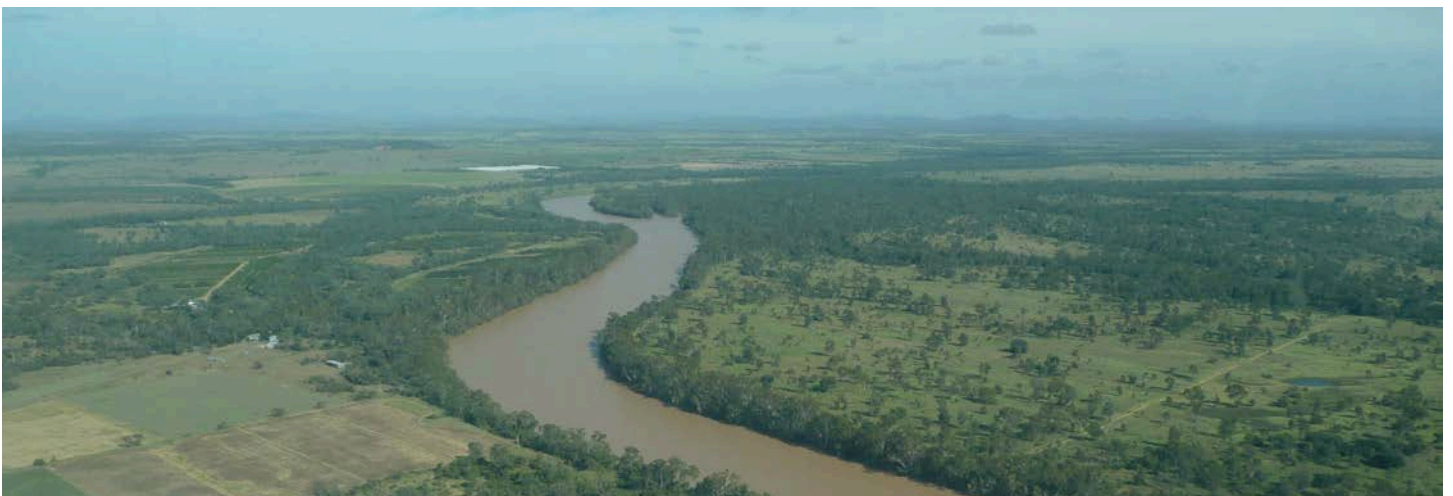


LOWER FITZROY RIVER

INFRASTRUCTURE PROJECT

Appendix K

Rookwood Weir Baseline Aquatic Fauna Report





Gladstone Area Water Board and SunWater

Lower Fitzroy River Infrastructure Project

Rookwood Weir Baseline Aquatic Fauna Report

June 2015

Executive summary

An aquatic ecology study was conducted for the proposed construction of Rookwood Weir. The study aims to provide sufficient baseline information to enable identification and assessment of the potential impacts of the Lower Fitzroy River Infrastructure Project on the existing environmental values of the lower Dawson, lower Mackenzie and Fitzroy Rivers upstream of the proposed weir at Rookwood and downstream to the upper limit of the Eden Bann Weir impoundment. Data for the study was collected from literature reviews and seasonal field surveys to achieve this objective.

The literature review included a study of relevant scientific and grey literature, database searches, and previously prepared technical reports. Field surveys were conducted to supplement the findings from the desktop assessments. Surveys were conducted in wet and dry seasons to document seasonal changes in the ecosystems. Habitat assessments were undertaken at accessible sites representing major aquatic habitats upstream of the Rookwood Weir site. These were selected on the basis of digital topography, aerial photographs, boat access and safety constraints and field reconnaissance. The results of habitat assessments, combined with an aerial overflight of the area, inferred the likely ecological values of downstream habitats.

The aquatic ecological assessment aims to describe aquatic fauna present or likely to be present in the Project footprint and downstream areas, as well as the environmental values of the aquatic system. These may encompass habitat composition and conditions, stream geomorphology and characteristics, presence or absence of macrophytes and adjacent land use. Findings of these searches and surveys inform the impact assessment on aquatic fauna, identifying potential impacts that construction and operation of the Project may have on environmental values such as species diversity, habitat, nesting habits and movement behaviour. Management measures would then be developed to avoid, minimise or mitigate these impacts.

In-stream habitats are dominated by seasonally-dynamic recurring pool-riffle-run sequences. These sequences represent the natural hydrological and geomorphologic regime of the rivers in the study area. Through habitat assessments, variable water velocity, depth, bank characteristics, in-stream habitat features (i.e. woody debris, macrophytes) and stream substrate were observed within and between aquatic habitat types that comprise the pool-riffle-run sequences of the Project footprint. Seasonal variability markedly alters the characteristics and linear extent of these habitats – a natural regime to which the aquatic species of the Fitzroy Basin catchment are adapted.

A number of creeks and off-stream water bodies provide further aquatic habitat beyond the main channel of the lower Dawson, lower Mackenzie and Fitzroy rivers. Creek habitats in the Project footprint were observed to provide a high abundance of microhabitat resources such as overhanging vegetation and in-stream woody debris. These resources provide habitat for an array of aquatic species, including small cryptic fish species, freshwater turtles and platypus. Off-stream water bodies have been identified as important reservoirs of fish biomass, nursery habitat for juvenile fish, and provide potential habitat for crocodiles and long-necked turtles.

Desktop and field surveys undertaken to inform this baseline assessment of the aquatic ecology within and downstream of the Rookwood Weir Project footprint revealed that 34 fish species, seven aquatic reptiles (six turtles, one crocodile), one aquatic mammal, 86 macroinvertebrate taxa and 105 macrophytes have the potential to occur within the Project footprint, based on previous records from the study area and the results of field surveys. Of particular note are conservation significant species which were confirmed present during field surveys, or are

known / predicted to occur based on a review of relevant literature. These include the Fitzroy River turtle, estuarine crocodile, southern saratoga, leathery grunter, golden perch and platypus.

Overall the general characteristics of aquatic habitats within the Rookwood Weir Project footprint, and the aquatic species they support, appear to represent a continuum of habitats downstream to the Eden Bann Weir impoundment, and are not unique in the values and resources they provide in the context of the wider study area. Aquatic habitats (and the species they support) within and downstream of the Rookwood Weir Project footprint have been impacted and altered by human processes occurring at the local to catchment-wide scale. Such impacts include degradation of riparian habitats by livestock, changes to water quality (agriculture and mining) and disruption to natural flow regimes and connectivity of aquatic systems.

Table of contents

1.	Introduction.....	1
1.1	Project overview	1
1.2	Report context.....	3
2.	Aquatic fauna assessment scope, approach and methodology.....	4
2.1	Assessment aim and scope.....	4
2.2	Nomenclature.....	5
2.3	Literature review	5
2.4	Field survey.....	7
2.4.1	Overview.....	7
2.4.2	Constraints and limitations.....	10
2.4.3	Animal ethics and approvals.....	11
2.4.4	Timing of field surveys.....	11
2.4.5	Climatic conditions.....	11
2.4.6	Site selection.....	12
2.4.7	Aquatic habitat assessment	13
2.4.8	Habitat segment analysis.....	16
2.4.9	Fish.....	16
2.4.10	Freshwater turtles.....	19
2.4.11	Crocodiles.....	22
2.4.12	Other fauna.....	22
2.4.13	Macroinvertebrates.....	22
2.4.14	Macrophytes.....	23
2.4.15	Summary of aquatic survey effort.....	24
2.5	Aquatic habitat calculation.....	24
3.	Aquatic ecology existing environmental values	26
3.1	Fitzroy Basin catchment.....	26
3.2	Field survey climatic conditions	27
3.2.1	Wet season.....	27
3.2.2	Dry season.....	27
3.3	Aquatic habitats	28
3.3.1	Overview.....	28
3.3.2	Aquatic habitat segment analysis.....	28
3.3.3	Pools.....	32
3.3.4	Runs	33
3.3.5	Riffles	34
3.3.6	Off-stream water bodies	35
3.3.7	Creeks.....	36
3.3.8	Upstream habitats	38
3.3.9	Habitat dynamics.....	38
3.4	Aquatic fauna and flora	41

3.4.1	Overview.....	41
3.4.2	Fish.....	42
3.4.3	Freshwater turtles.....	68
3.4.4	Crocodiles.....	85
3.4.5	Platypus.....	86
3.4.6	Macroinvertebrates.....	87
3.4.7	Macrophytes.....	91
4.	Summary	94
5.	References	96

Table index

Table 2-1	Summary of literature review and study approach / field effort	8
Table 2-2	AusRivAS River Bioassessment Program habitat variables and criteria rankings.....	15
Table 2-3	Summary of aquatic habitat assessment survey sites	15
Table 2-4	Summary of fish sampling effort Rookwood Weir Project footprint.....	18
Table 2-5	Summary of targeted turtle nesting bank survey sites	21
Table 2-6	Description of artificial substrate locations	23
Table 3-1	Linear extent of in-channel aquatic habitats within and downstream of Rookwood Weir Project footprint.....	28
Table 3-2	Habitat characteristic ratings of pool habitats.....	32
Table 3-3	Habitat characteristic ratings of run habitats	33
Table 3-4	Habitat characteristic ratings of riffle habitats.....	35
Table 3-5	Habitat characteristic ratings of the creek habitat.....	36
Table 3-6	Location of named creeks downstream of and within Rookwood Weir Project footprint.....	37
Table 3-7	Typical dynamics of aquatic habitats in the study area	39
Table 3-8	Examples of wet and dry season aquatic habitats in the Rookwood Weir Project footprint.....	40
Table 3-9	Total number of fauna species predicted to occur or recorded from the study area	41
Table 3-10	Fish species known to occur within the Project footprint and study area based on current study and past reports.....	43
Table 3-11	Wet and dry season fish captures in the Rookwood Weir Project footprint.....	47
Table 3-12	Ecology of the fish species in the Fitzroy Basin catchment.....	49
Table 3-13	Sensitivity of fish migration to hydrology	62
Table 3-14	Known distribution of freshwater turtles within the Fitzroy Basin catchment	69
Table 3-15	Ecology of freshwater turtle species in the Fitzroy Basin catchment	76

Figure index

Figure 1-1	Project location.....	2
Figure 2-1	Rookwood aquatic ecology Project footprint and aquatic survey sites.....	14
Figure 3-1	Linear extent of in-channel aquatic habitats within and downstream of Rookwood Weir Project footprint.....	29
Figure 3-2	Spatial distribution of in-channel aquatic habitats and off-stream water bodies and creeks within the Rookwood Weir Project footprint	30
Figure 3-3	Relationship between fish migration and flow in the Fitzroy River.....	61
Figure 3-4	Potential turtle nesting sites within the Rookwood Weir Project footprint.....	81

Plate index

Plate 2-1	Fyke net with attached float upstream of proposed Rookwood Weir site	17
Plate 2-2	Baited trap deployed amongst submerged structure	18
Plate 2-3	Potential turtle nesting bank surveyed during field assessments	20
Plate 3-1	Golden perch (<i>Macquaria ambigua orientalis</i>).....	46
Plate 3-2	Mouth almighty (<i>Glossamia aprion</i>).....	46
Plate 3-3	Fly-speckled hardyhead (<i>Craterocephalus stercusmuscarum</i>).....	59
Plate 3-4	Purple-spotted gudgeon (<i>Mogurnda adspersa</i>).....	59
Plate 3-5	Potential turtle nesting bank in Rookwood Weir Project footprint.....	79
Plate 3-6	Fitzroy River turtle captured on the Fitzroy River Barrage fish ladder (October 2008)	82
Plate 3-7	White-throated snapping-turtle caught in a fyke net in the Mackenzie River.....	84
Plate 3-8	Diptera, Chironominae.....	89
Plate 3-9	Ephemeroptera, Baetidae.....	89
Plate 3-10	Ephemeroptera, Caenidae.....	89
Plate 3-11	Ephemeroptera, Leptophebiidae.....	89
Plate 3-12	Gastropoda, Thiaridae	89
Plate 3-13	<i>Cherax quadricarinatus</i>	89
Plate 3-14	<i>Lomandra spp.</i> growing above the waterline under fringing <i>Melaleuca</i>	92
Plate 3-15	Filamentous algae growing in a run downstream of a riffle on the Mackenzie River	93

Appendices

Appendix A – Rookwood Weir aquatic fauna desktop results

Acronym	Term
AHD	Australian Height Datum
AusRivAS	Australia Rivers Assessment System
BoM	Australian Bureau of Metrology
DEEDI	Department of Employment, Economic Development and Innovation
DEHP	Department of Environment and Heritage Protection
DERM	Department of Environment and Resource Management
DEWHA	Department of Environment, Water, Heritage and the Arts
DNRW	Department of Natural Resources and Water
EIS	Environmental Impact Statement
EPBC Act	<i>Environmental Protection and Biodiversity Conservation Act 1999</i>
FSL	Full supply level
GHD	GHD Pty Ltd
NC Act	<i>Nature Conservation Act 1992</i>

1. Introduction

1.1 Project overview

The Lower Fitzroy River Infrastructure Project (Project) comprises the construction and operation of a raised Eden Bann Weir and/or a new weir at Rookwood on the Fitzroy River, Central Queensland to facilitate capture and storage of all high priority unallocated water (76,000 ML/a) in the Fitzroy system. The Fitzroy River forms at the confluence of the Mackenzie (flowing from the north) and Dawson (flowing from the south) Rivers. The Fitzroy River flows out into the Coral Sea including the Great Barrier Reef World Heritage Area and Marine Park, some 300 km downstream. The Fitzroy River passes through the city of Rockhampton which lies approximately 59 km from the river mouth.

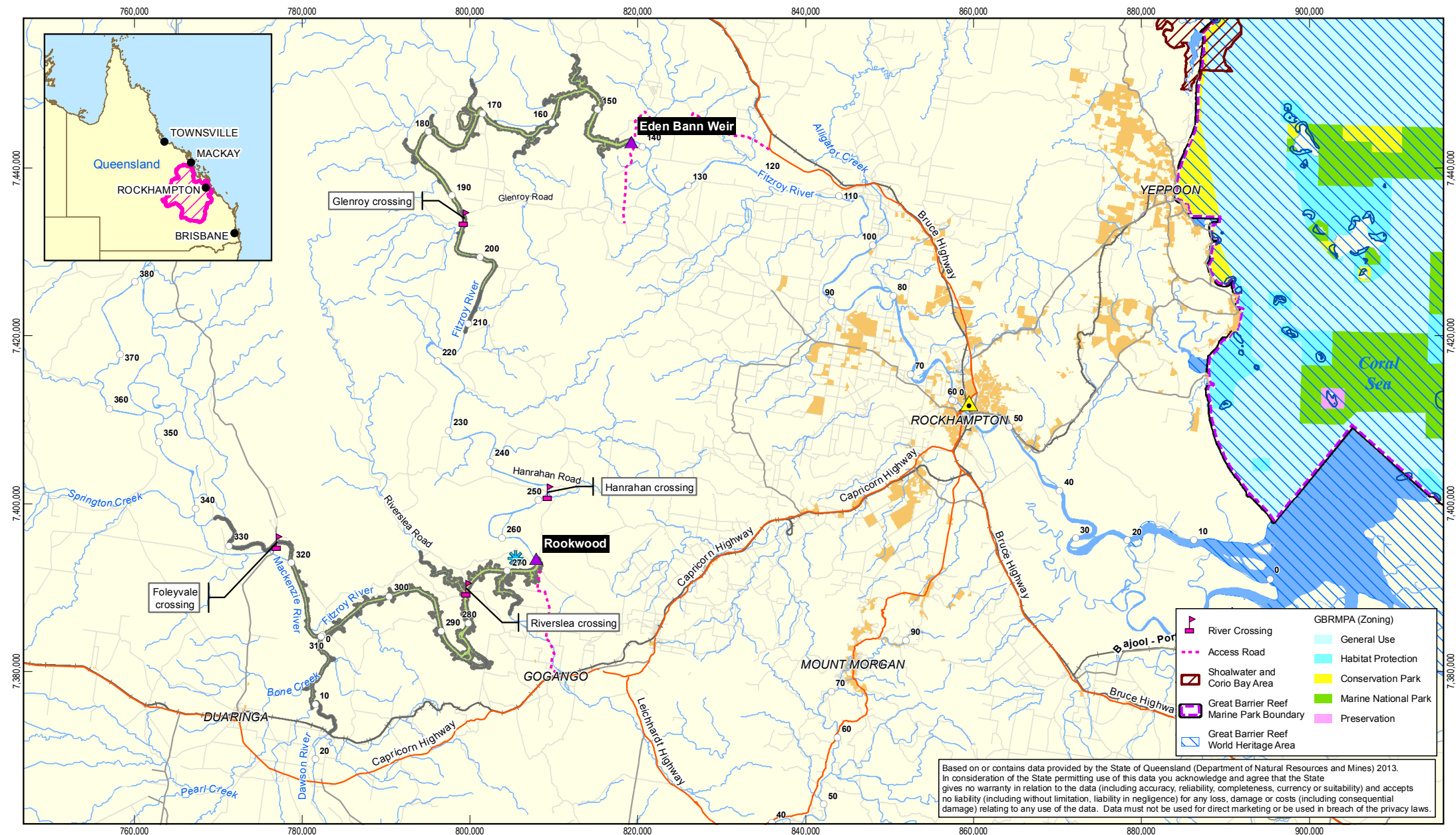
Key Project components include the following:

- Eden Bann Weir
 - Eden Bann Weir Stage 2 – a raise of the existing Eden Bann Weir to a full supply level (FSL) 18.2 m Australian Height Datum (AHD) and associated impoundment of the Fitzroy River.
 - Eden Bann Weir Stage 3 – the addition of 2 m high flap gates to achieve FSL 20.2 m AHD and associated impoundment of the Fitzroy River.
- Rookwood Weir
 - Rookwood Weir Stage 1 – a new build to FSL 45.5 m AHD, saddle dams and associated impoundment of the Fitzroy, Mackenzie and Dawson Rivers.
 - Rookwood Weir Stage 2 – the addition of 3.5 m high flap gates to achieve FSL 49.0 m AHD and associated impoundment of the Fitzroy, Mackenzie and Dawson Rivers.
 - Any combination of the above.
- Fish passage infrastructure and turtle passage infrastructure, namely fish locks and a turtle bypass, respectively, at each weir.

Other infrastructure components associated with the Project include:

- Augmentation to and construction of access roads (public and private) to and from the weir sites for construction and operations and upgrades to intersections.
- Construction of low level bridges in areas upstream of weir infrastructure impacted by the impoundments, specifically at Glenroy, Riverslea and Foleyvale crossings.
- Installation of culverts at Hanrahan Crossing downstream of Rookwood Weir to facilitate access during operation releases.
- Relocation of existing and/or installation of new gauging stations
- Removal and decommissioning of existing low level causeways and culverts at river crossings described above.
- Water supply for construction will be sourced directly from nearby rivers and creeks and will not require the construction of additional water supply infrastructure.

The location of Project components is shown on Figure 1-1.

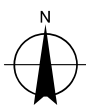


1:600,000 (at A4)

0 5 10 15 20

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55



LEGEND

- AMTD (km)
- ▲ Weir Location
- ▲ Fitzroy Barrage
- ▲ Saddle dams
- Highway
- Major Road
- Streets (Local)
- Access Road
- ▭ Fitzzy Basin
- ▭ Urbanised Area
- ▭ Rookwood Weir Stage 1 impoundment
- ▭ Eden Bann Weir Stage 2 impoundment
- ▭ Eden Bann Weir Stage 3 impoundment
- ▭ Rookwood Weir Stage 2 impoundment



Gladstone Area Water Board, SunWater
Lower Fitzroy River Infrastructure Project

Job Number 41-20736
Revision J
Date 01 Aug 2014

Project locality plan

Figure 1-1

G:\41\20736\GIS\Projects\MXD\200_Report\4120736_017_Rev_J.mxd

Copyright: This document is and shall remain the property of GHD. The document may only be used for the purpose for which it was produced. Unauthorised use of this document in any way is prohibited. © 2013.

© 2014. While GHD has taken care to ensure the accuracy of this product, GHD, DNR, SUNWATER, GBRMPA and GA make no representations or warranties about its accuracy, completeness or suitability for any particular purpose. GHD, DNR, SUNWATER, GBRMPA and GA cannot accept liability of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred as a result of the product being inaccurate, incomplete or unsuitable in any way and for any reason. *Please see Appendix for important copyright information.

Data Source: © Copyright Commonwealth of Australia (Geoscience Australia): Places, Waterways (2007); Sunwater: Waterways, Weir Locations - 2008; DNR: Railways, Roads, RAMSAR Wetlands, World Heritage Area - 2010; © Copyright Commonwealth of Australia (GBRMPA) Zoning, Boundary - 2011. Created by: MS *See Appendix for disclaimers and copyrights.

Level 9, 145 Ann Street Brisbane QLD 4000 Australia T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Operationally, the Project comprises the maintenance and management of the weir infrastructure, private access roads and impoundments, inclusive of a flood buffer. Water releases will be made through 'run of river' methods and no water distribution infrastructure is required. Water releases will be made to satisfy environmental and water security objectives in accordance with the *Water Resource (Fitzroy Basin) Plan 2011*. Operating regimes will be developed and implemented through the Fitzroy Basin Resource Operations Plan 2004 (as augmented).

The development of weir infrastructure (and associated works), the resultant storage of water (inundation of the river bed and banks) and the transfer of water between storages through 'run of river' methods on the Fitzroy River comprise the scope of the Project. Abstraction, transmission and distribution to end users are not considered as part of the proposed Project and are subject to their own environmental investigations.

1.2 Report context

In accordance with the Program of Works Notification (No 3) 2007, the investigations and studies for the Project commenced in late 2008 with most technical studies and reporting being undertaken in 2009. At that time, the target completion date for final development of a Project Business Case was 2009- 2010. It was however acknowledged that this would be dependent on the urgency associated with drought conditions in the region.

Since 2009, Central Queensland has experienced above average rainfalls and water supply infrastructure in the region has been operating at capacity. This has resulted in extended Project timeframes. Furthermore, the State had commissioned a number of investigations and assessments prior to 2008 which were used as a basis for the current environmental impact statement (EIS). Consequently, the EIS reporting spans a change of Government and subsequent reconfiguration of government departments. Names as were applicable to the specific reference are therefore used and not referenced as 'former', 'prior' or 'the then'.

The Rookwood Weir baseline aquatic fauna assessment commenced in 2009. Relevant and applicable updates have been made to the present (2014) as appropriate and necessary.

2. Aquatic fauna assessment scope, approach and methodology

2.1 Assessment aim and scope

The aim of the aquatic ecology study was to provide sufficient baseline information to enable identification and assessment of the potential impacts of the Project on the existing environmental values of the lower Dawson, lower Mackenzie and Fitzroy rivers.

The study area in relation to aquatic ecology values was broad. It included areas upstream of the Rookwood Weir site; downstream of the Rookwood Weir site to the existing Eden Bann Weir impoundment; downstream of the existing Eden Bann Weir and downstream reaches of the Fitzroy River to the Fitzroy Barrage. The estuarine environment immediately downstream of the Fitzroy Barrage and the marine environment into Keppel Bay are discussed in Volume 2, Chapter 7. Existing environment and indirect impacts are assessed in Volume 2, Chapters 8 through 11.

Project footprints comprise the Eden Bann Weir site (and immediate downstream reaches) and associated impoundment; reaches between Eden Bann Weir and the Rookwood Weir site; the Rookwood Weir site itself and associated impoundment along with river crossing locations.

To achieve this objective, desktop and literature reviews were conducted for the study area to provide information on aquatic habitats and species occurring or predicted to occur. The literature review included a study of relevant scientific and grey literature, database searches, and previously prepared technical reports.

Wet and dry season field surveys were conducted within the Project footprints to supplement and ground-truth findings from the desktop assessments and, where possible, fill any knowledge gaps.

Results of the desktop and literature reviews and field surveys specific to the Rookwood Weir site Project footprint (and areas immediately downstream) are presented herein (unless otherwise stated). Aquatic values for the Eden Bann Weir Project footprint and downstream reaches to the Fitzroy Barrage are described in Appendix J.

The distribution and extent of aquatic habitats downstream of the proposed Rookwood Weir site were primarily assessed through a desktop analysis of aerial photography. An aerial overflight of the study area, in conjunction with the results of aquatic habitat assessments upstream of the Rookwood Weir site, were used to infer the likely ecological values of these habitats. Information gathered from the literature review regarding potential aquatic fauna species assemblages and utilisation of downstream habitats was reviewed.

The scope of this aquatic ecological assessment was as follows:

- Describe the aquatic fauna present or likely to be present within the Project footprint including:
 - Diversity of fish, turtles, crocodiles, macroinvertebrates and other aquatic fauna (i.e. platypus)
 - Species which are poorly known but suspected of being threatened
 - The existence of conservation significant or otherwise noteworthy species or communities, including discussion regarding species range, habitat, breeding, recruitment, feeding and movement requirements, and the current level of protection

- Habitat requirements for aquatic fauna including movement, foraging and breeding requirements
- The existence and habitat utilisation of introduced species.
- Describe the environmental values of the aquatic system in terms of:
 - The integrity of ecological processes, including habitat composition, structure and function (particularly for conservation significant species)
 - Stream geomorphology, including channel width, channel depth, substrate and bank height
 - Stream characteristics (e.g. pool, run, riffle etc.)
 - General condition of riparian habitats, including bank vegetative stability and streamside cover
 - Presence / absence of aquatic macrophytes
 - Adjacent land use.

Baseline findings and conditions have informed the preparation of an impact assessment that:

- Identifies and assesses potential impacts that construction and operation of a proposed weir at Rookwood may have on the aquatic environmental values upstream and downstream of the proposed structure
- Outlines strategies and management recommendations to avoid, minimise and / or mitigate these potential impacts.

2.2 Nomenclature

Scientific names for aquatic species are consistent with those used in the following sources:

- A Field Guide to the Freshwater Fishes of Australia (Allen et al. 2003)
- Freshwater Fishes of North-Eastern Australia (Pusey et al. 2004)
- A Field Guide to Reptiles of Queensland (Wilson 2005)
- A Complete Guide to Reptiles of Australia (Wilson and Swan 2008)
- Australian Freshwater Turtles (Cann 1998)
- Mayfly Nymphs of Australia. A Guide to Genera. No. 7. (Dean and Suter 1996)
- The Mammals of Australia (Van Dyck and Strahan 2008).

2.3 Literature review

To inform field surveys, a literature review was conducted to document the aquatic environmental values within the Project footprint and study area and to also identify any conservation significant species that have been historically recorded or have the potential to occur within the area. This review underpinned the description of the baseline aquatic environmental values of the Project footprint presented here. The literature review included searches of:

- The former Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA) *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Environmental Reporting Tool (now the EPBC Act Protected Matters Search Tool) to identify species and / or their habitat listed under the EPBC Act, that are predicted to occur within the Project footprint area and downstream to the existing Eden Bann Weir impoundment, and also to identify invasive species of national significance. The search area was defined by a

transect line (with a 2 km buffer) following the meander of the Fitzroy River, extending upstream from Eden Bann Weir to the maximum proposed impoundment extent of Rookwood Weir

- The former Queensland Department of Environment and Resource Management (DERM) (now the Department of Environment and Heritage Protection (DEHP)) Wildlife Online Database to identify fauna species that have been historically recorded in or surrounding the study area, including threatened species listed under the Queensland *Nature Conservation Act 1992* (NC Act). Records were returned for a search area within a 10 km radius of the Rookwood Weir site. Additional searches were undertaken in 2013 as reported in Volume 1, Chapter 7 Aquatic ecology
- The Essential Habitat Mapping Database (Version 3.0, 2009) to identify essential habitats within the Project footprint
- The DEWHA EPBC Act Environmental Reporting Tool (now the EPBC Act Protected Matters Search Tool) to identify any Nationally Important Wetlands (recorded in the Directory of Important Wetlands in Australia) that occur within the study area. The search area was defined by a transect line (with a 2 km buffer) following the meander of the Fitzroy River extending upstream from Eden Bann Weir to the maximum proposed impoundment extent of Rookwood Weir
- The Queensland Museum's Specimen Database to obtain a record of aquatic vertebrates previously recorded in the study area. Data is stored for discrete regions on the Queensland Museum database, and as such, "search rectangles" encompassing the Rookwood Weir Project footprint was queried for aquatic fauna species records. The coordinates of the search rectangles were as follows:
 - 150° 7', -22° 59' (top right corner) and 149° 48', -23° 41' (bottom left corner)
 - 149° 48', -23° 29' (top right corner) and 149° 37', -23° 45' (bottom left corner)
- Threatened species profiles and field guides
- Previous studies and reports¹ conducted in the study area, including (but not limited to):
 - Impact assessment of modified water infrastructure (Fitzroy Barrage) on the Fitzroy River saltwater crocodile – Potential implications and proposed mitigation measures for saltwater crocodiles (*Crocodylus porosus*) (Britton 2007a)
 - Proposal for raising Eden Bann Weir and construction of Rookwood Weir – An assessment of the potential implications and proposed mitigation measures for saltwater crocodiles (*Crocodylus porosus*) (Britton 2007b)
 - Proposal for raising Eden Bann Weir and construction of Rookwood Weir – An assessment of the potential requirements for fish passage (Marsden and Power 2007)
 - Assessment of potential implications of modified water infrastructure on Fitzroy River fish passage and the fishway (Earth Tech 2007)
 - Do fish locks have potential in tropical rivers? (Stuart et al. 2007)
 - The assessment of Eden Bann Weir Fishlock, Fitzroy River, Queensland (Long and Meager 2000)
 - Freshwater fishes of the Fitzroy Basin catchment, Central Queensland (Berghuis and Long 1999)

¹ Not all material referenced is publically available having been produced as "commercial in confidence".

- Lower Fitzroy weirs discussion paper on fishway facilities for raised Eden Bann Weir (SunWater 2008a)
- Proposal for raising Eden Bann Weir and construction of Rookwood Weir – An assessment of the potential implications and mitigation measures for Fitzroy turtles (*Elseya albagula* and *Rheodytes leukops*) (Limpus et al. 2007)
- Fitzroy River Water, Modified Water Infrastructure EIS and Management Plan: Turtles (*Rheodytes leukops* and *Elseya albagula*) (frc environmental 2007)
- Lower Fitzroy Weirs discussion paper on turtle passage facilities for raised Eden Bann Weir and Rookwood (SunWater 2008b)
- Lower Fitzroy Weirs literature review and gap analysis (frc environmental 2008).

Further to this list, a wide range of studies focussing on various aspects of the aquatic ecology of the study area, and the ecology of species known to occur in the study area, were sourced from the scientific literature and other relevant material, and reviewed.

2.4 Field survey

2.4.1 Overview

Field surveys were conducted in order to ground-truth information acquired through the literature review regarding species and communities expected to occur within the Project footprint, and to verify the likely occurrence of EPBC Act and NC Act listed aquatic fauna species. Verification was based on direct and indirect (e.g. suitable habitat) observations. Where possible, given the limitations and constraints on the field studies outlined in Section 2.4.2, attempts were made to fill knowledge gaps identified through the literature review, including those highlighted by frc environmental in their 2008 literature review and gap analysis.

Areas of focus for the field survey effort included:

- Assessments of aquatic habitat characteristics and values throughout the Project footprint
- Assessment and mapping of potential turtle nesting banks throughout the Project footprint, including ranking of potential value
- Fish trapping to sample species diversity in riverine habitats to be impacted by inundation, as a supplement to information acquired through the literature review
- Opportunistic recordings of conservation significant fauna (including Fitzroy River turtle, estuarine crocodile and platypus)
- Macroinvertebrate sampling within the Project footprint to supplement information acquired through the literature review.

Surveys were conducted in the wet and dry season (refer to Section 2.4.4) to document seasonal changes in aquatic fauna assemblages, habitat condition and utilisation. Survey timing and design considered seasonal variation and the ecology of targeted threatened species.

Table 2-1 provides a summary of the literature reviewed and the study approach / field survey effort.

Table 2-1 Summary of literature review and study approach / field effort

Parameter	Information in literature to inform impacts	References	Current knowledge gaps	Field effort	Study approach and field effort
Freshwater turtles (including conservation significant Fitzroy River turtle)	<ul style="list-style-type: none"> Species diversity Distribution in catchment Aquatic habitat requirements Breeding ecology Threatening processes 	<p><u>Key reference</u></p> <p>Limpus et al. 2007</p> <p><u>Other references</u></p> <p>Cann 1998</p> <p>Clark 2008</p> <p>Clark et al. 2008</p> <p>frc environmental 2007</p> <p>frc environmental 2008</p> <p>Gordos 2004</p> <p>Gordos et al. 2003a,b</p> <p>Gordos et al. 2007</p> <p>Hamann et al. 2007</p> <p>Legler and Cann 1980</p> <p>Legler and Georges 1993</p> <p>Limpus et al. 2006</p> <p>Mathie and Franklin 2006</p> <p>Priest 1997</p> <p>Priest and Franklin 2002</p> <p>Rogers 2000</p> <p>SunWater 2008b</p> <p>Thomson et al. 2006</p> <p>Tucker 2000</p> <p>Tucker et al. 2001</p> <p>Venz et al. 2002</p>	<ul style="list-style-type: none"> Specific nesting bank requirements Nesting bank locations (including locations of any aggregated nesting sites) Movement behaviours 	<ul style="list-style-type: none"> Aquatic habitat assessments Opportunistic recordings of species (including conservation significant species) Identification, assessment and mapping of potential nesting banks for conservation significant turtles 	<p>A significant body of literature on freshwater turtles of the Fitzroy Basin catchment exists. This includes a comprehensive assessment for the Project undertaken by DERM (Limpus et al.) in 2007. This assessment drew on a number of previous studies and included detailed field assessments within the proposed impoundment areas of a raised Eden Bann Weir and a proposed weir at Rookwood.</p> <p>In light of the availability of information on species diversity, distribution in the Fitzroy Basin catchment and aquatic habitat requirements, trapping in the Project footprint was not deemed necessary.</p> <p>Given that potential nesting banks are poorly known from the Project footprint, that these habitats are likely to be impacted by the proposed weir at Rookwood, and that lack of recruitment has been cited as a major threat to these species (Limpus et al. 2007), targeted surveys for the Fitzroy River turtle and white-throated snapping turtle focussed on the identification, assessment and mapping of potential turtle nesting in the Project footprint. Due to the difficulty in trapping for the Fitzroy River turtle and white-throated snapping turtle, the distribution and abundance of these species within the Project footprint and study area was assessed based on the results of the past surveys detailed above. Where insufficient information was available, species occurrence was assessed based on habitat suitability.</p>
Estuarine crocodile	<ul style="list-style-type: none"> Distribution in catchment Relative abundance in catchment Aquatic habitat requirements Breeding ecology Threatening processes 	<p><u>Key references</u></p> <p>Britton 2007a</p> <p>Britton 2007b</p> <p><u>Other references</u></p> <p>DERM 2009</p> <p>EPA 2007</p> <p>frc environmental 2008</p> <p>Walsh and Whitehead 1993</p>	<ul style="list-style-type: none"> Movement behaviours Recruitment into population 	<ul style="list-style-type: none"> Aquatic habitat assessments Opportunistic recordings of crocodiles (including characteristic slides on banks) Opportunistic recordings of crocodile nests 	<p>Two comprehensive studies were undertaken to describe potential impacts (and associated mitigations measures) on estuarine crocodiles from water infrastructure development on the Fitzroy River (Britton 2007a; Britton 2007b). These studies provide a thorough description of estuarine crocodile populations (including abundance) and habitat utilisation in the Fitzroy River (including the Rookwood Weir Project footprint), based upon the results of detailed field assessments.</p> <p>Given the amount of information on estuarine crocodile ecology in the Fitzroy River, specific targeted field surveys were not deemed necessary for this species. Habitat assessments documented potentially suitable habitat, while any opportunistic recordings were noted.</p>
Fish	<ul style="list-style-type: none"> Species diversity in catchment General habitat preferences of fish species Barriers to movement in the Fitzroy River / use of fish passage devices 	<p><u>Key references</u></p> <p>Berghuis and Long 1999</p> <p>Long and Meager 2000</p> <p>Marsden and Power 2007</p> <p>Pusey et al. 2004</p> <p>Stuart et al. 2007</p> <p><u>Other references</u></p> <p>Allen, et al. 2003</p> <p>DEEDI 2009</p> <p>Earth Tech 2007</p> <p>frc environmental 2008</p> <p>Heindenreich and</p>	<ul style="list-style-type: none"> Species assemblages in specific aquatic habitat types 	<ul style="list-style-type: none"> Aquatic habitat assessments Fish sampling within, immediately upstream and immediately downstream of the Rookwood Weir Project footprint 	<p>The fish diversity of the Fitzroy Basin catchment has been studied in detail. In particular, the impacts of movement barriers on fish in the system has received notable attention, including a specific study on potential requirements for fish passage relating to the raising of Eden Bann Weir and the construction of the proposed weir at Rookwood (Marsden and Power 2007). Habitat preferences for fish species in the Fitzroy Basin catchment is generally well-described, based on the volume of sampling that has occurred throughout the catchment, including various aquatic habitats in the Fitzroy River.</p> <p>A number of constraints during EIS surveys limited both wet and dry season fish sampling in the Rookwood Weir Project footprint during the wet season (refer Section 2.4.2). Fish sampling in accessible parts of the Project footprint was undertaken to characterise species assemblages in various aquatic habitats within, and immediately upstream of the Rookwood Weir Project footprint. Likely species assemblages in other in-stream and off-stream aquatic habitat types were derived based on an analysis of the individual ecology of species, information contained within the literature, and from an extrapolation of results obtained from downstream fish sampling (i.e. between Eden Bann Weir and the Fitzroy Barrage).</p>

Parameter	Information in literature to inform impacts	References	Current knowledge gaps	Field effort	Study approach and field effort
		Broadfoot 2001 Stuart and Mallen-Cooper 1999 Stuart 1997 SunWater 2008a			
Platypus	<ul style="list-style-type: none"> Occurrence in the Dawson, Mackenzie and Fitzroy Rivers 	<u>References</u> Fish et al. 2001 frc environmental 2008 Gardner and Serena 1995 Grant and Temple-Smith 1998 Otley et al. 2000 Serena et al. 1998	<ul style="list-style-type: none"> Distribution and abundance in the Dawson, Mackenzie and Fitzroy Rivers 	<ul style="list-style-type: none"> Aquatic habitat assessments Opportunistic recordings 	Platypus are known to occur in the study area. A general characterisation of potentially suitable habitats for the platypus (based on the known ecology of the species from the literature) was ascertained through aquatic habitat assessments. Targeted searches for this species were not undertaken, although any opportunistic recordings of this species were noted.
Macroinvertebrates	<ul style="list-style-type: none"> General characterisation of diversity of macroinvertebrate taxa in the study area Non-occurrence of listed threatened species in the study area 	<u>References</u> Duivenvoorden et al. 2000 Duivenvoorden and Roberts 1997 frc environmental 2008	<ul style="list-style-type: none"> Description of species assemblages occurring in specific aquatic habitat types within the Rookwood Weir Project footprint Habitat requirements of key species 	<ul style="list-style-type: none"> Non-systematic deployment of artificial substrates in various aquatic habitat types throughout study area to supplement existing information about macroinvertebrate diversity in study area 	<p>Macroinvertebrate sampling in the Rookwood Weir Project footprint was severely limited by several constraints (refer to Section 2.4.2). Where possible, sampling was undertaken through deployment of artificial substrates, to contribute additional information regarding the general diversity of macroinvertebrates in the study area. It is recognised that there are limitations associated with the use of colonisation of artificial substrates to infer macroinvertebrate assemblage structure, however, this approach provided data which would otherwise not have been obtainable.</p> <p>As no threatened aquatic macroinvertebrates were identified from the literature review, a general characterisation of macroinvertebrate diversity from the literature (and supplemented, where possible, by field data) was considered sufficient to inform potential impacts on these animals from the Project.</p>
Macrophytes	General description of macrophytes known to occur in the study area Pest species known to occur in study area	<u>References</u> Duivenvoorden 1992 Noble et al. 1997 frc environmental 2008 Houston and Duivenvoorden 2002	<ul style="list-style-type: none"> Species presence, diversity and distribution in various aquatic habitat types Temporal patterns in macrophyte distribution 	<ul style="list-style-type: none"> Aquatic habitat assessments 	The presence of macrophytes was noted during aquatic habitat assessments throughout the Rookwood Weir Project footprint. A general description of macrophytes was recorded, however species-level identification was not undertaken. As the primary aim of recording macrophyte presence / absence and general characteristics was to inform potential value to aquatic fauna (i.e. provision of shelter and foraging resources), species level identification was deemed unnecessary at the environmental impact assessment level.
Aquatic habitats	Potential utilisation by aquatic fauna, including threatened species	<u>References</u> All references related to aquatic ecology of study area	<ul style="list-style-type: none"> Distribution and extent of aquatic habitats General characteristics of aquatic habitats Values of aquatic habitats for fauna 	<ul style="list-style-type: none"> Aquatic habitat assessments and field observations Aerial overflight of study area 	<p>Habitat assessments were undertaken at accessible sites representing major aquatic habitats throughout the Project footprint. Creek and off-stream water body habitats were assessed where access permitted. Where these habitats could not be accessed in the field (refer to limitations Section 1.4.1), a desktop approach to assessing the spatial distribution / extent of these habitat types was undertaken. Specifically, this involved an assessment of the Queensland Government's Wetland/Info Mapping service in conjunction with satellite imagery of the study area.</p> <p>In the absence of being able to access all habitats, habitat segment analysis was utilised to assess the extent of aquatic habitats, within, and downstream of the Rookwood Weir Project footprint. The distribution and linear extent of aquatic habitat types within and downstream of the Project footprint was quantified and mapped from aerial photographs, and where possible, verified in the field (including during the reconnaissance aerial overflight).</p>
Upstream and downstream habitats	Potential utilisation by aquatic fauna, including threatened species	<u>References</u> All references related to aquatic ecology of study area	<ul style="list-style-type: none"> Distribution and extent of aquatic habitats Values of aquatic habitats for fauna 	<ul style="list-style-type: none"> Aquatic habitat assessments within Project footprint Aerial overflight of study area 	<p>The distribution and extent of aquatic habitats within and downstream of the Project footprint was primarily assessed through a desktop analysis of aerial photography. An aerial overflight of the study area, in conjunction with the results of aquatic habitat assessments in the Rookwood Weir Project footprint was used to infer the likely ecological values of these habitats. Information from the literature about potential aquatic fauna species assemblages and utilisation of upstream and downstream habitats was reviewed.</p> <p>Habitats upstream of the Project footprint, which are predicted to suffer minimal impacts from the proposed weir, were inferred to be similar to those described within the Project footprint (based on aerial photo interpretation, field observations and literature reviews), and were not specifically addressed. However, upstream and downstream habitats of significant values (i.e. known populations of conservation significant fauna) identified in the literature reviews are discussed in subsequent sections of this report.</p>

2.4.2 Constraints and limitations

As specified in Section 2.1, the aim of this assessment was to provide sufficient information to inform the assessment of impacts and identification of appropriate mitigation measures. As such, habitat assessments and fauna trapping efforts were focussed on providing information that would:

- Ground-truth and supplement existing information on the ecological values of the Project footprint
- Assist in filling knowledge gaps revealed during the literature review
- Fulfil the assessment scope outlined in Section 2.1.

There were three main limitations that influenced field survey methodologies and effort:

- Flooding and wet weather access. Wet season field effort and accessibility was severely limited by flood activity and rainfall. For example, macroinvertebrates were not able to be sampled via kick-sampling and standard Australian Rivers Assessment System (AusRivAS 2001) methodology as was intended, due to safety concerns associated with trying to access suitable substrate in flood conditions. For this reason artificial substrates were deployed as surrogate measures (Section 2.4.13). The use of colonisation of artificial substrates to infer macroinvertebrate assemblage structure does have associated limitations, however this approach provided data which would otherwise not have been obtainable.

Seasonal flooding and rainfall through February and March 2009 also caused planned field trips to be delayed, largely due to restricted vehicular and boat access. In the wet season survey, a number of propeller blades (i.e. both on boats and spares) were broken attempting to traverse rapidly flowing shallow sections of the Fitzroy River (particularly around Riverslea Crossing). Therefore, only three fish trapping sites were able to be established safely. Flooding and high flows also resulted in high turbidity throughout the Project footprint, thereby limiting survey options for freshwater turtles reliant on visual detection (i.e. dip-netting).

- Dry weather access. Due to the large size of the Project footprint and study area, and the relative paucity of vehicle access points, boat travel was the most expedient form of transport with which to establish and access survey sites. However, in the dry season the ability to traverse by boat was hampered by the lack of water in the river, snags and submerged structures, particularly in the often shallow and narrow Dawson and Mackenzie Rivers. In an effort to overcome this, attempts to traverse the rivers by canoe were undertaken. Adequate sampling effort was able to be undertaken within the Project footprint, yet limited sampling (habitat assessments and fauna trapping) was undertaken immediately upstream (on the Dawson River) and downstream of the proposed impoundment. Assessment of the section of the river between the Rookwood Weir site and the upper extent of the proposed increased Eden Bann Weir impoundment, was undertaken via aerial photography analysis (refer to Section 1.4.7-aquatic habitat segment analysis), as canoe traverse along this length of the river was deemed to be unfeasible given time constraints, and safety concerns (given the lack of access out of the river in case of emergency).
- Safety concerns and requirements. While considered unlikely to occur in the Rookwood Weir Project footprint, the potential presence of estuarine crocodiles

represented a safety concern when conducting aquatic habitat assessments and fauna trapping. Therefore activities that involved wading in the river, such as seine netting, backpack electrofishing, snorkelling for turtles and in-stream macroinvertebrate sampling (i.e. kick-sampling) were not undertaken. Access to very remote areas, requiring long travel times over unsealed roads was also not undertaken for safety reasons, however, the use of boats (wet season) and canoes (dry season) as a mode of transportation was implemented (albeit with its own limitations) in an attempt to circumvent this.

In addition, landholder permission was required to access launching sites and riparian habitats throughout the Project footprint, and while in most cases this was granted, where it was not, survey could not be undertaken.

The field survey approach employed in this assessment (considering access limitations) did not attempt to sample all potential species, or all available habitats, that may occur within the Project footprint over the duration of the study. Rather, the approach allowed for the sampling of species that may have been poorly described in the literature, confirmation of the presence of conservation significant species (and/or their habitats), and the description of the general aquatic habitat values based on assessments of representative habitat types at a number of locations in the Rookwood Weir Project footprint. Despite limitations, given the body of literature reviewed and coverage achieved it is considered that sufficient baseline data was attained to provide a valid description of existing aquatic ecology values

2.4.3 Animal ethics and approvals

Aquatic fauna surveys were conducted under Section 52 of the *Animal Care and Protection Act 2001* (General Fisheries Permit - 113990) and supported by the former Queensland Department of Employment, Economic Development and Innovation (DEEDI) animal ethics committee (CA 2008/07/280).

2.4.4 Timing of field surveys

Wet and dry season field surveys were conducted in order to document seasonal changes in faunal assemblages and aquatic ecosystems within the study area. An initial reconnaissance of the study area was undertaken on 20 January 2009 (aerial overflight) and subsequent wet season surveys were conducted between 29 April and 1 May 2009. The dry season surveys were undertaken between 25 and 30 July 2009. Turtle nesting bank surveys were also conducted between 9 and 12 December 2008 and 25 and 30 July to coincide with turtle nesting / hatching seasons (refer to Section 2.4.10).

2.4.5 Climatic conditions

Climatic data was sourced from the Australian Bureau of Meteorology (BoM), recorded at the Rockhampton Airport weather station (039083) (BoM 2009). This data is considered to be indicative of the general climatic conditions in the study area, yet it does not necessarily represent the precise meteorological conditions prevailing at survey sites precisely when the field surveys were undertaken due to the separation distance from the sites to the Bureau of Meteorology station (approximately 60 km).

2.4.6 Site selection

Aquatic survey sites (for habitat assessments, turtle nesting bank surveys and aquatic fauna trapping) were selected based on a review of digital topography, georeferenced aerial photographs, streambed geology, road and boat access, safety constraints and field reconnaissance including an aerial overflight. Site selection was also influenced by logistical constraints associated with boat operation. These included safety concerns in fast-flowing waters (wet season) and low water levels preventing boat access (dry season) and the potential (although unlikely) presence of estuarine crocodiles in the Project footprint (refer to Section 2.4.2).

Habitat assessments were conducted at sites representing major aquatic habitats within the study area. These were defined as:

- **Pools:** zones of relatively deep, still or very slow flowing water over variable substrates (i.e. silt, sand, stone or rock) that occur naturally within the riverine environment (as opposed to upstream of man-made structures) (AusRivAS 2001). This aquatic habitat type occurs in the main channel, and may become isolated into a series of discrete water holes during dry conditions when flow ceases and water levels drop. The low (or zero) velocity of water flow differentiates a pool habitat from a faster flowing run habitat (AusRivAS 2001)
- **Riffles:** shallow (<0.3 m), fast-flowing (>0.2 m/s) water over a stony bed (AusRivAS 2001)
- **Runs:** relatively deep, fast flowing unbroken water over a sandy, stony or rocky bed (AusRivAS 2001). These habitats may occur immediately upstream and downstream of a riffle zone. Fast flowing water during high flow / flood conditions may result in the conversion of generally sluggish pool habitats and generally shallow riffle habitats into runs (AusRivAS 2001)
- **Off-stream water bodies** including:
 - Palustrine wetlands (vegetated swamps, billabongs), oxbow lakes, and farm dams in the floodplain adjacent to the main channel²
 - Flood-runners / secondary channels within the bed and banks (i.e. including the riparian zone)
- **Creeks:** small tributaries adjoining the main river channel that persist for varying distances across the adjacent floodplain and beyond. This does not include minor drainage lines that may only flow intermittently after rainfall.

Where possible, sites for deployment of nets and traps were selected to sample aquatic fauna in each of the habitat types, and in locations that allowed safe operation and had suitable structures (e.g. projecting branches or roots for attachment). Where appropriate, trapping sites were coincident with those of habitat assessments, but this was not always possible. For example, traps could not be deployed in areas with very fast flows due to the risk of trap loss and subsequent wildlife entrapment.

² For the purposes of this assessment, off-stream water bodies within 1 km of the main channel and adjoining creeks were considered.

Turtle nesting bank surveys were conducted at targeted sites based on the current knowledge of species preferences for particular substrate, slope, elevation and vegetation cover (refer to Section 2.4.10) Locations of habitat assessment, turtle nesting bank surveys and fauna trapping sites are provided in Figure 2-1.

2.4.7 Aquatic habitat assessment

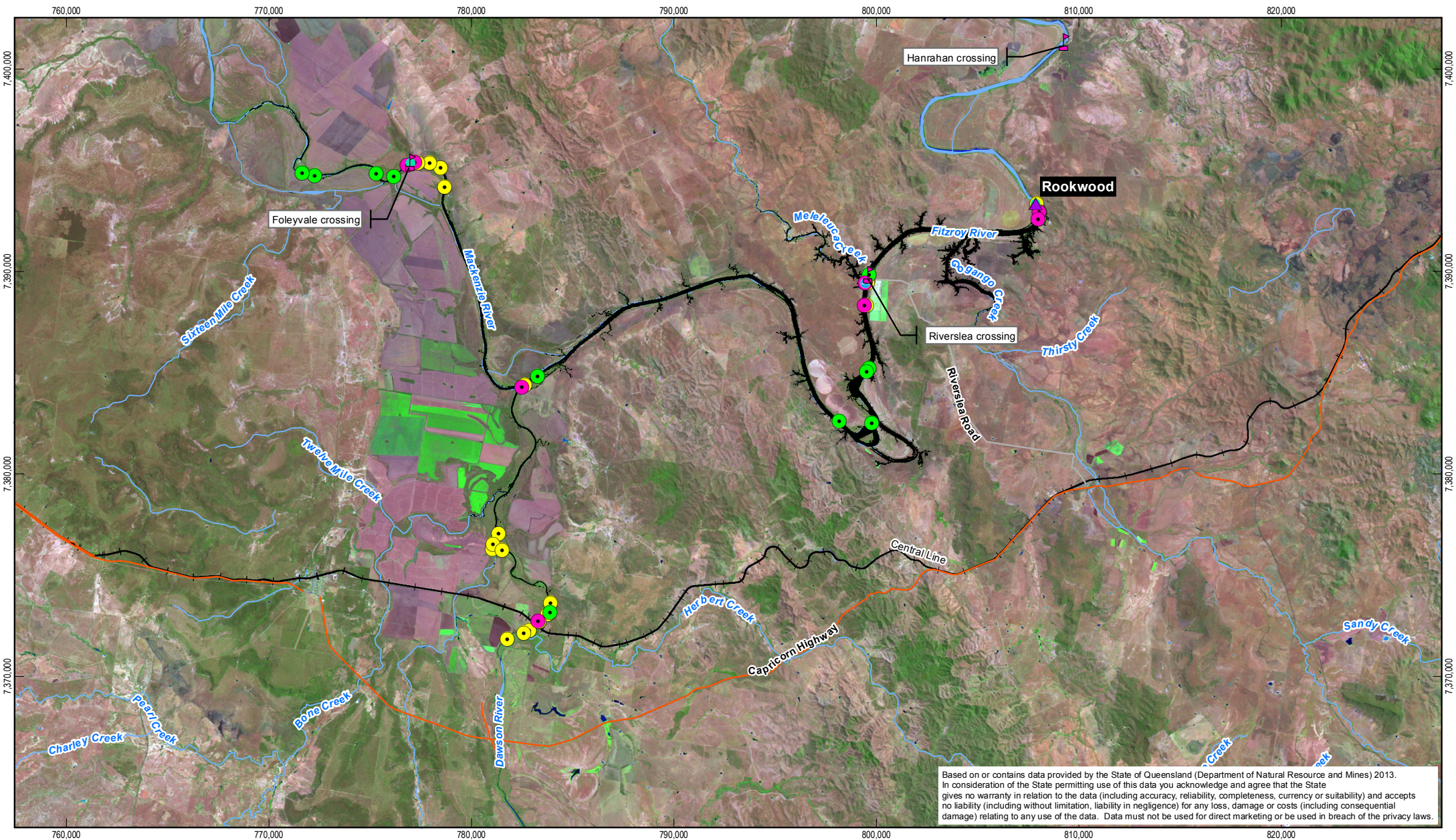
Habitat assessments were undertaken at accessible sites representing major aquatic habitats throughout the Project footprint. Each survey site was identified in relation to habitat type described above in Section 2.4.6 and the following parameters recorded:

- Stream channel and bank morphology (e.g. channel width, depth and bank height)
- Bank profile
- Substrate description (e.g. bedrock, gravel, sand or silt)
- Presence of plant material (e.g. aquatic plants, algae and submerged logs)
- Riparian vegetation description (e.g. width and length of stream side vegetation, overhanging and native vegetation)
- Adjacent land use
- Water velocity (e.g. deep and shallow areas)
- Position in relation to existing or proposed impoundment.

Creek and off-stream water body habitats were assessed where access permitted. Where these habitats could not be accessed in the field (refer to limitations Section 2.4.2), a desktop approach to assessing the spatial distribution / extent of these habitat types was undertaken. Specifically, this involved an assessment of Queensland Government's Wetland *Info* Mapping Service in conjunction with satellite imagery of the study area.

Habitat characteristics of each survey site were assessed from excellent to poor according to criteria of the AusRivAS River Bioassessment Program from which a sub sample of habitat variables relevant to the Project were selected (Table 2-2).

A summary of aquatic habitat assessment survey effort is provided in Table 2-3 below.

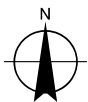


1:250,000 (at A4)

0 2.5 5 7.5 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA94)
Grid: Map Grid of Australia 1994, Zone 55



LEGEND

- | | | | |
|----------------|------------------|--|--|
| Weir Location | Minor Road | Aquatic Fauna Trapping (GHD) | Macroinvertebrate artificial substrate sites (GHD) |
| River Crossing | Railway | Habitat and Turtle Nesting Bank Assessment (GHD) | Principal study sites (Limpus et al 2011) |
| Highway | Impoundment Area | Turtle Nesting Bank Assessment (GHD) | |
| | Waterway | | |



CLIENTS | PEOPLE | PERFORMANCE



Gladstone Area Water Board, SunWater	Job Number	41-20736
Lower Fitzroy River Infrastructure Project	Revision	C
	Date	01 Aug 2014

Rookwood Aquatic Ecology Project Footprint and Aquatic Survey Sites

Figure 2-1

G:\41\20736\GIS\Projects\MXD\900_Baseline Terrestrial Fauna Report\4120736_912_Rookwood_Survey_Sites_Rev_C.mxd

Copyright: This document is and shall remain the property of GHD. The document may only be used for the purpose for which it was produced. Unauthorised use of this document in any way is prohibited. © 2013.

© 2013. While GHD has taken care to ensure the accuracy of this product, GHD, DNRM, SUNWATER and GA make no representations or warranties about its accuracy, completeness or suitability for any particular purpose. GHD, DNRM, SUNWATER and GA cannot accept liability of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred as a result of the product being inaccurate, incomplete or unsuitable in any way and for any reason.

Data Source: © Copyright Commonwealth of Australia (Geoscience Australia): Waterways, State (2007); Sunwater: Waterways, Weir Locations - 2008; DNRM: Roads - 2010,

Railways - 2010, Imagery/2005; GHD Fauna Survey - 2009. Created by IH

Level 9, 145 Ann St Brisbane QLD 4000 T 61 7 3316 3000 F 61 7 3316 3333 E bnemail@ghd.com.au W www.ghd.com.au

Table 2-2 AusRivAS River Bioassessment Program habitat variables and criteria rankings

Habitat variable	Excellent	Good	Fair	Poor
1. Bottom substrate / available cover	> 50% rubble, gravel, submerged logs, undercut banks, or other stable habitat.	30-50% rubble, gravel or other stable habitat.	10-30% rubble, gravel or other stable habitat.	<10% rubble, gravel or other stable habitat. Lack of habitat is obvious.
2. Bank stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%.	Moderately stable. Infrequent small areas of erosion. Side slopes up to 40% on some banks.	Moderately unstable. Moderate frequency and size of erosion areas. Side slopes up to 60% on some banks.	Unstable. Many eroded areas. Side slopes >60% are common. Exposed 'raw' areas frequent along straight sections and bends.
3. Bank vegetative stability	Over 80% of the streambank covered by vegetation or boulders and cobble.	50-79% of the streambank covered by vegetation, gravel or larger material.	25-49% of the streambank covered by vegetation, gravel or larger material.	<25% of the streambank covered by vegetation, gravel or larger material.
4. Streamside cover	Dominant vegetation is of tree form.	Dominant vegetation is shrub form.	Dominant vegetation is grass, sedge, ferns.	Over 50% of stream bank has no vegetation and dominant material is soil, rock, bridge materials or culverts.

Table 2-3 Summary of aquatic habitat assessment survey sites

Sampling site name	Coordinate	Site location	Aquatic habitat type sampled at time of survey	Sampling period*
RWA1	-23.541, 150.016	Fitzroy River (Rookwood Crossing)	Riffle / run	Dry
RWA2	-23.576, 149.935	Fitzroy River (Riverslea Crossing)	Pool	Dry
RWA3	-23.578, 149.934	Fitzroy River (upstream of Riverslea Crossing)	Mouth of creek adjoining Pool	Wet
RWA4	-23.588, 149.934	Fitzroy River (upstream of Riverslea Crossing)	Pool	Wet
RWA5	-23.626, 149.770	Fitzroy River (downstream of Dawson / Mackenzie confluence)	Riffle	Dry
RWA6	-23.528, 149.716	Mackenzie River (downstream of Foleyvale Crossing)	Run	Wet
RWA7	-23.539, 149.73	Mackenzie River (downstream of Foleyvale Crossing)	Pool	Dry
RWA8	-23.699, 149.756	Dawson River (downstream of Boolburra rail crossing)	Riffle	Dry

Sampling site name	Coordinate	Site location	Aquatic habitat type sampled at time of survey	Sampling period*
RWA9	-23.693, 149.759	Daw son River (downstream of Boolburra rail crossing)	Riffle	Dry
RWA10	-23.698, 149.756	Daw son River (downstream of Boolburra rail crossing)	Pool	Dry
RWA11	-23.700, 149.761	Daw son River (downstream of Boolburra rail crossing)	Run	Dry
RWA12	-23.723, 149.783	Daw son River (downstream of Boolburra rail crossing)	Pool / riffle / run	Dry
RWA13	-23.728, 149.783	Daw son River (downstream of Boolburra rail crossing)	Riffle	Dry
RWA14	-23.732, 149.779	Daw son River (downstream of Boolburra rail crossing)	Riffle	Dry
RWA15	-23.736, 149.775	Daw son River (upstream of Boolburra rail crossing)	Pool / run	Dry
RWA16	-23.737, 149.772	Daw son River (upstream of Boolburra rail crossing)	Pool	Dry
RWA17	-23.739, 149.764	Daw son River (upstream of Boolburra rail crossing)	Pool / run	Dry

* Wet: surveys conducted late April / early May 2009; Dry: surveys conducted late July 2009

2.4.8 Habitat segment analysis

In the absence of being able to access all habitats, habitat segment analysis was utilised to assess the extent of aquatic habitats, within and downstream of the Rookwood Weir Project footprint.

The distribution and linear extent of aquatic habitat types within the Project footprint (i.e. upstream of the Rookwood Weir site) as well as downstream, were quantified and mapped from aerial photographs, and where possible, verified in the field (within Project footprint during field studies and during the reconnaissance aerial overflight). Habitat boundaries were subsequently estimated based on the visual characteristics observed. The extent of each habitat type within the main river channel in the Project footprint was then calculated based on the percentage of river length covered by each habitat (off-stream water bodies and adjoining creeks not included). As habitat boundaries (e.g. the difference between a riffle and a run) vary between seasons, the percentages of each habitat type within the Project footprint provide an example of aquatic habitat extent. These values are likely to fluctuate substantially in response to seasonal variability in water flows.

Habitat quality was inferred to be similar to that of the aquatic habitats assessed within the Project footprint, given the similarity of surrounding land uses up and downstream.

2.4.9 Fish

Wet and dry season field surveys, using fyke nets and small collapsible baited traps, were undertaken in order to confirm and supplement the information acquired from the literature review, and also to reveal the potential presence of any cryptic and / or uncommon species.

Fish species in the main stream were surveyed using single wing fyke nets, with the cod end anchored to projections (such as logs and branches) protruding from the water at the stream bank, allowing any inadvertently captured turtles and platypus access to the surface (Plate 2-1). Fyke nets were deployed by boat / canoe to allow the wing panel to be deployed 10-15 m into the stream, perpendicular to the bank. At each site, a minimum of two fyke nets were deployed in the afternoon, left overnight, and checked the following morning.

Small collapsible baited traps (Plate 2-2) were deployed along the margins within the Project footprint, in order to sample small, cryptic fish and macroinvertebrate species that were less likely to be captured in fyke nets. Traps were baited with dry cat biscuits (prawn and sardine) and tied to overhanging or emergent vegetation or structure (such as logs) with a corner of the trap above the surface. This enabled small turtles to breathe in the unlikely event that they were caught in the trap. Five baited traps were deployed at each site in which fyke netting was undertaken, thereby allowing different microhabitats to be sampled within the same lotic habitat. These traps were also left overnight and checked the following morning. A summary of fish sampling effort is provided in Table 2-4.

In all netting / trapping operations, captured fish and macroinvertebrates were placed in a bucket of water and identified to species level. The number of individuals of each species was recorded and all individuals were subsequently returned live to the water body, with the exception of introduced mosquitofish (*Gambusia holbrooki*), which were euthanized and disposed of as per DERM methodology and in accordance with ethics permits. Turtles captured during fish sampling were immediately removed from the net and identified to the species level. The sex, size and age class of each turtle was also recorded, and the presence of tags from previous captures by DERM was also determined, before being returned to the water.



Plate 2-1 Fyke net with attached float upstream of proposed Rookwood Weir site



Plate 2-2 Baited trap deployed amongst submerged structure

Table 2-4 Summary of fish sampling effort Rookwood Weir Project footprint

Sampling site	Coordinate	Habitat sampled	Date	Number of fyke nets	Number of baited traps
RWA18	-23.545, 150.173	Pool, Fitzroy River (downstream of Rookwood Crossing)	Dry (28-29/07/2009)	2	5
RWA19	-23.548, 150.017	Run up-and downstream of riffle, Fitzroy River (upstream of Rookwood Crossing)	Dry (28-29/07/2009)	3	5
RWA20	-23.578, 149.934	Mouth of creek adjoining pool, Fitzroy River (upstream of Riverslea Crossing)	Wet (29-30/04/2009)	3	5
RWA4	-23.588, 149.934	Pool, Fitzroy River (upstream of Riverslea Crossing)	Wet (29-30/04/2009)	2	5
RWA5	-23.627, 149.769	Pool upstream of run / riffle, Fitzroy River (downstream of confluence)	Dry (29-30/07/2009)	3	5
RWA6	-23.528, 149.715	Run, Mackenzie River (downstream of Foleyvale Crossing)	Wet (30/4/2009 – 01/05/2009)	2	5
RWA21	-23.527, 149.714	Pool, Mackenzie River (downstream of Foleyvale Crossing)	Dry (27-28/07/2009)	3	5
RWA22	-23.529, 149.711	Pool, Mackenzie River (upstream of Foleyvale Crossing)	Dry (27-28/07/2009)	2	5
RWA14	-23.731, 149.779	Pool upstream of run / riffle, Dawson River (upstream of Boolburra rail crossing)	Dry (29-30/07/2009)	2	5

2.4.10 Freshwater turtles

An assessment of freshwater turtle populations within the Fitzroy Basin catchment was conducted by DERM in 2007, specifically focusing on the proposal for raising Eden Bann Weir and constructing a new weir at Rookwood (Limpus et al. 2007). The DERM assessment involved field studies, as well as a review of the results of past studies undertaken throughout the catchment (and in nearby catchments) since 1997. Past studies included:

- Cumulative effects of dams and weirs on freshwater turtles: Fitzroy, Kolan, Burnett and Mary Catchments. DERM study 1997-1999 (Tucker 2000)
- Fauna of the Dawson River Floodplain – An assessment of fauna downstream of the proposed Nathan Dam (Venz et al. 2002)
- Management plan for the conservation of *Elseya albagula* in the Burnett River Catchment (Hamann et al. 2007)
- Impact of dams and weirs on freshwater turtles - Fairbairn Dam (Limpus et al. 2006)
- DERM surveys for Fitzroy River turtle (*Rheodytes leukops*) and white-throated snapping turtle (*Elseya albagula*)
- Data from turtle biologists who have conducted research on freshwater turtles of the Fitzroy River:
 - Queensland University: Dr Matt Gordos PhD thesis (Gordos 2004); Toni Priest BSc Hon thesis (Priest 1997)
 - Central Queensland University: Dr John Parmenter
 - Carl Glen (unpublished Central Queensland University project).

An additional turtle survey focussing on the Fitzroy River turtle and white-throated snapping turtle was undertaken for the Project by frc environmental in 2007.

Combined, these studies sampled an extensive range of habitats throughout the Fitzroy Basin catchment including: isolated spring fed pools, farm dams, backwaters, weir pools and natural river habitats. Data collected included turtle abundance and diversity, distribution and aquatic habitats, life history parameters and nesting habitats (Limpus et al. 2007). Due to the amount of information available on freshwater turtles in the Fitzroy Basin catchment, trapping for turtle species was not undertaken within the Project footprint as part of this assessment. Incidental observations of turtles, including those caught in the fish fyke nets, were however, recorded and identified as described in Section 2.4.9.

The distribution and abundance of the Fitzroy River turtle and white-throated snapping turtle within the Project footprint was assessed based on the results of the past surveys detailed above. Where it was deemed that insufficient information was available to inform the risks associated with this project to the Fitzroy River turtle and white-throated snapping turtle, occurrence of these species was assessed based on habitat suitability using targeted nesting bank surveys. Additional distribution and abundance surveys of these species were not undertaken as part of this assessment due to the difficulty in safe turtle capture success. Populations of the Fitzroy River turtle and white-throated snapping turtle are difficult to survey as they rarely enter baited traps. Hand capture via snorkelling or dip netting is the most effective method of capture however these techniques are generally limited within the Fitzroy Basin catchment due to high turbidity levels (Limpus et al. 2007). Seine netting may also be an effective capture method, however, in potential habitats for survey the abundance of in-stream woody debris generally limits suitability in many habitats (Limpus et al. 2007).

Furthermore, both snorkelling and seine netting were not considered due to the potential occurrence of estuarine crocodiles.

Nesting bank surveys

Where access permitted, stream bank margins throughout the Project footprint were assessed for potential Fitzroy River turtle and white-throated snapping turtle nesting habitat. Surveys were conducted in December 2008 to coincide with late nesting / hatching of the Fitzroy River turtle and in July 2009 to coincide with white-throated snapping turtle nesting season. Accessible potential nesting areas (i.e. those comprising sand and / or loam banks (Plate 2-3) were identified and the following parameters recorded:

- Bank length
- Bank width
- Approximate slope
- Substrate type
- Percent vegetation cover
- Evidence of turtle activity and nesting
- Evidence of disturbance (e.g. from cattle and pigs).

Potential nesting banks were examined for signs of nesting (which included the presence of turtle tracks, diggings and predated egg shells) using a single strip transect parallel to the waters edge (as per standard DERM methodology (Limpus et al. 2007) and as discussed with DEHP's Senior Principle Conservation Officer Dr Col Limpus). Transects varied in length and width according to bank morphology. Nest locations were described in relation to distance and height from water. Predated egg shell was also collected for identification by DERM.



Plate 2-3 Potential turtle nesting bank surveyed during field assessments

Targeted turtle nesting bank surveys were performed within the Rookwood Weir Project footprint at the sites listed in Table 2-5.

Table 2-5 Summary of targeted turtle nesting bank survey sites

Sampling site name	Coordinate	Site location
NB1	-23.548, 150.017	Fitzroy River (Rookwood Crossing)
NB2	-23.545, 150.017	Fitzroy River (Rookwood Crossing)
NB3	-23.574, 149.936	Fitzroy River (just downstream of Riverslea Crossing)
NB4	-23.576, 149.935	Fitzroy River (just upstream Riverslea Crossing)
NB5	-23.616, 149.937	Fitzroy River (upstream of Riverslea Crossing)
NB6	-23.617, 149.935	Fitzroy River (upstream of Riverslea Crossing)
NB7	-23.640, 149.938	Fitzroy River (upstream of Riverslea Crossing)
NB8	-23.640, 149.923	Fitzroy River (upstream of Riverslea Crossing)
NB9	-23.622, 149.776	Fitzroy River (downstream of Mackenzie / Dawson confluence)
NB10	-23.626, 149.770	Fitzroy River (downstream of Mackenzie / Dawson confluence)
NB11	-23.539, 149.730	Mackenzie River (downstream of Foleyvale Crossing)
NB12	-23.530, 149.727	Mackenzie River (downstream of Foleyvale Crossing)
NB13	-23.528, 149.716	Mackenzie River (downstream of Foleyvale Crossing)
NB14	-23.535, 149.705	Mackenzie River (upstream of Foleyvale Crossing)
NB15	-23.533, 149.697	Mackenzie River (upstream of Foleyvale Crossing)
NB16	-23.535, 149.667	Mackenzie River (upstream of Foleyvale Crossing)
NB17	-23.534, 149.661	Mackenzie River (upstream of Foleyvale Crossing)
NB18	-23.727, 149.784	Dawson River (downstream of Boolburra rail crossing)

Based on an assessment of nesting bank slope, substrate type and vegetation cover, each sand / loam bank identified was assigned a broad nesting suitability rating. Four nesting suitability categories were utilised:

- **Low** – nesting banks with a relatively low gradient slope and / or predominantly unsuitable substrate (eg. gravel)
- **Medium** – nesting banks with a relatively medium to steep slope, predominantly sand / loam substrate and / or medium to high vegetation cover
- **High** – nesting banks with a relatively steep slope, sand / loam substrate and low vegetation cover
- **Confirmed** – nesting banks in which direct evidence of turtle nesting was observed (eg. predated egg shell).

The nesting suitability ratings were selected based on current data available on the optimal nesting conditions of both the Fitzroy River turtle and the white-throated snapping turtle. It is important to note that the classification of a bank as potential turtle nesting habitat does not guarantee that turtle nesting does / will occur in that area. Turtle nesting may also occur in areas not identified as potential habitat, however these areas are considered to be of low

quality and unlikely to support large numbers or achieve high nesting success. All incidental observations of turtle nesting were recorded.

2.4.11 Crocodiles

A review of the literature indicated that estuarine crocodiles (*Crocodylus porosus*) are rare in the Rookwood Weir Project footprint, especially compared with the relatively high densities that occur upstream of Eden Bann Weir (downstream of the Rookwood Weir site). Any opportunistic crocodile sightings as well as any signs of crocodile presence (e.g. characteristic slides on sand banks), were subsequently recorded.

2.4.12 Other fauna

The Platypus (*O. anatinus*) is known to occur within the Fitzroy Basin catchment (Grant and Temple-Smith 1998). A general characterisation of potentially suitable habitats for the platypus (based on the known ecology of the species from the literature) was ascertained through aquatic habitat assessments. Any opportunistic observations of this species were subsequently recorded. Other fauna that utilise aquatic habitats, including water birds, amphibians, eastern water dragon (*Physignathus lesuerii*) and water rat (*Hydromys chrysogaster*) were not considered in this aquatic assessment.

2.4.13 Macroinvertebrates

Information on macroinvertebrate assemblages in the Fitzroy River system was acquired from a review of the literature and supplemented by the results of field studies. Literature reviews were verified by opportunistic sampling for large macroinvertebrates during fish trapping whilst small and cryptic macroinvertebrates were sampled by deploying artificial substrates. Artificial substrates were utilised at the time of the surveys, due to the inability to undertake kick-sampling as a result of flooding and other logistical and safety concerns (refer to limitations Section 2.4.2).

The artificial substrates were 'rock basket' substrates based upon De Pauw et al. (1986) substrates. The substrates were approximately 2500 cm³ in volume, made of an open mesh and filled with potato / orange bags and rocks to the size of half a house brick. These substrates were placed into the water at depths no greater than five metres and allowed to be colonised for three to six weeks. Variation in duration of substrate colonisation was related to logistical issues associated with retrieving the samples. Five substrates were deployed at each survey site.

The substrates were collected into a 250 µm sweep net and rinsed, then placed into suitable sample jars and preserved with 70% ethanol. Samples were identified using a stereoscope and keys listed in Hawking (2000). Individuals from every sample jar were identified to family level and preserved in individual vials containing 90% ethanol for storage.

Artificial substrate site names, locations and habitat descriptions are outlined in Table 2-6 below.

Table 2-6 Description of artificial substrate locations

Site name	River	Site location	Site coordinate	Aquatic habitat type	Season sampled
FBA1	Fitzroy River	Creek adjoining Fitzroy Barrage weir pool between Fitzroy Barrage and Alligator Creek	-23.237, 150.409	Creek adjoining Fitzroy Barrage impounded pool	Dry
FBA2	Fitzroy River	Creek adjoining Fitzroy Barrage weir pool between Fitzroy Barrage and Alligator Creek	-23.251, 150.381	Creek adjoining Fitzroy Barrage impounded pool	Dry
FBA3	Alligator Creek	Alligator Creek	-23.246, 150.417	Creek	Dry
FBA6	Fitzroy River	Fitzroy Barrage impoundment between Fitzroy Barrage and Alligator Creek	-23.242, 150.342	Impounded pool	Wet
FBA6A	Fitzroy River	Fitzroy Barrage impoundment between Fitzroy Barrage and Alligator Creek	-23.242, 150.342	Impounded pool	Wet
FBA9	Fitzroy River	Fitzroy River between Fitzroy Barrage impoundment and Eden Bann Weir	-26.146, 150.362	Pool	Wet
FBA10	Fitzroy River	Fitzroy River between Fitzroy Barrage impoundment and Eden Bann Weir	-23.145, 150.376	Impounded pool	Wet
FBA11	Fitzroy River	Off-stream billabong adjacent to Fitzroy Barrage Impoundment	-23.248, 150.377	Off-stream water body	Wet
FBA13	Fitzroy River	Fitzroy Barrage impoundment between Fitzroy Barrage and Alligator Creek	-23.241, 150.342	Impounded pool	Wet
EBA14	Fitzroy River	Eden Bann Weir impoundment on bend, just downstream of Marlborough Creek	-23.058, 149.941	Impounded pool	Dry
EBA16	Fitzroy River	Eden Bann Weir impoundment on bend, just upstream of Eight Mile Creek	-23.087, 149.997	Impounded pool	Dry
EBA21	Fitzroy River	Eden Bann Weir impoundment (first bend upstream of weir)	-23.082, 150.066	Impounded pool / Impounded pool	Wet / Dry
EBA23	Fitzroy River	Eden Bann Weir impoundment (first bend upstream of weir) – opposite bank to EBA21	-23.082, 150.066	Impounded pool / Impounded pool	Wet / Dry
Riverslea	Fitzroy River	Upstream of Riverslea Crossing	-23.578, 149.934	Pool	Wet

2.4.14 Macrophytes

A review of the literature provided baseline information on the aquatic plant assemblages typically encountered in the Fitzroy system. Macrophytes were infrequently encountered throughout the Project footprint during field studies. If present, aquatic plant assemblages were recorded at locations in which habitat assessments were performed. While not identifying the macrophytes to species level, a general description of the plants, including whether they were emergent, submergent or floating, was noted.

2.4.15 Summary of aquatic survey effort

The following survey effort was conducted within the Rookwood Weir Project footprint:

- 17 aquatic habitat assessments (3 wet season, 14 dry season)
- 18 targeted turtle nesting bank surveys (11 wet season, 7 dry season)
- 22 fyke trap nights (7 wet season, 15 dry season)
- 45 baited trap nights (15 wet season, 30 dry season)
- Artificial substrates throughout entire study area including one site in the Rookwood Weir Project footprint during the wet season.

The survey effort employed in this assessment sought to combine existing information with data and observations recorded from field studies, in the context of the assessment objectives and identified limitations. Most importantly, this methodology allowed for the characteristics, value and spatial distribution of aquatic habitat types to be described, such that the loss / alteration of these habitats due to construction of the proposed weir at Rookwood and associated infrastructure could be assessed. Furthermore, the assessment considered a large amount of existing information on aquatic species in the Fitzroy Basin catchment, including previously prepared reports that have investigated the potential impacts of raising Eden Bann Weir and / or constructing a weir at Rookwood on conservation significant aquatic species (namely the Fitzroy River turtle and estuarine crocodile). The baseline environmental values detailed in these reports, and other studies relating to the aquatic fauna and flora of the Fitzroy Basin catchment (including comparative studies of riverine and weir environments), were ground-truthed and supplemented through the implementation of the survey effort outlined above. As a result of this combined desktop and field based assessment approach, the risks associated with constructing a weir at Rookwood on aquatic habitats and species (most notably, conservation significant fauna known or predicted to occur within the Project footprint) have been identified, thereby allowing for a thorough assessment of potential impacts and the development of appropriate migration strategies.

2.5 Aquatic habitat calculation

Aquatic habitat types included in the calculation of aquatic habitat within the Project footprint consist of pool, riffle, run habitats and creeks adjoining the main river. The Fitzroy River transports a substantial sediment load during periods of flood with high erosion and deposition rates which change the river and its boundaries overtime. Elsewhere in the EIS, cadastral boundaries have been used to define the extent of watercourse areas and adjacent landholdings however this was considered inappropriate for determining areas of aquatic habitat as land title boundaries in some cases are over 100 years old and the physical river channel as well as survey techniques and legislation defining watercourse boundaries have changed in that time. There was found to be no existing watercourse data that was suitable in terms of accuracy for use in calculating aquatic habitat. Cadastral data, Queensland land use mapping program data and regional ecosystem mapping data proved highly inaccurate when overlayed on satellite imagery as these mapped watercourse boundaries included land outside of the river channel, rocky outcrops in the river channel and sand banks.

In the absence of suitable GIS data, aquatic habitat was manually digitised using satellite imagery (Digital Globe World View 2, July 2010) based on the discernible boundaries of water within the river channel (excluding rock and sand banks) within the proposed Rookwood Weir impoundment. The digitised data was then cross-checked against river bed

level cross-section data at 58 locations. The cross-section data was available from the hydraulic model developed for the Project as described in Chapter 9 Surface water resources. Land survey cross-sections which enable calibration of the hydraulic model were used to validate the river width determined by the digitised river channel polygon. The cross-sections distinctly show where the river channel is and what profile the channel takes. The average difference between the digitised width and cross-section width is -0.9 m which is considered to show good correlation.

Water levels in the system fluctuate seasonally, as such July was considered the most appropriate time to represent near to stable water levels early in the dry season that are not influenced by wet season flood flows. While satellite imagery for other months was not available for use, aerial imagery captured in August and September 2009 was also assessed showing an average decrease in river width of 6 m at cross-sections when compared to the July 2010 data. The Fitzroy River is susceptible to seasonal high flow events during the wet season (approximately November to April), and occasional flooding in instances where intensive rainfall events occur within and up-stream of the Fitzroy subcatchment (Chapter 9 Surface water resources). As such, the use of imagery captured during the wet season would not be representative of flow conditions.

3. Aquatic ecology existing environmental values

3.1 Fitzroy Basin catchment

The Fitzroy Basin catchment is the largest catchment on the eastern seaboard of Australia, and is second only to the Murray-Darling Basin as Australia's largest catchment. It extends over an area of approximately 142,000 km² of Central and Eastern Queensland about the Tropic of Capricorn and drains into the Great Barrier Reef World Heritage Area. It consists of six major sub-catchments, namely:

- Isaac / Connors
- Nogoa
- Comet
- Mackenzie
- Dawson
- Fitzroy.

Strongly seasonal climatic factors heavily influence flows within the Fitzroy Basin catchment, with the sub-tropical climate fostering the majority of rainfall during the wet season (approximately November to April). The warm, wet season is generally interspersed with long, dry periods during the dry season (approximately May to October). Mean annual rainfall is generally higher in eastern parts of the catchment (800 – 1000 mm), and slightly lower inland to the west (600 mm) (Johnston et al. 2008). Total evaporation within the Fitzroy Basin catchment notably exceeds rainfall, thereby resulting in prevailing dry conditions and variable stream flow (Marsden and Power, 2007). Severe flooding occasionally occurs within the Fitzroy Basin catchment as a result of intensive rainfall events associated with severe storms, cyclones and tropical low pressure systems. Prolonged dry conditions and drought are also characteristic features of the highly variable and unpredictable nature of the Fitzroy Basin catchment climate is exposed to. Mean annual discharge from the catchment is 5 million ML, however flows can be as low as 100, 000 ML in dry years (DNRW 2008).

Although sparsely populated, large tracts of land within the Fitzroy Basin catchment have been modified for human land use practices, principally agriculture, which accounts for almost 90% of catchment land use (Johnston et al. 2008). Of this agricultural use, 81.7% is livestock grazing (Johnston et al. 2008). Other notable land uses within the Fitzroy Basin catchment include State Forest (6.65%), nature conservation (4.54%) and mining (0.38%) (Johnston et al. 2008). Although only a comparatively small component of land use, existing mining activities within the Fitzroy Basin catchment are concentrated in the northern and western parts of the catchment. As of 2008, 85% of the state's operational coal mines were located in the Fitzroy Basin catchment (Johnston et al. 2008).

Major water infrastructure has been constructed at a number of sites along rivers within the Fitzroy Basin catchment in order to meet irrigation, urban and industrial demands.

Infrastructure includes:

- **Mackenzie-Nogoa system:** Tartrus Weir, Bingegang Weir, Bedford Weir, Fairbairn Dam

- **Dawson River:** Neville Hewitt Weir, Moura Weir, Theodore Weir, Orange Creek Weir, Gyrranda Weir, Glebe Weir
- **Fitzroy River:** Eden Bann Weir, Fitzroy Barrage.

The freshwater fish community within the Fitzroy Basin catchment contains a unique combination of semi-arid / temperate and tropical / sub-tropical species, including two endemic species (southern saratoga (*Scleropages leichardti*) and leathery grunter (*Scortum hillii*)), and one endemic sub-species (golden perch (*Macquaria ambigua orientalis*)) (Stuart et al. 2007).

The Fitzroy Basin catchment supports one of the highest diversities of freshwater turtles in Australia, with six species occurring throughout the catchment, including two regionally endemic species (Fitzroy River turtle and white-throated snapping turtle). The Fitzroy River turtle is listed as 'Vulnerable' under the NC Act and the EPBC Act. Other conservation significant species occurring within the Fitzroy Basin catchment include the estuarine crocodile, listed as 'Vulnerable' under the NC Act and 'Migratory' and 'Marine' under the EPBC Act (Britton 2007a; Britton 2007b), and the platypus which is protected under the NC Act as a 'Special Least Concern' species.

3.2 Field survey climatic conditions

3.2.1 Wet season

Conditions during the wet season survey (29 April - 1 May 2009) were generally warm and dry. Temperatures ranged between 11.5°C and 29.6°C with averages of 12.5°C (min) and 28.6°C (max). Days were generally clear with low relative humidity (average 34.7% recorded at 3 pm). No rain fell during the survey period, however eleven millimetres of rain was recorded in the two-week period prior to the surveys, while 69.2 mm of rain occurred in the two months prior (March and April 2008).

3.2.2 Dry season

Conditions during the dry season survey (25 - 30 July 2009) were typified by warm days and cool nights. Temperatures ranged between 7°C and 26.7°C with averages of 10.6°C (min) and 24.7°C (max). Days were generally clear (i.e. little cloud cover) with moderately high relative humidity in the mornings (average 62.3% recorded at 9 am) and low relative humidity in the afternoons (average 33% recorded at 3 pm). 0.2 mm of rainfall was recorded during the survey period yet no rainfall was recorded in the two-week period prior to the surveys, however 7.8 mm of rain occurred in the two months prior (26 May 2009 and 25 July 2009).

3.3 Aquatic habitats

3.3.1 Overview

Approximately 660 ha of aquatic habitat occurs within the Rookwood Weir Project footprint. Five main aquatic habitat types occur within the Project footprint upstream and downstream of the proposed weir at Rookwood and in downstream reaches to the Eden Bann Weir impoundment. Aerial photograph interpretation informed a description of the linear extent of these habitat types within and downstream of the Rookwood Weir Project footprint (aquatic habitat segment analysis). Based on the aquatic habitat segment analysis, field observation based habitat assessments and field observations, and information acquired from the literature review, the general characteristics and features of these aquatic habitat types were determined.

3.3.2 Aquatic habitat segment analysis

Based on the assessment of aerial photography and field survey observations (as discussed in Section 2.4.7), the linear extent of various in-channel³ aquatic habitat types in the Project footprint area and downstream to Eden Bann Weir was determined⁴. The results of this analysis are provided below in Table 3-1 and Figure 3-1. The spatial distribution of in-channel aquatic habitats, as determined through the analysis, is provided in Figure 3-2.

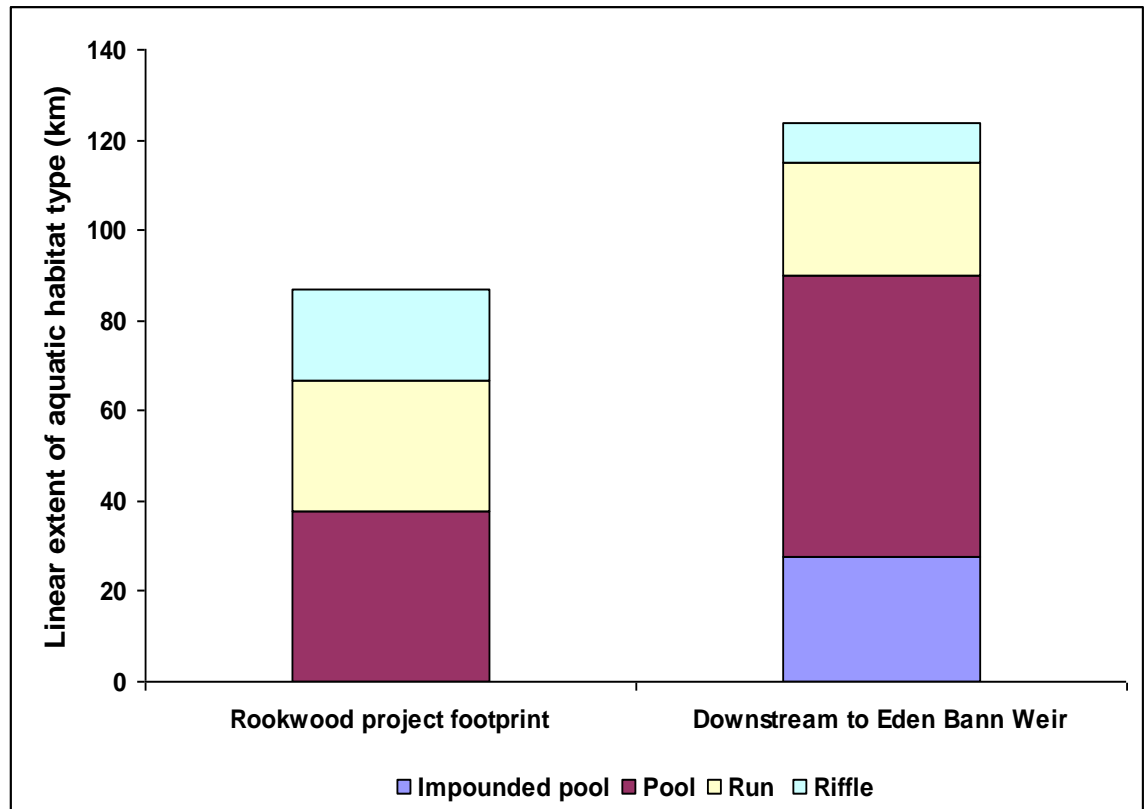
Table 3-1 Linear extent of in-channel aquatic habitats within and downstream of Rookwood Weir Project footprint

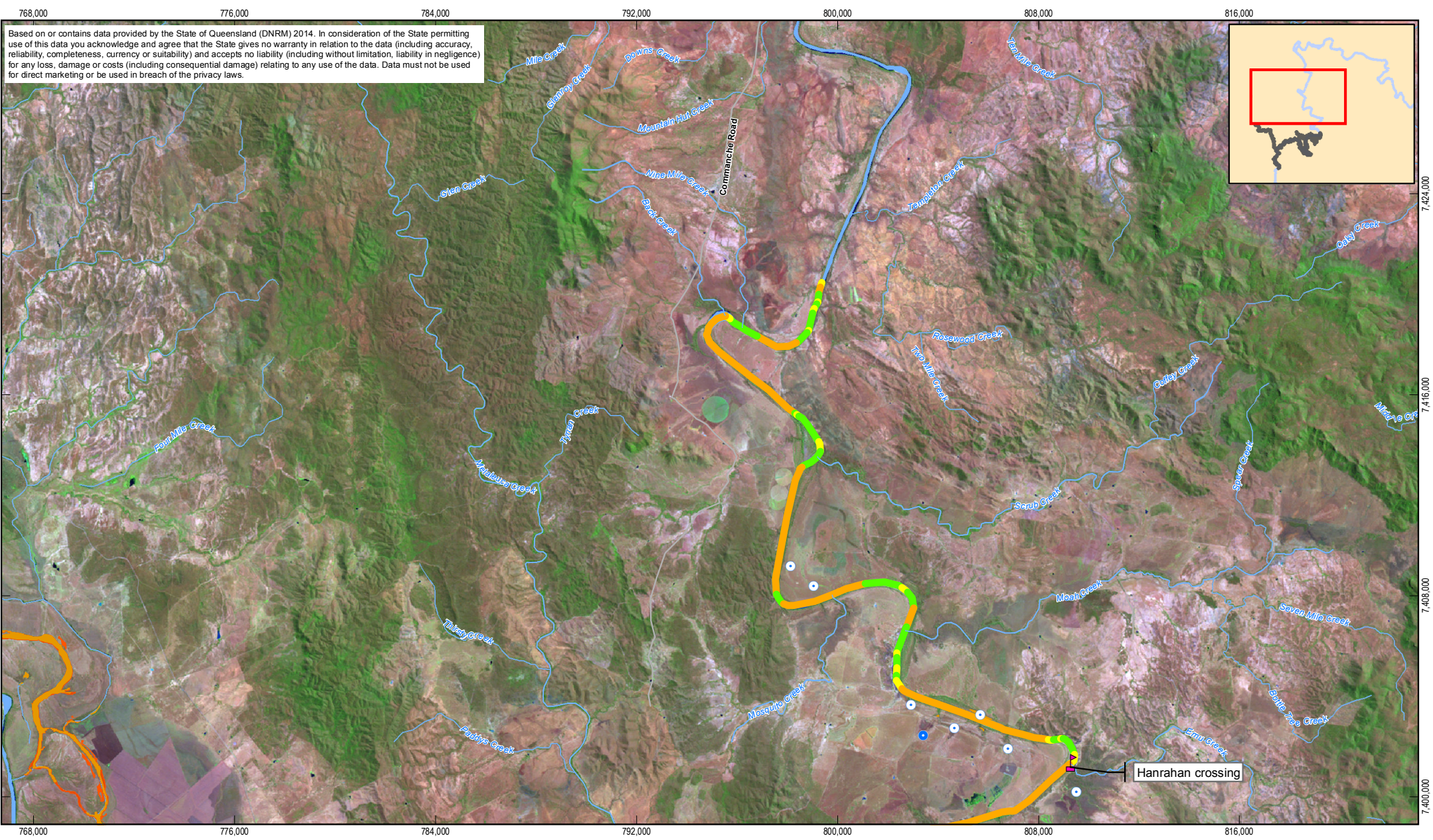
	Linear extent of habitat in Rookwood Weir Project footprint (km)	% linear extent of habitat in Rookwood Weir Project footprint	Linear extent of habitat downstream of Rookwood Weir Project footprint (to Eden Bann Weir) (km)	% linear extent of habitat downstream of Rookwood Weir Project footprint (to Eden Bann Weir)
Impounded pool	0	0	27.8	22.44
Pool	37.6	43.27	62.1	50.12
Run	29.1	33.49	25.2	20.34
Riffle	20.2	23.25	8.8	7.10
Total	86.9 km	100%	123.9 km	100%

³ In-channel refers to habitats within the main stream of the Dawson, Mackenzie and Fitzroy Rivers. It excludes adjoining creeks and off-stream water bodies.

⁴ Habitat boundaries were estimated based on visual characteristics observed. As habitat boundaries (e.g. the difference between a riffle and a run) vary substantially between seasons, the percentages of each habitat type within and downstream of the Project footprint provide an example of aquatic habitat extent only. These values are likely to fluctuate substantially in response to seasonal variability in water flows and management of the storage (2.4.8). It is also noted that data presented here for impounded pool overlaps with data presented for the Eden Bann Weir Project footprint area as presented in Appendix J.

Figure 3-1 Linear extent of in-channel aquatic habitats within and downstream of Rookwood Weir Project footprint





1:200,000 (at A4)

0 2 4 6 8

Kilometres

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

Legend

▲ Weir Location	— Minor Road	■ Stage 1 impoundment	● Palustrine	— Run
▲ River Crossing	— Railway	■ Stage 2 impoundment	■ Aquatic Habitats	■ Wetland Protection Area
— Highway	— Waterway	— Off-stream Waterbodies	— Pool	— High Ecological Significance Wetlands
	— Waterway	● Lacustrine	— Riffle	

GHD
CLIENTS | PEOPLE | PERFORMANCE

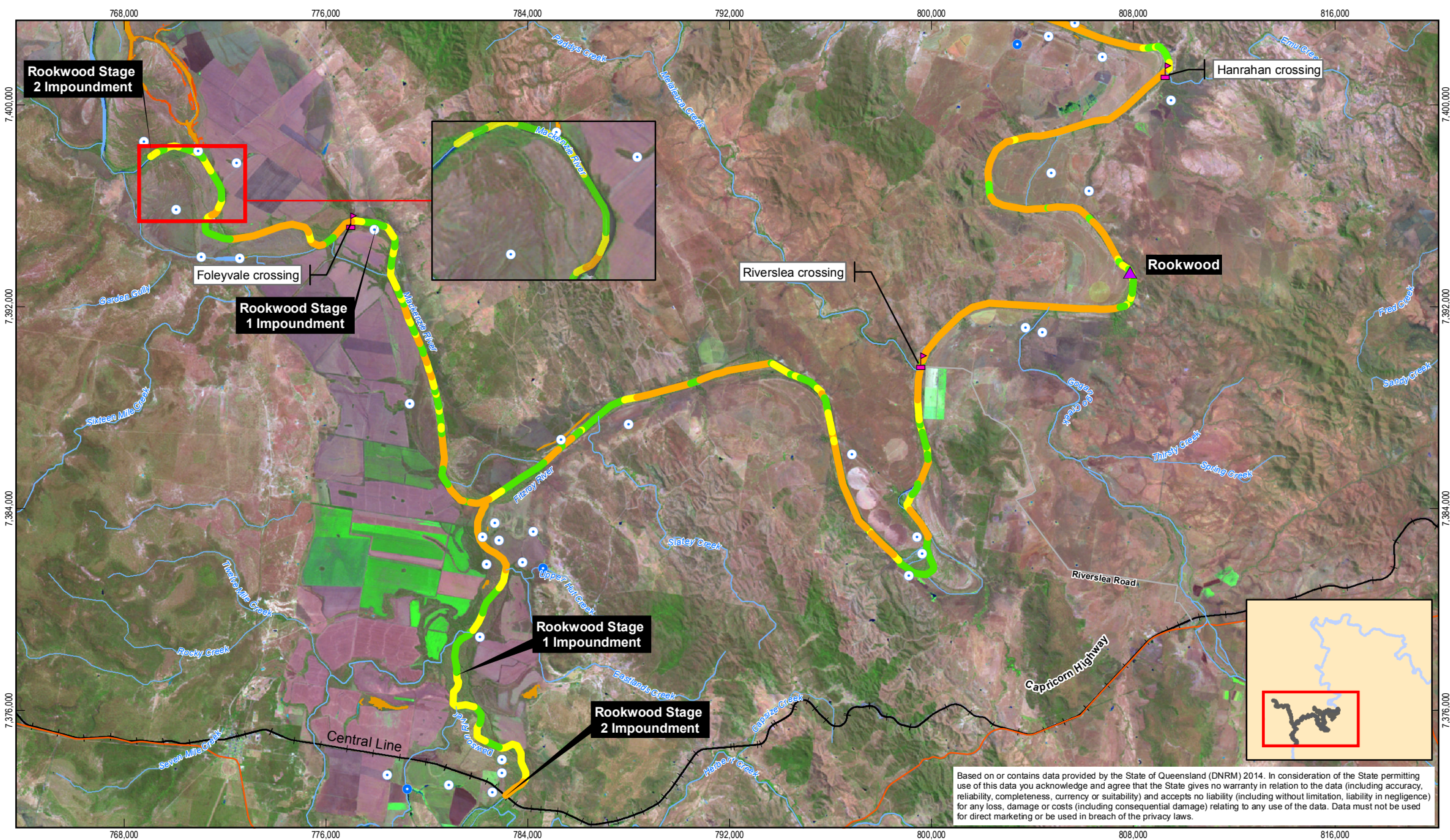
Gladstone Area Water Board

SunWater
Making Water Work

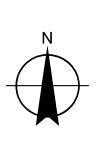
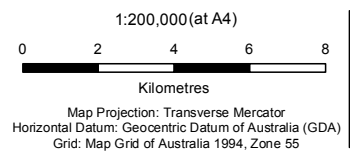
Gladstone Area Water Board, SunWater Job Number 41-20736
Lower Fitzroy River Infrastructure Project Revision D
Date 19 Aug 2014

Spatial distribution of in-channel aquatic habitats and off-stream water bodies and creeks within the Rookwood Weir Project footprint

Sheet 1
Figure 3-2



Based on or contains data provided by the State of Queensland (DNRM) 2014. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws.



Legend	
	Minor Road
	Railway
	Waterway
	Off-stream Waterbodies
	Lacustrine
	Pool
	Riffle
	High Ecological Significance Wetlands



Gladstone Area Water Board, SunWater Job Number 41-20736
Lower Fitzroy River Infrastructure Project Revision D
Date 19 Aug 2014

Spatial distribution of in-channel aquatic habitats and off-stream water bodies and creeks within the Rookwood Weir Project footprint

Sheet 2
Figure 3-2

3.3.3 Pools

General characteristics

Pool habitat are defined as relatively deep, still / very slow flowing water over variable substrates (i.e. silt, sand, stone or rock) that occur naturally within the riverine environment (as opposed to upstream of man-made structures) (AusRivAS 2001). This aquatic habitat type occurs in the main channel, and may become isolated into a series of discrete water holes during dry conditions when flow ceases and water levels drop. The low (or zero) velocity of water flow differentiates a pool habitat from a faster flowing run habitat (AusRivAS 2001).

Within the Project footprint, the following characteristics of pool habitats were identified based on five aquatic habitat assessments:

- Average stream width approximately 43 m (range 15-100 m)
- Average channel depth could not be determined for all sites (i.e. no boat access), but was predicted to be >1.5 metres
- Average bank height approximately 11.2 m (3-20 m)
- Typical substrate: Gravel (2-16 mm)
- Logs and coarse-woody debris occurred at the margins of pool habitats at all sites, and were plentiful at two sites
- Aquatic macrophytes were encountered at only one of five sites.

As described in Section 1.4.6, the habitat characteristics of the pool habitats were assessed from excellent to poor according to the AusRivAS River Bioassessment Program. The results of this assessment are provided in Table 3-2 and summarised below.

Table 3-2 Habitat characteristic ratings of pool habitats

Habitat assessment site	Bottom substrate / available cover		Bank stability		Bank vegetative stability		Streamside cover	
	Left bank	Right bank	Left bank	Right bank	Left bank	Right bank	Left bank	Right bank
RWA2	Fair	Fair	Good	Good	Good	Excellent	Fair	Good
RWA4	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
RWA10	Excellent	Excellent	Good	Good	Good	Good	Excellent	Excellent
RWA12	Excellent	Excellent	Good	Good	Good	Good	Excellent	Good
RWA16	Good	Good	Good	Good	Good	Good	Good	Good

As displayed in Table 3-2, rankings for bottom substrate / available cover, bank stability, bank vegetation stability and stream side cover were generally *good* or *excellent*. As observed throughout the Rookwood Weir Project footprint, habitat features in pool habitats were concentrated around river margins, and typically comprised a combination of submerged logs, undercut banks, overhanging / inundated vegetation, and less frequently, macrophytes.

While not quantifiably assessed, a notable field observation throughout the Rookwood Weir Project footprint (and indeed the entire study area) was that the quality of marginal aquatic habitats (in terms of likely value for fauna) was higher where cattle access to the river was prevented or restricted. This observation not only applies to pool habitats, but to all aquatic habitats, including off-stream water bodies and adjoining creeks.

Spatial distribution and extent of habitat

Pool habitats dominate the linear continuum of the lower Dawson, lower Mackenzie and Fitzroy Rivers, as identified from the aquatic habitat segment analysis. Approximately 37.6 km of the 86.9 km comprising the Rookwood Weir Project footprint was mapped as pool habitat. The longest individual pool habitat was 8.8 km. Similarly, the downstream reach of the Fitzroy River between the Rookwood Weir site and Eden Bann Weir is dominated by pool habitat (62.1 km out of 123.9 km).

3.3.4 Runs

General characteristics

Run habitats are defined as relatively deep, flowing unbroken water over a sandy, stony or rocky bed (AusRivAS 2001). These habitats may occur immediately upstream and downstream of a riffle zone. Fast flowing water during high flow / flood conditions may result in the conversion of sluggish pool habitats and shallow riffle habitats into runs (AusRivAS 2001).

Within the Project footprint, the following characteristics of run habitats were identified based on five aquatic habitat assessments:

- Average stream width approximately 28.2 m (range 6-60 m)
- Average channel depth could not be determined for all sites (i.e. no boat access), but was predicted to be >1.5 metres
- Average bank height approximately 8 m (4-12 m)
- Typical substrate: clay / silt (<0.006 mm), clay / silt and sand (0.006-2 mm), gravel (2-16 mm)
- Logs and coarse-woody debris occurred at the margins of run habitats at four of five sites, and were plentiful at two sites
- Aquatic macrophytes were absent at all but one of the sites assessed
- Water velocity was generally slow to moderate at the time of habitat assessments.

As described in Section 2.4.6, the habitat characteristics of the run habitats were assessed from excellent to poor according to the AusRivAS River Bioassessment Program. The results of this assessment are provided in Table 3-3 and summarised below.

Table 3-3 Habitat characteristic ratings of run habitats

Habitat assessment site	Bottom substrate / available cover		Bank stability		Bank vegetative stability		Streamside cover	
	Left bank	Right bank	Left bank	Right bank	Left bank	Right bank	Left bank	Right bank
RWA11	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
RWA12	Good	Good	Good	Good	Good	Good	Excellent	Excellent
RWA15	Excellent	Excellent	Good	Good	Good	Good	Excellent	Excellent
RWA17	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
RWA6	Fair	Fair	Fair	Good	Good	Excellent	Fair	Fair

The quality of run habitats was, like other aquatic habitats in the Project footprint and wider study area, largely dependent on adjacent land use. The most notable influence was the extent of cattle access to the riparian zone and river margins. Where cattle were able to access the waterway, potential habitat quality for aquatic fauna was notably reduced. Habitat assessments and field observations showed that run habitats were typically narrower (and likely shallower) than pool habitats within the Rookwood Weir Project footprint. In-stream habitat features were most prevalent in the shallow margins of run habitats. This was particularly the case in the lower Dawson River, where bottom substrate / available cover (namely submerged logs and undercut banks) was ranked as being either *good* or *excellent*. Throughout the Project footprint, bank stability was generally rated *good* with small areas of erosion occurring infrequently. (Bank vegetative stability was considered *good* to *excellent* and a relatively high abundance of trees and shrubs generally resulted in *excellent* streamside cover.

Spatial distribution and extent of habitat

Based on the aquatic habitat segment analysis, run habitats account for a combined 29.1 km of in-channel aquatic habitats representing the Rookwood Weir Project footprint. This represents 33.49% of the Project footprint. Downstream of Rookwood (to Eden Bann Weir), approximately 20.3% of the 123.9 km of the Fitzroy River is classified as run habitat.

3.3.5 Riffles

General characteristics

Riffle habitats are defined as shallow (<0.3 m), fast-flowing (>0.2 m/s) reaches over a stony bed (AusRivAS 2001). The unique combination of shallow, fast flowing water that is (relatively) highly oxygenated and flows over hard substrate differentiates this habitat type from pool and run habitats.

Within the Project footprint, the following characteristics of riffle habitats were identified based on six habitat assessments:

- Average stream width approximately 13.4 m (range 5-30 m)
- Riffle depth generally less than 0.3 m (up to a maximum of 0.75 m)
- Substrate dominated by cobble (256-64 mm), gravel (16-2 mm) and pebbles (64-16 mm)
- Woody debris at the margins of all but one site assessed
- Macrophytes present at only one of seven sites
- Fast flowing water.

As described in Section 2.4.6, the habitat characteristics of the riffle habitat was assessed from excellent to poor according to the AusRivAS River Bioassessment Program. The results of this assessment are provided in Table 3-4 and summarised below.

Table 3-4 Habitat characteristic ratings of riffle habitats

Habitat assessment site	Bottom substrate / available cover		Bank stability		Bank vegetative stability		Streamside cover	
	Left bank	Right bank	Left bank	Right bank	Left bank	Right bank	Left bank	Right bank
RWA1	Good	Good	Excellent	Good	Excellent	Excellent	Good	Good
RWA5	Excellent	Excellent	Fair	Good	Good	Good	Good	Good
RWA8	Excellent	Excellent	Good	Good	Excellent	Excellent	Good	Good
RWA9	Excellent	Excellent	Good	Good	Excellent	Excellent	Good	Good
RWA13	Excellent	Excellent	Good	Good	Good	Good	Excellent	Good
RWA6	Good	Good	Good	Good	Excellent	Excellent	Good	Good

Field assessments revealed that riffle habitats tended to occur immediately downstream of runs, and were narrow, shallow and featured a rocky substrate. Submerged logs were generally associated with riffle zone habitats while aquatic macrophytes were infrequently observed. The bottom substrate / available cover of the riffle habitats were rated *good* to *excellent* while banks were considered moderately stable (*good*). Bank vegetative stability was generally *good* (50 - 79% cover) or *excellent* (> 80% cover) and streamside cover was predominately shrub form (*good*).

Spatial distribution and extent of habitat

Riffle habitats account for 23.25% of the Rookwood Weir Project footprint, as determined by the aquatic habitat segment analysis. These habitats were mapped as extending from 0.1 km to 2.3 km in length. The total combined length of riffle habitats in the Rookwood Weir Project footprint was 21.2 km. Between the Rookwood Weir site and Eden Bann Weir, 8.8 km of riffle habitat was identified, accounting for 7.1% of the linear extent of in-channel habitats between the two sites.

3.3.6 Off-stream water bodies

General characteristics

For the purposes of this assessment, off-stream water bodies were defined as palustrine wetlands (i.e. vegetated swamps, billabongs), oxbow lakes, and farm dams in the floodplain adjacent to the main channel⁵ of the lower Dawson, lower Mackenzie and Fitzroy Rivers within the Rookwood Weir Project footprint. While no off-stream habitats were formally assessed during field surveys in the Rookwood Weir Project footprint (largely due to access limitations), the general characteristics of these habitats were deduced based on observations throughout the wider study area. In general, these habitats featured a variety of habitat resources including inundated and overhanging riparian vegetation, woody debris, variable depth, and a relatively greater abundance of macrophytes.

Spatial distribution of habitats

An analysis of satellite imagery and the Queensland Government's Wetland *Info* mapping service informed the location of off-stream water body habitats within and downstream of the

⁵ For the purposes of this assessment, off-stream water bodies within 1 km of the main channel and the lower reaches of adjoining creeks were considered.

Rookwood Weir Project footprint. A total of 31 of-stream water bodies were identified from the Rookwood Weir Project footprint (comprising 29 palustrine wetlands and two lacustrine wetlands). Between the Rookwood Weir site and the upper extent of the Eden Bann Weir Project footprint, eight off-stream water bodies were identified (seven palustrine, one lacustrine). The locations of the off-stream water body habitats are presented in Figure 3-2.

3.3.7 Creeks

Creek habitats include small tributaries adjoining the main river channel that persist for varying distances across the adjacent floodplain and beyond (refer to Section 2.4.6). The variable geomorphology of these habitats (i.e. depth, width, length), adjacent land use and proximity to water infrastructure, varies the characteristics and potential fauna habitat values these waterways feature.

A habitat assessment was undertaken at one creek habitat in the Rookwood Weir Project footprint. The following characteristics of this creek habitat were identified from the assessment:

- Channel width: 20 m
- Channel depth: 1.2 m
- Bank height: 8 m
- Substrate: clay / silt
- Woody debris present
- Macrophytes absent.

As described in Section 2.4.6, the habitat characteristics of the creek habitat was assessed from excellent to poor according to the AusRivAS River Bioassessment Program. The results of this assessment are provided in Table 3-5 and summarised below.

Table 3-5 Habitat characteristic ratings of the creek habitat

Habitat Assessment site	Bottom substrate / available cover		Bank stability		Bank vegetative stability		Streamside cover	
	Left bank	Right bank	Left bank	Right bank	Left bank	Right bank	Left bank	Right bank
RWA3	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent

The creek assessed supported habitat resources (most notably an abundance of cover) for aquatic fauna. While the creek upstream of Riverslea Crossing scored particularly high rankings against the AusRivAS River Bioassessment Program criteria for the four selected habitat features, more generally throughout both the Rookwood Weir Project footprint and the wider study area, the quality of creek habitats was influenced by adjacent land use. Marginal habitat features such as macrophytes and overhanging vegetation were observed to be less prevalent / degraded where cattle could access the waterway.

Spatial distribution of habitats

An analysis of satellite imagery and the Queensland Government's Wetland/Info Mapping Service highlighted the location of creek habitats⁶ within and downstream of the Rookwood Weir Project footprint. A total of 8 named creeks join the Fitzroy, Dawson and Mackenzie Rivers within the Rookwood Weir Project footprint (Fitzroy: 3, Dawson: 4, Mackenzie: 1). Six named creeks flow into the Fitzroy River downstream of the Rookwood Weir site (to the upper extent of the Eden Bann Weir Project footprint) (Table 3-6). The locations of all named creeks are presented, with the major creeks illustrated in Figure 3-2.

Table 3-6 Location of named creeks downstream of and within Rookwood Weir Project footprint

Creek name	Location of junction w ith main river	River creek drains into	Tributaries of creek		
Downstream of Rookw ood Weir Project footprint (to upper extent of Eden Bann Weir Project footprint)					
Nine Mile Creek	-23.316, 149.897	Fitzroy River			
Back Creek	-23.308, 149.889	Fitzroy River			
Scrub Creek	-23.361, 149.927	Fitzroy River			
Mosquito Creek	-23.412, 149.934	Fitzroy River			
Moah Creek	-23.423, 149.963	Fitzroy River			
Emu Creek	-23.470, 150.028	Fitzroy River			
Rookwood Weir Project footprint					
Gogango Creek	-23.555, 149.984	Fitzroy River	Thirsty Creek		
Melaleuca Creek	-23.577, 149.933	Fitzroy River	Paddy Creek	Thirsty Creek	
Slatey Creek	-23.598, 149.811	Fitzroy River			
Eastlands Creek	-23.652, 149.776	Daw son River	Upper Hut Creek		
Bone Creek	-23.675, 149.762	Daw son River	Tw elve Mile Creek	Rocky Creek	
Sharpers Creek	-23.701, 149.757	Daw son River			
Herbert Creek	-23.737, 149.773	Daw son River	Capsize Creek	Waw oon Creek	Lemon Tree Creek
Sixteen Mile Creek	-23.538, 149.699	Mackenzie River			

⁶ Only named creeks were selected for this study. Small, ephemeral unnamed creeks and drainage lines were not considered.

3.3.8 Upstream habitats

Upstream aquatic habitats (in-channel, adjoining and off-stream) were inferred to be similar to those described within the Project footprint (based on aerial photo interpretation, field observations from three sites assessed upstream of the Rookwood Weir Project footprint and literature reviews). As the landscape (i.e. topography, gradient) and adjacent human land use along the Dawson and Mackenzie Rivers is similar to that within the Rookwood Weir Project footprint, it is likely that the aquatic habitat types, and the general characteristics of these habitats (including value to fauna) as observed along the lower reaches of the two rivers, would persist upstream of the Project footprint. Subsequent sections of this report discuss some upstream habitats that literature reviews identified as having significant values (i.e. known populations of/ habitat for conservation significant fauna).

3.3.9 Habitat dynamics

Aquatic habitats in the Fitzroy, Mackenzie and Dawson Rivers are highly dynamic. The temporal distribution and spatial extent of the aquatic habitat types discussed above is related to fluctuating water levels driven by factors including climate (i.e. rainfall or lack thereof with the Fitzroy River sub-catchment and upstream catchments), management of water storages (i.e. such as Eden Bann Weir and the Fitzroy Barrage), extraction of water from waterways by adjacent land holders, evaporation and ground seepage. Due to the highly unpredictable nature of these individual drivers, and the combined influence of the variable interactions of these factors, aquatic habitat distribution and extent is in a constant state of flux. A generalised description of the typical dynamics of the system, as observed in the field (both within the Rookwood Weir Project footprint, and throughout the wider study area), and as described in the literature is outlined below, and summarised in Table 3-7. Examples of aquatic habitat diversity by season are provided in Table 3-8.

During and post wet season – approximately November to April

The lower Dawson, lower Mackenzie and Fitzroy Rivers primarily exist as deep fast-flowing channels (run habitat) in which in-channel aquatic habitats such as pools and riffles are inundated as a result of a significant increase in water depth and velocity. This was evident throughout the Rookwood Weir Project footprint during wet season field surveys. Depending on localised rainfall patterns, creek habitats may increase in depth and width as flow rates increase. Off-stream water body habitats such as billabongs may also be inundated during flooding events as river levels rise above bank height (observed downstream of the Eden Bann Weir during wet season surveys). This periodic flooding is important to off-stream water bodies to recharge water levels, provide flushing and allow for biological connectivity with the main stream.

Dry and pre-wet season – approximately April to October

As flows decline following the wet season, the river channel is transformed into a series of pool-riffle-run sequences. These sequences were prevalent upstream of the Rookwood Weir site during dry season field surveys. Off-stream water bodies lose connection with the main channel, and, unless recharged by groundwater (or unseasonal rainfall), begin to recede. As the dry season persists, many of the riffle and run habitats dry out and much of the river exists as a series of isolated non-flowing pools (Limpus et al. 2007; Marsden and Power 2007). These isolated pools act as refugia for aquatic fauna during the dry season (Limpus et al. 2007).

Table 3-7 Typical dynamics of aquatic habitats in the study area

	Wet season and post-wet	Dry-season	Pre-wet
Pool	Flowing water converts pools to runs	Predominant habitat type	Likely to become isolated as lack of run-off and water level in river channel declines (evaporation, ground seepage, extraction)
Run	Predominant aquatic habitat type upstream of impounded pool	Flowing water that links deeper natural pools	May dry out, or become narrower and shallower
Riffle	Drowned out due to increased water level in river (i.e. runs)	Where stream bed geomorphology is suitable (rocky substrate), shallow water between natural pools (often preceded and immediately followed by runs)	Dry out
Off-stream water body	Recharge through rainfall and flooding	Water levels decrease, unless water body is recharged by groundwater (or unseasonal rainfall)	Water levels decrease to the point where habitats may dry out completely, unless water body is recharged by groundwater (or unseasonal rainfall) – also dependent on size and depth of water body
Creek	Increased depth and flow – dependent on rainfall within creek catchment. Lower reaches may also be inundated by flood waters moving downstream along the main river channel	Reduced rate of flow and depth due to lack of runoff	Reduced rate of flow and depth – creek may become series of isolated pools

Table 3-8 Examples of wet and dry season aquatic habitats in the Rookwood Weir Project footprint

Wet season	 <p>Run habitat at Riverslea Crossing on the Fitzroy River (February 2009)</p>	 <p>Run habitat in Mackenzie River (December 2008)</p>	 <p>Run habitat at Foleyvale Crossing on the Mackenzie River (December 2008)</p>
Dry season	 <p>Pool at Riverslea Crossing on Fitzroy River (July 2009)</p>	 <p>Riffle zone on Mackenzie River downstream of Foleyvale Crossing (July 2009)</p>	 <p>Series of isolated pools in Fitzroy River near Rookwood (November 2009)</p>

3.4 Aquatic fauna and flora

3.4.1 Overview

Aquatic species predicted to occur or recorded in the study area include: 34 fish species, seven reptiles, one mammal, 86 taxa of macroinvertebrates and 105 species of macrophytes⁷. Desktop surveys and field assessments identified a number of threatened and other conservation significant species that occur in the Project footprint, have been previously recorded in the study area, or are predicted to occur based on bioclimatic modelling. Fauna species considered as rare, threatened with extinction, or as having high conservation value, are protected under Commonwealth and State legislation. At the national level, fauna are protected under EPBC Act. Within Queensland, rare and threatened fauna are listed under the NC Act and its subordinate legislation (namely the *Nature Conservation (Wildlife) Regulation 2006*). At a regional level, priority conservation significant fauna have been identified in the 'Back on Track' prioritisation framework for conservation management of Queensland's wildlife in the Fitzroy Natural Resource Management area. While this tool has no legislative power, it outlines management and recovery actions for selected priority species. The habitat preference of each conservation significant species and their likely occurrence within the Project footprint and wider study area is discussed in the relevant sections below.

Table 3-9 summarises the total number of aquatic fauna and flora species recorded according to the information source or survey method. Database search results are presented in Appendix A.

Table 3-9 Total number of fauna species predicted to occur or recorded from the study area

	DEWHA Environmenta l Reporting Tool (predicted to occur)	DERM Wildlife Online Database (historically recorded)	Queensland Museum Specimen Database (historically recorded)	Previous Studies (historically recorded)	Field Surveys (observed w ithin Project footprint)
Species Diversity	-	8 fish 4 reptiles 1 mammal	1 fish 1 reptile	34 fish 7 reptiles 1 mammal 86 macroinvertebrat e taxa 105 macrophytes	18 fish 2 reptiles 59 macroinvertebrat e taxa
EPBC Act and NC Act Threatened Species	1 reptile	2 reptiles	1 reptile	3 reptiles	1 reptile
EPBC Act 'Marine' and / or 'Migratory' Species	1 reptile	-	-	1 reptile	-

⁷ 105 species of macrophyte previously recorded within Fitzroy Basin catchment

	DEWHA Environmenta l Reporting Tool (predicted to occur)	DERM Wildlife Online Database (historically recorded)	Queensland Museum Specimen Database (historically recorded)	Previous Studies (historically recorded)	Field Surveys (observed w ithin Project footprint)
Endemic / Range Restricted Species	1 reptile	1 fish 2 reptiles	1 fish 1 reptile	3 fish 2 reptile	2 fish 1 reptile
Introduced / Pest Species	-	-	-	3 fish	1 fish

3.4.2 Fish

Species diversity

A total of 34 fish species have been previously recorded in the study area (i.e. the lower Dawson, lower Mackenzie and Fitzroy Rivers). Table 3-10 details the fish species data attained during wet and dry season field surveys, as well as previous records from various studies reported in Marsden and Power (2007). The species recorded include two endemic species, the southern saratoga (*Scleropages leichardti*) and the leathery grunter (*Scortum hillii*), and one endemic subspecies of golden perch (*Macquaria ambigua oriens*). No listed-threatened species have been previously recorded or are predicted to occur in the study area.

An additional six species, i.e. pacific short-finned eel (*Anguilla obscura*); freshwater mullet (*Myxus petardi*); striped gudgeon (*Gobiomorphus australis*); Marjorie's hardyhead (*Craterocephalus marjoriae*); guppy (*Poecilia reticulata*) and silver perch (*Bidyanus bidyanus*), have been recorded in the broader Fitzroy Basin catchment and although not observed in the study area to date, these species have the potential to occur. The silver perch, which was recorded in the Fitzroy Basin catchment by Berghuis and Long (1999), was also listed as 'Vulnerable' in 1996 on the IUCN (International Union for the Conservation of Nature) Red List of Threatened Species. A native of the Murray-Darling system, the silver perch is likely to have been introduced into the Fitzroy Basin catchment, where it does not naturally occur. It is not known to occur within the Rookwood Weir Project footprint.

The Fitzroy Basin catchment has a relatively low diversity of introduced / pest fish species with only three species (i.e. mosquitofish, goldfish and guppy) known to occur throughout the system. The highly invasive and destructive European carp (*Cyprinus carpio*) has been recorded in a lagoon adjacent to Tartus Weir on the Mackenzie River (Limpus et al. 2001) upstream of the Project area.

Table 3-10 Fish species known to occur within the Project footprint and study area based on current study and past reports

Family	Species	Project footprint		Past reports (study area)					
		Wet Season Survey	Dry Season Survey	Stuart et al. 2007	Marsden and Power 2007	Heindenreich and Broadfoot 2001	Long and Meager 2000	Berghuis and Long 1999	Stuart 1997
Catadromous									
Anguillidae	long-finned eel (<i>Anguilla reinhardtii</i>)			✓	✓	✓	✓		✓
Centropomidae	barramundi (<i>Lates calcarifer</i>)			✓	✓	✓			✓
Scorpaenidae	bullrout (<i>Notesthes robusta</i>)								✓
Synbranchidae	sw amp eel (<i>Ophisternon</i> spp.)					✓			
Amphidromous									
Ariidae	blue catfish (<i>Arius graeffei</i>)	✓	✓	✓	✓	✓	✓	✓	✓
Belonidae	freshw ater longtom (<i>Strongylura krefftii</i>)		✓	✓	✓	✓	✓	✓	✓
Gobiidae	speckled goby (<i>Redigobius bikolanus</i>)				✓				
Hemiramphidae	snub-nosed garfish (<i>Arrhamphys sclerolepis</i>)		✓	✓		✓	✓		✓
Megalopidae	oxeye herring (<i>Megalops cyprinoides</i>)							✓	✓
Mugilidae	sea mullet (<i>Mugil cephalus</i>)								✓
Potamodromous									
Apogonidae	mouth almighty (<i>Glossamia aprion</i>)	✓	✓	✓	✓	✓	✓	✓	✓

Family	Species	Project footprint		Past reports (study area)					
		Wet Season Survey	Dry Season Survey	Stuart et al. 2007	Marsden and Power 2007	Heindenreich and Broadfoot 2001	Long and Meager 2000	Berghuis and Long 1999	Stuart 1997
Atherinidae	fly-specked hardyhead (<i>Craterocephalus stercusmuscarum</i>)		✓		✓	✓		✓	✓
Chandidae	Agassiz's glassfish (<i>Ambassis agassizii</i>)		✓	✓		✓	✓	✓	✓
Clupeidae	bony bream (<i>Nematalosa erebi</i>)			✓	✓	✓	✓	✓	✓
Cyprinidae	goldfish* (<i>Carassius auratus</i>)				✓				
Eleotridae	empire gudgeon (<i>Hypseleotris compressa</i>)				✓			✓	✓
Eleotridae	flathead gudgeon (<i>Philypnodon grandiceps</i>)	✓	✓						
Eleotridae	Midgley's carp gudgeon (<i>Hypseleotris</i> species 1)		✓			✓		✓	✓
Eleotridae	purple-spotted gudgeon (<i>Mogurnda adspersa</i>)		✓			✓			
Eleotridae	sleepy cod (<i>Oxyeleotris lineolata</i>)	✓	✓	✓	✓	✓	✓	✓	✓
Eleotridae	western carp gudgeon (<i>Hypseleotris klunzingeri</i>)		✓		✓	✓			✓
Melanotaeniidae	eastern rainbow fish (<i>Melanotaenia splendida splendida</i>)	✓	✓	✓	✓	✓	✓	✓	✓
Osteoglossidae	southern saratoga1 (<i>Scleropages leichardti</i>)			✓	✓	✓	✓	✓	
Percichthyidae	golden perch2 (<i>Macquaria ambigua orientalis</i>)	✓	✓	✓	✓	✓	✓	✓	✓

Family	Species	Project footprint		Past reports (study area)					
		Wet Season Survey	Dry Season Survey	Stuart et al. 2007	Marsden and Power 2007	Heindenreich and Broadfoot 2001	Long and Meager 2000	Berghuis and Long 1999	Stuart 1997
Plotosidae	black catfish (<i>Neosilurus ater</i>)					✓	✓		
Plotosidae	freshwater catfish (<i>Tandanus tandanus</i>)		✓	✓	✓	✓	✓	✓	
Plotosidae	Hyrtl's tandan (<i>Neosilurus hyrtlii</i>)	✓	✓	✓	✓	✓	✓	✓	
Plotosidae	Rendahl's catfish (<i>Porochilus rendahlī</i>)			✓					✓
Poeciliidae	mosquitofish* (<i>Gambusia holbrooki</i>)	✓			□	□			✓
Pseudomugilidae	Pacific blue-eye (<i>Pseudomugil signifier</i>)							✓	
Terapontida	barred grunter (<i>Amniataba percoides</i>)		✓	✓	✓	✓	✓	✓	✓
Terapontidae	leathery grunter ¹ (<i>Scortum hillii</i>)		✓	✓	✓	✓	✓	✓	✓
Terapontidae	sooty grunter (<i>Hephaestus fuliginosus</i>)				✓	✓			
Terapontidae	spangled perch (<i>Leiopotherapon unicolor</i>)			✓	✓	✓	✓		✓

¹ endemic species; ² endemic sub-species; * introduced species

The information in this table incorporates wet and dry season field data and a summary of previous records from various studies.

A total of 18 fish species were recorded during wet and dry season field surveys within the Rookwood Weir Project footprint (Table 3-11) all of which were common freshwater species previously recorded in the study area. No conservation significant species were encountered during the field survey program. The blue catfish (*Arius graeffei*) was the most commonly encountered large fish species in the wet season, while golden perch (*Macquaria ambigua oriens*) (Plate 3-1) and sleepy cod (*Oxyeleotris lineolata*) were captured at several sites throughout the Project footprint in the dry season. Small native fish including the eastern rainbowfish (*Melanotaenia splendida splendida*), mouth almighty (*Glossamia aprion*) (Plate 3-2) and flathead gudgeon (*Philypnodon grandiceps*) were recorded in both seasons. One introduced species; the mosquitofish (*Gambusia holbrooki*) was recorded in the wet season.



Plate 3-1 Golden perch (*Macquaria ambigua oriens*)



Plate 3-2 Mouth almighty (*Glossamia aprion*)

Table 3-11 Wet and dry season fish captures in the Rookwood Weir Project footprint

Site name	Fitzroy River (upstream of Riverslea)	Fitzroy River (upstream of Riverslea Crossing)	Mackenzie River (downstream of Foleyvale Crossing)	Fitzroy River (downstream of Rookwood Crossing)	Fitzroy River (upstream of Rookwood Crossing)	Fitzroy River (downstream of confluence)	Mackenzie River (downstream of Foleyvale Crossing)	Mackenzie River (upstream of Foleyvale Crossing)	Dawson River (upstream of Boolburra rail crossing)	Opportunistic records
Habitat type sampled	Mouth of creek adjoining natural pool	Pool	Run	Pool	Run immediately upstream and downstream of riffle	Pool upstream of run / riffle	Pool	Pool	Pool upstream of run / riffle	
Season sampled	Wet	Wet	Wet	Dry	Dry	Dry	Dry	Dry	Dry	
blue catfish (<i>Arius graeffei</i>)	4									
freshwater longtom (<i>Strongylura krefftii</i>)										Dry season at Riverslea Crossing on Fitzroy River
snub-nosed garfish (<i>Arrhamphys sclerolepis</i>)										Dry season in Mackenzie River downstream of Foleyvale Crossing
mouth almighty (<i>Glossamia aprion</i>)	2	1		1	1	1			3	
fly-speckled hardyhead (<i>Craterocephalus stercusmuscarum</i>)						5			35	
Agassiz's glassfish (<i>Ambassis agassizii</i>)						6			131	
Midgley's carp gudgeon (<i>Hypseleotris species 1</i>)				1	6	25	28	3	16	
western carp gudgeon (<i>Hypseleotris klunzingeri</i>)				5	6	41	1	3	46	
sleepy cod (<i>Oxyeleotris lineolata</i>)			2	2	2	1	2			
flathead gudgeon (<i>Philypnodon grandiceps</i>)		1				1			1	
purple-spotted gudgeon (<i>Mogurnda adspersa</i>)						2			2	
eastern rainbow fish (<i>Melanotaenia splendida</i>)			1						10	
golden perch ² (<i>Macquaria ambigua</i>)	2			4	1	2				
Hyrtl's tandan (<i>Neosilurus hyrtlii</i>)	1								1	
freshwater catfish (<i>Tandanus tandanus</i>)				1						
barred grunter (<i>Amniataba percoides</i>)										Dry season in Mackenzie River downstream of Foleyvale Crossing
leathery grunter ¹ (<i>Scortum hillii</i>)										Dry season in Mackenzie River downstream of Foleyvale Crossing
mosquitofish * (<i>Gambusia holbrooki</i>)		2								

¹ endemic species; ² endemic sub-species; * introduced species

Ecology

A species specific description of the ecology of all 41 species known and predicted to occur in the study area (including habitat preferences, dietary requirements and movement behaviour), is provided in Table 3-12, while a broad summary is detailed below.

Habitat preferences

Fish species in the Fitzroy Basin catchment have adapted to the highly dynamic and variable nature of this system (Long 2000), represented by the specific foraging, breeding and sheltering preferences of the species that occur. A review of the ecology of fish species known to occur within the Fitzroy Basin catchment revealed that most species prefer (or are tolerant of) the still or slow flowing conditions that are present in pool habitats (Pusey et al. 2004; Allen et al. 2003; Marsden and Power 2007). The relatively deep water areas within large pools provide habitat for larger-bodied pelagic (e.g. freshwater longtom, southern saratoga and golden perch) and benthic (e.g. freshwater catfish and Rendahl's catfish) species, while the shallow water margins are preferred by smaller bodied species such as western carp gudgeon, eastern rainbowfish and fly-specked hardyhead. Whilst generalist species such as the long-finned eel, striped gudgeon and barred grunter are known to inhabit the fast-flowing conditions of riffles and runs, few species in the Fitzroy Basin catchment are specifically adapted to these habitats. Species that are known to prefer flowing conditions include Marjorie's hardyhead, silver perch, and sooty grunter. None of these species were recorded during wet and dry season surveys, however the sooty grunter had been previously recorded in the study area.

Foraging and breeding in the majority of fish species is associated with in-stream microhabitats in the form of fallen logs, undercut banks, root masses and macrophytes. Creeks and off-stream habitats such as floodplains and billabongs generally contain a high diversity of in-stream microhabitats and as a result provide habitat for a range of species including spangled perch, black catfish, southern saratoga, eastern rainbowfish and purple-spotted gudgeon. Off-stream water bodies also provide breeding and nursery habitat for fish species. The breeding season of a number of species (i.e. barramundi, long-finned eel, oxeye herring, spangled perch, eastern rainbowfish and empire gudgeon) is known to occur during the wet season when flows within the river are increased and off-stream water bodies are connected to the river system, facilitating access to these microhabitat environments (Reynolds 1983; Pusey et al. 2004; Stuart 1999; Stuart and Berghuis 1997).

Table 3-12 Ecology of the fish species in the Fitzroy Basin catchment

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
Catadromous					
Anguillidae	long-finned eel (<i>Anguilla reinhardtii</i>)	500-3000 mm	<p>Prefers high gradients, shallow depths and high velocities in riffles and runs however will inhabit lakes, swamps, flood plains and impoundments. Adults most commonly occur around 100 km upstream of the river mouth while juveniles are generally found at lower elevations</p> <p>Oceanic waters are required for breeding</p>	Omnivorous - juveniles and sub-adults predominantly take invertebrate prey, whilst adults feed on fish, aquatic and terrestrial invertebrates and vegetation matter	<p>Adults – catadromous, migrate from sea from late summer to autumn for spawning. Also move within the river for habitat and dispersal. Passage between freshwater and saltwater habitats are an obligatory component of the species' life history</p> <p>Juveniles (elvers) – migrate from the sea to coastal rivers during spring - summer</p> <p>Rising flows and increasing water temperature are suspected cues for movement</p>
Anguillidae	Pacific short-finned eel (<i>Anguilla obscura</i>)	Maximum 1100 mm, more commonly encountered up to approximately 600 mm	<p>Prefers lower reaches of rivers and brackish coastal lagoons. Also known to occur in streams, swamps and impoundments</p> <p>Juveniles commonly occur in estuarine areas.</p> <p>Oceanic waters are required for breeding</p>	Omnivorous - juveniles and sub-adults predominantly take invertebrate prey, whilst adults feed on fish, aquatic and terrestrial invertebrates and vegetation matter	<p>Catadromous - passage between freshwater and saltwater habitats are an obligatory component of the species' life history</p> <p>Downstream migration thought to peak during summer and autumn months (November – May)</p> <p>Rising flows and increasing water temperature are suspected cues for movement</p>
Centropomidae	barramundi (<i>Lates calcarifer</i>)	Maximum 1800 mm, more commonly encountered up to approximately 1200 mm.	<p>Prefers a variety of freshwater, brackish and coastal habitats, notably areas with submerged logs and rock ledges</p> <p>River mouths are required for breeding</p> <p>Floodplain habitats are highly important for larvae</p>	Carnivorous - feed on micro- and macro-invertebrates and fish	<p>Adults – catadromous, migrate from the river to the sea to spawn. Passage between freshwater and saltwater habitats are an obligatory component of the species' life history</p> <p>Juveniles move upstream from estuarine nursery habitats for dispersal. Peak movement occurs from October - December</p> <p>Rising flows and increasing water temperature are suspected cues for movement</p>

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
Mugilidae	freshwater mullet (<i>Myxus petardi</i>)	Maximum 800 mm, more commonly encountered up to 400 mm	Prefers gently flowing rivers channels Estuarine and oceanic habitats are required for breeding	Largely herbivorous with algae and other plant material constituting the bulk of the diet	Catadromous - passage between freshwater and saltwater habitats are an obligatory component of the species' life history Spawns in estuaries and the sea, peaking in February
Scorpaenidae	bullrout (<i>Notesthes robusta</i>)	Up to 300 mm	Occurs in still or slow-flowing waters, often associated with underwater structures such as vegetation and logs Estuarine habitats are required for breeding	Carnivorous – a benthic ambush predator. Aquatic insects and crustaceans are the primary prey items for this species	Catadromous - passage between freshwater and saltwater habitats are an obligatory component of the species' life history Spawns in estuarine waters during winter months (May to September). Peak upstream movement in the Fitzroy River has been recorded between July and November Low flows and cooler temperatures are suspected as cues for movement
Synbranchidae	swamp eel (<i>Ophisternon</i> spp.)	Up to 600 mm	Occurs in well-vegetated backwaters of estuarine and lower freshwater reaches of rivers. Habitats with an abundance of leaf litter and overhanging riparian vegetation are preferred	Feeding biology poorly known – probably carnivorous, with fish and aquatic macroinvertebrates dominating the diet	Catadromous - passage between freshwater and saltwater habitats are an obligatory component of species' life history
Amphidromous					
Ariidae	blue catfish (<i>Arius graeffei</i>)	Up to 600 mm	Prefers a variety of habitats including coastal marine waters, estuaries, and freshwater rivers. Also known to inhabit impoundments	Omnivorous generalist feeder, bulk of diet comprising invertebrate prey	Amphidromous – although adults can complete entire life cycle in river Increasing water temperature is a suspected cue for movement
Belonidae	freshwater longtom (<i>Strongylura krefftii</i>)	Maximum 800 mm, more commonly encountered between 300-400 mm.	Prefers various freshwater habitats including rivers, creeks and lagoons. Occurs in still and slow flowing water. A pelagic species that often ambushes prey on the surface	Carnivorous ambush predator – small fish are the major prey item	Amphidromous - predominantly a freshwater species that rarely occurs in the marine estuarine environments. As spawning is thought to occur in freshwater, does not necessarily need access to marine environment as part of life history requirements Spawning thought to occur during northern Australian wet season (November – April)

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
					Increasing water temperature suspected as a cue for movement
Eleotridae	striped gudgeon (<i>Gobiomorphus australis</i>)	Maximum 180 mm, more commonly encountered up to 120 mm	Adults - various freshwater habitats from still, muddy pools to swiftly-flowing streams. Habitats with an abundance of in-stream debris and overhanging riparian vegetation are preferred Larvae/juveniles inhabit estuarine habitats Hard surfaces such as logs and rocks are required for oviposition	Carnivorous aquatic macroinvertebrates are the primary food source for this species	Possibly amphidromous Spawning occurs in freshwater (late summer and autumn) and larvae are carried downstream to estuarine habitats. Juvenile fish are thought to migrate upstream during spring
Gobiidae	speckled goby (<i>Redigobius bikolanus</i>)	Uncommon above 40 mm	Broad range of habitat use including brackish and estuarine habitats, and freshwater rivers and streams. Thought to prefer open, sunny habitats over heavily vegetated areas	Predominantly carnivorous with aquatic insects the major food source	Amphidromous – eggs and larvae develop in downstream reaches of rivers with adults migrating upstream
Hemiramphidae	snub-nosed garfish (<i>Arrhamphys sclerolepis</i>)	Maximum 400 mm, more commonly encountered between 150-200 mm.	Shallow habitats in coastal and estuarine waters, lower reaches of freshwater systems, and freshwater impoundments. A pelagic species	Predominantly herbivorous, with filamentous algae representing a principle food source	Amphidromous – thought to breed in estuaries under natural conditions, but capable of completing entire life-cycle in freshwater impoundments Increasing water temperature suspected as a cue for movement
Megalopidae	oxeye herring (<i>Megalops cyprinoides</i>)	Maximum 1300 mm, more commonly encountered up to 500 mm	Coastal, estuarine and freshwater habitats. Juvenile fish may utilise smaller backwaters branching off larger rivers. Habitats with an abundance of macrophytes are preferred Estuarine and near-shore oceanic habitats required for breeding	Predominantly carnivorous, taking small fish, aquatic and terrestrial insects and crustaceans	Amphidromous – spawning occurs in estuarine and near-shore coastal environments. Juvenile tarpon move upstream post-metamorphous. Passage between freshwater and saltwater habitats is not considered essential for species' life cycle Adults migrate to marine environments to breed between December and March. Juveniles migrate upstream into freshwater habitats between January and May Increasing water temperature suspected as a cue for movement

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
Mugilidae	sea mullet (<i>Mugil cephalus</i>)	Up to 750 mm	Occurs in freshwater habitats and tends to avoid fast flowing waters, with a preference for shallow waters with a soft benthos Oceanic waters are required for breeding	Omnivorous, with algae and detritus the core components of the diet of this species	Amphidromous – spawning occurs in the marine environment passage between freshwater and saltwater habitats an obligatory component of this species' life history Spawning occurs in the sea – adults migrate in large schools to river mouths and adjacent coastlines during winter months. Juvenile fish migrate up rivers during spring / summer months. 1 -2 year old fish occasionally make non-spawning related migrations to the marine environment
Potamodromous					
Apogonidae	mouth almighty (<i>Glossamia aprion</i>)	Up to 180 mm	Most habitats with a preference for shallow well-vegetated margins. Is tolerant of a variety of environmental conditions	Largely carnivorous taking aquatic invertebrates and small fish	Potamodromous – a freshwater species that does not require access to estuarine or marine environment at any stage of life cycle Increasing water temperature suspected as a cue for movement
Atherinidae	fly-specked hardyhead (<i>Craterocephalus stercusmuscarum</i>)	Maximum 80 mm, more commonly encountered between 50-60 mm.	Occurs in a variety of habitats including flood plains, billabongs, brackish estuaries and impoundments. Prefers slow-flowing areas dominated by aquatic vegetation and gravel substrates Aquatic root masses may be important for spawning	Feeds on small aquatic invertebrates and algae	Potamodromous - entire life-cycle (including spawning) occurs in freshwater Increasing water temperature suspected as a cue for movement
Atherinidae	Marjorie's hardyhead (<i>Craterocephalus marjoriae</i>)	Up to 85 mm	Prefers clear, flowing shallow water in streams and creeks. Aquatic vegetation and sandy or gravel substrates are preferred by this species Aquatic macrophytes and submerged marginal vegetation are preferred habitat for spawning	Feeds on small aquatic invertebrates and algae	Potamodromous - a freshwater species that does not require access to estuarine or marine environment at any stage of life cycle Movement behaviour poorly understood although not thought to undertake large movements. August to April represents periods of increased movement

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
					Increasing water temperature is a suspected cue for movement
Chandidae	Agassiz's glassfish (<i>Ambassis agassizii</i>)	Up to 75 mm	Occurs in 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	Largely carnivorous – microcrustaceans and small aquatic insects the major prey items	Potamodromous - adults and juveniles move upstream (September-February) for habitat and dispersal, possibly in response to flooding. A freshwater species that does not require access to estuarine or marine environment at any stage of life cycle Rising flows and increasing water temperature suspected as cues for movement
Clupeidae	bony bream (<i>Nematalosa erebi</i>)	Maximum 470 mm, more commonly encountered between 150-200 mm	Prefers shallow waters with little or no flow, in creeks, streams and rivers. Is also tolerant of a range of environmental conditions including high turbidity	Omnivorous – detritus a major component of the diet	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 Increasing water temperature is a suspected cue for movement
Cyprinidae	goldfish* (<i>Carassius auratus</i>)	Seldom greater than 200 mm	Still and slow-flowing freshwater environments. Capable of withstanding high temperatures and low dissolved oxygen levels	Omnivorous – detritus, plant matter and aquatic insects form the bulk of the diet of this species	Potamodromous
Eleotridae	Empire gudgeon (<i>Hypseleotris compressa</i>)	Attains a size of 120 mm	Occurs in lower reaches of rivers, occasionally estuarine waters. Prefers still or slow-flowing waters with underwater structure Oviposition likely to occur on aquatic macrophytes, rocks and woody debris	Omnivorous – feeds on small invertebrate prey and vegetation matter	Potamodromous - a predominantly freshwater species where access to estuarine or marine environments is not an essential component of the life history Upstream migrations for spawning and juvenile dispersal occur in late spring and early summer Rising flows and increasing water temperature are suspected cues for movement
Eleotridae	flathead gudgeon (<i>Philypnodon grandiceps</i>)	Maximum 120 mm, more commonly encountered up to 80 mm	Predominantly found in freshwater habitats (creeks, rivers, billabongs) with little or no flow, and underwater structure (vegetation, undercut banks, logs). Also occurs in brackish tidal	Predominantly carnivorous, with aquatic insects a favoured food item	Potamodromous - a predominantly freshwater species where access to estuarine or marine environments is not an essential component of the life history May move in response to periods of peak

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
			environments Rocks and woody debris are required for oviposition		flow (August to April) Rising flows and increasing water temperature are suspected as cues for movement
Eleotridae	Midgley's carp gudgeon (<i>Hypseleotris species 1</i>)	Up to 60 mm	Occurs in streams, creeks, swamps, wetlands and ponds boasting underwater structure such as aquatic vegetation, rocks and logs Hard surfaces near the substrate are preferred for oviposition	Predominantly carnivorous, with aquatic insects a favoured food item	Potamodromous - a freshwater species that does not require access to estuarine or marine environment at any stage of life cycle Spawning peaks between September and January Increased water temperature and day length are suspected as cues for movement
Eleotridae	purple-spotted gudgeon (<i>Mogurnda adspersa</i>)	Up to 120 mm	Avoids areas of high water flow. Seeks out aquatic vegetation in slow-flowing parts of rivers and streams, often with rocky substrate. Also occurs in still water bodies including billabongs Aquatic macrophytes, rocks and woody debris required for oviposition	Predominantly carnivorous, with aquatic insects a favoured food item	Potamodromous - a freshwater species that does not require access to estuarine or marine environment at any stage of life cycle Increasing water temperature is a suspected cue for movement
Eleotridae	sleepy cod (<i>Oxyeleotris lineolata</i>)	Maximum 500 mm, more commonly encountered up to 200 mm	Slow-flowing water amongst submerged structure (vegetation, timber) in rivers, creeks, lagoons and billabongs. Tolerant of turbid conditions Large woody debris required for spawning	Predominantly carnivorous, with aquatic insects a favoured food item	Potamodromous – does not make substantial migrations and does not require access to estuarine or marine environments at any stage of life cycle Rising flows associated with rainfall and increasing water temperature are suspected cues for movement
Eleotridae	western carp gudgeon (<i>Hypseleotris klunzingeri</i>)	Rarely exceeds 45 mm	Avoids areas of high water flow. Seeks out aquatic vegetation in slow-flowing parts of rivers and streams. Also still water bodies such as lakes and impoundments Aquatic macrophytes, submerged marginal vegetation and woody debris may be important for oviposition	Predominantly carnivorous, with aquatic insects a favoured food item	Potamodromous - a freshwater species that does not require access to estuarine or marine environments at any stage of life cycle May move upstream to spawn during the wet season Increased water temperature and day length are suspected cues for movement

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
Melanotaeniidae	eastern rainbow fish (<i>Melanotaenia splendida splendida</i>)	Maximum 140 mm, more commonly encountered up to 80 mm	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	Omnivorous – algae and aquatic invertebrates the major component of this species' diet	Potamodromous – a freshwater species that does not require access to estuarine or marine environment at any stage of life cycle Recorded moving upstream of the Fitzroy Barrage throughout the year, particularly between November and April. The number of fish recorded ascending the Fitzroy Barrage was low Rising flows and increasing water temperature are suspected cues for movement
Osteoglossidae	southern saratoga ¹ (<i>Scleropages leichardti</i>)	Maximum 1000 mm, more commonly encountered up to 550 mm	Occurs in billabongs, large pools, impoundments and slow-flowing rivers and streams. Submerged structure and turbid waters are favoured by this species	A pelagic carnivorous predator that takes insects, crustaceans, fish and frogs	Potamodromous - strictly a freshwater species – unknown whether migration occurs within freshwater systems
Percichthyidae	golden perch ² (<i>Macquaria ambigua orientalis</i>)	Maximum 760 mm, more commonly encountered up to 500 mm.	Inhabits rivers, creeks, billabongs and lakes. Favours deeper, slow-flowing, turbid habitats with an abundance of in-stream debris and shade	Carnivorous – primarily preys on aquatic invertebrates and small fish	Potamodromous - a freshwater species that does not require access to estuarine or marine environment at any stage of life cycle Movement recorded in the Fitzroy River (through the Fitzroy Barrage) during spring and summer months Spawning and recruitment triggered by increased flows and water temperatures above 23° C
Plotosidae	black catfish (<i>Neosilurus ater</i>)	Maximum 470 mm, more commonly encountered up to 250 mm.	A benthic species that prefers fast-flowing waters in streams and rivers. Also occurs in wetlands, pools, and slow-flowing tributaries and side-channels of rivers	Omnivorous, although diet dominated by aquatic invertebrates	Potamodromous – a freshwater species that does not require access to estuarine or marine environments at any stage of life cycle Migrations upstream thought to coincide with spawning at the outset of the wet season (January-February). Downstream migration of adults and juveniles post-spawning is poorly understood Rising flows and increasing water

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
					temperature are suspected cues for movement
Plotosidae	freshwater catfish (<i>Tandanus tandanus</i>)	Maximum 900 mm, more commonly encountered up to 450 mm.	Prefers slow flowing streams, also lakes and impoundments. A benthic species that generally favours sandy or gravel substrates Gravel substrate required for spawning	Omnivorous, although diet dominated by aquatic invertebrates	Potamodromous - a generally sedentary freshwater species that does not require access to estuarine or marine environments at any stage of life cycle May be territorial Rising flows and increasing water temperature are suspected cues for movement
Plotosidae	Hyrtl's tandan (<i>Neosilurus hyrtl</i>)	Maximum 340 mm, more commonly encountered up to 200 mm	Occurs in most freshwater habitats above estuarine reaches Tributary streams and gravel substrates may be important for spawning	Omnivorous, although diet dominated by aquatic invertebrates	Potamodromous – upstream migrations from dry season refugia thought to coincide with spawning Movement in the Fitzroy River system greatest between November and March Rising flows is a suspected cue for movement
Plotosidae	Rendahl's catfish (<i>Porochilus rendahli</i>)	Up to 240 mm	A benthic species inhabiting river channels and tributaries. Usually associated with muddy substrates. Also tolerant of turbid water	Omnivorous, although diet dominated by aquatic invertebrates	Potamodromous – adults migrate downstream to spawn in flooded low land lagoons Upstream migration of adults and juveniles coincident with the start of the dry season
Poeciliidae	guppy* (<i>Poecilia reticulata</i>)	Females up to 60 mm, males up to 30 mm	Prefers still and slow-flowing waters predominantly with shoal around the margins of water bodies, amongst aquatic and overhanging bankside vegetation	Omnivorous	Potamodromous
Poeciliidae	mosquitofish* (<i>Gambusia holbrooki</i>)	Females to 60 mm, males to 35 mm	Prefers shallow, warm waters with little or no flow. Generally occurs along margins of stream bank	Omnivorous	Potamodromous
Pseudomugilidae	Pacific blue-eye (<i>Pseudomugil signifer</i>)	Up to 70 mm	Occurs in marine to freshwater environments. Usually frequents habitats boasting submerged structure, but may also occur in pools and clear streams. Shallow, flowing water is favoured by this species	Omnivorous, although diet dominated by aquatic invertebrates	Potamodromous - although this species is known to utilise estuarine and marine environments, access to saline habitats is not obligatory for survival Increasing water temperature is a suspected cue for movement

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
			Breeding can occur in freshwater and saltwater habitats		
Terapontidae	barred grunter (<i>Amniataba percoides</i>)	Maximum 180 mm, more commonly encountered up to 120 mm	Benthic species that occurs in still to fast-flowing water. Tolerant of highly variable temperature, turbidity and pH	Omnivorous, although diet dominated by aquatic invertebrates	<p>Potamodromous – thought to move downstream in the wet season into lowland floodplains. Access to saline habitats is not obligatory for population viability in this species</p> <p>Recorded moving through Eden Bann Weir between April and January (concentrated during dry season). Upstream movement beyond the Fitzroy Barrage peaks between September and November</p> <p>Movements associated with spawning correspond with increasing water temperatures and possibly increased day length</p>
Terapontidae	leathery grunter ¹ (<i>Scortum hillii</i>)	Maximum 350 mm, more commonly encountered up to 250 mm	Occurs in flowing streams and still water bodies. Tolerant of turbid conditions and temperatures up to 35 °C. Also found in estuarine environs	Omnivorous freshwater mussels and algae constitute the two major food items for this species	Potamodromous – a predominantly freshwater species that migrates upstream to spawn during the wet season
Terapontidae	silver perch (<i>Bidyanus bidyanus</i>)	Maximum size of 400 mm	In riverine environments prefers areas of faster flow (often below riffle zones, weirs etc). Also occurs in still habitats such as lakes and reservoirs	Omnivorous – feeds on aquatic invertebrates and algae	<p>Potamodromous – a freshwater species that does not require access to estuarine or marine environments at any stage of life cycle</p> <p>Upstream spawning migration occurs in spring (September – January)</p> <p>Rising flows and increasing water temperature are suspected cues for movement</p>
Terapontidae	sooty grunter (<i>Hephaestus fuliginosus</i>)	Up to 450 mm	<p>Large flowing waterways, particularly the upstream reaches of rivers. Prefers habitats boasting aquatic vegetation on a sandy or rocky substrate</p> <p>Fast-flowing habitats may be important for spawning</p>	Omnivorous – feeds on aquatic invertebrates, algae and aquatic and terrestrial vegetation	<p>Potamodromous - a freshwater species that does not require access to estuarine or marine environments at any stage of life cycle</p> <p>May migrate between wet season (August – February) spawning grounds (upstream in rapids) and dry season refugia</p>

Family	Species	Fish size	Habitat preferences	Diet	Movement behaviour
Terapontidae	spangled perch (<i>Leiopotherapon unicolor</i>)	Up to 300 mm	A generalist species that occurs in most permanent and temporary freshwater habitats including billabongs, impoundments, rivers and streams. Highly tolerant of environmental variability Non-flowing, shallow habitats with soft substrate are preferred for spawning	Omnivorous – feeds on aquatic invertebrates, algae and aquatic and terrestrial vegetation	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 Rising flows and increasing water temperature are suspected cues for movement

¹ endemic species; ² endemic sub-species; * introduced species

Ecological information in table sourced from Pusey et al. (2004), Allen et al. (2003), Marsden and Power (2007)

Field surveys conducted within the Project footprint confirmed the general habitat preferences detailed from the literature review. The relatively deep, slow-flowing habitat in natural pools was found to be suitable habitat for various species including blue catfish, golden perch, Hyrtl's tandan and freshwater catfish. Flowing water habitats including runs and upstream and downstream of riffles, supported sleepy cod and mouth almighty. Along the margins of wide natural pools in the Fitzroy and Mackenzie Rivers, and in narrow, sheltered stretches of river (such as the lower reaches of the Dawson River) small native species dominated catches. These included the Agassiz's glassfish, western carp gudgeon, Midgley's carp gudgeon, fly-speckled hardyhead (Plate 3-3), purple-spotted gudgeon (Plate 3-4), and eastern rainbowfish. Whilst no off-stream water bodies were sampled within the Project footprint, off-stream waterbody habitats downstream of Eden Bann Weir (Appendix J) demonstrated that these habitats support predominantly small-bodied native fish including Agassiz's glassfish, Midgley's carp gudgeon, fly-speckled hardyhead, purple-spotted gudgeon, spangled perch and eastern rainbowfish.



Plate 3-3 Fly-speckled hardyhead
(*Craterocephalus*
stercusmuscarum)



Plate 3-4 Purple-spotted gudgeon
(*Mogurnda adspersa*)

The Fitzroy Basin catchment is a highly regulated system and much of the natural aquatic habitat has been inundated as a result of weir / dam operations. Long (2000) investigated the impact of such river regulation on the spatial and temporal trends in fish habitat utilisation. Specifically, Long (2000) compared species diversity and abundance in weir and riverine environments in the Dawson River. Of the 19 species caught during the two year study, 16 were caught in both the weir and riverine habitats (Long 2000).

A notable finding of Long's study was that while species diversity between weir and riverine habitats was similar, the relative abundance of most species inhabiting these environments (as deduced from catch rates) differed. This difference was not consistent across species. For example:

- Golden perch: number caught in riverine environments twice that of weirs
- Leathery grunter: number caught in riverine environments five times that of weirs
- Hyrtl's tandan: number caught in riverine environments half that of weirs
- Spangled perch: number caught in riverine environments eight times that of weirs
- Eel-tailed catfish (freshwater catfish): number caught in riverine environments twice that of weirs.

Bony bream, the most commonly encountered species at all sites in Long's study (2000), were equally as prevalent in weir environments as riverine habitats. This species has been documented to increase in numbers in modified waterways of the Murray-Darling Basin, in spite of river regulation (Long 2000; Puckridge and Walker 1990). The bony bream is an important prey item for higher level consumers (Pusey et al. 2004) such as larger predatory fish, piscivorous birds and crocodiles, and as such, this species is an important component of aquatic trophic systems within impounded habitats.

Movement behaviour and hydrological requirements

Fish species within the Fitzroy Basin catchment regularly move among spawning, feeding and refuge habitats. Movement behaviours can be classified into one of three groups:

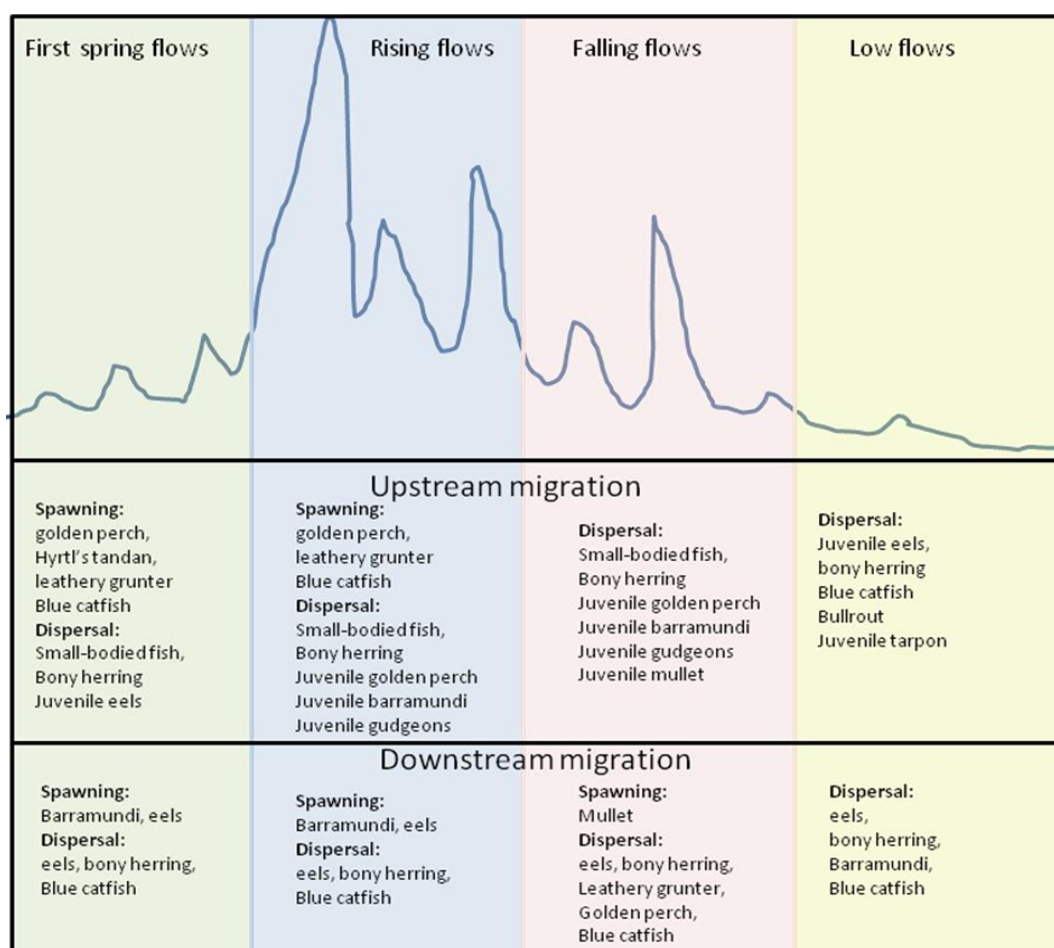
- Catadromous: fish that spend the majority of their lives in freshwater, but migrate to the sea to breed
- Amphidromous: fish that move between freshwater and estuarine marine environments at defined periods of their life cycle, but not for the purposes of reproduction
- Potamodromous: fish that carry out their entire life cycle within the freshwater environment.

Fish species diversity recorded in the Project footprint was dominated by potamodromous species (83%) with a small number of amphidromous species also recorded (17%). No catadromous species were captured during the field surveys however four catadromous species (i.e. long-finned eel, barramundi, bullrout and swamp eel) have been previously recorded in the study area.

The Fitzroy system is typical of many dry tropical rivers in northern Australia where local fish migration is strongly associated with hydrological changes (Hogan et al. 1997; Renfree and Marsden 2006). Other factors or combinations of environmental factors which stimulate migration include water temperature, day length, food availability, fish biomass and water chemistry. The hydrological cue, however, is recognised as one of the most important for influencing tropical river fish communities and their migrations (Baran 2006; Sheaves et al. 2007). Hydrology can be divided into a number of different, but related, factors including: variation in river height, variation in discharge, turbidity, and first rainfalls of the (pre)-wet season.

Golden perch is highlighted as the species most sensitive to high flow and flood migration triggers (Stuart and Mallen-Cooper 1999; Mallen-Cooper and Edwards 1991; Marsden and Power 2007). Nevertheless, the majority of species that inhabit the Fitzroy Basin catchment demonstrate a strong migratory tie to large flood events (>120,000 ML/d) and many others respond to increased flows (Stuart and Mallen-Cooper 1999; Mallen-Cooper and Edwards 1991; Marsden and Power 2007). A migration model demonstrating the temporal relationship between migratory behaviour of fish in the Fitzroy River system and river flow is provided in Figure 3-3.

Figure 3-3 Relationship between fish migration and flow in the Fitzroy River



Source: modified from Marsden and Power, 2007

As shown in Figure 3-3 the first post winter flood is likely to trigger spawning and dispersal migrations for a number of species and these are likely to continue during summer flows (Marsden and Power 2007). For catadromous fish (e.g. barramundi and eels), high flows and floods are especially important for spawning migrations to downstream estuarine and marine waters. Barramundi have shown increased recruitment and strong year-classes associated with high flows when fish can migrate laterally into off-stream water bodies (Staunton-Smith et al. 2004). Low flow events are important for upstream dispersal migrations of several juvenile fish species including sea mullet, leathery grunter, Hyrtl's tandan and empire gudgeon (Marsden and Power 2007).

Fish migration at high flows is well known to the Aboriginal people who constructed the Brewarrina fish traps to collect migratory golden perch and other fishes during flow events on the Darling system (Dargin 1976). These observations are supported by state fisheries agency surveys of the Darling and Murray systems during flooding when large numbers of golden perch were migrating upstream at weirs (Mallen-Cooper and Edwards 1991, Harris et al. 1992, Mallen-Cooper 1996). In the Australian tropics, state fisheries agency studies that have also collected large numbers of fish at high flows include Hogan et al. (1997) (flows of more than 127,000 ML/d) and Renfree and Marsden (2006) in the fishway on the Burdekin system at Clare Weir where large numbers of fish (comprising 27 species were collected during the study) (flows of 60,000 ML/d).

On the Fitzroy River at Eden Bann Weir, large numbers of fish were collected migrating at flows of 35,000 plus ML/d (higher flows could not be sampled due to safety considerations) (Stuart et al. 2007). Observations of considerable numbers of fish in the rock pools below the weir, after high flow events, indicated that there had been migration during flood events (Stuart et al. 2007). Fish species most noted to migrate on high flows were golden perch, blue catfish and leathery grunter.

At the Fitzroy Barrage, fish (primarily catfish species and long-finned eels) were collected on major flow events (more than 197,000 ML/d (exceeded 0.5 per cent of the time)) before the fishway drowned-out and sampling was suspended (Stuart and Mallen-Cooper 1999). These represent some of the highest flows ever sampled because these conditions usually present insurmountable safety hazards to field staff.

For catadromous fish, high flows and floods are especially important for downstream migration, often over weirs on their journey to estuarine and marine waters for spawning. Barramundi have shown increased recruitment and strong year-classes associated with high flows when fish migrate laterally into connected floodplains (Staunton-Smith et al. 2004). Hence, catadromous fish have evolved a migration strategy to take advantage of flooding.

In the order of 30 per cent of species in the Fitzroy River migrate strongly on large floods (defined as being more than 120,000 ML/d) and many others respond to increasing flows as shown in Table 3-13.

Table 3-13 Sensitivity of fish migration to hydrology

Fish species	Flood migration	First spring flow migration	Maximum discharge when observed (where available)
Diadromous			
Long-finned eel	✓	✓	+195,757 ML/d (+2265 m ³ /s) ^{1, 3}
Swamp eel			127,457 ML/d (1475 m ³ /s) ¹
Bullrout			6,937 ML/d (80 m ³ /s) ³
Barramundi	✓	✓	127,457 ML/d (1475 m ³ /s) ¹
Blue catfish	✓	✓	195,757 ML/d (2265 m ³ /s) ¹
Striped mullet	✓		127,457 ML/d (1475 m ³ /s) ¹
Oxeye herring			127,457 ML/d (1475 m ³ /s) ¹
Freshwater longtom			660 ML/d (8 m ³ /s) ¹
Snub-nosed garfish			660 ML/d (8 m ³ /s) ¹
Potamodromous			
Spangled perch	✓	✓	127,457 ML/d (1475 m ³ /s) ¹
Sooty grunter			660 ML/d (8 m ³ /s) ¹
Banded grunter	✓	✓	127,457 ML/d (1475 m ³ /s) ¹
Leathery grunter	✓	✓	+195,757 ML/d* (+2265 m ³ /s) ^{3, 5}
Golden perch	✓	✓	119,581 ML/d (1384 m ³ /s) ^{2, 3, 5}
Bony herring	✓	✓	127,457 ML/d (1475 m ³ /s) ^{1, 3, 5}
Fly-specked hardyhead			65,466 ML/d (758 m ³ /s) ¹
Olive perchlet			65,466 ML/d (758 m ³ /s) ¹
Rendahl's catfish		✓	
Hyrtl's tandan	✓	✓	195,757 ML/d (2265 m ³ /s) ³

Fish species	Flood migration	First spring flow migration	Maximum discharge when observed (where available)
Black catfish	✓		127,457 ML/d (1475 m ³ /s) ¹
Mouth almighty			65,466 ML/d (758 m ³ /s) ¹
Eastern rainbow fish			119,581 ML/d (1384 m ³ /s) ^{1, 3, 5}
Sleepy cod			127,457 ML/d (1475 m ³ /s) ^{1, 5}
Empire gudgeon			127,457 ML/d (1475 m ³ /s) ^{1, 4}
Purple-spotted gudgeon			65,466 ML/d (758 m ³ /s) ¹
Midgley's carp gudgeon		✓	
Western carp gudgeon		✓	
Eel-tail catfish		✓	

Hydrological requirements for key large-bodies fish species are summarised:

- Golden perch

Golden perch from the Fitzroy basin are a genetically and morphologically distinct sub-species from the southern population. The species is distributed widely throughout the sub-catchments and has been observed moving through the fishways at the Fitzroy Barrage (Stuart 1997), Eden Bann (Stuart et al. 2007) and other weirs (Marsden and Power 2007).

Migratory requirements include the need to migrate upstream and downstream to breed (Reynolds 1983; Pusey et al. 2004; O'Connor et al. 2005). The flood recruitment model has been proposed in the past as the main mechanism for recruitment for golden perch in the Murray-Darling Basin but they can also recruit during rising flows within the river channel (Lake 1967; Mallen-Cooper and Stuart 2003). In the Fitzroy River system, there is strong recruitment in years associated with high flows and floods in late spring and summer (Roberts et al. 2008). The degree of river regulation can also depress recruitment patterns. This strategy potentially allows larvae to benefit from the floodplain at times of maximum inundation, and maximum exposure to larval food supplies (O'Connor et al. 2003)

Migration often occurs in the spring and summer months but has also been recorded after flow events in autumn and winter (Stuart and Berghuis 1999; pers. com. Dawson River Fish Stocking Group). This indicates that migrations are most likely temperature independent and more driven by opportunistic flow events (Marsden and Power 2007). Migration is triggered by environmental cues such as temperature and flow events but is not necessarily restricted to initial or periods of high flow (Marsden and Power 2007). The species have been witnessed moving through the Fitzroy River barrage over a wide range of flows (Stuart 1997). It has been determined that 1.83 m/s is an appropriate water velocity in fishways for an adult golden perch (Mallen-Cooper 1994).

- Barramundi

Barramundi spawn in saltwater and the juveniles often migrate upstream into freshwater (Mallen-Cooper 1992). Juveniles move upstream on high flow events preferably on the tail of the hydrograph, at least three days after the peak flow but they can also move upstream opportunistically at lower flows (Marsden and Power 2007).

Barramundi generally move during spring and summer with sub-adult fish (100-400 mm) forming the majority of migrating fish (Stuart 1999, Renfree and Marsden 2006). Individuals will still continue migrations throughout the cooler months but in lower numbers (Marsden and Power 2007). There is limited fish movement when water temperature is below 22.5°C. In other rivers, upstream movement has not been recorded at low flows. In the Fitzroy River movement has been observed at a range of flows up to about 8,000 ML/day (Pusey et al. 2004). Juvenile barramundi (43 mm) have been recorded moving through laboratory fishways with a swimming speed of 0.66 m/s (Mallen-Cooper 1992). This is thought to be a conservative estimate of barramundi swimming speed due to the low water temperature used in the experiment. Within the Fitzroy River, barramundi were observed negotiating a fishway with a maximum water velocity of 1.4 m/s (Stuart 1997). Barramundi can also pass barriers and obstacles during a period of drown-out (Marsden and Power 2007).

- Long-finned eel

Long-finned eels are catadromous with adults migrating downstream on a variety of flows in order to breed at sea. Migration downstream occurs in autumn with the onset of cooler weather. As movement occurs under a variety of flow conditions, this movement is most likely temperature dependent (Stuart and Berghuis 1999). Elders (50-100 mm) migrate upstream during high flow events in spring and summer. This movement is protracted as individuals must allow time to acclimate to reduced salinity upstream (Pusey et al 2004). Within the freshwater environment, fish are thought to exhibit limited local movement (Pusey et al. 2004).

Long-finned eels have been recorded above Tartrus Weir, on which no fishway is present. This occurrence might be explained by the fact long-finned eels have been demonstrated to migrate past barriers of a similar size to Tartrus Weir (Marsden and Power 2007). This species has been observed climbing obstacles and travelling short distances over damp ground. Several researchers have advocated the inclusion of roughened substrate on fishways in order to enable climbing (friction with substrate) (Langdon and Collins 2000; Stuart and Berghuis 2002). The swimming ability of this species (0.32-0.75 m/s) may be below that necessary to negotiate the high velocities frequently observed in fishways (Langdon and Collins 2000).

- Stripped mullet

Stripped mullet are amphidromous moving downstream during autumn as part of their annual migration to spawning grounds in the sea (Stuart and Berghuis 1999, Stuart 1999). These downstream migrations are triggered by specific water temperature conditions. They migrate downstream in the autumn with the onset of cooler weather and on a variety of flows (Stuart and Berghuis 1999). The juveniles then disperse upstream during spring and summer (Power and Marsden 2006). The juveniles utilise low flows to undertake dispersal migrations and have been recorded migrating on low flows through a fishway on Raglan Creek, indicating the importance of passage at that time (Power and Marsden 2006). Fish under 40 mm have been observed negotiating the Fitzroy Barrage and Burnett vertical-slot fishways which have a maximum water velocity of 1.4 m/s (Stuart and Mallen-Cooper 1999; Stuart and Berghuis 2002).

- Saratoga

The saratoga is endemic to the Fitzroy River system. While there is limited knowledge of the movement biology of this species it is present throughout the upper Fitzroy, Dawson and Mackenzie rivers and is not considered to be migratory (Merrick and Schmida 1984).

Local anglers have reported large numbers of saratoga congregating below the Neville Hewitt Weir during flow events (pers. com. Dawson River Fish Stocking Group). This anecdotal evidence indicates this species may undertake facultative migrations. One saratoga has been collected in the Eden Bann Weir fish lock (Stuart et al. 2007).

- Fort-tailed catfish

Fork-tailed catfish are an amphidromous species. They reproduce in freshwater and in estuarine waters and movement may be stimulated by various conditions (Pusey et al. 2004). Individuals have been recorded moving through Eden Bann Weir's fish lock, reaching peak numbers at the top of each flow event throughout the summer months (Stuart and Berghuis 1997), while lower numbers occur on flow peaks throughout the rest of the year (Stuart 1999; Marsden and Power 2007). At the Kolan River Barrage, the species has been observed migrating upstream in flows up to 5500 ML/d (Broadfoot et al. 2000). Movement at high flows has also been observed at the Fitzroy Barrage (1.6 per cent exceedence). Movement is greatly reduced in the colder winter months.

- Leathery grunter

The leathery grunter is endemic to the Fitzroy Basin. Upstream migration has been documented prior to spawning suggesting the species is potamodromous (Merrick and Schmida 1984). Sampling at barriers within the Fitzroy catchment indicate the first flood of spring as being a major migration cue for the species (Stuart et al. 2007). This species undertakes upstream migrations coinciding with summer rainfall prior to spawning. Anecdotal reports suggest that the numerous barriers on the Fitzroy-Dawson river systems prevent upstream migration necessary for reproduction (Marsden and Power 2007).

- Sleepy cod

It does not appear as though this species undertakes substantial migrations (Pusey et al. 2004). Only five and 21 individuals have been observed moving through the Fitzroy Barrage and Eden Bann Weir fishway, respectively. A small number have also been recorded at the Clare Weir fishway in the Burdekin system (Renfree and Marsden 2006). It is expected that this species moves in response to changing abundance of prey fish rather than a need to migrate.

- Oxeye herring

A small number of oxeye herring have been detected ascending the Fitzroy River Barrage during March and April only (Kowarsky and Ross 1981) and they have also been found in the Burnett Barrage fishway. It is believed that this species undertakes downstream spawning migrations. There is debate as to whether adults return upstream after spawning (Pusey et al. 2004). This species has been recorded attempting to ascend Clare Weir fishway on the Burdekin River under flow conditions (65,466 ML/d – 127,467ML/d).

Hydrological requirements for key small-bodies fish species are summarised:

- Fly speckled hardyhead

The movement pattern of the fly speckled hardyhead is described as facultative potamodromy. Access to estuarine areas is not a necessary component of the life cycle. The species is abundant in streams that are periodically disconnected during low flow. Therefore the species has the ability to survive in isolated pools and rapidly recolonise previously dry stretches (Pusey et al. 2004). Within the Fitzroy River, upstream migration

peaks in early summer with low fish movement occurring for the remainder of the year. There are few records of this species undertaking downstream movement (Stuart 1997). The environmental cue for movement is unknown however elevated flows are a likely stimulus (Pusey et al. 2004). The fly speckled hardyhead has been recorded moving through a fishway at flows of 18,305 ML/d. This flow is exceeded 10 per cent of the time in the Fitzroy River (Stuart 1997). The species has difficulty ascending pool-weir type fishways and has been observed in large numbers immediately downstream of obstructions (Pusey et al. 2004).

- Eastern rainbowfish

The eastern rainbowfish is a potamodromous species. Adults migrate upstream in order to spawn. During high flow events the species undertakes dispersal migration (Pusey et al. 2004). Eastern rainbowfish have been observed in low numbers moving through fishways on the Fitzroy River at low flows (Stuart 1997). The highest rate of movement has been recorded from November to April.

- Hyrtl's tandan

The Hyrtl's tandan is a potamodromous species. Adults migrate upstream to spawn, and then disperse downstream (Pusey et al. 2004). Individuals have been observed moving upstream through fishways on the Fitzroy River. Movement occurs between November and March under most flow conditions. Small fish (<150 mm) only moved upstream during low flow conditions (18 ML/d) (Stuart 1997). At Eden Bann Weir, there has been a strong migration response of Hyrtl's tandan to the first rising flows of spring and this has also been observed elsewhere (A. Berghuis, pers. comm.).

- Midgleys carp gudgeon

Midgleys carp gudgeon has been observed moving upstream in a tributary of the Fitzroy River (Wager 1997). Upstream migration may occur after being displaced from a flow event or as dispersal movements when flow conditions allow.

- Empire gudgeon

The species is described as facultative potamodromous or semi-amphidromous. The species engage in a facultative mass dispersal phase and mass upstream migrations (Renfree and Marsden 2006). It is unclear whether empire gudgeon undertake migration for spawning or simply recolonising freshwater (Pusey et al. 2004). They have the ability to breed in freshwater. They have been observed entering the Fitzroy Barrage fishway on a wide variety of flows (18-18,305 ML/d) (flows are exceeded about 82 per cent to 8 per cent of the time respectively) (Stuart 1997). Upstream migration usually takes place in spring and summer, particularly on large flow events. They have the ability to swim at a velocity of 1 m/s (Hogan et al. 1997).

Barriers such as weirs compromise the ability of fish to freely move downstream and upstream within the freshwater environment or between the freshwater and estuarine / marine environment. A vertical-slot fishway at the Fitzroy Barrage and a fish lock at Eden Bann Weir facilitate up- and downstream movement of many fish species. The vertical slot-fishway at Fitzroy Barrage represents a successful upgrade to the 'weir-and-pool' fishway originally constructed. However the smallest fish species, and small size-classes (i.e. immature and juveniles) of larger species are often unable to negotiate the structure, likely as a result of their inability to swim against the high velocity water flow at the downstream entrance of the fishway (Stuart and Mallen-Cooper 1999). During low flows, the Eden Bann Weir fish lock has been recorded to successfully pass a broad size range (35 – 710 mm long) of species, however

passage efficiency is reduced at high flows due to a reduced attraction of the fishway entrance (Long and Meager 2000; Stuart et al. 2007).

Conservation significant species

While no fish species listed as threatened under the EPBC Act or NC Act were identified from the literature review and field studies as occurring / potentially occurring in the Fitzroy Basin catchment (including the Project footprint), the following species are considered conservation significant due to their restricted geographic range.

- **Southern saratoga (*Scleropages leichardti*)** – the southern saratoga is endemic to the Fitzroy Basin catchment. As it has a restricted natural geographic range (the species has been stocked in waterways of South East Queensland), is endemic and generally uncommon, and is a unique remnant of a primitive group of fish, the southern saratoga is considered to have important local conservation values. This species prefers slow flowing pools and backwaters, and is tolerant of turbid conditions (Allen et al. 2003). Pool and creek habitats within the Project footprint represent potentially suitable habitat, and while no southern saratoga were encountered during wet and dry season surveys, the species is known to occur in the study area and is likely to occur in the Project footprint.
- **Leathery grunter (*Scortum hillii*)** – the leathery grunter is endemic to the Fitzroy Basin catchment. As it has a restricted natural geographic range, is endemic and relatively uncommon, the leathery grunter is considered to have important local conservation values. It prefers flowing waters where it feeds near the benthos (particularly on mussels and algae), however it also inhabits still areas, and is tolerant of turbid conditions (Allen et al. 2003). One leathery grunter was observed in a flowing pool in a 'pool-riffle-run' sequence on the lower Mackenzie River during dry season surveys. It has been previously recorded throughout the study area, and is considered likely to occur throughout the Project footprint.
- **Golden perch (*Macquaria ambigua orientalis*)** – this sub-species of the golden perch is endemic to the Fitzroy Basin catchment with relatively secure populations (Marsden and Power 2007). The golden perch occurs in a variety of aquatic habitats, but shows a preference for slow-flowing turbid habitats with an abundance of in-stream debris. Golden perch were encountered throughout the Project footprint during wet and dry season surveys.
- **Ornate rainbowfish (*Rhadinocentrus ornatus*)** – due to its restricted distribution and habitat degradation, the ornate rainbowfish has been identified as high priority under the 'Back on Track' prioritisation framework for conservation management of Queensland's wildlife within the Fitzroy Natural Resource Management area (DERM 2008). This species is typically associated with waterways in coastal lowland wallum and rainforest ecosystems, as well as coastal sand islands (Pusey et al. 2004). The ornate rainbowfish was not recorded during wet and dry season surveys, and has not been previously recorded in the study area. Due to the lack of suitable habitat, it is unlikely to occur in the Project footprint.

Recreationally and commercially important fish species

Species with significant fisheries values previously recorded upstream of the Rookwood Weir site include the barramundi (*Lates calcarifer*), a species that is a key target of the Queensland East Coast Inshore Fin Fish Fishery (DEEDI 2009). Whilst commercial fishing does not occur upstream or within the Project footprint, the life-history traits of the barramundi include utilisation of both freshwater and saltwater habitats. As such, barramundi occurring upstream of

Rookwood should be considered a potential component of the downstream commercial fishery. Other commercially-important catadromous / amphidromous species known to occur above Rookwood include the long-finned eel. Important recreational species recorded in the study area include barramundi, southern saratoga, golden perch, blue catfish (*Arius graeffei*), freshwater catfish (*Tandanus tandanus*), sleepy cod (*Oxyeleotris lineolata*), oxeye herring (*Megalops cyprinoides*) and snub-nosed garfish (*Arrhamphus sclerolepis*).

3.4.3 Freshwater turtles

Species diversity

The Fitzroy Basin catchment supports one of the highest diversities of freshwater turtles in Australia, including two regionally endemic, conservation significant species. Turtle species that inhabit the Fitzroy River include:

- Fitzroy River turtle (*Rheodytes leukops*)
- White-throated snapping turtle (*Elseya albagula*)
- Saw-shelled turtle (*Elseya latisternum*)
- Krefft's river turtle (*Emydura krefftii*)
- Broad-shelled river turtle (*Chelodina expansa*)
- Eastern snake-necked turtle (*Chelodina longicollis*).

The Fitzroy River turtle is endemic to the Fitzroy Basin catchment and is listed as 'Vulnerable' under the EPBC Act and the NC Act. The white-throated snapping turtle is endemic to the Fitzroy, Burnett and Mary river catchments and is listed as least concern under the NC Act and is ranked as high priority under DEHP's Back on Track framework. The white-throated snapping turtle has been nominated for threatened species status under the NC Act and the EPBC Act (Limpus et al 2011a) and is included in the Australian Government's Department of the Environment's Finalised Priority Assessment List for the period commencing 1 October 2013. The Threatened Species Scientific Committee will provide advice on the nomination by 30 March 2016. All six turtle species have been previously recorded within the Rookwood Weir Project footprint (Table 3-14).

Table 3-14 Known distribution of freshwater turtles within the Fitzroy Basin catchment

Species	Known distribution within the catchment		Survey reference
Fitzroy River turtle	Project footprint	Rookwood Weir site – Fitzroy River	N = 3 deceased - Limpus et al. 2007
		Foleyvale Crossing – Mackenzie River	N = 1 deceased - Limpus et al. 2007
	Downstream of Project footprint	Fitzroy River Impoundment	N = 1 - This study
		Alligator Creek junction – Fitzroy River	N = 4 live, 3 deceased N = 10 confirmed nesting banks - Limpus et al. 2007
		Wattlebank Control Weir – Fitzroy River	N = 5 - frc 2007
		Marlborough Creek – Fitzroy River	N = 1 - Cann 1998 N = 6 - Limpus et al. 2007 N = 8 - Gordos and Franklin 2002; Gordos et al. 2003
		Redbank Crossing – Fitzroy River	N = 8 - Legler 1977 N = 2 deceased - Limpus et al. 2007 N = 38 - Legler and Cann 1980 N = 2 nests - Legler and Cann 1980
		Glenroy Crossing – Fitzroy River	N = 11 - Tucker et al. 2001 N = 13 live, 14 deceased - Limpus et al. 2007 N = confirmed nesting - Limpus et al. 2007 N = 1 - Legler and Cann 1980
	Upstream of Project footprint	Windah Creek – Fitzroy River	Legler and Cann 1980
		Gainesford – Dawson River	Legler and Cann 1980
		Theodore Weir – Dawson River	N = 118 - Limpus et al. 2007
		Duck ponds – Nogoa River	Limpus et al. 2007
		Cardowan irrigation farm – Connors River	N > 12 N = 2 nests - Limpus et al. 2007
		Connors River	N = 16 - Gordos et al. 2003a,b N = 182 – frc environmental 2011
		Connors River Dam	N = 7 captured, 9 sighted – frc environmental 2010a

Species	Known distribution within the catchment		Survey reference
		Nathan Dam and surrounds	N = 1 nest – frc environmental 2010b
		Tartus Weir	N = 81 – Limpus et al 2011
White-throated snapping turtle	Project footprint	Rookwood Weir site	N = 2 - Limpus et al. 2007 N = 2 nests - This study
		Riverslea Crossing – Fitzroy River	N = 1 - Limpus et al. 2007 N = 3 - This study
		Foleyvale Crossing – Mackenzie River	N = 1 deceased - Limpus et al. 2007 N = 1 - This study
		Boolburra Crossing – Dawson River	N = 1 nest - Limpus et al. 2007
	Downstream of Project footprint	Fitzroy barrage Impoundment – Fitzroy River	N = 5 - frc 2007 N = 2 - This study
		Alligator Creek junction – Fitzroy River	N = 83 live, 2 deceased - Limpus et al. 2007 N = 13 - frc 2007 N = 56 - Hamann et al. 2007
		Alligator Creek to Wattlebank Control Weir – Fitzroy River	N = 11 - frc 2007
		Wattlebank Control Weir – Fitzroy River	N = 8 - frc 2007
		Eden Bann Weir – Fitzroy River	N = 22 live, 1 deceased - Limpus et al. 2007 N = 1 - This study
		Marlborough Creek – Fitzroy River	N = 15 - Limpus et al. 2007
		Redbank Crossing – Fitzroy River	N > 10 - Limpus et al. 2007 Legler and Cann 1980
		Glenroy Crossing – Fitzroy River	N = 36 live, 2 deceased - Limpus et al. 2007
	Upstream of Project footprint	Gainesford – Dawson River	Legler and Cann 1980
		Theodore Weir – Dawson River	N = 20 - Limpus et al. 2007
		Glebe Weir – Dawson River	N > 4 deceased - Limpus et al. 2007
		Callide Dam – Callide Creek	Limpus et al. 2007

Species	Known distribution within the catchment		Survey reference
		Hutton Creek (Warndoo Station spring fed pools) – Dawson River	N = 1 - Limpus et al. 2007
		Hutton Creek (Korcha Station spring fed pools) – Dawson River	N > 1 - Limpus et al. 2007
		Cardowan irrigation farm – Connors River	N = 28 - Limpus et al. 2007
		Connors River Dam site – Connors River	N = 2 - Summarised in SKM 2010 N = 9 - frc environmental 2010a
		Connors River Dam Site – Cattle Creek and Collaroy Creek	N = 1 – SKM 2007
		Duck ponds – Nogoa River	Limpus et al. 2007
		Tartus Weir	N = 40 – Limpus et al. 2011
		Nathan Dam and surrounds	N = 3 – SKM 2012 N = 2 - frc environmental 2010b N = 1 - frc environmental 2012
Saw-shelled turtle	Project footprint	Foleyvale Crossing – Mackenzie River	N = 1 - Limpus et al. 2007
	Downstream of Project footprint	Marlborough Creek – Fitzroy River	N = 26 - Limpus et al. 2007
		Glenroy Crossing – Fitzroy River	N = 1 live, 2 deceased - Limpus et al. 2007
	Upstream of Project footprint	Theodore Weir – Dawson River	N = 22 - Limpus et al. 2007
		Glebe Weir – Dawson River	N = 2 deceased - Limpus et al. 2007
		Hutton Creek (Korcha Station spring fed pools) – Dawson River	N = 1 deceased - Limpus et al. 2007
		Carnarvon Creek	N = 47 - Limpus et al. 2007
		Cardowan irrigation farm – Connors River	N = 1 - Limpus et al. 2007
		Connors River Dam site – Connors River	N = 4 - Summarised in SKM 2010
		Cattle Creek	N = 1 – SKM 2007
		Collaroy Creek	N = 1 – SKM 2007
		Tartus Weir	N = 5 – Limpus et al. 2011
Kreff's river	Project footprint	Rookwood Weir site	N = 43 - Limpus et al. 2007

Species	Known distribution within the catchment		Survey reference
turtle		Riverslea Crossing – Fitzroy River	N =7 - Limpus et al. 2007 N = 6 - This study
		Fitzroy – Mackenzie – Dawson Confluence	N = 1 - This study
		Foleyvale Crossing – Mackenzie River	N =43 - Limpus et al. 2007 N = 15 - This study
	Downstream of Project footprint	Boolburra Crossing – Dawson River	N = 2 deceased - Limpus et al. 2007 N = 1 - This study
		Fitzroy Barrage Impoundment – Fitzroy River	N = 92 - This study
		Alligator Creek junction – Fitzroy River	N = 451* live, 6 deceased - Limpus et al. 2007
		Eden Bann Weir – Fitzroy River	N = 89 live, 2 deceased -Limpus et al. 2007 N = 14 - This study
		Marlborough Creek – Fitzroy River	N = 6 - Limpus et al. 2007
		Redbank Crossing – Fitzroy River	N > 66 - Limpus et al. 2007 Legler and Cann 1980
		Glenroy Crossing – Fitzroy River	N = 199 live, 6 deceased - Limpus et al. 2007
	Upstream of Project footprint	Gainesford – Dawson River	Legler and Cann 1980
		Theodore Weir – Dawson River	N = 93 - Limpus et al. 2007
		Glebe Weir – Dawson River	N ≈ 100 deceased - Limpus et al. 2007
		Hutton Creek (Warndoo Station spring fed pools) – Dawson River	N = 17 live, 8 deceased - Limpus et al. 2007
		Hutton Creek (Korcha Station spring fed pools) – Dawson River	N ≈ 12 - Limpus et al. 2007
		Callide Dam – Callide Creek	N =657 - Limpus et al. 2007
		Bedford Weir – Mackenzie River	N = 109 - Limpus et al. 2007
		Fairbairn Dam – Nogoia River	N = 500 live, 179 deceased - Limpus et al. 2007
		Cardowan irrigation farm – Connors River	N = 67 - Limpus et al. 2007
		Connors River Dam site – Connors River	N = 33 - Summarised in SKM 2010 N = 7 - frc environmental 2010a

Species	Known distribution within the catchment		Survey reference
		Funnel Creek – Connors River	N = 2 - Summarised in SKM 2010
		Murray Creek	N = 6 – SKM 2007
		Connors River	N = 1 SKM 2007
		Cattle Creek	N = 8 SKM 2007
		Collaroy Creek	N = 5 SKM 2007
		Sandy Creek	N = 9 SKM 2007
		Nathan Dam and surrounds	N = 32 - SKM 2012 N = 8 – frc environmental 2010 b N = 12 frc environmental 2012
		Tartus Weir	N = 235 – Limpus et al. 2011
Broad-shelled river turtle	Project footprint	Boolburra Crossing – Dawson River	N = 1 deceased - Limpus et al. 2007
	Downstream of Project footprint	Fitzroy Barrage Impoundment	N > 1 - This study
		Gavial Creek floodplain billabong – Fitzroy River	N = 24 - Limpus et al. 2007
		Alligator Creek junction – Fitzroy River	N = 9* live, 1 deceased - Limpus et al. 2007
		Eden Bann Weir – Fitzroy River	N = 1 - Limpus et al. 2007 N = 1 nest - This study
		Redbank Crossing – Fitzroy River	N = 1 deceased - Limpus et al. 2007
		Glenroy Crossing – Fitzroy River	N = 3 live, 1 deceased - Limpus et al. 2007 Legler and Cann 1980
	Upstream of Project footprint	Theodore Weir – Dawson River	N = 3 - Limpus et al. 2007
		Glebe Weir – Dawson River	N > 5 - Limpus et al. 2007
		Hutton Creek (Warndoo Station spring fed pools) – Dawson River (anecdotal evidence)	Limpus et al. 2007
		Duck ponds – Nogoa River	Limpus et al. 2007
		Fairbairn Dam – Nogoa River	N = 2 live, 5 deceased - Limpus et al. 2007

Species	Known distribution within the catchment		Survey reference
Eastern long-necked turtle		Nathan Dam and surrounds	N = 1 - SKM 2012 N = 1 frc environmental 2010 b
		Broad-shelled long necked turtle	N = 1 – Limpus et al. 2011
	Project footprint	Capricorn Highway Crossing – Dawson River	N = 1 - This study
	Downstream of Project footprint	Alligator Creek junction – Fitzroy River	N = 11 - Limpus et al. 2007
	Upstream of Project footprint	Theodore Weir – Dawson River	Limpus et al. 2007
		Glebe Weir – Dawson River	N = 1 – deceased - Limpus et al. 2007
		Hutton Creek (Crowman and Oakwell Station dams)	N = 26 > live, 17 deceased - Limpus et al. 2007
		Hutton Creek (Korcha Station spring fed pools) – Dawson River	N > 2 - Limpus et al. 2007
		Callide Dam – Callide Creek	Limpus et al. 2007
		Connors River Dam site – Connors River	N = 1 - Summarised in SKM 2010
		Nathan Dam and surrounds	N = 1 - SKM 2012 N = 1 – frc environmental 2010 b
		Tartus Weir	N = 3 – Limpus et al 2011

* cumulative total from multiple survey events

Ecology

A species specific description of the ecology, including habitat preferences, nesting behaviour, respiratory physiology, dietary requirements, and movement behaviours of the six turtle species recorded within the Fitzroy Basin catchment is provided in Table 3-15 while a broad summary is described below.

Aquatic habitats

Habitat preferences vary considerably between turtle species and range from ephemeral waterholes and pools to fast-flowing riffle zones and structurally complex creeks. The Krefft's river turtle is the most generalist species occurring in all freshwater habitats throughout the Fitzroy Basin catchment excluding isolated farm dams (Limpus et al. 2007). This species was the most widespread and abundant species encountered within the Project footprint during DERM surveys (Limpus et al. 2007).

The saw-shelled turtle is thought to occur in low abundance throughout the Fitzroy Basin catchment with a higher number of individuals occurring in the flowing streams of the upper catchment than the larger riverine habitats of the lower catchment (Limpus et al. 2007). Foleyvale Crossing is the only record of this species within the Project footprint (Table 3-14). The broad-shelled river turtle is primarily known to occur in the slow flowing riverine reaches, impoundments and billabongs of the middle and lower catchment (Limpus et al. 2007). One deceased individual has been recorded at Boolburra Crossing in the Project footprint (Table 3-14). The eastern snake-necked turtle is known to occur in the Dawson River Catchment and the lower Fitzroy River Catchment. This species is primarily encountered in off-stream ephemeral water bodies such as swamps, lagoons, man-made dams and billabongs (Limpus et al. 2007). One eastern long-necked turtles was recorded walking through a paddock adjacent to the Dawson River during the GHD terrestrial field survey.



The Fitzroy River turtle and the white-throated snapping turtle are specialist species that inhabit the natural permanent riverine habitats of the Fitzroy Basin catchment. Riffle zones are considered particularly important habitat for these species however individuals may also inhabit run, pool, creek and impounded habitats that support an abundance of undercut banks, submerged roots and fallen trees (Limpus et al. 2007). The aquatic habitats of these species within the Project footprint are further discussed below.



Nesting habitats



Nesting by the Krefft's river turtle, saw-shelled turtle, broad-shelled river turtle and eastern snake-necked turtle can occur in a variety of river bank substrates from hard clays and grass covered banks to soft sands (Cann 1998; Limpus et al. 2007). The majority of nesting occurs close to the waters edge (5 - 50 m), however, the broad-shelled river turtle and eastern snake-necked turtle have been observed nesting up to 1 km from river banks.

In comparison to these species, the preferred nesting habitat of the Fitzroy River turtle and white-throated snapping turtle is more specific with nesting primarily occurring in alluvial sand / loam banks that occur in depositional areas (Plate 3-5) (Limpus et al. 2007; Hamann et al. 2007). These banks generally form at the rivers edge and extend back into the immediate riparian zone, however islands are also known to occur in places.

Table 3-15 Ecology of freshwater turtle species in the Fitzroy Basin catchment

Species	Adult size (mm)	Habitat	Nesting behaviour	Respiratory physiology	Diet	Type of movement
Fitzroy River turtle <i>Rheodytes leukops</i> 	240-260	<p>Endemic to the natural permanent riverine habitats of the Fitzroy Basin catchment</p> <p>Utilises fast-flowing riffle zones however will also occur in slow moving or non-flowing permanent pools</p> <p>Areas with an abundance of submerged logs, undercut banks and tree trunks are preferred</p> <p>Does not occur in off-stream water bodies separated from the flowing stream (e.g. ephemeral billabongs)</p>	<p>Nesting generally occurs on sand and loam banks between September and October</p> <p>Nesting aggregations can occur at traditional nesting banks</p>	<p>High reliance on aquatic respiration</p> <p>Well developed cloacal bursae allows the Fitzroy River turtle to extract at least 70% of its oxygen requirements from the water</p> <p>As a result, this species can remain submerged underwater for weeks at a time</p>	<p>Specialist forager - the Fitzroy River turtle has a unique foraging technique of 'scrape feeding' whereby the turtle uses the horny sheaths of the upper jaw to scrape the surface of the substrate</p> <p>This method of foraging primarily produces slow moving benthic invertebrates, invertebrate eggs, aquatic insects, sponges and algae</p>	<p>Home range size thought to be relatively small (up to 4 ha)</p> <p>Large scale movement may occur for dispersal, courtship and nesting and repositioning following flooding events</p> <p>Migrations may be triggered by rainfall</p> <p>Movement over land only known to occur over very short distances between adjacent pools</p>
White-throated snapping turtle <i>Elseya albagula</i> 	320-450	<p>Occurs throughout the catchment in the permanent freshwater reaches</p> <p>Flowing habitats with suitable shelter and refuges are preferred</p> <p>Does not occur in off-stream water bodies separated from the flowing stream (e.g. ephemeral billabongs)</p>	<p>Nesting primarily occurs on sand and loam banks between March and September</p> <p>Nesting aggregations can occur at traditional nesting banks</p>	<p>Medium reliance on aquatic respiration</p> <p>The white-throated snapping turtle can extract 40-60% of its oxygen requirements from the water</p>	<p>Primarily herbivorous – adult turtles primarily feed on aquatic macrophytes (including Vallesnaria leaves and filamentous algae) and fruit and leaves from riparian vegetation</p> <p>Small amounts of animal material will be consumed including terrestrial and aquatic insects</p> <p>Juveniles are primarily carnivorous</p>	<p>Home range size thought to be relatively small (500 m) but some individuals known to move larger distances (10 – 55 km)</p> <p>Large scale movement may occur for dispersal, courtship and nesting and repositioning following flooding events</p> <p>Migrations may be triggered by rainfall</p> <p>Movement over land generally only known to occur over very short distances between adjacent pools</p>

Species	Adult size (mm)	Habitat	Nesting behaviour	Respiratory physiology	Diet	Type of movement
Saw-shelled turtle Elseya latisternum 	200-300	<p>Inhabits flowing areas in the upper catchment</p> <p>Is most abundant in small tributaries off the main river channel</p> <p>Prefers areas with abundant fallen logs, submerged rocks and undercut banks</p>	Nesting is thought to occur on the river banks during late spring-summer	<p>Medium – low reliance on aquatic respiration</p> <p>The saw-shelled turtle can extract 10-30% of its oxygen requirements from the water</p>	<p>Opportunistically omnivorous – adult turtles feed on crustaceans, frogs, aquatic and terrestrial insects and aquatic plants</p> <p>Juvenile turtles are primarily carnivorous</p>	<p>Home range size unknown</p> <p>Large scale movement may occur for dispersal, courtship and nesting and repositioning following flooding events</p> <p>Migrations may be triggered by rainfall</p> <p>Movement over land only known to occur over very short distances between adjacent pools</p>
Kreffft's river turtle Emydura krefftii 	210-350	<p>Inhabits all freshwater habitats throughout the catchment except isolated farm dams</p>	Extended nesting season occurs during spring and summer	<p>Medium – low reliance on aquatic respiration</p> <p>The Krefft's river turtle can extract 10-30% of its oxygen requirements from the water</p>	<p>Opportunistically omnivorous – variable diet including gastropods, bivalves, terrestrial and aquatic insects, aquatic macrophytes, algae and sponge</p>	<p>Home range size unknown</p> <p>Large scale movement may occur for dispersal, courtship and nesting and repositioning following flooding events</p> <p>Migrations may be triggered by rainfall</p> <p>May move short distances overland</p>

Species	Adult size (mm)	Habitat	Nesting behaviour	Respiratory physiology	Diet	Type of movement
Broad-shelled river turtle Chelodina expansa 	350-480	Recorded in slow flowing riverine reaches, impoundments and billabongs in the lower and middle reaches of the Fitzroy River Catchment Turbid areas with abundant debris and submerged roots are preferred	Nesting is thought to occur on the river banks during March-September Nesting may occur up to 1 km from the waters edge	Low reliance on aquatic respiration No specialisation of cloacal bursae Very little oxygen extracted from the water	Carnivorous – ambush predator feeding on small fish and crustaceans	Home range size unknown Large scale movement may occur for dispersal, courtship and nesting and repositioning following flooding events Migrations may be triggered by rainfall May move long distances overland
Eastern snake-necked turtle Chelodina longicollis 	190-260	Most abundant in shallow ephemeral water bodies such as swamps, lagoons, man-made dams and billabongs Within the Fitzroy River Catchment, this species occurs within the Dawson Catchment and the lower Fitzroy River	Nesting is thought to occur in firm substrates during summer Nesting may occur up to 500 m from the waters edge	Low reliance on aquatic respiration No specialisation of cloacal bursae Very little oxygen extracted from the water	Opportunisticly carnivorous –thought to primarily feed on aquatic insects and crustaceans however plankton, nekton, benthic macroinvertebrates and carrion may also be consumed	Home range size unknown Large scale movement may occur for dispersal, courtship and nesting and repositioning following flooding events Migrations may be triggered by rainfall Undertake long distance overland migrations for nesting and dispersal

Ecological information in table sourced from: Preist 1997; Cann 1998; Gordos 2004; Mathie and Franklin 2006; Limpus et al. 2007; Hamann et al. 2007; Rogers 2000



Plate 3-5 Potential turtle nesting bank in Rookwood Weir Project footprint

There is insufficient evidence available on species specific nesting requirements to accurately describe the optimal nesting bank conditions for the Fitzroy River turtle and white-throated snapping turtle, however, banks with a relatively steep slope ($\sim 27^\circ$ elevation), low density of ground / understorey vegetation and shade cover appear to be preferred (Limpus et al. 2007). Nesting in both species generally occurs approximately 5-6 m from the waters edge, however, the white-throated snapping turtle has been recorded nesting up to 60 m from the waters edge (Limpus et al. 2007; Hamann et al. 2007).

The largest nesting aggregation for the Fitzroy River turtle and white-throated snapping turtle occurs at Alligator Creek, located within the upper reaches of the Fitzroy Barrage impoundment (downstream of the Project footprint). Outside this area, only isolated nests of both species have been observed (Limpus et al. 2007). Within the Project footprint, white-throated snapping turtle nesting has been historically recorded at Boolburra on the Dawson River, and a number of unidentified nest have been recorded at Riverslea Crossing on the Fitzroy River. A total of six confirmed nesting banks were identified in the Project footprint during the current wet and dry season surveys. Predated egg shell from five of these banks was identified by DERM as potential Fitzroy River turtle, saw-shelled turtle or Krefft's river turtles, while the two nests recorded at the proposed Rookwood Weir site were confirmed as white-throated snapping turtle. Nest predation was observed at all confirmed nesting banks and habitat degradation from pigs and cattle was evident throughout the Project footprint.

An additional twelve banks were identified as potential turtle nesting areas with one ranked as having high suitability (although unconfirmed), eight being ranked as medium suitability and three ranked as low suitability. As the occurrence of suitable turtle nesting habitats are relatively limited within the study area, all sand / loams banks located within the Project footprint should be considered potentially important habitat. The location of potential turtle nesting sites within the Project footprint is shown in Figure 3-4. It is important to note that the classification of a bank as potential turtle nesting habitat does not guarantee turtle nesting

does / will occur in that area. Turtle nesting may also occur in areas not identified as potential habitat, however these areas are considered to be of low quality and unlikely to support large numbers or achieve high nesting success. Note: mapped nest location points may represent a series of adjacent nesting banks

Movement

Very little is known about the long-term movement requirements of freshwater turtles in the Fitzroy Basin catchment. Home ranges are thought to be generally small, however movements in the scale of tens of kilometres have been recorded in some species (Limpus et al. 2007; Hamann et al. 2007). Migrations are generally associated with courtship, nesting, dispersal and repositioning following flood displacement. The broad-shelled river turtle and eastern snake-necked turtle are also known to undertake overland migrations in response to nesting and habitat degradation (e.g. drying of ephemeral pools) (Limpus et al. 2007).

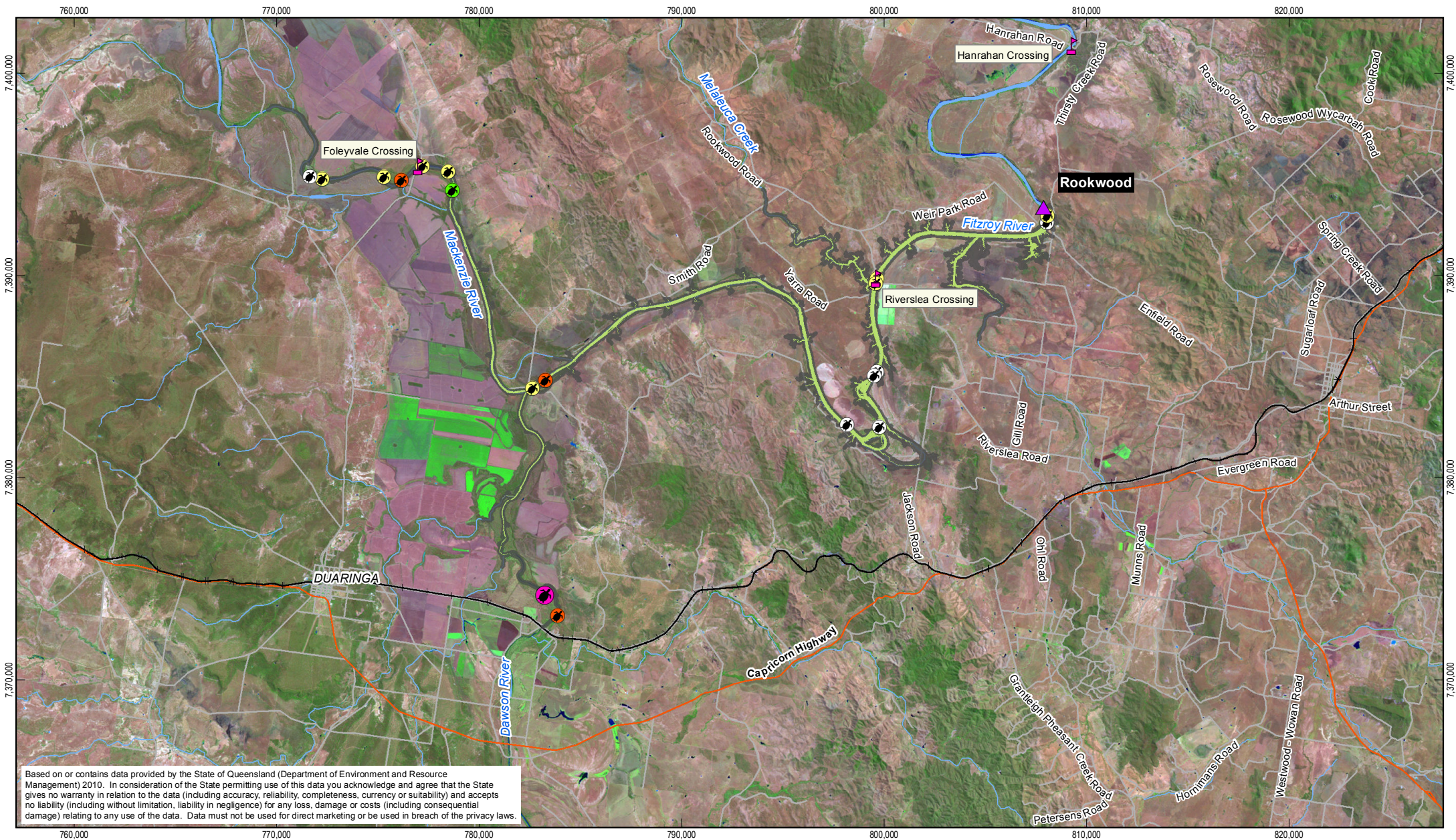
Within the Fitzroy Basin catchment, long-distance movement of turtles is significantly compromised as a result of the eighteen major water infrastructures that occur within the catchment. These structures can physically inhibit the upstream and downstream movement of turtles throughout the catchment. Although some of the dams and weirs within the Fitzroy Basin catchment contain fishways, these structures have not been designed to accommodate freshwater turtles and as a result, have relatively low, to no, success at facilitating turtle passage (Limpus et al. 2007).

Conservation significant species

Fitzroy River turtle

The Fitzroy River turtle (Plate 3-6) is endemic to the Fitzroy Basin catchment and is thought to inhabit the permanent freshwater riverine habitats from the Fitzroy Barrage to the upper reaches of the Dawson, Nogoia and Connors Rivers (Limpus et al. 2007) (Table 3-14). The type localities⁸ for the species are located at Glenroy Crossing and Redbank Crossing (approximately 72 km and 81 km downstream of the proposed Rookwood Weir site, respectively), are important localities as they contain the preferred habitat for the species. During the 1980s, the Fitzroy River turtle was the most abundant turtle species inhabiting these localities (Legler and Cann 1980) however high levels of mortality has been detected in recent years (Limpus et al. 2007). Poor water quality as a result of drought conditions and agricultural / pastoral activities has been suggested as a potential cause of the species decline in these areas (Limpus et al. 2007). In addition to the type localities, Marlborough Creek and Alligator Creek have also been identified as important habitat areas for the Fitzroy River turtle (Leger and Cann 1980; Cann 1998; Limpus et al. 2007). Whilst no important habitat areas have been identified within the Rookwood Weir Project footprint, a small area of mapped essential habitat for this species has been mapped just upstream of the footprint on the lower Dawson River between the Boolburra rail crossing and the Capricorn Highway.

⁸ Type locality refers to the place/s where the holotype or type specimen was collected

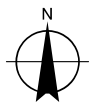


1:250,000 (at A4)

0 2.5 5 7.5 10

Kilometres

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



LEGEND

- ▲ Weir Location
- River Crossing
- Railway
- Highway
- Minor Road
- Waterway
- Rookwood Weir Stage 1 impoundment
- Rookwood Weir Stage 2 impoundment
- Confirmed Turtle Nesting Site
- High Potential Turtle Nesting Suitability
- Medium Potential Turtle Nesting Suitability
- Low Potential Turtle Nesting Suitability
- Historical Turtle Nesting Site



CLIENTS | PEOPLE | PERFORMANCE



Gladstone Area Water Board



Gladstone Area Water Board, SunWater Job Number 41-20736
Lower Fitzroy River Infrastructure Project Revision D
Date 19 Aug 2014

Potential turtle nesting sites
within the Rookwood Weir
Project footprint

Figure 3-4

G:\41\20736\GIS\Projects\MXD\900_Baseline Terrestrial Fauna Report\4120736_913_Rookwood_Potential_Turtle_Nesting_Sites_Rev_D_Fig5.mxd

© 2014. While GHD has taken care to ensure the accuracy of this product, GHD, DNRM, SUNWATER and GA make no representations or warranties about its accuracy, completeness or suitability for any particular purpose.

GHD, DNRM, SUNWATER and GA cannot accept liability of any kind (whether in contract, tort or otherwise) for any expenses, losses, damages and/or costs (including indirect or consequential damage) which are or may be incurred as a result of the product being inaccurate, incomplete or unsuitable in any way and for any reason.

Data Source: © Copyright Commonwealth of Australia (Geoscience Australia); Waterways, State (2007); Sunwater: Waterways, Weir Locations - 2008; DNRM: Roads - 2010, Railways - 2010, Imagery/2005; GHD: Fauna Survey - 2009. Created by MS

Level 9, 145 Ann St Brisbane QLD 4000 T 61 7 3316 3000 F 61 7 3316 3333 E bnemail@ghd.com.au W www.ghd.com.au



Plate 3-6 Fitzroy River turtle captured on the Fitzroy River Barrage fish ladder (October 2008)

Within the Project footprint, Fitzroy River turtle has only been identified by a small number of deceased individuals recorded at the proposed Rookwood Weir site and Foleyvale Crossing on the Mackenzie River (Table 3-14). Predated egg shell identified by DERM as potential Fitzroy River turtle, has also been recorded from six locations throughout the Project footprint (Figure 3-4). Due to the availability of suitable habitat and the confirmed distribution of the species both upstream and downstream of the Project footprint, it is considered highly likely that this species does permanently inhabit the area.

The Fitzroy River turtle is one of a unique group of Australian freshwater turtles that can extract oxygen from both air and water. Aerial respiration is achieved via the lungs at the water's surface, whilst aquatic respiration occurs underwater via gill like structures in the cloaca (Priest and Franklin 2002). The ability to respire aquatically allows the Fitzroy River turtle to remain underwater for a longer period of time than a primarily air-breathing species. The Fitzroy River turtle can support at least 70% of its oxygen requirements from the water, which allows this species to remain submerged underwater for days or weeks at a time (Priest 1997; Gordos et al. 2003). Benefits of aquatic respiration include: increased time available for foraging and breeding, reduced exposure to predation, reduced energy expenditure and habitation of fast-flowing riffle zones (Gordos 2004; Clark 2008). Due to their high surface area-to-volume ratio, hatchling turtles have a relatively high reliance on aquatic respiration (compared to adults) and this is considered particularly beneficial for predator avoidance (Clark et al. 2008). Successful aquatic respiration in freshwater turtles is dependent upon a range of environmental conditions such as water temperature and dissolved oxygen levels. Changes in these conditions can influence the amount of oxygen the turtle can extract from the water and can, therefore, directly influence the ecological behaviour of the species (Clark 2008).

The ability of the Fitzroy River turtle to respire aquatically allows this species to inhabit fast-flowing riffle zones from which primarily air-breathing species are excluded (Gordos 2004). High water velocities within riffle zones make surfacing for air energetically expensive and dangerous. The ability of the Fitzroy River turtle to respire aquatically limits these problems of surfacing within a high velocity environment (Gordos 2004). The Fitzroy River turtle is also uniquely negatively buoyant, which allows the turtle to easily maintain its position on the river bottom. The ability of the Fitzroy River turtle to inhabit riffle zones provides them with access to an abundance and diversity of food resources (Gordos 2004). The Fitzroy River turtle has a

unique foraging technique of 'scrape feeding' whereby the turtle uses the horny sheaths of the upper jaw to scrape the surface of the substrate, particularly submerged logs and rocks. This method of foraging primarily produces slow moving benthic invertebrates, invertebrate eggs, aquatic insects, sponges and algae (Leger and Cann 1980; Rogers 2000; Tucker et al. 2001; Limpus et al. 2007). Food resources for the Fitzroy River turtle can often be in short supply within natural pools and impounded habitats and access to the highly productive riffle zones or flowing shallow water margins are thought to be necessary for the species to build up sufficient fat reserves for breeding (Limpus et al. 2007).

Whilst the Fitzroy River turtle is often referred to as a riffle zone specialist, the species also inhabits pools, runs and creeks. Foraging in these habitats is generally associated with in-stream debris such as fallen logs. Undercut banks, root mats, logs and rocks also provide important sheltering habitat. Whilst flowing waters are thought to be preferred by the species, the Fitzroy River turtle retreats into non-flowing, potentially isolated pools during the dry season (Limpus et al. 2007). The Fitzroy River turtle has also been recorded within impounded habitats, such as the Neville Hewitt Weir, and approximately 116 individuals were captured from the plunge pool below Theodore Weir (Limpus et al. 2007). The largest known nesting aggregation for the Fitzroy River turtle occurs in the upper reaches of the Fitzroy Barrage impoundment (downstream of the Project footprint) (Limpus et al. 2007). Given this, isolated natural pool and impounded habitats are expected to have a lower carrying capacity for the species compared to natural pool-riffle-run habitats (Limpus et al. 2007). The Fitzroy River turtle is not known to occur in off-stream habitats such as farm dams, billabongs, or flood plains (Limpus et al. 2007).

Little is known about the movement patterns of the Fitzroy River turtle. Initial studies suggest that home range size is relatively small (up to 4 ha) with local movement generally occurring between riffle zones and adjacent pools. Large scale movements in the order of tens of kilometres may potentially occur for the purpose of dispersal, courtship and nesting migrations and repositioning following flood displacement (Tucker et al. 2001). Movement over land is only known to occur between adjacent pools. Rainfall is a suggested cue for turtle movement, with individuals observed attempting to move past impoundments during rainfall and small flow events (Limpus et al. 2007). The habitat and movement requirements of hatchling turtles are unknown.

Whilst the Fitzroy River turtle spends the majority of its time in the water, females emerge for nesting laying up to two egg clutches per year during spring (September-October) with hatching occurring approximately 46 days later in summer (November-December) (Limpus et al. 2007). Nesting is generally restricted to alluvial sand / loam banks which are deposited during flood events (see above). Within the Project footprint, Fitzroy River turtle nesting has been historically recorded at Redbank Crossing and Glenroy Crossing. Figure 3-4 shows the location of potential turtle nesting sites within the Project footprint.

The biggest threat to the survival of the Fitzroy River turtle is the lack of recruitment into the population. Predation of nesting banks by feral animals, goannas and water rats and trampling by cattle results in extremely poor survival of egg clutches. The bias in favour of adult turtles within the Fitzroy Basin catchment indicates that low recruitment of hatchlings has been occurring over a number of decades (Limpus et al. 2007).

White-throated snapping turtle

The white-throated snapping turtle (Plate 3-7) occurs throughout the Fitzroy, Burnett and Mary River Catchments. Like the Fitzroy River turtle, the white-throated snapping turtle inhabits permanent waters within flowing streams and is not thought to occur within farm dams,

ephemeral swamplands or brackish waters (Hamann et al. 2007). Within the Project footprint, this species has been previously recorded at the proposed Rookwood Weir site, Riverslea Crossing, Foleyvale Crossing and Boolburra Crossing (Table 3-14). One individual was caught in a fyke net upstream of Riverslea Crossing on the Fitzroy River during the GHD wet season surveys and another individual was also caught in a fyke net on the lower Mackenzie River (downstream of Foleyvale Crossing) during the GHD dry season surveys. Two white-throated snapping turtle nests were recorded at the proposed Rookwood Weir site during the dry season GHD survey.



Plate 3-7 White-throated snapping-turtle caught in a fyke net in the Mackenzie River

The white-throated snapping turtle is one of Australia's largest turtle species with adult females weighing up to 9 kg. As for the Fitzroy River turtle, the white-throated snapping turtle can also respire aquatically, with turtles obtaining ~40-60% of their oxygen requirements from the water (Mathie and Franklin 2006). This species inhabits permanent flowing reaches of the river that are characterised by steep sides, a sand-gravel substrate and an abundance of underwater refuge (e.g. rocks, logs and undercut banks) (Hamann et al. 2007). During the day, the white-throated snapping turtle is generally found in deep pools (>6 m) either up- or downstream from a riffle zone, whereas at night the turtle moves into the shallow riffle zones (Gordos et al. 2007; Hamann et al. 2007). Due to the relatively high abundance of overhanging vegetation and macrophytes within creeks, these habitats are often utilised by this species for foraging and sheltering. During the dry season, the white-throated snapping turtle is restricted to the less productive slow moving pools where they compete for limited resources with other turtle species and aquatic fauna. Juvenile white-throated snapping turtle are carnivorous, while adult turtles are primarily herbivorous, feeding on fruit and leaves of riparian vegetation and aquatic macrophytes (Rogers 2000).

The white-throated snapping turtle is also known to inhabit impounded pools with individuals recorded within the Fitzroy Barrage, Eden Bann Weir, Theodore Weir, Glebe Weir and Callide Dam (Table 3-14). Due to a shortage of foraging and sheltering resources within impounded habitat, the carrying capacity of this species is expected to be lower in these areas than in the natural pool-riffle-run sequences (Limpus et al. 2007). The occurrence of the largest known nesting aggregation in the upper reaches of the Fitzroy Barrage impoundment does however indicate that successful breeding can occur within the flowing margins of impounded habitats.

The home range of the white-throated snapping turtle is generally less than 500 m and is usually restricted to the one pool. On occasions the turtle has been known to move large distances (10 - 55 km) in association with dispersal, courtship and nesting and repositioning

following flood displacement (Hamann et al. 2007). Movement over land is generally only known to occur between adjacent pools. Rainfall is a suggested cue for turtle movement with individuals observed attempting to move past impoundments during rainfall and small flow events (Hamann et al. 2007; Limpus et al. 2007). The habitat and movement pattern of hatchling turtles is largely unknown.

The white-throated snapping turtle has an extended breeding season that occurs between March and September. Once they reach sexual maturity (at least 18 years of age) female turtles are thought to breed annually. Nesting occurs from autumn through to early spring with hatching generally occurring in early summer after an embryonic diapause over the winter months (Hamann et al. 2007). Nesting in the white-throated snapping turtle is generally restricted to sand / loam alluvial deposits (see nesting habitats above). The location of potential turtle nesting sites within the Project footprint is shown in Figure 3-4. Predation of nests by foxes, goannas, feral cats, and water rats is extremely high, indicated by the lack of hatchling and juvenile turtles within the population which suggests that there has been very little recruitment into the population over the last decade (<2%) (Hamann et al. 2007).

3.4.4 Crocodiles

The estuarine crocodile (*Crocodylus porosus*) is listed as 'Marine' and 'Migratory' under the EPBC Act and 'Vulnerable' under the NC Act and occur in the lower reaches of the Fitzroy River system. Crocodiles are occasionally observed upstream of the Rookwood Weir site (Limpus et al. 2007), however they are uncommon beyond Glenroy Crossing on the Fitzroy River. The Fitzroy River is at the southern distribution limit for the estuarine crocodile and as such population abundance is naturally low throughout the area. The construction of the Fitzroy Barrage and the Eden Bann Weir on the Fitzroy River has however increased the availability of suitable habitat for this species and anecdotal evidence suggests abundance has increased within these local areas.

A 2007 study commissioned by the former Queensland Department of Natural Resources and Water (DNRW) on the distribution and abundance of crocodiles upstream of Eden Bann Weir and upstream of the proposed Rookwood Weir site, observed 43 non-hatchling crocodiles in the Eden Bann Weir Project footprint, and zero crocodiles in the Rookwood Weir Project footprint (Britton 2007b). The study concluded that the Fitzroy River upstream of the Rookwood Weir site represents generally unsuitable habitat for the species, and any crocodiles occurring there are likely to be transient individuals from the downstream (Eden Bann Weir pool) population (Britton 2007b).

No crocodiles, and no evidence of crocodiles (slides, nests) were observed in the Project footprint during wet and dry season surveys.

Ecology

Growing up to 7 metres in length, the estuarine crocodile is the apex predator of tropical Australia's inland and coastal waters. This species ranges from Gladstone in southern Queensland across the top half of the country to north-west Western Australia, as well as southeast Asia. Whilst it is usually associated with tidal coastal and estuarine environments, it often occurs well inland (hundreds of kilometres) in freshwater habitats (such as rivers, creeks, swamps and billabongs) along large drainages. The physiology of this species allows it to readily move between salt- and freshwater environments.

Breeding peaks during October and November, with nesting occurring from December to April. Eggs are laid in a mound of vegetation and soil, which is constructed within close proximity of a permanent water body (DERM 2009). The nest is usually constructed amongst vegetation

(for example grasses, *Melaleucas*, mangroves etc. in tidal areas) well above the water level. Females aggressively defend their nest against predators such as pigs and goannas. Embryo development is heavily dependent on temperature, with average internal nest temperatures of approximately 32°C producing predominantly male young, and temperatures slightly above or below 32°C resulting in relatively more females (DERM 2009).

Dispersal in estuarine crocodiles is generally related to access to resources and / or excessive competition where crocodiles occur at high densities. Whilst large male crocodiles may dominate particular home ranges, overlapping home ranges of a number of adult crocodiles are not uncommon (EPA 2007). Estuarine crocodiles are faithful to their home range, and although individuals are known to undertake natural migrations of hundreds of kilometres, translocated “problem” crocodiles have been recorded moving almost 300 kilometres from the point of their release back to the river system in which they were originally captured (Walsh and Whitehead 1993).

Seasonal migrations from lotic habitats to ephemeral swamps and billabongs occur during the wet season, as these temporary water bodies are generally rich in food resources (EPA 2007). Estuarine crocodiles are opportunistic ambush predators. Juveniles take insects, crustaceans, frogs and small fish, whilst adult crocodiles consume fish, turtles, birds and mammals (including macropods, livestock and feral pigs). Adult crocodiles will also readily scavenge carrion.

3.4.5 Platypus

The platypus (*Ornithorhynchus anatinus*) is listed as ‘Special Least Concern’ common wildlife under the NC Act. ‘Special Least Concern’ wildlife are those species considered as having inherent value and potential importance for the maintenance of ecosystem processes. ‘Special Least Concern’ fauna are also considered a source of genetic information integral to an understanding of the evolution of the Australian biota and a genetic resource of potential benefit to society. These species are also considered culturally significant. No platypus were observed during wet and dry season field surveys, however a recent record does exist within the Project footprint (lower Dawson River) for this species (DERM Wildlife Online Database) (recorded in March 2000).

Potentially suitable aquatic habitat for platypus, as described by Grant and Temple-Smith (1998), occurs throughout the Rookwood Weir Project footprint. However the spatial utilisation of habitat is expected to be restricted to reaches of the lower Dawson, lower Mackenzie and Fitzroy Rivers (and adjoining creeks) that support necessary resources for burrowing (i.e. earthen banks consolidated by the roots of riparian vegetation, overhanging vegetation, undercut banks (Grant and Temple-Smith 1998)). As described in Section 3.3 the variability in riparian habitats in the Project footprint is heavily influenced by adjacent land use, most notably cattle grazing in the riparian zone.

Based on observations in the Project footprint, it is inferred that where riparian habitats have been degraded by cattle, suitable platypus burrowing habitat is unlikely to be prevalent, and thus the species is likely to be limited in abundance or absent. Bank vegetative stability (a measure of the percentage of bank covered by vegetation and other habitat features such as boulders) was generally *good* or *excellent* (see habitat assessments summarised in Section 3.3.3 to Section 3.3.7). Habitat assessments and observations from the lower Dawson River revealed that habitats along this reach may be particularly ideal for platypus, due to the combination of appropriate aquatic and burrowing habitat observed. While cattle degradation was prevalent in some areas, less disturbed riparian and aquatic habitats in the lower Dawson River are likely to support the species.

Ecology

Platypus are distributed along Australia's east coast (including Tasmania). The species inhabit lotic and lentic freshwater habitats, with a preference for areas that have steep, well vegetated banks. Shelter and nesting occur in a burrow constructed in the river bank just above the water level with an entrance to the burrow usually concealed by overhanging vegetation or an undercut bank. Burrows used for nesting tend to be longer and more elaborate than those used for shelter (Van Dyck and Strahan 2008).

Whilst largely solitary, a number of platypus may occur within a relatively small area (i.e. the same pool in a river). Platypus show fidelity to home ranges (up to several kilometres of river). Once established in a home range, platypus may undertake daily foraging movements of several kilometres (Gardner and Serena 1995). Platypus are capable of limited overland movement (Fish et al. 2001). A study of movement behaviour in Tasmania recorded platypus moving up to 1.5 km overland (Otley et al. 2000). Serena et al. (1998) speculated that platypus may occasionally undertake overland movements to bypass natural obstacles in river systems such as waterfalls and strong rapids.

Benthic aquatic invertebrates constitute the significant majority of platypus prey. Prey is sifted from amongst the streambed sediments through the use of their unique bill, and / or taken from the water column and subsequently chewed on the surface. The platypus is most active at dawn and dusk, although they may occasionally forage during the day and at night.

3.4.6 Macroinvertebrates

Diversity

A total of 4270 individuals from 59 families of macroinvertebrates were collected from artificial substrates in the study area⁹ during the wet season and 233 individuals from 28 families during the dry season. The most dominant families across all the sites combined were:

- Diptera, Chironominae (non-biting midge, Plate 3-8) - Chironominae are a subfamily of Chironomidae. Chironominae can be simple detritivores, omnivores or carnivores that feed on a mixture of algae and bacteria in soft sediments. They are found in a variety of water sources and most genera are relatively tolerant to pollution
- Diptera, Tanypodinae (non-biting midge) - Tanypodinae are a subfamily of Chironomidae. Tanypodinae are predators that also feed on some algae, bacteria and diatoms in their early larval stages. They are found in a variety of water sources and most genera are relatively tolerant to pollution
- Ephemeroptera, Baetidae (mayfly, Plate 3-9) - Baetidae is the second most diverse family of mayflies in Australia. They have a worldwide distribution and like all mayflies are excellent indicators for environmental monitoring due to their intolerance for poor water quality and habitat degradation. They are algal feeders and are more diverse in cooler, flowing waters of southern Australia but also occur in lowland systems and wetlands of northern Australia
- Ephemeroptera, Caenidae (mayfly, Plate 3-10) - Caenidae inhabit slow-flowing streams and are often found on bark, logs and rocks in streams, wetlands and pools. They are detritivores and herbivores. Most mayflies are pollution intolerant and are frequently

⁹ Within the Rookwood Project footprint and downstream to the Fitzroy Barrage

used as an indicator group for environmental monitoring programs (Dean and Suter 1996)

- Ephemeroptera, Leptophlebiidae (mayfly, Plate 3-11) - Leptophlebiidae is the most diverse family of mayflies in Australia. They have a worldwide distribution and like all mayflies are excellent indicators for environmental monitoring due to their intolerance for poor water quality and habitat degradation. They are algal and detrital feeders and occur across Australia
- Gastropoda, Hydrobiidae - Hydrobiidae are small dextrally coiled snails that occur across Australia. They occupy a diverse range of habitats and little is known about their biology. They can occur in huge quantities but have very restricted habitat tolerances. One genus of this family is an introduced pest from New Zealand, however this genus was not noted during this study
- Ostracoda (seed shrimps) - Ostracoda look like small freshwater mussels but are in fact small multi-segmented crustaceans. They are herbivores and detritivores, filter feeding by generating a current through their shell with their legs. This order is very common and has 11 families that occur in Australia
- Gastropoda, Thiaridae (sculptured snails, Plate 3-12) - Thiaridae are as the name suggests an ornately sculptured snail. They are asexual reproducers and as such can rapidly produce large populations from a single animal.



Plate 3-8 Diptera, Chironominae



Plate 3-9 Ephemeroptera, Baetidae



Plate 3-10 Ephemeroptera, Caenidae



Plate 3-11 Ephemeroptera, Leptophebiidae

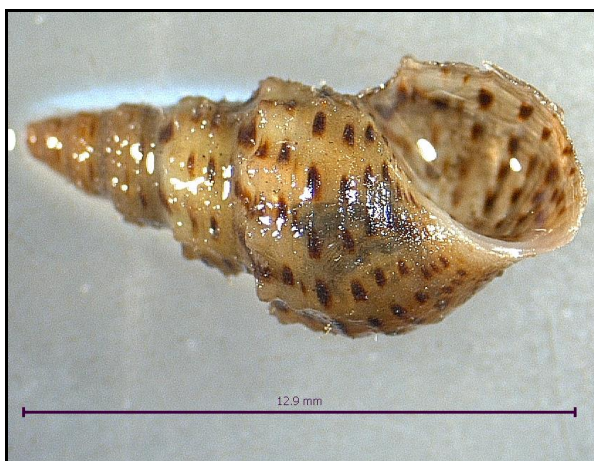


Plate 3-12 Gastropoda, Thiaridae



Plate 3-13 Cherax quadricarinatus

Furthermore, fish trapping (fyke and bait traps) within the Project footprint revealed the presence of three species belonging to the order Decapoda. Freshwater shrimp (*Paratya australiensis*, family: Atyidae) were recorded from all sites sampled in the dry season, and a freshwater (*Macrobrachium spp.*, family: Palaemonidae) was also recorded at several sites (Dawson and Fitzroy Rivers) in the dry season and sites on the Fitzroy River (Riverslea Crossing) and Mackenzie River (Foleyvale Crossing) in the wet season. Red-claw crayfish (*Cherax quadricarinatus*, family: Parastacidae) were recorded from the margins of a deep, narrow pool on the lower Dawson River in the dry season (Plate 3-13), while freshwater mussels (family: Hyriidae) were observed in sandy substrates in the lower Mackenzie and upper Fitzroy Rivers.

Several studies have characterised the macroinvertebrate diversity of the Fitzroy Basin catchment. Data collected by the former DNRW (and summarised by frc environmental, 2008) from three sites in the lower Fitzroy Basin catchment (Mackenzie River at Tartrus Weir headwater (1997), Dawson River at Boolburra Crossing (1998, 2001), Fitzroy River at Wattlebank (1994-1996)) returned 66 macroinvertebrate taxa. Duivenvoorden and Roberts (1997) study investigating macroinvertebrate assemblages from the major drainages of the Fitzroy Basin catchment recorded over 70 families, with the most prevalent taxa including:

- Coleopteran (beetles)
- Diptera (flies)
- Ephemeroptera (mayflies)
- Hemiptera (sucking bugs)
- Odonata (dragon and damselflies)
- Trichoptera (caddisflies)
- Bivalvia (mussels)
- Gastropoda (snails)
- Decapoda (shrimps and crayfish)
- Isopoda (shrimp-like taxa).

As well as sampling riverine habitats, Duivenvoorden and Roberts (1997) investigated macroinvertebrate assemblages in off-stream wetland habitats and lower order adjoining streams. The off-stream habitats sampled had relatively high macroinvertebrate diversity (> 30 species), and relative abundance at these sites was also observed to be higher. The results obtained in creek habitats were similar to off-stream water bodies, excluding a creek site in a semi-urban landscape (Duivenvoorden and Roberts 1997).

A study of macroinvertebrate diversity in the Dawson River between 1997 and 1999 returned 86 taxa from four sites (Duivenvoorden et al. 2000). Taxa numbers per site showed statistically significant temporal variability (Duivenvoorden et al. 2000). Spatial variability was also shown to be statistically significant – most notably, there was a statistically significant difference in taxa richness between impounded sites and riverine sites (Duivenvoorden et al. 2000). A major conclusion of the study was that macroinvertebrate populations at impounded sites had fewer taxa, appeared to be generally lower in abundance and featured fewer pollution sensitive taxa when compared with riverine sites (Duivenvoorden et al. 2000). The impacts of rapid and extreme water level fluctuations within weir environments on food and habitat availability were hypothesised as a potential explanation for this observed spatial trend (Duivenvoorden et al. 2000). The loss of more specialist taxa, which are less tolerant of sudden habitat changes (i.e. due to water level fluctuations), was thought to account for observed temporal variability in

macroinvertebrate assemblages, and may have contributed towards the lower taxon richness in weir environments (Duivenvoorden et al. 2000). The relatively lower numbers of taxa sensitive to poor water quality (namely Ephemeropteran and Trichopteran) was also speculated to be a reflection of the modified and highly variable aquatic environment within impounded pool habitats (Duivenvoorden et al. 2000). Importantly, the sensitive taxa were always present in weir habitats, thus suggesting that the predicted impacts of river regulation are not necessarily severe enough to exclude these taxa entirely from variable impounded pool habitats (Duivenvoorden et al. 2000).

As a result of the limitations encountered in assessing macroinvertebrates in the study area (as described in Section 2.4.2), sampling in this study did not seek to identify temporal and spatial trends in taxa diversity / abundance, nor did it attempt to quantify differences in macroinvertebrate habitat utilisation. The studies summarised above provide a snapshot of macroinvertebrate taxa richness in the Fitzroy Basin catchment, and the results obtained in this investigation provide additional information about macroinvertebrate diversity in the study area. The prevalence of Diptera, Ephemeroptera and Gastropoda recorded in this study corresponds with previous studies which have recorded these taxa from the Fitzroy Basin catchment (i.e. Duivenvoorden and Roberts 1997; Duivenvoorden et al. 2000). The results of the study undertaken by Duivenvoorden et al. (2000) provide information about the potential impacts of weirs on macroinvertebrate assemblages in the Fitzroy Basin catchment, which will contribute towards assessing the impacts of a weir at Rookwood on these animals.

3.4.7 Macrophytes

Diversity

One hundred and five species of macrophytes have been previously recorded in the Fitzroy Basin catchment (Duivenvoorden 1992). At the time of survey (1989-1991), the most commonly recorded species were from the genera *Persicaria*, *Cyperus*, *Juncus* and *Potamogeton*. The diversity of macrophytes species recorded at each survey site at any one time was relatively low (average two – five species), however extreme climatic events (e.g. severe flooding followed by drought) were observed to notably impact temporal macrophyte species diversity (Duivenvoorden 1992). These results are consistent with localised studies in the Mackenzie and Dawson Rivers which recorded a maximum of 11 and 10 macrophyte species per site, respectively (Duivenvoorden 1997). The macrophytes species recorded from the Mackenzie River were predominately desiccation-resistant, emergent species located high on the bank (Duivenvoorden 1997). Common macrophyte genera recorded on the Dawson River included: *Azolla*, *Cyperus*, *Lomandra*, *Ludwigia*, *Muelenbeckia*, *Persicaria*, *Polygonum*, *Rumex* and *Spirodela* (Duivenvoorden 1995).

Macrophytes were generally in low abundance at sites assessed within the Rookwood Weir Project footprint. Of 18 sites in which aquatic habitat assessments were undertaken, macrophytes were recorded at only three. Submergent and floating aquatic vegetation was scarce, whilst emergent macrophytes occurred in shallow margins of some less disturbed pools (particularly along the shallow, narrow lower Dawson River).

While in-stream aquatic vegetation was generally scarce, semi-aquatic vegetation belonging to the genus *Lomandra* was ubiquitous in less disturbed riparian habitats. In some locations along the lower Dawson and Mackenzie Rivers, *Lomandra* dominated the groundcover above the waterline (Plate 3-14), often occurring under *Melaleucas* fringing and overhanging the stream. Due to the dynamic nature of flows in the river system, this streamside vegetation is likely to experience seasonal inundation. Where cattle had access to the riparian zone, *Lomandra* was less common or absent.



Plate 3-14 *Lomandra* spp. growing above the waterline under fringing *Melaleuca*

The generally low diversity and abundance of macrophytes in the Fitzroy Basin catchment has been related to factors including the highly variable climate (and its influence on the hydrology of the system), high turbidity levels and cattle grazing / degradation in marginal and riparian habitats (Nergus 2007). Fluctuating water levels in impoundments and turbidity were cited as potential explanations for an observed lack of submerged macrophytes upstream of weirs on the Dawson River (Duivenvoorden et al. 2000).

Weed and pest species

Salvinia (*Salvinia molesta*) is an exotic weed that can rapidly infest waterways and severely degrade aquatic ecosystems. It is a declared Weed of National Significance, and is listed as a Class 2 Declared Plant under the Queensland *Land Protection (Pest and Stock Route Management) Act 2002*. This species has been recorded downstream of Eden Bann Weir (within the Fitzroy Barrage) (Limpus et al. 2007), and is predicted to occur (by DEWHA Environmental Reporting Tool) upstream of Eden Bann Weir based on bioclimatic modelling.

The replacement of native aquatic vegetation by the exotic semi-aquatic grass *Hymenachne amplexicaulis* has markedly altered the ecology of waterways adjoining the Fitzroy River. Like salvinia, this species is a declared Weed of National Significance, and is listed as a Class 2 Declared Plant under the *Land Protection (Pest and Stock Route Management) Act 2002*. Where this highly invasive species has replaced native aquatic vegetation in quieter backwaters (e.g. creeks, off-stream water bodies etc.), macroinvertebrate assemblages were found to be different, with a decline in several orders (Houston and Duivenvoorden 2002).

Algae

Algae diversity is relatively low within the Fitzroy Basin catchment with a total of 52 species previously recorded (Noble et al. 1997). Within the Project footprint, filamentous algae was particularly prevalent in riffle and run habitats where clear, shallow water occurred (Plate 3-15).

Potentially toxic blue-green algae blooms are known to occur throughout the Fitzroy Basin catchment in response to high pH, high nutrients and low flows (Noble et al. 1997). Since, October 2007, only low levels of blue-green algae have been recorded from the existing Eden Bann Weir impoundment (frc environmental 2008; Volume 1, Chapter 11 Water quality).



Plate 3-15 Filamentous algae growing in a run downstream of a riffle on the Mackenzie River

4. Summary

Aquatic habitats within and downstream of the Rookwood Weir Project footprint were assessed through a combination of field surveys, literature reviews and aerial photograph interpretation. In-stream habitats are dominated by seasonally-dynamic recurring pool-riffle-run sequences. These sequences represent the natural hydrological and geomorphologic regime of the rivers in the study area. Through habitat assessments, variable water velocity, depth, bank characteristics, in-stream habitat features (i.e. woody debris, macrophytes) and stream substrate were observed within and between aquatic habitat types that comprise the pool-riffle-run sequences of the Project footprint. Seasonal variability markedly alters the characteristics and linear extent of these habitats – a natural regime to which the aquatic species of the Fitzroy Basin catchment are adapted.

A number of creeks and off-stream water bodies provide further aquatic habitat beyond the main channel of the lower Dawson, lower Mackenzie and Fitzroy Rivers. Creek habitats in the Project footprint were observed to provide a high abundance of microhabitat resources such as overhanging vegetation and in-stream woody debris. These resources provide habitat for an array of aquatic species, including small cryptic fish species, freshwater turtles and platypus. Off-stream water bodies have been identified as important reservoirs of fish biomass, nursery habitat for juvenile fish, and provide potential habitat for crocodiles and long-necked turtles.

Desktop and field surveys undertaken to inform this baseline assessment of the aquatic ecology within and downstream of the Rookwood Weir Project footprint revealed that 34 fish species, seven aquatic reptiles (six turtles, one crocodile), one aquatic mammal, 86 macroinvertebrate taxa and 105 macrophytes have the potential to occur within the Project footprint, based on previous records from the study area and the results of field surveys. Of particular note are conservation significant species which were confirmed present during field surveys, or are known / predicted to occur based on a review of relevant literature. These include:

- Fitzroy River turtle - known to occur within the Rookwood Weir Project footprint from a small number of deceased individuals. Predated egg shell identified as potential Fitzroy River turtle, has also been recorded from six locations throughout the Project footprint. Due to the availability of suitable habitat within the Project footprint and the confirmed distribution of the species both upstream and downstream, it is considered highly likely that this species does permanently inhabit the area. Important habitat for this species has been identified within the broader study area at Glenroy Crossing, Redbank Crossing, Marlborough Creek and Alligator Creek and upstream of Boolburra rail crossing
- Estuarine crocodile – known to occur in the study area. Thought to be uncommon upstream of Rookwood Weir but more abundant downstream within the Eden Bann Weir impoundment (Appendix J)
- Southern saratoga – known to occur in the study area and predicted to occur in the Project footprint due to availability of suitable habitat
- Leathery grunter - confirmed present in the Project footprint during field surveys and known to occur in the study area including within and downstream of the Rookwood Weir Project footprint
- Golden perch - confirmed present in the Project footprint during field surveys and known to occur in the study area including within and downstream of the Rookwood Weir Project footprint

- Platypus - known to occur in the study area and predicted to occur in the Project footprint due to availability of suitable habitat.

Overall the general characteristics of aquatic habitats within the Rookwood Weir Project footprint, and the aquatic species they support, appear to represent a continuum of habitats downstream to the Eden Bann Weir impoundment, and are not unique in the values and resources they provide in the context of the wider study area. Aquatic habitats (and the species they support) within and downstream of the Rookwood Weir Project footprint have been impacted and altered by human processes occurring at the local to catchment-wide scale. Such impacts include degradation of riparian habitats by livestock, changes to water quality (agriculture and mining) and disruption to natural flow regimes and connectivity of aquatic systems.

5. References

- Allen, GR, Midgley, SH and Allen, M 2003, '*Field Guide to the Freshwater Fishes of Australia*', Perth, Western Australian Museum.
- Australian Bureau of Meteorology (BoM) 2009, '*Latest Weather Observations for Rockhampton*', Australian Bureau of Meteorology, retrieved 21 August, 2009, from <<http://www.bom.gov.au/products/IDQ60801/IDQ60801.94374.shtml>>.
- Baran, E 2006, '*Fish migration triggers in the Lower Mekong Basin and other tropical freshwater systems*', MRC Technical Paper No. 14. Mekong River Commission.
- Berghuis, AP and Long, PE 1999, '*Freshwater fishes of the Fitzroy Catchment, Central Queensland*', *Proceedings of the Royal Society of Queensland*, vol. 108, pp. 13-25.
- Britton, A 2007a, '*Impact assessment of modified water infrastructure (Fitzroy Barrage) on the Fitzroy River saltwater crocodile – Potential implications and proposed mitigation measures for saltwater crocodiles (Crocodylus porosus)*', Commercial-in-confidence report prepared for the Department of Natural Resources and Water, Queensland.
- Britton, A 2007b, '*Proposal for raising Eden Bann Weir and construction of Rookwood Weir – An assessment of the potential implications and proposed mitigation measures for saltwater crocodiles (Crocodylus porosus)*', Commercial-in-confidence report prepared for the Department of Natural Resources and Water, Queensland.
- Broadfoot, CD, Berghuis AP, and Heidenreich, MJ 2000, *Assessment of the Kolan River barrage vertical-slot fishway*. Queensland Department of Primary Industries Report for the Department of Natural Resources State Water Projects.
- Cann, J 1998, '*Australian freshwater turtles*', Beaumont Publishing Pty Ltd, Singapore.
- Clark, NJ 2008, '*The diving physiological ecology of Australian freshwater turtle hatchlings*', PhD Thesis, University of Queensland, Brisbane.
- Clark, NJ, Gordos, MA and Franklin, CE 2008, '*Diving behaviour, aquatic respiration, and blood respiratory properties: a comparison of hatchling and juvenile Australian turtles*', *Journal of Zoology*, vol. 275, pp. 399–406.
- De Pauw, M, Roels, D and Fontoura, AP 1986, '*Use of artificial substrates for standardized sampling of macroinvertebrates in the assessment of water quality by the Belgian Biotic Index*', *Hydrobiologia*, vol. 133, pp. 237-258.
- Dean, JC and Suter, PJ 1996, '*Mayfly nymphs of Australia. A guide to genera. No. 7*', Albury: Cooperative Research Centre for Freshwater Ecology iii 82 pp.
- Department of Employment, Economic Development and Innovation (DEEDI) 2009, '*East Coast Inshore Fin Fish Fishery*', Department of Employment, Economic Development and Innovation', retrieved 11 September, 2009, from <http://www.dpi.qld.gov.au/cps/rde/dpi/hs.xsl/28_14415_ENA_HTML.htm>.
- Department of Environment and Resource Management (DERM) 2009, '*Estuarine Crocodile*', Department of Environment and Resource Management, retrieved 11 September, 2009, from <http://www.epa.qld.gov.au/nature_conservation/wildlife/living_with_wildlife/crocodiles/estuarine_crocodile.html>.

Department of Environment and Resource Management (DERM) 2008, '*Fitzroy NRM Region 'Back on Track' Biodiversity Action Plan*,' Department of Environment and Resource Management, Queensland.

Department of Natural Resources and Water (DNRW) 2006, '*Central Queensland Regional Water Supply Strategy*,' Rockhampton, Queensland Government.

Department of Natural Resources and Water (DNRW) 2008, '*Fitzroy Basin draft water resource plan information report*,' Department of Natural Resources and Water, Queensland.

Duivenvoorden, LJ, Hamilton, DR, Price, MD and Attard, TB 2000, '*Temporal Variation of Macroinvertebrate Communities of impounded and riverine sites in Central Queensland*', in RM Noble (ed.), *River Health in the Fitzroy Catchment: Community Ownership*, Department of Natural Resources, Rockhampton, Queensland.

Duivenvoorden, LJ and Roberts, DT 1997, '*Aquatic Invertebrates*', in RM Noble, Duivenvoorden, LJ, Rummenie, SK, Long, PE and Fabbro, LD, *Downstream Effects of Land Use in the Fitzroy Catchment*, Department of Natural Resources, Queensland.

Duivenvoorden, L 1995, '*Biological and ecological data (excluding fisheries) on the Dawson River system with particular reference to the proposed Nathan Dam*,' Report prepared for Centre for Land Water and Resource Development.

Duivenvoorden, LJ 1992, '*Aquatic macrophytes of the Fitzroy River Catchment*', in LJ Duivenvoorden, Yule, D, Fairweather, L and Lawrie, G (eds), *Proceedings of the Fitzroy Catchment Symposium*, University of Central Queensland, Rockhampton, Queensland.

Earth Tech 2007, '*Assessment of potential implications of modified water infrastructure on Fitzroy River fish passage and the Fishway*,' Report prepared for Fitzroy River Water.

Environmental Protection Agency (EPA) 2007, '*Draft Management program for Crocodylus porosus in Queensland 2007-2017*', Environmental Protection Agency, retrieved September, 2009, from <<http://www.epa.qld.gov.au/register/p02075aa.pdf>>.

Fish, FE, Frappell, PB, Baudinette, RV and Macfarlane, PM 2001, '*Energetics of terrestrial locomotion of the platypus Ornithorhynchus anatinus*', The Journal of Experimental Biology, vol. 204, pp. 797-803.

frc environmental 2008, '*Lower Fitzroy Weirs Literature Review and Gap Analysis*,' report prepared for SunWater.

frc environmental 2007, '*Modified Water Infrastructure EIS and Management Plan: Turtles (Rheodytes leukops and Elseya albagula)*,' report prepared for Fitzroy River Water.

frc environmental 2010a, Connors River Dam Fitzroy River Turtle Survey, August 2010, Wellington Point, pp 27

frc environmental 2010b, Nathan Dam Fitzroy River Turtle Distribution, Reproductive Condition and Nesting Survey, 2010, Wellington Point, pp 24

frc environmental 2012, Nathan Dam and Pipeline Project: Fitzroy River Turtle Survey September – October 2012, Wellington Point, pp 31

Gardner, JL and Serena, M 1995, '*Spatial organisation and movement patterns of adult male platypus, Ornithorhynchus anatinus (Monotremata: Ornithorhynchidae)*', Australian Journal of Zoology, vol. 43, pp. 91-103.

Gordos, MA, Hamann, M, Schauble, CS, Limpus, CJ, and Franklin, CE 2007, '*Diving behaviour of Elseya albagula from a naturally flowing and hydrologically altered habitat*', *Journal of Zoology*, vol. 272, pp. 458-469.

- Gordos, MA 2004, '*Diving physiological ecology of the bimodally respiring freshwater turtle, Rheodytes leukops*'. PhD Thesis, University of Queensland. Brisbane.
- Gordos, MA, Franklin, CE and Limpus, CJ 2003a, '*Seasonal changes in the diel surfacing behaviour of the bimodally respiring turtle Rheodytes leukops*'. Canadian Journal of Zoology, vol. 81, pp. 1614-1622.
- Gordos, MA, Franklin, CE and Limpus, CJ 2003b, '*Seasonal changes in the diving performance of the bimodally respiring freshwater turtle Rheodytes leukops in a natural setting*'. Canadian Journal of Zoology. vol. 81, pp. 617-625.
- Grant, TR and Temple-Smith, PD 1998, '*Field biology of the platypus (Ornithorhynchus anatinus): historical and current perspectives*', Philosophical Transactions of the Royal Society B: Biological Sciences, vol. 353, pp. 1081-1091.
- Hamann, M, Schauble, CS, Limpus, DJ, Emerick, SP, and Limpus, CJ 2007, '*Management plan for the conservation of Elseya sp. (Burnett River) in the Burnett River Catchment*', Queensland Environmental Protection Agency.
- Hawking, JH 2000, '*Key to Keys. A guide to keys and zoological information to identify invertebrates from Australian inland waters*', Identification Guide No. 2 2nd Edition, Cooperative Research Centre for Freshwater Ecology.
- Heindenreich, M and Broadfoot, C 2001, '*Migratory Fish Communities and Fish Passage options at Tartrus Weir, Mackenzie River*', Department of Primary Industries, Queensland.
- Hogan, A, Graham, P, and Vallance, T 1997, '*Redesign of the Clare Weir Fishway: Identification of fish movement*' in Proceedings of the Second National Fishway Technical Workshop, Rockhampton.
- Houston, WA and Duivenvoorden, LJ 2002, '*Replacement of littoral native vegetation with the ponded pasture grass Hymenachne amplexicalus: Effects on plant, macroinvertebrate and fish biodiversity in backwaters in the Fitzroy River, Central Queensland, Australia*', Marine and Freshwater Research, vol. 53, pp. 1235-1244.
- Johnston, N, Peck, G, Ford, P, Dougall, C and Carroll, C 2008, '*Fitzroy Basin Water Quality Improvement Report*', Fitzroy Basin Association Inc., December 2008.
- Kowarsky, J and Ross, AH 1981, '*Fish movement upstream through a central Queensland (Fitzroy River) coastal fishway*'. Australian Journal of Marine and Freshwater Research, 32, pp 93-109.
- Lake JS. 1967. '*Rearing experiments with five species of Australian freshwater fishes. I. Inducement to spawning*'. Australian Journal of Marine and Freshwater Research 18, pp 155–173.
- Langdon, SA and Collins, AL 2000, '*Quantification of the maximal swimming performance of Australasian glass eel, Anguilla australis and Anguilla reinhardtii, using hydraulic flume swimming chambers*'. New Zealand Journal of Marine and Freshwater Research, 34, pp. 629-636.
- Legler, JM and Georges, A 1993, '*Family Chelidae*' in CJ Glasby, Ross, GJB and Beesley, PL (eds) *Fauna of Australia vol 2A*, Australian Government Publishing Service, Canberra.
- Legler, JM and Cann, J 1980, '*A new genus and species of Chelid turtle from Queensland, Australia*', Contributions to the Science and Natural History Museum Los Angeles County, vol. 324, pp. 1-18.

- Legler, JM 1977, '*Stomach flushing: a technique for chelonian dietary studies*', *Herpetologica*, vol. 33, pp. 281-284.
- Limpus, DJ, Hodge, WJ and Limpus, CJ, 2006, '*Impacts of dams and weirs on freshwater turtle: Fairbairn Dam*', Queensland Environmental Protection Agency, Queensland.
- Limpus, CJ, Limpus, DJ, Parmenter, CJ, Hodge, J, Forrest, MJ, and McLachlan, J 2007, 'Proposal for raising Eden Bann Weir and construction of Rookwood Weir – an assessment of the potential implications and mitigation measures for Fitzroy Turtles,' Commercial-in-confidence report prepared for the Department of Infrastructure, Queensland.
- Limpus, CJ., Limpus, DJ., Hollier, C., Savige, M., McAllister, D. 2011, Survey of freshwater turtle populations and nesting habitat – Tartus Weir Turtle Population Project September – December 2011, Department of Environment and Heritage Protection, Queensland Government, pp 32
- Long, P and Meager, M 2000, '*The assessment of Eden Bann Weir fishlock, Fitzroy River, Queensland*', Department of Primary Industries, Queensland.
- Long, PE 2000, '*Fish communities in the Dawson River – Weir and Riverine Environments*' in RM Noble (ed.), *River Health in the Fitzroy Catchment: Community Ownership*, Department of Natural Resources, Rockhampton, Queensland.
- Mallen-Cooper, M 1992, *Swimming Ability of Juvenile Australian Bass, Macquaria novemaculeata (Steindachner) , and Juvenile Barramundi, Lates calcarifer (Bloch), in an Experimental Vertical-slot Fishway*, Australian Journal of Freshwater Research, 43, pp. 823-34.
- Mallen-Cooper, M 1994, *Swimming Ability of adult golden perch, Macquaria ambigua (Percichthyidae), and adult silver perch, Bidyanus bidyanus (Teraponidae) , in an experimental vertical-slot fishway*, Australian Journal of Freshwater Research, 45, pp. 191-198.
- Mallen-Cooper, M. and Edwards, E 1991, '*Fish passage through the main weir at Menindee lakes during the flood of September 1990*,' NSW Fisheries Research Institute Report.
- Marsden, T and Power, T 2007, '*Proposal for raising Eden Bann Weir and construction of Rookwood Weir – An assessment of the potential requirements for fish passage*', Commercial-in-confidence report prepared for the Department of Natural Resources and Water, Queensland.
- Mathie, NJ and Franklin, CE 2006, '*The influence of body size on the diving behaviour and physiology of the bimodally respiring turtle Elseya albagula*', *Journal of Comparative Physiology B*, vol. 176 pp. 739-747.
- Nergus, P 2007, '*National Action Plan for Salinity and Water Quality State-Level Investment Project Water Quality Information Summary for the Fitzroy Region*,' Report prepared for Department of Natural Resources and Water, Queensland.
- Noble, RM, Duivenvoorden, LJ, Rummenie, SK, Long, PE and Fabbro, LD 1997, '*Downstream Effects of Land Use in the Fitzroy Catchment*,' Department of Natural Resources, Queensland.
- O'Connor, J, O'Mahony, D, and O'Mahony, J 2003, *Downstream movements of adult Murray-Darling fish species*, Arthur Rylah Institute of Environmental Research, Heidelberg, Victoria. Project Report. Agriculture, Fisheries and Forestry Australia, Canberra.
- O'Connor, J. P., O'Mahony, D. J., and O'Mahony, J. M. 2005, *Movements of Macquaria ambigua, in the Murray River, south-eastern Australia*. *Journal of Fish Biology* 66, 392-403.
- Otley, HM, Munks, SA and Hindell, MA 2000, '*Activity patterns, movements and burrows of platypuses (Ornithorhynchus anatinus) in a sub-alpine Tasmanian lake*', *Australian Journal of Zoology*, vol. 48, pp. 701-713.

Priest, TE and Franklin, CE 2002, '*Effects of water temperature and oxygen levels on the diving behaviour of two freshwater turtles: Rheodytes leukops and Emydura macquarii*', Journal of Herpetology, vol. 36, pp. 55-561.

Priest, T 1997, '*Bimodal respiration and diving behaviour of the Fitzroy River turtle Rheodytes leukops*'. BSc Honours Thesis, University of Queensland, Brisbane.

Puckridge, JT and Walker, KF 1990, '*Reproductive biology and larval development of gizzard shad, Nematolosa erebi (Gunther) (Dorosomatinae: Teleostei), in the Murray River, South Australia*', Australian Journal of Marine and Freshwater Research, vol. 41, pp. 695-712.

Pusey, B, Kennard, M and Arthington, A 2004, '*Freshwater Fishes of North-Eastern Australia*', CSIRO Publishing, Collingwood.

Queensland Australian River Assessment System (AusRivAS) 2001, '*Sampling and Processing Manual*', Report Prepared for Queensland Department of Natural Resources and Mines, August 2001.

Renfree, M and Marsden, T 2006, '*Clare Weir Fishlock Monitoring, Post-construction Report*', Queensland Department of Primary Industries – Fisheries Service, Mackay.

Reynolds, LM 1983, '*Migration patterns of five fish species in the Murray-Darling River system*'. Australian Journal of Marine and Freshwater Research. vol 34, pp. 857- 871.

Roberts, D., Duivenvoorden, L., and Stuart, I. (2009). *Factors influencing recruitment patterns of golden perch (Macquaria ambigua orientalis) within a hydrologically variable and regulated Australian tropical river system*. Ecology of Freshwater Fish 17, 577-589.

Rogers, VM 2000, '*Dietary ecology including dietary resources partitioning of four species of chelid turtle in a tributary of the Fitzroy River, central Queensland*', BSc Honours Thesis, Central Queensland University, Rockhampton.

Serena, M, Thomas, JL, Williams, GA and Officer, RCE 1998, '*Use of stream and river habitats by the platypus, Ornithorhynchus anatinus, in an urban fringe environment*', Australian Journal of Zoology, vol. 46: pp. 267-282.

Sheaves, M, Johnston, R, Molony, B and Shepard, G. 2007, '*The effect of impoundments on the structure and function of fish fauna in a highly regulated dry tropics estuary*'. Estuaries and Coasts, vol 30, pp. 507-517.

Sinclair Knight Merz (SKM) 2010, '*Connors River Dam and Pipelines Environmental Impact Statement*', SunWater.

SKM 2007, Appendix E-6.0 FRC aquatic flora and fauna dry season field survey (December 2007), pp 86

SKM 2012, Nathan Dam and Pipelines Project EIS

Staunton-Smith, J, Robbins JB, Mayer, DG, Sellin, M.J and Halliday, IA 2004, '*Does the quantity and timing of fresh water flowing into a dry tropical estuary affect year-class strength of barramundi (Lates calcarifer)?*'. Marine and Freshwater Research, vol. 55, pp. 787.

Stuart, IG 1997, '*Assessment of a Modified Vertical-Slot Fishway, Fitzroy River, Queensland*'. Department of Primary Industries, Queensland. Project report QO97023.

Stuart, IG, and Berghuis, AP 1997, '*Assessment of Eden Bann Weir Fishlock Fitzroy River, Queensland*,. 'Project Report, Queensland Department of Primary Industries and Fisheries, Bundaberg.

- Stuart, IG and Mallen-Cooper, M 1999, '*An assessment of the effectiveness of a vertical-slot fishway for non-salmonid fish at a tidal barrier on a large tropical/subtropical river*', Regulated Rivers Research and Management, vol.15, pp. 575-590.
- Stuart, IG, Berghuis, AP, Long, PE and Mallen-Cooper, M 2007, '*Do fish locks have potential in tropical rivers?*', River Research and Applications, vol. 23, pp. 269-286.
- SunWater 2008a, '*Lower Fitzroy weirs discussion paper on fishway facilities for raised Eden Bann Weir*', SunWater.
- SunWater 2008b, '*Lower Fitzroy weirs discussion paper on turtle passage facilities for raised Eden Bann Weir and Rook wood*', SunWater.
- Thomson, S, Georges, A, and Limpus, CJ 2006, '*A new species of freshwater turtle in the Genus Elseya (Testudines: Chelidae) from Central Coastal Queensland, Australia*', Chelonian Conservation and Biology, vol. 5, pp. 74-86.
- Tucker, AD, Limpus, CJ, Priest, TE, Cay, J, Glen, C and Guarino, F 2001, '*Home ranges of Fitzroy River turtles (Rheodytes leukops) overlap riffle zones: potential concerns related to river regulation*'. Biological Conservation, vol 102, pp 171-181.
- Tucker, AD 2000, '*Cumulative effects of dams and weirs on freshwater turtles: Fitzroy, Kolan, Burnett and Mary Catchments.*' Report prepared for Queensland Department of Natural Resources.
- Van Dyck, S and Strahan, R 2008, '*The Mammals of Australia.*' 3rd edn, Reed New Holland, Sydney.
- Venz, M, Mathieson, M and Schulz, M 2002, '*Fauna of the Dawson River Floodplain – an assessment of fauna downstream of the proposed Nathan Dam*', Queensland Environmental Protection Agency.
- Wager, R 1997, '*Aquatic biota assessment.* Comet River proposal. Impact assessment study, proposed Starlee Dam site Rolleston, Central Queensland.
- Walsh, B and Whitehead, PJ 1993, '*Problem crocodiles (Crocodylus porosus) at Nhulunbuy, Northern Territory, Australia: An assessment of relocation as a management strategy*', Wildlife Research, vol. 20, pp. 127-135.
- Wilson, S 2005, '*A Field Guide to Reptiles of Queensland*,' Reed New Holland, Sydney.
- Wilson, S and Swan, G 2008, '*A Complete Guide to Reptiles of Australia*,' Reed New Holland, Sydney.

Appendices

Appendix A – Rookwood Weir aquatic fauna desktop results

DEWHA Environmental Reporting Tool

DERM Wildlife Online

Queensland Museum

I

Environmental Reporting Tool

You are here: [Environment Home](#) > [ERIN](#) > [ERT](#)

5 March 2009 10:34

Database Report

This report includes places of national environmental significance that are registered in the Department of the Environment and Water Resources' databases, for the selected area. The information presented here has been provided by a range of groups across Australia, and the accuracy and resolution varies.

Search Type: Line

Buffer: 2 km

Coordinates: -23.32223305,149.913523, -23.31015381,149.8880523, -
23.31792244,149.8820136, -23.3380793,149.9077018, -
23.33475288,149.9022926, -23.34468254,149.9161132, -
-23.3546122,149.9273322, -23.36022362,149.9277633, -
23.36540398,149.9187034, -23.40770325,149.9109328, -
-23.41331276,149.913092, -23.41417297,149.9208625, -
23.40899262,149.9351028, -23.40511307,149.9519332, -
-23.40640244,149.9618629, -23.41374382,149.9657424, -
-23.42582306,149.9605735, -23.43748268,149.9584144, -
-23.44395241,149.9605735, -23.45906242,150.0080436, -
-23.46036324,150.0261748, -23.46769318,150.0291923, -
-23.48582253,150.0084823, -23.49532303,149.964453, -
23.5061129,149.9584144, -23.51819405,149.9631637, -
23.51796142,149.9968427, -23.5409502,150.0152765



Report Contents: [Summary](#) >> [Details](#) >> [Caveat](#) >> [Acknowledgment](#)

Biodiversity

Threatened Species:	16
Migratory Species:	16
Listed Marine Species:	15
Invasive Species:	9
Whales and Other Cetaceans:	None
Threatened Ecological Communities:	2

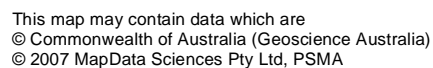
Heritage

World Heritage Properties:	None
Australian Heritage Sites:	None

Wetlands

Ramsar sites: (Internationally important)	1
Nationally Important Wetlands:	None

National Pollutant Inventory



Protected Areas

Threatened Species [[Dataset Information](#)]

Birds

Mammals

[Dasyurus hallucatus](#)

Northern Quoll

Endangered Species or species habitat may occur within area

[Nyctophilus timoriensis \(South-eastern form\)](#)

Eastern Long-eared Bat

Vulnerable Species or species habitat may occur within area

Reptiles[Denisonia maculata](#)

Ornamental Snake

Vulnerable Species or species habitat likely to occur within area

[Egernia rugosa](#)

Yakka Skink

Vulnerable Species or species habitat likely to occur within area

[Furina dunmalli](#)

Dunmall's Snake

Vulnerable Species or species habitat may occur within area

[Paradelma orientalis](#)

Brigalow Scaly-foot

Vulnerable Species or species habitat likely to occur within area

[Rheodytes leukops](#)

Fitzroy River Turtle, Fitzroy Tortoise, Fitzroy Turtle

Vulnerable Species or species habitat may occur within area

Plants[Cycas megacarpa](#)

Endangered Species or species habitat likely to occur within area

[Dichanthium queenslandicum](#)

King Blue-grass

Vulnerable Species or species habitat likely to occur within area

[Digitaria porrecta](#)

Finger Panic Grass

Endangered Species or species habitat likely to occur within area

[Eucalyptus raveretiana](#)

Black Ironbox

Vulnerable Species or species habitat likely to occur within area

Migratory Species [[Dataset Information](#)]

Status Comments

Migratory Terrestrial Species**Birds**[Haliaeetus leucogaster](#)

White-bellied Sea-Eagle

Migratory Species or species habitat likely to occur within area

[Hirundapus caudacutus](#)

White-throated Needletail

Migratory Species or species habitat may occur within area

[Hirundo rustica](#)

Barn Swallow

Migratory Species or species habitat may occur within area

[Merops ornatus](#)

Rainbow Bee-eater

Migratory Species or species habitat may occur within area

[Monarcha melanopsis](#)

Black-faced Monarch

Migratory Species or species habitat may occur within area

[Myiagra cyanoleuca](#)

Satin Flycatcher

Migratory Species or species habitat likely to occur within area

Migratory Wetland Species**Birds**[Ardea alba](#)

Great Egret, White Egret

Migratory Species or species habitat may occur within area

[Ardea ibis](#)

Cattle Egret

Migratory Species or species habitat may occur within area

<i>Gallinago hardwickii</i> Latham's Snipe, Japanese Snipe	Migratory	Species or species habitat may occur within area
<i>Nettapus coromandelianus albigennis</i> Australian Cotton Pygmy-goose	Migratory	Species or species habitat may occur within area
<i>Numenius minutus</i> Little Curlew, Little Whimbrel	Migratory	Species or species habitat may occur within area
<i>Rostratula benghalensis s. lat.</i> Painted Snipe	Migratory	Species or species habitat may occur within area
Migratory Marine Birds		
<i>Apus pacificus</i> Fork-tailed Swift	Migratory	Species or species habitat may occur within area
<i>Ardea alba</i> Great Egret, White Egret	Migratory	Species or species habitat may occur within area
<i>Ardea ibis</i> Cattle Egret	Migratory	Species or species habitat may occur within area
Migratory Marine Species		
Reptiles		
<i>Crocodylus porosus</i> Estuarine Crocodile, Salt-water Crocodile	Migratory	Species or species habitat likely to occur within area
Listed Marine Species [Dataset Information]	Status	Comments
Birds		
<i>Anseranas semipalmata</i> Magpie Goose	Listed - overfly marine area	Species or species habitat may occur within area
<i>Apus pacificus</i> Fork-tailed Swift	Listed - overfly marine area	Species or species habitat may occur within area
<i>Ardea alba</i> Great Egret, White Egret	Listed - overfly marine area	Species or species habitat may occur within area
<i>Ardea ibis</i> Cattle Egret	Listed - overfly marine area	Species or species habitat may occur within area
<i>Gallinago hardwickii</i> Latham's Snipe, Japanese Snipe	Listed - overfly marine area	Species or species habitat may occur within area
<i>Haliaeetus leucogaster</i> White-bellied Sea-Eagle	Listed	Species or species habitat likely to occur within area
<i>Hirundapus caudacutus</i> White-throated Needletail	Listed - overfly marine area	Species or species habitat may occur within area
<i>Hirundo rustica</i> Barn Swallow	Listed - overfly marine area	Species or species habitat may occur within area
<i>Merops ornatus</i> Rainbow Bee-eater	Listed - overfly marine area	Species or species habitat may occur within area
<i>Monarcha melanopsis</i>	Listed -	Species or species habitat may

Black-faced Monarch	overfly marine area	occur within area
Myiagra cyanoleuca Satin Flycatcher	Listed - overfly marine area	Species or species habitat likely to occur within area
Nettapus coromandelianus albigenis Australian Cotton Pygmy-goose	Listed - overfly marine area	Species or species habitat may occur within area
Numenius minutus Little Curlew, Little Whimbrel	Listed - overfly marine area	Species or species habitat may occur within area
Rostratula benghalensis s. lat. Painted Snipe	Listed - overfly marine area	Species or species habitat may occur within area

Reptiles

Crocodylus porosus Estuarine Crocodile, Salt-water Crocodile	Listed	Species or species habitat likely to occur within area
---	--------	---

Invasive Species [[Dataset Information](#)]

Status Comments

Selected Invasive Species: 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 Resources Audit, 2001.

Mammals

Capra hircus Goat	Feral	Species or species habitat may occur within area
Felis catus Cat, House Cat, Domestic Cat	Feral	Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit	Feral	Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox	Feral	Species or species habitat likely to occur within area

Plants

Alternanthera philoxeroides Alligator Weed	WoNS	Species or species habitat may occur within area
Cryptostegia grandiflora Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda	WoNS	Species or species habitat likely to occur within area
Hymenachne amplexicaulis Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass	WoNS	Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage,	WoNS	Species or species habitat likely to occur within area

White Sage, Wild Sage

[Parthenium hysterophorus](#)

Parthenium Weed, Bitter Weed, Carrot Grass,
False Ragweed

WoNS

Species or species habitat likely to
occur within area

Threatened Ecological Communities [[Dataset Information](#)]

Status

Comments

[Brigalow \(Acacia harpophylla dominant and co-dominant\)](#)

Endangered

Community known to occur within
area

[Weeping Myall Woodlands](#)

Endangered

Community likely to occur within
area

Wetlands

Wetlands of International Importance (Ramsar sites) [[Dataset Information](#)]

[SHOALWATER AND CORIO BAYS AREA](#)

Within same catchment as Ramsar
site

Caveat

The information presented here has been drawn from a range of sources, compiled for a variety of purposes. Details of the coverage of each dataset are included in the metadata [Dataset Information] links above.

Acknowledgment

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

- | [New South Wales National Parks and Wildlife Service](#)
- | [Department of Sustainability and Environment, Victoria](#)
- | [Department of Primary Industries, Water and Environment, Tasmania](#)
- | [Department of Environment and Heritage, South Australia Planning SA](#)
- | [Parks and Wildlife Commission of the Northern Territory](#)
- | [Environmental Protection Agency, Queensland](#)
- | [Birds Australia](#)
- | [Australian Bird and Bat Banding Scheme](#)
- | [Australian National Wildlife Collection](#)
- | Natural history museums of Australia
- | [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](#)
- | Other groups and individuals

[ANUcliM Version 1.8, Centre for Resource and Environmental Studies, Australian National University](#) was used extensively for the production of draft maps of species distribution. The Department is extremely grateful to the many organisations and individuals who provided expert

Environmental Reporting Tool

You are here: [Environment Home](#) > [ERIN](#) > [ERT](#)

5 March 2009 10:38

Database Report

This report includes places of national environmental significance that are registered in the Department of the Environment and Water Resources' databases, for the selected area. The information presented here has been provided by a range of groups across Australia, and the accuracy and resolution varies.

Search Type: Line

Buffer: 2 km

Coordinates: -23.6273732,149.7678944, -23.62837571,149.7591491, -
23.62343391,149.7510627, -23.58662399,149.7465728,
-23.546213,149.7286132, -23.5358828,149.7299636, -
23.52914223,149.7250236, -23.526903,149.7137931, -
23.53229317,149.7088531, -23.53678307,149.7003234,
-23.52959236,149.6917937, -23.53498253,149.6720336,
-23.5345324,149.6581252, -23.53024013,149.6561875, -
23.52679987,149.6595427, -23.51884219,149.6632959,
-23.50523586,149.6544628, -23.50252951,149.6412031,
-23.51176707,149.6284255, -23.51166942,149.620842



Report Contents: [Summary](#) >> [Details](#) >> [Caveat](#) >> [Acknowledgment](#)

Biodiversity

Threatened Species:	16
Migratory Species:	15
Listed Marine Species:	14
Invasive Species:	11
Whales and Other Cetaceans:	None
Threatened Ecological Communities:	3

Heritage

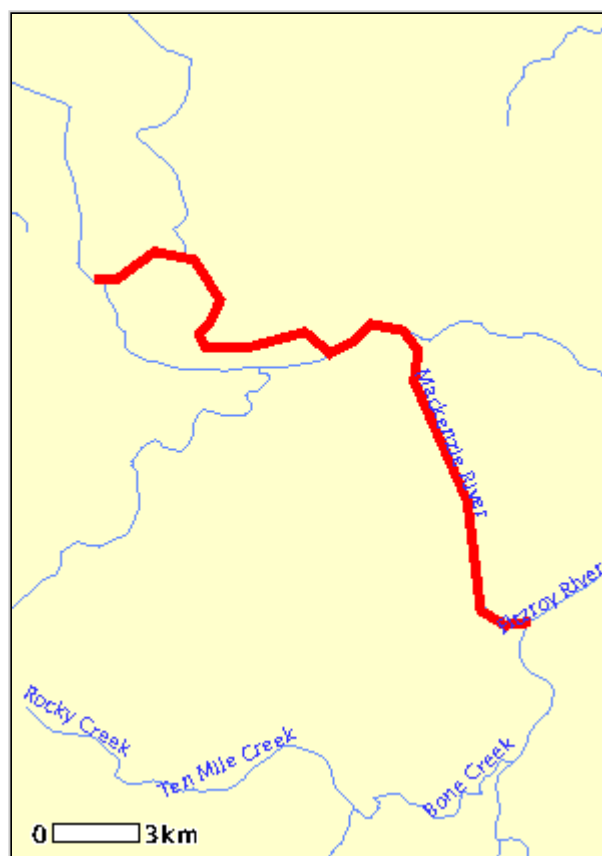
World Heritage Properties:	None
Australian Heritage Sites:	None

Wetlands

Ramsar sites: (Internationally important)	1
Nationally Important Wetlands:	None

National Pollutant Inventory

Reporting Facilities:	None
Airsheds:	None
Catchments:	1



Protected Areas

Reserves and Conservation Areas None

Regional Forest Agreements: None

This map may contain data which are
 © Commonwealth of Australia (Geoscience Australia)
 © 2007 MapData Sciences Pty Ltd, PSMA

Biodiversity

Threatened Species [[Dataset Information](#)]

Status

Comments

Birds[Erythrotriorchis radiatus](#)

Red Goshawk

Vulnerable

Species or species habitat likely to occur within area

[Geophaps scripta scripta](#)

Squatter Pigeon (southern)

Vulnerable

Species or species habitat likely to occur within area

[Neochmia ruficauda ruficauda](#)

Star Finch (eastern), Star Finch (southern)

Endangered

Species or species habitat likely to occur within area

[Rostratula australis](#)

Australian Painted Snipe

Vulnerable

Species or species habitat may occur within area

Mammals[Chalinolobus dwyeri](#)

Large-eared Pied Bat, Large Pied Bat

Vulnerable

Species or species habitat may occur within area

[Dasyurus hallucatus](#)

Northern Quoll

Endangered

Species or species habitat may occur within area

[Nyctophilus timoriensis \(South-eastern form\)](#)

Eastern Long-eared Bat

Vulnerable

Species or species habitat may occur within area

Reptiles[Denisonia maculata](#)

Ornamental Snake

Vulnerable

Species or species habitat likely to occur within area

[Egernia rugosa](#)

Yakka Skink

Vulnerable

Species or species habitat likely to occur within area

[Furina dunmali](#)

Dunmall's Snake

Vulnerable

Species or species habitat may occur within area

[Paradelma orientalis](#)

Brigalow Scaly-foot

Vulnerable

Species or species habitat likely to occur within area

[Rheodytes leukops](#)

Fitzroy River Turtle, Fitzroy Tortoise, Fitzroy Turtle

Vulnerable

Species or species habitat may occur within area

Plants[Cadellia pentastylis](#)

Ooline

Vulnerable

Species or species habitat likely to occur within area

[Dichanthium queenslandicum](#)

King Blue-grass

Vulnerable

Species or species habitat likely to occur within area

[Digitaria porrecta](#)

Finger Panic Grass

Endangered

Species or species habitat likely to occur within area

[Eucalyptus raveretiana](#)

Black Ironbox

Vulnerable

Species or species habitat likely to occur within area

Migratory Species [[Dataset Information](#)]

Status

Comments

Migratory Terrestrial Species

Birds

<i>Haliaeetus leucogaster</i> White-bellied Sea-Eagle	Migratory	Species or species habitat likely to occur within area
<i>Hirundapus caudacutus</i> White-throated Needletail	Migratory	Species or species habitat may occur within area
<i>Merops ornatus</i> Rainbow Bee-eater	Migratory	Species or species habitat may occur within area
<i>Monarcha melanopsis</i> Black-faced Monarch	Migratory	Species or species habitat may occur within area
<i>Myiagra cyanoleuca</i> Satin Flycatcher	Migratory	Species or species habitat likely to occur within area

Migratory Wetland Species**Birds**

<i>Ardea alba</i> Great Egret, White Egret	Migratory	Species or species habitat may occur within area
<i>Ardea ibis</i> Cattle Egret	Migratory	Species or species habitat may occur within area
<i>Gallinago hardwickii</i> Latham's Snipe, Japanese Snipe	Migratory	Species or species habitat may occur within area
<i>Nettapus coromandelianus albipennis</i> Australian Cotton Pygmy-goose	Migratory	Species or species habitat may occur within area
<i>Numenius minutus</i> Little Curlew, Little Whimbrel	Migratory	Species or species habitat may occur within area
<i>Rostratula benghalensis s. lat.</i> Painted Snipe	Migratory	Species or species habitat may occur within area

Migratory Marine Birds

<i>Apus pacificus</i> Fork-tailed Swift	Migratory	Species or species habitat may occur within area
<i>Ardea alba</i> Great Egret, White Egret	Migratory	Species or species habitat may occur within area
<i>Ardea ibis</i> Cattle Egret	Migratory	Species or species habitat may occur within area

Migratory Marine Species**Reptiles**

<i>Crocodylus porosus</i> Estuarine Crocodile, Salt-water Crocodile	Migratory	Species or species habitat likely to occur within area
Listed Marine Species [Dataset Information]	Status	Comments

Birds

<i>Anseranas semipalmata</i> Magpie Goose	Listed - overfly marine area	Species or species habitat may occur within area
<i>Apus pacificus</i> Fork-tailed Swift	Listed - overfly marine area	Species or species habitat may occur within area
<i>Ardea alba</i> Great Egret, White Egret	Listed - overfly	Species or species habitat may occur within area

	marine area	
<i>Ardea ibis</i> Cattle Egret	Listed - overfly marine area	Species or species habitat may occur within area
<i>Gallinago hardwickii</i> Latham's Snipe, Japanese Snipe	Listed - overfly marine area	Species or species habitat may occur within area
<i>Haliaeetus leucogaster</i> White-bellied Sea-Eagle	Listed	Species or species habitat likely to occur within area
<i>Hirundapus caudacutus</i> White-throated Needletail	Listed - overfly marine area	Species or species habitat may occur within area
<i>Merops ornatus</i> Rainbow Bee-eater	Listed - overfly marine area	Species or species habitat may occur within area
<i>Monarcha melanopsis</i> Black-faced Monarch	Listed - overfly marine area	Species or species habitat may occur within area
<i>Myiagra cyanoleuca</i> Satin Flycatcher	Listed - overfly marine area	Species or species habitat likely to occur within area
<i>Nettapus coromandelianus albigularis</i> Australian Cotton Pygmy-goose	Listed - overfly marine area	Species or species habitat may occur within area
<i>Numenius minutus</i> Little Curlew, Little Whimbrel	Listed - overfly marine area	Species or species habitat may occur within area
<i>Rostratula benghalensis s. lat.</i> Painted Snipe	Listed - overfly marine area	Species or species habitat may occur within area

Reptiles

<i>Crocodylus porosus</i> Estuarine Crocodile, Salt-water Crocodile	Listed	Species or species habitat likely to occur within area
Invasive Species [Dataset Information]	Status	Comments

Selected Invasive Species: 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 Resources Audit, 2001.

Mammals

<i>Capra hircus</i> Goat	Feral	Species or species habitat may occur within area
<i>Felis catus</i> Cat, House Cat, Domestic Cat	Feral	Species or species habitat likely to occur within area
<i>Oryctolagus cuniculus</i> Rabbit, European Rabbit	Feral	Species or species habitat likely to occur within area

<i>Sus scrofa</i> Pig	Feral	Species or species habitat likely to occur within area
<i>Vulpes vulpes</i> Red Fox, Fox	Feral	Species or species habitat likely to occur within area

Plants

<i>Acacia nilotica</i> subsp. <i>indica</i> Prickly Acacia	WoNS	Species or species habitat may occur within area
<i>Alternanthera philoxeroides</i> Alligator Weed	WoNS	Species or species habitat may occur within area
<i>Hymenachne amplexicaulis</i> Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass	WoNS	Species or species habitat may occur within area
<i>Lantana camara</i> Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage	WoNS	Species or species habitat may occur within area
<i>Parkinsonia aculeata</i> Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean	WoNS	Species or species habitat may occur within area
<i>Parthenium hysterophorus</i> Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed	WoNS	Species or species habitat likely to occur within area
Threatened Ecological Communities [Dataset Information]	Status	Comments
Brigalow (<i>Acacia harpophylla</i> dominant and co-dominant)	Endangered	Community known to occur within area
Natural Grasslands of the Queensland Central Highlands and the northern Fitzroy Basin	Endangered	Community may occur within area
Weeping Myall Woodlands Wetlands	Endangered	Community may occur within area
Wetlands of International Importance (Ramsar sites) [Dataset Information]		
SHOALWATER AND CORIO BAYS AREA		Within same catchment as Ramsar site

National Pollutant Inventory

Catchment [Dataset Information]	Substances	Sources
Dawson River, QLD	2	12

Caveat

The information presented here has been drawn from a range of sources, compiled for a variety of purposes. Details of the coverage of each dataset are included in the metadata [Dataset Information] links above.

Acknowledgment

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

- | [New South Wales National Parks and Wildlife Service](#)

- | [Department of Sustainability and Environment, Victoria](#)
- | [Department of Primary Industries, Water and Environment, Tasmania](#)
- | [Department of Environment and Heritage, South Australia Planning SA](#)
- | [Parks and Wildlife Commission of the Northern Territory](#)
- | [Environmental Protection Agency, Queensland](#)
- | [Birds Australia](#)
- | [Australian Bird and Bat Banding Scheme](#)
- | [Australian National Wildlife Collection](#)
- | Natural history museums of Australia
- | [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](#)
- | Other groups and individuals

[ANUCLiM Version 1.8, Centre for Resource and Environmental Studies, Australian National University](#) was used extensively for the production of draft maps of species distribution. The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Environmental Reporting Tool

You are here: [Environment Home](#) > [ERIN](#) > [ERT](#)

5 March 2009 10:40

Database Report

This report includes places of national environmental significance that are registered in the Department of the Environment and Water Resources' databases, for the selected area. The information presented here has been provided by a range of groups across Australia, and the accuracy and resolution varies.

Search Type: Line

Buffer: 2 km

Coordinates: -23.6273732,149.7678944, -23.63650245,149.7639511, -23.64388616,149.7669273, -23.64672145,149.7729704, -23.65262398,149.7762054, -23.6728228,149.7640823, -23.6800135,149.7568954, -23.6862925,149.7577956, -23.69331975,149.7587289, -23.69617256,149.7564529, -23.70021233,149.7568954, -23.70021233,149.7640823, -23.70470223,149.7667754, -23.7114428,149.7649825, -23.71503243,149.7753051, -23.71538047,149.7819188, -23.72848503,149.7838949, -23.74288308,149.7606833, -23.80151098,149.7609415



Report Contents: [Summary](#) >> [Details](#) >> [Caveat](#) >> [Acknowledgment](#)

Biodiversity

Threatened Species:	12
Migratory Species:	15
Listed Marine Species:	14
Invasive Species:	12
Whales and Other Cetaceans:	None
Threatened Ecological Communities:	

Heritage

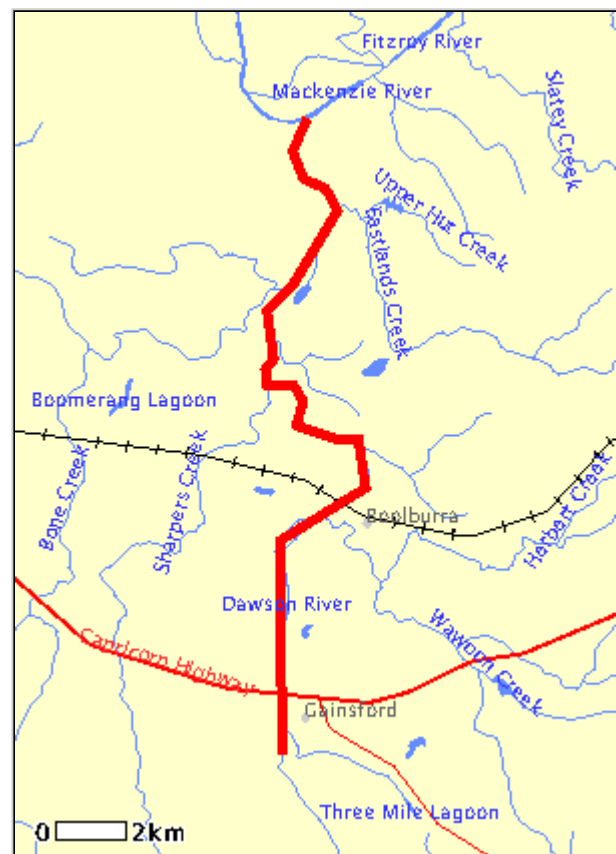
World Heritage Properties:	None
Australian Heritage Sites:	None

Wetlands

Ramsar sites: (Internationally important)	1
Nationally Important Wetlands:	None

National Pollutant Inventory

Reporting Facilities:	None
Airsheds:	None
Catchments:	1



Protected Areas

Reserves and Conservation AreasNone

Regional Forest Agreements: None

This map may contain data which are
 © Commonwealth of Australia (Geoscience Australia)
 © 2007 MapData Sciences Pty Ltd, PSMA

Biodiversity

Threatened Species [[Dataset Information](#)]

Status

Comments

Birds[Erythrotriorchis radiatus](#)

Red Goshawk

Vulnerable

Species or species habitat likely to occur within area

[Geophaps scripta scripta](#)

Squatter Pigeon (southern)

Vulnerable

Species or species habitat likely to occur within area

[Neochmia ruficauda ruficauda](#)

Star Finch (eastern), Star Finch (southern)

Endangered

Species or species habitat likely to occur within area

[Rostratula australis](#)

Australian Painted Snipe

Vulnerable

Species or species habitat may occur within area

Mammals[Chalinolobus dwyeri](#)

Large-eared Pied Bat, Large Pied Bat

Vulnerable

Species or species habitat may occur within area

[Dasyurus hallucatus](#)

Northern Quoll

Endangered

Species or species habitat may occur within area

[Nyctophilus timoriensis \(South-eastern form\)](#)

Eastern Long-eared Bat

Vulnerable

Species or species habitat may occur within area

Reptiles[Denisonia maculata](#)

Ornamental Snake

Vulnerable

Species or species habitat likely to occur within area

[Egernia rugosa](#)

Yakka Skink

Vulnerable

Species or species habitat likely to occur within area

[Furina dunmalli](#)

Dunmall's Snake

Vulnerable

Species or species habitat may occur within area

[Paradelma orientalis](#)

Brigalow Scaly-foot

Vulnerable

Species or species habitat likely to occur within area

[Rheodytes leukops](#)

Fitzroy River Turtle, Fitzroy Tortoise, Fitzroy Turtle

Vulnerable

Species or species habitat may occur within area

Migratory Species [[Dataset Information](#)]

Status

Comments

Migratory Terrestrial Species**Birds**[Haliaeetus leucogaster](#)

White-bellied Sea-Eagle

Migratory

Species or species habitat likely to occur within area

[Hirundapus caudacutus](#)

White-throated Needletail

Migratory

Species or species habitat may occur within area

[Merops ornatus](#)

Rainbow Bee-eater

Migratory

Species or species habitat may occur within area

[Monarcha melanopsis](#)

Black-faced Monarch

Migratory

Species or species habitat may occur within area

[*Myiagra cyanoleuca*](#)

Satin Flycatcher

Migratory

Species or species habitat likely to occur within area

Migratory Wetland Species**Birds**[*Ardea alba*](#)

Great Egret, White Egret

Migratory

Breeding likely to occur within area

[*Ardea ibis*](#)

Cattle Egret

Migratory

Species or species habitat may occur within area

[*Gallinago hardwickii*](#)

Latham's Snipe, Japanese Snipe

Migratory

Species or species habitat may occur within area

[*Nettapus coromandelianus albigenis*](#)

Australian Cotton Pygmy-goose

Migratory

Species or species habitat may occur within area

[*Numenius minutus*](#)

Little Curlew, Little Whimbrel

Migratory

Species or species habitat may occur within area

[*Rostratula benghalensis s. lat.*](#)

Painted Snipe

Migratory

Species or species habitat may occur within area

Migratory Marine Birds[*Apus pacificus*](#)

Fork-tailed Swift

Migratory

Species or species habitat may occur within area

[*Ardea alba*](#)

Great Egret, White Egret

Migratory

Breeding likely to occur within area

[*Ardea ibis*](#)

Cattle Egret

Migratory

Species or species habitat may occur within area

Migratory Marine Species**Reptiles**[*Crocodylus porosus*](#)

Estuarine Crocodile, Salt-water Crocodile

Migratory

Species or species habitat likely to occur within area

Listed Marine Species [[Dataset Information](#)]

Status

Comments

Birds[*Anseranas semipalmata*](#)

Magpie Goose

Listed -
overfly
marine area

Species or species habitat may occur within area

[*Apus pacificus*](#)

Fork-tailed Swift

Listed -
overfly
marine area

Species or species habitat may occur within area

[*Ardea alba*](#)

Great Egret, White Egret

Listed -
overfly
marine area

Breeding likely to occur within area

[*Ardea ibis*](#)

Cattle Egret

Listed -
overfly
marine area

Species or species habitat may occur within area

[*Gallinago hardwickii*](#)

Latham's Snipe, Japanese Snipe

Listed -
overfly
marine area

Species or species habitat may occur within area

[*Haliaeetus leucogaster*](#)

White-bellied Sea-Eagle

Listed

Species or species habitat likely to occur within area

[*Hirundapus caudacutus*](#)

Listed -

Species or species habitat may

White-throated Needletail	overfly marine area	occur within area
Merops ornatus Rainbow Bee-eater	Listed - overfly marine area	Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch	Listed - overfly marine area	Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher	Listed - overfly marine area	Species or species habitat likely to occur within area
Nettapus coromandelianus albigenis Australian Cotton Pygmy-goose	Listed - overfly marine area	Species or species habitat may occur within area
Numenius minutus Little Curlew, Little Whimbrel	Listed - overfly marine area	Species or species habitat may occur within area
Rostratula benghalensis s. lat. Painted Snipe	Listed - overfly marine area	Species or species habitat may occur within area

Reptiles

Crocodylus porosus Estuarine Crocodile, Salt-water Crocodile	Listed	Species or species habitat likely to occur within area
Invasive Species [Dataset Information]	Status	Comments

Selected Invasive Species: 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 Resources Audit, 2001.

Mammals

Capra hircus Goat	Feral	Species or species habitat may occur within area
Felis catus Cat, House Cat, Domestic Cat	Feral	Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit	Feral	Species or species habitat likely to occur within area
Sus scrofa Pig	Feral	Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox	Feral	Species or species habitat likely to occur within area

Plants

Acacia nilotica subsp. indica Prickly Acacia	WoNS	Species or species habitat may occur within area
Alternanthera philoxeroides Alligator Weed	WoNS	Species or species habitat may occur within area
Cryptostegia grandiflora	WoNS	Species or species habitat may

Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda		occur within area
Hymenachne amplexicaulis Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass	WoNS	Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage	WoNS	Species or species habitat may occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean	WoNS	Species or species habitat may occur within area
Parthenium hysterophorus Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed	WoNS	Species or species habitat likely to occur within area
Threatened Ecological Communities [Dataset Information]	Status	Comments
Brigalow (Acacia harpophylla dominant and co-dominant)	Endangered	Community known to occur within area
Natural Grasslands of the Queensland Central Highlands and the northern Fitzroy Basin	Endangered	Community may occur within area
Weeping Myall Woodlands Wetlands	Endangered	Community may occur within area
Wetlands of International Importance (Ramsar sites) [Dataset Information]		
SHOALWATER AND CORIO BAYS AREA		Within same catchment as Ramsar site
National Pollutant Inventory		
Catchment [Dataset Information]	Substances	Sources
Dawson River, QLD	2	12

Caveat

The information presented here has been drawn from a range of sources, compiled for a variety of purposes. Details of the coverage of each dataset are included in the metadata [Dataset Information] links above.

Acknowledgment

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

- | [New South Wales National Parks and Wildlife Service](#)
- | [Department of Sustainability and Environment, Victoria](#)
- | [Department of Primary Industries, Water and Environment, Tasmania](#)
- | [Department of Environment and Heritage, South Australia Planning SA](#)
- | [Parks and Wildlife Commission of the Northern Territory](#)
- | [Environmental Protection Agency, Queensland](#)
- | [Birds Australia](#)

- | [Australian Bird and Bat Banding Scheme](#)
- | [Australian National Wildlife Collection](#)
- | Natural history museums of Australia
- | [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](#)
- | Other groups and individuals

[ANUCLiM Version 1.8, Centre for Resource and Environmental Studies, Australian National University](#) was used extensively for the production of draft maps of species distribution. The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

DERM Wildlife Online Database

Scientific name	Common name	NC Act status	EPBC Act status
Mammals			
<i>Ornithorhynchus anatinus</i>	platypus	*	
Reptiles			
<i>Elseya albagula</i>	southern snapping turtle	#	
<i>Emydura macquarii krefftii</i>	Krefft's river turtle		
<i>Macrochelodina expansa</i>	broad-shelled river turtle		
<i>Rheodytes leukops</i>	Fitzroy River turtle	V	V
Fish			
<i>Anguilla reinhardtii</i>	longfin eel		
<i>Arius graeffei</i>	blue catfish		
<i>Craterocephalus stercusmuscarum</i>	flyspecked hardyhead		
<i>Glossamia aprion</i>	mouth almighty		
<i>Melanotaenia splendida splendida</i>	eastern rainbowfish		
<i>Nematalosa erebi</i>	bony bream		
<i>Neosilurus hyrtlui</i>	Hyrtl's catfish		
<i>Scortum hillii</i>	leathery grunter		

*'Special Least Concern' common wildlife under the NC Act

#Has been recommended for listing as 'Endangered' under NC Act

Queensland Museum Database

Scientific name	Common name	NC Act status	EPBC Act status
Reptiles			
<i>Rheodytes leukops</i>	Fitzroy River turtle	V	V
Fish			
<i>Scortum hillii</i>	leathery grunter		

GHD

145 Ann Street Brisbane QLD 4000

GPO Box 668 Brisbane QLD 4001




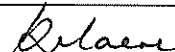
T: (07) 3316 3000 F: (07) 3316 3333 E: bnemail@ghd.com

© GHD 2014

This document is and shall remain the property of GHD. The document may only be used for the purpose for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

G:\41\20736\WP\448699.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	N Clark J Simmonds	G Squires		L Delaere	On file	01/08/2014
1	-	G Squires		L Delaere	On file	19/08/2014
2	-	G Squires		L Delaere		05/06/2015

www.ghd.com

