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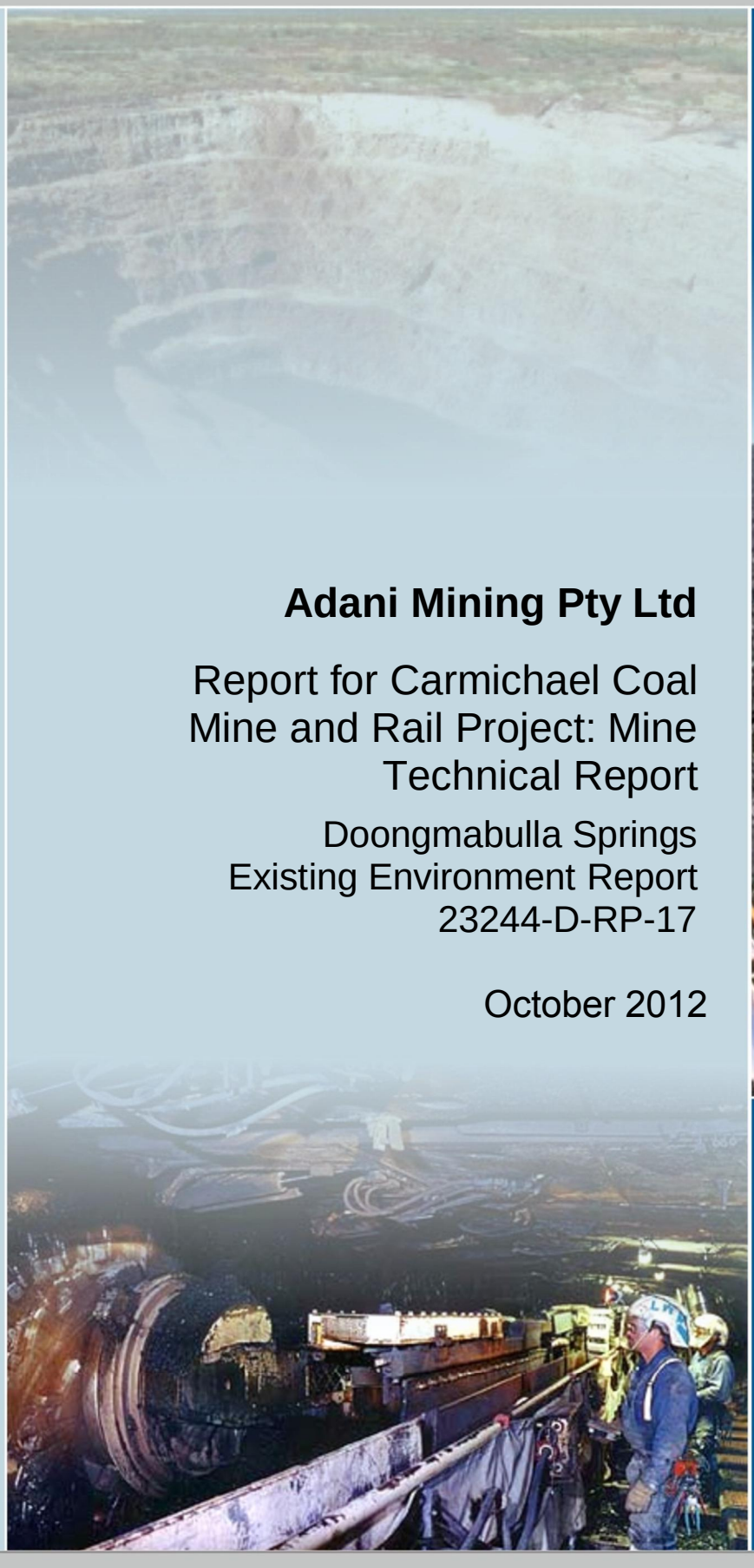

Adani Mining Pty Ltd

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

Doongmabulla Springs Existing Environment Report 23244-D-RP-17

October 2012

GHD

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Contents

Executive Summary vii

1. Introduction 1-1
   - 1.1 Project Background 1-1
   - 1.2 Terms of Reference and Report Scope 1-4
   - 1.3 Assessment Scope 1-5
   - 1.4 Study Area 1-5
   - 1.5 Terminology 1-7
   - 1.6 Report structure 1-7
   - 1.7 Methods 1-7

2. Description of Environmental and Conservation Values 2-1
   - 2.1 Great Artesian Basin Springs 2-1
   - 2.2 Doongmabulla Springs 2-5
   - 2.3 Flora and Fauna 2-16

3. Conclusion 3-1

4. References 4-1

Table Index

Table 1-1	Terms of Reference Cross Reference for this Report	1-4
Table 1-2	Summary of Desktop Sources Reviewed	1-8

Figure Index

Figure 1-1	Project Location	1-2
Figure 1-2	Great Artesian Basin with Project Location	1-3
Figure 1-3	Carmichael Coal Mine and the Doongmabulla Spring Complex and Wetland	1-6
Figure 2-1	Doongmabulla Wetland Regional Context	2-2
Figure 2-2	Doongmabulla Wetland Regional Ecosystem Mapping	2-12

Plate Index

Plate 2-1	Examples of springs in the Moses spring group draining directly into nearby Cattle Creek	2-6
Plate 2-2	Small artesian seeps of the Doongmabulla springs complex	2-8
Plate 2-3	Non-mounding artesian springs with vegetated drainage pathways	2-9
Plate 2-4	Typical mound springs of the Moses spring group	2-9
Plate 2-5	Joshua – a large, modified mound spring used for domestic purposes	2-10
Plate 2-6	Little Moses spring group	2-11
Plate 2-7	Sporobolus pamelae grassland (left); mixed sedgeland (right)	2-13
Plate 2-8	Weeping paperbark forest (left) and peppermint box open woodland (right)	2-14
Plate 2-9	Damage to wetlands by pigs (left) and cattle (right)	2-15
Plate 2-10	Eriocaulon carsonii (left) and growing in mats (right)	2-16
Plate 2-11	Eryngium fontanum (left) and Hydrocotyle dipleura (right)	2-17
Plate 2-12	Livistona lanuginosa	2-18
Plate 2-13	Myriophyllum artesium (left) and Sporobolus pamelae (right)	2-18
Plate 2-14	Freshwater mussel shells of *Velesunio* sp. from a pool beside a mound spring	2-32

Appendices

A Flora species list

B Wildlife online search

C Protected matters search

D Habitat assessment proforma

E Flora assessment proforma

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
the Study Area	The area including and immediately adjacent to the cluster of springs known collectively as the Doongmabulla wetland or Doongmabulla spring complex

Generic Terminology	
Abbreviation	**Term**
ANZECC	Australian and New Zealand Environment and Conservation Council
AquaBAMM	Aquatic Biodiversity Assessment Mapping Method
AusRivAS	Australian River Assessment System
BOM	Bureau of Meteorology
DERM	Department of Environment and Resource Management (Qld)
DO	Dissolved oxygen
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EIS	Environmental impact statement
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPC	Exploration Permit for Coal
GAB	Great Artesian Basin
GBR	Great Barrier Reef
IUCN	International Union for Conservation of Nature
km	Kilometre
Matters of NES	Matters of National Environmental Significance
Mtpa	Million tonne per annum
N/A	Not applicable
NC Act	*Nature Conservation Act 1992*
NRM	Natural Resource Management
QLD	Queensland

RE	Regional ecosystem
SA	South Australia
SDPWO Act	*State Development and Public Works Organisation Act 1971*
Spring complex	A cluster of spring groups in a similar geomorphic setting within six kilometres of each neighbouring spring group
Spring group	A cluster of individual springs in a similar geomorphic setting where no one pair of springs is more than one kilometre apart
TEC	Threatened ecological community
ToR	Terms of reference

Executive Summary

This report provides a description of the ecology of the Doongmabulla spring complex, located eight kilometres to the west of the proposed Carmichael Coal Project, based on a desktop investigation and site inspection. This site contains a Great Artesian Basin (GAB) spring complex comprised of two spring groups, Moses and Joshua, located on Doongmabulla station near the confluence of three creek systems, Cattle Creek, Dyllingo Creek and Carmichael Creek, all of which join to form the Carmichael River.

The Moses spring group comprises approximately 30 individual mound springs which contribute seepage to a series of adjacent wetlands. These perennial wetlands are comprised of grassland and sedgeland containing six plants listed as being of conservation significance under state or federal legislation. In addition, Moses spring group has a high level of endemicity, with seven species present, mostly flora, occurring only in association with GAB spring wetlands.

The Joshua spring group contains one spring, which has been modified to a turkey's nest dam that provides water to the station homestead and to livestock. This spring has a considerable flow rate.

Based on high levels of endemicity to the Great Artesian Basin (and including two species endemic to the Moses spring group), the Doongmabulla spring complex has been given a rating among GAB spring complexes of 1a. In addition to high endemicity levels, 10 species of conservation significance have been recorded at the wetland, including the black throated finch southern subspecies (*Poephila cincta cincta*) and the flora species *Eryngium fontanum* and *Eriocaulon carsonii,* all of which are listed as endangered at both state and federal level. Overall, the findings in this report include records from the springs (either historical or confirmed during the site inspection) of 10 species of flora or fauna of conservation significance, including five endangered species, four vulnerable species, and one near threatened species. One fauna and one flora species not currently listed as being of conservation significance are believed endemic to this spring complex only.

1. Introduction

1.1 Project Background

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 in central Queensland. All coal will be railed via a privately owned rail line connecting to the existing QR National rail infrastructure at Moranbah, and shipped through coal terminal facilities at the Port of Abbot Point and the Port of Hay Point (Dudgeon Point expansion). The Project will have an operating life of approximately 90 years.

The Carmichael Coal Mine and Rail Project (the Project) comprises two major components:

- The Project (Mine): a greenfield coal mine over exploration permit for coal (EPC) 1690 and part of EPC 1080, which includes both open cut and underground mining, on mine infrastructure and associated mine processing facilities (the Mine) and offsite infrastructure.
- The Project (Rail): a greenfield rail line connecting the Mine to the existing Goonyella rail system to provide for transport of coal to the Port of Abbot Point and/or the Port of Hay Point (Dudgeon Point expansion).

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 to ensure that all potential environmental, social and economic impacts of the Project are identified and assessed and that adverse impacts so identified are avoided or mitigated.

Detailed descriptions of the Project are provided in Volume 2 Section 2 Project Description (Mine) and Volume 3 Section 2 Project Description (Rail) of the EIS. Figure 1-1 shows the Project location, and Figure 1-2 shows the location of the Project (Mine) in relation to the Doongmabulla spring complex.

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

N

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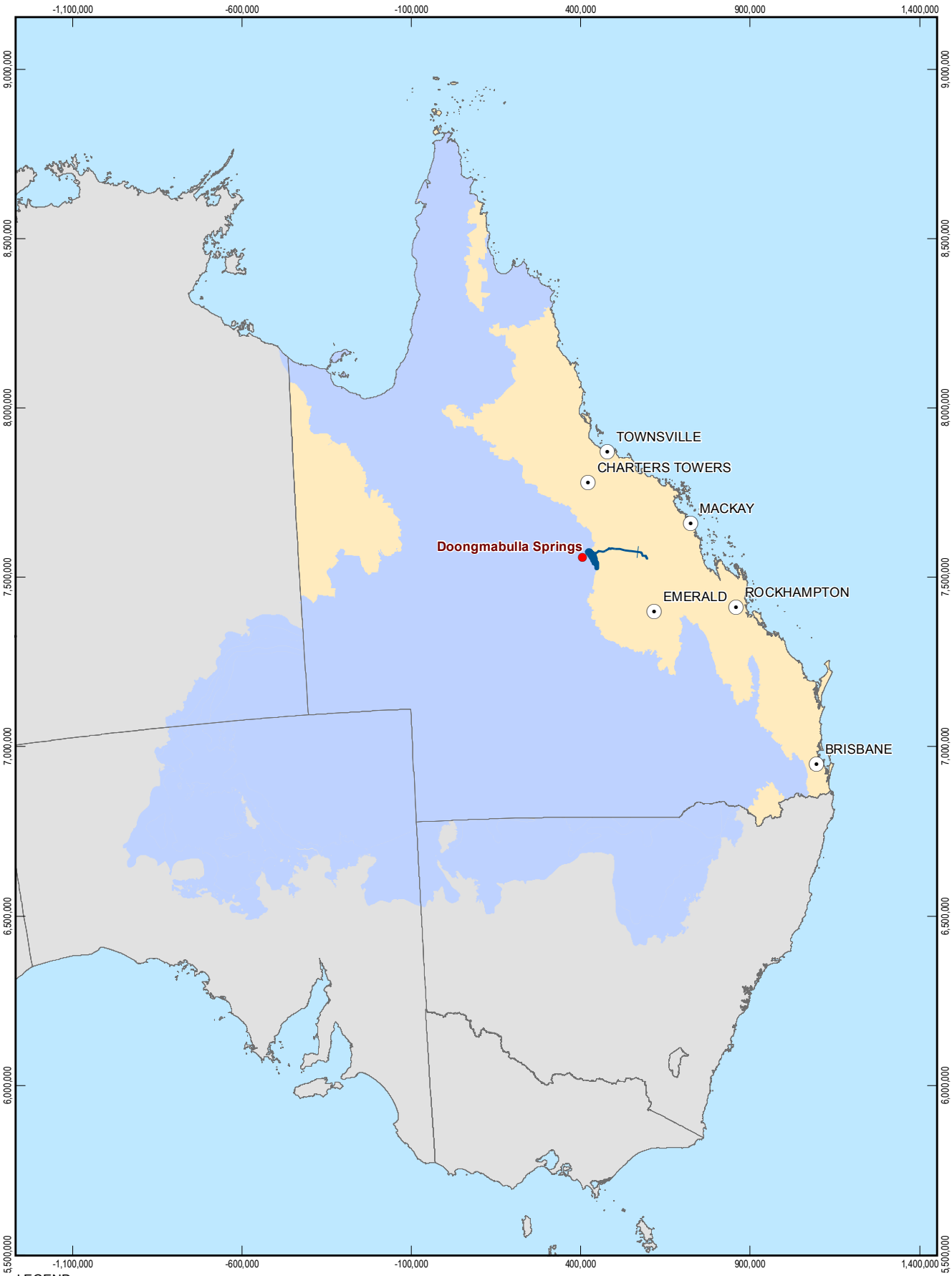
Data Source: © Commonwealth of Australia (Geoscience Australia): Town, Railways, Watercourses (2007); DERM: LGA, (2011), Hillshade (2009); DMR: State Roads (2008); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011); Adani: Alignment Opt9 Rev3 (2012). Created by: BW, JVC



LEGEND

- Locality
- Doongmabulla Springs
- Project (Rail)
- Project (Mine)
- Great Artesian Basin
- Other States and Territories
- Queensland

1:16,000,000 (at A4)

0 100 200 300 400 500

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

Great Artesian Basin with Project Location

Job Number	41-25215
Revision	A
Date	06-11-2012

Figure: 1-2

G:\41\25215\GIS\Maps\MXD\300_Hydrogeology\41-25215_332_rev_a.mxd 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: Artesian Basin, Locality (2007), Springs (2009), DME: EPC1690 (2010), EPC1080 (2011); GA: State and Territories (2011); Adani: Alignment Opt9 Rev3 (SP1 & 2) (2012). Created by: AJ, MS

1.2 Terms of Reference and Report Scope

This assessment of the Doongmabulla spring complex addresses the final terms of reference (ToR) for the Project (Mine) component of the Project EIS (May 2011). Table 1-1 provides a cross reference with the Project ToR specifically associated with the Doongmabulla Springs.

Table 1-1 Terms of Reference Cross Reference for this Report

Terms of Reference Section	Report Section
Doongmabulla Springs	
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
Describe the environmental values of the surface waterways and groundwater of the affected area in terms of dependant ecosystems.	Section 2
Identify all types of groundwater-dependent ecosystems occurring within and outside the Project Area and potentially impacted by project activities.	Section 2
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
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 2
A map is to be included which identifies aquatic ecosystems in the Project Area and regional scale.	Figure 1-1, Figure 1-3
Assess the environmental water requirements for protecting the identified groundwater-dependent ecosystems. Groundwater dependent ecosystems may include: subterranean ecosystems, phreatophytic terrestrial and riparian vegetation, springs and other wetlands and stream communities dependent on base flow.	Section 2 Volume 2 Section 5.4.5
Identify listed TECs that could be affected, directly and indirectly, by the proposal. Include baseline information on known distribution of the TEC (including a description of vegetation condition) and discuss the relative importance of the occurrence of the TEC that occurs in the proposed Project Area. Specifically, identify the community of native species dependent on natural discharge of groundwater from the Great Artesian Basin.	Section 2.3

This report considers the habitat values of the Doongmabulla wetland and their associated aquatic flora and fauna, centred on the Doongmabulla spring complex. Habitat values are specifically discussed for fish, amphibians, aquatic reptiles and aquatic invertebrates – taxa which potentially inhabit the Doongmabulla wetland.

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 Project Area
- Volume 4 Appendix P Mine Hydrology Report which assesses the surface water flows of the Project Area
- Volume 4 Appendix Q Mine Water Quality Report which assesses the surface water quality environmental of the Project Area
- Volume 4 Appendix R Mine Hydrogeology Report which includes the assessment of the groundwater environments (including stygofauna) of the Study Area
- Volume 4 Appendix O Aquatic Ecology Report which assesses the aquatic flora and fauna ecological values of the Project Area.

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

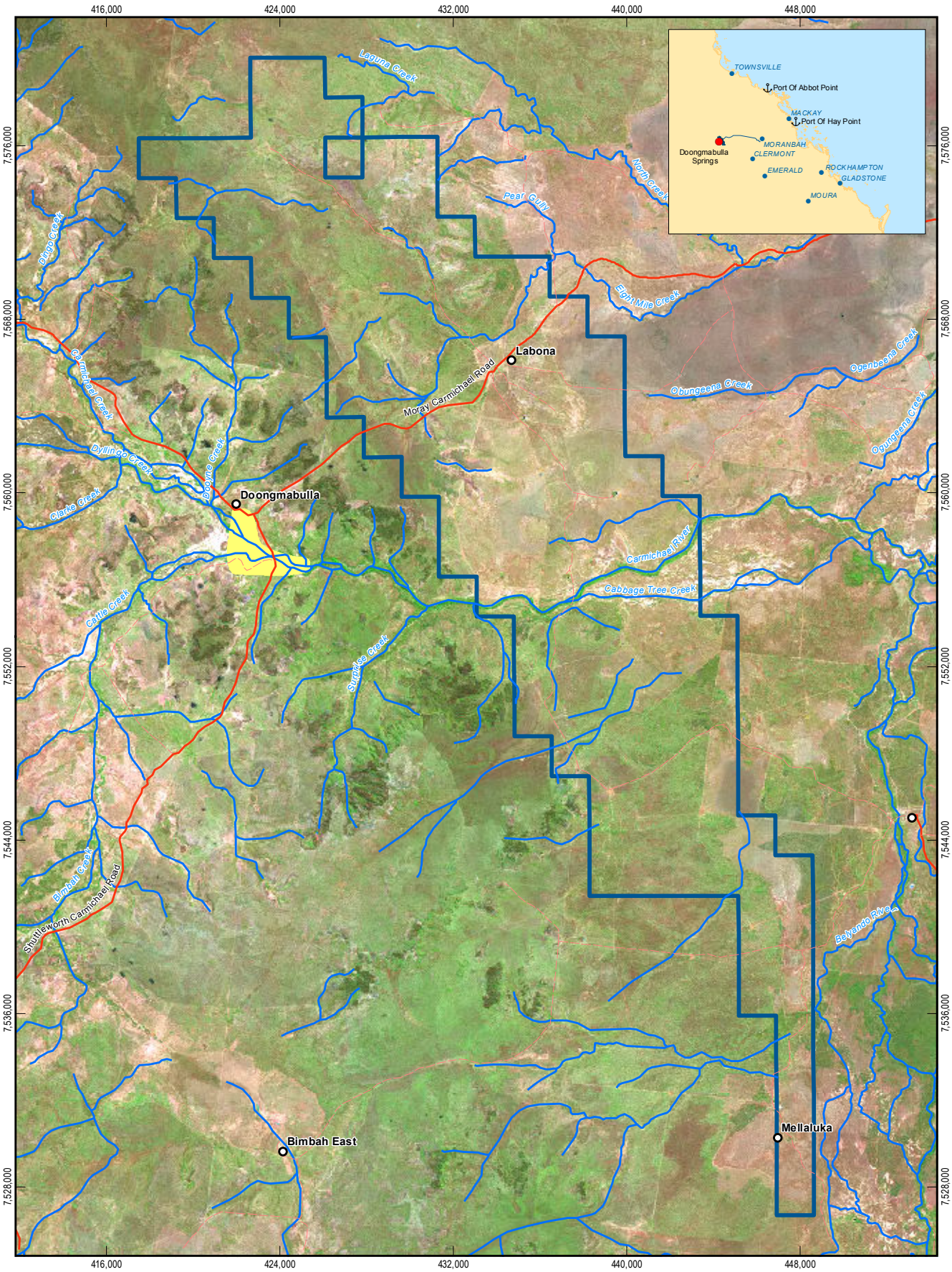
1.3 Assessment Scope

This ecological assessment of the Doongmabulla wetland addresses the final ToR for the mine component of the Project EIS (May 2011). It focuses on the ecological values (both terrestrial and aquatic) of a perennial wetland located at the head of the Carmichael River on Doongmabulla Station. This wetland (known as the Doongmabulla wetland) comprises discrete pools and patches of grassland, sedgeland and woodland created by the outflow of artesian water from a cluster of spring groups (Joshua, Little Moses and Moses) whose location is shown in Figure 1-3. Each spring group contains at least one spring - in the case of Moses, there are more than 30. Collectively, the spring groups are known as the Doongmabulla spring complex. The complex is approximately 4.5 km in diameter, and is located approximately eight kilometres to the west of the Project (Figure 1-2).

Both desktop assessments and in-field observations were used to describe the existing ecological values of the Doongmabulla spring complex. Desktop studies provided information specific to the springs and surrounding areas pertaining to water bodies, sensitive habitats, flora and fauna species and communities within and/or of relevance to the Doongmabulla spring complex. Field assessments were performed to gain an *in situ* understanding of the springs, and to ground-truth desktop search results. Field surveys included an inventory of spring-associated vegetation, and assessments of habitat values for aquatic fauna.

1.4 Study Area

The Study Area for this report focuses on the Doongmabulla wetland – that is, the Doongmabulla spring complex and the land in its immediate vicinity that provides habitat for wetland flora and fauna (Figure 1-3).



LEGEND

- Homestead
- Watercourse
- Minor Road
- Project (Mine)
- Track
- Doongmabulla Springs

1:250,000 (at A4)

0 2 4 6 8

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

Project (Mine) and the Doongmabulla Spring Complex and Wetland

Job Number 41-25215
Revision A
Date 06-11-2012

Figure: 1-3

G:\41\25215\GIS\Maps\MXD\300_Hydrogeology\41-25215_333_rev_a.mxd 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: Data Source: GA: Watercourses, Roads, Homesteads (2007); DME: Carmichael Mine Site; DERM: Springs (2009), Landsat (2005); Adani: Alignment Opt9 Rev3 (SP1 & 2) (2012). Created by: AJ, MS

1.5 Terminology

Throughout this report, where reference is made to the wetland (that is the aquatic and terrestrial ecological components, rather than the springs themselves), the name 'Doongmabulla wetland' will be used. Where reference is made to an individual spring group, it will be referred to by name (either Moses, Little Moses, or Joshua). Where reference is made to the spring complex, the name 'Doongmabulla springs' will be used.

All botanical binomials in this document follow those adopted in the Queensland Herbarium 2010 census of Queensland flora (Bostock and Holland, 2010).

The regional ecosystem (RE) mapping provided and discussed is from the official DERM version 6.1 RE mapping layer. RE units are as defined in the Regional Ecosystem Description Database (Queensland Herbarium, 2009).

1.6 Report structure

The structure of this existing environment report of the Doongmabulla Springs is as follows:

- **Section 1: *Introduction*** – description of Project background, the study area and scope and study methodology.
- **Section 2: *Description of Environmental and Conservation Values*** – discussion of the wider environmental values of artesian springs, and a description of the specific environmental values of the Doongmabulla wetland (comprising the three spring groups known as the Doongmabulla spring complex). This section also details the specific ecological values of conservation significance that are relevant to the Doongmabulla wetland, as identified by field surveys and desktop assessments.
- **Section 3: *Conclusion***
- **Section 4: *References***

1.7 Methods

1.7.1 Literature Review and Desktop Assessment

Information relating to the 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. A total of nine search tools were used to identify both the relevant ecosystem types and function, and the ecological communities that occur in the region.

Table 1-2 Summary of Desktop Sources Reviewed

Source and name	Description of information source	Search extent	Limitations of use
Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) Protected Matters Search Tool and Environmental Reporting Tool	The Protected Matters Search Tool identifies matters of national environmental significance (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.	A point search (approximating with the centre of the Study Area: -22.083, 146.247) with a 5 km buffer was searched.	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	The Directory identifies nationally important wetlands. The 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.	A point search (approximating with the centre of the Study Area: -22.083, 146.247) with a 5 km buffer was searched.	N/A - 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.
Queensland Department of Environment and Resource Management[1] (DERM) Wetland mapping	Various mapping layers produced by DERM (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 DERM AquaBAMM Method – the on-ground values of individual wetlands identified through this method 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.

Source and name	Description of information source	Search extent	Limitations of use
DERM[1] *Burdekin Natural Resource Management (NRM) Region Back on Track Actions for Biodiversity* report (DERM, 2010)	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 DERM 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).	Since the Burdekin NRM region encompasses a large area of central Queensland some species/impacts listed in this document are not relevant to the Study Area.
DERM[1] Wildlife Online database	The DERM 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.	A point search (approximating with the centre of the Study Area: -22.083, 146.247) with a 5 km buffer was searched.	This database catalogues records of species reported by the holders of various wildlife and research permits in their annual returns. It is not subject to verification, and is limited by the skill of the reporter, which is not known. DERM 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).
Queensland Herbarium HERBRECS specimen database	The HERBRECS database catalogues flora specimen records obtained throughout Australia that have been submitted to the Queensland Herbarium, identified and incorporated into their collection. Specimens not incorporated into their collection are not included.	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 22.032 and 22.124 south and 146.192 and 146.296 east.	This database catalogues records of species lodged with the Queensland Herbarium and retained in their collection, within a defined area. It is not an exhaustive record of all species identified by the Herbarium, but a collection record. The lack of spatial precision associated with older records may limit their value for inclusion in current studies in some instances.

Source and name	Description of information source	Search extent	Limitations of use
Queensland Museum Queensland Museum Data Search	The Queensland Museum catalogues records of fauna specimens submitted to the Museum for identification.	A rectangular area was searched, such that the diagonal extending from the approximate centre of the Study Area (-22.083, 146.247) to each corner was 5 km. The co-ordinates of the search were between 22.032 and 22.124 south and 146.192 and 146.296 east.	This database catalogues records of fauna specimens lodged with the Queensland Museum. It is not an exhaustive record, but a collection record. 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.
DERM[1] (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.

[1] Note, DERM is no longer the name of the administering authority for these documents. However, according to standard referencing practice the documents quoted above are attributed to the name of the department as it was at the time the source was procured (in the case of databases) or produced (in the case of documents).

1.7.2 Field Inspection

A number of documented botanical surveys have been completed at the Doongmabulla wetland over the previous 20 years, including by Dr Rod Fensham, Dr John Thompson and Dr Bryan Simon (all of the Queensland Herbarium) (Simon, B.K. 1993; Herbrecs database search results; R. Fensham, pers. comm. 24/07/2012). These surveys have compiled detailed species lists for the wetland. Consequently, a short field inspection (over three days from the 22nd to 24th May 2012) was conducted of the Doongmabulla wetland to ground truth desktop research and gain site familiarity. Due to the unique characteristics of the springs, the field inspection was focussed on understanding the geographic context of the Study Area, the spatial characteristics of the spring outlets, how the various spring outlets present, and to gain an appreciation of the range of vegetation communities and habitat values present.

1.7.2.1 Aquatic Habitat Assessment

At each spring group, an assessment of the aquatic habitat values was undertaken to record the diversity and quality of aquatic habitat and its suitability for aquatic flora and fauna. The current impacts (from both humans and animals) were noted for each spring group.

The following variables were assessed at the Joshua and Little Moses spring groups, and at a number of springs within the Moses spring group:

- Water turbidity
- Substrate
- Habitat features (for example, undercut banks, woody debris and/or overhanging vegetation)
- Presence of algae and macrophytes (submerged, floating and emergent)
- Opportunistic observations of aquatic fauna within and adjacent to springs
- Riparian zone quality and features (for example the presence of trailing vegetation)
- Dimensions of mounds
- Flora communities within and adjacent to springs.
- Habitat information was collected on proformas modelled on the Queensland Australian River Assessment System (AusRIVAS) habitat assessment proforma (Department of Natural Resources and Mines, 2002). A copy of this proforma is provided as Appendix D.

1.7.2.2 Flora Assessment

There were a number of objectives to the flora assessment:

- To determine the general species composition of vegetation communities present at each spring group.
- In particular to confirm the presence of species of conservation significance and gain an understanding of their spatial distribution within the Doongmabulla wetland.
- To understand the context of the Doongmabulla wetland in relation to local topography and vegetation.

Each spring group was inspected and observations were made of the wetland and immediately adjoining areas in accordance with the quaternary site inspection methodology outlined in Neldner et. al. (2005). A copy of the proforma used for this purpose is provided as Appendix E. Flora samples were collected for identification where this was not possible in the field. Samples were submitted to the Queensland Herbarium for confirmation where an identification was tenuous (these are identified in Appendix A).

1.7.2.3 Weather Conditions

Weather data (presented below) was sourced from the Australian Bureau of Meteorology (BOM). The Ulcanbah weather station (station ID: 036050) was used as a proxy for rainfall measurements, as it is the closest station to the Doongmabulla springs (BOM 2012). This station does not record temperature, which was obtained from the Barcaldine weather station (station ID: 4008).

During the survey period (22 May 2012 to 24 May 2012), no rainfall was recorded at the Ulcanbah weather station (being some 27 km from the Study Area), although precipitation was noted during surveys on the afternoon of 24 May 2012. Mean monthly rainfall for the month of May is 24.4 mm for the Ulcanbah weather station.

During the survey, weather conditions were typified by warm days and cool evenings, becoming overcast and cooler towards the conclusion of the survey. The minimum temperature at the Barcaldine weather station during this time was 13.4°C, with a maximum temperature of 27.6°C. However, it should be noted that temperatures in the Study Area are likely to differ from these recordings, as the Barcaldine weather station is some 90 km from the Doongmabulla spring complex.

2. Description of Environmental and Conservation Values

2.1 Great Artesian Basin Springs

2.1.1 Overview

The GAB occupies approximately 1,711,00 km^2, covering much of Queensland (Figure 1-2) and South Australia and extending into the Northern Territory and New South Wales (Noble et al., 1998; Ponder, 2002). This large subterranean aquifer is an essential domestic and agricultural resource for many regions where permanent surface water is scarce (Ponder 2002). Worldwide, the GAB is considered to be one of the major groundwater basins – storing approximately 8,700 million megalitres of water, some of which is estimated to be nearly two million years old (Torgersen et al., 1991; Noble et al., 1998). The GAB itself is approximately 100 to 250 million years old, and was formed by the layering of sandstone aquifers between impermeable layers of silt and mudstones (Ponder, 2002).

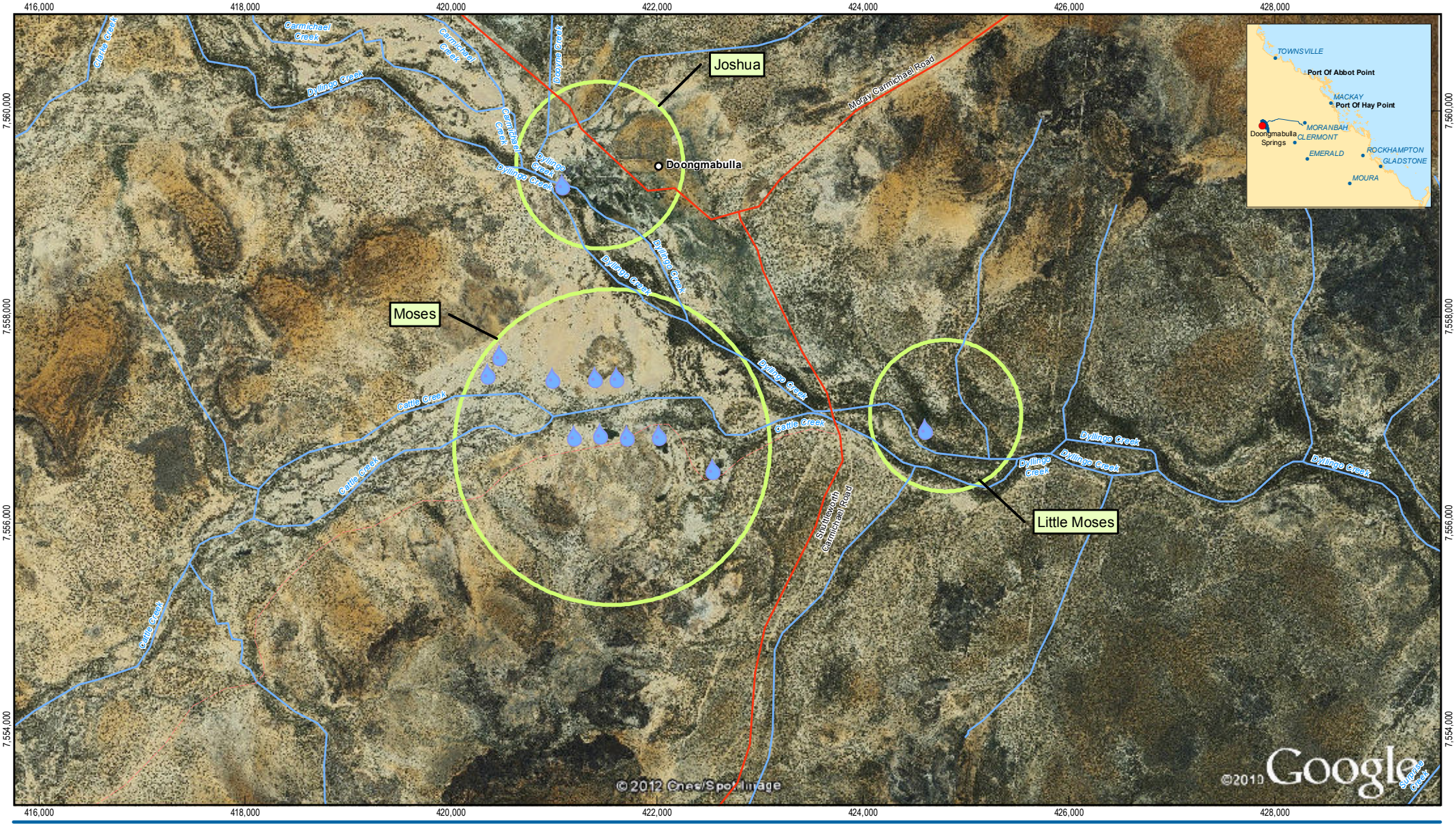
The discovery and characterisation of the GAB in the mid to late 1800s was heralded as a permanent and inexhaustible solution to the constant droughts and aridity that are typical of mainland Australia (Fairfax and Fensham, 2002). While natural surface outlets for this basin occur across Australia, many artificial bores have been installed for water extraction (Fairfax and Fensham, 2002). However, current extraction rates are recognised as being unsustainable, as falling groundwater pressure has resulted in spring inactivity (Noble et al., 1998; Rolfe 2010; Fensham et al., 2011).

Springs within the GAB occur in clusters and are divided into the following groups (Fairfax and Fensham, 2002):

- A *spring group* is the smallest cluster, and represents multiple springs in a similar geomorphic setting where no one pair of springs are more than one kilometre apart. This grouping may extend over many kilometres, but no single spring outlet is more than one kilometre from at least one other spring. A spring group is often referred to in the singular as a spring – this report concerns three spring groups, Little Moses, Moses and Joshua (Figure 1-3).

A spring complex refers to a cluster of spring groups occurring in a similar geomorphic setting within six kilometres of each neighbour. The spring group cluster that is the subject of this report is the Doongmabulla spring complex (Figure 2-1).

- A *supergroup* is a major regional cluster of spring complexes with broadly similar geomorphic characteristics and within a defined geographic proximity. The Doongmabulla spring complex is located within the Barcaldine supergroup.



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Metres

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

N

LEGEND

- Homestead
- Springs
- Minor Road
- Track
- Watercourse
- Spring Groups

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Doongmabulla Wetland
Regional Context

Job Number 41-25215
Revision A
Date 06-11-2012

Figure 2-1

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Data Source: GHD: Spring Complex/2012, Springs/2012; GA: Watercourses, Roads, Homesteads (2007); DME: Carmichael Mine Site; Google: Imagery (2012). Created by:SB

2.1.2 Spring Morphology

Mound springs form around vents (the spring's surface outlet) where erosion or geological faults penetrate the artesian aquifer, with subterranean pressure pushing water up through weaknesses. Over time, mounds form around the seep, as carbonate-rich artesian water solidifies the surrounding substrate (Mudd, 2000). Mound morphology can be variable, but will typically be a raised mound with a central pool fringed by vegetation.

In the GAB, mounds can be sizeable features, with the now inactive Hamilton Hill spring being some 40 m above the ground (Habermehl 1982). Extant mound springs can be up to 8 m high and 30 m in diameter. A wetland may surround the mound, provided the flow rate is sufficient to sustain partial saturation. The size of the wetland is directly proportional to the spring flow rate (Williams and Holmes 1978). Flow rates can be highly variable between springs, but also within a spring, and can be dependent on many factors such as the evaporation rate and atmospheric pressure (Mudd 2000).

2.1.3 Species Endemism in the Great Artesian Basin

As a result of the unique and often hydrologically disconnected habitats presented by artesian springs, distinct groundwater associated communities often develop within or adjacent to these habitats (Fensham et al., 2011). Endemicity in GAB springs is largely the combined result of three factors:

- The unique environmental conditions (especially water chemistry) presented by artesian springs, which provide an ecological niche into which species can adapt (Fensham et al., 2011).
- Prolonged, historical periods of hydrological isolation, during which time springs have become isolated, discrete systems (Ponder 2002), resulting in genetic isolation and consequently (over long periods of time) speciation (Perez et al., 2005).
- Endemic species may represent a relict population of a once widespread species forced into the refugia provided by persistent springs as mainland Australia became more arid during the Tertiary period (Fensham et al., 2011).

Numerous species of fish are known to be endemic to GAB spring wetlands, namely Edgbaston Springs (Queensland), Elizabeth Springs (Queensland) and the Dalhousie Springs (South Australia). While many of the species are locally abundant, their specialised and compressed distribution has led to International Union for Conservation of Nature (IUCN) listing for most populations (Allen et al., 2002). Dalhousie Springs in South Australia is a particular hotspot of fish endemism, with five species found at this spring complex only. These highly adapted species are generally able to tolerate the relatively extreme climatic and habitat conditions presented by the springs in this region, particularly the wide variability in temperature, pH, salinity and low levels of dissolved oxygen (Allen et al., 2002). In Queensland, several endemic species can also be found in artesian springs – the Elizabeth Springs goby (*Chlamydogobius micropterus*) and two species from the Edgbaston Springs, the red-finned blueye (*Scaturiginichthys vermeilipinnis*) and the Edgbaston goby (*Chlamydogobius squamigenus*).

Spring-associated endemism in the GAB is by no means limited to fish. Other examples of endemic fauna species can be found in several invertebrate taxon, including spiders, molluscs and crustaceans (Ponder et al., 1995; Fensham and Fairfax 2003; Fensham and Price 2004). Perhaps the most diverse endemic fauna group is the hydrobiid snails (Perez et al., 2005). To date, over 15 species from five genera have been described (Mudd 2000). Overall, this prolific endemism in

discharge spring invertebrates is attributable to low dispersal capability and lack of hydrological connectivity between springs (Tyre et al., 2001; Wilmer et al., 2007; Fensham et al., 2011).

Floral endemism is also a significant feature of GAB discharge spring communities. In 2010, Fensham et. al. listed 320 native flora species considered to be associated with GAB spring wetlands, of which 13 flora species from 10 genera were recognised as being endemic to spring wetlands (Fensham et al. 2010). All of the endemic flora species are herbs, sedges or grasses, of which four species are restricted to one spring complex and three species to either two or three spring complexes.

The level of floral endemicity exhibited by a spring complex was used by Fensham and Price (2004) to rank GAB springs, with six spring complexes having three or more endemic species. Of these, the Doongmabulla spring complex (referred to as Moses in the paper in question) was ranked highest of all GAB spring wetlands in terms of floral endemicity. However, Dr Fensham has since stated that, if this ranking exercise were conducted again, Doongmabulla spring complex would not be at the top (R. Fensham, pers. comm. 24/07/2012). This is because a number of species originally considered to have a highly restricted distribution (either to Doongmabulla spring complex only, or to a small set of spring complexes including Doongmabulla) are now known to be more widespread. In addition, one of the species thought at that time to be restricted to Doongmabulla spring complex only (and so weighted heavily in the ranking process), *Peplidium* sp. (R.J. Fensham 3380), is now considered to belong to an existing species of Peplidium (R. Fensham, per. comm. 24/07/2012).

2.1.4 Threatening Processes

Under the Commonwealth *Environment Protection and Biodiversity Act 1999* (the EPBC Act), ecological communities dependant on GAB discharge springs are included within the endangered threatened ecological community (TEC) 'The community of native species dependant on natural discharge of groundwater from the Great Artesian Basin' (referred to in this report as the 'GAB discharge springs community TEC'). The greatest threatening process for this TEC is drawdown resulting from groundwater extraction (for domestic and agricultural use) and mining/coal seam gas extraction (Fensham et al., 2010). This extraction has led to the inactivity of the majority of artesian-fed springs, with an estimated 81 per cent of springs currently listed as inactive since their discovery, due to reduced subterranean pressure (Fairfax and Fensham 2002).

Further impacts on the spring-associated ecological communities arise from artificial alterations of the seep points, with some springs being removed altogether, or modified to suit the needs of livestock (Fensham et al., 2011). Introduced plants and animals have had significant impacts on the integrity and robustness of GAB spring communities, with pugging (from both feral animals and livestock), pig rooting and wallowing and direct and indirect competition for resources all acting to degrade ecological values of springs. Other threatening processes include uncontrolled access by tourists and the impoundment of springs (Fensham and Price 2004).

2.2 Doongmabulla Springs

2.2.1 Overview

The springs are situated approximately eight kilometres from the western edge of the Project (Mine) (Figure 1-2). The Doongmabulla spring complex comprises three spring groups – Little Moses, Moses and Joshua (Figure 1-3), all of which are included within the Doongmabulla Nature Refuge. Cumulatively, these spring groups are estimated to have a daily flow rate of 1.35 ML (Fensham, pers comm. 16 January, 2012). It forms part of the Barcaldine GAB supergroup, located within the Belyando catchment (a part of the greater Burdekin River catchment). The spring complex is situated on a gently undulating to undulating plain of Quaternary alluvium, surrounded by mid to late Triassic sandstone of the Moolayember formation (Bureau of Mineral Resources, Geology and Geophysics, 1972). It is located near the junction of three third order streams, Cattle Creek (in the south), Dyllingo Creek (in the centre) and Carmichael Creek (in the north). These watercourses converge within a kilometre of each other to form the Carmichael River (Figure 1-3).

The Doongmabulla spring complex and associated wetlands are listed as being of national significance in the directory of important wetlands, as they exhibit the following qualities:

- It is a good example of a wetland type occurring within a biogeographic region in Australia
- 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, 2012).

2.2.2 Spring Groups

The Joshua spring group comprises one very active spring vent, located near the Doongmabulla homestead and just north of Carmichael Creek. This spring has been heavily modified to provide drinking water for the station homestead and livestock, and now comprises a large ‘turkey nest’ dam and associated overflow dams.

The Moses spring group is located approximately two kilometres to the south of Joshua, and comprises at least 30 vents spread over a radius of 2.5 km, all of which are within 400 m (either north or south) of Cattle Creek. Among these are well-formed mound springs supporting central pools to 1.5 m tall, and small isolated ‘seepage mounds’ of 20 cm or more. In four locations these mound springs have contributed water to broad shallow pools (often only a few centimetres deep), which has formed wetlands of approximately 3.5 ha in total. Elsewhere, mounds have sometimes formed localised shallow pools up to 20 m in diameter. Other springs do not appear to have caused pooling of any kind. Most mounds (and associated wetlands) are generally heavily vegetated with a characteristic suite of species that identify them from a distance, in particular the grass *Sporobolus pamalae*, which only occurs in association with GAB mound springs (Simon and Alfonso, 2011).

In contrast to the others, this spring group is characterised by broad open areas dominated by grassland, sedgeland or bare (scalded) land. As artesian water is discharged over the life of a mound spring, the chemical composition of the surrounding soil is altered (particularly pH), which accounts for the specialised suite of flora that inhabit these areas (Fensham, R. pers. comm. 24/07/2012). The open nature of the vegetation at Moses is likely symptomatic of this, with vegetation characteristic of the alluvial plain in this area excluded by higher salinity levels. Therefore, large open areas with extensive grassland and sedgeland containing a proportion of specialised and endemic flora species are likely indicators of a mature wetland community that has been in place for a long time.

The Little Moses spring group comprises a small number (two were located during the field inspection) of spring outlets draining into a closed depression that appears to be part of a relict channel of the Carmichael River. The spring outlets are located at approximately the same elevation (i.e. in a line that is parallel to the contour) within 100 m of each other on a gentle run-off slope near the foot of a plain, at the point at which the plain approaches the Carmichael River. They have not formed mounds and the water is emanating from shallow gullies. The flow is sufficient that, as it approaches the relict channel in which it is collecting, it is eroding a substantial gully (almost 2 m deep and at least 30 m long) back into the plain.

These springs are situated within woodland of river red gum (*Eucalyptus camaldulensis* var. *obtusa*), in a clay loam. This spring group is located approximately two kilometres to the east of Moses spring group, and almost four kilometres south east of Joshua spring group. Little Moses differs from the Moses spring group in a number of ways. None of the GAB spring wetland endemics were observed here, and the grassland so prevalent at Moses spring group is also absent (replaced by an intact woodland characteristic of river banks and floodplains throughout the Carmichael River catchment). In addition, the soil was distinctly dark brown to black and of a heavier nature, unlike the scalded, pale appearance of the lighter, sandier soils at Moses.

It has been postulated that Little Moses may be a very young spring group (Fensham, R. pers. comm. 24/07/2012). This is suggested by the lack of those features that over time indicate the presence of abundant, perennial artesian water at the surface – grassland and sedgeland (or bare ground) (as opposed to woodland), soil that is pale and scalded (as opposed to dark); and the presence of a number of GAB spring wetland endemics.

Where the springs flow directly to waterways they act as an important source maintaining perennial habitat for both aquatic and terrestrial flora and fauna. Plate 2-1 shows an example of two springs from the Moses spring group that have direct hydrological inputs into neighbouring creeks. In the left image, the shallow channel seen in the foreground converges with Cattle Creek (the riparian tree line in the background, some 150 m away). In the image on the right, the proximity of a small mound spring to the edge of a relict stream channel (also associated with Cattle Creek) is illustrated. All spring groups were observed to be contributing to local waterways feeding the Carmichael River.

Plate 2-1 Examples of springs in the Moses spring group draining directly into nearby Cattle Creek

Groundwater assessments identified that the Doongmabulla springs provide base flow to the adjacent Carmichael River, and this is discussed in Volume 4, Appendix R (Mine Hydrogeology Report) of the EIS. Waterways surrounding the Doongmabulla springs are displayed in Figure 1-3.

The Doongmabulla spring complex is currently (and were historically) used for watering livestock, which directly impacts the springs through trampling, pugging, fouling of water and compaction. In addition, there is prolific use of artesian bores in the region, resulting in aquifer drawdown. Consequently, the springs are considered under threat (Mitchell et al., 2002).

2.2.3 Spring Endemicity

When a ranking exercise based on floral endemicity was conducted for GAB spring wetlands, the Doongmabulla spring complex achieved the highest score overall - a ranking of 1a, and the highest relative score overall (compared to all other GAB discharge spring complexes) (Fensham and Price, 2004). As discussed in Section 2.1.3, if this ranking exercise were to be undertaken again Moses spring would be unlikely to achieve the highest overall score (R. Fensham, pers. comm. 24/07/2012). However, Doongmabulla spring complex does contain a comparatively high number of species endemic to GAB spring wetlands as identified by Fensham et al. in the *Recovery Plan for the community of native species dependant on natural discharge of water from the Great Artesian Basin* (2010):

- *Eriocaulon carsonii* – listed as endangered under both the Queensland NC Act and the Commonwealth EPBC Act, with 15 known populations
- *Eryngium fontanum* – listed as endangered under the NC Act and the EPBC Act, with two known populations
- *Myriophyllum artesium* - listed as endangered under the NC Act, with 15 known populations
- *Peplidium* sp. R.J. Fensham 3380 – now considered to belong to an existing species of Peplidium that is not endemic to GAB spring wetlands (R. Fensham, pers. comm. 24/07/2012)
- *Sporobolus pamelae* – listed as endangered under the NC Act, with six other populations known
- *Gabbia rotunda* – a mollusc that is not listed under either the NC Act or the EPBC Act, but that is considered to be endemic to the Doongmabulla spring complex.

It should be noted that all of the flora species have only been recorded from the Moses spring group. The Joshua spring is highly modified and is now unlikely to provide suitable habitat for any of these species. During the recent visit, none of these species were observed at the Little Moses spring, and the Herbrecs database has no records from this location either. This may be due to the postulated young age of the Little Moses spring group, either because these endemics have not had time to disperse here yet, or because the conditions required for the endemics to survive (lighter soils and grassland/sedgelands) have not had time to develop (R. Fensham, pers. comm. 24/07/2012).

Two fauna taxa recorded from the Doongmabulla spring complex are considered to be endemic – the mollusc *Gabbia rotunda* (only recorded from the Doongmabulla spring complex) and the water mite *Mamersella* sp. AMS KS85341 (Fensham et al., 2010). However, the Doongmabulla wetland is little studied and complex, and there remains the possibility for the discovery of more endemic, spring-adapted species. Indeed, Fensham and Price (2004) suggest there is evidence to support the supposition that spring wetlands with high floral endemicity are also likely to contain endemic fauna. While endemic faunal speciation may not have occurred in the Doongmabulla wetland (as far as is

currently known), it is possible that conditions are driving evolutionary processes, and that selection and divergence may have led to genetically distinct populations in the springs and/or surrounding aquatic habitats (Gotch et al., 2008; Fensham et al., 2011).

2.2.4 Spring Morphologies

For the purposes of this report, the springs observed within the Doongmabulla spring complex have been categorised into five main 'morphologies', outlined below.

Small Artesian Seeps

These were small springs that appeared to be geologically 'new', or with historically low flow, resulting in seeps with no distinct, raised mound, or only a very small one (less than 20 cm) (Plate 2-2). Given the size and flow of these springs, no wetland had formed on the margins, and spring-dependant flora was sometimes absent. These springs potentially provide habitat for frogs, aquatic invertebrates and endemic flora, but were unsuitable for turtles and fish. They sometimes supported *Sporobolus pamelae* tussocks, and are generally surrounded by a scalded margin of bare, sandy loam.

Plate 2-2 Small artesian seeps of the Doongmabulla springs complex

Non-Mounding Artesian Springs

One spring within the Doongmabulla spring complex did not form a mound, but vented from a point within a grove of river red gums (*Eucalyptus camaldulensis* var. *obtusa*) (Plate 2-3). This was the only example of this type observed. It was easily identified by a small channel leading from the outlet to a shallow wetland approximately 100 m long and 60 m wide. This wetland provided valuable habitat for fish, invertebrates, amphibians and flora, including the endemic species *S. pamelae, Myriophyllum artesium*, and *Eriocaulon carsonii* subsp. *orientale*, and the threatened species *Hydrocotyle dipleura* (vulnerable under the NC Act) and *Sporobolus partimpatens* (near threatened under the NC Act). It is situated beside an unnamed first order stream, and is characterised by a sandy alluvial soil.

Plate 2-3 Non-mounding artesian springs with vegetated drainage pathways

Mound Springs

This morphology covers the characteristic mound spring, with an easily distinguishable, raised mound – varying in height from approximately 40 cm to 1.5 m above the ground level. These mounds generally had central pools that were completely congested with dense, floating vegetation. Only one spring was found with an open central pool. Spring discharge was variable, with some mounds feeding large wetlands (as in Plate 2-4). These moderately-sized springs were often connected to nearby drainage lines and creeks, and provided potential habitat for fish, amphibians and turtles. They also indirectly provide habitat for aquatic taxa in the region by contributing to surface water in neighbouring creeks. Associated wetlands were generally saturated and characterised by grassland of *S. pamelae* or mixed sedgelands. The endangered herb *Eryngium fontanum* was found at only two sites, both within this type of wetland and always in low densities. These wetlands were generally located within large patches of bare sandy alluvium.

Plate 2-4 Typical mound springs of the Moses spring group

Modified, High Flow Spring

The spring known as Joshua has been modified to a 'turkey-nest' dam to service the domestic needs of Doongmabulla Station (Plate 2-5). This was the largest spring in both height and discharge. However, it was completely modified from its natural state and did not contain any of the endemic flora associated with the Doongmabulla spring complex, although it was considered to be of high

value to aquatic fauna. Given the depth and permanency of this spring, it is likely that a number of fish, amphibian, turtle and invertebrate species are utilising it, especially during the dry season. It was the only site to contain a declared weed – the outflow channel was choked with the grass *Hymenachne amplexicaulis*, a class two declared weed. Scalded earth was not observed at this site, and it is speculated that this spring may have historically appeared much as the Little Moses spring does today (see below) – only with a much larger flow.

Plate 2-5 Joshua – a large, modified mound spring used for domestic purposes

Incipient Mound Spring

A fifth spring type was observed at the Little Moses spring group, approximately two kilometres to the east of Moses spring group, beside the Carmichael River (closer to the Project (Mine), and downstream from the other spring groups). This morphology has been given the tentative title 'incipient mound spring' based on the theory that a number of characteristics indicate it may be a very young (incipient) spring (as discussed in Section 2.2.2). The main characteristics of this spring that differentiate it from the other spring morphologies and their associated habitats are that:

- It does not contain any of the GAB spring wetland endemics, or other spring associated species such as Hydrocotyle dipleura
- It has a dark, clay loam soil (instead of pale, sandy soil)
- It is located within a woodland of river red gum (instead of grassland, sedgeland or bare ground).

It discharges into a tear-dropped shaped wetland situated in black clay (see Plate 2-6), in what appears to be a former channel of the Carmichael River. This wetland is densely vegetated with a range of sedges, dominated by *Eleocharis pallens.* There are at least two other small (approximately 10 m diameter), circular wetlands in the immediate vicinity with a similar species composition. It is recommended that the differences between the Little Moses and Moses spring groups be investigated further when possible.

Plate 2-6 Little Moses spring group

2.2.5 Spring Vegetation Communities

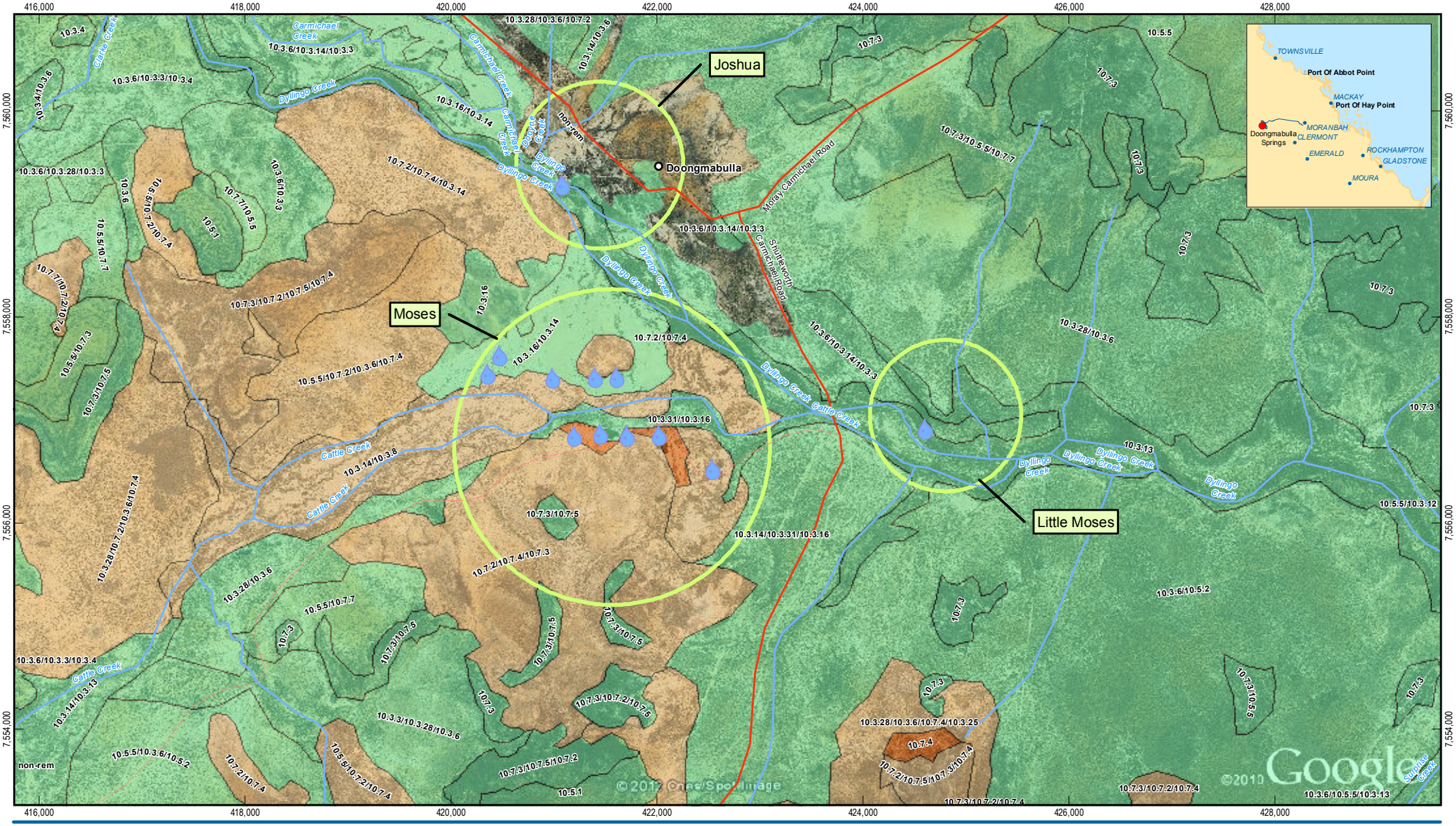
At least five broad vegetation community types were observed within the Doongmabulla spring complex. A regional ecosystem (RE) map (based on the official version 6.1 RE mapping) for the Doongmabulla spring complex is provided as Figure 2-2. All vegetation communities described below have been aligned with a corresponding RE. Any classification given for an RE in this report is according to the *Vegetation Management Act 1999* (the VM Act).

Bare, scalded clay pan

Conspicuous in aerial photography, the approaches to the Moses spring group wetland are dominated in places, particularly to the north, by large bare clay pan. Situated on a flood plain, the clay pan often has a covering of sandy alluvium. It is characterised by a very sparse grass and herb coverage, including the near threatened grass *Sporobolus partimpatens* and low chenopod shrubs. This vegetation community is contained within the 'of concern' RE 10.3.31 (Queensland Herbarium, 2009). This RE is incorporated in the GAB discharge springs community TEC.

Sporobolus pamelae grassland

Within the wetland, the main habitat type present (in terms of area) was grassland generally dominated by *Sporobolus pamelae* (seen in Plate 2.7) on the left, with mixed sedgeland occupying the foreground). This grass, growing to around 1.2 metres tall, has a feathery appearance and is a conspicuous marker for the presence of artesian-fed spring water. This community occasionally contained other grasses such as *Cynodon dactylon, Sporobolus virginicus, Eragrostis speciosa, Pseudoraphis spinescens, Echinochloa inundata, Pennisetum alopecuroides* and *Leersia hexandra.* The vegetation community was generally growing in the saturated zone or very close to it, and it is considered to be an obligate groundwater dependent ecosystem (that is, it requires permanent access to groundwater for survival). Sedges from the sedgeland described below were also present in places, in particular *Fimbristylis dichotoma*. This vegetation community is contained within the of concern RE 10.3.31 (Queensland Herbarium, 2009). This RE is incorporated in the GAB discharge springs community TEC.



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0 500 1,000 1,500 2,000

Meters

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

N

LEGEND

- Homestead
- Springs
- Minor Road
- Track
- Watercourse
- Spring Groups

Regional Ecosystems v6.1

- Endangered - Dominant
- Endangered - Sub-dominant
- Of Concern - Dominant
- Of Concern - Sub-dominant
- Not of Concern
- Clear

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Doongmabulla Wetland Regional Ecosystem Mapping

Job Number 41-25215
Revision A
Date 06-11-2012

Figure 2-2

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Data Source: GHD: Spring Complex/2012, Springs/2012; GA: Watercourses, Roads, Homesteads (2007); DERM: Regional Ecosystems Version 6.1 (2011); DME: Carmichael Mine Site; Google: Imagery (2012). Created by:SB

Plate 2-7 Sporobolus pamelae grassland (left); mixed sedgeland (right)

Mixed sedgeland

Growing alongside this grassland in the wetter areas was a mixed species sedgeland, with a high proportion of grasses in places. This is illustrated in Plate 2-7 – mixed sedgeland occupies the foreground in the left side picture, and the background in the right picture (both taken at the main wetland in the Moses spring group). This sedgeland was from 10 cm to 1 m tall, and was dominated by sedges such as *Cyperus laevigatus, C. polystachyos, C. difformis, Eleocharis cylindrostachys* and *Fuirena umbellata.* Grasses present included *Leptochloa fusca, Isachne globosa, Ischaemum australe* and *Sacciolepis indica.* Other herbs present included the endangered species *Eryngium fontanum, Eriocaulon carsonii* subsp. *orientale* and *Myriophyllum artesium*. This sedgeland was often present in quite small patches within a mosaic dominated by *Sporobolus pamelae* grassland. The mosaic of sedgeland and grassland was frequently observed completely smothering mound springs to the extent that it had formed an impenetrable roof tens of centimetres deep over the central pool. This vegetation community is contained within the of concern RE 10.3.31 (Queensland Herbarium, 2009). This RE is incorporated in the GAB discharge springs community TEC.

In places outside the saturated wetland associated with permanent artesian flows a variant of this sedgeland has formed. This variant is a low sedgeland to approximately 20 cm tall and has a much lower species diversity than the spring communities, generally being dominated by *Fimbristylis dichotoma.* It occurs on the margin of larger springs, and sometimes has very sparse, very small mound springs located within it, which may host a single *S. pamelae* tussock each. The herb *Hydrocotyle dipleura* is common, and there is also a small population of emergent *Livistona lanuginosa,* a vulnerable species of palm. Both variants of this sedgeland are considered to be obligate groundwater dependent communities.

Coolibah/river red gum woodland and open woodland

Directly fringing bare clay pan, and in some places with mound springs located within it, was woodland to open woodland dominated by *Eucalyptus coolabah* and *E. camaldulensis* var. *obtusa.* This is the dominant woody vegetation type present along the braided channels of Cattle Creek, and surrounding the Joshua and Little Moses spring groups. This woodland is generally characterised by a sparse to mid-dense shrub layer of species such as *Carissa ovata, Flindersia dissosperma, Geijera parviflora, Acacia excelsa* and *Melaleuca nervosa*. However, in places (as at Little Moses) the woodland was grassy with a very sparse shrub layer, the ground layer being dominated by short grasses (at least, in the vicinity of the springs) such as freshwater couch (*Cynodon dactylon*).

This vegetation community is contained within the least concern RE 10.3.14. Both *E. coolabah* and *E. camaldulensis* are considered facultative groundwater dependant, that is, not permanently dependant on access to groundwater, but adapted to periodic access as occurs on broad floodplains (Eamus et al., 2006). Therefore, this community is likely to be a facultative groundwater dependant ecosystem, although in this case, parts of this community are likely to have permanent access to groundwater supplies associated with the springs.

Weeping paperbark forest

Located at only one spot along the southern boundary of the Moses spring group are three small mono-specific stands of *Melaleuca leucadendra*. These stands are within the saturated zone of the wetland, and have a sedge-dominated ground layer (see Plate 2-8). This is considered to be an obligate groundwater dependant ecosystem. This vegetation community is contained within the of concern RE 10.3.31.

Plate 2-8 Weeping paperbark forest (left) and peppermint box open woodland (right)

Peppermint box open woodland

Fringing the Moses spring group, and in some cases directly abutting wetland, is an arid habitat characterised by low open woodland of *Eucalyptus persistens* over a grassy ground layer dominated by *Triodia longiceps* and *T. pungens* (see Plate 2-8). This community is located on low, undulating remnant sandstone surfaces that terminate in an abrupt, short scarp, sometimes metres from active mound springs. This community corresponds with the least concern RE 10.7.2, and is not groundwater dependant.

Reid River box woodland

The main habitat type fringing the Doongmabulla spring is *Eucalyptus brownii* woodland and open woodland on undulating plains with sandy alluvial soils. This vegetation community covers vast areas within the region. It has a very sparse shrub layer dominated by species such as *Petalostigma pubescens, Melaleuca nervosa* and *Eremophila mitchellii*, and a very sparse grassy ground layer. This community meets the description of the least concern RE 10.3.6. As for the peppermint box open woodland, this community is not groundwater dependant.

2.2.6 Habitat Condition

In general, habitats within the Doongmabulla wetland exhibited minor disturbance. While the wetland is exposed to introduced and native wildlife, minimal animal impacts were noted for most sites. Cattle trampling was observed only at Little Moses spring group (Plate 2-9 left).

The greatest damage to the wetlands was caused by feral pigs. Pigs were evident in many regions, with pug marks frequently encountered, and at one time a troupe of at least 20 animals (mostly juveniles) was observed. The mounds themselves did not seem to be utilised by either pigs or cattle. However, parts of some wetlands were highly disturbed by pigs wallowing and foraging (Plate 2-9). These actions degrade and reduce available habitat for aquatic organisms by changing the water quality and physically removing cover and food resources.

Plate 2-9 Damage to wetlands by pigs (left) and cattle (right)

Most sites were also free of weeds, although the larger mound springs in the Moses spring group contained the tall aquatic grass *Phragmites australis*. Although native, species such as *P. australis* can dominate wetlands such as these at the expense of species diversity. In addition, this species has a high transpiration rate, and if it becomes common, can increase the rate of moisture loss to the atmosphere, with negative consequences for the availability of surface water in the wetland (Fensham et al., 2010). However, *P. australis* was only present at two mound springs in the one wetland (the largest in the Moses spring group), and then only in low densities.

Outside of the wetland, the class two declared weed *Parthenium hysterophorus* was common. This weed does not grow in saturated ground and is not considered a threat to the wetland. It is well established in the surrounding ground and is not likely to become a greater problem than it presently. In addition, the class two weed rubber vine (*Cryptostegia grandiflora*) was present along Cattle Creek. This weed was growing in very low densities, as scattered individuals. However, it is growing near mound springs within the Moses spring group, and is considered a potential future threat.

Joshua spring group was the most impacted, and is completely altered from its natural state. It now consists of a single turkey's nest dam and two associated scrapes, with limited habitat value. The overflow channel for the spring (which carries a significant volume of water) is infested with the grass *Hymenachne amplexicaulis,* a class two declared weed. Located this far up-catchment, this infestation is a major concern – if it becomes established in the Carmichael River it has the potential to infest large areas downstream.

2.3 Flora and Fauna

2.3.1 Flora Species of Conservation Significance

All listed threatened and near threatened species identified in desktop searches as potentially occurring within the Doongmabulla spring complex were located. All species were present in the Moses spring group, none were found at the Joshua spring, and only one was found at the Little Moses. These species are discussed below.

Eriocaulon carsonii

Eriocaulon carsonii (salt pipewort) is a tiny aquatic herb growing in shallow water in permanent GAB discharge spring wetlands (see Plate 2-10). It has been recorded from 22 spring complexes, including Doongmabulla (Fensham et al., 2010). Three subspecies have been described – the subspecies found at Doongmabulla (within the Moses spring group) is *E. carsonii* subsp. *orientale.* It was observed at all of the wetlands within the Moses spring group, often growing in dense floating carpets (although the water was generally 10 cm deep at most). These mats can be seen clearly in Plate 2-10 on the right, and in the foreground at the foot of *Sporobolus pamelae* in Plate 2-13. *Eriocaulon carsonii* is listed as endangered under the EPBC Act and the NC Act. This species was predicted to be present by the DSEWPaC Protected Matters tool, and there are previous records from Herbrecs. The Doongmabulla Nature Refuge is believed to contain the only population of this species located within a protected area (Fensham et al., 2010).

Plate 2-10 Eriocaulon carsonii (left) and growing in mats (right)

Eryngium fontanum

Eryngium fontanum (blue devil) is an erect herb in the family Apiaceae growing to 80 cm tall (see Plate 2-11). It occurs on floodplains associated with GAB discharge spring wetlands and is found in only two spring complexes, one of which is the Doongmabulla spring complex (Fensham et al., 2010). It is listed as endangered under the EPBC Act and the NC Act. Of all of the species of conservation significance located at the Doongmabulla spring complex, it was the rarest, only being observed growing in dense sedgeland and *Sporobolus pamelae* grassland in three locations, within the largest wetlands within the Moses spring group. Fensham et al. (2004) estimates there are 10,000 individuals at Doongmabulla (making it the largest population of the species), and that only 20% of the Moses discharge spring wetland is suitable habitat for this species. All observations made during this survey were from the southern margin of the Moses spring group. This species was predicted to be present

by the DSEWPAC Protected Matters tool, and there are previous records from Herbrecs. It is believed that the Moses spring group contains the only population of this species protected under any type of legal agreement (in this case, a Nature Refuge Agreement).

Plate 2-11 Eryngium fontanum (left) and Hydrocotyle dipleura (right)

Hydrocotyle dipleura

Hydrocotyle dipleura is a perennial prostrate herb with kidney-shaped leaves (see Plate 2-11) and a specialised habitat, found only on the margins of GAB springs in saline soils, beyond the saturated zone (Bean and Henwood, 2003). It has been recorded from south west of Cunnamulla, at Moses, and at another artesian spring to the west of Moses (Australian Virtual Herbarium, 2012).

This species was found along the margins of all of the wetlands within the Moses spring group, including isolated mounds situated many hundreds of metres from other populations, often in association with *Fimbristylis dichotoma*. *Hydrocotyle dipleura* is listed as vulnerable under the NC Act. It is not listed under the EPBC Act. Previous records for this species exist from the Moses spring group in Herbrecs.

Livistona lanuginosa

Livistona lanuginosa is a palm of the 'cabbage tree' variety, growing to 18 m tall, and endemic to the Burdekin River catchment (Dowe and Jones, 2011). During this survey it was observed growing in a loose stand of approximately 15 individuals at all stages of maturity (most were almost at full height) near the south east corner of the Moses spring group (see Plate 2-12), and as a few small individuals at the Little Moses spring group. *Livistona lanuginosa* is listed as vulnerable under the EPBC Act and NC Act. No previous records for this species exist from the Doongmabulla station area, and it was not predicted to occur by the DSEWPaC Protected Matters search tool. It is considered likely that this palm may be found as scattered individuals throughout the Carmichael River catchment (John Thompson, pers comm., 29 June 2012). The role of groundwater in the distribution of this species is not known, and there is no information to indicate it may be an obligate groundwater dependant species.

Plate 2-12 Livistona lanuginosa

Myriophyllum artesium

Myriophyllum artesium is a creeping, mat-forming aquatic herb growing to 15 cm high (see Plate 2-13), and restricted to wetlands associated with artesian springs and their drains. It is a Queensland endemic, and is known only from 17 spring complexes (Halford and Fensham, 2001). This species was a common constituent of all the wetlands within the Moses spring group, growing in shallow pools. It is listed as endangered under the NC Act, but has no listing under the EPBC Act. Records for this species from the Moses spring group exist in Herbrecs.

Plate 2-13 Myriophyllum artesium (left) and Sporobolus pamelae (right)

Sporobolus pamelae

Sporobolus pamelae is a perennial grass to 1.2 m tall with broad panicles (Simon, 1993). The type specimen was collected from the Moses spring group, and it is now known to be present from at least seven other GAB discharge spring wetland sites within Queensland (Australian Virtual Herbarium, 2012a). This grass was the most conspicuous element in the grasslands associated with the wetland areas within the Moses spring group, and was a useful indicator of the presence of artesian water at or near the surface (see Plate 2-13). It grows in shallow water and on dry land along the margins of the wetland, and is often found growing over even the largest mounds. *Sporobolus pamelae* is listed as endangered in the NC Act, but has no listing under the EPBC Act. It is recorded for this spring group in Herbrecs.

Sporobolus partimpatens

Sporobolus partimpatens is a perennial grass growing to 60 cm tall with a 'rat tail' type panicle (Simon, 1993). It has been recorded from at least seven other sites, all artesian springs within Queensland (with the exception of one record from a footpath in the town of Barcaldine) (Australian Virtual Herbarium, 2012b). It was commonly found on the edge of most of the wetlands within the Moses spring group, growing in scalded or otherwise bare ground, or in sparse grassland. This species is listed as near threatened under the NC Act (it has not listing under the EPBC Act), and has been recorded previously at the Moses spring group in Herbrecs.

2.3.2 Terrestrial Fauna

A number of species of terrestrial fauna of conservation significance were predicted to be occur within the buffered search area. These species are listed below. If a species was observed during the field inspection, this is noted. However, the objective of the field inspection was to record the aquatic species present, and not to survey terrestrial fauna. Therefore, any sightings were incidental only. Assessments of likelihood of occurrence were made using the following guidelines:

- Likely to occur – a species is considered to be likely to occur if:
  - it has been recorded from the Study Area previously
  - its recorded distribution encompasses the Study Area
  - habitat suitable for the species is present within, or adjacent to, the Study Area
- Unlikely to occur – a species is considered to be unlikely to occur if:
  - its recorded distribution does not encompass the Study Area
  - habitat suitable for the species is not present within, or adjacent to, the Study Area

Ornamental snake (*Denisonia maculata*)

The ornamental snake's distribution is confined to the northern brigalow belt bioregion, where it is typically found in areas of brigalow, riverside woodland and open forest on natural levees (DSEWPaC, 2011b). Habitats features known to be utilised by the species include cracking clay and sandy substrates where water pools and frogs (its main food source) are present. Although there was no brigalow present at the Doongmabulla spring complex, the presence of permanent water and sandy substrates are likely to provide a perennial food source for the ornamental snake, and as the Doongmabulla wetland occurs within the recorded distribution for this species, it is considered that it is *likely to occur*. This species is listed as vulnerable under the EPBC Act and the NC Act.

Yakka skink (*Egernia rugosa*)

The yakka skink is endemic to dry sclerophyll open forests, woodlands and rocky areas of central and eastern Queensland, where it lives in communal burrow complexes, often taking refuge among low vegetation or under heaped dead timber, logs, rocks and in deep rock crevices (Wilson, 2005; DSEWPAC, 2011c). The Doongmabulla wetland contains woodland and rocky areas, and is located within the distribution of this species. Therefore, it is considered that it is *likely to occur* at the Doongmabulla wetland. The yakka skink is listed as vulnerable under the EPBC Act and the NC Act.

Squatter pigeon (*Geophaps scripta scripta*)

The squatter pigeon (southern) is listed as vulnerable under the EPBC Act and the NC Act. It has not been recorded previously, but was observed on numerous occasions during the GHD field inspection of Doongmabulla spring complex and appears to be a common constituent of the bird assemblage in the region. It favours open habitats in the vicinity of water and the Doongmabulla wetland is likely to offer perennial habitat of high quality (DSEWPaC, 2011g). Therefore, this species is *confirmed present.*

Greater bilby (*Macrotis lagotis*)

The greater bilby is listed as vulnerable under the EPBC Act and endangered under the NC Act. This species was historically recorded through much of arid and semi-arid Australia. However, it is now restricted to desert areas of central Australia. In Queensland, the species is known from a small area between Birdsville and Boulia in the south west of the state (Van Dyck and Strahan, 2008). The study area and surrounding landscape is not within the current known distribution of the species, and there are no records for this species from the Doongmabulla spring complex in the Wildlife Online database. Therefore, it is considered that the greater bilby is *unlikely to occur* at the Doongmabulla spring complex.

Koala (*Phascolarctos cinereus*)

The koala is listed as vulnerable within Queensland under the EPBC Act (it is only listed as vulnerable under the NC Act in the Southeast Queensland bioregion). Koalas utilise sclerophyll woodland that contain preferred food trees across much of central and south east Queensland, in particular riparian corridors (Van Dyck and Strahan, 2008). The Wildlife Online report for the Doongmabulla area has one record for the koala. It is likely that koalas are still present in the area and may utilise the habitat at the Doongmabulla wetland, which includes sclerophyll woodland. Therefore, it is considered that the koala is *likely to occur* at the Doongmabulla wetland.

Black-throated finch (*Poephila cincta cincta*)

The black-throated finch (southern) is listed as endangered under the EPBC Act and the NC Act. There has been one previous record from the site, as recorded in Wildlife Online. However, this species was not observed during the Doongmabulla wetland inspection. Large flocks of black-throated finches have been recorded by GHD on the Project (Mine) nearby, and it is considered likely that this site will host a population, particularly given the large areas of Reid River box woodland and coolabah woodland adjacent to permanent water provided at the Moses spring group. In addition, black faced woodswallows (*Artamus cinereus*) were seen frequently, and this species is considered an indicator for the presence of black-throated finches in suitable habitat (DEWHA, 2010). Therefore, it is considered that this species is *likely to occur* at the Doongmabulla wetland.

Australian painted snipe (*Rostratula australis*)

The Australian painted snipe is listed as vulnerable under the EPBC Act and the NC Act. This species has not been previously recorded, and was not observed during the Doongmabulla field inspection. This species has a scattered distribution across eastern and northern Australia, utilising shallow freshwater wetlands. Such wetlands may include swamps, claypans, and inundated / waterlogged grassland (Marchant and Higgins, 1993). Therefore, although this species is naturally uncommon, it is possible that individuals may utilise the spring wetlands of Doongmabulla from time

to time. As this area is within the recorded distribution of the Australian painted snipe, it is considered that this species is *likely to occur* at the Doongmabulla wetland.

2.3.3 Fish

As the Doongmabulla spring complex occurs in an upper, arid region of the Burdekin River catchment, fish species are expected to be limited by the environmental and geographical factors associated with inland locations. Fish can be broadly categorised by their patterns of dispersal and migration, according to the following terms:

- Catadromous**:** species that may spend much of their lives in freshwater before migrating as adults to the sea or brackish/estuarine areas to spawn
- Amphidromous: species that migrate between freshwater and the sea at some stage in their life cycle but not for the purposes of reproduction
- Marine vagrant/facultative freshwater: marine or estuarine breeding species that are not dependent on access to freshwater though may spend limited to substantial time in freshwater, usually lower reaches.
- Potadromous: species which undertake breeding or dispersal migrations wholly within freshwater
- Sedentary: species that do not actively or directionally migrate, which can fulfil their entire life cycle within a single wetland, pool or river reach

A total of 18 fish species were predicted to occur in surface waters either within, or adjacent to the Doongmabulla spring complex (Table 2-1). No surveys for fish were carried out in the GHD field investigation. In previous studies of fish communities in the Project Area, 11 of these species were recorded, namely:

- Agassiz's glassfish (*Ambassis agassizii*)
- Midgley's carp gudgeon (*Hypseleotris* species 1)
- Purple-spotted gudgeon (*Mogurnda adspersa*)
- Sleepy cod (*Oxyeleotris lineolata*)
- Eastern rainbowfish (*Melanotaenia splendida splendida*)
- Hyrtl's tandan (*Neosilurus hyrtlii*)
- Spangled perch (*Leiopotherapon unicolor*)
- Barred grunter (*Amniataba percoides*)
- Flyspecked hardyhead (*Craterocephalus stercusmuscarum*)
- Western carp gudgeon (*Hypseleotris klunzingeri*)
- Bony bream (*Nematalosa erebi*)
- The details of this study can be found in Volume 4, Appendix O (Aquatic Ecology Report).

Table 2-1 Biological and ecological characteristics of predicted fish species within or adjacent to the Doongmabulla Springs

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.	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. Aquatic root masses may be important for spawning.	Potamodromous – Undertakes local dispersal and colonisation movements. Entire life-cycle (including spawning) occurs in freshwater.	Increasing water temperature and elevated flows are likely to stimulate movement. This species can tolerate temperatures in excess of 30°C. Has been collected over a fairly large range of physicochemical conditions.
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 and is relatively widespread in eastern Australian coastal and inland drainages.	Well-vegetated areas in rivers, creeks, swamps and ponds; generally in areas of little or no flow. Macrophytes and submerged marginal vegetation preferred for spawning. May be found in all freshwater habitats in the investigation corridor.	Potamodromous - Larger fish move upstream during late autumn and spring – possibly in response to increased flows. A freshwater species that does not require access to estuarine or marine environment at any stage of life cycle.	Tolerant to a wide range of physicochemical conditions (temperature, dissolved oxygen (DO), pH and salinity). Increases in water temperature and elevated flows are believed to be cues for movement.

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
Clupeidae	Bony bream* (*Nematalosa erebi*)	Known to occur throughout the Burdekin Catchment. Widespread species throughout Australia and found in most major basins of Queensland.	A wide array of habitats, including salt lakes, rivers, billabongs, impoundments and streams. Requires well-oxygenated waters. Shallow, still habitats required for spawning.	Potamodromous – Adults and juveniles move upstream for dispersal. A freshwater species that does not require access to estuarine or marine environment at any stage of life cycle.	Is tolerant of a range of environmental conditions including high turbidity. However, is highly sensitive to reductions in dissolved oxygen.
Eleotridae	Western carp gudgeon* (*Hypseleotris klunzingeri*)	Known to occur throughout the Burdekin Catchment and in coastal drainages south to central New South Wales.	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.	Possibly potamodromous – Move upstream during the wet season.	Tolerant of a wide range of physicochemical conditions. Typically a hardy species.

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
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 and is found in most coastal drainages of eastern Australia.	Particularly common in wetlands and swamps. Found in a variety of habitats, including coastal streams, rivers, floodplains and impoundments. It is a benthic species that is often in direct contact with the substrate. Hard surfaces near the substrate are preferred for oviposition.	Potamodromous – Undertakes local dispersal and colonisation movements. Spawning peaks between September and January.	Regarded as a hardy species that can tolerate poor water quality. The species has been collected in heavily degraded habitats. Present in inland desert drainages suggesting a high temperature. Also tolerant of highly turbid environments. Increased water temperature and day length are suspected as cues for movement.
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 and occurs in most coastal drainages of eastern Australia from Cape York Peninsula to northern New South Wales.	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.	Sedentary – Undertakes small-scale movements, but is not considered potamodromous. Possibly able to climb hard, wet surfaces around waterfalls.	Tolerant of a wide range of physicochemical conditions, but prefers lower turbidity.

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. Species has been translocated above Burdekin Falls and now widely distributed in the upper catchment.	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.	Sedentary – A relatively sedentary species that does not undergo any specific migration or dispersal events.	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, although eggs are sensitive to oxygen depletion Wide thermal tolerance (15°C to 38°C). Not tolerant of saline conditions or pH values that deviate widely from neutral.
Eleotridae	Flathead gudgeon (*Philypnodon grandiceps*)	Recorded in the upper Burdekin River though not detected during surveys. Occurs in coastal catchments from central Queensland to south-eastern Australia.	Small coastal streams, rivers and floodplain habitats. Also found in saline lakes and coastal wetlands. Generally found in low elevations. Commonly found in riffles. Prefers coarse substrates with macrophytes, roots, undercuts, leaf litter.	Amphidromous – A predominantly freshwater species where access to estuarine or marine environments is not an essential component of the life history. However, reported to migrate to higher salinities to kill freshwater ectoparasites.	Tolerates low dissolved oxygen, mild acidity and higher salinity. Prefers lower turbidity, but is thought to tolerate higher levels. Sensitive to habitat degradation.

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
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 and the east coast of Queensland.	A habitat generalist that occurs in a wide array of still to slow-flowing freshwater habitats. Includes creeks, swamps, wetlands, rivers and impoundments. Aquatic vegetation and root masses preferred for oviposition.	Potamodromous – Rising flows and increasing water temperature are suspected as cues for movement.	*M. s. splendida* tolerates a large range of water quality conditions. The species can tolerate moderate disturbance such as reductions in riparian canopy. Will not survive abrupt changes in salinity. Rising flows cues for movement.
Percichthyidae	Golden perch[2] (*Macquaria ambigua*)	Deliberately and accidentally translocated into the Burdekin Catchment and has been widely translocated into eastern Australian rivers.	Inhabits rivers, creeks, billabongs and lakes. Favours deeper, slow-flowing, turbid habitats with an abundance of in-stream debris and shade.	Potamodromous – Movement recorded in the Fitzroy River (through the Fitzroy Barrage) during spring and summer months. Migration seems to be in association with increased hydrological connectivity.	Tolerant of a wide range of temperatures and low oxygen levels. Can move between freshwater and saline environments. Tolerant of high turbidity levels. Spawning and recruitment triggered by increased flows and water temperatures above 23° C.

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
Plotosidae	Black catfish (*Neosilurus ater*)	Widespread and abundant throughout the Burdekin Catchment, occurring across northern Australia.	A benthic species that prefers still/slow flowing waters in streams and rivers. Also occurs in wetlands, pools, and slow-flowing tributaries and side-channels of rivers. Benthic species in close association with substrate. Spawning occurs in riffles.	Potamodromous – Migrations upstream thought to coincide with spawning at the outset of the wet season (January to February). Downstream migration of adults and juveniles post-spawning poorly understood.	Prefers higher temperatures of between 21° C and 34° C. Tolerates a wide range in dissolved oxygen, pH and turbidity, but is sensitive to saline conditions. The species has barbels which allow the species to forage in elevated turbidity and low light conditions.
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 and also Australia.	A benthic species that occurs in most freshwater habitats above estuarine reaches. Tributary streams and gravel substrates may be important for spawning.	Potamodromous – Upstream migrations from dry season refugia thought to coincide with spawning.	The species has barbels which allow the species to forage in elevated turbidity and low light conditions. Prefers warm waters and is able to withstand hypoxic conditions.
Plotosidae	Soft-spined catfish[1] *Neosilurus mollespiculum*	Endemic to the Burdekin Catchment with a patchy distribution. Reported in the Belyando River sub-catchment.	A benthic species that occurs in most freshwater habitats above estuarine reaches. Tributary streams and gravel substrates may be important for spawning.	Specific movement patterns are not understood for this species.	Prefers higher temperatures of between 21°C and 34°C. Tolerates a wide range in dissolved oxygen, pH and turbidity, but is sensitive to saline conditions. The species has barbels which allow the species to forage in elevated turbidity and low light conditions.

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
Plotosidae	Rendahl's catfish (*Porochilus rendahli*)	Widely distributed throughout the Burdekin Catchment and patchily distributed across northern Australia.	A benthic species inhabiting river channels and tributaries generally containing muddy substrate.	Patterns of movement and dispersal are unknown, although spawning migration to muddy lagoons has been recorded.	Like other species of catfish can tolerate highly turbid water. Well-developed tolerance to hypoxia. Found only in warmer waters.
Terapontidae	Barred grunter* (*Amniataba percoides*)	A widely distributed, common, generalist species that occurs across coastal (and some inland) drainages of mid to northern Australia.	Benthic species that occurs in still to fast-flowing water. Collected in areas with a dominant substrate of sand. Not as associated with bank-side structure as other terapontids.	Sedentary – Some upstream movement recorded within catchments, but not considered potamodromous.	Tolerant of highly variable temperature and pH. Recorded in freshwater only. Can tolerate turbidity, but prefers clearer waters. Preference for fast-flowing riffle/run habitat suggests need for well-oxygenated water.
Terapontidae	Spangled perch* (*Leiopotherapon unicolor*)	Recorded in the Study Area during field survey. Found in the Carmichael River. Widely distributed throughout the Burdekin Catchment and Australia.	A generalist species that occurs in most permanent and temporary freshwater habitats including billabongs, bores, impoundments, rivers and streams. Non-flowing, shallow habitats with soft substrate are preferred for spawning.	Potamodromous – Depending on locality moves upstream or downstream within the freshwater environment to spawn. Spawning migrations coincide with the wet season (October – April). This species may also undertake substantial movements away from dry season habitats as they recede. Very adept at colonising newly inundated habitat.	Highly tolerant of environmental variability. Can tolerant saline conditions but rarely encountered in estuarine areas. Despite being a visual predator can survive in turbid inland drainages.

Family	Species	Distribution with respect to the Study Area	Habitat preferences	Movement behaviour	Environmental tolerance
Terapontidae	Small-headed grunter[1] (*Scortum parviceps*)	Endemic to the Burdekin Catchment though patchily distributed. Most common in the main channel of the Burdekin River and larger south-west tributaries.	Most common in riverine reaches. Thought to prefer deep (>1 m) habitats with a sand, fine gravel substrate and little or no flow.	Dispersal patterns are not understood for this species.	Unlikely to tolerate salinity. Prefers warmer temperatures. Found in clear and turbid waters.
Toxotidae	Seven-spot archerfish (*Toxotes chatareus*)	Widely distributed in the Burdekin River and also across northern Australia. 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.	Sedentary – Considered to be sedentary, although some evidence of passive dispersal of juvenile individuals following large flows. Upstream migrations were performed soon after.	Susceptible to poor water quality. Tolerant of higher salinities. Can survive in turbid waters.

* - Species recorded during field surveys

[1] endemic species; [2] translocated species

Habitat and distribution information sourced from Allen et al., (2002), Pusey et al., (2004) and Carter & Tait (2008).

Due to the distance upstream, no marine vagrants were predicted to occur within or adjacent to the Doongmabulla spring complex. A single amphidromous species (the flathead gudgeon) is expected to occur at the Moses spring group. The majority of predicted species were identified as catadromous (migrating within freshwater reaches) or sedentary – behaviours that are largely adapted to the unpredictable, ephemeral hydrological connectivity of inland reaches of arid Australia.

Due to the varying morphologies of each spring, few were considered to be directly habitable by aquatic macro-fauna communities. No fish or turtles were observed within the mound themselves, although a small school of eastern rainbowfish was observed in shallow pools of the surrounding wetland (within the Moses spring group).

While the Doongmabulla spring complex may provide a relatively small area for fish, the value of these springs is better realised in a more indirect way. From many of the springs, surface flows were sufficient to create wetlands around the point source. Additionally, surface waters in some areas drained directly into the neighbouring waterways. From this perspective, these springs maintain perennial surface water (this was confirmed in personal communication with the owner of the Doongmabulla station). This surface water may be particularly significant for aquatic communities in the region by providing refugial habitat during seasonal conditions and periods of drought.

Refugial habitats are of high value in arid regions of Australia, as the variable climate and seasonal precipitation typically results in surface waters receding, or evaporating entirely. The aquatic communities in these environments (typified in the Burdekin River catchment) rely on the persistence of such refugial habitats. For this reason, the Doongmabulla spring complex is likely to provide important habitat in the springs, wetlands and adjacent waterbodies.

2.3.4 Amphibians

Desktop assessments of species recorded within or adjacent to the Doongmabulla spring complex identified four frog species in the search area, namely the:

- Eastern snapping frog (*Cyclorana novaehollandiae*)
- Bumpy rocketfrog (*Litoria inermis*)
- Striped rocketfrog (*Litoria nasuta*) (observed during the field inspection)
- Ornate burrowing frog (*Platyplectrum ornatum*)

None of these species are listed as being of Commonwealth, state or regional significance. It should also be noted that a total of 11 amphibian species (included the above listed) were recorded during surveys performed for the EIS in the Project Area, the specific details and methodologies of which are available in Volume 4 Appendix N1 (Terrestrial Ecology Report) of the EIS.

Frogs were observed or heard at many of the springs. As was expected, frogs appeared to be absent from small springs with little or no surrounding wetland (that is, little or no suitable habitat). Overall, the Doongmabulla spring complex, and in particular the Moses spring group, provide abundant suitable habitat for frogs in the region. The density of vegetation and abundance of perennial water makes the Doongmabulla Springs and associated wetlands an important amphibian habitat in an otherwise arid environment.

2.3.5 Aquatic Reptiles

No reptiles were listed in any of the desktop searches. However, the distribution of several freshwater turtle species spans the Doongmabulla spring complex (Cann 1998; Cann 2008). These species are as follows:

- Cann's long-necked turtle (*Chelodina canni*)
- Snake-necked turtle (*Chelodina longicollis*)
- Irwin's turtle (*Elseya irwini*)
- Saw-shelled turtle (*Wollumbinia latisternum*)
- Krefft's river turtle (*Emydura macquarii krefftii*)

None of these turtle species are listed as being of conservation significance 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 DERM '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, Volume 4 Appendix O (Mine Aquatic Ecology Report) of the EIS. The specific habitat requirements for Irwin's turtle and the saw-shelled turtle were not observed within or near to the Doongmabulla spring complex, and consequently these species are not expected to occur in the complex.

Potential habitat was observed for Cann's long-necked turtle, snake-necked turtle and Krefft's river turtle. While turtles were not observed during surveys of the Doongmabulla Springs, their presence is likely. Both the snake-necked turtle and Krefft's river turtle were observed in previous surveys in the Project Area. Further details of this study can be found in Volume 4, Appendix O (Aquatic Ecology Report) of the EIS.

These three species occur in off-channel aquatic environments, including billabongs and swamps. While surface water in the wetlands was generally shallow (<0.05 m), some deeper pools were present. Of greater relevance to turtles were the nearby drainage lines, creeks and billabongs, which were supplemented by flows from the springs. Similarly to fish, turtles rely on perennial water during the dry season. For this reason, the Doongmabulla spring complex is likely to be of indirect importance in maintaining viable habitat for freshwater turtles in the region.

2.3.6 Aquatic Invertebrates

Previous surveys of aquatic invertebrates in the Project Area identified numerous families of invertebrates. The details of this study can be found in Volume 4, Appendix O (Aquatic Ecology Report) of the EIS. Overall, the Doongmabulla Springs provides a diverse range of habitat for aquatic invertebrates, including freshwater mussels (Plate 2-14), crayfish, freshwater crabs and various insects.

Plate 2-14 Freshwater mussel shells of *Velesunio* sp. from a pool beside a mound spring

The diversity and abundance of aquatic invertebrates is largely determined by the habitat structure and type (for example clay substrates with root masses) and the availability of foraging material (for example leaf litter and other organic detritus). Suitable habitat was observed within the springs themselves, within the wetlands, and also in adjacent waterways. Substrates ranged from sand (suitable for freshwater mussels) to clays (preferred by many aquatic insects), and were mostly provided with abundant organic matter utilised by invertebrates for shelter and as a food source. The perennial flows of the Doongmabulla spring complex provide constant habitat for aquatic invertebrates, and it is likely that this site supports a diverse invertebrate community. Of note are the two endemic invertebrate species previously recorded at the Doongmabulla wetland, the mollusc *Gabbia rotunda* (endemic to this wetland) and the water mite *Mammersela* sp. AMS KS85341 (endemic to GAB spring wetlands) (Fensham et al., 2010).

3. Conclusion

The Doongmabulla spring complex contains three spring groups, Little Moses, Joshua and Moses. Of these Joshua has the highest flow but has been highly modified, and now comprises a turkey's nest dam providing water for the Doongmabulla station homestead and for livestock. However, its considerable flow makes a perennial contribution to the Carmichael River channel.

The Moses spring group is almost entirely intact, with the exception of impacts from cattle and pigs. It straddles Cattle Creek and comprises approximately 30 vents or springs spread over 2.5 km and forming a wetland of approximately 3.5 ha.

The Little Moses spring group is located to the east of the Moses spring group. Little Moses differs from the main Moses spring group in being much smaller (it has approximately two vents) and being located within a woodland with different soils. It is postulated that this spring group may be much younger than the springs of the Moses spring group.

The Doongmabulla spring complex is located within the Doongmabulla Nature Refuge. Much of the Moses spring group in particular is a unique ecological site that can fairly be described as one of Queensland's biodiversity 'hotspots'. In a study comparing all GAB spring wetland communities based on the level of endemicity, the Doongmabulla spring complex was given the highest score of all sites compared (although it now considered this rating is no longer valid), and a rating of 1a. Its values can be summarised as follows, based on historical records and from observations made during the site inspection:

- Four species of flora listed as endangered under either the EPBC Act or the NC Act (or both, in two cases), all of which were confirmed in the GHD site inspection:
  - *Eriocaulon carsonii* (listed under both Acts) – a GAB spring endemic
  - *Eryngium fontanum* (listed under both Acts) – found only at Moses spring group and one other
  - *Myriophyllum artesium* (listed under the NC Act) – a GAB spring endemic
  - *Sporobolus pamelae* (listed under the NC Act) – a GAB spring endemic
- One species of fauna listed as endangered under both the EPBC Act and the NC Act – the southern black-throated finch subspecies (*Poephila cincta cincta*) (not confirmed in the GHD site inspection, but for which a historical records exists)
- Two vulnerable flora species, one listed under both the EPBC Act and the NC Act, both of which were confirmed in the GHD site inspection:
  - *Hydrocotyle dipleura* (listed under the NC Act) – a GAB spring endemic
  - *Livistona lanuginosa* (listed under both Acts)
- Two fauna species listed as vulnerable, one listed under both the EPBC Act and the NC Act (only the former species was confirmed during the GHD site inspection – the latter species is recorded in Wildlife Online):
  - Squatter pigeon (*Geophaps scripta scripta*) (listed under both Acts)
  - Koala (*Phascolarctos cinereus*) (listed under the EPBC Act)
- One species listed as near threatened under the NC Act – *Sporobolus partimpatens*, – a GAB spring specialist (confirmed in the GHD site inspection)

In addition, there is one species (not listed as being of conservation significance) historically recorded that is known to be endemic to the Moses spring group alone - *Gabbia rotunda*, a mollusc.

A species of water mite, *Mamersella* sp. AMS KS85341, known to be endemic to GAB spring wetlands, is also recorded historically from the Moses spring group.

In addition, the wetland is recognised as the endangered threatened ecological community 'The community of native species dependant on natural discharge of groundwater from the Great Artesian Basin' under the EPBC Act.

Collectively, the springs of the Doongmabulla spring complex are estimated to have a flow rate of 1.35 ML/day. Much of this flow proceeds directly to the Carmichael River, contributing to its baseline flow. The spring complex also provides habitat for a wide range of least concern species of flora and fauna.

In general, the habitats present within the Moses spring group are intact and in good ecological condition, with the following comments:

- Some of the wetlands exhibit damage from pig-rooting and grazing, and pigs were noted in large groups on at least one occasion.
- Cattle damage was observed only at the spring on the eastern outskirts of the Doongmabulla Nature Refuge. However, it is unclear whether this spring is a GAB spring and what its relation to the main Moses spring group is, if any.
- The main weed of note observed in the Moses spring group was parthenium (a class two weed), but this was only present around the margins in very sparse densities, and not in the wetland areas. The class two weed rubber vine (*Cryptostegia grandiflora*) is also present, as scattered individuals along Cattle Creek.
- The native species *Phragmites australis,* which can become troublesome in GAB spring wetlands, was present in the Moses spring group wetlands, but in very low numbers.
- Joshua spring has a dense infestation of the exotic aquatic grass *Hymenachne amplexicaulis,* a class two weed; however this was contained within an overflow channel. This weed does not appear to have spread elsewhere. A species of *Typha* was also observed at Joshua – like *P. australis,* this species can be troublesome in GAB spring wetlands.

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Appendix A

Flora species list

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Family	Species	Status	Habitat type (with comments)
Adiantaceae	*Cheilanthes sieberi*	LC	CoW
Aizoaceae	*Trianthema* sp. (Coorabulka R.W. Purdie 1404)	LC	MxdSe
Amaranthaceae	*Alternanthera pungens*	*	Bare, CoW
Apiaceae	*Eryngium fontanum*	E, **E**	MxdSe, SpG
Apocynaceae	*Carissa ovata*	LC	CoW, RRBoxW
	Cryptostegia grandiflora	* (2)	CoW
Araliaceae	*Hydrocotyle dipleura*	V	MxdSe, SpG
Arecaceae	*Livistona lanuginosa*	V, **V**	CoW, MxdSe
Asteraceae	*Chrysocephalum apiculatum*	LC	CoW, RRBoxW
	Emilia sonchifolia	LC	CoW
	Epaltes sp. (SFD1555)#^		
	Minuria integerrima	LC	CoW
	Parthenium hysterophorus	* (2)	CoW
	Pterocaulon serrulatum	LC	CoW, RRBoxW
Capparaceae	*Apophyllum anomalum*	LC	CoW
Chenopodiaceae	*Chenopodium carinatum*	LC	Bare
	Salsola kali	LC	Bare
	*Sclerolaena glabra^*	LC	Bare
	Sclerolaena diacantha	LC	Bare, CoW
	Sclerolaena everistiana	LC	Bare, CoW, RRBoxW
Cyperaceae	*Cyperus conicus* var. *conicus^*	LC	MxdSe
	*Cyperus difformis^*	LC	MxdSe, SpG
	*Cyperus exaltatus^*	LC	CoW
	Cyperus laevigatus	LC	MxdSe, SpG
	*Cyperus polystachyos^*	LC	MxdSe
	*Cyperus sanguinolentus^*	LC	MxdSe, SpG
	Cyperus victoriensis	LC	MxdSe, SpG
	*Eleocharis equisetina^*	LC	MxdSe
	*Eleocharis pallens^*	LC	MxdSe
	*Eleocharis plana^*	LC	MxdSe
	Fimbristylis dichotoma	LC	MxdSe, SpG
	*Fimbristylis ferruginea^*	LC	MxdSe, SpG
	Fimbristylis littoralis	LC	MxdSe, SpG
	*Fimbristylis rara^*	LC	MxdSe
	Fuirena umbellata	LC	MxdSe, SpG
Eriocaulaceae	*Eriocaulon carsonii* ssp. *orientale*	E, **E**	MxdSe, SpG
Erythroxylaceae	*Erythroxylum australe*	LC	RRBoxW
Haloragaceae	*Myriophyllum artesium*	E	MxdSe, SpG
Juncaceae	*Juncus aridicola*	LC	MxdSe
	*Juncus usitatus^*	LC	MxdSe
Lentibulariaceae	*Utricularia dichotoma^*	LC	MxdSe
	Utricularia gibba	LC	MxdSe
Onagraceae	*Ludwigia octovalvis*	LC	MxdSe
Poaceae	*Aristida jerichoensis*	LC	RRBoxW
	Austrochloris scariosa	LC	Bare, CoW
	Bothriochloa pertusa	LC	Bare, CoW, RRBoxW, non-remnant areas

Family	Species	Status	Habitat type (with comments)
Poaceae (cont.)	*Cenchrus ciliaris*	*	Bare, CoW, RRBoxW, non-remnant areas
	Chloris inflata	LC	Bare, CoW
	Chloris virgata	LC	Bare, CoW
	Cynodon dactylon	LC	Bare, SpG, CoW
	Dactyloctenium radulans	LC	Bare, CoW
	Dichanthium sericeum	LC	CoW
	Digitaria ciliaris	*	CoW
	*Echinochloa inundata^*	LC	SpG, Bare
	Enteropogon acicularis	LC	Bare, CoW
	Eragrostis speciosa	LC	SpG, CoW, RRBoxW
	Hymenachne amplexicaulis	* (2)	CoW (Joshua spring overflow)
	Imperata cylindrica	LC	SpG, CoW, RRBoxW
	Isachne globosa	LC	SpG
	Ischaemum australe var. *australe^*	LC	SpG
	*Leersia hexandra^*	LC	SpG, MxdSe
	*Leptochloa fusca^*	LC	SpG
	Paspalidium rarum	LC	CoW, MxdSe (along edges)
	Pennisetum alopecuroides	LC	SpG
	Phragmites australis	LC	SpG
	Pseudoraphis spinescens	LC	SpG
	*Sacciolepis indica^*	LC	SpG
	Sporobolus caroli	LC	Bare, CoW
	*Sporobolus coromandelianus^*	*	Bare, CoW
	*Sporobolus creber^*	LC	Bare, CoW
	Sporobolus pamelae	E	SpG, MxdSe
	*Sporobolus partimpatens^*	NT	Bare, SpG
	Triodia longiceps	LC	PeBoxW
	Triodia pungens	LC	PeBoxW
Marsileaceae	*Marsilea hirsuta^*	LC	CoW
Menyanthaceae	*Nymphoides crenata*	LC	CoW
Mimosaceae	*Acacia excelsa*	LC	Cow, RRBoxW
	Acacia farnesiana	*	CoW
	Acacia holosericea	LC	CoW
	Acacia laccata	LC	RRBoxW
	Acacia melleodora	LC	PeBoxW
	Acacia salicina	LC	RRBoxW
Myoporaceae	*Eremophila mitchellii*	LC	CoW, RRBoxW
Myrtaceae	*Corymbia brachycarpa*	LC	RRBoxW
	Corymbia dallachiana	LC	RRBoxW, PeBoxW
	Corymbia erythrophloia	LC	RRBoxW, PeBoxW
	Corymbia terminalis	LC	RRBoxW, PeBoxW
	Corymbia tessellaris	LC	CoW
	Eucalyptus brownii	LC	RRBoxW
	Eucalyptus coolabah	LC	CoW
	Eucalyptus camaldulensis var. *obtusa*	LC	CoW
	Eucalyptus melanophloia	LC	PeBoxW, RRBoxW
	Eucalyptus persistens	LC	PeBoxW
	Melaleuca leucadendra	LC	MxdSe, CoW

Family	Species	Status	Habitat type (with comments)
	Melaleuca nervosa	LC	CoW, RRBoxW
	Melaleuca tamariscina	LC	RRBoxW
Nymphaeaceae	*Nymphaea gigantea*	LC	Joshua spring dam
Rutaceae	*Flindersia dissosperma*	LC	CoW, RRBoxW
	Geijera parviflora	LC	CoW, RRBoxW
Scrophulariaceae	*Stemodia glabella^*	LC	MxdSe
Typhaceae	*Typha orientalis/domingensis*	*/LC	Joshua spring dam. Definitive ID was not obtained.

Status symbols

* = exotic - (2) refers to a declared weed listing if relevant; LC = least concern (NC Act); NT = near threatened (NC Act); V = vulnerable; E = endangered; **Bold** denounces EPBC Act listing

= unnamed species known to the Queensland Herbarium; ^ = identifications confirmed by the Queensland Herbarium

Habitat type

SpG = *Sporobolus pamelae* grassland; MxdSe = mixed sedgeland; Bare = bare clay pan; CoW = coolabah/river red gum woodland; RRBoxW = Reid River box woodland; PeBoxW = peppermint box woodland

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Appendix B

Wildlife online search

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Queensland Government

Wildlife Online Extract

Search Criteria: Species List for a Specified Point
Species: All
Type: All
Status: All
Records: All
Date: All
Latitude: 22.0831
Longitude: 146.2467
Distance: 5
Email: Peter.Wagner@ghd.com
Date submitted: Wednesday 06 Jun 2012 16:12:09
Date extracted: Wednesday 06 Jun 2012 16:20:02

The number of records retrieved = 277

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	amphibians	Hylidae	*Cyclorana novaehollandiae*	eastern snapping frog		C		3/3
animals	amphibians	Hylidae	*Litoria inermis*	bumpy rocketfrog		C		1/1
animals	amphibians	Hylidae	*Litoria nasuta*	striped rocketfrog		C		1/1
animals	amphibians	Limnodynastidae	*Platyplectrum ornatum*	ornate burrowing frog		C		1/1
animals	birds	Acanthizidae	*Gerygone fusca*	western gerygone		C		1
animals	birds	Accipitridae	*Haliastur sphenurus*	whistling kite		C		1
animals	birds	Anatidae	*Chenonetta jubata*	Australian wood duck		C		1
animals	birds	Anatidae	*Aythya australis*	hardhead		C		1
animals	birds	Anatidae	*Anas gracilis*	grey teal		C		1
animals	birds	Anhingidae	*Anhinga novaehollandiae*	Australasian darter		C		1
animals	birds	Artamidae	*Cracticus tibicen*	Australian magpie		C		1
animals	birds	Artamidae	*Cracticus nigrogularis*	pied butcherbird		C		1
animals	birds	Artamidae	*Artamus leucorynchus*	white-breasted woodswallow		C		1
animals	birds	Cacatuidae	*Cacatua galerita*	sulphur-crested cockatoo		C		1
animals	birds	Charadriidae	*Vanellus miles miles*	masked lapwing (northern subspecies)		C		1
animals	birds	Charadriidae	*Elseyornis melanops*	black-fronted dotterel		C		2
animals	birds	Climacteridae	*Climacteris picumnus*	brown treecreeper		C		1
animals	birds	Columbidae	*Phaps chalcoptera*	common bronzewing		C		1
animals	birds	Columbidae	*Geopelia striata*	peaceful dove		C		2
animals	birds	Corcoracidae	*Struthidea cinerea*	apostlebird		C		1
animals	birds	Corvidae	*Corvus orru*	Torresian crow		C		1
animals	birds	Corvidae	*Corvus bennetti*	little crow		C		1
animals	birds	Corvidae	*Corvus coronoides*	Australian raven		C		1
animals	birds	Cuculidae	*Cacomantis pallidus*	pallid cuckoo		C		1
animals	birds	Estrildidae	*Poephila cincta cincta*	black-throated finch (white-rumped subspecies)		E	E	1
animals	birds	Estrildidae	*Neochmia modesta*	plum-headed finch		C		1
animals	birds	Estrildidae	*Taeniopygia bichenovii*	double-barred finch		C		1
animals	birds	Estrildidae	*Taeniopygia guttata*	zebra finch		C		1
animals	birds	Gruidae	*Grus rubicunda*	brolga		C		1
animals	birds	Halcyonidae	*Dacelo novaeguineae*	laughing kookaburra		C		2
animals	birds	Halcyonidae	*Dacelo leachii*	blue-winged kookaburra		C		2
animals	birds	Hirundinidae	*Petrochelidon nigricans*	tree martin		C		1
animals	birds	Maluridae	*Malurus lamberti*	variegated fairy-wren		C		1
animals	birds	Megaluridae	*Cincloramphus mathewsi*	rufous songlark		C		1
animals	birds	Meliphagidae	*Philemon citreogularis*	little friarbird		C		1
animals	birds	Meliphagidae	*Acanthagenys rufogularis*	spiny-cheeked honeyeater		C		1
animals	birds	Meliphagidae	*Ptilotula penicillatus*	white-plumed honeyeater		C		2
animals	birds	Meliphagidae	*Philemon corniculatus*	noisy friarbird		C		1
animals	birds	Meliphagidae	*Lichmera indistincta*	brown honeyeater		C		1
animals	birds	Meliphagidae	*Ptilotula plumulus*	grey-fronted honeyeater		C		1
animals	birds	Meliphagidae	*Manorina flavigula*	yellow-throated miner		C		1
animals	birds	Meliphagidae	*Entomyzon cyanotis*	blue-faced honeyeater		C		1
animals	birds	Monarchidae	*Myiagra inquieta*	restless flycatcher		C		1
animals	birds	Monarchidae	*Grallina cyanoleuca*	magpie-lark		C		1
animals	birds	Motacillidae	*Anthus novaeseelandiae*	Australasian pipit		C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Nectariniidae	*Dicaeum hirundinaceum*	mistletoebird		C		1
animals	birds	Pachycephalidae	*Pachycephala rufiventris*	rufous whistler		C		1
animals	birds	Pardalotidae	*Pardalotus striatus*	striated pardalote		C		1
animals	birds	Pelecanidae	*Pelecanus conspicillatus*	Australian pelican		C		1
animals	birds	Pomatostomidae	*Pomatostomus temporalis*	grey-crowned babbler		C		1
animals	birds	Psittacidae	*Platycercus adscitus*	pale-headed rosella		C		1
animals	birds	Psittacidae	*Aprosmictus erythropterus*	red-winged parrot		C		1
animals	birds	Psittacidae	*Melopsittacus undulatus*	budgerigar		C		1
animals	birds	Rhipiduridae	*Rhipidura leucophrys*	willie wagtail		C		2
animals	birds	Threskiornithidae	*Platalea flavipes*	yellow-billed spoonbill		C		1
animals	birds	Threskiornithidae	*Threskiornis molucca*	Australian white ibis		C		1
animals	birds	Threskiornithidae	*Threskiornis spinicollis*	straw-necked ibis		C		1
animals	mammals	Macropodidae	*Macropus giganteus*	eastern grey kangaroo		C		1
animals	mammals	Phascolarctidae	*Phascolarctos cinereus*	koala		C	V	1
plants	ferns	Adiantaceae	*Cheilanthes sieberi*			C		1
plants	ferns	Azollaceae	*Azolla pinnata*	ferny azolla		C		1
plants	ferns	Marsileaceae	*Marsilea hirsuta*	hairy nardoo		C		1
plants	higher dicots	Acanthaceae	*Nelsonia campestris*			C		3/1
plants	higher dicots	Acanthaceae	*Dipteracanthus australasicus subsp. australasicus*			C		1/1
plants	higher dicots	Acanthaceae	*Dipteracanthus australasicus*			C		1
plants	higher dicots	Acanthaceae	*Brunoniella australis*	blue trumpet		C		1
plants	higher dicots	Acanthaceae	*Rostellularia adscendens*			C		1
plants	higher dicots	Aizoaceae	*Trianthema sp. (Coorabulka R.W.Purdie 1404)*			C		2/2
plants	higher dicots	Aizoaceae	*Trianthema triquetra*	red spinach		C		5/2
plants	higher dicots	Amaranthaceae	*Alternanthera pungens*	khaki weed	Y			1/1
plants	higher dicots	Amaranthaceae	*Gomphrena sp. (Doongmabulla E.J.Thompson+ GAL137)*			C		3/1
plants	higher dicots	Apiaceae	*Eryngium fontanum*			E	E	7/3
plants	higher dicots	Apiaceae	*Centella asiatica*			C		1
plants	higher dicots	Apocynaceae	*Marsdenia viridiflora*			C		1
plants	higher dicots	Araliaceae	*Hydrocotyle dipleura*			V		3/2
plants	higher dicots	Araliaceae	*Hydrocotyle acutiloba*			C		1
plants	higher dicots	Asteraceae	*Aster subulatus*	wild aster	Y			3
plants	higher dicots	Asteraceae	*Epaltes australis*	spreading nutheads		C		1
plants	higher dicots	Asteraceae	*Emilia sonchifolia*		Y			1
plants	higher dicots	Asteraceae	*Pluchea baccharoides*	narrow-leaved plains bush		C		2/1
plants	higher dicots	Asteraceae	*Pluchea rubelliflora*			C		1/1
plants	higher dicots	Asteraceae	*Pterocaulon serrulatum*			C		1
plants	higher dicots	Asteraceae	*Parthenium hysterophorus*	parthenium weed	Y			2/2
plants	higher dicots	Asteraceae	*Chrysocephalum apiculatum*	yellow buttons		C		1
plants	higher dicots	Asteraceae	*Pluchea ferdinandi-muelleri*			C		1
plants	higher dicots	Asteraceae	*Emilia sonchifolia var. sonchifolia*		Y			1/1
plants	higher dicots	Asteraceae	*Acmella grandiflora var. brachyglossa*			C		2/1
plants	higher dicots	Caesalpiniaceae	*Petalostylis labicheoides*			C		1
plants	higher dicots	Campanulaceae	*Isotoma*			C		1/1
plants	higher dicots	Campanulaceae	*Isotoma sp. (Myross R.J.Fensham 3883)*			C		2
plants	higher dicots	Capparaceae	*Apophyllum anomalum*	broom bush		C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Caryophyllaceae	*Polycarpaea spirostylis subsp. compacta*			C		2/1
plants	higher dicots	Celastraceae	*Maytenus cunninghamii*	yellow berry bush		C		2
plants	higher dicots	Chenopodiaceae	*Sclerolaena ramulosa*			C		4/3
plants	higher dicots	Chenopodiaceae	*Dissocarpus paradoxus*	cannonball burr		C		1/1
plants	higher dicots	Chenopodiaceae	*Sclerolaena calcarata*	red burr		C		1/1
plants	higher dicots	Chenopodiaceae	*Sclerolaena diacantha*	grey copper burr		C		1/1
plants	higher dicots	Chenopodiaceae	*Sclerolaena tricuspis*	giant red burr		C		2/1
plants	higher dicots	Chenopodiaceae	*Dysphania plantaginella*			C		2/1
plants	higher dicots	Chenopodiaceae	*Sclerolaena everistiana*			C		1/1
plants	higher dicots	Chenopodiaceae	*Tecticornia pergranulata*			C		1
plants	higher dicots	Chenopodiaceae	*Einadia nutans subsp. linifolia*			C		1
plants	higher dicots	Chenopodiaceae	*Sclerolaena bicornis var. bicornis*			C		1/1
plants	higher dicots	Chenopodiaceae	*Dissocarpus sp. (Doongmabulla E.J.Thompson+ GAL21)*			C		3/2
plants	higher dicots	Chenopodiaceae	*Atriplex sp. (Doongmabulla Homestead E.J.Thompson+ GAL20)*			C		1/1
plants	higher dicots	Chenopodiaceae	*Atriplex*			C		1
plants	higher dicots	Chenopodiaceae	*Einadia hastata*			C		1
plants	higher dicots	Chenopodiaceae	*Maireana georgei*			C		1/1
plants	higher dicots	Chenopodiaceae	*Sclerolaena glabra*			C		5/3
plants	higher dicots	Chenopodiaceae	*Tecticornia indica*			C		1/1
plants	higher dicots	Chenopodiaceae	*Rhagodia spinescens*	thorny saltbush		C		1/1
plants	higher dicots	Chenopodiaceae	*Sclerolaena bicornis*			C		2
plants	higher dicots	Convolvulaceae	*Evolvulus alsinoides*			C		1
plants	higher dicots	Erythroxylaceae	*Erythroxylum australe*	cocaine tree		C		2
plants	higher dicots	Fabaceae	*Vigna luteola*	dalrymple vigna	Y			3/1
plants	higher dicots	Fabaceae	*Rhynchosia minima*			C		1
plants	higher dicots	Fabaceae	*Zornia muriculata*			C		1
plants	higher dicots	Fabaceae	*Glycine tomentella*	woolly glycine		C		1
plants	higher dicots	Fabaceae	*Indigofera brevidens var. brevidens*			C		1
plants	higher dicots	Fabaceae	*Indigofera pratensis*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia leptoclada*			C		1
plants	higher dicots	Fabaceae	*Vigna vexillata var. angustifolia*			C		2/1
plants	higher dicots	Fabaceae	*Sesbania cannabina*			C		1
plants	higher dicots	Haloragaceae	*Myriophyllum artesium*			E		4/1
plants	higher dicots	Lamiaceae	*Clerodendrum floribundum*			C		1
plants	higher dicots	Lamiaceae	*Plectranthus intraterraneus*			C		1/1
plants	higher dicots	Lamiaceae	*Prostanthera leichhardtii*			C		1
plants	higher dicots	Lamiaceae	*Plectranthus parviflorus*			C		1
plants	higher dicots	Lentibulariaceae	*Utricularia dichotoma*	fairy aprons		C		5/3
plants	higher dicots	Lentibulariaceae	*Utricularia caerulea*	blue bladderwort		C		5/2
plants	higher dicots	Lentibulariaceae	*Utricularia gibba*	floating bladderwort		C		6/2
plants	higher dicots	Loranthaceae	*Dendrophthoe glabrescens*			C		2/1
plants	higher dicots	Malvaceae	*Sida*			C		1
plants	higher dicots	Malvaceae	*Sida filiformis*			C		1
plants	higher dicots	Mimosaceae	*Acacia excelsa*			C		1
plants	higher dicots	Mimosaceae	*Acacia sericophylla*			C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Mimosaceae	*Acacia leptostachya*	Townsville wattle		C		1
plants	higher dicots	Mimosaceae	*Acacia stipuligera*			C		2/1
plants	higher dicots	Mimosaceae	*Acacia stenophylla*	belalie		C		1
plants	higher dicots	Mimosaceae	*Acacia tenuissima*			C		1
plants	higher dicots	Mimosaceae	*Acacia melleodora*			C		1
plants	higher dicots	Mimosaceae	*Acacia catenulata*	bendee		C		1
plants	higher dicots	Mimosaceae	*Acacia shirleyi*	lancewood		C		2
plants	higher dicots	Mimosaceae	*Acacia salicina*	doolan		C		2/1
plants	higher dicots	Mimosaceae	*Acacia oswaldii*	miljee		C		1
plants	higher dicots	Myoporaceae	*Eremophila longifolia*	berrigan		C		1
plants	higher dicots	Myoporaceae	*Eremophila latrobei*			C		1
plants	higher dicots	Myoporaceae	*Myoporum montanum*	boobialla		C		1
plants	higher dicots	Myrtaceae	*Corymbia setosa*			C		1
plants	higher dicots	Myrtaceae	*Melaleuca fluviatilis*			C		2/1
plants	higher dicots	Myrtaceae	*Corymbia lamprophylla*			C		1
plants	higher dicots	Myrtaceae	*Corymbia tessellaris*	Moreton Bay ash		C		1
plants	higher dicots	Myrtaceae	*Eucalyptus coolabah*	coolabah		C		3/1
plants	higher dicots	Myrtaceae	*Corymbia terminalis*			C		2/2
plants	higher dicots	Myrtaceae	*Eucalyptus similis*	Queensland yellowjacket		C		1
plants	higher dicots	Myrtaceae	*Eucalyptus camaldulensis*			C		3
plants	higher dicots	Myrtaceae	*Eucalyptus camaldulensis subsp. acuta*			C		1/1
plants	higher dicots	Myrtaceae	*Corymbia aparrerinja - C.dallachiana (Benth.)*			C		1/1
plants	higher dicots	Myrtaceae	*Melaleuca leucadendra*	broad-leaved tea-tree		C		5/1
plants	higher dicots	Onagraceae	*Ludwigia peploides*		Y			1
plants	higher dicots	Onagraceae	*Ludwigia octovalvis*	willow primrose		C		2
plants	higher dicots	Oxalidaceae	*Oxalis perennans*			C		1
plants	higher dicots	Pentapetaceae	*Melhania oblongifolia*			C		1
plants	higher dicots	Phyllanthaceae	*Phyllanthus fuernrohrii*			C		1
plants	higher dicots	Picrodendraceae	*Petalostigma banksii*			C		1
plants	higher dicots	Pittosporaceae	*Bursaria incana*			C		1
plants	higher dicots	Polygonaceae	*Persicaria decipiens*	slender knotweed		C		3/1
plants	higher dicots	Portulacaceae	*Portulaca oleracea*	pigweed	Y			2
plants	higher dicots	Proteaceae	*Persoonia falcata*			C		1
plants	higher dicots	Rhamnaceae	*Alphitonia excelsa*	soap tree		C		1
plants	higher dicots	Rubiaceae	*Everistia vacciniifolia*			C		1
plants	higher dicots	Sapindaceae	*Dodonaea stenophylla*			C		1
plants	higher dicots	Scrophulariaceae	*Scoparia dulcis*	Scoparia	Y			2
plants	higher dicots	Scrophulariaceae	*Peplidium foecundum*			C		1
plants	higher dicots	Scrophulariaceae	*Peplidium*			C		1/1
plants	higher dicots	Sparrmanniaceae	*Grewia retusifolia*			C		1
plants	higher dicots	Sparrmanniaceae	*Corchorus tomentellus*			C		1
plants	higher dicots	Stylidiaceae	*Stylidium velleioides*			C		1
plants	lower dicots	Lauraceae	*Cassytha filiformis*	dodder laurel		C		1
plants	lower dicots	Nymphaeaceae	*Nymphaea gigantea*			C		3/1
plants	monocots	Amaryllidaceae	*Crinum flaccidum*	Murray lily		C		1
plants	monocots	Cyperaceae	*Cyperus betchei*			C		2

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	monocots	Cyperaceae	*Cyperus flavidus*			C		3/1
plants	monocots	Cyperaceae	*Eleocharis plana*	ribbed spikerush		C		2/1
plants	monocots	Cyperaceae	*Fuirena ciliaris*			C		2/1
plants	monocots	Cyperaceae	*Baumea rubiginosa*	soft twigrush		C		5/2
plants	monocots	Cyperaceae	*Cyperus difformis*	rice sedge		C		7/2
plants	monocots	Cyperaceae	*Cyperus exaltatus*	tall flatsedge		C		1
plants	monocots	Cyperaceae	*Fimbristylis rara*			C		4/2
plants	monocots	Cyperaceae	*Fuirena umbellata*			C		2
plants	monocots	Cyperaceae	*Cyperus dactylotes*			C		1/1
plants	monocots	Cyperaceae	*Cyperus laevigatus*			C		5/2
plants	monocots	Cyperaceae	*Cyperus polystachyos*			C		4
plants	monocots	Cyperaceae	*Cyperus victoriensis*			C		3/1
plants	monocots	Cyperaceae	*Cyperus alterniflorus*			C		1/1
plants	monocots	Cyperaceae	*Eleocharis equisetina*			C		6/2
plants	monocots	Cyperaceae	*Cyperus sanguinolentus*			C		7/1
plants	monocots	Cyperaceae	*Fimbristylis dichotoma*	common fringe-rush		C		13/5
plants	monocots	Cyperaceae	*Schoenoplectus validus*			C		4/2
plants	monocots	Cyperaceae	*Fimbristylis littoralis*			C		2/1
plants	monocots	Cyperaceae	*Schoenoplectus mucronatus*			C		2
plants	monocots	Cyperaceae	*Eleocharis cylindrostachys*			C		1
plants	monocots	Cyperaceae	*Cyperus betchei subsp. betchei*			C		2/2
plants	monocots	Cyperaceae	*Cyperus haspan*			C		1
plants	monocots	Cyperaceae	*Cyperus laevis*			C		1
plants	monocots	Eriocaulaceae	*Eriocaulon carsonii*			E	E	3
plants	monocots	Eriocaulaceae	*Eriocaulon scariosum*			C		1
plants	monocots	Eriocaulaceae	*Eriocaulon carsonii subsp. orientale*			E		3/3
plants	monocots	Juncaceae	*Juncus polyanthemus*			C		4/1
plants	monocots	Juncaceae	*Juncus usitatus*			C		1/1
plants	monocots	Juncaginaceae	*Triglochin multifructa*			C		1/1
plants	monocots	Philydraceae	*Philydrum lanuginosum*	frogsmouth		C		1
plants	monocots	Poaceae	*Panicum*			C		1
plants	monocots	Poaceae	*Eulalia aurea*	silky browntop		C		2/1
plants	monocots	Poaceae	*Chloris inflata*	purpletop chloris	Y			4/2
plants	monocots	Poaceae	*Isachne globosa*	swamp millet		C		6/3
plants	monocots	Poaceae	*Panicum effusum*			C		1
plants	monocots	Poaceae	*Triodia pungens*			C		1
plants	monocots	Poaceae	*Cynodon dactylon*		Y			3
plants	monocots	Poaceae	*Leersia hexandra*	swamp rice grass		C		6/2
plants	monocots	Poaceae	*Leptochloa fusca*	brown beetle grass		C		8
plants	monocots	Poaceae	*Themeda triandra*	kangaroo grass		C		1
plants	monocots	Poaceae	*Chloris pectinata*	comb chloris		C		2/1
plants	monocots	Poaceae	*Sporobolus caroli*	fairy grass		C		2/1
plants	monocots	Poaceae	*Triodia longiceps*	giant grey spinifex		C		3/2
plants	monocots	Poaceae	*Chloris ventricosa*	tall chloris		C		1
plants	monocots	Poaceae	*Chrysopogon fallax*			C		3/1
plants	monocots	Poaceae	*Echinochloa colona*	awnless barnyard grass	Y			1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	monocots	Poaceae	*Eragrostis falcata*	sickle lovegrass		C		2/1
plants	monocots	Poaceae	*Eragrostis sororia*			C		3/1
plants	monocots	Poaceae	*Eriachne mucronata*			C		1
plants	monocots	Poaceae	*Ischaemum australe*			C		3
plants	monocots	Poaceae	*Paspalum dilatatum*	paspalum	Y			2
plants	monocots	Poaceae	*Paspalum distichum*	water couch		C		1
plants	monocots	Poaceae	*Paspalum vaginatum*	saltwater couch		C		2/1
plants	monocots	Poaceae	*Pennisetum ciliare*			C		1
plants	monocots	Poaceae	*Sacciolepis indica*	Indian cupscale grass		C		9/2
plants	monocots	Poaceae	*Sporobolus pamelae*			E		8/2
plants	monocots	Poaceae	*Triodia mitchellii*	buck spinifex		C		1
plants	monocots	Poaceae	*Enteropogon ramosus*			C		2/1
plants	monocots	Poaceae	*Eragrostis elongata*			C		1/1
plants	monocots	Poaceae	*Eragrostis speciosa*			C		1
plants	monocots	Poaceae	*Imperata cylindrica*	blady grass		C		1
plants	monocots	Poaceae	*Leptochloa digitata*			C		1
plants	monocots	Poaceae	*Paspalidium gracile*	slender panic		C		2/1
plants	monocots	Poaceae	*Echinochloa inundata*	marsh millet		C		2/1
plants	monocots	Poaceae	*Eragrostis lacunaria*	purple lovegrass		C		1
plants	monocots	Poaceae	*Sporobolus scabridus*			C		2/1
plants	monocots	Poaceae	*Tripogon loliiformis*	five minute grass		C		2/1
plants	monocots	Poaceae	*Aristida jerichoensis*			C		1
plants	monocots	Poaceae	*Cenchrus purpurascens*			C		3/3
plants	monocots	Poaceae	*Cymbopogon bombycinus*	silky oilgrass		C		1
plants	monocots	Poaceae	*Sporobolus disjunctus*			C		1/1
plants	monocots	Poaceae	*Sporobolus virginicus*	sand couch		C		4/1
plants	monocots	Poaceae	*Aristida inaequiglumis*			C		1
plants	monocots	Poaceae	*Echinochloa crus-galli*	barnyard grass	Y			4/1
plants	monocots	Poaceae	*Enneapogon polyphyllus*	leafy nineawn		C		1
plants	monocots	Poaceae	*Enteropogon acicularis*	curly windmill grass		C		1/1
plants	monocots	Poaceae	*Dactyloctenium radulans*	button grass		C		1
plants	monocots	Poaceae	*Pseudoraphis spinescens*	spiny mudgrass		C		2/1
plants	monocots	Poaceae	*Sporobolus partimpatens*			NT		4/2
plants	monocots	Poaceae	*Pennisetum alopecuroides*	swamp foxtail		C		3
plants	monocots	Poaceae	*Sporobolus australasicus*			C		2/1
plants	monocots	Poaceae	*Eriochloa pseudoacrotricha*			C		4/2
plants	monocots	Poaceae	*Leptochloa fusca subsp. fusca*			C		3/3
plants	monocots	Poaceae	*Cynodon dactylon var. dactylon*		Y			1/1
plants	monocots	Poaceae	*Ischaemum australe var. australe*			C		1/1
plants	monocots	Poaceae	*Ischaemum australe var. villosum*			C		1/1
plants	monocots	Poaceae	*Aristida holathera var. holathera*			C		3/1
plants	monocots	Poaceae	*Chloris divaricata var. divaricata*	slender chloris		C		2/1
plants	monocots	Poaceae	*Hymenachne amplexicaulis cv. Olive*		Y			1/1
plants	monocots	Poaceae	*Chloris sp. (Edgbaston R.J.Fensham 5694)*			C		1/1
plants	monocots	Poaceae	*Bothriochloa decipiens var. cloncurrensis*			C		2/1
plants	monocots	Poaceae	*Eriachne mucronata forma (Burnham R.W.Purdie 1370)*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	monocots	Potamogetonaceae	*Potamogeton tricarinatus*	floating pondweed		C		2/1
plants	monocots	Typhaceae	*Typha orientalis*	broad-leaved cumbungi		C		1
plants	monocots	Typhaceae	*Typha domingensis*			C		3/1

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

Appendix C

Protected matters search

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Australian Government

Department of Sustainability, Environment, Water, Population and Communities

EPBC Act Protected Matters Report

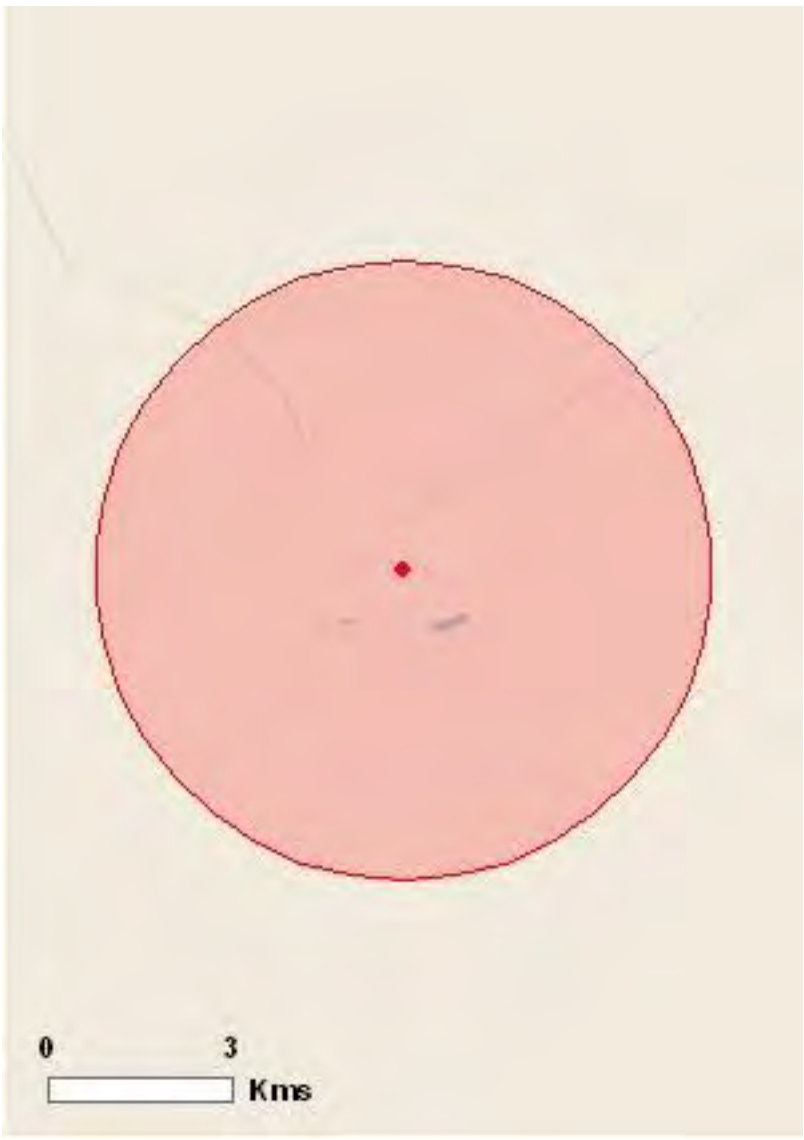
This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information about the EPBC Act including significance guidelines, forms and application process details can be found at http://www.environment.gov.au/epbc/assessmentsapprovals/index.html

Report created: 06/06/12 16:03:58

Summary
Details
Matters of NES
Other Matters Protected by the EPBC Act
Extra Information
Caveat
Acknowledgements



Coordinates

Buffer: 5.0Km

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance - see http://www.environment.gov.au/epbc/assessmentsapprovals/guidelines/index.html

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Threatened Ecological Communities:	1
Threatened Species:	10
Migratory Species:	10

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage/index.html

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species. Information on EPBC Act permit requirements and application forms can be found at http://www.environment.gov.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	8
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

Place on the RNE:	1
State and Territory Reserves:	1
Regional Forest Agreements:	None
Invasive Species:	8
Nationally Important Wetlands:	1

Details

Matters of National Environmental Significance

Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin	Endangered	Community likely to occur within area

Threatened Species		[Resource Information]
Name	Status	Type of Presence
BIRDS		
Geophaps scripta scripta		
Squatter Pigeon (southern) [64440]	Vulnerable	Species or species habitat may occur within area
Poephila cincta cincta		
Black-throated Finch (southern) [64447]	Endangered	Species or species habitat likely to occur within area
Rostratula australis		
Australian Painted Snipe [77037]	Vulnerable	Species or species habitat may occur within area
MAMMALS		
Macrotis lagotis		
Greater Bilby [282]	Vulnerable	Species or species habitat may occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)		
Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat may occur within area
PLANTS		
Acacia ramiflora		
[7242]	Vulnerable	Species or species habitat may occur within area
Eriocaulon carsonii		
Salt Pipewort, Button Grass [10584]	Endangered	Species or species habitat likely to occur within area
Eryngium fontanum		
Blue Devil [64516]	Endangered	Species or species habitat likely to occur within area
REPTILES		
Denisonia maculata		
Ornamental Snake [1193]	Vulnerable	Species or species habitat may occur within area
Egernia rugosa		
Yakka Skink [1420]	Vulnerable	Species or species habitat may occur within area

Migratory Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundapus caudacutus		
White-throated Needletail [682]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Migratory Wetlands Species		
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Gallinago hardwickii		
Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato)		
Painted Snipe [889]	Vulnerable*	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Gallinago hardwickii		
Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundapus caudacutus		
White-throated Needletail [682]		Species or species habitat may occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato)		
Painted Snipe [889]	Vulnerable*	Species or species habitat may occur within area

Extra Information

Places on the RNE [Resource Information]

Note that not all Indigenous sites may be listed.

Name	State	Status
Natural		
Doongmabulla Spring	QLD	Indicative Place

State and Territory Reserves [Resource Information]

Name	State
Doongmabulla Mound Springs	QLD

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit,

Name	Status	Type of Presence
Frogs		
Bufo marinus Cane Toad [1772]		Species or species habitat likely to occur within area
Mammals		
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Parthenium hysterophorus Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]		Species or species habitat likely to occur within area
Prosopis spp. Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area

Nationally Important Wetlands [Resource Information]

Name	State
Doongmabulla Springs	QLD

Coordinates

-22.08306 146.24667

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Appendix D

Habitat assessment proforma

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QUEENSLAND SITE INFORMATION SHEET

Queensland Government
Natural Resources and Mines

SITE NUMBER ……...

SITE NAME ……..……...

LATITUDE …… **LONGITUDE** ……

GRID REFERENCE ……**GPS**……

MAP NAME …… **MAP NUMBER** …… **SCALE** ……

ALTITUDE (m) ……. **STREAM ORDER** ……

SLOPE (m/m) …… **DISTANCE FROM SOURCE (km)** ……..

AMTD (km)…… **REACH** **upland** **midland** **lowland**

CATCHMENT AREA (km^2) …….

REFERENCE or TEST **ASSESSMENT** (see last page)……..…

NEAREST RAINFALL STATION ……

NEAREST WEATHER STATION ……...

ACCESS DETAILS

Directions ……
…….……
…….……
…….……
…….……
Property Owner …… **Phone No.** ..……
Contact ..…… **Phone No.** ..……...…..
Access Instructions ..…….
…….……
…….……
…….……
Notify before each visit? **[ ] Yes** **[ ] No**
Permission required? **[ ] Yes** **[ ] No**
Key required? **[ ] Yes** **[ ] No**
Key available from ……...
……..

MUDMAP OF ACCESS ROUTE

SKETCH OF REACH

No.	Reference Condition Selection Criteria	Level of impact *
1	Influence of intensive agriculture upstream.* Intensive agriculture is that which involves irrigation, widespread soil disturbance, use of agrochemicals and pine plantations. Dry-land grazing does not fall into this category.	
2	Influence of major extractive industry (current or historical) upstream.* This includes mines, quarries and sand/gravel extraction.	
3	Influence of major urban area upstream. This will be relative to population size, river size and distance between the site and the impact.	
4	Influence of significant point-source waste water discharge upstream.* Exceptions can be made for small discharges into large rivers.	
5	Influence of dam or major weir* Sites within the ponded area of impoundments also fail.	
6	Influence of alteration to seasonal flow regime This may be due to abstraction or regulation further upstream than the coverage by Criterion 5. Includes either an increase or decrease in seasonal flow.	
7	Influence of alteration to riparian zone Riparian vegetation should be intact and dominated by native species.	
8	Influence of erosion and damage by stock on riparian zone and banks. Stock damage to the stream bed may be included in this category.	
9	Influence of major geomorphological change on stream channel Geomorphological change includes bank slumping, shallowing, braiding and unnatural aggradation or degradation.	
10	Influence of alteration to instream conditions and habitats This may be due to excessive algal and macrophyte growth, by sedimentation and siltation, by reduction in habitat diversity by drowning or drying out of habitats (e.g. riffles) or by direct access of stock into the river	
	SITE ASSESSMENT	

* Note: the level of impact at a site will generally decrease as the distance from the source of impact increases.

Each criterion relates to an aspect of human activity that impacts on freshwater ecosystems, where impact is defined as a 'change from natural condition'. Each criterion is given a score according to the following categories:

1. Very major impact
2. Major impact
3. Moderate impact
4. Minor impact
5. Indiscernible impact

Potential reference sites are assessed using the total score for the ten criteria. To be considered as being in reference condition, a site must score no less than '4' on each criterion. Any sites that fail reference are 'test' sites.

1. LONGITUDINAL PROFILE SKETCH OF STREAM REACH

Scale: _____

Please indicate on sketch and tick off each item when completed.

- ☐ Biological sampling sites for each habitat type.
- ☐ Water quality measurement and water sample collection sites.
- ☐ Location from where photograph(s) taken.
- ☐ Flow direction
- ☐ Location of cross-sectional profile sketch.
- ☐ Riparian vegetation (include approx. heights).
- ☐ Riparian zone width.

2. CROSS-SECTIONAL PROFILE SKETCH OF STREAM REACH

Scale: _____

Please indicate on sketch and tick off each item when completed.

- ☐ Bankfull bank height
- ☐ Bankfull stream width
- ☐ Stream wetted width
- ☐ "Normal" wetted width
- ☐ Riparian vegetation height
- ☐ Riparian zone width
- ☐ Water depth

3. COMMENTS

_____

_____

_____

_____

_____

_____

_____

(*Office use only*) Entered into AQEIS ___/___/___ by _____ Checked on ___/___/___ by _____

REACH OBSERVATIONS (of 100 m stream length)

Upstream landuse: . . . . . .

Adjacent landuse: Left bank: Score . . . . . Type . . . . . Right bank: Score . . . . . Type . . . . . .

0. Urban/semi-urban, industrial
1. Irrigated cropping, intensive forestry or heavy grazing
2. Non-irrigated cropping, moderate grazing
3. Light grazing, vegetation clearing
4. Natural

Local catchment erosion:	None	Little	Some	Moderate	Extensive
Water colour:	Clear	Green	Opaque	Tannin	Other . . . . .
Sediment deposits:	None	Sand	Silt	Other	
Algae: On substrate:	None	Little	Some	Moderate	Extensive
In water column:	None	Little	Some	Moderate	Extensive
Water odour:	No	Yes	Specify		
Substrate odour:	No	Yes	Specify		
Water surface:	Normal	Slick	Scum	Foaming	Other . . . . .
Variety of habitat: (circle all types)	Shallow	Deep	Pool	Run	Riffle
	Undercut bank		LWD	Macrophytes	Other . . . . .

Bars: (bed surface protruding from normal water level and forming a bar) . . . . . %

Flow level: (relative to 'watermark' i.e. normal inundation level shown by limit of terrestrial grasses, or by eroded area, or boundary in bank sediment types).

No flow	Low	Moderate	High	Flood
(dry/isolated)	(<watermark)	(=watermark)	(>watermark)	

RIPARIAN ZONE (to maximum 100 m width)

Width of riparian zone: Left bank . . . . . m Right bank . . . . . m

*** Bare ground**	None	Little	Some	Moderate	Extensive
*** Grass**	None	Little	Some	Moderate	Extensive
*** Shrubs**	None	Little	Some	Moderate	Extensive
*** Trees <10 m high**	None	Little	Some	Moderate	Extensive
*** Trees >10 m high**	None	Little	Some	Moderate	Extensive
Presence of exotic riparian species	None	Little	Some	Moderate	Extensive

Width of continuous tree zone from bank: Left bank . . . . . m Right bank . . . . . m

None = 0% Little = 1–10% Some = 10–50% Moderate = 50–75% Extensive >75% * Can add to >100%

MACROPHYTES Indicate the presence and abundance of the following common taxa in the 100 m reach:

Native

Azolla	N	L	S	M	E	Water Ribbon (*Triglochin*)	N	L	S	M	E
Duckweed	N	L	S	M	E	Water Lettuce (*Pistia stratiotes*)	N	L	S	M	E
Hornwort (*Ceratophyllum*)	N	L	S	M	E	Water Primrose (*Ludwigia*)	N	L	S	M	E
Stoneworts (*Chara* or *Nitella*)	N	L	S	M	E	Sedge (*Cyperus*)	N	L	S	M	E
Hydrilla	N	L	S	M	E	Common Rush (*Juncus*)	N	L	S	M	E
Water Milfoil (*Myriophyllum*)	N	L	S	M	E	Cumbungi (*Typha*)	N	L	S	M	E
Pondweeds (*Potamogeton*)	N	L	S	M	E	Slender Knotweed (*Persicaria*)	N	L	S	M	E
Ribbonweed (*Vallisneria*)	N	L	S	M	E	. . . . .	N	L	S	M	E
. . . . .	N	L	S	M	E	. . . . .	N	L	S	M	E

Exotic

Water Hyacinth (*Eichhornia*)	N	L	S	M	E	Alligator Weed (*Alternanthera*)	N	L	S	M	E
Salvinia	N	L	S	M	E	Elodea	N	L	S	M	E
Para Grass (*Urochloa*)	N	L	S	M	E	*Egeria*	N	L	S	M	E
. . . . .	N	L	S	M	E	. . . . .	N	L	S	M	E

Comments: . . . . . .

. . . . . .

N = none L = 1-10% (little) S = 10-50% (some) M = 50-75% (moderate) E = >75% (extensive)

AEF005

WATER PLANTS and DIATOMS SAMPLING FIELD SHEET

Queensland Government
Natural Resources and Mines

Site Number [| | | | | |] **Sample Number** [| | | | | | | | | | | | |]

Site Name _____

Project Code [| | | | | |] **Date** [| / | / | | |]

Run Code [| | | | | |] **Time** (24 hrs) [| : |]

MACROPHYTES and MACROALGAE

Includes all stream-dependent species, whether growing in water or not

I = isolated; S = scattered; B = beds/stands; O = overgrowing/filling channel

(List and circle abundance category per section - two if intermediate)

Species	Specimen retained	1 (d/s)	2	3	4 (u/s)
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O
		I S B O	I S B O	I S B O	I S B O

DIATOMS

(Tick flow type and substratum sampled)

VIAL 1

Riffle (standing waves - unbroken)	[ ]	Rock	[ ]
Run (visible current - rippled surface)	[ ]	Wood	[ ]
Glide (visible current - smooth surface)	[ ]	Emergent macrophyte	[ ]
Pool (no visible current)	[ ]	Floating/submerged macrophyte	[ ]
		Fine particle (sand/silt/clay)	[ ]

VIAL **2**

Riffle (standing waves - unbroken)	[ ]		
Run (visible current - rippled surface)	[ ]	Rock	[ ]
Glide (visible current - smooth surface)	[ ]	Wood	[ ]
Pool (no visible current)	[ ]	Emergent macrophyte	[ ]
		Floating/submerged macrophyte	[ ]
		Fine particle (sand/silt/clay)	[ ]

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AEF007

River Bioassessment Program

Queensland Government
Natural Resources and Mines

HABITAT ASSESSMENT FIELD SHEET

SITE NUMBER: [| | | | | |] **SITE NAME:** _____

Date: ____/____/_____ **Time (24 hrs): [| | |]** **GPS:** _____ **Project Name:** _____

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
1. Bottom substrate/available cover	Greater than 50% rubble, gravel, submerged logs, undercut banks or other stable habitat. 20, 19, 18, 17, 16	30-50% rubble, gravel or other stable habitat. Adequate habitat. 15, 14, 13, 12, 11	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 10, 9, 8, 7, 6	Less than 10% rubble, gravel or stable habitat. Lack of habitat is obvious. 5, 4, 3, 2, 1, 0
2. Embeddedness	Gravel, cobble and boulder particles are between 0 & 25% surrounded by fine sediment. 20, 19, 18, 17, 16	Gravel, cobble and boulder particles are between 25% & 50% surrounded by fine sediment. 15, 14, 13, 12, 11	Gravel, cobble and boulder particles are between 50 & 75% surrounded by fine sediment. 10, 9, 8, 7, 6	Gravel, cobble and boulder particles are over 75% surrounded by fine sediment. 5, 4, 3, 2, 1, 0
3. Velocity/depth category	Slow deep (<0.3 m/s & >0.5 m); slow shallow; fast deep; fast shallow; habitats all present. 20, 19, 18, 17, 16	Only 3 of the four habitat categories present (missing riffles or runs receive lower score than missing pools). 15, 14, 13, 12, 11	Only two of the four habitat categories present (missing riffles/runs receive lower score). 10, 9, 8, 7, 6	Dominating by one velocity/depth category (usually pool). 5, 4, 3, 2, 1, 0
4. Channel alteration	Little or no enlargement of islands or point bars and/or no channelisation. 15, 14, 13, 12	Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present. 11, 10, 9, 8	Moderate deposition of new gravel, coarse sand, on old and new bars; pools partly filled with silt; and/or embankments on both banks. 7, 6, 5, 4	Heavy deposits of fine materials, increased bar development; most pools filled with silt; and/or extensive channelisation. 3, 2, 1, 0
5. Bottom scouring and deposition	Less than 5% of the bottom affected by scouring and deposition. 15, 14, 13, 12	5-30% affected. Scours at constrictions and where grades steepen, some deposition in pools. 11, 10, 9, 8	30-50% affected. Deposits and scours at obstructions and bends. Some deposition in pools. 7, 6, 5, 4	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. 3, 2, 1, 0

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River Bioassessment Program

HABITAT ASSESSMENT FIELD SHEET cont.

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
6. Pool/riffle, run/bend ratio. *(Distance between riffles divided by stream width)*	0-7 Variety of habitat. Deep riffles and pools. 15, 14, 13, 12	7-15 Adequate depth in pools and riffles. Bends provide habitat. 11, 10, 9, 8	15-25 Occasional riffle or bend. Bottom contours provide some habitat. 7, 6, 5, 4	>25 Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 3, 2, 1, 0
7. Bank stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. 10, 9	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. 8, 7, 6	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme/high flows. 5, 4, 3	Unstable. Many eroded areas. Side slopes > 60% common. 'Raw' areas frequent along straight sections and bends. 2, 1, 0
8. Bank vegetative stability	Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. 10, 9	50-79% of the streambank surfaces covered by vegetation, gravel or larger material. 8, 7, 6	25-49% of the streambank covered by vegetation, gravel or larger material. 5, 4, 3	Less than 25% of the streambank surfaces covered by vegetation, gravel or larger material. 2, 1, 0
9. Streamside cover	Dominant vegetation is of tree form. 10, 9	Dominant vegetation shrub. 8, 7, 6	Dominant vegetation is grass, sedge, ferns. 5, 4, 3	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 2, 1, 0

Column Totals				

Score

○ ○ ○ ○

Appendix E

Flora assessment proforma

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Quaternary site proforma

Location

Site No. _____ **Recorder:** _____ **Day/Date:** _____

Purpose _____

Locality: _____

GPS coordinates Zone [ ][ ] E [ ][ ][ ][ ][ ][ ][ ] N [ ][ ][ ][ ][ ][ ][ ] **Datum:** _____

Vegetation structure

Median height of EDL is to be measured
Cover density is to be estimated

Stratum	Median height	Height interval	Est. cover density (D,M,S,V)
E			
T1			
T2			
T3			
S1			
S2			
G			

Structural formation: (including height)

Ecologically dominant layer:

Landform/pattern, geology, soils etc:

Plant species

Record relative (numerical) dominance for each stratum;
d – dominant; ***c*** – codominant; ***s*** – subdominant; ***a*** – associated.

Str.	Rel. dom.	Scientific Name

Notes: _____

END

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Document Status

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