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Aquatic ecology assessment report

Santos GLNG Gas Field Development Project

AUGUST 2014

Prepared for

Santos GLNG

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42627287

URS

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Abbreviations

Abbreviation	Description
AquaBAMM	Aquatic Biodiversity Assessment and Mapping Method
ATP	Authority to prospect
AusRivAS	Australian River Assessment System
DOTE	Department of the Environment, Commonwealth Government
EHP	Department of Environment and Heritage Protection, Queensland Government
EIS	Environmental Impact Statement
EP Act	*Environmental Protection Act 1994* (Qld)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
EPP Water	*Environmental Protection (Water) Policy 2009* (Qld)
Fisheries Act	*Fisheries Act 1994* (Qld)
GFD Project	Gas Field Development Project
GLNG Project	Gladstone Liquefied Natural Gas Project
IDAS	Integrated Development Assessment System
LNG	Liquefied Natural Gas
MNES	Matters of National Environmental Significance
NC Act	*Nature Conservation Act 1992* (Qld)
OGIA	Office of Groundwater Impact Assessment
PET	Plectoptera, Ephemeroptera, and Tricoptera
PL	Petroleum lease
SIGNAL	Stream Invertebrate Grade Number — Average Level
SPP	State Planning Policy
ToR	Terms of Reference
UWIR	Underground Water Impact Report

Executive Summary

URS Australia Pty Ltd (URS) was engaged by Santos GLNG to complete an assessment of the potential impacts of the proposed Gas Field Development Project (the GFD Project) on aquatic ecology environmental values.

The GFD Project is located in central and southern Queensland and will involve the progressive development of production wells and associated facilities across Santos GLNG petroleum leases, referred to as the GFD Project area.

This assessment responds to the requirements outlined in Section 4.10.4 of the *Terms of reference* (ToR) *for an environmental impact statement* (EIS), issued by the Office of the Queensland Coordinator-General in March 2013, and has been prepared to support the EIS process for approval of the GFD Project.

This assessment supports the GFD Project EIS by providing an assessment of aquatic environmental values and potential impacts within the GFD Project area. Aquatic ecological values are described based on a desktop study that considered the field surveys done for the GLNG Project EIS (2009 EIS), and also other relevant EISs and studies completed in the region. A field survey for the critically endangered Boggomoss snail was undertaken in the GFD Project area in 2013 to complement existing data used in this assessment.

The GFD Project tenures are located across three catchment areas: the Dawson River catchment, the Comet River catchment, and the Condamine-Balonne River catchment. The Dawson River and Comet River catchments both lie within the Fitzroy Basin. These catchments originally shared a greater connection, however the ephemerality of the water courses and impediments to movements such as weirs currently reduce the movement of aquatic biota between these two catchments. In contrast, the Condamine-Balonne catchment lies within the Murray-Darling Basin and is completely disconnected from the Dawson and Comet rivers. Although aquatic habitats are similar, no natural instream movement of aquatic biota is possible between these basins.

Aquatic habitats in the GFD Project area include watercourses, wetlands, springs and groundwater ecosystems. Watercourses in the GFD Project area are mostly ephemeral (with the exception of major watercourses such as the eastern portion of the Dawson River and parts of the Condamine River) and many are in a moderate to poor ecological condition. The decline of ecological conditions are a result of impacts associated with historic vegetation clearing, cattle grazing, river flow regulation and watercourse crossings for roads and other linear infrastructure. Despite these impacts, watercourses in the GFD Project area continue to provide habitat for aquatic biota that is representative of the wider regional area, including aquatic plants, macroinvertebrates, fish, turtles and platypus. Generally only fish and macroinvertebrate species that are tolerant of varying and often harsh conditions are likely to occur in the GFD Project area. Wetlands, deep watercourse pools and springs in the GFD Project area provide permanent aquatic habitat. Many wetlands and springs have been impacted by clearing and cattle access; although some of these sensitive ecosystems are in good ecological condition and provide habitat for conservation significant species.

The following species and communities listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) are either known to occur or could potentially occur within the GFD Project area:

- Fitzroy River turtle (*Rheodytes leukops*) (vulnerable) (known to occur)
- Murray cod (*Maccullochella peelii peelii*) (vulnerable) (could potentially occur)
- Salt pipewort (*Eriocaulon carsonii*) (endangered) (known to occur)
- Community of native species dependent on natural discharge of groundwater from the Great Artesian Basin (endangered) (known to occur).

The following species are those that are known to occur and/ or have the potential to occur within the GFD Project area and are listed under the *Nature Conservation (Wildlife) Regulation 2006* (Qld):

- Artesian milfoil (*Myriophyllum artesium*) (endangered) (known to occur)
- *Eleocharis blakeana* (near threatened) (known to occur)
- Wandering fringe-rush (*Fimbristylis vagans*) (near threatened) (could potentially occur).

Potential impacts on aquatic environmental values were assessed on the basis of aquatic flora and fauna community composition, and aquatic habitat using a significance assessment method. This involved a qualitative assessment of both the sensitivity and magnitude of potential impacts on aquatic environmental values. Mitigation measures to reduce the risks associated with potential impacts were identified using management frameworks within Santos GLNG's existing operations, and additional measures specific to the GFD Project identified as necessary. A monitoring program to measure and assess changes in environmental values throughout each phase of the GFD Project has also been described.

Introduction

URS Australia Pty Ltd (URS) was engaged by Santos GLNG to complete an assessment of the potential impacts of the proposed Gas Field Development Project (the GFD Project) on aquatic ecology environmental values. It provides a description of the relevant aquatic environmental values and an assessment of the potential direct and indirect impacts of the GFD Project on these values and proposes mitigation measures. This assessment responds to the requirements outlined in Section 4.10.4 of the *Terms of reference* (ToR) *for an environmental impact statement* (EIS), issued by the Office of the Queensland Coordinator-General in March 2013, and has been prepared to support the EIS process for approval of the GFD Project.

1.1 Project overview

Santos GLNG intends to further develop its Queensland gas resources to augment supply of natural gas to its existing and previously approved Gladstone Liquefied Natural Gas (GLNG) Project.

The GFD Project is an extension of the existing approved gas field development and will involve the construction, operation, decommissioning and rehabilitation of production wells and the associated supporting infrastructure needed to provide additional gas over a project life exceeding 30 years.

Specifically, the GFD Project seeks approval to expand the GLNG Project's gas fields from 6,887 square kilometres (km^2) to 10,676 km^2 to develop up to 6,100 production wells beyond the currently authorised 2,650 wells; resulting in a maximum of up to 8,750 production wells. The GFD Project will continue to progressively develop the Arcadia, Fairview, Roma and Scotia gas fields across 35 Santos GLNG petroleum tenures in the Surat and Bowen basins, and associated supporting infrastructure in these tenures and in adjacent areas. The location of the GFD Project area and primary infrastructure is shown on Figure 1-1.

This GFD Project will include the following components:

- Production wells
- Fluid injection wells, monitoring bores and potentially underground gas storage wells
- Gas and water gathering lines
- Gas and water transmission pipelines
- Gas compression and treatment facilities
- Water storage and management facilities
- Access roads and tracks
- Accommodation facilities and associated services (e.g. sewage treatment)
- Maintenance facilities, workshops, construction support, warehousing and administration buildings
- Utilities such as water and power generation and supply (overhead and/or underground)
- Laydown, stockpile and storage areas
- Borrow pits and quarries
- Communications.

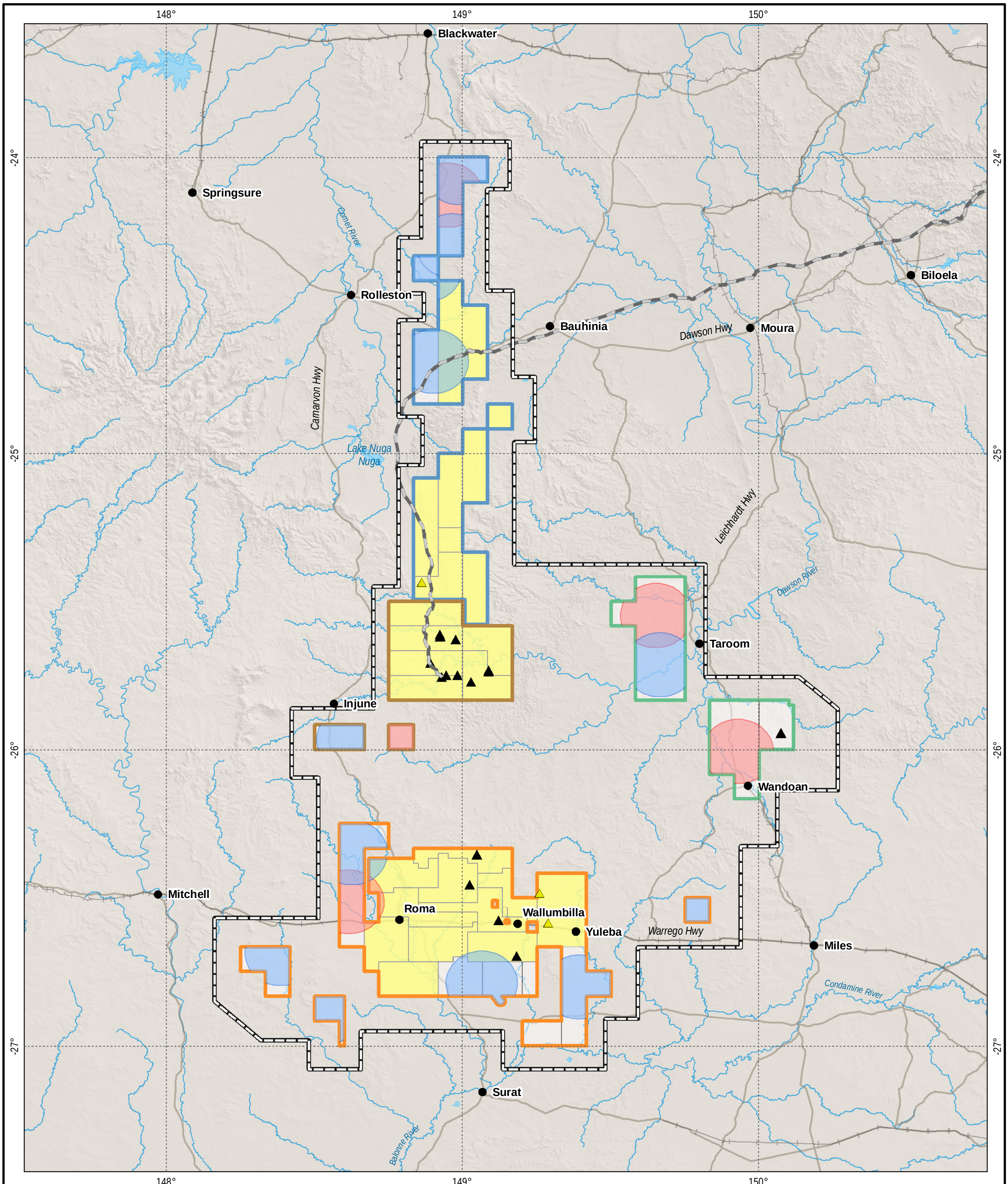
The final number, size and location of the components will be determined progressively over the GFD Project life and will be influenced by the location, size and quality of the gas resources identified through ongoing field development planning processes, which include consideration of land access agreements negotiated with landholders, and environmental and cultural heritage values.

1 Introduction

For the purposes of transparency this EIS shows an area off-tenure that may be used for infrastructure such as pipelines and temporary camps (supporting infrastructure area). While not assessed specifically in this EIS, any infrastructure that may be located within this area would be subject to further approval processes separate to this EIS.

Where practicable, the GFD Project will utilise existing or already approved infrastructure (e.g. accommodation camps, gas compression and water management facilities) from the GLNG Project or other separately approved developments. The GFD Project may also involve sourcing gas from third-party suppliers, as well as the sharing or co-location of gas field and associated facilities with third parties.

Approved exploration and appraisal activities are currently underway across the GFD Project's petroleum tenures to improve understanding of the available gas resources. As the understanding of gas resources improves, investment decisions will be made about the scale, location and timing of the next stages of field development.



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GLNG Project infrastructure
- Proposed (indicative) facility
- Operating/Under construction facility
- Gladstone gas transmission pipeline
- GLNG Project tenures

GFD Project infrastructure *
- Potential gas compression and water management facility
- Potential gas compression facility

* Indicative infrastructure locations - to be located within this area. For assessment purposes only.

GFD Project area
- Arcadia gas field
- Fairview gas field
- Roma gas field
- Scotia gas field
- Possible area for supporting infrastructure

- Towns
- Railways
- Major roads
- Major drainage

N E S W

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Projection: GDA94

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Santos GLNG Project

GFD PROJECT EIS

GFD PROJECT AREA AND PRIMARY INFRASTRUCTURE

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AQUATIC ECOLOGY

Figure: **1-1**

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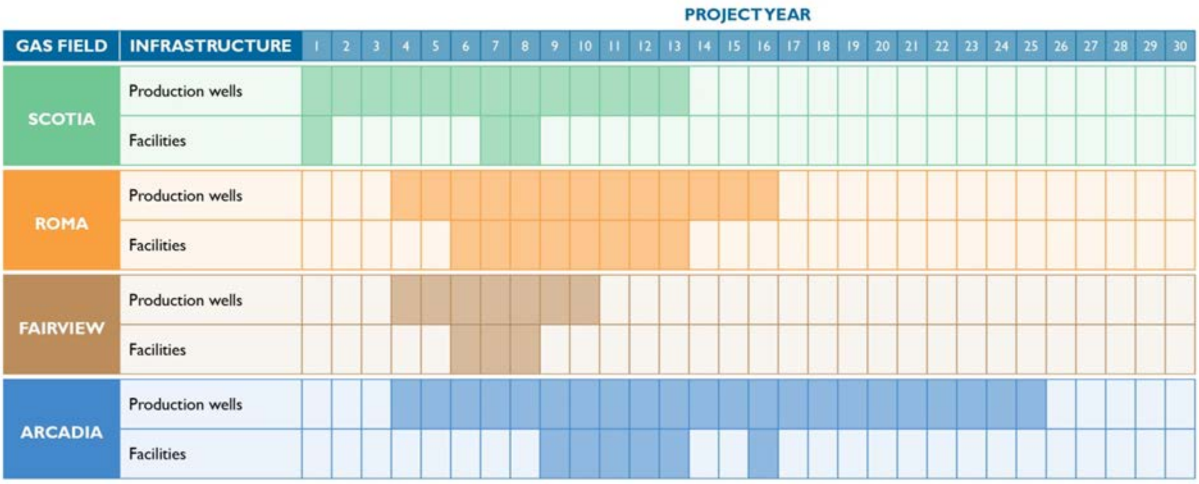
1 Introduction

For the purposes of this EIS, a scenario based on the maximum development case was developed at the approval of the ToR. This scenario assumed that production from the wells and upgrading of the gas compression facilities in the Scotia gas field would commence in 2016, followed by the GFD Project wells in the Roma, Arcadia and Fairview gas fields in mid-2019. This schedule is indicative only and was used for the purpose of the impact assessment in this EIS. The proposed GFD Project schedule is outlined in Figure 1-2. This schedule provides an overall field development scenario for the purposes of assessment in this EIS.

Figure 1-2 Proposed GFD Project development schedule



Decommissioning and rehabilitation will occur progressively throughout the life of the GFD Project as construction activities cease and exhausted gas wells are decommissioned. However, final decommissioning and rehabilitation will occur at the end of gas production in accordance with relevant approvals and regulatory requirements.

1.2 GFD Project infrastructure

A list of the GFD Project infrastructure components and footprint during the operations phase is given in Table 1-1. The area of the operations footprints will be less than those required during construction. The location, size and timing of each of the GFD Project's operations elements will be confirmed as part of the ongoing field development process and presented in plans of operations.

Table 1-1 Estimated footprints for key GFD Project infrastructure

GFD Project component	Construction footprint	Operations footprint
Well lease	Single well: 1.5 ha	Single well: 0.3 ha
	Multi-well: 2.5 ha	Multi-well: 0.5 ha
Access tracks and roads	1.5 to 3 ha per km	0.8 to 1.5 ha per km
Gas and water gathering lines	1 to 2.5 ha per km	None (right of way maintained)
Gas and water transmission pipelines	2.5 to 5.0 ha per km	None (right of way maintained)
Hub gas compression facility	20 to 40 ha	10 to 15 ha
Nodal gas compression facility	2 to 8 ha	1 to 4 ha
Laydown and storage yards[1]	5 to 40 ha	None

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GFD Project component	Construction footprint	Operations footprint
Borrow pits	5 to 50 ha	None
Camps[2]	1 to 20 ha per camp	0.5 to 10 ha per camp
Water storage	Up to 1 ha for large tank 5 to 16 ha for large dam	Up to 0.5 ha for large tank 3 to 8 ha for large dam
Water management facility	5 to 10 ha per facility	2 to 5 ha per facility

[1]Laydown and storage yards include fuel storage, workshops and maintenance areas. [2]Camps include accommodation facilities, water and sewage treatment facilities, recreational, storage and laydown areas. ha: hectare. km: kilometre.

Facilities for energy supply, water supply and telecommunications will also be incorporated within GFD Project infrastructure. Most of the supporting infrastructure will be constructed within the GFD Project's tenures, although some may also be located off-tenure in the supporting infrastructure area.

The GFD Project development may potentially lead to the following impacts with regards to values of the aquatic ecology receiving environment:

- Increased sedimentation (adverse impacts on water quality and geomorphology)
- Erosion of stream banks
- Surface water contamination (adverse impact on surface water quality; toxicity to aquatic ecosystems)
- Altered surface water flow regime (risk to overland flow paths, infrastructure, riparian vegetation, terrestrial ecosystems, baseflow from aquifers, and environmental flow regime)
- Altered geomorphic character (e.g. increased lateral instability; significant alteration of geomorphic units).

Santos GLNG has a management framework in place to avoid or minimise and mitigate such impacts. A risk assessment of each of the impacts listed above is presented in Section 5 of this report, along with a detailed summary of the management framework and associated avoidance or minimisation and mitigation measures that will be used to manage impacts to aquatic ecology values.

1.3 Description of GFD Project area

The GFD Project is located across two river basins: Fitzroy River Basin constituting the northern and eastern portions of the GFD Project area, and the Condamine-Balonne Sub-basin constituting the southern portion of the GFD Project area. Within the Fitzroy Basin, the GFD Project tenures span the Dawson River catchment and Comet River catchment. Within the Condamine-Balonne sub-basin, the GFD Project area tenures span the Condamine-Balonne River catchment. This study area covers an area of approximately 30,000 km^2 within central and southern Queensland, inclusive of the tenures associated with the proposed GFD Project.

The location of the GFD Project tenures in relation to these catchments is described in Table 1-2 and shown in Figure 1-3.

1 Introduction

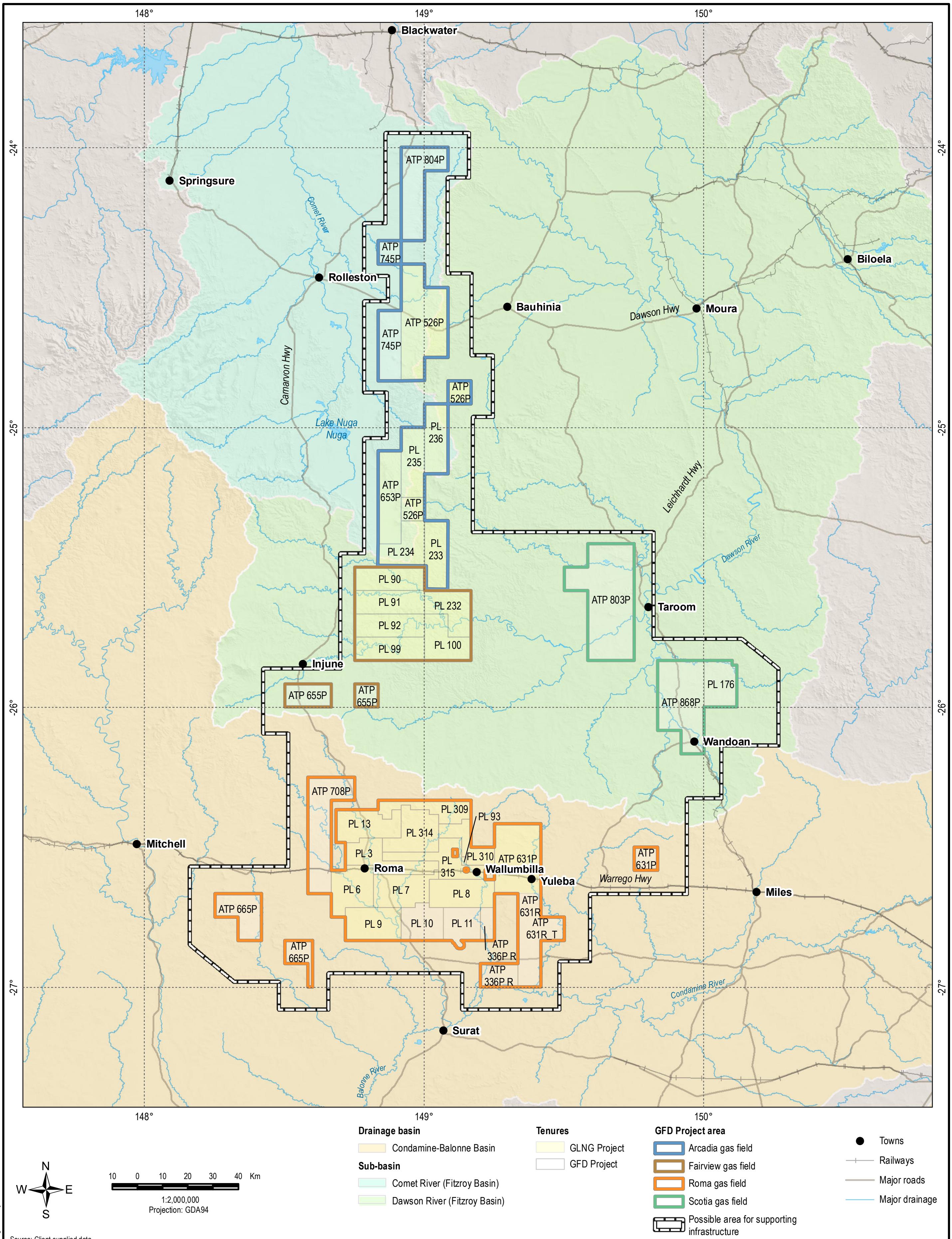
Table 1-2 Catchments relevant to the GFD Project area

Catchment	Tenures
Comet River	ATP 653P, 745P, 804P and part of ATP 526P PL 234, 235, 236 PLA 420, 421, 440
Dawson River	ATP 655P, 803P, 868P and part of ATP 526P, PL 234, 235, 236 PL 90, 91, 92, 99, 100, 176, 232, 233
Condamine-Balonne River	ATP 336P R, 631R, 631P, 631R_T, 665P, 708P PL 3, 6, 7, 8, 9, 10, 11, 13, 93, 309, 310, 314, 315 PLA 281, 282

The Comet River originates in the Expedition Range and flows into the Mackenzie River approximately five kilometres (km) to the north of the town of Comet. The Mackenzie River joins with the Dawson River to form the Fitzroy River, approximately 85 km southwest of Rockhampton.

The Condamine River originates on Mt Superbus, part of the Main Range and flows northwest until its confluence with Dogwood Creek just upstream of Surat. From here it becomes the Balonne River where it shifts direction, flowing southwest towards the Darling River.

The aquatic ecology assessment includes the watercourses, wetlands, springs and groundwater ecosystems within each of the GFD Project area tenures, watercourses downstream of the GFD Project area (which may be affected by indirect impacts such as changes in water quality, flows or connectivity/fish passage), and wetlands, springs and aquifers outside of the GFD Project area that are potentially affected by coal seam depressurisation.



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Santos GLNG Project

GFD PROJECT EIS

GFD PROJECT AREA TENURES AND STUDY CATCHMENTS

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AQUATIC ECOLOGY

Figure: **1-3**

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Regulatory framework

This section presents an overview of regulatory frameworks relevant to protecting aquatic environmental values within the GFD Project area, and the broad implications of the regulation for the GFD Project.

2.1 Commonwealth legislation

2.1.1 Environment Protection and Biodiversity Conservation Act

The *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) provides for the management and protection of national and international flora and fauna of environmental significance; referred to as matters of national environmental significance (MNES).

Gas field developments can potentially disrupt aquatic ecosystems and therefore have adverse impacts on MNES such as particular aquatic species, water resources and wetlands of international importance. An action with the potential for a significant impact on MNES must be referred to the Department of the Environment (DOTE) and may require approval under the EPBC Act.

The MNES under the EPBC Act are as follows:

- World heritage properties
- National heritage places
- Wetlands of international importance (often called 'Ramsar' wetlands after the international treaty under which such wetlands are listed)
- Listed threatened species and communities
- Migratory species
- Commonwealth marine areas
- The Great Barrier Reef Marine Park
- Nuclear actions (including uranium mining)
- A water resource (2013 EPBC Amendment Act – Water trigger).

The GFD Project is a controlled action requiring assessment and approval under the EPBC Act before it can proceed. The controlling provisions are:

- Wetlands of international importance (sections 16 and 17B)
- Listed threatened species and communities (sections 18 and 18A)
- Listed migratory species (sections 20 and 20A)
- Water resources (sections 24D and 24E).

2.2 State (Queensland) legislation and policies

2.2.1 Environmental Protection Act

The *Environmental Protection Act 1994* (Qld) (EP Act) aims to:

"[*Protect*] *Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development)*."

The EP Act governs the management of surface water with regards to gas fields. The primary instrument by which this is achieved it the *Environmental Protection (Water) Policy 2009* (Qld) (EPP Water) (refer to section 2.2.2). The EP Act is administered by the Queensland Department of Environment and Heritage Protection (EHP).

2.2.2 Environmental Protection (Water) Policy 2009

The EPP Water is an instrument of the EP Act. Amongst other functions, EPP Water governs the discharge of wastewater to land, surface water, and groundwater, aims to protect environmental values and sets water quality objectives to provide guidance to protect environmental values.

The following regulations and policies are also relevant under the EP Act:

- *Environmental Protection (Waste Management) Policy 2000*
- *Environmental Protection (Waste Management) Regulation 2000*
- *Environmental Protection Regulation 2008.*

These instruments are supported by EHP's *Coal Seam Gas Water Management Policy 2012*, which guides operators in managing coal seam water under their environmental approvals.

2.2.3 Fisheries Act 1994

The *Fisheries Act 1994* (Qld) (Fisheries Act) aims to protect Queensland waters from degradation by direct or indirect means. If it is likely that litter, soil, a noxious substance, refuse or other polluting matter may adversely affect fishery resources or a fish habitat, the Chief Executive of the Department of Agriculture, Fisheries and Forestry may issue a notice requiring the person suspected of causing the pollution to take action to redress the situation. The polluting matter may be on land (including the foreshore and non-tidal land), in waters, or in a fish habitat.

2.2.3.1 Waterway barriers

Under Part 5, Division 3A, Subdivision 3 (76G) of the Fisheries Act, a waterway barrier works approval is needed to build any structure across a freshwater waterway, whether it is temporary or permanent. The purpose of this part of the Act is to provide a balance between the need to construct water storages, weirs, culverts and road crossings and the need to maintain fish movement.

The construction and raising of a waterway barrier is classed as operational works under the *Sustainable Planning Act 2009* (Qld), and therefore requires a development approval through the Integrated Development Assessment (IDAS) process. The construction of waterway barrier works may be either assessable or self-assessable development, depending on the nature of works. Where waterway barriers are within a petroleum tenure, the Sustainable Planning Act does not apply.

The provision of effective fish passage will be required for the GFD Project where waterway barriers (temporary or permanent) will be installed. Whether GFD Project activities will require approval under the Fisheries Act or the Sustainable Planning Act will be determined at the detailed design phase of the GFD Project.

2.2.4 Fisheries Regulation 2008

2.2.4.1 Declared noxious fish

Declared noxious species are listed under the *Fisheries Regulation 2008* (Qld). Declared noxious fish cannot be kept, hatched, reared or sold, and must be destroyed if caught. There are two known declared noxious species [(mosquito fish) (*Gambusia holbrooki*) and common carp (*Cyprinus carpio*)] in the GFD Project area.

Section 4 provides further discussion on fish species known from the catchments relevant to the GFD Project.

2.2.4.2 Non-indigenous fish

Under the Fisheries Regulation 2008, non-indigenous fish are fish living in an area where they are not naturally found. A non-indigenous fish can be a native Australian species or a non-native species (i.e. exotic). For example, mosquito fish (*Gambusia holbrooki*) are declared noxious species and are also considered exotic non-indigenous species.

Section 4 provides further discussion on fish species known from the catchments relevant to the GFD Project.

2.2.5 Land Protection (Pest and Stock Route Management) Act 2002

The *Land Protection (Pest and Stock Route Management) Act 2002* (Qld) provides a framework for improved management of weeds, pest animals and the stock route network. Declared noxious weeds in Queensland are listed under the *Land Protection (Pest and Stock Route Management) Regulation 2003* (Qld).

Class 1 declared pests under this regulation are uncommon in Queensland, and if introduced, are likely to have adverse economic, environmental or social impacts. Class 1 pests established must be eradicated. Class 2 and 3 declared pests are established in Queensland and have, or could have, an adverse economic, environmental or social impact. Landowners must take all reasonable steps to keep their land free from Class 2 pests. Landowners are not required to remove Class 3 pests, unless their land is next to an environmentally significant area (e.g. national park).

Noxious aquatic plants are further discussed in section 4.

2.2.6 Nature Conservation Act 1992

Native flora and fauna species are protected in Queensland under the *Nature Conservation Act 1992* (Qld) (NC Act). The subordinate Nature Conservation (Wildlife) Regulation contains the following categories reflecting both abundance and levels of legislative protection: extinct in the wild, endangered, vulnerable, near threatened and least concern.

Additionally the NC Act also provides a framework for the establishment and management and use of protected areas. Protected areas on State land such as National Parks and Conservation Parks are listed in the *Nature Conservation (Protected Areas) Regulation 1994* (Qld). These areas also have a role in protecting aquatic species.

2.2.7 Water Act 2000

The purpose of the *Water Act 2000* (Qld) (Water Act) is to provide for the sustainable management of water and other resources. The GFD Project may require approvals under the Water Act for the construction, control and management of works with respect to water conservation and protection, drainage, supply, flood control and prevention. Under Section 269 of the Water Act, a riverine protection permit is required to:

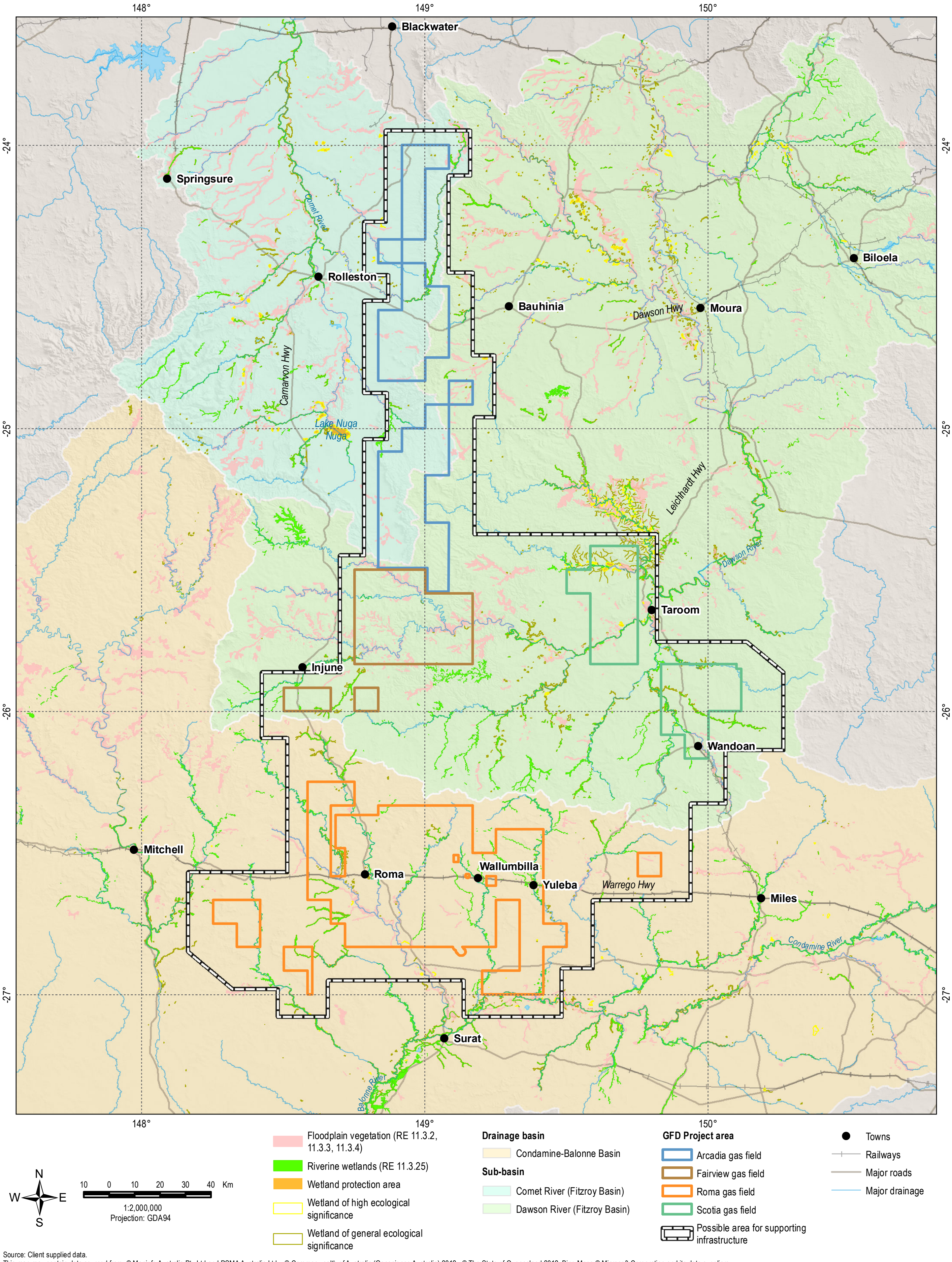
- Remove vegetation in a watercourse, lake or spring
- Excavate in a watercourse, lake or spring and/or
- Place fill in a watercourse, lake or spring.

However, on-tenure petroleum activities are exempt from the requirement for a riverine protection permit under section 814 of the Water Act and sections 49-51 of the *Water Regulation 2002* (Qld).

2.2.8 State Planning Policy

Some wetlands of high ecological significance are protected within the Great Barrier Reef catchments under the *State Planning Policy* (SPP) which is a statutory instrument under the *Sustainable Planning Act 2009* (Qld)*.* The jurisdiction of the SPP includes catchments of the Fitzroy Basin such as the Dawson and Comet river catchments, which form part of the GFD Project. One purpose of this code is to ensure that development in or adjacent to wetlands of high ecological significance in Great Barrier Reef catchments is planned, designed, constructed and operated to prevent the loss or degradation of the wetlands and their environmental values, or enhances these values (Figure 2-1).

Lacustrine (e.g. lakes) and palustrine (e.g. swamps) wetlands, riverine systems (e.g. river and creek channels, and known waterholes within these systems) and springs have been mapped in the EHP's *Wetland Mapping Program* (EHP, 2013).



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Santos GLNG Project

GFD PROJECT EIS

WETLANDS OF STATE AND REGIONAL SIGNIFICANCE IN THE GFD PROJECT AREA

URS

AQUATIC ECOLOGY

Figure: 2-1

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2.3 Santos GLNG policy framework

The following sub-sections introduce the high level policies and Environment, Health and Safety Management System standards employed by Santos GLNG in their general operations. The framework is used to inform corporate responsibility and key principles across all Santos GLNG operations at the corporate level. As such, they will also apply to the proposed GFD Project.

Santos GLNG has adopted the corporate *Environmental Policy* to “continuously seek to find new ways to minimise our environmental impact across the lifecycle of our activities”; it includes specific commitments for maintenance and improvement of the Environment, Health and Safety Management System, and provides general principles of environmental stewardship responsibilities for Santos GLNG employees and contractors.

The Environmental Policy also outlines a commitment to operations compliance, including monitoring, auditing, reviewing and reporting processes. The Environment, Health and Safety Management System and accompanying Environment Hazard Standards (EHS) are designed to facilitate achievement of the commitments outlined at corporate level, and therefore provide practical guidance and procedures for operations activities. These standards have been applied to develop the management plans outlined in Section 5.3 for mitigation of potential impacts within the aquatic environment.

Table 2-1 and Table 2-2 explain how each of the Environment, Health and Safety Management System management standards and EHS will be applicable to management of aquatic environmental values within the GFD Project area, respectively.

Table 2-1 Santos GLNG management standards and corporate policies relevant to aquatic ecology

Management standard	Description	Applicability to GFD Project
EHSMS01	Environment, Health and Safety Policies	Activities of Santos GLNG employees and contractors with regards to improving environment, health and safety performance.
EHSMS02	Legal obligations and other requirements	Compliance with EA conditions, legislation, permits, industry codes, commitments and other obligations.

Table 2-2 Santos GLNG environmental hazard standards relevant to aquatic ecology

Environment hazard standard	Description	Applicability to GFD Project
EHS01	Biodiversity and Land Disturbance	Outlines requirements for planning and conducting operations in a way which avoids or minimises disturbances to land and allows affected areas to be restored within reasonable time frames (applicable to erosion and sediment management practices).
EHS03	Produced Water Management	Defines requirements for minimising environmental impacts associated with produced water.
EHS10	Water Resource Management	Outlines requirements to ensure protection from degradation and the sustainable use of watercourses, lakes, springs, overland flows, underground water and other natural ecosystems associated with these water resources.

2.3.1 Post-EIS field planning process

The constraints approach is based upon the *GFD Project environmental protocol for constraints planning and field development* (Constraints protocol). The Constraints protocol applies to all gas field related activities. The scope of the Constraints protocol is to:

- Enable Santos GLNG to comply with all relevant State and Federal statutory approvals and legislation
- Support Santos' environmental policies and the General Environmental Duty (GED) as outlined in the EP Act
- Promote the avoidance, minimisation, mitigation and management of direct and indirect adverse environmental impacts associated with land disturbances
- Minimise cumulative impacts on environmental values.

The Constraints protocol details the process that Santos GLNG will use to identify, assess and manage potential impacts to the environment during field planning and development. This process has been successfully used for the approved GLNG Project, which increases the certainty of GFD Project environmental outcomes.

The general principles of the Constraints protocol, in order of preference, are to:

- Avoid — avoid direct and indirect impacts
- Minimise — minimise potential impacts
- Mitigate — implement mitigation and management measures to minimise adverse impacts
- Remediate and rehabilitate — actively remediate and rehabilitate impacted areas
- Offset — offset residual risk in accordance with regulatory requirements.

Consistent with Santos GLNG's environmental management hierarchy, the Constraints protocol prioritises avoidance of environmental impact during field planning by identifying those areas that are not amenable to development. This includes areas of high environmental value as identified in regulatory frameworks and Santos GLNG's baseline surveys. For areas that are considered appropriate to develop, Santos GLNG will identify impacts to environmental values that could potentially occur due to the construction, operations and decommissioning activities of the GFD Project, and determine pre-mitigated impacts (i.e. those that would occur without mitigation).

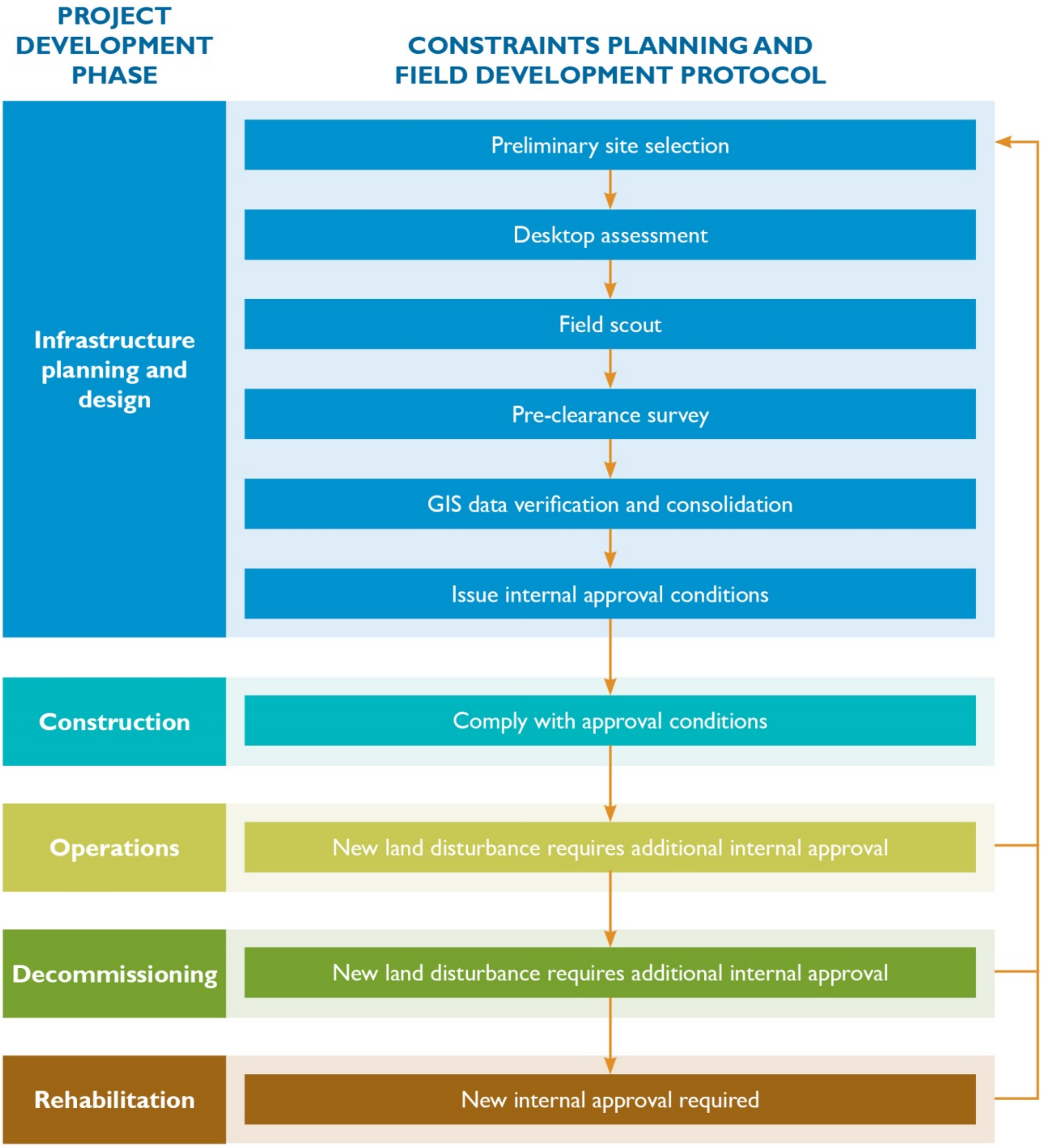
Relevant mitigation and management measures based on the approved environmental management framework already implemented for the GLNG Project are then applied to the pre-mitigated impacts to identify the mitigated (residual) impacts. This process increases certainty about potential impacts by identifying those areas that are not amenable to development, and for those areas where development could occur, how development should proceed.

The post-EIS field development process is a continuation of the field planning process and will be ongoing throughout the life of the GFD Project. The field development process will inform the GFD Project's design, together with a range of other factors including technical feasibility, cost and risk as required by standards applicable to the design, construction, operations, decommissioning and rehabilitation of gas developments. This information will be used to support the subsequent approvals process such as environmental approval application and the plan of operations.

The tasks involved in the field development process are summarised in Figure 2-2.

2 Regulatory framework

Figure 2-2 Field development process



Methodology of assessment

3.1 Scope of assessment

As discussed in previous sections, the purpose of this assessment is to inform the EIS for the GFD Project; as such, the scope of the assessment was designed to fulfil the requirements of the ToR. The ToR is inherently designed to satisfy the requirements of the relevant federal and state legislation detailed in Section 2. This assessment includes a detailed desktop assessment of aquatic environmental values and assesses the sensitivity of these values to potential impacts that may arise from the development of the GFD Project. It also provides a summary of the management frameworks and mitigation measures that may be used to reduce the risks associated with the identified potential impacts on the aquatic environmental values.

3.2 Description of the existing aquatic environmental values

URS undertook an extensive literature review of previous studies undertaken by Santos GLNG, publicly available EIS documents and technical reports produced by other resource project operators within and directly downstream of the GFD Project area. Additionally, general peer-reviewed documents such as government reports and databases were also taken into account. The purpose of the exercise was to identify potential sources of data relevant to the GFD Project area, and gain insight into the context within which the aquatic ecology assessment would be undertaken. This information was then used to assist in defining the nature of aquatic environmental values for the GFD Project area.

A large number of sources were reviewed for this assessment; the key references are listed below according to source group.

Santos GLNG studies and EIS documentation

The assessment of aquatic ecology values prepared for the 2009 EIS (URS, 2009) summarises many earlier studies as well as aquatic surveys undertaken across the entire Santos GLNG development area as part of the background work to the 2009 EIS.

External sources

The reports listed in Table 3-1 were reviewed for information pertaining primarily to aquatic ecology.

Table 3-1 External sources of information (literature review)

Source	Year	Title	Relevant river basin
Xstrata Glencore	2008	Wandoan Coal Project EIS: MLA Areas and Surrounds – Volume 1, Aquatic Ecology Technical Report	Fitzroy Basin
APLNG	2010	APLNG Gas Pipeline EIS: Volume 3, and Chapter 9 (Aquatic Ecology)	Condamine -Balonne Basin, Fitzroy Basin
Arrow Energy	2011	Arrow Surat Gas Project: Appendix J (Aquatic Ecology).	Condamine -Balonne Basin, Fitzroy Basin
SunWater	2012	Nathan Dam EIS: Appendix 11A, 11B, 11C, 11D, 12A, 12B, 12C, 12D, 13A and 13B	Fitzroy Basin
Stanmore Coal	2012	The Range Project:	Condamine-Balonne Basin
Arrow Energy	2012	Arrow Bowen Gas Project EIS: Appendix J (Aquatic Ecology)	Fitzroy Basin
Bandanna Energy	2013	Springsure Creek Coal Mine: Section 12 (Ecology)	Fitzroy Basin

Santos GLNG aquatic ecology and surface water studies

A number of aquatic ecology and surface water studies were completed by Santos GLNG from 2007 that formed part of the 2009 EIS (URS, 2009) and SEIS (URS, 2010). Numerous other investigations have been undertaken that provide location-specific ecological data relevant to the GFD Project. Due to variations in sampling methodology and data availability, the results of these studies were reviewed on a qualitative basis. Key sources are listed in Table 3-2.

Table 3-2 Additional sources of information

Source	Year	Title	Relevant river basin
EnviroTest	2003, 2004a	Biological monitoring of macroinvertebrate communities in the Upper Dawson River	Fitzroy Basin
EnviroTest	2005a, 2005b, 2006a, 2006b	River Health Assessment of the Upper Dawson River	Fitzroy Basin
Simmonds and Bristow	2007a, 2007b, 2008a, 2008b, 2010a, 2010b, 2011	River Health Assessment of the Upper Dawson River	Fitzroy Basin
Simmonds and Bristow	2012a	Waterhole Impact Resilience Assessment (Summer 2012), Dawson River Release Scheme	Fitzroy Basin
Simmonds and Bristow	2012b	Waterhole Impact Resilience Assessment, Dawson River Release Scheme	Fitzroy Basin
Simmonds and Bristow	2012c	River Health Monitoring and Assessment Report, Horseshoe Lakes	Fitzroy Basin
URS	2013a	River Health Monitoring and Assessment Report Upper Dawson River Post-wet 2013	Fitzroy Basin
URS	2013b	Dawson River Release Scheme Receiving Environment Metals in Sediment	Fitzroy Basin
URS	2014	Spring Mitigations Option Assessments and Selection – EPMOR. Ecological Assessment	Fitzroy Basin

Source: Santos GLNG

Databases and other resources

The desktop analysis of available information also involved the review of numerous government reports and databases, as well as other published studies. These are detailed below:

- DOTE *EPBC Act Protected Matters Search Tool* with the geographic extent of searches covering GFD Project tenure and an additional 10 km beyond the boundary of each tenure
- Queensland EHP *Wildlife Online* database, with the geographic extent of searches covering GFD Project tenure and an additional 10 km beyond the boundary of each tenure
- EHP Wetland*info* Wetland Mapping and Classification search tool version 3.0
- Government studies such as the *State of the Rivers* assessments (Van Manen, 2001; Henderson, 2000; Telfer, 1995 and *Aquatic Conservation Assessments* (using the AquaBAMM methodology))
- Underground Water Impact Report (QWC 2012)
- Published studies regarding groundwater-dependent ecosystems and communities.

3.2.1 Field data

This assessment draws on available field data related to watercourses, wetlands and groundwater dependent ecosystems (springs) of the GFD Project area. On this basis, this assessment provides a description of the aquatic environmental values of the GFD Project area in accordance with the ToR. However, the assessment of the existing environment does not include location-specific values of each watercourse, wetland, spring and aquifer in the GFD Project area. Once the exact nature and location of the impacting processes has been identified, location-specific aquatic ecology surveys may be undertaken to refine the proposed controls to avoid, minimise and mitigate potential impacts to aquatic ecology as required. Key aquatic ecosystem receptors for post-EIS surveys include:

- Potentially impacted watercourse springs (especially refuge pools in close proximity to these springs) and vent springs
- Significant wetlands.

3.2.2 Boggomoss snail survey

A field survey for the critically endangered Boggomoss snail was undertaken in the GFD Project area between 16 and 19 September 2013. The results were used to improve confidence in the interpretation of the existing body of information on this species.

3.2.3 Characterisation of catchments

The aquatic habitat condition of waterways and wetlands in the GFD Project area has been comprehensively assessed in the State of the Rivers surveys completed in the region. These studies were undertaken in the late 1990s and early 2000s and the results were used in the more recent *Aquatic Conservation Assessments* (using AquaBAMM methods) (DERM, 2011a). Numerous EIS studies and other monitoring programs (including Santos GLNG) have been undertaken in the region, including the numerous seasonal river health assessments of the Upper Dawson River (e.g. Envirotest, 2004a; Simmonds and Bristow, 2007a). These studies either used the State of the Rivers methodology, or the Australian River Assessment System (AusRivAS) methodology, including the River Bioassessment Program score datasheets (DNRM, 2001). These reports have been used to characterise the aquatic environmental value for each catchment.

3.3 Impact assessment and mitigation

Impacts were assessed on the basis of the characterisation of the aquatic environmental values detailed in this assessment. Both environmental sensitivity and potential magnitude of impacts are considered in the assessment, as well as, where applicable, current Santos GLNG management and impact mitigation strategies and commitments proposed as a part of the 2009 EIS. Potential impacts to the aquatic environmental values arising from the proposed GFD Project developments are presented in Section 5.2 whereas measures for the mitigation of the identified environmental impacts are listed in Section 5.3.

Description of existing environment

Aquatic ecosystems, including streams, rivers, wetlands and springs within the GFD Project area and study area provide habitat and dispersal corridors for aquatic fauna species (i.e. fish, turtles and macroinvertebrates including macrocrustaceans) and flora, and many also provide habitat and supply water for terrestrial fauna. Furthermore, many terrestrial vegetation types may be dependent on the presence of surface water or springs (groundwater dependant ecosystems) and form essential habitats and protected areas.

The following section provides a summary of the aquatic habitat, aquatic flora and fauna composition and Great Artesian Basin (GAB) springs present with each catchment and are outlined in further detail for macroinvertebrates in Appendix A, aquatic flora in Appendix B, fish and turtles in Appendix C and GAB springs in Appendix D.

4.1 Dawson River catchment

4.1.1 Aquatic habitat

The Dawson River originates in the Carnarvon section of the Great Dividing Range and flows into the Fitzroy River, approximately 85 km southwest of Rockhampton. The Dawson River is the largest tributary of the Fitzroy River, with a catchment covering 35% of the Fitzroy Basin (Joo *et al.*, 2000). Key water courses identified within the Dawson River catchment include:

- Dawson River
- Baffle Creek
- Hutton Creek
- Juandah Creek
- Bungaban Creek
- Robinson Creek.

The larger watercourses in the catchment exhibit seasonal flow regimes that vary from intermittent to perennial (e.g. Dawson River). Most contain perennial waterholes and wetlands that provide refuge for aquatic fauna. Smaller watercourses are typically dry with intermittent flows in response to rainfall events. Wetlands and springs provide intermittent to perennial aquatic habitat. Wetlands within the Dawson River catchment portion of the GFD Project area (Figure 4-1) include:

- ATP 803 contains four lacustrine wetlands, 11 palustrine wetlands, including Lake Murphy; one riverine regional ecosystem - the Dawson, which includes a mapped waterhole (Lotus waterhole)
- ATP 868 contains 31 lacustrine wetlands, nine palustrine wetlands, and two riverine regional ecosystems
- PL 176 contains one lacustrine wetland, two palustrine wetlands, and no riverine regional ecosystems
- ATP 655 contains four lacustrine wetlands, no palustrine wetlands, and one riverine regional ecosystem.

One of the wetlands in ATP 803 is mapped as having high ecological value (referrable) wetlands in the Great Barrier Reef catchments – Lake Murphy Conservation Area. These wetlands contain species and regional ecosystems of conservation significance under both the EPBC Act and the NC Act.

4 Description of existing environment

The AquaBAMM methodology assigns a conservation value to wetlands and watercourses using a range of indicators including:

- Presence of exotic aquatic species
- Macroinvertebrate community condition, as measured by macroinvertebrate indices including AusRivAS scores
- Habitat features and modifications based on the State of the Rivers surveys (discussed in this section)
- Hydrological modification
- Water quality.

The majority of wetlands in the Dawson River catchment were rated as having a medium conservation value using the AquaBAMM methodology, although conservation values ranged from very low to very high (DERM, 2009a).

Aquatic habitat within the Dawson River catchment is generally in moderate to poor condition. Watercourses are generally ephemeral or intermittent and characterised by isolated pools for much of the year. However, the aquatic habitat of some watercourses in the Upper Dawson River catchment such as Baffle Creek, Hutton Creek and the upper reaches of the Dawson River have moderate to high aquatic habitat values. This reflects the local geology and diversity of substrate types, as well as the presence of flowing water and greater diversity of instream habitat (e.g. riffles and runs) compared to other watercourses.

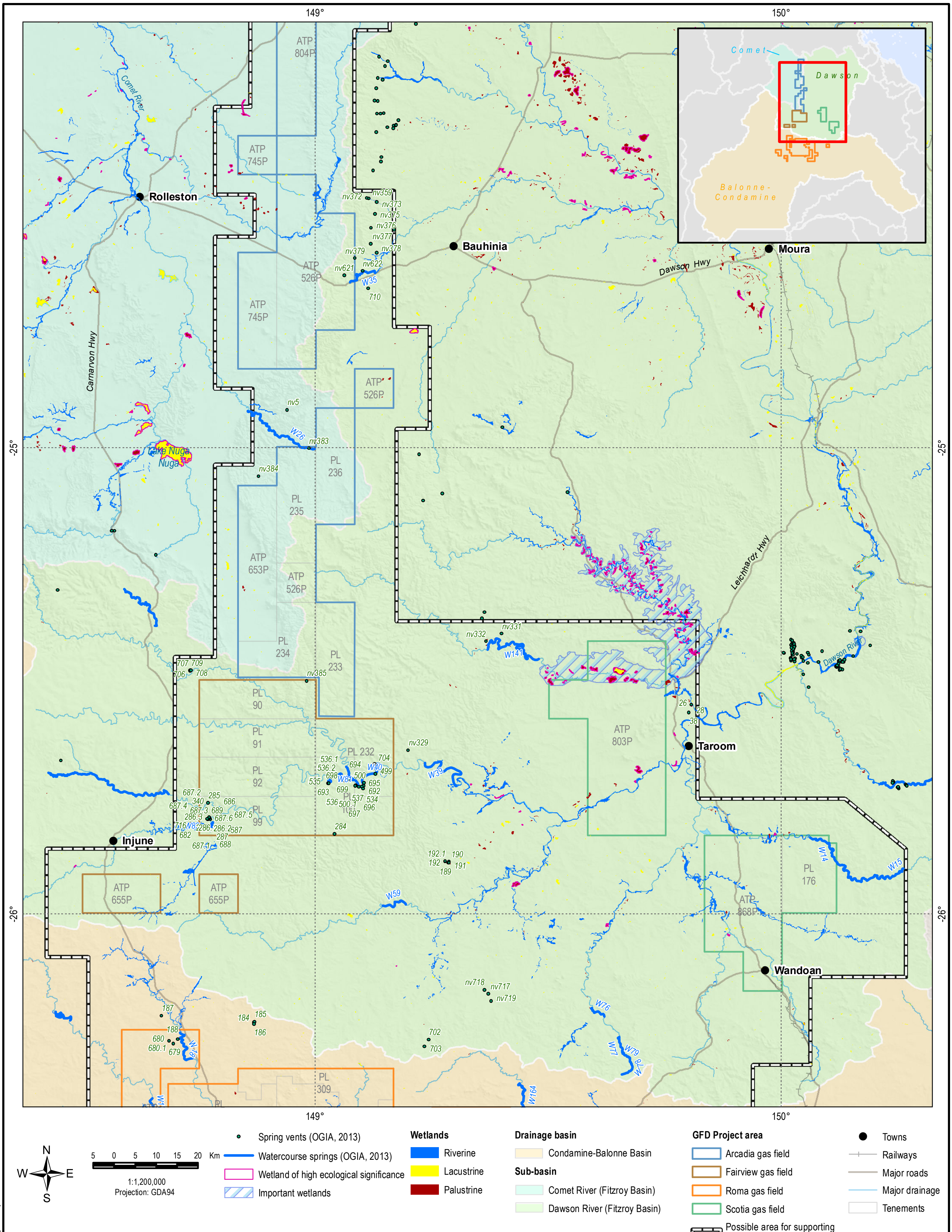
In the State of the Rivers survey the findings were as follows for the Upper Dawson sub-catchment:

- 37% was assessed to be in very good condition (ratings for most categories were very high, and the bed and bank habitats were stable)
- 20% was in good condition (ratings for most categories were high, and the bed and bank habitats were stable)
- 43% was in moderate condition (ratings for most categories were moderate, and the bed and bank habitats were moderately stable) (Telfer, 1995).

The findings were as follows for the southern tributaries:

- 7% percent was in good condition
- 23% was in moderate condition
- 63% was in poor condition
- 7% of the sub-catchment was in very poor condition (ratings for most categories were very low, and the bed and bank habitats were very unstable).

Streams in the catchment range in conservation value from low to very high; however, the majority of streams are of moderate conservation value (DERM, 2009b).



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Santos GLNG Project

GFD PROJECT EIS

WETLANDS AND WATERHOLES WITHIN THE DAWSON RIVER CATCHMENT

URS

AQUATIC ECOLOGY

Figure: **4-1**

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4 Description of existing environment

4.1.1.1 Reach environment

The reach environment includes the overall condition of the stream reaches, taking into consideration surrounding land uses and existing human disturbances. During the State of the Rivers survey, streams in the Upper Dawson River Sub-catchment were mainly rated as highly (50%) or moderately (25%) disturbed; streams in the Southern Tributaries were rated as either extremely (15%) or highly (43%) disturbed (Telfer, 1995). Much of the land adjacent to the locations surveyed in the State of the Rivers assessment had been cleared, and was covered in native pasture being used for cattle grazing (Telfer, 1995). Other disturbances included bridges, culverts, fords and forestry activities. This is consistent with the surveys undertaken for the 2009 EIS (FRC Environmental, 2009a) and the surveys undertaken as part of regular river health assessments of the Dawson River (e.g. Envirotest, 2004a; Simmonds and Bristow, 2007a).

4.1.1.2 Substrate composition

Substrates in the waterways of the Dawson River catchment are comprised mostly of sand and silt/clay, although larger sediments such as gravel, pebbles and cobble and boulders are present in some streams (FRC Environmental, 2009a; Plate 4-1).

4.1.1.3 Riparian vegetation and adjacent land use

The most dominant structural riparian vegetation types were grasses, rushes and sedges, small (<10 m) and medium sized trees (10–30 m). Native species included *Eucalyptus* spp., cypress pines (*Callitris* spp.), *Lomandra* spp., *Acacia* spp., *Melaleuca* spp., *Acacia* spp. and *Callistemon* spp. (Telfer, 1995).

Most of the riparian zones in the Dawson River catchment are rated as in poor condition, due to agricultural clearing, grazing and weeds; however, larger trees are common along the larger watercourses (Telfer, 1995). This is consistent with the EIS surveys undertaken for the GLNG Project, Wandoan Coal Project and Nathan Dam (FRC Environmental, 2007, 2009a, 2009b; Plate 4-1 and Plate 4-2) and the river health assessments of the Upper Dawson River Project (e.g. Envirotest, 2004a; Simmonds and Bristow, 2007a).

Plate 4-1 Boulders in Woleebee Creek.

Source: Wandoan Coal Project EIS surveys, 2009

Plate 4-2 Riparian zone at Juandah Creek, Roma-Taroom Road.

Source: Wandoan Coal Project EIS surveys, 2009

4.1.1.4 Bank stability

Eroding banks were observed across the Upper Dawson Sub-catchment and at 96% of locations in the Southern Tributaries Sub-catchment (Telfer, 1995). Locations surveyed within river health assessments of the Upper Dawson River Project (e.g. Envirotest, 2004a; Simmonds and Bristow, 2007a) typically exhibited low to moderate erosion. However, major erosion and movement of sediments were noted following flood events with major disturbance to the riparian zone including the uprooting and transport of trees. The presence of grazing stock, land clearing, man-made structures, flood scouring and eroded walking tracks negatively affects bank stability throughout the sub-catchments (Telfer, 1995). Similar impacts were seen in the EIS surveys done for the GLNG Project, Wandoan Coal Project and Nathan Dam (FRC Environmental, 2007, 2009a, 2009b). Most stream banks in the Upper Dawson and Southern Tributaries Sub-catchments were rated as stable during the State of the Rivers survey, though most locations were affected to some degree by erosive processes (Telfer, 1995).

4.1.1.5 Channel diversity

Channels across the Dawson River sub-catchments lack diversity; the State of the Rivers survey rated diversity from very low to moderate (Telfer, 1995). The upper Dawson River was mostly dominated by one flow category (Simmonds and Bristow, 2007a); although several locations (including Baffle Creek) had two or three flow categories (e.g. riffles). Riffles on the Dawson River were typical of the sub-catchment; the riffle on Injune Creek was considerably narrower and shallower (FRC Environmental, 2009a). Hydrologic barriers were not present at locations assessed within the river health assessments of the Upper Dawson River, and road causeways created in-stream barriers at several locations (e.g. Envirotest, 2004a; Simmonds and Bristow, 2007a). Sediments in the upper banks and streambeds varied from boulders to fine silt, and lower banks were composed of sand and fine silt (FRC Environmental, 2009a). Organic matter made up between 5–27.5% of the sediment in pools, runs and riffle habitats (Telfer, 1995).

4.1.1.6 Instream habitat

Habitat types found in the upper Dawson River included gravel, cobbles, submerged logs and undercut banks (Simmonds and Bristow, 2007a). Logs, branches, leaves and twigs provided in-stream cover (see Plate 4-3). Stream cover was provided by forest canopy, vegetation overhang, root overhang and bank overhang. Good riparian cover in the Upper Dawson River Sub-catchment is the major factor in the provision of in-stream habitat in this sub-catchment. Conversely, the poor riparian cover in the southern tributaries was believed to have reduced the supply of vegetative debris, contributing to impacted aquatic habitat. Most watercourses in the GFD Project area are ephemeral or temporary, and instream habitat provided by the presence of surface water was highly variable at a number of locations in the upper Dawson River (Simmonds and Bristow, 2007a). This is consistent with the findings of the 2009 EIS surveys, which found habitat of moderate to good condition in the Dawson River, and poorer habitat in many of the smaller waterways (FRC Environmental, 2009a). Similarly, aquatic habitats in the sub-catchments were mostly rated good to very good (52%) in the Upper Dawson River Sub-catchment and poor to very poor in the southern tributaries sub-catchment (69%) by the State of the Rivers assessment (Telfer, 1995).

4 Description of existing environment

Plate 4-3 Overhanging vegetation, branch pile and undercut banks at Hutton Creek

Source: GLNG Project EIS survey

4.1.2 Aquatic flora

Of the 3,776 known plant species within the Fitzroy River Basin, 173 are wetland indicator species (DERM, 2012b) that is, macrophyte species that naturally occur and reproduce in wet conditions (DERM, 2012a).

Twenty-seven aquatic flora species have been recorded across the Dawson River catchment in recent investigations. During the Nathan Dam and Pipelines EIS studies of the Dawson River and tributaries, 10 species of aquatic flora was recorded at 7 locations, with species richness at locations varying greatly, ranging from 0 to 8 species. Aquatic plants were emergent (non-free floating or submerged species) (FRC Environmental, 2007). During the Wandoan Coal Project EIS, nine aquatic flora species were identified, with species richness ranging from one to six species. The most abundant and common aquatic plant was *Juncus usitatus* (common rush) (FRC Environmental, 2009b), which is consistent with the 2009 EIS field survey (FRC Environmental, 2009a).

Exotic species such as reed sweetgrass (*Glyceria maxima*), awnless barnyard grass (*Echinochloa colona*) and curled dock (*Rumex crispus*) are known in the catchment and may be present in the GFD Project area.

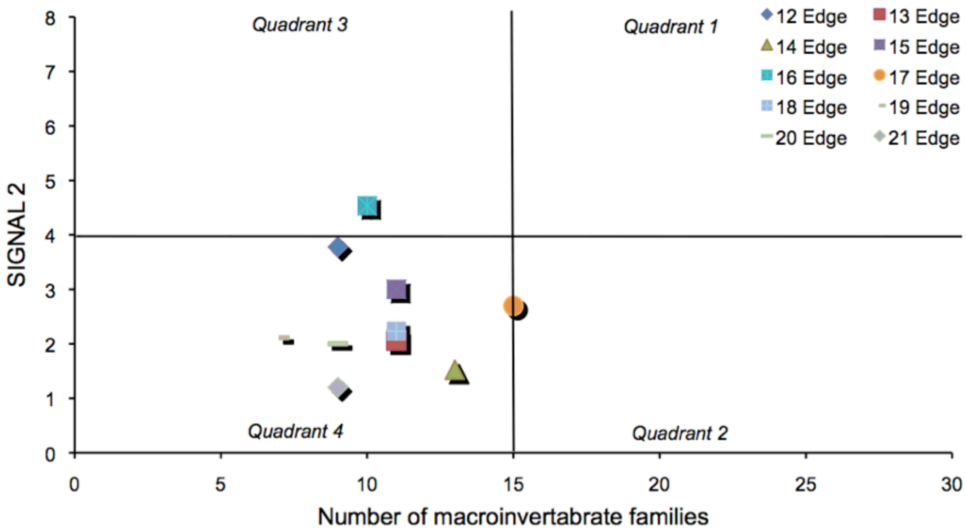
No listed threatened species were recorded in the Dawson River catchment during the EIS surveys for the Nathan Dam and Pipelines Project, the Australia Pacific LNG Project or the Wandoan Coal Project (FRC Environmental, 2007 and 2009b; Hydrobiology, 2009). However, salt pipewort (*Eriocaulon carsonii*), listed as endangered under the EPBC Act and Nature Conservation (Wildlife) Regulation, and artesian milfoil (*Myriophyllum artesium*), listed as endangered under the Nature Conservation (Wildlife) Regulation, have been recorded in springs in the Dawson River catchment. Flowing or active mound springs are critical to the survival of salt pipewort and artesian milfoil (Fensham *et al.*, 2004). Springs have been recorded within some of the GFD Project area tenures (Section 4.1.7).

4.1.3 Macroinvertebrates

During the 2009 EIS surveys, macroinvertebrate richness was typically low in the locations surveyed in the Dawson River catchment; mean richness in edge, bed and riffle habitats was 10.5, 5.4 and 8.5

taxa respectively (FRC Environmental, 2009a). Plectoptera, ephemeroptera, and tricoptera (PET) richness ranged from 0 to 3 at most locations and was generally indicative of poor to moderate habitat and water quality. However, PET richness on the upper Dawson River was 4 in edge and riffle habitat, which was indicative of good water and / or habitat quality. This is consistent with river health assessments of the Upper Dawson River Project (e.g. Envirotest, 2004a; 2005a; 2005b; 2006a; 2006b; Simmonds and Bristow, 2007a), which found relatively high PET Richness at locations in the upper Dawson River. Communities were generally within Quadrant 4 of the Stream Invertebrate Grade Number — Average Level (SIGNAL) 2 / family bi-plot and were indicative of impacts from surrounding landuses, although locations on the upper Dawson River were in Quadrant 3 (Figure 4-2), which is often indicative of toxic pollution or harsh physical conditions (Chessman, 2003). This may reflect the harsh environment of ephemeral or intermittent waterways in western Queensland.

Figure 4-2 SIGNAL 2 / family bi-plot for edge habitat at locations surveyed in the Dawson River catchment



Source: URS, 2009

During the Wandoan Coal Project EIS, non-biting and phantom midge larvae (sub-family Chironominae, Tanypodinae and Chaoboridae), diving beetles (family Dytiscidae) and water bugs (family Corixidae) dominated the macroinvertebrate communities (FRC Environmental, 2009b). These taxa are tolerant of a range of environmental conditions and are common in systems with poor or degraded water quality and / or habitat (Chessman, 2003). Richness in the dry season ranged from 7 and 18 taxa in edge habitat and 2 to 15 taxa in bed habitat. PET richness was low and indicative of a degraded environment. The communities were in Quadrant 4 of the SIGNAL 2 bi-plot, which is indicative of urban or agricultural pollution (Chessman, 2003).

A summary of macroinvertebrate investigations undertaken to date (detailed in FRC Environmental, (2009a) suggest the macroinvertebrate communities of the Dawson River tend to be diverse and contain more taxa that are sensitive to pollution and disturbance than the communities of ephemeral and intermittent waterways in the GFD Project area. The Dawson River has permanent water, and therefore offer more stable habitat for macroinvertebrates. In contrast, the communities in ephemeral creeks are influenced by harsh physical conditions, such as the drying of pools and subsequent die back of aquatic vegetation.

At the Dawson River at Taroom (approximately 4 km east of ATP 803), taxonomic richness was between 17 and 32 individuals in edge habitat and between 7 and 25 individuals in pool habitat (sandy and rocky) from 1994 to 2004. PET richness was between one and six individuals in edge and pool habitats. Macroinvertebrate communities in edge habitat in the Dawson River were within quadrants one and two of the family bi-plot, indicating that there was generally good water and habitat quality in the Dawson River at Taroom, although water quality sometimes had high nutrient or salinity levels (which may be natural). Macroinvertebrate communities in bed habitat in the Dawson River were within quadrants two and four, which may be indicative of some anthropogenic impacts to this system.

Temporal variation in macroinvertebrate taxonomic richness is reported for locations in the upper Dawson River (e.g. Simmonds and Bristow: 2007a; 2007b; 2008a; 2008b; 2010a; 2010b; 2011; URS, 2013a). Periods when taxonomic richness is relatively low may be associated with natural variation in habitat conditions between seasons or between years with different rainfall patterns. In years with less rainfall the available surface water is reduced, pools may become isolated or dry completely, and natural changes to water quality may represent stressors to aquatic fauna. Periods when taxonomic richness is relatively high are likely to be associated with an improvement in habitat and water quality characteristics, and recolonisation by macroinvertebrates.

Macrocrustaceans such as freshwater shrimp (family Atyidae), the freshwater prawn (*Macrobrachium australiense*), the freshwater crab (*Austrothelphusa transversa*) and the freshwater yabby (*Cherax destructor*) are known in the catchment (FRC Environmental, 2007, 2009a, 2009b; Simmonds and Bristow 2007a, 2012).

4.1.4 Fish

Twenty-three species from 15 families have been recorded in the Dawson River catchment, out of a known 27 species from 18 families in the Fitzroy Basin (Table 4-1). Of these species, 11 have been recorded during the 2009 EIS and more recent surveys of the GLNG Project gas transmission pipeline (Table 4-1). No listed threatened species are known from the Dawson River catchment. Two of the known species in the catchment are non-indigenous, exotic species:

- Goldfish (*Carassius auratus*)
- Mosquito fish (*Gambusia holbrooki*).

Table 4-1 Fitzroy Basin fish species with known presence in Dawson River catchment

Family *Species*	Common name	Known presence	GLNG Project survey
Ambassidae			
Ambassis agassizii	Agassiz's glassfish	✓	✓
Anguillidae			
Anguilla reinhardtii	Long-finned eel	×	×
Antherinidae			
Craterocephalus stercusmuscarum	Fly-specked hardyhead	✓	✓
Apogonidae			
Glossamia apron gillii	Mouth almighty	✓	×
Ariidae			
Arius graeffei	Fork-tailed catfish	✓	×

4 Description of existing environment

Family *Species*	Common name	Known presence	GLNG Project survey
Belonidae			
Strongylura kreftii	Freshwater longtom	✓	×
Centropomidae			
Lates calcarifer	Barramundi	×	×
Clupeidae			
Nematolosa erebi	Bony bream	✓	✓
Cyprinidae			
Carassius auratus [a]	Goldfish	✓	✓
Eleotridae			
Hypseleotris compressa	Empire gudgeon	✓	×
Hypseleotris spp.	Carp gudgeon	✓	✓
Mogurnda adspersa	Purple spotted gudgeon	✓	×
Oxyeleotris lineolatus	Sleepy cod	✓	×
Philypnodon grandiceps	Flathead gudgeon	✓	×
Gobiidae			
Redigobius bikolanus	Speckled goby	×	×
Melanotaeniidae			
Melanotaenia splendida splendida	Eastern rainbowfish	✓	✓
Osteoglossidae			
Scleropages leichardti	Southern saratoga	✓	–
Percichthyidae			
Macquaria ambigua oriens	Golden perch	✓	✓
Plotosidae			
Neosilurus hyrtlii	Hyrtl's tandan	✓	×
Porochilus rendahli	Rendahl's catfish	✓	×
Tandanus tandanus	Freshwater catfish	✓	×
Poecillidae			
Gambusia holbrooki [b]	Mosquito fish	✓	✓
Pseudomugilidae			
Pseudomugil signifer	Pacific blue eye	✓	✓
Terapontidae			
Amniataba percoides	Banded grunter	✓	×
Hephaestus fuliginosus	Sooty grunter	×	×
Leiopotherapon unicolor	Spangled perch	✓	✓
Scortum hillii	Leathery grunter	✓	✓

Source data: Berguis & Long, 1999; FRC Environmental, 2004, 2007, 2009a, 2009b and 2012; Ecowise, 2008; Marsden & Power, 2007
✓ present; × not present; a - exotic non-indigenous species; b - exotic non-indigenous species, declared noxious under the *Fisheries Regulation 2008*

During the 2009 EIS surveys, species richness of fish in the Dawson River catchment ranged from zero to six species at each location surveyed (FRC Environmental, 2009a). This is a similar result to the Wandoan Coal Project EIS surveys in 2008 and 2009 (FRC Environmental, 2009b). A greater number of species (19) were recorded during surveys of the Dawson River and its major tributaries for the Nathan Dam and Pipelines EIS (FRC Environmental, 2007; Ecowise, 2008). This is likely to be due to the greater number of locations surveyed on the Dawson River during this study. It is expected that the perennial Dawson River supports a greater diversity and abundance of fish than the ephemeral streams in the GFD Project area.

4.1.5 Turtles

The Fitzroy River Basin has a high conservation value with respect to freshwater turtles, as there are many species endemic to the region. Six species have been recorded in the Fitzroy River Basin, with all six also having been recorded in the Dawson River catchment (Limpus *et al.*, 2007):

- *Chelodina expansa* (broad-shelled river turtle)
- *Chelodina longicollis* (snake-necked turtle)
- *Elseya albagula* (white-throated snapping turtle)
- *Emydura macquarii krefftii* (Krefft’s river turtle)
- *Rheodytes leukops* (Fitzroy river turtle)
- *Wollumbinia latisternum* (saw-shelled turtle).

The Krefft’s river turtle and white-throated snapping turtle were caught in the upper Dawson River catchment during the 2009 EIS surveys (FRC Environmental, 2009a). Krefft’s river turtles were also caught in the Dawson River for the Nathan Dam EIS surveys, and in farm dams in the Wandoan region during the Wandoan Coal Project EIS (FRC Environmental, 2007 and 2009b). It is possible that the species listed above occur within the parts of the GFD Project area that are in the Dawson River catchment.

4.1.6 Other aquatic vertebrates

Platypus (*Ornithorhynchus anatinus*) are found in freshwater streams, rivers, lakes and water storages with a preference for steep, well vegetated banks for burrowing (Menkhorst & Knight, 2004). Platypus has been recorded in the region, and local residents of Taroom have reported platypus in the upper Dawson River. However, no evidence of platypus was observed in the recent EIS surveys undertaken in the region (Aquateco, 2011; BAAM, 2009; FRC Environmental, 2009a; 2009b); and it is unlikely that they would inhabit ephemeral streams in the area. However, they may be present in more permanent watercourses in the region, such as the Dawson River and Comet River; and possibly springs and wetlands. Platypus burrows were identified at Hutton Creek in the upper Dawson River during the surveys undertaken for the pipeline component of the GLNG Project (FRC Environmental, 2012b).

4.1.7 Springs

Eleven spring complexes feed 45 spring vents within GFD Project tenures in the Dawson River catchment (Table 4-2). Of these, only complex 230 (Lucky Last), with 12 vents, and complex 591 (Yebna2), with one vent are considered part of the EPBC Threatened Ecological Community (TEC) *The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin*. The EPBC Act-listed aquatic plant salt pipewort (*Eriocaulon carsonii*) has been recorded at the Lucky Last complex and the nearby Abyss complex (592) (Fensham *et al*., 2011). The presence of an EPBC Act-listed plant species does not necessarily mean the spring is part of the EPBC Threatened Ecological Community (TEC) *The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin*.

Some Boggomoss springs on the Dawson River support the critically endangered (EPBC Act) Boggomoss snail (*Adclarkia dawsonensis*) (Stanisic, 1996). Extensive targeted surveys for the Boggomoss snail were undertaken as a part of this GFD Project EIS within tenures ATP 803 and PL 176. Boggomoss snails were not found during the surveys.

Ratings of spring condition vary within the catchment from very good to very poor. Livestock impacts are the main factor affecting condition ratings (Fensham *et al*., 2004; refer to Plate 4 4). FRC Environmental (2009a) noted that the condition of artesian springs in the Upper Dawson catchment varied considerably between the springs surveyed, with the state of each spring largely dependent on the presence of water, the ability of stock to gain access to the spring, and the presence and abundance of terrestrial weeds.

Four watercourse springs are found within GFD Project tenures in the Dawson River catchment (Note: the presence of an EPBC Act-listed species does not necessarily infer that the spring conforms to the EPBC TEC The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin

Plate 4-4 Cattle damage at vent 340 of the Lucky Last Complex

Source: URS

Table 4-2 Artesian springs in GFD Project tenures within the Dawson River catchment

Spring complex	Complex name	Spring vent	EPBC-listed community	Values	Tenure
229	Ponies	284	No	Isolated population - *Myriophyllum gracile* var. *lineare*, *Eriocaulon athertonense*	PL 100
230	Lucky Last	287, 340, 686, 687, 687.1, 687.2, 687.3, 687.4, 687.5, 687.6, 688, 689	Yes	Listed species - *Eriocaulon carsonii*	PL 99
307	Elgin	x381	No	-	ATP 562P
311	311	499, 500, 500.1, 537, 692, 695, 696, 697, 698, 699, 704	No	Isolated population - *Isachne globosa*	PL 232
		535, 536, 536.1, 536.2, 693, 694, x431	No		PL 100
327	327	nv385	No	-	PL 90
561	Spring Rock Creek	285	No	-	PL 99
583	Lenore Hills	nv621	No	-	ATP 526P
591	Yebna 2	534	No	-	PL 232
592	Abyss	286, 286.1, 286.2, 286.3	No	Listed species - *Eriocaulon carsonii*	PL 99

Note: the presence of an EPBC Act-listed species does not necessarily infer that the spring conforms to the EPBC TEC The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin

Table 4-3 Watercourse springs in GFD Project tenures within the Dawson River catchment

Site number	River / Reach	Tenure
W14	Bungaban Creek	PL 176
W40	Dawson River (Cen)	PL 232
W81	Hutton Creek	PL 100
W82	Dawson River	PL 99

4.2 Comet River catchment

4.2.1 Aquatic habitat

The larger watercourses in the catchment, including the Comet River, contain perennial waterbodies isolated by dry river channels during the dry season. During the wet season, flow is dominated by intermittent high flow events in response to rainfall. Smaller watercourses are typically intermittent or ephemeral although wetlands and springs also provide some perennial aquatic habitat (as mapped in the EHP *Wetlands Mapping Program*). Key water courses in the Comet River catchment include:

- Comet River
- Springsure Creek
- Humboldt Creek
- Planet Creek
- Meteor Creek
- Clematis Creek
- Brown River.

Wetlands within the Comet River catchment portion of the GFD Project area (Figure 4-3) include:

- ATP 804 contains eight lacustrine wetlands, a mapped waterhole (Scrubber's waterhole) and two springs (Middle and Mud springs; i.e. springs 551 and 552)
- ATP 745 contains 11 lacustrine wetlands and 2 palustrine wetlands.

None of these wetlands are mapped as high ecological value (referrable) wetlands in the Great Barrier Reef catchment. The conservation value of wetlands in the catchment ranges from very low to very high, though the majority are of moderate conservation value (DERM, 2009a).

Overall, streams in the Comet River catchment were regarded to be in moderate to poor condition during the State of the Rivers survey, with 54% of stream in the eastern tributaries sub-catchment rated as poor (ratings for most categories were very low, and the bed and bank habitats were very unstable) (Henderson, 2000). Similarly, aquatic habitat in the 2009 EIS surveys was considered to be in poor to moderate condition (FRC Environmental, 2009a). Streams in the catchment range in conservation value from low to very high; however, the majority of streams are of moderate conservation value (DERM, 2009b).

4.2.1.1 Reach environment

In the State of the Rivers survey, 60% of streams in the eastern tributaries sub-catchment were subject to high, very high or extreme disturbance. The most common form of disturbance was grazing with some influence from man-made structures such as unformed track crossings, culverts, roads and water extraction infrastructure (Henderson, 2000). This is consistent with the surveys done for the 2009 EIS (FRC Environmental, 2009a) and discharge options projects (URS, 2009d).

4.2.1.2 Substrate composition

Substrates in the Comet River catchment are dominated by fine sediments, with larger sediment types found intermittently (FRC Environmental, 2009a; Henderson, 2000).

4.2.1.3 Riparian vegetation and adjacent land use

Riparian vegetation including grasses such as kangaroo grass (*Themeda triandra*), medium and small trees [*Eucalyptus* spp., *Melaleuca* spp., *Acacia* spp., *Casuarina* spp. and brigalow (*Acacia harpophylla*)], shrubs and rushes (such as *Lomandra* spp.) were identified during the State of the Rivers survey (Henderson, 2000). During the 2009 EIS surveys, grass was the dominant vegetation type, and fewer small trees and shrubs were observed (FRC Environmental, 2009a).

In the State of the Rivers survey, the majority of the riparian zones across the eastern tributaries sub-catchment were in very poor to moderate condition (72% of locations) (Henderson, 2000). Exotic grasses were recorded at 73% of locations. Exotic plants commonly observed were green panic (*Panicum maximum*), noogoora burr (*Xanthium pungens*) and parthenium (*Parthenium hysterophorus*) (Henderson, 2000). These species were present in the 2009 EIS surveys (FRC Environmental, 2009a).

4.2.1.4 Bank stability

Stream banks are generally stable or very stable, although erosion is widespread at bends (refer Plate 4-5), obstacles and seepage points. Aggradations are prominent at bends and obstacles at some locations (Henderson, 2000). The major factor influencing stability is the presence of stock in the riparian zone; although runoff, water flow and clearing of vegetation are also common factors (FRC Environmental, 2004, 2009a; Henderson, 2000).

Plate 4-5 Meteor Creek bend – eroded bank impacted by cattle access

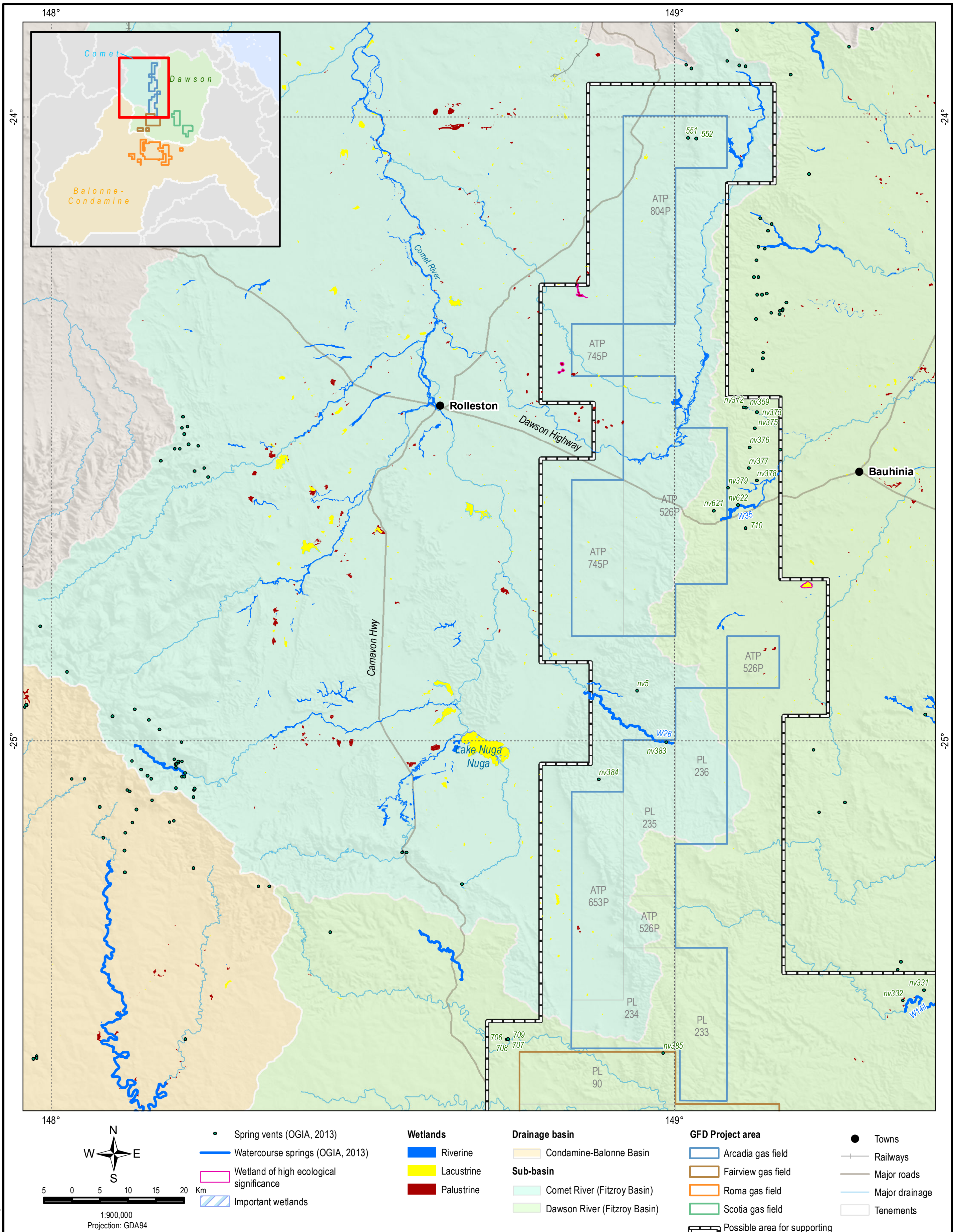
Source: FRC Environmental, 2004

4.2.1.5 Channel diversity

Pools across the sub-catchments consisted mainly of silt, while runs contained both silt and sand, and riffles were comprised mostly of larger particles (Henderson, 2000). Organic matter made up between 5 and 26% of streambed sediment in pools, runs and riffles (Henderson, 2000). The State of the Rivers survey found channel habitat diversity to be low or very low, with pools and runs the most prevalent habitat types (Henderson, 2000). More recent surveys completed by Santos GLNG confirmed these results (FRC Environmental, 2009a).

4.2.1.6 In-stream habitat

Logs, branches, leaves, twigs and tree roots were the most widespread forms of in-stream habitat. Poor riparian vegetation likely reduced the supply of vegetative debris, resulting in poor aquatic habitat (Henderson, 2000). During the State of the Rivers assessment, aquatic habitat was rated as being in poor or very poor condition at the majority of locations (Henderson, 2000). Aquatic habitat was also poor at most locations in the 2009 EIS surveys, although the larger streams, such as the lower Comet River, supported a moderate amount of aquatic habitat (FRC Environmental, 2009a).



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WETLANDS AND WATERHOLES WITHIN THE COMET RIVER CATCHMENT

URS

AQUATIC ECOLOGY

Figure: 4-3

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4.2.2 Aquatic flora

The State of the Rivers assessment (Henderson, 2000), mostly rated the aquatic vegetation communities of the Comet River catchment as very poor. This likely reflects the high turbidity levels at the time of survey, which prevented an accurate assessment at many locations; turbidity was considered too high to accurately estimate cover at 18% of locations. Aquatic vegetation that was recorded in the Comet River catchment included the emergent common reed (*Phragmites australis*), free-floating water fern *(Azolla* spp.) and submerged *Blyxa* spp. These species are common throughout the Fitzroy Basin.

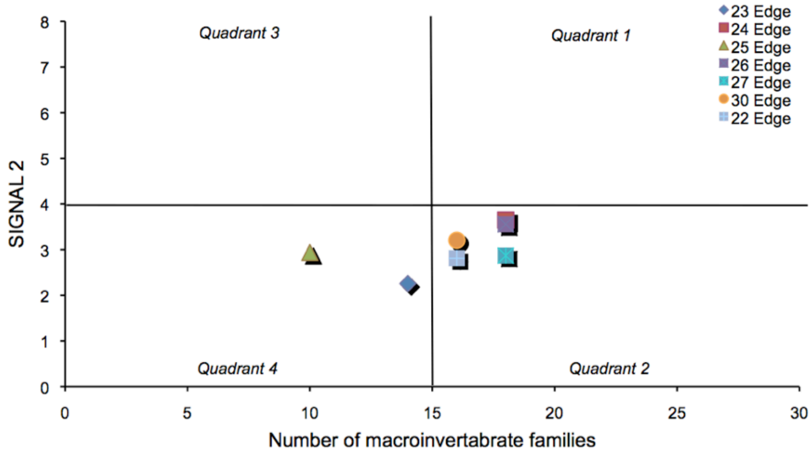
During the 2009 EIS surveys, 15 species of aquatic plant were recorded at locations in the Comet River catchment (FRC Environmental 2009a). Exotic species such as reed sweetgrass (*Glyceria maxima*), awnless barnyard grass (*Echinochloa colona*) and curled dock (*Rumex crispus*) are known from the catchment and may be present in the GFD Project area (FRC Environmental 2009a), though none of these are weeds of national significance. Other exotic aquatic plants have also been recorded in the Fitzroy River Basin (detailed in Appendix B), but were not observed during recent EIS surveys (e.g. Rolleston Coal Project EIS, Rolleston Expansion project EIS and 2009 EIS) in the vicinity of the GFD Project area (FRC Environmental, 2004, 2009a, 2012b).

No listed threatened species were recorded in the Comet River catchment during the EIS surveys for the 2009 GLNG Project or Rolleston Project, or during the detailed survey of watercourse crossings for the GLNG Project gas transmission pipeline (FRC Environmental, 2004, 2009a, 2012b).

4.2.3 Macroinvertebrates

During the 2009 EIS surveys, macroinvertebrate richness in the Comet River ranged from 0 to 18 taxa and was higher than in the Dawson River catchment. Edge habitats of Carnarvon Creek and the Comet River had the highest richness of all edge habitats surveyed across the GFD Project area (FRC Environmental, 2009a). Mean richness in edge and bed habitats in the Comet River catchment was 15.7 and 9.7 taxa, respectively. PET richness ranged from 0 to 4 per location, but was generally between 2 and 4 and indicative of moderate water and habitat quality. Communities were within Quadrants 2 and 4 of the SIGNAL 2 / family bi-plot (Figure 4-4). Quadrant 2 can indicate the presence of high salinity or nutrient levels, but these locations are interpreted as being less impacted than other locations in Quadrant 4.

Figure 4-4 SIGNAL 2 / family bi-plot for edge habitat at locations surveyed in the Comet River catchment



Source: URS, 2009

The Queensland Department of Natural Resources and Mines (DNRM) sampled macroinvertebrates from the Comet River catchment in the vicinity of the GFD Project, between 1995 and 1998. This sampling (data provided by DNRM) included the survey of edge habitats on the Brown River (approximately 5 km west of ATP 745) between 1998 and 1999, and surveys of edge and bed habitats on the Comet River (approximately 35 km west of ATP 745 and ATP 804) between 1995 and 1999. In general, these surveys found a higher taxonomic and PET richness than the 2009 EIS surveys, which may be related to different climatic conditions during the surveys (the 2009 EIS surveys were undertaken during the dry season and during a drought period), and / or location-specific differences in habitat and water quality. Most locations were in Quadrant 2 of the SIGNAL 2 / family bi-plot, which is indicative of high nutrient and / or salinity levels, which may be natural.

Macrocrustaceans such as freshwater shrimp (family Atyidae), the freshwater prawn (*Macrobrachium australiense*), the freshwater crab (*Austrothelphusa transversa*) and the freshwater yabby (*Cherax destructor*) are known from the catchment (FRC Environmental, 2004, 2009a; data provided by DNRM).

4.2.4 Fish

Fourteen species from eight families have been recorded in the Comet River catchment, out of a known 27 species from 18 families in the Fitzroy River Basin (Table 4-4). Of these species, nine have been recorded during the 2009 EIS and more recent surveys of the GLNG Project gas transmission pipeline (FRC Environmental, 2009a, 2012b). No listed threatened species are known from the Comet River catchment. Two of the known species in the catchment are non-indigenous, exotic species:

- Goldfish (*Carassius auratus*)
- Mosquito fish (*Gambusia holbrooki*).

Table 4-4 Fitzroy Basin fish species and their occurrence in the Comet River catchment

Family species	Common name	Known presence	GLNG Project surveys
Ambassidae			
Ambassis agassizii	Agassiz's Glassfish	✓	✓
Anguillidae			
Anguilla reinhardtii	Long-Finned Eel	×	×
Antherinidae			
Craterocephalus stercusmuscarum	Fly-Specked Hardyhead	✓	✓
Apogonidae			
Glossamia apron gillii	Mouth Almighty	×	×
Ariidae			
Arius graeffei	Fork-Tailed Catfish	×	×
Belonidae			
Strongylura kreftii	Freshwater Longtom	×	×
Centropomidae			
Lates calcarifer	Barramundi	×	×
Clupeidae			
Nematolosa erebi	Bony Bream	✓	✓
Cyprinidae			
Carassius auratus [a]	Goldfish	×	×
Eleotridae			
Hypseleotris compressa	Empire Gudgeon	✓	×
Hypseleotris spp.	Carp Gudgeon	✓	✓
Mogurnda adspersa	Purple Spotted Gudgeon	✓	✓
Oxyeleotris lineolatus	Sleepy Cod	✓	×
Philypnodon grandiceps	Flathead Gudgeon	×	×
Gobiidae			
Redigobius bikolanus	Speckled Goby	×	×
Melanotaeniidae			
Melanotaenia splendida splendida	Eastern Rainbowfish	✓	✓
Osteoglossidae			
Scheropages leichardti	Southern Saratoga	×	×
Percichthyidae			
Macquria ambigua oriens	Golden Perch	✓	✓
Plotosidae			
Neosilurus hyrtlii	Hyrtl's Tandan	✓	×
Porochilus rendahli	Rendahl's Catfish	✓	×
Tandanus tandanus	Freshwater Catfish	✓	✓
Poecillidae			
Gambusia holbrooki [b]	Mosquito fish	×	×
Pseudomugilidae			
Pseudomugil signifer	Pacific Blue Eye	×	×

Family species	Common name	Known presence	GLNG Project surveys
Terapontidae			
Amniataba percoides	Banded Grunter	×	×
Hephaestus fuliginosus	Sooty Grunter	×	×
Leiopotherapon unicolor	Spangled Perch	✓	✓
Scortum hillii	Leathery Grunter	✓	×

Sources Berguis & Long 1999; FRC Environmental 2004, 2007, 2009a, 2009b and 2012; Ecowise 2008; Marsden & Power 2007

✓ present; × not present; a - exotic non-indigenous species; b - exotic non-indigenous species, declared noxious under the *Fisheries Regulation 2008*

4.2.5 Turtles

As stated in Section 4.1.5, six species of turtles have been recorded across the Fitzroy River Basin. Two species of turtle; *Emydura krefftii* (Krefft's river turtle) and *Elseya albagula* (white–throated snapping turtle) were recorded in the 2009 EIS surveys (FRC Environmental, 2009a) (Plate 4-6 and Plate 4-7). It is likely that turtles exist in other parts of the Comet River catchment.

Plate 4-6 Adult female Krefft's river turtle - Lake Nuga Nuga in the Comet River catchment

Source: URS, 2009

Plate 4-7 Adult female white-throated snapping turtle - Carnarvon Creek in the Comet River catchment

Source: URS, 2009

4.2.6 Springs

Two spring complexes comprising three vents are present within the GFD Project tenures in the Comet River catchment; complex 78, vents 551 and 552 and complex 308, vent nv383. Neither complex corresponds to the EPBC Act-listed TEC *Community of native species dependant on natural discharge of groundwater from the GAB.* The spring vents located within the Comet River catchment and relevant GFD Project tenures are listed in Table 4-5. Fensham *et al.* (2011) notes that complex 78 fits into conservation ranking Category 3: Spring wetland vegetation without isolated populations (Category 2) with at least one native plant species that is not a widespread coloniser of disturbed areas. No information is available for Complex 308.

One section of a watercourse spring is located within the GFD Project tenures in the Comet River catchment; W26 located on GFD Project tenure PL 235.

Table 4-5 Artesian springs within the GFD Project tenements in the Comet River catchment

Spring complex	Spring vent	EPBC-listed community	Tenure
78	551, 552	No	ATP 804P
308	nv383	No	PL 235

Table 4-6 Watercourse springs within the GFD Project tenements in the Comet River catchment

Site number	River / Reach	Tenure
W26	Clematis Creek	PL 235

4.3 Condamine-Balonne River catchment

4.3.1 Aquatic habitat

The Condamine River originates in the Great Dividing Range and flows into the Balonne River at its confluence with Dogwood Creek, approximately 60 km east of the town of Surat. The Balonne River flows into the Culgoa River north of the township of Dirranbandi, which joins the Darling River at the town of Burke. The Condamine-Balonne River catchment covers 13% of the Murray-Darling Basin (CSIRO, 2008).

The larger watercourses in the catchment, including the Condamine River, have perennial waterbodies and an intermittent flow regime. Smaller watercourses are likely to be intermittent or ephemeral waterbodies with an ephemeral flow regime. Key watercourses identified in the Condamine-Balonne River catchment include:

- Balonne River
- Dogwood creek
- Tchanning Creek
- Dulacca Creek
- Paddy Creek
- Yuleba Creek
- Wallumbilla Creek
- Blythe Creek
- Bungil Creek
- Amby Creek
- Eurella Creek
- Washpool Creek.

Wetlands and springs also provide perennial aquatic habitat (as mapped in the EHP *Wetlands Mapping Program*). Wetlands within the Condamine-Balonne River catchment portion of the GFD Project area (Figure 4-5) include:

- ATP 631 contains five lacustrine wetlands, five palustrine wetlands, and no riverine Regional Ecosystems
- ATP 665 contains ten lacustrine wetlands, as well as two mapped waterholes (Wallaby and Bundaberg waterholes), no palustrine wetlands, and one riverine Regional Ecosystem
- PL 10 contains four lacustrine wetlands, one palustrine wetland, and one riverine Regional Ecosystem
- PL 11 contains two lacustrine wetlands, and no palustrine wetlands or riverine Regional Ecosystems
- ATP 708 contains seven lacustrine wetlands, one palustrine wetland, five springs, and three riverine Regional Ecosystems.

Wetlands within the Condamine-Balonne River catchment were classified as being of moderate conservation value using the AquaBAMM methodology, although several wetlands near Roma were of high conservation value (DERM, 2011a).

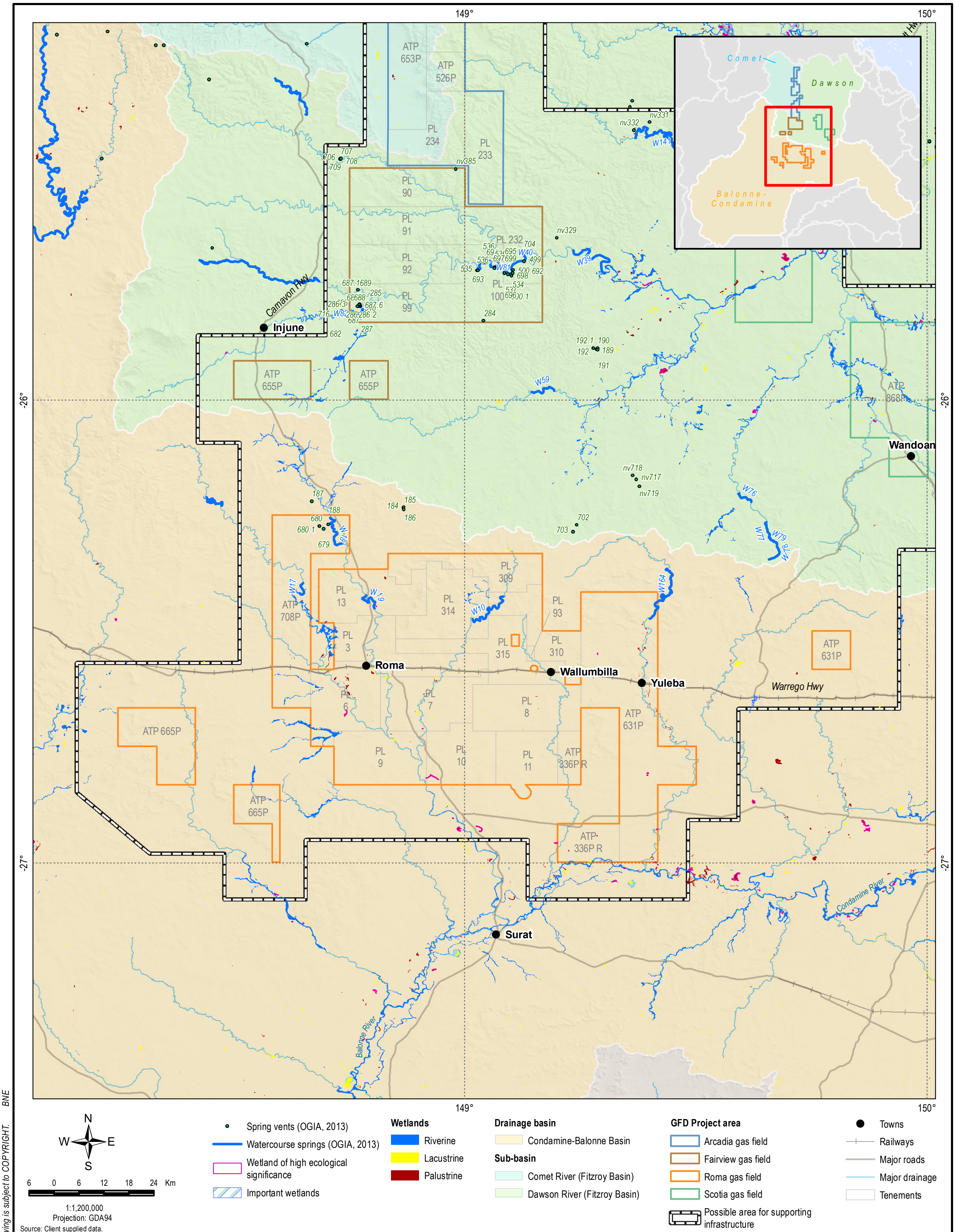
The waterways in the catchment carry large flood flows and during flood events instream habitat is altered due to scouring, sediment transport, erosion and the deposition of material such as large woody debris; i.e. instream habitat is not constant over time (EECO, 2009). Of the locations surveyed in the Condamine sub-catchment in the State of the Rivers assessment:

- 29% had low disturbance (intact vegetation on both sides of the stream, with minor disturbance from introduced species)
- 26% were moderately disturbed (cleared on one side of the stream, but native vegetation on the other side undisturbed)
- 45% were highly to extremely disturbed (vegetation on one side of the stream was completed cleared, and vegetation on the other side was highly disturbed or had a significant weed presence) (Van Manen, 2001).

In the Upper Balonne sub-catchment:

- 8% of locations had low disturbance
- 34% were moderately disturbed
- 53% were highly or very highly disturbed (Van Manen, 2001).

Waterways within the GFD Project area were classified as being in moderate condition using the AquaBAMM methodology (DERM, 2011a).



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WETLANDS AND WATERHOLES WITHIN THE CONDAMINE-BALONNE RIVER CATCHMENT

URS

AQUATIC ECOLOGY

Figure: 4-5

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4.3.1.1 Reach environment

Major land uses identified (e.g. grazing and cropping) were considered to contribute significantly to the disturbance of the reach environments, with roads, bridges or culverts (refer Plate 4-9), and water extraction also being significant disturbance factors (Van Manen, 2001; Phillips and Moller, 1995). In the State of the Rivers survey, the reach environments of most stream lengths in the Condamine-Balonne River catchment were considered to be in very poor to moderate condition, although they were considered to be good in forested areas. This is consistent with the findings of the AquaBAMM assessment, where most streams had a medium conservation value, but streams in forested areas had a high or very high conservation value (DERM, 2011a). During the 2009 EIS surveys, erosion at road crossings was a major form of disturbance at many locations across the GFD Project area (FRC Environmental, 2009a).

Plate 4-8 Unformed crossings act as a physical barrier to water flows and aquatic passage during periods of very low flow

Source: FRC Environmental, 2009a

Plate 4-9 Obstructions upstream of the box culverts on Wallumbilla Creek likely to restrict the passage of aquatic fauna.

Source: FRC Environmental, 2009a

4.3.1.2 Substrate composition

Substrates in the waterways of the Condamine-Balonne River catchment were comprised mostly of sand and silt/clay, although larger sediments such as gravel, pebbles and cobble and boulders are present in some streams (FRC Environmental, 2009a, 2012a; Hydrobiology, 2009).

4.3.1.3 Riparian vegetation and adjacent land use

Riparian vegetation includes trees, shrubs, vines, rushes, grasses, and mosses. Native species recorded during the State of the Rivers surveys included: *Eucalyptus* spp., cypress pines (*Callitris* spp.), *Lomandra* spp., *Acacia* spp., *Casuarina* spp. and *Melaleuca* spp. (Van Manen, 2001; Phillips and Moller, 1995). Eucalypt trees dominate the riparian zone of the lower Balonne River, with low to moderate disturbance (EM, 2004). Most riparian zones in the sub-catchments were in poor or very poor condition (68% of the Condamine River and 88% of the Upper Balonne River sub-catchments, respectively), due to agricultural clearing and grazing.

Weed species were recorded from 88% of locations; these were mostly exotic grasses and herbs, including Mayne's pest (*Verbena tenuisecta*) and prickly pear (*Opuntia* spp.) (Van Manen, 2001; Phillips and Moller, 1995). However, riparian condition was better at locations located within forested areas (Van Manen, 2001).

These findings are consistent with the surveys done for the 2009 EIS, where riparian zones within the GFD Project area are generally 10–30 m wide (FRC Environmental, 2010a). Native riparian vegetation was found to be mostly cleared with farmlands and grazing pastures growing right up to the creek.

4.3.1.4 Bank stability

Stock access, scouring from water flows, and clearing of vegetation negatively affected bank stability throughout the sub-catchments (Van Manen, 2001). Bank erosion was noted at most locations, as was some aggradation at bends and obstacles. Stream banks at 85% of locations surveyed in the Condamine River Sub-catchment were rated as being stable or very stable; 58% of stream banks in the Upper Balonne River Sub-catchment were rated as being in a stable to very stable condition. This is consistent with the surveys done for the 2009 EIS, where considerable erosion was observed at many survey locations (FRC Environmental, 2009a). Bank stability was found to be variable; areas with low riparian vegetation exhibited high erosion, while areas with higher levels of riparian vegetation maintained stability and exhibited lower rates of stream bank erosion.

4.3.1.5 Channel diversity

Channels generally were only comprised of two habitats: pool and riffle (Phillips & Moller, 1995). In the State of the Rivers survey, channel diversity in the upper Condamine-Balonne River catchment was poor or very poor. Channel diversity was also low in the 2009 EIS surveys where watercourses were dominated by isolated pools, although this was not un-expected as surveys were completed in the dry season.

Sediments in the upper banks and streambeds vary from boulders to fine silt. Lower banks are composed of sand and fine silt (FRC Environmental, 2009a; Van Manen, 2001).

4.3.1.6 In-stream habitat

In the State of the Rivers survey, most aquatic habitats were rated as poor or very poor (91% of the Condamine River and 69% of the Upper Balonne River respectively) (Phillips and Moller, 1995). Instream cover varied throughout the 2009 EIS survey area and included woody debris, instream vegetation, deep pools and cobbles (FRC Environmental, 2009a).

4.3.2 Aquatic flora

Of the 4,050 plant species in the Condamine-Balonne River catchment, approximately 140 are wetland indicator species. In general, aquatic plant richness and abundance is low. Emergent aquatic plants are the most common form, although submerged and floating species are also known from waterways near the GFD Project area. Recent surveys of aquatic flora in the Condamine-Balonne River catchment have confirmed the presence of 32 species.

Common aquatic plants in the catchment include:

- Common reed (*Phragmites australis*)
- Cumbungi (*Typha spp.)*
- Common rush (*Juncus usitatis*) (refer Plate 4-10)
- Azolla (*Azolla sp.)* (refer Plate 4-11)
- Knotweeds (*Persicaria spp*.)
- Sedges (family Cyperaceae) (Hydrobiology, 2009).

Eleocharis blakeana and wandering fringe-rush (*Fimbristylis vagans*) have been recorded from, or are likely to occur in the Condamine-Balonne River catchment. These species are listed as near threatened in the Nature Conservation (Wildlife) Regulation.

Eleocharis blakeana grows in ephemeral watercourses and is often associated with brigalow and belah woodland and on clay soils (Harden, 1993). Wandering Fringe-rush (*Fimbristylis vagans*) is associated with palustrine wetlands (DERM, 2011b) but may also occur in other ecosystems; other *Fimbristylis* spp. are common in pastures of central Queensland (Anderson, 1993). These species may occur in the GFD Project area, which contains both ephemeral watercourses and palustrine wetlands.

Exotic species such as umbrella sedge (*Cyperus eragrostis*), barnyard grass (*Echinochloa crus-galli*), awnless barnyard grass (*Echinochloa colona*) and para grass (*Urochola mutica*) are known from the catchment and may be present in the GFD Project area. The following exotic aquatic plants have also been recorded in the Condamine-Balonne River catchment, but were not observed during recent EIS surveys in the vicinity of the Condamine-Balonne River catchment portion of the GFD Project area (DERM, 2012a):

- Annual beardgrass (*Polypogon monspeliensis*)
- *Arundo donax*
- Buffalo grass (*Stenotaphrum secundatum*)
- Dense waterweed (*Egeria densa*)
- Jointed rush (*Juncus articulatus*)
- Salvinia (*Salvinia molesta*)
- Water hyacinth (*Eichhornia crassipes*)
- Water lettuce (*Pistia stratiotes*)
- Water parsnip (*Berula erecta*)
- Weeping willow (*Salix babylonica*)
- Yorkshire fog (*Holcus lanatus*).

Plate 4-10 ***Juncus usitatus*** **(common rush) - Condamine-Balonne River catchment**

Plate 4-11 **Free-floating Azolla sp. - Condamine-Balonne River catchment**

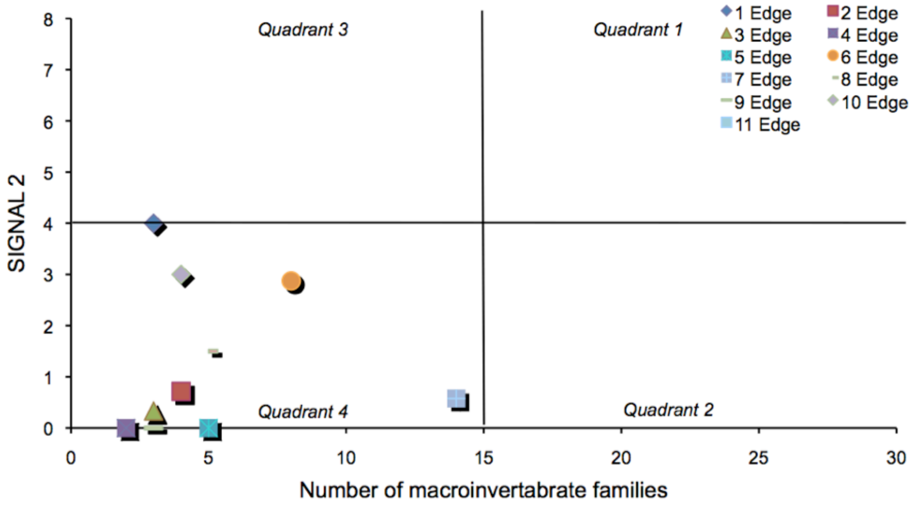
4.3.3 Macroinvertebrates

During the 2009 EIS surveys in the Condamine-Balonne River catchment, richness ranged from 0 to 16 taxa, and was higher in edge habitat than bed habitat (FRC Environmental, 2009a).

PET richness at locations surveyed in the 2009 EIS in the Condamine-Balonne River catchment ranged from 0 to 3 but was typically 1 or less. Thus, the macroinvertebrate communities reflected moderate to degraded water and habitat quality.

During the 2009 EIS surveys in the Condamine-Balonne River catchment, communities were within Quadrant 4, which indicates that these communities may be impacted by urban, industrial or agricultural pollution (and given the locality of the study locations, most likely impacts from agricultural land uses) (Figure 4-6; Chessman, 2003).

Figure 4-6 **SIGNAL 2 / family bi-plot for edge habitat at locations surveyed in the Condamine-Balonne River catchment**



Source: URS, 2009

The DNRM sampled macroinvertebrates from the Condamine–Balonne River catchment in the vicinity of the GFD Project area between 1994 and 2004. This sampling included the survey of bed and edge habitats from:

- The Balonne River at Weribone (approximately 30 km south of PL 10) between 1994 and 2004
- Bungil Creek at Tabers (approximately 13 km east of the GFD) in 1997
- Bungil Creek south of Roma (approximately 15 km east of ATP 708) in 1998
- Yuleba Creek at the Forestry Station (approximately 25 km east of ATP 631) in 1997[1].

During the DNRM surveys, the richness of macroinvertebrate communities varied over time and among locations, ranging from 16 to 26 in edge habitats and from 4 to 20 in bed habitats, which is higher than the richness recorded in the 2009 EIS. The PET richness was also higher in the DNRM surveys. However, similar to the 2009 EIS surveys, communities from many of the DNRM locations were within Quadrant 4 of the SIGNAL 2 / family bi-plot.

During the Australia Pacific LNG dry season survey of locations in the Condamine-Balonne River catchment (including locations on the Condamine River), there were between 13 and 35 taxa at each location in edge habitat (Hydrobiology, 2009). In the wet season survey, taxonomic richness in edge habitat was slightly lower, with 12 to 29 taxa at each location (Hydrobiology, 2010). In each survey, there were four PET families at two of the three locations surveyed in the Condamine-Balonne River catchment (Hydrobiology, 2009; 2010), which was indicative of good quality of water and/or habitat condition. Communities were within quadrants 2 and 4 of the bi-plot, which indicated that these communities were likely to be influenced by high turbidity and salinity, and high concentrations of nutrients, or other forms of disturbance such as urban or agricultural runoff (Hydrobiology, 2009; 2010). The findings were generally consistent with the findings of the 2009 EIS, although it appears that the perennial Condamine River supports more taxa than ephemeral watercourses.

Macrocrustaceans such as freshwater shrimp (family Atyidae), the freshwater prawn (*Macrobrachium australiense)* and the freshwater yabby (*Cherax destructor*) are known in the catchment (FRC Environmental, 2009a; Hydrobiology, 2009; 2010; data provided by DNRM).

4.3.4 Fish

Twenty-three fish species from 13 families have been recorded in the Condamine-Balonne River catchment (Table 4-7). Of these species, the Murray cod (*Maccullochella peelii peelii*) is listed as vulnerable under the EPBC Act. Four of the known species in the catchment are exotic species:

- Goldfish (*Carassius auratus*)
- Common carp (*Cyprinus carpio*) (Plate 4-12)
- Mosquito fish (*Gambusia holbrooki*)
- Guppy (*Poecilia reticulata*).

Common carp and mosquito fish are declared noxious species under the Fisheries Regulation.

[1] Based on or contains data provided by the State of Queensland. 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.

4 Description of existing environment

Plate 4-12 Adult common carp - Dulacca Creek in the Condamine-Balonne River catchment

Source: FRC Environmental, 2009a

During the 2009 EIS surveys, species richness of fish in the Condamine-Balonne River catchment ranged from zero to six species at each location surveyed (FRC Environmental, 2009a).

Table 4-7 Condamine–Balonne River catchment fish species presence GLNG Project surveys

Family *Species*	Common name	GLNG Project surveys
Ambassidae		
Ambassis agassizii	Agassiz's Glassfish	✓
Antherinidae		
Craterocephalus aciculums	Darling River Hardyhead	×
Craterocephalus stercusmuscarum	Fly-Specked Hardyhead	×
Clupeidae		
Nematalosa erebi	Bony Bream	✓
Cyprinidae		
Carassius auratus [a]	Goldfish	✓
Cyprinus carpio [a]	Common Carp	✓
Eleotridae		
Hypseleotris galii	Firetail Gudgeon	✓
Hypseleotris spp.	Carp Gudgeon	✓
Mogurnda adspersa	Purple Spotted Gudgeon	×
Philypnodon grandiceps	Flathead Gudgeon	×
Galaxiidae		
Galaxias olidus	Mountain galaxias	×
Gadopsidae		
Gadopsis marmoratus	River Blackfish	×
Melanotaeniidae		
Melanotaenia duboulayi	Crimson-Spotted Rainbowfish	×
Melanotaenia fluviatilis	Murray River Rainbowfish	×
Percichthyidae		

Family *Species*	Common name	GLNG Project surveys
Macquaria ambigua	Golden Perch	✓
Maccullochella peelii peelii	Murray Cod	×
Plotosidae		
Neosilurus hyrtlii	Hyrtl's Tandan	×
Tandanus tandanus	Freshwater Catfish	×
Poecilidae		
Gambusia holbrooki [b]	Mosquito fish	✓
Poecilia reticulata [a]	Guppy	×
Retropinnidae		
Retropinna semoni	Australian Smelt	×
Terapontidae		
Bidyanus bidyanus	Silver Perch	×
Leiopotherapon unicolor	Spangled Perch	✓

Sources DPI 2002; DERM 2012c; FRC Environmental 2009a; Hydrobiology 2009

a - exotic non-indigenous species; b - exotic non-indigenous species, declared noxious under the Fisheries Regulation 2008

4.3.5 Turtles

Four species of turtle have been recorded within the Condamine-Balonne River catchment (DERM, 2012d):

- *Chelodina expansa* (broad-shelled river turtle)
- *Chelodina longicollis* (snake-necked turtle)
- *Emydura macquarii macquarii* (Murray turtle)
- *Wollumbinia latisternum* (saw-shelled turtle).

None of these species were caught during the 2009 EIS surveys (FRC Environmental, 2009a). The broad-shelled river turtle and the Macquarie turtle were identified from the Condamine – Balonne River catchment in the Australia Pacific LNG EIS surveys (BAAM, 2009) and the Arrow Energy EIS surveys (Aquateco, 2011). A snake-necked turtle was caught during previous environmental investigations near the townships of Condamine and Tara (FRC Environmental, unpublished data). These species are native and have a wide-ranging diet including aquatic plants, invertebrates and small vertebrates (Wilson & Swan, 2008).

It is considered that the four species listed above may occur in the parts of the GFD Project area that are in the Condamine-Balonne River catchment, and that they would occur in permanent or semi-permanent waterholes within watercourses, or within other permanent aquatic habitat such as springs or wetlands.

4.3.6 Springs

A single spring complex (507) feeds four vents in the GFD Project area of the Condamine-Balonne River catchment (Table 4-8). This complex does not support the EPBC-listed TEC *The community of native species dependent on natural discharge of groundwater from the GAB*. Fensham *et al.*, 2011 note that these spring wetlands have been destroyed by impoundment or excavation and therefore have been given a very low conservation rank. No species of aquatic plant listed under the EPBC Act or the Nature Conservation (Wildlife) Regulation are known to occur at this complex.

Five watercourse springs are located on GFD tenures within the Condamine-Balonne River catchment (Table 4-9).

Table 4-8 Artesian springs within the GFD Project area in the Condamine-Balonne River catchment

Spring complex	Spring vent	EPBC-listed community	Tenure
507	188, 679, 680, 680.1	No	ATP 708P

Table 4-9 Watercourse springs within the GFD Project area in the Condamine-Balonne River catchment

Site number	River / Reach	Tenure
W10	Blyth Creek	PL 314 / PL 310
W17	Bungeworgorai Creek	ATP 708P
W18	Bungil Creek	ATP 708P
W19	Bungil Creek	Pl 13
W164	Yuleba Creek	ATP 613P

4.4 Summary of aquatic environmental values

Based on the review of environmental values within the catchments of the Dawson River (Section 4.1), Comet River (Section 4.2) and Condamine-Balonne River (Section 4.3), the aquatic ecology environmental values can be summarised as follows.

4.4.1 Conservation significant species and ecological communities

The following EPBC Act listed species and communities have the potential to occur within the GFD Project area:

- Fitzroy river turtle (*Rheodytes leukops*) (vulnerable)
- Murray cod (*Maccullochella peelii peelii*) (vulnerable)
- Salt pipewort (*Eriocaulon carsonii*) (endangered)
- Community of native species dependent on natural discharge of groundwater from the Great Artesian Basin (endangered).

The following species have the potential to occur within the GFD Project area and are listed under the Nature Conservation (Wildlife) Regulation:

- Artesian milfoil (*Myriophyllum artesium*) (endangered)
- *Eleocharis blakeana* (near threatened)
- Wandering fringe-rush (*Fimbristylis vagans*) (near threatened).

The White-throated snapping turtle (*Elseya albagula*) is listed as least concern under the NC Act and is listed as 'high priority' under the Queensland Government's Back on Track species prioritisation framework. This species is known from springs in the Dawson River catchment, and has the potential to also occur in the major watercourses and wetlands in the GFD Project area.

4.4.2 Watercourses

Environmental values are broadly defined in the EPP Water by maintaining water quality suitable for the biological integrity of an aquatic ecosystem (modified or pristine), recreational use, drinking water supply (with minimal treatment), agricultural use and industrial use.

The EPP Water Schedule 1 prescribes environmental values for specific water bodies in Queensland. Recently the Dawson River has been included in the range of water bodies for which environmental values are prescribed (EHP, 2005; EHP, 2011). The environmental values are:

- Aquatic ecosystems
- Irrigation
- Agricultural supply/use
- Aquaculture
- Stock water
- Human consumer
- Primary recreation
- Secondary recreation
- Visual recreation
- Drinking water
- Industrial use
- Cultural and spiritual.

The aquatic environmental values of watercourses within the GFD Project area are low to moderate and consistent with those of the wider catchments, and consistent with a slightly to moderately disturbed ecosystem.

Aquatic environmental values are dictated primarily by the ephemeral nature of many of the region's waterways, although agricultural development (particularly grazing) within the region has significantly influenced water quality and the physical characteristics of aquatic habitat. Degraded creeks in the GFD Project area are characterised by riparian vegetation loss, erosion, low habitat diversity, invasion of weed species, poor water quality and sedimentation. Existing road and potentially pipeline crossings of creeks in the GFD Project area are likely to cause alterations of flow and restrict aquatic fauna passage under particular flow regimes.

Biodiversity is low to moderate, and generally only fish and macroinvertebrate species that are tolerant of varying and often harsh conditions are likely to occur in the GFD Project area. Natural variation in water flow and water quality often creates variation in taxonomic richness of aquatic fauna, although most species of aquatic fauna in the region have physiological and dispersal adaptations to persist in these hash habitats. Introduced species, including the declared noxious mosquito fish and carp, and the introduced goldfish, are likely to be present in the GFD Project area. Nevertheless, the waterways of the GFD Project area are likely to offer habitat for native fish species that are known from each catchment, and possibly provide habitat for breeding and dispersal during periods of high flow.

The larger waterways in the GFD Project area, such as the Dawson River and its major tributaries, are perennial, and therefore offer more stable habitat for aquatic organisms. As a result, these waterways would be expected to support more abundant and diverse communities, particularly of larger aquatic vertebrates, such as fish, turtles (potentially including the vulnerable Fitzroy River turtle) and platypus. These waterways have a higher ecological value than the ephemeral watercourses in the GFD Project area, but are still in slightly to moderately disturbed condition.

No near-threatened or threatened species of aquatic fauna have been recorded from the watercourses of the GFD Project area. However, the watercourses in the Condamine-Balonne River catchment may provide suitable breeding or dispersal habitat for Murray cod, and the Dawson River upstream of Taroom contains suitable habitat for the Fitzroy River turtle, and may support this species. The white-throated snapping turtle, a high priority species for conservation, is likely to occur in the GFD Project area. Near threatened aquatic plant (sedge) species may also be present in the GFD Project area.

4.4.3 Wetlands and springs

Wetlands and springs in the GFD Project area provide permanent or semi-permanent aquatic habitat, and are therefore likely to support a greater diversity of aquatic flora and fauna than the ephemeral watercourses of the GFD Project area. In particular, these habitats can support a range of conservation significant aquatic fauna and flora species. The condition of springs and wetlands in the GFD Project area is likely to vary, with the condition of each spring largely dependent on the presence of water, the ability of stock to gain access to the wetland or spring, the presence and abundance of terrestrial weeds and the presence of feral animals such as wild pigs. Cattle damage and weeds were common at springs surveyed during the 2009 EIS and had degraded the condition of many springs. Other impacts from agricultural land use include drainage, constructing roads and tracks across these habitats.

As such, the majority of wetlands and springs in the GFD Project area are likely to be in slightly to moderately disturbed condition. The exceptions are those wetlands listed as a nationally important wetland in *A Directory of Important Wetlands in Australia* (Environment Australia, 2001): Lake Murphy, and part of the Palm Tree and Robinson Creeks Wetland Complex located in the Lake Murphy Conservation Park (refer to Figure 2-1).

The Fitzroy Basin Authority (FBA) recently compiled technical reports and management guidelines for the Palm Tree and Robinson Creek wetlands. Six areas of study were conducted: terrestrial vertebrate fauna, flora, birdlife, aquatic ecology, hydrology and social history.

The aquatic ecology study (Alluvium, 2014) utilised desktop and field data. Findings include:

- Cattle grazing on pastoral leases remains the dominant land use in the study area
- Palustrine and lacustrine wetland regional ecosystems 11.3.27g, 11.3.27d, 11.3.27c and 11.3.27 are present; all are classified as of concern (Biodiversity status)
- The Palm Tree Creek and Robinson Creek wetlands support only a moderate diversity and abundance of aquatic macroinvertebrates and fish
- Six native Australian species of fish were caught in April 2013.

The study also determined that the wetlands possess the following values (Alluvium, 2014):

- It is a regionally unique wetland complex
- The wetlands have a diverse and abundant native wetland flora
- Ecological value of the wetlands in terms of aquatic fauna and flora is moderate to high
- The wetlands and surrounding vegetation communities provide habitat for threatened species, including squatter pigeon, turquoise parrot, cotton pygmy goose, black- necked stork, freckled duck and koala
- The large wetland complex may provide critical refuge for populations of many wetland species
- The wetlands provide a water resource for stock
- The wetlands provide recreation opportunities and visual amenity

Although in a slightly to moderately disturbed condition, springs can provide habitat for a diverse range of aquatic species (including a high number of aquatic flora species), springs are considered to be rare in Queensland and have significant social, economic and environmental values (EHP, 2012).

The endangered aquatic plants salt pipewort and artesian milfoil have been recorded at springs in the Dawson River catchment. The critically endangered Boggomoss snail was not identified within the study area, although are known to occur within the Dawson River and Boggomoss springs complex downstream of Taroom (Stanisic, 1996; BAAM, 2009; SKM, 2009; JKR, 2010).

4.4.4 Aquatic environmental values

Aquatic environmental values identified in the GFD Project area are summarised in Table 4-10*.*

Table 4-10 Aquatic environmental values in the GFD Project area

Associated aquatic environmental value	Receptor
Protection of high ecological value habitat for aquatic flora and fauna	Lake Murphy Wetland of National Importance, High Ecological Value wetland
	Springs
	Communities of native species dependent on the natural discharge of groundwater from the Great Artesian Basin
Protection of listed threatened species	Fitzroy River turtle (*Rheodytes leukops*)
	Murray cod (*Maccullochella peelii peelii*)
	Salt pipewort (*Eriocaulon carsonii*)
	Artesian milfoil (*Myriophyllum artesium*)
Protection of high conservation priority species	White-throated snapping turtle (*Elseya albagula*)
	Platypus (*Ornithorhynchus anatinus*)
	Near threatened emergent aquatic plants (*Fimbristylis vagans* and *Eleocharis blakeana*)
Protection of aquatic ecosystem values	Watercourse and wetland habitat (not High Ecological Value)
	Native aquatic fauna including native freshwater fish, macroinvertebrates and turtles and emergent aquatic flora (non-threatened)
	Submerged aquatic plants (non-threatened) flora

Watercourses, native aquatic flora and fauna are likely to occur in each of the tenures of the GFD Project. The distribution of the other receptors across the GFD Project tenures is presented in Table 4-11.

Table 4-11 Presence of aquatic environmental values per GFD Project tenures

Aquatic environmental value	Tenure										
	ATP804	ATP745	ATP655	ATP803	ATP868	PL176	ATP708	ATP631	ATP665	PL10	PL11
Nationally important wetlands	×	×	×	✓	×	×	×	×	×	×	×
High ecological significance wetlands	×	×	×	✓	×	×	×	×	×	×	×
Springs	✓	×	×	×	×	×	✓	×	×	×	×
Potential habitat for Fitzroy River Turtle	×	×	×	×	✓	✓	×	×	×	×	×
Potential habitat for Murray cod	×	×	×	×	×	×	✓	✓	✓	✓	✓
Potential habitat for White-Throated Snapping Turtle	✓	×	×	✓	✓	✓	×	×	×	×	×
Potential habitat for platypus	×	×	×	✓	✓	✓	✓	✓	✓	✓	✓
Potential habitat for endangered and near threatened aquatic plants	✓	×	×	✓	✓		✓	✓	✓	✓	✓

Impact assessment and mitigation

Infrastructure and activities that are expected to occur during construction, operations, decommissioning and rehabilitation phases of the GFD Project have the potential to impact on aquatic ecology environmental values identified in Section 4.4. These potential impacts are detailed in Section 5.2. A high level review of management frameworks applied to existing Santos GLNG operations was conducted to identify suitable mitigation measures that would also apply to the similar infrastructure and activities being developed for the GFD Project. Further location-specific assessments will be conducted where required once the specific detail regarding the location and form of infrastructure is confirmed.

5.1 Impact assessment methodology

The potential impacts on aquatic environmental values that may arise from the GFD Project have been assessed on the basis of the findings detailed in Section 4. A significance assessment methodology was employed, whereby the following aspects were considered:

- Relevant aquatic environmental values (as discussed in Section 4), and their perceived sensitivity and/or vulnerability to GFD Project activities
- The magnitude of impacts that may occur as a result of GFD Project activities, based on the sensitivity of aquatic environmental values
- The significance of potential impacts as a function of sensitivity and magnitude
- Appropriate mitigation measures (as commitments to mitigation from Santos GLNG) that could be employed to reduce the significance of impacts
- Residual significance of impacts, following effective use of mitigation measures.

The criteria for quantifying the sensitivity of aquatic environmental values to potential impacts are outlined in Table 5-1, while criteria for assessment of the magnitude of potential impacts are included in Table 5-2.

Table 5-1 Sensitivity criteria

Sensitivity	Description
High	The environmental value is listed on a recognised or statutory state, national or international register as being of conservation significance. The environmental value is intact and retains its intrinsic value. The environmental value is unique to the environment in which it occurs. It is isolated to the affected system/area which is poorly represented in the region, territory, country or the world. It has not been exposed to threatening processes, or they have not had a noticeable impact on the integrity of the environmental value. GFD Project activities would have an adverse effect on the value.
Moderate	The environmental value is recorded as being important at a regional level, and may have been nominated for listing on recognised or statutory registers. The environmental value is in a moderate to good condition despite it being exposed to threatening processes. It retains many of its intrinsic characteristics and structural elements. It is relatively well represented in the systems/areas in which it occurs but its abundance and distribution are limited by threatening processes. Threatening processes have reduced its resilience to change. Consequently, changes resulting from GFD Project activities may lead to degradation of the prescribed value. Replacement of unavoidable losses is possible due to its abundance and distribution.

5 Impact assessment and mitigation

Sensitivity	Description
Low	The environmental value is not listed on a recognised or statutory register. It might be recognised locally by relevant suitably qualified experts or organisations e.g., historical societies. The environmental value is in a poor to moderate condition as a result of threatening processes, which have degraded its intrinsic value. It is not unique or rare and numerous representative examples exist throughout the system / area. It is abundant and widely distributed throughout the host systems / areas. There is no detectable response to change or change does not result in further degradation of the environmental value. The abundance and wide distribution of the environmental value ensures replacement of unavoidable losses is achievable.

Table 5-2 Magnitude criteria

Magnitude	Description
High	An impact that is widespread, long lasting and results in substantial and possibly irreversible change to the environmental value. Avoidance through appropriate design responses or the implementation of site-specific environmental management controls are required to address the impact.
Moderate	An impact that extends beyond the area of disturbance to the surrounding area but is contained within the region where the GFD Project is being developed. The impacts are short term and result in changes that can be ameliorated with specific environmental management controls.
Low	A localised impact that is temporary or short term and either unlikely to be detectable by monitoring or could be effectively mitigated through standard environmental management controls.

Qualitative classifications from both the significance and magnitude assessment criteria were applied to each potential impact, and used to assess the level of significance for that impact according to the matrix illustrated in Table 5-3.

Table 5-3 Significance matrix

Magnitude	Sensitivity		
	High	Moderate	Low
High	Major	High	Moderate
Moderate	High	Moderate	Low
Low	Moderate	Low	Negligible

The significance classifications used in Table 5-3 (major, high, moderate, low and negligible) are defined in Table 5-4.Classifications for significance of an impact were defined as follows:

Table 5-4 Significance classifications

Significance	Description
Major	Arises when an impact will potentially cause irreversible or widespread harm to an environmental value that is irreplaceable because of its uniqueness or rarity. Avoidance through appropriate design responses is the only effective mitigation.
High	Occurs when the proposed activities are likely to exacerbate threatening processes affecting the intrinsic characteristics and structural elements of the environmental value. While replacement of unavoidable losses is possible, avoidance through appropriate design responses is preferred to preserve its intactness or conservation status.
Moderate	Results in degradation of the environmental value due to the scale of the impact or its susceptibility to further change even though it may be reasonably resilient to change. The abundance of the environmental value ensures it is adequately represented in the region, and that replacement, if required, is achievable.
Low	Occurs where an environmental value is of local importance and temporary or transient changes will not adversely affect its viability provided standard environmental management controls are implemented.
Negligible	Does not result in any noticeable change and hence the proposed activities will have negligible effect on environmental values. This typically occurs where the activities are located in already disturbed areas.

A summary of the identified potential impacts to aquatic ecology values and related GFD Project activity, and applicable management plans are outlined in **Error! Reference source not found.**.

5.2 Potential impacts on aquatic ecology values

The potential impacts of the GFD Project infrastructure activities described in Section 1.1 and 1.2 on the aquatic environmental values identified in Section 4 can be allocated to each GFD Project phase (i.e. construction, operations, decommissioning and rehabilitation).

The post-EIS (constraints) field planning process described in Section 2.3.1 will play a significant role in the mitigation of potential impacts to aquatic environmental values within the GFD Project area. For example, Santos GLNG has prohibited development of intrusive activities in areas classified as no-go or surface development exclusion areas. Table 5-5 provides an outline of the level of constraint, constraint type and associated prohibited activities that will be applied to protect aquatic environmental values.

Potential (pre-mitigated) impacts will be determined after the application of the avoidance measures set out in Table 5-5.

Table 5-5 Aquatic ecology related constraints

Level of constraint	Constraint layer
No-go area	Category A environmentally sensitive areas including national parks, conservation parks, and forest reserves (NC Act).
	EPBC Act-listed spring vents and complexes including primary 200 m buffer.
	Wetlands of national importance including 200 m buffer.
	Wetlands of high ecological significance or high conservation value (*Map of Referrable Wetlands*).
Surface development exclusion area	Primary 200 m buffer for Category A environmentally sensitive areas.
	The following Category C environmentally sensitive areas: • Nature refuges (NC Act) • Koala habitat areas (*Nature Conservation (Koala) Conservation Plan 2006)* • Declared catchment areas (*Water Act 2000* (Qld)).
	The following Category B environmentally sensitive areas: • Coordinated conservation areas (NC Act). • State forest park/special forestry areas (*Forestry Act 1959* (Qld) (Forestry Act)) • Ramsar sites listed as wetlands of international importance.
High constraint area	Watercourses (stream orders) including 100 m buffer.
	Wetland defined as 'general ecologically significant wetland' or 'wetland of other environmental value' (*Map of Referrable Wetlands*).
	Spring vents and complexes (not protected under the EPBC Act) including primary 200 m buffer.
Moderate constraint area	Secondary 100 m buffer for Category A environmentally sensitive areas.
	Secondary 100 m buffer for spring vents and complexes (EBPC Act).
	Matters of national environmental significance including habitats (threatened species habitat and migratory species habitat), threatened ecological communities (derived from state regional ecosystem mapping or verified from field surveys), flora species.
	State forests and timber reserves.
	Endangered regional ecosystems including primary 200 m buffer.
	The following Category C environmentally sensitive areas: • Essential habitat including primary 200 m buffer (NC Act). • Essential regrowth habitat including primary 200 m buffer (NC Act). • Of concern regional ecosystems including primary 200 m buffer. • Resource reserve (NC Act). • State forests / timber reserves (Forestry Act).
	Endangered, vulnerable and near-threatened species (NC Act).
Low constraint areas	High value regrowth (endangered and of concern regional ecosystems).
	No concern at present regional ecosystems.
	Type A species (NC Act).
	Existing Santos GLNG infrastructure.
	Existing road, rail, pipeline and other infrastructure.
	Remaining areas once other constraints have been applied.

5 Impact assessment and mitigation

[1]Low impact petroleum activities means petroleum activities which do not result in the clearing of native vegetation, earthworks or excavation work that cause either, a significant disruption to the soil profile or permanent damage to vegetation that cannot be easily rehabilitated immediately after the activity is completed. Examples of such activities include (but are not necessarily limited to) chipholes, coreholes, geophysical surveys, seismic surveys, soil surveys, topographic surveys, cadastral surveys, ecological surveys, installation of environmental monitoring equipment (including surface water).

[2] Linear infrastructure means linear infrastructure including (but not limited to) gas and water gathering lines, low and high pressure gas and water pipelines, powerlines, communication, roads and access tracks (associated with limited petroleum activities and petroleum activities.

[3] Limited petroleum activities means any low impact petroleum activity and single well sites (includes observation, pilot, injection and production wells) and associated infrastructure (water pumps and generators, sumps, flare pits or dams) located on the well site, multi-well sites and associated infrastructure (water pumps and generators, sumps, flare pits, dams or tanks) located on the well sites, construction of new access tracks that are required as part of the construction or servicing a petroleum activity, upgrading or maintenance of existing roads or tracks, power and communication lines, gas gathering lines from a well site to the initial compression facility, water gathering lines from a well site to the initial water storage or dam, and camps within well site that may involve sewage treatment works that are a no release works.

[4] Petroleum activities include low impact petroleum activities or limited petroleum activities and all other GFD Project activities including major facilities such as permanent accommodation camps, gas treatment facilities, air strips, water facilities including dams, water storage infrastructure, water treatment and amendment facilities, gas hubs, and nodal compressors.

Recognising that avoidance (i.e. constraints planning processes) would apply to siting decisions, potential impacts to the aquatic environmental values that may result from construction, operation and decommissioning phases of the GFD Project include:

- **Contamination (sediment) to water** – may temporarily increase turbidity levels in the vicinity of the contamination source and downstream as the plume disperses.
- **Contamination (pollutants) to water** – may temporarily increase toxicity (depending on the properties of the pollutant and rate of processes such as biodegradation) in the vicinity of the source and downstream as the plume disperses; however some toxins may accumulate in the environment (e.g. substrate, vegetation, etc.) over time.
- **Altered flow regime** – increased or changed flow regime as a result of GFD Project activities (e.g. stream discharge) may disrupt seasonal patterns affecting dependent riparian vegetation and fauna, resulting in long-term changes to species diversity.
- **Disturbance of stream channel and associated habitat (e.g. pools, riffles, etc.)** – localised change associated with GFD Project infrastructure (e.g. waterway crossings) or activities (e.g. stream discharge) may apply for the life of the infrastructure/activity; however change can generally be reversed by natural flows over time.
- **Loss of abundance and diversity of riparian vegetation and aquatic biota**, including groundwater dependent ecosystems – generally localised impact associated with clearing and traffic movement, which may be long-term due to time required to restore pre-disturbance species composition/abundance before dependent fauna return.

5.3 Management framework

The purpose of this section is to describe the Santos GLNG impact mitigation framework, which provides for numerous management plans. **Error! Reference source not found.** details the relevant management plans and applicable commitments to mitigate against potential impacts.

Santos GLNG has developed specific management strategies to avoid, minimise or mitigate potential impacts associated with the GLNG Project. This management framework has been developed during and following the approval of the GLNG Project and consists of strategies, plans and procedures to ensure that the GFD Project is developed and operates in accordance with legislative and approval requirements.

Impacts to aquatic ecology are managed and mitigated through the management plans summarised in Table 5-6.

Mitigation measures to reduce the significance of potential impacts on aquatic environmental values were identified on the basis of existing management frameworks utilised by Santos GLNG, which reflect best practice methods within the industry as a whole. Detail on the relevant mitigation measures within each management plan is summarised in

Table 5-6 Santos GLNG management framework

Management plan	Description and applicability to GFD Project
Chemical and fuel management plan (CFMP)	The CFMP details the appropriate storage and handling practices of chemicals and fuels. The objectives of the plan are to: • Facilitate compliance with relevant legislation, regulations and approvals • Provide a framework for Santos GLNG to store and handle bulk chemicals and fuels in a way that minimises risk to the environment and human health • Assess the potential risk of a chemical or fuel prior to its use • Identify and implement appropriate mitigation measures.
Contingency plan for emergency environmental incidents (Contingency plan)	The Contingency plan details the management practices in place within Santos GLNG to minimise environmental harm during an emergency environmental incident. The plan identifies potential incidents, and provides response actions, including escalation, communication, reporting and monitoring.
Decommissioning and abandonment management plan (DAMP)	The DAMP describes the management framework in place for when petroleum activities cease. The objectives of the plan are to: • Undertake decommissioning of assets in a manner that complies with regulatory requirements and minimises the risk of environmental harm • Undertake decommissioning activities in a manner that meets stakeholder expectations • Leave a landform that is stable and compatible with intended post-closure land use • Provide for the beneficial reuse of Santos GLNG infrastructure constructed to third parties (e.g. landholders or local authorities) where an appropriate agreement has been signed by both parties and regulatory authorities are satisfied.
Draft Environmental management plan (Draft EM Plan)	The Draft EM Plan identifies the environmental values potentially affected by the GFD Project and proposes measures to manage the risk of potential adverse impact to these environmental values. The Draft EM Plan comprises: • Environmental values potentially affected by the GFD Project • Environmental management objectives and associated management measures • Environmental monitoring and reporting • Coal seam water management • Proposed conditions.

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Management plan	Description and applicability to GFD Project
Erosion and sediment control management plan (ESCMP)	The ESCMP identifies erosion and sedimentation risk and provides an erosion and sediment control strategy that incorporates understanding of the risk inherent to local land resource characteristics. The ESCMP is supported by the Erosion and Sediment Control Manual, which provides erosion, sediment and drainage controls in line with best practice guidelines.
Fauna management plan (FMP)	The FMP provides Santos GLNG's strategy to manage fauna during the construction and operations phases of the GFD Project. The plan: • Identifies fauna species present within the gas fields • Prioritises management of both livestock and wildlife • Provides mitigation measures to minimise impacts to fauna from Santos GLNG activities.
GFD Project Environmental protocol for constraints planning and field development (the Constraints protocol)	The Constraints protocol applies to all gas field related activities. The scope of the Constraints protocol is to: • Enable Santos GLNG to comply with all relevant State and Federal statutory approvals and legislation • Support Santos GLNG's environmental policies and the General Environmental Duty (GED) as outlined in the EP Act • Promote the avoidance, minimisation, mitigation and management of direct and indirect adverse environmental impacts associated with land disturbances • Minimise cumulative impacts on environmental values. The Constraints protocol provides a framework to guide placement of infrastructure and adopts the following management principles: • Avoidance — avoiding direct and indirect impacts • Minimisation — minimise potential impacts • Mitigation — implement mitigation and management measures • Remediation and rehabilitation — actively remediate and rehabilitate impacted areas • Off-set — offset residual adverse impacts in accordance with regulatory requirements. The Constraints protocol enables the systematic identification and assessment of environmental values and the application of development constraints to effectively avoid and / or manage environmental impacts. The Constraints protocol identifies the protection of surface water resources (wetlands, lakes, watercourses and flood prone areas) as a planning constraint for the placement and design of GFD Project infrastructure. The Constraints protocol applies as follows: • No-go area constraint applies to spring vents and/or spring complexes protected under the EBPC Act plus a 200 m buffer zone, wetlands of high ecological significance, and wetlands of national importance plus a 200 m buffer zone. • Surface development exclusion areas apply to Ramsar sites. • High constraint areas include watercourses (stream orders) plus a 100 m buffer, general ecologically significant wetlands and wetlands of other environmental value ((Map of Referrable Wetlands dataset), and all other spring vents and spring complexes plus a 200 m primary buffer. • Moderate constraint areas include a 100 m secondary buffer around spring vents and spring complexes protected under the EPBC Act and the 200 m primary buffers.
Land release management plan (LRMP)	The LRMP addresses the management of releases of water to land in Santos GLNG's gas fields, including: • Coal seam water use for irrigation, construction and operations purposes • Treated sewage effluent releases to land • Use of treated sewage effluent for construction and operations purposes • Low point drain water releases to land

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Management plan	Description and applicability to GFD Project
	• Hydrostatic test water releases to land. The document includes the principles, methods and controls to effectively manage and minimise the risk environmental harm being caused by release of water to land.
Offset strategy	Offsets are a mechanism to counterbalance any significant adverse residual impact, after the hierarchy of avoidance, minimisation, mitigation, remediation and rehabilitation measures have been implemented. The Offset strategy is part of the management framework and will be further developed and implemented to meet regulatory requirements. The purpose of the strategy is to: • Summarise the Australian and Queensland Governments' offset requirements and policies • Identify the environmental values that exist within the GFD Project area that after avoidance, minimisation, mitigation and remediation and rehabilitation measures may require offsetting • Demonstrate offsets completed as part of the Santos GLNG Project • Identify where existing Santos GLNG offset areas may be used for future additional offset required for the GFD Project • Provide a description of Santos GLNG's staged offsets approach to provide potential offset delivery options and proposed method of delivery.
Pest and weed management plan (PWMP)	The management of pest and weed species will be undertaken in accordance with the PWMP. The plan includes measures such as: • Identification of pest and weed species and areas of infestation • Avoidance of traversing and placing infrastructure in areas of known infestation • Prevention of the spread of pest and weed species by implementing appropriate work practices and promotion of risk awareness • Control of identified pest and weeds through containment, reduction or eradication as required by legislation.
Receiving environmental management plan (REMP)	The REMP has been specifically developed for the authorised Dawson River Release Scheme, an activity of the Santos GLNG Project. The REMP has been developed, in accordance with environmental authority conditions (EPPG00928713), to monitor, identify and describe adverse impacts to the waters in the receiving environment resulting from the release of treated coal seam water.
Rehabilitation management plan	The Rehabilitation management plan outlines the rehabilitation objectives for Project-related disturbances within the GFD Project Area. This includes the phasing of rehabilitation to first achieve stabilisation and subsequently final rehabilitation for disturbances to land (i.e. ground surface). The Rehabilitation management plan: • Describes Santos GLNG's approach to rehabilitation • Identifies key rehabilitation objectives and criteria to deem rehabilitation success • Outlines general rehabilitation actions to be undertaken by Santos GLNG when rehabilitation a disturbance • Provides an overview of monitoring and maintenance actions to be conducted on rehabilitated areas.

Management plan	Description and applicability to GFD Project
Significant species management plan (SSMP)	The plan provides an overview of the strategy, methods and controls implemented by Santos GLNG to manage adverse impacts *to* EPBC Act- listed significant species and their habitats, and threatened ecological communities. Specifically, the SSMP: • Identifies and profiles significant species and threatened ecological communities that are present, or may occur, within the gas fields • Identifies key threats to significant species and threatened ecological communities caused by activities within the gas fields Outlines general mitigation measures to be implemented by Santos GLNG to minimise the potential adverse impact of key threats to significant species and threatened ecological communities caused by Santos GLNG activities.
Water resource management plan (WRMP)	The WRMP has been developed to proactively detail how Santos GLNG manages and monitors potential adverse impacts to water resources, recently defined as a matter of national environmental significance.

5.4 Residual impact significance

An assessment of the magnitude and significance of the potential impacts to aquatic environmental values associated with GFD Project activities was conducted (Table 5-7) in accordance with the process outlined in Section 5.1. Table 5-9 provides an analysis of how the perceived risks may be reduced through the implementation of mitigation measures outlined in Table 5-8 throughout the life of the GFD Project.

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Table 5-7 Project activities and potential impacts on aquatic ecology environmental values

Potential impact	Activity by GFD Project phase			Applicable management plans
	Construction	Operations	Decommissioning	
Contamination (sediment) to water Temporary increase in turbidity levels in the vicinity of the contaminant source and downstream as the plume disperses.	• Vegetation clearing and earthworks • Discharge of hydrostatic test water to waterway • Construction (soil disturbance) of water course crossings for roads, pipelines, power lines, discharge points, etc. • Traffic movement, particularly near waterways and at water course crossings • Vehicle wash-down	• Maintenance of access tracks, power lines and gathering line, and inspection and monitoring of waterways • Traffic movement, particularly near waterways and at water course crossings • Discharge of water (e.g. coal seam water or sewage) to stream channel • Sediment control infrastructure	• Wells and surface infrastructure decommissioned and surrounding area rehabilitated • Traffic movement, particularly near waterways and at water course crossings • Sediment control infrastructure • Incomplete rehabilitation of disturbed areas	• Constraints protocol • Draft Environmental management plan • Erosion and sediment control management plan • Land release management plan • Decommissioning and abandonment management plan • Rehabilitation management plan
Contamination (pollutants) to water Temporary increase in toxicity levels (depending on the properties of the pollutant) in the immediate vicinity of the source and downstream as the plume disperses; however some toxins may accumulate in the environment (e.g. substrate, vegetation, etc.) over time.	• Vegetation clearing and earthworks • Construction (soil disturbance) of water course crossings for roads, pipelines, power lines, discharge points, etc. • Traffic movement, particularly near waterways and at water course crossings • Vehicle wash-down • Fuel and contaminant spills	• Traffic movement, particularly near waterways and at water course crossings • Discharge of water (e.g. coal seam water or sewage) to stream channel • Waste management (e.g. containment, disposal, etc.) • Uncontrolled release of sewage effluent (from accommodation camps) • Fuel and contaminant spills	• Wells and surface infrastructure decommissioned and surrounding area rehabilitatedTraffic movement, particularly near waterways and at water course crossings • Release of concentrated brine or solid salts (if not properly contained) • Fuel and contaminant spills • Incomplete rehabilitation of disturbed areas	• Constraints protocol • Chemical andfFuel management plan • Draft Environmental management plan • Land release management plan • Contingency plan for emergency environmental incidents • Decommissioning and abandonment management Plan

Potential impact	Activity by GFD Project phase			Applicable management plans
	Construction	Operations	Decommissioning	
Altered flow regime Increased or changed flow regime as a result of GFD Project activities (e.g. stream discharge) may disrupt seasonal patterns affecting dependent riparian vegetation and fauna, resulting in long-term changes to species diversity	• Earthworks and watercourse diversion • Watercourse crossings for linear infrastructure (roads, pipelines, powerlines, etc)	• Discharge of water (e.g. coal seam water or treated sewage) to stream channel • Overtopping of water storages • Use of watercourse crossings, diversions and permanent structures in stream channel	• Earthworks and watercourse diversion • Traffic movement, particularly near waterways and at water course crossings	• Constraints protocol • Draft Environmental management plan • Decommissioning and abandonment management plan • Rehabilitation management plan
Disturbance of stream channel and associated habitat Localised change associated with GFD Project infrastructure (e.g. waterway crossings) or activities (e.g. stream discharge) may apply for the life of the infrastructure/activity; however change can generally be reversed by natural flows over time.	• Vegetation clearing and earthworks adjacent to watercourse • Construction of water course crossings for roads, pipelines, power lines, etc. • Construction of discharge release points	• Maintenance of access tracks, power lines and gathering line, and inspection and monitoring of waterways • Discharge of treated water (e.g. coal seam water or sewage) to stream channel	• Wells and surface infrastructure decommissioned and surrounding area rehabilitatedTraffic movement, particularly near waterways and at water course crossings	• Constraints protocol • Draft Environmental management plan • Rehabilitation management plan • Erosion and sediment control management plan

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Potential impact	Activity by GFD Project phase			Applicable management plans
	Construction	Operations	Decommissioning	
Loss of abundance and diversity of riparian vegetation and aquatic biota, including groundwater dependent ecosystems Generally localised to source of impact, which may be long-term due to time on tenure and time required to restore pre-disturbance species composition/abundance.	• Vegetation clearing and earthworks • Construction of water course crossings for roads, pipelines, power lines, etc. • Construction of discharge release points • Traffic movement, particularly near waterways and at water course crossings • Transfer of non-indigenous and exotic species • Fuel and contaminant spills	• Traffic movement, particularly near waterways and at water course crossings • Maintenance of access tracks, power lines and gathering line, and inspection and monitoring of waterways • Discharge of treated water (e.g. coal seam water or sewage) to stream channel • Potential drawdown of water table from coal seam water extraction • Overtopping of water storages • Transfer of non-indigenous and exotic species • Fuel and contaminant spills	• Wells and surface infrastructure decommissioned and surrounding area rehabilitatedTraffic movement, particularly near waterways and at water course crossings • Transfer of non-indigenous and exotic species • Fuel and contaminant spills	• Constraints protocol • Draft Environmental management plan • Rehabilitation management plan • Erosion and sediment control manual. • Fauna management plan • Pest and weed management plan • Chemical and fuel management plan

Table 5-8 Existing management framework and impact mitigation measures

Management plan	Function	Mitigation measures
Environmental protocol for constraints planning & field development (the Constraints protocol)	The Constraints protocol identifies the protection of surface water resources (wetlands, lakes, watercourses and flood prone areas) as a planning constraint for the placement and design of infrastructure.	The Constraints protocol includes mitigation measures such as: • Locate petroleum activities outside of the environmental constraints of wetlands of high ecological significance (HES), and within the 200 m buffer of the primary protection zone, petroleum activities must not negatively impact HES. • Construction and/or maintenance of linear infrastructure may be undertaken in a watercourse, general ecological significance (GES) wetlands and springs. Construction and/or maintenance of linear infrastructure in GES wetlands must be done in accordance with the EA. • No petroleum activities are permitted in Wetlands of High Ecological Significance (HES), as detailed in the EHP Map of Referrable Wetlands dataset • No petroleum activities are permitted within a 200 m buffer around springs that are either a Great Artesian Basin TEC spring, or those that support EPBC-listed species.
Rehabilitation management plan	This plan will be implemented to enable the return of disturbed areas to a pre-clearance state or another stable landform consistent with the surrounding undisturbed areas or to final acceptance criteria.	The Rehabilitation management plan includes mitigation measures such as: • Progressive removal or reuse of infrastructure where gas field operations cease during the project life • Establishes management practices and safeguards to minimise environmental disturbance • Defines rehabilitation actions for the infrastructure sites following decommissioning • Optimises rehabilitation options for all disturbed landuses
Erosion and sediment control management plan	Prevent water quality degradation and sedimentation of surface water resources caused by erosion of exposed soils and poor site drainage control.	The ESCMP includes measures such as: • Drainage control (on a site-specific basis) may include: — Diversion of up-slope stormwater runoff around disturbed areas including stockpiles and waste storage areas — Installation of lateral catch drains or flow diversion banks to minimise rill erosion along steep continuous slopes (i.e. >10%) especially associated with linear infrastructure construction (i.e. pipelines, roads and powerlines) — Placement of velocity control structures such as rock check dams to reduce the flow velocity in channels; — Lining of channel with scour resistant materials including erosion control matting or rock lining; — Use of energy dissipation structures at the outlets of banks, drains and chutes. • Erosion and sediment control (on a site-specific basis) may include: — Prioritising drainage and erosion control measures, rather than allowing erosion to occur and trying to trap the resulting sediment. — Spreading mulch or retained native vegetation over disturbed areas as soon as practicable after construction to

Management plan	Function	Mitigation measures
		— reduce splash erosion and sheet erosion. — Use of erosion blankets (i.e. jute and coir matting) as an alternative to mulching in drainage channels or areas of strong winds or overland flow. — Use of sediment traps (i.e. sheet flow, kerb inlet and field inlet sediment traps) and sediment basins. — Use of 'ripping' or similar techniques on finished soil surfaces to encourage revegetation where required. — Routine inspection of erosion and sediment controls and maintained for capacity and structural integrity, particularly following significant rainfall events. • Sediment basin water quality will be monitored prior to discharge to determine compliance with any relevant Environmental Authority (EA) water quality release limits. • Where linear petroleum activities are being constructed within or adjacent watercourses, water quality monitoring will be undertaken at upstream (background) and downstream (20m from watercourse crossing works) locations to determine compliance with EA conditions requiring downstream turbidity levels are no more than 10% above upstream turbidity levels.
Significant species management plan	The Significant Species Management Plan details specific measures to be implemented during pre-construction, construction and operations phases of the GLNG Project to avoid or mitigate adverse impacts to significant species and ecological communities.	• If clearing occurs within or adjacent to permanent water pools the spotter catcher will undertake regular visual inspections of the area to ensure any turtles are not harmed • Watercourse and wetland crossings to conform to the requirements of any approvals issued under the Fisheries Act (i.e. raising of a waterway). Alternatively works are to be undertaken in with Queensland Primary Industries and Fisheries (QPIF) Code for self-assessable development Minor waterway barrier works and QPIF Code for self-assessable development temporary waterway barrier works on low order inland waterways • For minor waterway crossings where horizontal directional drilling is not the agreed construction method, the watercourse bed and bank material and trench spoil will be stockpiled separately outside the buffer zone (15 m) to reduce any potential impacts to the turtle nest areas (where applicable). • Weather permitting, rehabilitation and reconsolidation of impacted watercourses shall commence immediately after the pipeline has been lowered in and backfilled • Work with the local landholder to exclude cattle from watercourses and wetlands • All reasonable and practical measures are taken to minimize the area cleared and to avoid the clearing of mature trees within 200 m of a wetland and/or watercourse. • Where constructability allows avoid works within: — 200 metres from any natural significant wetland — 100 metres from any natural wetland, lakes or springs — 100 metres of the high bank of any other watercourse.

Management plan	Function	Mitigation measures
		• All vegetation clearing within the riparian zones must comply with clearing approval conditions (e.g. NC Act approval). • All vegetation clearing within the riparian zones must comply with the relevant clearing approval conditions • Minimise fragmentation of riparian vegetation along watercourses • The total clearing footprint within the riparian zones identified will be that required for safe construction • Revegetation shall be consistent with the plant density, floristic composition and distribution of the adjacent riparian and creek bed communities • To avoid impacting on regenerating riparian zone and associated species habitat, vehicle and pedestrian access within and adjacent watercourses and wetlands is restricted to the defined access tracks • A buffer of riparian vegetation should be maintained for watercourses. If regrowth trees within this buffer require removal, it should be done by hand In the event that aquatic fauna are injured or killed during works or where there is illegal clearing of vegetation or native flora, the current mitigation strategies will be reviewed in conjunction with a aquatic fauna specialist and any recommended changes implemented
Fauna management plan	The Fauna management plan will be implemented to mitigate and manage potential impacts to fauna during construction.	The Fauna management plan includes measures such as: — Scheduling watercourse crossings, where practicable, during low flow periods. — Ensure mitigation measures for creek crossings are consistent with AS2885 ‘Pipelines’, ‘Gas, Liquid and Petroleum’ and Australian Pipeline Industry Association Code of Environmental Practice’ and the conditions of any specific approval (such as waterway barrier works). — Fauna passage devices such as pipes that allow the movement of fish and other aquatic fauna should be considered for major watercourse crossings. — Implement measures to reduce soil erosion and stream sedimentation.
Pest and weed management plan	The management of pest and weed species will be undertaken in accordance with the Pest and Weed Management Plan.	The plan includes measures such as: • Identification of pest and weed species and areas of infestation • Avoidance of traversing and placing infrastructure in areas of known infestation • Prevention of the spread of pest and weed species by implementing appropriate work practices and promotion of risk awareness • Control of identified pest and weeds through containment, reduction or eradication as required by legislation.

Table 5-9 Mitigation of potential impacts using existing management framework

Potential impact	Phase	Pre-mitigated significance			Mitigation	Residual significance	
		Sensitivity	Magnitude	Significance		Magnitude	Significance
Contamination (sediment) to water	Construction	Moderate	Moderate	Moderate	• Draft Environmental management plan • Erosion and sediment control management plan • Land release management plan • Decommissioning and abandonment management plan • Rehabilitation management plan	Low	Low
	Operations		Low	Low		Low	Low
	Decommissioning		Moderate	Moderate		Low	Low
Contamination (pollutants) to water	Construction	High	Moderate	High	• Chemical and fuel management plan • Draft Environmental management plan • Land release management plan • Contingency plan for emergency environmental incidents • Decommissioning and abandonment management plan	Low	Moderate
	Operations		Moderate	High		Low	Moderate
	Decommissioning		Moderate	High		Low	Moderate
Altered flow regime	Construction	Moderate	Moderate	Moderate	• Draft Environmental management plan • Decommissioning and abandonment management plan • Rehabilitation management Plan	Low	Low
	Operations		Low	Low		Low	Low
	Decommissioning		Low	Low		Low	Low
Disturbance of stream channel and associated habitat	Construction	Moderate	Moderate	Moderate	• Draft Environmental management plan • Rehabilitation management plan • Erosion and sediment control management plan	Low	Low
	Operations		Low	Low		Low	Low
	Decommissioning		Low	Low		Low	Low

Potential impact	Phase	Pre-mitigated significance			Mitigation	Residual significance	
		Sensitivity	Magnitude	Significance		Magnitude	Significance
Loss of abundance and diversity of riparian vegetation and aquatic biota, including groundwater dependent ecosystems	Construction	High	Moderate	High	• Draft Environmental management plan • Rehabilitation management plan • Erosion and sediment control manual. • Fauna management plan • Pest and weed management plan • Chemical and fuel management plan	Low	Moderate
	Operations		Low	Low		Low	Low
	Decommissioning		Low	Low		Low	Low

5.5 Residual impacts

The outcomes of mitigation depicted in **Error! Reference source not found.** illustrate that the residual significance of the potential impacts identified will be reduced to either low or moderate level following implementation of the detailed mitigation measures and management frameworks.

5.6 Cumulative impacts

The GFD Project construction and operations activities have the potential to impact on downstream aquatic and spring environmental values. Existing Santos GLNG gas extraction operations within the GFD Project area, as well as those of other gas companies such as Origin APLNG, Arrow and QGC whom are also currently operating within or near the GFD Project area, all have the potential to impact the aquatic environment.

While at a regional level resource industry activities will have a certain cumulative impact on the river and spring systems of the GFD Project area, these impacts are considered to be small, temporary and reversible. In some cases the impact will provide a positive benefit, such as where treated coal seam water is released to streams, it can provide benefits of maintaining baseline flows for aquatic ecology communities in perennial systems, and more reliable supply of domestic and irrigation water for downstream users.

The impacts on the aquatic environment associated with the GFD Project and other existing gas projects will be smaller than the impacts from other land uses in the catchments, particularly agriculture.

It has been identified that of all aquatic receptors, springs are potentially at the most risk from coal seam water extraction. The Underground Water Impact Report (UWIR) (QWC, 2012) identified the springs that overlie geologic formations in which water pressure are expected to decline by more than 0.2 m because of water extraction. The UWIR noted that within the Surat CMA, springs are not known to be fed from the Walloon Coal Measures or the Bandanna Formation, the target formations for petroleum and gas production. However, springs that are fed from the Precipice Sandstone, Hutton Sandstone, the Clematis Group, the Basalts, Gubberamunda Sandstone and the Boxvale Sandstone Member of the Evergreen Formation could be affected because of interconnectivity between the spring's source aquifer and the target formations.

The UWIR identified a total of 330 spring vents and 43 watercourse springs within the Surat CMA. However, the most up to date springs data set provided by the Office of Groundwater Impacts Assessment (OGIA) in August 2013 identified 329 spring vents. This is because four of the spring vents in the original data set could not be found during field investigations (x346, x380, x381 and x431) and three new spring vents have been identified by a proponent (complex 605 including spring vents nv717, nv718 and nv719). This assessment has considered the latest springs data set provided by OGIA.

In mid-2013 the OGIA re-ran the regional groundwater flow model for the Surat CMA to simulate development changes associated with the Santos GLNG GFD Project and another coal seam gas industry proponent's development plans. This is referred to as 'the EIS Scenario'.

5.6.1 Springs of interest

Groundwater model results for the EIS Scenario were used to conduct an initial screening to identify springs of interest; defined as springs underlain by a formation (including the coal seams) where the long-term maximum predicted impact on water pressures at the location of the spring (but not necessarily in the source aquifer of the spring) exceeds 0.2 m, or is within 10 km of 0.2 m of depressurisation. As a precautionary approach, EPBC springs located just outside the 10 km buffer were also included, which translated to including EPBC springs a further 5 km beyond the 10 km buffer. The buffers are precautionary as they allow for the limitations associated with modelling very small changes in water pressure.

There are 45 spring complexes (Table 5-10) and 33 watercourse springs (Table 5-11) located within the Surat CMA that have been recognised as springs of interest.

5.6.2 Springs at risk of impacts in the Surat CMA

A risk-based methodology was employed to assess the likelihood of the springs of interest experiencing impacts due to the cumulative development of gas in the Surat CMA under the EIS scenario. The approach recognises that there is some uncertainty associated with the source aquifers nominated in the OGIA dataset. The methodology was developed in consultation with the OGIA and follows a similar approach to that used in the UWIR for the Surat CMA.

Springs where impacts to a source aquifer nominated in the OGIA (2013) dataset were predicted under the EIS Scenario have been identified as being at risk of impacts. For the remaining springs of interest, the numerical groundwater modelling predicted impacts to an underlying aquifer that is not the source aquifer nominated in the OGIA dataset.

A total of 13 spring complexes and 19 watercourse springs have been identified as being at risk of impacts due to the cumulative development of gas in the Surat CMA under the EIS scenario. The results are presented in Table 5-10 and Table 5-11.

Table 5-10 Spring complexes at risk of impacts in the Surat CMA under the EIS scenario

Complex number	Complex name	Vent number[1]	Source aquifer (OGIA, 2013)	Risk of impact under the EIS scenario	EPBC listed community	Catchment
1	Rainbow spring	nv4, nv337, nv339, nv340, nv343, nv365, nv366, nv368, nv369, 549, 550	Precipice Sandstone, Clematis Sandstone	No	No	Comet
8	Dawson River 8	**26, 28, 38**	Hutton Sandstone	Yes	Yes	Dawson
9	Cockatoo Creek	**64, 64.1, 65, 65.1, 65.2, 66, 319, 320, 320.1, 321, 321.1, 321.2, 321.3, 321.4, 321.5, 321.6, 321.7, 327.8, 684**	Precipice Sandstone	No	Yes	Dawson
16	16	548	Clematis Sandstone	No	No	Dawson
35	35	nv367, nv386	Clematis Sandstone	No	No	Dawson/Comet
68	SF2120	547, nv341	Clematis Sandstone	No	No	Dawson/Comet
74	Yebna	nv329	Evergreen Formation, Precipice Sandstone, Clematis Sandstone	No	No	Dawson
76	Eden Vale	701, nv605	Evergreen Formation (Boxvale Sandstone)	No	No	Condamine-Balonne
78	78	551, 552	Clematis Sandstone	No	No	Comet
84	Conom	nv356, nv357, nv358	Clematis Sandstone	No	No	Dawson
85	Newton	538, nv328, nv331, nv332	Hutton Sandstone	No	No	Dawson
229	Ponies	284	Hutton Sandstone	Yes	No	Dawson
230	Lucky Last	**287, 340, 686, 687, 687.1, 687.2, 687.3, 687.4, 687.5, 687.6, 688, 689**	Evergreen Formation (Boxvale Sandstone), Precipice Sandstone	Yes	Yes	Dawson

Complex number	Complex name	Vent number[1]	Source aquifer (OGIA, 2013)	Risk of impact under the EIS scenario	EPBC listed community	Catchment
233	Moolayember	408, 675, 676	Clematis Sandstone	No	No	Comet
254	254	nv5	Clematis Sandstone	No	No	Comet
260	Scott's Creek	**189, 190, 191, 192, 192.1**	Hutton Sandstone	Yes	Yes	Dawson
267	267	nv6, nv7	Hutton Sandstone	No	No	Condamine-Balonne
283	Barton	702, 703	Gubberamunda Sandstone	Yes	No	Dawson
296	Carnarvon Gorge	553, 554, 554.3, 555, 556, 677, 678, **712**, 713, 714, 715, nv392, nv394, nv396, nv435	Evergreen Formation (Boxvale Sandstone), Precipice Sandstone, Hutton Sandstone	No	No	Comet
302	302	539, 539.1	Precipice Sandstone	Yes	No	Dawson
304	ExpedRange	541, 542, 543, 544, 544.1, 544.2, 544.3, 545, 546, nv2, nv3, nv348, nv349, nv350, nv351, nv352, nv353, nv354, nv355	Clematis Sandstone, Cainozoic Sediments	No	No	Dawson
306	306	nv371	Clematis Sandstone	No	No	Dawson
307	Elgin	nv359, nv372, nv373, nv375, nv376, nv377, nv378, nv379	Clematis Sandstone	No	No	Dawson
308	308	nv383	Clematis Sandstone	No	No	Comet
309	309	nv384	Clematis Sandstone	No	No	Comet
310	310	nv370	Precipice Sandstone	No	No	Dawson

Complex number	Complex name	Vent number[1]	Source aquifer (OGIA, 2013)	Risk of impact under the EIS scenario	EPBC listed community	Catchment
311	311	499, 500, 500.1, 535, 536, 536.1, 536.2, 537, 692, 693, 694, 695, 696, 697, 698, 699, 704	Evergreen Formation, Precipice Sandstone	Yes	No	Dawson
326	326	705	Clematis Sandstone	No	No	Comet
327	327	nv385	Precipice Sandstone	No	No	Dawson
328	328	nv374	Precipice Sandstone	No	No	Dawson
335	335	nv406	Hutton Sandstone	No	No	Dawson
339	Lonely Eddie	706, 707, 708, 709	Precipice Sandstone	Yes	No	Dawson
506	SprRidge	184, 185, 186	Gubberamunda Sandstone	No	No	Condamine-Balonne
507	VI_mile	187, 188, 679, 680, 680.1	Gubberamunda Sandstone	No	No	Condamine-Balonne
510	Cleanskins	nv417	Clematis Sandstone	No	No	Dawson
561	Spring Rock Creek	285	Evergreen Formation (Boxvale Sandstone), Precipice Sandstone	Yes	No	Dawson
583	Lenore Hills	710, nv621, nv622	Clematis Sandstone	No	No	Dawson
584	Wambo	711, 711.1	Cainozoic Sediments	Yes	No	Condamine-Balonne
586	Boxvale	nv437	Evergreen Formation (Boxvale Sandstone)	No	No	Dawson
587	Timor	x436	Hutton Sandstone	No	No	Dawson
591	Yebna 2	**534**	Evergreen Formation, Precipice Sandstone	Yes	Yes	Dawson
592	Abyss	286, 286.1, 286.2, 286.3, 682, 716	Hutton Sandstone	Yes	No	Dawson
593	Cockatoo3	685	Precipice Sandstone	No	No	Dawson
594	Elgin2	**540**	Clematis Sandstone	No	Yes	Dawson

Complex number	Complex name	Vent number[1]	Source aquifer (OGIA, 2013)	Risk of impact under the EIS scenario	EPBC listed community	Catchment
605[2]	Kangaroo Creek	nv717, nv718, nv719	Springbok Sandstone, Cainozoic Sediments	Yes	Unknown	Dawson
TOTAL NUMBER POTENTIALLY AFFECTED SPRING VENT COMPLEXES				**13**		

[1] - **Bold:** EPBC Act listed vents.

[2] Newly discovered complex – no other information available.

Table 5-11 Watercourse springs at risk of impacts in the Surat CMA under the EIS scenario

Site number	River/Reach	Source aquifer (OGIA 2013)	Springs impacted under the EIS scenario
W40	Dawson River (Central)	Precipice Sandstone	Yes
W80	Hutton Creek	Hutton Sandstone	Yes
W81	Hutton Creek	Hutton Sandstone	Yes
W82	Injune Creek	Hutton Sandstone	Yes
W10	Blyth Creek	Mooga Sandstone, Gubberamunda Sandstone	Yes
W14	Bungaban Creek	Hutton Sandstone	Yes
W15	Bungaban Creek (North)	Hutton Sandstone	Yes
W18	Bungil Creek	Gubberamunda Sandstone	Yes
W19	Bungil Creek	Mooga Sandstone	Yes
W164	Yuleba Creek	Mooga Sandstone	Yes
W39	Dawson River	Hutton Sandstone	Yes
W16	Bungeworgorai Creek	Gubberamunda Sandstone	Yes
W17	Bungeworgorai Creek	Mooga Sandstone	No
W22	Carnarvon Creek	Precipice Sandstone	No
W26	Clematis Creek	Clematis Sandstone	No
W28	Cockatoo Creek	Precipice Sandstone	No
W29	Cockatoo Creek	Precipice Sandstone	No
W35	Conciliation Creek	Clematis Sandstone	No
W42	Dawson River (NW)	Precipice Sandstone	No
W105	Maranoa River	Gubberamunda Sandstone	No
W106	Maranoa River	Mooga Sandstone, Gubbermunda Sandstone	No
W113	Mimosa Creek	Clematis Sandstone	No
W114	Mimosa Creek Tributary	Clematis Sandstone	No
W141	Robinson Creek	Hutton Sandstone	Yes
W6	Bethecurriba Creek	Kumbarilla Beds	No
W7	Bethecurriba Creek	Kumbarilla Beds	No
W122	Murri Murri Creek	Kumbarilla Beds	No
W160	Western Creek	Kumbarilla Beds	Yes
W59	Eurombah Creek	Hutton Sandstone	Yes

Site number	River/Reach	Source aquifer (OGIA 2013)	Springs impacted under the EIS scenario
W76	Horse Creek (East Branch)	Gubberamunda Sandstone	Yes
W77	Horse Creek (East Branch)	Mooga Sandstone, Gubberamunda Sandstone	Yes
W78	Horse Creek (East Branch) Tributary	Mooga Sandstone, Gubberamunda Sandstone	Yes
W79	Horse Creek (East Branch) Tributary	Mooga Sandstone, Gubberamunda Sandstone	Yes
TOTAL NUMBER POTENTIALLY AFFECTED WATERCOURSE SPRINGS			**19**

5.6.3 Springs at risk of impacts within or near to GFD Project tenures

Of the 13 spring complexes and 19 watercourse springs in the Surat CMA identified as being at risk of impacts due to cumulative development of gas under the EIS scenario, 8 spring complexes and 12 watercourse springs are located within or near GFD Project tenures (Table 5-12 and Table 5-13).

The UWIR identified 6 spring complexes and 12 watercourse springs located within or near Santos GLNG tenures to be at risk of impacts. Two additional spring complexes (302 and 339) and one additional watercourse spring (W141) located within or near GFD Project tenures have been assessed to be at risk of impacts under the EIS scenario.

Table 5-12 Spring complexes at risk of impacts within or near GFD Project tenures

Spring complex name	Spring complex number	Vent number(s)	Most likely source aquifer (OGIA, 2013)	Impacted underlying formations where the source aquifer is not impacted*	Gas field
Ponies	229	284	Hutton Sandstone	Precipice Sandstone, Clematis Sandstone, Bandanna Formation	Fairview
Lucky Last	230	287,340, 686, 687, 687.1, 687.2, 687.3, 687.4, 687.5, 687.6, 688, 689	Evergreen Formation (Boxvale Sandstone), Precipice Sandstone	NA	Fairview
302	**302**	**539, 539.1**	Precipice Sandstone	Bandanna Formation	East of Arcadia
311	311	499, 500, 500.1, 535, 536, 536.1, 536.2, 537, 692, 693, 694, 695, 696, 697, 698, 699	Precipice Sandstone	NA	Fairview
Lonely Eddie	**339**	**706, 707, 708, 709**	Precipice Sandstone	NA	NW of Fairview
Spring Rock Creek	561	285	Evergreen Formation (Boxvale	NA	Fairview

Spring complex name	Spring complex number	Vent number(s)	Most likely source aquifer (OGIA, 2013)	Impacted underlying formations where the source aquifer is not impacted*	Gas field
			Sandstone), Precipice Sandstone		
Yebna 2	591	534	Evergreen Formation, Precipice Sandstone	NA	Fairview
Abyss	592	286, 286.1, 286.2, 286.3, 682, 716	Hutton Sandstone	Precipice Sandstone, Clematis Sandstone, Bandanna Formation	Fairview

(1) NA – Not applicable

(2) **Bold** Impacted under the EIS Scenario but not the UWIR Scenario

* Impacted underlying formations shown where the source aquifer is not impacted

Table 5-13 Watercourse springs at risk of impacts within or near GFD Project tenures

Watercourse spring site number	Watercourse name	Most likely source aquifer (OGIA, 2013)	Impacted underlying formations where the source aquifer is not impacted*	Gas field
W10	Blyth Creek	Mooga Sandstone, Gubberamunda Sandstone	NA	Roma
W14	Bungaban Creek	Hutton Sandstone	NA	Scotia
W15	Bungaban Creek (North)	Hutton Sandstone	NA	East of Scotia
W16	Bungeworgorai Creek	Gubberamunda Sandstone	NA	North West of Roma
W18	Bungil Creek	Gubberamunda Sandstone	NA	Roma
W19	Bungil Creek	Mooga Sandstone	NA	Roma
W40	Dawson River (Central)	Precipice Sandstone	NA	Fairview
W80	Hutton Creek	Hutton Sandstone	Precipice Formation, Clematis Sandstone, Bandanna Formation	West of Fairview
W81	Hutton Creek	Hutton Sandstone	Precipice Formation, Clematis Sandstone, Bandanna Formation	Fairview
W82	Injune Creek	Hutton Sandstone	Precipice Formation, Clematis Sandstone, Bandanna Formation	Fairview
W141	**Robinson Creek**	Hutton Sandstone	NA	West of Scotia
W164	Yuleba Creek	Mooga Sandstone	NA	Roma

(1) NA – Not applicable

(2) **Bold** Impacted under the EIS Scenario but not the UWIR Scenario

* Impacted underlying formations shown where the source aquifer is not impacted.

A number of mining activities such as the Wandoan Coal Project (Xstrata Glencore); Range Project (Stanmore Coal) and Springsure Creek Coal Mine (Bandanna Energy) operating or proposed within or adjacent to the GFD Project area, also have the potential to impact aquatic ecosystems in receiving waters of the area. The degree of cumulative impact from these projects will be dependent on the following:

- Project planning resulting in reduction of development area in watercourse catchments
- Constraints planning and field development to minimise impacts on local watercourses
- Erosion and sediment control management techniques to minimise impacts caused by sediment laden surface runoff
- Coal seam water management and monitoring techniques aimed at beneficially using coal seam water where practicable
- Decommissioning techniques that allow for the progressive rehabilitation of the landscape's EVs.

As part of this EIS, Santos GLNG has in place numerous mitigation and control strategies to responsibly manage potential impacts to the aquatic environment. It is expected that the other resource operators within and close to the GFD Project area have similar control and mitigation measures.

5.7 Monitoring and reporting

Implementation of a monitoring and reporting strategy supporting the protection of aquatic environmental values is an important component of Santos GLNG's GFD Project to demonstrate the effectiveness of the mitigation and controls and to demonstrate compliance with regulatory approvals. Strategies for implementation of a monitoring program throughout the GFD Project duration have been identified. Monitoring programs would be undertaken consistent with Santos GLNG's management plans discussed in Section 5.3 to assess the effectiveness of management strategies outlined in Section 7. The Draft EM Plan will inform the development of development-specific monitoring programs.

5.7.1 Water quality monitoring during construction

As a priority, accepted construction in the vicinity of waterways will be timed to avoid seasonal flows where practicable. When ephemeral streams are flowing, erosion and control measures will be put in place to minimise impacts on watercourses and downstream environmental values during construction. Visual monitoring for sediment plumes and increases in turbidity will be undertaken during the construction of watercourse crossings (if water is present). If observed, corrective actions will be implemented and existing erosion and sediment measures will be repaired or revised as required.

5.7.2 Post construction monitoring

Upon completion of the construction and rehabilitation, each crossing location will be inspected by a suitably qualified person to verify that the rehabilitation has been completed to a standard suitable for protecting the ecological values of the watercourse in the long-term and in accordance with regulatory approvals. Reports will be provided to the relevant authority (EHP) as required.

5.7.3 Release of coal seam water to watercourses

Where coal seam water will be released to natural watercourses, a receiving environment monitoring program (REMP) must be developed to monitor the impacts of such releases. The REMP is to be designed and submitted to the relevant authority (EHP) for approval prior to implementation. Factors to be considered in the REMP are outlined below.

5.7.3.1 Survey design

Surveys should include locations in the receiving environment, as well as background (control or reference) sites. The background sites may be located upstream of the discharge point, or on nearby (unaffected) watercourses in the same catchment that have similar characteristics. Where practical, existing stream monitoring locations should be utilised to provide information prior to release commencing.

Survey timing will need to consider the seasonality of aquatic ecological values. For example in ephemeral watercourses, a wet season and post-wet season survey each year may be appropriate; whereas in larger perennial watercourses, seasonal surveys (summer, autumn, winter and spring) surveys may be required.

Where practical, baseline (pre-discharge) surveys will be undertaken to provide a basis for future impact assessment.

5.7.3.2 Indicators

Indicators to be monitored should reflect the likely aquatic environmental values that may be impacted by the discharge, as informed by detailed baseline surveys done for the Draft Environmental Management Plan. This may include, but is not limited to: water and sediment quality, bank stability, aquatic habitat condition, aquatic flora communities, aquatic macroinvertebrates, fish and turtles. The methods for monitoring each indicator will be determined during the REMP design process, and will be consistent with the *Monitoring and Sampling Manual 2009* (DERM, 2010) and other relevant standards.

5.7.4 Impacts to groundwater dependent ecosystems

Depressurisation and drawdown of aquifers may reduce water at discharge vent springs and watercourse springs. The Office of Groundwater Impacts Assessment (OGIA) has established a value of 0.2 m drawdown at monitoring bores for springs to trigger the need for the preparation of Spring Impact Management Strategies (SIMS), which outline both monitoring requirements and schedules and impact mitigation strategies, (if deemed required) including mitigation approaches such as the use of offsets and injected treated water into spring source aquifers. Biological monitoring is included within the SIMS framework and enables assessment of ecological responses by spring communities to changed hydrology.

Santos GLNG, together with three other proponents in the Surat CMA, have developed a Joint Industry Plan (JIP) for a groundwater monitoring and management system to protect the EVs of springs protected by the EPBC Act from the production of gas. The JIP establishes an Early Warning System (EWS) to provide adequate time for assessment and implementation of management measures prior to potential impacts on the EVs of springs associated with an EPBC Act listing.

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Appendix A Macroinvertebrate indices

Physical and chemical monitoring of water quality can only provide a snapshot of the conditions in an aquatic ecosystem during a single point of time. Biological monitoring provides a more time-integrated picture of ecosystem health, and may, for example, indicate the pollution history of an environment. A number of indices have been developed for freshwater macroinvertebrate communities, to provide an indication of ecosystem health. Aquatic macroinvertebrates are a significant source of food for many terrestrial species, such as some bird species and spiders that inhabit riparian areas.

Previous macroinvertebrate studies in the GFD Project area have used the standard AusRivAS method for collection and standard approaches towards data analysis, including calculation of taxonomic richness, PET richness, SIGNAL 2 scores and AusRivAS model outputs (e.g. FRC Environmental, 2009a; Hydrobiology, 2009, 2010; Simmonds and Bristow, 2004, 2007). Therefore, measures of diversity, abundance and overall condition are comparable between these studies. It should be noted that a number of these indices were developed in south-eastern Australia, rather than ephemeral and naturally turbid systems typically of the GFD Project area, so the results should be interpreted with care.

Taxonomic richness

Taxonomic richness is the number of taxa (typically families) in a sample. Taxonomic richness is the most basic and unambiguous diversity measure, and is considered to be among the most effective diversity measures.

PET richness

While some groups of macroinvertebrates are tolerant of pollution and environmental degradation, others are sensitive to these stressors (Chessman 2003). The **P**lecoptera (stoneflies), **E**phemeroptera (mayflies), and **T**richoptera (caddisflies) are referred to as PET taxa, and they are particularly sensitive to disturbance. There are typically more PET families in sites with good habitat and water quality than in degraded sites, and PET Taxa are often the first to disappear when water quality or environmental degradation occurs (DNRM, 2001). The lower the PET score, the greater the inferred degradation. In general, PET richness of:

- <1 indicates degraded quality of water or habitat condition
- 1 to 4 indicates moderate quality of water or habitat condition
- >4 indicates good quality of water or habitat condition (Gooderham and Tsylin, 2002).

SIGNAL 2 scores

SIGNAL (**S**tream **I**nvertebrate **G**rade **N**umber — **A**verage **L**evel) scores are also based on the sensitivity of each macro-invertebrate family to pollution or habitat degradation. The SIGNAL system has been under continual development for over 10 years, with the current version known as SIGNAL 2. The interpretation of SIGNAL 2 scores, in conjunction with the number of macroinvertebrate families recorded, enables the simple characterisation of aquatic macroinvertebrate communities on a bi-plot.

Appendix A - Macroinvertebrate indices

AusRivAS scores

AusRivAS scores can be determined using the AusRivAS model, where observed / collected taxa are compared with the taxa expected under a multivariate model based on habitat characteristics. The model combines the values of macroinvertebrate indices (O/E Families [the ratio of the number of families observed at the site to the number of families expected to occur] and O/E Signal [the ratio of the observed to expected Signal scores for the site]) to place the site within a band, which represents the degree of departure of the macroinvertebrate communities at the test site from the model predictions. However, it should be noted that investigation of the Queensland AusRivAS models carried out by the DNRM has highlighted the need for caution in the use of these current AusRivAS models. It appears that the classification of reference sites gives relatively weak groups and this may lead to higher than desirable model misclassification rates. As a result, the Queensland models may only be capable of predicting widespread generalist taxa that are also likely to be the more tolerant taxa given the extremes of climate found in Queensland. This would suggest that a “poor” rating using the models may mean that a site is in very poor condition, but a “good” rating may only mean that it isn’t a very “poor” site.

Thus, the current models only really provide the power to detect sites with obvious impacts but not those without impacts. It would be prudent to evaluate other associated data (e.g. taxonomic composition, taxonomic richness, PET richness, water quality, etc.) before a final assessment or interpretation is made.

B

Appendix B Aquatic flora recorded across the GFD Project area

Table B-1 Aquatic flora recorded across the GFD Project area

Family Species	Common Name	Growth Form	Native/ Exotic	Presence in Catchment Dawson	Comet	Condamine Balonne
Alismataceae						
Damasonium minus	Starfruit	E	Native			✓
Amaranthaceae						
Alternanthera denticulata	Lesser Joyweed	E	Native	✓	✓	✓
Araceae						
Lemna disperma		FF	Native	✓	✓	✓
Azollaceae						
Azolla sp.	Azolla	FF	Native	✓		✓
Cyperaceae						
Bulboschoenus fluviatilis	Marsh Clubrush	E	Native			✓
Carex appressa	Tall Sedge	E	Native	✓		
Cyperus aquatilis	Water Nutgrass	E	Native	✓		
Cyperus difformis	Dirty Dora	E	Native		✓	✓
Cyperus digitatus	Flatsedge	E	Native	✓		
Cyperus eragrostis	Umbrella Sedge	E	Exotic			✓
Cyperus exaltatus	Giant Sedge	E	Native	✓		✓
Cyperus polystachyos	Bunchy Sedge	E	Native	✓	✓	✓
Eleocharis acuta	Common Spike-Rush	E	Native	✓	✓	✓
Eleocharis cylindrostachys	Spikerush	E	Native	✓		
Eleocharis sphacelata	Tall Spike Rush	E	Native			✓
Schaenoplectus mucronatus		E	Native	✓		
Haloragaceae						
Myriophyllum sasugineum	Watermilfoil	S	Native	✓		✓
Myriophyllum verrucosum	Red Watermilfoil	S	Native		✓	
Myriophyllum artesium	Artesian Milfoil	S	Native	✓		
Hydrocharitaceae						
Vallisneria nana	Ribbon Weed	S	Native	✓	✓	

Appendix B - Aquatic flora recorded across the GFD Project area

Family Species	Common Name	Growth Form	Native/ Exotic	Presence in Catchment Dawson	Comet	Condamine Balonne
Juncaceae						
Juncus prismatocarpus		E	Native	✓		
Juncus usitatus	Rush	E	Native	✓	✓	✓
Juncaginaceae						
Triglochin multifructa	Water Ribbon	E	Native			✓
Triglochin procera	Ribbon Weed	E	Native			✓
Lomandraceae						
Lomandra longifolia	Mat Rush	E	Native	✓	✓	✓
Marsileaceae						
Marsilea drummondi	Nardoo	FA	Native		✓	✓
Marsilea hirsuta		S			✓	
Marsilea mutica	Nardoo	FA	Native			✓
Menyanthaceae						
Nymphoides crenata	Wavy Marshwort	S	Native		✓	
Najadaceae						
Najas tenuifolia	Waternymph	S	Native	✓		
Onagraceae						
Ludwigia peploides	Ludwigia	FA	Native	✓		✓
Poaceae						
Cynodon dactylon	Water Couch	E	Native	✓	✓	✓
Diplachne fusca	Brown Beetle Grass	E	Native			✓
Echinochloa colocrus-gallina	Barnyard Grass	E	Exotic			✓
Echinochloa colona	Awnless Barnyard Grass	E	Exotic	✓	✓	✓
Eragrostis elongata	Clustered Lovegrass	E	Native	✓		
Glyceria maxima	Reed Sweetgrass	E	Exotic	✓	✓	
Leptochloa digitata	Umbrella Canegrass	E	Native	✓	✓	✓

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Appendix B - Aquatic flora recorded across the GFD Project area

Family Species	Common Name	Growth Form	Native/ Exotic	Presence in Catchment		
				Dawson	Comet	Condamine Balonne
Phragmites australis	Common Reed	E	Native	✓	✓	✓
Pseudoraphis spinescens	Spiny Mudgrass	E	Native		✓	
Urochola mutica	Para Grass	E	Exotic			✓
Polygonaceae						
Persicaria attenuata	Smartweed	E	Native	✓	✓	✓
Persicaria decipiens	Slender Knotweed	E	Native	✓	✓	✓
Persicaria orientalis	Prince's Feather	E	Native	✓	✓	
Potamogetonaceae						
Potamogeton crispus	Curly Pondweed	S	Native		✓	✓
Potamogeton octandrus		S	Native			✓
Typhaceae						
Typha spp.	Bulrush, Cumbungi	E	Native	✓	✓	✓

Sources: Aquateco 2011; FRC Environmental 2004, 2007, 2009a, 2009b, 2010, 2012a, 2012b; Ecowise 2008; Hydrobiology 2009
E = emergent, S = submerged, FF = free-floating, FA = floating attached.

Appendix C Description of fish and turtles in the GFD Project area

Fish

Ecology of known Species in the GFD Project area

The relative composition and abundance of fish communities within the GFD Project area is largely controlled by the life history requirements of the species involved. Species richness and fish abundance is dependent on a range of factors including the historical biogeography of the region, the level of connectivity in the waterway, the size of the waterbody surveyed, water quality and the presence and abundance of physical habitat, such as large woody debris, in the waterway.

Many of the fish native to ephemeral systems of central and western Queensland migrate up and downstream and between different habitats at particular stages of their lifecycle. Stimuli for movement include small and large discharge events and changes in water temperature. Australian rivers have highly variable flow regimes, and fish may need to move up and downstream to avoid undesirable water quality and the drying out of pools (Kennard, 1997, Freshwater Fisheries Advisory Committee, 1996).

Of the fish likely to be found in the GFD Project area, most undertake freshwater or potamodromous migrations (Cotterell 1998, Marsden & Power 2007, see Table C-1). Adult Golden Perch and Spangled Perch move upstream to spawn, and juveniles move downstream for dispersal. This movement typically occurs in spring and summer, and is triggered by large flow events (Cotterell, 1998). Glassfish, Rainbowfish, Leathery Grunter and Gudgeons move within freshwaters to disperse to new habitats. This movement is also associated with flow events in the GFD Project area when the isolated pools become connected. Weirs downstream of the GFD Project area in both the Fitzroy and Murray-Darling Basins create substantial barriers to movement of many of these fish.

Spangled Perch, Glassfish, Carp Gudgeons, Eastern Rainbowfish and Eel-Tailed Catfish are tolerant species that can live in water characterised by low dissolved oxygen levels, high conductivity and relatively high turbidity (Table C-2). Although exact water quality tolerances could not be sourced for the exotic common carp (*Cyprinus carpio)*, goldfish and mosquito fish, these species are also reported to have wide environmental tolerances. Golden Perch, Bony Bream, Fly-Specked Hardyheads, Purple-Spotted Gudgeons and Pacific Blue-Eye have narrower water quality tolerances than the other species collected (Table C-2).

Table C-1 Timing of critical movements of fish known to inhabit the region

Family *Species*	Common name	Season			
		Summer	Autumn	Winter	Spring
Ambassidae					
Ambassis agassizii	Agassiz's glassfish	s	L	L	L
Atherinidae					
Craterocephalus stercusmuscarum	Fly-specked hardyhead	s	–	S	L
Clupeidae					
Nematalosa erebi	Bony bream	L	L	L	L
Cyprinidae					
Cyprinus carpio	Common carp	Li	Li	Li	Li
Carassius auratus	Goldfish	Li	Li	Li	Li

Appendix C - Description of fish and turtles in the GFD Project area

Family *Species*	Common name	Season			
		Summer	Autumn	Winter	Spring
Eleotridae					
Hypseleotris spp.	Carp gudgeons	L	Li	Li	Li
Mogurnda adspersa	Purple spotted gudgeon	Li	Li	Li	Li
Oxyeleotris lineolatus	Sleepy cod	Li	Li	Li	Li
Philypnodon grandiceps	Flathead gudgeon	Li	Li	Li	Li
Galaxiidae					
Galaxias olidus	Mountain galaxias	Li	Li	Li	Li
Gadopsidae					
Gadopsis marmoratus	River blackfish	Li	Li	Li	Li
Melanotaeniidae					
Melanotaenia splendida	Eastern rainbowfish	s	s	S	L
Melanotaenia fluviatilis	Murray river rainbowfish	Li	Li	Li	Li
Osteoglossidae					
Scleropages leichardti	Southern saratoga	s	Li	Li	s
Percichthyidae					
Maccullochella peelii peelii	Murray river cod	L	s	S	L
Macquaria ambigua oriens	Golden perch	L	s	S	L
Plotosidae					
Neosilurus hyrtlii	Hyrtl's tandan	L	Li	Li	L
Porochilus rendahli	Rendahl's catfish	L	Li	Li	L
Tandanus tandanus	Freshwater catfish	Li	Li	Li	Li
Poecillidae					
Poecilia reticulata	Guppy	Li	Li	Li	Li
Gambusia holbrooki	Mosquito fish	Li	Li	Li	Li
Retropinnidae					
Retropinna semoni	Australian smelt	Li	Li	Li	Li
Pseudomugilidae					
Pseudomugil signifer	Pacific blue eye	Li	Li	Li	Li
Terapontidae					
Leiopotherapon unicolor	Spangled perch	L	s	S	L
Bidyanus bidyanus	Silver perch	L	s	S	L
Scortum hillii	Leathery grunter	s	s	S	s

Sources Cotterell 1998; Marsden & Power 2007
L= large number of fish migrate, s = small numbers of fish migrate, Li = limited information

Appendix C - Description of fish and turtles in the GFD Project area

Table C-2 Reported water quality tolerances of native fish species known from, or that are considered likely to occur in, the GFD Project area

Family Species	Common name	Water Temperature (º C)	Dissolved Oxygen (mg/L)	pH	Conductivity (µS/cm)	Turbidity
Ambassidae						
Ambassis agassizii	Agassiz's Glassfish	11 – 33	0.3 – 19.5	6.3 – 9.9	19.5 – 15,102	0.2 – 144
Atherinidae						
Craterocephalus stercusmuscarum	Fly-Specked Hardyhead	12 – 33.6	2.9 – 19.5	6.1 – 9.1	19.1 – 5,380	0.2 – 62.3
Clupeidae						
Nematalosa erebi	Bony Bream	24 – 29	4.8 – 11	6.9 – 8.8	70 – 770	4 – 160
Eleotridae						
Hypseleotris spp. [a]	Carp Gudgeons	8.4 – 31.2	0.3 – 19.5	4.4 – 8.9	51 – 4,123	0.1 – 331.4
Morgurnda adspersa [a]	Purple-Spotted Gudgeon	11.9 – 31.7	0.6 – 12.8	5.6 – 8.8	72.0 – 2,495	0.2 - 200
Melanotaeniidae						
Melanotaenia splendida [c]	Eastern Rainbowfish	15 – 32.5	1.1 – 10.8	6.8 – 8.5	49 – 790	0.6-16, but up to 600
Melanotaenia fluviatilis	Murray River Rainbowfish	NA	NA	NA	NA	NA
Percichthyidae						
Macquaria ambigua [b]	Golden Perch	24 – 31	3.6 – 10.0	7.2 – 8.8	NA	4 – 40 cm secchi depth
Plotosidae						
Tandanus tandanus [a]	Freshwater Catfish	8.4 – 33.6	0.3 – 17.1	4.8 – 9.1	19.5 – 3,580	0.2 – 250
Pseudomugilidae						
Pseudomugil signifer	Pacific Blue-Eye	8.4 – 31.7	3.6 – 12.3	6.0 – 9.1	72 – 1,897.5	0.3 – 144
Retropinnidae						
Retropinna semoni [a]	Australian Smelt	8.4 – 31.7	0.6 – 16.2	6 – 9.1	51 – 1,624.2	0.4 – 144
Terapontidae						
Leiopotherapon unicolor	Spangled Perch	5 – 41	≥ 0.4	4 – 8.6	0.2 – 35.5 ppt salinity	1.5 – 260

Source Pusey *et al.* 2004
a environmental data from captures during surveys in south-east Queensland, approximately 300 km east of the GFD Project area
b environmental data from captures during surveys in the Fitzroy Basin
c environmental data from captures during surveys in the Burdekin Basin, approximately 300 km north of the GFD Project area

Appendix C - Description of fish and turtles in the GFD Project area

7.1.1.1 Agassiz's Glassfish (*Ambassis agassizii*)

Agassiz's Glassfish is commonly found in rivers, creeks, ponds, reservoirs, drainage ditches and swamps from Cairns in Queensland to Lake Hiawatha in New South Wales, and in the Murray-Darling system (McDowall, 1996, Allen *et al.*, 2002). This species can be found in a variety of still or slow-flowing habitats in lowland larger rivers, upland rivers and streams and small coastal streams, and occasionally in lakes, and river impoundments, particularly in areas with submerged macrophyte and bank side vegetation (Pusey *et al.*, 2004). This species has a temperature range of 18–27°C (Merrick & Schmida, 1984), although they are not tolerant of low dissolved oxygen levels (Tait & Perna, 2002), and are generally found in areas of low turbidity (Pusey *et al.*, 2004). The diet of this species consists largely of small crustaceans and adult and larval insects, including mosquitoes (McDowall, 1996). This species spawns and completes its lifecycle in freshwater, and during spawning deposits and fertilises demersal eggs on aquatic vegetation (Merrick & Schmida 1984). Information on the migration habits of Agassiz's Glassfish is limited, however it appears that this species may undertake upstream migrations triggered by increased flow (Pusey *et al.*, 2004). The Agassiz's Glassfish is likely to occur in all catchments relevant to the GFD Project area.

7.1.1.2 Australian Smelt (*Retropinna semoni*)

Australian Smelt are common from the Fitzroy River in Queensland to the Murray River mouth in South Australia, and are also found in Cooper Creek (Allen *et al.*, 2002). Australian Smelt are usually found in slow flowing streams and still water, and they shoal near the surface or around aquatic plants and woody debris (Allen *et al.*, 2002). Their diet included insects, microcrustaceans and algae (Allen *et al.*, 2002). Spawning tends to occur at temperatures over 15^{o}C, usually in late winter and spring (Pusey *et al.*, 2004). Eggs are laid among aquatic vegetation and hatch in about 10 days (Allen *et al.*, 2002). Australian Smelt were not observed in the 2009 EIS but were caught during surveys for the Nathan Dam pipeline within the Condamine-Balonne River catchment (FRC Environmental, 2007).

7.1.1.3 Bony Bream (*Nematalosa erebi*)

Bony Bream are abundant detritivores/algivores that form the basis of the food chain for a number of higher order consumers including larger fishes and birds, such as cormorants and pelicans (Pusey *et al.*, 2004). Bony Bream commonly occur in the shallows of still or slow-flowing streams, particularly in turbid waters, such as those of the region (Allen *et al.*, 2002). Within the Fitzroy River system, Bony Bream have been recorded from water temperatures between 24 and 29°C (Pusey *et al.*, 2004). They have a wide pH (6.9 - 8.8) tolerance and have been recorded from waters with salinity levels approaching those of the seawater (Pusey *et al.* 2004). High salinity tolerance is undoubtedly one of the factors influencing the widespread distribution of Bony Bream throughout Australia's freshwater habitats. However, they cannot tolerate low dissolved oxygen levels (Allen *et al.*, 2002) and are the first species to perish when ephemeral habitats start to dry up (Allen *et al.*, 2002). *Nematalosa erebi* (Bony Bream) are likely occur in all catchments relevant to the GFD Project area.

7.1.1.4 Common Carp (*Cyprinus carpio*)

Common Carp are an exotic species, and are listed as noxious in Queensland, under the *Fisheries Regulation 2008*. Their diet includes: molluscs, crustaceans, insect larvae and seeds but when food is scarce, aquatic plants and detritus is sucked from the substrate causing high turbidity (Allen *et al.* 2002). They prefer still or slow flowing water with abundant aquatic vegetation, but can also be found in brackish lower reaches of rivers and coastal lakes (Allen *et al.*, 2002). Eggs are deposited on any fibrous plant matter and hatch after only a few days, with juveniles growing rapidly in warm water (McDowall, 1996). Common Carp are only likely to occur in the GFD Project area tenures within the Condamine–Balonne River catchment.

7.1.1.5 Carp Gudgeons (Hypseleotris spp.)

There is considerable taxonomic uncertainty surrounding the systematics of this genus (especially in juveniles), with some species capable of hybridising, however ecologically, the species are probably very similar (Pusey *et al.*, 2004). Carp Gudgeons (*Hypseleotris* spp.) are common in coastal drainage basins of eastern Australia, from the northern section of the Murray-Darling Basin and parts of coastal NSW to north Queensland. Some species such as *Hypseleotris compressa* have broader distributions extending across northern Australia (Pusey *et al.*, 2004). Gudgeons are often shelter around aquatic vegetation and under logs and tree roots, commonly in slow moving water in streams, ponds, swamps and drains (Allen et al 2002; Marsden & Power 2007). Adult carp and firetail gudgeons are known to feed on invertebrates, such as mosquito larvae (Diptera: Culicidae), and small crustacea such as cladocerans and ostracods (Merrick & Schmida, 1984; Allen et al 2002). These species are quite tolerant to changes in water quality, and under ideal conditions can rapidly increase in numbers (Merrick & Schmida, 1984). Most *Hypseleotris* species undertake upstream spawning migrations in low to high water flow, however the timing of migration and spawning can vary among the different species (Marsden & Power, 2007). These species are likely to be common and abundant in each of the three catchments relevant to the GFD Project area.

7.1.1.6 Eastern rainbowfish (Melanotaenia s. splendida)

The Eastern rainbowfish is common to many parts of north-eastern and central Australia, and is usually abundant wherever it occurs (Allen *et al.*, 2002). Where found, this species usually prefers areas of sluggish water flow, and can be found a variety of habitats including streams, wetlands, floodplains and lowland rivers (Pusey *et al.*, 2004). This tropical species is tolerant of a wide range of environmental conditions, however is not often found in highly degraded streams (Marsden & Power, 2007). This species spawns all year round, although spawning peaks immediately before and during flood periods (Merrick & Schmida, 1984). Adults migrate upstream to spawn during the wet season from (November to April) when water flows are high and juveniles disperse from the spawning grounds (Merrick & Schmida, 1984). During the 2009 EIS, Eastern rainbowfish were captured at many sites in both the Upper Dawson and Comet river catchments (FRC Environmental, 2009a). This is consistent with the findings of other studies in the region, suggesting this species is likely to be common in the waterways of the GFD Project area that are within the Comet and Dawson river catchments. Creeks of the GFD Project area may provide breeding habitat for this species; spawning tends to occur in slow-flowing, weedy areas (Merrick & Schmida, 1984).

Appendix C - Description of fish and turtles in the GFD Project area

7.1.1.7 Fly-Specked Hardyhead (*Craterocephalus stercusmuscarum*)

The Fly-Specked Hardyhead is a very widespread species found in coastal and inland drainages of eastern and northern Australia, south to the Queensland border (Pusey *et al.*, 2004). This species is common and widely distributed in central Queensland, and is known to occur in the Fitzroy River Basin (Berghuis & Long, 1999; Pusey *et al.*, 2004). The species can be found in a variety of habitat types including rivers, streams, lakes, water impoundments and in brackish river estuaries, with moderate to fast water flows (Pusey et al 2004). This species is likely to migrate year round, migrating upstream to spawn (Marsden & Power, 2007), although only low numbers have been found in barrage fishways in the Fitzroy River Basin (Pusey *et al.*, 2004).

This tropical species is moderately tolerant of a wide range of temperatures, dissolved oxygen, pH and conductivity levels, however appears to be intolerant to high turbidity levels (>100 NTU) (Pusey *et al.*, 2004 and references within). This species is a microphagic carnivore consuming aquatic insects and microcrustaceans and to a lesser extent aquatic algae and macrophytes (Pusey et al 2004 and references cited within). Fly-Specked Hardyhead were only recorded in Carnarvon Creek during the 2009 EIS however they have been recorded in the Dawson, Comet and Condamine-Balonne river catchments in previous studies.

7.1.1.8 Freshwater Catfish (*Tandanus tandanus*)

Freshwater catfish have been stocked throughout eastern Australia for recreational angling. They are found in a range of habitats, from small-order streams to rivers, and they are generally more abundant when the riparian zone is intact and there is abundant terrestrial debris in the channel to provide habitat (Pusey *et al.* 2004). In general, they are tolerant of low oxygen concentrations and a range of temperatures (8.4–33.6°C), although they can be sensitive to sudden decreases in temperature (Pusey *et al.*, 2004). They mainly feed on aquatic insects as juveniles and switch to a more varied diet as adults. Adults exhibit some parental care by building circular nests in gravel beds. Eel-Tailed Catfish were only recorded in the Comet River catchment in the 2009 EIS, but have been recorded in the Dawson and Condamine-Balonne river catchments during other surveys.

7.1.1.9 Golden Perch (*Macquaria ambigua oriens*)

Golden Perch are large piscivorous predatory fish that are sought after by anglers. Golden Perch inhabit numerous waterbodies east of the Great Dividing Range, due to transplanting and stocking, however the Fitzroy River Basin is the only drainage (east of the Great Dividing Range) where they naturally occur as the subspecies *Macquaria ambigua oriens.* Golden Perch can tolerate extremes in temperature (4–35°C) (Allen et al 2002) (Midgeley, 1942, cited in Pusey *et al.*, 2004). Golden Perch are very tolerant of high turbidity (Gehrke *et al.*, 1993), and may move long distances upstream during floods (Allen *et al.*, 2002). This species was recorded in Dulacca Creek in the Condamine – Balonne River catchment and the Dawson River in the Upper Dawson River catchment in the 2009 EIS, and was recorded in larger waterholes, wetlands and water storages during other surveys in the region (FRC Environmental, 2009b, 2012a). They are unlikely to be common in the smaller, isolated pools that characterise many of the creeks in the GFD Project area.

Appendix C - Description of fish and turtles in the GFD Project area

7.1.1.10 Goldfish (Carassius auratus)

Goldfish are an exotic species, introduced into Australia in the 1960's as an ornamental fish (Allen *et al.*, 2002). They have are now established in the Murray-Darling and Fitzroy basins (Allen *et al.*, 2002). Inhabiting slow or still water, they are able to tolerate high temperatures and low oxygen concentrations (Allen *et al.*, 2002). Goldfish feed on plant materials, organic detritus and a variety of small insects (McDowall, 1996). Eggs are laid among aquatic plants and hatch after a few days, at which point the young attach themselves to aquatic plants for a few days while they absorb the remainder of their egg yolk (McDowall, 1996). Goldfish may occur in all catchments relevant to the GFD Project area, although their presence in the Comet River catchment is uncertain.

7.1.1.11 Hyrtl's Tandan (Neosilurus hyrtlii)

This species is very common and widespread in coastal drainages of northern Australia, as far south as Mary River on the east coast and the Pilbara on the west coast (Allen *et al.*, 2002). It also occurs widely throughout central Australia (Allen *et al.*, 2002) and is known to occur in the Fitzroy River (Merrick & Schmida, 1984). Hyrtl's tandan is a shoaling species that occupies a diverse range of habitats including still or flowing waters, pools and billabongs (Allen et al 2002). This species feeds on insects, molluscs, small crustaceans and worms (Allen *et al.*, 2002). The spawning behaviours of interior populations are unknown; however, northern populations breed at the beginning of the wet season in shallow, sandy areas in the upper reaches of streams (Allen et al 2002). Further research is required as this species may actually represent more than one species (Allen *et al.*, 2002). Hyrtl's tandan was not recorded in the 2009 EIS. They are likely to occur, but not be common, in the waterways and wetlands of the GFD Project area.

7.1.1.12 Murray Cod (Maccullochella peelii peelii)

The Murray Cod is found in a range of warm-water habitats in the waterways of the Murray Darling Basin (DEWHA, 2007). This species can be found in a variety of habitats, including slow-flowing turbid waters as well as fast-moving, clear waters in upstream reaches (Allen *et al.*, 2002). However, it prefers deeper-water habitats around in-stream habitat structures such as boulders, logs, undercut banks and overhanging vegetation (Allen *et al.*, 2002). In-stream woody debris is particularly important to this species, with adults establishing home 'territories' around a particular snag (DEWHA, 2007). Murray Cod are predators that feed on a variety of prey items according to taxon density, including microcrustaceans, macrocrustaceans, invertebrates and other fish (including the introduced carp and goldfish) (DEWHA, 2007). This species migrates upstream (up to 120 km upstream) during spring and early summer to spawn (Kearney & Kildea, 2001; Hydrobiology, 2009), with adults then returning to their home territory (DEWHA, 2007).

Murray Cod were not recorded during the initial field survey for the Ironbark EIS (Hydrobiology 2009). However they are known to occur in the Condamine River system and they typically occur throughout the Murray-Darling Basin in all but the upper tributaries of river systems (DEWHA, 2007), where it is thought that there have been serious declines in numbers due to habitat loss and declines in water quality (Kearney & Kildea, 2001). In-stream structures such as weirs have the potential to impact movement and migration of Murray Cod, although stocking programs in the river may mask the effects of this, and other impacting processes, on populations of this species. Fingerlings are regularly stocked to a number of impoundments on the Condamine River, including Miles, Dalby and Chinchilla weirs, and Cooby and Leslie dams on tributaries to the Condamine River (Kearney & Kildea, 2001).

Appendix C - Description of fish and turtles in the GFD Project area

Based on the above information, it is considered possible that there are Murray Cod in the lower reaches of Undulla Creek. However, it is considered unlikely that there are Murray Cod in the upper reaches of Undulla Creek in the GFD Project area for a significant amount of time; that is, if they are present, their presence is likely to be transitory.

Available data suggests that Murray Cod are main channel specialists, with a preference for deep water, the edge of the channel, overhanging vegetation and woody debris (Boys & Thoms, 2006; Jones & Stuart, 2007; Koehn, 2009). These areas provide shelter from predators, high velocity flows and sunlight; as well as trap organic matter and provide attachment sites for macroinvertebrates, which are prey of the Murray Cod (Crook & Robertson, 1999; Koehn, 2009). Both juveniles and adults have a preference for the same type of habitat and favour residency in 1-3 'home' areas (Jones & Stuart, 2007). However, Murray Cod undertake freshwater migrations for spawning, with adults moving upstream to spawn and juveniles moving downstream for dispersal (Cotterell, 1998; Marsden & Power, 2007). This movement typically occurs in spring and summer (Cotterell, 1998).

However, spawning is not necessarily correlated with flow; it occurs under a range of flow conditions (Humphries, 2005; Koehn & Harrington, 2006; Koehn, 2009). Adults lay adhesive eggs in nests on hard substrata and males then guard the nests (Humphries, 2005; Koehn & Harrington, 2006; Koehn, 2009). Larval numbers are at their highest in reduced flows after a high flow event, possibly due to washout from nests, and strong year classes are typically recorded in years following high flow events (Humphries, 2005; Koehn & Harrington, 2006). However, the spawning season occurs regularly, regardless of flow, and appears to be influenced by environmental cues that are correlated with date or annual rhythms, for example temperature, day length or moon phases (Humphries, 2005; Koehn & Harrington, 2006). Moderate to warm water temperatures, greater than 15ºC for a period of three to four months, are associated with Murray Cod spawning; this is not considered a driving factor in spawning, but free embryos develop faster at higher temperatures (Humphries, 2005; Koehn, 2009).

Juvenile Murray Cod are obligate and active drifters that can choose their location in the water column and are rarely caught outside their preferred habitat (Humphries, 2005). The abundance of juveniles is variable in time and space, and may be related to the size of the river and the time of day; there is no clear correlation between abundance of juveniles and flow (Humphries, 2005; Koehn & Harrington, 2006). Once outside of the nest, juvenile Murray Cod drift downstream for 5-7 days, with their rate of growth and development linked to temperature (Humphries, 2005). Overall, the recruitment of Murray Cod is driven by the survival of larvae and juveniles, which in turn is affected by temperature, flow, food availability, habitat availability and predation (Koehn & Harrington, 2006).

7.1.1.13 Murray River Rainbowfish (Melanotaenia fluviatilis)

Murray River Rainbowfish are the most southward ranging rainbowfish, adapted to low winter temperatures (Allen *et al.*, 2002). They extend within the Murray-Darling Basin system from Roma in Queensland to the Murray River and its tributaries in New South Wales, Victoria and South Australia (Allen *et al.*, 2002). They often congregate along grassy banks or around submerged logs and branches (Allen *et al.*, 2002). Murray River Rainbowfish were not recorded in the 2009 EIS but they were recorded in surveys for the Australia Pacific LNG EIS in the Condamine River and tributaries, approximately 50–100 km east of the portion of the GFD Project area that lies within the Condamine-Balonne River catchment (Hydrobiology, 2009).

Appendix C - Description of fish and turtles in the GFD Project area

7.1.1.14 Mosquito fish (Gambusia holbrooki)

The Mosquito fish is an introduced species in Australia. The Mosquito fish is declared noxious under the Fisheries Regulation 2008. They were initially brought into the country for aquariums and subsequently introduced into waterways to help control the mosquito populations (McDowall, 1996; Allen *et al.*, 2002). They are widespread and abundant throughout Victoria, New South Wales, South Australia, coastal drainages of Queensland and parts of Western Australia. They prefer warm gently flowing or still waters and are typically associated with aquatic vegetation. They are livebearers and spawning occurs in spring. They feed on terrestrial and aquatic insects, including mosquitoes, and have the capacity to displace native fish populations. Mosquito fish are likely to be present in the GFD Project area tenures within the Condamine-Balonne and Dawson river catchments; their presence in the Comet River catchment is uncertain.

7.1.1.15 Pacific Blue-Eye (Pseudomugil signifer)

This species is found along the eastern Australia, along the coast from Cape York Peninsula, south to Narooma (NSW) (Pusey *et al.*, 2004 and references cited within). This species is common and widespread in a variety of fast flowing coastal habitats including rivers, lagoons, streams and estuaries in central Queensland (Pusey *et al.*, 2004 and references cited within). This loosely schooling species is most commonly found in the mid to upper water column, in association with some form of submerged cover. This species is tolerant of a wide variety of temperatures and salinity levels, given the distribution, and generally prefers well-oxygenated, low turbidity waters (Pusey *et al.*, 2004). This species can complete reproduction naturally in fresh or marine waters and may undertake dispersal migrations, although these are not common (Pusey et al 2004). This species is a microphagous carnivore. In freshwater habitats more than 62% of its diet consists of aquatic insects, with a greater proportion of flying aquatic insects in estuarine situations (Pusey *et al.*, 2004). Pacific Blue-Eye were only recorded in the Dawson River during the 2009 EIS, and they are unlikely to be present in the ephemeral waterways of the GFD Project area based on the results of previous studies and their habitat preferences.

7.1.1.16 Purple-Spotted Gudgeons (Morgurnda adspersa)

Purple-Spotted Gudgeons (*Mogurnda adspersa*) occur along the east coast of Australia from Cape York to the Murray-Darling River. This species is generally found in slow-flowing waters over a range of substrate types. It prefers areas of cover, and it can be found amongst submerged or emergent vegetation, although it requires solid substrates on which to deposit eggs (Pusey *et al.*, 2004). They feed mostly on aquatic insects, terrestrial invertebrates and molluscs (Pusey *et al.*, 2004). Purple spotted gudgeons were only recorded in the Comet River catchment in the 2009 EIS, but have previously been recorded in the Dawson River catchment for the Nathan Dam and Pipelines EIS (FRC Environmental, 2007; Ecowise, 2008).

7.1.1.17 Sleepy Cod (Oxyeleotris lineolata)

Sleepy Cod are common and widespread in northern Australia between the Ord River on the west coast and Noosa on the east coast (Allen *et al.*, 2002). They are a hardy species inhabiting rivers, creeks and billabongs, usually in quiet or slow-flowing water among vegetation, around woody debris or beneath undercut banks (Merrick & Schmida 1984, Allen et al 2002). This species is a sluggish bottom dwelling carnivore that feeds on insects, small fishes and crustaceans (Merrick & Schmida, 1984; Allen *et al.*, 2002). Sleepy Cod appear to have a lower thermal limit of 15°C and Northern

Territory populations can withstand temperatures to 32°C (Merrick & Schmida, 1984). Sleepy Cod generally do not undertake substantial migrations, with spawning usually occurring between October and February (Allen et al 2002), when water temperatures reach 24°C. The nest is located on a solid surface (usually rock, tree roots or submerged log) and the male guards the nest for the incubation period of 5–7 days (Merrick & Schmida, 1984; Allen *et al.*, 2002). Sleepy Cod were not recorded in the 2009 EIS, though they were recorded during other surveys such as those done for the Nathan Dam EIS and Wandoan Coal Project EIS (FRC Environmental, 2007, 2009b). They are likely to be present in the larger waterbodies in the GFD Project area.

7.1.1.18 Spangled Perch (Leiopotherapon unicolor)

Spangled Perch are Australia's most widespread native fish, being abundant within most aquatic habitats extending across coastal northern Australia and inland waters (Allen *et al.*, 2002; Pusey et al 2004). Of particular relevance to their abundance in western and central Queensland creeks is their ability to aestivate in wet mud or under moist leaf litter in ephemeral water holes during droughts (Allen *et al.*, 2002), therefore Spangled Perch are likely to persist in the creeks within the GFD Project area throughout the year. As an adaptation to living in quick-drying waterholes, Spangled Perch eggs hatch in 2 days and the larvae develop in 24 days (Allen *et al.*, 2002). This species can generally tolerate a wide range of environmental conditions including water temperatures (5–44°C), salinity (0–34 ppt) and pH (4–10.2) (Pusey *et al.*, 2004).

The Spangled Perch is also capable of rapid and extensive movements and migrating past barriers that impede other fish species (Pusey *et al.*, 2004; Marsden & Power, 2007). Adults migrate upstream during high flow events to spawn and adults and juveniles undertake dispersive (lateral) migrations from refuge habitats to floodplain habitats during the wet season (Marsden & Power, 2007).

Spangled Perch were caught at roughly 30% of the sites surveyed during the 2009 EIS; they were found in each of the three Catchments and are likely to persist in the creeks within the GFD Project area throughout the year.

Turtles

Surveys conducted by FRC Environmental for the GLNG Project recorded two turtle species. Krefft's River Turtle (*Emydura krefftii*) was captured from the Dawson River in the Upper Dawson River catchment, and from Lake Nuga Nuga and the Comet River in the Comet River catchment. The White-Throated Snapping Turtle (*Elseya albagula*) was recorded from the Dawson River. In addition, three White-Throated Snapping Turtles were captured by hand in a tributary of the Dawson River. A single White-Throated Snapping Turtle was also captured by hand from Carnarvon Creek in the Comet River catchment.

7.1.1.19 Ecology of the species known in the GFD Project area

Freshwater turtles typically move between habitats in the order of tens of kilometres apart (but they may be displaced in the order of hundreds of kilometres) (Limpus *et al.*, 2007), and as such populations at any given location are likely to vary over the year. Movement is likely to occur in conjunction with the drying of habitats in the dry season, with turtles moving into large pools, which act as dry season refuge habitat (Limpus *et al.*, 2007). The Snake-Necked Turtle is known to migrate overland in a strategy to seek out quality food sources (Chessman, 1984).

Appendix C - Description of fish and turtles in the GFD Project area

The abundance and distribution of individual animals may also be expected to vary during the breeding season, with an increase in the abundance of female turtles adjacent to suitable nesting sites, followed by an increase in the abundance of juveniles post hatching. The White-Throated Snapping Turtle nests in autumn and winter; the Fitzroy River Turtle nests in spring; the Macquarie River Turtle, Krefft's River Turtle and saw-shelled turtle nest in spring and summer and the eastern snapping turtle nest in summer (Limpus *et al.*, 2007).

The Fitzroy River Turtle is listed as vulnerable under the EPBC Act and the NC Regulation. The White-Throated Snapping Turtle is not listed as a threatened species, but it is ranked as a high priority species under the EHP's *Back on Track* species prioritisation framework.

7.1.1.20 Fitzroy River Turtle (Rheodytes leukops)

The Fitzroy River Turtle is endemic to the natural permanent riverine habitats of the Fitzroy Basin, where it has been recorded from the Fitzroy Barrage to the Theodore Weir on the Dawson River, the Connors River, and the Duck Ponds on the Lower Nogoa River, upstream of the Comet-Mackenzie Junction (FRC Environmental, 2011, Limpus *et al.*, 2007). Fitzroy River Turtles were not caught in the 2009 EIS surveys or subsequent surveys of the gas transmission pipeline (FRC Environmental, 2009a, 2012b). It has not been recorded in the Upper Dawson River or Comet River catchments, however extensive field surveys have only been conducted in the Dawson River at Korcha Station, Hutton Creek at Warndoo Station and at Carnarvon Creek; and the EHP's turtle group expect that with further survey, the Fitzroy River Turtle will be identified in the Dawson River upstream of Theodore, and at additional sites within the middle to upper Comet River (Limpus *et al.*, 2007).

Little information is available on the abundance and life history of the Fitzroy River Turtle across its distribution. Riffles are an important habitat type for the Fitzroy River Turtle, with the home ranges of individuals typically overlapping these habitats (Tucker *et al.*, 2001), possibly due to increased foraging success in these habitats (Legler & Cann, 1980), or due to a greater efficiency of aquatic cloacal respiration in highly oxygenated waters such as riffle zones (Priest, 1997; Franklin, 2000; Gordos *et al.*, 2004).

However, under low-flow events, or as riffle zones become seasonally ephemeral (i.e. completely dry), the Fitzroy River Turtle retreats to deeper sections of pool habitats, or even isolated waterholes, next to riffle zones (Tucker *et al.*, 2001; Limpus *et al.*, 2007). As riffle zones throughout most of the range of the Fitzroy River Turtle are likely to be ephemeral, this species should not be considered to be a riffle zone specialist; rather, they exploit this habitat to forage for abundant food sources such as benthic invertebrates and algae in the wet season and early dry season (Limpus *et al.*, 2007). This allows the turtles to take up nutrients and build fat reserves for the dry season, which is essential for preparing to breed (Limpus *et al.*, 2007). Therefore, while large, slow-flowing pools can support populations of the Fitzroy River Turtle, the pools are likely to have a lower carrying capacity than reaches with riffle zones (Limpus *et al.*, 2007).

Female Fitzroy River Turtles nest on sandy banks with a deep layer of sand and a low vegetative cover. Biological data on the movement patterns of the Fitzroy River Turtle is largely limited to tracking studies conducted in the Fitzroy River at Glenroy Crossing (above the Eden Bann Weir) (Tucker *et al.* 2001). Home ranges typically vary widely among individuals, however, on average, turtles were observed to have a local mean range span of 562 m (Tucker *et al.* 2001), suggesting that viable populations are likely to be limited to waters in relative proximity to potential nesting habitat.

Appendix C - Description of fish and turtles in the GFD Project area

Based on the known habitat preferences of this species (i.e. large, permanent pools with ephemeral riffles, large woody debris and sandy banks) (Limpus *et al.*, 2007), it is considered possible that the Fitzroy River Turtle occurs in the GFD Project area; however if present, its distribution is likely to be restricted to high-order watercourses such as the Dawson River.

7.1.1.21 White-Throated Snapping Turtle (Elseya albagula)

The White-Throated Snapping Turtle was only described in 2006 (Thomson *et al.*, 2006); previously it had been regarded as part of the more common and widely distributed northern snapping turtle (*Elseya dentata*). It is found in the Fitzroy, Raglan, Burnett and Mary River drainages in central and southern Queensland. Within the Fitzroy River Basin, this species occurs from the barrage on the lower Fitzroy River to the uppermost spring fed pools in the Upper Dawson, Mackenzie and Comet River catchments (FRC Environmental, 2009a, Limpus *et al.*, 2007).

The White-Throated Snapping Turtle has been recorded almost exclusively in close association with permanent flowing stream reaches, typically characterised by a sand-gravel substrate with submerged rock crevices, undercut banks and/or submerged logs and fallen trees (Hamman *et al.*, 2007). Within the Fitzroy and Mary River catchments, the White-Throated Snapping Turtle is regularly associated with areas of high shade, including submerged logs and overhanging riparian vegetation, during the day; and shallow riffle zones at night (Hamman *et al.*, 2007). The White-Throated Snapping Turtle is rarely found in reaches without such refuge (Hamman *et al.*, 2007). The White-Throated Snapping Turtle has not been recorded in man-made waterbodies that are isolated from flowing streams (e.g. water storages on farms or sewage treatment plants), suggesting that the White-Throated Snapping Turtle DOTEs not move extended distances over dry land (Hamman *et al.*, 2007).

It is considered likely that the White-Throated Snapping Turtle occurs in the GFD Project area, where there is suitable habitat (such as high order watercourses, e.g. the Dawson River or spring-fed watercourses).

7.1.1.22 Broad-Shelled River Turtle (Chelodina expansa)

The Broad-Shelled River Turtle occurs throughout the Murray-Darling Catchment, in South Australia, Victoria, New South Wales and western Queensland, and in the coastal rivers and streams of Queensland from the Albert to the Fitzroy River catchments (Cogger, 1996, Limpus *et al.*,2007). It typically inhabits floodplain billabongs, wetlands, and the larger, slower flowing reaches of coastal rivers (Cogger, 1996, Limpus *et al.*, 2007), and is therefore unlikely to be abundant in the ephemeral creeks in the GFD Project area.

7.1.1.23 Eastern Snake-Necked Turtle (Chelodina longicollis)

The eastern Snake-Necked Turtle occurs throughout the Murray-Darling Catchment, in South Australia, Victoria, New South Wales and western Queensland, and in coastal drainages from New South Wales to Central Queensland (Cogger, 1996, Limpus *et al.*, 2007). This species is most abundant in shallow ephemeral waterways and in water storages on farms that are remote from natural permanent water (Cogger, 1996, Limpus *et al.*, 2007). This species survives extended dry periods by either burrowing into the substrate of drying waterholes or aestivating, and has the capacity to make large overland movements to take up residence in previously dried out habitats (Limpus *et al.*, 2007). This species is likely to be present in the waterways and wetlands of the GFD Project area.

Appendix C - Description of fish and turtles in the GFD Project area

7.1.1.24 Macquarie River Turtle (*Emydura macquarii*)

The Macquarie River Turtle occurs in the Murray-Darling River system and associated drainages west of the Great Diving Range (Cogger, 1996). They occur in rivers, creeks and lagoons, but are most abundant in larger rivers and floodplain waterholes (Cogger, 1996). This species may be present in larger, deeper pools within the tenures located in the Condamine-Balonne River catchment.

7.1.1.25 Krefft's River Turtle (*Emydura macquarii krefftii*)

Krefft's River Turtles occur in all coastal drainages of Queensland, from the Mary River north to Princess Charlotte Bay (Cann, 1998; Wilson & Swan, 2008). They inhabit rivers, creeks and lagoons, and is the most widespread and abundant turtle in the Fitzroy Basin, occurring from the uppermost spring fed pools down to the billabongs and estuarine waters of the coastal plains (Limpus *et al.*, 2007). Krefft's River Turtles have been recorded in both the Upper Dawson and Comet River catchments previously (Limpus *et al.*, 2007; FRC Environmental, 2007), and are likely to be relatively common in the larger permanent waterways of the tenures located within the Dawson and Comet river catchments.

7.1.1.26 Saw-shelled turtle (*Wollumbinia latisternum*)

The saw-shelled turtle occurs in coastal rivers from Arnhem Land, down through coastal Queensland to the Richmond River in northern New South Wales (Cann, 1998; EPA, 2007; Wilson & Swan, 2008). It is widespread at a relatively low density throughout the Fitzroy Basin, but is more common in the flowing streams of the upper catchment than in the slower flowing lower reaches (Limpus *et al.* 2007). Saw-Shelled Turtles have been recorded in both the Upper Dawson and Comet River catchments (Limpus *et al.*, 2007), and may be relatively common in the faster flowing upper tributaries of the main rivers within the GFD Project area.

Appendix D Analysis of springs in the GFD Project area

Ecology of spring habitats

The stability of aquatic organisms in artesian spring communities is related to the supply of water and the variability in the discharge of this water at the spring itself. Historically, the supply of water to GAB springs was relatively consistent, and flow at the springs was fairly constant across years, but varied across seasons (EPA, 2005a). Artesian springs are known to exhibit natural temporal dynamism in both presence and condition (Ponder, 2002; Fensham & Fairfax, 2003); the condition of the aquatic communities at each spring varies with changes in hydraulic activity. That is, artesian springs (and the aquatic communities that they support) may come and go naturally over longer ecological time scales. Indeed, recently emerged mound springs have been recorded in the GAB, and there are examples of mound springs that probably 'dried out' prior to European settlement (Fensham & Fairfax, 2003).

Since the GAB was discovered as a water resource in 1878, the pressure of the GAB has been reduced through the continued extraction of water, an effect known as "drawdown" (Ponder, 2002, Fensham & Fairfax 2003, EPA 2005a). Roughly 80% of natural discharge springs, and 8% of recharge springs, have become completely or partially inactive during this time (Fensham & Fairfax 2003; Fensham & Price, 2004). The impact of this draw-down is felt across the entire basin, not just at the point of water extraction, and has reduced the volume and rate of discharge at certain springs, resulting in a localised loss of flora and fauna species, especially those species that require permanent water (Fensham & Fairfax, 2003). The higher rates of inactivity for discharge springs compared with recharge springs may reflect the higher density of bores in the relatively arid discharge areas (Fensham & Fairfax, 2003). The limited effect of drawdown on recharge springs may also be reflective of their occurrence in areas with relatively high rainfall (Fensham & Fairfax, 2003).

Fensham *et al.* (2003) examined similarities and differences in the floral communities occupying springs in the Brigalow Belt and throughout Queensland using non-metric multidimensional scaling. This study investigated 269 springs or spring complexes (springs within 6 km of each other) containing at least four native macrophytes. Floral communities in non-GAB springs were found to be similar to GAB recharge sites; both communities were significantly different from GAB discharge communities. This was considered to result from the pH of the spring water, because water pH, soil pH and soil texture were found to be a major influence of macrophyte communities. The pH of discharge springs was consistently higher than that of recharge springs. Communities growing on coarse-grained sediments (quartose sandstones) are also usually distinct from communities growing on recent alluvium, the latter being most similar to fine-grained sediments (Fensham *et al.*, 2004).

Springs in the GFD Project area

The GAB is an extensive series of interconnected aquifers that covers much of Queensland, and parts of New South Wales, South Australia, and the Northern Territory. Three types of spring occur in the GFD Project area:

- Recharge vent springs occur where rates of recharge are greater than rates of water infiltration; thus, 'rejection' of water causes seepage of water at the surface from exposed formations. Recharge springs are commonly an ephemeral feature in a local aquifer and not necessarily connected to the water table.
- Discharge vent springs occur where faulting or rapid thinning occur against basement highs disrupting lateral through- flow of groundwater or where water-bearing zones approach the ground surface and pressurised groundwater breaks through fractures in thin confining beds.

Appendix D - Analysis of springs in the GFD Project area

- Watercourse springs are a section of a watercourse where groundwater enters the stream from an aquifer through the streambed. These springs occur where an outcropping aquifer has been eroded to create a depression in the surface of sufficient depth to reach the water table.

The Office of Groundwater Impact Assessment provides the Underground Water Impact Report (UWIR) (QWC 2012) which set the boundaries for petroleum companies in terms of regulations for management of potentially impacted springs. The GFD Project area is situated within the Surat Basin Cumulative Management Area. Under the regulatory framework, a spring is a potentially affected spring if it overlies an aquifer where the long-term predicted impact on water levels at the location of the spring resulting from the extraction of water by petroleum tenure holders, exceeds 0.2 m. Potentially impacted artesian springs and watercourse springs are detailed for each catchment in Section 4.

Springs that are sustained by natural discharge of the GAB are protected under the EPBC Act; this would include some of the discharge vent springs and watercourse springs in the GFD Project area. However, all springs in the GFD Project area are likely to support diverse and abundant macrophyte communities, and may support populations of Salt Pipewort (*Eriocaulon carsonii*) which is listed as endangered in the EPBC Act, Artesian Milfoil (*Myriophyllum artesian*), which is listed as endangered under the *Nature Conservation (Wildlife) Regulation 2006*, and *Eleocharis blakeana* and Wandering Fringe-rush (*Fimbristylis vagans*), which are listed as near threatened under the Nature Conservation (Wildlife) Regulation 2006. While emergent macrophytes are the most common growth form in springs, some submerged and floating species may also occur (FRC Environmental, 2009a). Larger springs also provide habitat for aquatic fauna, including aquatic snails, fish and turtles (FRC Environmental, 2009a). Springs in the GFD Project area, especially watercourse springs, may provide habitat for White-Throated Snapping Turtle (*Elseya albagula*), which is a conservation significant species in Queensland, as it is listed as a priority species in EHP's 'Back on Track' species prioritisation framework. Many springs throughout the GFD Project area have vegetation communities that are consistent with Regional Ecosystem 11.3.22 (palustrine wetland), which is an 'Of Concern' vegetation type under the *Vegetation Management Act 1999*. Overall, the condition of the springs in the region varies considerably, depending on factors such as the presence of water, the ability of stock to gain access to the spring, and the presence and abundance of terrestrial weeds. Many stream reaches throughout the GFD Project area tend to be dry for most months of the year and may only contain water for short periods in the summer wet season. Thus, permanent pools and waterholes are 'critical habitat areas' for aquatic biota (Abell *et al.*, 2007) throughout the otherwise dry landscape and provide refuge habitat that enable aquatic species to persist during dry periods (Sheldon *et al.*, 2010), including conservation significant fauna such as White-Throated Snapping Turtle and Salt Pipewort. These refuge pools also provide a source of water for terrestrial fauna during dry periods. It is possible that such refuge pools are associated with, and even sustained by, watercourse springs. The location of refuge pools, and their dependence on groundwater inputs for permanence, will need to be assessed in the vicinity and downstream of watercourse springs that have been identified as likely impacted by the GFD Project.

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