requiring an EIS under section 26(1)(a) of the Queensland *State Development and Public Works Organisation Act* 1971 (SDPWO Act). The Commonwealth has accredited the Queensland EIS process under the SDPWO Act and as such, the Project will be assessed by the Commonwealth Environment Minister under the bilateral

agreement with the Queensland Government. Approval for the Project under Part 9 of the EPBC Act will be required from the Commonwealth Environment Minister before it can proceed.

1.5.4 *Queensland Nature Conservation Act 1992* and Nature Conservation (Wildlife) Regulation 2006

The *Nature Conservation Act 1992* (NC Act) provides for the conservation of nature through protection of all native plants and animals in Queensland. Protection is provided under the NC Act through conservation of land as protected areas and wildlife protection outside of protected areas. Actions impacting on protected native flora and fauna are regulated under the NC Act. Permits for disturbance to native flora and fauna can be administered under the NC Act. The Queensland Nature Conservation (Wildlife) Regulation 2006 lists flora and fauna species considered to be extinct, endangered, and vulnerable, near threatened or special least concern in Queensland.

1.5.5 Queensland Environmental Protection (Water) Policy 2009

The *Environmental Protection (Water) Policy 2009* (EPP (Water)) is subordinate legislation that supports the EP Act. The EPP (Water) provides a framework for the development of environmental values (EVs) and water quality objectives (WQOs) for all Queensland waters. Environmental values are defined by the EPP (Water) as the qualities of waterways that need to be protected to ensure that the ecological, social and economic values and uses of the waterway are maintained. The EVs to be enhanced or protected under the EPP (Water) are:

- Biological integrity of an aquatic ecosystem
- Suitability for recreational use
- Suitability for minimal treatment before supply as drinking water
- Suitability for agricultural use
- Suitability for industrial use

Water quality objectives are defined by the EPP (Water) as measurable indicators of the characteristics needed to protect the EVs of a waterway. Specific EVs and WQOs for the Burdekin Basin are yet to be scheduled in the EPP (Water). The development of Burdekin Basin specific EVs and WQOs is underway, with scheduling expected to be achieved by December 2013.

The EPP (Water) provides a framework for the development of environmental values (EVs) and water quality objectives (WQOs) for all Queensland waters. This framework has been applied for the current assessment and is documented in Volume 4, Appendix Q Mine Water Quality Report.

1.5.6 State Planning Policy 4/11: Protecting Wetlands of High Ecological Significance in Great Barrier Reef Catchments (Wetlands SPP)

The Wetlands State Planning Policy (SPP) seeks to ensure development involving high impact earthworks in or near wetlands of high ecological significance (HES) is planned, located, designed, constructed and operated appropriately. The Wetlands SPP took effect on 25 November 2011. The Department of Environment and Heritage Protection (DEHP) has produced a map of referrable wetlands, indicating where the Wetlands SPP applies. Wetlands considered being of high ecological significance in Great Barrier Reef catchments have been mapped as Wetland Protection Areas. These core protection areas have a 500 metre (m) assessable development trigger area (measured

from the wetland boundary) around them. The Wetlands SPP includes an assessment code to guide decision makers with regards to future development in wetlands considered to be of high ecological significance in Great Barrier Reef catchments.

The Wetlands SPP for the protection of wetlands of HES in Great Barrier Reef Catchments is a statutory instrument under the *Sustainable Planning Act 2009*.

1.5.7 Western Australian Environmental Protection Agency Guidance Statements 54 and 54a (2003 and 2007)

Queensland Department of Environment Heritage and Planning (DEHP) requires sampling in areas where stygofauna are 'likely' to occur and for the Project, sampling was required to meet the requirements for surveys undertaken for environmental impact assessment (EIA) in Western Australia (WA), as detailed in:

- WA EPA Guidance Statement No. 54, Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment in Western Australia (EPA, 2003)
- WA EPA Guidance Statement No. 54a, Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia (EPA, 2007)

DEHP do not have any established (published) protocols for sampling stygofauna in Queensland and adopt the WA guidelines (2003 and 2007) by default. The WA Guidance Statements provide information which the WA EPA considers important when assessing proposal where subterranean fauna is a relevant environmental factor.

Further details of the Guidance statement requirements are reported in Volume 4, Appendix O2 Stygofauna Survey.

1.6 Methodology

1.6.1 Literature Review and Desktop Assessment

Information relating to the aquatic ecological values of the Study Area was obtained from a variety of sources. Details of these sources and search extents are provided in Table 1-2. The search extents in the context of the Study Area (including the EPC 1690, EPC 1080 and offsite infrastructure) are provided in Figure 1-3.

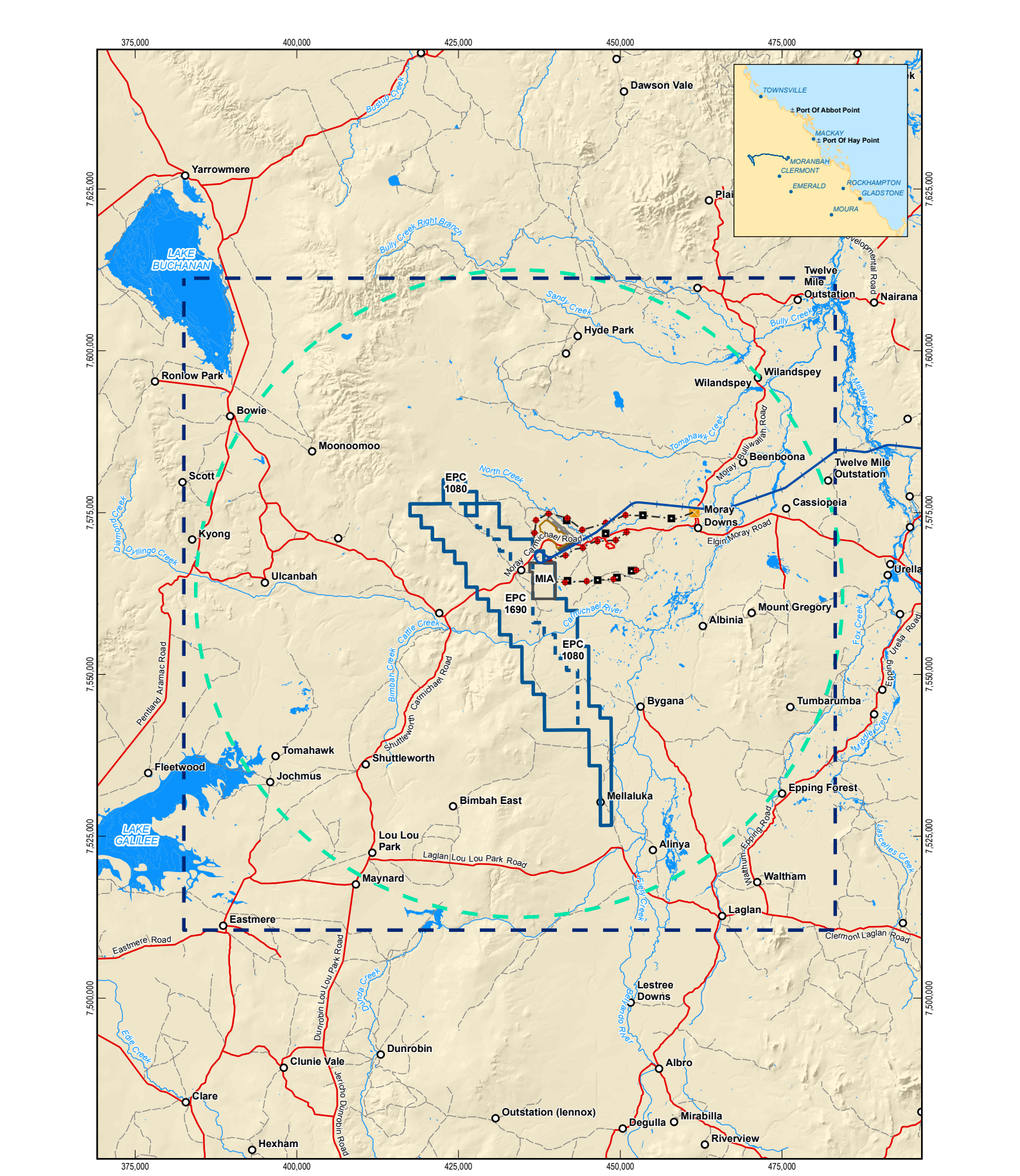
Table 1-2 Summary of Desktop Sources Reviewed

Source and name	Description of information source	Search extent	Limitations of use
DSEWPaC Protected Matters Search Tool and Environmental Reporting Tool	The Protected Matters Search identifies matters of NES and other matters protected by the EPBC Act that may occur within or relate to the Study Area. The tool predicts the potential presence of a species/ecological community in an area based on bioclimatic modelling, known distribution and habitat preferences. The Environmental Reporting tool was also queried to provide information on invasive species that have the potential to occur, and nationally important wetlands within or near the Study Area.	Study Area: A point search (approximating with the centre of the Study Area: -22.041, 146.364) with a 50 km buffer was searched. Offsite Water Infrastructure: polygon over option (approximately 43.5 x 32.5 km)	This is a predictive tool only – it does not necessarily indicate that a species/ecological community occur in a defined area. Presence of a species/ecological community is predicted based on a combination of bioclimatic modelling, known distribution and habitat preferences. In predicting species/community presence, it allows for field survey efforts to be targeted.
DSEWPaC Directory of Important Wetlands in Australia	The Directory identifies nationally important wetlands. The Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) Protected Matters Search Tool (see above) lists nationally important wetlands occurring within or related to prescribed search extents and the directory provides more detailed information on the wetlands.	Study Area: A point search (approximating with the centre of the Study Area: -22.041, 146.364) with a 50 km buffer was searched. Offsite Water Infrastructure: polygon over option (approximately 43.5 x 32.5 km)	This mapping identifies the location of wetlands that satisfy at least one criterion agreed upon by the Australian and New Zealand Environment and Conservation Council (ANZECC) Wetlands Network in 1994.

Source and name	Description of information source	Search extent	Limitations of use
DEHP Wetland mapping	Various mapping layers produced by DEHP (including Wetland Protection Areas).	Mapping obtained for the Study Area and adjacent landscape in an electronic data layer for GIS analysis.	Wetlands are identified using the DEHP AquaBAMM Methodology – the on-ground values of individual wetlands identified through this methodology have not necessarily been assessed, as designation is primarily based on existing literature and expert opinion. As such, designation does not reveal the value of these systems for local flora and fauna.
DEHP *Burdekin Natural Resource Management (NRM) Region Back on Track Actions for Biodiversity* report (DERM, 2010a)	This document identifies priority species in the Burdekin NRM region, details the regional threatening processes impacting upon these species, and proposes a range of actions to address regional threats. Priority taxa are identified through the DEHP Back on Track species prioritisation framework, in consultation with a range of stakeholders from the region. The document seeks to guide priority species conservation in the region over the next five years.	The document covers the entire Burdekin NRM region (in which the Study Area occurs).	Some species/impacts listed in this document are not relevant to the Study Area, as the Burdekin NRM region encompasses a large area of central Queensland with a wide range of habitats.
DEHP Wildlife Online database	The DEHP Wildlife Online database maintains a catalogue of animal and plant species records from specific localities across Queensland. As well as common species, records of animals and plants listed as threatened under the NC Act are contained within the database.	Study Area: A point search (approximating with the centre of the Study Area: -22.041, 146.364) with a 50 km buffer was searched. Offsite Water Infrastructure: polygon over option (approximately 43.5 x 32.5 km)	This database catalogues known records of species in a defined area. DEHP recommend that independent verification of records should be undertaken to inform the accuracy and completeness of information catalogued within this database (i.e. field surveys).

Source and name	Description of information source	Search extent	Limitations of use
DEHP (Queensland Herbarium) HERBRECS specimen database	The HERBRECS database catalogues flora specimen records obtained throughout Queensland.	A rectangular area was searched, such that the diagonal extending from the approximate centre of the Study Area (22.041, 146.364) to each corner was 50 km. The co-ordinates of the search were between latitudes -21.598 and -22.512, and longitudes 145.865 and 146.837.	This database catalogues known records of species in a defined area The age and lack of spatial precision of species records may limit their value for inclusion in current studies in some instances.
Queensland Museum Queensland Museum Data Search	The Queensland Museum catalogues vertebrate fauna specimen records obtained throughout Queensland.	A rectangular area was searched, such that the diagonal extending from the approximate centre of the Study Area (22.041, 146.364) to each corner was 50 km. The co-ordinates of the search were between latitudes -21.598 and -22.512, and longitudes 145.865 and 146.837.	This database catalogues known records of species in a defined area The age and lack of spatial precision of species records may limit their value for inclusion in current studies in some instances.
Burdekin Dry Tropics & Australian Government Freshwater Fish of Burdekin Dry Tropics NRM Region	The report documents the diversity and distribution of freshwater fish species within the Burdekin Dry Tropics NRM Region.	The document covers the entire Burdekin Dry Tropics NRM region (in which the Study Area occurs).	Some species listed in this document are not relevant to the Study Area, as the Burdekin Dry Tropics NRM region encompasses a large area of central Queensland. Species distributions are described in terms of sub-catchments and distribution maps are useful to identify species with potential to occur.

Source and name	Description of information source	Search extent	Limitations of use
DEHP (Natural Resources and Environment Division) Expert Panel Reports: Burdekin Region	These three reports; aquatic fauna, aquatic flora and aquatic ecosystems, are part of the Aquatic Conservation Assessment for riverine and non-riverine wetlands in the Great Barrier Reef (GBR) catchment. The reports identify rare and threatened, priority and exotic species, species richness, and priority ecosystems and special features of the Burdekin region.	These documents assess the riverine and non-riverine wetlands of the Burdekin region	Some species listed in this document are not relevant to the Study Area, as the Burdekin catchment encompasses a large area of central Queensland.



LEGEND

- Homestead
- Local Road
- Track
- Watercourse
- EPBC / DOI Wetlands / Wildlife Online Search Area
- Queensland Museum / Herbrecs Search Area
- Waterbody
- Rail (West)
- Mine (Onsite)
- Mine Infrastructure Area
- Mine (Offsite)
- Borehole
- Storage Site (Instream)
- Storage Facility (Offstream)
- Pipeline Network
- Airport Location
- Rail Siding
- Industrial Area
- Workers Accommodation Village

1:750,000 (at A4)

0 5 10 15 20 25

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

Aquatic Ecology
Desktop Search Areas

Job Number 41-25215
Revision D
Date 30-08-2012

Figure: 1-3

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Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DERM: Waterbody (2009); GHD: Desktop Search Areas (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Road, Homestead, Watercourse (2007); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011). Created by: BW.

1.6.2 Field Assessment – Surface Aquatic Ecosystems

1.6.2.1 Survey Timing

Temporally separated field assessments to identify the aquatic ecology values of the Study Area were undertaken to account for the ephemeral nature of the watercourses in the region and to supplement and ground truth the information obtained from the desktop assessment. Assessments were undertaken prior to and immediately following wet season conditions in order to capture the extremes in seasonal state of the aquatic ecosystems. Survey sites were selected to provide information representative of the aquatic ecosystems and habitats within the Study Area.

The Study Area is defined in Section 1.4 and shown in Figure 1-2. The desktop assessments described above (Section 1.6.1) provided background information on expected aquatic ecosystem values of the Study Area and assisted in targeting the field survey approach. Three survey events were undertaken.

- Event 1 November was undertaken between 9 and 13 November 2010 within the phase one assessment extent. This survey consisted of habitat assessment at 11 sites. Water volume and flow was minimal and absent in many watercourses during this visit. Habitat assessment provided an understanding of habitat availability and character.
- Event 2 May was undertaken between 5 April and 8 May 2011 after a significant wet season for Queensland. The Study Area expanded to the phase two assessment extent and additional sampling sites were chosen to increase the total number to 18 sites. This survey consisted of habitat assessments (18 sites), fish and crustacean sampling (5 sites), and macroinvertebrate sampling (3 sites). Given the ephemeral nature of the watercourses in the region, the aquatic habitats are most productive during wet season conditions and hence the sampling at the additional locations was undertaken during a period when the systems are likely to demonstrate the greatest ecological values. Capturing data during this period is more likely to identify sensitive features for consideration during impact assessment so it was not considered a concern that all these areas were not assessed during the Event 1 November (prior to wet season).
- Event 3 November was undertaken between 8 and 10 November 2011 to assess aquatic ecosystems associated with EPC 1080 and the mine offsite infrastructure. This survey consisted of habitat assessment at 8 sites. Field knowledge and results from the previous two survey events as well as desktop information was used to select survey sites to undertake targeted ground truthing. The field survey was undertaken to confirm parallels with aquatic habitat values already identified in previous surveys.

The sampling techniques employed and the location for their application was influenced by accessibility, habitat and microhabitat availability, representation of water body types within the site, position within the catchment and information gaps. The weather conditions during the survey events are described in Section 1.6.2.2 and further discussion on sampling technique selection is provided in Section 1.6.2.6.

Results from all field surveys have been considered in the identification of potential impacts and mitigation measures. Aquatic ecology assessment was also undertaken at the nearby Doongmabulla Springs in May 2012. The details of the assessment and results are documented in Volume 4, Appendix N2 Doongmabulla Springs Existing Environment Report.

An offsite Water Infrastructure assessment was undertaken by Hyder Consulting on 27 June 2012 in potential locations of water supply options, including existing bores and water storages and potential sites of additional water extraction. A rapid site assessment was undertaken at a number of sites.

1.6.2.2 **Animal Ethics and Approvals**

Aquatic field assessments were conducted in accordance with methodologies approved by the GHD Animal Ethics Committee (Queensland Department Agriculture, Forestry and Fisheries (DAFF) accredited). Fish sampling was undertaken under a job specific General Fisheries Permit 144362, by appropriately qualified aquatic ecologists.

1.6.2.3 **Weather Conditions**

All weather data presented below was sourced from the nearest Australian Bureau of Meteorology (BOM) weather station – Clermont Sirus Street (Station ID035019), located approximately 150 km south-east of the Study Area (BOM, 2011).

In the three months leading up to Event 1 November 2010 (i.e. August – October 2010), 308.8 mm of rain was recorded in Clermont. This is well above the long-term (1870-2010) average of 74.8 mm for these three months (BOM, 2011). During the survey period, rainfall occurred on several days, with heaviest rains on 11 and 12 November at the site. On these days' watercourses and drainage lines at the Study Area exhibited flash flows that receded within several f hours of the rainfall easing.

In the three months leading up to the Event 2 May 2011 (i.e. January – March 2011), 277 mm of rain was recorded in Clermont. This is marginally below the long-term (1870-2010) average of 306.7 mm for these three months (BOM, 2011). During the survey period, a heavy storm occurred on one of the survey days (7 May). The downpour persisted for over four hours and resulted in flash flows similar to those observed during Event 1 November. As for the Event 1 November, the flow in watercourses were observed to be dry prior to the downpour and ceased within 12 hours.

In the three months leading up to the Event 3 November 2011 (i.e. August – October 2011), 95.6 mm of rain was recorded in Clermont. No rainfall was recorded during this field survey period.

1.6.2.4 **Site Selection**

The watercourse GIS mapping layer produced by DEHP identifies a number of watercourses, minor drainage lines and dams across the Study Area (i.e. EPC 1690, EPC 1080 and proposed offsite infrastructure).

A total of 26 sites were assessed during the survey program. These are considered to be representative of the different aquatic habitats within the Study Area and provide spatial variability in assessment. The locations of the sites and timing of the assessments are described in Table 1-3. Habitat assessment sites are displayed in Figure 1-4.

Sites for survey were selected using a two-step process, incorporating desktop assessment and ground-truthing in the field. Watercourse and water body mapping, wetland mapping and aerial photography provided desktop information to allow for potential sampling sites to be selected prior to field visits with the aim of survey sites representing the range of potential aquatic habitats within the Study Area. Factors considered for site selection included stream order, wetland type (palustrine, lacustrine), protected areas (wetland protection areas), permanency of water, and distribution across the Study Area, catchment location, and existing information on habitat quality and site accessibility. During site visits, a subset of sites was selected in order to maximise both the number of sites and a

range of aquatic habitats. Site selection was additionally influenced by Project timeframes and the need to provide adequate representation across the site. Sites were revisited where possible to obtain temporal information. Sites prioritised for temporal assessment targeted higher value ecosystems, while maintaining adequate representation of habitat. Table 1-3 shows the number of sampling visits to each site selected.

An assessment site is defined as a 100 m reach for water bodies and includes bed and banks. The assessment considers all the habitats within this area.

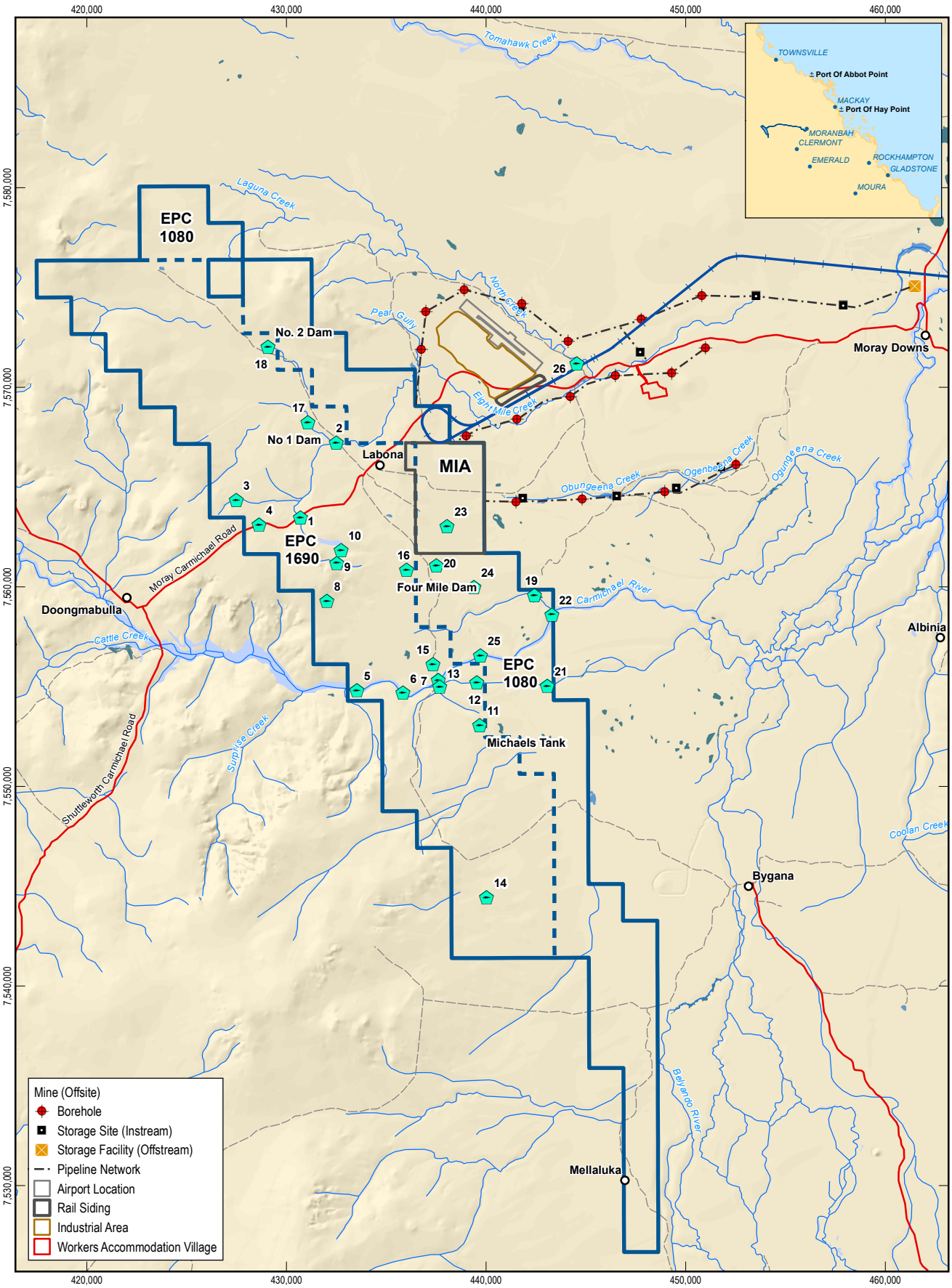
Assessment techniques and their selection are discussed in Sections 1.6.2.5, 1.6.2.6 and 1.6.2.7.

Table 1-3 Aquatic Assessment Sites

Site No.	Waterbody Type	Watercourse	Habitat Assessment			Other Sampling Techniques
			Event 1 Nov (2010)	Event 2 May (2011)	Event 3 Nov (2011)	
1	Drainage line	Eight Mile Creek (south branch)	✓	✓		
2	Drainage line	Eight Mile Creek	✓	✓		
3	Drainage line	Eight Mile Creek (west branch)	✓	✓		
4	Drainage line	Drainage line	✓	✓		
5	Riverine	Carmichael River (upstream)	✓	✓		Event 2 May: Fish/crustacean trapping (16 soak hrs), macroinvertebrate sampling (edge sampling), macrophyte assessment
6	Riverine	Carmichael River (central)	✓	✓		Event 2 May: Macroinvertebrate sampling (edge sampling), macrophyte assessment
7	Riverine	Carmichael River (downstream)	✓	✓		Event 2 May: Fish/crustacean trapping (16 soak hrs), macroinvertebrate sampling (edge sampling), macrophyte assessment
8	Drainage line	Drainage line site 8	✓	✓		
9	Drainage line	Drainage line site 9	✓	✓		
10	Drainage line	Drainage line site 10	✓			

Site No.	Waterbody Type	Watercourse	Habitat Assessment			Other Sampling Techniques
			Event 1 Nov (2010)	Event 2 May (2011)	Event 3 Nov (2011)	
11	Palustrine	Michael's Tank (dam)		✓		Event 2 May: Macrophyte assessment
12	Palustrine	Cabbage Tree Creek (east)		✓		Event 2 May: Fish/crustacean trapping (16 soak hrs), macrophyte assessment
13	Palustrine	Cabbage Tree Creek (west)		✓		Event 2 May: Fish/crustacean trapping (16 soak hrs), macrophyte assessment
14	Drainage line	Drainage line site 14		✓		
15	Palustrine	Swamp Tank (dam)	✓	✓		Event 2 May: Fish/crustacean trapping (16 soak hrs), macrophyte assessment
16	Lacustrine	Four Mile Dam		✓		Event 2 May: Macrophyte assessment
17	Lacustrine	Number 1 Dam		✓		Event 2 May: Macrophyte assessment
18	Lacustrine	Number 2 Dam		✓		Event 2 May: Macrophyte assessment
19	Palustrine	Mapped Wetland			✓	
20	Gilgai	Gilgai			✓	
21	Riverine	Cabbage Tree Creek			✓	Event 3 Nov: Fish/crustacean trapping (7 soak hours) and seine netting, macroinvertebrate sampling (edge sampling), macrophyte assessment
22	Riverine	Carmichael River			✓	Event 3 Nov: Fish/crustacean trapping (16 soak hours) and seine netting, macrophyte assessment
23	Lacustrine	Brigalow Dam			✓	

Site No.	Waterbody Type	Watercourse	Habitat Assessment			Other Sampling Techniques
			Event 1 Nov (2010)	Event 2 May (2011)	Event 3 Nov (2011)	
24	Palustrine	Gladys Dam			✓	Event 3 Nov: Fish/crustacean trapping (29.75 soak hours), macrophyte assessment
25	Riverine	Carmichael River			✓	Event 3 Nov: Fish/crustacean trapping (36 soak hours) and seine netting, macroinvertebrate sampling (edge sampling), macrophyte assessment
26	Drainage Line	North Creek			✓	



LEGEND

- Homestead
- Aquatic Ecology
  - Habitat Assessment Site
- Local Road
- Track
- Watercourse
- Wetland Type
  - Lacustrine
  - Palustrine
  - Riverine
- Rail (West)
- Mine (Onsite)
- Mine Infrastructure Area

1:275,000 (at A4)

0 2 4 6 8 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

Aquatic Ecology
Habitat Assessment Sites

Job Number 41-25215
Revision D
Date 30-08-2012

Figure: 1-4

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Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DERM: Waterbody (2011), HYD Wetland (2009); GHD: Aquatic Ecology Assessment Site (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Road, Homestead, Watercourse (2007); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011). Created by: BW.

1.6.2.5 **Habitat Assessment**

Aquatic habitat assessments were undertaken at all sites (Table 1-3) within the Study Area to characterise the water bodies with respect to ecological values for aquatic flora and fauna. Seasonal assessment of some sites confirmed the presence or absence of aquatic habitat temporally.

Visual habitat assessments of the 100 m reach were used to describe the aquatic ecosystems in terms of habitat diversity and extent, suitability for aquatic fauna groups, sensitivity to change, existing disturbances/modifications or barriers, riparian condition and flow characteristics. This was achieved using a standardised proforma approach modelled on the Queensland Australian River Assessment System (AusRivAs) assessment protocols.

Key features noted included:

- Substrate: in terms of per cent representation by bedrock, boulder (>256 mm), cobble (64-256 mm), pebble (4-64 mm), gravel (2-4 mm), sand (0.05-2 mm) and silt/clay (<0.05 mm) classifications
- Snags and woody debris: in terms of representation of detritus (leaves, twigs), sticks (<2 cm diameter), branches (<15 cm diameter) and logs (>15 cm diameter) classifications. These are estimated in terms of cover within the reach as either none, little (1-10 per cent), some (10-50 per cent), moderate (50-75 per cent) or extensive (>75 per cent)
- Habitat attributes: note is taken for the presence of periphyton, moss, filamentous algae, macrophytes, bank overhang vegetation, trailing bank vegetation, blanketing silt and substrate anoxia. The same ‘none’ to ‘extensive’ categories are used as for snags and woody debris
- Sediment deposits: refers to the presence of in-stream deposits of either sand or silt (or none)
- Odour: the presence of water or substrate odour is noted
- Variety of habitat: the presence of shallow, deep, pool, run, riffle, undercut bank, woody debris and macrophytes habitats is noted

In addition to the key features listed, observations relating to intactness and size of the riparian zone, shading, disturbances and water quality were considered.

1.6.2.6 **Fauna Assessment**

Survey for fish and crustaceans was undertaken using baited traps during the Event 2: May survey and a combination of bait traps and seine netting techniques during the Event 3: November survey. Sites where these techniques were undertaken are identified in Table 1-3.

The fauna assessment aimed to supplement the desktop information on fauna species in the region and provide information specific to the Study Area.

The sites selected for fauna assessment are environments representative of the aquatic habitats on the site that were expected to be important for fish and crustaceans. Low trapping success in some areas led to the prioritisation for sampling at the riverine and palustrine habitats rather than dams that are considered to have lower habitat values.

Box and opera house traps were baited and set for a minimum of two hours within suitable habitats. GHD standard operating procedures allow for a greater soak time than two hours, however to reduce stress and minimise in-trap predation and trap escapement, a two hour soak time was considered suitable. Previous experience indicates that two hours soak time is sufficient for these habitats. Low

flow conditions and minimal shading at some sites may have led to stress on captured individuals and these onsite characteristics contributed to individual trap placement and soak time.

A minimum of eight traps were set at each site. Individual trap placement aimed to sample the variety of microhabitats within the 100 m reach, for example woody debris, root balls and trailing bank vegetation. A total of 64 trap soak hours were achieved over the survey. Individuals caught were identified and sorted into size groupings before release.

Seine netting was conducted using a five metre seine net with a mesh size of 2 mm. The length of the seine transects were determined by the characteristics (depth, length and presence of woody debris) of the water body however they did not exceed 10 m for each trawl. After each trawl, fish were placed in a bucket of water for recovery and processing, and then returned to the water body after identification.

Aquatic macroinvertebrate sampling was undertaken in accordance with the AusRivAS Sampling and Processing Manual (NRM, 2001) during the Event 2 May and Event 3 November surveys. Macroinvertebrate communities can be used as an indicator of stream condition but also for this Project have been assessed to meet the Project TOR and may provide some baseline data for ongoing monitoring.

The assessments were undertaken using field sampling and live pick procedures, laboratory analysis and community data analysis. Additional invertebrates, often larger species such as crabs and yabbies, are not considered in the community analysis as it is not consistent with AusRivAS protocol. These are detected through the other fauna sampling techniques and are discussed separately.

1.6.2.7 Flora Assessment

Aquatic flora assessment was undertaken in conjunction with habitat assessments. Species present and relative abundance was recorded.

Riparian assessment was conducted in riparian vegetation communities across the Study Area as part of the terrestrial flora ecology assessment and is reported in the Volume 4, Appendix N1 Mine Terrestrial Ecology Report. The extent and condition of riparian flora will be considered in the impact assessment process and in identifying suitable management or mitigation measures.

This report addressed aquatic macrophytes and water dependant species only.

1.6.3 Field Assessment - Subterranean Ecosystems

1.6.3.1 Survey Timing

Stygofauna sampling was undertaken using methods outlined in the WA EPA Guidance Statement No. 54 and 54a. The aim of the surveys was to determine if stygofauna were present in groundwater associated with the Project, and within the constraints of the study design, determine the range of taxa present and their conservation significance.

Two sampling events were undertaken across two seasons spaced 10 months apart as follows:

- Stygofauna Event 1 covered 20 groundwater bores and was undertaken during the post-wet season between 24 and 27 October 2011.
- Stygofauna Event 2 covered the same 20 groundwater bores as Event 1 and was undertaken during the post-west season between 10 and 13 August 2012.

1.6.3.2 Survey Sites

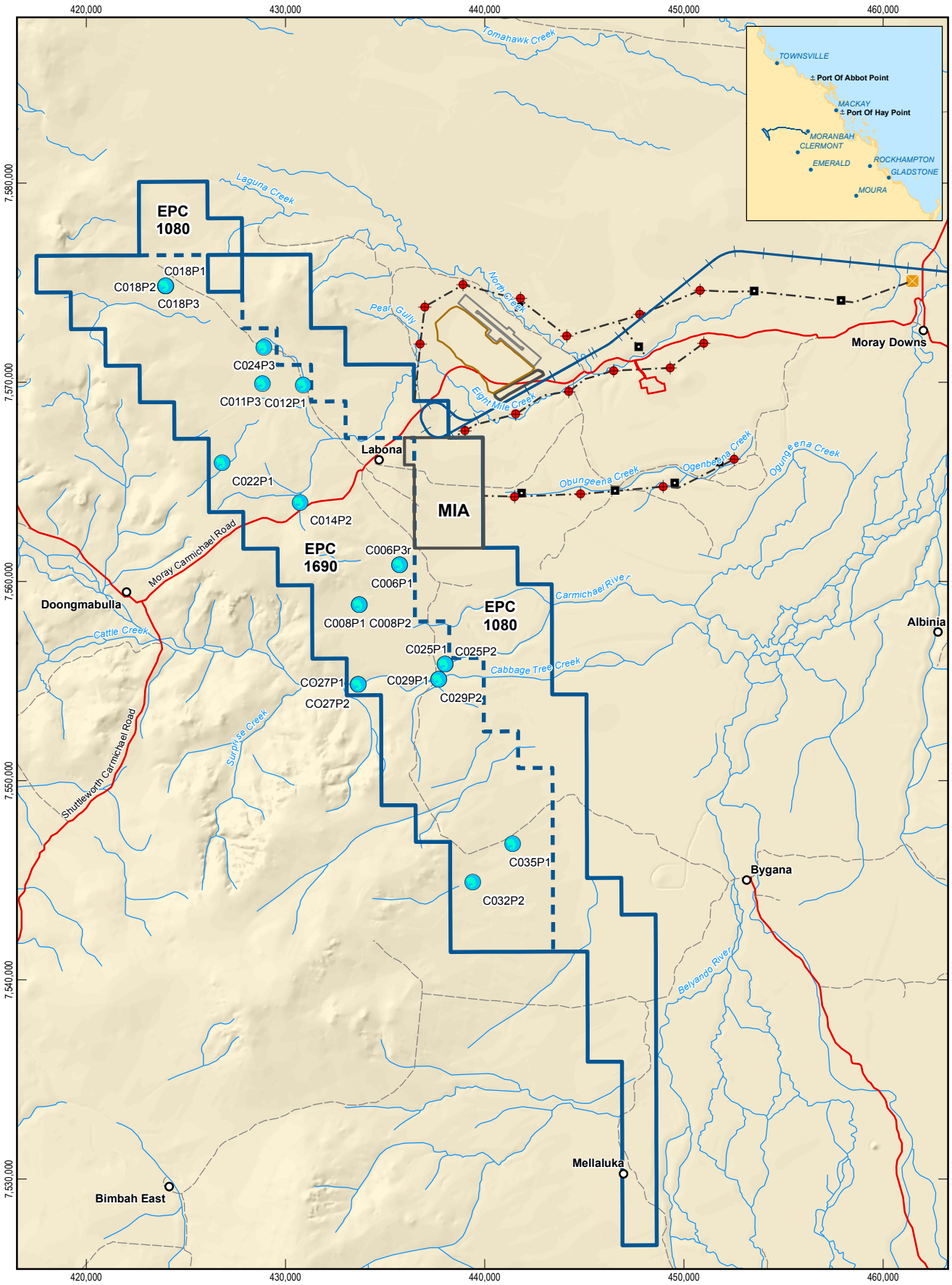
A total of 20 groundwater bores were selected for stygofauna sampling. The sampling sites were geographically well spread across EPC 1690 and covered all major hydrogeological units present. Further discussion on the hydrogeological units present is reported in Volume 4, Appendix R Mine Hydrogeology Report and the criteria for bore selection reported in Volume 4, Appendix O2 Stygofauna Survey Report.

A combination of Rotary Wash Bore and Percussion Air-hammer drilling were used to create the groundwater bores. Each bore was installed with a 50 mm diameter uPVC casing (glued and/or screwed), machine slotted screen and fitted with a secure, lockable cover. Further detail on the bore installation is reported in Volume 4, Appendix O2 Stygofauna Survey Report. The location of the groundwater bores for stygofauna sampling are shown in Figure 1-5.

1.6.3.3 Stygofauna Assessment

The stygofauna assessment included field sampling and laboratory processing. A 400 m diameter phraetobiological net, to conform with WA guidelines, was used to collect stygofauna samples. Between four and six hauls were completed at each sampling site with contents transferred to a sample jar for preservation and stain.

Samples were then sorted in the laboratory with individuals identified to Order/Family (or lower taxanomic rank if possible) in accordance with the Project ToR. Groundwater quality samples were also collected at the time of stygofauna sampling using a hand held water quality meter.



LEGEND

- Stygofauna Bore Locations
- Homestead
- Local Road
- Track
- Watercourse
- Rail (West)
- Mine (Onsite)
- Mine Infrastructure Area
- Mine (Offsite)
- Borehole
- Storage Site (Instream)
- Storage Facility (Offstream)
- Pipeline Network
- Airport Location
- Rail Siding
- Industrial Area
- Workers Accommodation Village

1:275,000 (at A4)

0 2 4 6 8 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision A
Date 05-09-2012

Sample Locations

Figure: 1-5

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Data Source: DERM: Elevation (2011); GHD: Stygofauna Bore Locations (2012); © Copyright Commonwealth of Australia - Geoscience Australia: Road, Homestead, Watercourse (2007); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011).Created by: BW.

1.6.4 Water Quality

A field-based surface water and in-stream sediment quality assessment of the Study Area was undertaken from April to September 2011. The objective of this assessment was to characterise the quality of the existing surface water resources. Outcomes of this assessment are documented in Volume 4, Appendix Q Mine Water Quality Report and have been considered in interpreting the results of the aquatic ecology assessment.

Water quality monitoring included a combination of *in-situ* sampling of physical water quality parameters and collection of water samples for laboratory analysis of basic and broad suites.

1.6.5 Limitations

A limitation of the surface aquatic ecology study is that seasonal variability has been recorded from observations made during two seasonal periods. Field visits were not achievable during all wet season months due to access restrictions hence surveys were undertaken prior to and immediately following the wet period in order to best capture the values under these conditions. Habitat assessment, species profiles and hydrological information has been used to provide an understanding of the aquatic systems throughout the year in conjunction with the seasonal observations (Section 1.6.2.4) and hence an understanding of seasonal variability. In addition, it is not possible to account for inter-annual variability on the basis of a single year's sampling, and in non-permanent water bodies inter-annual variability in the invertebrate biota may be substantial.

2. Description of Environmental Values

2.1 Regional Context

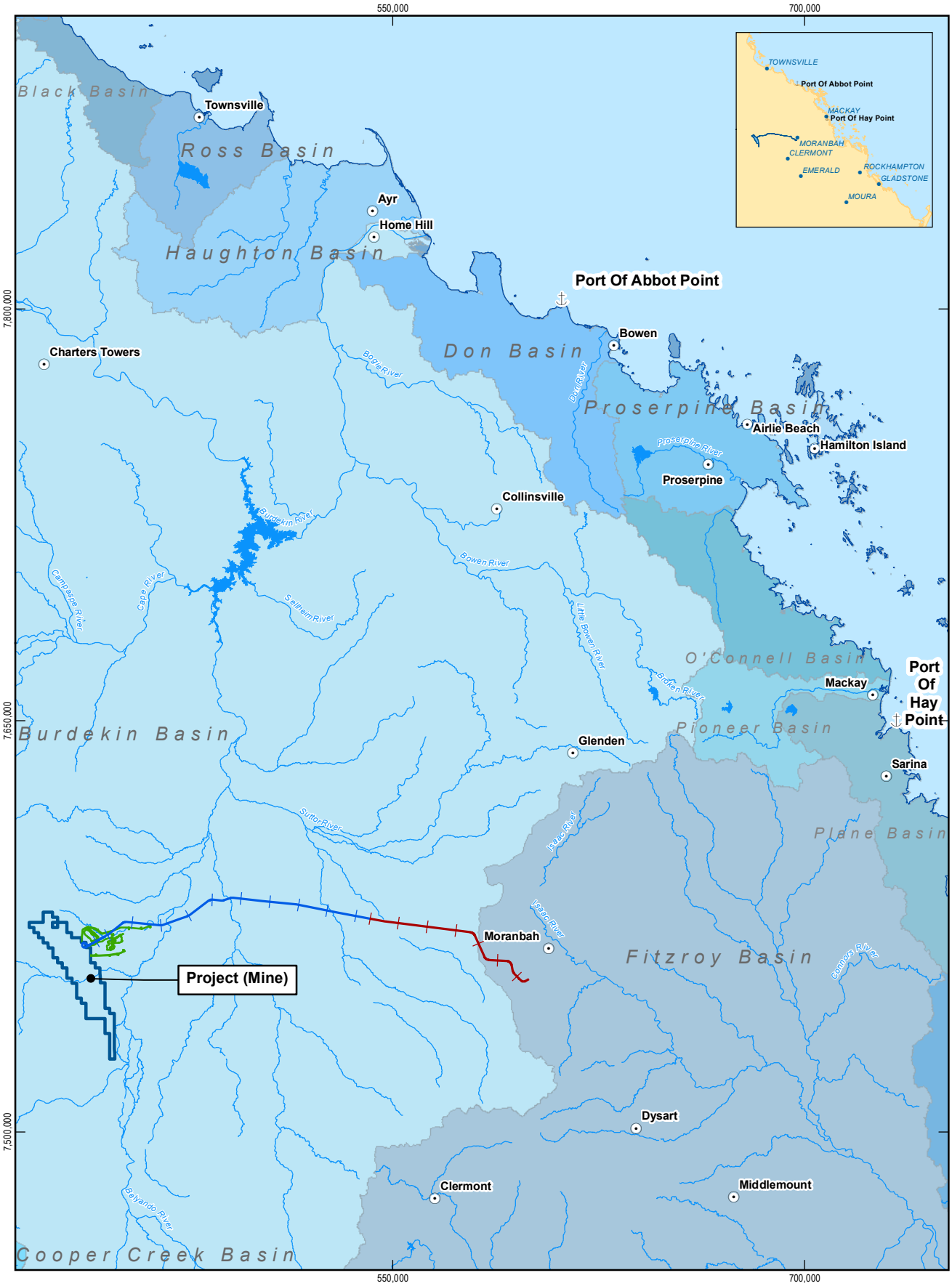
The Study Area is located within the Burdekin River Catchment (Figure 2-1). Key features of this catchment are the Burdekin River Gorge and falls, and the Burdekin Falls Dam, which lie downstream of the study area. The gorge is thought to have been formed over 10 million years ago and surrounds an 18 km long water body with the falls at its top. The number of fish species able to move upstream through this obstacle is expected to be very low, and with the construction of the dam in 1985, even lower (Pusey *et al.*, 1998). The main basins of the catchment include the Upper Burdekin basin, Cape Campaspe basin, Belyando basin, Suttor basin, Bowen Broken Bogie Basin and Lower Burdekin basin (Dight, 2009). The gorge falls and dam have influenced the ecology of the catchment by restricting movement from the eastern coastal area to the upper catchment areas.

The Study Area is located within the Belyando basin of the Burdekin River Catchment where land use is dominated by grazing and natural pastures, and widespread clearing has resulted in a decline in riparian habitat condition and occurrence over the past 30 years (Dight, 2009). Connectivity of remnant vegetation at a landscape level is maintained by tracts of vegetation including mature river red gum (*Eucalyptus camaldulensis*) and Paper Bark (*Melaleuca leucadendra*) associated with major watercourses including the Carmichael and Belyando Rivers. Further information regarding the vegetation in the study area is provided in Volume 4 Appendix N1 Mine Terrestrial Ecology Report.

Unlike the more undulating and wetter northern part of the Burdekin Catchment, which features highly erodible soils, the Belyando basin is characterised by generally low relief floodplains drained by braided channels and surrounded by wide alluvial plains. Little is known of the ecology and condition of aquatic habitats in this sub-catchment, including records of permanent waterholes (Dight, 2009).

The Study Area is bisected by the Carmichael River, which flows through EPC 1690 and EPC 1080 and joins the Belyando River almost 20 km downstream of the eastern boundary of the EPCs. Cabbage Tree Creek to the south of the Carmichael River is an ephemeral distributary creek of the Carmichael River. The majority of the Study Area, however, drains not into the Carmichael River but east into a series of ephemeral creeks including Pear Gully and Eight Mile Creek. These creeks become undefined before reaching the Belyando River. Eight Mile Creek is located at the north of the Study Area. There are also a number of ill-defined watercourses to the north and the south of the Carmichael River within the Study Area that drain generally in an easterly direction toward the Belyando River. A detailed assessment of hydrology is provided in Volume 4 Appendix P1 Mine Hydrology Report and surface water quality for the study area is provided in Volume 4 Appendix Q Mine Water Quality Report.

The Belyando River converges with the Suttor River and the waterway eventually drains into the Burdekin River. As a result of the high location in the catchment and seasonality in rainfall, flows are generally restricted to the wetter months, November to March, with many streams and drainage channels drying entirely and larger rivers sustaining only pools or low flows by the winter months (June/July). During extended dry periods the Carmichael and Belyando Rivers are thought to maintain a series of semi-permanent to permanent waterholes. This suggests that the major watercourses and the associated remnant riparian vegetation are groundwater-dependent to a degree in the regions upstream of the Project (Mine). Watercourses within and downstream of the Study Area are more likely to be losing to groundwater according to Appendix R Mine Hydrogeology Report.



LEGEND

- Town
- Major Port
- Watercourse
- Project (Mine)
- Mine (Offsite)
- Rail (West)
- Rail (East)

1:2,000,000 (at A4)

0 20 40 60 80

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

Relationship of Study Area to River Catchments

Job Number 41-25215
Revision A
Date 31-08-2012

Figure: 2-1

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Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DERM: Drainage Basins (2009); GA: Towns, Watercourses, Mainlands (2007); DME: Carmichael Mine Site (2011); GHD: Major Ports (2010); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: BW,MS

2.2 Aquatic Ecosystems

2.2.1 Aquatic Habitats

2.2.1.1 Study Area

Aquatic habitats vary in size and geomorphology across the Study Area. They can be grouped into five broad water body types: lacustrine, palustrine, riverine, drainage lines and gilgais. Figure 1-4 shows the lacustrine, palustrine and riverine habitats across the site according to the DERM water body mapping layer.

Lacustrine habitat is defined as wetland and deep water habitats located in a topographic depression or a damned river channel (DERM, 2010b). Lacustrine habitats also have vegetation (including trees, shrubs, persistent emergents, mosses or lichens) coverage less than 30 per cent (DERM, 2010b). Within the Study Area habitats within this description are most commonly represented as dammed watercourses north of the Carmichael River.

Palustrine habitat describes water bodies that are dominated by vegetation (including trees, shrubs, persistent emergents, mosses or lichens) (DERM, 2010b). These are also represented by dams in the Study Area with the difference to lacustrine habitat being the greater presence of macrophytes or trees and shrubs (greater than 30 per cent cover). DERM mapping (Figure 1-4) identifies 12 areas (three in EPC 1690 and nine in EPC 1080) of this habitat category near the Carmichael River in the Study Area. One of these areas is a large dam (Site 15 Swamp Tank) with abundant floating, submerged and emergent macrophytes, and some inundation of fringing trees/shrubs when at water volume capacity. The palustrine habitat features were also observed in Cabbage Tree Creek (Site 13). The other two areas depicted on the map to the west of Swamp Tank, within EPC 1690, and other smaller mapped areas in EPC 1080 did not exhibit permanent standing water and are located in topographic depressions. They are vegetated by melaleuca and other species common to wetter areas, though demonstrated no aquatic habitat values at the time of survey.

Riverine habitats are those with a formed channel that periodically or continuously contain flowing water (DERM, 2011a). The Carmichael River and reaches of Cabbage Tree Creek (Site 12) can be classified as riverine. There are a number of drainage lines that have established stream banks and a formed channel, however, these lines provide limited long term aquatic habitat. The Carmichael River (5th order stream) represents the largest watercourse within the Study Area and maintains aquatic habitat throughout the year, even if in isolated pools. Cabbage Tree Creek also provides permanent aquatic habitat for flora and fauna within the Study Area.

Drainage lines are narrow drainage paths (often 1st order streams or not mapped) and occur at the top of stream catchments and meander in other areas of the Study Area. These paths do not have defined banks; rather they can be identified by a change in substrate from the adjacent area. Within the Study Area drainage lines often have a loose sandy substrate with adjacent geology being much more compact. These lines provide a pathway for runoff during high volume downpours and are not expected to accommodate long term flows or isolated pools. There is very little erosion observed in these shallow profile drainage lines.

Gilgais are distributed across the Study Area though are not necessarily related to the location of waterways. Gilgais are micro-relief land forms of mounds and depressions formed on shrink-swell and cracking clay soils where water can collect seasonally to form gilgai wetlands (DERM, 2011b). They are depressions in the landscape that can contain water and can attract a variety of reptiles,

amphibians, birds, mammals and invertebrates (DERM, 2011b). The gilgais within the Study Area do not contain permanent water to support aquatic fauna though there is some evidence of water dependant plants persisting in these areas. The gilgais observed to have water were shallow, narrow (no greater than four metres across) and are not expected to be sustained throughout the dry season. The ecological values of the gilgais as they related to terrestrial species are discussed in Volume 4, Appendix N1 Mine Terrestrial Ecology Report.

Habitat features at the sites assessed are summarised in Table 2-1. The Carmichael River and Cabbage Tree Creek demonstrated the greatest diversity of aquatic habitats for aquatic fauna however macrophytes were observed only in the dams. Cabbage Tree Creek demonstrated the greatest diversity of habitat, which was also reflected in the results of fish and crustacean sampling in this water body (see Section 2.3.2).

Table 2-1 Aquatic Habitat Assessment Summary

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
Lacustrine Habitat				
16	Permanent Dam "4 Mile Dam"	*Substrate:* 100% silt/clay *Snags and woody debris:* None *Habitat attributes:* Small amounts of emergent and fringing macrophytes, trailing bank vegetation and blanketing silt *Sediment deposits:* Silt *Odour:* No water odour, anoxic substrate odour *Variety of habitat:* shallow, deep, pool, macrophytes	◗ Approximately 40 m across, bank drop off from vegetated edge ◗ Very turbid ◗ No shading ◗ Cattle disturbance ◗ Waterbirds present, habitat or refuge for turtles	 *Event 1 November*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
17	Permanent Dam "No 1. Dam"	*Substrate:* 100% silt/clay *Snags and woody debris:* No detritus, no sticks, little branches, little logs *Habitat attributes:* Little amounts of blanketing silt *Sediment deposits:* Silt *Odour:* No water odour, substrate odour stemming from cattle use of area *Variety of habitat:* shallow, deep, pool, woody debris	◗ Approximately 20 m across, gently sloping bank/bed ◗ No shading ◗ Dead trees within water body ◗ Cattle disturbance ◗ Waterbirds present, habitat or refuge for turtles, habitat for fish, however limited opportunity for recruitment	 *Event 2 May*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
18	Permanent Dam "No. 2 Dam"	*Substrate:* 100% silt/clay *Snags and woody debris:* Little detritus, no sticks, no branches, little logs *Habitat attributes:* Some macrophytes, some blanketing silt, some substrate anoxia *Sediment deposits:* Silt *Odour:* No water odour, anoxic substrate odour *Variety of habitat:* shallow, deep, pool, woody debris	◗ Approximately 30 m across, gently sloping bank/bed ◗ No shading ◗ Heavy cattle disturbance ◗ Waterbirds present, habitat or refuge for turtles, habitat for fish, however limited opportunity for recruitment	 *Event 2 May*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
23	Permanent Dam “Brigalow Dam”	*Substrate:* 100% silt/clay *Snags and woody debris:* No detritus, no sticks, no branches, no logs *Habitat attributes:* No macropytes or aquatic vegetation, little amounts of blanketing silt *Sediment deposits:* Silt *Odour:* No water odour, no substrate odour *Variety of habitat*: shallow turbid pool	◗ Approximately 50 m across, moderately sloping bank/bed ◗ Small pool of water at the bottom of the dam at the time of observations ◗ Very turbid ◗ No shading ◗ Cattle and pig disturbance ◗ At time of survey this dam provided limited value as aquatic habitat for turtles and fish. Limited opportunity for recruitment.	 *Event 3 November*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
Palustrine Habitat				
11	Permanent Dam Michael's Tank	*Substrate:* 100% silt/clay *Snags and woody debris:* Little detritus, little sticks, no branches, no logs *Habitat attributes:* Some filamentous algae, some macrophytes, little trailing bank vegetation, some blanketing silt, little substrate anoxia *Sediment deposits:* Silt *Odour:* No water odour, substrate odour *Variety of habitat:* shallow, deep, pool, macrophytes	◗ Two adjacent dams approximately 30 m across ◗ No shading ◗ Heavy cattle disturbance ◗ Submerged, emergent and floating macrophytes ◗ Dense grass groundcover on margins ◗ Waterbirds present, habitat or refuge for turtles, habitat for fish, however limited opportunity for recruitment	 *Event 2 May*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
13	Cabbage Tree Creek (west)	*Substrate:* 100% silt/clay *Snags and woody debris:* Little detritus, little sticks, little branches, little logs *Habitat attributes:* Some macrophytes, medium blanketing silt *Sediment deposits:* Silt *Odour:* No water odour, no substrate odour *Variety of habitat:* shallow, deep, pool, woody debris, macrophytes	◗ Isolated pool approximately 20 m across with limited riparian zone ◗ Depth range from 10 cm to 1.5 m, gently sloping bank and bed ◗ Mapped as 1st order stream ◗ Low-Moderate shading ◗ Very turbid ◗ Cattle and pig disturbance ◗ Submerged, emergent and floating macrophytes ◗ Algae on the substrate ◗ Habitat or refuge for turtles, habitat for fish however opportunity for recruitment limited to high flows when connects to Carmichael River	 *Event 2 May*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
15	Dam Swamp Tank	*Substrate:* 100% silt/clay *Snags and woody debris:* Little detritus, no sticks, no branches, no logs *Habitat attributes:* Little filamentous algae, some macrophytes, little trailing bank vegetation (grass), some substrate anoxia *Sediment deposits:* Silt *Odour:* No water odour, substrate odour stemming from cattle *Variety of habitat:* shallow, deep, pool, macrophytes	◗ Approximately >50 m across, gently sloping bed ◗ No shading ◗ Turbid ◗ Heavy cattle disturbance ◗ Submerged, emergent and floating macrophytes ◗ Algae on the substrate ◗ Waterbirds present, habitat or refuge for turtles, habitat for fish, however limited opportunity for recruitment	 *Event 2 May*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
19	Mapped wetland	*Substrate:* 100% silt/clay *Snags and woody debris:* Some detritus, sticks, branches and logs *Habitat attributes:* Provides seasonal habitat for aquatic species including water birds during the wet season or after significant rainfall *Sediment deposits:* None No water sustained during dry season	◗ This area is mapped as a GBR Wetland Protection Area (see Figure 3-2) ◗ No standing water or associated aquatic vegetation was present at the time of the survey ◗ A drainage line directs localise overland flow into wetland area ◗ Well established remnant vegetation within a depressions ◗ High shading ◗ The area surrounding the GBR Wetland Protection Area has been cleared and contains juvenile trees and grass species ◗ Seasonal aquatic habitat. Evidence that habitat utilised by water birds during the wet season or after significant rainfall	 *Event 3 November*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
24	Permanent Dam Gladys Dam	*Substrate:* 100% silt/clay *Snags and woody debris:* No detritus, no sticks, no branches, no logs *Habitat attributes:* Moderate amounts of macrophytes along the edge, little amounts of blanketing silt *Sediment deposits:* Silt *Odour:* No water odour, no substrate odour *Variety of habitat*: deep pool with fringing macrophytes	◗ Approximately 50 m across, moderately sloping bank/bed ◗ Small dam above main dam ◗ Windmill present ◗ No shading ◗ Cattle and pig disturbance ◗ Waterbirds present, habitat or refuge for turtles, habitat for fish, however limited opportunity for recruitment	 *Event 3 November*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
Drainage Line Habitat				
1	Eight Mile Creek Upstream (South Branch)	*Substrate:* 10% pebble, 10% gravel, 80% sand *Snags and woody debris:* Little detritus, little sticks, little branches, some logs *Habitat attributes:* Little trailing bank vegetation *Sediment deposits:* Sand No water sustained water during wet or dry season	◗ No permanent water seasonally, facilitates flash flows only (as observed during downpour) ◗ Creek meanders showing evidence of high flows creating scour at bends ◗ Minimal terrestrial vegetation within the streambed suggesting sufficient flows or wet periods to limit growth or unsuitability of soils ◗ Cattle disturbance ◗ Numerous areas of scour and vertical banks ◗ Very low shading ◗ Mapped as 2nd order stream ◗ No long term aquatic habitat	 Event 1 *November*  Event 2 *May*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
2	Eight Mile Creek (proper)	*Substrate:* 5% bedrock, 5% pebble, 5% gravel, 75% sand *Snags and woody debris:* Little detritus, little sticks, little branches, some logs *Habitat attributes:* None *Sediment deposits:* Sand, silt No water sustained water during wet or dry season	◗ No permanent water seasonally, facilitates flash flows only ◗ Creek meanders showing evidence of high flows creating scour at bends ◗ Minimal terrestrial vegetation within the streambed suggesting sufficient flows or wet periods to limit growth or unsuitability of soils ◗ Cattle disturbance ◗ Mapped as 3rd order stream though 2 dams upstream ◗ No long term aquatic habitat	 Event 1 *November*  Event 2 *May*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
3	Eight Mile Creek Upstream (West Branch)	*Substrate:* 90% sand, 10% silt *Snags and woody debris:* Little detritus, little sticks, little branches, no logs *Habitat attributes:* Little trailing bank vegetation *Sediment deposits:* Sand, silt No water sustained water during wet or dry season	◗ Narrow drainage channel with little relief – low bank slope ◗ No steep slopes though patches of bare ground and erosion during high flows ◗ No isolated pools during the wet season ◗ Flash flows during rain (photo taken during heavy downpour) ◗ Mapped as 1st order stream ◗ No aquatic habitat	 *Taken during extreme heavy downpour (Event 1 November) that persisted up to 1 day. Flows receded soon after rain ceased.*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
4	Drainage Line Site 4 - Moray Carmichael Rd	*Substrate:* 20% gravel 80% sand *Snags and woody debris:* Little detritus, little sticks, no branches, no logs *Habitat attributes:* None *Sediment deposits:* Sand No water sustained water during wet or dry season	◗ Narrow drainage channel with little relief ◗ No steep slopes though patches of bare ground and erosion during high flows ◗ No isolated pools during the wet season ◗ Flash flows during rain (photo taken during heavy downpour) ◗ No aquatic habitat	 *Taken during extreme heavy downpour (Event 1 November) that persisted up to 1 day. Flows receded soon after rain ceased.*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
8	Drainage Line Site 8	Substrate: 90% sand, 10% silt/clay Snags and woody debris: Little detritus, little sticks, little branches, little logs Habitat attributes: Little bank overhanging vegetation Sediment deposits: Sand No water sustained water during wet or dry season	◗ Narrow drainage channel with little relief ◗ No steep slopes though patches of bare ground and erosion during high flows ◗ No isolated pools during the wet season ◗ Flash flows only during heavy rain ◗ No aquatic habitat	 *Event 1 November*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
9	Drainage Line Site 9	*Substrate:* 10% bedrock, 10% cobble, 10% pebble, 10% gravel, 60% sand *Snags and woody debris:* Little detritus, little sticks, little branches, some logs *Habitat attributes:* None *Sediment deposits:* Sand No water sustained water during wet or dry season	◗ Narrow drainage channel ◗ Patches of bank slumping and erosion, limited defined riparian zone ◗ No isolated pools during the wet season ◗ Cattle disturbance ◗ Flash flows during rain (photo taken during heavy downpour) ◗ No aquatic habitat	 *Taken during extreme heavy downpour (Event 1 November) that persisted up to 1 day. Flows receded soon after rain ceased.*  Event 2 *May*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
10	Drainage Line Site 10	*Substrate:* 60% sand, 40% silt/clay *Snags and woody debris:* Little detritus, little sticks, little branches, no logs *Habitat attributes:* Little bank overhanging vegetation *Sediment deposits:* Sand No water sustained water during wet or dry season	◗ Narrow drainage channel with little relief ◗ No steep slopes though patches of bare ground and erosion during high flows ◗ No isolated pools during the wet season ◗ Cattle disturbance ◗ Mapped as riverine habitat however ground-truthing identified ephemeral drainage line habitat ◗ Flash flows during rain (photo taken during heavy downpour) ◗ No aquatic habitat	 *Taken during extreme heavy downpour (Event 1 November) that persisted up to 1 day. Flows receded soon after rain ceased.*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
14	Drainage Line Site 14	*Substrate:* 20% bedrock, 80% sand *Snags and woody debris:* No detritus, no sticks, little branches, little logs *Habitat attributes:* None *Sediment deposits:* Sand No water sustained water during wet or dry season	◗ Drainage channel ranging in width from 2 m to 10 m ◗ Patches of bank slumping and erosion, limited defined riparian zone ◗ Erosion and scour where groundcover absent ◗ No isolated pools during the wet season though some moisture in creek bed substrate ◗ Cattle disturbance ◗ No aquatic habitat	 Event 2 *May*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
26	North Creek	*Substrate:* 90% silt and 10% sand *Snags and woody debris:* Detritus and sticks present in the stream bed. Some branches and logs observed in stream *Habitat attributes:* None *Sediment deposits:* Silt and sand No water sustained during dry season	◗ Stream width of 2 m to 4 m ◗ Shading provided by riparian zone ◗ No isolated pools during the dry season ◗ Some cattle disturbance ◗ Some fire damage to riparian zone ◗ Evidence of yabbie holes and aquatic snails observed	 *Event 3 November*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
Riverine Habitat				
5	Carmichael River (Upstream)	*Substrate:* 100% sand *Snags and woody debris:* Some detritus, little sticks, some branches, some logs *Habitat attributes:* Little trailing bank vegetation *Sediment deposits:* Sand *Odour:* No water odour, no substrate odour *Variety of habitat:* shallow, deep, pool, run, undercut bank, woody debris	◗ Meandering river with some braided areas. Width range from 1 m to 8 m ◗ Evidence of high flows with debris high up in trees ◗ Well established riparian zone >20 m wide ◗ Vehicle crossing within reach ◗ Depth range from 10 cm to >2 m, some steep slopes ◗ Mapped as 5th order stream ◗ High shading ◗ Very turbid during wet season flow ◗ No in-stream vegetation, limited substrate variation ◗ Habitat for turtles, fish, crustaceans	 Event 1 *November*  Event 2 *May*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
6	Carmichael River (Central)	*Substrate:* 95% sand, 5% silt/clay *Snags and woody debris:* Moderate detritus, some sticks, moderate branches, moderate logs *Habitat attributes:* Some bank overhang vegetation *Sediment deposits:* Sand, silt *Odour:* No water odour, no substrate odour *Variety of habitat:* shallow, deep, pool, run, undercut bank, woody debris	◗ Meandering river with some braided areas. Width range from 1 m to 8 m, mosaic of isolated pools in dry season ◗ Evidence of high flows with debris high up in trees ◗ Well established riparian zone >20 m wide ◗ Depth range from 10 cm to 1 m, ◗ Mapped as 5th order stream ◗ High shading ◗ No in-stream vegetation, limited substrate variation, though substantial amounts of debris for structure ◗ Habitat for turtles, fish, crustaceans	 Event 1 *November*  Event 2 *May*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
7	Carmichael River (Downstream)	*Substrate:* 100% sand *Snags and woody debris:* Some detritus, little sticks, little branches, little logs *Habitat attributes:* Little bank overhang vegetation, some trailing bank vegetation *Sediment deposits:* Sand *Odour:* No water odour, no substrate odour Variety of habitat: Shallow, pool, run, woody debris	◗ Meandering river with some braided areas. Width range from 1 m to 8 m, ◗ Evidence of high flows with debris high up in trees ◗ Well established riparian zone >20 m wide ◗ Vehicle crossing within reach ◗ Depth range from 10 cm to >2 m, ◗ Mapped as 5th order stream ◗ Medium to High shading ◗ No in-stream vegetation, limited substrate variation, though some undercut bank and root balls ◗ Habitat for turtles, fish, crustaceans	 *Event 1 November*  Event 2 *May*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
12	Cabbage Tree Creek (East)	*Substrate:* 100% silt/clay *Snags and woody debris:* Some detritus, little sticks, little branches, little logs *Habitat attributes:* Little trailing bank vegetation, little blanketing silt, little substrate anoxia *Sediment deposits:* None *Odour:* No water odour, anoxic substrate odour *Variety of habitat:* shallow, deep, pool, woody debris	◗ Part of long narrow lagoon with intact riparian zone (though narrow), approximately 20 m across, depth range from 10 cm to >2 m ◗ Mapped as 1st order stream ◗ Moderate shading ◗ Some erosion ◗ Cattle disturbance ◗ Habitat for turtles and individuals were observed as well as and diversity of depth, structure, and shading providing good habitat for fish diversity	 Event 2 *May*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
21	Cabbage Tree Creek	*Substrate:* 100% silt/clay *Snags and woody debris:* moderate detritus, moderate sticks, little branches, little logs *Habitat attributes:* No macrophytes, some blanketing silt *Sediment deposits:* Silt *Odour:* No water odour, anoxic substrate odour *Variety of habitat:* shallow, deep, pool, woody debris	◗ Isolated pool approximately 7 m across with narrow riparian zone ◗ Depth range from 0.1 m to 0.75 m, gently sloping bank and bed ◗ Mapped as 1st order stream ◗ Some shading ◗ Very turbid ◗ Cattle disturbance ◗ No macrophytes observed ◗ No algae observed ◗ Provides habitat for fish and habitat or refuge for turtles. Recruitment of fish limited to high flows when connects to Carmichael River	 *Event 3 November*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
22	Carmichael River	*Substrate:* 100% sand *Snags and woody debris:* Moderate detritus, moderate sticks, moderate branches, moderate logs *Habitat attributes:* trailing bank vegetation in the form of roots and overhanging vegetation *Sediment deposits:* Sand *Odour:* No water odour, anoxic substrate odour *Variety of habitat:* shallow, deep, pool, undercut bank, woody debris	◗ Straight stretch of river. Width range approximately 5 m. ◗ Tannic water ◗ Well established riparian zone >30 m wide. ◗ Continuous tree line >150 m. ◗ Depth range from 10 cm to 75 cm. ◗ Mapped as 5th order stream ◗ High shading ◗ No aquatic vegetation ◗ Substantial amounts of debris for structure ◗ Habitat for turtles, fish, crustaceans	 *Event 3 November*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
25	Carmichael River	*Substrate:* 95% sand, 5% silt/clay *Snags and woody debris:* Moderate detritus, moderate sticks, moderate branches, moderate logs *Habitat attributes:* Small amounts of submerged macrophytes, trailing bank vegetation and overhanging vegetation *Sediment deposits:* Sand, silt *Odour:* No water odour, anoxic substrate odour *Variety of habitat:* shallow, deep, pool, undercut bank, woody debris	◗ Straight stretch of river. Width range approximately 5 m. ◗ Well established riparian zone >20 m wide ◗ Depth range from 10 cm to 1.5 m. ◗ Mapped as 5th order stream ◗ High shading ◗ Some aquatic vegetation, substantial amounts of debris for structure ◗ Habitat for turtles, fish, crustaceans	 *Event 3 November*

Site no.	Site name	Habitat assessment summary	General description and other notes	Photograph example
Gilgai Habitat				
20	Gilgai	*Substrate:* 100% silt/clay *Snags and woody debris:* None *Habitat attributes:* Some macrophytes and blanketing silt *Sediment deposits:* Silt *Odour:* No water odour, anoxic substrate odour *Variety of habitat:* shallow seasonal pool, macrophytes	◗ Approximately 4 m across, bank drop off from vegetated edge ◗ Very turbid ◗ Limited shading provided by sedges ◗ Cattle and pig disturbance ◗ Potential seasonal habitat or refuge for turtles and waterbirds	 *Event 3 November*

2.2.1.2 Mine offsite Infrastructure Area

Aquatic habitats are consistent with those recorded in the Study Area and include:

- Lacustrine habitat at each of the four water storage sites located along Obungeena Creek
- Riverine habitat on the Belyando River and the eastern portion of North Creek
- Drainage line habitat in the western sections of North Creek and Obungeena Creek
- Gilgais are expected to occur

2.2.2 Groundwater Dependant Ecosystems

Aquatic habitats may be dependent on groundwater to the extent that the surface water environment relies upon groundwater sources for the availability of water. Preliminary assessment of groundwater level monitoring data collected in the vicinity of the Carmichael River indicates that interaction between groundwater and surface water in the Carmichael River are likely to be occurring (refer to Volume 4, Appendix R Mine Hydrogeology Report). The findings include:

- An upward gradient from the underlying deposits (Tertiary-age strata and Dunda Beds) to the overlying alluvium next to the river
- Groundwater levels in the alluvium above the level of the river bed showing a typical exponential decline in groundwater levels following a significant rainfall event
- Similarities in major ion chemistry between groundwater next to the Carmichael River and surface water
- Continuous flow recorded at the upstream gauge installed on the Carmichael River suggests groundwater discharge is occurring upstream of the gauge location
- Apparent flow losses between the upstream and downstream gauges suggest surface water leakage to groundwater is also occurring

Information on the groundwater levels and a comparison of groundwater and surface water quality data for the Carmichael River (provided in Volume 4 Appendix Q Mine Water Quality Report and Volume 4 Appendix R Mine Hydrogeology Report) suggests that flows/ and/or water levels are at least partly supported by direct groundwater flow.

2.2.2.1 Springs and Vegetation

During the terrestrial ecology assessment the open forest and woodland fringing the Carmichael River was identified as a groundwater dependant ecosystem (GDE). This GDE is discussed further in Volume 4, Appendix N Mine Terrestrial Ecology Report.

Desktop review of information relating to the location of springs within the Study Area and surrounds is discussed in Volume 4, Appendix R Mine Hydrogeology Report. The hydrogeology assessment identified two potential springs near the Study Area: Doongmabulla and Mellaluka.

Doongmabulla Springs are listed on the Directory of Important Wetlands and aquatic ecological values are discussed further in Section 3.2.4.1. They are a group of permanent artesian, fresh water springs (based on information provided in the *Directory of Important Wetlands - Information Sheet* for Doongmabulla Springs, Australian Government Department of Sustainability, Environment, Water, Population and Communities), located approximately 10 km west of Study Area. Reference to

information held within the Queensland Spring Database which is understood to be largely based on the work of Fensham and Fairfax (2005) suggests that the Doongmabulla complex comprises 11 separate springs.

As described in Volume 4, Appendix N2 Doongmabulla Springs Existing Environment Report, field survey undertaken at the springs detected three main spring groups, Little Moses, Moses (at least 30 spring vents) and Joshua (one spring vent), all of which are located within the Doongmabulla Nature Refuge. The springs can be categorised into five main morphologies, each of which demonstrate ecological values for aquatic flora and fauna.

Queensland Spring Database also suggests the presence of two further springs around 10 km south of the Study Area to the north of Mellaluka. These springs are identified as non-GAB Eastern Desert Upland springs typically associated with outcropping Dunda Beds. The groundwater modelling (detailed in Volume 4 Appendix R Mine Hydrogeology Report) of the area to the south of the Carmichael River suggests groundwater flow typically in an easterly direction. It is therefore possible that these springs are fed by recharge to outcropping Dunda Beds close to the western margin of the lease which then discharges through the overlying Permian and Tertiary strata at the Mellaluka springs.

2.2.2.2 Subterranean Ecosystems

In Australia stygofauna are known from alluvial, limestone karst, fractured rock, and calcrete aquifers (Hancock *et al*., 2005; Humphreys, 2008). To be suitable for stygofauna, aquifers must have sufficient porosity of fractionation (connectivity) for adequate living space, and have sufficient organic matter and dissolved oxygen (Humphreys, 2008). Generally stygofauna biodiversity is highest near the water table and declines with depth (Datry *et al*. 2005). Alluvial aquifers adjacent to large permanent rivers often have suitable conditions, and can contain diverse stygofauna communities (Danielopol and Marmonier, 1992; Hancock and Boulton, 2008). Stygofauna diversity is also higher in areas of recharge where the water table is close (<10 m) to the land surface (Humphreys, 2000; Hancock and Boulton, 2008) as the water table is likely to have the highest concentration of oxygen and organic matter. Stygofauna still occur at considerable depth below the water table, but are fewer in number, have lower diversity, and may be different species (Datry *et al*., 2005). As more stygofauna sampling occurs both seasonally and over a wide geographic area encompassing different geologies and hydrogeologies, a better understanding of the ecological requirements of Queensland stygofauna will develop.

Within the stygofauna assessment, two groundwater bores recorded the presence of subsurface species which can be classed as stygofauna. Of particular interest was the detection of these species in a bore that intersected the AB Coal Seam with a depth of 89 m. The recovery of stygofauna from this bore is significant as it extends the limited body of knowledge on stygofauna in the Galilee Basin as well as providing further evidence that these groundwater dependent animals exist in coal seam aquifers and that relatively young bores can be successfully sampled for stygofauna.

Stygofauna species are discussed in Section 2.3.5.4.

2.3 Aquatic Species

2.3.1 Aquatic Dependant Flora

2.3.1.1 Desktop Assessment

The Great Barrier Reef catchments Aquatic Conservation Assessments (ACA) for both riverine and non-riverine wetlands identify 'aquatic dependant flora' within the Burdekin catchment (Inglis and Howell, 2009). Aquatic dependant flora includes both riparian and macrophyte species and are defined as:

'*those species that are adapted to and dependant on living and wet conditions for at least part of their lifecycle and found either within or immediately adjoining a non-riverine or riverine wetland*' (Inglis and Howell, 2009).

Review of the aquatic dependant native and exotic species listed for the Burdekin River catchment identified 150 native species and 20 exotic species previously recorded within the catchment. Query of the DEHP Wildlife Online database identified 37 native and one exotic of the listed species to have been previously recorded within 50 km of the Study Area. Of the 38 species (shown in Appendix B) previously recorded in the vicinity of the Study Area, four are listed as endangered or vulnerable under the NC Act, including:

- *Eriocaulon carsonii* subsp. *orientale*, – endangered
- *Hydrocotyle dipleura* – vulnerable
- *Myriophyllum artesium* – endangered
- *Sporobolus pamelae* – endangered

These species are all considered unlikely to occur in the Study Area based on habitat requirements.

2.3.1.2 Field Assessment

Field assessments showed a low diversity and abundance of macrophytes especially within the Carmichael River. No macrophytes were observed at all but one of the survey locations on the Carmichael River where a small patch of submerged macrophytes was observed (Site 25). This is typical of riverine habitats that experience high flow events for short durations followed by extended dry periods.

The following macrophyte species were detected at Cabbage Tree Creek and Swamp Tank and Gidgee Dam sites:

- *Persicaria attenuata* – this is a broad leaf emergent common to swamp, wetland and billabong habitats of approximately one metre depth (Sainty and Jacobs, 2003). This species is a food resource for waterbirds and was detected at Swamp Tank (Site 15) and Cabbage Tree Creek (Site 13). These sites are considered good habitat for waterbirds.
- Swamp lily (*Ottelia ovalifolia*) – this is a floating (attached) macrophyte that inhabits still and slow-moving water bodies and creeks (Sainty and Jacobs, 2003). It was detected at Swamp Tank (Site 15) and Cabbage Tree Creek (Site 13) as one of the more dominant species.

- Dirty dora (*Cyperus difformis*) and *Cyperu*s sp. – dirty dora is a narrow leaf emergent species that inhabits shallow still water bodies (Sainty and Jacobs, 2003). It was detected at the margins of Swamp Tank (Site 15). *Cyperus* sp. was detected in Gidgee Dam (Site 24).
- Monochoria (*Monochoria cyanea*) – this is a floating macrophyte that inhibits shallow still or slow moving water bodies (Sainty and Jacobs, 2003). It was detected at Cabbage Tree Creek (Site 13) as one of the more dominant species.
- *Myriophyllum* sp. and *Potamogeton* sp. were also noted in Gidgee Dam (Site 24).

Small patches of submerged macrophytes were also observed at Four Mile Dam (Site 16) and No. 2 Dam (Site 18); and water dependant plants were observed at the gilgai site where water was present (Site 20).

2.3.2 Fish

2.3.2.1 Desktop Assessment

Desktop assessment identified approximately 88 fish species that occur within the Burdekin Catchment (Carter and Tait, 2008; DEHP Wildlife Online; Inglis and Howell, 2009). These include:

- Two freshwater fish species listed as vulnerable under the EPBC Act, the freshwater sawfish (*Pristis microdon*) that has historically been recorded in the Burdekin Catchment (Inglis and Howell, 2009), and the Australian lungfish (*Neoceratodus forsteri*) that was recorded in the catchment in 1870 (DEHP Wildlife Online).
- Two endemic species, the soft-spined catfish (*Neosilurus mollespiculum*) and the small-headed grunter (*Scortum parviceps*).
- One translocated native species, the golden perch (*Macquaria ambigua*).
- Native species.
- Introduced exotic species.

Neither of the conservation significant species (freshwater sawfish and Australian lungfish) were recorded within or adjacent to the Study Area and are not considered likely to occur. The freshwater sawfish occurs in lower reaches of large river systems in areas of mud bottoms though it is occasionally found up to 400 km upstream (DSEWPaC, 2011a). Individuals are thought to move up stream after flooding (DSEWPaC, 2011a). The species is not found near riparian vegetation (DSEWPaC, 2011a). As a result of the Burdekin River barriers (the falls dam and weirs) as well as lack of habitat in the Study Area, it is considered highly unlikely that this species occurs within the Study Area and surrounds. The distribution of the Australian lungfish is restricted to south-eastern Queensland (DSEWPaC, 2011b) and the only record of the species in the catchment is from 1870 (DEHP Wildlife Online).

Based on migration patterns, fish species can be classified as either diadromous or potamodromous. Diadromous fish species migrate between the marine and freshwater environment while potamodromous species move only within freshwater. Most, if not all, diadromous species are thought to be restricted to the lower Burdekin Catchment (Pusey *et al*., 1998; Cater and Tait, 2008) as a result of a direct influence by both natural and artificial barriers to fish passage (Pusey *et al*., 1998). Fish community structure and distribution within the Burdekin Catchment has been directly influenced by the Burdekin Falls in the lower end of the catchment, historically acting as a natural barrier to fish

passage and preventing the colonisation of upstream habitats by diadromous species. Artificial impoundments such as Burdekin Falls Dam and Clare Weir have further restricted the distribution of these species. The Burdekin Falls Dam has been in place since 1985 and diadromous species populations would not have been sustained since this barrier was installed given a lack of access to marine areas for lifecycle processes. Only potamodromous species are likely to persist so fish species found in the Carmichael River and surrounding catchment are likely to be potamodromous species.

For the Study Area and a 50 km buffer, searches of desktop databases (Wildlife Online and Queensland Museum) identified no records of fish species. Other desktop sources (published and grey literature), previous studies and species profiles identified 17 species that may occur. None of these species are listed as threatened under the EPBC Act or NC Act. The identified species and their ecology, including habitat preferences, dietary requirements, movement behaviours and environmental tolerances of these species is presented in Table 2-2.

2.3.2.2 **Field Assessment**

Fish survey was undertaken in three main water bodies during the latter two sampling events:

Event 2 May:

- Swamp Tank which is a man-made dam, isolated pool with no flow (Site 15)
- Cabbage Tree Creek in a seasonally isolated pool with no flow (sites 12 and 13)
- Carmichael River which is a seasonally variable flowing watercourse (sites 5, 6 and 7)

Event 3 November:

- Gidgee Dam which is a man-made dam, isolated pool with no flow (Site 24)
- Cabbage Tree Creek in a seasonally isolated pool with no flow (Site 21)
- Carmichael River, the seasonally variable flowing watercourse (sites 22 and 25)

Eleven of the 17 fish species predicted to occur within the Study Area were recorded during field surveys. All of the fish recorded are common freshwater species previously recorded in the upper Burdekin Catchment. No conservation significant species were detected during the field survey. Agassiz's glassfish (*Ambassis agassizii*) (Plate 2-1) and midgley's carp gudgeon (*Hypseleotris species 1*) were the most commonly recorded species during field surveys. Other species captured included purple-spotted gudgeon (*Mogurnda adspersa*), sleepy cod (*Oxyeleotris lineolata*), eastern rainbowfish (*Melanotaenia splendida splendida*) (Plate 2-1 and Plate 2-2), Hyrtl's tandan (*Neosilurus hyrtlii*), spangled perch (*Leiopotherapon unicolor*), barred grunter (*Amniataba percoides*), fly speckled hardyhead (*Craterocephalus stercusmuscarum*), western carp gudgeon (*Hypseleotris klunzingeri*) and bony bream (*Nematalosa erebi*).

Plate 2-1 Agassiz glassfish (*Ambassis agassizii*)

Plate 2-2 Eastern rainbowfish (*Melanotaenia splendida splendida*)

During Event 2 May, a trap site was established at Swamp Tank with low species diversity demonstrated by only two species being recorded, Agassiz's glassfish and Midgley's carp gudgeon. In Event 3 November, sampling was undertaken at Gidgee Dam where the same two species were recorded as well as western carp gudgeon. These dams represent permanent water sources and contain suitable micro-habitat in the form of macrophyte beds and occasional woody debris. The habitat has no natural connectivity to other fish populations and there are very limited opportunities for recruitment and dispersal for fish species.

Two trapping sites were located along Cabbage Tree Creek; one in EPC 1690 (Event 2 May) and one in EPC 1080 (Event 3 November). At all sites along Cabbage Tree Creek diversity and abundance of fish species was recorded to be greater than the Carmichael River and dam sites results. Cabbage Tree Creek displayed greater habitat complexity in the form of in-stream habitat structure, variation in depth and profile, shading and the presence of macrophytes. The dominant species detected in this watercourse were Midgley's carp gudgeon and Agassiz's glassfish.

Midgley's carp gudgeon was detected in large numbers from these habitats. This species is known to have a mean length of 33 mm and maximum length of 51 mm (Pusey *et al.,* 2004). The majority of individuals sampled during field surveys in the May event measured less than 20 mm suggesting the population, during the period following the wet season includes a relatively large number of juveniles. During the Event 3 November the majority of individuals of Midgley's carp gudgeon captured in Cabbage Tree Creek were greater than 20 mm and sizes varied. The population of this gudgeon during Event 3 November was not dominated by juveniles as it was in the previous survey.

Agassiz's glassfish is widespread in rivers in central Queensland (Pusey *et al.,* 2004), preferring extensive aquatic macrophyte beds or filamentous algae. Individuals are usually collected in close proximity to shelter in water bodies with low water velocity. The mean length of the species is known to be 30 mm and the maximum length is 70 mm (Pusey *et al.,* 2004). Trapping results for this survey detected a range of lengths suggesting diversity in age structure.

Both of these dominant species undertake upstream dispersal, which allows them to quickly colonise upstream habitat when flow conditions allow passage (Pusey *et al.,* 2004). This tendency coupled with their preferred habitat of macrophyte beds and complex in-stream cover is likely to explain the abundance and distribution in the Cabbage Tree Creek habitat where the preferred habitat characteristics are represented.

Trapping results at the sites within the Carmichael River recorded low numbers of individuals in comparison to Cabbage Tree Creek. Some of the species detected in the Carmichael River were not detected in Cabbage Tree Creek during the survey. These species included the sleepy cod (Plate 2-3), Hyrtl's tandan and spangled perch. All of these species inhabit a range of habitats but prefer slow flowing waters.

Plate 2-3 Sleepy cod sub adult - (*Oxyeleotris lineolata*)

Table 2-2 Ecology of Fish Species in the Study Area

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
Atherinidae	Fly-specked hardyhead (*Craterocephalus stercusmuscarum*)	Known to occur throughout the Burdekin Catchment, however the species is less common in turbid environments. Highly turbid waters were observed in the Carmichael River. Species is abundant in streams that are periodically disconnected during low flow which is characteristic of Cabbage Tree Creek. (Pusey *et al*., 1998; Carter and Tait, 2008)	Occurs in a variety of habitats including flood plains, billabongs, brackish estuaries and impoundments. Prefers low flow environments which contain macrophyte beds and gravel substrates. (Pusey *et al*., 2004)	Potamodromous – Undertakes local dispersal and colonisation movements (Pusey *et al*., 2004).	Increasing water temperature and elevated flows are likely to stimulate movement (Pusey *et al*., 2004).
Chandidae	Agassiz's glassfish (*Ambassis agassizii*)	Recorded in the Study Area during field survey. Found in Cabbage Tree Creek and Swamp Tank. Known to occur throughout the Burdekin Catchment (Carter and Tait, 2008) and is relatively widespread in eastern Australian coastal and inland drainages (Pusey *et al*., 2004).	Well-vegetated areas in rivers, creeks, swamps and ponds, generally in areas of little or no flow. Utilises macrophyte and submerged marginal vegetation preferred for spawning. (Pusey *et al*., 2004)	Potamodromous - Adults and juveniles move upstream (September-February) for habitat and dispersal, possibly in response to flooding (Pusey *et al*., 2004).	Tolerant to a wide range of physicochemical conditions (temperature, DO, pH and salinity). Increases in water temperature and elevated flows are believed to be cues for movement. (Pusey *et al*., 2004)
Clupeidae	Bony bream (*Nematalosa erebi*)	Known to occur throughout the Burdekin Catchment (Carter and Tait, 2008) though not detected during field survey. Widespread species throughout Australia and found in most major basins of Queensland (Pusey *et al*., 2004).	Known from a wide variety of habitats including salt lakes, lagoons, floodplains and streams. Preference for low or no flow environments. (Pusey *et al*., 2004)	Potamodromous – Adults and juveniles move upstream for dispersal.	Tolerant of a range of environmental conditions including high turbidity (records in the Belyando River in 581 NTU) (Pusey *et al*., 2004), though susceptible to low dissolved oxygen (Carter and Tait, 2008). Reductions in abundance observed in streams receiving mine effluents with elevated copper concentrations (Pusey *et al*., 2004).

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
Eleotridae	Flathead gudgeon (*Philypnodon grandiceps*)	Recorded in the upper Burdekin River (Carter and Tait, 2008) though not detected in the Study Area during survey. Occurs in coastal catchments from central Queensland to south-eastern Australia (Pusey *et al*., 2004).	Prefers freshwater habitats (creeks, rivers, billabongs) with little or no flow, and underwater structure (vegetation, undercut banks, logs). Prefers areas with abundant cover. Rocks and woody debris are required for oviposition. (Pusey *et al*., 2004)	Facultative potamodromous – A predominantly freshwater species where access to estuarine or marine environments is not an essential component of the life history. However known to move through a system. May move in response to periods of peak flow (August to April). (Pusey *et al*., 2004)	Species collected in a wide range of physicochemical conditions. Tolerant of water quality and habitat degradation. (Pusey *et al*., 2004)
Eleotridae	Midgley's carp gudgeon (*Hypseleotris species 1*)	Recorded in the Study Area during field survey. Found in Cabbage Tree Creek and Swamp Tank. Known to occur throughout the Burdekin Catchment (Carter and Tait, 2008) and is found in most coastal drainages of eastern Australia (Pusey *et al*., 2004).	Species that utilises macrophyte beds, detritus, root balls and undercut banks. Found in streams, creeks, swamps, wetlands and ponds. Hard surfaces near the substrate are preferred for oviposition. (Pusey *et al*., 2004)	Potamodromous – Undertakes local dispersal and colonisation movements. Spawning peaks between September and January. (Pusey *et al*., 2004)	Regarded as a hardy species that can tolerate poor water quality. The species has been collected in heavily degraded habitats. Increased water temperature and day length are suspected as cues for movement. (Pusey *et al*., 2004)
Eleotridae	Purple-spotted gudgeon (*Mogurnda adspersa*)	Recorded in the Study Area during field survey. Found in Cabbage Tree Creek. Widely distributed throughout the Burdekin Catchment (Carter and Tait, 2008) and occurs in most coastal drainages of eastern Australia from Cape York Peninsula to northern New South Wales (Pusey *et al*., 2004).	Avoids areas of high water flow. Inhibits areas aquatic vegetation in slow-flowing parts of rivers and streams, often with rocky substrate. Also noted in still water bodies including billabongs. The species is highly dependent on bank-side structure. Aquatic macrophytes, rocks and woody debris required for oviposition. (Pusey *et al*., 2004)	Potamodromous – Increasing water temperature suspected as a cue for movement (Pusey *et al*., 2004).	Species collected over a relatively wide range of physicochemical conditions (Pusey *et al*., 2004).

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
Eleotridae	Sleepy cod (*Oxyeleotris lineolata*)	Recorded in the Study Area during field survey. Found in the Carmichael River. Occurs widely in northern Australia including easterly flowing rivers of Queensland (Pusey *et al*., 2004). Species has been translocated above Burdekin Falls and now widely distributed in the upper catchment (Carter and Tait, 2008).	Slow-flowing water amongst submerged structure (vegetation, timber) in rivers, creeks, floodplains, lagoons and billabongs. Large woody debris is a key requirement for spawning and general cover. (Pusey *et al*., 2004)	Potamodromous – Does not make substantial migrations (Pusey *et al*., 2004).	Tolerant of turbid conditions. Collected in muddy lagoons with mud substrate Species is not a powerful swimmer and is considered to be a still/slow flow species. Tolerant of hypoxia in still pools. Not tolerant of saline conditions and can only survive in freshwater. (Pusey *et al*., 2004)
Eleotridae	Western carp gudgeon (*Hypseleotris klunzingeri*)	Known to occur throughout the Burdekin Catchment (Carter and Tait, 2008) and in coastal drainages south to central NEW South Wales (Pusey *et al*., 2004). The northern extent of the distribution is uncertain and records in the Burdekin River may be mis-identifications or translocations (Pusey *et al*., 2004).	Inhabits aquatic vegetation in slow-flowing parts of rivers, streams, as well as still water bodies such as lakes and impoundments. Aquatic macrophytes, submerged marginal vegetation and woody debris may be important for oviposition. (Pusey *et al*., 2004)	Potamodromous – May move upstream to spawn during the wet season.	Tolerant of a wide range of physicochemical conditions (Pusey *et al*., 2004).
Melanotaeniidae	Eastern rainbowfish (*Melanotaenia splendida splendida*)	Recorded in the Study Area during field survey. Found in Cabbage Tree Creek. Known to occur throughout the Burdekin Catchment (Carter and Tait, 2008) and the east coast of Queensland (Pusey *et al*., 2004).	A habitat generalist that occurs in a wide array of still to slow-flowing freshwater habitats. Includes creeks, swamps, wetlands, rivers and impoundments (Allen *et al*., 2003) Aquatic vegetation and root masses preferred for oviposition (Pusey *et al*., 2004).	Potamodromous – Rising flows and increasing water temperature are suspected as cues for movement.	*M. s. splendida* tolerates a large range of water quality conditions (Pusey *et al*., 2004).

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
Percichthyidae	Golden perch[2] (*Macquaria ambigua*)	Deliberately and accidentally translocated into the Burdekin Catchment (Carter and Tait, 2008) and has been widely translocated into eastern Australian rivers (Pusey *et al*., 2004).	Inhabits rivers, creeks, billabongs and lakes. Favours deeper, slow-flowing, turbid habitats with an abundance of in-stream debris and shade (Pusey *et al*., 2004).	Potamodromous – Movement recorded in the Fitzroy River (through the Fitzroy Barrage) during spring and summer months (Pusey *et al*., 2004).	Tolerant of a wide range of temperatures and low oxygen levels. Can move between freshwater and saline environments. Tolerant to high turbidity levels. Spawning and recruitment triggered by increased flows and water temperatures above 23° C. (Pusey *et al*., 2004)
Plotosidae	Black catfish (*Neosilurus ater*)	Widespread and abundant throughout the Burdekin Catchment (Carter and Tait, 2008), occurring across northern Australia (Pusey *et al*., 2004).	A benthic species that prefers still/slow flowing waters in streams, rivers, wetlands, pools, slow-flowing tributaries and side-channels of rivers (Allen *et al*., 2003).	Potamodromous – Migrations upstream thought to coincide with spawning at the outset of the wet season (January-February). Rising flows are suspected as cues for spawning. (Pusey *et al*., 2004)	Can occur in intermittent tributary streams as well large rivers. Adapted to forage in elevated turbidity and low light conditions. (Pusey *et al*., 2004)
Plotosidae	Hyrtl's tandan (*Neosilurus hyrtlii*)	Recorded in the Study Area during field survey. Found in the Carmichael River. Widely distributed across the Burdekin Catchment (Carter and Tait, 2008) and also Australia (Pusey *et al*., 2004).	A benthic species that occurs in most freshwater habitats above estuarine reaches. Tributary streams and gravel substrates may be important for spawning. (Pusey *et al*., 2004)	Potamodromous – Upstream migrations from dry season refugia thought to coincide with spawning (Pusey *et al*., 2004)	The species has barbels which allow the species to forage in elevated turbidity and low light conditions. Rising flows suspected as cue for movement. (Pusey *et al*., 2004)
Plotosidae	Rendahl's catfish (*Porochilus rendahli*)	Widely distributed throughout the Burdekin Catchment (Carter and Tait, 2008) and patchily across northern Australia ((Pusey *et al*., 2004).	A benthic species inhabiting river channels and tributaries generally containing muddy substrate ((Pusey *et al*., 2004).	Potamodromous – Adults migrate downstream to spawn in flooded lowland lagoons (Pusey *et al*., 2004).	Like other species of catfish can tolerate highly turbid water. Well-developed tolerance to hypoxia. (Pusey *et al*., 2004)

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
Plotosidae	Soft-spined catfish[1] *Neosilurus mollespiculum*	Endemic to the Burdekin Catchment with a patchy distribution. Reported in the Belyando River sub-catchment as well as the Fanning, Keelbottom, Fletcher, Bowen and Burdekin (Upper and Lower) catchments. (Carter and Tait, 2008)	Rocky pools of large creek and main rivers channels (Allen *et al*., 2003).	Potamodromous – Very little known. Data suggests spawning migrations to tributary streams do not occur as for other *Neosilurus* species - more information required to provide more robust conclusions (Pusey *et al*., 2004).	Limited data Recorded in freshwater only. Observed in both clear waters and areas with high sediment load. (Pusey *et al*., 2004)
Terapontidae	Small-headed grunter[1] (*Scortum parviceps*)	Endemic to the Burdekin Catchment though patchily distributed (Carter and Tait, 2008) Most common in the main channel of the Burdekin River and larger south-wet tributaries (Pusey *et al*., 2004).	Most common in riverine reaches. Thought to prefer deep (>1 m) habitats with a sand, fine gravel substrate and little or no flow. (Pusey *et al*., 2004)	Potamodromous – Movement patterns relatively unknown however upstream migration prior to spawning is predicted (Pusey *et al*., 2004).	Recorded in freshwater only and unlikely to tolerate elevated salinity. Tolerant of high turbidity levels. (Pusey *et al*., 2004)
Terapontidae	Spangled perch (*Leiopotherapon unicolor*)	Recorded in the Study Area during field survey. Found in the Carmichael River. Widely distributed throughout the Burdekin Catchment (Carter and Tait, 2008) and Australia (Pusey *et al*., 2004).	A generalist species that occurs in most permanent and temporary freshwater habitats including billabongs, bores, impoundments, rivers and streams (Allen *et al*., 2003).	Potamodromous – Depending on locality moves upstream or downstream within the freshwater environment to spawn Spawning migrations coincident with the wet season (October – April). This species may also undertake substantial movements away from dry season habitats as they recede. (Pusey *et al*., 2004)	Highly tolerant of environmental variability. Can tolerant saline conditions but rarely encountered in estuarine areas. Rising flows and increasing water temperature are suspected as cues for movement. (Pusey *et al*., 2004)

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
Toxotidae	Seven-spot archerfish (*Toxotes chatareus*)	Widely distributed in the Burdekin River (Carter and Tait 2008) and also northern Australia (Pusey *et al*., 2004). Unlikely to occur in the Study Area due to unsuitable and degraded riparian vegetation.	Inhabits large low gradient rivers. Not believed to frequent fast- flowing streams. Heavily reliant on intact riparian zones. Waterways associated with degraded riparian systems contain very few individuals. Juveniles observed in macrophyte beds. (Pusey *et al*., 2004)	Potamodromous – Disperses widely during the wet season. Does not require access to estuarine or marine environment at any stage of life cycle. However barriers to movement expected to have negative impact (reduced food dispersal and passive transport of juveniles downstream). (Pusey *et al*., 2004)	This species is a visual predator that has a low tolerance to turbidity. Slight increases in turbidity can cause reduction in species abundance. Tolerant of a wide range of temperatures and dissolved oxygen levels. (Pusey *et al*., 2004)

[1] endemic species; [2] translocated species

The diversity of potamodromous fish species in the Study Area, as determined from literature and field surveys, is relatively low compared to other similar catchments in northern Queensland (Pusey *et al*., 1998). This may be a result of a number of factors including:

- Hydrology. High flows are generally short in duration and interspersed by long dry periods. This is likely to have reduced the ability of specialist species to colonise the catchment. Furthermore these prolonged dry conditions are likely to select against species with low tolerance to changing environmental conditions (Pusey *et al*., 1998).
- The Study Area exhibited a low diversity of aquatic habitats and microhabitats with the system primarily characterised by open shallow water with a sandy/gravel substrate and limited in-stream debris and macrophytes (This Study; Pusey *et al*., 1998). This environment provides habitat for generalist species.
- Degradation of aquatic habitats through land use practises has reduced the availability of habitat resources.

Pest Species

No pest fish species were detected during field surveys and no previous records were identified within 50 km of the Study Area. The desktop assessment identified a number of introduced species that are known to occur in the wider Burdekin Catchment, although these species are not present in the Belyando sub-catchment (Mozambique tilapia (*Oreochromis mossambicus*), spotted tilapia (*Tilapia mariae*), guppy (*Poecilia reticulata*) and mosquitofish (*Gambusia holbrooki*)) (Carter and Tait, 2008).

2.3.3 Reptiles

2.3.3.1 Desktop Assessment

Desktop assessments identified seven aquatic reptiles to inhabit the Burdekin Catchment including two crocodile and five freshwater turtle species (Protected Matters Search; Cann, 1998; Cann, 2008).

The estuarine crocodile (*Crocodylus porosus*) and freshwater crocodile (*Crocodylus johnstoni*) are known to inhabit the catchment. These are conservation significant species under the EPBC Act. The estuarine crocodile (*Crocodylus porosus*) has only been recorded below the Burdekin Dam and is not expected to be found in the Study Area.

The distribution of the freshwater crocodile includes the eastern Queensland Gulf, northern Northern Territory and northern Western Australia. Surveys of the east coast of Queensland in 2009/2010 detected a number of individuals (80 per cent hatchlings) in the Burdekin River though these were recorded below the Burdekin River Dam (Sullivan *et al*., 2010). Desktop searches identified no previous records within 50 km of the Study Area and the Study Area is not expected to provide important habitat for any crocodile species.

Freshwater turtle species known to occur within the Burdekin Catchment include: Cann's long-necked turtle (*Chelodina canni*); snake-necked turtle (*Chelodina longicollis*); Irwin's turtle (*Elseya irwini*); saw-shelled turtle (*Wollumbinia latisternum*) and Krefft's turtle (*Emydura macquarii krefftii*). None of these turtle species is listed as conservation significant species under the EPBC Act or NC Act. Irwin's turtle is endemic to the catchment and has been listed as high priority for conservation under the DEHP 'Back on Track' prioritisation framework for conservation management of Queensland's wildlife. 'Back on Track' species are discussed in further detail in Section 3.4.

2.3.3.2 Field Assessment

Field assessments undertaken across the three survey events included habitat assessments, including an assessment of suitability for aquatic reptiles. The results of the desktop study identified that the turtle species of the catchment inhabit a variety of habitats ranging from ephemeral waterholes and pools to structurally complex rivers and creeks. These habitat features were noted during field survey.

The Irwin's turtle generally prefers sandy riverine habitats with an abundance of macrophytes and in-stream debris (Cann, 1998; Cann, 2008). The sandy habitats within the Study Area were generally ephemeral or, in the case of the Carmichael River, recorded little or no macrophytes. For this reason the Study Area is not expected to provide habitat for the Irwin's turtle. The species is likely to be primarily restricted to the Bowen and potentially the Bogie River.

The Cann's long-necked turtle and snake-necked turtle are primarily encountered in off-stream habitats such as lagoons, billabongs and swamps (Cann, 2008). A snake-necked turtle was observed in the vicinity of a gilgai near Bygana West Nature Refuge in the south of the Study Area. Gilgais occur across the Study Area and may provide temporary habitat for the Cann's long-necked turtle and snake-necked turtle in conjunction with the dams and Cabbage Tree Creek waterholes. A deceased snake-necked turtle was observed at Gidgee Dam (Site 24) in Event 3 November, though no obvious sign of cause of mortality was evident.

The saw-shelled turtle is commonly observed in upstream water courses as well as lagoons and billabongs that support abundant in-stream habitat (Cann, 1998). Some watercourses in the Study Area show these habitat characteristics including the dams, and the species may occur, although it was not observed during survey work.

Krefft's river turtle is a generalist species that occurs in most freshwater habitats (Wilson, 2009). Three deceased juveniles were observed on the banks of Swamp Tank during field surveys though no live individuals were observed. Cause of mortality could not be determined, as there were no obvious signs of injury noted on the carapace of the individuals. Suitable habitat for the species exists in all water bodies in the Study Area however recruitment to those permanent water sources separated from the riverine environments are less likely.

2.3.4 Mammals

2.3.4.1 Desktop Assessment

Desktop assessment of the Wildlife Online database did not identify previous records of aquatic mammals within the Study Area. The known distribution of the platypus (*Ornithorhynchus anatinus*) includes the Burdekin catchment (Van Dyck, 2008). However the species has not been recorded within a 50 km buffer of the Study Area (Wildlife Online). Platypus are listed as special least concern wildlife under the NC Act.

2.3.4.2 Field Assessment

Habitat assessment undertaken across all survey sites noted the suitability of the habitat for platypus. Platypus inhabits freshwater environments, with a preference for areas that have steep, well vegetated banks. The species requires permanently inundated water bodies that support resources necessary for burrowing (i.e. earthen banks consolidated by the roots of riparian vegetation, overhanging vegetation, undercut banks (Grant and Temple-Smith, 1998)). Platypus do utilise

ephemeral rivers and creeks for foraging purposes, however, these habitats must be located adjacent to permanent water bodies that have suitable stream bank characteristics for burrowing. The species is territorial and occupies small home ranges up to several kilometres in length. Individuals also have a limited ability to travel overland (Grant and Temple-Smith, 1998). Based on the lack of these habitat requirements within the Study Area this species is considered unlikely to occur.

2.3.5 Invertebrates

2.3.5.1 Desktop Assessment

Desktop assessment (Queensland Museum crustacean database) identified two crustacean species recorded within 50 km of the Study Area. Both species, *Daphniopsis pusilla* and *Moina baylyi*, were recorded near a salt lake, Lake Buchanan, which is outside the catchment basin containing the Carmichael River. These species inhabit halophilic waters of salinity of 3-60 g l^{-1} (Timms, 1987) and are unlikely to occur in the Study Area.

2.3.5.2 Field Assessment – Surface Aquatic Ecosystems

Invertebrates were also detected during field surveys during fish trapping and as part of the targeted aquatic macroinvertebrate sampling techniques (discussed below). Trapping (bait traps) during field surveys detected redclaw (*Cherax quadricarinatus*) (Plate 2-4) within the Carmichael River and Cabbage Tree Creek, though given the available habitats these crustaceans are expected to occur in other water bodies across the Study Area as well. This species is tolerant of a wide variety of habitats and conditions and is also likely to be present in man-made water bodies (dams) (Jones and Morgan, 2007). Numerous freshwater crab shells from the Family Parathelphusidae were observed in the Study Area near all types of aquatic habitats and some gilgais implying this taxon is common across the sites surveyed.

Plate 2-4 Redclaw (*Cherax quadricarinatus*) Captured in Cabbage Tree Creek (Event 2 May)

Macroinvertebrate Communities

Macroinvertebrate sampling was undertaken during the post wet season survey (Event 2 May) at three locations along the Carmichael River and during a pre-wet season survey (Event 3 November) at one location along the Carmichael River and one along Cabbage Tree Creek. A total of 230

individuals were collected from 41 families of aquatic macroinvertebrates across the five sites sampled. The highly variable and unpredictable environmental conditions of the river systems represented in the Burdekin Catchment are reflected in the relatively low macroinvertebrate diversity (Parsons Brinkerhoff, 2009).

The AusRivAs sampling manual defines autumn as the months of May to July and spring months as October to December.

Ninety-one individuals were collected from 27 families of aquatic macroinvertebrates at the three sampling sites during autumn sampling. Two out of the three EPT (Ephemeroptera, Plecoptera and Trichoptera) taxa were recorded, though in very low numbers. The EPT ratio is a widely used measure based on three macroinvertebrate orders that have been identified as being sensitive to disturbance and pollutants, and therefore are considered good indicators of disturbance. The ratio is derived from the ratio of EPT taxa represented to the whole community at each site. High EPT ratios indicate a greater prevalence of taxa that are less tolerant to disturbance (and can reflect higher habitat values). The EPT ratios for the sampled sites are low potentially indicating disturbance of aquatic habitats. The raw data is provided in Appendix B.

One hundred and thirty-nine individuals were collected from 13 families of aquatic macroinvertebrates at the two sampling sites during spring sampling. All three EPT (Ephemeroptera, Plecoptera and Trichoptera) taxa were recorded, though in very low numbers with the exception of Trichoptera families comprising 25 per cent of the community sampled at Cabbage Tree Creek (Site 21).

Table 2-3 Summary of Macroinvertebrate Sampling Results

Site	No. of Individuals	No. of Families	EPT Ratio (as a percentage)
Autumn			
5 (Carmichael River Upstream)	49	15	6.7%
6 (Carmichael River Central)	22	13	7.7%
7 (Carmichael River Downstream)	20	13	7.7%
Spring			
25 (Carmichael River)	102	19	15.8%
21 (Cabbage Tree Creek)	37	10	30.0%

The dominant invertebrate taxa recorded varied between sites and seasons. Overall true bugs were recorded in greatest numbers, with Family Pleidae (pygmy backswimmers) recorded in greatest numbers. Pleidae are found in still waterbodies among aquatic vegetation (Gooderham and Tsyrlin, 2005). Family Dytiscidae (diving beetles) was also recorded in relatively greater numbers. No macrophytes were recorded in the sites sampled however trailing bank vegetation, detritus and root balls were well represented in the river habitats, providing habitat for this group. Dytiscids are found in a variety of habits including lakes, swamps and seasonally flowing streams of slow flows or still areas (Gooderham and Tsyrlin, 2005). These two dominant families were the only two recorded at all

sites sampled and both have adult aquatic stages which can fly, and thus readily disperse to new aquatic habitats..

Although not recorded in as great numbers, Chironiminae (non-biting midges) were detected at most sites. These are common and found in most rivers and lakes (Gooderham and Tsyrlin, 2005)

The uniform sandy substrate of the Carmichael River is expected to substantially influence the low macroinvertebrate community diversity at most sites. The species detected throughout the study area have habitat preferences including aquatic vegetation, woody debris, root balls and detritus. These habitat features were more abundant at Site 25 on the Carmichael River where a greater invertebrate diversity was detected. Although the preferred habitat was observed within the Carmichael River, the sandy bed and bank habitat was dominant .

2.3.5.3 Desktop Assessment – Subterranean Ecosystems

Few stygofauna species are known from coal seam aquifers. Eight taxa have been recorded by GHD (unpublished data) from coal seam aquifers in Queensland to date including species of harpacticoid copepod collected from central Queensland; a species of *Notobathynella* (Syncarida), a species of Trombidiidae (water mites) and two species of Pezidae (water mites) from a coal seam aquifer (89 m deep) in the Galilee Basin (current study), a species of Amphipoda and a species of Cyclopoid copepod from one bore from the northern Bowen Basin and a species of Astigmata (water mite) from a groundwater bore (75 m deep) from the Styx Basin located on the Central Queensland Coast.

In Queensland, diverse stygofauna communities have also been collected from alluvial aquifers of the Pioneer River, Burnett River, as well as Clermont, Nebo, Glenden, Collinsville, Rolleston, Marlborough, and Wondoan regions of the Bowen, Galilee, Styx and Surat Basins (GHD unpublished data). These communities were mostly collected from shallow alluvial aquifers of unconsolidated, heterogeneous sediments. Other significant stygofauna communities also appear common in alluvial aquifers, particularly where the aquifers are connected to rivers that flow for most of the year (Hancock and Boulton, 2008). This is because hydrological exchanges between surface and groundwater may be important sources of nutrients and oxygen to groundwater foodwebs (Hancock et al 2005, Boulton *et al.,* 2003).

2.3.5.4 Field Assessment – Subterranean Ecosystems

A total of 19 groundwater bores were successfully sampled for stygofauna in October 2011 (Stygofauna Event 1) and 18 groundwater bores in August 2012 (Stygofauna Event 2). Details of the quality of the samples are provided in Volume 4, Appendix O2 Stygofauna Survey Report.

Analysis of the Stygofauna Event 1 samples revealed the presence of stygofauna in one bore (C018P2) (refer Figure 1-5), which included two obligate groundwater species. This bore is relatively deep with high water quality characteristics that are highly prospective for stygofauna. The water table was at a suitable depth to allow adequate vertical movement of organic matter through the soil horizon.

Analysis of the Stygofauna Event 2 samples revealed the presence of stygofauna in two bores (C018P2) and C008P1) (refer Figure 1-5), which included two obligate groundwater species. Stygofauna were detected at C018P2 during both sampling events and given groundwater quality characteristics were identified as being prospective for stygofauna. C008P1 recorded groundwater quality with very high salinity concentrations in excess of 21,000 µS/cm on both sampling occasions, which would normally be considered as unlikely to contain stygofauna.

Stygofauna groups identified include:

- At C018P2 – Acarina, Trombidiidae, Pezidae sp1 and Pezidae sp2, and Syncarida, *Notobathynella* sp.
- At C008P1 – Copepoda, Cyclopoida

Absence of stygofauna in the remaining bores sampled does not necessarily indicate that stygofauna are not present in these aquifers, rather, it may be due to unsuitable geological conditions (low porosity, low hydraulic conductivity), inadequate range of bores selected for sampling, poor groundwater quality, recent bore disturbance, or simply a low abundance of animals coupled with a heterogeneous distribution highlighting the basic need for replicated sampling covering different seasons and seasonal events.

The knowledge of stygofauna in the Galilee Basin is very limited at present as very few surveys have been conducted in this extensive region of Queensland. This sampling adds substantially to this body of knowledge. Given that only two of the 20 groundwater bores sampled recovered stygofauna across two comprehensive sampling events and that only five stygobitic taxa were recovered, it would seem reasonable to conclude that stygofauna are in low diversity and abundance from this locality. Recent multiple stygofauna surveys conducted by GHD in the southern Galilee Basin have also failed to identify significant stygofaunal communities which would suggest that stygofauna may be poorly represented in the wider geographic region.

3. Conservation Significant Aquatic Ecological Values

3.1 Introduction

Conservation significant areas and species, relevant to aquatic ecology, occurring within or of relevance to the Study Area include those classified as having Commonwealth, Queensland and/or regional biodiversity significance. The conservation significant aquatic ecological values identified during desktop and field investigations of the Study Area are summarised in Table 3-1 and discussed in detail in this section.

Table 3-1 Summary of Conservation Significant Aquatic Ecological Values

Significance classification	Summary	Section discussed
Commonwealth		
Commonwealth EPBC Act – Matter of NES (controlling provisions based on referral of Project (2010/5736))		
World Heritage properties	No World Heritage properties within or of relevance to Study Area. The Study Area is located over 300 km due west and approximately 320 km upstream of the Great Barrier Reef World Heritage area and over 300 km south of the Wet Tropics World Heritage area.	Section 3.2.1
National Heritage places	No National Heritage properties within or of relevance to Study Area. The Tree of Knowledge and curtilage at Barcaldine is the closest National Heritage place to the Study Area and outside the influence of the Burdekin River. It is located approximately 200 km south-west of the Study Area and not downstream.	N/A
Wetlands (Ramsar)	No World Heritage properties within or of relevance to Study Area. Shoalwater and Corio Bay is approximately 380 km east of the Study Area and outside the influence of the Burdekin River, and Coongie Lakes is approximately 800 km south-west of the Study Area and not downstream.	Section 3.2.2
Listed threatened species and communities	The desktop assessment and field surveys identified no EPBC Act listed threatened aquatic flora or fauna species. No EPBC Act listed threatened aquatic flora or fauna species have been previously recorded or are predicted to occur within the desktop search extent encompassing the Study Area.	N/A
Listed migratory species	No EPBC Act listed migratory aquatic species recorded during field surveys in Study Area. Three EPBC Act listed migratory birds were confirmed present at the Study Area during terrestrial field surveys. The details of these species are provided in the Volume 4, Appendix N1 Mine Terrestrial Ecology Report.	N/A
Great Barrier Reef Marine Park	The Study Area is located over 300 km due west and approximately 320 km upstream of the Great Barrier Reef Marine Park. Significant overland barriers would inhibit any site attributes having an influence on the Marine Park and, as such, this is considered to be not applicable to Study Area.	Section 3.2.3

Significance classification	Summary	Section discussed
Other Commonwealth matters		
Listed marine species	No EPBC Act-listed marine aquatic species were recorded during field surveys in Study Area or desktop search. A total of 22 EPBC Act-listed marine birds were recorded during terrestrial field surveys in the Study Area. The details of these species are provided in the Volume 4, Appendix N1 Mine Terrestrial Ecology Report.	N/A
Nationally Important Wetlands	Doongmabulla Springs are listed under the Directory of Important Wetlands and located outside the footprint of the Study Area approximately 11 km west of the centre of the Study Area. The springs are located within the Burdekin catchment and Belyando River subcatchments. Lake Galilee is also listed under the Directory of Important Wetlands though is located over 40 km south-west of the Study Area and not in the same drainage basin.	Section 3.2.4
State		
Queensland NC Act		
Threatened flora and fauna species	No NC Act-listed threatened aquatic flora species recorded during field surveys in Study Area or desktop searches. Based on species information, distribution and habitat preferences, no threatened or conservation significant aquatic flora or fauna listed under the NC Act are considered likely to occur. One species considered of special cultural significance was identified through desktop assessment.	Section 3.3.1
GBR Wetland Protection Areas	Three GBR Wetland Protection Areas are mapped within the Study Area (Figure 3-2).	Section 3.3.2
Protected areas	Two protected areas of relevance to aquatic ecology values occur within 50 km of the Study Area: ◗ Bygana West Nature Refuge – occurs entirely within Study Area ◗ Doongmabulla Mound Springs Nature Refuge – approximately 11 km west of centre of Study Area	Section 3.3.3
Fish Habitat Areas	Fish habitat areas are declared for the long-term protection of fish habitats essential for sustaining Queensland's fisheries under the Queensland *Fisheries Act 1994*. No fish habitat areas are located within or adjacent to the Study Area.	N/A
Regional		
Burdekin Natural Resource Management (NRM) Region Back on Track Actions for Biodiversity report priority taxa	The 'Back on Track' report identifies priority vertebrate fauna taxa for the Burdekin NRM region, including one aquatic reptile with potential to occur in the Study Area.	Section 3.4

3.2 Commonwealth Matters of National Environmental Significance

3.2.1 Great Barrier Reef World Heritage Area

The Study Area is located over 300 km due west and approximately 320 km upstream of the Great Barrier Reef World Heritage Area. The Carmichael River that bisects the Study Area flows east for approximately 20 km to its juncture with the Belyando River. From this point the Belyando River flows in a northerly direction for approximately 90 km where it joins the Suttor River. Beyond its juncture with the Belyando River, the Suttor River flows north (approximately 50 km) to the Burdekin Falls Dam (Lake Dalrymple). The Burdekin River downstream of Burdekin Falls Dam flows for approximately 160 km to its mouth at Upstart Bay near Ayr.

The Study Area is located over 300 km south of the Wet Tropics World Heritage Area.

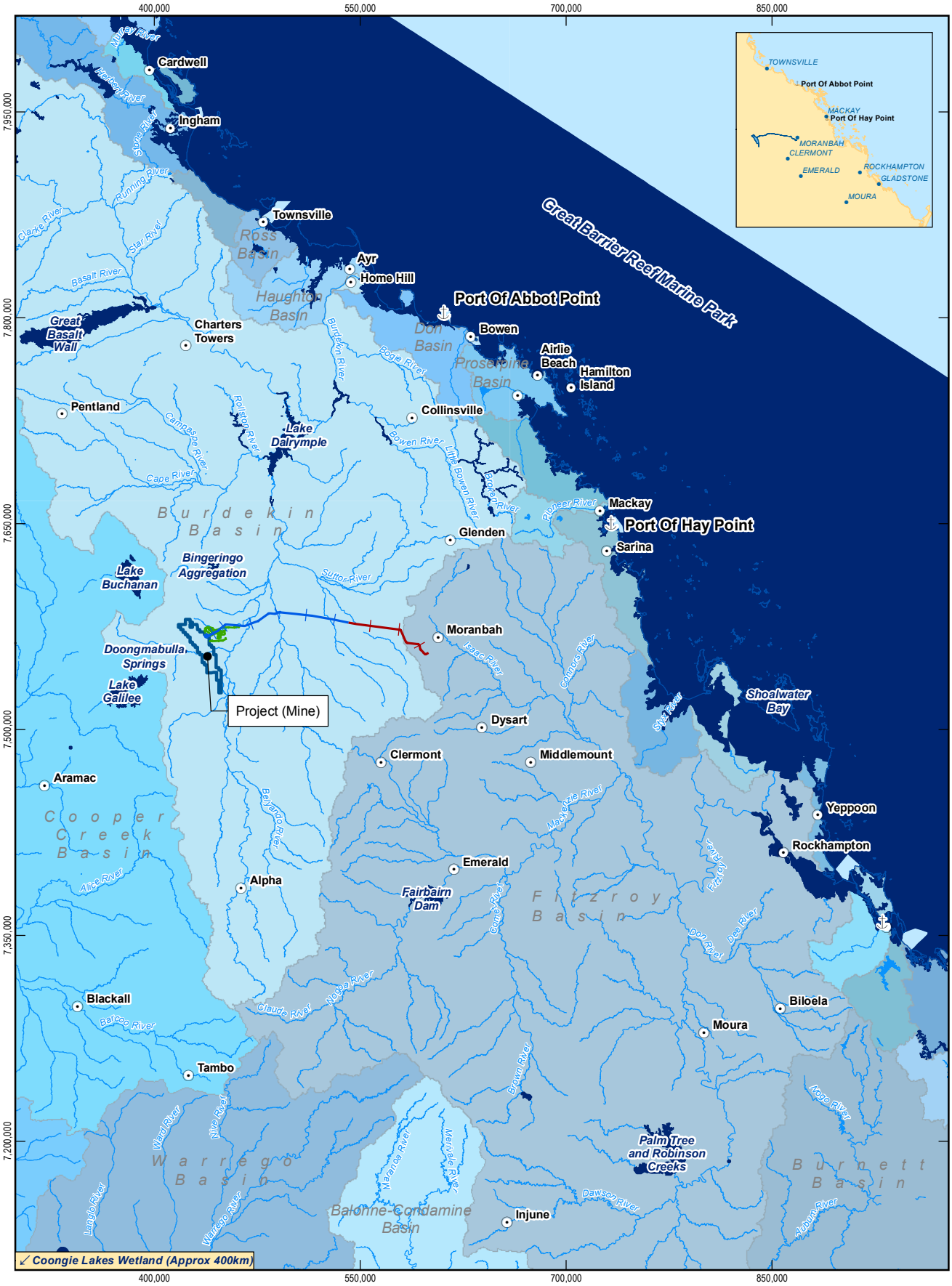
3.2.2 Ramsar Wetlands

The closest wetland of international importance (Ramsar wetland) is the Shoalwater and Corio Bays Areas, approximately 380 km east of the Study Area and outside the influence of the Burdekin River catchment. Substantial overland barriers occur between the Study Area and the Shoalwater and Corio Bays Area, and between the ocean and the Study Area watercourse barriers also occur, including the Burdekin River dam and falls. The distance from the protected area, and the existence of various barriers downstream, make it unlikely that activities at the site would have an influence on these protected values.

The DSEWPaC Protected Matters Search Tool indicated that the Coongie Lakes Ramsar site in South Australia (located approximately 800 km south-west of the Study Area) is of relevance to the Project as the Study Area occurs near the extreme north-east of the Cooper Creek Catchment, which drains in a south-westerly direction towards north-east South Australia (Coongie Lakes and Lake Eyre). The Study Area lies wholly within the Burdekin River Catchment and no surface waters within the Cooper Creek Catchment are located within the Study Area or surrounds (see Figure 3-1). Accordingly the Coongie Lakes Ramsar site is not connected to the Study Area.

3.2.3 Great Barrier Reef Marine Park

The Study Area is located over 300 km due west and approximately 320 km upstream of the Great Barrier Reef Marine Park (refer to Section 3.2.1 above – Great Barrier Reef World Heritage Area).



LEGEND

- Town
- Major Port
- Watercourse
- Directory of Important Wetlands Listed Area (Includes RAMSAR Sites)
- Project (Rail)
  - Rail (West)
  - Rail (East)
- Project (Mine)
- Mine (Offsite)

1:4,000,000 (at A4)

0 25 50 75 100

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

Job Number	41-25215
Revision	C
Date	30-08-2012

Conservation Significant Areas

Figure: 3-1

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Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DERM: DOI Wetlands, Drainage Basins (2009); GA: Towns, Watercourses, Mainlands (2007); DME: Carmichael Mine Site (2011); GHD: Major Ports (2010); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: BW.

3.2.4 Other Commonwealth Matters of Conservation Significance

Two sites considered to be nationally important wetlands are located within the desktop search extent for the Study Area. These are Doongmabulla Springs and Lake Galilee.

3.2.4.1 **Doongmabulla Springs**

Doongmabulla Springs are located within the Burdekin and Belyando River catchments and approximately 10 km west of the centre of the Study Area. Doongmabulla is a freshwater spring system that has been included in the directory of important wetlands because it satisfies two criteria:

1. It is a good example of a wetland type occurring within a biogeographic region in Australia
2. It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail (DSEWPaC, 2011b)

These are permanent springs that support an unusual habitat type unique to the surrounding area, in particular habitat for a number of threatened plant species (DSEWPaC, 2010). The plant communities include mixed grassland, sedgeland and forbland (DSEWPaC, 2010). No threatened macrophytes are listed as occurring in these springs. The threatened plant species listed to occur in this area are discussed in the Volume 4, Appendix N1 (Mine Terrestrial Ecology Report). The site is currently, and has historically been, used for watering domestic stock and existing key threats are identified as trampling and grazing by stock and feral animals, as well as aquifer draw down (DSEWPaC, 2010). The springs are expected to provide a permanent refuge habitat for aquatic flora and fauna in an area where most watercourses are ephemeral and only large watercourses sustain standing water throughout the year. The opportunity for recruitment may be reduced as a result of low connectivity to migration paths (rivers, streams).

Doongmabulla Springs is also recognised as a Great Artesian Basin (GAB) discharge spring. The EPBC Act lists the community of native species dependant on natural discharge of groundwater from the GAB as a Threatened Ecological Community (TEC). The community comprises species of flora and fauna including fish, invertebrates and aquatic and terrestrial plants clustered around discharge springs emanating from the GAB (Fensham, Ponder and Fairfax, 2010). The main threatening processes for this TEC are aquifer drawdown (due primarily to uncapped bores, but also to mining activities), excavation of springs, exotic flora and fauna invasion and stock damage, access by tourism, and impoundments (Fensham *et al*, 2010). Detailed assessment to describe and assess potential impact to this TEC is provided in Volume 4, Appendix N1 Mine Terrestrial Ecology Report and Appendix N2 Doongmabulla Springs Existing Environment Report.

The Doongmabulla Mound Spring Nature Refuge covers a large portion of the Doongmabulla Springs site (DSEWPaC, 2010) (see Section 3.3.3.2).

Groundwater assessment identified that these Doongmabulla Springs provide base flow to the adjacent Carmichael River. The results of this are discussed in Volume 4, Appendix R Mine Hydrogeology Report.

3.2.4.2 **Lake Galilee**

Lake Galilee occurs within the Thomson River Catchment of the Cooper Creek Basin. This basin drains in a south-westerly direction towards north-east South Australia. The lake is located over

40 km to the south-west of the Study Area and is not in the same drainage basin. Accordingly this lake is not considered to be connected to the Study Area.

3.3 State Matters of Conservation Significance

3.3.1 Species of Special Cultural Significance

Under section 34 (3) of the Queensland *Nature Conservation (Wildlife) Regulation 2006*, selected animals are designated as special least concern wildlife. This listing, as noted under Section 2.3.4, includes the platypus (*Ornithorhynchus anatinus*).

In addition to the management intent for least concern wildlife documented in the regulation, decision makers are required to take into account the special cultural significance and the need to conserve existing populations of special least concern animals.

The platypus is known to occur in the Burdekin Catchment, however, has not been recorded within the Study Area or surrounds (50 km buffer). Habitat requirements are discussed in Section 2.3.4 and this species is considered unlikely to occur in the Study Area based on its specific habitat requirements and lack of these supported by the site.

3.3.2 Great Barrier Reef Wetland Protection Areas

Great Barrier Reef (GBR) Wetland Protection Areas have been mapped by DEHP using the Aquatic Biodiversity Assessment Mapping Methodology (AquaBAMM) (Clayton *et al*., 2006) which identifies relative wetland conservation values within a catchment. The mapping uses a range of criteria, indicators and measures in combination with peer review to categorise the riverine and non-riverine freshwater wetlands in the catchment. Where more detailed site information is available mapped areas can be refined using the Queensland Wetland Definition and Delineation Guideline (DERM, 2010).

Three GBR Wetland Protection Areas (WPA) are mapped in the Study Area (Figure 3-2). The mapping data describes the mapped areas as displaying one of the 'priority ecosystem/special features' within the catchment. That being, these mapped areas are 'seasonal palustrine/swamps of the floodplain with native macrophyte communities (Regional Ecosystem (RE) 11.3.27)'. Ground-truthing of the vegetation communities in the three WPA areas did not confirm the presence of RE 11.3.27 and in some cases no remnant vegetation was detected.

The WPAs are mapped north of the Carmichael River up to two kilometres from the waterway. Ground truthing at these locations did not detect any standing water at the time of survey.

The western most mapped WPA displayed little evidence of water retention. The area instead appeared to be a depression in the landscape where, during wetter periods, the substrate retained moisture. No floating macrophytes or emergent grass species were present. The area displayed heavy cattle and pig disturbance evidence. The aquatic ecology values of this area are considered to be low for aquatic flora and fauna (Plate 3-1).

Plate 3-1 Western most mapped Great Barrier Reef Wetland Protect Area within the Study Area (August 2011)

The WPA mapped where the boundaries of EPC 1690 and EPC 1080 meet also displayed little evidence of water retention. Ground truthing of the vegetation confirmed that the area is comprised on non-remnant vegetation and does not appear to provide ecological values for aquatic flora and fauna (Plate 3-2).

Plate 3-2 Great Barrier Reef Wetland Protect Area on the boundary between EPC 1690 and EPC 1080 (November 2011)

The third WPA is mapped at the east of the Study Area on a first order stream that joins the Carmichael River downstream of the area. Ground truthing of this location detected remnant vegetation RE 11.3.3 within a shaded depression. The watercourse is expected to channel localised rainfall into the mapped wetland area. The area surrounding the WPA is predominantly cleared, and dominated by grasses and some woody regrowth. No standing water or associated aquatic

vegetation was present at the time of the survey (Plate 3-3). Evidence of recent water was noted with many of the surrounding trees exhibiting a watermark at about 0.5 m from the ground level. Recent waterbird nesting activity was also observed in the form of numerous nests (no longer being used). Although the special feature regional ecosystem community was not present, the WPA is likely to provide seasonal habitat for aquatic species including waterbirds during the wet season or after significant rainfall. Further detail relating to the vegetation communities of the Study Area is provided in Volume 4, Appendix N Mine Terrestrial Ecology Report.

Plate 3-3 Great Barrier Reef Wetland Protection Area at the east of the Study Area (November, 2011)

3.3.3 Other Protected Areas

Two protected areas relevant to aquatic ecology values occur within 15 km of the Study Area: the Bygana West Nature Refuge and the Doongmabulla Mound Springs Nature Refuge.

A number of other protected areas occur within 50 km of the Study Area however these are protected mainly due to their terrestrial ecology features. A discussion on each is provided in Volume 4 Appendix N1 Mine Terrestrial Ecology Report.

3.3.3.1 Bygana West Nature Reserve

The Bygana West Nature Refuge wholly occurs within the southern part of Study Area (Figure 3-2). No potential aquatic habitat occurs within the nature refuge with the exception of gilgais, which were observed during a visit (May 2011) to the area to ground-truth desktop information. Very little standing water was observed within the gilgais during wet season surveys (Plate 3-4). Minor drainage lines occur, however, these are expected to drain flash flows only and no isolated pools were observed. These drainage lines are similar to those observed in areas north of the Carmichael River which were observed to provide a pathway for runoff during high volume downpours but did not accommodate long term flows.

Plate 3-4 Gilgais at Bygana West Nature Reserve (May 2011)

3.3.3.2 Doongmabulla Mound Springs Nature Refuge

The nature refuge extent consists of two discrete sections separated east-west by a gap of approximately 1.4 km. The total area of the nature refuge is 280 ha.

As documented in the *Nature Conservation (Protected Areas) Amendment Regulation (No. 5) (2000),* Doongmabulla Mound Springs Nature Refuge is characterised by the following values:

- Contains significant artesian springs
- Supports the largest Australian populations of the plants *Eyngium fonatum* and *Sporobolus pamelae*
- Supports the endangered plant *Eriocaulon carsonii* (near artesian springs)

The nature refuge corresponds with the locality listed under the Directory of Important Wetlands in Australia as Doongmabulla Springs (and discussed in Section 3.2.4.1). As noted in Section 3.2.4.1 the surface watercourses within the Study Area have limited influence on the surface water aquatic ecosystems at Doongmabulla Springs as a result of limited connectivity.

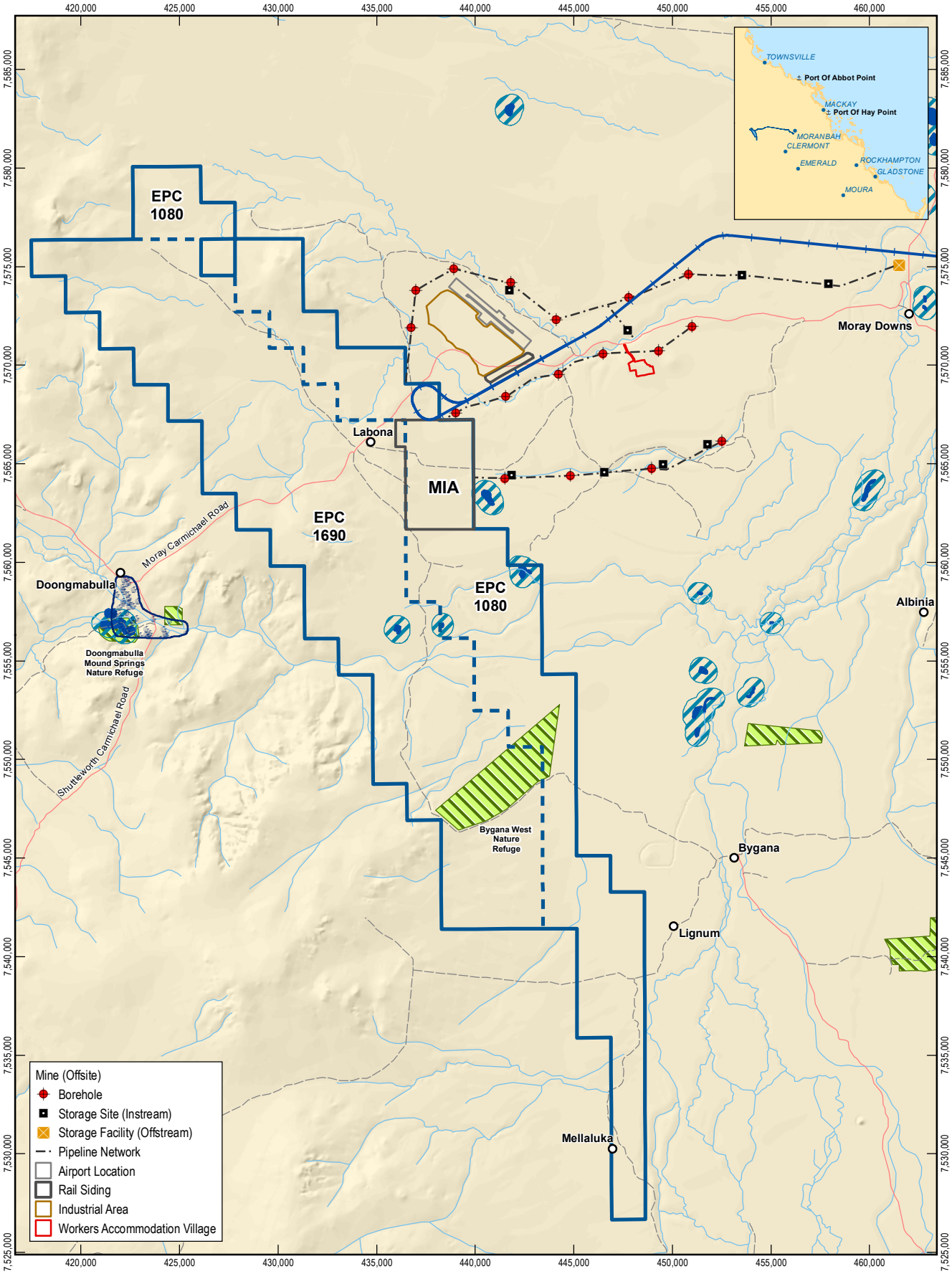
3.4 Regional Matters of Conservation Significance

The Burdekin Natural Resource Management Region 'Back on Track' Actions for Biodiversity document (DERM, 2010a) identifies (amongst other items) priority species for conservation and management effort in the Burdekin NRM region. For these priority species regional threatening processes and proposed actions to address threats are identified. Within the document a number of aquatic species are listed as priority species for conservation. Of relevance to the Study Area and surrounds is the listing of Irwin's turtle (*Elseya irwini*). The species is endemic to the Burdekin Catchment and is listed as high priority. Other species relevant to the Study Area and surrounds are terrestrial and discussion can be found in the Volume 4 Appendix N1 Mine Terrestrial Ecology Report.

The threats identified to the Irwin's turtle include:

- Feral pigs and foxes – feral pigs have the potential to result in loss and/or removal of individuals, including next predation. Feral pigs can raid turtle nests for food and likely contribute to river degradation as they move through the banks and root around. Foxes may also predate turtle nests.
- Inappropriate grazing regimes – inappropriate grazing regimes are likely to lead to degradation of habitat by lowering water quality, introducing or spreading weeds and tramping the riparian strip.
- Water quality – decline in water quality may result in habitat degradation for the species.
- Collectors – illegal collection of individuals is considered a minor threat to the species (DERM, 2010a).

The 'Back on Track' documentation recommends actions for the region to address major threats. These relate to regional, local and DEHP management strategies, and include community capacity building, research and monitoring initiatives. Documented within these actions, focus areas for prioritisation are noted. For the Irwin's turtle they include the Bowen and Broken Rivers and lower reaches of Burdekin River (DERM, 2010a). The Study Area is located in the upper reaches of the Burdekin River Catchment and is not recognised as a focus area for the species. No individuals were recorded during field surveys.



LEGEND

- Homestead
- Local Road
- Track
- Watercourse
- Rail (West)
- Mine (Onsite)
- Mine Infrastructure Area
- Great Barrier Reef Wetland Protection Area
- Great Barrier Reef Wetland Protection Trigger Area
- Directory of Important Wetlands
- Category C Environmentally Sensitive Area
- Nature Refuge

1:275,000 (at A4)

0 1 2 3 4 5

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

Great Barrier Reef Wetland Protection Areas

Job Number 41-25215
Revision C
Date 27-08-2012

Figure: 3-2

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Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DERM: DOI Wetland (2007), GBR Wetland Protection Areas (2009), Nature Refuges (2010)© Copyright Commonwealth of Australia - Geoscience Australia: Road, Homestead, Watercourse (2007); Adani: Alignment Opt9 Rev3, SP3 (2012); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011). Created by: BW,MS

4. Potential Impacts and Mitigation Measures – Construction

4.1 Introduction

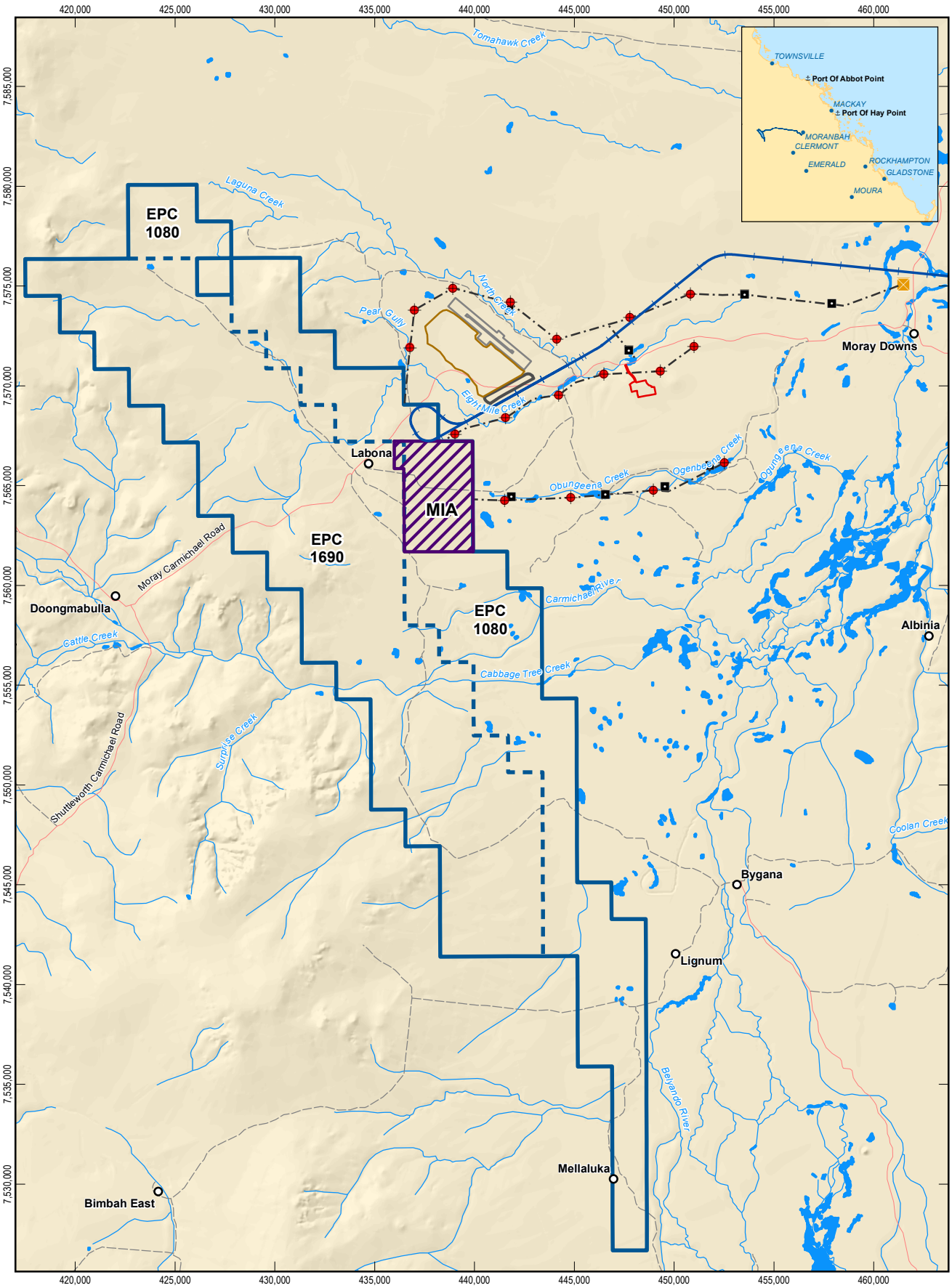
This assessment has been structured to address impacts associated with primary construction activities for the mine aspects of the Project. These activities will comprise:

- Development of the Mine Infrastructure Area (MIA) – which will require the removal of a farm dam (Brigalow Dam)
- Construction of an industrial precinct and airport and land designated for industrial use
- Construction of a workers accommodation village comprising a construction camp and initial mine operations accommodation
- Construction of bridge across the Carmichael River to provide access to the southern portion of the lease
- Construction of offsite water supply infrastructure comprising:
  - Expansion of capacity of existing dams on North Creek and Obungeena Creek
  - Construction of turkey nest (i.e. no catchment) water storage dams
  - Construction of bores and associated access tracks
  - Construction of in-stream extraction pumping infrastructure on Belyando River and North Creek
  - Development of water supply pipeline infrastructure for conveyance of water between all water supply sources
  - Facilities for treatment and storage of treated water

The following should be noted with respect to the potential impacts of this construction phase on aquatic ecosystems:

- All water leaving construction areas will be captured and treated prior to discharge and/or reuse
- Water required for construction will be sourced from either onsite or the offsite water supply infrastructure
- Sanitation for construction crew will be treated to A standard and discharged/reused onsite

Figure 4-1 provides the extent of the expected disturbance area during the construction phase of the Project.



LEGEND

- Homestead
- Local Road
- Track
- Watercourse
- Waterbody
- Construction Phase Disturbance Footprint
- Rail (West)
- Mine (Onsite)
- Mine Infrastructure Area
- Mine (Offsite)
- Borehole
- Storage Site (Instream)
- Storage Facility (Offstream)
- Pipeline Network
- Airport Location
- Rail Siding
- Industrial Area
- Workers Accommodation Village

1:275,000 (at A4)
0 1 2 3 4 5
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Construction Phase
Disturbance Footprint

Job Number 41-25215
Revision C
Date 31-08-2012

Figure: 4-1

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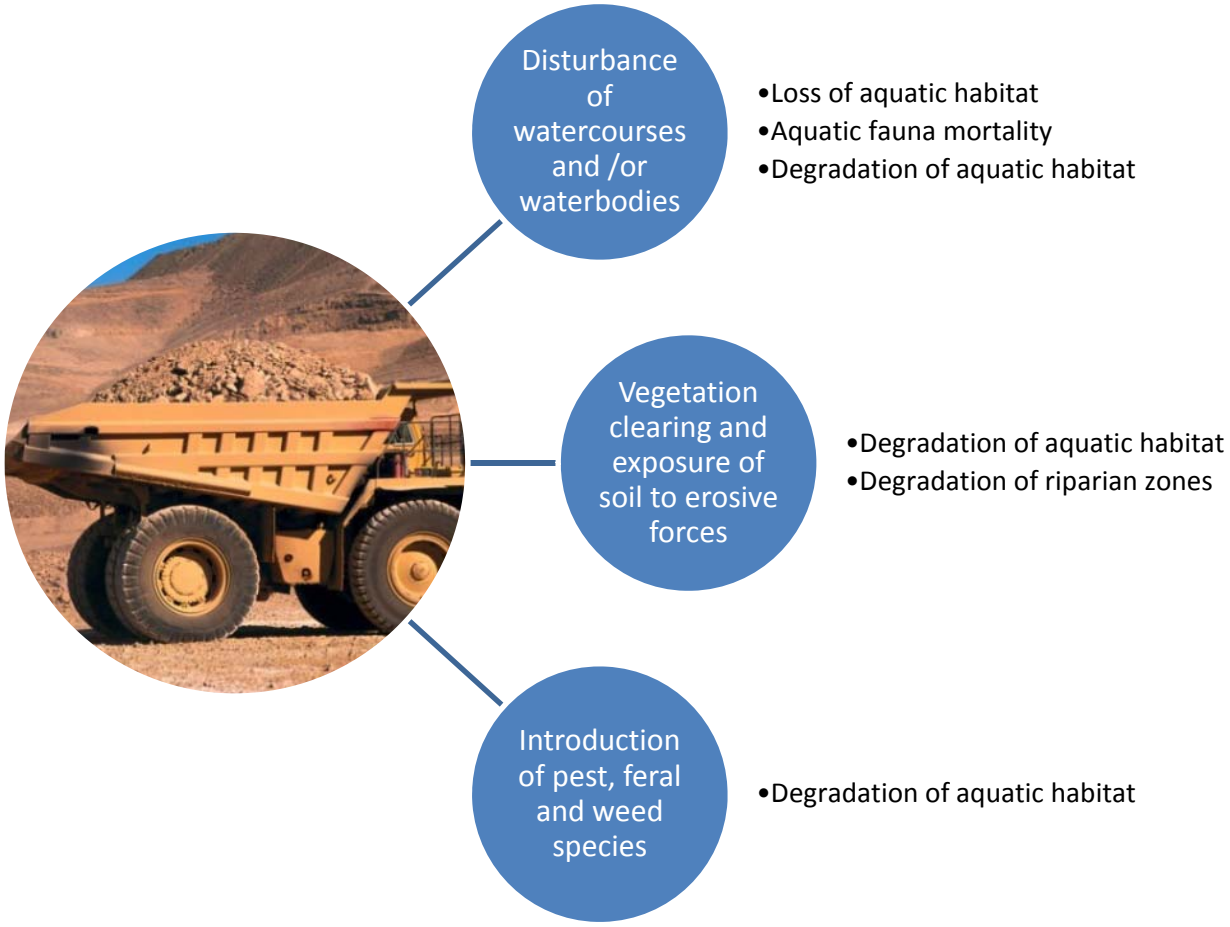
Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DERM: Waterbody (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Road, Homestead, Watercourse (2007);
GHD: Disturbance Footprint (2011); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011). Created by: TH.

The potential impacts to aquatic ecosystems during the construction phase are summarised in Figure 4-2, and appropriate management measures have been proposed in Sections 4.2, 4.3 and 4.4 to avoid or mitigate impacts.

Additional discussion of impacts and mitigation relevant to surface water quality are reported in Volume 4 Appendix Q Mine Water Quality.

Figure 4-2 Conceptual Diagram of Potential Construction Phase Impacts



4.2 Removal and Disturbance of Watercourses or Waterbodies

4.2.1 Overview

Construction of the MIA and offsite water supply infrastructure will result in direct disturbance of aquatic habitat.

Potential direct aquatic ecological impacts arising from activities in the construction phase include:

- Loss and disturbance of habitat for aquatic flora and fauna species
- Aquatic fauna mortality

4.2.2 Loss of and Disturbance to Aquatic Habitat

4.2.2.1 Potential Impact

Construction of the MIA and other Infrastructure

Brigalow Dam will be drained and in-filled to facilitate construction of the MIA. Brigalow Dam is a low value lacustrine aquatic habitat. It is a farm dam with no connectivity to watercourses and exhibits disturbance from cattle and feral pigs. The water body water level was very low at the time of survey and the water present appeared highly turbid. The dam substrate is silt and clay and the margins consist of grasses only. The dam provides limited value for native aquatic flora and fauna, particularly as there is no in-water structure to provide for habitat variety, and no connectivity to the (surface) waterway system and hence little opportunity for recruitment of aquatic species. There will be a localised impact to resident native fish, crustaceans and turtle species in this dam when the water body is drained or filled with material.

There are no mapped water bodies within the workers accommodation village or industrial precinct and airport.

Construction of the Offsite Water Supply Infrastructure

Existing farm dams on North Creek and Obungeena Creek will be expanded to capture flood flows for the water supply. This process will require these dams to be temporarily drained so that the expansion can be undertaken. The temporary removal of these artificial aquatic habitats will result in localised, short-term impacts to non-conservation significant fish, macrophytes, crustaceans and turtles that are likely to be present; in the medium to longer term, this habitat will be restored when the water is returned.

North Creek and Obungeena Creek are ephemeral second order creek systems that play an important role in providing seasonal connectivity for aquatic fauna upstream and downstream in times of flow. This connectivity is important in maintaining gene flow and genetic diversity between periodically isolated populations. Additionally, these connecting waterways provide for recolonisation and/or population supplementation in the event of a population extinction or bottleneck. The expansion of the existing water supply dams on these creeks may create habitat fragmentation if flows are reduced due to larger volumes of water captured in the dams.

There is likely to be minimal impact to this aquatic habitat connectivity along watercourses from proposed dam expansions; however if creek diversions are proposed during construction, temporary loss of impacted sections of instream habitat may occur.

If flows occur in either waterway during construction, construction activities will probably preclude fish movement upstream. However, the construction period is short and impedance to movement over a single wet season is not likely to have any long term effects on fish populations. Impacts are also anticipated to be localised, with no aquatic species or habitats of conservation significance affected by the loss of habitat or impedance to movement during construction.

Construction of pump sites and associated pipelines in the riparian zones of North Creek and Belyando River will also impact on aquatic and riparian habitat. Construction of the offsite water supply infrastructure will also result in temporary disturbance of aquatic habitats while pipelines are installed across streams and drainage lines. These include ephemeral drainage lines; North Creek, Obungeena Creek and Eight Mile Creek.

Construction areas for water supply pipeline corridors, including laydown areas and stockpiles will be located within the pipeline corridor, where possible to minimise vegetation clearing related impacts. Additionally, the pipeline right of way within the riparian zone of Belyando River and North Creek will be reduced, where possible to minimise impacts to vegetation communities. The disturbance of the riparian zone may trigger erosion and sedimentation impacts and resulting degradation of adjacent and downstream habitats, as outlined in Section 5.2.3.

4.2.2.2 Management and Mitigation

Removal of the low value aquatic habitat at Brigalow Dam is unavoidable. In the event that any aquatic fauna species are present at the time of construction, measures to avoid impact to fauna species that may be present in the dam in Section 4.2.3 should be utilised.

The planning and concept design for offsite water supply infrastructure has aimed to avoid areas of high aquatic value where possible by avoiding riparian habitat, referrable wetlands and gilgais. The number of pipeline crossings of waterways have also been minimised and crossings have been located to reduce disturbance to the bed and banks of watercourses in the Study Area wherever possible.

Potential to further reduce disturbance to stream habitats by infrastructure will be reviewed in the detailed design phase, including consideration of:

- Selection of crossing locations to avoid or minimise disturbance to important areas of aquatic flora, waterholes, watercourse junctions and watercourses with steep banks
- Opportunities to use existing access tracks and other previously disturbed areas wherever possible
- Further opportunities to consolidate infrastructure alignments to minimise the number of crossings
- Design of pipeline crossings such that the level of the stream bed is not altered

While these design strategies will minimise the impacts on aquatic and riparian environments, some disturbance is expected to occur as a result of construction activities. Consequently, mitigation strategies will be required during construction to further reduce these impacts. Mitigation strategies will be based on compliance with the relevant DEHP *Guidelines for carrying out activities in a watercourse, lake or spring* and, if applicable, be undertaken in accordance with requirements for development approvals.

Mitigation strategies will include:

- In-stream works to be undertaken in nil or low flow conditions wherever possible
- Duration of in-stream works to be minimised through prior planning such that all equipment and materials are available to allow works to be completed as quickly as possible
- For dam raising sediment control measures to be installed where in-stream disturbance must be undertaken during flow conditions. This will most likely involve sediment weirs. If sediment weirs are installed, care will be taken to minimise effects of the sediment weirs on aquatic habitat
- Minimisation of disturbance area within streams and riparian areas. Equipment parking and laydown areas will be located outside these areas. The area of disturbance within streams and riparian zones will be the minimum area required for safe working and the area of disturbance for infrastructure installation clearly marked
- Prompt stabilisation of disturbed areas to prevent flow-related scouring of bed and banks of stream. Stabilisation is to use “soft” engineering solutions rather than concrete or similar
- Where existing dams are to be extended and/or the dam wall uplifted to increase storage capacity, works will be staged accordingly so as not interfere with the existing environment where practical.

4.2.2.3 Summary

In the context of aquatic habitat values within the Study Area and surrounds, the aquatic habitat to be removed within the construction footprint is considered to be of relatively low value and loss of aquatic habitat due to infrastructure installation is not considered to be significant. Stabilisation and rehabilitation of disturbed areas will further minimise losses.

The existing habitat within Brigalow Dam is an artificially created, disturbed environment not considered to play an important role in the aquatic biodiversity of the area. It is not connected to other water bodies and does not provide critical habitat to any native aquatic species but is accessed by cattle for watering. The ecological values of small farm dams such as Brigalow Dam, for terrestrial fauna species and communities are discussed in Volume 4, Appendix N1 Mine Terrestrial Ecology Report.

No aquatic habitat will be permanently lost as a result of the workers accommodation village or industrial precinct and airport. Impacts to aquatic habitat as a result of offsite water supply infrastructure will be primarily of a temporary nature, as such there will be no permanent loss of aquatic habitat. Management and mitigation controls will be implemented during construction to further minimise temporary loss of habitat associated with construction of required water supply infrastructure.

4.2.3 Aquatic Fauna Mortality

4.2.3.1 Potential Impact

Mortality or injury to resident native aquatic fauna can potentially occur when construction activities are undertaken within or adjacent to a water body. This usually arises as a result of vehicle/machinery strike or strike from falling vegetation or woody debris, but also as a result of fish and other aquatic fauna being stranded when the water is drained from waterways or dams. Fish, turtles and crustaceans were detected in aquatic habitats in the Study Area during surveys, and these

species are likely to occur in the Brigalow Dam, Obungeena Creek and North Creek. Consequently, there are likely to be aquatic species that are at risk of mortality or injury.

The removal of Brigalow Dam through filling or draining the dam will result in the mortality of any resident aquatic communities present and the time of construction. Brigalow Dam is an isolated aquatic habitat, and as such, the fish and crustacean populations are not able to independently move to a refugial habitat. These communities are isolated populations likely to have been established as a result of stocking or incidental transfer by birds or the like. During wetter months this population is not likely to be connected to others hence will not contribute to the local biodiversity of the aquatic communities in the river and creek systems in the region. Though the community may not be important in the context of local biodiversity, all native species are protected under the NC Act and destruction of native species is prohibited without the required approvals. Approval conditions will include requirements to reduce the risk of fauna mortality when the dam is drained or in-filled.

Potential aquatic fauna mortality impacts with regard to construction of offsite water supply infrastructure are associated with construction activities within watercourses, such as pipeline crossings and draining of dams on Obungeena Creek and North Creek. Existing dams on North Creek and Obungeena Creek potentially contain commonly occurring native fish, crustaceans and turtles. Temporary draining of dams that are to be raised may therefore result in injury or mortality of some native species. Construction within riparian zones and within the bed and banks of ephemeral creeks such as North Creek, Obungeena Creek and Eight Mile Creek may also result in both direct and indirect aquatic fauna mortality. For example, direct mortality will occur in the event that an individual is struck by machinery or a falling object.

Indirect mortality may also occur in the event that a waterway is drained, or if there are significant and sudden changes in water quality and fish and other aquatic animals are unable to escape. For example, the removal of the riparian zone will reduce shading over the waterway. This will potentially result in an increase in surface water temperatures, a subsequent reduction in dissolved oxygen (as warmer water has reduced oxygen holding capacity) and death of aquatic biota due to hypoxic conditions.

When in flow, North Creek, Obungeena Creek and Eight Mile Creek provide dispersal pathways for aquatic flora and fauna. Consequently, when construction is undertaken during flow conditions there is a risk of fauna mortality along these waterways. Although aquatic fauna species present are common and loss of individuals is not likely to have any significant impact on biodiversity of aquatic ecosystems, all native species are protected under the NC Act and destruction of native species is prohibited without the approval under the NC Act. Subsequently, all reasonable and practical measures will be undertaken to minimise the occurrence of such events.

4.2.3.2 Management and Mitigation

To avoid mortality of aquatic fauna during drainage of Brigalow Dam and the dams on North Creek and Obungenna Creek, fauna salvage and relocation may be required where there is water in the dams at the time of construction. This will involve:

- Survey of the dams immediately prior to draining to identify presence of fish and large crustacean species

- Depending on species identified, development and implementation of a relocation techniques to capture species and identify appropriate locations for relocation in accordance with the Department of Primary Industries and Fisheries Fish Salvage Guidelines (2004)
- Monitor during drainage of dams to check for stranding

To avoid potential mortality of aquatic fauna during construction within riparian zones and within the bed and banks of ephemeral creeks, construction activities will ideally be undertaken during dry or controlled conditions. Timing of construction in and adjacent to watercourses during dry conditions will assist in minimising potential indirect impacts to aquatic ecosystems at crossing sites and downstream. These potential indirect impacts and mitigation measures are discussed in Section 4.3.

4.2.3.3 Summary

Direct and indirect injury or mortality to aquatic fauna may occur during the planned construction in North Creek, Obungeena Creek, Eight Mile Creek and Brigalow Dam. These consequences are most likely to be the result of individuals being struck by machinery or falling objects, significant degradation of water quality or as a result of the draining of dams. Although high value aquatic habitats and species of conservation significance are not affected, all native animals are protected under the NC Act and this requires mitigation.

4.3 Land Disturbance

4.3.1 Overview

Construction activities will involve removal of vegetation, removal of topsoil, and cut, fill and compaction works within the footprint. This comprises approximately 1945 ha to be cleared for construction of the MIA, and approximately 3,313 ha to be cleared for construction of the offsite industrial area, workers accommodation village and airport. The majority of construction will occur over a period of 36 to 48 months however, will continue until the Project (Mine) reaches full production in 2022.

During construction, the landscape will be exposed within the MIA, workers accommodation village and industrial precinct and airport, until construction is finalised or the cleared areas are stabilised. Similarly, the construction of offsite water supply infrastructure will require construction activities to occur adjacent to and temporarily within watercourses. Some clearing of riparian vegetation will also be required at points where pipelines cross waterways. Small amounts of terrestrial vegetation fringing some existing farm dams may need to be removed during expansion works, which will have minor impacts to aquatic fauna by reducing shelter and nutrient inputs (organic matter) to the dam.

Potential impacts that may be realised as a result of land clearing include:

- Indirect degradation of aquatic habitats as a result of:
  - Changes in water quality as a result of mobilisation of sediments and pollutants from disturbed areas
  - Changes in the surface water flow regime which has the potential to alter seasonal and temporal habitat availability and change geomorphology
  - In cases of severe erosion, geomorphological changes in streams as a result of mass sediment mobilisation

- Degradation of the function of the riparian zone with respect to protection of the aquatic ecosystem, including reduced shading and microhabitat

4.3.2 Degradation of Aquatic Habitat

4.3.2.1 Potential Impact

The indirect impacts of clearing of land have the potential to degrade aquatic ecosystems by leading to changes in chemical (water quality) and physical (geomorphology and flow patterns) characteristics of the existing aquatic habitats within the construction footprint and downstream catchment. The direct loss of habitat as a result of construction is discussed in Section 4.2 and degradation of downstream habitats has the potential to further reduce local habitat availability for native aquatic flora and fauna species.

Specific to the construction phase, aquatic ecosystems at risk of degradation are those within the construction area and directly downstream of the dams (on North Creek and Obungeena Creek) and extraction locations on North Creek, Obungeena Creek and Belyando River, and pipeline crossing locations. Additionally, any areas receiving runoff flows from areas of land cleared for the MIA, workers accommodation village, industrial precinct and airport are likely to be impacted.

An infrastructure corridor, including a spanned bridge will be required to facilitate mining operations on the south side of the river. The crossing infrastructure will be designed such that no infrastructure will be placed in the bed of the Carmichael River. It is likely however that during construction vehicles may require access to the bed of the river; hence a temporary loss of habitat may result. Installation of the infrastructure across this watercourse will potentially result in a small loss of aquatic habitat, create a barrier to movement for native aquatic fauna species and/or alter hydrological flow. These effects will however be temporary during construction and unlikely to have any medium or long term effects.

Changes in Water Quality

Physical changes in water quality have the potential to reduce the suitability of the aquatic environment for some aquatic flora and fauna species. The surface water quality of the Study Area is described in Volume 4 Appendix Q Mine Water Quality Report. The main sources of water quality changes are related to the mobilisation of sediments and pollutants.

Land clearing at the MIA, workers accommodation village, industrial precinct and airport will result in a local increase in exposed earth surfaces. The source of most suspended particulates (and in turn increase in turbidity), nutrients and other contaminants attached to particulates in waterways is mobilisation of soils through surface runoff , stream bank erosion and dust. Construction activities within or adjacent to watercourses for the offsite water supply infrastructure has the potential to disturb bed and bank substrates and lead to localised erosion and sediment transport to downstream habitats. Suspended particulates can influence the aquatic ecosystem when:

- In suspension – when in the water column particulates reduce light penetration and thus primary production as well as affecting gill function of fish
- Settling out – when settled sediments can smother organisms and their habitats (ANZECC, 2000)

Turbidity in streams in disturbed catchments is closely connected with rainfall and surface runoff with spikes in turbidity typically occurring after rain events, and then reduced turbidity levels as flows

reduce and sediment is able to settle. The surface water quality assessment for the project identified that turbidity results were recorded above the nominated water quality objectives (WQO) on a number of occasions (Volume 4 Appendix Q Mine Water Quality Report). Although aquatic ecosystems in highly ephemeral systems are likely to be adapted to peaks in high turbidity during some periods, an increase in the magnitude or the frequency of these peaks of turbidity has the potential to have a detrimental effect on aquatic ecosystems.

Sediment movement can also mobilise nutrients and pollutants to aquatic habitats. Soils from the exposed areas, and potential pollutants, will be readily mobilised into local drainage lines and water bodies via erosion processes. The potential for mobilisation of soils and potential pollutants will be maximised after rain events and during high winds. Nutrient pollution has the potential to impact upon a system via the stimulation of growth of nuisance plants and cyanobacteria (ANZECC and ARMCANZ, 2000). Growth of these plants can lead to changes in the biological community composition as well as flow on affects to habitat suitability and aspects of water quality such as dissolved oxygen concentration which can impact upon aquatic fauna communities.

Within the Study Area concentrations of nutrients were generally higher in the still water bodies than in the Carmichael River. In the Carmichael River nutrient water quality sampling results were also detected to be linked to rainfall and surface runoff. Nutrient concentrations recorded higher (above WQOs) at the end of the wet season followed by a decrease during drier months and a gradual increase back to values above WQOs in September when wet season conditions begin. As with turbidity, aquatic ecosystems are adaptive to the existing seasonal variation in nutrients however increases in magnitude and frequency of peaks in this variable may have the potential to adversely impact ecosystems.

Oils, fuel, lubricants and other substances containing chemicals will be required to operate construction machinery. Accidental spills or leaks anywhere within the catchment, including within the MIA, workers accommodation village, industrial precinct and airport have the potential to result in contaminants being transported to the aquatic environment via rainfall runoff. Commonly used substances contain elements that, at high concentrations, can be toxic to aquatic organisms.

Surface Flows and Geomorphology

Changing the direction or volume of runoff flows to watercourses and within watercourses has the potential to change the watercourse geomorphology as a result of scour and deposition. The mobilisation and subsequent deposition of sediments into watercourses has the potential to locally change bed and bank profiles. Such physical changes have the potential to reduce habitat suitability for existing communities and change the diversity and/or structure of the community by creating or removing microhabitat types to which the existing community has adapted.

The construction phase will result in a change to the current open grazing land with relatively permeable soils to compacted developed areas within the footprint. The resultant land use will have a relatively increased potential for runoff of rainfall to occur as the permeability of the soils is reduced within the footprint. As discussed in Volume 4 Appendix P Mine Hydrology Report, given the relatively small area of the catchment to be disturbed, it is unlikely that this increase in catchment permeability will substantially change runoff flow volume to the downstream catchment. Minor changes to topography will also occur as a result of construction which in turn may mean that flow paths change. Again, the magnitude of change in the context of the catchment is unlikely to result in any significant changes to stream flows.

Alteration of volumes and flows in North Creek and Obungeena Creek associated with construction works to expand existing dams may result in changes to watercourse geomorphology.

Trenching of pipelines associated with waterway crossings at Obungeena, North and Eight Mile Creeks may also result in temporary localised impacts to geomorphology. These geomorphology impacts will mostly be due to the overland flow changes resulting from the buried pipeline 'crown' left on the soil surface. With rehabilitation of the pipeline right of way, this impact will be reduced as the right of way returns to a natural state with vegetation coverage.

4.3.2.2 Management and Mitigation

Potential impacts on aquatic habitats as a result of land based activities such as clearing, can be largely avoided or mitigated through the implementation of construction specific management measures.

Mitigation measures will be detailed in the Mine and Offsite Environmental Management Plans, which will include erosion and sediment control requirements to be implemented and monitored throughout the construction phase of the Project.

To limit the degradation of downstream aquatic habitat during construction activities, mitigation and management will focus on reducing the potential mobilisation of sediments or pollutants, diversion of stormwater flows from disturbed areas and limiting sediment transport from exposed areas.

Controlling site runoff from all areas disturbed during construction and minimising bank disturbance will be important in limiting the degradation of habitats downstream of the construction footprints. The management and mitigation of the mobilisation of sediment and pollutants during construction is described in Volume 4 Appendix Q Mine Water Quality Report and these measures will assist in limiting the degradation of aquatic habitats. The measures identified include (but are not limited to):

- Avoiding clearing of vegetation and major earthworks during overland flow events.
- Installing stormwater diversion and collection systems as early as possible in the construction period.
- Developing and implementing erosion and sediment control plans. Further details on erosion and sediment control are provided in the Mine and Offsite Environmental Management Plans
- Maximising retention of surface cover by clearly delineating clearing areas and restricting activities to these areas. .
- Locating soil or mulch stockpiles away from watercourses and key stormwater flow paths to limit potential for transport of these substances into the watercourses via runoff.
- Dust suppression activities to be undertaken where appropriate. Stabilisation of disturbed areas as soon as practicable after disturbance.
- Wherever possible, staging the clearing of vegetation as construction progresses and minimising the disturbance footprint at all times.
- Undertaking revegetation according to Rehabilitation Plan requirements.
- Development of emergency response protocols and procedures for implementation in the event of a contaminant spill or leak and provision of spill response equipment.

- Storage of fuels, chemicals, wastes and other potentially environmentally hazardous substances in bunded or otherwise contained areas away from watercourses.
- Refuelling and in areas away from watercourses.
- Regularly checking vehicles and equipment for oil leaks.

The design of the MIA, workers accommodation village, industrial precinct and airport will incorporate stormwater management infrastructure and mechanisms to manage runoff. This may include holding tanks and/or gross pollutant traps (GPT) or other stormwater management techniques. Stormwater management mechanisms and monitoring requirements will be developed prior to any construction activities and incorporated in the Mine and Offsite Environmental Management Plans.

Monitoring will include:

- Regular checks of fuel, chemical and waste storage areas for leaks or improper storage
- Regular checks, including checks prior to forecast rain events, of erosion and sediment control devices to make sure these are in good working order
- Pre-rain checks of erosion and sediment control devices
- Inspections of streams for scouring and sediment deposition
- Ongoing water quality monitoring (refer Volume 2, Section 6 - Water Quality and Volume 4, Appendix Q – Mine Water Quality Report)

4.3.2.3 Summary

Construction activities have the potential to impact aquatic habitats by changing both chemical and physical characteristics of aquatic ecosystems within and downstream of the construction footprints. Potential impacts are relatively minor given both the scale of disturbance in the context of the catchments, and the relatively low aquatic ecosystem and habitat values present. It is unlikely there will be a change in runoff flow volume such that it may impact aquatic habitats and with management of the potential impacts on impact to water quality, the impact to aquatic habitats can be limited. During the construction period it is expected that the aquatic ecology impacts associated with offsite water supply infrastructure will be localised and temporary.

Impacts can be effectively managed through the implementation of management measures to minimise erosion and prevent the mobilisation and transport of sediments and to prevent other potential water quality contaminants that may arise from spills and leaks of fuel and chemicals.

Additionally, design measures have been adopted to condense and minimise the footprint of disturbance in the riparian zones.

Monitoring requirements will be included in the Mine and Offsite Environmental Management Plans for both effectiveness of the management measures and the water quality conditions.

4.3.3 Degradation of Riparian Zones

4.3.3.1 Potential Impact

The riparian zone plays an important role in the composition, function and protection of aquatic ecosystems. Established zones assist in stabilising soil, filtering toxicants and nutrients, provision of shade and as a source of large woody debris and organic matter for the functioning of aquatic

ecosystems. Removal of riparian vegetation will be required for construction of the following offsite water supply infrastructure:

- In-stream dams on North Creek and Obungeena Creek
- In-stream extraction pumping infrastructure on the Belyando River and North Creek
- Pipeline crossing locations on North Creek (two locations), Obungeena Creek (one location) and Eight Mile Creek (one location)

The riparian zone of the Belyando River is characterised by a relatively consistent corridor of open forest and woodland dominated by *Eucalyptus coolabah* (coolabah) and *E. camaldulensis* (river red gum) canopy trees. The riparian zones of North Creek, Obungeena Creek and Eight Mile Creek are more fragmented.

Disturbance of riparian vegetation has the potential to lead to increased erosion and sediment transport to downstream habitats during flood and high flow runoff periods. The effect of increased erosion and sedimentation is discussed in Section 4.3.2.

The removal of a section of the riparian zone also exposes adjacent riparian communities to weed invasion. Discussion on the impacts of weed and pest species is in Section 4.4.

4.3.3.2 Management and Mitigation

Where unavoidable loss of the riparian zone for the construction phase will occur, sediment and erosion control measures will be implemented. The design and layout of the offsite water supply infrastructure will minimise the width of disturbance to the riparian zone. Sensitive areas in the vicinity of all construction will be clearly demarcated prior to construction to avoid accidental clearing or disturbance. A suitably qualified ecologist will be required to provide advice on the location of sensitive areas for demarcation.

These measures will be incorporated into the Mine and Offsite Environmental Management Plans to be prepared prior to any construction at the site. The management and mitigation of the potential impacts related to erosion and sediment transport are described in Section 4.3.2.

4.3.3.3 Summary

There is potential for the removal of the riparian zone to lead to degradation of aquatic habitats. By minimising the disturbance width required for the construction of offsite water supply infrastructure, implementing erosion and sediment control measures and weed management measures, no residual impacts to riparian vegetation and aquatic habitats are expected from activities in the riparian zone.

4.4 Introduction of Pest and Weed Species

4.4.1 Aquatic Habitat Degradation and Reduction in Resource Availability

4.4.1.1 Potential Impact

Soil disturbance and clearing of vegetation has the potential to result in the introduction and/or spread of terrestrial and aquatic weed and pest species. As discussed in Section 2.3.2 there are a number of pest fish species that occur in the Burdekin catchment. Although no pest species were recorded within the Study Area, pest species often flourish in disturbed habitats and in the event species are introduced (via translocation or stocking) or become prevalent closer to the Study Area, aquatic

habitats may be susceptible. The introduction of these species can affect native fish communities through direct competition for resources (food and habitat), predation, habitat alteration and the introduction of diseases or parasites (DEEDI, 2011).

Aquatic weeds can also affect native communities by shading out native plants, reducing the quality of habitat for aquatic fauna communities and degrading water quality (DERM, 2011). Both weed and pest fauna species can be introduced when the numbers of people are visiting the area is increased. Weeds and weed seeds can be introduced in material (e.g. earth fill), water for water supply and vehicle (e.g. water trucks) vectors brought to the site during construction. The water supply plan for the Project incorporates the extraction of water from North Creek and the Belyando River outside the Study Area for use. In the event the water extraction location is in an area where aquatic weeds are present, seeds and propagules have the potential to be introduced.

Terrestrial weed and pest species, and the potential ecological impacts associated with them are also discussed in Volume 4, Appendix N1 Mine Terrestrial Ecology Report. Some terrestrial weed species and pest animals also have the potential to impact upon the aquatic environment directly and indirectly. Terrestrial weeds can invade riparian zones and aquatic habitats, whereby reducing aquatic habitat quality, diversity and availability. Pest animals such as pigs can have detrimental effects to watercourses by rooting 'ploughs' up to 20 m around a water body (DEEDI, 2010). This disturbance can lead to degradation of downstream water quality and habitat for aquatic species by creating erosion (DEEDI, 2010) destroying in-stream habitat and allowing opportunity for weed establishment rather than native riparian communities.

Introduction of pest and weed species locally has the potential to impact all aquatic habitats in the affected catchment if these species establish locally and spread to area with more permanent aquatic habitat such as the Carmichael River and Cabbage Tree Creek.

4.4.1.2 Management and Mitigation

Weed and pest species spread and the potential for their introduction will require management during the construction phase of the Project. An integrated suite of actions will be embedded in Volume 2 Section 13 Environmental Management Plan to manage both aquatic and terrestrial introduced species, including:

- Assessment of risk of aquatic weed transport at water supply extraction point such that filters or screens can be used to inhibit seeds and propagules or eggs being transferred to the Study Area
- Disposal of vegetation waste (in a manner that minimises potential for spread of weeds)
- Monitoring of weed levels and where increased weed levels occur, weed control programs
- Cleaning of vehicles, equipment and plant before entry to the site
- Regular weed and pest monitoring of the Study Area to confirm adequacy of management and mitigation approaches. Monitoring requirements and corrective actions will be clearly articulated in a Construction Management Plan.

Management and mitigation relating to the control of terrestrial weed and pest species is documented in Volume 4, Appendix N1 Mine Terrestrial Ecology Report. Implementation of those measures will manage the impact to the aquatic ecosystems as well as terrestrial ecosystems.

4.4.1.3 Summary

Introduced species can affect native aquatic communities through direct competition for resources, predation, habitat alteration and the introduction of diseases or parasites. Both terrestrial and aquatic weed and pest species have the potential to be introduced to the site as a result of:

- Opportunistic establishment of a population of disturbed habitats by species migrating from downstream locations that may be have been stocked or translocated
- Transport within offsite water supply

Implementation of the mitigation strategies, largely via the development and execution of the Mine and Offsite Environmental Management Plans will assist in minimising the potential for aquatic weeds and pest animals to establish in and near the Study Area. Regular, monitoring will be a core component of the successful implementation of these plans, with corrective actions (including eradication) to be undertaken at the earliest opportunity after monitoring reveals a new weed species or pest animal incursion. Management and mitigation of terrestrial weed and pest species is described in Volume 4, Appendix N1 Mine Terrestrial Ecology Report and these measures will assist in managing the potential impact of terrestrial weeds and pests on aquatic environments.

5. Potential Impacts and Mitigation – Operation

5.1 Introduction

This assessment has been structured to address impacts associated with primary operational activities for the mine aspects of the Project. These activities will comprise:

- Staged, development of the mine over 90 years, incorporating
  - Underground mining extending in a string from roughly north to south along the west of the lease
  - Open cut mining along the middle of the lease
  - Overburden disposal (out of pit waste dumping) at the east of the lease
- Establishment of clean water diversion drains through the mining lease to avoid mine affected area
- Establishment of a flood levee to protect mine workings from flooding of the Carmichael River
- Maintenance of a strip at least 500 m wide along either side of the Carmichael River that will not be cleared
- Establishment of MAW dams and sediment ponds to receive dirty water from mining operations
- Operation of the offsite water supply infrastructure including:
  - Pumping of water from North Creek and the Belyando River during peak flow periods
  - Extraction from storage dams on North and Obungeena Creeks
  - Pumping of local groundwater reserves in the Moray Downs property, outside of the active mining leases

Volume 1, Section 2 - Description of the Project provides a breakdown of the progress of the mine operation within the Study Area. It should be noted when interpreting this impact assessment that the disturbance to aquatic ecosystems will occur gradually as the mine develops.

This time frame will allow for an adaptive management approach to mitigation and management, whereby mitigation, management and rehabilitation measures can be modified based on learnings as the mine progresses, as well as to incorporate emerging techniques in relation to environmental management and mitigation.

The Mine and Offsite Environmental Management Plans will allow for revision of management aspects and monitoring requirements at least every 10 years (if not more frequently) in order to gauge the response of aquatic ecosystems to both the mining operation and other non-project related factors (for example climate and other operations in the region) that may result in the requirement for alternative approaches to conserve ecosystem values.

Volume 4 Appendix Q – Mine Water Quality Report, provides details regarding the proposed mine water management strategies. The following should be noted with respect to the potential impacts of this operation phase on the aquatic ecosystems:

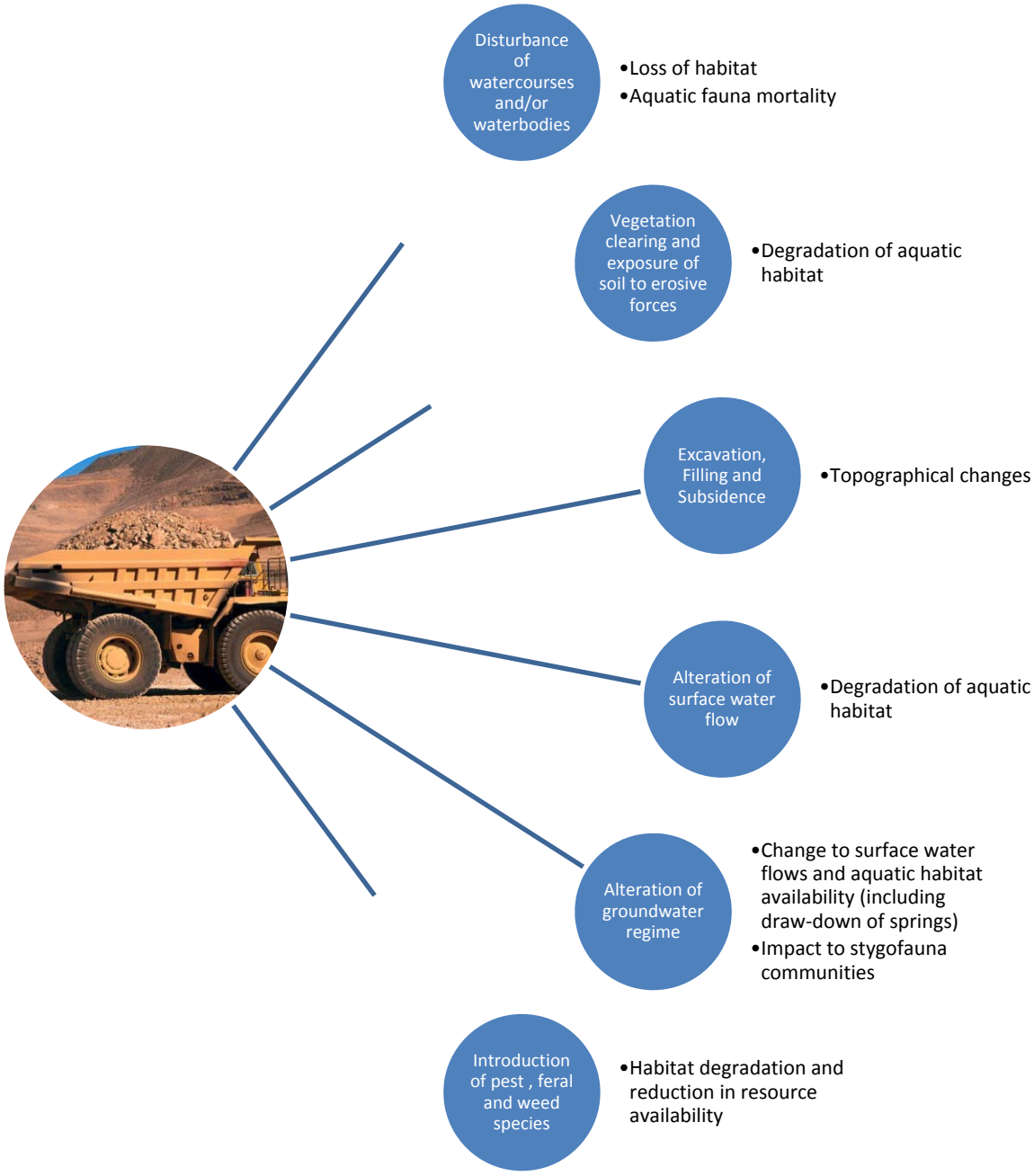
- All clean water to be diverted to the Carmichael River will pass through sediment basins / traps prior to discharge

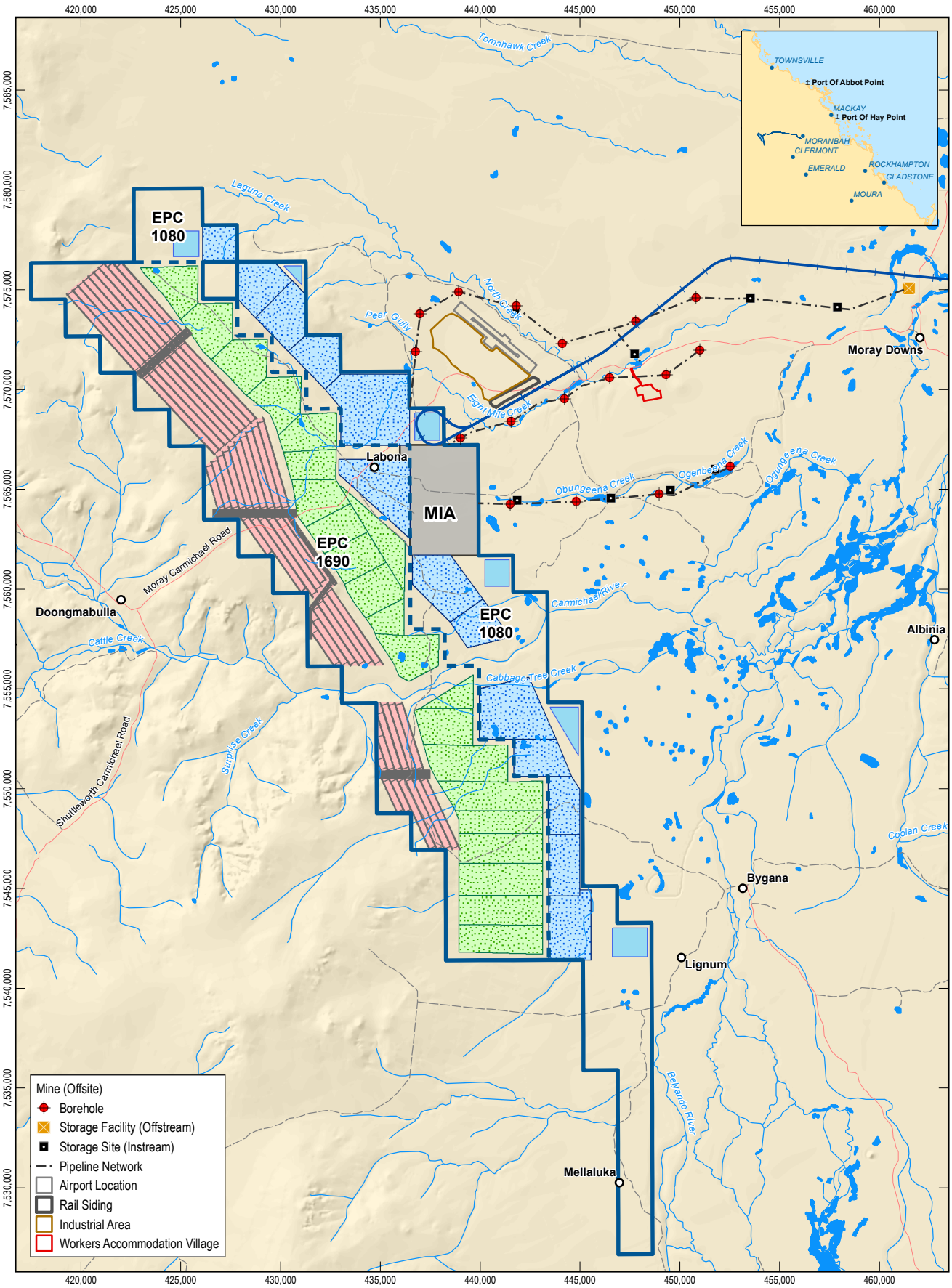
- Water management dams will be constructed and used for the variety of water treatment and storage requirements
- Access to the southern portion of the lease will be achieved via one access point, a spanned bridge across the Carmichael River
- No water will be extracted from the Carmichael River for operation of the mine
- All water runoff from the mine footprint will be captured, treated and reused
- Sewage waste for the operation workforce will be treated in a package treatment plant to an A standard. All effluent will be recycled onsite for reuse or controlled discharge.

Figure 5-2 provides the extent of the expected disturbance area during the operation phase of the Project for the underground mining area, open cut mining area, water management dams and waste dumps.

The potential impacts to aquatic ecosystems during the operation phase are summarised in Figure 5-1. These impacts have been considered, and appropriate management and mitigation measures proposed to ameliorate them.

Figure 5-1 Conceptual Diagram of Potential Operation Phase Impacts





LEGEND

- Homestead
- Local Road
- Track
- Watercourse

Operation Phase
- Underground Mine Area
- Out of Pit Waste Dumps
- Open Cut Blocks
- Water Management Dams

Construction Phase
- Waterbody
- Rail (West)
- Mine (Onsite)

1:275,000 (at A4)
0 1 2 3 4 5
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Operation Phase
Disturbance Footprint

Job Number 41-25215
Revision B
Date 31-08-2012

Figure: 5-2

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Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DERM: Waterbody (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Road, Homestead, Watercourse (2007);
Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011). Created by: TH.

5.2 Disturbance of Watercourses and Water Bodies

5.2.1 Overview

In order to facilitate the operations of the mine, water bodies and watercourses across the Study Area will be directly disturbed. The operations include footprints for open cut pits, out of pit waste dumps (overburden storage areas), water management dams, access corridors, explosive storage area and above ground mine support facilities. Within the various operational areas water bodies will be in-filled or excavated resulting in a loss of these habitats (permanent and ephemeral). The habitats to be removed include a number of farm dams, reaches of the ephemeral Eight Mile Creek Tree Creek and numerous smaller ephemeral watercourses and drainage lines (Figure 5-2). An area 500 m either side of the Carmichael River will be left uncleared though at one location a transport infrastructure corridor will be established and a bridge will span the river.

A description of the aquatic habitats is provided in Section 2.2. In general they comprise lacustrine and palustrine habitats in dams and some isolated pools in watercourses, riverine habitat of Cabbage Tree Creek, gilgais and drainage lines. The palustrine, lacustrine and riverine habitats provide habitat for a low to moderate diversity of native aquatic flora and fauna species, with no species of conservation significance identified. The only likely permanent habitats are the farm dams and the isolated pools on Cabbage Tree Creek.

The operation of the mine and disturbance to each of the identified footprints will be staged over the life of the mine that extends beyond 90 years. As such, disturbance across the entire mining footprint will not occur in a single event, but be staged to correspond with the progressive coal extraction. Figures provided in Volume 1, Section 2 Description of the Project show the staged progress of the mine and the sequencing of disturbance. In general mining will commence north of the river near the MIA with open cut pits becoming active on the southern side of the Carmichael River proposed for around 2037.

The disturbance to watercourses and water bodies will impact upon all aquatic habitat types identified within the Study Area hence the potential aquatic ecological impacts arising from the operation of the mine are related to:

- Loss of aquatic habitat within the operation footprints
- Aquatic fauna mortality when habitats are excavated or in-filled

Table 5-1 provides the area of disturbance required for development of the mine and the proportion within the Carmichael River catchment and the Eight Mile Creek catchment. The potential impacts associated with changes to surface water flows are discussed in Section 5.3 and the effects of subsidence are discussed in Section 5.4.

Additional ecological impacts relating to the terrestrial ecosystems, including riparian habitats and corridor values are discussed in Volume 4 Appendix N1 Mine Terrestrial Ecology Report.

Table 5-1 Disturbance to Local Catchments

Area of Mine	Area within Carmichael River Catchment	% of total catchment (21,291 ha)	Area within Eight Mile Creek Catchment	% of total catchment (77,816 ha)
Open cut blocks (ha)	2,713.05	12.7	2,703.66	3.5
Out of pit waste dumps (ha)	1,430.38	6.7	3,356.67	4.3
Underground areas - potentially exposed to subsidence) (ha)	2,217.69	10.4	3,953.70	5.1

5.2.2 Loss of Aquatic Habitat

5.2.2.1 Potential Impact

Aquatic habitat within the mining footprints that will be excavated or in-filled includes a minimum of 12 permanent farm dams, ephemeral watercourses (streams orders 1 and 2), drainage lines and gilgai areas. The mine plan incorporates a number of water management dams that will be created for water storage and collection and treatment of runoff from mining operational areas and these will potentially replace aquatic habitat loss from the farm dams (dependant on the habitat values that are established).

The majority of the watercourses within the footprint are ephemeral and many facilitate flow during heavy downpour or flooding events only, channelling runoff to the Carmichael River or Belyando River via Eight Mile Creek. Ephemeral habitat with intermittent base flow that is often reduced to unconnected waterholes is characteristic of the Burdekin Catchment (Negus *et al*., 2008); hence the habitat within the Study Area is considered characteristic and well represented on a regional scale. The removal of the habitat described at the site will reduce the availability of aquatic habitat on a local scale however; the loss of these habitats is not expected to have an impact to the aquatic biodiversity of the region as:

- The types of habitat are well represented within the Burdekin Catchment
- Much of the habitat is farm dams or ephemeral waterways that do not contribute to regional re-colonisation or connect permanent aquatic habitats
- Studies show that aquatic habitats in the study area support low to moderate diversity and do not support any aquatic species of conservation significance

The removal of the ephemeral watercourse reaches will be occur gradually throughout the entire mine operation (over 90 years). These watercourses are at the top of the Eight Mile Creek catchment or are 1st order streams draining to the Carmichael River and hence, diversion is not required.

Many of the farm dams, similar to Brigalow dam (discussed for removal during the construction phase), exhibit cattle and pig disturbance, have a silt and clay substrate with limited benthic microhabitat and have limited connectivity to watercourses that would facilitate aquatic species recruitment. Infilling or excavation of those dams will have a localised impact to native aquatic flora and fauna diversity and no impact on a regional scale. The water management dams to be

(progressively) created during the mining operation have the potential to provide equivalent aquatic habitats provided that water quality is appropriately managed. These artificial water bodies have the potential to provide similar habitat values as the existing farm dams.

Overall, given the relatively low values of aquatic habitats to be destroyed, impacts on aquatic biodiversity are not expected. Loss of habitat will to some extent be offset during rehabilitation.

Along the Carmichael River, a 500 m wide strip of riparian vegetation on each bank will not be cleared. Impacts of groundwater drawdown have the potential reduce the complexity and/or extent of this zone; these are discussed in Section 5.5. An infrastructure corridor, including a spanned bridge will be required in 2047 to facilitate mining operations on the south side of the river. The Carmichael River is the largest watercourse in the landscape and has more continual flow than other watercourses in the study area; this river provides the most connected aquatic habitat at the site. The crossing infrastructure will be designed such that no infrastructure will be placed in the bed of the Carmichael River. It is likely however that during construction vehicles may require access to the bed of the river; hence a temporary loss of habitat may result. Installation of the infrastructure across this watercourse will potentially result in a small loss of aquatic habitat, create a barrier to movement for native aquatic fauna species and/or alter hydrological flow. These effects will however be temporary during construction and unlikely to have any medium or long term effects.

Where temporary or permanent barriers to fish movement are proposed, there is the potential of a reduction in species abundance and distribution, localised extinction and a reduction in diversity. This restriction of access to habitat areas has the potential to reduce biodiversity of the Carmichael River within, upstream and downstream of the Study Area.

The expansion of existing dams on North and Obungeena Creeks and maintenance activities within pipeline easements may result in aquatic habitat fragmentation. However, these impacts are likely to be localised.

5.2.2.2 Management and Mitigation

The removal of the aquatic habitats of the farm dams and ephemeral, low stream order, watercourses within the mine operation footprints area is unavoidable. Although these habitats are not considered to be high value, many provide habitat for native aquatic species. In recognition of the staged approach to the mining it will be important to maintain the ecological values of watercourses in undisturbed states until scheduled for disturbance in order to limit indirect impacts to downstream habitats. Measures to manage undisturbed habitats include those already listed in Sections 4.2.2 and 4.3 and are related to the management of erosion and runoff, wastes, clearing activities and the demarcation of sensitive and no-clear zones.

In addition to the management of indirect impacts to areas not planned for disturbance within the Study Area, rehabilitation of disturbed areas will provide opportunities to recreate aquatic habitat. This is discussed further in Section 6.

The enhancement of aquatic habitats created will be undertaken in accordance with a Rehabilitation Management Plan. The Rehabilitation Management Plan will incorporate measures relevant to the protection of downstream aquatic habitats as described above and measures to enhance aquatic habitats that may be created throughout the mining operation including:

- Establishing riparian zones with suitable native species adjacent to new flow paths created within and around the mined open cut pits and overburden stockpiles.

- Establishing aquatic habitat structure in areas that may provide temporary or permanent aquatic habitats, for example in permanent topographical voids remaining at mined open cut pits or other depressions. This may include woody debris or other suitable structure that will promote establishment of aquatic flora and fauna.
- Identifying and implementing enhancement opportunities in undisturbed areas or waterbodies that may form as a result of subsidence.

A 500 m wide strip on each bank of the Carmichael River will not be cleared of vegetation for operation of the project which will assist in protecting the riparian ecosystem from direct impacts of mining operations. Management of the crossing will be required to limit the potential impact of this infrastructure on the aquatic ecosystems of the river at the crossing location and downstream. There are potential indirect impacts to the riparian zone of the Carmichael River as a result of changes to the groundwater regime. These are discussed in Section 5.5. Measures to minimise the impact of the crossing of the Carmichael River include engineering solutions and management actions:

- Design and layout of the crossing will incorporate a bridge design that spans the watercourse bed and avoids construction within the banks as much as possible. Spanning the watercourse will avoid the removal of aquatic habitat, avoid installation of a barrier to movement by aquatic fauna and avoid alteration of hydrological flows locally.
- Design of the bridge crossing will consider fish passage requirements. Although the crossing will not be physically within the watercourse bed or banks, other non-physical factors can influence fish movement such as light availability. Guidelines are available that recommend minimum widths for light availability and design criteria for other factors that have the potential to influence movement.

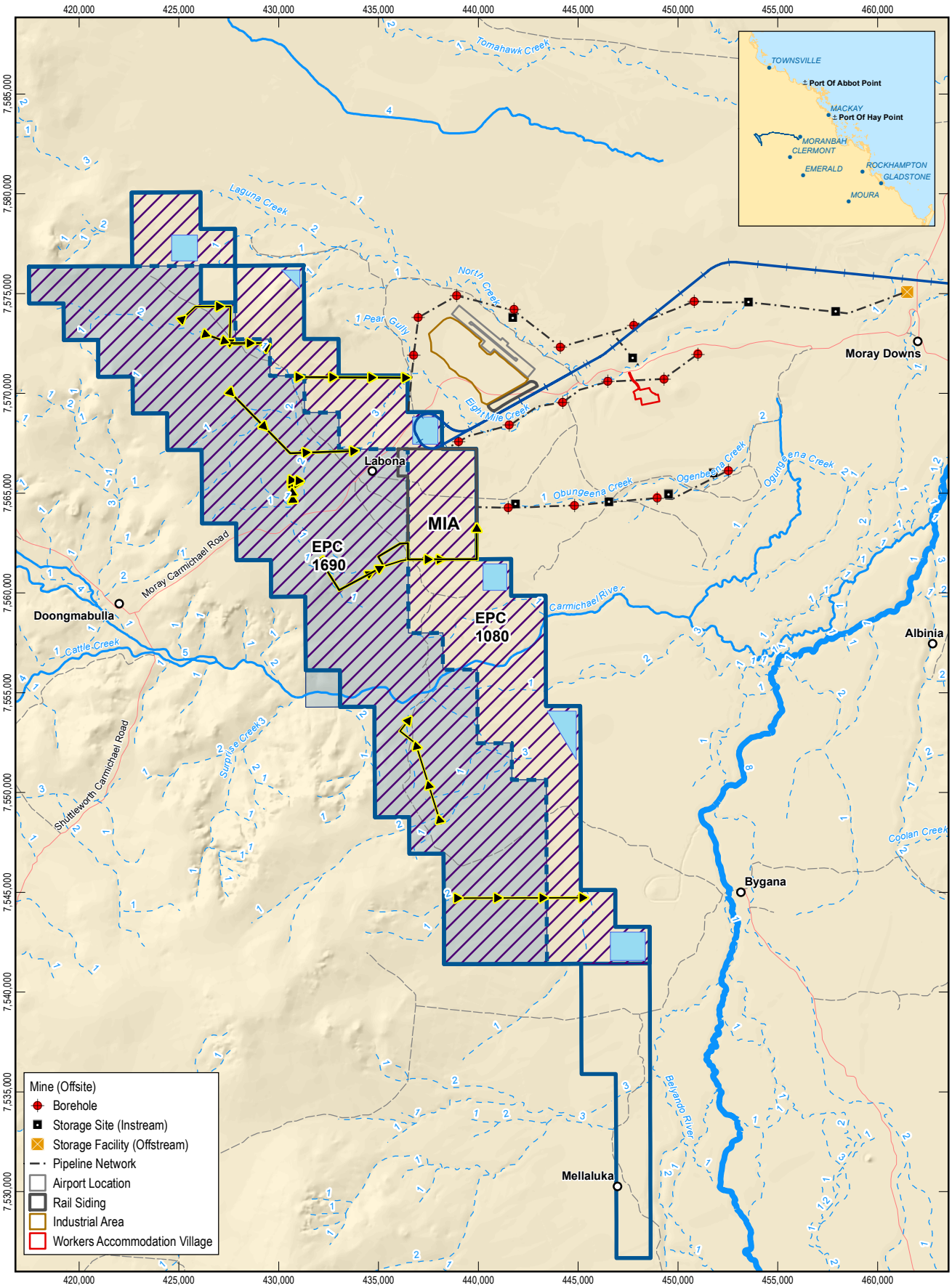
Management of potential impacts associated with operation of the offsite water supply infrastructure will include:

- Undertake vegetation clearing associated with maintenance of pipeline easement in a sequential manner to allow more mobile species the opportunity to disperse away from clearing areas
- Operational rules will be developed with the purpose of maintaining watercourse flows during flood harvesting, to maintain the physical connectivity of aquatic habitats between upstream and downstream catchment areas

5.2.2.3 Summary

The majority of the aquatic habitats to be removed within the operation footprints are of low value and are well represented within the Burdekin Catchment. The Carmichael River will remain undisturbed and through appropriate design measures the loss of habitat within the watercourse can be avoided when constructing the required infrastructure corridor. Indirect impacts to other aquatic habitats in the catchment are discussed in Section 5.3.

Mitigation and management will incorporate protection and enhancement of aquatic habitats (existing or to be created during the mining operation) through a Rehabilitation Management Plan that will consider the sequencing of the mining operation (i.e. timing of disturbance to some areas) and types of aquatic habitats present. With the implementation of the mitigation and management measures proposed and design aspects to be included, the impact to aquatic flora and fauna biodiversity in the region as a result of habitat loss is expected to be low and the potential for new aquatic habitat to be created locally may provide for native species colonisation.



LEGEND

- Homestead
- Local Road
- Track
- Stream Order: 1; 2; 3 / 4; 5; 6 / 7; 8; 9
- Operational Phase Footprint
- Surface Water Quality Study Area
- Water Management Dams
- Proposed Diversion
- Rail (West)
- Mine (Onsite)
- Mine Infrastructure Area

1:275,000 (at A4)
0 1 2 3 4 5
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

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Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision B
Date 31-08-2012

Diversion of Watercourses

Figure: 5-3

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Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DERM: DCDB, Stream Network (2010); DME: EPC1690 (2010), EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Road (2007); GHD: Operation Phase Footprint, Water Management Areas, Proposed Diversion Areas (2011); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: AJ.

5.2.3 Aquatic Fauna Mortality

5.2.3.1 Potential Impact

As described in Section 4.2.3 mortality or injury to aquatic fauna has the potential to occur when activities are undertaken within or adjacent to a water body. There will be a number of farm dams that will be removed during the operation of the mine. Each of the dams has the potential to contain native fish, crustaceans and turtles, all of which are protected under the NC Act and destruction of native species is prohibited without the required approval. .

With respect to the Carmichael River crossing, machinery and vehicles may be required to work within the watercourse to build the infrastructure. Although this habitat will not be removed there is potential for vehicle or machinery to strike aquatic fauna resulting in injury or mortality. The temporary habitat loss as a result of construction with the watercourse is discussed in Section 5.2.2. Once built, fauna mortality is not considered to be an impact as the bridge will elevate all vehicles out of the aquatic habitats.

Pumping of water from Belyando River, North Creek and Obungeena Creek may result in the entrainment of aquatic fauna species resulting in injury or death. Preventing entrainment at the point of water extraction presents the most suitable method of mitigating the effects of pumping systems on aquatic fauna. Draw down of water levels during periods of flood harvesting to the extent that dams are drained on Obungeena Creek and North Creek may also result in the mortality of resident aquatic species. To avoid this scenario, operating rules will govern the extraction, with the intent that no water harvesting can occur below a set critical level. This approach will manage and maintain the water levels to this critical level. However, beyond this dams may also naturally dry during periods of drought.

5.2.3.2 Management and Mitigation

For the dam habitats, the required mitigation and management is consistent with that outlined for the construction phase in Section 4.2.3. Fauna salvage and relocation may be required which will involve similar management and mitigation approaches to those outlines in Section 4.2.3.

The management of potential fauna mortality as a result of offsite water supply infrastructure operation will include:

- Screen pump intakes with mesh to protect aquatic life
- Develop operational procedures for flood harvesting, to prevent dams on Obungeena and North Creek being pumped dry where practicable

5.2.3.3 Summary

There is potential for aquatic fauna mortality to occur when the dams across the mining area and other water bodies are removed, construction across the Carmichael River is undertaken and water is extracted from the Belyando River, North Creek and Obungeena Creek. Upon confirmation of a resident population of aquatic fauna species in each of the dams, appropriate management will be implemented to avoid impacts to native species. At the Carmichael River crossing, fauna mortality will be avoided by implementing management actions that consider the presence/absence of aquatic habitat at the time of construction and with the implementation of a Relocation Plan this potential impact can be avoided. Impacts on aquatic fauna as a result of offsite water supply infrastructure

operation will be managed through the development of infrastructure operational and maintenance procedures and plans

5.3 Land Disturbance

5.3.1 Degradation of Aquatic Habitat as a Result of Changes to Water Quality and Runoff

5.3.1.1 Potential Impact

Vegetation will be extensively cleared to facilitate the open cut mining pits and also to provide overburden disposal areas when required. The requirement for the clearing follows the progression of the coal extraction, that is, land will be cleared for the open cut pits and overburden storage areas when they become active throughout the life of the mining operation. Land will also be cleared to facilitate the offsite water infrastructure.

The mine operation area will remove 16,375 ha from the local river catchments, comprising 6,361 ha (29.9 per cent) from the Carmichael River catchment and 10,014 ha (12.9 per cent) from the Eight Mile Creek catchment (see Table 5-1. Surface runoff from these areas to creeks downstream of the disturbed areas may convey sediment and other contaminants, with consequent impacts on water quality and aquatic ecosystems.

As described in Section 4.3.1 land clearing will result in an increase in exposed earth surfaces and a reduction in vegetated buffer between the location of the activity and the watercourses not yet disturbed. These changes have the potential to change water quality of the aquatic ecosystems, subsequently degrading aquatic flora and fauna habitats. Works in creeks and drainage lines during clearing have the potential to disturb bed and bank substrates and lead to localised erosion and sediment transport to downstream habitats.

The potential impacts to aquatic ecosystems downstream of mine impact areas (dependant on stage in life of the mine) are consistent with those discussed in Section 4.3.2 though the extent of clearing is much greater. Sedimentation of water supplied downstream has the potential to degrade aquatic habitats in the downstream catchment as described in Section 4.3.2.

Acid mine drainage (AMD) can arise in coal seams where there is a high sulphur content. If this is the case, coal seams, when exposed to air and water can produce sulphuric acid (NSW Department of Planning, 2005). Acidic runoff into a watercourse is likely to have adverse impacts to surface water quality and in turn aquatic habitat suitability. The potential for acid mine drainage and management measures proposed are further discussed in Volume 2 Section 10 Waste.

Water treatment within the mining operation will consider the potential for AMD and will be designed such that discharge from the footprint of the mine and into any watercourses achieves the required WQO for the Project. WQO will be developed for the Study Area, including for all water to be released into the waterways of the area (refer to Volume 4, Appendix Q Mine Water Quality for further detail on WQO).

5.3.1.2 Management and Mitigation

The disturbance of land within the operation footprint is unavoidable. Protection of the aquatic ecosystems downstream of the Study Area is highly dependent on the management of the water quality of runoff and releases from the site.

The approach to managing water quality and runoff with respect to aquatic habitat is consistent with the construction phase measures, recognising the scale of the removal is much larger for operation. Runoff within the mine footprint will be managed via a number of management and engineering solutions including:

- Development and maintenance of clean water diversion drains to be established along the western boundary of the lease, and separating clean inflows from dirty water areas
- Management of clean water through sediment basins/traps prior to discharge
- Management of dirty water from operations through capture in sediment ponds for reuse
- Overflows of water from sediment ponds to nearest drainage line only to occur in accordance with environmental authority conditions (refer to Volume 4, Appendix Q Mine Water Quality Report)
- Sewage waste will be treated to A standard and recycled onsite/discharged.
- Contaminants that have the potential to cause environmental harm will not be released to the environment except under environmental authority permit conditions. Waters to be released to the environment must comply with the contaminant release limits which will be identified in a Receiving Environment Monitoring Program (refer to Volume 4, Appendix Q Mine Water Quality Report)
- Identifying and implementing enhancement opportunities in newly created aquatic habitats that may arise as a result of subsidence

As the mining operation, and hence habitat removal, will be staged, management and mitigation actions will correspond with activities of the time in order to protect areas not yet disturbed and the downstream catchment habitats. The Mine Environmental Management Plan (Volume 2, Section 13) will take into account the progression of the disturbance and identify areas to be managed in terms of erosion and sediment control and at what stage the required management must be applied. These measures focus on limiting sediment transport, risk of erosion and pollutants and are consistent with those identified in Section 4.3.2. There will also be the opportunity to incorporate lessons learnt and corrective actions into the Mine Environmental Management Plan (Volume 2, Section 13).

Aquatic ecosystem monitoring will be incorporated into the receiving environment monitoring program (REMP). The REMP will set out monitoring requirements, water quality targets, ecological indicators, corrective actions and reporting requirements. Further management and mitigation measures specific to these aspects are detailed in Volume 4 Appendix P Mine Hydrology Report, Appendix R Mine Hydrogeology Report and Appendix Q Mine Water Quality Report.

5.3.1.3 Summary

During the operation of the mine, changes to water quality and in turn degradation of aquatic habitat suitability, have the potential to result from:

- Surface runoff of exposed areas
- Works in creek and drainage lines
- Acid mine drainage

The approach to managing these activities with respect to runoff is consistent with construction phase measures that include both engineering and management solutions. The scale of disturbance during the operation of the mine is of a larger scale than during construction. The mining operation and

hence land disturbance will be staged and management and mitigation actions will correspond with activities of the time and order to protect not yet disturbed and downstream catchment habitats. The Mine Environmental Management Plan (Volume 2, Section 13) and REMP will take into account the mine progression, type of disturbance and locality to sensitive areas.

5.4 Excavation, Filling and Subsidence

5.4.1 Topographical Changes

5.4.1.1 Potential Impact

Topographical changes will occur during the operation phase of the Project as a result of excavation and filling, and subsidence. The mining operation requires substantial excavation and movement of earth from and around the Study Area. The result of this is changes in topography which will alter the existing surface water flow paths and velocities. The key components include open cut pits, overburden piles where the material removed from the pits is stored, underground mining cavity and water storage dams. Each of these components will contribute to a change in topography across the Study Area. The management of runoff at the site will be such that runoff from areas of surface disturbance (open cut and overburden pits) will be collected in sediment ponds for release during major rain events. As a result the potential impact is associated with the localised change in overland flows to the Carmichael River which is discussed in Section 5.2.

Within the Study Area the watercourse pathways to be disturbed by pits or piles are generally ephemeral reaches at the top of a catchment rather than reaches that connect permanent aquatic habitat areas.

Underground mining activities have the potential to result in surface subsidence which can be small and localised or spread over greater extents (Blodgett and Kuipers, 2002). Subsidence has the potential to change existing topography via vertical shifts in the topography that influence the flow path and/or collection of water across the underground footprint. A number of potential impacts from underground mining have been documented in a Strategic Review of Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield (NSW Department of Planning, 2008) and in a report on Coal Mining Potential in the Upper Hunter Valley Strategic Assessment (NSW Department of Planning, 2005). Review of these has informed this assessment, taking into account operational activities specific to this Project. From this, the following impacts to watercourses have been identified as potentially impacting upon aquatic ecosystems across the Project Area:

- Reduction in surface flows and/or water levels which can increase the frequency, duration and magnitude of drying aquatic habitats
- Reduction of aquatic habitats as a result of complete drying of river pools
- Reduction in connectivity between river pools

These potential impacts will adversely affect aquatic habitat availability and suitability for aquatic flora and fauna. The area above the underground mining operation is drained by ephemeral watercourses and no permanent stream pools were observed during field survey, hence the potential for an impact to permanent habitat is avoided. Habitat values and diversity in these streams was low. The main potential adverse impact as a result of subsidence will be a reduction in connectivity between

watercourse reaches in times of flow though the underground mining footprint mainly corresponds with the top area of the catchments and first order stream reaches that do not connect river pools.

There is potential for rainfall runoff to accumulate in subsidence depressions, creating new water bodies and habitats for aquatic flora and fauna, hence opportunity for a positive impact arises.

The operation of the water supply infrastructure may also alter watercourses in the event the operation of the dams alters the environmental flows. Section 5.5 discusses the potential impacts of a chance to surface water flows as a result of the offsite water infrastructure.

5.4.1.2 Management and Mitigation

The change in topography has the potential to impact downstream habitats, block existing connections between habitat areas and create new water bodies in subsidence areas.

To manage the impact to downstream areas, the potential for increased erosion, scouring and deposition will be managed using erosion and sediment control mechanisms and by stabilising exposed surfaces as soon as is practicable. Steep slopes of overburden piles where it may take time for vegetation to establish will require regular monitoring for signs of erosion and where required corrective actions will be established to slow runoff velocities and/or reduce scour potential by using alternative stabilisation techniques. Mitigation and management for the potential degradation of downstream impacts are discussed in Section 4.3.2 and are consistent with operation phase approaches to be undertaken. These are to be integrated in the Operation Management Plan.

5.4.1.3 Summary

Changes to aquatic habitat within the Study Area will occur during mining operations as a result of establishment of open cut pits, overburden stockpiles, underground mining subsidence and offsite water infrastructure operation. Within the Study Area this impact is unavoidable however the indirect impacts to downstream habitats can be managed, in particular by using sediment and erosion control principles. Measures to manage surface flows (volume and velocity) from the site, sediment and erosion and water quality will reduce the residual impact of this change to offsite areas.

5.5 Alteration of Surface Water Flow

5.5.1.1 Potential Impact

The operation phase for water supply infrastructure will incorporate extraction of water from North Creek and the Belyando River (Moray Anabranch) during peak flow periods and in-stream river extractions on North and Obungeena Creeks. Water captured from the above-mentioned water supply sources will be stored, captured, treated (where required) to fulfil mine site water demands.

Both proposed flood harvesting and in-stream extraction have the potential to alter the surface water flow regime (volume and frequency) of these ephemeral systems. Watercourses in the area are ephemeral and hence aquatic communities present and downstream reflect the seasonal nature of water flow and volume. The extent of impact to the aquatic ecosystems will relate to the volume of water extracted from the watercourses and the timing of the extraction. Water resource modelling undertaken for the Project (Volume 2, Chapter 6 Water Resources) indicated that the proposed water extractions would have minimal impact against the *Water Resource (Burdekin Basin) Plan 2007* environmental flows objectives. The plan defines hydrological characteristics of the connected water

system that makes up the Burdekin Basin, including flow, velocities and flood extents at low, medium and high levels.

The fluctuating or prolonged lowering of water levels at the reservoirs on Obungeena and North Creeks may also adversely impact on habitat for aquatic species. Resident aquatic species, such as fish and crustaceans that reside in dams may be impacted where pumping results in draining of water from the dams. Species such as macrophytes may also be impacted by rising and falling water levels during periods of flood harvesting.

Alternatively, the proposed expansion of existing dams may result in the creation of additional habitat and resources for aquatic fauna species. Measures will be investigated to promote biodiversity values and improved habitat quality.

5.5.1.2 Management and Mitigation

The Belyando River and North Creek flood harvesting will operate according to procedures that will be informed by the water modelling undertaken (Volume 2, Chapter 6 Water Resources). The flood harvesting will be undertaken such that small flows are largely unaffected. Pump will activate when a defined flood level is reached and in accordance with a Water Licence. All pipelines will include flow meters and all pumps will be controlled remotely to ensure that permitted extraction volumes are not exceeded.

The value of water bodies created as a result of mining activities and offsite water infrastructure (for aquatic flora and fauna will depend on the characteristics of the water body and it's potential to provide habitat values. When new habitat (or potential habitat) is created with the expansion of the in-stream dams on North Creek, Obungeena Creek and the Belyando River an assessment on a case by case basis will be required to tailor management to the characteristics of the feature and opportunities for enhancement (see Section 5.2.2 for further discussion on the management of habitat creation opportunities). Riparian zone establishment and habitat structure establishment actions will assist in promoting colonisation by aquatic species. However, the utilisation of artificially created waterbodies by aquatic taxa is also dependent on the hydrological connectivity and persistence of the waterbody. A newly established waterbody will not be readily colonised by aquatic species if it remains disconnected from nearby waterways. In this situation, colonisation will only occur through chance dispersal via birds. This occurs when eggs, larvae or other small individuals are trapped on the feet and feathers of wading birds that then move to another waterbody. Furthermore, the persistence of aquatic communities depends on the persistence of the waterbody in which they reside. As discussed in Section 5.2.2, a Rehabilitation Management Plan for the Project will incorporate measures to enhance aquatic habitats that may be created throughout the mining operation, where suitable.

5.5.1.3 Summary

The development of operational procedures for offsite water supply will minimise adverse impacts on aquatic habitats within and downstream of the Study Area. New aquatic habitats may be created as a result of subsidence and the expansion of in-stream storage dams and there is potential that rehabilitation measures can be implemented to promote colonisation by native aquatic species.

5.6 Alteration of Groundwater Regime

5.6.1 Change to Surface Water Habitats as a result of change to Groundwater Regime

5.6.1.1 Potential Impact

Given the proximity of the Carmichael River to the proposed open cut and underground mine workings significant impacts on groundwater levels in the vicinity of the river are anticipated. Groundwater model predictions suggest water table drawdowns of up to around 30 m in the vicinity of the river under the post closure scenario and that groundwater discharges to local water courses, predominantly the Carmichael River, will be reduced by up to 1,000 m^3/d or 7 per cent of pre-development discharge during the operational phase. Where groundwater discharge is reduced by 7 per cent this may have some impact on the duration of zero flow and/or low flow periods in the Carmichael River and also possibly the Belyando River downstream. Further details regarding the groundwater modelling are reported in the Volume 4 Appendix R Mine Hydrogeology Report.

The Carmichael River is the largest watercourse in the Study Area and has groundwater dependant vegetation in the riparian zone. The river is likely to support aquatic habitats throughout the year (depending on rainfall). A reduction in the groundwater table has the potential to:

- Reduce or remove the base flow that currently provides the main water source to the river during the dry season and result in removal of the water source for aquatic habitats that provide refuge for aquatic flora and fauna. The result will be a reduction in aquatic habitat availability where the groundwater table is impacted
- Reduce groundwater influence to the riparian zone leading to a loss of this buffer zone
- Increase the duration of zero flow and/or low flow periods in the Carmichael River. No significant reduction in peak flows in the Carmichael River are anticipated as a result of the mine dewatering, given the peak flows are a result of direct rainfall and surface water runoff to the river in relation to rainfall. This anticipated change in the surface flow regime will reduce the temporal availability of aquatic habitat.

Overall the impacts associated with a drawdown of the groundwater table in the vicinity of the river relate to a reduction in the availability of aquatic habitats spatially and temporally and the reduction in the quality of the riparian zone. The Carmichael River provides habitat for native species during the wet and dry season and removal of this habitat will reduce the availability of aquatic habitat on a local scale as well as reduce the population of aquatic species that recolonise up and downstream habitats during the wet season when isolated pools are connected. In the event the riparian zone is degraded as a result of groundwater drawdown the role it plays in the composition, function and protection of aquatic ecosystems will be diminished. Established zones assist in stabilising soil, filtering toxicants and nutrients, provision of shade, large woody debris and organic matter for the functioning of aquatic ecosystems.

Doongmabulla Springs is a Directory of Important Wetlands listed wetland approximately 10 km to the west of the Study Area (refer Section 3.2.4.1) and permanent artesian springs which provide base flow to the adjacent Carmichael River. This spring has a number of identified terrestrial ecology values and is known to support macrophyte species. A change in the groundwater supply to the springs has the potential to reduce the suitability of the ecosystems to support the ecological values for which it is listed.

Further information on flows in the Carmichael River and on discharges from the Doongmabulla Springs is required to quantify the significance of these impacts. Further field work (including ground water measurement) and ground water modelling is underway. Further work is planned for 2013 and these additional data sets will significantly reduce uncertainty in model predictions. The findings from the revised predictive modelling will be used in developing the management plans for the operation of the mine, including the Mine Environmental Management Plan (Volume 2, Section 13). This plan will be provided to the relevant agencies for review and/or confirmation of suitability prior to any operation activities at the site.

Alteration of groundwater regimes may also occur in association with water supply from bore fields in the Study Area. It is expected the bores will be drilled into the more productive Triassic to Quaternary aquifers. Based on preliminary modelling output and anticipated aquifer parameters, it is expected that after 10 years of extraction, the radius of influence of each bore would range between 3 and 5 km. Assuming a 10-year extraction period with cone of influence of 2 km radius, drawdown is expected to range between 0.7 and 2.5 m. This analysis is based on anticipated parameters and should be validated by aquifer testing and subsequent modelling. Once the proposed bores have been developed (exploration permit in application) with the required yield tests carried out, detailed groundwater surveys can be completed to verify the modelled estimates. It is proposed to position 17 bores within the Study Area with the following constraints:

- No bore would be placed inside the Great Artesian Basin (GAB) Water Resource Plan area
- The distance between the bores would be greater than 2 km to reduce cumulated drawdown
- The minimum sustainable distance would be maintained between the bores and the ecosystems at risk (Carmichael River, Doongmabulla springs, and Mellaluka springs). The sustainable distance is defined as the maximum expected radius of influence of the extraction bores, at peak extraction. Currently this is estimated as 10 km; however this value will be verified pending the modelling results.

The Study Area and adjacent areas contain a number of ecosystems dependent upon the current groundwater regime. Changes to groundwater levels associated with pumping water from borefields could potentially impact on these values, which include:

- Groundwater dependent riparian vegetation communities in riparian areas of the Carmichael and Belyando Rivers reliant upon, in part groundwater base-flows.

Valenza (2012) found that the predicted cone of influence of the nearest bore to these spring systems does not extend beneath the GAB Doongmabulla Spring complex, and the Mellaluka Springs. For the Belyando River some of the bores have been positioned at distances ranging between 2 and 3 km from the river, resulting in some parts of the river being within the bore field's cone of influence Preliminary analysis undertaken by Valenza (2012) found that the impact on groundwater levels is likely to range between 0.5 and 2.5 m. This could potentially result in localised reductions in base-flows to the Belyando River system. Impacts to the Carmichael River will be minimal as the extraction boreholes are located away from the river system.

5.6.1.2 Management and Mitigation

Mitigation and management of the groundwater and surface water regimes during operation of the mine is proposed in Volume 4 Appendix R Mine Hydrogeology Report and Volume 4 Appendix P1 Mine Hydrology Report. Given the potential for a reduction in surface water flows in the Carmichael

River and further downstream in the catchment, which has been predicted by the modelling, further investigation and monitoring have commenced to establish a reliable baseline data set.

In particular, further manual gauging should be undertaken at the existing upstream and downstream level monitoring sites so that a reliable pre-development flow record can be developed for these gauges. Mitigation measures will be developed, where necessary, to account for identified losses and a subsequent compensation scheme. In the event that groundwater level and/or surface water flow impacts are identified post development then Adani Mining Pty Ltd would work with the relevant environmental authorities to compensate the water balance for identified losses. Potential alternative sources of water which could be used to mitigate observed flow impacts on the Carmichael include the discharge of suitably treated inflows to the proposed mine workings.

The design of the groundwater borefield focused on reducing potential impacts on GDEs by allowing for a suitable distance between the abstraction bores and the listed GDEs, considering the expected cone of influence associated with the groundwater drawdown.

Given the potential for a reduction in groundwater base-flow to surface water flows in the Carmichael and Belyando Rivers and associated tributaries, it is proposed that detailed continuous monitoring of groundwater levels and surface water flows at those locations be undertaken. These monitoring requirements are further detailed in the Groundwater Monitoring Plan, included as a supporting report to this EIS (Valenza, 2012).

5.6.1.3 Summary

Groundwater modelling suggests there will be a water table drawdown of up to around 30 m in the vicinity of the Carmichael River under the post closure scenario and that groundwater discharges to local water courses, predominantly the Carmichael River, will be reduced by up to 1,000 m^3/d or 7 per cent of pre-development discharge during the operational phase.

The Carmichael River is the largest watercourse in the Study Area and has groundwater dependant vegetation in the riparian zone. It supports aquatic habitats throughout the year (depending on rainfall) and the groundwater assessment suggests that the river is influenced by the groundwater source particularly during dry conditions. Given the proximity of the Carmichael River to the proposed open cut and underground mine workings significant impacts on groundwater levels in the vicinity of the river are anticipated. See Volume 4 Appendix R Mine Hydrogeology Report for additional detail on impacts to groundwater

Doongmabulla Springs is also associated with the groundwater environment of the Study Area. The spring is listed under the national Directory of Important Wetlands and is listed to contain a variety of ecological values, including for macrophyte species. The modelled influence of mining activities is a reduction in the groundwater table of between <0.05 and 0.12 m in vicinity of the springs. Impacts to Stygofauna communities are discussed in Section 5.6.2.

5.6.2 Impact to Stygofauna Communities

5.6.2.1 Potential Impact

Many species of stygofauna are restricted to small geographical areas. This means that any process that threatens the aquifer, potentially threatens an entire species and community. There is also a high degree of endemism in alluvial aquifers, even between adjacent systems (Hancock and Boulton, 2008).

Mining activities have the potential to impact stygofauna communities with respect to the extent of the proposed groundwater drawdown zone and the likely impacts on groundwater quality. Both these factors, over time, may cause prospective stygofauna habitat to be degraded or lost with the potential for significant impact on groundwater communities.

The Doongmabulla springs are located around eight kilometres west of the mining lease and are permanent artesian springs which provide base flow to the adjacent Carmichael River. The groundwater model predicted maximum drawdown impacts in the Clematis Sandstone which is thought to represent the source aquifer for these springs range from <0.05 to 0.12 m after 40-70 years at the two closest springs to the proposed mining area, i.e. the Little Moses spring to the north and the Doongmabulla Spring to the east.

The Mellaluka springs are located approximately ten kilometres south of the mining lease. Little is known about the Mellaluka spring system. The geology at the spring location is thought likely to comprise shallow near surface Quaternary and or Tertiary age strata overlying the older Permian units. Model results predict maximum drawdowns at the Mellaluka Springs of between 0.7 and 0.8 m.

Based on recent assessments of the potential for impacts on GAB springs, drawdowns of over 0.2 m are considered to be potentially significant (Queensland Water Commission 2012). Predicted drawdowns at all springs in the Doongmabulla system are less than 0.12 m throughout the operational period with the majority of predicted impacts lower than 0.05 m.

Further details regarding the groundwater modelling are reported in the Volume 4 Appendix R Mine Hydrogeology Report.

Mining activities of the proposed project have the potential to have direct effects on groundwater dependent ecosystems due to:

- Aquifer drawdown may have a detrimental impact on stygofauna. This may occur within and outside the operation area (for example at Mellaluka Springs and to a lesser extent the Doongmabulla Springs)
- Acid mine drainage and other geological or soil type influences to recharge have the potential to adversely impact stygofauna communities through changing groundwater quality. Section 5.3.1 describes impacts relating to acid mine drainage
- Excavation below the water table will result in groundwater drawdown around mine pits and changes to groundwater quality which can extend beyond the mine operation area. It will be important to assess the location and distribution of the stygofauna recovered against the aquifers from which they originated and the forecasted drawdown zone. As described the drawdown zone modelling will incorporate further fieldwork to refine model predictions such that the extent of impact can be identified.

The stygofauna collected from two bores within EPC 1690 have been identified as belonging to the Acarina Families, Trombiidae and Pexidae, the Syncarid Family, Parabathyneliidae and the Copepod Family, Cyclopoida. The level of taxanomic analysis undertaken in this study is in accordance with that specified by DEHP in the ToR. No stygofauna surveys have been carried out at Mellaluka Springs.

In Queensland, to satisfy the ToR, endemism needs to be disproved at the Family or Order level for stygofauna, in which cast the Acarina, Syncarid and Copepod Families are not endemic because the Families they belong to occur in all Australian States.

5.6.2.2 Management and Mitigation

Management and mitigation approaches will align with those identified to manage impacts to groundwater quality, quantity and interactions (Volume 2, Appendix R Mine Hydrogeology Report)

Specific to understanding the significance of impacts to the stygofauna community, the following management approaches are recommended:

- Build on and extend the existing baseline survey by conducting annual stygofauna surveys during mine construction, operation and closure phases in order to monitor and measure groundwater health and condition both within the Study Area and outside (i.e. the Doongmabulla and Mellaluka Springs)
- Extend the stygofauna sampling to the Mellaluka Springs to determine the presence to stygofauna and to identify if endemicity in the stygofauna community exists within the aquifer

5.6.2.3 Summary

Two sampling events confirmed the presence of stygofauna species at two bores within EPC 1690. There is an overall limited knowledge of stygofauna in the Galilee Basin given the small number of surveys undertaken in the region. Recent stygofauna surveys conducted by GHD in the southern Galilee Basin have also failed to identify significant stygofaunal communities which would suggest that stygofauna may be poorly represented in the wider geographic region.

Mining activities that have the potential to alter groundwater quality or create a drawdown zone may impact stygofauna communities through habitat loss or degradation. It is recommended that further analysis is undertaken and the baseline data is built on with further sampling and an extension of the sampling area to include the Doongmabulla and Mellaluka Springs, to eliminate the risk of potential significant impacts to stygofauna species.

5.7 Introduction of Pests and Weed Species

5.7.1 Aquatic Habitat Degradation and Reduction in Resource Availability

5.7.1.1 Potential Impact

The potential impacts of pest and feral species to aquatic habitats is described in Section 4.4.1. The potential impacts for the construction phase are consistent with those during operation activities though with a larger scale of land disturbance and activity in the area, the risk of introduction and spread of pest and feral species is proportionally increased. As discussed in Section 4.4.1 weed and pest species can compete with native species for resources and reduce the availability and quality of habitat at the site and in downstream environments. These impacts have the potential to reduce the aquatic biodiversity in the catchment.

5.7.1.2 Management and Mitigation

Management and mitigation for weed and pest species during the operation of the mine is consistent with the measures proposed for during the construction phase of the Project (Section 4.4.1). The measures include mechanisms to manage waste on the site to avoid encouraging establishment and increase in pest species as well as specific weed and pest management to prevent the introduction and spread of these species. Measures, management and monitoring requirements will be embedded in an Operation Management Plan. Emphasis on monitoring and corrective action is

important during the operation of the mine especially as the sequence of mining moves from the north side of the Carmichael River to the south. When mining begins on the southern side of the Carmichael River vehicles and machinery will be moving between disturbance areas and between the north and south sides of the river where existing weed and pest distributions differ. Given that the operational life of the mine extend approximately 90 years, the control measures and target species will require revisitation to confirm the applicability of the approach to management.

5.7.1.3 Summary

The management of weed and pest species is an important component of the operation of the mine with respect to both the terrestrial and aquatic ecosystems. The impact of the introduction or increased population of these species has the potential to impact the flora and fauna community at the site and downstream of the mine. With the development and implementation of an appropriate management and monitoring regime of weed and pest communities within and adjacent to the mine area that incorporates corrective action, this potential impact can be managed to reduce the resultant impact to native flora and fauna communities.

6. Potential Impacts and Mitigation – Closure and Decommissioning

The mining at the site is scheduled to extend beyond 90 years. There are a number of aspects of relevance to environmental management when decommissioning the mining operation, including:

- Rehabilitation and remediation of open cut pits and voids, and out of pit dumps
- Removal of industrial infrastructure, workers accommodation village and airport

Details on the approach to decommissioning the mining operation are provided in Volume 1, Section 2 of the Project EIS, Project Description. With respect to the potential impacts to the environment and associated mitigation for this phase, the decommissioning of the mine will require detailed planning. Planning and subsequent development of a Decommissioning Environmental Management Plan should incorporate a phase of impact assessment that includes consideration of the potential impacts to the aquatic ecosystems within and downstream of the site as they occur at the time of decommissioning with reference to pre-mining state, as described therein.

The resultant plan should consider (but not be limited to) incorporation of the following with respect to the management of aquatic habitats:

- Remediation and development of the final landform to consider drainage, erosion resistance and potential resultant change to surface water flows (direct and volume) in order to minimise changes to the aquatic habitats of the Carmichael River and downstream
- Rehabilitation requirements for any watercourse crossings
- Rehabilitation or re-establishment of riparian zones for watercourses
- Monitoring requirements for aquatic communities and water quality

It is recommended that at the time of decommissioning, suitably qualified ecologists are consulted during planning and implementation to provide appropriate direction on management of the aquatic ecosystems and to incorporate the relevant policy, legislation and standards of the time.

The final surface will consist of out of pit overburden stockpiles, partially filled open cut pits and subsidence troughs over the underground mine. In order to create a final land surface that is stable and erosion free, stable drainage lines will need to be re-established and this will provide opportunities to recreate ephemeral stream habitat. The final landform in the concept design includes a number of large final voids, typically situated towards the west of the proposed open cut mining area. Where possible these final voids will be backfilled using redirected pre-strip waste from adjacent pits.

Rehabilitation will be specific to the geomorphology of the watercourse or water body created and the activities undertaken will require input from a suitably qualified ecologist to identify areas suitable for enhancement and appropriate actions.

The Rehabilitation Plan for the operation of the mine will include local and regional biodiversity management and enhancement initiatives, including biodiversity offsets and will be developed and refined in coordination with the relevant agencies and ecologists and finalised prior to any

construction or operation activities occurring within the Study Area. The Rehabilitation Plan is discussed in more detail in Volume 4 Appendix N1 Mine Terrestrial Ecology Report.

7. Conclusion

The assessment of the existing aquatic ecology values within the Study Area identified a number of habitat types and seasonal variability in aquatic habitat availability. The watercourses within the Study are ephemeral with many lacking water through most of the year. The Carmichael River and Cabbage Tree Creek provide more permanent habitat with isolated pools observed during all field survey visits.

The proposed mining activities and water infrastructure (construction and operation) will result in the loss of ephemeral stream habitat within the footprint however the Carmichael River will be maintained.

The primary impact of the Project is the loss of aquatic habitats, other potential impacts include:

- An alteration to the ground/surface water interaction in the vicinity of the Carmichael River, resulting in a reduction in base flow contribution to the river and water supply for dry period aquatic habitats
- Aquatic fauna mortality during construction and operation
- Degradation of downstream aquatic habitats as a result of an increase in erosions and sediment mobilisation within the site
- Introduction of pest and weed species

Most of the potential impacts to aquatic ecology values associated with the construction, operation and decommissioning of the Project can be managed or mitigated using a combination of engineering and construction management solutions. Adaptive management mechanisms and environmental monitoring will be required to allow for corrective actions to be implemented if required. Management and monitoring requirements will be embedded into the Mine and Offsets Environment Management Plan for the Project (Volume 2, Section 13 and 14). A Rehabilitation Plan for the operation of the mine (discussed in more detail in Volume 4, Appendix N1 Mine Terrestrial Ecology Report) will include opportunities for enhancement of water bodies (existing and those created as a result of mining).

Impacts associated with a change in the relationship between surface and groundwater environments have the potential to substantially reduce the availability of aquatic habitats during dry periods when rainfall does not provide volumes to sustain isolated pools in the Carmichael River.

Groundwater modelling suggests there will be a water table drawdown of up to around 30 m in the vicinity of the Carmichael River under the post closure scenario and that groundwater discharges to local water courses, predominantly the Carmichael River, will be reduced by up to 1,000 m^3/d or 7 per cent of pre-development discharge during the operational phase. Further details regarding the groundwater modelling are reported in the Volume 4 Appendix R Mine Hydrogeology Report.

The groundwater model predicted maximum drawdown impacts to the Doongmabulla springs range from <0.05 to 0.12 m after 40-70 years at the two closest springs to the proposed mining area, i.e. the Little Moses spring to the north and the Doongmabulla Spring to the east. Model results also predict maximum drawdowns at the Mellaluka Springs of between 0.7 and 0.8 m. Aquifer drawdown may have a detrimental impact on stygofauna. This may occur within and outside the Study Area (eg at Mellaluka Springs and to a lesser extent the Doongmabulla Springs).

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Appendix A

Terms of Reference Cross Reference

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Terms of Reference Cross Reference

3.3.4 Aquatic Ecology

Describe the aquatic flora and fauna occurring in the areas affected by the proposal, noting the patterns and distribution in the waterways (e.g. rivers, streams, creeks and other bodies of water) and any associated wetlands. The description of the flora and fauna present or likely to be present in the area should include:	
• fish species, mammals, reptiles, amphibians, crustaceans and aquatic invertebrates occurring in the waterways within the affected area and any associated wetlands	Section 2.3
• any near-threatened or threatened aquatic species	Section 3
• reference to Ramsar wetlands of international importance in terms of proximity to proposal and likelihood of impacts	Section 3.2.2
• a description of the habitat requirements and the sensitivity of aquatic species to changes in flow regime, water levels and water quality in the project areas	Section 2.2, 4.2, 5.2
• aquatic plants including native and exotic/weed species. Refer to Biosecurity Queensland's Annual Pest Distribution Survey 2008 data and predictive maps and use the data in conjunction with Queensland Herbarium naturalised flora data to determine the occurrence of aquatic pest plants in the project area. Use Local Government area pest management plans to determine the occurrence of priority aquatic pest plants in the project area	Section 2
• aquatic and benthic substrate	Section 2.2
• habitat upstream and downstream of the project or potentially impacted due to currents in associated lacustrine and aquatic environments	Section 2.2
• an identification of all types of groundwater-dependent ecosystems occurring within and outside the project area and potentially impacted by project activities.	See Volume 2 Section 5.4
• Include a description to Order or Family taxonomic rank of the presence and nature of stygofauna occurring in groundwater likely to be affected by the project.	Section 2.3
• Sampling and survey methods should be in accordance with the best practice guideline currently published by the Western Australian Environmental Protection Authority – Guidance for the assessment of environmental factors No.54 (December 2003) and No.54a (August 2007).	See Volume 2 Section 5.4
• Assess the environmental water requirements for protecting the identified groundwater-dependent ecosystems. Groundwater-dependent ecosystems may include:	See Volume 2 Section 5.4
• aquatic substrate and stream type, including the locations and extent of any permanent and semi-permanent water holes or streams potentially affected by the mine and its operations and location.	Section 2.2
Describe the significance of national, state or regional wetlands including wetlands of international importance, and their values and importance for aquatic flora and fauna species.	Section 3
A map is to be included which identifies aquatic ecosystems in the project area and regional scale.	Section 3
Discuss the potential permanent and temporary impacts of the project on the aquatic ecosystems and describe proposed measures to avoid, minimise or mitigate actions, including:	

• details of proposed stream diversions, causeway construction and crossing facilities, stockpiled material and other impediments that would restrict free movement of aquatic fauna	Section 4.2, 5.2
• measures to avoid fish spawning periods, such as seasonal construction of waterway crossings and measures to facilitate fish movements through water crossings	Section 4.2, 5.2
• details of alternatives to waterway crossings where possible	Section 4.2, 5.2
• offsets proposed for unavoidable, permanent loss of fisheries habitat	Section 4.2, 5.2
• a description of methods to minimise the potential for introducing and/or spreading weed species or plant disease	Section 4.4, 5.5
• measures to avoid or mitigate potential impacts on groundwater-dependent ecosystems. Describe the proposed monitoring for each identified groundwater-dependent ecosystem. In any groundwater aquifers found to contain stygofauna, describe the potential impacts on stygofauna of any changes in the quality and quantity of the groundwater, and describe any mitigation measures that may be applied	See Volume 2 Section 5.4
• monitoring of aquatic ecology health, productivity and biodiversity in areas upstream and downstream of the project area.	Section 4, 5
Address any actions of the project or likely impacts that require an authority under the relevant legislation including the NC Act and/or the Fisheries Act 1994.	Section 4, 5 and Volume 4 – Appendix D – Project Approvals and Planning Assessment
Outline how these measures will be implemented in the overall EMP for the project.	Section 4, 5 and Volume 2 Section 13

Appendix B

Aquatic Dependant Flora Species

Previously recorded within 50 km of the Study Area

Aquatic Dependant Flora Species Previously Recorded within 50 km of the Study Area

Family	Scientific Name	Common Name	Act Status		Type	
			NC	EPBC	Riverine	Non-riverine
Alismataceae	*Caldesia oligococca*					✓
Araliaceae	*Hydrocotyle dipleura*		V			✓
Asteraceae	*Centipeda minima*					✓
Commelinaceae	*Cyanotis axillaris*					✓
Commelinaceae	*Murdannia graminea*	murdannia				✓
Cyperaceae	*Eleocharis atropurpurea*					✓
Cyperaceae	*Eleocharis equisetina*					✓
Cyperaceae	*Eleocharis pallens*	pale spikerush				✓
Cyperaceae	*Eleocharis plana*	ribbed spikerush				✓
Cyperaceae	*Fimbristylis aestivalis*					✓
Eriocaulaceae	*Eriocaulon carsonii subsp. orientale*		E			✓
Eriocaulaceae	*Eriocaulon cinereum*					✓
Eriocaulaceae	*Eriocaulon scariosum*					✓
Haloragaceae	*Myriophyllum artesium*		E			✓
Juncaceae	*Juncus polyanthemus*					✓
Juncaceae	*Juncus usitatus*					✓
Juncaginaceae	*Triglochin dubium*					✓
Juncaginaceae	*Triglochin multifructum*					✓
Lentibulariaceae	*Utricularia caerulea*	blue bladderwort			✓	✓
Lentibulariaceae	*Utricularia dichotoma*	fairy aprons				✓
Lentibulariaceae	*Utricularia gibba*	floating bladderwort				✓
Lythraceae	*Ammannia multiflora*	jerry-jerry				✓
Marsileaceae	*Marsilea hirsuta*	hairy nardoo				y
Marsileaceae	*Marsilea mutica*	shiny nardoo				✓

Family	Scientific Name	Common Name	Act Status	Type	
Mimosaceae	*Acacia salicina*	doolan		✓	
Mimosaceae	*Acacia stenophylla*	belalie		✓	✓
Myrtaceae	*Eucalyptus camaldulensis*			✓	✓
Myrtaceae	*Eucalyptus coolabah*	coolabah		✓	✓
Myrtaceae	*Melaleuca fluviatilis*			✓	
Myrtaceae	*Melaleuca leucadendra*	broad-leaved tea-tree		✓	✓
Myrtaceae	*Melaleuca linariifolia*	snow-in summer		✓	
Nymphaeaceae	*Nymphaea gigantea*				✓
Parkeriaceae	*Ceratopteris thalictroides*			✓	✓
Poaceae	*Hymenachne amplexicaulis cv. Olive*		exotic	✓	✓
Poaceae	*Leersia hexandra*	swamp rice grass		✓	✓
Poaceae	*Pseudoraphis spinescens*	spiny mudgrass			✓
Poaceae	*Sporobolus pamelae*		E		✓
Typhaceae	*Typha domingensis*				✓

Appendix C

Macroinvertebrate Data

Survey Sampling Data

Class/Order	Family	Count				
		Site 7	Site 6	Site 5	Site 21	Site 25
Arachnida	Tetragnathidae		1			
Bivalva	Sphaeriidae			1		
Coleoptera	Dytiscidae	4	3	2	5	16
	Haliplidae		1			1
	Hydrochidae		1			9
	Hydrophilidae					2
	Hygrobiidae			1		1
	Noteridae			10		
	unknown			14		
Decapoda	Aytidae	1			3	1
	Palaemonidae	1	1			
	Parasaticidae	1				
Diptera	Ceratopogonidae	2				
	Chironominae	5	1	1		7
	Orthocladiinae					3
	Tanypodinae			1	3	2
Ephemeroptera	Baetidae					2
	Caenidae	1		2		2
Gastropoda	Planorbidae					1
	Viviparidae				2	
Hemiptera	Corixidae			1	7	4
	Gerridae	1		1		
	Mesoveliidae			1		
	Nepidae	1				
	Notonectidae					4
	Pleidae	1	3	8	6	32

Class/Order	Family	Count				
		Site 7	Site 6	Site 5	Site 21	Site 25
	Veliidae		1	4		
Hirudinea	Glossiphoniidae				1	
Nematomorpha	Gordiidae		1			
Odonata	Gomphidae	2	4			3
	Isostictidae		1	1		5
	Libellulidae			1		1
	Urothemistidae	1	1			
Oligochaeta		1				
Plecoptera	Unknown (early instar)				1	
Trichoptera	Ecnomidae				5	6
	Leptoceridae		1		4	

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