

Draft environmental management plan

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Gas Field Development Project Draft Environmental Management Plan

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1 Introduction

This Draft Environmental management plan (Draft EM Plan) supports Santos Gladstone Liquefied Natural Gas (GLNG) proposal to develop the Santos GLNG Gas Field Development Project (the GFD Project). The GFD Project is an expansion of the existing approved GLNG Project and will involve the construction, operation, decommissioning and rehabilitation of production wells, and associated supporting infrastructure necessary to provide additional gas over a project life exceeding 30 years.

The GLNG Project was approved by the Queensland Government in 2010 and is one of Australia's major liquefied natural gas (LNG) projects. As approved, it involved the development of approximately 2,650 exploration and production wells and a 420 km underground pipeline connecting coal seam gas (CSG) fields with a 7.8 million tonnes per annum (Mtpa) initial capacity LNG facility on Curtis Island, Gladstone.

The GFD Project seeks approval to expand the GLNG Project's gas fields tenure from 6,887 km² to 10,676 km² 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.

Through the GFD Project, Santos GLNG proposes to develop gas fields to meet projected GLNG demands over the next 30 years and beyond. CSG from the GFD Project will be transported via the GLNG gas transmission pipeline (GTP) to the GLNG export facility.

This document summarises the potential environmental impacts identified during the assessments conducted for the GFD Project Environmental Impact Statement (EIS). The Draft EM Plan proposes measures to avoid, mitigate and manage adverse impacts during the construction, operation and decommissioning phases of the GFD Project.

1.1 Project background

In November 2012, Santos GLNG lodged an application to have the GFD Project declared a 'significant project' and an initial advice statement with the Queensland Department of State Development, Infrastructure and Planning (DSDIP). The initial advice statement sought to provide the Coordinator-General with sufficient information on the GFD Project and its potential environmental, social and economic impacts to determine whether to declare the GFD Project to be a 'significant project' under the State Development and Public Works Organisation Act 1971 (SDPWO Act). On 16 November 2012, the GFD Project was deemed a 'significant project' in accordance with requirements of Section 26 of the SDPWO Act and therefore requires an EIS.

In November 2012, the GFD Project was referred to the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities (SEWPaC) under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). On 3 December 2012, SEWPaC deemed the GFD Project to be a controlled action (reference number EPBC 2012/6615). The controlling provisions under the EPBC Act are; Wetlands of international importance; listed threatened species and communities; and listed migratory species. In October 2013, Santos GLNG was advised by the Commonwealth Department of the Environment (successor of SEWPaC) that an additional controlling provision relating the impact of coal seam gas development on water resources also applied to the GFD Project.

The EIS has been prepared in accordance with Chapter 3, Part 2 of the Queensland Environmental Protection Act 1994 (EP Act). This allows the proponent of a proposed development to voluntarily prepare an EIS as a step in the process of seeking an environmental authority (EA) for a petroleum activity project, as defined under Chapter 5A of the EP Act. The EIS informs decision makers, interested and affected stakeholders, and the public about the GFD Project's potential environmental, social and economic impacts and how these impacts will be avoided, mitigated and managed.

1.2 Environmental management plan purpose

The Draft EM Plan incorporates environmental and social mitigation measures from the EIS as a framework for continuing management, monitoring, reporting and improvement. The primary purpose of the Draft EM Plan is to identify the environmental values potentially affected by the GFD Project and propose measures to manage the risk of potential adverse impact to these environmental values.

The Draft EM Plan and accompanying documentation have been prepared to fulfil the requirements of the final Terms of Reference (ToR) and is further detailed in Section 2 of this Draft EM Plan.

1.3 Relevant stakeholders

Santos GLNG identified relevant stakeholders through:

- Existing stakeholder relationships and networks established in the Santos GLNG Project
- Desktop research on the local and regional areas to identify gaps and understand new areas
- Information obtained during engagement activities.

This included “interested and affected stakeholders” under the EP Act.

Stakeholders were identified and prioritised based on their relative interest and influence on the GFD Project. Santos GLNG consulted with more than 1000 participants from 11 regional communities potentially affected by the GFD Project.

Consultation was undertaken in the following communities:

- Arcadia Valley
- Surat
- Mitchell
- Roma
- Yuleba
- Wallumbilla
- Wandoan
- Taroom
- Rolleston
- Springsure
- Injune.

The key stakeholders and communities for the GFD Project are identified in Table 1-1.

Section 10 of this Draft EM Plan provides additional detail with regards to the potential impacts as well as mitigation measures to manage these potential impacts to the values listed above.

Table 1-1 Key stakeholders identified and engaged for the GFD Project

Stakeholder group	Organisation		
Local government (mayor, councillors and relevant council officers)	- Banana Shire Council - Maranoa Regional Council	Central Highlands Regional Council	Western Downs Regional Council
Elected representatives	Deputy Premier	Federal, elected members	Local, elected member
State government departments and agencies	- Department of Aboriginal and Torres Strait Islander and Multicultural Affairs - Department of Agriculture, Fisheries and Forestry - Department of Communities, Child Safety and Disability Services - Department of Community Safety - Department of Education, Training and Employment - Department of Energy and Water Supply - Department of National Parks, Recreation, Sport and Racing - Queensland Rural Fire Service	- Department of Natural Resources and Mines - Department of Premier and Cabinet - Department of Science, Information Technology, Innovation and the Arts - Department of State Development Infrastructure and Planning - Department of Tourism, Major Events, Small Businesses and the Commonwealth Games - Department of Transport and Main Roads - Queensland Police Service - Skills Queensland	- Department of Environment and Heritage Protection - Department of Housing and Public Works - Department of Justice and Attorney General - Department of Local Government, Community Recovery and Resilience - Department of Treasury and Trade - Queensland Gas Fields Commission - Queensland Health (hospitals, health centres / clinics within the area)
Federal government departments and agencies	Australian Department of the Environment (former Department of Sustainability, Environment, Water, Population and Communities)	Central Queensland Medicare Local	Independent Expert Scientific Committee
Aboriginal and Torres strait Islander groups and services	- Mandandanji - Iman - Bidjara	Charleville and Western Areas Aboriginal Torres Strait Islander Community Health	- Queensland South Native Title Services - Sandlewood Aboriginal Projects

Stakeholder group	Organisation		
Regional communities and landholders	Communities in the area (Arcadia Valley, Injune, Surat, Roma, Mitchell, Wandoan, Yuleba, Wallumbilla, Taroom, Rolleston, Springsure)	Affected landholders within authority to prospect (ATP) tenures and petroleum leases(PLs)	
Environment and agricultural groups	- AgForce - Basin Sustainability Alliance - Dawson Catchment Co-ordinating Association	- Fitzroy Basin Association - Queensland Great Artesian Basin Advisory Council	- Queensland Marry-Darling Committee - Upper Dawson Wildlife Preservation Society
Community and interest groups	Local and regional tourism associations	Local and regional development / progress associations	- Local historical and heritage societies - Regional social and philanthropic clubs
Local business and industry groups	Chambers of Commerce and Regional Development Organisations	Media and community publications	
Service providers	Community Service Providers (Blue Care Roma Community Care, Roma Interagency Group, Anglicare Roma, Rolleston Library)	Local schools and training providers	

1.4 Project description

Santos GLNG intends to further develop its Queensland gas resources to augment supply of natural gas to its existing and previously approved 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 tenure from 6,887 km² to 10,676 km² 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 adjacent areas.

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.

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.

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.

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 increases, investment decisions will be made about the scale, location and timing of the next stages of field development.

1.4.1 Project locality

The GFD Project will be located across an area covering 10,676 km² of the Bowen and Surat basins. The Bowen Basin occupies about 160,000 km² of eastern central Queensland, while the Surat Basin covers 300,000 km² of central southern Queensland and extends into northern New South Wales.

The GFD Project area is located in the Banana Shire Council and Central Highlands, Maranoa and Western Downs Regional Council areas. The nearest towns include Bauhinia, Blackwater, Injune, Miles, Mitchell, Rolleston, Roma, Springsure, Surat, Taroom, Wallumbilla, Wandoan, and Yuleba.

1.4.1.1 Land Use and Tenure

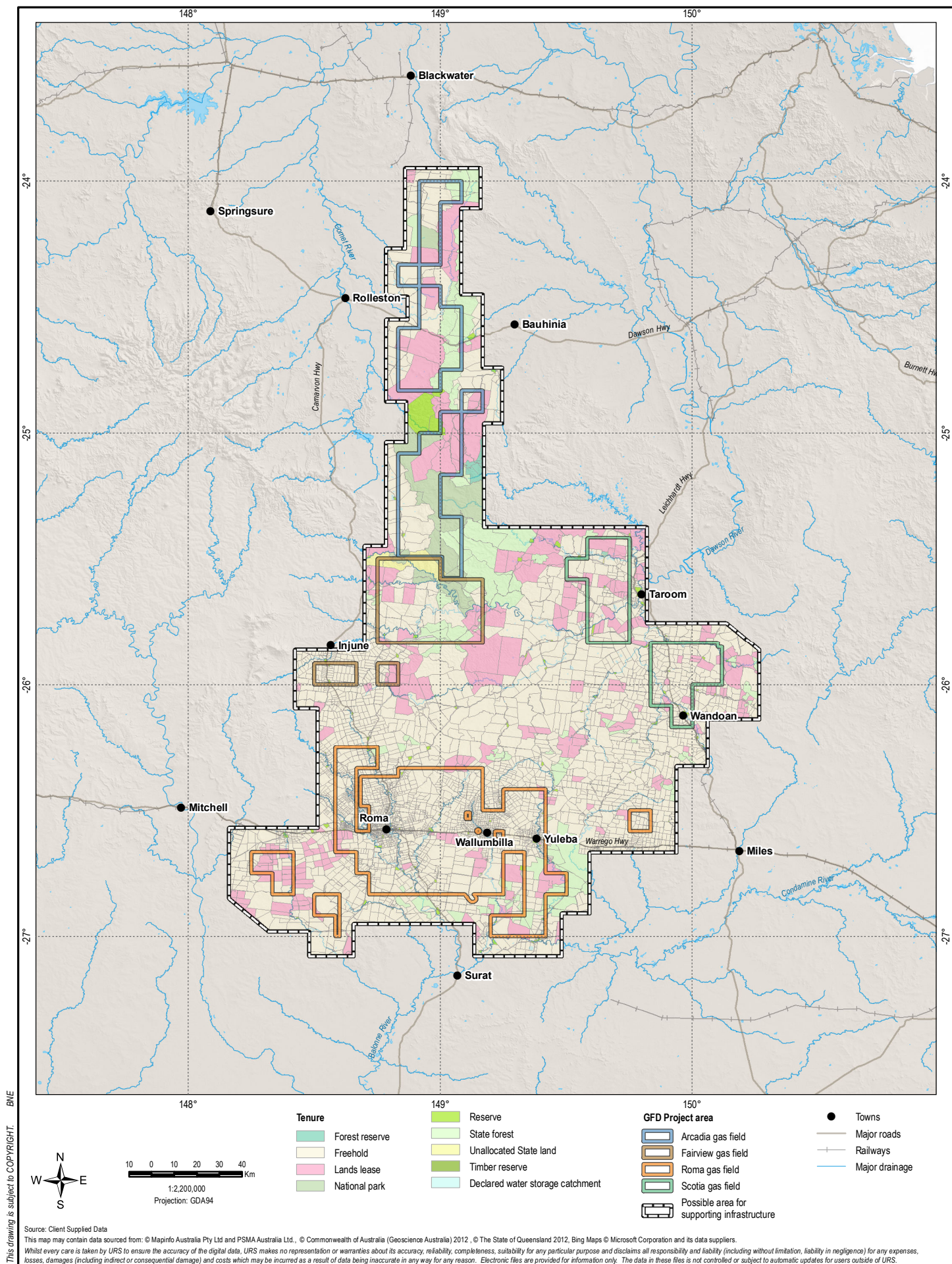
The GFD Project area includes a range of land uses including large areas of agricultural production, resource extraction, Native Title and protected areas with conservation, tourism and recreation values. In addition, the GFD Project area includes a number of urban areas, from larger rural centres such as Roma and Injune to smaller localities including Taroom, Wandoan, Springsure, Wallumbilla, and Yuleba. In keeping with the large areas of agricultural production across the GFD Project area, rural residences are common outside of the urban areas. Of the 20 declared catchment areas in Queensland administered by the Department of Natural Resources and Mines (DNRM), none are located within the GFD Project area.

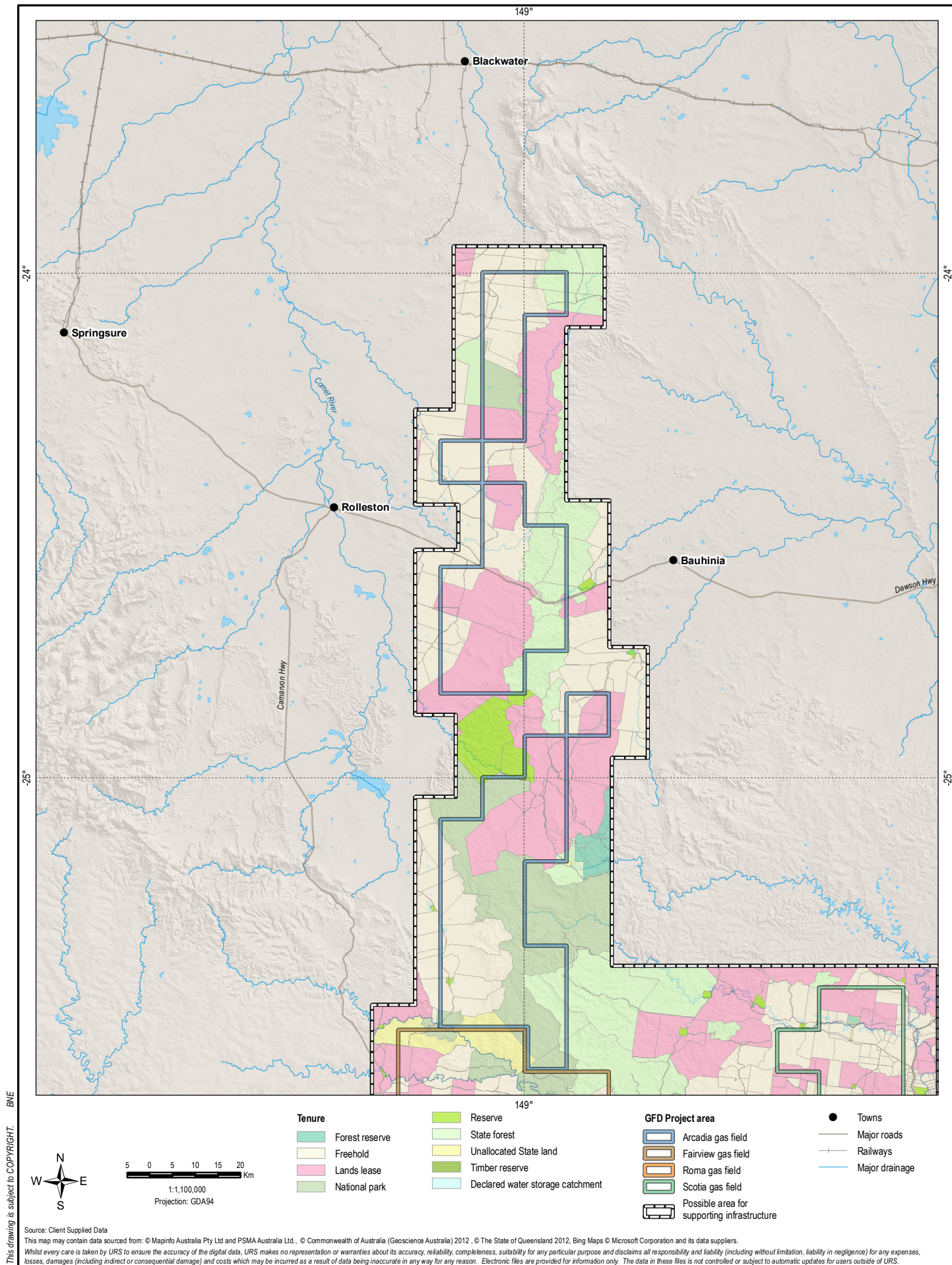
The GFD Project area contains a total of 7,817 cadastral allotments under the tenures of freehold, leasehold and Crown land (including various reserves, national parks and State forests), with the predominant tenure being freehold. A summary of the land tenures of the GFD Project area are provided in Table 1-2 below. These allotments and their tenures are shown on Figure 1-1, and for each gas field in Figure 1-2 to Figure 1-5.

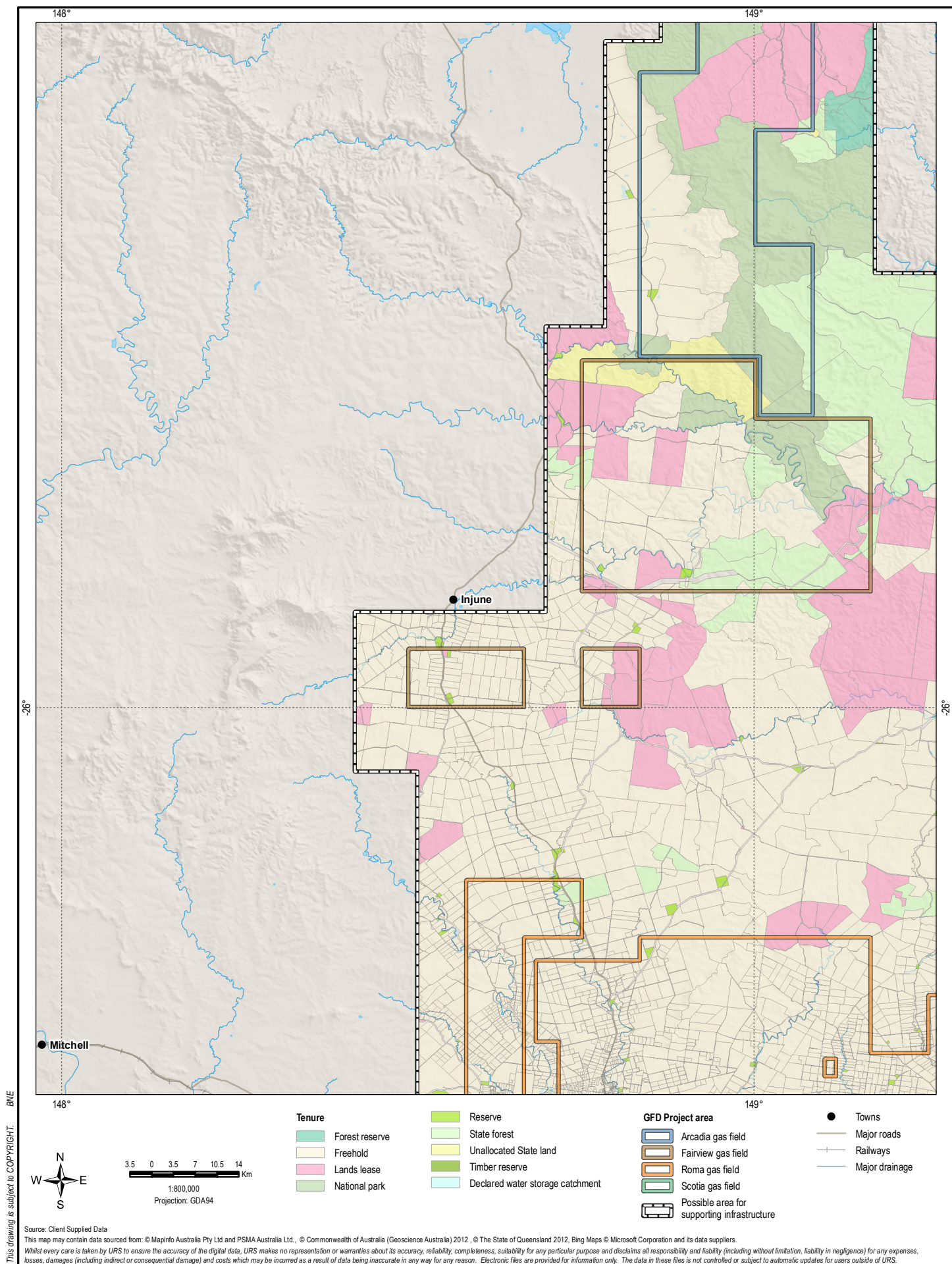
Table 1-2 Project land tenures

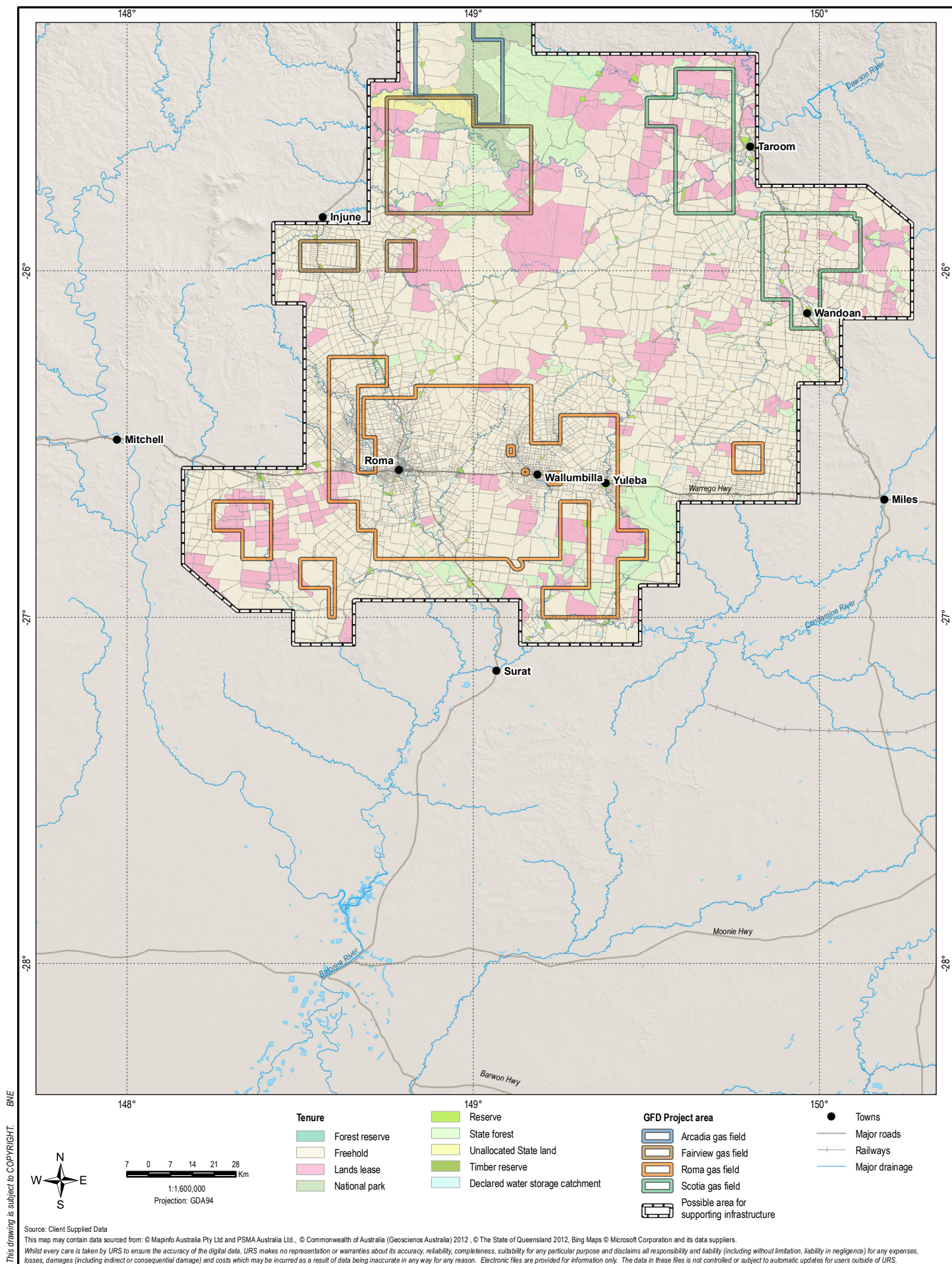
Gas field	Freehold	Lands lease	State held tenures			
			National park	Reserve	State forest	Unallocated State land
Arcadia	40	15	2	2	6	2
Fairview	112	18	2	10	5	1
Roma	6,461	144	0	159	8	77
Scotia	637	60	2	46	0	8
Total	7,250	237	6	217	19	88

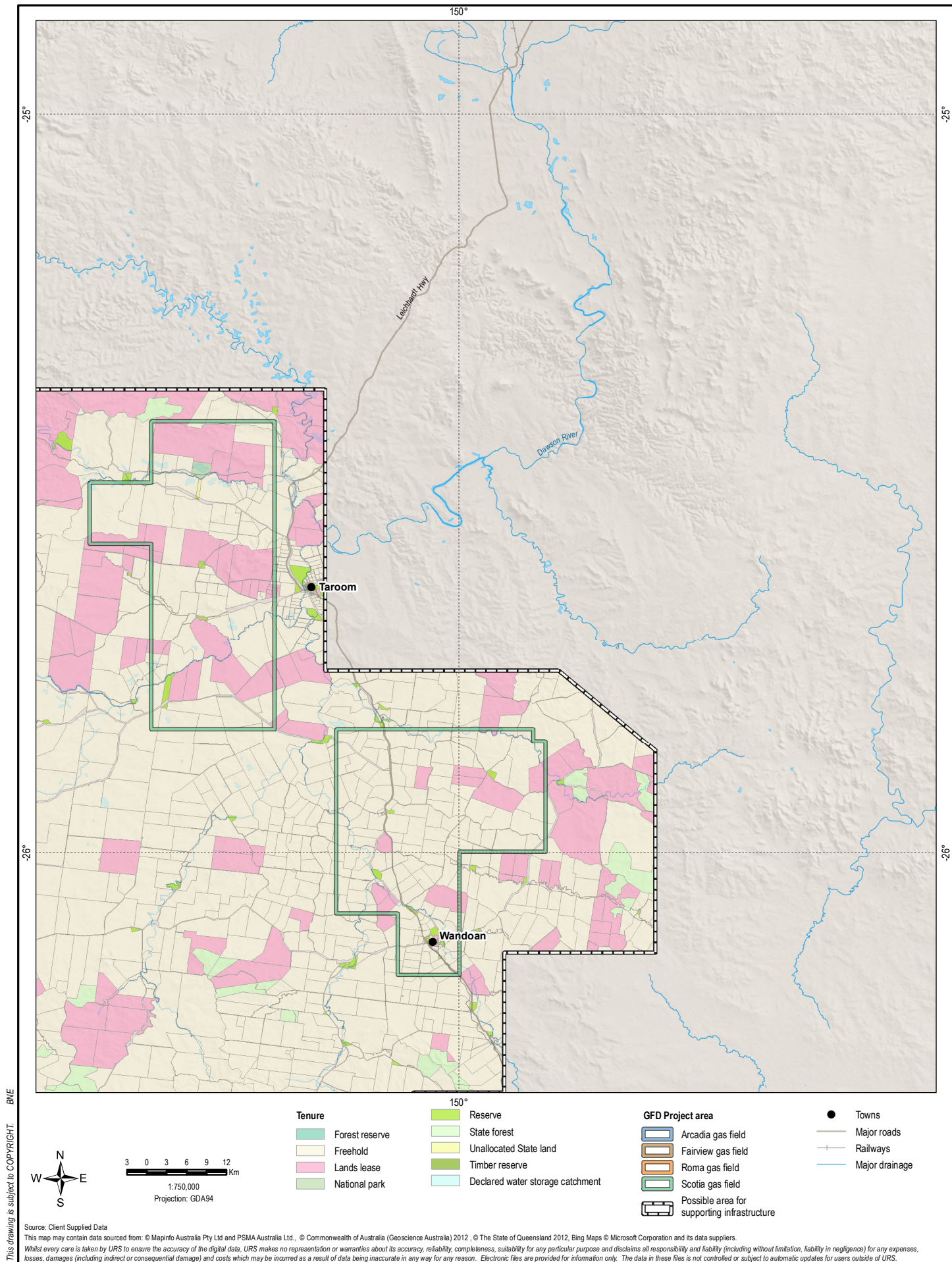
Source: Land use, planning and tenure assessment (URS, April 2014).











1.4.2 Petroleum tenures

The development of the gas fields will be undertaken pursuant to petroleum authorities granted under the Petroleum and Gas (Production and Safety) Act 2004 (P&G Act) and the Petroleum Act 1923 administered by DNRM.

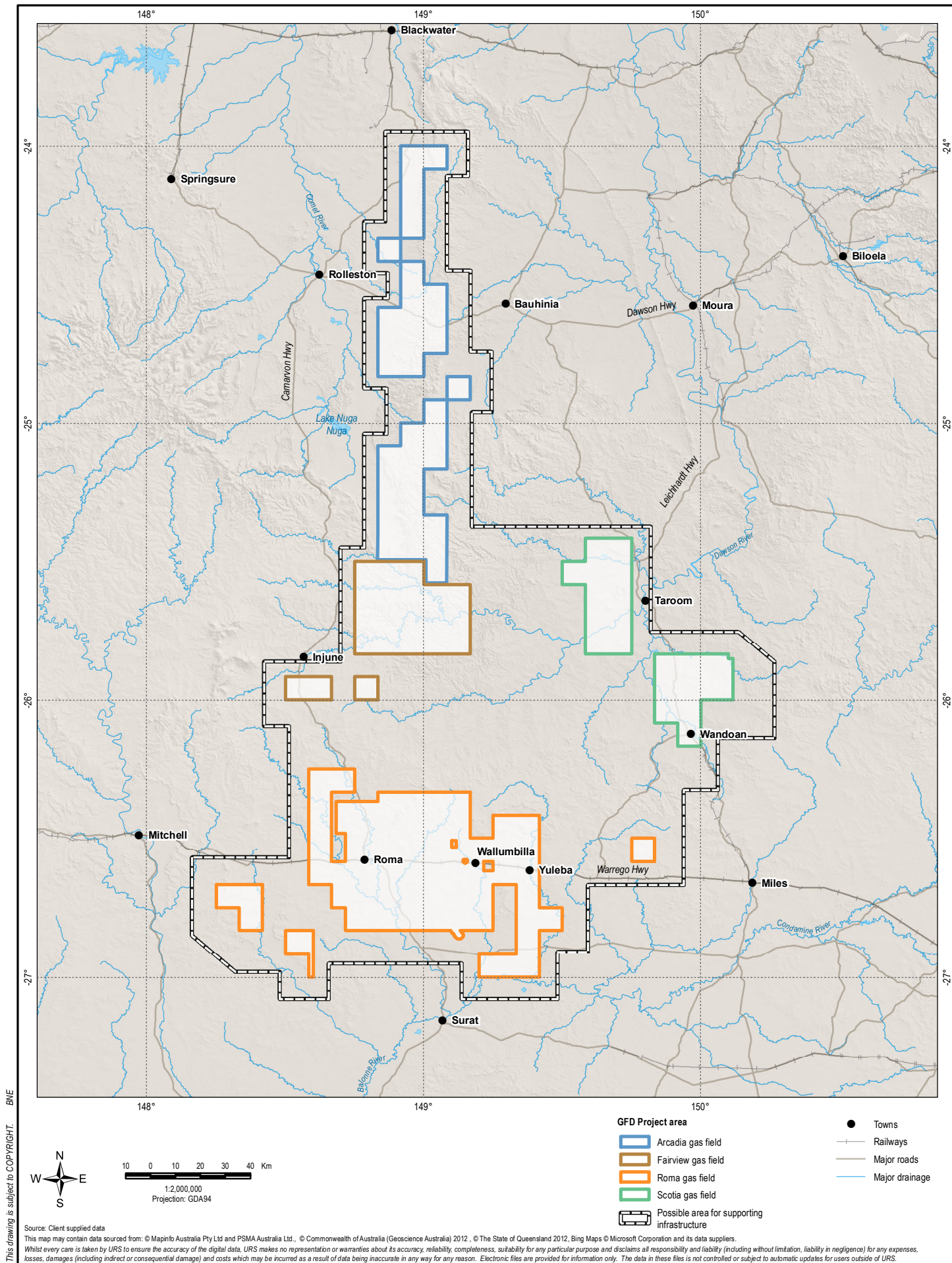
Santos GLNG has the necessary petroleum tenures to authorise gas field development activities including authorities to prospect (ATPs) for exploration and appraisal activities, and petroleum leases (PLs) for advanced appraisal and production activities. Petroleum tenures allow certain petroleum activities (i.e. gas production) to occur on existing land tenures. EAs are required for both authorities to prospect and petroleum leases.

If the exploration investigations indicate the presence of gas in commercial quantities, the ATP holder must apply for a PL to develop the gas reserve and produce gas. The PL authorises petroleum production, processing, storage and other incidental activities including construction of facilities and use of equipment to support that extraction. Activities carried out under a PL are regulated by the conditions attached to that lease and the associated EA issued under the EP Act, which is administered by the Department of Environment and Heritage Protection (DEHP).

The GFD Project area comprises 35 petroleum tenures including 11 ATPs and 24 PLs as listed in Table 1-3. For operational purposes, Santos GLNG has divided the petroleum tenures into four separate gas fields – Arcadia, Fairview, Roma and Scotia gas fields. These separate gas fields and the extent of the GFD Project area (as considered for the EIS and the Draft EM Plan) are shown on Figure 1-6.

Table 1-3 Petroleum tenures within the GLNG Upstream Project area

Gas field (number of tenures)	Tenures				Area (km ²)
	Petroleum lease (PL)/ Petroleum lease application (PLA)		Authority to Prospect (ATP)		
	GLNG Project	Additional for GFD Project	GLNG Project	Additional for GFD Project	
Arcadia (8 tenures)	PL 233 PL 234 PL 235 PL 236	PLA 420 PLA 421 PLA 440	ATP 526P (5 parts) ATP 653P (1 part)	ATP 745P (2 parts) ATP 804P (1 part)	2,726
Fairview (7 tenures)	PL 90 PL 91 PL 92 PL 99 PL 100 PL 232			ATP 655P (2 parts)	1,962
Roma (17 tenures), including Roma East	PL 3 (313) PL 6 (316) PL 7 (317) PL 8 (318) PL 9 (319) PL 13 (322) PL 93 (323) PL 309 PL 310 PL 314 PL 315	PL 10 (320) PL 11 (321) PLA 281 PLA 282		ATP 336P (2 parts) ATP 631P (2 parts) ATP 665P (2 parts) ATP 708P (1 part)	4,383
Scotia (3 tenures)		PL 176		ATP 803P (1 part) ATP 868P (1 part)	1,605
Total (35 tenures)	21 PLs	3 PLs	2 ATPs	9 ATPs	10,676



2 Legislative framework

The GFD Project has been declared a significant project for which an EIS is required under section 26(1)(a) of the SDPWO Act. A ToR is required under Part 4 of the SDPWO Act, and the development of a Draft EM Plan is required under the final ToR issued by the Coordinator-General for the GFD EIS.

The ToR requires the following:

- Draft EM Plan for a Chapter 5A activity to meet the mandatory content requirements of section 310D of the EP Act (reprinted 14 August 2012) and section 24AA of the *Environmental Protection Regulation 2008* (EP Reg)
- Draft EM Plan to be prepared in accordance with the (superseded) Draft EM Plan Guideline (DERM, 2010).

In March 2014, the EP Act was revised and no longer requires Draft EM Plans for EA applications or amendments, as per sections 125 and 126 (EP Act, reprinted 28 March 2014). The Draft EM Plan Guideline from 2010 has also been superseded by one from 2012 (DEHP, 2012).

As a result of the revisions to the EP Act and the change in requirements for a Draft EM Plan, some of the Draft EM Plan Guideline (DERM, 2010) will not be applicable. Where possible, this Draft EM Plan aligns with the more recent version of the Draft EM Plan Guideline (DEHP, 2012). Where alignment with the 2012 version is not possible, the Draft EM Plan aligns with the Draft EM Plan Guideline from 2010 (DERM, 2010).

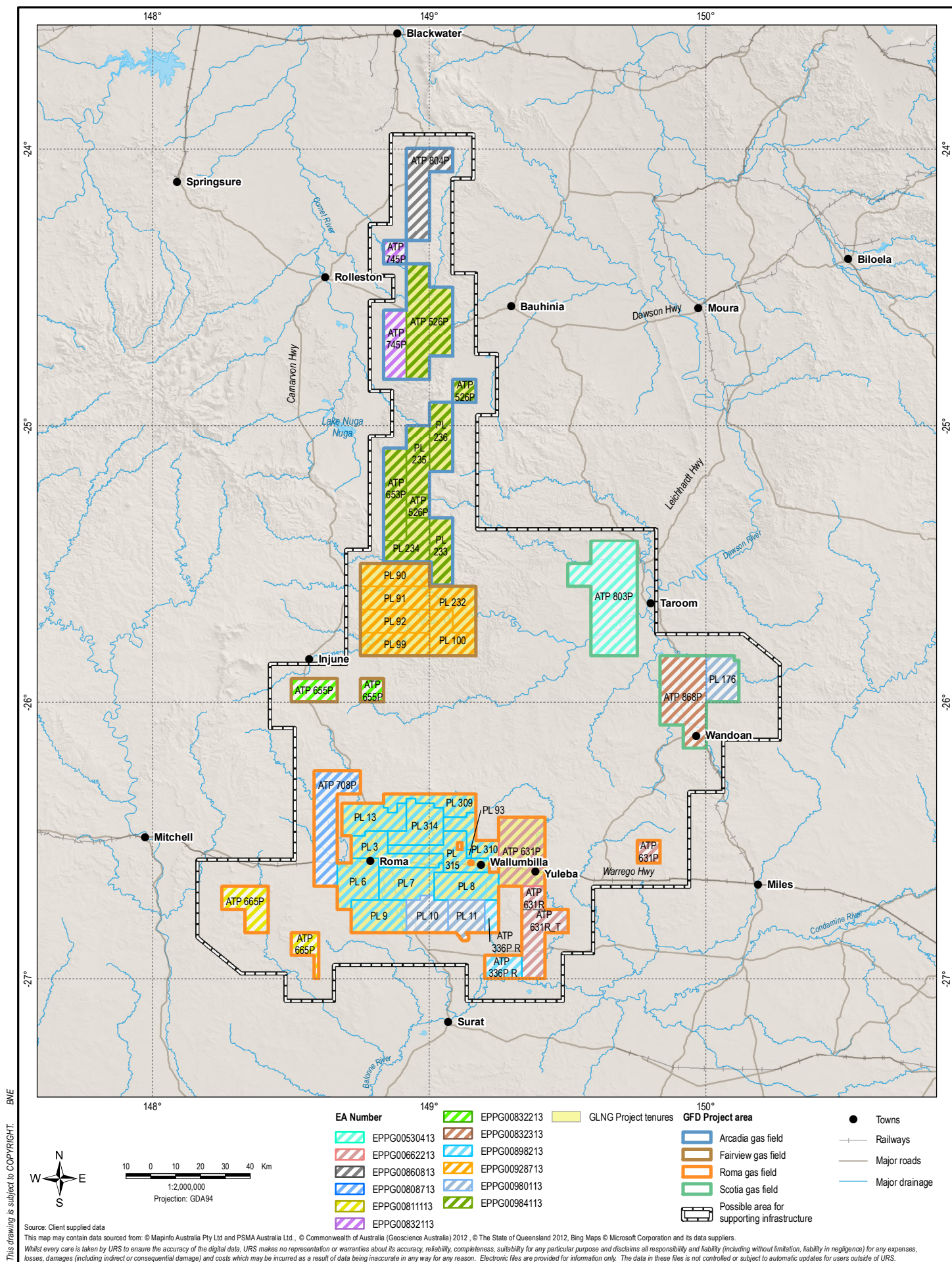
In accordance with Section 24AA of the EP Reg, the CSG Water Management Policy has been considered. This Draft EM Plan has been developed in accordance with the relevant legislative requirements.

The GFD Project incorporates existing EAs and associated authorised environmentally relevant activities (ERAs). Authorised ERAs and specified relevant activities are subject to the conditions set out in the EAs.

The tenures associated with the existing GLNG Project EAs and proposed for inclusion within the GFD Project area are shown on Figure 2-1 and listed in Table 2-1 below. This assessment was undertaken in early 2014 and the tenures shown in Table 2-1 and Figure 2-1 were representative at that time. The EAs which are located in Appendix A are those representative of October 2014.

Table 2-1 Existing Santos GLNG Project upstream gas field environmental authorities

Gas field	Petroleum tenure	Environmental authorities
Arcadia	ATP 526P, 653 PL 233, 234, 235, 236, 420, 421 and 440	EPPG 00984113
	ATP 804P	EPPG 00860813
	ATP 745P	EPPG 00832113
Fairview	PL 90, 91, 92, 99, 100 and 232 PPL 76, 92	EPPG 00928713
	ATP 655P	EPPG 00832213
Roma	ATP 631 PL 281 and 282	EPPG 00662213
	ATP 336□PL 309, 310, 3/313, 314, 315, 6/316, 7/317, 8/318, 9/319, 13/322 and 93/323	EPPG 00898213
	PL 10, 11	EPPG 00980113
	ATP 665P	EPPG 00811113
	ATP 708P	EPPG 00808713
	ATP 631P	EPPG 00808613
	ATP 336P	EPPG 00898213
Scotia	PL 176	EPPG 00980113
	ATP 868P	EPPG 0832313
	ATP 803P	EPPG 00530413



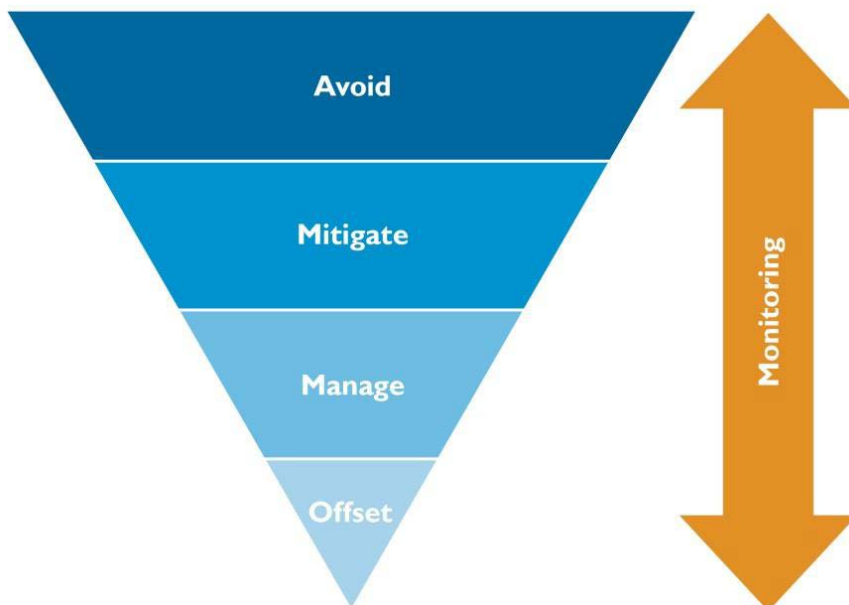
3 Environmental management framework

This section outlines the environmental management framework that Santos GLNG will apply to the GFD Project. The framework adopts the hierarchy of preferred environmental management practices (illustrated on Figure 3-1) which will be implemented across every phase of the GFD Project.

The framework has been developed and successfully implemented for the approved GLNG Project, and refined over the last four years. This framework includes systems and procedures that will be applied to the GFD Project to achieve predictable and sustainable outcomes. Specifically, the environmental management framework comprises:

- Core values
- Policy statements
- Environment, health and safety management system
- Management plans
- Procedures and processes.

Figure 3-1 Preferred environmental management hierarchy



3.1 Environment, health and safety management system

Santos GLNG will use its company-wide Environment, Health and Safety Management System, which provides a structured framework for effective environmental and safety practice across all Santos GLNG activities and operations.

The framework has been developed to ensure compliance with Australian Standard 4801:2000 Occupational Health and Safety Management Systems – Specification with guidance for use, and AS/NZS ISO 14001:1996 Environmental Management Systems – Specification with guidance for use.

The Environment, Health and Safety Management System documents are maintained in electronic form on Santos GLNG central server, which is accessible to all employees and contractors.

The Environment, Health and Safety Management System framework consists of three primary layers:

- Environment, health and safety management standards (EHSMS) — identify how to systematically manage environmental health and safety risks
- Environmental hazard standards (EHS) — identify and provide controls to manage the environmental risks associated with specific activities
- Health and safety hazard standards (HSHS) — identifies and provide controls to manage the health and safety risks associated with specific activities.

3.2 Existing management plans and procedures

Management plans have been developed to incorporate Commonwealth and State regulatory requirements. These plans also incorporate the Santos GLNG corporate values, policies and Environment, Health and Safety Management System into project-level documents that set out measures and commitments to avoid, minimize and manage the risk of adverse impacts to environmental values.

As the GFD Project is an extension of the gas field component of the GLNG Project, there will be common infrastructure, resources, workforces and activities across both projects. Consequently, the management plans and strategies developed and implemented for the approved GLNG Project will be applied to the GFD Project. Many of the plans are incorporated as appendices to this Draft EM Plan.

The applicable management plans are listed in Table 3-1 below.

Table 3-1 Management plan summary

Full name	Abbreviation	Management Plan Summary	Applicability to GFD Project Draft EM Plan
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.	Attached as Appendix F
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. The Contingency plan is aligned with the requirements outlined within the Draft EA.	Attached as Appendix D
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.	Attached as Appendix N

Full name	Abbreviation	Management Plan Summary	Applicability to GFD Project Draft EM Plan
Draft environmental management plan	Draft EM plan	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.	This document
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 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 • Offset — 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.	Attached as Appendix B

Full name	Abbreviation	Management Plan Summary	Applicability to GFD Project Draft EM Plan
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. The ESCMP is aligned with the requirements set forth in Schedule B of the Draft EA.	Attached as Appendix E
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. The FMP considers the fauna management requirements provided in Schedule E of the Draft EA.	Attached as Appendix I
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 operational purposes • Low point drain water releases to land • 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. • This document is aligned with the requirements set forth in the Draft EA.	Attached as Appendix G

Full name	Abbreviation	Management Plan Summary	Applicability to GFD Project Draft EM Plan
Hydraulic fracturing risk assessment: compendium of assessed fluid systems	Hydraulic fracturing risk assessment	The Hydraulic fracturing risk assessment report, in support of Schedule J of the Draft EA, synthesises the hydraulic fracturing risk assessments completed on various hydraulic fracturing fluids and provides a framework for including new fluid systems within the risk assessment document. The body of the report provides generalised information, including the geology and hydrogeology of the area, risk assessment methodologies (qualitative and quantitative) and a high level understanding of current results. The appendices include risk assessments of individual hydraulic fracturing fluid systems. This report provides information critical to the effective management and monitoring of hydraulic fracturing activities, and is integral to the existing Santos GLNG Management Framework.	Attached as Appendix P.
Noise management plan	NMP	The NMP identifies potential noise impacts from Santos GLNG activities and provides a strategy, methods and controls to: • Avoid — plan the activity and engage with potentially affected stakeholders • Minimise — implement noise mitigation measures to minimise noise impacts • Manage — conduct monitoring, review mitigation methods and ensure compliance with Santos GLNG procedures. The NMP is aligned with Schedule F of the Draft EA.	Attached as Appendix K.

Full name	Abbreviation	Management Plan Summary	Applicability to GFD Project Draft EM Plan
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.	The Offset Strategy is not directly applicable to the EA; however, it is integral to the existing Santos GLNG Management Framework and has been referenced here for completeness.
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. Santos GLNG will review local government's pest and weed management plans and apply measures from these to the PWMP where it is appropriate.	Attached as Appendix J.

Full name	Abbreviation	Management Plan Summary	Applicability to GFD Project Draft EM Plan
Plan of Operations		The Plan of Operations details the way in which conditions Santos GLNG will comply with the conditions of environmental authorities associated with the GFD Project. The plan includes: • Description of the environmentally relevant activities that will take place as part of the GFD Project • An action program for compliance with the EA conditions • Rehabilitation program • Financial assurance for disturbances during the period of the plan.	The Plan of Operations is directly linked to the Draft EM Plan and provides information on how the project will operate in accordance with the approved EA conditions.
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. • The Rehabilitation management plan is aligned with Schedule I of the Draft EA.	Attached as Appendix M

Full name	Abbreviation	Management Plan Summary	Applicability to GFD Project Draft EM Plan
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 <i>Environment Protection and Biodiversity Conservation Act 1999</i> (Cth) listed significant species and their habitats, and threatened ecological communities (TECs). Specifically, the SSMP: • Identifies and profiles significant species and TECs that are present, or may occur, within the gas fields • Identifies key threats to significant species and TECS 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 TECs caused by Santos GLNG activities.	Attached as Appendix H.

Full name	Abbreviation	Management Plan Summary	Applicability to GFD Project Draft EM Plan
Social impact management plan	SIMP	The SIMP established for the GLNG Project will be implemented across the GFD Project. The plan outlines the roles, responsibilities and rights of Santos GLNG, the government, impacted communities and other stakeholders in relation to the GFD Project. In particular, it outlines the framework for community engagement, management strategies to avoid, mitigate or minimise potential impacts and to maximise opportunities and benefits arising throughout the life of the GFD Project, as well as a monitoring and reporting process. The GLNG Project SIMP will be supplemented by issue action plans relating to the GFD Project that focus on the following key areas as agreed with the Coordinated Project Delivery Division of the Coordinator-General's office: • Water and environment • Community safety • Social infrastructure • Community wellbeing and liveability • Local industry participation and training • Aboriginal engagement and participation. The SIMP is an operational document that is updated to reflect the ongoing needs of Santos GLNG and the communities it operates in. It is available on the web at: http://www.santosglng.com/resource-library/community/social-impact-management-plan-community-handbook.aspx	The SIMP is not directly applicable to the Draft EM Plan; however, it is integral to the existing Santos GLNG Management Framework.
Stimulation impact monitoring program		The plan was developed to provide a general description of the stimulation activities to be conducted by Santos GLNG, the regulatory requirements pertinent to stimulation monitoring, as well as the practices and procedures that comprise the monitoring program. The Stimulation Impact Monitoring Program is aligned with the requirements in Schedule J of the draft EA.	Attached as Appendix Q.
Waste management plan	WMP	The WMP details the strategy, methods and controls for managing waste generated by Santos GLNG activities. The plan identifies the types of wastes generated by Santos GLNG activities, and describes the waste management framework and how the waste management hierarchy is applied to generated waste.	Attached as Appendix L

4 Description of petroleum activities

4.1 GFD Project activities overview

The proposed process flow and key process steps of the GFD Project is explained in the sections below and presented in Table 4-2.

The 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.

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.

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.

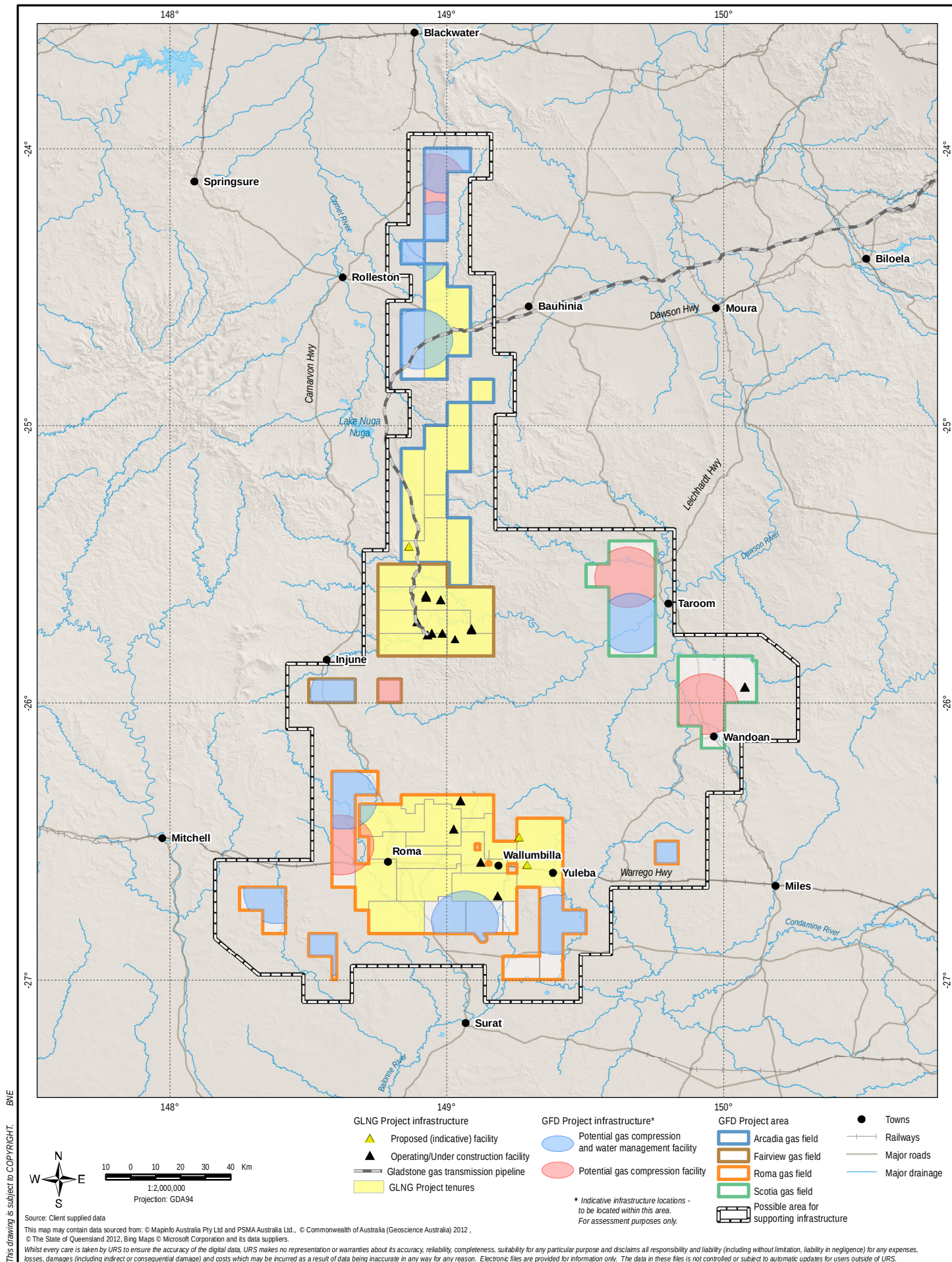
For the purposes of this EIS, a scenario based on the maximum development case was developed at the approval of the ToR. This scenario assumed that production from the wells and upgrading of the gas compression facilities in the Scotia gas field would commence in 2016, followed by the GFD Project wells 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 development case is outlined in Table 4-1.

Table 4-1 GFD Project potential gas field development (EIS assessment scenario)

Project components	Potential units
Production wells	Up to 6,100 production wells
Gathering lines / transmission pipelines	Up to 6,000 km
Nodal gas compression facilities	Up to 5 facilities (each processing up to 80 terajoules (TJ) per day
Hub gas compression facilities	Up to 10 facilities (each processing up to 240 TJ/day)
Water management facilities	Up to 15 facilities (each managing 5-20 ML/day)
Access roads	As needed

The GFD Project field layout concept is illustrated in Figure 4-1.



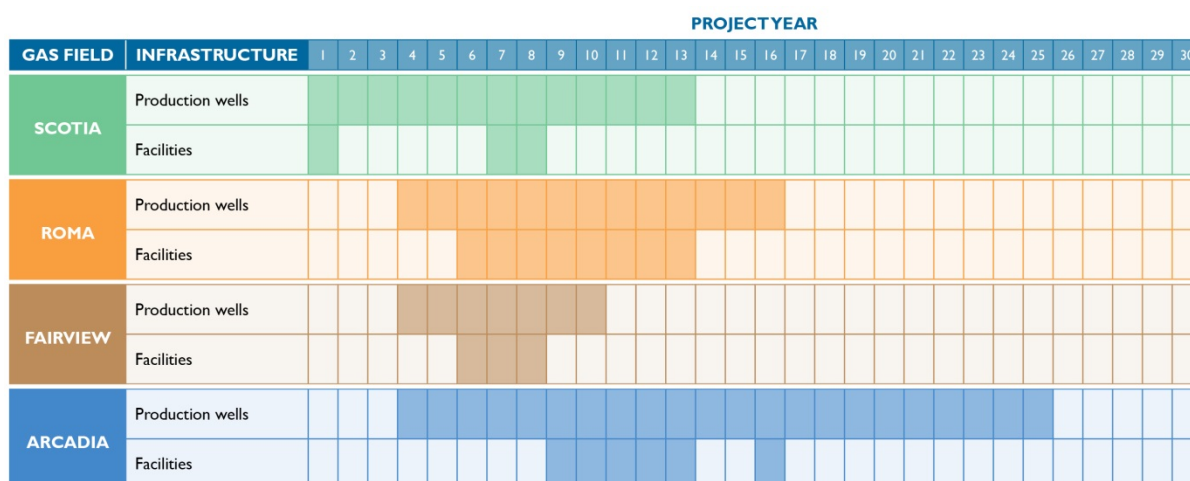
4.2 Construction phase

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 increases, investment decisions will be made about the scale, location and timing of the next stages of field development.

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 potential GFD Project schedule is outlined in Figure 4-2. This schedule provides an overall field development scenario for the purposes of assessment in this EIS.

Figure 4-2 Proposed GFD Project development schedule



The GFD Project will use the construction methods outlined in Table 4-2. The number and size of construction equipment used will vary according to the construction activity and is likely to include a combination of dozers, graders, excavators, trucks, cranes, drilling rigs, rollers, front end loaders, scaffolding, welders and hand-held equipment.

Table 4-2 GFD Project activities' construction method, typical footprint and timeframes

Infrastructure components	Description	Construction method	Construction footprint	Construction timeframes
Well lease	• Drill rig • Chemical and fuel storage • Gas generator • Water storage • Mud pit (where required or a tank is used) • Flare and flare sump • Production well(s) • In-well pump • Gas/water separator (if required) • Metering facilities • Fencing and signage where appropriate.	Onsite construction using rotary or air lift drill.	Single well lease: 1.5 ha Multi-well lease: 2.5 ha.	Civil works: 30-60 days Drilling: 24 hours per day, 10-30 days per well Completions: 150 days Commissioning: 60 days.
Access tracks and roads	Graded or gravel roads, aligned to existing fences and tracks where practicable.	Onsite construction.	1.5-3 ha per km.	Civil works: 30-60 days
Gas and water gathering lines	• HDPE¹ (or other) pipeline, aligned to existing fences and access tracks, where practical • Signage.	Laid on ground, or buried in open cut/trench, with trenchless (directional) drilling for crossing sensitive areas.	1- 2.5 ha per km.	Up to 4 days per 500 m to clear, trench and bury line; plus up to 14 days for installation of vents, drains, manifolds, etc.
Gas and water transmission pipelines	• Steel (or other) pipeline, aligned to existing fences and access tracks, where practical • Medium to high pressure flow of water or gas • Signage.	Buried in open cut/trench or with trenchless (directional drilling) methods.	2.5-5 ha per km.	Up to 5 days per 500 m for surveying, clearing and supplies; 2 days per 2 km for trenching, laying and burying; plus 1-7 days for hydrotesting.

Santos

GLNG Project

Infrastructure components	Description	Construction method	Construction footprint	Construction timeframes
Hub gas compression facilities	Centralised facility that compresses gas to the pressure required for transmission via the Gladstone gas transmission pipeline (or third party transmission pipeline) and, if required, treat gas to supply specifications. It comprises: • Relocatable modular units • Hub gas compression units • Gas turbine alternators to provide power • Water separator and oily water treatment • Triethylene glycol (TEG) dehydrator packages including reflux columns and TEG regenerative boilers • Emergency flare (able to burn 10 TJ/hour) • Backup diesel generator and diesel storage • Air compressors, pipework and transmission valving • Minor utilities like nitrogen generator for turbine seals • Control room, instrumentation and control systems • Office, workshops and equipment storeroom • Access roads/tracks.	Assembly of prefabricated modular units onsite.	20-40 ha each.	2-3 years
Nodal gas compression facilities	Field facility that compresses gas collected in the gas gathering lines to pressure for transmission or second stage (hub) compression. It comprises: • Relocatable modular units • Rotary screw compressors • Reciprocating engines to provide power, if not connected to grid • TEG dehydrator packages including reflux columns and TEG regenerative boilers • Air compressors, pipework and transmission valving • Control room, instrumentation and control systems • Access roads and tracks.	Assembly of prefabricated modular units onsite.	2-8 ha each.	1-2 years

Infrastructure components	Description	Construction method	Construction footprint	Construction timeframes
Water management facilities	- Water storage - Filtration units - Desalination treatment units e.g. reverse osmosis and/or ion exchange - Chemical balancing unit e.g. water amendment facility - Above ground valving and pipework.	Combination of site constructed structures (i.e. dams) and modular treatment units prefabricated offsite.	5-10 ha each.	180 days +
Water storage	Structures (tanks up to 15.5 ML, and dams up to 350 ML) for storage of coal seam water.	Onsite construction.	Tanks: Up to 1 ha each Large dams: 5-16 ha each.	Tanks: 30 days Large dams: 180 days +
Fluid (brine) storage	Regulated structures (up to 350 ML dams) for storage of fluid (brine).	Onsite construction	Large dams: 5-16 ha each.	Large dams: 180 days +
Camps	- Temporary or permanent accommodation facilities - Drill camps - Construction camps - Permanent camps - Modular in design and form, easily relocatable - Water supply - Sewage treatment facilities - Access roads.	Assembly of prefabricated modular units onsite.	1-20 ha each.	Large temporary camp (i.e. 400 persons): 6-9 months Permanent camp (i.e. 80 persons): 6-9 months
Laydown and storage yards	Cleared, graded area for temporary storage of materials, plant and equipment.	Onsite construction	5-40 ha each.	Up to 7 days
Borrow pits and quarries	Small area excavated to recover materials (e.g. soil, gravel).	Onsite construction.	5-50 ha each.	Up to 7 days

¹ High density polyethylene

4.2.1 Well lease establishment

Production wells, monitoring bores, underground gas storage and fluid injection wells will be constructed on a similar well lease area.

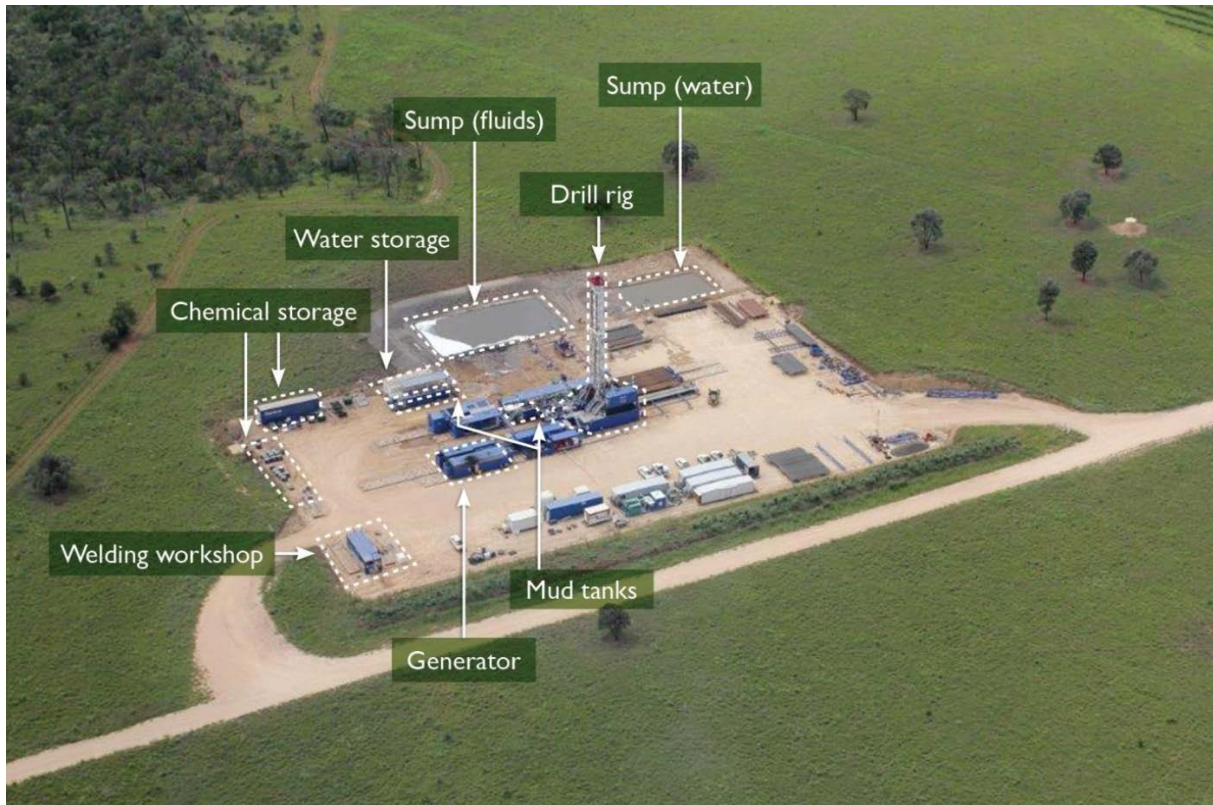
A well lease (the area cleared for each well) will be developed to accommodate the necessary drilling and completion equipment and support services.

An example of a Santos GLNG well lease layout under construction is given in Plate 4-1 and shows the key equipment and support services brought onto a well lease such as:

- Drill rig and associated equipment
- Gas generator
- Chemical and fuel storage
- Mud pit or tank for drilling fluids

- Flare and flare sump for disposal of gas during drilling and appraisal process
- Water storage (tank or small dam) for initial water supply and coal seam water during construction.

Plate 4-1 Example Santos GLNG well lease during construction



Where practicable, Santos GLNG will establish well leases with multiple wells (multi-well lease) to maximise gas recovery and reduce the number of well leases required. Although this may result in a larger area for each well lease, it will reduce the overall GFD Project footprint.

4.2.1.1 Drilling, casing and cementing

Methods for construction of production wells, monitoring bores, underground gas storage and fluid injection wells will be similar. During construction of wells, drilling will be carried out on a 24-hour basis for approximately 1-3 weeks per well. The time to complete each well is dependent on the depth of the well, the geology of the area and the type of rig used.

Drilling a vertical well involves a variety of drilling techniques to reach the target formation, including rotary or air techniques. For production wells, directional drilling can be applied to direct the well onto a horizontal plane to run along the coal seam or to increase the contact area of a well with a coal seam. This practice requires fewer wells and will decrease the surface footprint of the overall GFD Project.

Drilling fluids are circulated down the borehole during drilling to lubricate and cool the drill bit and remove drill cuttings from the bore. Drilling fluid and cuttings are collected in surface tanks or in pits and are removed from the well lease area for reuse, recycling or disposal.

Through multiple cycles of drilling, installing casing and cementing casing, the well is isolated from surrounding aquifers. Santos GLNG will test and prove the integrity of the well casing before gas extraction commences. The casing of the well in the coal seam is perforated using jet perforating guns to create the flow of gas from the well to the surface. To produce gas from a well, the well head is installed and completed with an in-well pump and surface facilities.

Where required, well stimulation techniques (such as hydraulic fracturing)) will be used as part of the commissioning of a production well to improve the gas flow rate from the coal seam to the well head. Once the wells have been drilled, they are used to extract coal seam water, which enables the production of gas. At the well head, the gas is passed through a separator tank to remove water held in the gas. The gas is piped to gas compression facilities and from there delivered via transmission pipelines to market. The water is transferred to water management facilities for storage, treatment (dependent on quality) and intended use or disposed of at a licensed facility. A detailed risk assessment is provided in the Hydraulic Fracturing Risk Assessment (EHS Support, 2013) and is attached as Appendix P.

Some wells might be subject to multiple stimulation events over their life. Santos GLNG is continually evaluating innovative techniques for enhancing gas production and minimising impacts. These techniques potentially include pneumatic techniques and fluid systems with lower concentrations of additives.

4.2.2 Gathering lines and transmission pipelines

To transport the gas and/or water from the production wells to the gas compression facilities/water management facilities, Santos GLNG will utilise existing gathering lines and transmission pipelines where practicable. Alternatively, new gas and water gathering lines and transmission pipelines will be constructed.

Construction activities will be undertaken with a combination of conventional earthmoving equipment and specialist pipeline trenching and lifting equipment. The construction process for both gathering lines and transmission pipelines will generally be similar.

Gas and water gathering lines will be high-density polyethylene (HDPE) pipe of between 100 millimetres (mm) and 1,000 mm in diameter and will be buried; however, water gathering lines may be laid on the ground where appropriate. Gas gathering lines will be designed and constructed to comply with *Australian Standards AS2885 – Pipelines Gas and Liquid Petroleum, Code of Practice for constructing and abandoning coal seam gas wells and associated bores in Queensland* (Department of Natural Resources and Mines, 2013), and the *Australian Pipeline Industry Association (APIA) Code of Environmental Practice* (2013).

Transmission pipelines will be constructed to transfer gas under pressure from nodal or hub compression facilities and water from water management facilities within tenures and between tenures.

Gas transmission pipelines will collect gas from nodal gas compression facilities (where present) within the gas fields and transport it under pressure to centralised hub gas compression facilities and into the Gladstone gas transmission pipeline or third party transmission pipelines. Similarly, water transmission pipelines can be constructed to transfer water to and from water management facilities or third parties.

Route selection for transmission pipeline corridors will be based on the final locations of the major facilities as well as the constraints identified and described in further assessments. Where practicable, they will be co-located with other linear infrastructure.

Watercourse crossings for pipelines will be constructed using a range of techniques and activities suited to the local conditions, including:

- Open-cut
- Flow diversion
- Isolation (through the construction of a temporary coffer dam)
- Trenchless (horizontal directional drilling or micro-tunnelling for large flowing watercourses).

4.2.3 Gas compression and treatment facilities

Standalone nodal gas compression facilities will be installed in the field where required to compress gas to the pressure required for transmission across significant distances or to achieve entry pressure into the hub gas compression facilities. The nodal gas compression facilities will range in size and will have the capacity to compress up to 30 terajoules per day (TJ/day) per facility. In some cases, nodal gas compression facilities will be co-located with the hub gas compression facilities.

Centralised hub gas compression facilities will be developed in each of the gas fields (Arcadia, Fairview, Roma and Scotia) to increase the pressure of the gas prior to transmission. The hub gas compression facilities will range in size and will have the capacity to compress up to 240 TJ/day per facility. Treatment at the hub gas compression facilities will include the removal of moisture and other impurities to meet supply specifications.

Gas compression facilities will be constructed using modular structures and processing units to minimise on-site construction activities, shorten the construction schedule, and limit the on-site construction workforce requirements.

Buildings at these facilities will include a control room, offices, workshop, storerooms and, in some cases, emergency accommodation. Additional support infrastructure and facilities during construction will be required.

4.2.4 Water management facilities

Facilities to manage water produced from the gas wells will be required across the four gas fields. Where practicable, Santos GLNG will utilise existing pipelines, water storage and water management facilities to assist in the management of water produced by the GFD Project. However, the GFD Project might also require the construction of new water management facilities. This will include water gathering lines and transmission pipelines as described in Section 4.2.2 of this Draft EM Plan (Gathering lines and transmission pipelines), as well as those described in the following sections.

4.2.4.1 Water and fluid (brine) storage

Coal seam water will have total dissolved solids ranging from 100 milligrams per litre (mg/L) (fresh water) to over 10,000 mg/L (brackish). Where water must be stored, dams and/or tanks will be constructed to store water prior to use, transferring to water management facilities or following treatment. These dams will be earthen, constructed from material sourced locally and have capacities of up to 350 ML. Tanks will be up to 15.5 ML in size, but would typically be 1-2 ML.

The dissolved salts and metals removed from the coal seam water during desalination treatment will be concentrated into a low volume reject fluid (brine) stream with dissolved salt content of around 20-60 grams per litre. Depending on the salt content it can be classified as 'brine'. The storage will be constructed as fully engineered, purpose-built dams of up to 350 ML constructed in accordance with the *Manual for assessing hazard categories and hydraulic performance of dams* (DEHP, 2012).

Dam construction will be undertaken in accordance with the requirements of the DEHP *Manual for assessing hazard categories and hydraulic performance of dams* (EHP, 2012). Tanks will be designed to the relevant Australian Standards. Tanks will be designed to the relevant Australian Standards.

Dam construction activities can include a range of conventional earthworks activities including excavation and lining. Design and construction activities can involve the following:

- Placement and testing of clay and/or liner materials to achieve the required hydraulic performance
- Leak detection sump and pipe work
- Transfer pump and associated pipework
- Escape areas for animals on dam slopes
- Emergency spillways lined with geotextile
- Erosion control blanket over topsoil on batters.

The dissolved salts and metals removed from the coal seam water during desalination treatment will be concentrated into a low volume reject fluid (brine) stream with dissolved salt content of around 20-60 grams per litre. Depending on the salt content it can be classified as 'brine'. The storage will be constructed as fully engineered, purpose-built dams of up to 350 ML constructed in accordance with the *Manual for assessing hazard categories and hydraulic performance of dams* (DEHP, 2012).

4.2.4.2 Water treatment facilities

As the GFD Project's water management facilities will be modular, they will be factory fabricated and transported to the GFD Project area. The modules will be assembled at specially prepared location and then the piping, electrical controls and instrumentation wiring will be installed.

A change in water quality needed to meet the required water quality of intended uses is primarily achieved through one or a combination of the following approaches:

- Desalination using reverse osmosis to separate a portion of the total dissolved solids and other constituents into a concentrated waste stream (brine) and produce a better quality permeate stream
- Amendment using chemical dosing to lower the sodium adsorption ratio and pH/residual alkalinity of coal seam water

- Temperature and ionic balance adjustment
- Filtration removing suspended solids (lowering the turbidity), bio-toxic elements and nutrients that can lead to algal blooms from the water
- Sterilisation to remove bacteria
- De-oxygenation
- Blending of separate water streams of differing quality to achieve a target water quality.

The appropriateness of these methods will be evaluated as information is refined regarding the expected water quality, the intended uses and associated water quality requirements according to relevant approvals. Where desalination treatment (e.g. reverse osmosis or ion exchange) is required, these facilities will be designed and constructed with incremental capacities of 5 ML per day per module. Relocatable modules will have a smaller capacity up to 2 ML per day. A number of modules will be co-located to provide the required design capacity for each treatment facility. Desalination will sometimes be co-located with a water amendment facility and include water storage such as modular tanks combined with dams. Other alternative technologies might be identified during the GFD Project evaluation and design process.

4.3 Operations phase

Following completion of construction activities, disturbed areas will be rehabilitated to reduce the extent of disturbance to the operations footprint of the facility and/or activity. The operations footprint of various GFD Project components is given in Table 4-3. The area of the operations footprint will be considerably less than those needed during construction (Table 4-3).

The locations, size and timing of each of the GFD Project's operations components will be confirmed as part of the ongoing field development process and presented in plans of operations, which is required by the EP Act (sections 287-288).

Table 4-3 GFD Project operations footprint and inspection timeframes

Project component	Operations footprint	Inspection timeframes
Well lease	Single well lease: 0.3 ha Multi-well lease: 0.5 ha	Ongoing, averaging five visits to pumps over the life of the well
Access tracks and roads	0.8-1.5 ha per km	Ongoing
Gas and water gathering lines	None (right of way maintained)	Quarterly checks, as required
Gas and water transmission pipelines	None (right of way maintained)	Ongoing
Hub gas compression facilities	10-15 ha each	Ongoing (onsite or remote control)
Nodal gas compression facilities	1-4 ha each	Ongoing (onsite or remote control)
Water management facilities	2-5 ha each	Ongoing (onsite or remote control)
Water storage	Up to 0.5 ha per tank 3-8 ha each for large dams	Annual inspection by suitably qualified and experienced person (in accordance with regulatory approvals) and routine inspections or telemetry-based monitoring of water levels.
Brine storage	Up to 8 ha each for large dams	
Camps	0.5-10 ha each	Ongoing, up to 52 weeks per year

4.3.1 Wells

Production wells become operational once they are connected to the gas and water gathering systems for delivery to the gas compression and water management facilities.

Initially, production wells will be fitted with pumps to extract water for the purpose of depressurising the coal seam. As water pressure declines, gas from the wells will begin to become free flowing with reservoir pressures driving the gas flow to the surface. Production wells are expected to operate for up to 30 years.

Examples of a Santos GLNG single-well lease and multi-well lease during operations phase are shown in Plate 4-2 and Plate 4-3.

Production wells can be monitored and controlled remotely. Information on production pressures and rates will be transmitted via radio telemetry or fibre optic cable to enable production to be controlled from remote sites, including the Santos GLNG Operational Centre in Brisbane and regional operations centres. Rapid changes in pressure can be detected and lead to automatic cut-off at the well head.

Wells and well lease equipment will be routinely inspected and maintained as required. Well workover (the major servicing of a well) is expected to occur several times over the life of the well. Specialised workover drilling rigs will re-enter the well as necessary to perform pump repairs, remove blockages, isolate intervals or deepen the well.

Plate 4-2 Single well lease (operations)



Plate 4-3 Multi-well lease (operations)



4.3.2 Gathering lines and transmission pipelines

Operational activities in the gas and water gathering systems will be limited. The gas and water gathering lines are simple networks that will operate without the need for complex equipment or ongoing servicing. There will be signage to identify the locations of the gathering lines in accordance with requirements of Australian Standards.

Gas lines will include water condensate drains at low points in the terrain. These allow water that condensates within the line to be removed to prevent build up in the pipe and will be automatically or manually operated. Water pipelines include vents at high points in the terrain for removal of the small amounts of gas that might be dissolved in the water. Drains and vents will be inspected as part of routine field maintenance activities.

Transmission pipelines for gas and water will be operated and maintained similarly to the gathering lines, except that they will be operating at higher pressure. There will be signage to identify the locations of the transmission pipelines.

Pipeline location marker posts and inspection points for integrity testing will be installed along the length of the transmission pipelines. Marker posts are important for both landholders and pipeline maintenance personnel to identify the location of buried pipelines. An easement will remain over the pipeline once constructed. Pipeline operators may need to access the easement to conduct visual inspections, integrity testing and other operational duties from time to time.

4.3.3 Gas compression and treatment facilities

Gas collected from the field will pass through nodal gas compression facilities and hub gas compression facilities to meet specifications for transmission and supply to market. Both stages of compression will be conducted within the same facility where wells are near the hub gas compression facility (i.e. to bring gas up to pressure required for transmission to market). Some gas supplied to the gas compression facilities can be extracted from underground gas storage.

The compression process involves filtration, dehydration, compression and cooling – a relatively simple process due to the low levels of other gas contaminants such as carbon dioxide or heavy hydrocarbons. Dehydration generally uses triethylene glycol (TEG) units to reduce the water vapour content of the gas prior to compression. A flare system will be used as a safety measure in the event of over pressurisation of the gas or an emergency event.

Gas compression facilities will be operated on a continuous basis and will be fully automated. They will be monitored for gas pressure, smoke, fire and gas quality.

Nodal gas compression facilities can be designed as unmanned facilities with routine maintenance and inspection. Hub gas compression facilities can be either unmanned or staffed during the day and remotely operated and monitored at night. Where the facilities are manned, the operators will generally live near the facility in operational camps.

Routine inspections and maintenance will be conducted on equipment at the facilities. This will comprise a combination of scheduled inspection and maintenance of select equipment and, in some instances, full shutdown with more extensive maintenance.

4.3.4 Water management facilities

The GFD Project water management facilities will accommodate a dynamic water management process designed to provide fit-for-purpose water for the intended use. Water management facilities can include:

- Water storage in tanks and dams at the well leases or at centralised locations
- Direct use of water from tanks or dams (where quality is suitable)
- Treatment by desalination (e.g. reverse osmosis or ion exchange), if required
- Water amendment, including chemical balancing or pre-treatment (e.g. pH adjustment), if required
- Adjustment of post-treatment water chemistry as required by final use
- Storage of water prior to distribution for its intended use
- Storage and management of brine.

Water management facilities will operate 24 hours a day, with short periods of shutdown to facilitate scheduled maintenance. Routine inspections and maintenance will be conducted.

4.3.4.1 Coal seam water management

The GFD Project will manage coal seam water in accordance with the relevant regulatory framework and maximise, where practicable, beneficial use while avoiding, minimising and mitigating environmental impacts.

The regulatory framework includes the *Coal Seam Gas Water Management Policy 2012* (DEHP, 2013). The policy sets out the following management hierarchy under the 1994 EP Act for prioritising management and use of coal seam water:

- Priority 1 – coal seam water is used for a purpose that is beneficial to one or more of the following: the environment, existing or new water users, and existing or new water-dependent industries.
- Priority 2 – after feasible beneficial use options have been considered, treating and disposing coal seam water in a way that firstly avoids, and then minimises and mitigates, impacts on environmental values.

In addition, the ‘making good’ requirements of the *Water Act 2000* (Qld) require operators to consider the feasibility of using coal seam water to meet obligations for provision of water to mitigate impacts resulting from a coal seam operation on bores.

The conditions within Schedule D of the draft EA detail additional requirements in relation to coal seam water management and use.

Additional detail on coal seam water management is presented within Section 14 of this Draft EM Plan.

4.3.4.2 Fluid (brine) management

Where desalination (e.g. reverse osmosis) is required a fluid (RO concentrate or brine) is generated that will require appropriate management and subsequent disposal in accordance with regulatory requirements.

The Queensland *Coal Seam Gas Water Management Policy 2012* (DEHP, 2013) sets out the management hierarchy for prioritising management of brine (saline waste):

- Priority 1 – brine or salt residues are treated to create useable products wherever feasible.
- Priority 2 – after assessing the feasibility of treating the brine or solid salt residues to create useable and saleable products, disposing of the brine and salt residues in accordance with strict standards that protect the environment.

The options available for utilisation for the GFD Project can be divided into two categories; commercial salt recovery and brine or salt disposal.

These wastes and their management are discussed further in Section 12 of this Draft EM Plan (Waste).

4.4 Supporting infrastructure

In addition to the gas and water extraction, transmission, compression and management facilities, other infrastructure will be required to support the construction and operation of the gas fields including:

- Accommodation facilities, including sewage treatment, for construction and operational staff
- Access roads
- Fuel storage, workshops and maintenance areas
- Laydown, stockpile and/or storage areas
- Borrow pits and quarries
- External infrastructure such as transport, energy generation and supply, water supply and communications.

Most of the supporting infrastructure will be constructed within the GFD Project's tenures, but some might be located off-tenure in the area designated for possible supporting infrastructure (see Section 4.4.5).

4.4.1 Accommodation facilities

Local residents employed on the GFD Project will already have local housing in the regional towns such as Roma, Wallumbilla, Taroom, Wandoan, Injune and Rolleston. Non-resident workers will be housed in purpose-built accommodation facilities (known as camps) close to work sites.

4.4.1.1 Camps

To accommodate the projected maximum workforce generated during the construction and operations phases, Santos GLNG will develop camps within the GFD Project area to supplement the existing accommodation, services and amenities. Field development planning processes will be used to determine the size and locations of these camps.

Camps will use modular structures that will accommodate one or two workers per unit. In general, the camps will comprise three alternative forms:

- Small temporary camps (also called drill camps) will be modular and relocatable facilities, less than 1 hectare (ha) in area, and will provide basic amenities for up to 20 people for short-term activities such as drilling or installation of gathering lines. To support the drill camps, water tanks and modular sewage treatment plants (STPs) will be provided.
- Larger semi-permanent camps will be built to support construction of large facilities (e.g. hub compression facilities). They will have an area of about 20 ha and will be adjacent to work areas and designed to provide more extensive services and facilities to larger workforces (about 400 people) for more long-term construction activities (two to three years).
- Permanent operations camps will be designed to provide accommodation for operations personnel for the duration of the GFD Project and will accommodate about 80 people.

At a minimum, camps will include accommodation units, kitchen, dining, ablution and laundry facilities. At larger more permanent camps, facilities will also include water supply (bores, tanks and treatment), sewage treatment and disposal, power generation (if not connected to the grid supply) and back-up power generators, fuel and materials storage areas, recreational facilities, offices and car parking.

4.4.1.2 Sewage treatment

Relevant approvals will be obtained to install and operate sewage treatment facilities at the camps. At the drill camps, small plants will be used as the number of site personnel will be fewer than 20 people. Effluent will be treated and released or transported offsite. At the construction sites and laydown yards, portable amenities will be provided and wastewater will be transported offsite. At the semi-permanent construction camps and permanent operations camps, the sewage treatment facilities will be designed and installed to store, treat and dispose to required standards.

4.4.1.3 Access roads

Roads and access tracks will be required for construction and operations activities. Access roads will be built to allow servicing of well leases and access to other infrastructure (e.g. gas compression facilities, accommodation camps, etc.). Wherever practicable, the GFD Project will use existing tracks, including existing access tracks and roads used by the GLNG Project, or already disturbed areas. Upgrades of existing access tracks and roads might be required to accommodate the construction and operations traffic associated with the GFD Project.

The construction activities associated with roads and access tracks will include:

- Upgrading and/or widening of existing roads and tracks (clearing and grubbing)
- Excavation and filling
- Preparation of sub grade
- Installation of drainage, such as culverts and floodways
- Progressive rehabilitation of the clearing width down to the formation width of the road.

4.4.2 Fuel storage, workshops and maintenance areas

A component of the GFD Project construction and operations activities will be the fuelling, maintenance, inspection and testing of equipment. Facilities for these activities will be established at major construction and operations centres including laydown areas, stockpile and storage areas, accommodation camps, and hub gas compression and water management facilities.

The fuelling facilities will be constructed as modular tank and pump facilities and will be relocatable. About half of the fuel storage facilities will have capacities greater than 10,000 litres. Fuel storage will comply with appropriate Australian Standards.

4.4.3 Laydown, stockpile and storage areas

General construction, maintenance and laydown yards will be established to support construction activities. These laydown yards will vary in size from less than 0.5 ha (drill camp laydown yards) to 25 ha (yards supporting development of a major gas compression facility).

The laydown, stockpile and storage areas will be used for storage of materials and equipment necessary for construction activities. These will be temporary facilities only used during the construction phase (a maximum of three years) and will be located close to construction sites.

During operations, a smaller number of laydown, stockpile and storage areas will be required to support ongoing operations activities. An equipment store will be located within the gas compression facilities to house critical spare parts.

4.4.4 Borrow pits and quarries

Borrow pits will be required to source sand, gravel and other materials needed for the field development program. The locations and methods of extraction for each of the borrow pits will be determined as the needs arise. They will be located in the gas fields. Alternatively materials will be sourced from third parties who are appropriately licensed, including State-owned quarries.

Borrow pit sites will be selected on the basis of the need for construction materials, the suitability of the sites to provide these materials, and the sites' proximity to the main areas of construction. Normal earthmoving equipment (trucks, dozers, etc.) will be used for excavation activities and mechanical screens used as necessary to screen and grade materials. Santos GLNG does not anticipate that blasting will be required to source fill materials; however, Santos GLNG will obtain if required and comply with the relevant approvals.

The borrow pits will be used mainly during construction and most will be rehabilitated following the completion of this phase. A number of borrow pits can be retained to provide sand and gravel for ongoing road and site maintenance activities.

4.4.5 External infrastructure requirements

The GFD Project will need to use external infrastructure such as transportation networks, water supply, electricity and communications infrastructure.

4.4.5.1 Transportation

Transport of the non-local construction workforce will be mainly fly-in/fly-out via Roma, Emerald and other regional airports. The construction workforce will be transported by bus from the airport to the accommodation camps, which will be close to work sites.

Table 4-4 through Table 4-6 illustrate the estimated workforce movements and accommodation aspects for Scotia, Arcadia Valley and Roma.

Transportation of equipment, materials and supplies during the GFD Project's construction and operations phases will predominantly be undertaken by road. Materials will be delivered from Brisbane via Toowoomba; however, quarry and concrete material will be sourced within the GFD Project area or from third parties. Access to various sites will be gained from main highways, using existing State or local roads.

Rail transportation may be possible and will be considered in the planning stages. The use of ports will be required for the importation of equipment and construction materials.

Table 4-4 Scotia local accommodation need estimate

Scotia workforce summary		
Scotia construction workforce (370 max)		
80% (296) non-resident (intra/inter-state)	15% Local Toowoomba-Roma (56)	5% Local Taroom-Wandoan (20)
Fly-in/fly-out of Roma	Fly-in/fly-out of Roma	Of these, 50% move to the area (10)
		Assuming 1.6 dependents per worker, 26 persons move to Taroom over the life of the GFD Project.
Scotia operations workforce (approximately 50)		
50% (25) non-resident (intra/inter-state)	30% Local Toowoomba-Roma (15)	20% Local Taroom-Wandoan (10)
Fly-in/fly-out of Roma	Fly-in/fly-out of Roma	Of these, 50% move to the area (5)
		Assuming 1.6 dependents per worker, 13 persons move to Taroom over the period leading up to the maximum workforce (generally 10 years)

Table 4-5 Arcadia local accommodation need estimate

Arcadia workforce summary		
Arcadia construction workforce (300 max)		
80% (240) non-resident (intra/inter-state)	15% Local Toowoomba (45)	5% Local Springsure-Rolleston (15)
Fly-in/fly-out of Roma	Fly-in/fly-out of Roma	Of these, 50% move to the area (say 8)
		Assuming 1.6 dependents per worker, 20 persons move to Springsure over the period leading up to the maximum gas field workforce generally 10 years)
Arcadia operations workforce (approximately 60)		
50% (30) non-resident (intra/inter-state)	25% Local Toowoomba (15)	25% Local Springsure-Rolleston (15)
Fly-in/fly-out of Roma	Fly-in/fly-out of Roma	Of these, 50% move to the area (say 8)
		Assuming 1.6 dependents per worker, 21 persons move to Springsure over the period leading up to the maximum gas field workforce generally 10 years)

Table 4-6 Roma local accommodation need estimate

Roma workforce summary		
Roma construction workforce (1,100 max)		
80% non-resident (intra/inter-state) (880)	20% Local Toowoomba-Roma (220)	
Fly-in/fly-out of Roma	Fly-in/fly-out of Roma	
	No re-location of construction workers to Roma-Fairview area	
Roma operations workforce (approximately 200)		
50% (100) non-resident (intra/inter-state)	30% Local Toowoomba-Roma (60)	20% Local Roma-Fairview (40)
Fly-in/fly-out of Roma		Of these, 50% move to the area (20)
		Assuming 1.6 dependents per worker, 52 persons move to Roma over the period leading up to the maximum workforce (generally 10 years).

It is assumed that construction and operations in the Fairview gas field will be supported by the Roma Centre. Construction of facilities will occur simultaneously with the construction of facilities in the Scotia area, utilising construction workers transitioning from the Roma area.

It is assumed that construction and operations in the Scotia gas field will be supported by the Roma Centre. The drilling workforce will be accommodated in drill camps co-located with the drilling rigs which will operate across the tenure areas in accordance with field planning.

In accordance with the Santos GLNG policy for local recruitment, it has been assumed that 80% of the construction workforce operates on a fly-in/fly-out basis from outside the region to Roma Airport.

4.4.5.2 Water supply and storage

Water supply and storage will be needed for construction activities, dust suppression, vehicle wash down, accommodation camps, and operations and maintenance activities. Coal seam water will be prioritised to meet the GFD Project's construction, operations and rehabilitation requirements. Water sourced from local water bores or surface water will be used on-lease or off-lease in accordance with legislation, the draft EA conditions and subsequent approvals as required.

Water of appropriate quality will be used for construction and dust suppression activities. Potable water for the drill camps will be trucked and stored in water tanks. Potable water for the construction and operations camps will be provided by bores installed into sandstone aquifers in the area. Operations water supply for maintenance activities and emergency services will be provided from water produced through gas extraction activities. This will require the construction of water storage dams or tanks at the facilities.

The water requirement for the construction workforce is anticipated to be between 0.2 and 0.4 ML/day (based on a construction workforce of 1,600 people). Operations workforce water requirements are anticipated to be around 0.04 ML/day (based on an operations workforce of 200 people).

Stormwater systems will be installed at each major facility and accommodation camp to manage stormwater runoff and will be designed to minimise environmental risks and impacts on receiving waters. Retention basins and sediment ponds will be used as necessary to manage stormwater runoff to ensure it is discharged at an acceptable quality. Erosion and sediment control systems will be installed as necessary including up-slope runoff diversions, designed channels and energy dissipation structures. All chemical and fuel storage areas will be bunded in accordance with relevant Australian Standards.

4.4.5.3 Energy supply

Santos GLNG anticipates that the GFD Project's electrical demand will be to the order of 30 to 60 megawatts (MW) for each gas field.

Power for the gas field operations will be generated by gas-fired generators or serviced by grid connections, where available. The energy sources, including gas-fired power options, will be investigated during the field development phase for the GFD Project. Santos GLNG and/or third parties will seek additional approvals as required, in the event that grid-based power generation is selected.

Where Santos GLNG is generating power, gas turbines (10-20 MW) will be installed at gas compression and water management facilities; however, power can also be supplied from reciprocating gas engines or via direct gas engines. Diesel generators (less than 2 MW each) will be used at temporary facilities with diesel stored in above-ground storage tanks and regularly delivered by tanker truck to site.

Where reticulated power is unavailable, gas-fired generators (up to 200 kilowatts capacity) will be provided at the well lease to power the pumps.

Where connection to the grid is the preferred option, a transmission network service provider may be engaged to construct transmission lines and other associated infrastructure to enable Santos GLNG to use electricity from the grid. In such cases, the major gas compression facilities will be used as the connection point for electricity that would subsequently be distributed to the remote facilities.

Regardless of the power source options selected, power will be reticulated throughout the GFD Project area via a combination of above and below-ground power lines co-located with other infrastructure such as water and gas gathering lines, transmission pipelines or access roads where practicable.

4.4.5.4 Communication

Communications services will include voice and data network services and telemetry services to the laydown and contractor yards, accommodation camps, well leases, gas compression and water management facilities.

Santos

GLNG Project

Where available, the GFD Project will use existing communications services. Alternatively, Santos GLNG will look to extend the GLNG Project's fibre networks or use satellite communications. Strategically located radio towers will be used for both data telemetry and voice radio services. Generally, communications and telemetry towers will be located at elevated locations and will be constructed to a height not exceeding 10 m. Usually, these towers will have a ground disturbance of less than 25 m² each. Power to most telecommunications facilities (repeater stations) will be provided via batteries and solar panels.

Construction activities for telemetry and telecommunication towers will be limited to site clearing, pouring of concrete pads and foundations, and construction of a standard kitset tower. Generally, telecommunication cables will be buried and co-located with existing or proposed facilities, gathering lines or transmission pipelines, or associated with power reticulation infrastructure.

5 Environmental authority conditions

The administering authority (DEHP) can impose conditions on the GFD Project. Based on the potential impacts of the GFD Project and the proposed commitments to avoid, minimise and manage those impacts, Santos GLNG has prepared a list of proposed EA conditions relevant to the GFD Project. The conditions proposed are a direct reflection of the generally low level of impact the GFD Project is expected to have on the surrounding environment and community.

Santos GLNG expects to negotiate the final EA conditions with DEHP prior to authorisation of the project. The list of ERAs that the EA will approve is listed below.

- ERA 9 (3b) – Hydrocarbon Gas Refining – consists of refining 200,000,000m³ or more of natural gas
- ERA 10 – Gas Producing – consists of manufacturing, processing or reforming 200 t or more of hydrocarbon gas in a year
- ERA 14 (1) – Electricity Generation – generating electricity by using gas at a rated capacity of 10MW electrical or more
- ERA 15 – Fuel Burning – consists of using fuel burning equipment that is capable of burning at least 500kg of fuel in an hour
- ERA 60 (1d) – Waste Disposal – operating a facility for disposing of, in a year, more than 200000 t of any combination of regulated waste, general waste and limited regulated waste and <5 t of untreated clinical waste (if in a scheduled area)
- ERA 63 (1b) – Sewage Treatment - Operating sewage treatment works, other than no release works, with a total daily peak design capacity of more than 100 EP to 1500 EP.
- ERA 8 – Chemical Storage - storing more than 500m³ of chemicals of class C1 or C2 combustible liquids under AS 1940 or dangerous goods class 3
- ERA 38 – Surface Coating – coating, painting or powder coating, using, in a year, more than 100 t of surface coating materials.
- ERA 47 – Timber milling and woodchipping – milling more than 100000 t of timber in a year.
- ERA 56 – Regulated Waste Storage – receiving and storing regulated waste. Aggregation and brine dams
- ERA 57 – Regulated Waste Transport – transporting regulated waste, other than tyres, in 36 or more vehicles. The transport of CS water and brine between project areas
- ERA 58 – Regulated Waste Treatment – operating a facility for receiving and treating regulated waste to render the waste non-hazardous or less hazardous
- ERA 60 – Waste Disposal – operating a facility for disposing of, in a year, more than 200000 t of any combination of regulated waste, general waste and limited regulated waste and <5 t of untreated clinical waste (if in a scheduled area)
- ERA 61 – Waste Incineration and Thermal Treatment – incinerating or thermally treating other regulated waste
- ERA 63 (1)(a)(i) – Sewage Treatment – Operating sewage treatment works (21-100 EP), other than no release works
- ERA 63 (1)(b)(i) – Sewage Treatment – Operating sewage treatment works (100-1500 EP), other than no release works
- ERA 64 – treating 10 ML or more raw water in a day. This ERA is for 'no release to waters' RO plants (the majority of our RO plants).

6 Environmental assessment

The GFD Project will use an assessment framework approach, which has been approved and successfully implemented for the GLNG Project. This process will increase certainty in the GFD Project's environmental outcomes.

Constraints analysis is a key component of the framework approach and increases certainty about potential impacts by identifying those areas not suitable for development, or if they were to be developed, how development should proceed. This occurs by identifying the constraints to development that exist within the GFD Project area and the environmental management controls to be applied to project activities in these constrained areas. In this way, Santos GLNG can optimise environmental outcomes by avoiding sensitive receptors where practicable. Where avoidance is not practicable, Santos GLNG will use a range of management and mitigation measures. This hierarchy will be maintained throughout all phases of the GFD Project, providing multiple opportunities for refinement of scope and execution.

In support of the GFD Project, an assessment of the environmental values and constraints study was undertaken, which included a review of available data, both spatial and non-spatial. The review included existing reports and documents, information sourced from various databases (government and other) and analysis of various spatial datasets, both government sourced datasets, and additional geological information system (GIS) datasets detailing results of investigations and surveys recorded for the GLNG Project and the GFD Project.

A summary of these assessments and an evaluation of the potential impacts are presented in the following sections:

- Section 7: Water
- Section 8: Land
- Section 9: Nature conservation
- Section 10: Noise
- Section 11: Air quality
- Section 12: Waste
- Section 13: Rehabilitation
- Section 14: Stimulation
- Section 15: Community and social
- Section 16: Heritage.

Each of the above sections has the following structure:

- **Environmental values:** Environmental values are defined in Section 9 of the EP Act as a quality or physical characteristic of the environment that is conducive to ecological health, public amenity or safety, or another quality of the environment identified and declared under an environmental protection policy or regulation.

- **Potential impacts:** The potential impacts include both beneficial and adverse impacts of the activities described in Section 4 on environmental values. The identification of potential impacts considers the type of activity, magnitude, size or extent of any impacts, the severity of the impact, the duration of the impact and any uncertainties or assumptions related to the impacts.
- **Environmental protection objectives:** These objectives describe the key environmental elements and the outcomes to be protected in order to minimise impacts on environmental values.
- **Management controls:** These controls provide a framework for the proposed EA conditions and detail the strategies to be employed to meet the environmental protection objectives.
- **Environmental protection performance indicators:** The performance indicators provide metrics to determine whether or not the environmental protection objectives have been achieved. These indicators are measurable and auditable.
- **Monitoring:** These are aligned with the existing and proposed monitoring to measure compliance with the proposed EA.

7 Water

7.1 Environmental values

7.1.1 Groundwater environmental values

The EPP Water provides a framework for identifying environmental values for Queensland waters and the water quality guidelines (WQGs) and water quality objectives (WQOs) to enhance or protect those environmental values. The EPP Water defines environmental values of water as:

“particular values or uses of the water that are conducive to a healthy ecosystem or for public amenity, safety or health and that require protection from the effects of habitat alteration, waste releases, contaminated runoff and changed flows”.

The Arcadia, Fairview and Scotia gas fields are located within the Comet and Dawson river sub-basins of the Fitzroy River Basin. Environmental values and WQOs have been adopted by the Queensland Government for these sub-basins and are included in the following documents listed under Schedule 1 of the EPP Water:

- Comet River Sub-basin Environmental Values and Water Quality Objectives (DERM, 2011a)
- Dawson River Sub-basin Environmental Values and Water Quality Objectives (DERM, 2011b).

The Roma gas field is located in the Condamine-Balonne River basin. Environmental values and WQOs have not yet been developed in the Condamine-Balonne Basine Water Resource Plan 2004. Environmental values proposed by the Queensland Murray-Darling Committee (QMDC; 2012) and regional water quality objectives for toxicants in surface waters from ANZECC 2000 were applied to sub-catchments within the Condamine-Balonne Basin instead.

The environmental values identified for the Comet, Dawson and Condamine-Balonne river basins are summarised in Table 7-1.

The GFD Project tenures are underlain by a number of aquifers that provide water for stock and domestic supply and to a lesser extent for urban water supply, agriculture (including irrigation and intensive stock watering) and industrial purposes. The major aquifers are associated with the Great Artesian Basin (GAB), which comprises water bearing units of the Surat and upper Bowen geological basins, as well as water bearing zones within Tertiary rocks and alluvial deposits. Most registered bores in GFD Project tenures take groundwater from the Mooga Sandstone, Gubberamunda Sandstone and Hutton Sandstone.

The aquifers underlying the GFD Project tenures also sustain springs including spring vents (grouped into spring complexes) and watercourse springs, which provide baseflow to streams. A spring vent is a single point in the landscape where groundwater is discharged at the surface. A watercourse spring is a section of a watercourse where groundwater enters the stream from a GAB aquifer through the streambed. There are 72 spring complexes in the Surat CMA, 11 of which are located in GFD Project tenures. There are 43 watercourse springs in the Surat CMA, 11 of which are located in GFD Project tenures. Some spring vents are of conservation value and are protected under the EPBC Act.

Table 7-1 Environmental values of groundwater in the Comet, Dawson and Condamine Balonne river basins

Environmental values	Comet River Sub-basin	Dawson River Sub-basin	Condamine-Balonne River Basin
Protection of aquatic ecosystem	✓	✓	✓
Primary contact recreation (e.g. swimming)*	✓	✓	✓
Secondary recreation (e.g. boating)*	✓	✓	✓
Visual (no contact) recreation*	✓	✓	✓
Drinking water supplies	✓	✓	✓
Crop irrigation	✓	✓	✓
Stock watering	✓	✓	✓
Farm supply/use	✓	✓	✓
Aquaculture (e.g. red claw, barramundi)	✗	✓	✓
Human consumers of aquatic food	✓	✓	✗
Industrial use (including manufacturing plants, power generation)	✓	✓	✗
Protection of cultural and spiritual activities	✓	✓	✓

*Primary, secondary and visual recreation contact have been included as environmental values for groundwater due to groundwater contributions to surface water baseflow in some tenures.

7.1.1.1 Sensitive groundwater receptors

The sensitive groundwater receptors in the GFD Project area are:

- Users that access groundwater from hydrogeological units for domestic water supplies and stock watering, and to a lesser extent, agriculture, aquaculture and industrial purposes
- Ecosystems dependent on groundwater from springs, including spring vents and watercourse springs.

Office of Groundwater Impact Assessment (OGIA, 2013) provided the data on landholder bores and springs used in this study, including interpretation of screened formation/source aquifer.

7.1.1.2 Hydrogeology

The GFD Project tenures are located within the GAB, which consists of Surat Basin sediments and the uppermost aquifer (the Clematis Sandstone) of the underlying Bowen Basin (QWC, 2012a). The main hydrogeological units in the GFD Project area include:

- Quaternary alluvial aquifer systems associated with the unconsolidated sediments of the Condamine-Balonne River, the Dawson River and the Comet River systems
- Minor aquifers within Tertiary fractured basalt and sediments caps

- Water bearing formations of the GAB. These include the Clematis Sandstone, Precipice Sandstone, Hutton Sandstone, Springbok Sandstone, Gubberamunda Sandstone, Mooga Sandstone and Bungil Formation.

An overview of the main hydrogeological units for water supply in the GFD Project area is presented in Table 7-2. The Bungil and Orallo formations are generally not considered to be aquifers, but are used for water supply in the GFD Project area and have therefore been included in Table 7-2. The alluvial systems and Tertiary fractured basalts are not connected across the GFD Project areas; however, these formations are still targeted for water supply.

Table 7-2 Main hydrogeological units for water supply in the GFD Project tenures

Aquifer	Gas field	Aquifer type	Thickness* (m)	Depth	Use/ development
Alluvium	Arcadia, Roma, Scotia, Fairview	Unconfined		At surface	Limited, stock, seasonal
Tertiary fractured basalts and sediments	Arcadia, Roma	Unconfined	10 to 30	At surface	Limited, Stock/domestic
Bungil Formation	Roma	Minor aquifer/ water bearing formation	up to 200	At surface north of Roma, dips south	Limited Stock/domestic
Mooga Sandstone	Roma	Important aquifer	25 to 200	At surface north of Roma, dips south	Stock/domestic, town water supplies, baseflow
Orallo Formation	Roma	Aquitard	140 to 270	At surface north of Roma, dips south	Limited, Stock/domestic
Gubberamunda Sandstone	Roma	Important aquifer	45 to 300	At surface north of Roma, dips south	Important GAB aquifer, town water supply, stock
Springbok Sandstone	Scotia, Fairview	Important aquifer	up to 70	At surface south of Injune, dips south	Limited, discontinuous, stock
Hutton Sandstone	Scotia, Fairview	Important aquifer	up to 700	At surface north of Injune and Taroom, dips south	Important GAB aquifer, drinking water, town water supplies, stock, baseflow
Precipice Sandstone	Fairview	Important aquifer	averaging 80	At surface north of Injune and Taroom, dips south	Important GAB aquifer, drinking water, town water supplies, stock, baseflow
Clematis Sandstone	Fairview, Arcadia	Important aquifer	up to 130	At surface south and west of Rolleston	Important GAB aquifer, town water supplies, stock, baseflow

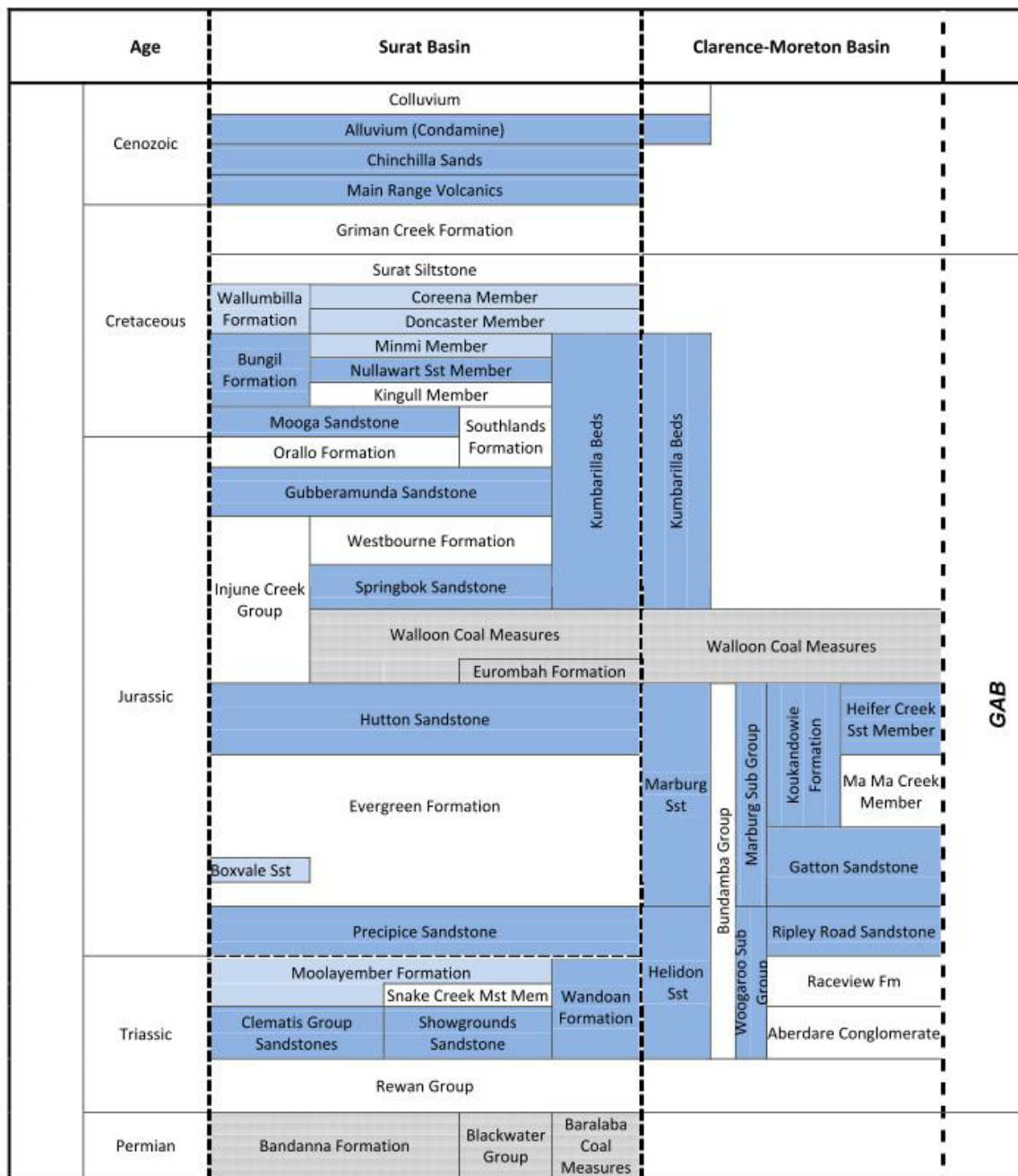
* Santos GLNG (2012), ^ Geoscience Australia website.

Data sourced from DNRm and Santos GLNG databases.

~ No data for Springbok Sandstone, values are for Injune Creek Group and sourced from DNRm datasets.

Regionally, the main aquifers and aquitards in the GAB are controlled by the lithology and extent of stratigraphic units or geologic formations. Figure 7-1 shows the sequence of the aquifers and aquitards within the basin. The sandstone units, defined as aquifers, store and transmit groundwater and are sufficiently permeable to yield economically significant quantities of groundwater. The siltstone and mudstone units within these systems are of low permeability. They restrict groundwater flow or leakage between aquifers and are defined as aquitards. At a local level most of the aquifers contain minor inter-bedded siltstone and mudstone reflected in lower bore yields. Similarly, several aquitards contain minor aquifers of permeable sandstone and siltstone units that can yield reasonable quantities of water in these otherwise unproductive formations (QWC, 2012a).

Figure 7-1 Sequence of aquifers and aquitards within the GAB



Legend

- Minor discontinuous aquifer
- Major aquifer
- Productive coal seam
- Aquitard

The GFD Project area is located in the recharge area of the GAB. Most recharge occurs along the outcrop areas in the north, northwest, northeast and east along the Great Dividing Range. Recharge occurs predominantly by rainfall, either by direct infiltration into the outcrop areas or indirectly via leakage from streams or overlying aquifers. Calibrated recharge rates estimated from QWC's regional groundwater model give recharge rates into the GAB aquifers ranging geographically from 1 to 30 mm per year with a median of 2.8 mm per year (QWC, 2012a).

Recharge water flows primarily along the bedding planes and fractures of aquifers and aquitards from the recharge areas to the south, southwest and west, though there is a minor northward flow component in some aquifers (Hodgkinson et al., 2009) e.g. near Taroom. Groundwater moves very slowly and flow velocities in the GAB have been estimated to range from 1 to 5 m per year (Habermehl, 1980). Groundwater movement within the GAB is dominated by sub-horizontal flow in the aquifers, with vertical leakage from the aquifers through the low permeability aquitards occurring throughout the basin at a much slower rate.

Natural discharge from aquifers in GFD Project tenures occurs through vent springs, baseflow to rivers (watercourse springs), vertical leakage between aquifers, and subsurface flow into adjoining areas. Extraction of groundwater in GFD Project tenures occurs via bores used for stock and domestic supply or agriculture, uncontrolled artesian bores, and petroleum and gas production.

7.1.1.3 Hydrogeological units used for water supply

Groundwater bores in Queensland are registered in the DNRM groundwater database, and water licence information is recorded in the Water Management System (WMS). Bore data provided by the OGIA (2013) (originally sourced from the DNRM groundwater database and WMS) indicates there are 872 registered landholder bores located within the GFD Project tenures. There could also be unregistered bores located within the GFD Project tenures. Most registered bores in GFD Project tenures take groundwater from the Mooga Sandstone. There are no registered bores screened in the Bandanna Formation in GFD Project tenures. The technical report for groundwater provides additional detail regarding the locations of the registered bores.

Registered bore data (OGIA, 2013) indicates groundwater in GFD Project tenures is mainly used for stock and domestic supply and to a lesser extent for urban water supply, agriculture (including irrigation and intensive stock watering) and industrial purposes (Figure 7-2). Groundwater used for petroleum and gas production is exempt from requiring a water licence and is not included in Figure 7-2. The spatial distribution of registered landholder bores and their use is shown on Figure 7-3.

The total estimated volume of groundwater taken from registered bores in GFD Project tenures is estimated to be 6,856 ML/year (ML/year) (OGIA, 2013). Estimated annual volumes of groundwater take by use are provided in Table 7-3. The volumes do not include groundwater taken for petroleum and gas production.

Within the GFD Project area, spring vents and watercourse springs fed by natural discharge from aquifers of the GAB are the main types of groundwater dependent ecosystems (GDEs) present. Other GDEs within the GFD Project area might include wetlands and vegetation ecosystems associated with shallow groundwater systems in localised areas, including alluvial and tertiary basalt systems. The GDE Atlas (Bureau of Meteorology, 2012) shows no subterranean ecosystems within the Surat CMA.

There are 72 spring complexes comprising 329 spring vents in the Surat CMA (OGIA, 2013) (shown on Figure 7-4). The Underground Water Impact Report identified 71 spring complexes comprising 330 spring vents; however, this has since been revised by the OGIA because four of the spring vents in the original data set could not be found during field investigations (x346, x380, x381 and x431) and new spring vents within identified spring complexes have been recorded.

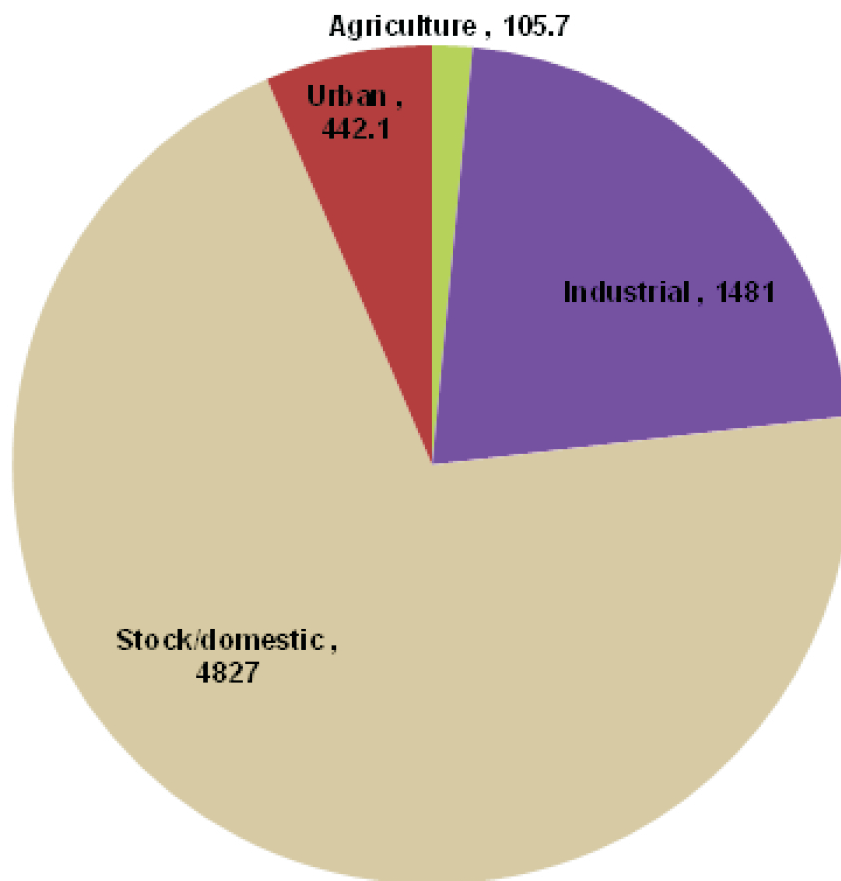
Table 7-3 Volume of groundwater extracted across the GFD Project tenures

Registered use	Agriculture	Industrial	Stock/Domestic	Urban
Number of bores	6	6	842	18
Annual volume TOTAL megalitres per year (ML/year)	105.7	1,481	4,827 [^]	442.1
Average annual volume per bore (ML/year)	17.6	246.8	5.7	24.6

Groundwater taken for petroleum and gas production not presented

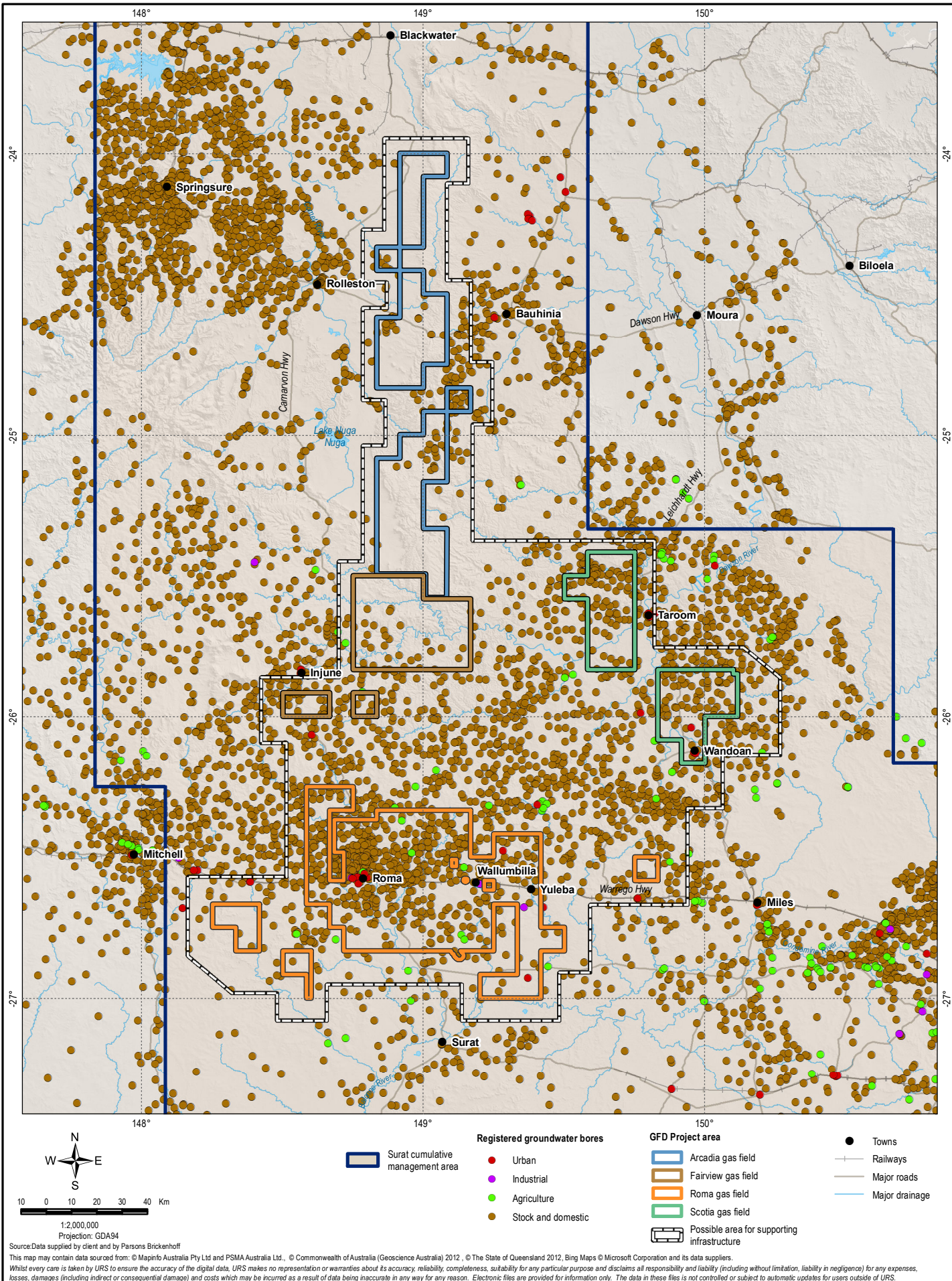
* Bore data provided by the OGIA (2013) was originally sourced from the DNRM groundwater database and WMS.

[^] Stock/domestic volumes estimated by the OGIA where not licensed.

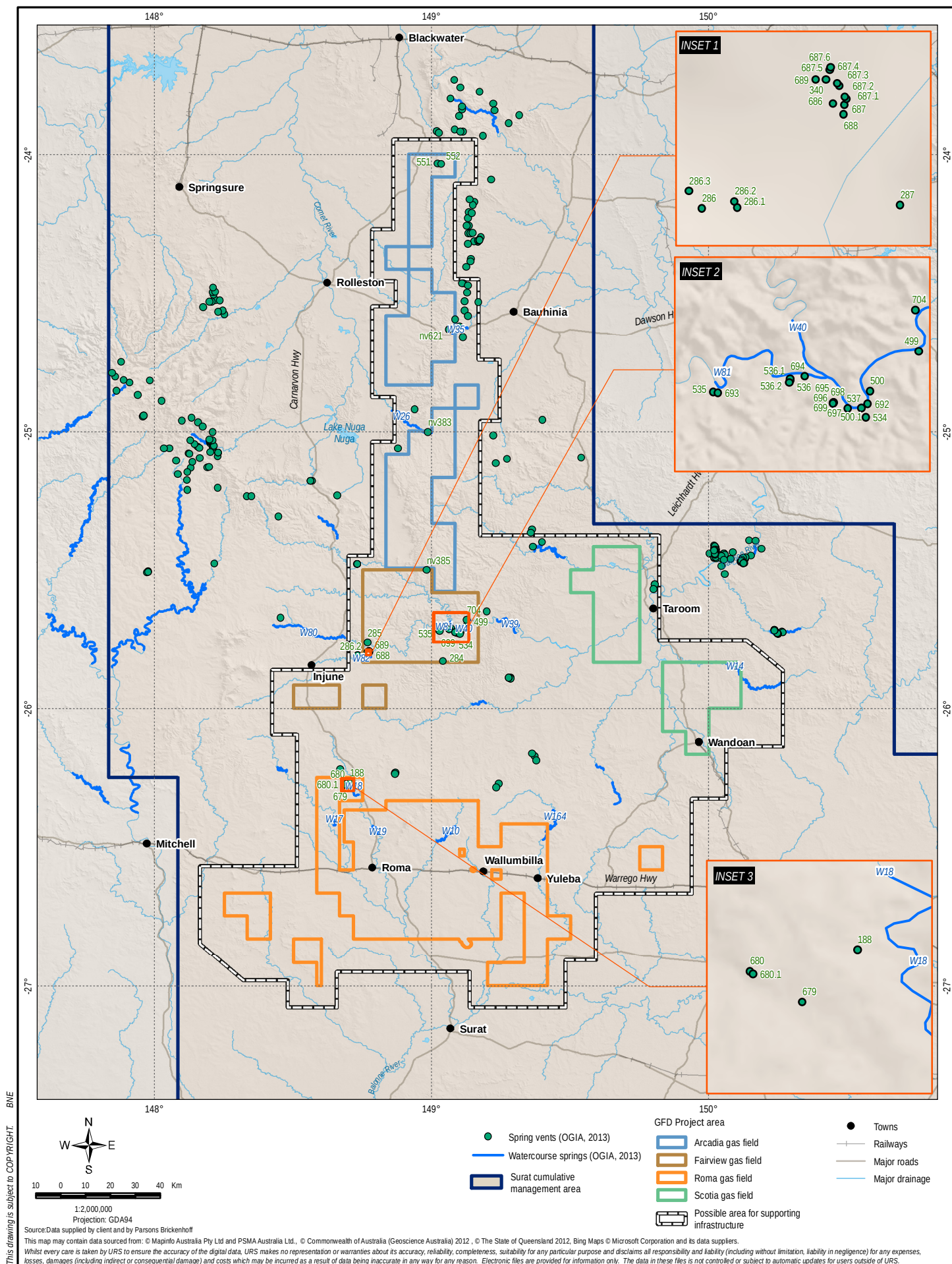


Source: Coal Seam Hydraulic Fracturing Risk Assessment, Combined Stage 1 and Stage 2 Risk Assessment for Schlumberger Methodology (Golder Associates, 2013)

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REGISTERED BORES IN THE GFD PROJECT AREA AND THE SURAT CMA



7.1.2 Surface water environmental values

Table 7-4 and Table 7-5 provide a summary of environmental values identified for the surface water receiving environment relevant to the GFD Project area for the Condamine-Balonne Basin and the Fitzroy Basin respectively. The distribution of referable high ecological significance and general ecological significance wetlands (EHP, 2013) throughout the surface water study sub-catchments is illustrated in Figure 7-5, along with high ecological value areas scheduled under the EPP Water. Lake Murphy and part of the Palm Tree and Robinson Creek wetland complex located in the Lake Murphy Conservation Park (GFD Project Tenure ATP803) are listed as nationally important (Environment Australia, 2001). This area is mapped as having high ecological value (referable) wetlands in the Great Barrier Reef catchments – Lake Murphy Conservation Area. These wetlands contain species and regional ecosystems (REs) of conservation significance under both the EPBC Act and the NC Act.

Table 7-4 Existing environmental values for surface waters within the GFD Project area (Condamine-Balonne Basin)

Environmental values	Condamine River		Balonne River			
	Dogwood Creek	Lower Condamine River	Yuleba Creek	Bungil and Murilla Creeks	Lower Maranoa	Balonne River
Aquatic ecosystems	High	High	High	High	High	High
Irrigating crops	High	High	High	High	High	High
Agriculture (farm use)	High	High	High	High	High	High
Stock watering	High	High	High	High	High	High
Aquaculture	Low	Low	Low	Low	Low	Low
Human consumption	High	High	High	High	High	High
Primary recreation	High	High	High	High	High	High
Secondary recreation	Low	High	High	High	High	High
Visual appreciation	High	High	High	High	High	High
Raw drinking water	High	High	High	High	High	High
Industrial use	Low	Low	Low	Low	Low	Low
Cultural and spiritual values	High	High	High	High	High	High

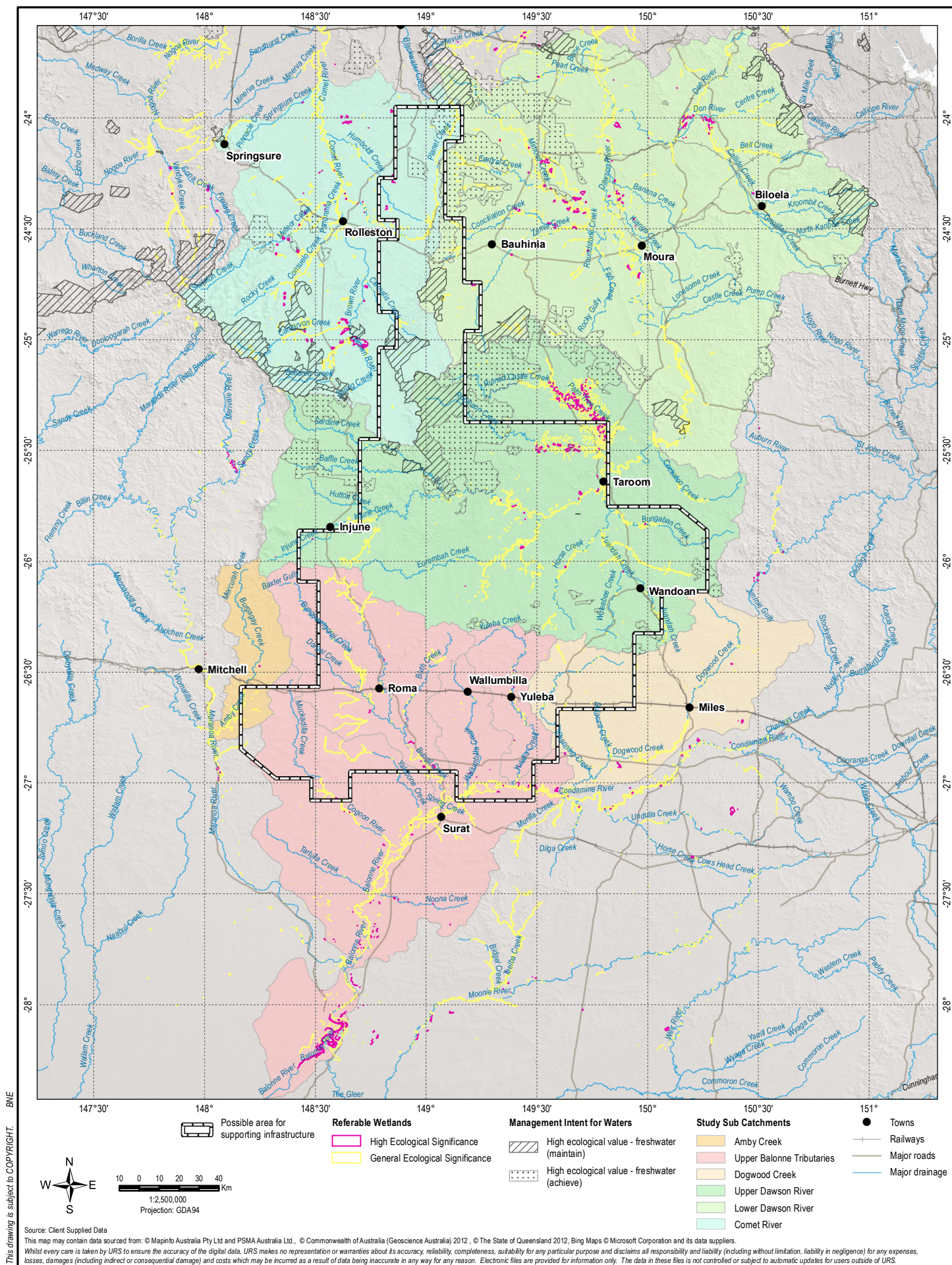
Note: Ecological values for the Condamine-Balonne Basin are listed in QMDC 2012 as either low or high priority. This distinction is not made for ecological values within the Fitzroy Basin (Table 7-5).

Table 7-5 Existing environmental values for surface waters within the GFD Project area (Fitzroy Basin)

Environmental value	Comet River			Upper Dawson River					Lower Dawson River					
	Main channel	Western tributaries	Eastern tributaries	Main channel (below Hutton Creek)	Western upland tributaries	Southern tributaries	Northern upland tributaries	Central tributaries	Northern upland tributaries	Main channel – unregulated reaches	Main channel – regulated reaches	Southern upland tributaries	Eastern Tributaries	Western tributaries
Aquatic ecosystems	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Irrigation	✓	✓	✓	✓	✗	✓	✓	✗	✓	✓	✓	✓	✓	✓
Agriculture	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓
Stock water	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Aquaculture	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✓	✗
Human consumer	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Primary recreation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Secondary recreation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Visual recreation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Drinking water	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓
Industrial use	✓	✓	✓	✓	✗	✓	✗	✗	✗	✓	✓	✗	✓	✗
Cultural and spiritual values	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓

1) ✓ = Environmental Value applicable to surface water resources within the GFD Project area.

2) ✗ = Environmental Value not applicable to surface water resources within the GFD Project area.



7.1.2.1 Catchments

The GFD Project tenures are drained by three river systems, the Comet River in the northwest, the Dawson River in the central and eastern part, and the Balonne River in the south and southwest.

The Condamine-Balonne catchment is located in the Murray Darling Basin which eventually discharges to the Great Australian Bight in South Australia. The Dawson River and Comet River catchments are located in the Fitzroy River Basin which discharges into the Coral Sea near Rockhampton. The Fitzroy River Basin in Central Queensland is the largest catchment in eastern Australia, covering an area of approximately 142,000 km², consisting of six sub-catchments: Nogoa, Comet, Mackenzie, Isaac-Connors, Dawson and Lower Fitzroy. The Fairview and Scotia gas fields are located in the southern section of the Fitzroy River Basin in the upper reaches of the Dawson River catchment. The Arcadia gas field is located in the central-eastern portion of the Comet River catchment and the Roma gas field is located in the upper reaches of the Condamine-Balonne catchment (see Figure 7-6).

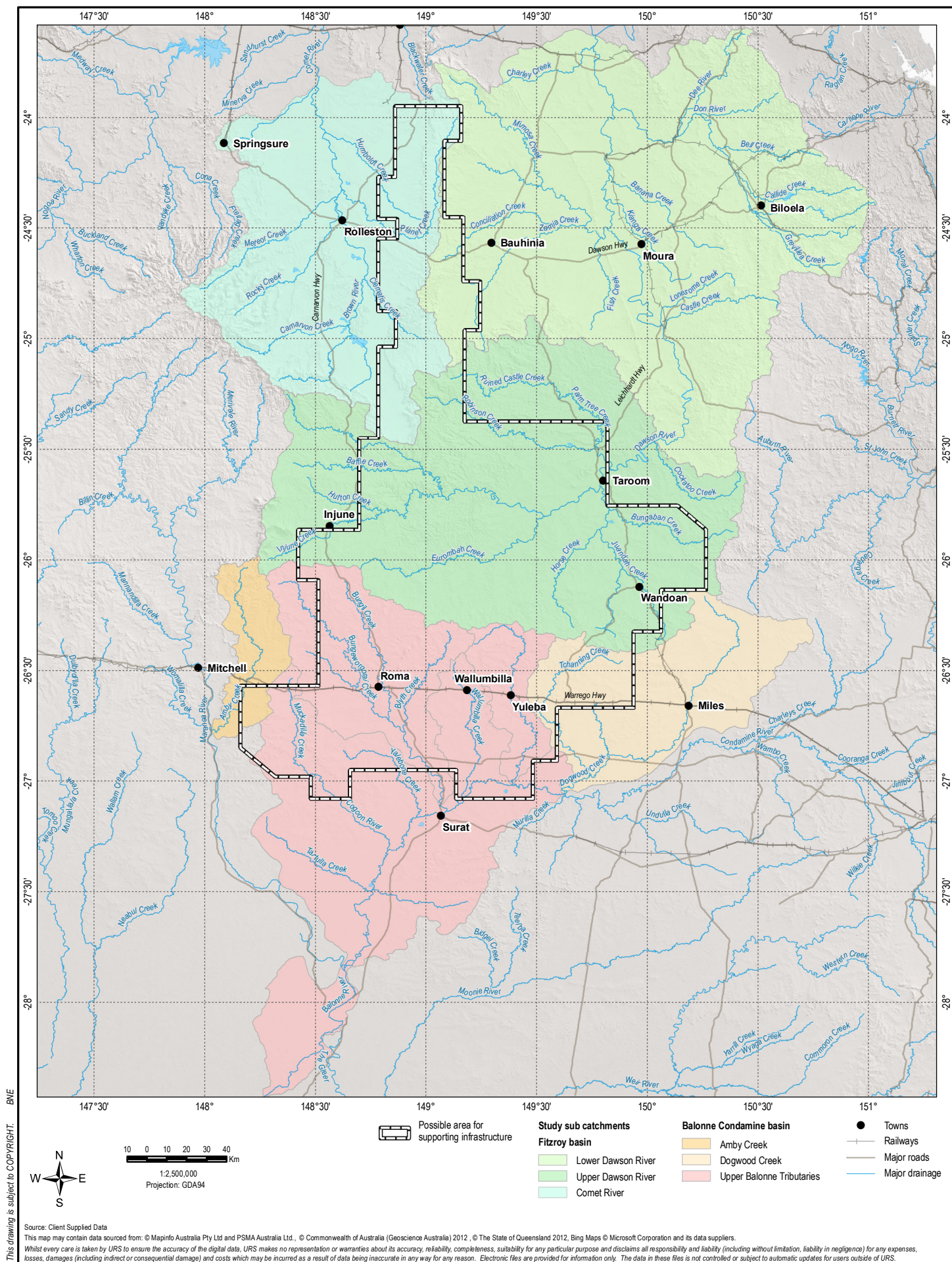
The majority of the rivers and streams in the GFD Project tenures are ephemeral and characterised by high variations in duration and volume of flows due to highly variable rainfall and runoff and high evaporation rates. Prolonged baseflow occurs only in wetter years in most streams. Some sections of streams in the GFD Project tenures are spring-fed.

The surface water study sub-catchments cover 30,000 km² across the Fitzroy and Condamine-Balonne basins. Watercourses within this large area exhibit a wide range of fluvial geomorphologic characteristics and typically show a moderate to high level of impact from the effects of land clearance for grazing and cropping, stock access and removal of riparian vegetation.

Watercourses in the headwater catchments of the Comet River, Upper Balonne tributaries and Upper and Lower Dawson River sub-catchments are typically located in steep, confined to partially-confined valleys which at times become gorges (e.g. Dawson River). In these catchments, changes in land use such, as land clearance and stock access, have increased the vulnerability of stream banks to erosion during high energy floods which results in downstream movement of large volumes of sediment.

Based on the fluvial geomorphology assessment, watercourses in the GFD Project area have the following characteristics:

- Flow regime and dependent ecosystems; the typically ephemeral and episodic nature of the flow regime of watercourses in the project area has resulted in the development of a range of flora and fauna dependent on the seasonality of flows.
- Stream bank stability; the stability of stream banks along watercourses within the project area is aided by riparian vegetation (and associated habitat values for flora and fauna), and can influence and be influenced by streamflow hydraulics.
- Channel geomorphology; watercourses in the project area can be subject to periodic, high energy flood events that may cause rapid adjustments to channel morphology.



7.1.2.2 Hydrology

Rainfall and resultant streamflow in the project area is characterised by a distinct seasonal and highly variable nature. Analysis of the relevant stream gauge data has shown that most watercourses within the project area are typically ephemeral in nature, only flowing during or immediately after significant rainfall events and subjected to relatively rapid flow recessions. Further clarification regarding the definition of a 'watercourse', and characterisation of flow regimes predominant within the GFD Project area is included in the GFD EIS.

Peak stream discharges usually occur during the wet season months of December through February when rainfall is highest, although the Dawson River downstream of the confluence with Hutton Creek shows a relatively consistent level of baseflow year round as a result of inflow from the Dawson River Springs. The high level of variability in both annual and monthly rainfall totals for the weather stations across the project area indicates a high likelihood of both floods and droughts.

7.1.2.3 Surface water quality

An analysis of existing data provided by Santos GLNG and sourced from other secondary sources (such as previous studies undertaken within the GFD Project area) enabled the physicochemical characterisation of existing water quality throughout the GFD Project area. The results of the data analyses were compared with applicable local and regional guideline values to determine the water quality objectives for the GFD Project.

A number of key water quality trends identified include:

- pH tended to be alkaline throughout the Comet and Upper Dawson River sub-catchments, neutral in the Upper Balonne River Tributaries, and slightly acidic in Dogwood Creek.
- Dissolved oxygen (DO) was elevated in most sub-catchments and trends appeared to be more clearly defined in tributaries than in main channels of the Dawson and Balonne rivers; this is possibly influenced by the time and season in which sampling occurred, and the ephemeral nature of the watercourses that were monitored.
- Electrical conductivity (EC) was highly variable but generally higher than the local guideline values within the Upper Dawson River sub-catchments, and elevated compared to sub-regional guidelines within the Upper Balonne River Tributaries. EC values reported by third party sources were lower than the applicable sub-regional guideline value within Dogwood Creek. A clear relationship between low flow conditions and elevated EC was established.
- Chromium, copper, lead and zinc were elevated above applicable guideline values for the majority of sub-catchments. Exceptions included the Upper Balonne River main channel, where heavy metals were below their respective guideline values, and Robinson Creek in the Upper Dawson River where only copper exceeded the regional guideline value.
- Ammonia was particularly elevated throughout the Upper Dawson River. While ammonia in the Upper Balonne tributaries did not exceed its guideline value, it should not be interpreted as these waters being of better quality than those of the Upper Dawson, as the guideline value for ammonia for the Upper Balonne River (900 micrograms per litre (µg/L)) is much higher than that of for the Upper Dawson River (20 µg/L).
- Nutrient enrichment (indicated by elevated total nitrogen, oxidised nitrogen, reactive and total phosphorus) was evident across the majority of sub-catchments.

In most cases there appeared to be a strong relationship between elevated turbidity, total suspended solids and concentrations of nutrients and heavy metals known to bind easily to particulate matter, such as chromium and zinc.

7.1.2.4 Surface water use

An assessment of existing human uses of surface water resources throughout the GFD Project area was undertaken; this included analysis of water entitlements data available from DNRM within a 50 km radius of the GFD Project area bounds to capture downstream users. In general, the following water uses are considered to be the most sensitive within the GFD Project area:

- Livestock water
- Impound water (e.g. farm dams, emergency fire-fighting water supply)
- Domestic supply
- Water harvesting
- Industrial use
- Town water supply.

7.2 Potential impacts

Impacts are listed for each phase of the GFD Project (construction, operations and decommissioning). A high level review of management frameworks applied to existing Santos GLNG operations was conducted to determine suitable mitigation measures that would also apply to the similar infrastructure and activities developed for the GFD Project. It should be noted that specific detail relating to the location and form of the infrastructure associated with the GFD Project has not yet been confirmed and therefore the assessment presented in this section is generic to the GFD Project area and not site specific (URS, 2014).

The potential impacts on ground water are listed in Table 7-6. The potential impacts on surface water are listed in Table 7-7.

Table 7-6 Potential impacts to groundwater

Potential impacts		Construction phase activities	Operations phase activities	Decommissioning and rehabilitation phase activities	Applicable management measures
Aquifer depressurisation	Decline in groundwater levels/pressure in bores and reduced supply to groundwater users.	Drilling and construction of production wells, fluid injection wells, water supply bores and monitoring bores.	Operation of production wells, i.e. extraction of groundwater for natural gas production Operation and maintenance of water supply bores.	None	GFD Project environmental protocol for constraints planning and field development (constraints protocol) Water resource management plan. Underground water impact report for the Surat cumulative management area.
	Reduced stream baseflow (watercourse spring flow) and loss or reduction of supply to downstream surface water users.				
	Reduced spring flow and loss or degradation of dependent ecosystems.				
	Reduced stream baseflow (watercourse spring flow) and loss or degradation of dependent aquatic ecosystems.				
	Subsidence, altering groundwater flow paths and aquifer storage.	None.	Operation of production wells, i.e. extraction of groundwater for natural gas production.	None	Water resource management plan. Underground Water Impact Report for the Surat Cumulative Management Area.
	Subsidence, causing ground surface displacement and altering surface water flow paths.				

Potential impacts		Construction phase activities	Operations phase activities	Decommissioning and rehabilitation phase activities	Applicable management measures
Changes to water quality.	Degradation of the beneficial use of groundwater supplies.	Drilling and construction of production wells, fluid injection wells, water supply bores and monitoring bores. Sub-surface activities, including the construction of borrow pits and quarries, laydown areas, buried pipelines and storage dams. Construction of surface infrastructure.	Hydraulic fracturing. Storage of brine generated during desalination of coal seam water. Brine disposal via fluid injection into deep formations. Storage of coal seam water. Disposal of coal seam water through reinjection into aquifers (Managed Aquifer Recharge). Disposal of coal seam water through beneficial reuse for irrigation and stock watering. Hydro-testing of gas or treated water pipelines. Sewage treatment facilities.	Decommissioning of production wells. Rehabilitation of surface infrastructure.	Constraints Protocol. Water resource management plan. Coal seam water management strategy. Hydraulic fracturing risk assessment. Contingency plan for emergency environmental incidents. Land release management plan. Underground Water Impact Report for the Surat Cumulative Management Area. Stimulation impact monitoring program.
	Loss or degradation of MNES ecosystems dependent on springs sourced from affected aquifers				

Source: Parsons Brinckerhoff, 2014. Groundwater Technical Report, Table 8.1

Table 7-7 Potential impacts to surface water

Potential impacts	Construction phase activities	Operations phase activities	Decommissioning and rehabilitation phase activities	Applicable management plans
Increased sedimentation (adverse impacts on water quality and geomorphology)	Vehicle wash down Soil compaction Construction (soil disturbance) Construction of watercourse crossings	Release to surface waters Permanent structures Minor earthworks	Demolition activities and earthworks Sediment control infrastructure Incomplete rehabilitation of disturbed areas	Environmental protocol for constraints planning and field development Water resource management plan Erosion and sediment control management plan
Erosion of stream banks	Disturbance of riparian habitat Construction of watercourse crossings	Permanent structures and minor earthworks Stream crossings and diversions	Sediment control infrastructure Incomplete rehabilitation	Land release management plan Decommissioning and abandonment plan
Surface water impact (adverse impact on surface water quality)	Refuelling vehicles Overturned vehicle resulting in release of fuel/ chemicals Vehicle wash-down Litter Leakage or spill of hydrotest water Uncontrolled release of drilling and completion fluids Uncontrolled release of treated sewage effluent (from STPs at construction camps)	Treated sewage discharges Controlled/uncontrolled discharges of processed coal seam water, water for hydro-testing or brine to surface water Operations wastes (e.g. litter) Uncontrolled release of treated sewage effluent (from STPs at accommodation and operational facilities) Land disposal of brine products, crystallised salts (see explanation for decommissioning phase)	Temporary refuelling facilities, chemical storage facilities and vehicle wash-down areas Land disposal of brine products, crystallised salts (could potentially result in impacts to surface water quality associated with runoff if storage area is not sufficiently contained)	Chemical and fuel management plan

Potential impacts	Construction phase activities	Operations phase activities	Decommissioning and rehabilitation phase activities	Applicable management plans
Altered surface water flow regime (risk to overland flow paths, infrastructure, riparian vegetation, terrestrial ecosystems, base flow from aquifers, and environmental flow regime)	Watercourse diversion (for example, re-direction of overland flow paths/ gullies); Construction of crossings	Watercourse diversion (e.g. re- direction of overland flow paths, gullies) Failure of water storage facilities, embankments, pipelines, bunds Release to surface waters (both controlled and uncontrolled)	N/A	
Altered geomorphic character (e.g. increased lateral instability; significant alteration of geomorphic units)	Watercourse diversion, construction of crossings (in-stream works)	Watercourses crossings, diversions and permanent structures in channel	Incomplete rehabilitation of disturbed areas	

Source: URS, 2014, Surface Water Technical Report, Table 9-5

7.3 Environmental protection objectives

In accordance with Santos GLNG's internal standards, the GFD Project will adopt the environmental performance objectives relevant to water management listed in Table 7-8.

Table 7-8 Environmental protection objectives

Environmental protection objectives

- Avoid or minimise impacts to the groundwater and surface water environmental values
- Avoid or minimise impacts to the physical integrity, fluvial processes and morphology of watercourses and wetlands.

7.4 Environmental protection performance indicators

The indicators within Table 7-9 will be utilised to determine whether the environmental performance objectives have been met and whether the control strategies implemented have been effective.

Table 7-9 Environmental protection performance indicators

Environmental protection performance indicators

- Erosion and sediment control management plan is implemented
- Release to surface waters do not exceed established limits for specified water quality parameters, unless specifically authorised by the EA
- Works involving significant disturbance near watercourses, wetlands and springs are in accordance to the EA
- Existing groundwater activities are managed in accordance with 'make good' provisions in Water Act
- Seepage Monitoring Program is implemented
- Data obtained via the Seepage Monitoring Program, or other groundwater monitoring programs, demonstrate that groundwater values have not been adversely impacted
- Other monitoring required under the Water Act 2000 and the EPBC Act show that groundwater pressure is appropriately monitored and groundwater quality is not adversely affected.

7.5 Management controls

7.5.1 Management control measures

The management control measures in Table 7-10 reflect the management controls that will be implemented to mitigate impacts to surface water and groundwater environmental values.

Table 7-10 Management control measures

Management plan	Key provisions/ function	Management control measures
GFD Project environmental protocol for constraints planning and field development	The Constraints protocol provides a framework to guide placement of infrastructure and adopts the management principles of avoid, minimise, mitigate, remediate and rehabilitate and offset. 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.	Santos GLNG will implement the Constraints protocol.
Hydraulic fracturing risk assessment: compendium of assessed fluid systems	The Hydraulic fracturing risk assessment report synthesises the hydraulic fracturing risk assessments completed on various hydraulic fracturing fluids and provides a framework for including new fluid systems within the risk assessment document. The body of the report provides generalised information, including the geology and hydrogeology of the area, risk assessment methodologies (qualitative and quantitative) and a high level understanding of current results. The appendices include risk assessments of individual hydraulic fracturing fluid systems.	• The Hydraulic fracturing risk assessment has been developed and will be carried out for every well to be stimulated prior to stimulation activities being carried out at that well. • Spill containment procedures will be implemented to prevent migration of chemicals into shallow groundwater systems. • Pressure tests of well casing and cement will be conducted prior to hydraulic fracturing to confirm the integrity of the well. This will determine the presence/ absence of significant leakage in the casing, tubing, or packer. Further, the integrity tests will identify the presence/ absence of significant fluid movement into another aquifer through vertical channels adjacent to the well bore hole. • Chemicals have been subjected to assessment through a quantitative risk assessment prior to use. • Process design will aim to retain fluids within the target coal seam. • Flow back fluids will be appropriately contained, managed, recycled or disposed of in accordance with regulatory requirements.

Management plan	Key provisions/ function	Management control measures
Contingency plan for emergency environmental incidents	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.	• The Contingency plan will be implemented. • In accordance with the Contingency plan, Santos GLNG will prepare for and respond to emergency environmental incidents in a manner that minimises the extent and duration of environmental harm caused by emergency incidents. • Santos GLNG will communicate with the appropriate parties in the event of emergency environmental incidents. • Santos GLNG will provide resources to be used in response to environmental emergency incidents. • The cause of emergency environmental incidents that have occurred will be investigated and, where necessary, remedial actions will be implemented to reduce the likelihood of recurrence of similar events. • Procedures will be implemented specific to responding to stimulation-related incidents, including non-routine events. • Procedures will be implemented related to the restoration of the loss of well mechanical integrity. • Santos GLNG will implement response procedures related to regulated structures. • Santos GLNG will develop /a receiving environment monitoring program to be implemented in the event of a release to waters or land to examine and assess potential environmental impacts.

Management plan	Key provisions/ function	Management control measures
Chemical and fuel management plan	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.	• The CFMP will be implemented • All chemical storage facilities associated with an ERA of chemical storage will be clearly and permanently marked for the life of the petroleum activities. • All chemical storages will: – Be stored in, or serviced by, an effective containment system that is impervious to the materials stored therein; and – Be stored and handled in accordance with the relevant Australian Standard where such Standard is available; and – Be managed to prevent the release of substances to waters or land.

Management plan	Key provisions/ function	Management control measures
Erosion and sediment control management plan	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.	• The ESCMP will be implemented. • The relevant ESCMP requirements for drainage control include mitigation measures such as: – 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. – Giving priority to preventing, or at least minimising soil erosion, rather than allowing erosion to occur and trying to trap the resulting sediment. Where this is not practicable, then reasonable and practicable measures need to be taken to minimize soil erosion even if the adopted sediment control measures comply with the required management standard. • Erosion and sediment control measures will be installed prior to carrying out limited petroleum activities undertaken within ESAs, in accordance with Schedule E of the proposed EA.

Management plan	Key provisions/ function	Management control measures
Land release management plan	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 operational purposes • Low point drain water releases to land • 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.	The LRMP will be implemented. The LRMP includes measures such as: • Procedures or strategies to ensure that the release of contaminants, hydrostatic test water and contaminants from low point drains (LPDs) to land are carried out in manner such that: – vegetation is not damaged; – soil quality is not adversely impacted; – there is no surface ponding or runoff to waters; – there is no aerosols or odours; – deep drainage below the root zone of any vegetation is minimised; – the quality of shallow aquifers is not adversely affected • Requirements for evaluation of quality and quantity of coal seam water used for irrigation. • Frequency and intensity of use of coal seam water for dust suppression (e.g. lighter, more frequent application is preferred over less frequent, heavier applications). • Conditions under which treated sewage effluent may be released are outlined in the EA and LRMP, and the associated mitigation measures are detailed in the LRMP. • Treated sewage effluent will be released to land by sub-surface or spray irrigation at designated, fenced contaminant release areas. • A buffer distance of 50 m will be maintained from the location of the effluent irrigation area to any watercourse, wetland or protected area, and 100 m from a potable water supply or stock drinking water supply. • Treated sewage effluent will be monitored to ensure compliance with the applicable treated sewage standards for releases to land, dust suppression, construction and operational purposes, as defined in the EA.

Management plan	Key provisions/ function	Management control measures
Decommissioning and abandonment management plan	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.	• The DAMP will be implemented. • Management of wastewater (including coal seam water and brine) during the decommissioning phase and demolition activities is detailed in the DAMP, along with management measures for stormwater and sediment.

Management plan	Key provisions/ function	Management control measures
Seepage monitoring program	The Seepage monitoring program will include procedures to detect seepage to groundwater as a result of storing contaminants in a regulated structure(s) such as a dam.	• The seepage monitoring program will be developed and implemented. • The Seepage Monitoring Program will be consistent with relevant Guidelines and Standards such that the Program design has: – a sufficient number seepage monitoring points and / or wells to obtain representative groundwater samples from the uppermost aquifer up-gradient and down-gradient of the potential influence; – if a salt monocell is constructed then a sufficient number of seepage monitoring bores are to be installed and located not more than 150 m from the monocell or the boundary of the monocell facility, whichever is the closer; – sufficient regularity and spatial and temporal replication to make statistically valid conclusions about the presence or absence of contaminants; – procedures to determine the quality of groundwater down gradient of potential sources of contaminants including groundwater passing the relevant seepage monitoring bore(s); – procedures to allow an assessment of whether there has been any statistically significant adverse change in groundwater quality at locations hydraulically down gradient of the containment activities. • A Seepage trigger action response procedure will be developed and implemented, which include but not be limited to the following: – trigger levels for the relevant trigger parameter(s); • trigger and action response measures at which investigations will be undertaken; – action levels for the relevant possible contaminants of concern at which additional investigation into the potential for environmental harm, including the validation and verification of the source, cause and extent of impact.

Management plan	Key provisions/ function	Management control measures
Stimulation impact monitoring program	The Stimulation impact monitoring program was developed to provide a general description of the stimulation activities to be conducted by Santos GLNG, the regulatory requirements pertinent to stimulation monitoring, as well as the practices and procedures that comprise the monitoring program.	• The Stimulation impact monitoring program will be implemented (refer Appendix Q). • Stimulation activities will not affect water quality, other than that within the stimulation impact zone of the target gas producing formation. Santos GLNG will implement practices and procedures to detect fractures that have or may result in the connection of a target gas producing formation and another aquifer as a result of stimulation activities. • Santos GLNG will monitor the stimulation fluids to be used in stimulation activities, flow back waters from stimulation activities, and landholder bores (as required by the EA). • Santos GLNG will monitor the relevant bores monthly for the first six months subsequent to the stimulation activities being undertaken, then annually for the first 5 years subsequent to the stimulation activities, or until the specified analytes and physico-chemical parameters are not detected in concentrations above baseline bore monitoring data on two consecutive monitoring occasions, in accordance with the EA.

Sources:

Parsons Brinckerhoff, 2014. Groundwater Technical Report, Table 8.2

URS, 2014, Surface Water Technical Report, Table 9-6

7.5.2 Consideration for dams

The assessment, design and construction of low hazard or regulated dams located within the GFD Project area will be undertaken in accordance with the *Manual for Assessing Hazard Categories and Hydraulic Performance of Dams*, as well as the guideline *Structures which are dams or levees constructed as part of Environmentally Relevant Activities*.

These structures will be located in accordance with the Constraints protocol. As required by the Draft EM Plan Guideline requirements, a list of dams (low hazard and regulated) will be provided to DEHP, including the following details:

- Location details including lats and long, camp accommodation, creeks, rivers, wetland and public recreation areas
- Purpose of the dam (e.g. aggregation, brine, etc.)
- Certified hazard assessment reports, design plans and 'as constructed' drawings
- Hydraulic performance
- Max surface area (ha)
- Max volume of dam (m³)
- Max depth of dam (m)
- Liner selection
- Leak detection system (if applicable).

For all new dams classified as significant or high hazard, Santos GLNG will submit a dam design report addressing all the requirements detailed in Appendix 2 of the guideline: *Structures which are dams or levees constructed as part of Environmentally Relevant Activities*.

A register of the existing regulated dams will be maintained as required by the EA.

Potential impacts associated with the installation, operation and maintenance of dams include:

- Diverting flood flows from natural drainage paths and alter flow distribution
- Increase in the flood duration and the risk of detainment of floods
- Associated risks to safety of persons from flooding
- Associated risk of damage posed to property from flooding
- Seepage from dams adversely impacting groundwater quality
- Risk of erosion along dam and its sidewalls/ banks.

All low hazard or regulated structures containing wastewater will be designed to effectively avoid environmental harm through contamination of surrounding or underlying land and groundwater.

The operation, modification and decommissioning will be carried out in accordance with the Manual for Assessing Hazard Categories and Hydraulic Performance of Dams and guideline Structures, which are dams or levees constructed as part of Environmentally Relevant Activities.

The consequence category of any structure will be assessed by a suitably qualified and experienced person in accordance with the *Manual for Assessing consequence Categories and Hydraulic Performance of Structures* as amended from time to time.

The consequence assessment will occur in any of the following situations:

- prior to the design and construction of the structure
- prior to any change in its purpose or its stored contents
- at least biennially after the construction of a structure assessed and certified as a high or significant consequence structure.

The required consequence assessment report and certification will be prepared by a suitably qualified and experienced person for any structure assessed

Where an existing structure is assessed for the first time as significant or high, the structure will meet the requirements for regulated structures as defined in the EA within 12 months of that assessment.

If a dam is assessed as low consequence, it will be constructed, operated and maintained in accordance with accepted engineering standards, as specified in the EA.

A design plan will be prepared for any dam determined to be a regulated structure and will contain the required information prescribed in the *Guideline – Structures which are dams or levees constructed as part of environmentally relevant activities*.

All regulated structures will be designed and constructed using the principles and guidelines provided in the *Manual for Assessing consequence Categories and Hydraulic Performance of Structures*, as amended from time to time.

Santos GLNG will mark the mandatory reporting level on each regulated dams in such a way that it is clearly observable during routine inspections of each dam. If Santos GLNG becomes aware that the mandatory reporting level has been reached, action will be taken to prevent, or if unable to prevent, to minimise any actual or potential environmental harm.

Further, on 1 November of each year, Santos GLNG will ensure that there is available storage in each regulated structure to meet the design storage allowance. If Santos GLNG becomes aware that the design storage allowance cannot be achieved on 1 November of each year, action will be taken to prevent, or if unable to prevent, to minimise any actual or potential environmental harm.

7.5.3 Consideration of sewage treatment and disposal

Sewage treatment plants (STPs) will be located in accordance with the Constraints protocol. As required by the Draft EM Plan Guideline requirements, a list of STPs will be provided to DEHP, including the following details:

- Description of the system (peak design capacity in equivalent persons, proposed plant specification and performance, proposed operational parameters)
- Systems operation, maintenance and management arrangements
- Proposed method of disposal for treated effluent and biosolids including water, salt and nutrient balances if proposing to dispose treated effluent to land and the method of application (e.g. drip irrigation, spray irrigation)
- Details of a monitoring program to assure the performance of the system and prevention of adverse environmental impacts.

The following documents will be taken into consideration when installing, operating and maintaining sewage treatment works and disposal systems:

- Queensland Water Recycling Guidelines
- Planning Guidelines for Water Supply and Sewerage
- On-Site Sewage Facilities: Guidelines for Vertical and Horizontal Separation Distance
- Australian Standard AS/NZS 1547:2000 On-site Domestic Wastewater Management
- Australian Guidelines for Sewerage Systems: Use of Reclaimed Water
- Australian Guidelines for Sewerage Systems: Biosolids Management
- Australian Guidelines for Sewerage Systems: Effluent Management.

Potential impacts associated with the installation, operation and maintenance of STPs include:

- Localised degradation of the soil resource
- Erosion of site
- Contribute high nutrient content water to waterways, resulting in algal blooms of these waterways and impacting aquatic ecology.

On-site treatment will be undertaken by a package treatment plant and with disposal by irrigation in accordance with applicable EA conditions. The effluent disposal area will be selected to include soil and vegetation types suitable to assimilate predicted effluent volumes and quality. Santos GLNG has several existing procedures which will be used to assist with the site selection process.

To inform the selection of appropriate effluent disposal areas for STPs greater than 20 equivalent persons, an evaluation will be undertaken of factors such as soil type, vegetation type and cover in conjunction with effluent quality, hydraulic flow and period of application. This evaluation will provide guidance as to the appropriate size of any STP related land application area required, the maximum irrigation rate and minimum volume of wet weather storage required.

Once the location has been determined as suitable for the release of treated sewage effluent to land, the treatment and disposal system will be designed to ensure the potential harm to the environment and people is minimised as far as practicable.

The disposal of treated sewage effluent will be carried out in accordance with the relevant approvals for the GFD Project as well as the LRMP (Santos, 2014).

7.6 Monitoring

Table 7-11 summarises the environmental monitoring and assessment considerations for the protection of groundwater and surfacewater environmental values within the GFD Project area. Details of the monitoring activities are described in the management plans. Additional monitoring considerations are also summarised in the table.

Table 7-11 Monitoring considerations for water

Existing management and monitoring plans

- WRMP
- Contingency plan
- CFMP
- ESCMP
- LRMP
- DAMP
- Stimulation impact monitoring program
- Underground water impact report for the Surat cumulative area

Additional monitoring considerations for water

General

- Monitoring will be undertaken by a suitably qualified person.
- Laboratory analyses and tests will be carried out by a laboratory that has NATA accreditation for such analyses and tests, unless NATA accredited tests are not available.
- Monitoring plans, systems, programs or procedures required to be developed and implemented by the environmental authority will be reviewed for performance and amended as required but not less than once every three years in accordance with the requirements for the particular plans, systems, programs and procedures in accordance with the conditions of the environmental authority.
- Monitoring programs specifically required by the EA will be certified by a suitably qualified person.
- An annual report will be prepared each year and submitted to the administering authority in the form requested by the administering authority. This report will include information as required by the environmental authority such as:
 - results of the Seepage Monitoring Program
 - results of annual regulated dam water quality monitoring
 - well closure reports
 - results of any baseline or stimulation impact monitoring program
 - any third party audit report
 - details of any exceedances with the conditions of this environmental authority and the dates and times these exceedances were reported to the administering authority
 - an outline of actions taken to minimise the risk of environmental harm from any circumstance, condition or elevated contaminant level identified by the monitoring or recording programs.

Additional monitoring considerations for water

Sampling methodology

- The methods of water sampling will comply with the latest edition of the Queensland Monitoring and Sampling Manual as amended from time to time
- The methods of groundwater sampling will comply with the latest edition of the Queensland Monitoring and Sampling Manual, AS/NZS 5667:11 1998 Water Sampling Guidelines – Part 11 Guidance on sampling groundwater, and the Australian Government's Groundwater Sampling and Analysis – A Field Guide (2009:27 GeoCat #6890.1) as relevant and as amended from time to time.

Works in watercourses, wetlands, lakes and springs

- Water quality monitoring will be carried out in relation to works in watercourses and wetlands at a frequency to ensure compliance with release limits to waters as prescribed in the EA.

Seepage monitoring program

- A Seepage Monitoring Program will be developed to detect seepage to groundwater as a result of storing water in a regulated structure(s). The Seepage Monitoring Program will be developed in accordance with the requirements of the EA.

Monitoring of regulated structures

- Containment structures will be monitored for early signs of loss of structural or hydraulic integrity, based on the advice of a suitably qualified and experienced person. The methods of monitoring and frequency of monitoring will be as assessed by the person who conducts the consequence assessment based on the particular circumstances of each structure.
- Regulated structures will be monitored for the water quality characteristics and at the monitoring location and frequency specified in the EA.
- Regulated structures will be inspected annually by a suitably qualified and experienced person. The regulated structure will be assessed for the condition and adequacy for dam safety and against the necessary structural, geotechnical and hydraulic performance against the criteria in each annual inspection.

Sewage effluent

- Treated sewage effluent released to land will be monitored at the frequency and for each quality characteristic specified in the EA.

Stimulation impact monitoring program

- A Stimulation Impact Monitoring Program will be developed in accordance with the requirements of the EA prior to the carrying out of stimulation activities which will be able to detect adverse impacts to water quality from stimulation activities
- Prior to undertaking stimulation activities, a baseline bore assessment of the quality of active landholder groundwater bores will be carried out in accordance with the EA. Stimulation baseline bore assessments will include the minimum water quality analytes and physico-chemical parameters identified in the *Baseline Assessment Guideline* (EHP) and restricted stimulation fluids as defined in the *Environmental Protection Act 1994*, as amended from time to time, in order to establish baseline water quality.

7.7 Commitments

Other monitoring and reporting considerations which are not covered by the scope of the EM Plan are detailed in the Environmental Monitoring and Reporting (EMR) report (Appendix C). The EMR includes specific monitoring and reporting considerations required under the *Water Act 2000* (Qld) and the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) that fall outside the *Queensland Environmental Protection Act 1994* (EP Act). These monitoring activities aid in the protection of environmental values associated with groundwater, surface water and aquatic ecosystems that could potentially be impacted by stimulation activities. Such monitoring requirements include the following:

- Water Act
 - Regional baseline bore assessments
 - Office of Groundwater Impact Assessment (OGIA) Underground Water Impact Report (UWIR) water quality and pressure monitoring
 - OGIA UWIR springs monitoring
 - Trigger levels and response
 - Reporting.
- EPBC Act
 - Monitoring of subsidence
 - Early warning monitoring for EPBC Act listed springs
 - Monitoring associated with hydraulic fracturing
 - Aquifer connectivity monitoring
 - Significant / listed Species
 - EPBC trigger levels and exceedance response
 - Notification and reporting.

7.8 Proposed environmental authority conditions

The following draft EA conditions in relation to water are proposed for the GFD Project. The conditions stipulate the required plans and management and monitoring requirements to enable adequate protection of the GFD Project area's environmental values. The draft EA conditions are reproduced in full in Appendix O.

SCHEDULE B – WATER

- B1 Contaminants must not be directly or indirectly released to any waters except as permitted under this environmental authority.

Erosion and Sediment Control Plan

- B2 For activities involving significant disturbance to land, control measures that are commensurate to the site-specific risk of erosion, and risk of sediment release to waters must be implemented to:
- a) Allow stormwater to pass through the site in a controlled manner and at non-erosive flow velocities;
 - b) Minimise soil erosion resulting from wind, rain, and flowing water;
 - c) Minimise the duration that disturbed soils are exposed to the erosive forces of wind, rain, and flowing water;
 - d) Minimise work-related soil erosion and sediment runoff; and
 - e) Minimise negative impacts to land or properties adjacent to the activities (including roads).

Works in watercourses, wetlands, lakes and springs

- B3 Petroleum activity(ies) that require earthworks, vegetation clearing, placing fill and/or that will result in significant disturbance other than that associated with the construction and/or maintenance of **linear infrastructure**, is not permitted in or within:
- a) 200 metres of any lake or spring; or
 - b) 100 metres of the high bank of any other watercourse.
- B4 All reasonable alternative locations must be considered prior to the construction of any linear infrastructure that will result in significant disturbance in or on the **bed and banks** of a watercourse or within the areas specified in condition (B3)(b).
- B5 Despite condition (B3), the infrastructure and associated activities necessary for construction and/or maintenance purposes specified in *Schedule B, Table 1 – Authorised Works in a Watercourse or within 200m of Springs* are permitted in the location specified *Schedule B, Table 1 – Authorised Works in a Watercourse or within 200m of Springs*.

Schedule B, Table 1 – Authorised Works in a Watercourse or within 200m of Springs

Tenure	Description of Infrastructure/Works	Latitude	Longitude

- B6 The construction and/or maintenance of linear infrastructure that will result in significant disturbance in or on the **bed and banks** of a watercourse or within the areas specified in (B3)(a) and (B3)(b) must be conducted in accordance with the following order of preference:
- a) conducting works in times when there is no water present;
 - b) conducting works in times of no flow;
 - c) conducting works in times of flow but in a way that does not impede low flow.
- B7 The construction and/or maintenance of linear infrastructure that will result in significant disturbance in or on the **bed and banks** of a watercourse or within the areas specified in (B3)(b), or in any **general ecologically significant wetland** must not release from the site any contaminants to any waters that exceed the water quality limits specified in Schedule B, Table 2.

Schedule B, Table 2 – Release Limits to Waters

Water quality parameters	Units	Water quality limits
Turbidity	NTU	For a wetland of other environmental value, if background water turbidity is above 45 NTU, no greater than 25% above background water turbidity measured within a 50m radius of the construction or maintenance activity. For a watercourse, if background water turbidity is above 45 NTU, no greater than 25% above background water turbidity measured within 50m downstream of the construction or maintenance activity.

Water quality parameters	Units	Water quality limits
		For a wetland of other environmental value, if background water turbidity is equal to, or below 45 NTU, a turbidity limit of no greater than 55 NTU applies, measured within a 50m radius of the construction or maintenance activity. For a watercourse, if background water turbidity is equal to, or below 45 NTU, a turbidity limit of no greater than 55 NTU applies, measured within 50m downstream of the construction or maintenance activity.
Hydrocarbons	-	No visible sheen

- B8 Background water turbidity must be measured within 20 metres upstream of the construction and/or maintenance activities.
- B9 Monitoring is undertaken at a reasonable frequency to ensure compliance with condition (B7).
- B10 Written notification detailing the location (GPS coordinates) of any significant disturbance to be undertaken in or on the **bed and banks** of a watercourse, or within the areas specified in condition (B3)(b), must be provided to the administering authority at least 24 hours prior to the commencement of the significant disturbance.
- B11 Petroleum activities must occur outside a **wetland of high ecological significance**.
- B12 Petroleum activities, other than linear infrastructure must occur outside a **general ecologically significant wetland**.
- B13 Petroleum activities must not negatively impact a wetland of high ecological significance.
- B14 Linear infrastructure activities, other than linear infrastructure construction and/or maintenance activities, must not change the existing surface water hydrological regime of any general ecologically significant wetland.

B15 The construction and/or maintenance of linear infrastructure in any general ecologically significant wetland must not:

- a) prohibit the flow of surface water in or out of the wetland;
- b) impact surface water quality in the wetland unless specifically authorised by this environmental authority;
- c) drain the wetland;
- d) fill the wetland;
- e) impact bank stability; or
- f) result in the clearing of riparian vegetation outside of the required footprint.

Floodplains

B16 Where the petroleum activity(ies) is carried out on **floodplains** petroleum activity(ies) must be carried out in a way that does not:

- a) concentrate flood flows in a way that will or may cause or threaten an adverse environmental impact; or
- b) divert flood flows from natural drainage paths and alter flow distribution; or
- c) increase the local duration of floods; or
- d) increase the risk of detaining flood flows; or
- e) pose an **unacceptable risk** to the safety of persons from flooding; or
- f) pose an **unacceptable risk** of damage to property from flooding.

Well testing

B17 Subject to Conditions (B18) and (B19) the injection of CSG water or better quality groundwater is authorised in wells that are not exploration, appraisal or development wells, for the purposes of hydraulic testing, where such hydraulic tests are undertaken for no more than two (2) consecutive days.

B18 The maximum volume of CSG water or better quality groundwater injected for the purposes of hydraulic testing identified in Condition (B17) must not exceed 1 ML per hydraulic test.

B19 Written notification detailing the type and location (GPS coordinates) of any hydraulic testing undertaken in accordance with condition (B17) must be provided to the administering authority at least 10 business days prior to the commencement of the hydraulic test.

SCHEDULE BB – GROUNDWATER

BB1 The extraction of groundwater as part of the petroleum activities from underground aquifers must not directly or indirectly cause environmental harm to any watercourse, lake, wetland or spring.

Seepage monitoring program

BB2 A Seepage Monitoring Program must be developed to detect any seepage to groundwater as a result of storing contaminants in a regulated structure(s) (e.g. surface dams, monocells).

BB3 The Seepage Monitoring Program, must include, but not necessarily be limited to:

- a) procedures to detect any seepage to groundwater and surrounding soils from regulated structure(s) and its possible effect on groundwater and soils;
- b) identification of seepage monitoring bores and their locations including:
 - (i) baseline / hydraulically up-gradient seepage monitoring bores (i.e. bores where groundwater quality will not have been affected by petroleum activities;
 - (ii) seepage monitoring bores that are within aquifers potentially affected by the regulated structure(s) authorised under this environmental authority;
 - (iii) a geodetic survey of all seepage monitoring bores; a geodetic survey showing groundwater potentiometric surface
- c) the Seepage Monitoring Program has been designed consistent with relevant guidelines and standards such that the Program design has:
 - (i) a sufficient number seepage monitoring points and / or wells to obtain representative groundwater samples from the uppermost aquifer up-gradient and down-gradient of the potential influence;
 - (ii) if a salt monocell is authorised under this environmental authority, a sufficient number of seepage monitoring bores located not more than 150 m from the monocell or the boundary of the monocell facility, whichever is the closer;
 - (iii) sufficient regularity and spatial and temporal replication to make statistically valid conclusions about the presence or absence of contaminants;
 - (iv) procedures to determine the quality of groundwater down gradient of any potential sources of contaminants including groundwater passing the relevant seepage monitoring bore(s);
 - (v) procedures to allow an assessment of whether there has been any statistically significant adverse change in groundwater quality at locations hydraulically down gradient of the containment activity(ies).
- d) procedures to determine groundwater flow direction, groundwater flow rate and hydraulic conductivity beneath the relevant regulated structure(s);
- e) sampling of all baseline or hydraulically up-gradient monitoring bores for the minimum groundwater parameters listed below quarterly over the 12 month period immediately prior to the commencement of any new containment activities:
- f) identification of the trigger parameter(s) associated with the potential contaminants of concern identified in (e);
- g) a sampling program of all seepage monitoring bores:
 - (i) to measure and record standing groundwater levels in metres accurate to 0.01 metres to be plotted as function of time (hydrograph) to identify seasonal patterns;
 - (ii) quarterly monitoring of seepage monitoring bores for the respective trigger parameter(s) identified in (f) whilst activities are being carried out;
 - (iii) annual monitoring of seepage monitoring bores for the respective trigger parameter(s) identified in (f) for a minimum of three (3) years after the containment activity(ies) ceases;
- h) a Seepage Trigger Action Response Procedure which must include but not be limited to the following:
 - (i) trigger levels for the relevant trigger parameter(s) identified in (f);
 - (ii) trigger and action response measures at which investigations will be undertaken;
 - (iii) action levels for the relevant possible contaminants of concern at which the holder of this environmental authority will undertake additional investigation into the potential for

environmental harm, including the validation and verification of the source, cause and extent of contamination;

- i) identification monitoring equipment to be used; and
- j) a rationale containing details on the Program's purpose, conceptualisation and verification of the procedures, determinations, analysis and assumptions undertaken.

BB4 Seepage monitoring bores identified in (BB3) must be monitored quarterly for the trigger parameter(s) specified in *Schedule BB – Table 1 (Seepage Monitoring Trigger Parameters)*.

Schedule BB, Table 1 – Seepage Monitoring Trigger Parameters

Parameter	Units	Untreated Coal Seam Water	Permeate	Brine
Static Water Level	m	Monitor	Monitor	Monitor
pH	pH unit	Monitor	Monitor	Monitor
EC	µS/cm	Monitor	Monitor	Monitor
Major Anions (sulphate, chloride)	mg/L	Monitor	-	-
Major Cations (calcium, magnesium, sodium and potassium)	mg/L	Monitor	-	-

Monitoring bores

BB5 The following information concerning each newly constructed seepage monitoring bore must be submitted to the administering authority with each annual return:

- a) bore ID and location presented on a plan;
- b) design of the monitoring bores installed;
- c) specific construction information including but not limited to geographical coordinate (including the geophysical coordinate system utilised) depth of bore, depth and length of casing, depth and length of screening, presence of any measuring probe;
- d) identification of any aquifers intercepted by the monitoring bores;
- e) standing groundwater level and water quality parameters including physical parameter and results of laboratory analysis for the possible contaminants of concern; and
- f) a lithological log and preferably a stratigraphic interpretation to identify the important features.

SCHEDULE C – REGULATED STRUCTURES

Assessment of consequence category

- C1 The **consequence category** of any **structure** must be assessed by a suitably qualified and experienced person in accordance with the *Manual for Assessing consequence Categories and Hydraulic Performance of Structures* as amended from time to time.
- C2 The **consequence assessment** required under condition (C1) must occur in any of the following situations:

- a) prior to the design and construction of the structure;
- b) prior to any change in its purpose or its stored contents;
- c) for a structure assessed and certified as a high or significant consequence structure, at least biennially after its construction.

C3 A consequence assessment report and **certification** must be prepared by a **suitably qualified and experienced person** for any **structure** assessed

Note: The consequence assessment report may include a consequence assessment for more than one structure.

C4 Where an existing structure is for the first time assessed as significant or high, the structure must meet the conditions required for regulated structures under this environmental authority within 12 months of that assessment.

Construction of low consequence dam to contain wetting front

C5 Where a dam is assessed as low consequence, it must be:

- a) constructed, operated and maintained in accordance with **accepted engineering standards** currently appropriate for the purpose for which the dam is intended to be used; and
- b) designed with a floor and sides made of material that will contain the wetting front and any entrained contaminants within the bounds of the containment system during both its operational life and including any period of decommissioning and rehabilitation.

C6 In the event of early signs of loss of structural or hydraulic integrity of a low consequence dam:

- a) immediate action to prevent or minimise any actual or potential environmental harm must be taken;
- b) any findings and actions taken must be reported in writing to the administering authority within 20 business days of that event.

Monitoring of low consequence dams

C7 The condition of all low consequence dams must be monitored for early signs of loss of structural or hydraulic integrity, based on the advice of a suitably qualified and experienced person. The methods of monitoring and frequency of monitoring shall be as assessed by the person who conducts the consequence assessment based on the particular circumstances of each dam.

Design and construction of a regulated structure

- C8 **Construction** of any dam determined to be a **regulated structure** is prohibited until:
- a) a **consequence category** assessment report and certification has been submitted to the administering authority;
 - b) a **design plan** for the regulated structure has been prepared by a **suitably qualified and experienced person**; and
 - c) certification from a suitable qualified and experienced person for the design and design plan and the associated operating procedures in compliance with the relevant conditions of this environmental authority has been received.
- C9 The design plan must contain the information prescribed in the *Guideline – Structures which are dams or levees constructed as part of environmentally relevant activities*, as amended from time to time.
- C10 All regulated structures must be designed by, and constructed under the supervision of, a suitably qualified and experienced person in accordance with the requirements of the *Manual for Assessing consequence Categories and Hydraulic Performance of Structures*, as amended from time to time.
- C11 All regulated structures must be constructed in accordance with a design plan that has been certified by a suitably qualified and experienced person in accordance with the requirements of the *Manual for Assessing consequence Categories and Hydraulic Performance of Structures*, as amended from time to time.
- C12 Certification by a suitably qualified and experienced person who supervises the construction must be submitted to the administering authority on the completion of construction of the regulated structure, and state that:

- a) the 'as constructed' drawings and specifications meet the original intent of the design plan for that regulated structure; and
- b) construction of the regulated structure is in accordance with the design plan.

C13 All **regulated structures** must be designed and constructed to prevent:

- c) floodwaters from entering the regulated structures from a watercourse or drainage line to the annual exceedance probability specified for determining spillway capacity in the *Manual for Assessing consequence Categories and Hydraulic Performance of Structures*, as amended from time to time; and
- d) wall failure due to erosion by floodwaters arising from the watercourse or drainage line to the annual exceedance probability specified in the *Manual for Assessing consequence Categories and Hydraulic Performance of Structures*, as amended from time to time; and
- e) overtopping as a result of a flood event of the annual exceedance probability specified for determining spillway capacity in the *Manual for Assessing consequence Categories and Hydraulic Performance of Structures*, as amended from time to time.

Operation of a regulated structure

C14 Operation of a regulated structure is prohibited unless:

- a) one paper copy and one electronic copy of the design plan and certification, and a set of 'as constructed' drawings and specifications has been submitted to the administering authority, together with certification that the structure:
 - (i) has been constructed in accordance with the design plan;
 - (ii) is capable of delivering the performance stated in the design plan; and
 - (iii) is compliant with the relevant conditions of this environmental authority;
- b) the conditions of this environmental authority relating to the construction of the structure have been met; and
- c) for regulated dams, the details required under this environmental authority have been entered into a Register of Regulated Dams.

Regulated dam register

C15 A register of regulated dams must be established in accordance with the administering authority's Regulated Dam Register template, as amended from time to time.

C16 The information contained in the register of regulated dams must always be current and complete on any given day.

Mandatory reporting level

C17 The Mandatory Reporting Level must be marked on each regulated structure in such a way that it is clearly observable during routine inspections of each dam.

C18 On becoming aware that the mandatory reporting level has been reached, action must be taken to prevent or, if unable to prevent, to minimise any actual or potential environmental harm.

Design storage allowance

- C19 On 1 November of each year, storage must be available in each regulated structure to meet the design storage allowance for the dam in accordance with the *Manual for Assessing consequence Categories and Hydraulic Performance of Structures*, as amended from time to time.
- C20 On becoming aware that the regulated structure will not have the available storage to meet the design storage allowance on 1 November of any year, action must be taken to prevent or, if unable to prevent, to minimise any actual or potential environmental harm.

Monitoring

- C21 The condition of all containment structures must be monitored for early signs of loss of structural or hydraulic integrity, based on the advice of a **suitably qualified and experienced person**. The methods of monitoring and frequency of monitoring shall be as assessed by the person who conducts the consequence assessment based on the particular circumstances of each dam.
- C22 Each regulated structure must be monitored for the water quality characteristics and at the monitoring location and frequency specified in *Schedule C – Table 1 Regulated Structure Contaminant Monitoring* as follows:

Schedule C – Table 1 Regulated structure contaminant monitoring

Quality characteristic	Monitoring location	Frequency of monitoring
pH (pH unit)	At least three (3) different structure profile depths for each sampling event and be taken as far as practicable from the edge of the regulated structure	During the month of October every year
Electrical Conductivity (µS/m)		
Turbidity (NTU)		
Temperature		
Dissolved Oxygen (mg/L)		
Sodium adsorption ratio (SAR)		
Aluminium (µg/L)		
Arsenic (µg/L)		
Barium (µg/L)		
Boron (µg/L)		
Cadmium (µg/L)		
Chromium (CrVI) (µg/L)		
Copper (µg/L)		
Iron (µg/L)		
Fluoride (µg/L)		
Lead (µg/L)		
Manganese (µg/L)		
Mercury (µg/L)		
Nickel (µg/L)		
Selenium (µg/L)		
Silver (µg/L)		
Strontium (µg/L)		

Quality characteristic	Monitoring location	Frequency of monitoring
Tin (µg/L)		
Zinc (µg/L)		
Total phosphorus (mg/L)		
Total Nitrogen (mg/L)		
Total petroleum hydrocarbons (µg/L)		
BTEX (µg/L)		
Polycyclic aromatic hydrocarbons (µg/L)		

Annual inspection and report

C23 Each regulated structure must:

- a) be inspected annually by a suitably qualified and experienced person.
- b) be assessed for the condition and adequacy for dam safety and against the necessary structural, geotechnical and hydraulic performance against the criteria in each annual inspection.

C24 A suitably qualified and experienced person must:

- a) prepare an annual inspection report containing details of assessment and including recommended actions to ensure the integrity of the structure;
- b) certify the annual inspection report in accordance with the *Manual for Assessing Categories and Hydraulic Performance of Dams*, as amended from time to time.

C25 The recommendations contained within the annual inspection report must be considered and action(s) taken to ensure that the regulated structure will safely perform its intended function.

C26 Within 20 days of receipt of the annual inspection report, the administering authority must be notified in writing of the recommendations of the inspection report and the actions to be or that are being taken to ensure the integrity of each regulated structure.

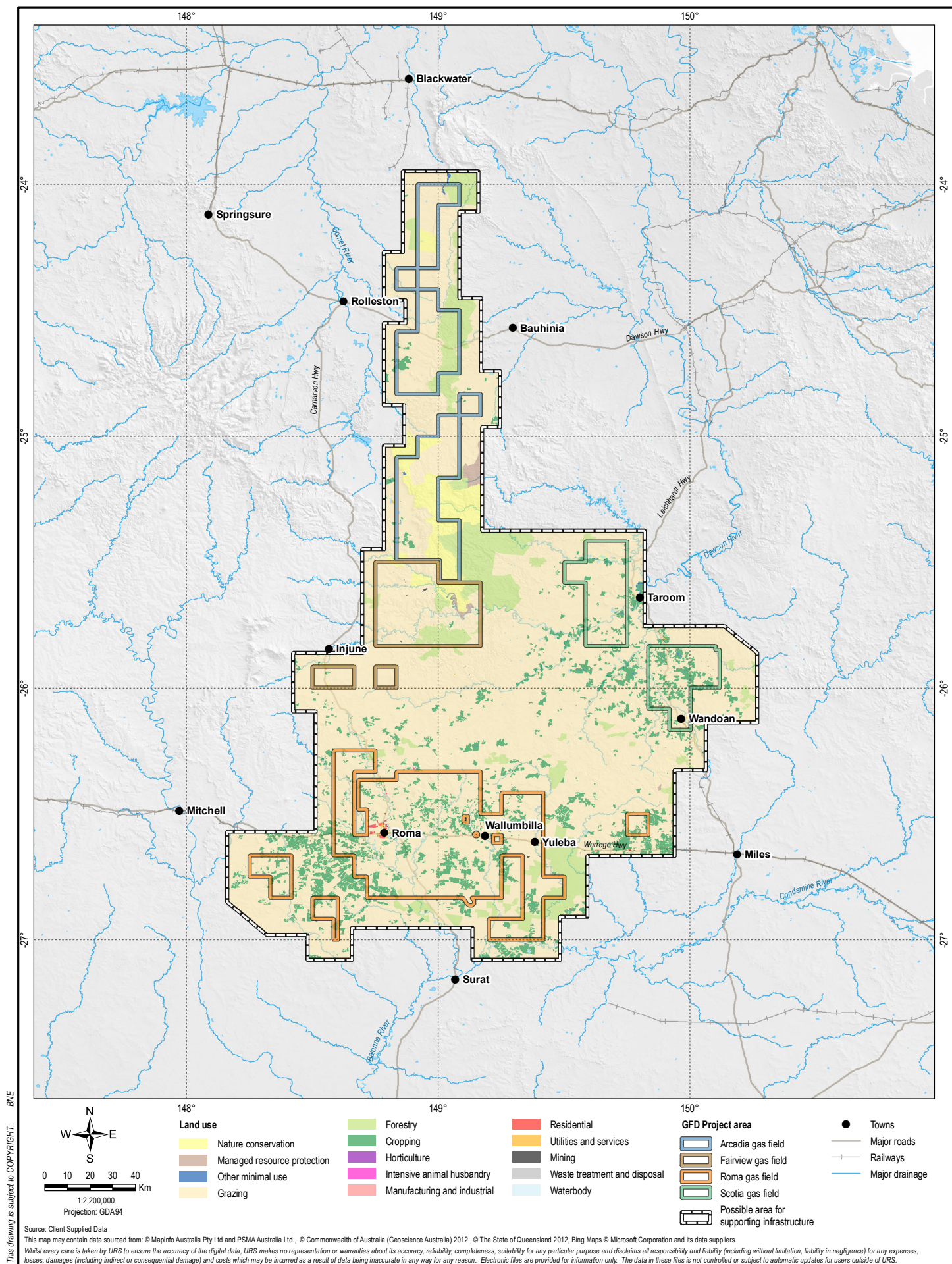
8 Land

8.1 Environmental values

8.1.1 Existing land use

The GFD Project area supports a variety of land uses including agriculture, resource extraction, urban and rural residences, and a variety of conservation, tourism and recreational activities. The primary land uses across the GFD Project area are shown on Figure 8-1. A number of urban areas are also included within the GFD Project area, from larger rural centres such as Roma and Injune to smaller localities including Taroom, Wandoan, Springsure, Wallumbilla and Yuleba. In keeping with the areas of agricultural production across the GFD Project area, rural residences are present outside of the urban areas.

The potential impacts arising from the GFD Project activities on land use and tenure are described, and mitigation measures are identified. Section 1.4 of this report includes additional information regarding land use and tenure throughout the GFD Project.



8.1.1.1 Agricultural

The predominant land use within the GFD Project area is agriculture, including livestock grazing, dryland and irrigated cropping, and horticultural activities. These activities are summarised in Table 8-1. In addition to each of the gas fields, the land uses associated with the possible area for supporting infrastructure (PAFSI) is also included in the table below.

Table 8-1 Agricultural land uses in GFD Project area (hectares)

Gas field	Cropping	Perennial horticulture	Irrigated perennial horticulture	Livestock grazing	Intensive animal production	Irrigated cropping*
Arcadia	4,868	-	-	174,266	-	-
Fairview	372	-	-	119,690	-	257
Roma	73,453	9	18	376,101	75	841
Scotia	25,947	-	-	132,449	35	-
Remainder**	167,530	-	4	1,665,763	192	1,558

Source: Santos GLNG, 2013. *Irrigated cropping represents Santos GLNG's irrigation practices
 **Additional land area within the possible area for supporting infrastructure outside of the gas fields
 Source: URS 2014d, Table 4-1

The Central Queensland and Darling Downs regional plans have introduced the concept of Priority Agricultural Areas (PAAs) to manage the competing State interests affecting the agricultural and resources sectors. PAAs identify a region's high value, intensive agricultural areas. The regional plans also identify Priority Agricultural Land Uses (PALUs), which are land uses classified by the Australian Land Use and Management Classification. The extent of these areas in the GFD Project area are summarised in Table 8-2.

Table 8-2 Protected agricultural areas in the GFD Project area

Gas field	Priority agricultural areas (PAA) (ha)	Priority agricultural land uses (PALU) (ha)
Arcadia	6,992	4,867
Fairview	0	629
Roma	0	74,316
Scotia	0	25,946
PAFSI	20,626	169,099

Source: URS 2014d, Table 4-2

8.1.1.2 Acid sulphate soils

The SPP sets out the State's interests concerning development involving acid sulfate soils which can occur in low-lying coastal areas. The SPP lists local authorities that may be acid sulfate soils-affected. The GFD Project area is not in a low lying coastal area and is outside of the local authority areas listed in the SPP. Hence, acid sulfate soils are not expected to occur.

8.1.1.3 Additional land uses

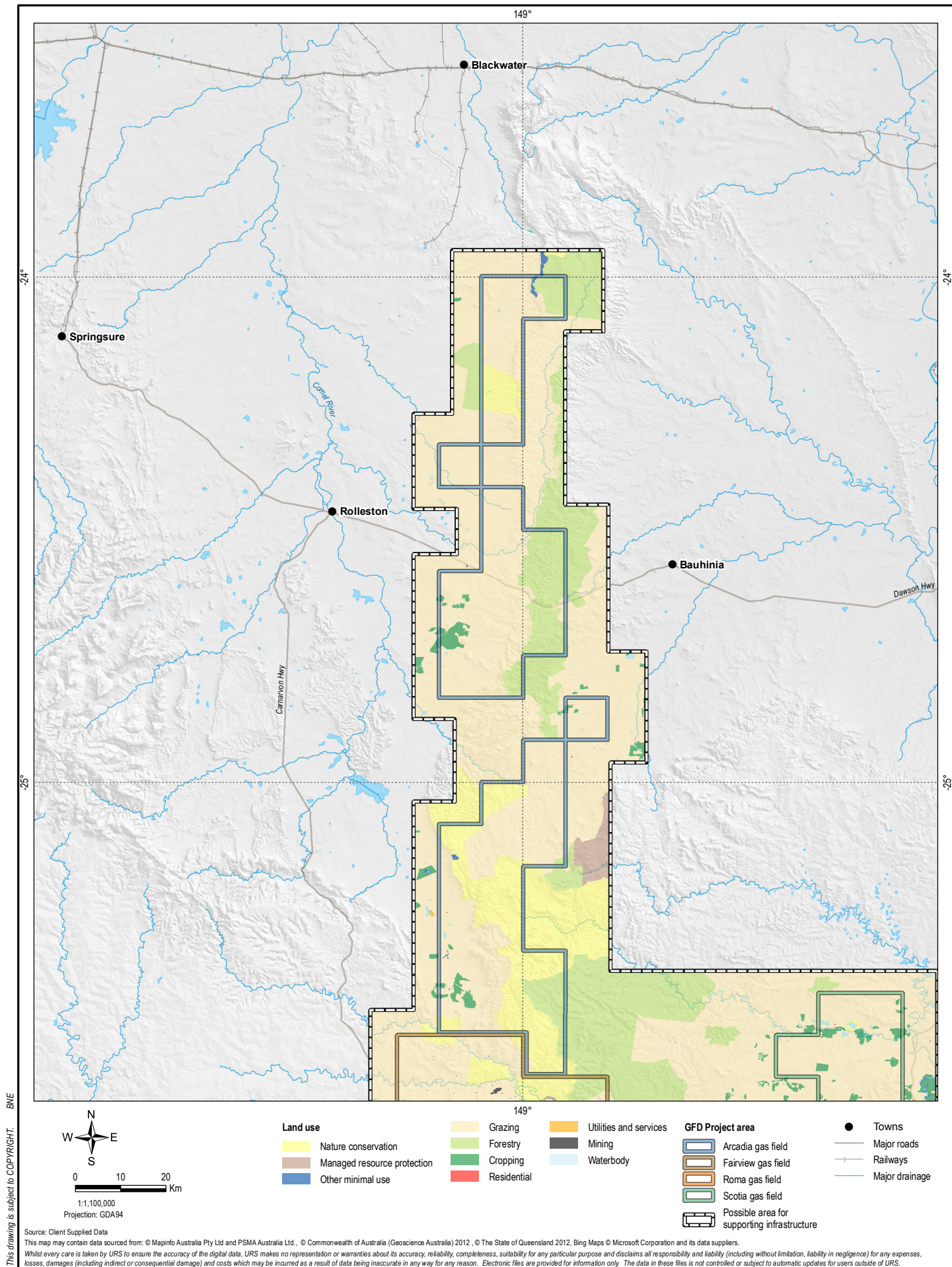
Forestry for millable timber and ancillary land uses to forestry such as quarrying, beekeeping and timber reserves are common throughout the GFD Project area. In addition, there are a number of timber processing facilities within the GFD Project area sourcing the region's native cypress and hardwood forestry products.

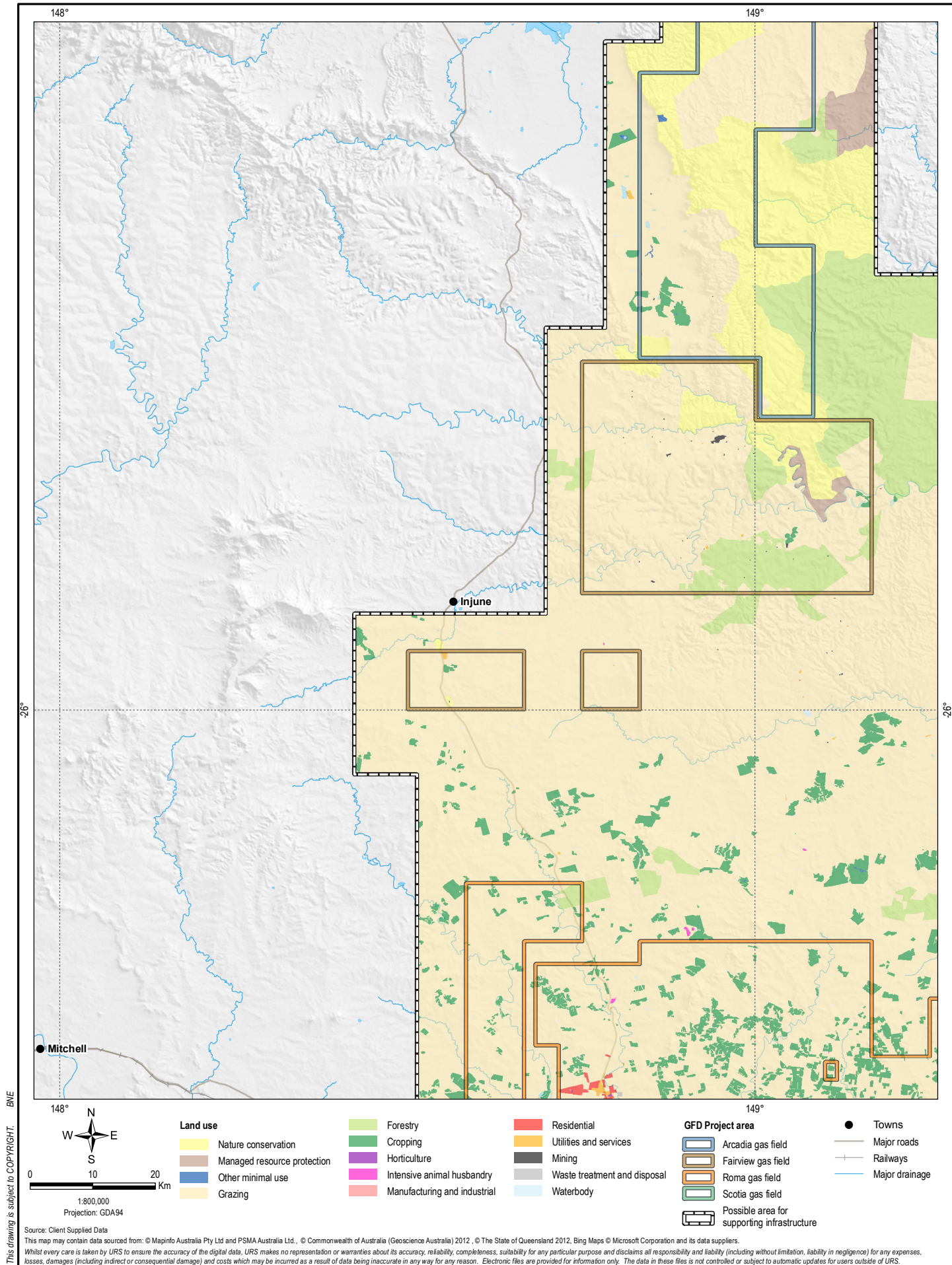
The dominant existing resource development activity in the GFD Project area is the approved development of production wells and associated infrastructure of the GLNG Project.

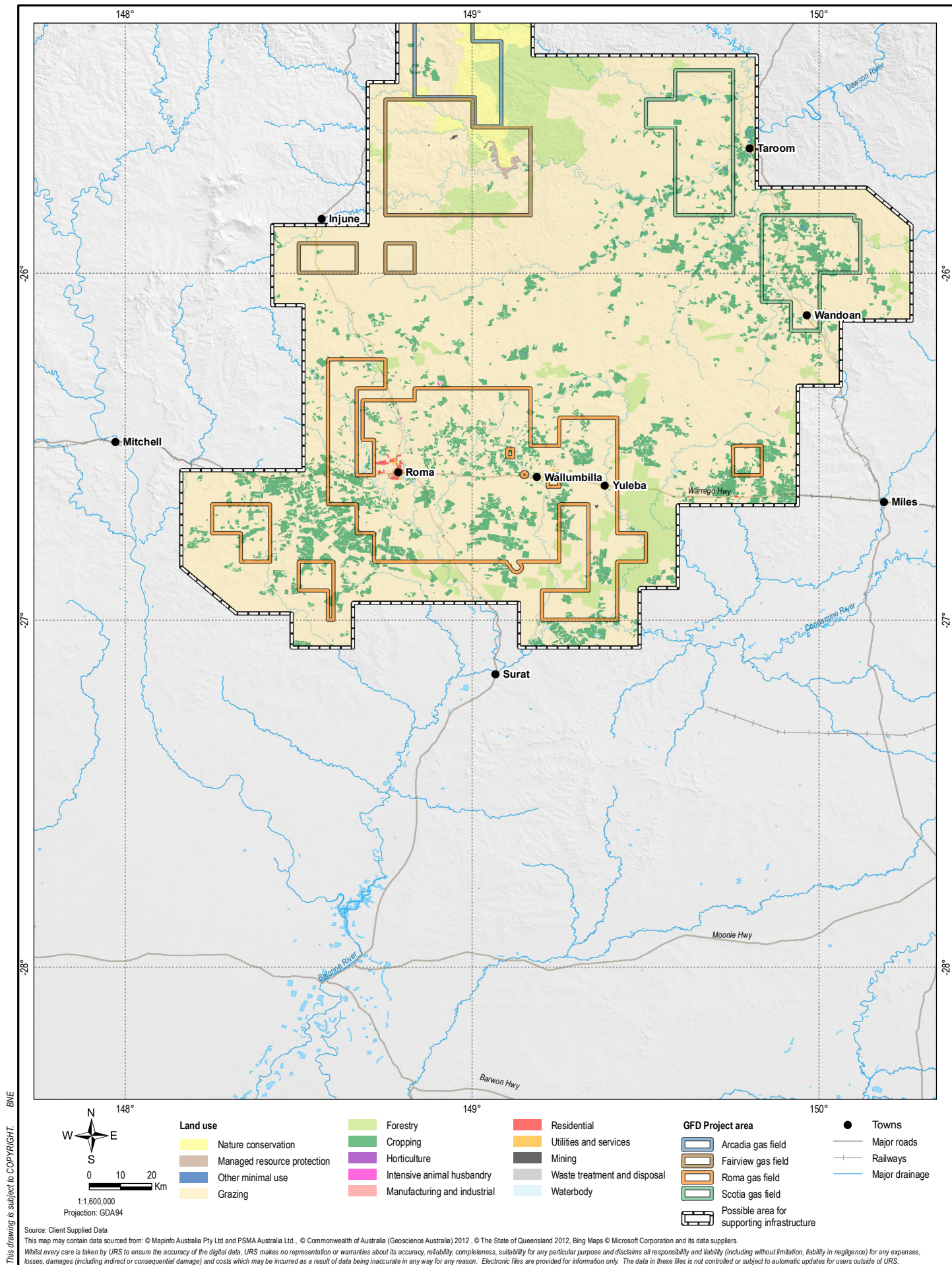
In addition, the GFD Project area includes the Yuleba Silica Sand Mine as well as numerous exploration tenures, which allow exploration activities including remote sensing, seismic surveys, drilling and sampling.

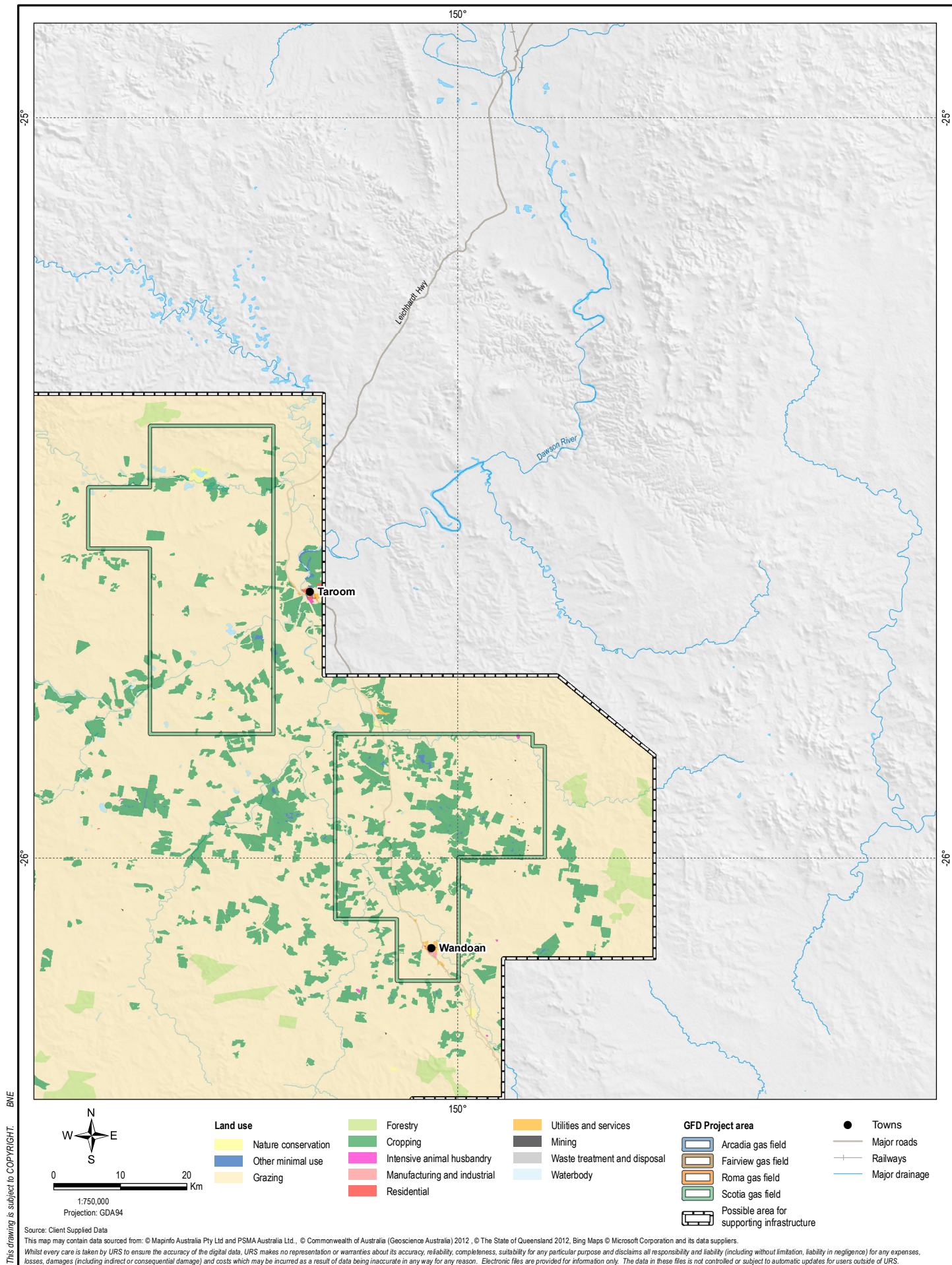
The GFD Project area contains a range of protected areas, which hold conservation, tourism and recreational values by virtue of their undeveloped and in most instances, natural status.

These land uses are shown on Figure 8-2 through Figure 8-5.









8.1.1.4 Strategic Cropping Areas

The RPI Act seeks to ensure the productive capacity of land considered highly suitable for cropping is protected from the impacts of development and where impacts are unavoidable, those impacts are managed. The RPI Act integrates the repealed *Strategic Cropping Land Act 2011* (Qld) policy framework for 'on-tenure' resource activities.

The RPI Act carries forward Strategic Cropping Land policies through:

- Declaring the SCA as an area of regional interest
- Applying the *SCA Assessment Criteria* to activities within the SCA that are not also located on a PALU within a PAA
- Providing for the chief executive to condition mitigation as part of a regional interest's development approval issued for an activity in the SCA.

The RPI Act protects land that is highly suited to cropping from development that could lead to its permanent alienation or diminished productivity. The RPI Act has various implications for resource projects depending on the status of tenure and environmental approvals at various prescribed dates as well as the location and the type of development proposed. Trigger maps, which are based on soil, climate and land information, were prepared by the Queensland Government to indicate areas where potential Strategic Cropping Land is likely to exist. The RPI Act will use these existing maps. While the trigger maps are a broadscale indicator of likely SCA, it is on-ground assessment against defined SCA criteria that determines the extent of SCA at a property level.

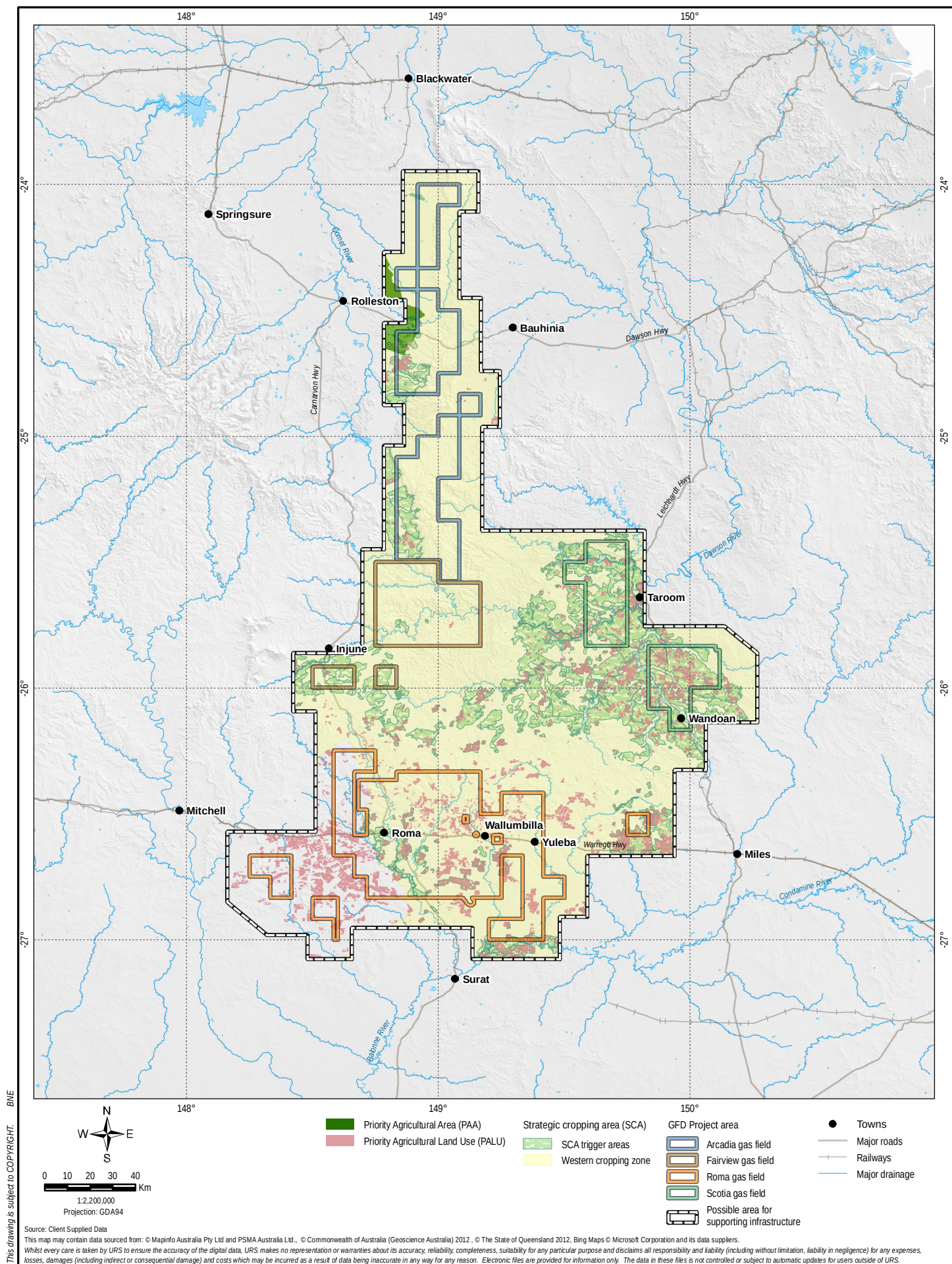
Table 8-3 summarises the extent of potential strategic cropping areas within the GFD Project area.

Table 8-3 Distribution of strategic cropping areas in the GFD Project area

Gas field	Total SCA trigger area (ha)
Arcadia	36,244
Fairview	12,576
Roma	34,451
Scotia	101,304
Remainder*	411,225
Total	595,799

*Additional land area within the possible area for supporting infrastructure boundary outside of the gas fields
Source: URS 2014d, Table 4-5

Figure 8-6 provides additional detail regarding the protected areas in the GFD Project.



8.1.2 Topography

The extent of the GFD Project area is approximately 375 km in a north-south direction and approximately 210 km from east to west. Overall, the topography has a north-south topographical high of the Expedition and Shotover Ranges and an east-west topographical high of the Great Dividing Range. Three major river systems are separated by these topographical highs: the Comet River in the north, draining to the northwest, the Dawson River in the east, draining to the northeast and the south draining Balonne River in the south.

The surface elevations within the GFD Project area vary between approximately 164 m to 770 m AHD. The general topography of the Santos GFD Project area is presented in Figure 8-7.

Notable topographic features within the GFD Project area include:

- Broad areas of low-relief undulating terrain and alluvial plains, interrupted by occasional low hills across the southern eastern part of the Roma and Scotia gas fields
- Near-level to strongly undulating plateau surface remnants cut by steep-sided ravines and terminating in sandstone escarpments, occurring in the central part of the Santos GLNG Project area including the Fairview and Arcadia gas fields
- Broad alluvial plains and foot slopes of the Arcadia-Comet valley feature extending northward from the northern margin of the Fairview gas field to the northern limit of the GFD Project area (URS 2014e).

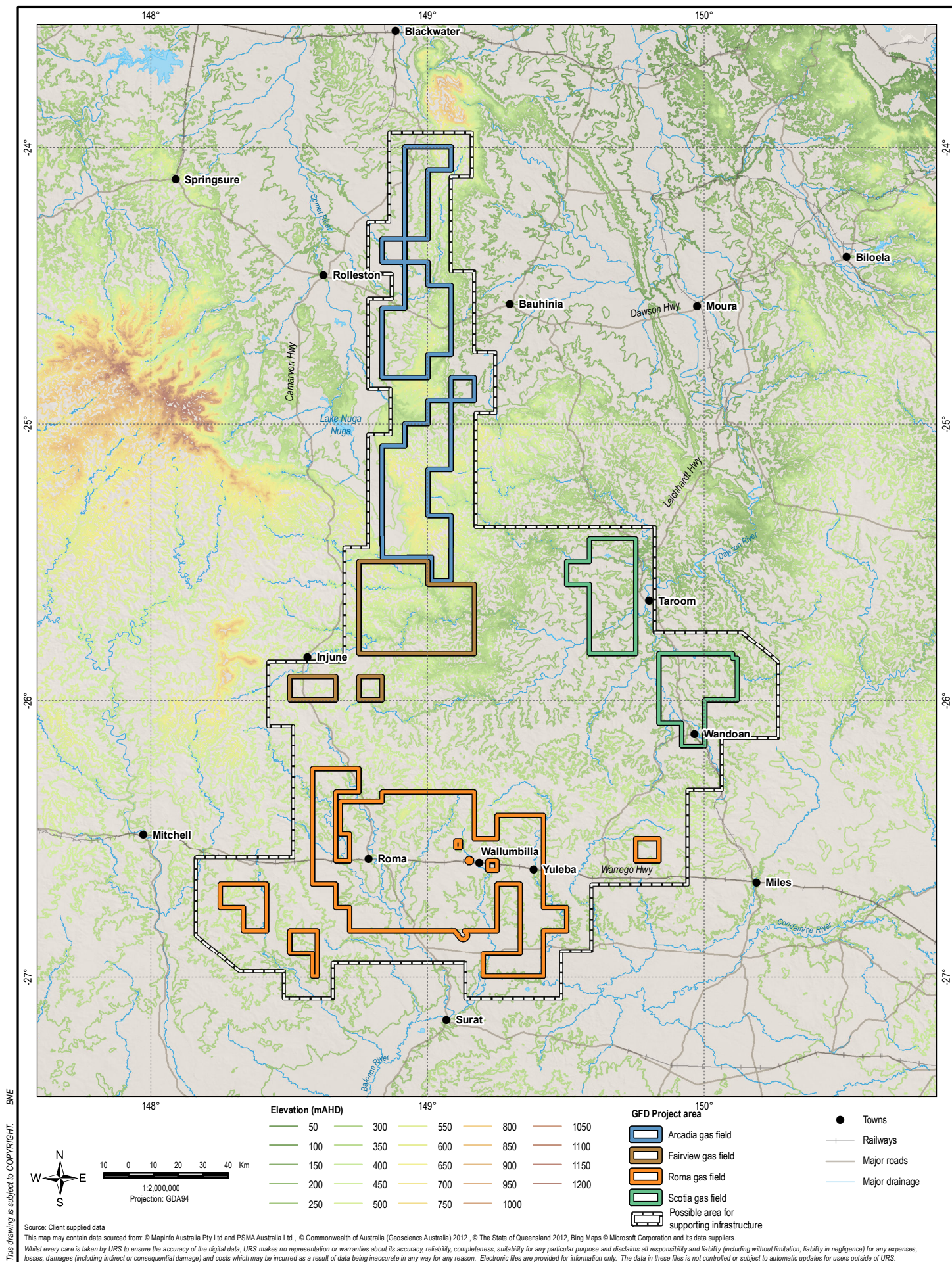
Surface slopes within the GFD Project area vary from near level (<1%) in parts of the alluvial plains to very steep, and in places vertical, sandstone escarpments and ravine slopes in the Expedition Range.

Across all four gas fields the slopes range from near level (<1%) to near vertical (>50%), and the elevation ranges for the four gas fields are presented in Table 8-4.

Table 8-4 GFD Project area elevation ranges

Gas field	Elevation Range (~m AHD)
Arcadia gas field	190 to 770
Fairview gas field	245 to 633
Roma gas field	241 to 635
Scotia gas field	186 to 375

Source: URS 2014e, Table 4-1



8.1.3 Geomorphology

On a regional scale, sediments generated from the weathering of sedimentary rocks within the high lying areas are transported by the streams that drain the GFD Project area. The sediment types are dominated by the source rocks, with erosive levels and sediment transport loads intermittent due to the climatic conditions and occur following extreme storm events and in excessive wet years when flooding occurs. In alternate years, the sediments are temporarily stored on the slopes, on the flood plains and within the stream channels. Abandoned river terraces of inferred Tertiary age along the northern edge of the Balonne River system, for example indicate that past climates allowed for the removal of large volumes of sediments, which are now stored as terrace materials which are occasionally reworked by streams.

Streams in general have well defined channels that are incised into the surrounding terrain to various degrees. This, combined with a relatively dry climate, has resulted in a low degree of lateral channel migration. Meander characteristics vary depending on localised geological and topographic conditions but the meanders are generally confined to the lowest floodplain level. Lateral channel migration is generally by either planar failure of sand dominated stream banks or erosion of flood return channels and relocation of the channels.

Most of the GFD Project area is considered “erosional”, except the alluvial plains where temporary sediment accumulation (deposition) occurs before re-mobilisation. Isolated mesas with steep slopes and escarpments occur where resistant sandstones or silicified rocks form remnant topographic highs. (URS 2014e).

8.1.4 Geology

This section describes the geology in the GFD Project, including:

- Regional geology
- Surficial geology
- Structural geology
- Seismic activity.

The key geological environmental values with the potentials to be impacted by the GFD Project include:

- Geology, being the physical attributes of the geological structure underlying and relating to the GFD Project and its intrinsic value
- Fossils.

8.1.4.1 Regional geology

The GFD Project area is located within the extensive Bowen and Surat basins, which are southdipping basins formed through the inflow and deposition of sediment in a depression within the Earth's crust, between the Permian (259 to 251 million years ago (ma)) to Cretaceous (141 ma to 65 ma) periods. These basins have structurally separate sedimentary depositional centres, but are stratigraphically and hydraulically connected (Habermehl, 2002). Most of the basins' sedimentary units dip at shallow angles (generally less than 10°) to the southwest.

The Early Permian to Mid-Triassic Bowen Basin geological units occur in the northern half of the GFD Project area, to about 100 km north of Taroom and about 50 km northeast of Injune. South of this area, sedimentary rocks of the Early Jurassic to Early Cretaceous Surat Basin sequence overlie the older Bowen Basin units. The geological setting of the GFD Project area is described in Table 8-5. The GFD Project area in relation to the two regional geological basins is shown on Figure 8-8.

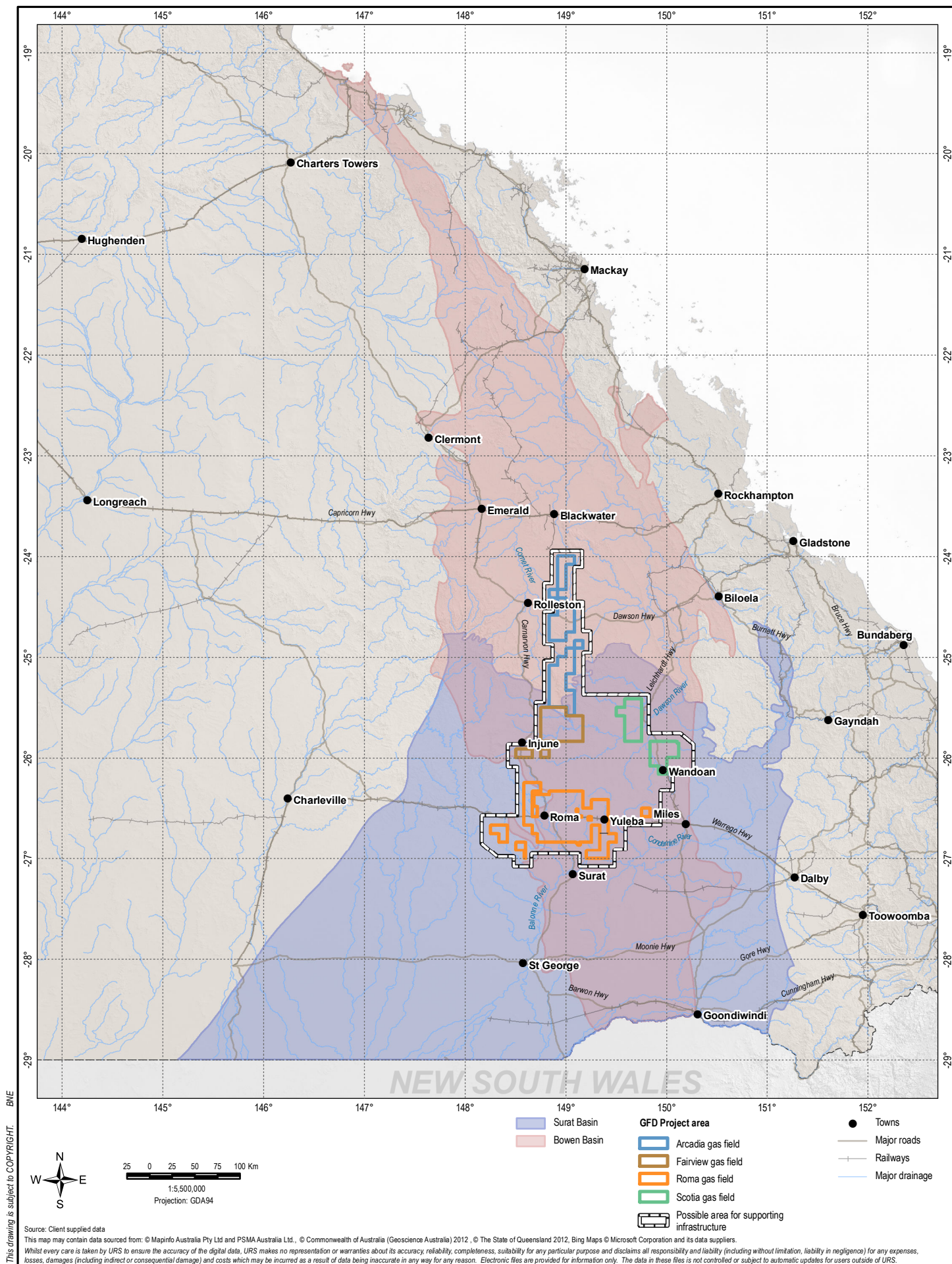


Table 8-5 Geological stratigraphy

Period	Basin	Group	Formation	Description
Quaternary			Alluvium / colluvium	Clay, silt, sand and gravel deposits; includes areas of colluvial and residual soil.
Tertiary sediments			Main Range Volcanics	Alkali-olivine basalt, minor tuff, sandstone, mudstone
			Sediments	Undifferentiated poorly consolidated sedimentary rocks; sub-labile to quartzose sandstone, siltstone, mudstone, minor conglomerate, coal, and limestone.
Unconformity ¹				
Cretaceous	Surat	Rolling Downs	Wallumbilla Formation-Coreena Member	Glauconitic siltstone, mudstone, very fine-grained sandstone, shelly fossils.
			Wallumbilla Formation-Doncaster Member	Mudstone, siltstone, minor quartz sandstone in part glauconitic, silty limestone, gypsum.
		Blythesdale	Bungil Formation	Glauconitic, labile to quartzose, siltstone, mudstone.
			Mooga Sandstone	Sandstone, siltstone, mudstone.
Jurassic			Orallo Formation	Sandstone, siltstone, mudstone, conglomerate, coal.
			Gubberamunda Sandstone	Sandstone, minor conglomerate, siltstone.
		Injune Creek	Westbourne Formation	Fluvial-lacustrine sediments; fine-grained sandstone interbedded with siltstone, claystone, minor coal.
			Springbok Sandstone	Clayey lithic sublabile to very lithic sandstone; calcareous in part; interbedded with carbonaceous mudstone and siltstone.
			Birkhead Formation/Walloon Coal Measures	Carbonaceous siltstone and mudstone, minor labile sandstone, coal. The Walloon Coal Measures transgressively grade into the siltstone and sandstone units of the Birkhead Formation.
			Eurombah Formation	Shale, siltstone, sandstone.
		Bundamba	Hutton Sandstone	Sublabile to quartzose sandstone, siltstone, mudstone, minor conglomerate and coal.
			Evergreen Formation	Labile and sublabile, sandstone, carbonaceous mudstone, siltstone and minor coal; local oolitic ironstone.
		Precipice Sandstone	Thick-bedded, cross-bedded, pebbly quartzose sandstone; minor lithic sublabile sandstone, siltstone, mudstone.	
Unconformity				
Triassic	Bowen	Mimosa	Moolayember Formation	Micaceous lithic sandstone, micaceous siltstone

Period	Basin	Group	Formation	Description
Permian			Clematis Sandstone	Quartz rich sandstone, conglomerate, siltstone, mudstone
			Rewan Formation	Lithic sandstone, green to reddish brown mudstone, minor volcanilithic pebble conglomerate.
		Blackwater	Bandanna Formation	Sandstone, siltstone, shale, mudstone, coal, tuff, conglomerate
			Black Alley Shale	Shale, siltstone, tuff bentonite, labile sandstone
		Back Creek	Peawaddy Formation	Carbonaceous mudstone and siltstone, lithic sublabile sandstone, coquintic siltstone.

Note:

1. Unconformity refers to a gap in the geological record.

Source: URS 2014e

8.1.4.2 Structural geology

Near the northern margin of the Surat Basin, the main geological units do not indicate deformation or complex faulted geology. Faulting and folding, recognised in the older subsurface strata, is either absent or attenuated in the outcropping Jurassic-Cretaceous sediments. Some features are visible in the outcrop including the Alicker and Eurombah Anticlines, the Hutton-Wallumbilla Fault and a number of west-northwest trending faults.

The northwest trending Hutton-Wallumbilla Fault is located west of Roma and is downthrown to the west with a displacement of ~450 m in the basement, but just 30 m in the overlying sediments. Small northwest trending faults elsewhere in the GFD Project area are likely related to the movements that formed the Hutton-Wallumbilla Fault.

West-northwest trending faults also occur in the Roma area. These faults are likely a result of gradual uplift or subsidence related to the Surat Basin through the Tertiary period (Santos GLNG, 2009). These faults have limited or no vertical displacement.

The central part of the GFD Project area near Injune is situated between two large reverse fault systems that are oriented approximately north-south. Immediately to the east of Injune is an anticline, which plunges to the south-southeast and corresponds to a southerly extension of the Comet Ridge in the geological basement.

The major structural feature in the north of the GFD Project area is the Comet Ridge, which comprises mainly Devonian (410 ma to 354 ma) age rocks and is covered by a relatively thin sequence of Permian and Triassic rocks. The Permian and Triassic sequence of sediments was folded during the late Triassic Period. Resultant fold axes are generally parallel trending northwest to the Comet Ridge axis. The Permian-Triassic folds are truncated by the erosional unconformity surface on which the Precipice Sandstone was deposited. The overlying Jurassic and Cretaceous (65.5 ma to the present) rocks are not folded (URS 2014e).

8.1.4.3 Seismic activity

The continent of Australia does not demonstrate significant seismic activity, particularly compared to the western US, Japan and New Zealand. Australia is on the Indo-Australian plate, relatively far from the plate boundaries, reducing the amount of seismic activity affecting the continent. Earthquakes in Australia are generally caused from the release of built-up stress in the interior of the Indo-Australian plate, which is being pushing north and is colliding with the Eurasian, Philippine and Pacific plates (EHS Support, 2014).

According to Geoscience Australia (2012), the highest seismicity hazard region in Queensland is along the eastern coast and near offshore regions, and along the Queensland/New South Wales border. The largest earthquakes recorded in Queensland occurred offshore of Gladstone in 1918 (Richter Magnitude 6.3) and near Gayndah in 1935 (Richter Magnitude 6.1). Structural damage to buildings was reported in the Rockhampton region during the Gladstone earthquake.

The GFD Project area is at a considerable distance from the most seismically-active areas of Queensland, and no earthquakes greater than Richter Magnitude 3 have occurred in the region of the GFD Project area in the last 50 years.

8.1.5 Soils

Eight major soil groups were identified within the GFD Project area. The major soil groups cover a wide range of soil types and include uniform coarse textured (sandy) soils, uniform and gradational medium-textured (loamy) soils (in particular uniform loams), gravelly loams, red and yellow earths, and lateritic red earths. Also included are sandy and loamy surface texture contrast (duplex) soils, uniform or gradational fine textured grey and brown non-cracking clays, and black, dark grey and brown cracking clay soils. The soil groups are characterised by increasingly finer texture and higher plasticity in the subsoil layers with increasing soil group number (URS 2014e).

Typical soil profile characteristics of the major soil groups have been mapped as 13 soil mapping units (SMUs), which have been determined from various sources including:

- The regional land system and soil mapping conducted by CSIRO (1967, 1968 and 1974)
- The Australian Soil Resource Information System (Department of Agriculture, Fisheries and Forestry, 2012)
- The *Digital Atlas of Australian Soils* (Digital Atlas, Bureau of Rural Science, 1991)
- The Santos GLNG Project EIS (2009).

The major soil groups identified cover a wide range of soil types and include uniform coarse textured (sandy) soils, uniform and gradational medium-textured (loamy) soils (in particular uniform loams), gravelly loams, red and yellow earths and lateritic red earths. Also included are sandy and loamy surface texture contrast (duplex) soils, uniform or gradational fine textured grey and brown non-cracking clays and black, dark grey and brown cracking clay soils. The soil groups are characterised by increasingly finer texture and higher plasticity in the subsoil layers with increasing soil group number (Table 8-6).

Table 8-6 Description of major soil groups

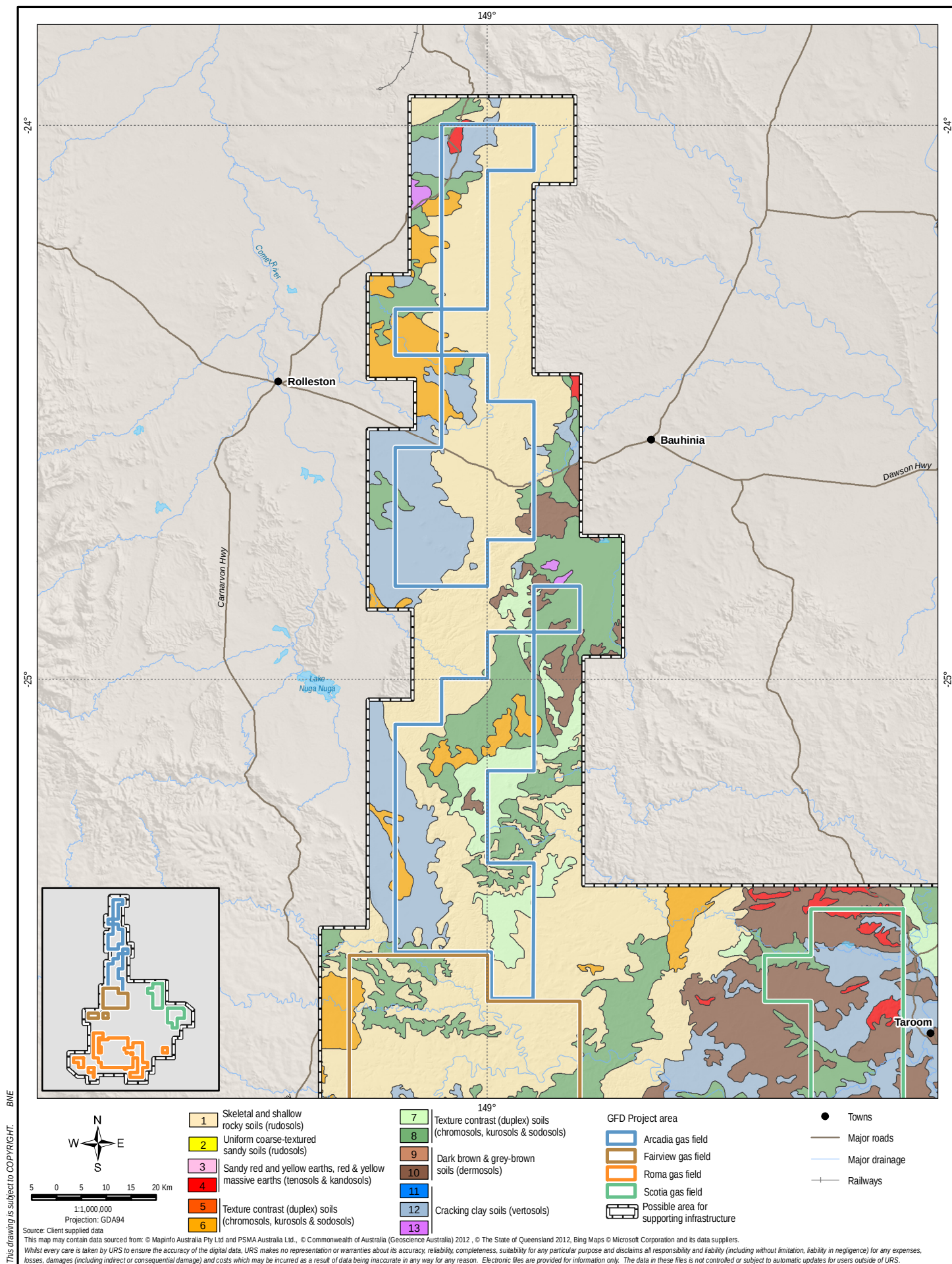
Soil group	Soil description	Soil classification		
		Aust. Soil Group ⁽¹⁾	P.P.F. ⁽²⁾	ASC ⁽³⁾
1	Skeletal, rocky or gravelly soils (>60% coarse fragments) with sandy, silty, loamy or clayey soil matrix	Shallow rocky soils; Lithosols	K- Uc1, Um1, Gn1, Uf1	Rudosols
2	Sandy soils; shallow to deep uniform or weakly gradational profiles; includes stratified alluvial soils, residual sand soils, earthy sands	Siliceous sands Earthy sands Lithosols	(Ucl-Uc6)(2)	Rudosols, Tenosols
3	Coarse to medium-textured soils; uniform or gradational profiles; predominantly sandy earths with sand, silty or clayey sand over clayey sand-sandy clay soil profiles	Sandy Earths Sandy Red-Yellow Earths	(Uc4-5, Uml-3); Gn2.11, Gn2.12	Tenosols
4	Medium-textured sandy, sandy loam or silt to clay loamy surface uniform or gradational profiles with clay loam, light clay or medium clay subsoils, in places with siliceous stone and/or ferruginous gravelly lenses included	Shallow Loams, Gravelly Loams, Red and Yellow Massive Earths, Lateritic Red-Yellow Earths	Um2.12 K Um2.12 Um4.11 Gn2.12 Gn2.22	Tenosols, Kandosols or Ferrosols
5	Sand, loamy sand, sandy loam or loamy surface duplex soils over acidic to locally strongly acidic, in places neutral or slightly alkaline sandy clay to medium to heavy clay subsoils	Red, Yellow & Brown Podzolic Soils ; Grey & Brown Soloths	Dr2.12, 2.22 Dy3.42, 3.22 Dy3.12, 3.32 Db1.41	Red-Brown Chromosols; Sodic Yellow & Brown Kurosols
6	Fine sandy, silty or clay loamy surface duplex soils with neutral to alkaline often calcareous, sodic and locally saline medium to heavy clay or heavy clay subsoils	Yellow, Brown, Red-brown Solodic Soils; Solodized Solonetz	Db1.33, 1.13 Dr2.13, Dy2.23, Dd1.13	Brown Sodosols, Chromosols, or Calcarosols
7	Shallow uniform often gravelly fine textured soils, medium to deep uniform fine-textured (non-cracking) clay soils or gradational often stony or gravelly clay loam or light clay surface soils over alkaline medium to heavy clay subsoils, locally sodic and saline in the deeper subsoils – some deep incipient cracking clays	Alluvial Soils Dark brown Grey-brown or Dark Reddish brown (Non-Cracking) Clay Soils, some Solonchaks	Uf6.31, 6.32 Uf6.61, 6.63 Uf6.32, 6.21 Gn3.22, 3.42 Gn3.93, 3.13 Gn3.12	Dermosols

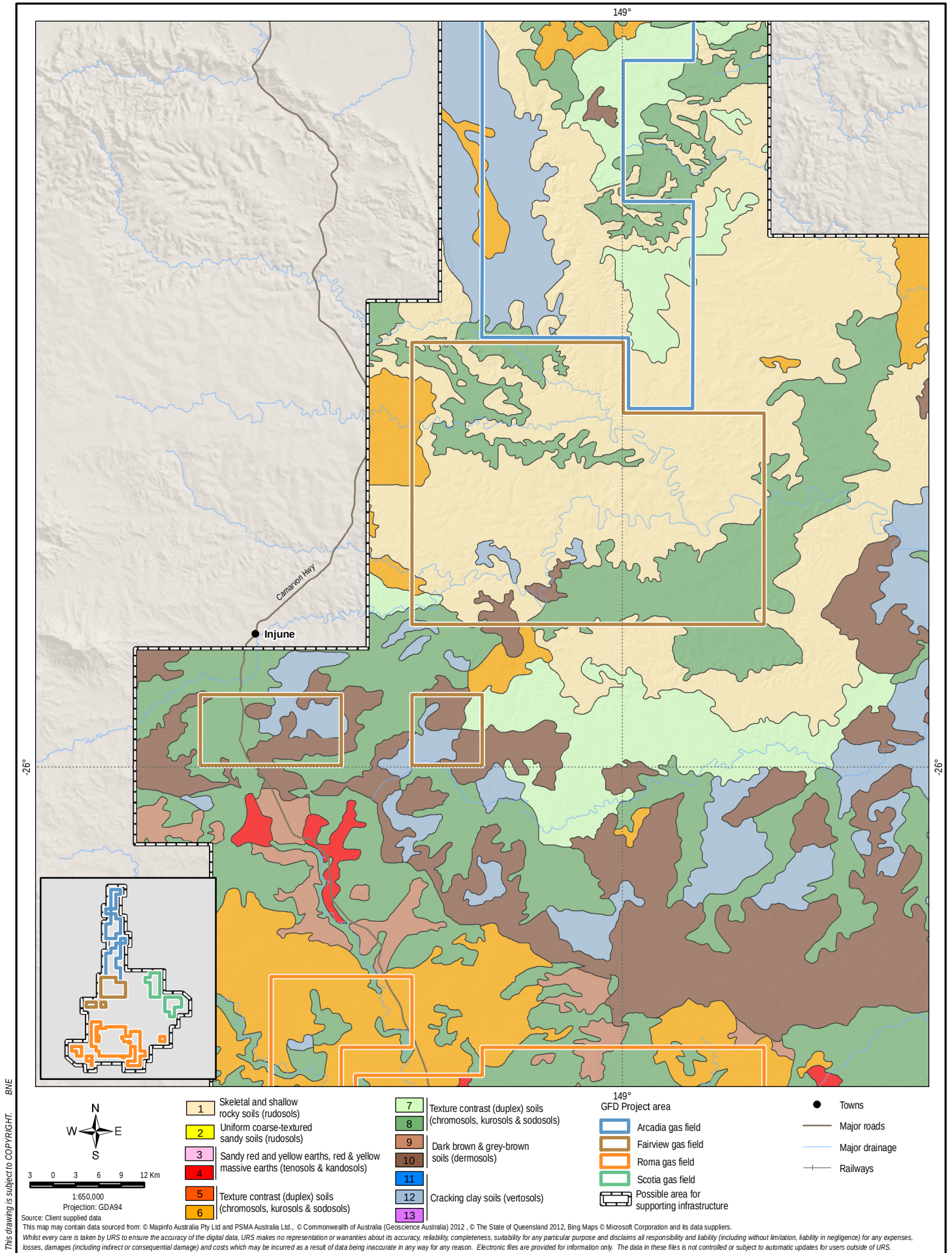
Soil group	Soil description	Soil classification		
		Aust. Soil Group ⁽¹⁾	P.P.F. ⁽²⁾	ASC ⁽³⁾
8	Shallow to medium to deep uniform fine-textured (cracking) clay soils, locally with thin self-mulching surficial soils with dark grey, brown or black mostly alkaline or alkaline over acidic heavy clay subsoils in areas with Gilgai micro-relief	Black Earths Grey, Brown and Black	Ug5.12, 5.21 Ug5.24, 5.25 Ug5.38, Ug5.15, 5.16	Vertosols

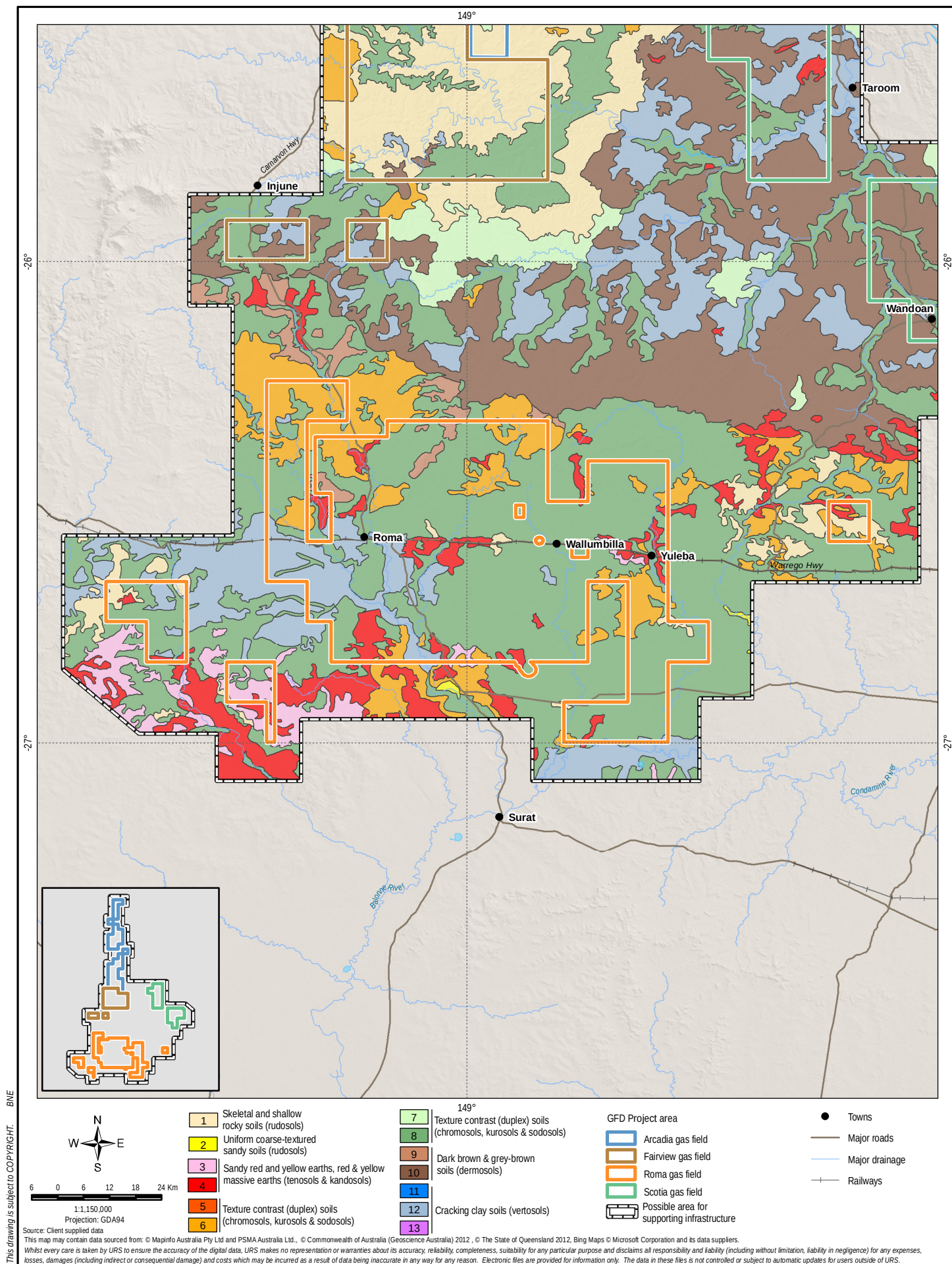
Notes: ⁽¹⁾ Soil Group (Stace et.al, 1968), ⁽²⁾ Principal Profile Form (Northcote, 1974), ⁽³⁾ Dominant Australian Soil Classification (Isbell, 2002).

Source: URS 2014e, Table 4-4

Each SMU consists of more than one soil type and provides an indication of which soil types are likely to occur. Consequentially, understanding the likely composition of a SMU guides appropriate soil management practices. A description of the SMUs is presented in Table 8-6, with the distribution of SMUs shown in Figure 8-9 to Figure 8-12. Area totals for the individual SMUs within each gas field and for the whole GFD Project area are summarised in Table 8-7.







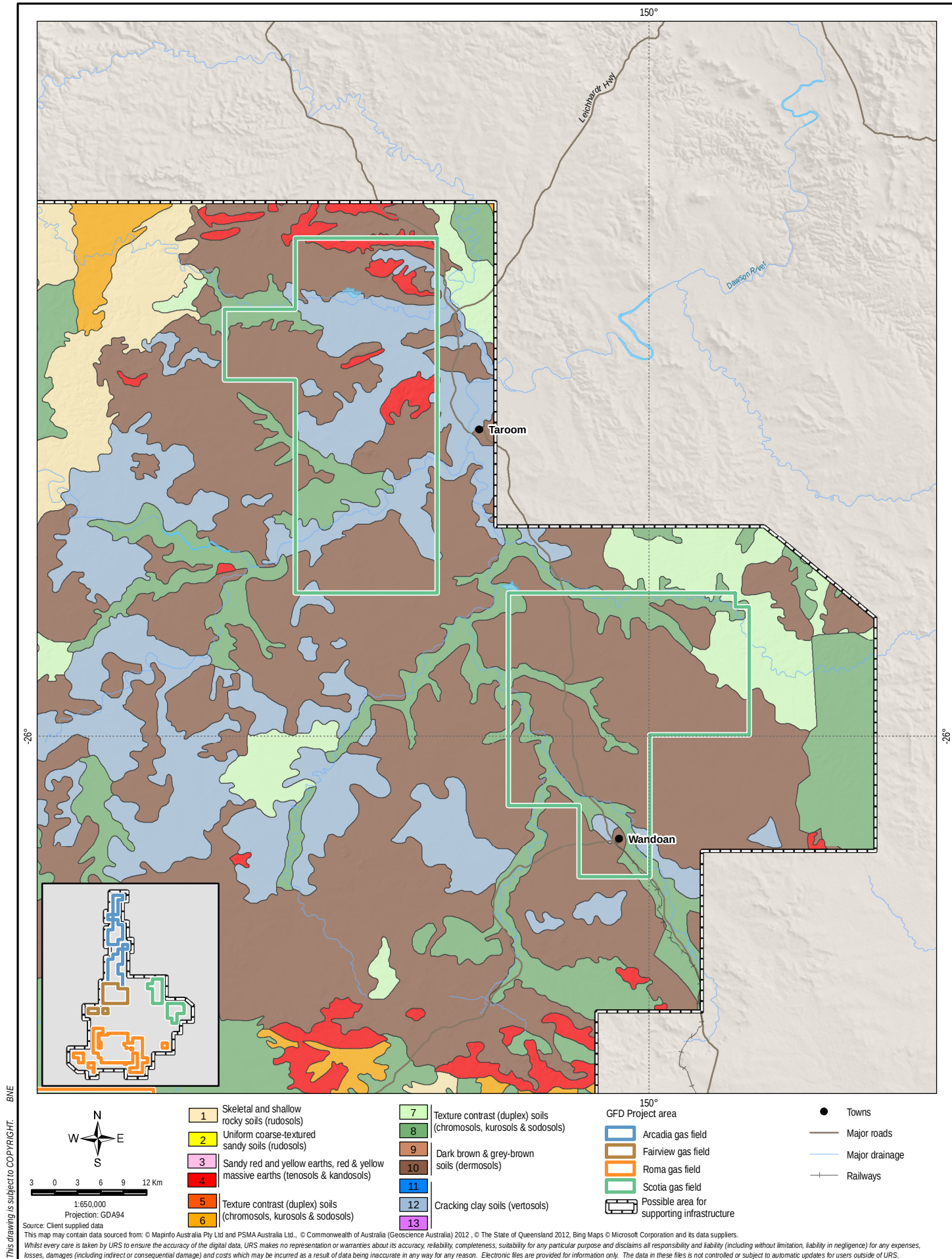


Table 8-7 GFD Project area soil mapping unit areas

SMU	Description	Gas field area (ha)		Remaining area (ha) ¹	Total (ha)
1	Rudosols – Skeletal and shallow rocky soils	Arcadia	125,074	6,898	233,744
		Fairview	92,944		
		Scotia	-		
		Roma	8,828		
2	Rudosols – Uniform coarse textured sandy soils	Arcadia	-	1,686	1,686
		Fairview	-		
		Scotia	-		
		Roma	-		
3	Tenosols and Kandosols – Sandy Red and Yellow Earths & Red and yellow massive earths – shallow to medium deep <0.6m	Arcadia	-	477	8,771
		Fairview	-		
		Scotia	-		
		Roma	8,294		
4	Tenosols and Kandosols – Sandy Red and Yellow Earths & Red and yellow massive earths –medium to deep 0.6- >1.0m	Arcadia	1,214	3,545	39,763
		Fairview	-		
		Scotia	5,773		
		Roma	29,231		
5	Chromosols, Kurosols & Sodosols – Duplex soils with neutral to moderately acidic, locally strongly acidic subsoils – shallow to medium deep <0.6m	Arcadia	-	-	-
		Fairview	-		
		Scotia	-		
		Roma	-		
6	Chromosols, Kurosols & Sodosols – Duplex soils with neutral to moderately acidic, locally strongly acidic subsoils – medium to deep 0.6- >1.0m	Arcadia	19,648	-	84,097
		Fairview	2,777		
		Scotia	-		
		Roma	61,672		
7	Chromosols, Kurosols & Sodosols – Duplex soils with neutral to moderately alkaline, locally strongly alkaline subsoils – shallow to medium deep <0.6m	Arcadia	20,924	-	27,540
		Fairview	1,476		
		Scotia	5,140		
		Roma	-		
8	Chromosols, Kurosols & Sodosols – Duplex soils with neutral to moderately alkaline, locally strongly alkaline subsoils –medium to deep 0.6- >1.0m	Arcadia	4,1693	4,105	424,637
		Fairview	46,502		
		Scotia	23,475		
		Roma	308,862		

SMU	Description	Gas field area (ha)		Remaining area (ha) ¹	Total (ha)
9	Dermosols – Dark Brown & Grey Brown Soils - shallow to medium deep <0.6m	Arcadia	-	-	6,185
		Fairview	-		
		Scotia	-		
		Roma	6,185		
10	Dermosols – Dark Brown & Grey Brown Soils - medium to deep 0.6- >1.0m	Arcadia	4,223	-	111,032
		Fairview	10,801		
		Scotia	96,008		
		Roma	-		
11	Vertosols – cracking clay soils - shallow to medium deep <0.6m	Arcadia	-	-	-
		Fairview	-		
		Scotia	-		
		Roma	-		
12	Vertosols – cracking clay soils - medium to deep 0.6- >1.0m	Arcadia	60,891	3,732	150,815
		Fairview	7,910		
		Scotia	29,992		
		Roma	48,290		
13	Vertosols – cracking clay soils - medium to very deep 0.6- >1.5m	Arcadia	-	2,487	2,487
		Fairview	-		
		Scotia	-		
		Roma	-		

Notes:

1: Remaining area of each of the SMU within the GFD Project boundary excluding the areas within each of the gas field tenures.

- : Indicates that no area of a particular SMU is known to be present.

Source: URS 2014e, Table 4-5

8.1.5.1 Soils with specific management requirements

The 2009 EIS identified three types of 'problem soils' occurring within the GLNG Project area that also occur within the GFD Project area:

- Reactive soils – cracking clays
- Sodic and/or dispersive soils – soils with a exchangeable sodium percentage (ESP) greater than 6%
- Saline soils – soils with a high level of natural or induced salinity, in either the subsoil layers or surface soils.

Based on the setting (topography and elevation), acid sulfate soils are not anticipated to occur in the GFD Project area.

Reactive soils (high shrink – swell capacity) are the cracking clay soils (Vertosols), with a moderate to high cation exchange capacity (CEC), which become compacted if trafficked when wet. These soils can cause damage to infrastructure, foundations and buried services such as pipelines due to differential ground movement if appropriate management such as engineering practices are not used.

Sodic (ESP > 6%) cracking and non-cracking clays, together with the majority of the duplex soils within the GFD Project area are dispersive and highly susceptible to degradation if disturbed and managed incorrectly. These soils are susceptible to rill, gully or tunnel erosion if exposed and left unprotected from rainfall impact or excessive water infiltration. Disturbance on these soils should be avoided or minimised and managed and ground cover established as soon as possible following disturbance. Amelioration with gypsum and/or lime (Kurosols) is recommended to improve soil structure, infiltration and soil aeration to promote vegetation establishment.

Soils with saline subsoils (often sodic) occur throughout the GFD Project area. Saline soils can impact plant growth and have the potential to corrode buried steel or concrete products.

In addition, a number of the sandy duplex soils within the GFD Project area have surface textures that have the potential to be hard-setting. When disturbed, these soils are prone to slaking when wet, and setting hard and becoming massive when allowed to dry out. As a result, handling properties, infiltration and the establishment of vegetation become difficult. Following disturbance, it is important to minimise the area of disturbance and the establishment of vegetative cover as soon as possible following disturbance to protect the soils.

8.1.5.2 Topsoil resources

Suitable growth media available for rehabilitation is usually confined to the surficial (A) horizon and in some situations the upper portion of the B21 horizon, as these upper horizons contain seed reserves, micro-organisms, organic matter and soil nutrients necessary for successful plant growth. These parameters generally decrease with profile depth, while soil properties affecting soil handling and plant growth increase with depth; for example, soil sodicity, salinity and excessive structure.

Indicative stripping depths of the potential depth of suitable growth media have been determined for the SMUs and soil types identified in Table 8-8.

Soil structure, soil depth, texture and soil chemistry (salinity, ESP and pH) are the major factors limiting the suitability of some soils within the GFD Project area.

The indicative stripping depths should be used only as a guide and more detailed, location specific soil investigations might need to be conducted at an appropriate scale and sampling intensity to inform soil management requirements. This can include more detailed soil information on the specific soil properties and soil chemistry.

Table 8-8 Indicative topsoil resources and stripping depths

SMU	Soil type	Indicative stripping depth (m)	Remarks
1	1	0	Skeletal to shallow rocky soils (>60% coarse fragments); rock outcrop and surface boulders
1,2,6	2.1	0.1	Utilise seedstock and organics
2	2.2	0	Potential source of bedding sand
2,6	2.3	0.25	Humic surface soil, strongly acidic subsoils
1,3	3.1	0.2	Strongly acidic subsoils (>0.2 m)
	3.2	0.3	Texturally suitable (0.3-0.6) but low levels of soil nutrients
	3.3	0.3	Dense gravel may occur in the subsoil (A2) horizon (>0.3 m)
1,3,4,6,8,11	4.1	0.2	Excess gravel/stone below 0.2 m
4,6,8,13	4.2	0.3	Texturally suitable (0.3-0.6) but high gravel content may occur
	4.3	0.3	Texturally suitable (0.3-0.6), but low soil nutrients
5,7,12	5.1	0.2	Strongly acidic in deeper subsoils
2,4,6	5.2	0.3	Bleached (A2) horizon (>0.3 m), source of bedding sand (0-0.6 m)
4,5,6,12	5.3	0.2	Bleached (A2) horizon (>0.2 m),
5,7	6.1	0.15	Shallow soils, bleached (A2) horizon, strongly alkaline subsoils
4,5,7,8,12,13	6.2	0.15	Thin pale or bleached layer over hard clay subsoils
2	6.3	0.25	Thick sandy A horizon, bleached A2 horizon (>0.25 m)
9,10,11,12	7.1	0.2	Excess gravel/stone below 0.2 m
10	7.2	0.3	Texturally suitable (0.3-0.6 m), highly alkaline/calcareous below
8,9,10,12,13	7.3	0.2	Locally strongly acidic sodic and moderately highly saline in the subsoil below about 0.2 m
9,10,11	8.1	0.2	Medium to coarse blocky structure (>0.15-0.2 m); some rock cobbles and gravel included
7,8,9,10,11,12	8.2	0.25	Medium to coarse hard blocky structure below 0.2-0.3 m
13	8.3	0.2 to 0.3	Medium to coarse hard blocky structure and mod. saline below 0.2 m on gilgai mounds

Source: URS 2014e, Table 4-6

8.1.5.3 Existing and potential soil erosion

The GLNG Project EIS Terrain Soils and Land Capability Study (2009) reported substantial areas of land are subject to accelerated soil erosion, in particular areas of extensive surface sheet and rill erosion. Areas of gully erosion mainly exist on the approaches or adjacent to the more major stream lines. The areas mostly affected include a range of landform types associated with the Jurassic and Triassic sandstone geological regimes, the Silurian volcanics and Permian sedimentary and intrusive rock types and in parts, in the Tertiary sediments geological regimes.

All landforms tend to have sand or sandy medium-textured surface soils, which in many parts have been subjected to extensive grazing and grazing-related land-use activities, such as the clearing of woody vegetation. Additional clearing of vegetation and stripping of topsoil resources expose the land to potential erosion due to the combined effects of surface slope and form, soil physical and chemical properties, as well as surface run on/runoff potential and the effects of wind erosion over time.

8.2 Potential impacts

The potential impacts to the physical land and visual character are provided in Table 8-9. The potential impacts will be more heavily weighted during the construction period of the GFD Project when soil movement and transportation of equipment and personnel is at the highest levels. Land impacts during the operation of the GFD Project will not vary significantly to the current identified impacts of the existing facilities.

Table 8-9 Potential impacts to land use and tenure

Impact Area	Potential Impacts	Applicable management measures
Agriculture and primary production	Loss of productive land	• Environmental protocol for constraints planning and field development • Conduct and compensation agreement • Decommissioning and abandonment management plan • Rehabilitation management plan
	Diminished productivity	• Environmental protocol for constraints planning and field development • Conduct and compensation agreement • Decommissioning and abandonment management plan • Rehabilitation management plan
	Disturbance of soil structure	• Environmental protocol for constraints planning and field development • ESCMP
	Changes to surface water and irrigation flow patterns	• Environmental protocol for constraints planning and field development
	Disruption to landholder operations	• Environmental protocol for constraints planning and field development • Conduct and compensation agreement • Decommissioning and abandonment management plan • Rehabilitation management plan
	Weed and pest introduction	• Pest and weed management plan
Forestry resources	Restrictions of access to forestry resources	• Environmental protocol for constraints planning and field development • Decommissioning and abandonment management plan • Rehabilitation management plan
	Loss or premature harvesting of millable timber	
	Reduction of the amount of land available for growing timber	
	Interference with logging operations	
	Additional traffic on logging tracks	

Impact Area	Potential Impacts	Applicable management measures
Residential areas — urban	Shortage of accommodation facilities	• Environmental protocol for constraints planning and field development • Social impact management plan • Social impact action plans
	Shortage of available and appropriately zoned and serviced residential land	• Environmental protocol for constraints planning and field development • Social impact management plan • Social impact action plans
	Increased demand for retail, commercial and industrial uses	• Social impact management plan • Social impact action plans
Residential areas – rural	Noise and vibration	• Environmental protocol for constraints planning and field development
	Dust	
	Increased traffic on local roads	
	Lighting	
Mining, petroleum and extractive industries	Restrictions to the extraction of other resources	• Overlapping tenure holder agreements
	Restrictions to the exploration for other resources	
Conservation, tourism and recreational values	Disturbance to vegetation and/or habitats	• Environmental protocol for constraints planning and field development • Significant species management plan • Fauna management plan
	Reduced amenity affecting existing tourism and recreational values	
Impacts to transport infrastructure	Disturbance to or interference with the operations of transport infrastructure such as roads, rail, aerodromes and landing grounds, and stock routes	• Environmental protocol for constraints planning and field development • Road use management plans
Utilities and service	Disturbance to or interference with existing high voltage transmissions lines, gas pipelines, water pipelines or telecommunications facilities	• Environmental protocol for constraints planning and field development

Table 8-10 Potential impacts to land resources

Potential Impact	Activity by GFD Project phase			Applicable management measures
	Construction	Operations	Decommissioning	
Altered geological setting	Drilling and well stimulation	- Depressurising coal seams - Well work over	-	- Environmental protocol for constraints planning and field development - Hydraulic fracturing risk assessment
Change to landform	- Earthworks - Borrow pits and quarries - Construction of water course diversion or crossings for roads, pipelines, power lines, discharge points, etc.	- 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)	- Demolition activities and earthworks (e.g. recontouring landform) - Traffic movement (particularly near waterways and at water course crossings)	- Environmental protocol for constraints planning and field development - Decommissioning and abandonment management plan - Rehabilitation management plan
Aquifer depressurisation and subsidence	-	Extraction from groundwater	-	- UWIR implementation plan - Water resource management plan
Loss of soil resources	- Vegetation clearing - Earthworks - Dust suppression	- Maintenance of access tracks, power lines and gathering line, and inspection and monitoring of waterways - Discharge of treated water to stream channel - Traffic movement (particularly near waterways and at water course crossings)	- Demolition activities and earthworks (e.g. recontouring landform) - Incomplete rehabilitation of disturbed areas - Traffic movement (particularly near waterways and at water course crossings)	- Environmental protocol for constraints planning and field development - Erosion and sediment control management plan - Land release management plan - Decommissioning and abandonment management plan - Rehabilitation management plan

Potential Impact	Activity by GFD Project phase			Applicable management measures
	Construction	Operations	Decommissioning	
Degradation of soil resources	- Vegetation clearing - Construction activities (e.g. compaction of hard stand)	- Placement of infrastructure - Discharge to land	- Disposal of concentrated brine products e.g. salts if not properly contained - Incomplete rehabilitation of disturbed areas	- Environmental protocol for constraints planning and field development - Decommissioning and abandonment management plan - Rehabilitation management plan
Restricted access to productive (agricultural or forestry) land	Construction of surface infrastructure	Placement of surface infrastructure	-	- Environmental protocol for constraints planning and field development - Decommissioning and abandonment management plan - Rehabilitation management plan
Authorised release to soil	- Dust suppression - Vehicle wash down - Application of treated sewage effluent to land	- Dust suppression - Vehicle wash down - Application of treated sewage effluent to land - Application of CS water to land (irrigation)	- Dust suppression - Vehicle wash down	- Environmental protocol for constraints planning and field development - Water resource management plan - Land release management plan - Decommissioning and abandonment management plan - Erosion and sediment control management plan
Uncontrolled release to soil	- Vehicle wash down - Storage and use of chemicals - Storage and use of fuels - Water storage - Sewage treatment	- Waste management (e.g. containment, disposal, etc.) - Vehicle wash down - Storage and use of fuels - Water storage - Sewage treatment	- Disposal of concentrated brine products - Vehicle wash down - Storage and use of fuels	- Environmental protocol for constraints planning and field development - Chemical and fuel management plan - Contingency plan - Decommissioning and abandonment management plan

Potential Impact	Activity by GFD Project phase			Applicable management measures
	Construction	Operations	Decommissioning	
Sterilisation of coal reserves	Construction of surface infrastructure	Placement of surface infrastructure	-	- Environmental protocol for constraints planning and field development - Decommissioning and abandonment management plan
Damage to fossils	- Earthworks and construction activities - Drilling and well stimulation - Borrow pits and quarries	- Traffic movement - Access and maintenance of water course diversion or crossings - Well work over	- Demolition activities and earthworks - Traffic movement	Environmental protocol for constraints planning and field development

Source:
URS, 2014e, Table 5-5

8.3 Environmental protection objectives

In accordance with Santos GLNG's internal standards, the GFD Project will adopt the environmental performance objectives relevant to land management listed in Table 8-11.

Table 8-11 Environmental protection objectives

Environmental protection objectives

- Avoid or minimise adverse impacts to the quality and stability of soils
- Avoid or minimise the disturbance of existing contaminated land
- Rehabilitate authorised disturbances to a safe, stable and non-polluting landform suitable for its intended ongoing land use.

8.4 Environmental protection performance indicators

The indicators within Table 8-12 will be utilised to determine whether the environmental performance objectives have been met and whether the control strategies implemented have been effective.

Table 8-12 Environmental performance indicator

Environmental performance indicator

- The Erosion and sediment control plan is implemented
- Releases of contaminants (including sewage effluent) to land are undertaken in accordance with the EA conditions
- All fuels and chemicals are stored in accordance with the relevant Australian standard
- The release of coal seam water to land is in accordance with EA conditions or BUA
- Disturbance to land is undertaken in accordance with the Environmental protocol for constraints planning and field development and the relevant EA conditions
- Project disturbances are rehabilitated to form a safe, stable and non-polluting landform suitable for its intended ongoing land use.

8.5 Management controls

The following control measures will be implemented to manage the potential impacts on land.

Table 8-13 Management control measures

Management plan	Key provisions/ function	Management control measures
Chemical and fuel management plan	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.	• The CFMP will be implemented. • All chemical storage facilities associated with an ERA of chemical storage will be clearly and permanently marked for the life of the petroleum activities. • All chemical storages must: – be stored in, or serviced by, an effective containment system that is impervious to the materials stored therein; and – be stored and handled in accordance with the relevant Australian Standard where such Standard is available; and – be managed to prevent the release of substances to waters or land.
Contingency plan for emergency environmental incidents	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.	• The Contingency plan will be implemented. • In accordance with the Contingency Plan, Santos GLNG will prepare for and respond to emergency environmental incidents in a manner that minimises the extent and duration of environmental harm caused by emergency incidents. • Santos GLNG will communicate with the appropriate parties in the event of emergency environmental incidents. • Santos GLNG will provide resources to be used in response to environmental emergency incidents. • The cause of emergency environmental incidents that have occurred will be investigated and, where necessary, remedial actions will be implemented to reduce the likelihood of recurrence of similar events. • Procedures will be implemented specific to responding to stimulation-related incidents, including non-routine events.

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GLNG Project

Management plan	Key provisions/ function	Management control measures
		- Procedures will be implemented related to the restoration of the loss of well mechanical integrity. - Santos GLNG will implement response procedures related to regulated structures. - Santos GLNG will develop /a receiving environment monitoring program to be implemented in the event of a release to waters or land to examine and assess potential environmental impacts.
GFD Project environmental protocol for constraints planning and field development	The Constraints protocol provides a framework to guide placement of infrastructure and adopts the management principles of avoid, minimise, mitigate, remediate and rehabilitate and offset. 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.	Santos GLNG will implement the Constraints protocol.
Land access and landholder engagement strategy	Santos GLNG has adopted an early engagement strategy where landholders that may be affected by GFD Project activities are able to discuss the potential location, timing and impacts of infrastructure on their property or business, and how Santos GLNG can help to minimise those impacts. This early engagement strategy has been developed in accordance with the Land Access Code (Department of Employment, Economic Development and Innovation, 2010). Santos GLNG will negotiate a Conduct and Compensation Agreement under the P&G Act with landholders on whose land the petroleum activities will be carried out. The locations of wells, gathering lines, and access tracks will be finalised in consultation with the landholder as part of the negotiations.	- Santos will implement the Land access and landholder engagement strategy - Conduct and compensation agreements will be negotiated with relevant landowners
Land release management plan	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	- The LRMP will be implemented. - Procedures will be followed to avoid damage to vegetation and to soil quality.

Management plan	Key provisions/ function	Management control measures
	• Use of treated sewage effluent for construction and operational purposes • Low point drain water releases to land • 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.	
Rehabilitation management plan	The Rehabilitation management plan provides the framework for rehabilitating land that has been disturbed as part of gas field activities. The plan will 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 plan includes: • Standardised remediation and rehabilitation procedures in line with current best practice • Principles to mitigate and manage direct and indirect impacts to matters of national environmental significance and environmentally sensitive areas • Remediation, rehabilitation and recovery management actions for a range of land uses and disturbance levels including benchmark guidelines and rehabilitation	• The Rehabilitation management plan will be implemented. • Significantly disturbed areas that are not required for the on-going petroleum activities will be transitionally rehabilitated within 12 months, typically, and maintained so that the areas are non-polluting and stable landforms. • Significantly disturbed areas will be re-profiled to contours consistent with the surrounding landform where the land has not been subject to significant cut and fill activities using appropriate best management practices. • Surface drainage lines will be re-established and the top-soil will be reinstated. • If needed, an alternative soil stabilisation methodology will be employed to achieve effective stabilisation.
Road use management plan	The Road-use management plan was developed to manage the impact associated with the implementation of the Santos GLNG Project. It will be adapted to manage the potential impacts resulting from the GFD Project.	The plan will: • Manage the efficiency of the road network impacted including State-controlled roads and local government roads • Ensure user safety and safe operation of vehicles • Minimise impacts on road infrastructure • Minimise traffic related complaints and incidents. • This plan will be revised for the GFD Project as appropriate and is not included in this EIS.

Management plan	Key provisions/ function	Management control measures
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. Specifically, the SSMP: - Identifies and profiles conservation significant species that are present, or may occur, within the gas fields - Identifies key threats to conservation significant species 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 conservation significant species caused by Santos GLNG activities.	Santos GLNG will implement the SSMP.
Social impact management plan (SIMP)	The SIMP established for the GLNG Project will be implemented across the GFD Project. The plan outlines the roles, responsibilities and rights of Santos GLNG, the government, impacted communities and other stakeholders in relation to the GFD Project. In particular, it outlines the framework for community engagement, management strategies to avoid, mitigate or minimise potential impacts and to maximise opportunities and benefits arising throughout the life of the GFD Project, as well as a monitoring and reporting process.	The GLNG Project SIMP will be supplemented by issue action plans relating to the GFD Project that focus on the following key areas as agreed with the Coordinated Project Delivery Division of the Coordinator-General's office: - Water and environment - Community safety - Social infrastructure - Community wellbeing and livability - Local industry participation and training - Aboriginal engagement and participation. The SIMP is an operational document that is updated to reflect the ongoing needs of Santos GLNG and the communities it operates in. It is available on the web at: http://www.santosglng.com/resource-library/community/social-impact-management-plan-community-handbook.aspx
Stimulation impact monitoring program	The plan was developed to provide a general description of the stimulation activities to be conducted by Santos GLNG, the regulatory requirements pertinent to stimulation monitoring, as well as the practices and procedures that comprise the monitoring program.	The Stimulation impact monitoring program will be implemented.

8.6 Monitoring

Table 8-14 summarises the environmental monitoring and assessment considerations for the protection of land environmental values within the GFD Project area. Details of the monitoring activities are described in the management plans. Additional monitoring considerations are also summarised in Table 8-14.

Table 8-14 Monitoring considerations for land

Existing management and monitoring plans

- ESCMP
- LRMP
- CFMP
- PWMP
- DAMP
- Rehabilitation management plan
- Contingency plan.

Additional monitoring considerations for water

General

- Monitoring will be undertaken by a suitably qualified person.
- Laboratory analyses and tests will be carried out by a laboratory that has NATA accreditation for such analyses and tests, unless NATA accredited tests are not available.
- Management or monitoring plans, systems, programs or procedures required to be developed and implemented by the EA will be reviewed for performance and amended as required but not less than once every three years in accordance with the requirements for the particular plans, systems, programs and procedures in accordance with the conditions of the EA.
- Management plans and monitoring programs specifically required by the EA will be certified by a suitably qualified person.
- An annual report will be prepared each year and submitted to the administering authority in the form requested by the administering authority. This report will include information as required by the EA such as:
 - any third party audit report
 - details of exceedances with the conditions of this EA and the dates and times these exceedances were reported to the administering authority
 - an outline of actions taken to minimise the risk of environmental harm from a circumstance, condition or elevated contaminant level identified by the monitoring or recording programs.

8.7 Proposed environmental authority conditions

The following draft EA conditions in relation to land are proposed for the GFD Project. The conditions stipulate the required plans and management and monitoring requirements to enable adequate protection of the GFD Project areas environmental values. The Draft EA conditions are reproduced in full in Appendix O.

SCHEDULE D — LAND

General

- D1 Contaminants must not be directly or indirectly released to land except as permitted under this environmental authority.
- D2 The release of contaminants to land must be carried out in a manner such that:
- a) vegetation is not damaged;
 - b) soil quality is not adversely impacted;
 - c) there is no surface ponding or runoff to waters;
 - d) there is no aerosols or odours;
 - e) deep drainage below the root zone of any vegetation is minimised;
 - f) the quality of shallow aquifers is not adversely affected.

Chemical storage

- D3 All chemical storages must:
- a) be stored in, or serviced by, an effective containment system that is impervious to the materials stored therein; and
 - b) be stored and handled in accordance with the relevant Australian Standard where such Standard is available; and
 - c) be managed to prevent the release of substances to waters or land.

Hydrostatic test water and low point drains

- D4 Contaminants that are hydrostatic test water from pipelines and contaminants from low point drains may be released to land in accordance with condition (D2).

Use of coal seam gas water

- D5 Coal seam gas water produced from the authorised petroleum activity(ies) which is used for:
- a) domestic or stock purposes must meet the *ANZECC and ARMCANZ Water Quality Guidelines 2000* for stock and domestic purposes, as amended from time to time;
 - b) irrigation purposes must meet the *ANZECC and ARMCANZ Water Quality Guidelines 2000* for irrigation purposes, as amended from time to time.
- D6 Coal seam gas water produced from the authorised petroleum activity(ies) may be used for:
- a) dust suppression on roads; and
 - b) for construction and operational purposes for the petroleum activity(ies) authorised by this environmental authority.
- D7 Coal seam gas water may be transferred to a third party to be used for the following purposes subject to compliance with conditions (D8) and (D9):
- a) dust suppression;
 - b) construction and operational purposes;
 - c) livestock watering purposes.

- D8 Any coal seam gas water supplied to a third party for livestock watering purposes in accordance with condition (D7)(c) must meet the *ANZECC and ARMCANZ Water Quality Guidelines 2000* for livestock watering purposes, as amended from time to time.
- D9 If the responsibility of coal seam gas water is given or transferred to a third party in accordance with condition (D7), the holder of environmental authority must ensure that:
- a) the responsibility of the coal seam gas water is given or transferred in accordance with a written agreement (the third party agreement); and
 - b) the third party is made aware of the General Environmental Duty under section 319 of the *Environmental Protection Act 1994*.

Sewage treatment works

- D10 Treated sewage effluent may only:
- a) be released to land by sub-surface or spray irrigation at designated, fenced contaminant release area(s);
 - b) be used for dust suppression, construction and operational purposes in accordance with conditions (D21) and (D23).

Conditions (D11) to (D14) apply to temporary and permanent sewage treatment plant operations

- D11 Treated sewage effluent may only be released to land by large droplet or by subsurface irrigation at designated, fenced and signed contaminant release areas.
- D12 A buffer distance of 50 meters must be applied from the location of the effluent irrigation area to any watercourse, wetland or protected area and 100m from any potable water supply (bore or a catchment) or stock drinking water supply.
- D13 When circumstances prevent the irrigation of treated sewage effluent to land, the contaminants must be directed to on-site storage or lawfully disposed of off-site.
- D14 The quantity of treated sewage effluent used in accordance with condition (D10) must be determined by an appropriate method, for example, a flow meter.

Conditions (D15) to (D16) apply to temporary and permanent sewage treatment plant operations with a design capacity of greater than 21 to 100 equivalent persons

- D15 Treated sewage effluent must comply, at the sampling and in-situ measurement point(s), with each of the release limits specified in *Schedule D, Table 1 – Treated Sewage Effluent Standards for Release to Land*.
- D16 Treated sewage effluent released to land must be monitored at the frequency and for each quality characteristic specified in *Schedule D, Table 1 – Treated Sewage Effluent Standards for Release to Land*.

Schedule D, Table 1 – Treated Sewage Effluent Standards for Release to Land

Quality Characteristic	Sampling and <i>in situ</i> measurement point location	Limit Type	Release Limit	Frequency
5-day Biochemical oxygen demand (BOD)	Release pipe from sewage treatment works	Maximum	20 mg/L	Quarterly
E. coli		80 th percentile based on at least 5 samples with not less than 30 minutes between samples	1000 cfu per 100 mL	
		Maximum	10000 cfu per 100 mL	
pH		Range	6.0-8.5	Monthly
Dissolved Oxygen		Minimum	2mg/L	
Electrical Conductivity		Monitor only	-	

Conditions (D17) through (D20) apply only to permanent sewage treatment plant operations with a design capacity of greater than 100 to 450 equivalent persons

- D17 Prior to construction of a sewage treatment facility, the minimum area of land and location to be utilised for irrigation of treated sewage effluent, excluding any necessary buffer zones, must be nominated.
- D18 All nominated locations and minimum areas of land in condition (D17) must be determined using the Model for Effluent Disposal using Land Irrigation (MEDLI) program or recognised equivalent.
- D19 A copy of results of the determinations required in condition (D18) must be submitted to the administering authority.
- D20 If, within 20 business days following the submission of the results required by condition (D19) the administering authority provides comments on the submission, the holder of this environmental authority must:
 - a) have due regard to that comment in the finalisation of the amended results; and
 - b) submit the finalised amended results within 40 business days after the administering authority provided comments; and
 - c) implement the amended results.

Conditions (D21) through (D23) apply only to treated sewage effluent use for the purposes of dust suppression, construction and operational purposes.

- D21 Treated sewage effluent produced from the authorised petroleum activity(ies) may only be used for dust suppression, construction and operational purposes provided that:
 - a) the treated sewage effluent has not been stored in a dam or tank prior to use and;
 - b) the treated sewage effluent quality meets the release limits specified in *Schedule D, Table 2 – Treated Sewage Effluent Standards for Dust Suppression, Construction and Operational Purposes* for each of the water quality characteristics; and
 - c) on local government controlled roads, written approval from the relevant Local Government has been given to the holder of this environmental authority.

- D22 Treated sewage effluent must comply, at the sampling and in-situ measurement point(s), with each of the release limits specified in *Schedule D, Table 2 – Treated Sewage Effluent Standards for Dust Suppression, Construction and Operational Purposes* for each quality characteristic.
- D23 Treated sewage effluent released to land must be monitored at the frequency and for each quality characteristics specified in *Schedule D, Table 2 – Treated Sewage Effluent Standards for Dust Suppression, Construction and Operational Purposes*.

Schedule D, Table 2 – Treated Sewage Effluent Standards for Dust Suppression, Construction and Operational Purposes

Quality Characteristic	Sampling and in-situ measurement point location	Limit type	Release Limit	Frequency
pH	e.g. treated sewage effluent storage	Range	6.0 to 8.5	Weekly ¹
5 – day Biochemical Oxygen Demand (BOD)		Median	20 mg/L	
E.Coli		Median	<10 cfu per 100 mL	
Electrical Conductivity		Maximum	1600 uS/cm	
Turbidity		95%ile (max)	2 (5) NTU	
Total Suspended Solids		Median	5 mg/L	

1 Monitoring is to be conducted on a weekly basis until 12 months of monitoring demonstrates no exceedances of the release limits. Monthly monitoring can occur thereafter, excluding E.Coli.

SCHEDULE E – DISTURBANCE TO LAND

Soil and land management

- E1 Top soil must be managed in a manner that preserves its biological and chemical properties.
- E2 Land that has been significantly disturbed by the petroleum activities must be managed in accordance with the Erosion and sediment control management plan.

Fauna management

- E3 Measures must be employed to prevent fauna entrapment:
 - a) during the construction of pipelines in pipe sections and pipeline trenches; or
 - b) during the construction and operation of well infrastructure and dams.

Confirming environmentally sensitive areas, wetlands and springs

- E4 Prior to undertaking petroleum activities that result in significant disturbance to land in areas of native vegetation, confirmation of on-the-ground environmentally sensitive areas, wetlands and springs at that location must be undertaken by a suitably qualified person.
- E5 A suitably qualified person must develop and certify a methodology so that condition (E4) can be complied with and which is appropriate to confirm on-the-ground environmentally sensitive areas, wetlands and springs.
- E6 Where areas mapped as environmentally sensitive areas, wetlands and springs differ from those confirmed under conditions (E4) and (E5), petroleum activities may proceed in accordance with the conditions of the environmental authority based on the confirmed on-the-ground values.
- E7 All documentation survey information photographs, field data or any material associated with the field validation requirements in (E4) must be maintained for the life of the environmental authority to demonstrate to the administering authority that surveys were conducted in a manner consistent with requirements contained in (E5).

Planning for land disturbance

- E8 The location of the petroleum activity(ies) must be selected in accordance with the following site planning principles:
 - a) maximise the use of areas of pre-existing disturbance;
 - b) in order of preference, avoid, minimise or mitigate any impacts, including cumulative; impacts, on areas of native vegetation or other areas of ecological value;
 - c) minimise disturbance to land that may otherwise result in land degradation;
 - d) minimise isolation, fragmentation or dissection of tracts of native vegetation; and
 - e) minimise clearing of native mature trees.

Disturbance to land – environmentally sensitive areas

E9 Petroleum activities must be carried out in accordance with *Schedule E, Table 1 – Petroleum Activities in Environmentally Sensitive Areas*, *Schedule E, Table 2 – Authorised Disturbance* and any other relevant conditions of this environmental authority.

Schedule E, Table 1 – Petroleum Activities in Environmentally Sensitive Areas

ESA category	Within the ESA	Primary protection zone of the ESA	Secondary protection zone of the ESA
Category A ESAs	No petroleum activities permitted	Only low impact petroleum activities permitted.	Only limited petroleum activities permitted
Category B ESAs excluding 'Endangered' Regional Ecosystems	Only low impact petroleum activities permitted	Only limited petroleum activities permitted Subject to condition (E11)	N/A
Category C ESAs that are Nature Refuges, Koala Habitat and/or Declared Catchment Areas	Only low impact petroleum activities permitted	Only limited petroleum activities permitted Subject to condition (E11)	N/A
Category B ESAs that are 'Endangered' Regional Ecosystems	Only limited petroleum activities permitted Subject to condition (E10)	Only limited petroleum activities permitted Subject to condition (E11)	N/A
Category C ESAs that are Essential Habitat, Essential Regrowth Habitat and/or 'Of Concern' Regional Ecosystems	Only limited petroleum activities permitted Subject to condition (E10)	Only limited petroleum activities permitted Subject to condition (E11)	N/A
Category C ESAs that are Resource Reserves	Only limited petroleum activities permitted Subject to condition (E10)	Only limited petroleum activities permitted Subject to condition (E11)	N/A
Category C ESAs that are State Forests and/or Timber Reserves	Limited petroleum activities permitted subject to condition (E10) Petroleum activities that are extraction activities and screening activities permitted.	N/A	N/A

Note: Approvals may be required under the Forestry Act 1959 where the petroleum activity(ies) is proposed to be carried out in ESAs that are State Forests or Timber Reserves.

Schedule E, Table 2 – Authorised Disturbances

Authorised activity	Authorised activity section	Location of development (GDA94)		Size of development		ESA
		Latitude	Longitude	Length (m)	Area of disturbance (ha)	

E10 Prior to carrying out limited petroleum activities undertaken within environmentally sensitive areas in accordance with *Schedule E, Table 1 – Petroleum Activities in Environmentally Sensitive Areas*, it must be demonstrated, in the following order of preference that:

1. no reasonable or practicable alternative exists for carrying out the limited petroleum activities within the **environmentally sensitive area**;
2. the **limited petroleum activities** are preferentially located in pre-existing areas of clearing or significant disturbance;
3. clearance widths for linear infrastructure is minimised to the maximum extent possible, taking into account the following matters:
 - a) safe vehicle movement;
 - b) drainage devices installed are of a type that is appropriate for the track type and location;
 - c) erosion and sediment control measures installed are in accordance with the Erosion and Sediment Control Plan required by conditions (B2) and (B3); and
 - d) power line stays have been preferentially located within the pipeline right of way where possible.
4. the maximum clearance widths specified in *Schedule E, Table 3 – Authorised Disturbance for Linear Infrastructure* are not exceeded.

Schedule E, Table 3 – Authorised Disturbance for Linear Infrastructure

Type of linear infrastructure	Clearance width (m)
(A) Access track(s) not associated with a pipeline(s), communication line(s) or power line(s):	
(a) single carriage access tracks	18
(b) dual carriage access tracks	21
(c) single or dual carriage access track and associated turnaround bay	35
(B) Access track(s) associated with a pipeline(s), communication line(s) or power line(s):	
(a) single carriage access tracks with a single pipeline, communication line or power line	24
(b) dual carriage access track with a single pipeline, communication line or power line.	27
(c) single or dual carriage access track and associated turnaround bay with a single pipeline, communication line or power line.	41
(d) additional clearing for any additional parallel pipeline, communication line or power line associated with (B)(a), (b) or (c)	7 ¹
(C) Additional clearing for take-off drains, power line stays or turnaround bays or other work areas:	

Type of linear infrastructure	Clearance width (m)
(a) Additional clearing for power line stays associated with (B)	10
(b) additional clearing for take-off drains associated with (A) or (B)	10

¹ Maximum total disturbance for (B) is 62m.

- E11 If limited petroleum activity(ies) are located within a primary protection zone or secondary protection zone of an environmentally sensitive area, that the activity(ies) must not negatively affect the adjacent environmentally sensitive area.

9 Nature conservation

9.1 Ecological assessment methodology

Santos GLNG undertook desktop studies and field assessments to evaluate the existing environment as pertaining to terrestrial and aquatic ecology. These assessments are detailed in the following sections.

9.1.1 Desktop study

9.1.1.1 Terrestrial ecology

Relevant literature, online resources and ecological databases were extensively reviewed to compile a list of threatened species and ecologically sensitive areas for consideration and to develop a map of ecologically sensitive areas, including those summarised in the table below.

Table 9-1 Literature and database review summary

Database/data source name	Database search date	Database search areas	Data type
Atlas of Living Australia (Atlas of Living Australia 2013)	22 August 2013	The extent of each tenure and a 10 km buffer *	Records of flora and vertebrate fauna including conservation significant species listed under the NC Act
Biodiversity Planning Assessment (BPA) mapping	21 November 2013	Regional extent	State, regional and locally significant biodiversity matters mapping. This mapping has been used to indicate the location of bioregional corridors (ie in the State, regional and local context). This mapping has also been used in the predictive modelling to identify 'core habitat' areas
Birdlife Australia database	3 March 2014	The extent of each tenure and a 25 km buffer	Records of bird species including conservation significant species listed under the NC Act
ESA mapping (Queensland Government 2013e)	21 November 2013	Regional extent	Category A, B and C Environmentally Sensitive Areas as defined under the <i>Environmental Protection Act 1994</i>
Essential Habitat Map, version 3.1	21 November 2013	Regional extent	Essential Habitat and Essential Regrowth Habitat under the Vegetation Management Act (VM Act) for a conservation significant species listed under the NC Act

Database/data source name	Database search date	Database search areas	Data type
HERBRECS database	4 March 2014	The extent of each tenure and a 25 km buffer	Records of vascular flora including conservation significant species listed under the NC Act
Zoology Data Search – Terrestrial vertebrates, fish, crustacea and land snails	10 March 2014	The extent of each tenure and a 25 km buffer	Records of terrestrial vertebrates, fish, crustacean and land snails held by the Queensland Museum
Regulated Vegetation Management Map	11 February 2014	Regional extent	Mapping of REs and HVR that provide habitat for TECs and conservation significant species under the NC Act
Register of critical habitat (Australian Government 2013b)	31 July 2013	Australian extent	Critical habitat listed under the EPBC Act
Map of Referrable Wetlands	21 November 2013	Regional extent	Includes State significant, referable wetlands, important wetlands in the Great Barrier Reef catchments and wetland REs
Wildlife Online database	14 November 2013	The extent of each tenure and a 25 km buffer	Records of flora and vertebrate fauna including conservation significant species listed under the NC Act

Source: Aurecon 2014, Table 3.1, modified

A total of 31 reports were identified to present ecological values of the GFD Project area, including species diversity, abundance and seasonal distribution. These reports include several Santos GLNG specific well site inspection reports carried out for the GLNG project, detailed field assessments undertaken for other projects in the area to meet EIS or environmental management plan requirements, and published research. As such, there is a high level of confidence in the assessments of terrestrial ecology undertaken within the Project area, including their adequacy for providing a baseline of the GFD Project area. The findings of each study were used to inform this assessment.

9.1.1.2 Aquatic ecology

The identification of existing ecological values was primarily based on a comprehensive desk study, informed by existing knowledge of the area. No aquatic field surveys were undertaken for this assessment. As locational information on GFD Project infrastructure had not been identified at the time of the EIS, the previous data collated was considered sufficient to identify aquatic ecology environmental values and receptors and undertake a preliminary assessment of the potential impact from GFD Project activities on these values and receptors. Any required in-depth field investigations will be carried out during phase two of the GFD Project (post-EIS).

Relevant data sources were accessed to describe the aquatic ecological values of the GFD Project area. Primary information sources included:

- Wildlife on-line database, with the geographic extent of searches covering all GFD Project tenures and an additional 10 km beyond the boundary of each tenure
- DEHP's Wetland mapping and classification search tool version 3.0, and the refrable wetlands search tool, with the geographic extent of searches covering all tenures and wetlands within 10 km downstream of the tenures
- Published Government studies such as the State of the Rivers assessments and Aquatic Conservation Assessments (using the AquaBAAM methodology). The State of the Rivers assessments incorporates the whole GFD Project area and provides a comprehensive assessment of the region. While these studies were completed in the late 1990s and early 2000s, they are the most recent and comprehensive surveys available
- Published studies regarding groundwater-dependent ecosystems and communities, such as springs and stygofauna
- Published information from other projects in the vicinity of the GFD Project area, including the Santos GLNG project (URS 2009, FRC Environmental 2009a), the Australia Pacific LNG project (Worley Parsons 2010), the Arrow Energy Surat Gas Project (Coffey Environments 2012), the Rolleston Coal project (FRC Environmental 2004), the Nathan Dam and Pipelines project (FRC Environmental 2007) and the Wandoan Coal project (FRC Environmental 2009b)
- The GLNG CSG Future Development Area EIS – Gap Analysis (URS 2011)
- River health assessments of the upper Dawson River using the AUSRIVAS methodology, completed on behalf of Santos GLNG to monitor the impacts of discharge of produced formation water on the receiving freshwater environment
- The results of detailed aquatic ecology surveys recently undertaken to support development of the Aquatic values management plan for the GLNG project Gas Transmission Pipeline
- Data obtained from the DEHP's and DNRM's biological monitoring network (data purchased from Queensland Government) (URS 2013).

9.1.2 Field assessments – terrestrial ecology

This section summarises the field assessment methodologies adopted, in accordance with relevant departmental guidelines or policies (i.e. survey guidelines, species recovery plans) undertaken by Aurecon, on behalf of Santos GLNG. Adequate justification for an alternative methodology where survey methodology is not compliant with applicable survey guidelines has been provided in the relevant sections.

The extent of fieldwork and modelling undertaken for the GFD Project, when used in conjunction with existing information, is considered adequate to provide sufficient confidence in predictions of potential impacts to terrestrial ecology, and well-informed decisions are subsequently possible. In addition, a pre-disturbance ecological assessment will be undertaken for each disturbance footprint to validate habitat mapping, assumptions and the results of the GFD EIS in relation to environmental values. These future surveys will assist in mitigating impacts to significant ecological values by providing increased resolution that will be used to avoid, minimise or mitigate significant environmental receptors.

Between 2011 and 2013, Aurecon conducted ecological assessments throughout the Roma and Fairview gas fields, as well as selected areas of the Arcadia and Scotia gas fields (Aurecon 2014). The survey effort conducted during this period has equated to 1,380 days, and has incorporated seasonal factors/variation (Aurecon 2014).

Table 9-2 Seasonal variation and survey effort for previous Aurecon field visits

Location	Season	Year	Survey effort (days)	Total survey effort per location (days)
Fairview gas fields	Autumn (March, May)	2011	112	725
	Autumn/Winter (May-June)	2011	16	
	Winter (June, August)	2011	350	
	Winter/Spring (August-September)	2011	32	
	Spring (September-November)	2011	93	
	Summer (January-February)	2012	16	
	Autumn (March-May)	2012	12	
	Winter (June-August)	2012	30	
	Spring (September)	2012	17	
	Summer (January-February)	2013	47	
Roma gas fields	Summer (January)	2011	2	606
	Autumn (March – May)	2011	215	
	Autumn/Winter (May-June)	2011	40	
	Winter (June-August)	2011	281	
	Spring (October)	2011	2	
	Summer (February)	2012	1	
	Autumn (March-May)	2012	15	
	Winter (June-July)	2012	30	
	Spring (September, November)	2012	17	
	Summer (December)	2012	3	
Arcadia gas fields	Spring (September, November)	2011	4	47
	Autumn (March, May)	2012	3	
	Winter (August)	2012	40	
Scotia gas fields	Autumn (April)	2012	2	2
Total				1,380

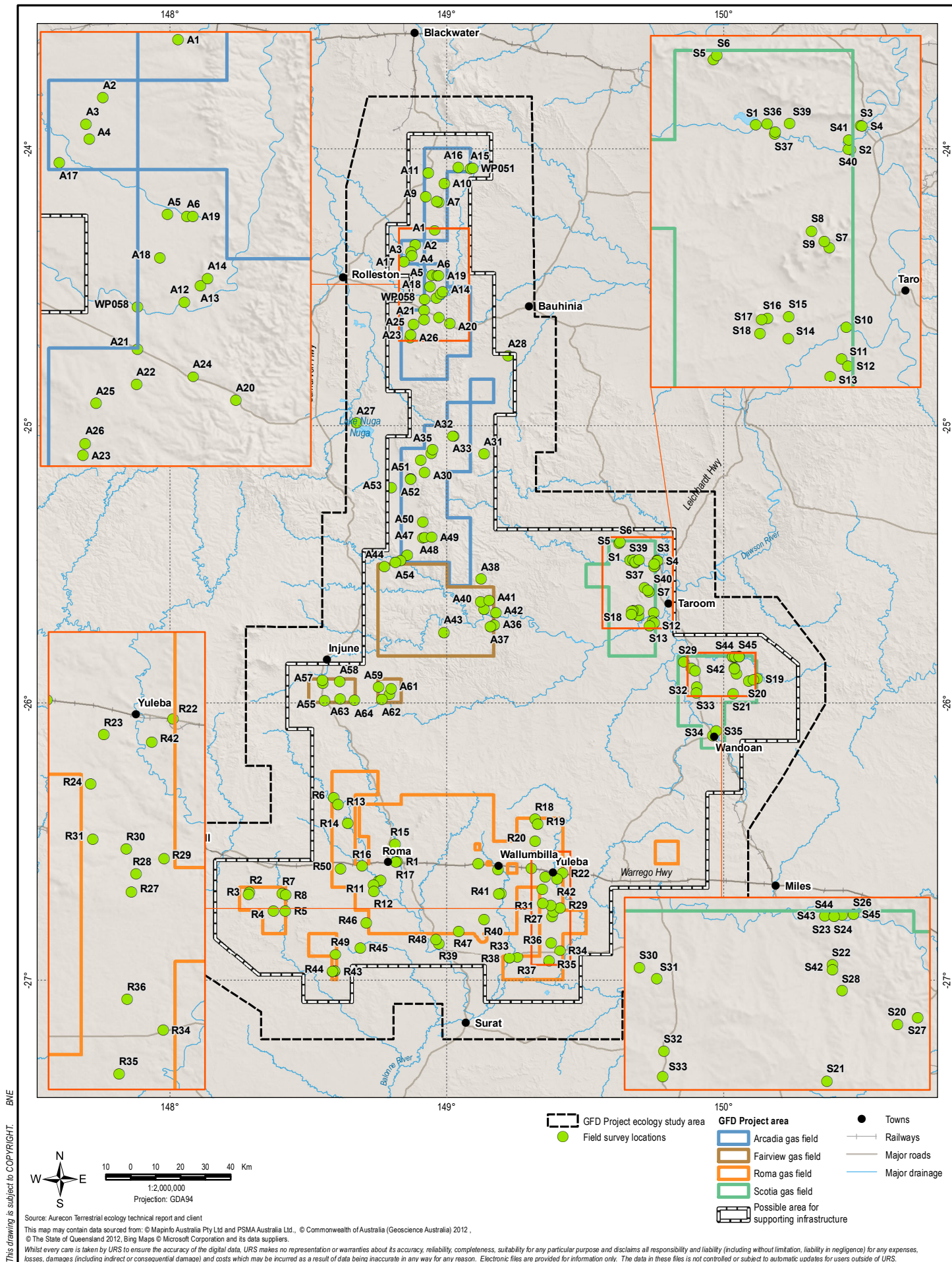
Source: Aurecon 2014, Table 3.2

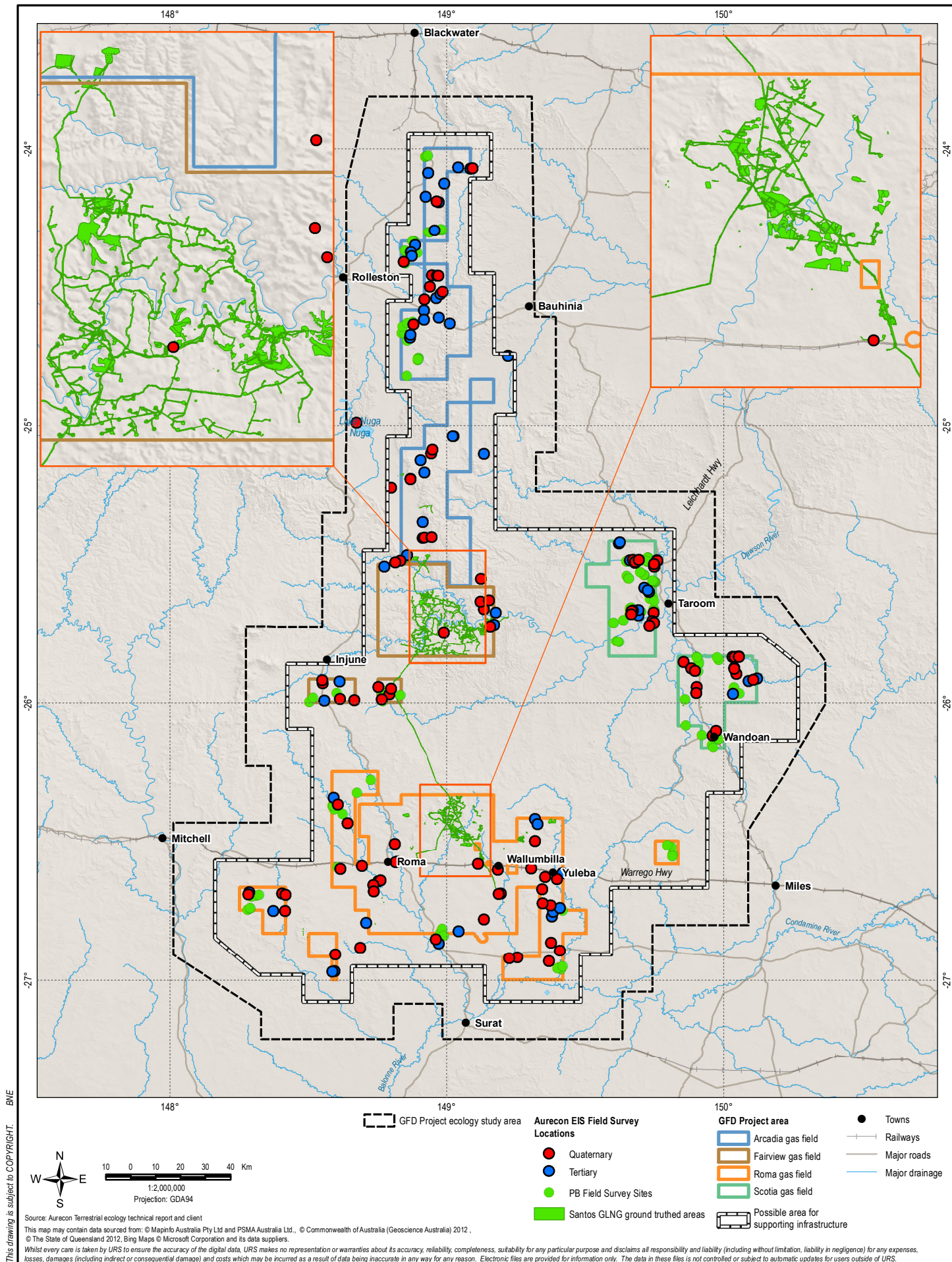
Aurecon's historic survey locations within the GLNG gas fields; Aurecon's field survey sites for the GFD Project area; Parsons Brinckerhoff's past survey effort; and the project area used for the database review are identified in Figure 9-1 and Figure 9-2. In addition, other consultancies such as Boobook Ecological Consultants, GHD, URS Corporation and RPS Australia East have also conducted surveys within the gas fields. Aurecon's historic sampling effort is provided in Table 9-2, which identifies the season within which surveys were undertaken. The results of each ecological assessment conducted within the GFD Project area has been used to inform this assessment.

A representative sampling approach was employed as part of the field sampling methodology.

Following the desktop component, sites were selected that were specifically identified as containing features of interest. Specifically, the following features were used to target areas:

- Areas containing a representative example of a distinct vegetation community (ie areas contained within mapped remnant vegetation, regrowth, and non-remnant vegetation areas)
- Areas containing landscape features that were considered likely to support conservation significant species when viewed from aerial photography (i.e. Gilgai areas, wetlands and jump-ups)
- Areas known to support conservation significant species
- Areas that were not subject to previous ground-truthing
- The location of survey locations associated with the GFD Project EIS is provided in Figure 9-1.





9.1.2.1 Flora

At each target site, a list of observed flora species were documented. If significant flora species not previously encountered were observed, a sample was collected and lodged at the Queensland Herbarium for formal identification.

Ground-truthing of a representation of distinctively different vegetation communities identified during the desktop evaluation was undertaken. The following outlines the sampling approach:

- Within a representative of each different type of vegetation community, a full vegetation survey occurred. Sampling for a full vegetation survey included an assessment of the relative density and species composition of the Emergent (E), Canopy (T1, T2, T3), Shrub (S1, S2, S3) and Ground (G) strata layers when they were present. All species observed were recorded during the full vegetation survey (including non-native species).
- Once a full vegetation survey was complete for each representative of the specific vegetation community, verification of the remaining map units of the same type was undertaken at the Quaternary level as described by Neldner et al. (2012)
- An assessment of ecosystem function was undertaken at all survey sites, which included the following elements:
 - Shape of vegetation community/ patch
 - Size of vegetation community/ patch
 - Location of vegetation community/ patch within the landscape
 - Level of weed invasion
 - Presence of edge-related impacts or effects.

9.1.2.2 Fauna

Fauna and habitat assessments were conducted using the methodologies summarized in the following table.

Table 9-3 Field assessment methodologies

Source name	Data type
A general habitat assessment and a record of all fauna encountered (i.e., observed/heard) was undertaken at every vegetation assessment survey site	Fauna habitat features recorded included, but was not limited to: • Presence and relative density of hollow bearing trees • Presence of canopy, sub-canopy and shrubs suitable for perching, shelter and foraging • Presence of coarse fallen woody material • Presence of boulders and other rocky material that would provide fauna habitat • Presence of features such as watercourses and formed banks that may provide shelter and nesting opportunities • Presence of cracking clays and/or gilgais • Availability/proximity to water • Level of weed invasion • Level of vegetation in the ground stratum and its potential to provide fauna habitat • Presence of feeding resources (i.e., fruiting/flowering trees) • All species of fauna observed were identified to the species level where possible.
Validation of the predictive habitat mapping was undertaken where applicable	• Field verification of predictive fauna habitat mapping was undertaken by comparing the species specific habitat assumptions derived from the desktop phase, to characteristics observed in the field. • Where site based field observations significantly deviate from the desktop derived habitat assumptions, these areas were removed from the predictive habitat mapping. • Where a conservation significant species was observed, these areas were elevated in status to either general habitat (for areas that were not currently mapped as general habitat for the species), or essential habitat (for locations that were already included within the general habitat mapping layer) • Several species have habitat requirements that were difficult to model using the available datasets (i.e., Squatter pigeon, Brush-tailed rock-wallaby and Northern quoll). For these species, specific habitat modelling was used which deviated slightly from the general model used for the remaining species that were evaluated within the Terrestrial Ecology Assessment Report (Aurecon 2014).

Source name	Data type
Use of specific techniques to identify conservation significant species	When areas were identified as containing habitat that is considered likely to support conservation significant species, specific techniques were employed to increase the likelihood of detecting these species, including. • Baited hair traps • Infra-red remote motion-sensing cameras at watering points and/or at baited feeding stations • ANABAT devices • Call playback • Nocturnal spotlighting • Active searches for cryptic fauna • Analysis of observed scats and scratch marks on trees were used to assess/confirm the presence of species such as Koala (<i>Phascolarctos cinereus</i>), Northern quoll (<i>Dasyurus hallucatus</i>), Brush-tailed rock wallaby (<i>Petrogale penicillata</i>), Yakka skink (<i>Egernia rugosa</i>) and various other conservation significant species.

9.2 Environmental values

Consistent with the relevant legislation, the overarching environmental values adopted for the GFD Project are:

- Queensland's natural environment and native flora and fauna
- Finite natural resources, including national parks, conservation parks, and wetlands
- Land conducive to the maintenance of existing land forms, ecological health, biodiversity, riverine and wetland areas
- Biodiversity
- Protection of high ecological value habitat for aquatic flora and fauna
- Protection of listed threatened species
- Protection of high conservation priority species
- Protection of aquatic ecosystem values.

9.2.1 Terrestrial ecology

9.2.1.1 Protected areas and environmentally sensitive areas

The GFD Project area contains areas protected under the NC Act (i.e. National Parks and Conservation Reserves) and the Forestry Act 1959 (i.e. Protected Forestry Areas). Protected areas contain a large portion of the remaining regional ecosystems (Res) within the GFD Project area; however, the RE types present generally have a biodiversity status of 'No concern at present'. No protected areas are present in ATP 745P, ATP 655P, ATP 665P, ATP 868P, PL 3, PL6, PL 7, PL 8, PL11, PL 13, PL 93, PL 176, PL 309, PL 310, PL 314 or PL 315 project tenures. Table 9-4 provides a summary of the protected areas present in the GFD Project area.

The GFD Project area contains Category A, B and C Environmentally Sensitive Areas (ESAs) as defined under the EP Act. Four Category A ESAs are present including:

- Expedition National Park – the largest National Park within the GFD Project area located in the Arcadia and Fairview gas fields. Approximately 63,558 ha of Expedition National Park is located within the GFD Project area
- Humboldt National Park – a large area of remnant vegetation (formerly State Forest) located in the Arcadia gas fields in ATP 804P. Approximately 7,445 ha of Humboldt National Park is located within the GFD Project area
- Lake Murphy Conservation Park – situated in the Scotia gas fields in ATP 803P. Lake Murphy Conservation Park protects a large perched ephemeral freshwater wetland (i.e. RE 11.3.27) situated beneath the Murphy Range. Approximately 520 ha of Lake Murphy Conservation Park is located within the GFD Project area
- Carraba Conservation Park – situated in the Scotia gas fields in ATP 803P. Approximately 49 ha of Carraba Conservation Park is located within the GFD Project area.

All tenures in the GFD Project area contain some ESAs, particularly 'Endangered' REs (i.e. Category B ESAs). State Forests are also prevalent (i.e. Category C ESAs) (refer Table 9-4).

Table 9-4 Summary of protected areas and ESAs in each GFD Project tenures

Gas field	Project tenure	Category A ESAs	Category B ESAs	Category C ESAs
Arcadia	ATP 526P	Expedition National Park	Seven 'Endangered' REs consisting of: 11.3.2/11.3.1; 11.3.2/11.3.1/11.3.25; 11.3.2/11.3.25/11.3.1; 11.3.1; 11.4.8; 11.4.9; 11.9.1; 11.9.1/11.9.5; 11.9.4; 11.9.5; 11.9.5/11.9.1; 11.9.8; 11.9.8/11.9.5	Yuleba State Forest Expedition State Forest Mount Nicholson State Forest Approximately 464.7 ha of mapped Referable wetlands Eleven 'Of concern' REs consisting of: 11.10.1/11.10.3/11.3.25; 11.10.1/11.3.25; 11.8.4/11.3.4; 11.8.4/11.3.6/11.3.25; 11.3.2; 11.3.2/11.3.25; 11.3.2/11.9.2; 11.3.25; 11.3.27; 11.8.11; 11.8.3
Arcadia	ATP 745P	-	Eight 'Endangered' REs consisting of: 11.3.2/11.3.1; 11.3.1/11.3.2; 11.4.8/11.4.1; 11.4.9; 11.9.1/11.9.5; 11.9.4; 11.9.5/11.9.1	Approximately 34.3 ha of mapped Referable wetlands Nine 'Of concern' REs consisting of: 11.8.4/11.3.6/11.3.25; 11.3.2; 11.3.2/11.3.19; 11.3.2/11.3.25; 11.3.2/11.9.2; 11.3.6; 11.8.11; 11.8.3
Arcadia	ATP 804P	Humboldt National Park	Ten 'Endangered' REs consisting of: 11.3.2/11.3.1; 11.5.2/11.7.2/11.5.3/11.9.1; 11.5.3/11.4.8; 11.5.3/11.4.9/11.4.8; 11.4.7; 11.4.8; 11.4.9; 11.9.1; 11.9.5	Shotover State Forest Approximately 22.9 ha of mapped Referable wetlands Five 'Of concern' REs consisting of: 11.5.2/11.5.18/11.5.3; 11.3.4; 11.5.18/11.5.3; 11.8.11
Arcadia	ATP 653P	Expedition National Park	Three 'Endangered' REs: 11.3.17; 11.9.4; 11.9.5	Approximately 30.5 ha of mapped Referable wetlands Three 'Of concern' REs consisting of: 11.3.2; 11.3.2/11.3.25; 11.3.25/11.10.1

Gas field	Project tenure	Category A ESAs	Category B ESAs	Category C ESAs
Arcadia	PL 233	Expedition National Park	-	Belington Hut State Forest Mapped Essential Habitat for <i>Eucalyptus beaniana</i> (Bean's ironbark) Mapped Essential Habitat for Large-eared pied bat (<i>Chalinolobus dwyeri</i>), Collared delma (<i>Delma torquata</i>), Squatter pigeon (<i>Geophaps scripta scripta</i>) and Brigalow scaly-foot (<i>Paradelma orientalis</i>) Three 'Of concern' REs consisting of: 11.10.13/11.10.1/11.3.25
Arcadia	PL 234	Expedition National Park	Four 'Endangered' REs consisting of: 11.10.1/11.9.4; 11.3.17; 11.9.4; 11.9.5; 11.9.5/11.10.1	Belington Hut State Forest Mapped Essential Habitat for <i>Xerothamnella herbacea</i> (Xerothamnella) Mapped Essential Habitat for Large-eared pied bat, Collared delma, Squatter pigeon and Brigalow scaly-foot Approximately 2.2 ha of mapped Referable wetlands One 'Of concern' RE: 11.3.2
Arcadia	PL 235	Expedition National Park	One 'Endangered' RE: 11.9.4	Approximately 11.4 ha of mapped Referable wetlands Mapped Essential Habitat for Large-eared pied bat, Collared delma, Squatter pigeon and Brigalow scaly-foot Mapped Essential Habitat for <i>Calytrix islensis</i>
Arcadia	PL 236	Expedition National Park	Three 'Endangered' REs consisting of: 11.10.1/11.9.5; 11.9.4; 11.9.5	Presho State Forest Three 'Of concern' REs consisting of: 11.10.1/11.3.2; 11.10.8; 11.3.2
Fairview	ATP 655P	-	Three 'Endangered' REs consisting of: 11.9.1/11.9.10; 11.9.1/11.9.5; 11.9.5	Approximately 131.5 ha of mapped Referable wetlands Three 'Of concern' REs consisting of: 11.3.2/11.3.25; 11.3.25/11.3.2/11.9.7; 11.3.25/11.9.7; 11.3.25/11.9.7/11.3.2; 11.9.7/11.3.2

Gas field	Project tenure	Category A ESAs	Category B ESAs	Category C ESAs
Fairview	PL 100	Expedition National Park	Two 'Endangered' REs: 11.9.4; 11.9.5	Beilba State Forest Hallett State Forest Stephenton State Forest Expedition Resources Reserve Approximately 64.8 ha of mapped Referable wetlands Mapped Essential Habitat for <i>Acacia islana</i> Four 'Of concern' REs consisting of: 11.10.13/11.10.1/11.3.25; 11.3.2; 11.3.2/11.3.25
Fairview	PL 232	Expedition National Park	Two 'Endangered' REs: 11.9.4; 11.9.5	Beilba State Forest Belington Hut State Forest Stephenton State Forest Expedition Resources Reserve Approximately 117.8 ha of mapped Referable wetlands Six 'Of concern' REs consisting of: 11.10.13/11.10.1/11.3.25; 11.10.3/11.3.25; 11.3.39/11.3.2; 11.3.2; 11.3.2/11.3.25
Fairview	PL 90	Expedition National Park	Four 'Endangered' REs consisting of: 11.10.1/11.9.4; 11.3.17; 11.9.4; 11.9.5	Approximately 9.1 ha of mapped Referable wetlands Mapped Essential Habitat for <i>Acacia islana</i> (Isla Gorge wattle) and <i>Xerothamnella herbacea</i> Four 'Of concern' REs consisting of: 11.10.11/11.3.2; 11.10.3/11.3.25; 11.3.2

Gas field	Project tenure	Category A ESAs	Category B ESAs	Category C ESAs
Fairview	PL 91	Expedition National Park	Four 'Endangered' REs consisting of: 11.9.10/11.9.7; 11.9.4; 11.9.5	Beilba State Forest Doonkuna State Forest Approximately 10.3 ha of mapped Referable wetlands Mapped Essential Habitat for <i>Melaleuca irbyana</i> (Swamp tea-tree) Six 'Of concern' REs consisting of: 11.10.3/11.3.25; 11.3.18/11.3.2; 11.3.39/11.3.2; 11.3.2; 11.3.2/11.3.25; 11.3.2/11.3.39; 11.3.25; 11.3.25/11.3.2; 11.9.7
Fairview	PL 92	-	Three 'Endangered' REs consisting of: 11.10.1/11.9.5; 11.9.4; 11.9.5	Beilba State Forest Doonkuna State Forest Hallett State Forest Approximately 3.1 ha of mapped Referable wetlands Mapped Essential Habitat for <i>Melaleuca irbyana</i> Two 'Of concern' REs consisting of: 11.3.2; 11.3.2/11.3.25
Fairview	PL 99	-	Three 'Endangered' REs consisting of: 11.10.1/11.9.5; 11.9.4; 11.9.5	Hallett State Forest Approximately 72.5 ha of mapped Referable wetlands Mapped Essential Habitat for <i>Eriocaulon carsonii</i> subsp. <i>orientale</i> (Salt pipewort) Three 'Of concern' REs consisting of: 11.3.2; 11.3.2/11.10.11; 11.3.2/11.3.25; 11.3.25/11.3.2

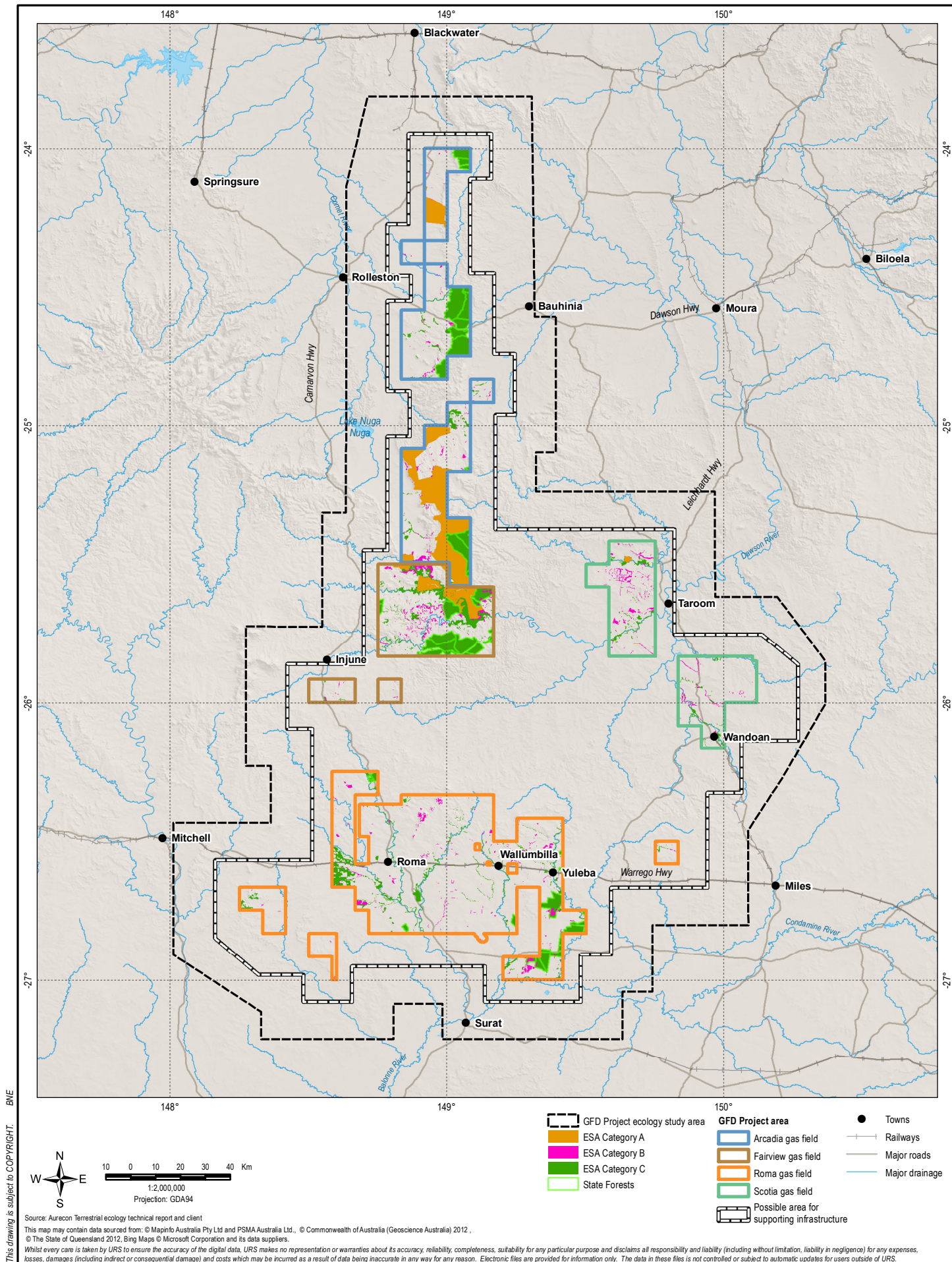
Gas field	Project tenure	Category A ESAs	Category B ESAs	Category C ESAs
Roma	ATP 336P R	-	Two 'Endangered' REs: 11.4.3; 11.9.5	Tinowon State Forest Wallabella State Forest Yuleba State Forest Approximately 106.1 ha of mapped Referable wetlands Six 'Of concern' REs consisting of: 11.3.25/11.3.2; 11.3.25/11.3.28/11.3.2; 11.3.25/11.3.3; 11.3.3; 11.5.13; 11.7.1
Roma	ATP 631P	-	Five 'Endangered' REs consisting of: 11.7.1/11.9.5; 11.7.6/11.9.5; 11.4.3; 11.9.10; 11.9.5; 11.9.5/11.9.10	Yuleba State Forest Inglebogie State Forest Approximately 144.6 ha of mapped Referable wetlands Eight 'Of concern' REs consisting of: 11.3.19/11.3.25; 11.5.1/11.7.1; 11.3.2; 11.3.25/11.3.2; 11.3.25/11.3.2/11.3.3; 11.3.3; 11.7.1; 11.9.7/11.5.5
Roma	ATP 665P	-	Three 'Endangered' REs consisting of: 11.7.1/11.9.5; 11.9.10; 11.9.5/11.9.10; 11.9.5	Approximately 96.8 ha of mapped Referable wetlands Six 'Of concern' REs consisting of: 11.7.2/11.7.1; 11.7.2/6.5.2/11.7.1; 11.3.25/11.3.2; 11.7.1; 11.7.1/6.5.2
Roma	ATP 708P	-	Four 'Endangered' REs consisting of: 11.3.25/11.3.21; 11.9.10; 11.9.5/11.9.10	Gubberamunda State Forest 1 Approximately 586.6 ha of mapped Referable wetlands Mapped Essential Habitat for <i>Solanum papaverifolium</i> Four 'Of concern' REs consisting of: 11.10.11/11.3.2; 11.3.2/11.3.25; 11.3.2/11.3.28/11.3.25; 11.3.25/11.3.2

Gas field	Project tenure	Category A ESAs	Category B ESAs	Category C ESAs
Roma	PL 10	-	Four 'Endangered' REs consisting of: 11.3.25/11.3.17; 11.9.5/11.9.10	Brucedale State Forest Approximately 26.4 ha of mapped Referable wetlands Three 'Of concern' REs consisting of: 11.3.2/11.3.28/11.3.25
Roma	PL 11	-	Two 'Endangered' REs consisting of: 11.9.5/11.9.10	Two 'Of concern' REs consisting of: 11.3.2; 11.3.25/11.3.2
Roma	PL 13	-	Four 'Endangered' REs consisting of: 11.8.3/11.9.4; 11.9.10; 11.9.10/11.9.5; 11.9.4/11.8.3; 11.9.5; 11.9.5/11.9.10	Approximately 39 ha of mapped Referable wetlands Three 'Of concern' REs consisting of: 11.10.11/11.3.2; 11.3.25/11.3.2
Roma	PL 3	-	Two 'Endangered' REs consisting of: 11.9.10; 11.9.5; 11.9.5/11.9.10	Approximately 158.5 ha of mapped Referable wetlands Mapped Essential Habitat for Yakka skink (<i>Egernia rugosa</i>) Four 'Of concern' REs consisting of: 11.3.25/11.3.2; 11.5.13; 11.9.7; 11.9.7/11.3.2
Roma	PL 309	-	Five 'Endangered' REs consisting of: 11.10.11/11.9.10; 11.9.10/11.9.5; 11.9.4/11.8.3; 11.9.5	Approximately 1.2 ha of mapped Referable wetlands Four 'Of concern' REs consisting of: 11.10.11/11.3.2; 11.3.2; 11.3.25/11.3.2; 11.9.7
Roma	PL 310	-	Four 'Endangered' REs consisting of: 11.7.6/11.7.2/11.9.5; 11.7.6/11.9.5; 11.9.10; 11.9.5/11.9.10	Approximately 116.9 ha of mapped Referable wetlands Mapped Essential Habitat for Brigalow scaly-foot Three 'Of concern' REs consisting of: 11.3.25/11.3.2; 11.9.7
Roma	PL 314	-	Four 'Endangered' REs consisting of: 11.9.10/11.9.5; 11.9.4/11.8.3; 11.9.5; 11.9.5/11.9.10	Approximately 193.4 ha of mapped Referable wetlands Four 'Of concern' REs consisting of: 11.3.2/11.10.11; 11.3.25/11.3.2; 11.9.7

Gas field	Project tenure	Category A ESAs	Category B ESAs	Category C ESAs
Roma	PL 315	-	Two 'Endangered' REs consisting of: 11.9.5/11.9.10	Mapped Essential Habitat for <i>Homopholis belsonii</i> (Belson's panic) and <i>Picris barbarorum</i> (Plain's picris) Three 'Of concern' REs consisting of: 11.3.25/11.3.2; 11.7.1
Roma	PL 6	-	Six 'Endangered' REs consisting of: 11.3.25/11.3.21; 11.4.3; 11.9.10/11.9.3; 11.9.5	Approximately 778.7 ha of mapped Referable wetlands Mapped Essential Habitat for Painted honeyeater (<i>Grantiella picta</i>) Four 'Of concern' REs consisting of: 11.3.2/11.3.28/11.3.25; 11.3.25; 11.3.25/11.3.2; 11.7.1
Roma	PL 7	-	Two 'Endangered' REs consisting of: 11.9.5; 11.9.5/11.9.10	Approximately 82.1 ha of mapped Referable wetlands Six 'Of concern' REs consisting of: 11.3.2/11.3.28/11.3.25; 11.3.25/11.3.2; 11.5.13; 11.9.7; 11.9.7/11.9.3
Roma	PL 8	-	Three 'Endangered' REs consisting of: 11.4.3; 11.9.5/11.9.10	Approximately 10.3 ha of mapped Referable wetlands Mapped Essential Habitat for Brigalow scaly-foot Two 'Of concern' REs consisting of: 11.3.2; 11.3.25/11.3.2
Roma	PL 9	-	Three 'Endangered' REs consisting of: 11.4.3; 11.9.5; 11.9.5/11.9.10	Trinidad State Forest Approximately 119.1 ha of mapped Referable wetlands Eight 'Of concern' REs consisting of: 11.5.5/11.5.13; 11.3.2/11.3.28/11.3.25; 11.3.25; 11.7.1; 11.9.7/11.9.3
Roma	PL 93	-	Three 'Endangered' REs consisting of: 11.9.5/11.9.10; 11.9.4; 11.9.5	Two 'Of concern' REs consisting of: 11.3.25/11.3.2

Gas field	Project tenure	Category A ESAs	Category B ESAs	Category C ESAs
Scotia	ATP 803P	Lake Murphy Conservation Park Carraba Conservation Park	Approximately 10,697.7 ha of the RAMSAR site, Palm Tree and Robinson Creeks, occurs within ATP 803P Four 'Endangered' REs consisting of: 11.9.10; 11.9.4; 11.9.4/11.10.1; 11.9.5	Approximately 656.2 ha of mapped Referable wetlands Mapped Essential Habitat for <i>Cadellia pentastylis</i> (Ooline) Mapped Essential Habitat for Imperial hairstreak (<i>Jaumenus eubulus</i>), Greater long-eared bat (<i>Nyctophilus corbeni</i>) and Brigalow scaly-foot Six 'Of concern' REs consisting of: 11.3.2; 11.3.25; 11.3.25/11.3.3; 11.3.25/11.3.39/11.3.2; 11.3.27; 11.3.3; 11.3.4/11.3.25
Scotia	ATP 868P	-	Five 'Endangered' REs consisting of: 11.3.25/11.9.10/11.9.7; 11.9.7/11.9.10; 11.9.10; 11.9.5; 11.9.5/11.9.10; 11.9.5/11.9.6	Approximately 1315.9 ha of mapped Referable wetlands Four 'Of concern' REs consisting of: 11.3.2; 11.3.2/11.3.25; 11.3.25; 11.3.25/11.3.19/11.3.2; 11.3.25/11.3.2; 11.9.7; 11.9.7/11.3.2
Scotia	PL 176	-	Two 'Endangered' REs consisting of: 11.9.1/11.9.5; 11.9.5; 11.9.5/11.9.1	Approximately 43.6 ha of mapped Referable wetlands Five 'Of concern' REs consisting of: 11.10.9/11.3.2; 11.3.25; 11.9.7; 11.9.7/11.10.9; 11.9.7/11.3.4

Source: Aurecon 2014b, Table 4.5



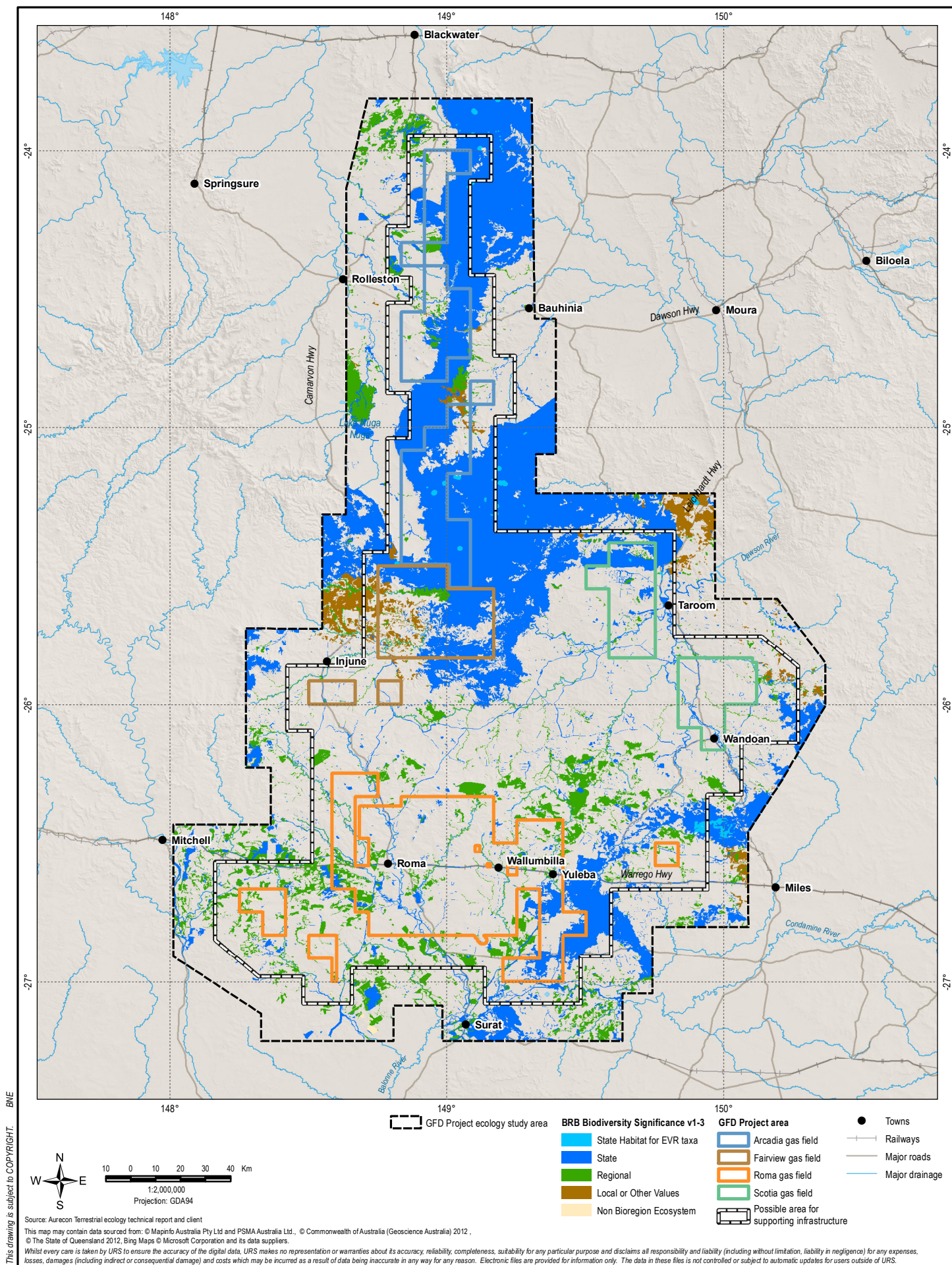
9.2.1.2 Biodiversity planning assessment

Biodiversity Planning Assessments (BPAs) for each of Queensland's bioregions have been prepared based on the methodology outlined in the Biodiversity Assessment and Mapping Methodology (BAMM) (Queensland Government 2002). The BPAs draw upon the DEHP certified RE mapping, database information and expert panel reports and incorporate information about threatened ecosystems and/or species, large tracts of habitat in good condition, ecosystem diversity, landscape context and connection, as well as buffers to wetlands or other types of important areas for ecological processes. The BPA assigns areas to one of three biodiversity significance levels:

- State significance — areas assessed as being significant for biodiversity at the bioregional or State scales
- Regional significance — areas assessed as being significant for biodiversity at the sub-bioregional scale
- Local significance and or other values — local values that are of significance at the local government scale All remnant vegetation will qualify into one of the above three categories. Figure 9-4 depicts the BPA mapping for the GFD Project area.

The BPAs and associated expert panel reports applicable to the GFD Project include:

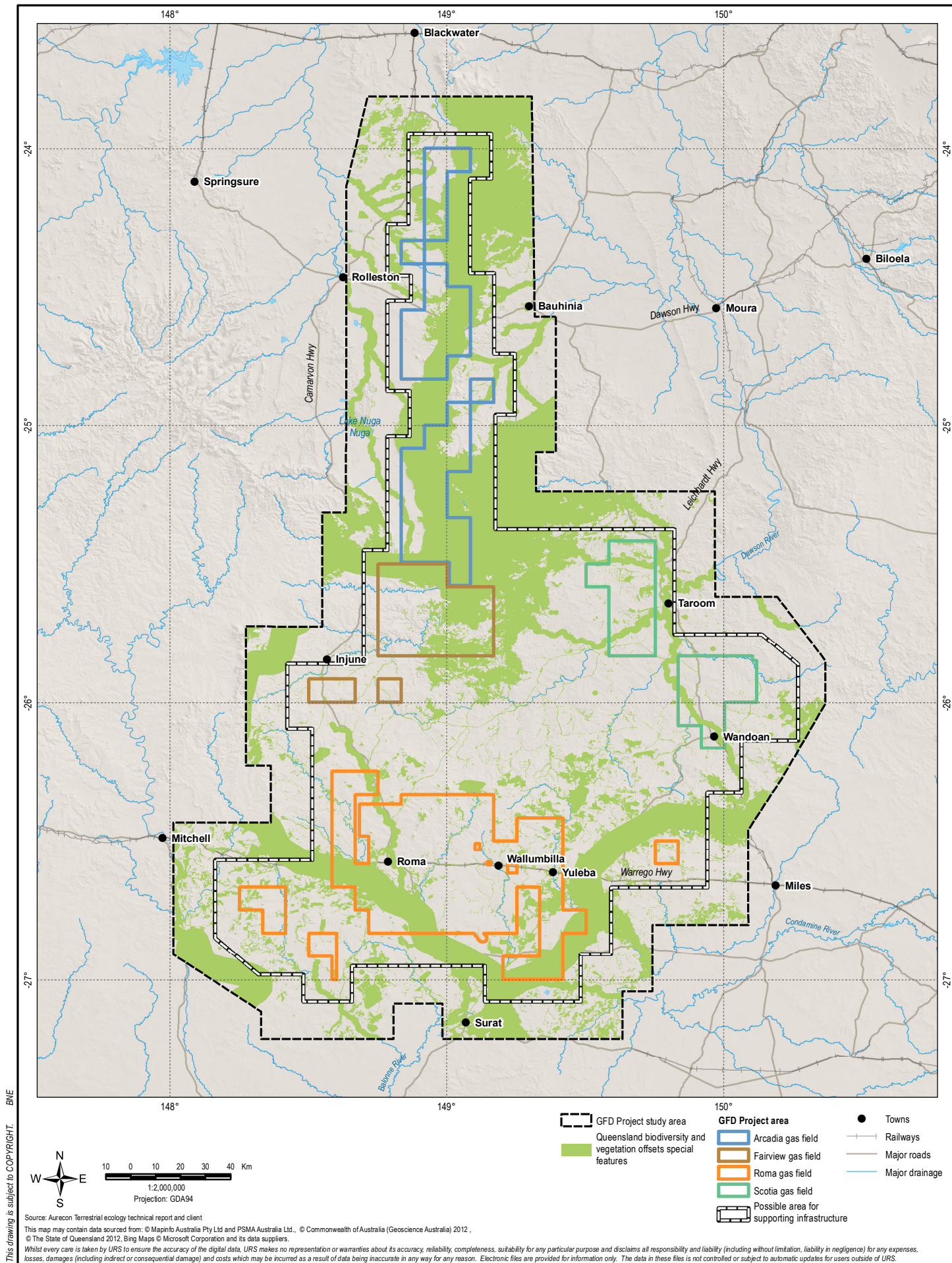
- The Brigalow Belt Biodiversity Planning Assessment, version 1.3
- Biodiversity Planning Assessment: Brigalow Belt North Landscape Expert Panel Report
- Biodiversity Planning Assessment: Brigalow Belt South Landscape Expert Panel Report
- Biodiversity Planning Assessment: Brigalow Belt South Flora Expert Panel Report
- Biodiversity Planning Assessment: Brigalow Belt South Fauna Expert Panel Report (Aurecon 2014b).



9.2.1.3 State significant biodiversity values

Queensland biodiversity and vegetation offsets special features are derived from the BPA utilised in the Queensland Government Ecological Equivalence Methodology. This methodology outlines 14 special feature criteria that are to be considered when determining the ecological equivalence of a proposed development site and offset site. These special features include BPA Criteria H (i.e. priority species), Criteria I (i.e. special biodiversity value areas), and Criteria J (i.e. corridors).

Figure 9-5 depicts the areas or features within the GFD Project area that are identified in the Queensland Government Environmental Offset Policy.



STATE SIGNIFICANT BIODIVERSITY VALUES FROM OFFSET POLICY

Figure: 9-5

9.2.1.3.1 Regional ecosystems

The majority of the GFD Project tenures contain non-remnant vegetation. However, there are still some extensive areas of remnant REs mapped within the GFD Project area (approximately 315,610 ha).

The most prevalent REs across the GFD Project tenures are RE 11.3.2, RE 11.3.25, RE 11.9.5 and RE 11.9.10. RE polygons within the GFD Project tenures range from those smaller fragments less than 1 ha in size (e.g. RE 11.5.2), to large tracts of intact vegetation approximately 11,925 ha in size (e.g. RE 11.10.1 in PL 235 in the Arcadia gas fields). Some of these REs are analogous to TECs listed under the EPBC Act. Five RE polygons greater than 5,000 ha in size exist within the GFD Project tenures within ATP 526P, ATP 653P, PL 100, PL 234, PL 235 within the Arcadia and Fairview gas fields. The smaller RE polygons are generally subject to edge effects and weed invasion from agricultural practices, such as cattle grazing. The larger polygons have been observed to be relatively undisturbed and are resilient to degradation due to their size and large area of core habitat.

A summary of the RE types according to their biodiversity status that are mapped in each project tenure is provided in Table 9-5.

Table 9-5 Summary of Regional Ecosystems grouped by biodiversity status mapped in the GFD Project tenures

Gas field	Project tenure	Area of mapped Regional Ecosystems (Biodiversity status) (ha)^			Total area of mapped REs (ha)^
		Endangered	Of concern	No concern at present	
Arcadia	ATP 526P	1,098	1,611	45,528	48,237
	ATP 653P	596	850	10,799	12,245
	ATP 745P	134	777	1,191	2,102
	ATP 804P	2,566	1,898	14,232	18,696
	PL 233	-	2,349	20,851	23,200
	PL 234	2,651	451	13,321	16,423
	PL 235	1,524	-	18,219	19,743
	PL 236	347	1,961	9,262	11,570
Fairview	ATP 655P	161	295	-	456
	PL 100	205	2,437	13,747	16,389
	PL 232	2,088	6,478	9,128	17,694
	PL 90	2,571	2,539	14,087	19,197
	PL 91	709	4,655	5,125	10,489
	PL 92	1,322	557	6,360	8,239
	PL 99	284	1,417	8,767	10,468
Roma	ATP 336P R	1,388	1,021	1,909	4,318
	ATP 631P	2,299	3,014	19,914	25,227
	ATP 665P	221	2,217	814	3,252

Gas field	Project tenure	Area of mapped Regional Ecosystems (Biodiversity status) (ha)^			Total area of mapped REs (ha)^
		Endangered	Of concern	No concern at present	
	ATP 708P	595	986	7,082	8,663
	PL 10	237	63	452	752
	PL 11	238	317	95	650
	PL 13	599	475	182	1,256
	PL 3	133	795	2,042	2,970
	PL 309	290	300	1,042	1,632
	PL 310	473	377	415	1,265
	PL 314	315	299	407	1,021
	PL 315	123	571	0.2	694
	PL 6	816	1,618	4,637	7,071
	PL 7	69	1,856	2,396	4,321
	PL 8	105	675	-	780
	PL 9	117	1,431	848	2,396
	PL 93	5	40	-	45
Scotia	ATP 803P	3,973	3,312	4,061	11,346
	ATP 868P	1,171	1,093	-	2,264
	PL 176	177	339	23	539
Total area (ha)^		29,600	49,074	236,936	315,610

Source: Aurecon 2014b, Table 4.12

Table notes: ^ = All areas are approximate; includes sub-dominant REs; based on DEHP certified RE mapping that has been that has been refined via Aurecon field assessment.

An outlier RE from the Mulga Lands bioregion, RE 6.5.2 (*Eucalyptus populnea*, *Acacia aneura* and/or *Eucalyptus. melanophloia* woodland on Quaternary sediments) occurs in ATP 665. This RE is at the eastern limit of its distribution within the Project area (Aurecon 2014b).

9.2.1.3.2 Inconsistencies in regional ecosystem mapping

As a result of ecological investigations and ground-truthing by Aurecon and other consultancies, 4,176 ha within the GLNG Project area has been proposed for RE map amendments. Given the level of inaccuracies in the current DEHP certified RE mapping, it is likely that future map modifications within the GFD Project area will be required as a result of future ecological investigations.

A total of 81 land parcels have been the subject of RE map amendments within the Arcadia, Fairview and Roma gas fields. No RE amendments have been made to any land parcels within the Scotia gas fields (refer Table 9-6).

Table 9-6 Lots that have been subject to RE amendments within each of the gas fields

Gas field	GFD Project tenure	Lot on Plan	Area size (ha)^
Arcadia	ATP 526P, ATP 653P, PL 234	27 NPW826	61
		5 TR18	457
	ATP 653P	6 TR11	6
		7 TR39	34
		9 TR17	16
	ATP 653P, PL 234	6 TR20	5
	PL 234	807PH1979	5
Fairview	PL 100, PL 232	1 AB247	14
	PL 100	4 SP204532	16
		62 FTY1809	9
		9 AB244	9
	PL 100, PL 232	2 AB247	151
		5 TR839674	7
	PL 100, PL 232, PL 92, PL 99	8 AB200	610
	PL 100, PL 91	27 NPW826	7
	PL 100, PL 92	20 FTY1805	21
	PL 100, PL 92, PL 99	55 FTY1153	582
	PL 90	807 PH1979	16
	PL 91	20 FTY1805	7
	PL 91, PL 92	3 WT216	21
		4 WT217	179
		5 WT217	79
		6 CP908635	189
	PL 92	20 WT32	241
		21 WT32	14
		4 WT175	2
	PL 92, PL 99	12 WT18	156
		13 WT18	216
	PL 99	11 WT15	5
		15 WT17	7
		1 RP58256	14
		22 WT277	60
		25 WT22	9
		3 RP58256	7
		3 WT313	39

Santos

GLNG Project

Gas field	GFD Project tenure	Lot on Plan	Area size (ha)^
Roma	ATP 631P	7 WT258	28
		286 WV459	9
		31 WV777	37
	PL 309	86 WV795	18
		24 WV432	2
		10 WV1758	118
	PL 309, PL 310, PL 314	28 WV433	16
		25 SP214993	34
		26 SP214993	45
	PL 309, PL 314	27 SP214993	35
		30 WV433	13
		31 WV433	9
		1 RP200575	2
		37 WV421	2
	PL 310	39 WV422	3
		40 WV436	8
		41 WV436	8
		49 WV422	3
		50 WV422	2
		11 WV1759	102
	PL 310, PL 314	42 WV1499	21
		586 WV394	47
	PL 310, PL 314, PL 315	43 WV437	5
		1 CP848049	31
	PL 310, PL 315	102 WV458	10
		104 WV1566	21
		112 WV1567	8
		113 WV1849	3
		129 WV908	13
		2 RP858912	3
		21 WV1519	8
		22 WV432	3
		3 RP858912	5
		4 RP858912	3
		79 WV1784	93
		83 WV455	10

Gas field	GFD Project tenure	Lot on Plan	Area size (ha)^
		88 WV456	16
		89 WV456	49
		94 WV456	5
		95 WV456	23
		96 WV457	5
	PL 314, PL 315	396 WV974	6
		85 WV455	8
	PL 315	585 WV394	3
		588 WV394	3
		589 WV394	3
		590 WV394	3
		690 WV394	3
	Total area size (ha)^		4,176

Source: Aurecon 2014b, Table 4.13

Table note: ^ = Area sizes are approximate

9.2.1.3.3 Endangered and Of Concern regional ecosystems

Forty-two 'Endangered' and fifty-three 'Of concern' RE codes are present in the GFD Project area (Biodiversity status). The most prevalent 'Endangered' RE type was RE 11.9.5 that is mapped across all GFD Project tenures on the DEHP certified RE mapping as either dominant or sub-dominant RE polygons. RE 11.9.5 is described as *Acacia harpophylla* and/or *Casuarina cristata* open forest on fine-grained sedimentary rocks (Queensland Herbarium 2013). Patch sizes of RE 11.9.5 dominant and sub-dominant RE polygons range from less than 1 ha, to large patches of approximately 1,120 ha. The smaller patches are generally heavily degraded and suffer from extensive weed invasion while some larger patches remain relatively undisturbed with weed invasion restricted to edges.

The most prevalent 'Of concern' RE types within the GFD Project area were RE 11.3.2 and RE 11.3.25, which are mapped across most GFD project tenures on the DEHP certified RE mapping. RE 11.3.2 is described as *Eucalyptus populnea* woodland on alluvial plains (Queensland Herbarium 2013). Patch sizes of RE 11.3.2 dominant and sub-dominant RE polygons range from less than 1 ha to larger patches of approximately 2,091 ha.

RE 11.3.25 is described as *Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines. Patch sizes of RE 11.3.25 dominant and sub-dominant RE polygons range from less than 1 ha to larger patches of approximately 3,515 ha for RE 11.3.25. All patches of RE 11.3.2 and RE 11.3.25 are subject to degradation and heavy weed invasion due to their situation on floodplains and, in the case of RE 11.3.25, their long linear shape fringing drainage lines.

9.2.1.3.4 Threshold regional ecosystems

Five RE types present in the GFD Project area (REs 11.9.8, 11.5.5, 11.5.5c, 11.8.3 and 6.5.2) are at the threshold of their current conservation status (i.e. are at risk of becoming 'Endangered' or 'Of concern' under the VM Act in the near future). The location of these threshold REs in the GFD Project area is outlined in Table 9-7.

Table 9-7 Summary of threshold regional ecosystems in each GFD Project tenure

Regional ecosystem code	Regional ecosystem description	Current VM Act status	Potential future VM Act status	Area (ha)^	Project tenures
6.5.2 *	<i>Eucalyptus populnea</i> , <i>Acacia aneura</i> and/or <i>Eucalyptus melanophloia</i> woodland on Quaternary sediments.	Least concern	Of concern	548	ATP 665P
11.8.3	Semi-evergreen vine thicket on Cainozoic igneous rocks. Steep hillsides.	Of concern	Endangered	134	ATP 526P ATP 745P PL 13 PL 3 PL 310 PL 314
11.5.5	<i>Eucalyptus melanophloia</i> , <i>Callitris glaucophylla</i> woodland on Cainozoic sand plains/remnant surfaces. Deep red sands.	Least concern	Of concern	8,834	ATP 336P R ATP 631P PL 10 PL 11 PL 9 PL 99
11.5.5c	<i>Eucalyptus melanophloia</i> , and/or <i>Eucalyptus populnea</i> +/- <i>Callitris glaucophylla</i> +/- <i>Allocasuarina luehmannii</i> sometimes <i>E. conica</i> is present in the overstorey.	Least concern	Of concern	786	ATP 526P ATP 745P ATP 804P
11.9.8	<i>Macropteranthes leichhardtii</i> thicket on fine grained sedimentary rocks.	Least concern	Of concern	248	ATP 526P

Source: Aurecon 2014b, Table 4.14

9.2.1.3.5 Critically limited regional ecosystems

Critically limited REs have a remnant extent below 5% of their pre-clearing extent and an area less than 500 ha in total extent, or that have a remnant extent less than 200 ha, or that are at risk of the remnant extent falling below 200 ha. One critically limited RE, 11.9.6 (*Acacia melvillei* +/- *Acacia harpophylla* open forest on fine-grained sedimentary rocks), is mapped within ATP 868P. No other GFD Project tenures contain any critically limited REs as mapped on the DEHP certified RE mapping that has been refined via Aurecon field assessment.

9.2.1.3.6 High value regrowth vegetation

Mapped patches of Endangered, Of Concern and Least Concern high value regrowth are present throughout the GFD Project tenures. The largest patches of regrowth vegetation are present in 526P, ATP 804P, ATP 665P, PL 236, PL 9 and ATP 803P. The remaining GFD project tenures also contain areas of mapped HVR but to a lesser extent. The patches of regrowth vegetation within the GFD Project tenures are generally in poor condition suffering from extensive weed invasion and disturbance from cattle grazing practices. Table 9-8 provides a summary of the extent of 'Endangered', 'Of concern' and 'Least concern' HVR in each project tenure.

Table 9-8 Summary of high value regrowth vegetation mapped in each GFD Project tenure

Region	Project tenure	Area (ha)^		
		Endangered	Of concern	Least concern
Arcadia	ATP 526P	1,331	117	3,495
	ATP 653P	773	758	151
	ATP 745P	1072	567	214
	ATP 804P	1296	108	921
	PL 233	-	-	11
	PL 234	638	128	69
	PL 235	-	271	297
	PL 236	294	866	1,232
Fairview	ATP 655P	364	212	-
	PL 100	106	314	470
	PL 232	132	350	113
	PL 90	79	188	590
	PL 91	2	206	270
	PL 92	182	323	568
	PL99	44	493	667
Roma	ATP 336P R	99	217	241
	ATP 631P	713	705	1,206
	ATP 665P	433	89	879
	ATP 708P	541	752	661
	PL 10	208	37	158
	PL 11	211	67	46
	PL 13	229	749	81
	PL 3	251	231	148
	PL 309	291	201	633
	PL 310	200	174	106
	PL 314	225	195	27

Region	Project tenure	Area (ha)^		
		Endangered	Of concern	Least concern
	PL 315	383	153	35
	PL 6	367	270	1
	PL 7	652	160	-
	PL 8	123	37	-
	PL 9	328	1,215	134
	PL 93	6	14	-
Scotia	ATP 803P	1120	856	667
	ATP 868P	573	825	10
	PL 176	56	412	117

Source: Aurecon 2014b, Table 4.15

Table notes:

^ = All areas are approximate and are based on DEHP Regrowth Vegetation mapping, version 2.1 ;

- = No HVR vegetation located within the GFD Project tenure.

9.2.1.3.7 Conservation significant flora species

Seven conservation significant flora species listed under the provisions of the NC Act were recorded in the gas fields during the previous field assessments conducted by Aurecon (refer Table 9-9).

Six flora species listed under the provisions of the NC Act were recorded in the GFD Project area during the EIS field assessments conducted by Aurecon. This includes an additional two conservation significant species listed as 'Near threatened' under the provisions of the NC Act, *Bertya pedicellata* and *Livistona nitida* (Canarvon fan palm). *Livistona nitida* is also listed as a 'Type A restricted plant' under the NC Act. Table 9-9 outlines the conservation significant flora species identified during the previous field assessments and the EIS field assessments.

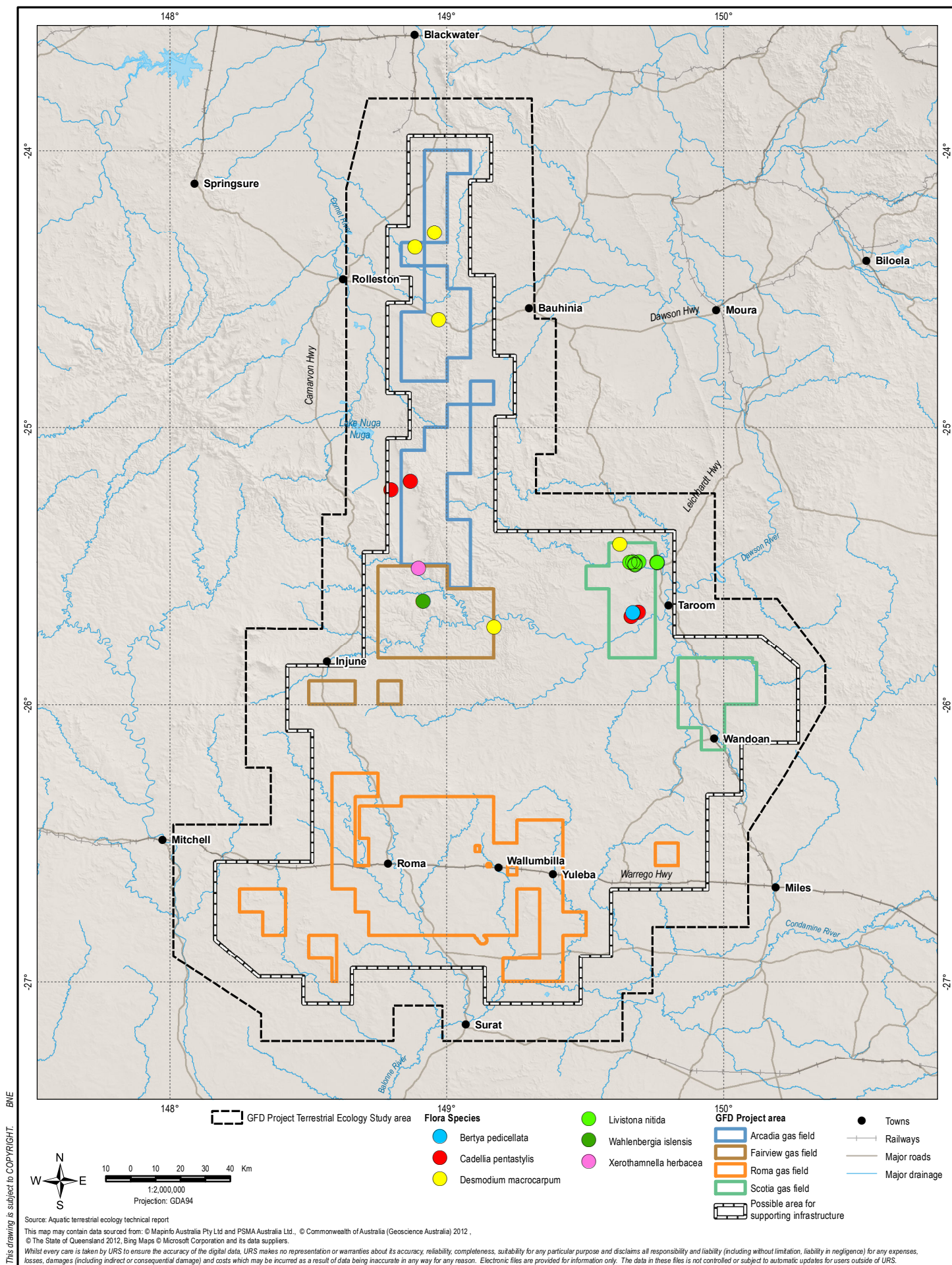
Figure 9-6 illustrates the location of the conservation significant species observed during the EIS field assessments.

Table 9-9 Conservation significant flora species Identified by Aurecon within the GFD Project area

Family name	Species name	Common name	Conservation status (NC Act)
Acanthaceae	<i>Xerothamnella herbacea</i> ^{1,2}	Xerothamnella	Endangered
Arecaceae	<i>Livistona nitida</i> ¹	Carnarvon Fan Palm	Near threatened
Campanulaceae	<i>Wahlenbergia islensis</i> ^{1,2}	Australian bluebell	Near threatened
Epacridaceae	<i>Leucopogon grandiflorus</i> ²	Whorl-leaved Heath	Near threatened
Euphorbiaceae	<i>Bertya pedicellata</i> ¹	-	Near threatened
Fabaceae	<i>Desmodium macrocarpum</i> ^{1,2}	Large-leaved desmodium	Near threatened
Mimosaceae	<i>Acacia islana</i> ²	Isla Gorge wattle	Vulnerable
Myrtaceae	<i>Melaleuca irbyana</i> ²	Swamp tea-tree	Endangered
Surianaceae	<i>Cadellia pentastylis</i> ^{1,2}	Ooline	Vulnerable

Source: Aurecon 2014b, Table 4.17

- = Not listed; 1 = species observed during EIS field assessments; 2 = species observed during previous Aurecon field assessments.



9.2.1.4 Flora species

A total of 79 conservation significant flora species listed under the provisions of the NC Act are predicted or are known to occur in the GFD Project area (refer Table 9-10) (Aurecon 2014b).

Seventy-seven species listed under the provisions of the NC Act are known to occur within the GFD Project area based on specimen-backed records in the Wildlife Online, HERBRECS and Atlas of Living Australia databases (refer Table 9-10).

Based on the likelihood of occurrence assessment, 73 flora species are known to occur within the tenures of the GFD Project area, due to the presence of suitable habitat and historic records. Five flora species are predicted to occur in the area and suitable habitat is present in some tenures of the GFD Project area. Therefore, these five species are considered to have a moderate likelihood of occurrence (refer Table 9-10).

One flora species, *Logania diffusa*, was recorded more than 30 years ago approximately 9 km north of the GFD Project area (Queensland Herbarium 2014). Due to the age of the historic record and the proximity to the GFD Project area, this species is considered to have a low likelihood of occurrence and therefore has been excluded from further assessment.

Table 9-10 Conservation significant flora species identified from database searches

Family	Scientific name	Common name	Status *		Data source		Likelihood of occurrence
			NC Act	HERBRECS	Wildlife Online	Atlas of Living Australia	
Acanthaceae	<i>Xerothamnella herbacea</i>	Xerothamnella	E	X	X	X	Known to occur
Apocynaceae	<i>Cerbera dumicola</i>	-	NT	X	X	X	Known to occur
Arecaceae	<i>Livistona fulva</i>	Blackdown Tablelands palm	NT	X	X	X	Known to occur
Arecaceae	<i>Livistona nitida</i>	Carnarvon fan palm	NT	X	X	X	Known to occur
Asclepidaceae	<i>Tylophora linearis</i>	Thin-leaved tylophora	E	-	-	-	Moderate likelihood of occurrence
Asteraceae	<i>Cymbonotus maidenii</i>	Darling daisy	E	X	X	-	Known to occur
Asteraceae	<i>Picris barbarorum</i>	Plains picris	V	X	X	-	Known to occur
Asteraceae	<i>Rutidosia crispata</i>	-	V	X	X	-	Known to occur
Asteraceae	<i>Rutidosia glandulosa</i>	-	NT	X	X	-	Known to occur
Asteraceae	<i>Rutidosia lanata</i>	-	E	X	-	X	Known to occur
Byttneriaceae	<i>Commersonia pearnii</i>	-	E	X	-	-	Known to occur
Caesalpiniaceae	<i>Senna acclinis</i>	Rainforest cassia	NT	X	X	-	Known to occur
Campanulaceae	<i>Wahlenbergia islensis</i>	Cliff bluebell	NT	X	X	X	Known to occur
Celastraceae	<i>Apatophyllum teretifolium</i>	Sandstone prickly bush	NT	X	X	-	Known to occur
Cupressaceae	<i>Callitris baileyi</i>	Bailey's cypress	NT	-	-	X	Known to occur
Cyperaceae	<i>Cyperus clarus</i>	-	V	X	-	X	Known to occur
Cyperaceae	<i>Eleocharis blakeana</i>	-	NT	X	X	X	Known to occur

Family	Scientific name	Common name	Status *		Data source		Likelihood of occurrence
			NC Act	HERBRECS	Wildlife Online	Atlas of Living Australia	
Ericaceae	<i>Leucopogon grandiflorus</i>	Large-flowered beard-heath	NT	X	X	X	Known to occur
Eriocaulaceae	<i>Eriocaulon carsonii</i>	Salt pipewort	E	X	X	X	Known to occur
Euphorbiaceae	<i>Bertya opposens</i>	-	C	-	X	X	Known to occur
Euphorbiaceae	<i>Bertya pedicellata</i>	-	NT	X	X	X	Known to occur
Fabaceae	<i>Daviesia discolor</i>	Bitter pea	V	X	-	X	Known to occur
Fabaceae	<i>Daviesia quoquoversus</i>	-	V	X	X	-	Known to occur
Fabaceae	<i>Desmodium macrocarpum</i>	Large-podded trefoil	NT	X	X	X	Known to occur
Fabaceae	<i>Swainsona murrayana</i>	Slender darling-pea	V	-	-	-	Moderate likelihood of occurrence
Fabaceae	<i>Zornia pallida</i>	-	NT	X	-	X	Known to occur
Haloragaceae	<i>Myriophyllum artesium</i>	Milfoil	E	X	X	X	Known to occur
Lamiaceae	<i>Plectranthus blakei</i>	-	NT	X	X	-	Known to occur
Lamiaceae	<i>Westringia parvifolia</i>	-	V	-	-	-	Moderate likelihood of occurrence
Loganiaceae	<i>Logania diffusa</i>	-	V	X	-	X	Low likelihood of occurrence
Loranthaceae	<i>Lysiana filifolia</i>	-	NT	X	-	-	Known to occur
Mimosaceae	<i>Acacia argentina</i>	-	V	X	X	X	Known to occur
Mimosaceae	<i>Acacia barakulensis</i>	Waajie wattle	V	-	X	-	Known to occur
Mimosaceae	<i>Acacia calantha</i>	Cracow wattle	NT	X	X	X	Known to occur

Family	Scientific name	Common name	Status *		Data source		Likelihood of occurrence
			NC Act	HERBRECS	Wildlife Online	Atlas of Living Australia	
Mimosaceae	<i>Acacia curranii</i>	Curly-bark wattle	V	X	X	X	Known to occur
Mimosaceae	<i>Acacia grandifolia</i>	-	C	-	X	-	Known to occur
Mimosaceae	<i>Acacia islana</i>	Isla Gorge wattle	V	X	X	X	Known to occur
Mimosaceae	<i>Acacia spania</i>	Western rosewood	NT	X	X	X	Known to occur
Mimosaceae	<i>Acacia storyi</i>	-	NT	X	X	X	Known to occur
Mimosaceae	<i>Acacia tenuinervis</i>	-	NT	-	X	X	Known to occur
Mimosaceae	<i>Acacia wardellii</i>	Thomby Range wattle	V	X	X	X	Known to occur
Myrtaceae	<i>Calytrix gurlmundensis</i>	-	V	X	X	X	Known to occur
Myrtaceae	<i>Calytrix islensis</i>	-	V	X	X	X	Known to occur
Myrtaceae	<i>Eucalyptus beaniana</i>	Bean's ironbark	V	-	-	X	Known to occur
Myrtaceae	<i>Eucalyptus curtisii</i>	Plunket mallee	NT	X	X	X	Known to occur
Myrtaceae	<i>Eucalyptus pachycalyx</i> subsp. <i>waajensis</i>	Pumpkin gum	E	X	X	-	Known to occur
Myrtaceae	<i>Eucalyptus sideroxylon</i> subsp. <i>improcera</i>	-	V	-	X	-	Known to occur
Myrtaceae	<i>Homoranthus decasetus</i>	-	NT	X	X	X	Known to occur
Myrtaceae	<i>Homoranthus decumbens</i>	A shrub	V	-	X	X	Known to occur
Myrtaceae	<i>Melaleuca groveana</i>	Grove's paper-bark	NT	X	X	X	Known to occur
Myrtaceae	<i>Melaleuca irbyana</i>	Swamp tea-tree	E	X	X	X	Known to occur
Myrtaceae	<i>Melaleuca pearsonii</i>	-	NT	X	-	-	Known to occur

Family	Scientific name	Common name	Status *		Data source		Likelihood of occurrence
			NC Act	HERBRECS	Wildlife Online	Atlas of Living Australia	
Myrtaceae	<i>Micromyrtus carinata</i>	Gurulmundi heath-myrtle	E	X	X	X	Known to occur
Myrtaceae	<i>Micromyrtus patula</i>	-	E	-	X	-	Known to occur
Myrtaceae	<i>Ochrosperma obovatum</i>	-	V	X	X	-	Known to occur
Myrtaceae	<i>Sannantha brachypoda</i>	-	NT	X	X	X	Known to occur
Oleaceae	<i>Notelaea pungens</i>	-	NT	X	-	X	Known to occur
Orchidaceae	<i>Chiloglottis longiclavata</i>	Northern wasp orchid	NT	-	-	X	Known to occur
Orchidaceae	<i>Phaius australis</i>	Swamp orchid	E	X	X	X	Known to occur
Orchidaceae	<i>Pterostylis cobarensis</i>	Cobar greenhood orchid	C	-	-	-	Moderate likelihood of occurrence
Picrodendraceae	<i>Pseudanthus pauciflorus</i>	-	NT	X	X	-	Known to occur
Poaceae	<i>Amphibromus whitei</i>	-	EX	X	-	X	Known to occur
Poaceae	<i>Aristida annua</i>	-	V	X	-	X	Known to occur
Poaceae	<i>Arthraxon hispidus</i>	Hairy-joint grass	V	X	X	X	Known to occur
Poaceae	<i>Dichanthium queenslandicum</i>	King bluegrass	V	X	X	X	Known to occur
Poaceae	<i>Dichanthium setosum</i>	Blue grass	NT	-	-	X	Known to occur
Poaceae	<i>Homopholis belsonii</i>	Belson's panic	E	X	X	X	Known to occur
Poaceae	<i>Sporobolus partimpatens</i>	-	NT	X	X	-	Known to occur
Proteaceae	<i>Hakea fraseri</i>	Fraser's hakea	C	-	-	X	Known to occur
Rhamnaceae	<i>Cryptandra ciliata</i>	Silky Cryptandra	NT	X	X	X	Known to occur
Santalaceae	<i>Thesium australe</i>	Toad flax	V	X	-	X	Known to occur

Family	Scientific name	Common name	Status *		Data source		Likelihood of occurrence
			NC Act	HERBRECS	Wildlife Online	Atlas of Living Australia	
Solanaceae	<i>Solanum dissectum</i>	-	E	X	X	-	Known to occur
Solanaceae	<i>Solanum elaeagnifolium</i>	-	E	X	X	-	Known to occur
Solanaceae	<i>Solanum papaverifolium</i>	-	E	X	X	-	Known to occur
Solanaceae	<i>Solanum stenopterum</i>	-	V	X	-	X	Known to occur
Surianaceae	<i>Cadellia pentastylis</i>	Ooline	V	X	X	X	Known to occur
Thelypteridaceae	<i>Thelypteris confluent</i>	Swamp fern	V	X	-	X	Known to occur
Zamiaceae	<i>Macrozamia platyrhachis</i>	Cycad	E	X	X	X	Known to occur

Source: Aurecon 2014b, Table 4.1

Table notes:

- = Species not listed or no common name

EX = Extinct

E = Endangered V = Vulnerable

NT = Near threatened NC Act = Nature Conservation Act 1992 (Qld)

C = Least concern

9.2.1.4.1 Essential habitat

Essential Habitat for ten conservation significant flora species has been mapped in the GFD Project area (refer Table 9-11). Essential Habitat for flora species is mapped in all gas fields within PL 233, PL 234, PL 235, PL 90, PL 91, PL 99, PL 100, PL 315, ATP 708P and ATP 803P.

Table 9-11 Essential Habitat mapped for conservation significant flora species within GFD Project area

Gas field	GFD Project tenure	Scientific name	Common name	NC Act status
Arcadia	PL 233	<i>Eucalyptus beaniana</i>	Bean's ironbark	V
	PL 234	<i>Xerothamnella herbacea</i>	Xerothamnella	E
	PL 235	<i>Calytrix islensis</i>	-	V
Fairview	PL 90	<i>Acacia islana</i>	Isla Gorge wattle	V
		<i>Xerothamnella herbacea</i>	Xerothamnella	E
	PL 91	<i>Melaleuca irbyana</i>	Swamp tea-tree	E
	PL 92	<i>Melaleuca irbyana</i>	Swamp tea-tree	E
	PL 99	<i>Eriocaulon carsonii subsp. orientale</i>	Salt pipewort	E
	PL 100	<i>Acacia islana</i>	Isla Gorge wattle	V
Roma	PL 315	<i>Homopholis belsonii</i>	Belson's panic	E
		<i>Picris barbarorum</i>	Plains picris	V
	ATP 708P	<i>Solanum papaverifolium</i>	-	E
Scotia	ATP 803P	<i>Cadellia pentastylis</i>	Ooline	V

Source: Aurecon 2014, Table 4.2

Table notes:

- = Species not listed or no common name

E = Endangered

CE = Critically Endangered

V = Vulnerable

9.2.1.4.2 Priority 'Back on Track' flora species

The Back on Track species prioritisation framework ('Back on Track') is an initiative of DEHP and is based on the method of Marsh et al. (2007), that ranks species as 'Critical', 'High', 'Medium' or 'Low' priority for the State and for the National Resource Management (NRM) region. There is also a 'data deficient' category according to three sets of criteria: probability of extinction, consequences of extinction and potential for successful recovery.

The GFD Project area covers two NRM regions: the Fitzroy NRM region and the Border Rivers Maranoa-Balonne NRM region. There are 336 'Back on Track' flora species identified for the Fitzroy NRM region and 261 'Back on Track' flora species identified for the Border Rivers Maranoa-Balonne NRM region (Aurecon, 2014b).

9.2.1.4.3 Brigalow Belt South priority flora species

Under the BAMB (DEHP, 2002), expert panels are convened to review and refine the results of initial determination of significance of the Biodiversity Planning Assessment framework (DEHP and Environmental Planning Southwest Queensland 2002a; 2002c; 2002d) at a Bioregional scale. These panels provide recommendations in relation to habitat for conservation significant species and Essential Habitat for priority taxa.

Nine priority taxa flora species for the Brigalow Belt South bioregion (not listed under the provisions of the NC Act) are known to be present in the GFD Project area. These species include *Acacia melvillei* (Melville's wattle), *Acacia omalophylla* (Yarran wattle), *Corchorus reynoldsiae*, *Corymbia bloxsomei* (Yellow bloodwood), *Eucalyptus baileyana* (Bailey's stringybark), *Eucalyptus bakeri* (Baker's mallee), *Eucalyptus melanoleuca* (Nanango's ironbark), *Eucalyptus rhombica* and *Eucalyptus suffulgens*. These species are mapped within PL 90 and PL 91 in the Fairview gas fields, as well as PL 234 and ATP 526P in the Arcadia gas fields.

All other priority taxa flora species for the Brigalow Belt South bioregion are listed as conservation significant under the provisions of the NC Act.

9.2.1.5 Fauna species

Based on database searches, 48 fauna species of conservation significance are known or are predicted to occur in the study area, including species listed under the provisions of the NC Act (refer Table 9-12). This includes one arthropod, 1 fish, 2 amphibians, 22 birds, 14 reptiles and 8 mammals. Twenty-two fauna species listed under the provisions of the NC Act are predicted to occur in the GFD Project area based on the EPBC Act Protected Matters Search Report.

Forty-two species listed under the provisions of the NC Act are also known to occur based on specimen-backed records in the Wildlife Online, Queensland Museum, Birds Australia and Atlas of Living Australia databases (refer Table 9-12).

Table 9-12 Conservation significant fauna species identified from database searches

Class	Common name	Scientific name	Status*	Data source					Likelihood of occurrence
			NC Act	Queensland Museum Records	EPBC Act Protected Matters Search Tool	Wildlife Online	Birds Australia	Atlas of Living Australia	
Amphibians	Cooloola tree frog	<i>Litoria cooloolensis</i>	NT	-	-	-	-	X	Low likelihood of occurrence
Amphibians	Rough frog	<i>Cyclorana verrucosa</i>	NT	X	-	X	-	X	Known to occur
Arthropods	Pale imperial hairstreak butterfly	<i>Jalmenus eubulus</i>	V	-	-	X	-	-	Known to occur
Aves	Australasian bittern	<i>Botaurus poiciloptilus</i>	C	-	X	-	-	-	Moderate likelihood of occurrence
Aves	Australian painted snipe	<i>Rostratula australis</i>	V	X	X	X	X	X	Known to occur
Aves	Black-breasted button-quail	<i>Turnix melanogaster</i>	V	-	X	X	-	-	Moderate likelihood of occurrence
Aves	Black-chinned honeyeater	<i>Melithreptus gularis</i>	NT	X	-	X	X	X	Known to occur
Aves	Black-necked stork	<i>Ephippiorhynchus asiaticus</i>	NT	-	-	X	X	X	Known to occur
Aves	Black-throated finch	<i>Poephila cincta</i>	E	-	X	-	-	-	Moderate likelihood of occurrence

Class	Common name	Scientific name	Status*	Data source					Likelihood of occurrence
			NC Act	Queensland Museum Records	EPBC Act Protected Matters Search Tool	Wildlife Online	Birds Australia	Atlas of Living Australia	
Aves	Cotton pygmy-goose	<i>Nettapus coromandelianus</i>	NT	X	-	X	X	X	Known to occur
Aves	Freckled duck	<i>Stictonetta naevosa</i>	NT	-	-	X	-	X	Known to occur
Aves	Glossy black-cockatoo	<i>Calyptorhynchus lathami</i>	V	X	-	X	X	X	Known to occur
Aves	Grey goshawk	<i>Accipiter novaehollandiae</i>	NT	-	-	-	-	X	Known to occur
Aves	Major mitchell's cockatoo	<i>Lophochroa leadbeateri</i>	V	-	-	X	X	-	Known to occur
Aves	Painted honeyeater	<i>Grantiella picta</i>	V	-	-	X	X	-	Known to occur
Aves	Paradise parrot	<i>Psephotus pulcherrimus</i>	EX	-	-	X	-	X	Low likelihood of occurrence
Aves	Plains-wanderer	<i>Pedionomus torquatus</i>	V	-	-	-	-	X	Moderate likelihood of occurrence
Aves	Powerful owl	<i>Ninox strenua</i>	V	-	-	X	-	-	Known to occur
Aves	Red goshawk	<i>Erythrotriorchis radiatus</i>	E	-	X	-	-	X	Moderate likelihood of occurrence
Aves	Square-tailed kite	<i>Lophoictinia isura</i>	NT	-	-	X	-	X	Known to occur
Aves	Squatter pigeon	<i>Geophaps scripta</i>	V	X	X	X	X	X	Known to occur

Class	Common name	Scientific name	Status*	Data source					Likelihood of occurrence
			NC Act	Queensland Museum Records	EPBC Act Protected Matters Search Tool	Wildlife Online	Birds Australia	Atlas of Living Australia	
Aves	Star finch	<i>Neochmia ruficauda</i>	E	-	X	-	-	X	Moderate likelihood of occurrence
Aves	Superb parrot	<i>Polytelis swainsonii</i>	C	-	X	-	-	X	Moderate likelihood of occurrence
Aves	Swift parrot	<i>Lathamus discolor</i>	E	-	X	-	-	-	Moderate likelihood of occurrence
Aves	Turquoise Parrot	<i>Neophema pulchella</i>	NT	-	-	-	-	X	Known to occur
Fish	Murray cod	<i>Maccullochella peelii</i>	C	-	X	-	-	-	Moderate likelihood of occurrence
Mammals	Bridled nail-tail wallaby	<i>Onychogalea fraenata</i>	E	-	-	-	-	X	Known to occur
Mammals	Brush-tailed rock-wallaby	<i>Petrogale penicillata</i>	V	-	X	-	-	-	Known to occur
Mammals	Grey-headed flying-fox	<i>Pteropus poliocephalus</i>	C	-	X	X	-	-	Known to occur
Mammals	Koala	<i>Phascolarctos cinereus</i>	V (SEQ), S	X	X	X	-	X	Known to occur

Class	Common name	Scientific name	Status*	Data source					Likelihood of occurrence
			NC Act	Queensland Museum Records	EPBC Act Protected Matters Search Tool	Wildlife Online	Birds Australia	Atlas of Living Australia	
Mammals	Large pied bat	<i>Chalinolobus dwyeri</i>	V	X	X	X	-	-	Known to occur
Mammals	Little pied bat	<i>Chalinolobus picatus</i>	NT	X	-	X	-	X	Known to occur
Mammals	Northern quoll	<i>Dasyurus hallucatus</i>	C	-	X	X	-	-	Moderate likelihood of occurrence
Mammals	South-eastern long-eared bat	<i>Nyctophilus corbeni</i>	C	-	X	X	-	X	Known to occur
Reptiles	Brigalow scaly-foot	<i>Paradelma orientalis</i>	V	X	-	X	-	X	Known to occur
Reptiles	Collared delma	<i>Delma torquata</i>	V	X	X	X	-	X	Known to occur
Reptiles	Collett's Snake	<i>Pseudechis colletti</i>	NT	-	-	-	-	X	Moderate likelihood of occurrence
Reptiles	Common death adder	<i>Acanthophis antarcticus</i>	NT	X	-	X	-	X	Known to occur
Reptiles	Darling Downs earless dragon	<i>Tympanocryptis tetraporophora</i>	E	-	-	X	-	-	Known to occur
Reptiles	Dunmall's snake	<i>Furina dunmali</i>	V	X	X	X	-	X	Known to occur

Class	Common name	Scientific name	Status*	Data source					Likelihood of occurrence
			NC Act	Queensland Museum Records	EPBC Act Protected Matters Search Tool	Wildlife Online	Birds Australia	Atlas of Living Australia	
Reptiles	Eyrean Earless Dragon	<i>Tympanocryptis tetraporophora</i>	E	-	-	-	-	X	Moderate likelihood of occurrence
Reptiles	Fitzroy river turtle	<i>Rheodytes leukops</i>	V	X	X	-	-	-	Known to occur
Reptiles	Five-clawed worm-skink	<i>Anomalopus mackayi</i>	E	-	X	-	-	-	Moderate likelihood of occurrence
Reptiles	Golden-tailed gecko	<i>Strophurus taenicauda</i>	NT	X	-	X	-	X	Known to occur
Reptiles	Grey snake	<i>Hemiaspis damelii</i>	E	-	-	X	-	X	Known to occur
Reptiles	Ornamental snake	<i>Denisonia maculata</i>	V	X	X	X	-	X	Known to occur
Reptiles	Woma	<i>Aspidites ramsayi</i>	NT	X	-	X	-	X	Known to occur
Reptiles	Yakka skink	<i>Egernia rugosa</i>	V	X	X	X	-	X	Known to occur

Source: Aurecon 2014b, Table 4.3

Table notes:

- = Species not listed C = Least concern
 S = Special least concern E = Endangered
 PE = Presumed extinct EX = Extinct
 NT = Near threatened V = Vulnerable
 NC Act = Nature Conservation Act 1992 (Qld)

Based on the likelihood of occurrence assessment, 33 species are known to occur within the tenures of the GFD Project area due to the presence of suitable habitat and historic records. In addition, 13 fauna species are predicted to occur in the area. Suitable habitat is present in some tenures of the GFD Project area and are therefore considered to have a moderate likelihood of occurrence. There are two fauna species that are considered to have a low likelihood of occurrence within the GFD Project area based on no historic records, unavailability of suitable habitat, or are locally extinct (refer Table 9-12).

9.2.1.5.1 Essential habitat

Essential Habitat for eight conservation significant fauna species has been mapped in the GFD Project area (refer Table 9-13). Essential Habitat for fauna species is mapped in the Arcadia, Roma and Scotia gas fields within PL 233, PL 234, PL 235, PL 3, PL 6, PL 8, PL 310 and ATP 803P.

Table 9-13 Essential Habitat mapped for conservation significant fauna species within the GFD Project tenures

Gas field	GFD Project tenure	Scientific name	Common name	NC Act status
Arcadia	PL 233	<i>Chalinolobus dwyeri</i>	Large-eared pied bat	V
		<i>Delma torquata</i>	Collared delma	V
		<i>Geophaps scripta scripta</i>	Squatter pigeon	V
		<i>Paradelma orientalis</i>	Brigalow scaly-foot	V
	PL 234	<i>Chalinolobus dwyeri</i>	Large-eared pied bat	V
		<i>Delma torquata</i>	Collared delma	V
		<i>Geophaps scripta scripta</i>	Squatter pigeon	V
		<i>Paradelma orientalis</i>	Brigalow scaly-foot	V
	PL 235	<i>Chalinolobus dwyeri</i>	Large-eared pied bat	V
		<i>Delma torquata</i>	Collared delma	V
		<i>Geophaps scripta scripta</i>	Squatter pigeon	V
		<i>Paradelma orientalis</i>	Brigalow scaly-foot	V
Roma	PL 3	<i>Egernia rugosa</i>	Yakka skink	V
	PL 6	<i>Grantiella picta</i>	Painted honeyeater	V
	PL 8	<i>Paradelma orientalis</i>	Brigalow scaly-foot	V
	PL 310	<i>Paradelma orientalis</i>	Brigalow scaly-foot	V
Scotia	ATP 803P	<i>Jalmenus eubulus</i>	Imperial hairstreak (northern subspecies)	V
		<i>Nyctophilus corbeni</i>	Greater long-eared bat	V
		<i>Paradelma orientalis</i>	Brigalow scaly-foot	V

Source: Aurecon 2014b, Table 4.4

Table notes:

- = Species not listed or no common name

V = Vulnerable

NC Act = Nature Conservation Act 1992 (Qld)

9.2.1.5.2 Priority 'Back on Track' fauna species

Back on Track is an initiative of DEHP and is based on the method of Marsh et al. (2007), that ranks species as 'Critical', 'High', 'Medium' or 'Low' priority, or 'data deficient' for the State and for the NRM region.

The areas assessed cover two NRM regions: the Fitzroy NRM region and the Border Rivers Maranoa-Balonne NRM region. There are 789 'Back on Track' terrestrial vertebrate fauna species identified for the Fitzroy NRM region and 606 'Back on Track' terrestrial vertebrate fauna species identified for the Border Rivers Maranoa-Balonne NRM region (Queensland Government 2009a).

9.2.1.5.3 Fauna biodiversity

Table 9-14, Table 9-15, Table 9-16 and Table 9-17 demonstrate the biodiversity of native and non-native fauna species observed within the GFD Project area.

Table 9-14 Native and non-native fauna diversity observed within the GFD Project area

Fauna diversity	Fairview/ Arcadia	Roma	Scotia	Total species diversity
Number of native species observed	205	149	100	251
Number of non-native species observed	11	13	3	16
Average number of native species observed per site	9.36	6.80	5.37	-
Average number of non-native species observed per site	0.38	0.28	0.07	-

Source: Aurecon 2014b, Table 4.19

Table 9-15 Fauna diversity grouped by class observed within the GFD Project area

Class	Fairview/ Arcadia	Roma	Scotia	Total species diversity in the GFD Project area
Amphibians	9	5	4	13
Aves	142	108	75	169
Gastropods	1	0	5	5
Mammals	40	35	12	49
Reptiles	23	15	4	32
Total species diversity per gas field	215	163	103	-

Source: Aurecon 2014b, Table 4.21

Table 9-16 Average number of fauna species grouped by class observed per site

Class	Fairview/Arcadia	Roma	Scotia
Amphibians	0.06	0.06	0.07
Aves	7.27	5.32	4.87
Gastropods	0.02	0.00	0.16
Mammals	1.80	1.44	0.27
Reptiles	0.59	0.26	0.09

Source: Aurecon 2014b, Table 4.22

Table 9-17 Standard deviations used for graphs that depict fauna diversity

Standard deviation	Fairview/Arcadia	Roma	Scotia
Amphibians	0.24	0.31	0.33
Aves	7.72	4.51	5.38
Gastropods	0.13	0.00	0.52
Mammals	3.33	2.14	0.94
Reptiles	1.06	0.53	0.36
Native fauna	9.46	5.41	5.96
Non-native fauna	0.63	0.54	0.25

Source: Aurecon 2014b, Table 4.23

At least 17 microbat species were detected during the recent Anabat call surveys conducted during the GFD field assessments.

Anabat recordings have confirmed the presence of at least one Long-eared Bat species (*Nyctophilus* sp.) within the GFD Project area. Bats of this genus are notoriously difficult to identify acoustically, and therefore call recordings for *Nyctophilus* species are considered indistinguishable. Four *Nyctophilus* species are known to occur within the range of the GFD Project area (*N. bifax*, *N. corbeni*, *N. geoffroyi* and *N. gouldi*). Of these, South-eastern long-eared bat (*Nyctophilus corbeni*; formerly *Nyctophilus timoriensis*) is the only species that is listed as 'Vulnerable' under the provisions of the NC Act. A *Nyctophilus* species was recorded at nine of the 23 survey locations. Suitable habitat for *N. corbeni* occurs within these survey locations, so it is considered likely that the South-eastern long-eared bat occurs within the GFD Project area.

Fifteen mammals were identified through trace analysis conducted by Barbara Triggs, during recent GFD EIS field assessments. These species were identified by analysing scats, hairs and owl pellets that were collected within the GFD Project area (Aurecon 2014).

9.2.1.5.4 Conservation significant fauna species

Seven conservation significant fauna species listed under the provisions of the NC Act were recorded in the gas fields during the previous field assessments conducted by Aurecon (refer Table 9-2).

Ten fauna species listed under the provisions of the NC Act were recorded in the GFD Project area during the EIS field assessments conducted by Aurecon. This includes an additional six conservation significant species listed under the provisions of the NC Act (refer Table 9-18).

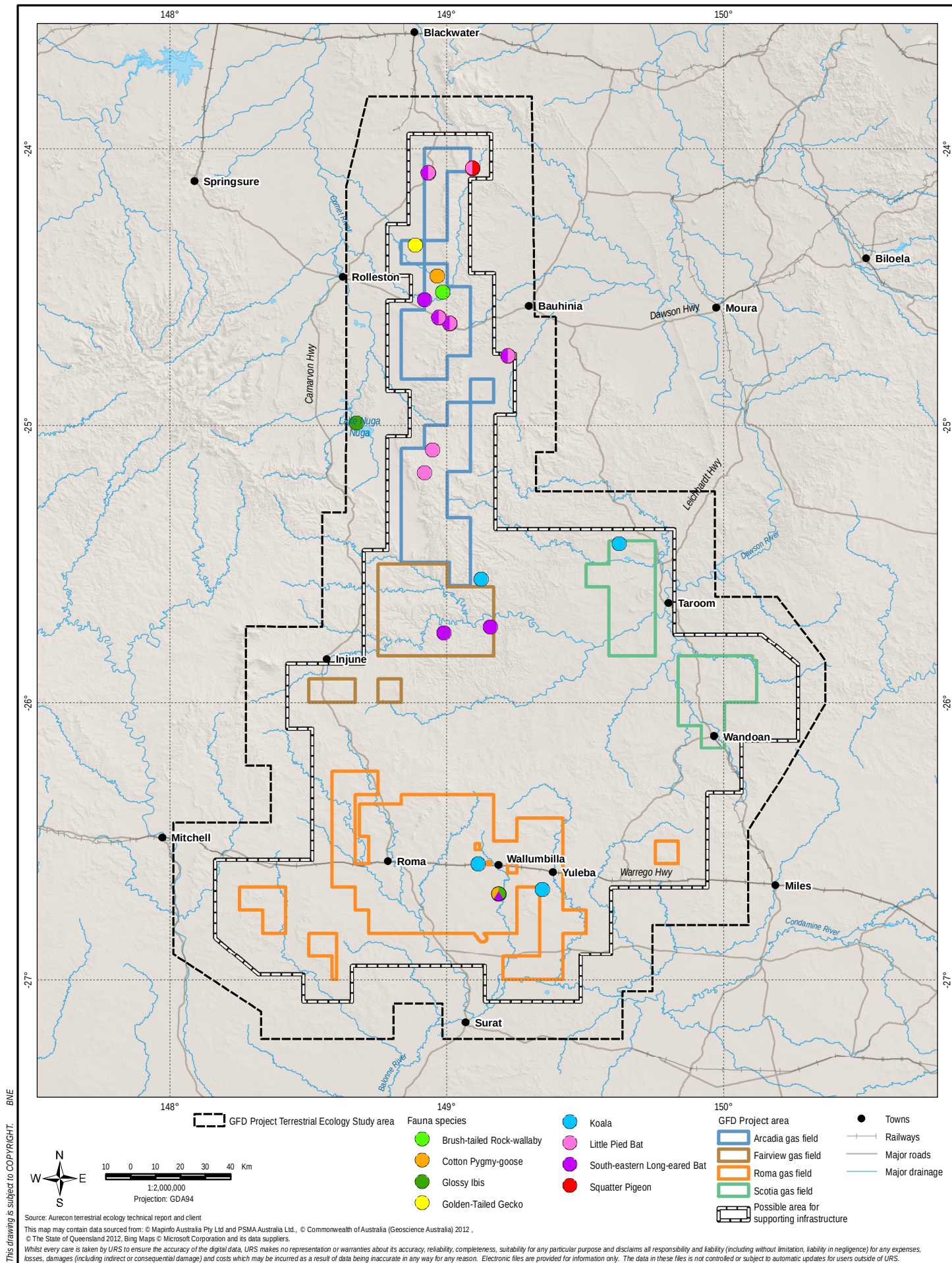
The conservation significant fauna species observed during the database are listed in Table 9-18. The locations of the conservation significant species observed during the EIS field assessments are presented in Figure 9-7.

Table 9-18 Conservation significant fauna species identified by Aurecon within the GFD Project area

Class	Common name	Species name	Conservation status
			NC Act status
Aves	Cotton pygmy-goose	<i>Nettapus coromandelianus</i> ¹	Near threatened
Aves	Glossy black-cockatoo	<i>Calyptorhynchus lathami</i> ²	Vulnerable
Aves	Glossy ibis	<i>Plegadis falcinellus</i> ¹	Special least concern
Aves	Rainbow bee-eater	<i>Merops ornatus</i> ¹	Special least concern
Aves	Red goshawk	<i>Erythrorhynchus radiatus</i> ²	Endangered
Aves	Squatter pigeon (southern sub-species)	<i>Geophaps scripta</i> ^{1,2}	Vulnerable
Mammals	Brush-tailed rock-wallaby	<i>Petrogale penicillata</i> ¹ (probable record)	Vulnerable
Mammals	Koala	<i>Phascolarctos cinereus</i> ^{1,2}	Vulnerable (SEQ); Special least concern
Mammals	Little pied bat	<i>Chalinolobus picatus</i> ¹	Near threatened
Mammals	Platypus	<i>Ornithorhynchus anatinus</i> ²	Special least concern
Mammals	Short-beaked echidna	<i>Tachyglossus aculeatus</i> ^{1,2}	Special least concern
Mammals	South-eastern long-eared Bat	<i>Nyctophilus</i> sp. (possibly <i>N. corbeni</i>) ¹	Least concern
Reptiles	Golden-tailed gecko	<i>Strophurus taenicauda</i> ^{1,2}	Near threatened

Source: Aurecon 2014b, Table 4.23

1 = Species observed during EIS field assessments; 2 = Species observed during previous Aurecon field assessments.



9.2.1.6 Weeds and pest animals

9.2.1.6.1 Weed species

Field assessments previously undertaken by Aurecon within the gas fields identified seven non-native flora species declared as pests under the *Land Protection Act* (LP Act). Five non-native flora species, declared as pests under the LP Act, were identified within the GFD Project and include one additional species, *Parthenium hysterophorus* (Parthenium), declared as a 'Class 2' pest under the LP Act. These declared pest species and their status under the LP Act are listed in Table 9-19.

Table 9-19 LP Act declared flora species identified by Aurecon in the GFD Project area

Family name	Species name	Common name	LP Act status*	Location and abundance
Asteraceae	<i>Parthenium hysterophorus</i> ¹	Parthenium	Class 2	This species has been recorded in the Arcadia gas fields in relatively low abundance
Cactaceae	<i>Harrisia martini</i> ²	Harrisia cactus	Class 2	This species has been recorded in the Arcadia, Roma and Fairview gas fields in relatively low abundance
Cactaceae	<i>Opuntia aurantiaca</i> ^{1,2}	Tiger pear	Class 2	This species has been recorded in the Roma and Arcadia gas fields in relatively low abundance
Cactaceae	<i>Opuntia stricta</i> ^{1,2}	Prickly pear	Class 2	This species has been recorded in the Roma, Fairview and Arcadia gas fields in moderate abundance
Cactaceae	<i>Opuntia tomentosa</i> ^{1,2}	Velvety tree pear	Class 2	This species has been recorded in the Roma, Arcadia, Scotia and Fairview gas fields in relatively high abundance
Mimosaceae	<i>Acacia nilotica</i> ²	Prickly acacia	Class 2	Present within Fairview gas fields with very low abundance
Solanaceae	<i>Lycium ferocissimum</i> ^{1,2}	African boxthorn	Class 2	This species has been recorded in the Scotia, Roma and Fairview gas fields in moderate abundance
Tamaricaceae	<i>Tamarix aphylla</i> ²	Athel pine	Class 3	Present within Fairview gas fields with very low abundance

Source: Aurecon 2014b, Table 4.18

1 = identified during EIS field assessments; 2 = identified during previous Aurecon field assessments.

9.2.1.6.2 Pest animal species

Five non-native fauna species, declared as pests under the LP Act, were identified within the gas fields during previous field assessments conducted by Aurecon (refer Table 9-20).

Six non-native fauna species, declared as pests under the LP Act, were identified within the GFD Project area during the recent EIS field assessments. This includes an additional two fauna pest species, including Goat (*Capra hircus*) and Red fox (*Vulpes vulpes*) (refer Table 9-20).

Table 9-20 LP Act declared fauna species identified by Aurecon within the GFD Project area

Class	Common name	Species name	LP Act status*
Mammal	Cat	<i>Felis catus</i> ^{1,2}	Class 2
Mammal	Dingo	<i>Canis lupus dingo</i> ²	Class 2
Mammal	Dog	<i>Canis lupus familiaris</i> ^{1,2}	Class 2
Mammal	European rabbit	<i>Oryctolagus cuniculus</i> ^{1,2}	Class 2
Mammal	Feral pig	<i>Sus scrofa</i> ^{1,2}	Class 2
Mammal	Goat	<i>Capra hircus</i> ¹	Class 2
Mammal	Red fox	<i>Vulpes</i> ¹	Class 2

Source: Aurecon 2014b, Table 4.24

Table notes:

Class 2 = Introduction, feeding, keeping, releasing and supplying is prohibited without a permit issued by Biosecurity Queensland. Landholders are required to control declared pests on their properties; * = Sourced from DAFF (2012); 1 = Species observed during EIS field assessments; 2 = Species observed during previous Aurecon field assessments.

9.2.2 Aquatic ecology

Based on the review of environmental values within the catchments of the Dawson River, Comet River and Condamine-Balonne River, 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 9-21.

Table 9-21 Presence of aquatic environmental values per GFD Project tenure

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

Source: URS 2013, Table 4-11

Notes:

X = present

- = not present

The aquatic ecology environmental values are summarised within the following subsections.

9.2.2.1 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 Project area and are listed under the *Nature Conservation (Wildlife) Regulation 2006*:

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

Elseya albagula (White-Throated Snapping Turtle) 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 Project area.

9.2.2.2 Watercourses

Environmental values are broadly defined in the *Environmental Protection (Water) Policy 2009* (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 (URS 2013). 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 macro-invertebrate species 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 harsh 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 might 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 might 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 might also be present in the GFD Project area (URS, 2013).

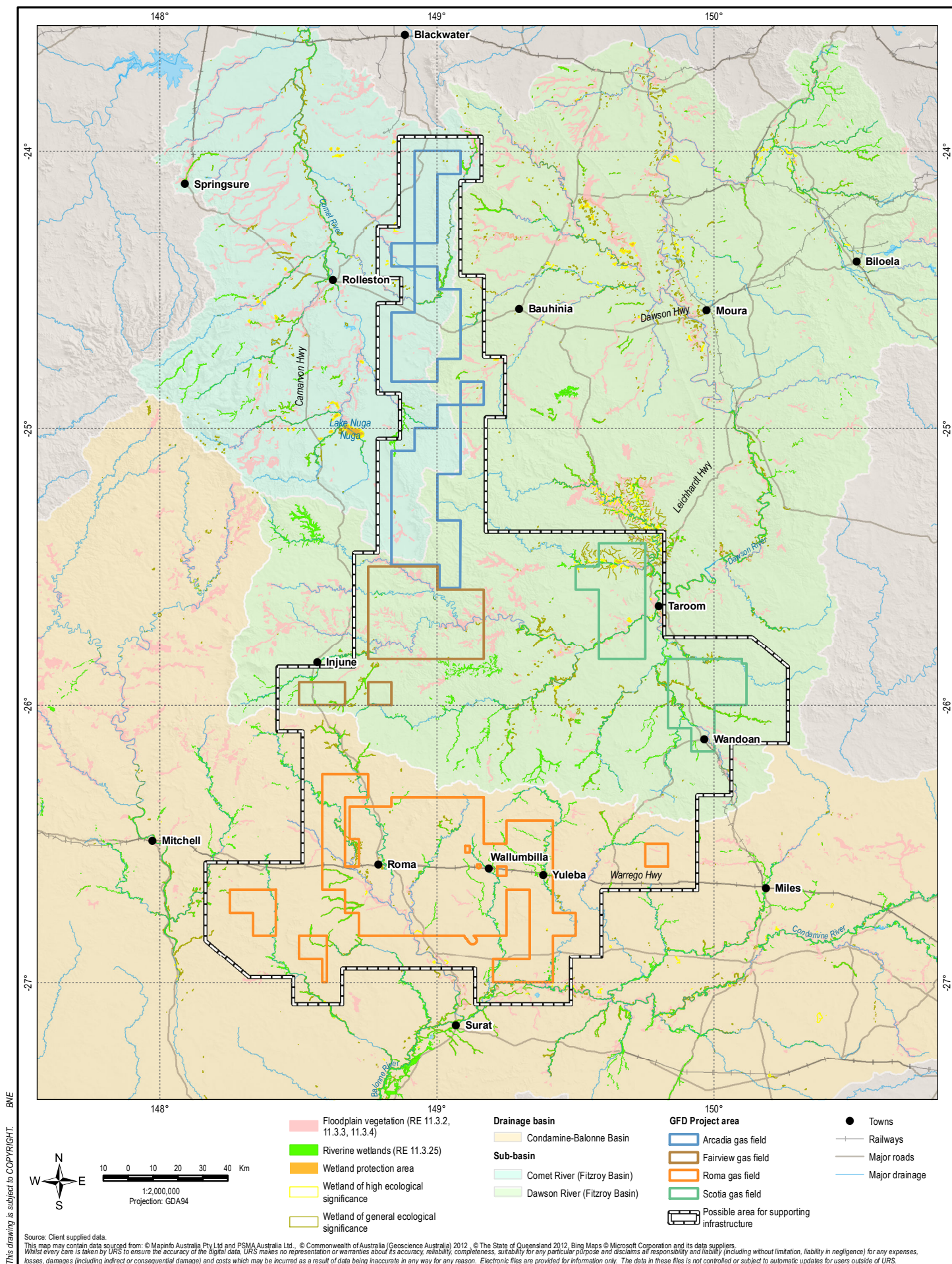
9.2.2.3 Wetlands and springs

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 are 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*; i.e. Lake Murphy, and part of the Palm Tree and Robinson Creeks Wetland Complex located in the Lake Murphy Conservation Park refer to (URS 2013).

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.

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 (URS 2013).



9.3 Potential impacts

The potential impacts to biodiversity were considered in terms of their context, intensity, duration, magnitude and geographic extent. The majority of biodiversity impacts are likely to occur during the discrete construction period of this Project.

While at a regional level gas extraction activities will have a certain cumulative impact on the river and spring systems of the GFD Project area, these impacts are judged to be small, temporary and reversible. In some cases the impact will provide a positive benefit, such as where treated CS water is authorised to be 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.

The potential impact areas were determined by applying specific high level assumptions based on predictive gas resources as well as topography to the Constraints Planning Assessment Model. Based on these outputs, the no-go constraint areas were applied and the potential impacts to terrestrial ecology receptors from a combination of available government mapping, some field validation and known records within the GFD Project tenures were identified.

Table 9-22 Potential impacts to biodiversity

Potential impact associated with construction and operation of infrastructure type	Infrastructure type	Nature of disturbance	Typical disturbance associated with construction
Vegetation removal	Laydown Yards	Temporary	5 to 40 ha each
	Dams	Temporary	5 to 16 ha each
Vegetation and topsoil removal	Field Compression	Permanent	2 to 8 ha each
	Hub Compression	Permanent	2 to 40 ha each
	Well Pads	Temporary	1.5 to 2.5ha each
	Gas Transmission Pipelines	Temporary	2.5 to 5 ha/km
	Gathering Lines	Temporary	1 to 2.5 ha/km
	Borrow Pits	Temporary	5 to 50 ha each
	Tracks and Roads	Temporary	1.5 to 3 ha/km
	Water Treatment	Temporary	5 to 10 ha each
	Camps	Temporary	1 to 20 ha each
Species injury or mortality Soil compaction Weeds and feral species Biodiversity corridors Edge effects Habitat fragmentation Barrier effects Noise, dust, light and contaminant disturbance	Well Pads	Temporary	1.5 to 2.5 ha each
	Field Compression	Permanent	2 to 8 ha each
	Hub Compression	Permanent	2 to 40ha each
	Gas Transmission Pipelines	Temporary	2.5 to 5 ha/km
	Gathering Lines	Temporary	1 to 2.5 ha/km
	Borrow Pits	Temporary	5 to 50 ha each
	Tracks and Roads	Temporary	1.5 to 3 ha/km
	Water Treatment	Temporary	5 to 10 ha each
	Laydown Yards	Temporary	5 to 40 ha each
	Camps	Temporary	1 to 20 ha each
Soil dumping	Laydown Yards	Temporary	5 to 40 ha each
Litter	Camps	Temporary	1 to 20 ha each

Source: Aurecon 2014b

Table 9-23 Potential impacts on terrestrial ecology values and applicable management plans

Potential impact associated with construction and operation of infrastructure type	Applicable management plans
Habitat loss from vegetation removal/clearing	Constraints protocol SSMP FMP
Fauna species injury or mortality	Constraints protocol SSMP
Reduction in biological viability of soil to support growth due to soil compaction	Constraints protocol
Displacement of flora and fauna species from invasion of weeds and pest species	Constraints protocol PWMP
Biodiversity corridors Edge effects Habitat fragmentation Barrier effects	Constraints protocol SSMP PWMP FMP
Noise, dust, light and contaminant disturbance	Constraints protocol
Increase in litter (waste)	Constraints protocol WMP

Table 9-24 Potential impacts on aquatic ecology values and applicable management plans

Potential impacts	Construction phase activities	Operations phase activities	Decommissioning and rehabilitation phase activities	Applicable management plans
Impact (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	- Abandonment activities and earthworks - Traffic movement, particularly near waterways and at water course crossings - Sediment control infrastructure - Incomplete rehabilitation of disturbed areas	- Constraints protocol - Erosion and sediment control management plan - Land release management plan - Decommissioning and abandonment management plan - Rehabilitation management plan

Potential impacts	Construction phase activities	Operations phase activities	Decommissioning and rehabilitation phase activities	Applicable management plans
Impact (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	- Abandonment activities and earthworks - Traffic 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 - Erosion and sediment control management plan - Land release management plan - Decommissioning and abandonment management plan - Rehabilitation management plan
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 - Decommissioning and abandonment management plan - Rehabilitation management plan

Potential impacts	Construction phase activities	Operations phase activities	Decommissioning and rehabilitation phase activities	Applicable management plans
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	- 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	- Abandonment activities and earthworks - Traffic movement, particularly near waterways and at water course crossings	- Constraints protocol - Rehabilitation management plan - Erosion and sediment control management plan

Potential impacts	Construction phase activities	Operations phase activities	Decommissioning and rehabilitation phase activities	Applicable management plans
Loss of abundance and diversity of riparian vegetation and aquatic biota, including groundwater dependent ecosystems	• 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	• Abandonment activities and earthworks • Traffic movement, particularly near waterways and at water course crossings • Transfer of non-indigenous and exotic species • Fuel and contaminant spills	• Constraints protocol • Rehabilitation management plan • Erosion and sediment control manual. • Fauna management plan • Pest and weed management plan • Chemical and fuel management plan

9.4 Environmental protection objectives

In accordance with Santos GLNG's internal standards, the GFD Project will adopt the environmental protection objectives listed in Table 9-25 to protect the ecological characteristics of the Project area and surrounds.

Table 9-25 Environmental protection objectives

- Avoid or minimise adverse impacts on and protect terrestrial and aquatic ecosystems and associated biodiversity and habitat of state and national conservation significance
- Avoid or minimise habitat loss and fauna mortality.
- Avoid or minimise adverse impacts to ESAs
- Control the spread or introduction of new or existing exotic terrestrial and aquatic flora or fauna species.
- Where impacts are unavoidable and result in the significant residual adverse impact of an environmental value, environmental offsets will be obtained in accordance with both State and Commonwealth Government requirements.

9.5 Management controls

The impacts to the ecology and biodiversity values on the GFD Project site and surrounding area as a result of the construction and operation of the Project are manageable and can be generally considered short-term if successfully managed. The control strategies are presented in Table 9-26.

Although impacts to the receptors will be avoided, minimised and mitigated where practicable, in some instances unavoidable impacts will occur.

Santos GLNG will provide secured environmental offsets for approval where impacts are unavoidable and result in the permanent loss of an environmental value in accordance with both State and Commonwealth Government requirements.

Table 9-26 Management controls measures

Management plan	Key provisions/ function	Management control measures
Significant species management plan	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. Specifically, the SSMP: - Identifies and profiles conservation significant species that are present, or may occur, within the gas fields - Identifies key threats to conservation significant species 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 conservation significant species caused by Santos GLNG activities	Santos GLNG will implement the SSMP.
Fauna management plan	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.	- Santos GLNG will implement the FMP. - The FMP 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.

Management plan	Key provisions/ function	Management control measures
Rehabilitation management plan	The Rehabilitation management plan provides the framework for rehabilitating land that has been disturbed as part of gas field activities. The plan will 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 plan includes: - Standardised remediation and rehabilitation procedures in line with current best practice - Principles to mitigate and manage direct and indirect impacts to Environmentally sensitive areas Remediation, rehabilitation and recovery management actions for a range of land uses and disturbance levels including benchmark guidelines and rehabilitation schedules.	- Santos GLNG will implement the Rehabilitation management plan P. - Santos GLNG will transitionally rehabilitate significantly disturbed areas that are no longer required for the ongoing petroleum activities. These areas will be transitionally rehabilitated within 12 months, unless an exceptional circumstance prevents this (i.e., a flood event). - Santos GLNG will rehabilitate all significantly disturbed areas caused by petroleum activities which are not being or intended to be utilised by the landholder or overlapping tenure holder. These areas will be rehabilitated to meet the acceptance criteria required by the EA and detailed in the Rehabilitation management plan. - Santos GLNG will rehabilitate significantly disturbed land within ESAs in accordance with the rehabilitation criteria required by the EA and detailed in the Rehabilitation management plan.
Pest and Weed Management Plan	The PWMP details how to minimise the potential spread of pest and weed species as a result of Santos GLNG activities. The PWMP provides a framework for Santos GLNG to: - Identify, monitor and prioritise the appropriate management of pest and weed species present at, or that pose a threat to, Santos GLNG assets and/or activities - Prevent and minimise the introduction and dispersal of pest and weed species into Santos GLNG locations and neighbouring properties - Develop asset/activity specific pest and weed management procedures as required during the GFD Project lifetime.	- Santos GLNG will implement the PWMP. - Santos GLNG will maintain areas of transitional rehabilitation, in accordance with the Rehabilitation management plan, so that declared pest species do not grow as part of the groundcover. - During rehabilitation activities, Santos GLNG will ensure that the per cent species richness of declared plant pest species is less than or equal to that of adjacent land uses or that of pre-disturbed land uses.

Management plan	Key provisions/ function	Management control measures
Environmental protocol for constraints planning and field development	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 — off-set 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.	• Santos GLNG will implement the Constraints protocol.
Erosion and sediment control management plan	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.	• The ESCMP will be implemented. • Erosion and sediment control measures will be installed prior to carrying out limited petroleum activities undertaken within ESAs, in accordance with Schedule E of the proposed EA.
Chemical and fuel management plan	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.	• The CFMP will be implemented. • All chemical storage facilities associated with an ERA of chemical storage will be clearly and permanently marked for the life of the petroleum activities. • All chemical storages must: – be stored in, or serviced by, an effective containment system that is impervious to the materials stored therein; and – be stored and handled in accordance with the relevant Australian Standard where such Standard is available; and – be managed to prevent the release of substances to waters or land.

Management plan	Key provisions/ function	Management control measures
Land release management plan	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 operational purposes • Low point drain water releases to land • 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.	• The LRMP will be implemented. • Procedures will be followed to avoid damage to vegetation and to soil quality.
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 Offset strategy is to: • Identify the environmental values that exist within the GFD Project area that after avoidance, minimisation, mitigation and remediation and rehabilitation measures may require off-setting • Demonstrate off-sets completed as part of the Santos GLNG Project • Identify where existing Santos GLNG off-set areas may be used for future additional off-set required for the GFD Project • Provide a description of Santos GLNGs staged off-sets approach to provide potential off-set delivery options and proposed method of delivery.	• Santos will implement the Offset strategy.

Management plan	Key provisions/ function	Management control measures
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 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.	• Santos GLNG will implement the DAMP.
Waste management plan	The Waste management plan identifies the required procedures and waste-handling requirements in compliance with EP Act 1994 and other relevant regulatory requirements.	• Santos GLNG will implement the Waste management plan.

Source: Aurecon 2014b, Table 5.11, modified

9.5.1 Offsets

Environmental values that require offsetting are defined in the relevant Australian and Queensland government offsets policies. For the purposes of this report, these values have been broadly grouped into Matters of State Environmental Significance (MSES) for matters regulated by the Queensland Government.

9.5.1.1 Matters of State Environmental Significance

State significant biodiversity values (SSBV) that are present within the GFD Project are summarised in Table 9-27.

Table 9-27 SSBV within the GFD Project area

MSES	Trigger	Likely presence with the GFD Project Area
Protected Areas	The following protected areas declared under the NC Act: - National park - National park (scientific) - National park (aboriginal land) - National park (torres strait islander land) - National park (cape york peninsular aboriginal land) - National park (recovery) - Conservation parks - Resources reserve - Nature refuges.	The following protected occur within the GFD Project area: <i>Expedition National Park</i> – the largest National Park within the GFD Project area located in the Arcadia and Fairview gas fields. Approximately 63,558 ha of Expedition National Park is located within the GFD Project area. <i>Humboldt National Park</i> – a large area of remnant vegetation (formerly State Forest) located in the Arcadia gas fields in ATP 804P. Approximately 7,445 ha of Humboldt National Park is located within the GFD Project area. <i>Lake Murphy Conservation Park</i> – situated in the Scotia gas fields in ATP 803P. Lake Murphy Conservation Park protects a large perched ephemeral freshwater wetland (ie RE 11.3.27) situated beneath the Murphy Range. Approximately 520 ha of Lake Murphy Conservation Park is located within the GFD Project area. <i>Carraba Conservation Park</i> – situated in the Scotia gas fields in ATP 803P. Approximately 49 ha of Carraba Conservation Park is located within the GFD Project area.
Marine Parks	The following zones of Queensland marine parks (Great Barrier Reef Coast Marine Park, Moreton Bay Marine Park and Great Sandy Marine Park) declared under the MP Act 2004: - Marine national park - Buffer - Marine conservation park - Scientific research - Preservation.	No zones of Queensland marine parks (Great Barrier Reef Coast Marine Park, Moreton Bay Marine Park and Great Sandy Marine Park) declared under the MP Act occur within the GFD Project Area.

MSES	Trigger	Likely presence with the GFD Project Area
Fish Habitats	The following areas and values declared or otherwise described under the <i>Fisheries Act 1994</i>: - Declared fish habitat areas - Marine plants - Fish passage.	There are no marine plants, Fish Habitat Areas or fish passages located within the GFD Project area.
The habitat for protected wildlife	Habitat for the following protected wildlife listed under the <i>Nature Conservation (Wildlife) Regulation 2006</i>: - Endangered wildlife (fauna and flora) - Vulnerable wildlife (fauna and flora) - Special least concern animals.	Based on database searches the following species under the <i>Nature Conservation (Wildlife) Regulation 2006</i> are known or are predicted to occur in the GFD Project area: 26 Species listed as Endangered 43 Species listed as Vulnerable 24 Species listed as special least concern animals (21migratory birds and 3 mammals) A full list of the protected wildlife listed under the <i>Nature Conservation (Wildlife) Regulation 2006</i> and their likelihood of occurrence is provided the <i>Draft Offset Strategy</i> (Santos, 2014)
Regulated vegetation	Regulated vegetation under the VM Act that is: - Category B areas on the regulated vegetation management map, that are 'endangered' or 'of concern' regional ecosystems - Areas of essential habitat on the essential habitat map for wildlife prescribed as 'endangered wildlife' or 'vulnerable wildlife' under the NC Act - Regional ecosystems that intersect with watercourses identified on the vegetation management watercourse map. - Regional ecosystems that intersect with wetlands identified on the vegetation management wetlands map.	Using the more conservative biodiversity status on the Regional Ecosystem Description Database (REDD), there are approximately 78,674 ha of Category B areas on the regulated vegetation management map, that are 'endangered' or 'of concern' regional ecosystems. Of that 29,600 ha are mapped as endangered and 49,074 ha are mapped as Of Concern. Essential Habitat for 10 conservation significant flora species and eight (8) conservation significant fauna species has been mapped in the GFD Project area. There are approximately 315,610 hectares of remnant vegetation (Category B areas on the regulated vegetation management map) within the GFD Project area. Given the size and the extent of some vegetation patches and the many wetlands and watercourses present within the GFD Project area, it is expected that many regional ecosystems will intersect with wetlands and watercourses identified on the vegetation management wetlands map and the vegetation management watercourse map. These will occur in all tenures.

MSES	Trigger	Likely presence with the GFD Project Area
Areas of Connectivity	Areas of vegetation that are of sufficient size and configured in a way that maintains ecosystem functioning and will remain in the landscape despite threatening processes.	Connectivity is present from the Blackdown Tablelands to the north of ATP 804P, to the remnant vegetation of Expedition Range adjacent to ATP 745P. A continuous State significant region of native vegetation extends from near Injune in the south to the Blackwater Tableland in the north, for a distance of approximately 260 km. Although as narrow as 5 km near Arcadia Valley in the south, the majority of the range exceeds 25 km in width and is over 32 km wide to the east of ATP 804P. There is also extensive State significant vegetation associated with the Expedition, Palmgrove, Isla Gorge and Precipice National Parks system link to Carnarvon National Park in the west. This body of interconnected vegetation provides high quality habitat for flora and fauna species. The Dawson Highway acts as a minor barrier to movement in this corridor. More mobile species and those with larger home ranges are considered to benefit greatest from landscape wide connectivity. Connectivity across the landscape of the remaining GFD Project tenures is generally fragmented; however, functional connectivity is retained through local linkages of remnant and regrowth vegetation, associated with roadside and riparian corridors linking larger patches of vegetation on private land and State Forests. These linkages are likely to provide landscape permeability for mobile species such as birds and bats. Areas of connectivity occur throughout the GFD Project area. It is likely the development of linear infrastructure in the GFD Project area will have some impact on these areas of connectivity.
Wild river areas	High preservation areas of wild river areas declared under the <i>Wild Rivers Act 2005</i>	There are no high preservation areas of wild river areas declared under the <i>Wild Rivers Act 2005</i> within the GFD Project area.
Wetlands	Wetlands in a wetland protection area or wetlands of high ecological significance shown on the Map of Referable Wetlands as defined in the <i>Environmental Protection Regulation 2008</i> , schedule 12.	Wetlands in a wetland protection area or wetlands of high ecological significance shown on the Map of Referable Wetlands occur throughout Arcadia, Roma and Scotia gas fields. Locations shown on the Map of Referable Wetlands include: • Areas associated with the Dawson River in ATP 803P • Areas associated with Blyth Creek in PL 7 • Areas between Chinchinbilla Creek and Lagoon Creek in PL 6 • Three wetlands in the central and northern parts of ATP 613 associated with Kangaroo, Yuleba and Blackfellows Creeks.

MSES	Trigger	Likely presence with the GFD Project Area
Wetlands and Watercourses	Wetlands and watercourses in high ecological value waters as defined in the <i>Environmental Protection (Water) Policy 2009</i> , Schedule 2.	The GFD Project area comprises the southern portion of the Fitzroy River Basin and the northern portion of the Condamine-Balonne River Basin. There are Six major sub-catchments and a number of wetlands. Wetlands and watercourses in high ecological value waters are likely to occur throughout the GFD Project area. It is likely the development of linear infrastructure in the GFD Project area will have some impact on these areas.
Legally Secured Offset Areas	All legally secured offset areas	The legally secured offsets register provides information on vegetation management offsets that have been approved in accordance with the Vegetation Management Act 1999, which is administered by the DNRM. This was received by Santos on 20 January 2014. It was last updated in June 2013. The Legally Secured Biodiversity Offsets Register provides information on offsets that have been approved in accordance with the Queensland Biodiversity Offsets Policy, which is administered by DEHP. This was received by Santos on 20 January 2014. It was last updated in November 2013. Within the GFD Project area, no offsets approved in accordance with the VM Act and no Biodiversity Offsets approved in accordance with the Queensland Biodiversity Offsets were identified on the legally secured offset register search.
Koala Habitat	Bushland habitat, high value rehabilitation habitat and medium value rehabilitation habitat as defined in South East Queensland Koala Conservation State Planning Regulatory Provisions, Schedule 4.	The whole of the GFD Project area is located within the Brigalow Belt Bioregion. There will be no residual significant impact to Koala habitat in the South East Queensland Bioregion as a result of the GFD Project. The Koala is a vulnerable species under the NC Act. Offsets for impact to the Kola may be required.

9.5.1.2 Staged offsets approach

The GFD Project area will be progressively developed as the gas resource is realised. This adaptive management approach and the highly variable nature of CSG field development means the full extent of impact is not known from stage to stage and a quantifiable residual significant impact cannot accurately be formulated at this stage. Without quantifiable significant residual impacts a suitable offsets is impossible to identify and secure.

Santos GLNG proposes to provide an offsets obligation in multiple stages to match the relevant disturbance for each stage. This staged offset strategy is promoted in the Queensland Draft Environmental Offsets Policy.

Santos GLNG's offset obligations will be managed by an Offsets plan. Each stage of the offsets program will apply to a proposed development activity and a fixed period of time. For example the infrastructure for a particular stage may consist of 40km of linear disturbance such as access tracks and pipelines and 30 wells and the fixed length of time for this development may be four years. Using this development snapshot instead of a whole of project estimate allows the residual impact on MSES (and Matters of National Environmental Significance (MNES), as appropriate) for each stage of infrastructure development to be estimated with relative accuracy.

9.5.1.2.1 Stage length

The offsets stage length will vary depending on the known work program and known gas resources. It is anticipated the length for each stage will be between three and five years and could, where relevant, coincide with the preparation and submission of the Plan of Operations for Resource Authorities as required under the EP Act.

9.5.1.2.2 Significant residual adverse impact

The Matters of National Environmental Significance Significant Impact Guidelines 1.1 define a 'significant impact' as 'an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts.'

The EPBC Act Offsets Policy states: 'Offsets provide environmental benefits to counterbalance the impacts that remain after avoidance and mitigation measures. These remaining, unavoidable impacts are termed 'residual impacts'. Offsets will be required to compensate for the significant residual adverse impacts on MNES and MSES as a result of the GFD Project. Santos will deliver offsets for residual significant adverse impacts to MNES and MSES.

9.5.1.2.3 Disturbance request, assessment and approval

Santos GLNG will adopt specific management principles when planning for and implementing new petroleum activities that may result in land disturbance. These management principles are applied using the following hierarchy:

1. Avoidance – Avoiding direct and indirect adverse environmental impacts where reasonable and practicably possible
2. Minimise – Minimise direct and indirect adverse environmental impacts where impacts cannot be avoided
3. Mitigate – Implement mitigation and management measures to minimise direct, indirect and cumulative adverse environmental impacts
4. Remediation and Rehabilitation – Actively remediate and rehabilitate impacted areas to promote and maintain long-term recovery
5. Offset – Where required, Santos GLNG will provide suitable offsets for activities that result in an unavoidable significant residual adverse impact to MSES (and MNES, as applicable). The offsets will be submitted for approval in accordance with both Queensland and Australian Government requirements.

The estimated offsets will be calculated following the application of these management principles. This approach allows Santos GLNG to demonstrate avoidance, mitigation and management of impacts to MSES (and MNES, as applicable) prior to the creation of an offsets obligation.

9.5.1.2.4 Estimated offsets obligation

Once a work program for each stage can be finalised a proposed land disturbance footprint can be created. The proposed land disturbance footprint will be used to create an estimated offsets obligation. This will be estimated using the area of unavoidable adverse impacts to MSES (and MNES, as applicable) that occur as a result of proposed land disturbance footprint. The estimated offset obligation will inform the offset delivery.

9.5.1.2.5 Offsets delivery

It is recognised that environmental offsets policy development is a dynamic policy area undergoing frequent and current changes. Santos GLNG commits to delivering offsets in accordance with the Queensland and Australian Government policies and regulations that apply to the GFD Project.

The development of the GFD Project could require the delivery of numerous offset stages. Each offset delivered will vary and will reflect the unavoidable significant residual adverse impacts to MSES (and MNES, as applicable) accrued during that stage. Each offset might comprise a combination of direct offsets and/or other compensatory measures. Where direct offsets are used, offsets will preferentially align with conservation priorities for the impacted matter in order to deliver a conservation gains for the matter impacted.

The offsets obligation for each stage will be delivered prior to the authorisation of unavoidable adverse impact to MSES (and MNES, as applicable) occurring.

9.5.1.2.6 Recording and tracking offset obligations

For all disturbances relating to MSES (and MNES, as applicable) the following details will be recorded:

- The location and extent of the disturbance and the type of infrastructure or activity responsible for the disturbance
- The related pre-construction field scouting and ecological survey documents identifying the environmental constraint
- The reasons for the decision including justification for the action taken, description of the efforts taken to avoid impact, and an explanation why, given the coexisting constraints, the decision was justified
- The environmental constraints disturbed
- The extent of the disturbance and the relevant effect on the disturbance limits set out in the approval documents
- Actions and commitments to remediate or rehabilitate.

The information will be recorded and maintained so that it can be audited. Disturbances will be frequently updated in Santos GIS so that predicted disturbances can be analysed with actual disturbances and records updated to accurately reflect cumulative disturbances levels. Where an actual disturbance has been identified as having a significant residual impact to a MSES (and MNES, as applicable) and the disturbance will require offsetting it will become an offsets obligation.

9.5.1.2.7 Reconciliation and accounting offsets obligations

At the end of each offsets stage an offset accounting and reconciliation process will be undertaken to ensure compliance with the proposed offset strategy. The assessment will be a GIS-based task where the geographic extent of actual disturbance is assessed against the estimated offsets obligation.

Where a new offsets stage follows an existing offsets stage, an analysis can be undertaken to identify if the estimated offset obligation is in debit or credit relative to the actual extent of on-ground impact. Any difference, either debit or credit, will be carried over onto the following offsets stage or where no offset stage follows and a debit remains and offset must be provided to account for offset obligation.

9.6 Environmental protection performance indicators

The indicators within Table 9-28 will be utilised to determine whether the environmental performance objectives have been met and whether the control strategies implemented have been effective.

Table 9-28 Environmental protection performance indicators

Environmental protection performance indicators

- The SSMP is implemented.
- The PWMP is implemented.
- The FMP is implemented.
- The ESCMP is implemented.
- The WMP is implemented.
- Petroleum activities undertaken within environmentally sensitive areas are carried out in accordance with the EA.
- The Offset strategy is implemented and offsets have been secured, as required, in accordance with both State and Commonwealth Government regulation.
- The clearance widths for linear infrastructure are within the required limits established in the EA.

9.7 Monitoring

Table 9-29 summarises the environmental monitoring and assessment considerations for the protection of terrestrial and aquatic ecology environmental values within the GFD Project area. Details of the monitoring activities are described in the management plans. Additional monitoring considerations are summarised in Table 9-29.

Table 9-29 Monitoring considerations for nature conservation

Existing management and monitoring plans
• ESCMP • SSMP • FMP • PWMP • DAMP • Rehabilitation management plan • Constraints protocol • Offset strategy.
Additional monitoring considerations for nature conservation
General • Monitoring will be undertaken by a suitably qualified person. • Laboratory analyses and tests will be carried out by a laboratory that has NATA accreditation for such analyses and tests, unless NATA accredited tests are not available. • Management or monitoring plans, systems, programs or procedures required to be developed and implemented by the EA will be reviewed for performance and amended as required but not less than once every three years in accordance with the requirements for the particular plans, systems, programs and procedures in the conditions of the EA. • Management plans and monitoring programs specifically required by the EA will be certified by a suitably qualified person. • An annual report will be prepared each year and submitted to the administering authority in the form requested by the administering authority. This report will include information as required by the EA such as: – any third party audit report – an outline of actions taken to minimise the risk of environmental harm from any circumstance, condition or elevated contaminant level identified by the monitoring or recording programs.

9.8 Proposed environmental authority conditions

The following draft EA conditions in relation to nature conservation are proposed for the GFD Project. The conditions stipulate the required plans and management and monitoring requirements to enable adequate protection of the GFD Project areas environmental values. The EA conditions are reproduced in full in Appendix O.

SCHEDULE D — LAND

- D1 Contaminants must not be directly or indirectly released to land except as permitted under this environmental authority.
- D2 The release of contaminants to land must be carried out in a manner such that:
- vegetation is not damaged;

Soil and land management

- E1 Top soil must be managed in a manner that preserves its biological and chemical properties.

- E2 Land that has been significantly disturbed by the petroleum activities must be managed in accordance with the Erosion and sediment control management plan.

Fauna management

- E3 Measures must be employed to prevent fauna entrapment:
- a) during the construction of pipelines in pipe sections and pipeline trenches; or
 - b) during the construction and operation of well infrastructure and dams.

Confirming environmentally sensitive areas, wetlands and springs

- E4 Prior to undertaking petroleum activities that result in significant disturbance to land in areas of native vegetation, confirmation of on-the-ground environmentally sensitive areas, wetlands and springs at that location must be undertaken by a suitably qualified person.
- E5 A suitably qualified person must develop and certify a methodology so that condition (E4) can be complied with and which is appropriate to confirm on-the-ground environmentally sensitive areas, wetlands and springs.
- E6 Where areas mapped as environmentally sensitive areas, wetlands and springs differ from those confirmed under conditions (E4) and (E5), petroleum activities may proceed in accordance with the conditions of the environmental authority based on the confirmed on-the-ground values.
- E7 All documentation survey information photographs, field data or any material associated with the field validation requirements in (E4) must be maintained for the life of the environmental authority to demonstrate to the administering authority that surveys were conducted in a manner consistent with requirements contained in (E5).

Planning for land disturbance

- E8 The location of the petroleum activity(ies) must be selected in accordance with the following site planning principles:
- a) maximise the use of areas of pre-existing disturbance;
 - b) in order of preference, avoid, minimise or mitigate any impacts, including cumulative; impacts, on areas of native vegetation or other areas of ecological value;
 - c) minimise disturbance to land that may otherwise result in land degradation;
 - d) minimise isolation, fragmentation or dissection of tracts of native vegetation; and
 - e) minimise clearing of native mature trees.

Disturbance to Land – Environmentally Sensitive Areas

- E9 Petroleum activities must be carried out in accordance with *Schedule E, Table 1 – Petroleum Activities in Environmentally Sensitive Areas*, *Schedule E, Table 2 – Authorised Disturbance* and any other relevant conditions of this environmental authority.

Schedule E, Table 1 – Petroleum activities in Environmentally Sensitive Areas

ESA Category	Within the ESA	Primary protection zone of the ESA	Secondary protection zone of the ESA
Category A ESAs	No petroleum activities permitted	Only low impact petroleum activities permitted.	Only limited petroleum activities permitted
Category B ESAs excluding 'Endangered' Regional Ecosystems	Only low impact petroleum activities permitted	Only limited petroleum activities permitted Subject to condition (E11)	N/A
Category C ESAs that are Nature Refuges, Koala Habitat and/or Declared Catchment Areas	Only low impact petroleum activities permitted	Only limited petroleum activities permitted Subject to condition (E11)	N/A
Category B ESAs that are 'Endangered' Regional Ecosystems	Only limited petroleum activities permitted Subject to condition (E10)	Only limited petroleum activities permitted Subject to condition (E11)	N/A
Category C ESAs that are Essential Habitat, Essential Regrowth Habitat and/or 'Of Concern' Regional Ecosystems	Only limited petroleum activities permitted Subject to condition (E10)	Only limited petroleum activities permitted Subject to condition (E11)	N/A
Category C ESAs that are Resource Reserves	Only limited petroleum activities permitted Subject to condition (E10)	Only limited petroleum activities permitted Subject to condition (E11)	N/A
Category C ESAs that are State Forests and/or Timber Reserves	Limited petroleum activities permitted subject to condition (E10) Petroleum activities that are extraction activities and screening activities permitted.	N/A	N/A

Note: Approvals may be required under the Forestry Act 1959 where the petroleum activity(ies) is proposed to be carried out in ESAs that are State Forests or Timber Reserves.

Schedule E, Table 2 – Authorised Disturbances

Authorised activity	Authorised activity section	Location of development (GDA94)		Size of development		ESA
		Latitude	Longitude	Length (m)	Area of disturbance (ha)	

E10 Prior to carrying out limited petroleum activities undertaken within environmentally sensitive areas in accordance with *Schedule E, Table 1 – Petroleum Activities in Environmentally Sensitive Areas*, it must be demonstrated, in the following order of preference that:

1. no reasonable or practicable alternative exists for carrying out the limited petroleum activities within the **environmentally sensitive area**;
2. the **limited petroleum activities** are preferentially located in pre-existing areas of clearing or significant disturbance;
3. clearance widths for linear infrastructure is minimised to the maximum extent possible, taking into account the following matters:
 - a) safe vehicle movement;
 - b) drainage devices installed are of a type that is appropriate for the track type and location;
 - c) erosion and sediment control measures installed are in accordance with the Erosion and Sediment Control Plan required by conditions (B2) and (B3); and
 - d) power line stays have been preferentially located within the pipeline right of way where possible.
4. the maximum clearance widths specified in *Schedule E, Table 3 – Authorised Disturbance for Linear Infrastructure* are not exceeded.

Schedule E, Table 3 – Authorised Disturbance for Linear Infrastructure

Type of Linear Infrastructure	Clearance Width (m)
Access track(s) not associated with a pipeline(s), communication lines(s) or power line(s):	
(a) single carriage access tracks	18
(b) dual carriage access tracks	21
(c) single or dual carriage access track and associated turnaround bay	35
Access track(s) associated with a pipeline(s), communication line(s) or power line(s):	
(a) single carriage access tracks with a single pipeline, communication line or power line	24
(b) dual carriage access track with a single pipeline, communication line or power line.	27
(c) single or dual carriage access track and associated turnaround bay with a single pipeline, communication line or power line.	41
(d) additional clearing for any additional parallel pipeline, communication line or power line associated with (B)(a), (b) or (c)	7 ¹
Additional clearing for take-off drains, power line stays or turnaround bays or other work areas:	
(a) Additional clearing for power line stays associated with (B)	10
(b) additional clearing for take-off drains associated with (A) or (B)	10

¹ Maximum total disturbance for (B) is 62m.

- (E11) If limited petroleum activity(ies) are located within a primary protection zone or secondary protection zone of an environmentally sensitive area, that the activity(ies) must not negatively affect the adjacent environmentally sensitive area.

SCHEDULE H – WASTE

General

- H1 All general and regulated waste must only be removed from the site and sent to a facility licensed to accept the waste under the *Environmental Protection Act 1994* except as permitted under another condition of this environmental authority.

SCHEDULE I – REHABILITATION

Rehabilitation planning

- I1 A Rehabilitation Plan must be developed by a suitably qualified person and must include the:
- a) rehabilitation goals; and
 - b) procedures to be undertaken for rehabilitation that will:
 - (i) achieve the requirements of conditions (I2) to (I7), inclusive; and
 - (ii) provide for appropriate monitoring and maintenance.
 - c) approach to establishing an alternative outcome to (I3) and (I4) by achieving a higher environmental value than that which was present prior to the significant disturbance from petroleum activities

10 Noise

The guideline *Prescribing Noise Conditions for Environmental Authorities for Petroleum and Gas Activities* (Noise Assessment Guideline), published by DEHP in 2012, supplements the application of the Environmental Protection (Noise) Policy 2008 (EPP Noise) in the administration of an EA for petroleum and gas activity projects. The environmental values defined in the EPP Noise aim to preserve or enhance qualities of the acoustic environment that protect human health and wellbeing (i.e. by ensuring suitable environments to sleep, study, learn, be involved in recreation, relaxation and conversation, and protect the amenity of the community), as well as health and biodiversity of ecosystems.

This guideline specifies 'best practice' noise limits for construction/decommissioning and operation noise limits. These best practice noise limits are considered to protect the acoustic values of a sensitive receptor in rural or isolated areas and achieve acoustic quality objectives set out in the EPP Noise, whilst considering cumulative impacts and background creep.

The Noise and Vibration Impact Assessment undertaken by SLR Consulting (April 2014) for the GFD Project describes the noise and vibration values and assesses the GFD Project's potential impacts on these values. Impacts were assessed using the compliance assessment methodology, which assesses the degree to which the GFD Project complies with quantifiable guidelines set out in the Noise Assessment Guideline (DEHP, 2012) to achieve the acoustic quality objectives set out in the EPP Noise.

10.1 Environmental values

Environmental noise values identified for the GFD Project area are based from the EPP Noise and include:

- Health and wellbeing
- Fauna health and wellbeing
- Property.

The guideline *Prescribing Noise Conditions for Environmental Authorities for Petroleum and Gas Activities* (Noise Assessment Guideline), published by DEHP in 2012, supplements the application of the EPP Noise in the administration of an EA for petroleum and gas activity projects.

This guideline applies to the GFD Project as it specifies 'best practice' noise limits (refer to Table 10-1). These best practice noise limits are considered to protect the acoustic values of a sensitive receptor in rural or isolated areas and achieve acoustic quality objectives set out in the EPP Noise, whilst considering cumulative impacts and background creep. The best practice noise emission limits were used to assess construction/decommissioning and operation noise sources.

It is considered that fauna (including domesticated mammals) exposed to less than 65 dBA L_{Aeq} are unlikely to experience adverse impacts.

Table 10-1 Best practice noise emission limits

Time Period	Parameter	Noise Limit (dBA)		
		Short-term ¹	Medium-term ²	Long-term ³
7:00 am – 6:00 pm	L _{Aeq, adj, 15mins}	45	43	40
6:00 pm – 10:00 pm	L _{Aeq, adj, 15mins}	40	38	35
10:00 pm – 6:00 am	L _{Aeq, adj, 15mins}	28	28	28
	Max L _{pA, 15 mins}	55	55	55
6:00 am – 7:00 am	L _{Aeq, adj, 15mins}	40	38	35

Source: SLR 2014, Table 3

Note 1: A short-term noise event is defined as a noise exposure lasting for no greater than eight hours and does not reoccur for at least seven days.

Note 2: A medium-term noise event is defined as a noise exposure lasting for no greater than five days and does not reoccur for at least four weeks.

Note 3: A long-term noise event is defined as a noise exposure lasting for greater than five days, even when there are respite periods when noise is inaudible within those five days. Most construction and operations scenarios will fall within this long-term noise event specification.

Environmental values were established based on baseline surveys of the ambient noise environment within the rural regions of the Surat and Bowen basins undertaken as part of the EIS for the GLNG Project (EIS 2009) in 2008 and the Australia Pacific LNG (APLNG) Project EIS (APLNG EIS) (Savery and Associates, 2009).

There were a number of noise monitoring locations used for the APLNG EIS that are considered relevant for the GFD Project due to their location with respect to the GFD Project area. Figure 10-1 illustrates the locations of the noise monitoring locations for EIS 2009 and APLNG EIS.

The monitored background noise levels, established during the 2009 EIS and APLNG EIS, follow typical diurnal pattern with noise levels reduced during the evening and night-time periods when bird, insect and road traffic activity is negligible.

Measurements of background noise levels for the 2009 EIS and APLNG EIS were both conducted during the cooler winter months. The ambient acoustic environment is likely to more often contain additional insect noise during the warmer months of the year. The potential for noise impacts is greater during the winter months when background noise levels are lower at night. On this basis, the measured background noise levels would represent the worst case in terms of seasonal variations. Table 10-2 outlines the background noise levels at the monitoring locations illustrated in Figure 10-1.

Measured noise levels of below 30 A-weighted decibels (dBA) noise level exceeding for 90% of the measurement period (L_{A90}) during the daytime and below 20 dBA (L_{A90}) during the evening and night-time are low and characteristic of rural environments with minimal noise influences. The exception was the "Gas pipeline 1" location in the township of Roma, where noise levels are influenced by traffic noise from the Warrego Highway.

The existing noise levels at the monitoring locations were primarily influenced by local birds and insect activity consistent with the rural environment in the GFD Project area. Depending on the proximity to local and main roads, intermittent local road traffic movements and distant road traffic noise from Currey Street – Roma, Warrego Highway and the Carnarvon Highway was audible during the daytime and evening periods. It is assumed that no significant road traffic noise is audible during night-time.

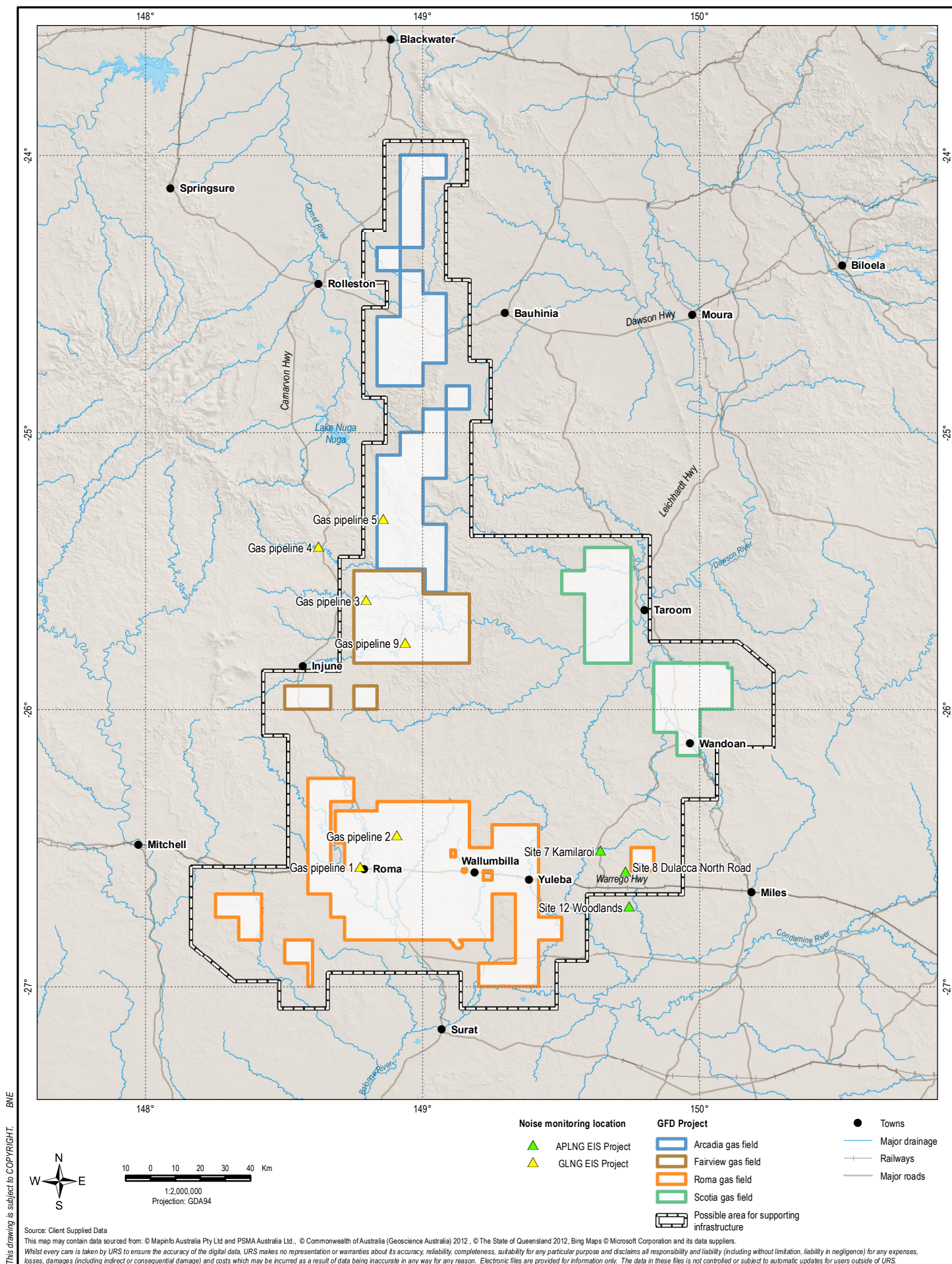


Table 10-2 Ambient background noise level

Location ¹	Adjusted rating background Level (L _{A90} dBA)			Maximum hourly noise levels (equivalent continuous level)(L _{Aeq(1hour)} dBA)		
	Day	Evening	Night	Day	Evening	Night
Deemed Background Noise Level ²	35	30	25	-	-	-
2009 EIS³						
Gas Pipeline 1	37	34	28	58	53	55
Gas Pipeline 2	23	18 ⁴	17 ⁴	55	45	45
Gas Pipeline 3	24	18 ⁴	18 ⁴	54	37	41
Gas Pipeline 4	27	19 ⁴	18 ⁴	52	38	43
Gas Pipeline 5	21	18 ⁴	17 ⁴	46	29	40
Gas Pipeline 9	30	29	29	49	40	47
APLNG EIS⁴						
Site 7 Kamilaroi	20	<15 ⁵	<15 ⁵	37	27	<15 ⁵
Site 8 Dulacca North Road	19	<15 ⁵	<15 ⁵	33	20	18
Site 12 Woodlands	25	<15 ⁵	<15 ⁵	42	27	21

Source: SLR 2014, Table 4

1 Monitoring locations were away from existing facilities and representative of typical background noise levels in the area without contribution from existing GLNG Project or APLNG Project-related facilities.

2 Petroleum and Gas Noise Assessment Guideline (DEHP, 2011)

3 2009 EIS Noise and Vibration (Terrestrial) 20-2014 - R1 (SLR, 2009)

4 Australia Pacific LNG Project, vol 5: Attachment 32: Noise and Vibration Impact Study (Savery and Associates, 2009)

5 Measured RBL adjusted for the measurement threshold of the noise logger

Sensitive Receptors for Noise and Vibration

Based on the existing noise environment with typically very low background noise levels, the nearest sensitive receptors and communities to the GFD Project might be sensitive to the level and characteristic of audible noise from the GFD Project.

Specific sensitive receptors within the GFD Project sensitive receptors are most likely located near highways or townships. If sensitive receptors are identified within specified impact distances of major facilities (such as compressor facilities), detailed modelling will be performed to enable site specific factors such as the surrounding topography and land use to be accounted for in the modelling and investigate if further noise management and/or mitigation measures are required.

The Noise Assessment Guideline provides deemed background noise levels that are the lower limit of applicable background noise levels for assessment purposes. The GFD Project has adopted the deemed background noise levels for noise sensitive receptors associated with the GFD Project. These levels are to be used in the determination of noise limits in rural areas where background noise levels can be very low (Table 10-2).

By comparing the deemed background noise levels with the measured background noise levels presented in Table 10-2, it can be seen that the measured background levels are lower than the deemed background levels for each monitoring location except for Gas pipeline 1.

It is likely that a small proportion of noise sensitive receptors associated with the GFD Project may have background noise levels higher than the deemed backgrounds; however, it is not practical to consider higher backgrounds until location-specific background measurements are conducted during future stages of the GFD Project.

Existing ambient ground vibrations are not expected to be perceptible at the vast majority of sensitive receptors in the GFD Project area. The exceptions to this would be sensitive receptors located near mines and quarries that conduct blasting. Other sources of ground vibration would be industry, construction and heavy transport corridors. These activities generally only result in perceptible ground vibrations within very close proximity (within 70 m) to the vibration source and therefore it is unlikely that many sensitive receptors within the GFD Project area are currently exposed to ground vibrations from these sources.

Nuisance does not occur if monitoring at a sensitive place shows that emissions do not exceed the limits for noise emissions stated in the applicable EA.

10.2 Potential impacts

10.2.1 Potential noise impacts

Potential noise impacts could occur when assessment criteria in Section 10.1 are exceeded. This can be expected when the noise sensitive receptor is located closer to the noise source than the impact distance (distance at which a specified noise criteria is met without noise management or mitigation measures).

Table 10-3 Potential impacts

Environmental value	Potential impact
Health and wellbeing	Noise and vibration emissions from the GFD Project could result in annoyance, stress, sleep disturbance and reduced wellbeing.
Fauna health and wellbeing	Noise emissions from the GFD Project could potentially disturb native fauna.
Property	Vibration emissions from the GFD Project could contribute to an exceedance of the criteria outlined in Section 10.1, which may result in cosmetic damage.

A number of scenarios representative of GFD Project construction, operation and decommissioning, and transportation activities were used to predict potential noise impacts on sensitive receptors. Noise level predictions for activities likely to occur during the day-time period were assessed under neutral meteorological conditions. Activities that are likely to occur 24 hours a day (i.e. drilling) were assessed for adverse meteorological conditions (where temperature inversions are considered applicable). Table 10-4 outlines the meteorological conditions that were utilised in predicting noise levels for construction, operation and decommissioning activities.

Table 10-4 Weather conditions – neutral and adverse

Parameter	Neutral weather	Adverse weather
Temperature	10°C	10°C
Humidity	70%	90%
Pasquill Stability Category	D	F
Wind Speed	0 m/s	2 m/s (source to receptor)

Source: SLR 2014, Table 10

10.2.1.1 Potential noise impacts – construction and decommissioning

Predicted construction noise levels will inevitably depend upon the number of plant items and equipment operating at one time and on their precise location relative to the sensitive receptor(s). Therefore a sensitive receptor will experience a range of values representing “minimum” and “maximum” construction noise emissions depending upon:

- The location of the particular construction activity (i.e. if the plant item of interest were as close as practical to or further away from the sensitive receptor of interest)
- The likelihood of the various items of equipment operating simultaneously.

Predicted noise levels at various distances for the construction scenarios are presented in Table 10-5 while Table 10-6 shows the distances at which various noise levels are experienced. Only drilling and completion activities will occur 24 hours a day, with the remaining major noise-generating construction activities likely to occur in daytime. Generally, decommissioning will consist of disconnection of services and disassembly and removal of infrastructure aboveground and abandonment of services below ground, followed by clear and grade and rehabilitation. This is similar to the construction of these facilities, but in reverse and with slightly lower noise emissions.

The data presented in Table 10-5 and Table 10-6 show that the highest noise levels are associated with drilling activities. Table 9-7 shows that for night-time drilling activities (typically only occurring for a period of two weeks), the noise criterion of 28 dBA (Table 9-1) will be achieved at sensitive receptors which are at distances greater than 2,800 m from the drilling. Should a blooie line (a flow line from the wellhead to a flare pit) be operating, the distance is 4,400 m. For sensitive receptors closer to the source, noise management and mitigation measures may be required.

For other construction activities, Table 10-5 shows that the noise criterion is 35 dBA (assuming construction activities are limited to 6 am to 10 pm). Table 10-6 shows that for the other construction activities the distances at which the criterion will be achieved vary from 850 m to 1,700 m depending on the activity. For sensitive receptors closer to the source, noise management and mitigation measures may be required.

Table 10-5 Predicted noise levels at various distances – construction and decommissioning

Construction scenario	Weather condition	Predicted noise level at distance (dBA L _{Aeq}) ¹						
		50 m	100 m	250 m	500 m	1,000 m	2,000 m	5,000 m
Drilling and Completion ²	Neutral	77 (85)	71 (78)	59 (67)	49 (57)	38 (47)	28 (36)	< 15 (19)
Drilling and Completion ²	Adverse	79 (86)	73 (80)	64 (72)	55 (63)	44 (53)	33 (42)	16 (25)
Facilities	Neutral	75	68	57	48	40	31	15
Gathering/transmission lines	Neutral	72	65	54	45	37	28	<15
Borrow pits	Neutral	76	70	58	50	42	32	17
Laydown areas	Neutral	70	64	52	43	35	26	<15
Communication infrastructure	Neutral	70	64	52	43	35	26	<15
Road/access tracks	Neutral	67	60	49	41	33	24	<15

Source: SLR 2014, Table 12

Note 1: The noise levels are predicted based on the expected summation of noise sources at the sensitive receptor for the noisiest construction stage.

Note 2: Values in brackets includes operation of blooie line.

Based on the predicted noise emission levels at various distances shown in Table 10-5, the distances to various noise levels have been presented in Table 10-6.

In reviewing Table 10-6 for construction of major facilities and infrastructure, the predicted noise emissions shows that distances of approximately 100 m to 150 m are required to achieve the noise criterion of 65 dBA L_{Aeq} to mitigate impacts on fauna. For drilling, potential impacts can occur up to a distance of 250 m under adverse weather conditions and with blooie line operation up to 450 m under adverse weather conditions.

Table 10-6 Potential impact distances for various predicted noise levels - construction and decommissioning estimates¹

Construction scenario	Weather condition	Distance to predicted noise level (m) ²								
		65 dBA	55 dBA	50 dBA	45 dBA	40 dBA	35 dBA	30 dBA	28 dBA	25 dBA
Drilling and completion ³	Neutral	200 (300)	350 (600)	450 (850)	650 (1,200)	900 (1,600)	1,300 (2,200)	1,800 (2,900)	2,000 (3,200)	2,400 (3,800)
Drilling and completion ²	Adverse	250 (450)	500 (900)	700 (1,200)	950 (1,700)	1,300 (2,300)	1,800 (3,100)	2,500 (4,000)	2,800 (4,400)	3,300 (5,100)
Facilities	Neutral	150	300	450	650	1,000	1,500	2,100	2,400	2,900
Gathering/transmission lines	Neutral	150	250	350	550	800	1,200	1,800	2,000	2,500
Borrow pits	Neutral	150	350	500	800	1,200	1,700	2,400	2,700	3,200
Laydown areas	Neutral	100	200	300	450	650	1,000	1,500	1,700	2,100
Communication infrastructure	Neutral	100	200	300	450	650	1,000	1,500	1,700	2,100
Road/access tracks	Neutral	100	150	250	350	550	850	1,300	1,500	1,900

Source: SLR 2014, Table 13

Note 1: Grey highlighted cells represent the distances where further noise management and mitigation measures may be required. Remaining cells (that are not grey) show the predicted distances outside which the activities are likely to achieve the relevant criteria without further noise management and mitigation measures for each modelled scenario.

Note 2: The distances are based on predicted noise levels at 50 m intervals up to 1,000 m and 100 m intervals thereafter.

Note 3: Values in brackets includes operation of blooie line

10.2.1.2 Potential noise impacts – operations

The predicted noise levels during operations at various distances from a number of operation scenarios (under adverse weather conditions) are presented in Table 10-7. The potential impact distances to various noise levels have been presented in Table 10-8. The data presented in these tables show that the highest noise levels are associated with the operation of a hub gas compression facility.

For a hub gas compression facility under normal operating conditions, Table 10-7 shows that the night-time noise criteria of 28 dBA will be achieved where sensitive receptors are at distance greater than 5,500 m (non-electrified) and 4,100 m (electrified). For other facilities, the distances at which the criterion will be achieved vary from 950 m to 3,500 m. For well operation, the distances at which the criterion will be achieved is 550 m (non-electrified) and 110 m (electrified/free-flowing). The predicted noise emissions outlined in Table 10-8 shows that distance required to achieve the noise criterion of 65 dBA LAeq for protecting fauna is up to 300 m under neutral weather conditions, increasing up to 400 m under adverse weather conditions for a non-electrified hub gas compression facility.

For sensitive receptors closer to the source than the above identified impact distances, the implementation of noise management and mitigation measures might be required.

10.2.2 Potential vibration impacts

Potential sources of vibration emission associated with construction of the GFD Project include:

- Rock breaking
- Compaction with vibratory rollers
- Heavy vehicle movements.

Based on the SLR assessment conducted for the GFD Project area (SLR, 2014), there is no significant vibration-generating plant or equipment associated with the operation of the GFD Project that has the potential to cause vibration levels perceivable outside the construction or development area. No significant vibration impacts are anticipated from the operation of the GFD Project.

Table 10-7 Predicted noise levels at various distances – operations

Operation scenario	Weather conditions	Predicted noise level at distance (dBA LAeq)						
		50 m	100 m	250 m	500 m	1,000 m	2,000 m	5,000 m
Hub gas compression facility (non-electrified)	Neutral	83	77	66	57	48	39	25
Hub gas compression facility (electrified)		77	71	59	50	42	33	19
Nodal gas compression facility		76	70	58	50	41	31	15
Water treatment facility		57	51	39	30	22	<15	<15
Well (non-electrified)		50	44	32	24	15	<15	<15
Well (electrified / free-flowing)		36	28	17	<15	<15	<15	<15
Gas compression facility - flaring		80	74	62	54	45	36	20
Accommodation camp		64	59	47	39	30	21	<15
Hub compression facility (non-electrified)	Adverse	84	78	69	62	53	44	30
Hub compression facility (electrified)		78	72	62	55	47	39	24
Nodal gas compression facility		78	72	63	55	46	37	21
Water treatment facility		58	52	44	36	27	17	<15
Well (non-electrified)		51	45	36	28	20	<15	<15
Well (electrified / free-flowing)		37	28	20	15	<15	<15	<15
Gas compression facility - flaring		81	75	67	59	51	41	25
Accommodation camp		64	59	50	42	34	25	<15

Source: SLR 2014, Table 14

Table 10-8 Potential impact distances for various predicted noise levels – operation¹

Construction scenario	Weather condition	Impact distance to predicted noise level (m) ²								
		65 dBA	55 dBA	50 dBA	45 dBA	40 dBA	35 dBA	30 dBA	28 dBA	25 dBA
Hub gas compression facility (non-electrified)	Neutral	300	600	900	1,300	1,900	2,700	3,700	4,100	4,900
Hub gas compression facility (electrified)		160	350	550	800	1,200	1,700	2,500	2,800	3,400
Nodal gas compression facility		150	350	500	750	1,100	1,600	2,200	2,500	3,000
Water treatment facility		<50	70	110	160	250	350	550	650	800
Well (non-electrified)		<50	50	60	80	140	200	300	350	450
Well (electrified / free-flowing)		<50	<50	<50	<50	<50	60	80	100	130
Gas compression facility - flaring		200	500	700	1,100	1,500	2,200	2,900	3,300	3,800
Accommodation camp		<50	140	200	300	500	700	1,000	1,200	1,500
Hub compression facility (non-electrified)	Adverse	400	900	1,300	1,900	2,700	3,700	4,900	5,500	6,500
Hub compression facility (electrified)		200	500	800	1,200	1,800	2,600	3,600	4,100	4,800
Nodal gas compression facility		250	500	750	1,200	1,700	2,300	3,200	3,500	4,200
Water treatment facility		<50	80	130	250	350	550	800	950	1,200
Well (non-electrified)		<50	50	60	110	180	300	450	550	700
Well (electrified / free-flowing)		<50	<50	<50	<50	<50	60	80	110	150
Gas compression facility - flaring		300	700	1,100	1,600	2,200	3,000	3,900	4,400	5,100
Accommodation camp		<50	160	250	400	600	900	1,400	1,600	2,000

Source: SLR 2014, Table 15

Note 1: Grey highlighted cells represent the distances where further noise management and mitigation measures may be required. Remaining cells (that are not grey) show the predicted distances outside which the activities are likely to achieve the relevant criteria without further noise management and mitigation measures for each modelled scenario.

Note 2: The distances are based on predicted noise levels at 10 m intervals up to 200 m, 50 m intervals up to 1,000 m and 100 m intervals thereafter.

10.2.3 Cumulative impacts

The cumulative noise predictions show that cumulative noise levels might need to be considered if a major GFD Project facility and another projects major facility are located within approximately 9.8 km and 13 km of each other for neutral and adverse weather conditions respectively. For situations where a GFD Project facility and another facility are located within the predicted cumulative impact distances, more detailed modelling will be conducted to determine if further noise management and mitigation measures are required.

The cumulative noise assessment of multiple well leases predicts no cumulative noise build-up within the high density gas fields (600 m between wells) with electrified or free flowing wells. A marginal cumulative noise build-up was shown for the non-electrified wells in the low density well configuration (1,000 m between wells). Effective placement of wells (in accordance with the Constraints Protocol) will help mitigate potential impacts on sensitive receptors.

Cumulative noise levels might need to be considered if a GFD Project facility and another facility are located within 13,000 m of each other for adverse weather conditions.

There are no predicted noise exceedances associated with GFD Project related vehicle movements on State-controlled roads.

Once preferred locations for individual major facilities (such as gas compression facilities) are identified and more details of the required size and number of equipment are known, more detailed modelling would be performed to enable location-specific factors such as the surrounding topography and land use to be accounted for in the modelling to quantify the impacts of these factors on the predicted noise and vibration levels. If sensitive receptors are identified within the specified impact distances, Santos will investigate if further noise management and/or mitigation measures are required.

10.3 Environmental protection objectives

In accordance with regulatory requirements and Santos GLNG's internal standards, the GFD Project will adopt the environmental performance objectives relevant to noise management listed in Table 10-10.

Table 10-9 Environmental protection objectives

Environmental protection objectives

- Protection of noise environmental values associated with the GFD Project.
- Emission of noise levels are in accordance with those specified in the EA.
- Blasting operations (if required) are in accordance with the requirements of the EA.

10.4 Environmental protection performance indicators

The indicators within Table 10-11 will be utilized to determine whether the environmental performance objectives have been met and whether the control strategies implemented have been effective.

Table 10-10 Environmental Performance Indicator

Environmental performance indicator
• The Noise management plan is implemented. • Noise emissions do not exceed the noise levels specified in the EA except where there are alternative arrangements in place. • If required, Blast management plans are developed in accordance with Australian Standard 2187 and implemented for each blasting activity. • Complaints advised by the administering authority which relate to noise and vibration are investigated, monitored and resolved in accordance with the environmental nuisance monitoring requirements of the EA.

10.5 Management controls

The control measures in Table 10-11 reflect the management controls that will be implemented to mitigate impacts to noise environmental values.

Table 10-11 Management control measures

Management plan	Key provisions/ function	Management control measures
Constraints protocol	The Constraints protocol provides a framework to guide placement of infrastructure and adopts the management principles of avoid, minimise, mitigate, remediate and rehabilitate and offset. 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.	Noise is identified as a planning constraint within the Constraints protocol. Santos GLNG will implement the Constraints Protocol (Refer Appendix B).
Noise management plan	The NMP identifies potential noise impacts from Santos GLNG activities and provides a strategy, methods and controls to: • Avoid — plan the activity and engage with potentially affected stakeholders • Minimise — implement noise mitigation measures to minimise noise impacts • Manage — conduct monitoring, review mitigation methods and ensure compliance with Santos GLNG procedures.	Santos GLNG will implement the NMP. Noise will be managed in accordance with the NMP, which includes reasonable and practicable control or abatement measures (including relocating the activity, altering the hours of operation, or having an alternate arrangement in place with any potentially affected person) that can be undertaken to ensure compliance with the noise limits in the EA. Prior to undertaking petroleum activities that could result in short-term, medium-term or long term noise events that are likely to impact on a sensitive receptor, and where there are no alternative arrangements in place, any potential noise emissions from the relevant petroleum activities will be modelled or calculated to demonstrate that noise emissions will not exceed the noise levels specified in the EA.
Blast management plan, if required	The Blast management plan includes measures to minimise the likelihood of any adverse effects being caused by airblast overpressure and / or ground borne vibrations at any sensitive receptor. It demonstrates current best practice environmental management.	Blasting is not anticipated for the GFD Project. If blasting be necessary, a blast management plan will be developed prior to blasting activity occurring in accordance with Australian Standard 2187 <i>Explosives - Storage, Transport and Use</i>.

Source: SLR, 2014. Table 22

10.6 Monitoring

Table 10-12 summarises the environmental monitoring and assessment considerations for the protection of noise environmental values within the GFD Project area.

Table 10-12 Monitoring considerations for noise and vibration

Existing management and monitoring plans

- NMP
- Blast management plan (if required)

Additional monitoring considerations

General

- Monitoring will be undertaken by a suitably qualified person.
- Laboratory analyses and tests will be carried out by a laboratory that has NATA accreditation for such analyses and tests, unless NATA accredited tests are not available.
- Management or monitoring plans, systems, programs or procedures required to be developed and implemented by the EA will be reviewed for performance and amended as required but not less than once every three years in accordance with the requirements for the particular plans, systems, programs and procedures in the conditions of the EA.
- Management plans and monitoring programs specifically required by the EA will be certified by a suitably qualified person.
- An annual report will be prepared each year and submitted to the administering authority in the form requested by the administering authority. This report will include information as required by the EA such as:
 - any third party audit report
 - the results of any vibration and blast monitoring
 - details of any exceedances with the conditions of this EA and the dates and times these exceedances were reported to the administering authority
 - an outline of actions taken to minimise the risk of environmental harm from any circumstance, condition or elevated contaminant level identified by the monitoring or recording programs.

Noise

- Noise monitoring and recording will include, but not necessarily be limited to:
 - LAN,T (where N equals the statistical levels of 1, 10 and 90 and T=15)
 - LAeq adj, 15 mins
 - background noise level as LA 90, 15 mins
 - Max LpA, 15 mins
 - the level and frequency of occurrence of impulsive or tonal noise and any adjustment and penalties to measured noise levels
 - atmospheric conditions including temperature, relative humidity and wind speed and directions
 - effects due to any extraneous factors such as traffic noise
 - location, date and time of monitoring
 - if the complaint concerns low frequency noise, Max LpZ, 15 min, and one-third octave band measurements in dB(LIN) for centre frequencies in the 10 – 200 Hz range for both the noise source and the background noise in the absence of the noise source.
- When the administering authority advises in writing of a valid complaint alleging noise nuisance at a sensitive place, the complaint will be investigated as soon as practical. The investigation will include monitoring of environmental nuisance at any sensitive place within a reasonable and practical timeframe as specified by the administering authority. The results of the noise monitoring will be provided to the administering authority within five business days after completing the noise monitoring, unless a longer time is agreed to by the administering authority.
- Noise monitoring and compliance testing will be conducted by a suitably qualified person in accordance with

Additional monitoring considerations

the prescribed standards in the Noise Measurement Manual (DEHP, 2013) and the *AS1055.1-1997 Acoustics - Description and Measurement of environmental noise - Part 1: General Procedures*.

Blast and vibration monitoring

- Any Blast management plan will be developed for required blasting activities in accordance with *Australian Standard 2187*.
- If blasting activities are required, monitoring and recording of the air blast overpressure and ground borne vibration of every blast will be undertaken.
- Blast and vibration monitoring will include but not necessarily be limited to:
 - maximum instantaneous charge
 - location of the blast within the site (including any bench level)
 - airblast overpressure level (dB Linear Peak)
 - peak particle velocity (mm / s)
 - location, date and time of recording
 - measurement instrumentation and procedure
- Meteorological conditions for blast monitoring (including temperature, relative humidity, temperature gradient, cloud cover, wind speed and direction); and distances from the blast site to potentially noise-affected buildings or structures.

10.7 Proposed environmental authority conditions

The following draft EA conditions in relation to noise are proposed for the GFD Project. The conditions stipulate the required plans and management and monitoring requirements to enable adequate protection of the GFD Project areas environmental values. The EA conditions are reproduced in full in Appendix O.

Monitoring

- A20 All monitoring required under this environmental authority must be undertaken by a suitably qualified person.
- A22 Any management or monitoring plans, systems, programs or procedures required to be developed and implemented by a condition of this environmental authority must be reviewed for performance and amended as required but not less than once every three (3) years in accordance with the requirements for the particular plans, systems, programs and procedures in the conditions of this environmental authority.

Noise sampling methodology

- A26 Noise must be measured in accordance with the prescribed standards in the Environmental Protection Regulation 2008.

Documentation and records management

- A27 A record of all documents required by this environmental authority must be kept for a minimum of five (5) years.
- A28 All plans and monitoring programs required by this environmental authority must be certified by a suitably qualified person.

A29 All plans and monitoring programs under this environmental authority must be implemented.

SCHEDULE F – ENVIRONMENTAL NUISANCE

- F2 When the administering authority advises of a complaint alleging nuisance, the complaint must be investigated as soon as practicable. The investigation is to include monitoring of environmental nuisance at any sensitive place within a reasonable and practical timeframe as specified by the administering authority.
- F3 The administering authority must be advised in writing of the results of the investigation (including an analysis and interpretation of the monitoring results) and actions proposed or undertaken to resolve the complaint within five (5) business days of completing the complaint investigation, unless a longer time is agreed to by the administering authority.
- F4 If the investigation or monitoring in accordance with condition (F2) indicates that emissions exceed the limits set in this environmental authority or are causing environmental nuisance, then:
- a) the complaint must be addressed including the use of alternative dispute resolution services if required; and / or
 - b) abatement or attenuation measures must be implemented so that the authorised petroleum activity(ies) do not result in further environmental nuisance.
- F5 Noise monitoring and recording under this environmental authority must include, but not necessarily be limited to:
- a) $L_{AN,T}$ (where N equals the statistical levels of 1, 10 and 90 and T=15);
 - b) LAeq adj, 15 mins;
 - c) background noise level as LA 90, 15 mins;
 - d) Max LpA, 15 mins
 - e) the level and frequency of occurrence of impulsive or tonal noise and any adjustment and penalties to measured noise levels;
 - f) atmospheric conditions including temperature, relative humidity and wind speed and directions;
 - g) effects due to any extraneous factors such as traffic noise;
 - h) location, date and time of monitoring;
 - i) if the complaint concerns low frequency noise, Max LpZ, 15 min; and
 - j) If the complaint concerns low frequency noise, one third octave band measurements in dB(LIN) for centre frequencies in the 10 – 200 Hz range for both the noise source and the background noise in the absence of the noise source.
- F8 Prior to undertaking petroleum activities that will result in short-term, medium-term or long term noise events that are likely to impact on a sensitive receptor, and where there are no alternative arrangements in place, any potential noise emissions from the relevant petroleum activity(ies) must be modelled or calculated to demonstrate that noise emissions will not exceed the noise levels specified in Schedule F, Table 1 – Noise Limits at Sensitive Receptors.
- F9 The emission of noise from the petroleum activities authorised under this environmental authority must not result in levels greater than those specified in Schedule F, Table 1 – Noise

Limits at Sensitive Receptors in the event of a valid complaint about noise being made to the administering authority.

Schedule F, Table 1 – Noise limits at sensitive receptors

Time period	Metric	Short term noise event	Medium term noise event	Long term noise event
7:00 am – 6:00 pm	L _{Aeq,adj} ,15 min	45dBA	43dBA	40dBA
6:00 pm – 10:00 pm	L _{Aeq,adj} ,15 min	40dBA	38dBA	35dBA
10:00 pm – 6:00 am	L _{Aeq,adj} ,15 min	28dBA	28dBA	28dBA
	Max L _{pA} , 15 mins	55dBA	55dBA	55dBA
6:00 am – 7:00 am	L _{Aeq,adj} ,15 min	40dBA	38dBA	35dBA

Note – The noise limits in Table 1 have been set based on the following deemed background noise levels (L_{ABG}):

7:00 am - 6:00 pm: 35 dBA

6:00 pm – 10:00 pm: 30 dBA

10:00 pm – 6:00 am: 25 dBA

6:00 am – 7:00 am: 30 dBA

- F10 If the noise subject to a complaint is tonal or impulsive, the adjustments detailed in *Schedule F, Table 2 – Adjustments to be Added to Noise Levels at Sensitive Receptors* are to be added to the measured noise level(s) to derive L_{Aeq, adj, 15 min}.

Schedule F, Table 2 – Adjustments to be added to noise levels at sensitive receptors

Noise characteristic	Adjustment to noise
Tonal characteristic is just audible	+ 2 dBA
Tonal characteristic is clearly audible	+ 5 dBA
Impulsive characteristic is just audible	+ 2 dBA
Impulsive characteristic is clearly audible	+ 5 dBA

- F11 Where alternative arrangements are in place with an affected person(s) at a sensitive receptor as referred to by condition (F7)(j), the noise limits in *Schedule F, Table 1 – Noise limits at Sensitive Receptors* do not apply at that sensitive receptor for the duration for which the alternative arrangements are in place.

Low frequency noise

- F12 Notwithstanding condition (F9), emission of any low frequency noise must not exceed the following limits in the event of a valid complaint about low frequency noise being made to the administering authority:
- 60 dB(C) measured outside the sensitive receptor; and
 - the difference between external A-weighted and C-weighted noise levels is no greater than 20 dB; or
 - 50 dB(Z) measured inside the sensitive receptor; and
 - the difference between the internal A-weighted and Z-weighted noise levels is no greater than 15 dB.

Vibration and blasting

- F13 A Blast management plan must be developed for each blasting activity in accordance with **Australian Standard 2187**.
- F14 Noise from blasting operations must not exceed an airblast overpressure level of 120 dB linear peak) at any time, when measured at or extrapolated to any sensitive receptor.
- F15 Ground-borne vibration peak particle velocity caused by blasting operations must not exceed 10 mm/s at any time, when measured at or extrapolated to any sensitive receptor.

Blast and vibration monitoring

- F16 Monitoring and recording of the air blast overpressure and ground borne vibration of every blast must be undertaken.
- F17 Blast and vibration monitoring must include but not necessarily be limited to:
- a) maximum instantaneous charge;
 - b) location of the blast within the site (including any bench level);
 - c) airblast overpressure level (dB Linear Peak);
 - d) peak particle velocity (mm / s);
 - e) location, date and time of recording;
 - f) measurement instrumentation and procedure;
 - g) meteorological conditions for blast monitoring (including temperature, relative humidity, temperature gradient, cloud cover, wind speed and direction); and
 - h) distances from the blast site to potentially noise-affected buildings or structures.

11 Air

This section describes the air environmental values within the GFD Project. It also describes the potential impacts and management controls to mitigate potential impacts to air environmental values.

The National Environment Protection Measure (NEPM) is legislation designed to protect particular aspects of the environment such as air and water quality, the protection of amenity from noise, site contamination, and hazardous wastes, and the reuse and recycling of materials. The NEPM for Ambient Air Quality (Air NEPM) and the NEPM for Air Toxics (Air Toxics NEPM) set ambient air quality standards and goals in Australia for a select number of pollutants. These standards have been adopted in Queensland in the Environmental Protection (Air) Policy 2008 (EPP Air).

The ambient air quality standards set out in the EPP Air intends to protect the qualities of the air environment that are conducive to human and ecosystem health, the appearance of natural and developed structures and agricultural use of the environment. To the extent that is reasonable to do so, Santos GLNG implements control processes that accord to the management hierarchy for air emissions in the EPP Air in the following order of preference:

- Avoid (e.g. using technology that avoids air emissions)
- Recycle (e.g. reusing in another industrial process)
- Minimise (e.g. treating air emissions before disposal)
- Manage (e.g. locating releases points of air emissions in a suitable area to reduce the impact of the air emissions).

11.1 Environmental values

The region is predominantly rural with populations residing in regional townships connected by sealed highways or isolated rural homesteads connected by sealed or unsealed rural roads. The air environment is influenced by dust from traffic on unsealed roads, wind erosion of bare soils from agricultural and resources activities and dust storms, and air emissions from industrial activities such as power generation, quarries and resources projects. It is a subtropical region characterised by hot summer months with some rainfall, and cold dry winters.

In accordance with EPP Air, the environmental values to be enhanced or protected are:

- The qualities of the air environment that are conducive to protecting the health and biodiversity of ecosystems
- The qualities of the air environment that are conducive to human health and wellbeing
- The qualities of the air environment that are conducive to protecting the aesthetics of the environment, including the appearance of buildings, structures and other property
- The qualities of the air environment that are conducive to protecting agricultural use of the environment.

The air quality objectives prescribed in Schedule 1 of the EPP Air include guideline emissions which are relevant to the study conducted for the GFD Project. The objectives and time frames measured can be found in the EPP Air, Schedule 1.

11.1.1 Sensitive receptors

The ambient air quality criteria set out in the EPP Air are designed to protect human health and the biodiversity of ecosystems, and to preserve amenity of land use. For the purpose of assessing potential air quality impacts, sensitive receptors can include:

- Dwellings
- Library or educational institutions
- Childcare centres or kindergartens
- Schools or playgrounds
- Hospitals, surgeries or other medical institution
- Commercial and retail activities
- Protected areas
- Parks or gardens that are open to the public
- Agricultural land.

New infrastructure for the GFD Project will be located in rural areas at significant distances from major population centres; as a result, most of the sensitive receptor types listed above will not be relevant. The types of sensitive receptors expected to be relevant to the GFD Project are scattered rural dwellings, agricultural land and protected areas.

11.1.2 Meteorology and climate

The following Bureau of Meteorology (BoM) weather stations were used to evaluate the existing environmental values:

- Rolleston Airport
- Injune Post Office
- Taroom Post Office
- Roma Airport
- Surat
- Miles Constance Street
- Miles Post Office.

A summary of the meteorological and climatic data relevant to the GFD Project is provided in Table 11-1.

Table 11-1 Summary of meteorological and climatic data

Meteorological aspect	Summary of findings
Wind speed and direction	Wind patterns vary across the GFD Project area, with the winds in the southern areas (Miles and Roma) predominantly blowing from the north and northeast quadrant, and winds in the northern area (Rolleston) predominantly blowing from the south and south-southeast, with the strongest winds yielding velocities of between 5.4 metres per second (m/s) and 7.9 m/s. Wind speeds are noticeably higher at Roma compared to Miles and Rolleston. In the south of the GFD Project area (Roma Airport), winds from the north and northeast quarter dominate, with the strongest winds ranging from 7.9 m/s and 10.7 m/s. The highest wind speeds are observed at Roma Airport at 9:00 am and 3:00 pm in the south of the GFD Project area. For observations taken at 9:00 am and 3:00 pm, the lowest wind speeds were observed in the winter months of May to July.
Temperature	Mean maximum temperature ranges from 34.8 degrees Celsius (°C) in January to 19.3°C in July, and mean minimum temperatures range from 22.2°C in January to below 3.1°C in July. The highest annual mean temperatures (approximately 24°C) can be found in the north of the region. Heatwave conditions can be expected between November and February and frosts between June and August.
Evaporation	The mean daily evaporation is highest between the summer months of November and February, when the mean daily evaporation rate is 8.3 mm (approximately 248 mm of evaporation per month). The winter months of June and July have a mean daily evaporation of approximately 3 mm, or 90 mm per month. For the whole year evaporation exceeds rainfall, which creates a surface water deficit.
Rainfall	Late spring and summer is characterised by rainfall with an annual median of 540 to 675 mm. Rainfall generally decreases from northwest to southeast and the majority of precipitation falls in the warmer months of the year (November to February). In the driest months of the year (April to September), median rainfall is between 14.2 mm at Rolleston in August, 98 mm at the Taroom Post Office, and 29.8 mm at Miles Post Office in June.
Solar exposure	Mean daily solar exposure is highest in the summer months. In November to January, the mean daily solar exposure was in excess of 25 megajoules per square metre (MJ/m²) at nominated BoM stations, which is approximately 750 MJ/m² per month. The lowest mean daily solar exposure of 12 MJ/m² was observed at Surat in June, which is approximately 360 MJ/m² per month and half the summer peak. The Rolleston and Surat records indicate that the solar exposure variation between winter and summer is greatest in the south and lowest in the north of the GFD Project area.
Relative humidity	Mean monthly 9:00 am relative humidity varies throughout the year with two peaks occurring in February and June. The highest 9:00 am relative humidity was observed in June for nominated BoM stations. The highest 9:00 am mean monthly relative humidity observation of 77% was made at Surat. Mean monthly 3:00 pm relative humidity peaks in February and June. Mean monthly relative humidity ranges from 27% to 49% while at 9:00 am the relative humidity readings range between 66% and 76%.

11.1.3 Ambient air quality

Monitoring records collected between 2003 and 2010 from the ambient air quality monitoring station at Toowoomba (nearest to the GFD Project area i.e. 330 km east-southeast of Roma) indicate background levels of NO₂ (1 hour average), CO (8 hour average) and PM₁₀ (24 hour average) are below the EPP Air guideline.

Estimated background NO₂ and CO concentrations in the GFD Project area have been conducted, and these predictions are outlined in Table 11-2, below. These predictions are based on assessments conducted through modelling analysis of emissions data reported to the National Pollutant Inventory (NPI) for industrial and commercial sources within modelling domain centred on the GFD Project area. The Air Quality Impact Assessment (SLR, 2014) provides additional detail regarding this study and the process that led to these predictions.

As Table 11-2 illustrates, there are areas in the Scotia gas field that are predicted to experience more elevated background NO₂ concentrations. These areas are close to existing sources, in particular mines and power stations. It is considered likely that the predictions close to these sources are conservatively high; however, they have been used as a worst case estimate of potential background concentrations.

A comparison of the levels measured at Toowoomba and the estimated background predictions shows long-term average NO₂ concentrations predicted in the project area are lower than the levels measured at Toowoomba; however short-term concentrations in some areas can on occasion be elevated. The predicted CO concentrations are also lower than the levels measured at Toowoomba.

Table 11-2 Estimated background NO₂ and CO concentrations in the GFD Project tenures

Gas field	NO ₂ concentration (micrograms per cubic meter (µg/m ³), assuming 100% oxides of nitrogen (NOX) in the form of NO ₂)		CO concentration (µg/m ³)
	1-Hour average	Annual average	
Fairview	40	3	10
Arcadia	15	1	5
Scotia	120	10	200
Roma	17	5	8
Ambient air quality guidelines	246	33	11,000

Source: SLR Consulting Australia Pty Ltd, 2014

11.2 Potential impacts

The assessment of air pollutant emissions during operation focused on NO₂ and CO from gas compression facilities as these will be the key emission sources. Other emissions would be emitted at very low and minor levels that will comply with the air quality assessment objectives. The air emission types, sources and potential impacts to environmental values are provided in Table 11-3, below. These emission types and sources are representative of infrastructure and activities that might be required and are similar to those activities currently approved within the Arcadia, Fairview, Roma and Scotia gas fields. The GFD Project will result in an incremental increase in the quantity and geographical spread of such emissions.

The main sources of potential air emissions associated with the GFD Project would be exhausts associated with the new gas compression facilities and power generation. Air emission sources at a typical hub gas compression facility will include exhaust emissions from gas combustion in the gas turbine alternators, gas turbine compressors, TEG re-boilers (reheating gas stream) and emergency flare.

Air dispersion modelling was performed to predict NO_x and CO impacts from the proposed GFD Project activities. Since the locations of future major facilities will be identified as the GFD Project develops, the approach used in this assessment was designed to provide a conservative assessment of downwind impacts from three worst case scenarios:

- A nominal large hub compression facility (240 TJ/day) – normal operations
- A nominal large hub compression facility (240 TJ/day) – major flaring event
- A nominal nodal compression facility (80 TJ/day) – normal operations.

As preferred locations for individual facilities are identified through the ongoing field development process, and details of the required size and number of engines and other fuel-burning equipment become known, more detailed modelling will be performed to enable an assessment of the potential impacts at sensitive receptors (if relevant).

Under all three worst case scenarios that were modelled, the NO₂ and CO concentrations were well below those ambient air quality guidelines outlined in the EPP Air. The dispersion modelling predicted concentrations from gas compression activities under normal operations and during flaring (commissioning and emergency) will comply with objectives for the preservation of health and wellbeing and biodiversity of ecosystems. These air emissions will have a low impact and will not require specific mitigation measures.

Potential impacts on regional air quality are expected to be minimal with the GFD Project operations not constituting a dominant source contribution to regional NO₂ levels.

As such, the impacts to air quality as a result of construction, operation and decommissioning activities will be effectively managed. The Air Quality Impact Assessment (SLR, 2014) provides further discussion regarding these worst case scenarios, as well as graphs illustrating this finding. Section 6.4.2 of this report (Draft EM plan) provides additional information regarding point source emissions generated from infrastructure within the GFD Project.

Potential odour emissions will be highly localised to the source and be dispersed within the immediate environment; therefore, odour-related nuisance impacts are not expected.

Table 11-3 outlines the potential air impacts associated with the following potential air emissions due to the various activities conducted during the construction, operation and decommissioning phases of the GFD Project:

- Pollutants emitted from the combustion of gas and (NO_x, CO, SO₂, PM, VOCs)
- Exhaust emission from the combustion of diesel and petrol and back-up diesel generators (NO_x, CO, SO₂, PM, VOCs)
- Fugitive particulate emissions during construction of infrastructure (PM₁₀ and PM_{2.5})
- Odour from small-scale STPs.

Table 11-3 Summary of potential air emissions, sources, environmental values and potential impacts

Potential air emissions	Air emission sources during GFD phases			Environmental value ¹	Potential impact
	Construction	Operations	Decommissioning		
Particulate matter (PM)	Clearing, topsoil removal and earthworks Vehicles, trucks and other mobile equipment. Concrete batching.	Vehicle movements on unpaved roads. Wind erosion of disturbed soils.	Rehabilitation activities such as grading and topsoil spreading. Vehicles, trucks and other mobile equipment. Demolition activities (possibly including blasting)	Health and wellbeing Biodiversity of ecosystems Aesthetics	Air emissions from the GFD Project contribute to an exceedance of one or more of the air quality objectives for PM ₁₀ or PM _{2.5} .
Oxides of nitrogen (NO _x)	Vehicles, trucks and other mobile equipment.	Gas-fired turbine compressors, alternators and TEG dehydrator reboilers at gas compression facilities. Flares. Reciprocating engines at wellheads. Vehicles, trucks and other mobile equipment.	Vehicles, trucks and other mobile equipment.	Health and wellbeing	Air emissions from the GFD Project contribute to an exceedance of the air quality objectives for NO ₂ .
				Health and biodiversity of ecosystems	
				Regional air quality	Acid deposition or acid rain caused by concentrations of NO _x
Carbon monoxide (CO)				Health and wellbeing	Air emissions from the GFD Project contribute to an exceedance of one or more of the air quality objectives for CO.
Volatile organic compounds (VOCs)				Regional air quality	Formation of photochemical smog caused by reaction of VOCs
Sulfur dioxide (SO ₂)	Diesel vehicles, trucks, generators and other equipment.	Diesel backup generators, pumps and other stationary equipment. Diesel vehicles, trucks and other mobile equipment	Diesel vehicles, trucks, generators and other equipment.	Regional air quality	Acid deposition or acid rain caused by concentrations of SO _x
Odour	Sewage treatment plants at accommodation camps.	Sewage treatment plants at accommodation camps.	Sewage treatment plants at accommodation camps.	Health and well being	Odour-related nuisance

Source: SLR Consulting Australia Pty Ltd, 2014. Santos GLNG Gas Field Development Project – Environmental Impact Statement – Air Quality Impact Assessment, Table E1

Note 1: Environmental value are from Schedule 1 of the EPP Air. Schedule 1 of the EPP Air include these environmental values and associate them with indicators that are included in this table as potential air emissions.

11.3 Greenhouse gas (GHG) emission profiles

The construction and decommissioning of the additional production wells associated with the GFD Project will generate minor GHG emissions as a result of land clearing, fuel use for drilling and vehicles associated with construction, flaring from well completion and connection activities, and fuel use for decommissioning. Emissions from these sources are dependent on the number of wells constructed. Other emissions (i.e. emissions from operation of those wells) are driven by the total volume of gas being produced, and were assessed within the 2009 EIS and 2010 supplementary EIS.

GHG emissions provided in this section were estimated in accordance with the GHG emission factors provided in the following instruments:

- The *National Greenhouse Accounts (NGA) Factors* (Department of Climate Change and Energy Efficiency (DCCEE), 2013); and
- The National Greenhouse and Energy Reporting (Measurement) Determination 2008 (DCCEE 2008) (NGER Determination).

The NGA Factors is designed for use by companies and individuals to estimate greenhouse gas emissions. While drawing on *the NGER Determination*, the methods used in the NGA Factors have a general application to the estimation of a broader range of greenhouse emissions inventories.

Emissions from each activity assessed are categorised as either scope 1 or 2, which are defined as follows (NGER Regulation 2008):

- Scope 1 (direct) GHG, in relation to a facility, means the release of greenhouse gas into the atmosphere as a direct result of an activity or series of activities (including ancillary activities) that constitute the facility
- Scope 2 (indirect) GHG emissions, in relation to a facility, means the release of greenhouse gas into the atmosphere as a direct result of one or more activities that generate electricity, heating, cooling or steam that is consumed by the facility but that do not form part of the facility.

Scope 1 and 2 emissions are required for reporting under the *National Greenhouse and Energy Reporting Act 2007* (NGER Act).

Table 11-4 Emission sources

Project phase	Scope	Emission source
Construction	Scope 1	• Diesel fuel used in drilling rigs, construction equipment, generators in camps and transportation of equipment, materials and personnel • Land clearing for well lease, water treatment and gas processing facilities, camps, access roads, gas and water gathering lines • Flaring during well completion activities
Operations ¹	Scope 1	• Gas fuel used for compression and for self-generated electricity production (to power gas compression, water management and camps) • Venting or flaring during abnormal conditions at facilities • Fugitive emissions (other than flaring or venting)
	Scope 2	• Electricity purchased from grid for pumps, gas compression, water management and camps
Decommissioning and rehabilitation	Scope 1	• Diesel fuel used for transporting personnel and equipment used for rehabilitating land

Note 1: Note that operations emissions from the GFD Project gas field were included in the assessment in the 2009 EIS and 2010 supplementary EIS.

In accordance with the Greenhouse Gas Protocol (World Business Council for Sustainable Development and the World Resource Institute 2004), emissions are estimated and expressed in values of carbon dioxide equivalent (CO₂e). Scientists have calculated the global warming potential (GWP) of each gas to be able to compare the warming effects of different greenhouse gasses. GWP measures how much a particular GHG contributes to global warming. The GWP compares the radiative forcing, or warming ability, of a particular gas to that of CO₂, which is used as a reference.

State and territory GHG inventories are published annually with quarterly updates made available to the public. The latest annual state and territory GHG inventories publically available are for 2011-2012. Australia's *National Inventory Report 2012* was submitted under the UNFCCC and the Kyoto Protocol (KP). The responsibility for Australia's GHG emissions reporting has been assigned to Australia Government Department of the Environment. Published results for both Australian and Queensland emissions profiles are summarised in Table 11-5.

Table 11-5 Australian and Queensland emissions profiles for 2011-2012

Annual reporting period 2011-12	Total GHG emissions (Mt CO ₂ -e)
Australian emissions profile (excluding land use, land use change and forestry (LULUCF)) for 2012.	543.6
Queensland emissions profile (excluding LULUCF) for 2011-2012.	134.5

Source: State and Territory greenhouse gas inventories, 2011-2012 (Department of the Environment 2014).

For Australia's total GHG emissions, the total provided in Table 11-5, above, represents an increase of 2.1 million tonnes of carbon dioxide equivalent (MtCO₂e) net emissions recorded in 2011 and an increase of 31.0% (128.7 MtCO₂-e above 1990 levels. For Queensland's total GHG, the total provided in Table 11-5, above, represents a 71.6% increase on 1989-1990.

11.3.1 Project life emissions

GHG emission management was addressed in the 2009 EIS and 2010 supplementary EIS. This assessment gave consideration to GHG emissions from the gas fields, pipelines, liquefaction processes on Curtis Island, shipping and product end-use associated with the GLNG Project. The 2009 EIS and 2010 supplementary EIS projected total annual GHG emissions of up to 7.2 MtCO₂e. This total was calculated based on the throughput of gas required to supply three trains capable of delivering up to 10 Mt per annum of LNG.

The GHG assessment for the GFD Project includes both the incremental emissions associated with the construction and decommissioning of the additional wells as well as the operations emissions that were already accounted for in the 2009 EIS and the 2010 supplementary EIS

Typical annual GHG emissions for construction of the GFD Project wells are projected to be in the order of 160,000 tonnes of carbon dioxide equivalent (tCO₂e).

Activities that will produce emissions for the GFD Project include: land clearing, fuel use for drilling and vehicles associated with construction, flaring from well completion and connection activities and fuel use for decommissioning. Emissions from these sources are dependent on the number of wells required. Other emissions, emissions from operations, are driven by the total volume of gas being produced and were assessed within the 2009 EIS.

Maximum GHG emissions occur around 2029 and 2030, coinciding with the projected maximum production output for the GFD Project. Table 11-6, below, provides an estimate of scope 1 and 2 GHG emissions for the worst-case construction and operational year for the GFD Project area only. A range of energy source options are being considered for the GFD Project. Annual operations GHG emissions projections have been provided for three scenarios in the table below:

- Electrification (0%): Annual scope 1 emissions are 1.8 MtCO₂e per year and there are no scope 2 emissions
- Electrification (50%): Annual scope 1 emissions are 1.1 MtCO₂e per year and total annual emissions (i.e. scope 1 and 2) are 2.2 MtCO₂e per year
- Electrification (100%): annual scope 1 emissions are 0.3 MtCO₂e per year and total annual emissions (i.e. scope 1 and 2) are 2.6 MtCO₂e per year.

Table 11-6 GFD Project predicted annual GHG emissions for peak production years, 2029

Activity	Electrification Scenario (%)	CO ₂ (tCO ₂ e)	CH ₄ (tCO ₂ e)	N ₂ O (tCO ₂ e)	Total (tCO ₂ e)
Construction					
Land clearing ¹	-	132,942	-	-	132,941
Fuel consumption in drilling	-	11,346	16	33	11,396
Fuel consumption in vehicles	-	6,132	18	44	6,194
Well completions and connections	-	12,882	568	138	13,587
Total emissions	-	163,302	602	215	164,119
Operations					
Flaring	-	234,727	10,350	2,507	247,584
Fugitives	-	0	6,210	0	6,210
Fuel combustion for power generation	0	752,876	3,508	425	756,809
	50	376,438	1,754	212	378,404
	100	0	0	0	0
Fuel consumption for stationary equipment (including compression)	0	824,036	3,840	465	828,341
	50	447,598	441	253	448,292
	100	71,160	332	40	71,532
Electricity purchased (scope 2)	0	-	-	-	-
	50	-	-	-	1,151,093
	100	-	-	-	2,302,186
Total operations scope 1 emissions	0	1,811,639	23,908	3,397	1,838,944
	50	1,058,763	18,755	2,972	1,080,490
	100	305,887	16,892	2,547	325,326
Total operations scope 1 and 2 emissions	0	1,811,639	23,908	3,397	1,838,944
	50	2,209,856	18,755	2,972	2,231,583
	100	2,608,073	16,892	2,547	2,627,512

Note 1: Revegetation programs will largely negate emissions from land clearing.

Total GHG emissions for operations of the GFD Project wells over the lifetime of the GFD Project, for 50% electrification scenario, including scope 1 and scope 2 emissions, are 5.7 MtCO₂-e. The total incremental emissions for the lifetime of the GFD Project are estimated to be 4.5 MtCO₂-e.

Table 11-7 provides a summary of the Lifetime GHG emissions for:

1. Operations at 50% electrification. These operations emissions are a subset of the total GLNG Project emissions and were previously included in the assessment in the 2009 EIS and 2010 supplementary EIS
2. GHG emissions from construction and decommissioning of the GFD Project's production wells over the lifetime of the GFD Project. These emissions are incremental to the emissions for the GLNG Project reported in the 2009 EIS and 2010 supplementary EIS.

Table 11-7 GFD Project Lifetime GHG

Activity	CO ₂ (tCO ₂ e)	CH ₄ (tCO ₂ e)	N ₂ O (tCO ₂ e)	Total (tCO ₂ e)
GFD Project (50% electrification) lifetime greenhouse gas emissions (operations, scope 1 and 2)				
Flaring	5,600,800	247,000	59,800	5,907,600
Fugitives	-	148,200	-	148,200
Fuel combustion for power generation	9,686,600	45,100	5,500	9,737,200
Fuel consumption for stationary equipment	11,436,900	53,300	6,500	11,496,700
Electricity purchased (scope 2)	-	-	-	29,620,000
Total operation scope 1 emissions	26,724,300	493,600	71,800	27,289,700
Total operation scope 1 and 2 emissions	56,344,300	493,600	71,800	56,909,700
GFD Project lifetime incremental greenhouse gas emissions				
Construction				
Land clearing	3,632,900	-	-	3,632,900
Fuel consumption in drilling	288,100	400	800	289,300
Fuel consumption in vehicles	150,800	400	1,100	152,300
Well completions and connections	316,800	14,000	3,400	334,200
Decommissioning				
Fuel consumption in vehicles and heavy machinery	75,400	200	550	76,150
Total incremental emissions	4,464,000	15,000	5,850	4,484,850

11.3.1.1 Fugitive emissions

Fugitive emissions are intentional or unintentional GHG releases that occur during natural gas exploration, production and processing. These emissions are reported as an assumed percentage of throughout. Fugitive emissions of gas from coal seams will occur during the construction of wells and during the operations phase as a result of leaks or failures of valves and flanges and other devices associated with surface equipment at well leases, compression facilities, pipework, etc. These emissions are predominantly CH₄, and do not have the potential to give rise to impacts on local air quality (i.e. impacts on human health or flora/fauna) and rapidly disperse (due to their lower density than air) in the atmosphere.

The fugitive emissions, based on Santos GLNG's NGER Determination, were reported in 2011/12 to be approximately 0.3% of total upstream emissions or 0.04% of total lifecycle emissions. Assuming a conservative estimate of 0.1% of gas lost, fugitive emissions, other than those from flaring or venting, make up less than 1% of the total lifecycle emissions.

Fugitive particulate emissions would also occur during construction of infrastructure such as production wells, gas compression facilities, water management facilities, roads and accommodation facilities.

11.3.1.2 Point source emissions

Point source emissions are generated from fixed and/or uniquely identifiable, such as stacks, outlet pipes or vents. Locations for infrastructure throughout the GFD Project that would generate point source emissions have not yet been determined. As described in Section 1.4 of this report, the final number, size and location of the GFD Project components will be determined progressively over the life of the GFD Project and will be influenced by the location, size and quality of the gas resources identified through ongoing field development planning processes. The potential air emission types and sources identified in Table 6-3, above, are representative of infrastructure and activities that may be required.

For fuel burning equipment burning less than 500 kg of fuel per hour, a register will be developed that includes the following information for each piece of equipment:

- Fuel burning or combustion equipment name and location
- Stack emission height (metres)
- Minimum efflux velocity (metres / second (m/s))
- Mass emission rates (gram / second (g/s)).

For gas compression facilities or other infrastructure with the potential to burn more than 500 kg/hour of fuel, detailed asset-specific modelling will be performed as part of the siting and design phases. The results of this modelling will include ground level concentrations for key air quality indicators (e.g. NO_x, CO and particulates) and will demonstrate that the air quality objectives in the EPP Air for the protection of the relevant air quality values have been met. As Section 6.2 (Potential Impacts) of this document describes the main sources of potential air emissions associated with the GFD Project would be exhausts associated with the new gas compression facilities and power generation. Air emission sources at a typical hub gas compression facility will include exhaust emissions from gas combustion in the gas turbine alternators, gas turbine compressors, TEG re-boilers (reheating gas stream) and emergency flare.

Under the three worst case scenarios modelled, the NO₂ and CO concentrations were well below those ambient air quality guidelines provided in the EPP Air. Section 11.2 provides detail of the potential impacts of these three worst case scenarios. The Air Quality Impact Assessment (SLR, 2014) provides further discussion regarding these worst case scenarios, including the detailed results of the modelling for stack and emission data for all three worst case scenarios:

- Large hub compression facility (240 TJ/day) – normal operations
- Large hub compression facility (240 TJ/day) – flaring
- Field nodal gas compression facility (80 TJ/day).

As preferred locations for individual facilities are identified through the ongoing field development process, and details of the required size and number of engines and other fuel-burning equipment become known, more detailed modelling will be performed to enable an assessment of the potential impacts at sensitive receptors (if relevant).

11.3.1.3 Impact on national and state emissions

Annual emissions from the GFD Project are shown as a percentage of Australia's and Queensland's GHG emissions in Table 11-8 (below). The emissions presented in this analysis are based on the year of maximum emissions (2029) whereas the emissions for Australia and Queensland represent those from 2011/12. Therefore, emissions will be considerably lower than those shown in Table 11-8 over most of the GFD Project life.

Table 11-8 GFD Project (at 50% electrification) emissions comparison to 2011/12 emissions

Sector	2011/12 emissions (Mt CO ₂ -e)	Total GFD Project emissions as a percentage of sector1 (%)	GFD Project incremental emissions as a percentage of the sector2 (%)
Queensland energy sector (for 2011-2012)	96.9	2.5	0.17
Total Queensland	134.5	1.8	.12
Australian Energy Sector (for 2012)	413.4	0.6	.04
Total Australia	543.6	0.4	.03

Note1: Construction and operations emissions for the 50% electrification scenario in the worst case year (2029), i.e. 2.40 Mt CO₂e.

Note 2: Construction emissions in 2029, i.e. 0.16 Mt CO₂e.

11.4 Environmental protection objectives

Queensland ambient air quality objectives are provided in the EPP Air as administered under the EP Act. In accordance with these and Santos GLNG internal standards, the GFD Project will adopt the environmental performance objectives relevant to air quality as listed in Table 11-9.

Table 11-9 Environmental protection objectives

Environmental protection objectives

- Protect air environmental values by meeting relevant air quality guidelines at sensitive receptors.
- Minimise greenhouse gas emissions throughout the life of the GFD Project in accordance with regulatory requirements.

11.5 Environmental protection performance indicators

The indicators within Table 11-10 will be utilised to determine whether the environmental performance objectives have been met and whether the control strategies implemented have been effective.

Table 11-10 Environmental performance indicators

Environmental performance indicators

- Fuel burning or combustion equipment are operated from the point sources described in the EA and do not exceed the specified release limits outlined in the EA
- Greenhouse gas emissions are minimised in accordance with regulatory requirements.
- Complaints advised by the administering authority which relate to air are investigated, monitored and resolved in accordance with the environmental nuisance monitoring requirements of the EA.

11.6 Management controls

Santos GLNG adopts the commitments within the controls outlined in Environment Hazard Standard EHS05 Air emissions required to manage risks of specific hazards associated with air emissions to acceptable levels. Additionally, Santos GLNG has its own corporate Climate change policy, which reflects a commitment to energy efficiency and reducing emissions across its operations, including the GFD Project.

The control measures in Table 11-11 are based on existing management plans that will be implemented to mitigate impacts to air environmental values. The following are additional management measures which are not covered by the existing management plans:

- Site-specific air dispersion modelling studies will be performed to identify potential impacts to air quality from proposed fuel burning equipment capable of burning at least 500 kg of fuel in an hour.
- Contaminants emitted from fuel burning equipment point sources will be emitted via appropriately designed stacks (i.e. at a suitable release height) to manage dispersion.
- The selection of compressor engines and other fuel burning equipment for new surface facilities will have the manufacturers' specifications taken into account to ensure that pollutant emission levels will comply with EA emission limits.
- Fuel burning equipment will be maintained and operated in accordance with the manufacturers' specifications to ensure pollutant emissions are minimised.

Table 11-11 Management control measures

Management plan	Key provisions/ function	Management control measures
GFD Project Environmental protocol for constraints planning and field development	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 • Offset — 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.	Santos GLNG will implement the Constraints protocol.

Management plan	Key provisions/ function	Management control measures
Erosion and sediment control management plan	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.	Santos GLNG will implement the ESCMP. The following measures from the ESCMP will be implemented: - Construction activities will aim to reduce exposure of disturbed areas to the minimum time period required, with progressive revegetation or rehabilitation as soon as practicable after the completion of construction. - Stabilisation of disturbed areas, including stockpiles, through the use of measures such as mulch, erosion blankets and establishment of ground cover.
Decommissioning and abandonment management plan	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.	Santos GLNG will implement the DAMP. Dust minimisation measures detailed in the DAMP will be implemented, including measures to mitigate and manage the potential for nuisance dust and other air quality impacts such as: - Dust suppression (water, mulching or alternative measures) will be applied to exposed surfaces that are generating dust. Dust suppression will be maintained and effort increased during periods of high risk (e.g. high winds). - Landholders with the potential to be impacted by dust emissions will be consulted with prior to the commencement of activities.

Management plan	Key provisions/ function	Management control measures
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.	The Rehabilitation management plan will be implemented. Disturbed areas will be rehabilitated to a safe, stable and non-polluting environment suitable for the intended land use in accordance with the strategies contained within the Rehabilitation management plan.
Chemical and fuels management plan	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.	The CFMP will be implemented for the safe handling and storage of chemicals and fuels including minimising fugitive emissions as per appropriate regulations and guidelines (refer Appendix F).

Sources:

SLR Consulting Australia Pty Ltd, 2014. Santos GLNG Gas Field Development Project – Environmental Impact Statement – Air Quality Impact Assessment, Table in Section 7.1

URS, 2014. Santos GLNG Gas Field Development Project - Climate, natural hazards and climate change

11.7 Monitoring

Table 11-12 summarises the environmental monitoring and assessment considerations for the protection of air environmental values within the GFD Project area.

Table 11-12 Monitoring considerations for air

Monitoring considerations

General

- Monitoring will be undertaken by a suitably qualified person.
- Laboratory analyses and tests will be carried out by a laboratory that has NATA accreditation for such analyses and tests, unless NATA accredited tests are not available.
- Management or monitoring plans, systems, programs or procedures required to be developed and implemented by the EA will be reviewed for performance and amended as required but not less than once every three years in accordance with the requirements for the particular plans, systems, programs and procedures in the conditions of the EA.
- Management plans and monitoring programs specifically required by the EA will be certified by a suitably qualified person.
- An annual report will be prepared each year and submitted to the administering authority in the form requested by the administering authority. This report will include information as required by the EA such as:
 - any third party audit report
 - details of any exceedances with the conditions of this EA and the dates and times these exceedances were reported to the administering authority
 - an outline of actions taken to minimise the risk of environmental harm from any circumstance, condition or elevated contaminant level identified by the monitoring or recording programs.

Fuel Burning or Combustion Equipment

- Fuel burning or combustion equipment will be monitored for the release limits at the release point locations and at the monitoring frequency specified in the EA.

GHG Measurement and Disclosure

- Santos GLNG will undertake an annual, independent audit of GHG emissions. In addition, regular audits in relation to implementation of, conformance with, and effectiveness of the Santos GLNG Environment, Health and Safety Management System will be performed. In accordance with the NGER Act, annual reporting of GHG emissions, energy production and energy consumption will be completed.

11.8 Proposed environmental authority conditions

The following draft EA conditions in relation to air are proposed for the GFD Project. The conditions stipulate the required plans and management and monitoring requirements to enable adequate protection of the GFD Project areas environmental values. The EA conditions are reproduced in full in Appendix O.

Monitoring

- A20 All monitoring required under this environmental authority must be undertaken by a suitably qualified person.
- A21 All laboratory analyses and tests required to be conducted under this environmental authority must be carried out by a laboratory that has NATA accreditation for such analyses and tests, unless NATA accredited tests are not available.
- A22 Any management or monitoring plans, systems, programs or procedures required to be developed and implemented by a condition of this environmental authority must be reviewed for performance and amended as required but not less than once every three (3) years in accordance with the requirements for the particular plans, systems, programs and procedures in the conditions of this environmental authority.

Documentation and records management

- A27 A record of all documents required by this environmental authority must be kept for a minimum of five (5) years.
- A28 All plans and monitoring programs required by this environmental authority must be certified by a suitably qualified person.
- A29 All plans and monitoring programs under this environmental authority must be implemented.

SCHEDULE F – ENVIRONMENTAL NUISANCE

Odour, dust and other airborne contaminants

- F1 The release of odour, dust or any other airborne contaminant(s), or light from the petroleum activities must not cause an environmental nuisance at any sensitive place.

Nuisance monitoring

- F2 When the administering authority advises of a complaint alleging nuisance, the complaint must be investigated as soon as practicable. The investigation is to include monitoring of environmental nuisance at any sensitive place within a reasonable and practical timeframe as specified by the administering authority.
- F3 The administering authority must be advised in writing of the results of the investigation (including an analysis and interpretation of the monitoring results) and actions proposed or undertaken to resolve the complaint within five (5) business days of completing the complaint investigation, unless a longer time is agreed to by the administering authority.

- F4 If the investigation or monitoring in accordance with condition (F2) indicates that emissions exceed the limits set in this environmental authority or are causing environmental nuisance, then:
- a) the complaint must be addressed including the use of alternative dispute resolution services if required; and / or
 - b) abatement or attenuation measures must be implemented so that the authorised petroleum activity(ies) do not result in further environmental nuisance.

SCHEDULE G – AIR

Fuel burning or combustion equipment

- G1 Fuel burning or combustion equipment must:
- a) not be operated unless it is listed in Schedule G, Table 1 – Authorised releases of contaminants to air from point sources;
 - b) not exceed the release limits specified in *Schedule G, Table 1 - Authorised releases of contaminants to air from point sources*;
 - c) be monitored for the release limits at the release point locations and at the monitoring frequency specified in *Schedule G, Table 1 - Authorised releases of contaminants to air from point sources*.

Schedule G, Table 1 – Authorised releases of contaminants to air from point sources

Resource authority	Facility	Release point locations	Release limits			Monitoring frequency
			Minimum release height (m)	Minimum efflux velocity (m/sec)	NOx as nitrogen dioxide maximum mass emission rate (g/s)	
						At least one release point must be monitored per year on a rotational basis.

Note: The above NOx release limits are applicable during all timings except start-up, shut down and calibration of emission monitoring devices. The start-up duration is allowed up to 30 minutes.

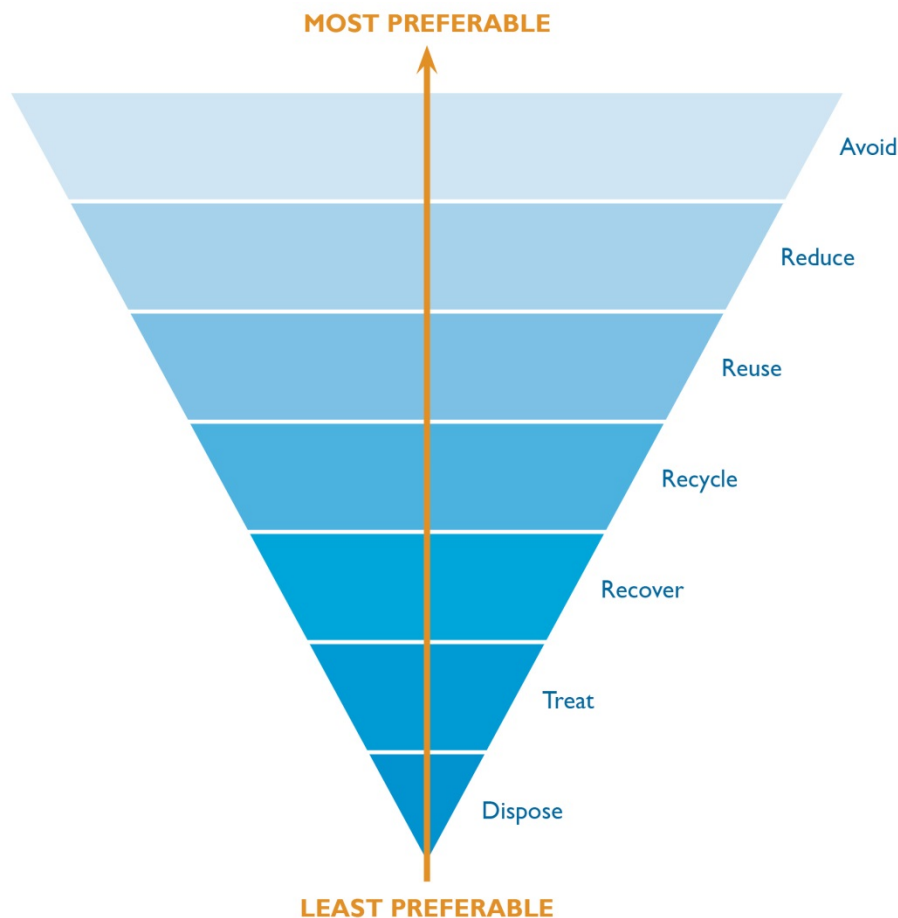
12 Waste

The identification of waste streams for the GFD Project is based on the maximum development scenario developed for the EIS and proposed methodology of construction. Existing Santos GLNG operations and similar construction works were assessed to determine the characteristics of the waste streams. Waste streams have been characterised as inert, general, recyclable, organic or regulated wastes.

In the GFD Project area and surrounding area, solid and liquid wastes are generated from domestic and commercial premises as well as agricultural, industrial and resource extraction activities. Regional councils provide waste collection, recycling and disposal facilities and services for residential and commercial properties. Commercially operated waste management facilities provide additional options for collection, treatment and disposal of solid and liquid wastes.

Waste management strategies are based on the management hierarchy within the *Waste Reduction and Recycling Act 2011*, *Waste Recycling and Recovery Regulation 2011* and the *Environmental Protection (Waste Management) Policy 2000* (EPP Waste) (QLD 2000). The waste management hierarchy comprises, in order of preference:

Figure 12-1 Waste management hierarchy



The waste management hierarchy and the management strategies described in the Santos GLNG Waste Management Plan (WMP) will be recognised and applied when managing wastes in the GFD Project.

Santos GLNG has developed licensed waste collection, treatment and disposal facilities (e.g. STPs, water management facilities, fluid injection facilities, etc.) to support GLNG Project operations, and also has used existing commercially operated waste management facilities. Details of the existing waste management facilities in proximity to the GFD Project area that have potential to accept waste from commercial operations are listed in Table 12-1. Allowable annual capacity will be confirmed from the relevant site EA.

Table 12-1 Waste management facilities located in region

Facility name	Operator	Commercial and Industrial	Construction/ Demolition	Domestic	Resource recovery
Blackwater Landfill Ardurad Road, Blackwater	Central Highlands Regional Council	x	x	x	Co-mingled recyclables, concrete, bricks etc., green waste, motor oil, regulated waste (asbestos, etc.), soil, steel, timber, tyres and wet-cell batteries.
Chinchilla Waste Management Facility Clarkes Road, Chinchilla	Western Downs Regional Council	x	x	x	Cardboard, co-mingled recyclables, concrete, bricks etc., cooking oil, green waste, motor oil, second hand goods, soil, steel and non-ferrous metals, timber, wet-cell batteries.
Dalby Waste Management Facility Dalby-Jandowae Road, Dalby	Western Downs Regional Council	x	x	x	Cardboard, co-mingled recyclables, concrete, bricks, asphalt, etc., cooking oil, drums, green waste, mobile phones, motor oil, printer cartridges, second hand goods, soil, steel and other metals, timber, wet-cell batteries.
Gemfields Landfill Rubyvale Road, Sapphire	Central Highlands Regional Council	x	x	x	Co-mingled recyclables, concrete, bricks etc., green waste, motor oil, steel, wet-cell batteries.
Lochlees Landfill Lochlees Road, Emerald	Central Highlands Regional Council	x	x	x	Co-mingled recyclables, concrete, bricks etc., green waste, motor oil, steel, wet-cell batteries.
Meandarra Landfill Meacle Road, Meandarra	Western Downs Regional Council	x	x	x	Steel.
Miles Landfill Leichhardt Hwy, Miles	Western Downs Regional Council	x	x	x	Cardboard, co-mingled recyclables, concrete, bricks, asphalt, etc., green waste, motor oil, soil, steel and non-ferrous metals, timber, wet-cell batteries.
Rolleston Landfill Rolleston Aerodrome Road, Rolleston	Central Highlands Regional Council	x	x	x	Co-mingled recyclables, concrete, bricks etc., green waste, motor oil, steel, wet-cell batteries.

Facility name	Operator	Commercial and Industrial	Construction/ Demolition	Domestic	Resource recovery
Roma Town Landfill Short Street, Roma	Maranoa Regional Council	x	x	x	Cardboard, glass, paper, steel and other metals, regulated waste (asbestos, grease trap, septic, etc.), soil, timber, tyres, waste oil, wet-cell batteries.
Tara Landfill Fry Street, Tara	Western Downs Regional Council	x	x	x	Cardboard, co-mingled recyclables, concrete, bricks etc., drums, green waste, motor oil, steel, timber, wet-cell batteries.
Tieri Landfill Tieri Road, Capella	Central Highlands Regional Council	x	x	x	Co-mingled recyclables, concrete, bricks etc., green waste, motor oil, steel, wet-cell batteries.
Trap Gully Landfill Forestry Road, Biloela	Banana Shire Council	x	x	-	Construction waste (concrete, bricks, asphalt, etc.), grease trap waste, regulated waste (asbestos), tyres.
Wandoan Landfill Tip Road, Wandoan	Western Downs Regional Council	x	x	x	Minor quantities of construction and demolition, and commercial and industrial waste are accepted, subject to approval. Steel.
Santos GLNG licensed waste disposal facilities					
STPs	Santos GLNG	x	-	-	Permanent and mobile STPs treat sewage generated from bathrooms, toilets, showers, sinks and kitchens at gas processing facilities (GPFs), water management facilities and accommodation facilities. Sewage from temporary accommodation facilities is treated and discharged to land as per site specific sewage effluent management plans.
Drilling Fluid Recycling Centres (DFRC)	Santos GLNG	x	-	-	Drilling mud and fluid mixtures produced from drilling activities at well sites across the GLNG Upstream Project area. There are two located in the GLNG Upstream Project area.

Facility name	Operator	Commercial and Industrial	Construction/ Demolition	Domestic	Resource recovery
Springwater Fluid Treatment Facility	Santos GLNG	x	-	-	Receives and treats hydraulic stimulation fluids and flowback water generated from the stimulation of coal seam wells. Located in the Fairview Project area
Wallumbilla Land Farm	Santos GLNG	x	-	-	Receive and remediate hydrocarbon contaminated soils resulting from Santos GLNG activities within the Roma Project Area.
Reverse Osmosis Plants (ROP)	Santos GLNG	x	-	-	Significantly improve the quality of raw coal seam water generated across the gas fields by primarily reducing the CS water salinity. There are a number of mobile ROPs utilised across the GLNG Upstream Project area. The number of mobile ROPs operating at any one time is dependent on demand and the type of activity(s) being carried out. The Fairview and Roma Project areas currently each possess a permanent ROP. ROPs are also being installed at the three Hub Compression Stations currently under construction in Fairview and Roma.
Associated Water Amendment Facilities (AWAFs)	Santos GLNG	x	-	-	Receive and amend raw coal seam water from the GLNG Upstream Project area. The water is chemically dosed and/or blended to create water of a suitable quality for re-use in Santos GLNG irrigation projects. Located in the Fairview Project area.

Facility name	Operator	Commercial and Industrial	Construction/ Demolition	Domestic	Resource recovery
Regulated Dams	Santos GLNG	x	-	-	Predominantly used to aggregate coal seam water gathered from across the GLNG Upstream Project area. These dams act as holding / water balancing ponds, prior to the coal seam water being directed to either a ROP, AWAf or other destination for treatment and/or for use. Regulated dams are also used to store permeate, amended water, reverse osmosis concentrate (ROC) and brine (until such time other re-use or disposal methods are developed). Santos GLNG Regulated Dam Register includes detailed information regarding the regulated dams in operation and under construction across the GLNG Upstream Project area. There are a number of regulated dams in operation and/or under construction across the GLNG Upstream Project area

Notes:

- x = Facility is relevant to respective phase of development
- = Facility is not relevant to respective phase of development

12.1 Environmental values

The EP Act (Section 3) defines waste as anything left over or an unwanted by-product, from an industrial, commercial, domestic or other activity. Consistent with the EPP Waste, the environmental values related to waste generation and management to be enhanced or protected are provided in Table 12-2. Specific key environmental values with the potential to be impacted by the waste generated from the construction, operation and decommissioning of the GFD Project are also included in Table 12-2.

Table 12-2 Waste-related environmental values

Environmental Values

- The life, health and wellbeing of people, including GFD Project workers
- The diversity of ecological processes and associated ecosystems
- Land use capability, having regard to economic considerations
- Visual amenity
- Natural environment, including land, water resources, air quality, fauna and flora
- Productive capability of land i.e. its potential for use for agricultural, forestry or other uses
- Sustainability of natural resources (e.g. construction materials, fuel, electricity, water, etc.)
- Available landfill capacity for waste disposal.

Source: EPP Waste; Draft EM Plan Guidelines (2012); GFD Project EIS

12.2 Potential impacts

Generation of waste will occur throughout the construction, operation and decommissioning of each project component; however a more detailed assessment of the decommissioning wastes will be undertaken closer to the GFD Project's closure. GFD Project operations and activities will generate solid, liquid and gaseous wastes, which can be broadly classified as:

- Regulated waste: wastes that require specific controls or actions as defined by legislation; listed, hazardous, regulated, controlled or trackable wastes typically have unique handling and disposal requirements in order to manage specific hazards associated with them.
- General waste: wastes not defined as regulated waste under legislation; general wastes comprise putrescible wastes (easily decomposed, recyclable by composting) and non-putrescible wastes (not easily decomposed, may be recyclable).
- Recyclable waste: waste types that are able to be reconditioned, reprocessed or reused.

Potential impacts to the identified environmental values and receptors might result from excessive waste generation from the inefficient use of resources or from the improper management of wastes generated during the construction, operation, decommissioning and rehabilitation of the GFD Project. The overall potential impacts are outlined in Table 12-3.

Table 12-3 Waste-related potential impacts

Hazard	Potential Impact
Waste generation	Excessive use of natural resources (disposed as waste)
	Waste to be disposed to landfill (additional to current levels)
Waste management	Impact to land, surface or ground waters and dependent ecosystems as a result of uncontrolled release of waste
	Impact to land, surface or ground waters and dependent ecosystems as a result of controlled release of waste
	Increase in vermin and pest populations.

Source: URS EIS Section 12, Santos GFD Project, 2014.

Specific potential impacts depend on the type of waste generated. Table 12-4 includes the major waste streams for the GFD Project as relevant to each main phase of the Project (construction, operation and decommissioning). Waste minimisation and cleaner production techniques and designs will be implemented at each stage of the GFD Project to prevent or minimise environmental impacts when selecting processes, equipment and facilities.

Beneficial impacts will also be identified throughout the lifecycle of the GFD Project. One example is the opportunity for reuse or recycling of valuable materials, compounds and constituents that might otherwise become wastes and thereby be disposed of without obtaining maximum benefit from reuse or recycling. This could include coal seam water, sewage, scrap metal, use of waste oil as fuel, and the recycling of plastics, glass, paper, and related materials.

Table 12-4 Description of wastes generated from construction, operation and decommissioning

Waste	Type	Construction		Operations		Decommissioning		Management
		Source	Quantity	Source	Quantity	Source	Quantity	
Air emissions (particulate matter)	Solid (can be either solid or liquid)	Dust generation from construction activities, vehicle operation and exposed areas.	Varies by activity and weather	Dust generation from vehicle operation and exposed areas.	Varies with activity and weather	Dust generation from demolition and rehabilitation activities, and vehicle operation.	Varies by activity and weather	Avoid generating dust by minimising disturbance, use sealed roads where available / practicable, implement dust suppression techniques and rehabilitate disturbed areas.
Air emissions (from fuel combustion e.g. SO ₂ and NO _x)	Gas	Vehicles.	Minor	Gas compression facility operation, burning of fuels for power generation, vehicles.	Minor	Vehicles.	Minor	Vehicles will be fitted with appropriate exhaust systems and devices maintained in good working order. Fuel burning or combustion equipment will be selected, operated and maintained in accordance with the manufacturer's specifications to comply with emission limits, and emit via appropriately designed stacks.
Coal seam water	Liquid; may be regulated waste if it does not meet the quality criteria in the EP Reg.	n/a	n/a	Operation of production wells.	Varies by the number and timing of producing wells, up to peak estimate of 40 ML/day for a gas field.	Decommissioning of water storage	Minor	Coal seam water will be managed in accordance with relevant regulatory requirements. Coal seam water will be used locally or stored in regulated water storages before being <i>beneficially used where practicable</i> . EHS03 Produced water applies.

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Waste	Type	Construction		Operations		Decommissioning		Management
		Source	Quantity	Source	Quantity	Source	Quantity	
Concentrated waste from desalination (i.e. concentrate, with total dissolved solids between 3,000-14,000 mg/L, varies by volume, quality and treatment method) and residual brine and solid salt	Liquid; regulated waste	N/A	N/A	Water management facility.	Estimate 10%-20% of water extracted from coal seams by volume	Decommissioning of brine storage	Minor	Brine concentrate and residual salt will be managed in accordance with relevant regulatory requirements. Brine will be stored in regulated brine storage before being directly disposed to long term storage (without further concentration), or concentrated to solid salt for recovery if commercially viable, or disposal to regulated waste facility. EHS03 Produced water applies.
Concrete	Solid; general waste	Construction of wells (casing), surface infrastructure (footings), footpaths, etc.	Minor	N/A	N/A	Demolition of surface infrastructure (footings), footpaths, etc.	To be quantified prior to demolition.	Excess concrete will be returned to the batching plant where practicable. Demolition waste will be crushed and reused as road base for the GFD Project, or disposed to a licensed landfill facility Footings may be abandoned below ground.

Waste	Type	Construction		Operations		Decommissioning		Management
		Source	Quantity	Source	Quantity	Source	Quantity	
Contaminated soil	Solid; regulated waste	Construction activities.	Minor	Leaks or spills from fuel and chemical storages or vehicle maintenance activities.	Minor	Storage during construction and operations and decommissioning activities.	Minor	Contaminated soil is to be suitably contained for management, removal and / or further treatment or disposal by a suitably licensed operator. Contaminated soil removed from a site on the EMR will have a disposal permit issued prior to removal. EHS08 Contaminated soils applies.
Drilling fluid, cuttings and flow back (may contain chemical additives used in drilling and completions)	Liquid; regulated waste	Construction and completion of wells.	2,500 tonnes per annum (tpa)	Well workover.	1,250 tpa	N/A	N/A	Contained at the well lease prior to reusing or recycling where feasible, or disposed of at a licenced waste management facility.
Electrical and batteries	Solid; may be regulated waste	Construction activities e.g. electrical parts, mobile phones, radios and batteries, and vehicle batteries.	6 tpa	Battery powered equipment (e.g. vehicle and plant, mobile phones, radios, etc.), maintenance of electrical systems, camp operations.	6 tpa	Decommissioning activities e.g. electrical parts, batteries, etc.	Minor	Dry- and wet-cell batteries will be segregated and stored in appropriately labelled and banded bins or pallets for collection by licensed waste contractor for reuse, reprocessing, recycling or disposal, as appropriate.
Excavation waste (i.e. soil and rock)	Solid; general waste	Earthworks, dam construction, pipeline trenches, etc.	Minor	N/A	N/A	Decommissioning and rehabilitation activities e.g. land contouring.	Minor	Used onsite for levelling, backfilling, constructing access roads or water storage, etc.

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Waste	Type	Construction		Operations		Decommissioning		Management
		Source	Quantity	Source	Quantity	Source	Quantity	
General waste (putrescible)	Solid; general waste	Construction activities and accommodation camps.	18,000 tpa	Operation of gas field facilities and accommodation camps.	4,500 tpa	Demolition activities and accommodation camps.	9,000 tpa	Non-recyclable general waste will be segregated in covered bins for collection and transport by licensed waste contractor to licensed landfill facility. HSHS10 Food safety applies.
Grease trap waste, cooking oil	Liquid	Accommodation camps.	150 tpa	Accommodation camps.	100 tpa	Accommodation camps.	50 tpa	Stored in designated grease trap or cooking oil storage container for collection by licensed waste contractor for reprocessing, recycling or disposal, as appropriate.
Green waste	Solid; general waste	Clearing of vegetation.	Minor	Vegetation management	Minor	N/A	N/A	Stockpiled and reused (potentially as mulch) for rehabilitation purposes. Declared weeds will be managed in accordance with the PWMP.
Oily waste (e.g. plastic containers, filters, absorbents, etc.)	Solid; regulated waste	Construction activities, vehicles.	10 tpa	Commissioning, operation and maintenance of gas field facilities and vehicles.	2 tpa	Decommissioning activities, vehicles.	1 tpa	Collected and stored in appropriately labelled and banded bins for collection by licensed waste contractor for reprocessing, recycling or disposal, as appropriate.

Waste	Type	Construction		Operations		Decommissioning		Management
		Source	Quantity	Source	Quantity	Source	Quantity	
Oily water	Liquid; may be regulated waste	Construction activities.	2,500 tpa	Commissioning and maintenance activities relating to gas production, separation and compression, and vehicle wash down.	500 tpa	Decommissioning activities.	250 tpa	Contained for treatment (e.g. via oil/water separator) or collection by licensed contractor for reprocessing, recycling or disposal, as appropriate.
Plastic (e.g. containers, pipe, etc.)	Solid; may be regulated waste	Construction activities, largely packaging.	5 tpa	Operation of gas field facilities and accommodation camps.	2 tpa	Decommissioning activities.	3 tpa	Segregated and stored in centralised waste storage area for recycling or disposal, as appropriate.
Recyclable waste (e.g. glass, paper, cardboard, timber, etc.).	Solid; general waste	Construction activities, largely packaging.	1,000 tpa	Operation of gas field facilities and accommodation camps.	1,000 tpa	Decommissioning activities.	250 tpa	Segregated and stored in appropriately labelled bins or stockpile areas in central waste storage area for collection by licensed waste contractor for recycling.
Scrap metal (e.g. pipe off-cuts, drums, aerosol and aluminium cans)	Solid; general waste	Construction activities.	100 tpa	Operation of gas field facilities and accommodation camps.	20 tpa	Decommissioning activities.	50 tpa	Segregated and stored in centralised waste storage area for reuse, or return to supplier, or collected by licensed waste contractor for recycling.

Waste	Type	Construction		Operations		Decommissioning		Management
		Source	Quantity	Source	Quantity	Source	Quantity	
Sewage/Septic (20 L/person/day approx.) and sewage biosolids	Liquid	Accommodation camps.	Approx. 4 ML/day for small drill camp, up to 80 ML/day for large temporary camp	Accommodation camps and management facilities.	Approx. 16 ML/day for permanent operations camp.	Accommodation camps.	Varies by size of camp	Treatment in a package sewage treatment plant, with treated effluent disposed by irrigation and biosolids collected for disposal at a licensed facility. EHS10 Water resources applies.
Storm water runoff	Liquid	Construction activities.	Varies with weather	Operational areas.	Varies with weather	Decommissioning activities.	Varies with weather	Chemical storage areas will be isolated from stormwater runoff.
Topsoil	Solid; general waste	Clearing of vegetation from disturbed or pastoral land, construction activities.	Minor	N/A	N/A	N/A	N/A	Stockpile, spread across disturbed areas as part of rehabilitation.
Triethylene glycol (TEG) coolant	Liquid, regulated waste	N/A	N/A	Commissioning and maintenance of gas compression facilities.	Minor	Decommissioning of gas compression facilities.	Minor	Collected in secure banded containers to be transported by a licensed contractor to a licensed regulated waste facility.
Tyres	Solid; regulated waste	Vehicle maintenance.	100 tpa	Vehicle maintenance.	20 tpa	Vehicle maintenance.	10 tpa	Stored in central waste storage area for collection by licensed waste contractor for treatment or disposal to regulated waste facility in accordance with product requirements.

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Waste	Type	Construction		Operations		Decommissioning		Management
		Source	Quantity	Source	Quantity	Source	Quantity	
Waste chemicals (e.g. paint, solvents, cleaning fluids, coolant, herbicides, hydraulic fracturing or weak acidising chemicals, etc.)	Liquid; regulated waste	Construction of wells, pipelines, facilities or roads, vehicle operation, etc.	50 tpa	Commissioning, operation and maintenance of gas field facilities and vehicles, weed control, etc.	10 tpa	Decommissioning activities, vehicle operation, etc.	1 tpa	Stored in bunded containers in central waste storage area for collection by licensed waste contractor for treatment or disposal to regulated waste facility in accordance with product requirements. HSHS08 Chemical management and dangerous goods applies.
Waste oil	Liquid; regulated waste	Construction activities, vehicles.	500 tpa	Commissioning and maintenance activities relating to gas production, separation and compression, and vehicles.	100 tpa	Decommissioning activities, vehicles.	50 tpa	Stored in bunded containers in central waste storage area for collection by licensed waste contractor for reprocessing, recycling or disposal to regulated waste facility.

Source: URS EIS Section 12, Santos GFD Project, 2014.

Note 1: Waste management approach has been derived from the waste management hierarchy.

12.3 Environmental protection objectives

In accordance with Santos GLNG's internal standards, the GFD Project will adopt the environmental performance objectives relevant to waste management listed in Table 12-5.

Table 12-5 Environmental protection objectives

Environmental protection objectives

- Avoid or minimise impact on waste-related environmental values
- Use waste management hierarchy and principles based on waste avoidance, reduction, reuse, recycling, treatment and disposal.

12.4 Environmental performance indicators

For the project, a number of environmental protection performance indicators have been developed to assess the performance of waste management practices during all phases of the Project. These are summarized in Table 12-6.

Table 12-6 Environmental protection performance indicators

Environmental protection performance indicators

- Implementation of a Waste management plan
- General and regulated waste are to be sent to a facility licensed to accept the waste under the EP Act
- Regulated waste are to be transported by a person who holds a current authority to transport regulated waste under the provisions of the EP Act
- Waste are not burned within the GFD Project area, with the exception of vegetation which is requires written authorisation under *Forestry Act 1959*
- Following completion of petroleum activities, residual brine and / or salt present in structures are removed and transported to a facility that can lawfully reuse, recycle or dispose of brine and / or salt under the EP Act
- Accurate and complete waste tracking certificates and/or waste log book, depending on classification of waste
- Noxious odours associated with wastes to impact a sensitive place
- Complaints advised by the administering authority which relate to environmental nuisance such as noxious odours associated with wastes are investigated, monitored and resolved in accordance with the environmental nuisance monitoring requirements of the EA.

12.5 Management controls

Santos GLNG is committed to minimising the waste generated by the proposed activities through cost-effective approaches to waste reduction, such as efficient use of resources, reuse and recycling to the highest feasible level on the waste hierarchy with regard to the principles of the EPP Waste. These strategies are detailed in Table 12-7 and the process of these strategies allows for continuous improvement of waste management systems.

Table 12-7 Management control measures

Management plan	Key provisions/ function	Management control measures
GFD Project environmental protocol for constraints planning and field development	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 • Offset — 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.	Santos GLNG will implement the Constraints protocol

Management plan	Key provisions/ function	Management control measures
Waste management plan	The WMP details the strategy, methods and controls for managing waste generated by Santos GLNG activities. The plan identifies the types of wastes generated by Santos GLNG activities, and describes the waste management framework and how the waste management hierarchy is applied to generated waste. Wastes generated by the GFD Project will be managed in accordance with the WMP. The WMP aims to minimise waste volumes and risk of environmental harm through improving operational efficiency and therefore environmental performance. The WMP details: • Applicable legislation, policies and regulations to waste management, transport and disposal • Classifications of generated wastes to determine applicable management measures • Management measures for storage, transport and disposal of wastes.	Santos GLNG will implement the WMP. The waste management hierarchy of waste avoidance, reduction, reuse, recycling, recovery, treatment and disposal will be adopted, in accordance with the Waste Reduction and Recycling Act 2011 (Qld).
Chemical and fuel management plan	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.	Santos GLNG will implement the CFMP. Santos GLNG will clearly and permanently mark any chemical storage facility associated with the environmentally relevant activity of chemical storage for the life of the petroleum activities with a unique reference name / number in such a way that it is clearly observable. Santos GLNG will ensure that all chemical storages will be: • be stored in, or serviced by, an effective containment system that is impervious to the materials stored therein; and • be stored and handled in accordance with the relevant Australian Standard where such Standard is available; and • be managed to prevent the release of substances to waters or land

Management plan	Key provisions/ function	Management control measures
Coal seam water management strategy	The Coal seam water management strategy outlines the overarching approach to managing coal seam water. The strategy prioritises the beneficial use of coal seam water where practicable, while avoiding, minimising and mitigating environmental impacts, in accordance with the relevant regulatory framework.	Santos GLNG will implement the Coal seam water management strategy
Contingency plan for emergency environmental incidents	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.	Santos GLNG will implement the Contingency plan
Decommissioning and abandonment management plan	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 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.	Santos GLNG will implement the DAMP Prior to commencement of decommissioning activities, Santos GLNG will: • Conduct an inspection to identify equipment and materials to be removed for reuse (by Santos GLNG or third parties) or recycling • Prepare an inventory of chemicals, fuels and oils and their required handling, storage and transportation requirements • Segregate general waste and regulated waste to be removed and sent to a recycling or disposal facility licensed to accept the waste • Implement a no burning policy.

12.6 Monitoring

Table 12-8, summarises the environmental monitoring and assessment considerations for the protection of waste-related environmental values within the GFD Project area. Details of the monitoring activities are described in the management plans. Additional monitoring considerations are also summarised in the table.

Table 12-8 Monitoring considerations for waste

Existing management and monitoring plans

- WMP

Monitoring considerations

General

- Monitoring will be undertaken by a suitably qualified person.
- Management or monitoring plans, systems, programs or procedures required to be developed and implemented by the environmental authority will be reviewed for performance and amended as required but not less than once every three years in accordance with the requirements for the particular plans, systems, programs and procedures in the conditions of the environmental authority.
- Management plans and monitoring programs specifically required by the environmental authority will be certified by a suitably qualified person.
- An annual report must will be prepared each year and submitted to the administering authority in the form requested by the administering authority. This report will include information as required by the environmental authority such as:
 - any third party audit report
 - an outline of actions taken to minimise the risk of environmental harm from any circumstance, condition or elevated contaminant level identified by the monitoring or recording programs.

Waste generation data

- Monitoring and reporting of waste generation, transport and disposal will be undertaken in accordance with the WMP. The implementation and effectiveness of the WMP and its associated procedures will be assessed against baseline waste characterisation data via:
 - Checklists to assess and manage compliance
 - Internal and third party audits to formally assess compliance with regulatory requirements and Santos GLNG procedures
 - Review of internal incidents, near misses or hazards.
- Analysis of relevant data collected to assess trends in waste generation and management. Assets and activities that generate, store or manage waste will use a waste management inventory to record details of wastes produced in accordance with the WMP, such as:
 - Type and volume of waste
 - Source of waste
 - Destination/fate of waste.

12.7 Proposed environmental authority conditions

The following draft EA conditions in relation to Waste are proposed for the GFD Project. The conditions stipulate the required plans and management and monitoring requirements to enable adequate protection of the GFD Project areas environmental values. The EA conditions are reproduced in full in Appendix O.

Odour, dust and other airborne contaminants

- F1 The release of odour, dust or any other airborne contaminant(s), or light from the petroleum activities must not cause an environmental nuisance at any sensitive place.

Nuisance Monitoring

- F2 When the administering authority advises of a complaint alleging nuisance, the complaint must be investigated as soon as practicable. The investigation is to include monitoring of environmental nuisance at any sensitive place within a reasonable and practical timeframe as specified by the administering authority.
- F3 The administering authority must be advised in writing of the results of the investigation (including an analysis and interpretation of the monitoring results) and actions proposed or undertaken to resolve the complaint within five (5) business days of completing the complaint investigation, unless a longer time is agreed to by the administering authority.

SCHEDULE H – WASTE

General

- H1 All general and regulated waste must only be removed from the site and sent to a facility licensed to accept the waste under the *Environmental Protection Act 1994* except as permitted under another condition of this environmental authority.
- H2 All regulated waste must only be removed from the site by a person who holds a current authority to transport such waste under the provisions of the *Environmental Protection Act 1994*.
- H3 Waste must not be burned unless it is vegetation and is authorised in writing under the *Forestry Act 1959*.

Brine and salt management

- H4 Following the completion of the petroleum activity(ies), any residual brine and / or solid salt present in any structure must be removed and transported to a facility that can lawfully reuse, recycle or dispose of such waste under the *Environmental Protection Act 1994*.

13 Rehabilitation

The end purpose of decommissioning and rehabilitation is to permit the surrender of the EA. In order to surrender the EA under the EP Act, all infrastructure is required to be decommissioned and rehabilitated unless related to permanent infrastructure (e.g. roads or tracks etc) or a water dam which will remain for on-going beneficial use. Both the landholder and the administering authority must agree in writing to its continuance for beneficial use. Surrender of petroleum EAs will be undertaken in accordance with the relevant regulatory requirements, including a final rehabilitation report (section 262 and 264 of the EP Act), and will include landholder signoff where necessary (e.g. where assets are to be transferred from Santos GLNG to the landholder).

This section focuses on rehabilitation and decommissioning activities are outlined in the DAMP. Decommissioning will be undertaken in accordance with the EP Act and the Santos GLNG DAMP (2014).

Rehabilitation activities will occur throughout the life of the GFD Project and through the various project phases. These activities will be conducted to address temporary and construction related activities as well as to address more permanent infrastructure locations (for example compressor stations and dams) developed for the project. Key activities that will be undertaken include:

- Rehabilitation of construction works, including site establishment and pipeline construction
- Rehabilitation of short-term infrastructure, such as appraisal wells and temporary drill camps
- Rehabilitation of production wells and associated infrastructure after depletion of gas supply
- Rehabilitation, at the end of the GFD Project, of remaining supporting infrastructure such as water management facility sites, wastewater dams and compressor stations, prior to relinquishment of the petroleum tenure and EA.

Further detail on the development phases are provided in Section 4 of this document.

Rehabilitation will be conducted in a manner similar to other Santos GLNG projects in Queensland, including the GLNG Project. Santos GLNG uses an environmental management framework as part of the GLNG Project and where relevant, this framework will be extended to include the GFD Project. Key legislation, policies and key documents comprising this framework are summarised in Table 13-1 below.

13.1 Regulatory framework

The current legislation and policies applicable to the rehabilitation of the Project site are summarised below.

Table 13-1 Regulatory framework and applicability

Legislation / policies	
P&G Act	Section 560 of the P&G Act obliges the petroleum authority holder to remove equipment or improvements from land on relinquishment (other than a petroleum well, pipeline, water observation bore or water supply bore) unless the owner of the land otherwise agrees. Permanent infrastructure such as roads and tracks, which are to be left for the landowner/holder, requires a written agreement to be submitted with the final rehabilitation report. Despite Section 560, EA surrender requirements under the EP Act will be retained (i.e. including obligations to remove infrastructure in order to comply with an EA condition). Chapter 5, Part 11 of the P&G Act, outlines the tenure surrender process. In order for all or part of the area covered by a petroleum authority to be surrendered, the relevant EA must be: Cancelled or surrendered in its entirety (for full surrender of the petroleum authority) or Amended or partially surrendered in a way that reflects the partial surrender of the petroleum authority.
EP Act EP Reg	The EP Act provides for environmental management practices and environmental safeguards. The EP Act is applicable to the GFD Project in regards to Environmental Authorities (EAs). Each stage of the development of a natural gas lease requires an EA before the issue of a license. The EP Act details the process of environmental assessment for the granting of EAs. Conditions of EAs will stipulate rehabilitation outcomes for Project disturbances. Rehabilitation is a requirement under the EP Act. Further, EAs cannot be surrendered until rehabilitation of all project disturbances is deemed successful. The EP Act provides a mechanism for Santos GLNG to give landholders infrastructure by agreement.
NC Act NC Reg	The primary purpose of the NC Act is to conserve biodiversity by protecting wildlife and its habitat. Permits are required for the taking and/or relocation of protected flora and fauna under this Act. Santos GLNG is exempt for the taking of protected plants on tenures granted under the <i>Petroleum Act 1923</i>. Rehabilitation is a commitment made to minimise impacts to these species and is usually a requirement of approval.
<i>Waste Reduction and Recycling Act 2011</i>	Contains a hierarchy of waste management options to minimise disposal to landfill and maximise waste reuse, as discussed in Section 12: Waste. Decommissioning of Project infrastructure will be undertaken with consideration of the waste management hierarchy.
<i>Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland 1998</i>	The assessment and management of contaminated land is governed by the EP Act. Assessment is also guided by the <i>Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland 1998</i>. Outlines trigger assessment criteria for investigation of contaminated land. Any sites requiring assessment for contamination during decommissioning and rehabilitation will be assessed in accordance with these guidelines (or their replacement). These guidelines (or appropriate contemporary guidelines) will be used to assist in the assessment of contaminated land during decommissioning of the Project.
<i>Guideline for Contaminated Land Professionals</i>	The purpose of the guideline is to establish best practice for managing land contamination through the planning and development control process.

Legislation / policies	
<i>Code of Practice for Constructing and Abandoning Coal Seam Gas Wells in Queensland (DEEDI 2011)</i>	This code was developed to ensure that all coal seam gas wells are constructed and decommissioned to a minimum acceptable standard resulting in long term well integrity, containment of gas and the protection of groundwater resources.
<i>Code of Environmental Practice Onshore Pipelines (APIA 2013)</i>	This code has been published as the minimum acceptable standard to mitigate or eliminate the environmental impact of pipeline activities.
<i>Code of Environmental Practice (APPEA 2008)</i>	This code gives guidance on objectives to be achieved when managing environmental impacts associated with petroleum exploration and production.
<i>Land Access Code (DEEDI 2010)</i>	The Land access code supports the P&G Act and imposes mandatory conditions concerning the conduct of resource activities on private land.

Due to the length of the GFD Project, it is expected that the legislative framework, regulatory provisions and environmental best practice will continue to develop and evolve. Therefore, detailed decommissioning and rehabilitation plans will be prepared closer to closure of the facility to ensure environmental best practices are adopted.

13.2 Rehabilitation objectives

The following sections provide the general rehabilitation objectives that will guide development of the GFD Project rehabilitation plan prior to closure. A final rehabilitation report is required under section 262 and 264 of the EP Act in order to surrender the EA. In developing the final rehabilitation report, consideration will be given to the following guidelines (or equivalent contemporary versions):

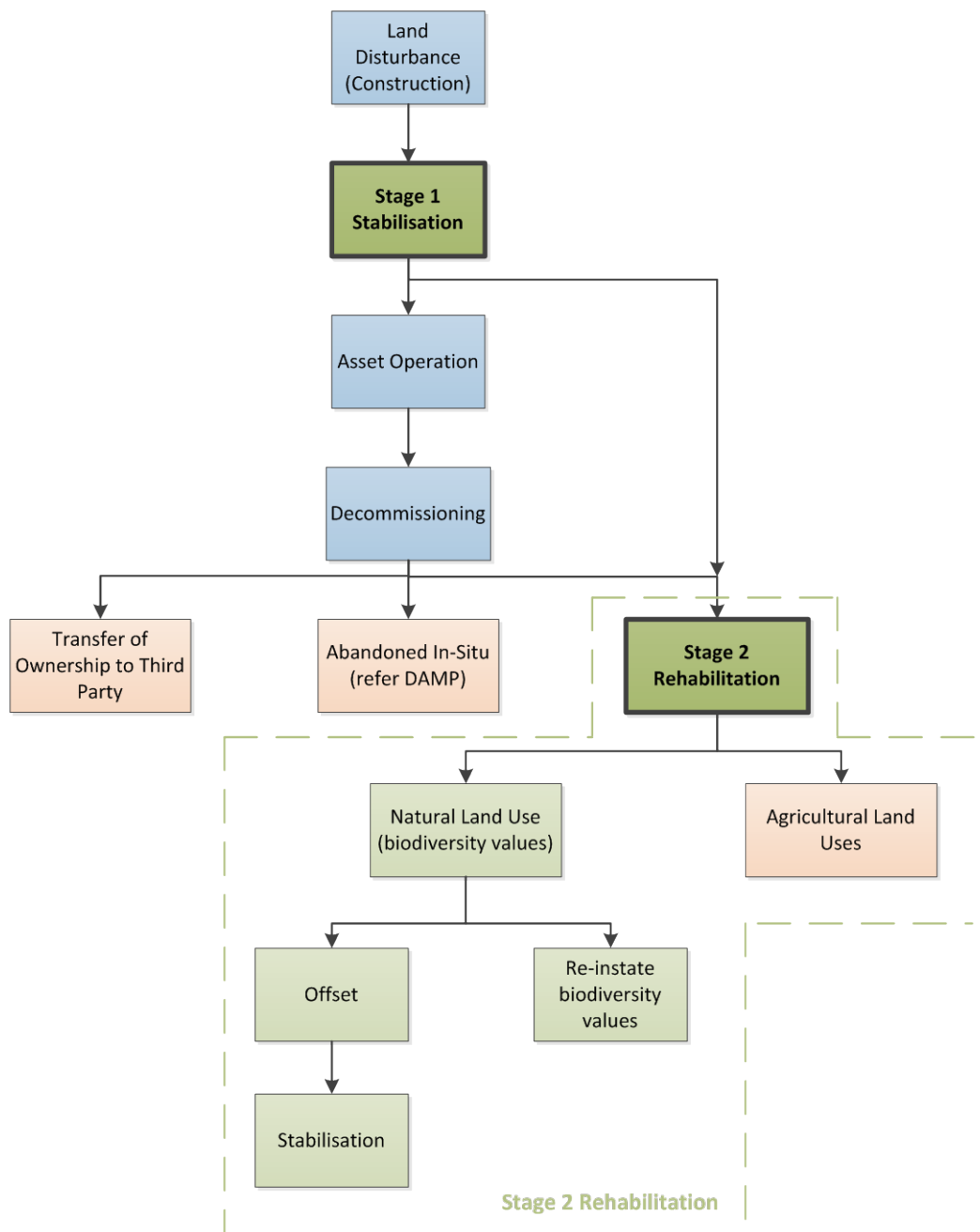
- Guideline EP Act – Final rehabilitation report for resource activities other than mining (DEHP 2013)
- Business and Industry Portal – Guideline - Surrendering or suspending an environmental authority (DEHP 2014).

Santos GLNG and DEHP will agree upon the rehabilitation objectives, indicators and completion criteria that will be developed. The criteria will be based on best practice environmental management and will consider the local landholders and wider community. There will be potential for the rehabilitation objectives, indicators and completion criteria to be amended at any time by application for an amendment of the EA and submission of a report to DEHP substantiating the reasons for the proposed amendment.

An overview of the lifecycle of disturbances within the GLNG Upstream Project Area is illustrated in Figure 13-1. Within the disturbance life-cycle, the Rehabilitation management plan identifies two distinct stages of rehabilitation works that are carried out by Santos GLNG for Project-related disturbances:

- **Stage 1 – Stabilisation** - Stabilisation works are completed post-construction within construction footprints of operational assets. Areas are stabilised to enable the safe and effective operation of assets, to minimise the risk of on-going environmental issues such as erosion, soil loss and weed invasion and to return areas to productive grazing wherever possible
- **Stage 2 - Rehabilitation** –Stage 2 involves the rehabilitation of disturbance footprints that are no longer required to be used for operational purposes. This stage of rehabilitation is where Santos GLNG will seek to return the capability of the disturbed land to the previous land-use, or to a land use in accordance with the landholder and in accordance with regulatory requirements. Alternatively, this may involve providing an offset or creating an environment conducive to returning pre-disturbance biodiversity values.

Figure 13-1 Disturbance lifecycle



13.2.1.1 Stage 1 – stabilisation

Stabilisation works are carried out on significantly disturbed areas of land associated with construction activities that surround or are adjacent to operational assets. The stabilised area might not be regularly utilised in day-to-day operational activities, however, it might still be required for the safe operation of the asset (e.g. safety buffer) or future additional construction / maintenance works (e.g. well work-over). In-line with Santos GLNG's rehabilitation objectives, stabilisation aims to achieve a landform which is safe, non-polluting and stable. Stabilisation works involve the following activities:

- Remediating areas of contaminated land resulting from petroleum activities (where required and in accordance with the *Santos EHS08-Contaminated Sites*)
- Re-establishing surface drainage lines
- Re-profiling of contours for operational use
- Reinstating the top soil
- Stabilising soils by either establishing groundcover vegetation (that is not a declared weed) or through use of other techniques such as spreading mulch or gravel or utilisation of geotextiles or other engineered materials.

Stabilisation works are to commence at the completion of construction activities, with the aim of being able to demonstrate the successful completion of the above works within 12 months of the time that the area is no longer required for day-to-day activities.

The most prevalent examples of disturbances required to undergo stabilisation works in the GLNG Upstream Project Area are extended areas of operational well leases and operational pipeline and flowline easements. Other examples may include the perimeter of assets, road verges and fire breaks.

The Rehabilitation management plan provides additional detail regarding these examples.

13.2.1.2 Stage 2 – rehabilitation

Stage 2 rehabilitation is carried out on significantly disturbed areas no longer required for operational use. This can occur post-construction (e.g. disturbed construction footprint not required for operations) or post-decommissioning (e.g. closure of temporary camps and laydown areas, well leases, pipelines etc.)

Stage 2 rehabilitation works carried out by Santos GLNG aim to achieve a final landform and land use. In most instances, this will be returning the land to its pre-disturbance state or providing the foundations for the land to return to its pre-disturbance state. Agricultural land uses, in the form of grazing and cropping or natural areas comprising ESAs and other forms of vegetation, are the two most common environmental values Santos GLNG will aim to rehabilitate.

Regardless of the end land use, all Stage 2 rehabilitation works will aim to achieve a safe, non-polluting and stable landform, incorporating the following activities:

- Remediation of contaminated land resulting from petroleum activities (where required and in accordance with the *Santos EHS08 – Contaminated Sites*)
- Re-established surface drainage lines
- Re-profiled contours to be consistent with the surrounding landform
- Safe landform to humans and livestock in areas of significant cut and fill
- Reinstated top soil
- Stable soil structure.

Rehabilitation objectives beyond those listed above for agricultural land uses and natural areas are outlined below.

For Santos GLNG activities involving significant cut and fill operations, in particular borrow pits and quarries, the above criteria are the complete rehabilitation objectives for the disturbance area. These areas will not be rehabilitated to the pre-existing or adjacent land use as this is not a practical or achievable outcome. Instead, the area will undergo landform management, to ensure the final landform is stable, non-polluting and safe to humans, livestock and wildlife through the use of methods such as benching, surface re-profiling, contouring and stormwater diversion.

13.2.1.2.1 Agricultural land use

Within the GFD Project area, agricultural land is most commonly comprised of grazing activities and to a smaller extent cropping (irrigated or dry land uses) and forestry. Rehabilitation works within these areas will concentrate on restoring the productive potential of the land, through considered soil and weed management. All rehabilitation works will be completed in consultation with the landholder.

The rehabilitation objective for agricultural land uses (in addition to those listed in above) is to be able to demonstrate that the:

- Percentage cover within the rehabilitated area is equal to or greater than the surrounding undisturbed area
- Percentage of declared species richness is less than or equal to the surrounding undisturbed area
- Landholder is satisfied that the rehabilitated land has no greater management input than for other surrounding land that is being used for a similar purpose (i.e. grazing or cropping).

Santos GLNG will conduct regular monitoring and maintenance of rehabilitated areas to ensure that works are on trajectory to meet the rehabilitation criteria and objectives. It is anticipated that successful Stage 2 rehabilitation within agricultural areas should be able to be attained within three to five years, but will be climate dependent. At this time, landholders will be requested to formally approve the rehabilitation to demonstrate their satisfaction of the completed works.

13.2.1.2.2 Natural areas (biodiversity values)

Natural areas within the GLNG Upstream Project area have been categorised into three groups:

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- ESAs (Endangered and Of Concern RE)
- Threatened Species (flora and fauna)
- All other REs.

Each category of natural area has slightly different rehabilitation criteria. This is primarily in recognition of the other significant contributions that Santos GLNG has made to minimise / mitigate impacts to these values in the form of offsets. Table 13-2 includes rehabilitation criteria for these categories. The Rehabilitation management plan includes additional details regarding these categories.

Table 13-2 Rehabilitation objectives

Category	Rehabilitation criteria
ESA	ESAs are one of the highest biodiversity values present within the GLNG Upstream Project area and are subject to significant regulation with respect to impacting these areas. Santos GLNG is required to offset each disturbance to counterbalance the residual adverse impact caused by the petroleum activity (at a ratio far in excess of 1:1). Santos GLNG will not rehabilitate disturbances in these areas to the pre-disturbance value. Instead, Santos GLNG will rehabilitate to a feasible level to achieve a safe, stable and non-polluting landform, by conducting the activities described in in this section. A groundcover will be returned to ensure that the site is stable. These foundations should be sufficient to enable natural regeneration of the area to occur over time. At this time, Santos GLNG will seek to absolve responsibility for the rehabilitation works.
Threatened species	Threatened species and their habitats are significant biodiversity values subject to substantial regulation and offset requirements. Santos GLNG proposes to offset residual adverse impacts to these species or their habitats, caused by Santos GLNG activities. Where an offset is provided for a residual adverse impact, the equivalent area will be rehabilitated to satisfy the same objectives for ESAs as discussed above. Where disturbances have not resulted in a residual adverse impact, the disturbed area will be rehabilitated with the objective of returning the land so as to match the values of the adjacent land use at the time of commencement of the rehabilitation works. Where the adjacent land use is natural, Santos GLNG will seek to return the biodiversity values of the area. Because this can be a very lengthy process due to the complexity of aged vegetation communities (in excess of 90 years for some communities), Santos GLNG propose to measure rehabilitation success by ensuring the following criteria are met: • A landform that is stable, non-polluting and safe to humans and wildlife • Greater than or equal to 70% of native groundcover species richness of the adjacent land use • Greater than or equal to 50% ground cover of the adjacent land use • Less than or equal to the declared pest species richness of the adjacent land use • The presence of relevant species that will form the ecologically dominant layer and define the target vegetation group. By satisfying the above criteria, Santos GLNG will have provided a stable landform with cover that is sufficiently diverse to prevent significant weed encroachment and support natural succession and regenerative processes. Habitat structures such as rock piles and woody debris that were collected during the construction phase will be returned to the disturbed area to promote use by species of fauna. The land should not require further management. At this time, Santos GLNG will seek to absolve responsibility for the rehabilitation works.
Other REs	All other REs that do not comprise an ESA or threatened species habitat (e.g. not of concern vegetation and regrowth) are less heavily regulated due their lower conservation status. Rehabilitation options for these are: Carryout rehabilitation works with the objective of returning the land to match the biodiversity values of the adjacent land use. The rehabilitation criteria to be met is in line with those described for threatened species.

Category	Rehabilitation criteria
	Seek an alternative outcome to rehabilitation where a greater environmental benefit can be obtained. This will be adopted for regional ecosystems where it is thought unlikely that rehabilitation criteria in (1) can be achieved due to reasons such as community complexity or localised conditions. Instead, Santos GLNG may identify opportunities where money can be invested to obtain a greater net environmental benefit. Examples include offsets or the delivery of green infrastructure such as improved riparian corridors or better linkages between significant remnant vegetation patches in a landscape. The decision to invest in such strategies will be made on a case-by-case basis. Where this approach is adopted, Santos GLNG would return the disturbed area to reflect the stable, non-polluting and safe landform principles. Santos GLNG will conduct regular monitoring and maintenance of all rehabilitated areas to ensure that works are on trajectory to meet the rehabilitation criteria and objectives. The anticipated timeframe for successful Stage 2 rehabilitation within natural areas will be dependent on numerous factors, many of which will be outside of Santos GLNG's control (such as weather). At the time rehabilitation is considered successful by Santos GLNG, landholders will be requested to formally approve the rehabilitation to demonstrate their satisfaction of the completed works.

Source:

Santos GLNG, 2014. Santos GLNG Upstream Rehabilitation management plan

13.3 Rehabilitation performance indicators

The indicators and criteria within Table 13-3 will be utilised to determine whether the environmental performance objectives have been met and whether the control strategies implemented have been effective.

Table 13-3 Rehabilitation performance indicators

Rehabilitation performance indicators and criteria

- The Rehabilitation management plan is implemented.
- Significantly disturbed areas that are no longer required for on-going GFD Project activities and are not intended to be used by a landholder or overlapping tenure holder are to commence rehabilitation within the period specified in the EA and in accordance with the Rehabilitation management plan.
- Significantly disturbed areas caused by GFD Project activities which are intended to be used by a landholder or overlapping tenure holder are safe, stable and non-polluting and compatible with the intended post-closure land use.
- Infrastructure that is no longer required for the carrying out of the petroleum activities is rehabilitated in accordance with the EA.
- Any dam that is being or intended to be used by a landholder or overlapping tenure holder is decommissioned to no longer accept inflow from petroleum activities and the contained water is of a quality suitable for the intended on-going uses(s) by the landholder or overlapping tenure holder.

13.4 Management controls

Table 13-4 summarises key rehabilitation actions that Santos GLNG will utilise, where required, to achieve the rehabilitation objectives and outcomes described in Section 13.3. These methods are further detailed in the Rehabilitation management plan (Appendix M).

Table 13-4 Management control measures

Document	Overview	Control measure
Rehabilitation management plan	The Rehabilitation management plan provides the framework for rehabilitating land that has been disturbed as part of gas field activities. The plan will 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. Specifically, the 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 rehabilitating a disturbance • Provides an overview of monitoring and maintenance actions to be conducted on rehabilitated areas.	The Rehabilitation management plan will be implemented (Refer Appendix M). Disturbed areas will be rehabilitated to a safe, stable and non-polluting environment suitable for the intended land use in accordance with the strategies contained within the Rehabilitation management plan.
Decommissioning and abandonment management plan	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.	Santos GLNG will implement the DAMP (Refer Appendix N). The DAMP describes the proposed decommissioning of specific Project assets comprising the GLNG Upstream Project Area. As part of this description, the DAMP also identifies infrastructure types that will be decommissioned in-situ (i.e. not removed from site) and therefore are not subject to the rehabilitation measures outlined in the Rehabilitation management plan.

Document	Overview	Control measure
Pest and weed management plan	The PWMP outlines Santos GLNG's approach to pest and weed management in the gas fields. The plan introduces measures to address the four key pest and weed management concepts of Identify, Avoid, Minimise / Mitigate and Control. The management of pests and weeds during rehabilitation activities will be critical in achieving rehabilitation success.	Santos GLNG will implement the PWMP (Refer Appendix J).
Erosion and sediment control management plan	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.	Santos GLNG will implement the ESCMP (Refer Appendix E)
EHS 01: Land Disturbance	This standard defines the requirements to minimise environmental impacts associated with disturbance to biodiversity and/or land during oil and gas exploration, production, processing and rehabilitation activities.	Santos GLNG will implement EHS 01: Land Disturbance
EHS06: Environmental Impact Assessment and Approvals	This standard discusses both external and internal approval requirements necessary prior to conducting disturbances to land.	Santos GLNG will implement EHS06: Environmental Impact Assessment and Approvals
EHS08: Contaminated Sites	This standard defines the minimum acceptable requirements for the protection of human health and the environment where site contamination has occurred at Santos operated or leased sites or independently owned properties impacted by Santos operations.	Santos GLNG will implement EHS08: Contaminated Sites
EHSMS 11.11 Decommissioning and abandonment	Provides for effective management of environmental, health and safety risks associated with the decommissioning of plant, equipment and facilities.	Santos GLNG will implement EHSMS 11.11 Decommissioning and abandonment

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Document	Overview	Control measure
Santos GFD Project Environmental offsets strategy	The Santos GFD Project Environmental Offsets Strategy is an approach to provide environmental benefits to counterbalance the impacts that remain after avoidance, minimisation, mitigation and remediation and rehabilitation measures. Where required, Santos GLNG will provide suitable offsets for activities that result in an unavoidable adverse impact Matters of State Environmental Significance (MSES). The Rehabilitation management plan describes different rehabilitation objectives for disturbances in natural areas that have been offset compared to all other natural areas.	Santos GLNG will implement Santos GFD Project Environmental Offsets Strategy

13.5 Monitoring and maintenance

Monitoring over a three to five year period will be undertaken at the completion of the rehabilitation works, as per the Rehabilitation management plan, to ensure that the objectives of the rehabilitation schedule are being achieved. Monitoring periods will be determined on a case-by-case basis and will be dependent on the success of rehabilitation, season or natural disasters impeding rehabilitation efforts. Sites will be monitored until such time the rehabilitation criteria discussed in Section 13.2 (Rehabilitation Objectives) can be demonstrated.

Monitoring will consist of vegetation surveys and photo monitoring. Monitoring locations are to be determined by a suitably qualified person and where practicable, established within the core of rehabilitation areas to avoid edge effects.

Within a three year period it is expected that the progression and improvement of key rehabilitation indicators such as species composition, weed cover, and plant densities will be evident.

Where monitoring identifies that performance criteria are not being met, maintenance actions will be implemented including replanting, weed removal, stabilisation and erosion and sediment control measures. Where rehabilitation areas require maintenance at the completion of the monitoring timeframes, due to ineffective rehabilitation activities or natural disasters, the monitoring and maintenance schedule will be extended until the rehabilitation area meets the rehabilitation criteria.

A summary of monitoring and maintenance actions is provided in Table 13-5.

Table 13-5 Maintenance and monitoring actions for rehabilitated areas

Time	Management actions	Monitoring
Ongoing monitoring (at regular intervals)	• Weed control • Replacement of plant mortalities (as required) • Where natural regeneration is deemed unsuccessful, replanting with tubestock • Watering as required • Reinstatement of erosion and sediment control measures (as required) • Maintain fencing as required • Additional management actions will be undertaken on an as needed basis, to be determined as part of each monitoring period.	• Photo monitoring • Vegetation surveys • Erosion and sediment control effectiveness • Survival of planted flora • Evidence of fauna habitat features (e.g. food sources, woody material & rocks).

Source:

Santos GLNG, 2014. Santos GLNG Upstream Rehabilitation management plan, Table 4

13.6 Rehabilitation report

The EP Act requires the submission of a final rehabilitation report to the administering authority. This report will provide details on all petroleum activities that have occurred, the remedial works conducted, and the status of the final land use. In accordance with Section 264 of EP Act, the final rehabilitation report will contain the following:

Include enough information to allow the administering authority to decide whether:

- the conditions of the EA (chapter 5A activities) have been complied with
- the land on which each relevant activity (chapter 5A activity) for the EA has been carried out has been satisfactorily rehabilitated
- Describe ongoing environmental management needs for the land
- For activities carried out under each relevant resource activity for the EA state the details of:
 - The monitoring program and the results of monitoring rehabilitation indicators required under any condition of the environmental authority
 - Any consultation with affected owners and occupiers, members of the public, community groups, government agencies, and other bodies about any completion criteria for rehabilitation stated in the environmental authority
- For activities carried out under each relevant resource activity for the EA state an environmental risk assessment of the land
- For activities carried out under each relevant resource activity for the EA propose the residual risks associated with the rehabilitation of the land, worked out under a guideline or other document publicly available from the administering authority
- Include another matter prescribed under a regulation (QLD 1994).

Prior to relinquishment, Santos GLNG will take steps to ensure affected landholders are satisfied with the standard of rehabilitation undertaken.

13.7 Proposed environmental authority conditions

The following draft EA conditions in relation to rehabilitation are proposed for the GFD Project. The conditions stipulate the required plans and management and monitoring requirements to enable adequate protection of the GFD Project area's environmental values. The EA conditions are reproduced in full in Appendix O.

SCHEDULE I – REHABILITATION

Rehabilitation planning

- 11 A Rehabilitation management plan must be developed by a suitably qualified person and must include the:
- a) rehabilitation goals; and
 - b) procedures to be undertaken for rehabilitation that will:

- (i) achieve the requirements of conditions (12) to (17), inclusive; and
 - (ii) provide for appropriate monitoring and maintenance.
- c) approach to establishing an alternative outcome to (13) and (14) by achieving a higher environmental value than that which was present prior to the significant disturbance from petroleum activities

Transitional rehabilitation

- 12 Significantly disturbed areas that are no longer required for the on-going petroleum activities, must be transitionally rehabilitated within 12 months (unless an exceptional circumstance in the area to be rehabilitated (e.g. a flood event) prevents this timeframe being met) and be maintained so that:
- a) contaminated land resulting from petroleum activities is remediated and rehabilitated
 - b) the areas are:
 - (i) non-polluting
 - (ii) a stable landform
 - (iii) re-profiled to contours consistent with the surrounding landform where the land has not been subject to significant cut and fill activities;
 - (iv) made safe to humans and livestock where significant cut and fill operations have been undertaken;
 - c) surface drainage lines are re-established
 - d) top soil is reinstated; and
 - e) either:
 - (i) groundcover, that is not a declared pest species, is growing; or
 - (ii) an alternative soil stabilisation methodology that achieves effective stabilisation is implemented and maintained.

Final rehabilitation acceptance criteria

- 13 All significantly disturbed areas caused by petroleum activities which are not being or intended to be utilised by the landholder or overlapping tenure holder, must be rehabilitated to meet the following final acceptance criteria measured either against the highest ecological value adjacent land use or the pre-disturbed land use:
- a) greater than or equal to 70 per cent of native ground cover species richness;
 - b) greater than or equal to the total per cent ground cover;
 - c) less than or equal to the per cent species richness of declared plant pest species;
 - d) where the adjacent land use contains, or the pre-clearing land use contained, one or more regional ecosystem(s), then:
 - (i) at least one regional ecosystem(s) from the same broad vegetation group, as demonstrated by the predominant species in the ecologically dominant layer, must be present; and,
 - (ii) the regional ecosystem present in (13)(d)(i) must possess an equivalent or higher conservation value (biodiversity status) than the regional ecosystem(s) in either the adjacent land or pre-disturbed land.
- 14 Where significant disturbance to land has occurred in an environmentally sensitive area, the following final rehabilitation criteria as measured against the pre-disturbance biodiversity values assessment (required by conditions (E4) and (E5)) must be met:

- a) greater than or equal to 70 per cent of native ground cover species richness;
 - b) greater than or equal to the total per cent ground cover;
 - c) less than or equal to the per cent species richness of declared plant pest species;
 - d) greater than or equal to 50 per cent of organic litter cover;
 - e) greater than or equal to 50 per cent of total density of coarse woody material; and
 - f) all predominant species in the ecologically dominant layer, that define the pre-disturbance regional ecosystem(s) are present.
- 15 Where it can be demonstrated that a higher environmental value than that which was present prior to the significant disturbance associated with petroleum activity(ies) has been achieved through means other than on-site rehabilitation required by (I3) and (I4), the criteria in (I2) apply as the final acceptance criteria and (I3) and (I4) are not required to be met.

Remaining infrastructure

- 16 Infrastructure that is no longer required for the carrying out of the petroleum activity(ies) is not subject to conditions (I 2) to (I5), inclusive, if the infrastructure has been approved in writing by the landholder(s) to remain in-situ.
- 17 Where there is a dam (including a low consequence dam) that is being or intended to be used by the landholder or overlapping tenure holder, the dam must be decommissioned to no longer accept inflow from the petroleum activity(ies) and the contained water must be of a quality suitable for the intended on-going uses(s) by the landholder or overlapping tenure holder.

14 Stimulation activities

14.1 Environmental values

Without appropriate management controls, environmental values associated with groundwater, surface water and aquatic ecosystems could potentially be impacted by stimulation activities. These environmental values are discussed in sections 7.1.1, 7.1.2, and 9.2.2 respectively.

14.2 Potential impacts

Potential impacts from well stimulation are detailed in the Santos GLNG Upstream Hydraulic fracturing risk assessment (Appendix P), which includes a qualitative assessment of environmental risk to the receiving aquatic environment, and a qualitative review of human health and terrestrial toxicity and assessment of surface and subsurface exposure pathways.

The scope of the qualitative risk assessment comprised:

- Issue identification – A description of the current environmental setting (including a description of potential receiving environments and the various factors, which act upon them, including climatic influences), detailed geological and hydrogeological information, gas well integrity and a description of the hydraulic fracturing process including an identification of the constituents of the hydraulic fracturing fluid
- Hazard assessment – An evaluation of the environmental hazard of relevant chemical additives in the hydraulic fracturing fluid based on aquatic toxicity, environmental persistence and bioaccumulation. The environmental hazard assessment provides a relative ranking of the chemical additives and those chemicals considered to represent a high hazard are identified as chemicals of potential concern (COPC) for further assessment. An evaluation of terrestrial and human health toxicity will also be presented
- Exposure assessment – The exposure assessment comprises of an evaluation of surface and subsurface exposure pathways assessment and mass balance calculation to identify the amount of each chemical additive of the hydraulic fracturing fluid. For the additives selected as COPC, fate and transport modelling is used to identify the likely extent of movement from the gas well
- Risk characterisation – A qualitative evaluation of environmental and human health risk associated with the hydraulic fracturing activities based on the identification of complete exposure pathways and hazard identification.

Based on the qualitative risk assessment, a summary of potential impacts is presented in Table 14-1 below.

Table 14-1 Potential impacts

Potential Impacts

- Livestock or human receptor exposure to fracturing fluids, flowback water or gas
- Spill or release of fracturing fluids or flowback water
- Exposure to sediments in mud pits/ turkey's nest.
- Dust from sediments in mud pit/ turkey's nest
- Human and/ or ecological exposures to fracturing fluid due to casing failures or through fractures into the surrounding aquifer
- Impacts to groundwater resources from fluid flow and/or discharge to shallow aquifers due to the high pressure of the injected fracturing fluids in the gas wells
- Releases of flowback water into shallow aquifers used for domestic or stock water supply, or discharge to surface water
- Direct release to surface water
- Overflow of flowback water from turkeys nest or mud pit.

Source:

EHS Support LLC 2014. Santos GLNG Upstream Hydraulic Fracturing Risk Assessment Compendium of Assessed Fluid Systems

14.3 Environmental protection objectives

In accordance with Santos GLNG's internal standards, the GFD Project will adopt the environmental performance objectives relevant to stimulation activities listed in Table 14-2.

Table 14-2 Environmental protection objectives

Environmental protection objectives

- Avoid or minimise impacts to groundwater, surface water and aquatic ecology environmental values
- Manage stimulation activities to minimise the risk if adverse environmental impact.

14.4 Environmental protection performance indicators

The indicators within Table 14-3 will be utilised to determine whether the environmental performance objectives have been met and whether the control strategies implemented have been effective.

Table 14-3 Environmental performance indicators

Environmental performance indicators

- Stimulation activities do not negatively affect water quality, other than that within the stimulation impact zone of the target gas producing formation
- A stimulation impact monitoring program that meets the requirements of the EA is implemented
- Stimulation activities do not cause a connection of the target gas producing formation and another aquifer
- A stimulation risk assessment is carried out for wells to be stimulated prior to stimulation activities being carried out at that well, in accordance with the EA.

14.5 Management controls

Considering the hazard and exposure assessment and controls implemented by Santos GLNG, the overall risk to human health and environment associated with the chemicals involved in hydraulic fracturing is low. These operational controls include those listed in Table 14-4.

Table 14-4 Management control measures

Management Plan	Key provisions/ function	Management control measures
Hydraulic fracturing risk assessment	The Hydraulic fracturing risk assessment, in support of Schedule J of the Draft EA, synthesises the hydraulic fracturing risk assessments completed on various hydraulic fracturing fluids and provides a framework for including new fluid systems within the risk assessment document. The body of the report provides generalised information, including the geology and hydrogeology of the area, risk assessment methodologies (qualitative and quantitative) and a high level understanding of current results. The appendices include risk assessments of individual hydraulic fracturing fluid systems. This report provides information critical to the effective management and monitoring of hydraulic fracturing activities, and is integral to the existing Santos GLNG Management Framework.	Santos GLNG will implement the Hydraulic fracturing risk assessment and carry out the risk assessment for wells to be stimulated prior to stimulation activities being carried out at that well. Santos GLNG will ensure that polycyclic aromatic hydrocarbons or products that contain polycyclic aromatic hydrocarbons are not used as additives in stimulation fluids in concentrations above the reporting limit. Santos GLNG will implement practices and procedures to detect, as soon as practicable, fractures that could result in the connection of a target gas producing formation and another aquifer. Santos GLNG will verify the internal and external mechanical integrity of the well system prior to and during well stimulation must be ensured such that there is: • no significant leakage in the casing, tubing, or packer; and • there is no significant fluid movement into another aquifer through vertical channels adjacent to the well bore hole.
Stimulation impact monitoring program	The program was developed to provide a general description of the stimulation activities to be conducted by Santos GLNG, the regulatory requirements pertinent to stimulation monitoring, as well as the practices and procedures that comprise the monitoring program. The Stimulation Impact Monitoring Program is aligned with the requirements in Schedule J of the draft EA.	Santos GLNG will implement the Stimulation impact monitoring program. Santos GLNG will undertake the monitoring, as required by the EA and detailed in the Stimulation impact monitoring program, which includes the monitoring of: • stimulation fluids • flow back waters • all bores, as required by the EA, and at the specified frequency. Santos GLNG will provide the results of the Stimulation impact monitoring program to any potentially affected landholder upon request.

14.6 Commitments

Other monitoring and reporting considerations which are not covered by the scope of the EM Plan are detailed in the EMR (Appendix C). The EMR includes specific monitoring and reporting considerations required under the Water Act 2000 and the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) that fall outside the Queensland Environmental Protection Act 1994 (EP Act). The monitoring activities aid in the protection of environmental values associated with groundwater, surface water and aquatic ecosystems that could potentially be impacted by stimulation activities. Such monitoring requirements include the following:

Water Act (Queensland)

- Regional baseline bore assessments
- Office of Groundwater Impact Assessment (OGIA) Underground Water Impact Report (UWIR) water quality and pressure monitoring
- OGIA UWIR springs monitoring
- Trigger levels and response
- Reporting.

EPBC Act (Commonwealth)

- Monitoring of subsidence
- Early warning monitoring for EPBC Act listed springs
- Monitoring associated with hydraulic fracturing
- Aquifer connectivity monitoring
- Significant / listed Species
- EPBC trigger levels and exceedance response
- Notification and reporting.

14.7 Monitoring

Table 14-5, summarises the environmental monitoring and assessment considerations for the GFD Project stimulation activities. Details of the monitoring activities are described in the management plans. Additional monitoring considerations are summarised in Table 14-5.

Table 14-5 Monitoring considerations for stimulation activities

Existing management and monitoring plans

- Hydraulic fracturing risk assessment
- Stimulation impact monitoring program

Monitoring considerations

General

- Monitoring will be undertaken by a suitably qualified person
- Laboratory analyses and tests will be carried out by a laboratory that has NATA accreditation for such analyses and tests, unless NATA accredited tests are not available
- An annual report will be prepared each year and submitted to the administering authority in the form requested by the administering authority. The annual report will include information required by the EA including the results of any baseline or stimulation impact monitoring program.

Water quality baseline monitoring

- Prior to undertaking stimulation activities a baseline bore assessment will be undertaken in accordance with the requirements of the EA
- Prior to undertaking stimulation activities at a well, sufficient water quality data will be obtained to accurately represent the water quality in the well to be stimulated
- Stimulation baseline bore assessments will include the minimum water quality analytes and physico-chemical parameters identified in the Baseline Assessment Guideline (EHP) and any restricted stimulation fluids as defined in the Environmental Protection Act 1994, as amended from time to time, in order to establish baseline water quality.

Stimulation impact monitoring program

- The Stimulation Impact Monitoring Program will be developed prior to the carrying out of stimulation activities. The program will be designed to detect adverse impacts to water quality from stimulation activities. It will consider the findings of the Stimulation Risk Assessment which will also be carried out in accordance with the requirements of the EA.
- The Stimulation Impact Monitoring Program will provide for monitoring of:
 - analytes and physico-chemical parameters relevant to baseline bore and well assessments to enable data referencing and comparison
 - any other analyte or physico-chemical parameters that will enable detection of adverse water quality impacts and the inter-connection with a non-target aquifer as a result of stimulation activities including chemical compounds that are actually or potentially formed by chemical reactions with each other or coal seam materials during stimulation activities
- The internal and external mechanical integrity of the well system will be maintained and verified prior to and during well stimulation
- Internal and external mechanical integrity of well systems will be verified prior to and during well stimulation such that there is no significant leakage in the casing, tubing or packer, and there is no significant fluid movement into another aquifer through vertical channels adjacent to the well bore hole
- Stimulation risk assessment will be undertaken in accordance with the EA prior to well stimulation activities.
- A baseline bore assessment will be undertaken in accordance with the EA

The results of the stimulation impact monitoring program will be readily available to potentially affected landholders who request for it.

14.8 Proposed environmental authority conditions

The following draft EA conditions in relation to Stimulation Activities are proposed for the GFD Project. The conditions stipulate the required plans and management and monitoring requirements to enable adequate protection of the GFD Project areas environmental values. The EA conditions are reproduced in full in Appendix O.

Contingency Plan for Emergency Environmental Incidents

- A17 Responses to environmental emergency incidents must be undertaken in accordance with the *Santos GLNG Upstream Contingency Plan for Emergency Environmental Incidents*.
- A18 The *Santos GLNG Upstream Contingency Plan for Emergency Environmental Incidents* must include, but not necessarily be limited to:
- a) procedures for responding to incidents resulting from stimulation activities, including specific rectification measures in the event of non-routine stimulation events;

Monitoring

- A23 An annual report must be prepared each year and submitted to the administering authority in the form requested by the administering authority. This report must include but not necessarily be limited to:
- (i) the results of any baseline or stimulation impact monitoring program that is required by this environmental authority, where applicable;

SCHEDULE J – WELL CONSTRUCTION, MAINTENANCE AND STIMULATION ACTIVITIES

Drilling activities

- J1 Oil based or synthetic based drilling must not be used in the carrying out of the petroleum activity(ies).
- J2 Drilling activities must not result in the connection of the target gas producing formation and another aquifer.
- J3 Practices and procedures must be in place to detect, as soon as practicable, any fractures that have or may result in the connection of a target gas producing formation and another aquifer as a result of drilling activities.

Stimulation activities

- J4 Polycyclic aromatic hydrocarbons or products that contain polycyclic aromatic hydrocarbons must not be used in stimulation fluids in concentrations above the reporting limit.
- J5 Stimulation activities must not negatively affect water quality, other than that within the stimulation impact zone of the target gas producing formation.
- J6 Stimulation activities must not cause the connection of the target gas producing formation and another aquifer.

- J7 The internal and external mechanical integrity of the well system prior to and during well stimulation must be ensured such that there is:
- a) no significant leakage in the casing, tubing, or packer; and
 - b) there is no significant fluid movement into another aquifer through vertical channels adjacent to the well bore hole.
- J8 Practices and procedures must be in place to detect, as soon as practicable, any fractures that cause the connection of a target gas producing formation and another aquifer.

Stimulation risk assessment

- J9 Prior to undertaking well stimulation activities, a risk assessment be developed to ensure that stimulation activities are managed to prevent environmental harm.
- J10 The stimulation risk assessment required must be carried out for every well to be stimulated prior to stimulation activities being carried out at that well and address issues at a relevant geospatial scale such that changes to features and attributes are adequately described and must include, but not necessarily be limited to:
- a) a process description of the stimulation activity to be applied, including equipment and a comparison to best international practice;
 - b) provide details of where, when and how often stimulation is to be undertaken on the tenures covered by this environmental authority;
 - c) a geological model of the field to be stimulated including geological names, descriptions and depths of the target gas producing formation(s);
 - d) naturally occurring geological faults;
 - e) seismic history of the region (e.g. earth tremors, earthquakes);
 - f) proximity of overlying and underlying aquifers;
 - g) description of the depths that aquifers with environmental values occur, both above and below the target gas producing formation.
 - h) identification and proximity of landholders' active groundwater bores in the area where stimulation activities are to be carried out;
 - i) the environmental values of groundwater in the area;
 - j) an assessment of the appropriate limits of reporting for all water quality indicators relevant to stimulation monitoring in order to accurately assess the risks to environmental values of groundwater;
 - k) description of overlying and underlying formations in respect of porosity, permeability, hydraulic conductivity, faulting and fracture propensity;
 - l) consideration of barriers or known direct connections between the target gas producing formation and the overlying and underlying aquifers;
 - m) a description of the well mechanical integrity testing program;
 - n) process control and assessment techniques to be applied for determining extent of stimulation activities (e.g. microseismic measurements, modelling etc);
 - o) practices and procedures to ensure that the stimulation activities are designed to be contained within the target gas producing formation;
 - p) groundwater transmissivity, flow rate, hydraulic conductivity and direction(s) of flow;

- q) a description of the chemicals used in stimulation activities (including estimated total mass, estimated composition, chemical abstract service numbers and properties), their mixtures and the resultant compounds that are formed after stimulation;
- r) a mass balance estimating the concentrations and absolute masses of chemicals that will be reacted, returned to the surface or left in the target gas producing formation subsequent to stimulation;
- s) an environmental hazard assessment of the chemicals used including their mixtures and the resultant chemicals that are formed after stimulation including:
 - (i) toxicological and ecotoxicological information of chemicals used;
 - (ii) information on the persistence and bioaccumulation potential of the chemicals used;
 - (iii) identification of the stimulation fluid chemicals of potential concern derived from the risk assessment;
- t) an environmental hazard assessment of use, formation of, and detection of polycyclic aromatic hydrocarbons in stimulation activities;
- u) if used, identification and an environmental hazard assessment of using radioactive tracer beads in stimulation activities
- v) an environmental hazard assessment of leaving stimulation chemicals in the target gas producing formation for extended periods subsequent to stimulation;
- w) human health exposure pathways to operators and the regional population;
- x) risk characterisation of environmental impacts based on the environmental hazard assessment;
- y) potential impacts to landholder bores as a result of stimulation activities;
- z) the determination of the likelihood of causing interconnectivity and/or negative water quality as a result of stimulation activities undertaken in close proximity or each other; and
- aa) potential environmental or health impacts which may result from stimulation activities including but not limited to water quality, air quality (including suppression of dust and other airborne contaminants), noise and vibration.

Water quality baseline monitoring

- J11 Prior to undertaking any stimulation activity, the holder of this environmental authority must undertake a baseline bore assessment of the quality of:
 - a) all landholders' active groundwater bores (subject to access being permitted by the landholder) that are spatially within a two (2) kilometre horizontal radius from the location of the stimulation initiation point within the target gas producing formation; and
 - b) all active landholders' groundwater bores (subject to access being permitted by the landholder) in any aquifer that is within 200 metres above or below the target gas producing formation and is spatially located with a two (2) kilometre radius from the location of the stimulation initiation point; and
 - c) any other bore that could potentially be adversely impacted by the stimulation activity(ies) in accordance with the findings of the risk assessment required by conditions (J9) and (J10).
- J12 Prior to undertaking stimulation activities at a well, the holder of this environmental authority must have sufficient water quality data to accurately represent the water quality in the well to be stimulated. The data must include as a minimum the results of analyses for the parameters in condition (J13).

- J13 Stimulation baseline bore assessments required in Condition (J11) must include the minimum water quality analytes and physico-chemical parameters identified in the *Baseline Assessment Guideline* (EHP) and any restricted stimulation fluids as defined in the *Environmental Protection Act 1994*, as amended from time to time, in order to establish baseline water quality.

Stimulation impact monitoring program

- J14 A Stimulation impact monitoring program must be developed prior to the carrying out of stimulation activities which must be able to detect adverse impacts to water quality from stimulation activities and must consider the findings of the risk assessment required by conditions (J9) and (J10) that relate to stimulation activities and must include, as a minimum, monitoring of:
- a) the stimulation fluids to be used in stimulation activities at sufficient frequency and which sufficiently represents the quantity and quality of the fluids used; and
 - b) flow back waters from stimulation activities at sufficient frequency and which sufficiently represents the quality of that flow back water; and
 - c) flow back waters from stimulation activities at sufficient frequency and accuracy to demonstrate that 150 % of the volume used in stimulation activities has been extracted from the stimulated well; and
 - d) all bores in accordance with condition (J11) at the following minimum frequency:
 - e) monthly for the first six (6) months subsequent to the stimulation activities being undertaken; then
 - f) annually for the first five (5) years subsequent to the stimulation activities being undertaken or until analytes and physico-chemical parameters listed in condition (J13) are not detected in concentrations above baseline bore monitoring data on two (2) consecutive monitoring occasions.
- J15 The Stimulation impact monitoring program must provide for monitoring of:
- a) analytes and physico-chemical parameters relevant to baseline bore and well assessments to enable data referencing and comparison including, but not necessarily being limited to the analytes and physico-chemical parameters in condition (J13); and
 - b) any other analyte or physico-chemical parameters that will enable detection of adverse water quality impacts and the inter-connection with a non-target aquifer as a result of stimulation activities including chemical compounds that are actually or potentially formed by chemical reactions with each other or coal seam materials during stimulation activities.
- J16 The results of the Stimulation Impact Monitoring Program must be made available to any potentially affected landholders upon request by that landholder.

15 Community and social

15.1 Social area of influence

The potential for impacts to occur on social values was assessed within each gas field individually (i.e., Arcadia, Fairview, Roma, and Scotia). The key population centres within each gas field include:

- Arcadia – Rolleston, Springsure
- Fairview – Injune
- Roma – Roma, Wallumbilla
- Scotia – Taroom, Wandoan.

Although the GFD Project will undertake the same activities within each gas field, the impacts will differ depending on the existing social conditions present within the host communities. The Fairview and Roma gas fields were assessed together, recognising that there are considerable linkages between the primary urban centres (Roma and Injune) and are both located in the Maranoa Regional Council area.

The risk assessment and social baseline conducted updates the investigation undertaken for the GLNG Project EIS in 2009. Additional investigations were undertaken to describe the social baseline of the communities within the GFD Project area, and to understand the current impacts being experienced by these communities in relation to existing resource development projects in their vicinity.

15.2 Social values

Social values were identified based on information contained in the social baseline profile and consultation with key stakeholders (refer Section 1.3). The social values identified include the following:

- Liveable community
- Affordable lifestyle
- Community identity and spirit
- Capacity for sustainable economic activity.

15.2.1 Non-indigenous

Details of the non-indigenous social values applicable to each gas field as summarised in Table 15-1.

Table 15-1 Non-indigenous social values

Gas field	Liveable community	Affordable lifestyle	Community identity and spirit	Capacity for sustainable economic activity
Arcadia	- Has a high level of liveability - Moderately vulnerable to perceived effects of development activity	- Area remains affordable - Moderately vulnerable to population influx associated with gas field development	- Strong agricultural identity and independent spirit in remote areas - Some vulnerability to marginalisation in the development process if community engagement is not effective	- Highly value the economy built from good quality agriculture land - Recognise the contribution of regional sustainability that energy development will bring
Fairview and Roma	- Has a high level of liveability - Moderately vulnerable to perceived effects of development activity on infrastructure in rural communities	- Area remains affordable - Modest level of vulnerability from population influx associated with gas development - Ongoing moderate vulnerability to infrastructure impacts (e.g., housing and cost of living increases in regional areas)	- Strong agricultural identity and independent spirit in remote areas - Strong on-going community engagement by gas industry proponents	- Highly value the economy built from good quality agriculture land - Recognise the contribution of regional sustainability that further energy development from on-shore gas will bring
Scotia	Liveability is a moderately robust characteristic with some potential for stress from future development (e.g. Wandoan area)	- Area remains affordable - Potential threat from rising land values and local government rates and service charges	- Strong attachment to existing rural-based identity and spirit - Willing to embrace new economic activity while building on and sustaining agricultural heritage	- Acceptance of gas development with intense interest in managing the environment (e.g., surface and groundwater) - Assurance of environmental integrity will be essential to maintain agriculture

15.2.2 Indigenous

While Indigenous people would identify in broad terms with the social values listed in the previous section, there are likely to be different indicators for their values reflecting their particular circumstances and experience as a distinct cultural group. The assessment of impact on the Indigenous community has been based on the social values and indicators listed in Table 15-2.

Table 15-2 Indigenous social values

Liveable community	Affordable lifestyle	Community identity and spirit	Capacity for sustainable economic activity
- Indigenous people across the GFD Project area generally live in a mutually respectful relationship with the non-indigenous community. - Concerned with the lack of culturally appropriate service delivery (in particular for health) which is a significant issue given the poor health outcomes within the community.	Likely that housing costs for Indigenous people remains a significant issue.	Indigenous community identity and spirit has a modest recognition to those outside of the Indigenous community, with ongoing action by the Indigenous community aimed at strengthening both identity and spirit.	- Indigenous capacity for sustainable economic activity is limited across the region, and severely constrained in Woorabinda. - Capacity for economic sustainability for Indigenous communities is limited.

15.3 Potential impacts

Non-indigenous

The potential social impacts of the GFD Project on the non-indigenous community are summarised in Table 15-3.

Table 15-3 Potential non-indigenous community and social impacts

Environmental value	Potential impacts
Liveable community	Workforce demand on public health facilities and services An increase in population can be expected to increase demand on public health facilities and services. Demand on these services from a GFD Project-related population increase can be expected to be at a maximum with the workforce presence in each gas field.
	Intra-community conflict Possible community tension and a perceived reallocation of resources, and intra-community conflict between those who oppose and those who support the development.
	Construction and operational traffic on local roads and in the town areas - An increase in vehicles on roads throughout the GFD Project area has the potential to increase traffic accidents, which in turn could increase the work load of police and emergency services. - Long-term residents of rural towns, with set habits and lifestyle patterns which are disrupted by the presence of higher traffic levels in town streets, may also resent the impairment to their perceived level of community amenity.
	Presence of a younger, predominantly male workforce in social venues and general town areas - The introduction of a younger and predominantly male workforce has, in some instances, been associated with increases in anti-social and alcohol-related offences. - The presence of male-dominated workforces in small rural communities can raise concerns with regard to public behaviour and challenges to a long-established order. Even where impacts do not eventuate, community concerns about large male workforces ("perceived" impacts) may be significant in themselves
	Demand on public physical infrastructure The influx of population due to the GFD Project has the potential to increase demand on physical infrastructure such as water supply, sewage treatment, waste disposal facilities and telecommunications. The level of impact in each gas field is based on the existing capacity of physical infrastructure.

Environmental value	Potential impacts
Affordable lifestyle	Increased demand for housing Small communities can experience decreased housing affordability as a result of the introduction or expansion of major resource projects.
	Increased wage pressures on local businesses The GFD Project will provide employment opportunities, such as camp operations and logistics, which may draw labour away from local businesses and service providers.
Community identity and spirit	Local employees working extended shift hours and rosters Worker fatigue and associated impacts on health, an increase in familial burden to their partners, and reduced participation of workers in community activities.
	Visible presence of gas industry workers in local community venues and the presence and scale of project facilities The introduction of largely transient workforces during construction, coupled with large-scale project facilities, has the potential to be perceived to reduce the rural character of communities. The presence of transient workforces in public spaces is often coupled with increased economic revenue for local businesses.
	High occupancy of short-term accommodation by project contractors, displacing visitors to communities - Potential for project workforces to place demand on short-term accommodation, which could displace other visitors to these communities such as tourists. - Conversely, increased demand for short-term accommodation may stimulate the provision of additional, often higher quality, accommodation that may be beneficial to the capacity to accommodate visitors within a locality.
	Migration of long-term residents from high impacted properties The construction of wells and associated infrastructure on landholder properties has the potential to result in the out-migration of primary producers from the area.

Environmental value	Potential impacts
Capacity for sustainable economic activity	Disruption to agricultural production through field operations The introduction of alternative non-agricultural land uses by an external party to properties has the potential to disrupt existing agricultural operations.
	Construction activity deters local tourism and highway trade - Potential for initial GFD Project workforces to place demand on short-term accommodation prior to accommodation camps being available. - Elevated levels of construction traffic may also deter self-drive tourists from either visiting or passing through the area, thereby depriving local businesses of some level of trade.
	Perception that gas extraction creates uncertainty around water availability for agriculture - Community concern about the impact of gas production on groundwater and surface water quality and supply, and the potential consequences for agricultural production. - The converse of this situation is where the presence of a gas well provides an income stream and is seen as a positive attribute to a property, making it more attractive to buyers.
	Inward movement of larger enterprises to local area - Some GFD Project supply opportunities may be forgone by local businesses due to factors such as supply chain constraints, prohibitive costs, incompatible business models or proximity to larger regional centres. - Beneficial impacts may accrue during the life of the GFD Project, including in the provision of enhanced employment opportunities and skills development pathways, greater diversity of economic capacity and services, and higher rates revenues for local governments

Source:

URS, 2014. Social Impact Assessment – Santos GLNG Gas Field Development Project, Appendix A, Table A-1

15.3.1 Indigenous

The potential social impacts of the GFD Project on the Indigenous community are summarised in Table 15-4.

Table 15-4 Potential Indigenous community and social impacts

Environmental value	Potential impacts
Liveable community	Uncertainty with regard to environmental impact The Indigenous community has indicated that land use and the environment are important issues for them. With construction work occurring across an extensive area, there is a potential for environmental disturbance. This has the potential to induce anxiety in the absence of a sound understanding of the nature and extent of the impact, the areas in which it is occurring, and the measures being adopted to either avoid or manage the impact.
	Lack of cultural awareness of in-migrating construction and operations workforce When non-residential workforces do not have an appreciation of the cultural traits of a host community, whether Indigenous or non-indigenous, there is a potential for misunderstanding and conflict. The potential for conflict will also be dependent on the proximity of the workforce to the community and the level of day-to-day interaction.
	Tension between different segments of Indigenous populations over access to project benefits Should some segments of a local Indigenous population not benefit from GFD Project-induced opportunities to the same extent as others, intra-community tension may result. These tensions may affect the relationships within and the liveability of a community.
	Out-migration of elements of family groups due to inability to afford housing Living in proximity to relations is important for many people, and perhaps more so for persons who are members of minority groups including Indigenous people. The inability to afford housing due to rent increases may result in segments of extended families having to leave a community, thereby impairing the liveability of the community for those family members remaining.
Affordable lifestyle	Increased housing costs - Due to the socio-economic disadvantage evident in the Indigenous population when compared to the non-indigenous population, an increase in housing costs due to increased rental demand from in-migrating workers is likely to affect family budgets. - Where the affordability of housing is affected for low income groups it is likely to affect the Indigenous community to a greater extent due to the higher proportion of households in low income ranges compared to non-indigenous households. This would have an adverse effect on the cost of living in the community, and on Indigenous home ownership policy objectives of both Commonwealth and State Governments.
Community identity and spirit	Inadvertent interference with cultural heritage While there are cultural heritage management plans in place to manage impacts on cultural heritage material (refer to Section 20: Cultural heritage), it remains possible that there may be unintended interference with cultural heritage during construction of the GFD Project. If this occurs, some members of the Indigenous community could feel that their cultural identity is being disregarded.

Environmental value	Potential impacts
	Increased Indigenous employment presents staffing difficulties for Indigenous organisations The spirit of a community is generally fostered by organisations that work to advance community interests in priority areas such as a community health service. Should staffing for these organisations be difficult due to the recruitment of staff into higher paying jobs available through the GFD Project, it may impair the operation of the organisation in the short-term.
	General level of development marginalises Indigenous presence in community - A rapid expansion of the non-indigenous population, who are generally in the higher end of the income scale, may take attention away from issues of concern to the Indigenous community. For example, the rapid development of new housing subdivisions to cater for an expanding non-indigenous population may not do anything to address the over-crowding of Indigenous households. - Should this occur, there may be a diminution of community spirit as perceptions of being marginalised potentially arise. This is considered to be a sensitive issue for a segment of the community that has experience of being excluded in the past.
	Resentment at perceived landholder benefit from the occupation of traditional land While Native title groups have entered into appropriate agreements and processes with Santos GLNG, (refer to Section 20: Cultural heritage), it remains the case that these groups are descendants of the original traditional owners who were removed from the land. Publicity surrounding the income derived from hosting gas wells and infrastructure on agricultural holdings may foster a degree of resentment toward the current landholders, and possibly impede any community reconciliation process that may be in train, or make it harder to commence such a process.
Capacity for sustainable economic activity	High-paying, short-term construction work draws higher-level students from schooling The availability of high-paying construction jobs can influence the retention of students, apprentices and trainees in educational institutions, as individuals opt to take up opportunities to earn large incomes in the short-term. This rational economic behaviour for the short-term may have negative long-term consequences for the ability of individuals to maintain a higher earning capability in the absence of formal trade or technical qualifications in a post-construction environment.
	Unsupportive workplace environment for local Indigenous employees The lack of a supportive work environment can have a negative influence on the retention of workers in general and Indigenous workers in particular if they lack a depth of workplace experience. This can lead to a high turnover and wasted training resources should the individual not secure another job that draws on the experience and skills acquired. Negative experiences may also deter an individual from actively seeking to participate further in the workforce.

Source: URS, 2014. Social Impact Assessment – Santos GLNG Gas Field Development Project, Appendix A, Table A-2

15.4 Environmental protection objectives

In accordance with Santos GLNG's internal standards, the GFD Project will adopt the environmental performance objectives relevant to the social environment listed in Table 15-5.

Table 15-5 Environmental protection objectives

Environmental protection objectives

- Avoid or minimise adverse impacts on and protect social values

15.5 Environmental protection performance indicators

The indicators within Table 15-6 will be utilised to determine whether the environmental performance objectives have been met and whether the control strategies implemented have been effective.

Table 15-6 Environmental performance indicator

Environmental performance indicator

- Minimal complaints received by the community and complaints received are effectively closed out
- Emergencies and/or incidents are minimal and if they occur they are handled as soon as practicable as specified in the EA.

15.6 Management controls

In general, the Social impact management plan (SIMP) will be used to mitigate potential impacts on community and community values. The established Santos GLNG SIMP will be implemented across the entire GFD Project. The SIMP is not directly applicable to the Draft EM Plan however it is integral to the existing Santos GLNG Management Framework. The SIMP provides additional detail on managing potential impacts related to communities and stakeholders in relation to the GFD Project Commitments

Santos GLNG has developed Social issues action plans which contain the mitigation measures Santos GLNG will implement to manage the social impacts from the GFD Project. As agreed with the Coordinated Project Delivery Division of the Coordinator-General's office, the action plans are linked to the existing GLNG Social impact management plan framework. The action plans build on the extensive work already underway to manage the social impacts of the Santos GLNG Project. Santos GLNG reports progress against the commitments and initiatives contained within the SIMP annually to the Coordinator General.

Santos GLNG is committed to implementing the mitigation measures in the action plans to manage potential social impacts and maximise opportunities associated with its ongoing presence in the project regions. A summary is provided in Table 15-7.

Table 15-7 Other management commitments

Management framework	Key provisions/ function
SIMP	The SIMP established for the GLNG Project will be implemented across the GFD Project. The plan outlines the roles, responsibilities and rights of Santos GLNG, the government, impacted communities and other stakeholders in relation to the GFD Project. In particular, it outlines the framework for community engagement, management strategies to avoid, mitigate or minimise potential impacts and to maximise opportunities and benefits arising throughout the life of the GFD Project, as well as a monitoring and reporting process. The GLNG Project SIMP will be supplemented by issue action plans relating to the GFD Project that focus on the following key areas as agreed with the Coordinated Project Delivery Division of the Coordinator-General's office: • Water and environment – Maximise the beneficial reuse of coal seam water where practicable including construction, irrigation, dust suppression and other approved uses. – Monitor impacts associated with the management of coal seam water. – Minimise harmful effects on land environments. – Prevent the spread of weeds and pest animals. – Minimise impacts on air quality. • Community safety – Minimise road safety risks to the community – Minimise health and safety risks to Santos GLNG employees, contractors and the community – Minimise potential social dysfunction associated with our workforce – Social Infrastructure. – Minimise the impact on regional social infrastructure. • Community wellbeing and liveability – Minimise the impacts to landholders of gas field development activity. – Support and enhance the liveability and wellbeing of regional communities where Santos GLNG operates. • Local industry participation and training – Maximise the availability of skilled labour within regional communities. – Maximise opportunities for local business and industry to participate in the Santos GLNG projects. • Aboriginal engagement and participation – Minimise the impact of our activities on Aboriginal communities – Minimise the potential for damage to culturally significant sites – Strive to achieve enduring and mutually beneficial relationships.

Management framework	Key provisions/ function
Land access and landholder engagement	Santos GLNG has adopted an early engagement strategy where landholders that may be affected by GFD Project activities are able to discuss the potential location, timing and impacts of infrastructure on their property or business, and how Santos GLNG can help to minimise those impacts. This early engagement strategy has been developed in accordance with the <i>Land Access Code</i> (Department of Employment, Economic Development and Innovation, 2010). Santos GLNG will negotiate a conduct and compensation agreement under the P&G Act with landholders on whose land the petroleum activities will be carried out. The locations of wells, gathering lines, and access tracks will be finalised in consultation with the landholder as part of the negotiations.
Aboriginal engagement policy	This policy focuses on the elements of Native Title, cultural heritage, employment and training, enterprise development, community capacity and corporate social responsibility.
Regional Rules	Santos GLNG developed the Regional Rules framework in order to provide a coordinate approach to risks associated with work in the Maranoa region. The framework focuses on land access, business communication, vehicle movements and Santos GLNG's response to regional natural events.
Community policy	Santos GLNG has adopted a corporate community policy, which provides overarching guidance on ensuring that Santos GLNG establishes and maintains enduring mutually beneficial relationships with the communities of which it is a part.
Cultural heritage management plans	Santos GLNG takes cultural heritage obligations very seriously and works closely with traditional owners to undertake cultural heritage surveys and implement agreed management measures for any potential or actual impacts to cultural heritage in accordance with cultural heritage management plans to ensure Indigenous cultural heritage is treated with appropriate respect.

15.7 Monitoring

Table 15-8, summarises the environmental monitoring and assessment considerations for the protection of community and social values.

Table 15-8 Monitoring considerations for community and social

Monitoring considerations

Monitoring - General

- Monitoring required by the EA will be undertaken by a suitably qualified person.

Nuisance Monitoring

- When the administering authority advises of a complaint alleging nuisance, Santos GLNG will investigate the complaint as soon as practicable. The investigation will include monitoring of environmental nuisance at any sensitive place within a reasonable and practical timeframe as specified by the administering authority.
- If the investigation or monitoring in accordance with the EA indicates that environmental nuisance is occurring, then:
 - Santos GLNG will address the complaint including the use of alternative dispute resolution services if required; and / or
 - Santos GLNG will implement abatement or attenuation measures so that the authorised petroleum activities do not result in further environmental nuisance.

Community Issues

- A record of all complaints and actions taken in response to the valid complaint will be maintained and kept. Santos GLNG will record the following details for all complaints received and provide this information to the administering authority on request:
 - name, address and contact number for complainant
 - time and date of complaint
 - reasons for the complaint as stated by the complainant
 - investigations undertaken in response to the complaint
 - conclusions formed
 - actions taken to resolve complaint
 - any abatement measures implemented to mitigate the cause of the complaint
 - name and contact details of the person responsible for resolving the complaint.

15.8 Proposed environmental authority conditions

The following draft EA conditions in relation to community and social aspects are proposed for the GFD Project. The conditions stipulate the management and monitoring requirements to enable adequate protection of the GFD Project area's community and social values. The EA conditions are reproduced in full in Appendix O.

SCHEDULE F – ENVIRONMENTAL NUISANCE

Odour, dust and other airborne contaminants

- F1 The release of odour, dust or any other airborne contaminant(s), or light from the petroleum activities must not cause an environmental nuisance at any sensitive place.

Nuisance monitoring

- F2 When the administering authority advises of a complaint alleging nuisance, the complaint must be investigated as soon as practicable. The investigation is to include monitoring of environmental nuisance at any sensitive place within a reasonable and practical timeframe as specified by the administering authority.
- F3 The administering authority must be advised in writing of the results of the investigation (including an analysis and interpretation of the monitoring results) and actions proposed or undertaken to resolve the complaint within five (5) business days of completing the complaint investigation, unless a longer time is agreed to by the administering authority.
- F4 If the investigation or monitoring in accordance with condition (F2) indicates that emissions exceed the limits set in this environmental authority or are causing environmental nuisance, then:
- a) the complaint must be addressed including the use of alternative dispute resolution services if required; and / or
 - b) abatement or attenuation measures must be implemented so that the authorised petroleum activity(ies) do not result in further environmental nuisance.

SCHEDULE K – COMMUNITY ISSUES

- K1 A record of all complaints and actions taken in response to the valid complaint must be maintained and kept.
- K2 The holder of this environmental authority must record the following details for all complaints received and provide this information to the administering authority on request:
- a) name, address and contact number for complainant;
 - b) time and date of complaint;
 - c) reasons for the complaint as stated by the complainant;
 - d) investigations undertaken in response to the complaint;
 - e) conclusions formed;
 - f) actions taken to resolve complaint;
 - g) any abatement measures implemented to mitigate the cause of the complaint; and
 - h) name and contact details of the person responsible for resolving the complaint.

16 Heritage

Santos GLNG has an established process for protecting and managing cultural heritage across all its projects. Cultural heritage (non-indigenous) is managed (in consultation with the relevant stakeholders) primarily through the Santos EHSMS - Environmental Hazard Standard EHS11 Cultural Heritage. This standard establishes a Cultural Heritage management system that manages risk, and ensures compliance with all legislative requirements related to Santos' Australian operations. The standard also outlines conditions and procedures for field inspections, site management, training and awareness programs and supporting systems and procedures.

The GFD Project area played host to early European exploration in Queensland and thus contains places reflective of exploration, early settlement and European-Indigenous frontier conflict and interaction. A full description of the historical background of the GFD Project area is located in the report *Santos GLNG GFD Project – NICH Technical Report* (Converge Heritage + Community, 2014).

16.1 Environmental values

The GFD Project area contains a variety of cultural heritage places reflective of its Indigenous settlement and early European exploration and consequent settlement. For the purposes of the Draft EM plan, the cultural heritage values in the GFD Project area include:

- Known heritage places of State and local significance, and unassessed sites
- Unknown heritage places of State and local significance
- Significant heritage landscapes.

16.1.1 Non-Indigenous cultural heritage

The project area is located within some of the earliest explored and settled regions of Queensland, including the Maranoa and Leichhardt pastoral regions.

Statutory registers are associated with national, State and local legislation. Places included on these registers generally possess an established level of significance. The absence of a place on these registers is likely to imply that its significance has not been considered to date and does not mean it is without heritage significance.

The non-indigenous cultural heritage values of the GFD Project area have been identified through a review of the following:

- Statutory registers
- Non-statutory registers
- Surveys.

For the purposes of the Draft GFD EM Plan, the Queensland Heritage Register, including state heritage places, archaeological places or protected areas was reviewed.

Local heritage registers for places of cultural heritage significance and / or heritage overlays or other lists of heritage places found in local planning schemes.

The search of registers and reports identified a wide range of non-indigenous cultural heritage sites throughout the GFD Project area, including:

The approximate locations of the non-indigenous cultural heritage places within the GFD Project area identified in registers are indicated in Figure 16-1. This figure includes non-indigenous cultural heritage places located on national /international, state and local registers /sources. The assessment conducted comprised of desktop assessment, which was undertaken in order to:

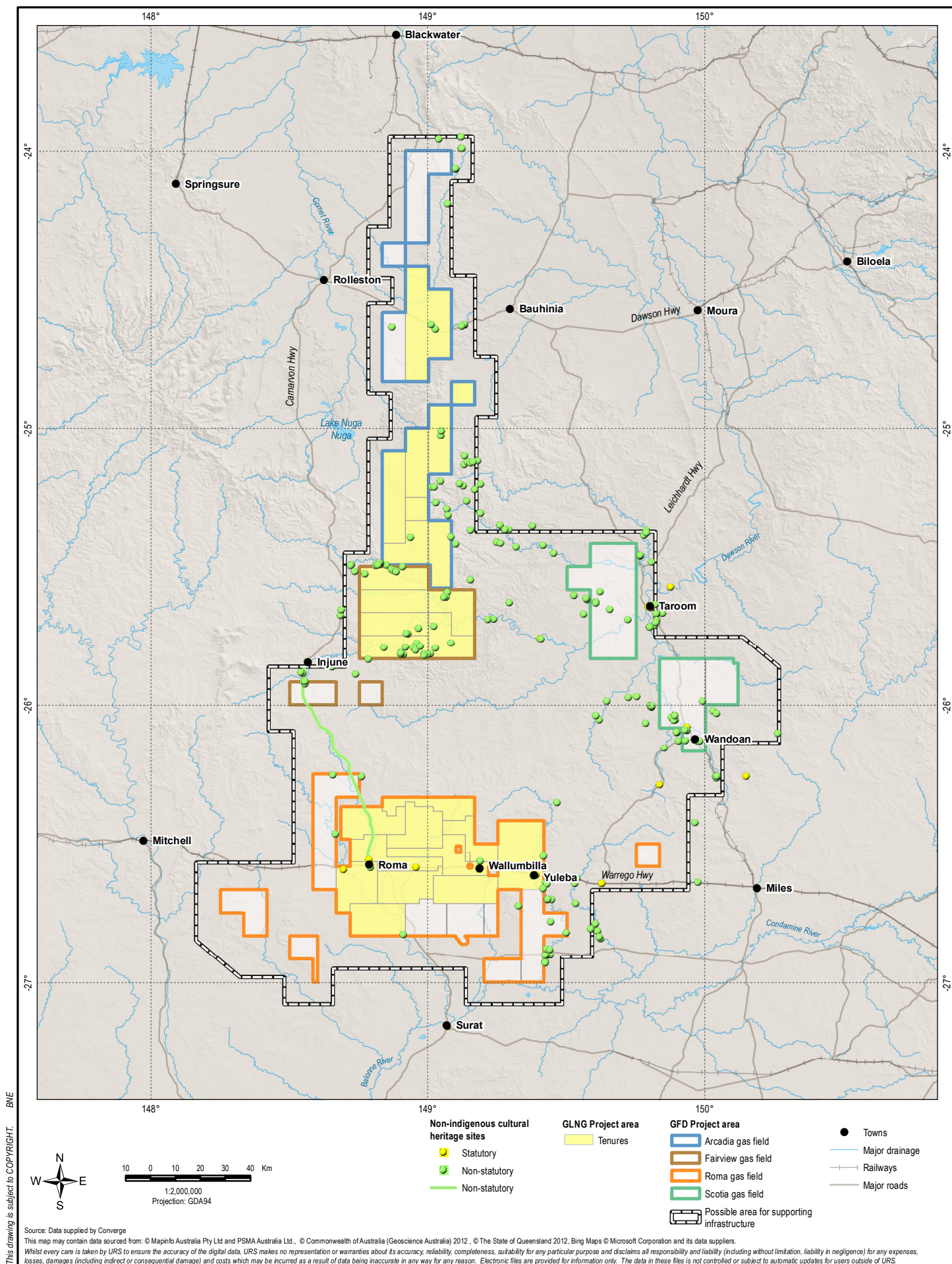
- Prepare a brief contextual history for the GFD Project area
- Assess the existence, extent and significance of those places previously identified within the GFD Project area
- Assess the existence, extent and probable levels of significance of additional (potential) places likely to be located within the GFD Project area.

As the precise location of places is not always indicated in the register, an expanded spatial search criterion was used as detailed in Table 16-1.

Table 16-1 Spatial Area – Non-Indigenous cultural heritage register search

Jurisdiction	Register/source	Area
National and international	World Heritage List, National Heritage List and the Commonwealth Heritage List	GFD Project area
State	Queensland Heritage Register, Nature Conservation Act 1992 (Qld)	GFD Project area + 10 km buffer
Local	Local heritage registers (Taroom Shire, Bauhinia Shire, Duaringa Shire, Bendemere Shire, Bungul Shire and Roma Town Council)	GFD Project area + 5 km buffer

Additionally, there is potential for further, currently unknown, places of non-indigenous cultural heritage significance within the GFD Project area. These potential places are likely to be similar in type as those identified on the various statutory and non-statutory registers and to vary in cultural heritage significance.



16.1.1.1 Statutory searches

The review undertaken identified 11 places on the State register (Queensland Heritage Register), 6 places listed under State acts (NC Act) and 28 additional places on local registers (Local Heritage Register). These are identified in Table 16-2, below.

Table 16-2 Non-Indigenous cultural heritage within GFD Project tenures

Receptor	Results		
	Identified place name	Town	LGA
Queensland Heritage Register (QHR)	Leichhardt Tree (QHR:600835)	Taroom	Banana
	Fraser family grave site and memorial, Hornet Bank (QHR: 602075)	Taroom	Banana
	War Memorial and Heroes Avenue (QHR: 600824)	Roma	Maranoa
	State Butcher's Shop (former) (QHR: 602155)	Roma	Maranoa
	Roma Court House and Police Buildings (QHR: 601285)	Roma	Maranoa
	Roma Government Complex (Roma State School) (QHR: 601536)	Roma	Maranoa
	QHR: 600371 Mount Abundance Homestead (QHR: 600371)	Roma	Maranoa
	Hibernian Hall (QHR: 601689)	Roma	Maranoa
	Romavilla Winery (QHR: 601767)	Roma	Maranoa
	Hunter's Emporium (QHR: 601775)	Roma	Maranoa
	Nostalgic Queen's Theatre (QHR: 602378)	Wallumbilla	Maranoa
<i>The Nature Conservation Act 1992</i>	Humboldt National Park	-	Central Highlands
	Lake Murphy Conservation Park	-	Banana Shire
	Carraba Conservation Park	-	Western Downs (formerly Taroom)
	Expedition National Park	-	Banana Shire
	Palmgrove National Park	-	Banana Shire and Central Highlands
	Blackdown Tableland National Park	-	Central Highlands
Local Heritage Register (LHR) ¹	Taroom Cemetery	Taroom	Western Downs (former Taroom Local Government Area (LGA))

Receptor	Results		
	Identified place name	Town	LGA
	Wandoan Cemetery	Wandoan	Western Downs (former Taroom LGA)
	Donohue Family (Private) cemetery	None listed	Western Downs (former Taroom LGA)
	Rocky Creek Bridge ²	Jackson	Maranoa (former Bendemere LGA)
	Yuleba Railway Complex ²	Yuleba	Maranoa (former Bendemere LGA)
	Combidiban Creek Bridge ²	Yuleba	Maranoa (former Bendemere LGA)
	Wallumbilla Railway Complex ²	Wallumbilla	Maranoa (former Bendemere LGA)
	Wallumbilla Hospital ²	Wallumbilla	Maranoa (former Bendemere LGA)
	Blythe Creek Bridge ²	Bungil	Maranoa (former Bungil/ Roma)
	Bungil Creek Bridge ²	Roma	Maranoa
	Roma Railway Complex ²	Roma	Maranoa
	1st Masonic Hall ²	Roma	Maranoa
	Roma Hospital ²	Roma	Maranoa
	Main Block ²	Roma	Maranoa
	Engineers Office ²	Roma	Maranoa
	Nurses Quarters ²	Roma	Maranoa
	Pathology Block ²	Roma	Maranoa
	St Paul's Anglican Church ³	Roma	Maranoa
	Ace Drapers ³	Roma	Maranoa
	Commonwealth Hotel	Roma	Maranoa
	McCabe's Pharmacy	Roma	Maranoa
	Old Town Council Building	Roma	Maranoa

Receptor	Results		
	Identified place name	Town	LGA
	Royal Hotel	Roma	Maranoa
	School of Arts Hotel	Roma	Maranoa
	Skill Centred Office	Roma	Maranoa
	Western Star Office	Roma	Maranoa
	Winnathoola	Roma	Maranoa
	Cobb & Co Corduroys	Warroo	Maranoa

Note 1: Places identified on the QHR are automatically included on LHRs, but have not been relisted specifically for LHR in this table.

Note 2: Place is 'Reported' only on the Bendemere's Shire list and Bungil Shire's list and the Roma Town Council's list and are not on any register and have been recorded as places of possible cultural heritage significance.

Note 3: Places identified in planning scheme as State heritage values

16.1.1.2 Non-statutory searches and previous surveys

There are also sources of heritage places or historic places that are not listed on statutory registers, and so are not afforded legislative protection. These places contribute to a better understanding of the GFD Project area and may include places that have been overlooked or not yet accepted for entry on statutory heritage registers. They also provide indication of the potential non-indigenous cultural heritage values of currently unassessed areas within the GFD Project area. The review undertaken identified 8 places on the national register (former Register of the National Estate (RNE)) and 166 places on State registers (Queensland National Trust and the former Environmental Protection Agency list):

- The (former) RNE – eight places and six of these places are identified in either the QHR and/or LHR outlined in Table 16-2, above
- The Queensland Branch of the National Trust of Australia (QNT) – 14 places listed (previously appear in either the QHR or Local Heritage Register (LHR) identified in Table 16-2, above
- Queensland Environment Protection Agency (EPA, now DEHP) – 152 places in addition to those listed on the QHR are located within the GFD Project
- The Queensland DNRM – using the Interactive Resource Tenure Map (IRTM), which is limited to the last 100 years, no historic mines and/or prospects were identified in the GFD Project area. It is known that coal mining and oil extraction industries operated at various times within the GFD Project area.

There are additional previously prepared reports that have relevance as they were located either totally or partially within the current GFD Project area. Eleven project reports reviewed identified 68 heritage places having at least local cultural heritage significance, with 60 previously unrecorded and 8 previously identified on the various statutory and non-statutory registers. An additional 90 places were identified and assessed as having minimal cultural heritage value. The majority of these places were dams, telegraph/telephone poles, survey trees, fencing, stock yards, some more recent dumps, some road structures, buildings and more recent commercial premises.

16.1.2 Indigenous cultural heritage

Santos GLNG has developed an understanding of the Indigenous cultural heritage landscape of the GLNG Project area by conducting more than 1,000 inspections and/or surveys since 2009. These surveys have covered an area of more than 19,500 hectares (or 195 square kilometres) and have been undertaken in accordance with Santos GLNG's existing CHMPs and cultural heritage clearance process, as outlined in section 20.6. It is possible that other areas and places of Indigenous cultural heritage will be identified during the ongoing field development process of the GFD Project.

The nature and distribution of many forms of Indigenous cultural heritage in a landscape is associated with factors such as geology, climate and landforms which affect:

- The availability of plants, animals and water
- The location of suitable camping places and suitable surfaces upon which rock art could be performed.

Such environmental factors affect the degree to which cultural remains have survived natural and human-induced processes. In addition, European land-use practices often destroy or disturb artefacts land with potential for cultural value from their original location and condition.

The Indigenous cultural heritage values of the GFD Project area have been identified with the relevant Aboriginal Parties through a review of applicable registers (section 20.4.1.1), existing literature (section 20.4.1.2) and field surveys (section 20.4.1.3) previously undertaken across the GFD Project area.

16.1.2.1 Registered places

A review of relevant Indigenous cultural heritage registers has indicated that there are a number of registered Indigenous heritage places in the GFD Project area, which include artefact scatters, paintings and scarred trees. The results of the review are summarised in Table 16-3.

Table 16-3 Registered Indigenous cultural heritage places within the GFD Project area

Jurisdiction ¹	Register or source	Number of places
National and international	World Heritage List, National Heritage List and Commonwealth Heritage List	0
State	Cultural heritage database and register maintained by the Department of Aboriginal and Torres Strait Islander and Multicultural Affairs	1,845

¹ There is no formal local register of Indigenous cultural heritage places.

16.1.2.2 Existing literature

A number of early archaeological studies were carried out in and around the GFD Project area during the 1970s and 1980s. These studies, undertaken by Mulvaney and Joyce (1965), Beaton (1977 and 1991a) and then Morwood (1978, 1979, 1981 and 1984), were primarily focused upon Aboriginal occupation of caves and rock shelters across the Carnarvon Ranges which traverse the northern portion of the GFD Project area. The most important of these was Mulvaney and Joyce's investigation of Kenniff Cave, which provided the first firm evidence for a Pleistocene (>10,000 years) occupation of Australia (1984).

Significant literature relevant to the GFD Project area and surrounds includes:

- Investigations of Kenniff Cave on Moffat Station, which is perhaps the best known Indigenous place in the area (Mulvaney and Joyce, 1965)
- A series of investigations into rock shelters in the region, particularly in the Carnarvon Ranges, with investigations undertaken at Cathedral Cave, Rainbow Cave and Wanderer's Cave by Beaton (1977, 1991a, 1991b)
- Excavations conducted by Morwood in the late 1970s at: Ken's Cave, a small rock shelter on the upper Belyando River; Turtle Rock, a large silcrete boulder on the southern flank of the Buckland River; and two native wells located on the upper Warrego River near the head of Stockwhip Creek (Morwood, 1978, 1979, 1981)

- A scientific investigation of Buckland Bower, an open site on a ridge overlooking Buckland Creek a tributary of the Nogoia River, which included the systematic surface collection of more than 7,000 stone artefacts (Beaton, 1977; Morwood, 1984).

16.1.2.3 Field surveys

In conjunction with the existing literature discussed in section 16.1.2.2, many field surveys have been completed in the Bowen and Surat basins to support approval for resource exploration and development as well as industrial and infrastructure projects. These assessments (Archaeo, 2007; Hatte, 1996) have identified many Indigenous cultural heritage places, including artefact scatters of variable density, open camp sites with grinding plates, top stones, and edge ground axes, scarred trees, stone arrangements and hearths. Sources of raw material in the region included ochre, silcrete and sandstone.

16.2 Potential impacts

Potential impacts to cultural heritage values that might occur as a result of the GFD Project are outlined in Table 16-4.

Table 16-4 Potential impacts – cultural heritage

Environmental value	Potential impact
Known heritage places of State and local significance, and unassessed sites	Disturbance or encroachment on a place of known and unknown cultural heritage significance.
Unknown heritage places of State and local significance	
Significant heritage landscapes	

There are currently 26 projects that are in development stage within a 50 km buffer of the GFD Project area. Cumulatively, the construction and operation of the infrastructure and activities associated with these projects, including the GFD Project, has the potential to generate cumulative impacts on cultural heritage. These projects have the potential, when considered together, to change the character of the region through the reduction in the number and type of historic places and, as cultural heritage is a non-renewable resource, incrementally impact on the number and diversity of cultural heritage places within the GFD Project area.

16.3 Environmental protection objectives

In accordance with Santos GLNG's internal standards, the GFD Project will adopt the environmental performance objectives relevant to the cultural heritage listed in Table 16-5.

Table 16-5 Environmental protection objectives

Environmental protection objectives
• Avoid or minimise impacts to known places of cultural heritage values • Avoid or minimise impacts to unknown places of cultural heritage values • Preserve significant heritage landscapes.

16.4 Environmental protection performance indicators

The indicators within Table 16-6 will be utilised to determine whether the environmental performance objectives have been met and whether the control strategies implemented have been effective.

Table 16-6 Environmental performance indicators

Environmental performance indicator
- In the event that an item of cultural heritage significance is found, the correct procedures are followed - Known heritage places and heritage landscapes remain preserved - Emergencies and/or incidents are minimal and when occur are handled as soon as practicable as specified in the EA - Minimal complaints received from the community and complaints received are effectively closed out.

16.5 Management controls

Management strategies directly applicable to the Draft EM Plan are outlined in Table 16-7. In addition to those mitigation measures outlined in the table, the Environmental Hazard Standard (EHS) 11 Cultural heritage, which is not directly applicable to the Draft EM Plan will also be implemented.

Table 16-7 Management strategies

Management plan	Key provisions / function	Management control measures
Constraints protocol	The Constraints protocol provides a framework to guide placement of infrastructure and adopts the management principles of avoid, minimise, mitigate, remediate and rehabilitate and offset. 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.	Santos GLNG will implement the Constraints Protocol. Known heritage places will be loaded into the Santos GLNG geographical information system (GIS) to assist in identifying the location of GFD Project infrastructure and activities to assist in the ongoing constraints planning and field development process.

16.6 Commitments

Table 16-8 details management commitments to minimise the risk of cultural heritage related impacts.

Table 16-8 Other management commitments

Management framework	Key provisions/ function
Environmental hazard standard 11 Cultural heritage (EHS11)	Implementation of EHS11 will identify and avoid, where practicable, or otherwise minimise impacts on cultural heritage places through awareness training, pre-clearance surveys to verify values, informing siting decisions, and providing procedures for discovery, clearances, monitoring and reporting.
Cultural heritage management plans (CHMPs)	The GFD Project will operate within the bounds of the CHMPs developed with each relevant Aboriginal Party under the <i>Aboriginal Cultural Heritage Act 2003</i> .

16.7 Monitoring

Table 16-9, summarises the environmental monitoring and assessment considerations for the protection of heritage values within the GFD Project area.

Table 16-9 Monitoring considerations for heritage

Monitoring considerations
Monitoring - general - Monitoring will be undertaken by a suitably qualified person - Where impact to a cultural heritage place is likely, internal and statutory approvals in consultation with relevant stakeholders will be obtained. Santos GLNG will conduct monitoring and reporting in accordance with relevant regulatory requirements.
Nuisance monitoring - When the administering authority advises of a complaint alleging nuisance, Santos GLNG will investigate the complaint as soon as practicable. The investigation will include monitoring of environmental nuisance at any sensitive place within a reasonable and practical timeframe as specified by the administering authority - If the investigation or monitoring in accordance with the EA indicates that environmental nuisance is occurring, then: - Santos GLNG will address the complaint including the use of alternative dispute resolution services if required; and / or - Santos GLNG will implement abatement or attenuation measures so that the authorised petroleum activities do not result in further environmental nuisance.
Community issues - A record of all complaints and actions taken in response to the valid complaint will be maintained and kept. Santos GLNG will record the following details for all complaints received and provide this information to the administering authority on request: - name, address and contact number for complainant - time and date of complaint - reasons for the complaint as stated by the complainant - investigations undertaken in response to the complaint - conclusions formed - actions taken to resolve complaint - any abatement measures implemented to mitigate the cause of the complaint - name and contact details of the person responsible for resolving the complaint.

16.8 Proposed environmental conditions

The following draft EA conditions in relation to cultural heritage are proposed for the GFD Project. The conditions stipulate the management and monitoring requirements to enable adequate protection of the GFD Project area's cultural heritage values. The EA conditions are reproduced in full in Appendix O.

SCHEDULE F – ENVIRONMENTAL NUISANCE

Odour, dust and other airborne contaminants

- F1 The release of odour, dust or any other airborne contaminant(s), or light from the petroleum activities must not cause an environmental nuisance at any sensitive place.

Nuisance monitoring

- F2 When the administering authority advises of a complaint alleging nuisance, the complaint must be investigated as soon as practicable. The investigation is to include monitoring of environmental nuisance at any sensitive place within a reasonable and practical timeframe as specified by the administering authority.
- F3 The administering authority must be advised in writing of the results of the investigation (including an analysis and interpretation of the monitoring results) and actions proposed or undertaken to resolve the complaint within five (5) business days of completing the complaint investigation, unless a longer time is agreed to by the administering authority.
- F4 If the investigation or monitoring in accordance with condition (F2) indicates that emissions exceed the limits set in this environmental authority or are causing environmental nuisance, then:
- a) the complaint must be addressed including the use of alternative dispute resolution services if required; and / or
 - b) abatement or attenuation measures must be implemented so that the authorised petroleum activity(ies) do not result in further environmental nuisance.

SCHEDULE K – COMMUNITY ISSUES

- K1 A record of all complaints and actions taken in response to the valid complaint must be maintained and kept.
- K2 The holder of this environmental authority must record the following details for all complaints received and provide this information to the administering authority on request:
- a) name, address and contact number for complainant;
 - b) time and date of complaint;
 - c) reasons for the complaint as stated by the complainant;
 - d) investigations undertaken in response to the complaint;
 - e) conclusions formed;
 - f) actions taken to resolve complaint;
 - g) any abatement measures implemented to mitigate the cause of the complaint; and
 - h) name and contact details of the person responsible for resolving the complaint.

17 Coal seam water management

The management of coal seam water extracted during gas production is regulated under the *Environmental Protection Act 1994* (EP Act). In accordance with the EP Act, an application for an Environmental Authority (EA) (Chapter 5 Activities) must include specific information regarding the management of coal seam water (Section 126 of the EP Act) and must consider the Coal Seam Water Management Policy (DEHP, 2012). Based on this application, the EA may authorise specific coal seam water management options. Alternatively, select management options may be authorised under a Beneficial Use Approval (BUA).

The EP Act includes the following requirements specific to coal seam water management:

Section 126 Requirements for site-specific applications—CSG activities

- (1) *A site-specific application for a CSG activity must also state the following—*
 - (a) *the quantity of CSG water the applicant reasonably expects will be generated in connection with carrying out each relevant CSG activity;*
 - (b) *the flow rate at which the applicant reasonably expects the water will be generated;*
 - (c) *the quality of the water, including changes in the water quality the applicant reasonably expects will happen while each relevant CSG activity is carried out;*
 - (d) *the proposed management of the water including, for example, the use, treatment, storage or disposal of the water;*
 - (e) *the measurable criteria (the **management criteria**) against which the applicant will monitor and assess the effectiveness of the management of the water, including, for example, criteria for each of the following—*
 - (i) *the quantity and quality of the water used, treated, stored or disposed of;*
 - (ii) *protection of the environmental values affected by each relevant CSG activity;*
 - (iii) *the disposal of waste, including, for example, salt, generated from the management of the water;*
 - (f) *the action proposed to be taken if any of the management criteria are not complied with, to ensure the criteria will be able to be complied with in the future.*

The objective of the Coal Seam Water Management Policy (DEHP 2012) is to encourage management of coal seam water in a way that protects the environment and maximises its productive use as a resource. To achieve this objective, the management and use of coal seam water should be consistent with the following hierarchy:

- Priority 1 – coal seam water should be used for a purpose that is beneficial to one or more of the following: the environment, existing or new water users, and existing or new water-dependant industries.
- Priority 2 – after feasible beneficial use options have been considered, coal seam water should be treated and disposed of in a way that firstly avoids, and then minimises and mitigates, impacts on environmental values.

The following hierarchy applies for managing saline waste:

- Priority 1 – brine or salt residues should be treated to create useable products whenever feasible.
- Priority 2 – after assessing the feasibility of treating brine or solid salt residue to create useable and saleable products, disposal of the brine and salt residues should be in accordance with strict standards that protect the environment.

Quantity and flow rate of extracted water

In coal seams, natural gas and water are stored in the cleats (fractures) that naturally occur in coal. However, the majority of the gas is adsorbed in the coal matrix. The gas is held in place by confining pressure from the overlying rock, and groundwater (hydrostatic pressure).

When recovering natural gas from coal seams, the coals remain in place. Gas is produced by drilling a well into the coal seam and removing groundwater from the coal seam to reduce the confining hydrostatic pressure. This allows the gas to separate from the coal (desorb) and flow through fractures within the coal seams to the well and on to the surface. In general, producing natural gas from coal seams does not require all of the groundwater to be removed from the coal seam – typically hydrostatic pressure is reduced only to the extent required to achieve consistent gas flow.

The rate of groundwater extracted from coal seams reduces relatively quickly; however, given the large volumes of gas adsorbed on the coal, it can take more than 20 years for the coal seam to completely deliver its producible gas.

Generally, commercial development of coal seam gas fields occurs incrementally. The development cycle for a prospective area includes exploration, appraisal, production well and infrastructure construction, production operations, and then decommissioning and rehabilitation. New information gained from ongoing exploration, appraisal and production activities is used to inform future field development planning.

The overall water production characteristics from a gas field can be forecast using established techniques and field data. The forecast (often termed the water production profile) provides the rate and total volume of coal seam water extracted over a gas field area.

Figure 17-1 presents the annual volume of coal seam water extracted for the Roma, Fairview, Arcadia Valley and Scotia gas fields of the GFD Project based on the maximum development scenario defined for the EIS. The same information expressed in daily extraction rates is shown in Figure 17-2. The metrics are also expressed in Table 17-1.

Figure 17-1 Estimated annual coal seam water extraction volume (GFD Project, Maximum Development Scenario)

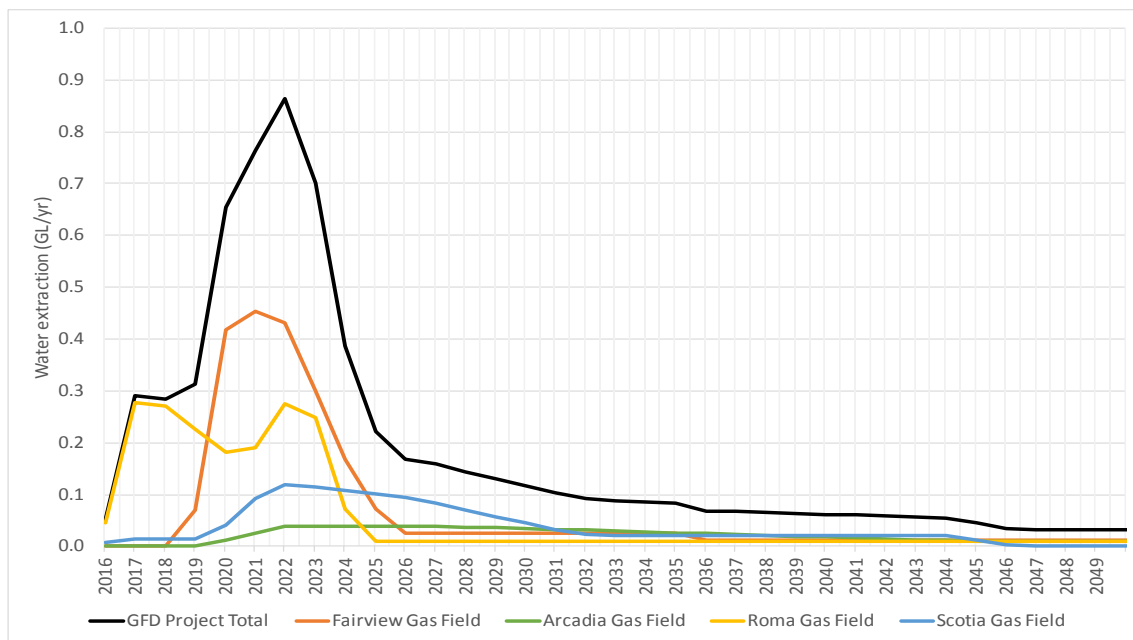
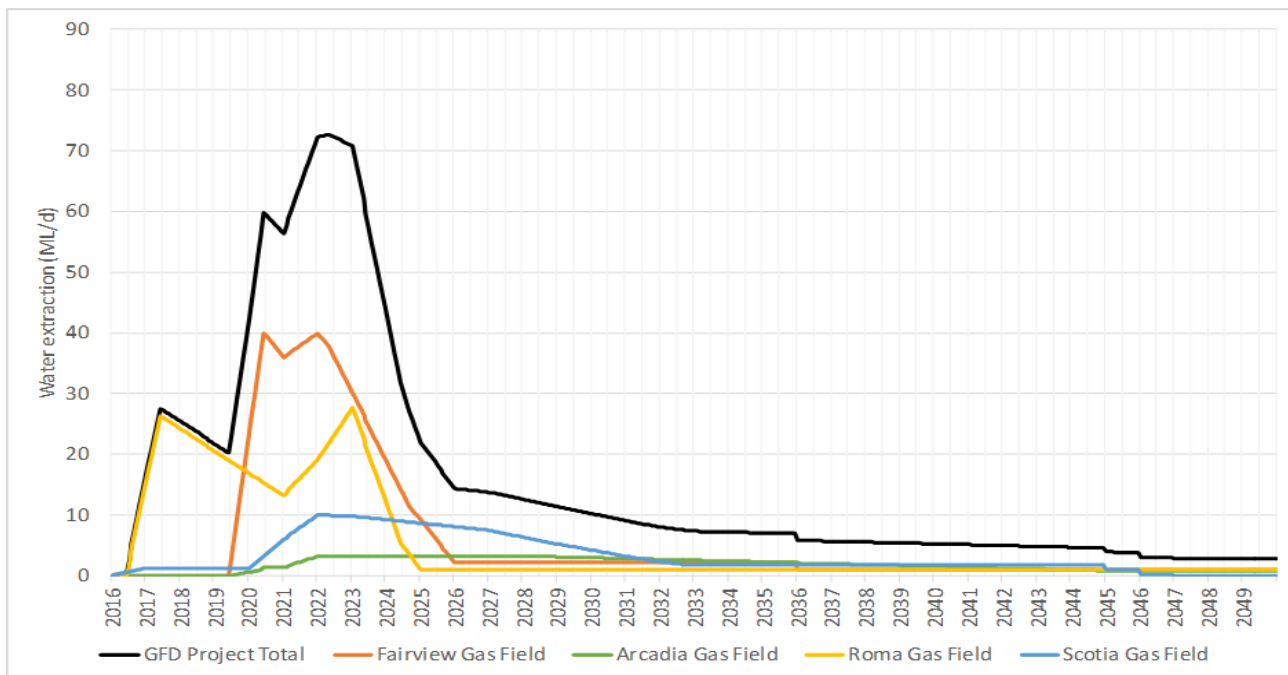


Figure 17-2 Estimated daily coal seam water extraction rate (GFD Project, Maximum Development Scenario)



Based on the maximum development scenario used in the EIS, the total volume of water forecast to be extracted over the life of the GFD Project is 219 GL, as shown in Table 17-1. This volume is comparable to the amount extracted by all other non-petroleum groundwater users in the Surat Cumulative Management Area in a single year (215 GL) (QWC, 2012).

Table 17-1 Coal seam water extraction metrics

Metrics	Fairview	Arcadia	Roma	Scotia	GFD Project Total
Peak daily extraction rate (ML/d)	40.0	3.2	27.6	10.0	72.7
Total extraction over the GFD Project life (GL)	79.0	32.1	68.2	39.5	218.8

Quality and changes in quality of extracted water

The quality of water extracted from coal seams is primarily dependent on the geology of the target coal seam. The Walloon Coal Measures is the target formation for gas development and production with the Roma gas field, and the Bandanna Formation (or equivalent Baralaba Formation) is the target formation for development and gas production within the Fairview, Arcadia and Scotia gas fields.

Over the lifetime of a given gas production well, water quality is expected to remain relatively constant. However, water quality will vary between wells based on the localised geological setting and age and depth of the coal seam. Indicative coal seam water quality for the Fairview, Arcadia, Roma and Scotia gas fields is presented in Table 17-2.

Table 17-2 Coal seam water quality

Parameter	Unit	Fairview				Arcadia				Roma				Scotia			
		Min	Mean	Max	<i>n</i>	Min	Mean	Max	<i>n</i>	Min	Mean	Max	<i>n</i>	Min	Mean	Max	<i>n</i>
Electrical conductivity (EC) at 25°C	µS/cm	320	3,353	11,300	381	553	15,246	21,500	56	1,000	5,155	13,900	811	1,100	6,365	9,800	110
Total dissolved solids (TDS) at 180°C	mg/L	161	1,996	6,590	381	6740	9,814	14,900	55	1150	3,009	99,70	578	130	3,688	6,300	65
Calcium (dissolved)	mg/L	0.5	2.07	9.0	374	4	16.1	44	55	1	7.19	39	521	4	9.7	23	69
Magnesium (dissolved)	mg/L	0.5	0.66	4.0	387	3	4.8	10	55	0.5	1.50	10	522	2	5.5	15	70
Potassium (dissolved)	mg/L	0.5	4.69	35	376	12	41.0	115	54	2	32.6	296	519	9	56.3	421	71
Sodium (Dissolved)	mg/L	0.5	777.1	2,610	387	2,060	3,735	5,680	55	473	1163	3,380	525	94	1,034	2,710	70
Sodium adsorption ratio (SAR)	-	0.5	5.36	93	377	133	253.1	416	39	46.9	115.4	190	459	89.2	1,103	1,480	24
Chloride	mg/L	0.01	137.1	268	146	2,850	4,413	5,150	55	35	1326	6,180	846	7	1,604	3,500	112
Fluoride	mg/L	0.5	472	2,460	384	1	3.0	8.7	55	0.4	2.35	5.9	530	0.1	0.6	1.8	70
pH (Lab)	-	0.05	3.12	10.6	387	6.4	7.9	8.9	63	7.56	8.27	8.91	501	5.2	8.1	8.8	110
Sulfate as SO42- (dissolved)	mg/L	6.4	8.55	9.35	399	0.5	4.6	56	55	0.5	3.70	100	520	0.2	9.3	300	111
Boron (dissolved)	mg/L	0.03	0.98	3.0	299	0.025	1.5	2.2	39	0.025	0.57	1.0	521	0.17	1.8	8.3	65
Strontium (dissolved)	mg/L	0.01	0.56	2.55	296	0.0005	3.7	6.6	39	0.16	1.62	13.6	487	0.49	1.7	4.7	62

The quality of coal seam water determines the potential treatment requirements for its proposed use. Not all water extracted from coal seams requires treatment before use. Due to the lifecycle impacts (particularly energy) of some treatment processes it is preferable to minimise the amount of treatment wherever possible.

Treatment of coal seam water will be undertaken to provide water of appropriate quality for the proposed use. Where a change in water quality is needed to meet the required water quality of intended uses, this will primarily be achieved through one or a combination of the following approaches:

- Desalination using reverse osmosis to separate a portion the total dissolved solids and other constituents into a concentrated fluid waste stream (brine) and produce a better quality permeate stream
- Amendment using chemical dosing to lower the sodium adsorption ratio and pH/residual alkalinity of coal seam water
- Temperature and ionic balance adjustment
- Filtration removing suspended solids (lowering the turbidity), bio-toxic elements and nutrients that can lead to algal blooms from the water
- Sterilisation to remove bacteria
- De-oxygenation
- Blending of separate water streams of differing quality to achieve a target water quality.

Management of coal seam water

Water balance modelling for the maximum development scenario used for the EIS accommodates uncertainties inherent in the prediction of the rate, volume and quality of the coal seam water to be extracted, as well as accounting for variable weather. The maximum development scenario assumes:

- Existing Santos GLNG Project infrastructure to manage GFD Project coal seam water is not used and therefore new infrastructure is required
- For the purpose of calculating maximum theoretical size of infrastructure an extremely unlikely scenario where all water is required to be stored and treated at a water management facility by desalination, which has a 90% recovery ratio and 95% up-time availability
- For the purpose of calculating maximum theoretical size of infrastructure, the scenario assumes that all RO concentrate produced over the lifetime of the project is stored in dams, and no further concentration measures for RO concentrate are employed. This is considered as extremely conservative as brine disposal options have been identified as fluid injection or disposal at a licensed facility in accordance with *Queensland Coal seam gas water management policy 2012* (EHP, 2013). A key characteristic of the water management approach is to maintain flexibility to respond to change whilst ensuring that fit-for-purpose water can be used whilst minimising and managing impacts to environmental values. Based on these assumptions the maximum (unlikely) capacity of potential treatment facilities and associated storages within each field are listed in Table 17-3.

It is noted that water extraction estimates may change as a result of ongoing field development planning, the storage and management requirements presented here may change but are considered as extremely conservative.

Table 17-3 Total indicative facility and storage capacities

Gas field	Treatment facilities*	Coal seam water management dam	Treated Water management dam*	RO concentrate management dam**
Fairview	40 ML/d	545 ML	675 ML	2,030 ML
Arcadia	3.5 ML/d	75 ML	55 ML	665 ML
Roma	28 ML/d	580 ML	795 ML	1,685 ML
Scotia	10 ML/d	120 ML	145 ML	775 ML

* Assumes that all coal seam water will be treated through RO

** Assumes that storage is required for the life of the project when brine/solid salt disposal options are available for all fields.

Santos GLNG proposes to adopt water management portfolios. Given the number of management options available in each field, a number of combinations of water management options may be used.

The Santos GLNG Coal seam water management strategy (Santos, 2013a) outlines how Santos GLNG proposes to manage coal seam water in accordance with the regulatory framework established by the Queensland and Commonwealth Governments. The GLNG Project already has an approved plan in place for existing operations. The strategy for the GFD Project builds upon the experience and understanding of the operations to date. The strategy is sufficiently flexible to accommodate changes in policy, technology and field conditions, based on a rigorous evaluation and decision-making framework as alternative technologies may be identified during the GFD Project design and implementation process.

In addition, the 'making good' requirements of the *Water Act 2000* (Qld) may require operators to consider the feasibility of using coal seam water to meet obligations for provision of water to mitigate impacts that may result from a coal seam operation on bores.

The water quality and volumes extracted from coal seams will vary depending on the well location and the production plan. The overall water production characteristics can be forecast with reasonable certainty to enable effective management of the water.

The quality of coal seam water determines the potential treatment requirements for its proposed use. Not all water extracted from coal seams requires treatment before use. Due to the lifecycle impacts (particularly energy) of some treatment processes it is preferable to minimise the amount of treatment wherever possible. Treatment of coal seam water will be undertaken to provide water of appropriate quality for the proposed use.

The Coal seam water management strategy for the GFD Project has adopted the Coal Seam Water Management Policy's management hierarchy:

Priority 1 – Beneficial Use

Coal seam water should be used for a purpose that is beneficial to existing users including GFD Project requirements and to meet "make good" obligations, new water users, and / or existing or new water-dependant industries. Management solutions will be determined based on an evaluation framework that includes full lifecycle assessments of potential benefits and liabilities associated with each option or suite of options. The objective of the framework is to identify feasible options which maximise beneficial use and minimise environmental impacts.

Potential beneficial uses that will be prioritised include:

- Make Good – Utilising water extracted from coal seams for “make good” arrangements under the Water Act.
- Operational Use - Using water extracted from coal seams for operational purposes to maximise benefit to the Project whilst minimising the take from other water supplies. This may include uses such as construction, compaction, drilling and completions, dust suppression, heat exchange and rehabilitation where appropriate.
- Substitution of water allocation - Providing water extracted from coal seams directly to a third party to reduce or cease their take on a water resource as an option to minimise or mitigate an adverse impact to an environmental value associated with project activities.
- Depleted coal seam injection - Injecting water extracted from coal seams into a depleted coal seam as an option to minimise or mitigate the risk of an adverse impact associated with project activities to an environmental value or water resource.
- Aquifer injection – Injecting water extracted from coal seams into an aquifer as an option to minimise or mitigate the risk of an adverse impact to a water resource (i.e. spring) associated with project activities.

Coal seam water remaining after meeting requirements for make good arrangements and project uses will be utilised for other beneficial purposes where feasible. These beneficial use options may include activities such as:

- Landholder activities - Providing water extracted from coal seams under a contractual arrangement for use by the landholder. This may include activities such as stock watering and irrigation.
- Regional users - Providing water extracted from coal seams under a contractual arrangement to a third-party. These may include new or existing users of water such as irrigators, feed lots, industry, council road construction and mining etc.
- Surface water release - Releasing water extracted from coal seams to a watercourse to provide a benefit to the environment or downstream users of water.
- Aquifer injection - Injection of water extracted from coal seams into an aquifer to minimise or mitigate impacts to a water resource as a result of non-project related activities.

Priority 2 – Disposal

After feasible beneficial use options have been considered, coal seam water will be disposed of in a way that firstly avoids, and then minimises and mitigates, impacts on environmental values. Other management options may include activities such as:

- Surface water release – release of water extracted from coal seams to surface water where it does not mitigate impacts of the Project or provide a benefit to downstream users or the environment.
- Aquifer injection – Injection of water extracted from coal seams into a target formation with appropriate characteristics to receive the water where it does not mitigate impacts of the Project nor provide a benefit to users of water or the environment.
- Evaporation of water extracted from coal seams in purpose built and engineered structures in accordance with EHP guidelines.

Apportionments for water management options based on reasonable assumptions about existing land use and have been adopted for the EIS. These apportionments are set out in Table 17-4.

Table 17-4 Conceptual coal seam water use portfolios

Coal Seam Water Use Option	Indicative Range of Water Management Options (%)			
	Fairview	Arcadia	Roma	Scotia
Operational use options	5-20	5-20	5-20	5-20
Irrigation to land	40-80	50-90	50-80	30-80
Managed Aquifer Recharge	0-5	-	10-45	15-65
Release to surface water	15-50*	5-45**	0-45***	-

Dash denotes that demand is not present in gas field

* This activity is currently authorised for Fairview

**Discharge location would be within the adjacent Fairview gas field

*** Any planned releases in Roma field will be subject to further regulatory assessment and approval.

Management of brine or solid salt

Where desalination (e.g. reverse osmosis) is required a waste stream (RO concentrate or brine) is generated that will require appropriate management and subsequent disposal in accordance with regulatory requirements.

In line with the Coal Seam Gas Water Management Policy, the options available for management of the brine stream can be divided into two broad categories; commercial salt recovery and brine or salt disposal.

- **Commercial salt recovery** - Commercial recovery of saleable salt product requires an assessment of a number of critical factors such as technical feasibility, environmental impacts, market proximity and economic factors. Currently this option is not considered feasible for Santos GLNG due to the energy intensity, cost and low commercial volumes of salt. Commercial salt beneficial use options may become more economic where economies of scale can be employed.
- **Brine or salt disposal** - Brine may be disposed of through deep well injection into suitable geological formations. This is already occurring in accordance with regulatory approvals within the GLNG Project and trials at other localities are ongoing. The transfer of brine or solid salt to a licenced waste management facility will only occur after other options have been assessed and considered unfeasible. Brine concentration options may be used to reduce the volume of brine requiring final management or to sufficiently concentrate brine to allow crystallisation of solid salt. Various technologies are available to be utilised, each with advantages and challenges to feasibility including thermal evaporation. These technologies have differing energy intensity, environmental footprint, technical complexity, operability and economics.

Santos GLNG Project options

The Santos GLNG Project undertakes a range of water management options in accordance with existing regulatory approvals. A summary of the current management options for each gas field and associated supporting infrastructure capacity is provided in the sections below. Where feasible, Santos GLNG will utilise existing management options and associated infrastructure for the GFD Project.

- **Fairview gas field** - The current water management options include dust suppression and construction purposes, operational purposes, irrigation and discharge to surface water (Dawson River). The current storage capacities are for 1,060 ML of water storage and 1,400 ML of brine storage. The current treatment capacities comprises of 26 ML/day of reverse osmosis and 16 ML/day of water amendment.
- **Roma gas field** - The current water management options include dust suppression and construction purposes, operational purposes, irrigation and managed aquifer recharge. The current storage capacities comprise 1,930 ML of water storage and 1,200 ML of brine storage. The current treatment capacities comprise 13 ML/day of reverse osmosis and 2 ML/day of water amendment.
- **Arcadia gas field** - The current water management options include dust suppression and construction purposes and operational purposes. The current storage capacities comprise 720 ML of water storage. The current treatment capacities comprises of 0.6 ML/day of reverse osmosis.
- **Scotia gas field** - The current water management options include dust suppression and construction purposes and operational purposes. The current storage capacities comprise 8 ML of water storage and 15 ML of brine storage. The current treatment capacities comprises of 0.4 ML/day of reverse osmosis.

Measurable criteria and action triggers

Table 17-5 provides measurable criteria and associated action triggers for the management of coal seam water.

Table 17-5 Measurable criteria and action triggers for coal seam water management¹

Preferred use option	Location	Environmental values	Monitoring or management tasks	Performance indicators and actions
Operational use, OR Provision to/use by third parties, OR Irrigation to land	On-tenure	- Groundwater dependent ecosystems - Use of groundwater for drinking supply; stock watering - Aquatic ecosystem - Use of surface water for drinking supply; stock watering; irrigation (downstream users).	- Seepage monitoring program: - Seepage monitoring bore locations: - Baseline/hydraulically up-gradient - Within aquifers potentially affected by a regulated structure - Geodetic survey of all seepage monitoring bores, showing groundwater potentiometric surface - Contaminants are not directly or indirectly released to any waters except as permitted under the relevant EA. - Compliance with conditions of general BUA	- Detection of seepage to groundwater as a result of storing coal seam water in a regulated structure. - Procedures allow an assessment of whether there has been a statistically significant adverse change in groundwater quality at locations hydraulically down-gradient of the containment activity (e.g. regulated structure). - Identification of the trigger contaminant of concern in the event of seepage; initiate Seepage Trigger Action Response Procedure (parameters for analyse will be scheduled in the EA) - Performance indicators associated with general BUA

Preferred use option	Location	Environmental values	Monitoring or management tasks	Performance indicators and actions
	Off-tenure		- Compliance with conditions set out in general BUA: - General conditions - Standard water quality conditions (including fortnightly sampling for sodium adsorption ratio (SAR), pH and EC; and initial monthly monitoring for other parameters. Six-monthly monitoring after three consecutive detects which are less than 50% of the prescribed water quality objectives) - Variation to standard water quality conditions (site-specific objectives derived in accordance with BUA) - General monitoring and operating conditions - Compliance with conditions set out in specific BUA	- Site-specific water quality objectives derived in accordance with the BUA are met at point of supply - All plant and equipment necessary for compliance with the BUA are installed, maintained and operated in proper and effective condition
Release to surface water	Designated discharge location (on- and/or off-tenure)	- Maintain surface water quality and hydrological regime for protection of aquatic ecosystems - Use of surface water for drinking supply; stock watering; irrigation (downstream users)	- Monitoring of water quality parameters prior to release, and at a downstream location following release (specified by the relevant EA). - Measurement of water quality parameters upstream of release point	Comply with release limits to waters for specific parameters as scheduled in the relevant EA (e.g. specified percentage of background turbidity levels downstream of discharge location)

Preferred use option	Location	Environmental values	Monitoring or management tasks	Performance indicators and actions
Fluid Injection (Managed Aquifer Recharge)	Designated MAR location (on- and/or off-tenure)	- Maintain groundwater quality for protection of groundwater dependent ecosystems - Use of groundwater for drinking supply; stock watering; irrigation (downstream users) - Protect the environment and maximise the productive use of coal seam water as a valuable resource	- Only inject fluids authorised under EA, into aquifer(s) scheduled within the EA - Construct injection wells in accordance with the design requirements outlined in the DEHP guideline - <i>Treated coal seam gas (CSG) water injection well construction requirements</i> (April 2013) - Fluid injection well(s) authorised by the relevant EA have appropriate records and documents which support and indicate mechanical integrity - Monitor for changes in groundwater pressure resulting from coal seam water injection trials, within a given radius of each well in accordance with monitoring requirements specified in the relevant EA. - Development and implementation of an Injection management plan (site-specific), as required. - Development and implementation of a Well Closure Plan following cessation of fluid injection at each well, as required.	- No significant leakage in the casing, tubing, or packer of injection well - No significant fluid movement into a water resource aquifer through vertical channels adjacent to the bore hole - Fluid injection well(s) hold a certificate of mechanical integrity prepared and certified by a suitably qualified person - Injection operation does not exceed the dry overburden pressure of the base of the overlying aquitard, at depths less than 100 m (or as prescribed by the relevant EA) - Injection operation does not exceed 90% of the formation fracture pressure at depths greater than 100 m (or as prescribed by the relevant EA) - Fluids used for well injection activities comply with specific contaminant limits for injection fluid, set in the relevant EA. Includes water quality release limits and monitoring frequency. - Volume of fluid injected to any well must not exceed the volume limit explicitly listed in the relevant EA.

Notes:

¹ Drafted in accordance with DEHP 2013 *Guideline for CSG water management: Measurable criteria*, Department of Environment and Heritage Protection, Queensland, 3pp.

<https://www.ehp.qld.gov.au/management/non-mining/documents/csg-water-measurable-criteria.pdf>

² ANZECC 2000 *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian and New Zealand Environment and Conservation Council and the Agriculture and resource Management Council of Australia and New Zealand, October 2000, Canberra.

18 Traffic and transport

The GFD Project area is administered by four local government areas (LGAs) (Banana Shire and Central Highlands, Maranoa and Western Downs) and is serviced by an extensive transport network including road, rail and aviation facilities that link the region internally and to surrounding regions. This transport network supports community connectivity and a diverse regional economy based primarily on agriculture, resources, tourism and construction.

Regional towns are connected by a network of highways, regional and rural roads, with rural access to isolated properties. Roads are used for local trips, tourism, heavy vehicle traffic moving bulk agricultural and extractive resources products and resource project inputs (such as fuel, equipment and materials), school buses and vehicles transporting resources sector workforce.

18.1 Environmental values

The following values demonstrate sensitivity to increased traffic volumes by road type:

- Efficiency – the aspects of the road network that contribute to function and accessibility, which facilitate the efficient operation of the network. This includes consideration of the function of road links, the overall volume of traffic using road links and intersection forms. State road authorities and councils have made significant capital investments in developing road infrastructure. Therefore, it is important that road infrastructure is managed and used in a manner that maximises its service life and maintains the level of quality expected by road users
- Safety – the aspects of the road network relating to the location and provision of physical infrastructure. Physical infrastructure incorporates components such as bridges, rail crossings, cattle grids, pavement and road construction standard
- Amenity – the sensory experience of those who are located near the road network. This primarily includes nearby residents and other land users. Receptors that are sensitive to changes in amenity include dwellings, schools, hospitals and churches. These adjacent users can be affected through issues such as light nuisance, dust nuisance and noise due to changes in traffic volumes or road functionality.

18.2 Potential impacts

The potential impacts that may occur as a result of the GFD Project's traffic EIS maximum development scenario as they relate to the traffic and transport values are outlined in Table 18-1. The assessment of potential impacts considers a range of characteristics that may change on each functional road type (highway, regional connecting road, rural connecting road and rural access road) in response to development of the GFD Project.

Table 18-1 Potential impacts – traffic and transport

Environmental value	Potential impact
Efficiency	Reduced efficiency related to increased traffic volumes and reduced standard of pavement and intersection control.
Safety	Reduced safety related to increased traffic volumes on bridges, cattle grids, rail crossings, school bus routes, traffic composition and driver fatigue controls.
Amenity	Reduced amenity related to stock route co-location, sensitivity of adjacent land uses, potential for dust nuisance and light glare issues.

18.3 Environmental protection objectives

In accordance with Santos GLNG's internal standards, the GFD Project will adopt the environmental performance objectives relevant to the cultural heritage listed in Table 18-2.

Table 18-2 Environmental protection objectives

Environmental protection objectives
• Manage the efficiency of the road network impacted including State-controlled roads and local government roads • Ensure user safety and safe operation of vehicles • Minimise impacts on road infrastructure • Minimise traffic related complaints and incidents.

18.4 Environmental protection performance indicators

The indicators within Table 18-3 will be utilised to determine whether the environmental performance objectives have been met and whether the control strategies implemented have been effective.

Table 18-3 Environmental performance indicators

Environmental performance indicator
• Areas where Santos GLNG activity exceeds the threshold for mitigation intervention are identified • Minimal complaints received by the community and complaints received are effectively closed out.

18.5 Management controls

Management strategies directly applicable to the Draft EM Plan are outlined in Table 18-4. In addition to those mitigation measures outlined in the table, the Environmental Hazard Standard (EHS) 11 Cultural heritage, which is not directly applicable to the Draft EM Plan will also be implemented.

Table 18-4 Management strategies

Management plan	Key provisions / function	Management control measures
Road-use management plan	The Road-use management plan was developed to manage the impact associated with the implementation of the Santos GLNG Project. It will be adapted to manage the potential impacts of the GFD Project. The objectives of the plan include: • Manage the efficiency of the road network impacted including State-controlled roads and local government roads • Ensure user safety and safe operation of vehicles • Minimise impacts on road infrastructure condition • Minimise traffic related complaints and incidents to maintain community amenity.	Santos GLNG will implement the Road-use management plan
Road impact assessments (RIA)	RIAs will be developed to identify: • Potential transport routes for use by the GFD Project that are State and Local Government controlled roads • Assessment of the condition of the identified roads • Estimated forecast of GFD Project traffic for construction, operations, decommissioning and rehabilitation • Thresholds for mitigation intervention • Mitigation required as a result of GFD Project activities to adequately prepare and/or maintain the condition of the road for GFD Project and public use and the proportion of the required mitigation attributable to the GFD Project.	RIAs will be developed in line with regulatory requirements.
Infrastructure agreement (IA)	Infrastructure agreements have been established with the DTMR and all relevant regional councils impacted by the Santos GLNG Project. The IAs: • Establish a framework for negotiating road impact mitigation • Conducting RIAs • Establish the forward work schedule to confirm costs and timing of road treatments • Managing variations and disputes.	Santos GLNG will continue to engage with TMR and regional councils in the application of existing infrastructure agreements to the GFD Project.

Santos

GLNG Project

Management plan	Key provisions / function	Management control measures
Social impact management plan (SIMP)	The SIMP established for the GLNG Project will be implemented across the GFD Project. The plan outlines the roles, responsibilities and rights of Santos GLNG, the government, impacted communities and other stakeholders in relation to the GFD Project. In particular, it outlines the framework for community engagement, management strategies to avoid, mitigate or minimise potential impacts and to maximise opportunities and benefits arising throughout the life of the GFD Project, as well as a monitoring and reporting process. The GLNG Project SIMP will be supplemented by issue action plans relating to the GFD Project that focus on the following key areas as agreed with the Coordinated Project Delivery Division of the Coordinator-General's office: • Water and environment • Community safety • Social infrastructure • Community wellbeing and liveability • Local industry participation and training • Aboriginal engagement and participation. The SIMP is an operational document that is updated to reflect the ongoing needs of Santos GLNG and the communities it operates in. It is available on the web at: http://www.santosglng.com/resource-library/community/social-impact-management-plan-community-handbook.aspx	Santos GLNG will implement the SIMP.

Management plan	Key provisions / function	Management control measures
Pest and weed management plan (PWMP)	The PWMP details how to minimise the potential spread of pest and weed species as a result of Santos GLNG activities. The PWMP provides a framework for Santos GLNG to: - Identify, monitor and prioritise the appropriate management of pest and weed species present at, or that pose a threat to, Santos GLNG assets and/or activities - Prevent and minimise the introduction and dispersal of pest and weed species into Santos GLNG locations and neighbouring properties - Engage stakeholders including landholders and local communities in assisting Santos GLNG in the identification and management of pests and weeds at Santos GLNG assets and activities Develop asset / activity specific pest and weed management procedures as required during the GFD Project lifetime.	Santos GLNG will implement the PWMP.
Waste management plan (WMP)	The WMP details the strategy, methods and controls for managing waste generated by Santos GLNG activities. The plan identifies the types of wastes generated by Santos GLNG activities, and describes the waste management framework and how the waste management hierarchy is applied to generated waste.	Santos GLNG will implement the WMP.
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.	Santos GLNG will implement the ESCMP.
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.	Santos GLNG will implement the Contingency Plan.

Management plan	Key provisions / function	Management control measures
Emergency response plan (ERP)	The ERP forms part of Santos GLNG's overall emergency response. It is supplementary to the Queensland incident management plan and provides the necessary information to deal with emergencies at the asset level. This is an operational document and is not included in this EIS.	Santos GLNG will implement the ERP.

18.6 Monitoring

Table 18-5 summarises the environmental monitoring and assessment considerations for the protection of heritage values within the GFD Project area.

Table 18-5 Monitoring considerations for traffic and transport

Monitoring considerations
Monitoring - general Monitoring will be undertaken by a suitably qualified person in line with the <i>Guidelines for Assessment of Road Impacts of Development</i> (Department of Main Roads, 2006).
Nuisance monitoring - When the administering authority advises of a complaint alleging nuisance, Santos GLNG will investigate the complaint as soon as practicable. The investigation will include monitoring of environmental nuisance at any sensitive place within a reasonable and practical timeframe as specified by the administering authority - If the investigation or monitoring in accordance with the EA indicates that environmental nuisance is occurring, then: - Santos GLNG will address the complaint including the use of alternative dispute resolution services if required; and / or - Santos GLNG will implement abatement or attenuation measures so that the authorised petroleum activities do not result in further environmental nuisance.
Community issues - A record of all complaints and actions taken in response to the valid complaint will be maintained and kept. Santos GLNG will record the following details for all complaints received and provide this information to the administering authority on request: - name, address and contact number for complainant - time and date of complaint - reasons for the complaint as stated by the complainant - investigations undertaken in response to the complaint - conclusions formed - actions taken to resolve complaint - any abatement measures implemented to mitigate the cause of the complaint - name and contact details of the person responsible for resolving the complaint.

18.7 Proposed environmental authority conditions

The following draft EA conditions in relation to traffic and transport aspects are proposed for the GFD Project. The conditions stipulate the management and monitoring requirements to enable adequate protection of the GFD Project area's community and social values. The EA conditions are reproduced in full in Appendix O.

SCHEDULE F – ENVIRONMENTAL NUISANCE

Odour, dust and other airborne contaminants

- F1 The release of odour, dust or any other airborne contaminant(s), or light from the petroleum activities must not cause an environmental nuisance at any sensitive place.

Nuisance monitoring

- F2 When the administering authority advises of a complaint alleging nuisance, the complaint must be investigated as soon as practicable. The investigation is to include monitoring of environmental nuisance at any sensitive place within a reasonable and practical timeframe as specified by the administering authority.
- F3 The administering authority must be advised in writing of the results of the investigation (including an analysis and interpretation of the monitoring results) and actions proposed or undertaken to resolve the complaint within five (5) business days of completing the complaint investigation, unless a longer time is agreed to by the administering authority.
- F4 If the investigation or monitoring in accordance with condition (F2) indicates that emissions exceed the limits set in this environmental authority or are causing environmental nuisance, then:
- a) the complaint must be addressed including the use of alternative dispute resolution services if required; and / or
 - b) abatement or attenuation measures must be implemented so that the authorised petroleum activity(ies) do not result in further environmental nuisance.

SCHEDULE K – COMMUNITY ISSUES

- K1 A record of all complaints and actions taken in response to the valid complaint must be maintained and kept.
- K2 The holder of this environmental authority must record the following details for all complaints received and provide this information to the administering authority on request:
- a) name, address and contact number for complainant;
 - b) time and date of complaint;
 - c) reasons for the complaint as stated by the complainant;
 - d) investigations undertaken in response to the complaint;
 - e) conclusions formed;
 - f) actions taken to resolve complaint;
 - g) any abatement measures implemented to mitigate the cause of the complaint; and
 - h) name and contact details of the person responsible for resolving the complaint.

19 Financial assurance

Financial assurance (FA) estimates have been developed for those tenures with existing EAs within the GFD Project area. A summary of the FA currently held for the existing EAs within the GLNG Project area is provided in Table 19-1 below.

The FA estimate is based on independent estimates developed for key tasks using third-party unit rates and a conservative set of assumptions for each task. All costs have been developed in accordance with DEHP requirements for Level 1 petroleum activities. The estimates for rehabilitation and restoration were developed in accordance with the detailed methodologies provided in the relevant environmental management plans and in accordance Australian Standards and Santos GLNG Demolition and Decommissioning Procedures. These costs have been further validated using the actual costs of rehabilitation work completed by Santos GLNG.

In developing the cost estimates, the project schedule and anticipated life cycle of the project were used to calculate the projected disturbances. In addition to considering incremental disturbance and restoration over the project life cycle, changes in the nature of the disturbance between construction and operational phases were also considered.

The GFD Project Plan of Operations will include an updated FA calculation. The revised FA calculations will be submitted for DEHP approval along with the submittal of the GFD Project Plan of Operations.

Table 19-1 Summary of financial assurance estimates for existing Project areas

Existing Santos GLNG Project area	EA reference	FA amount
Fairview Project Area	EPPG00928713	\$54,416,268
Roma Shallow Gas Project Area	EPPG00898213	\$31,717,704
Arcadia Valley Project Area	EPPG00984113	\$8,331,557
Scotia Project Area	EPPG00980113	\$5,563,125
Roma Shallow Gas Project Area East	EPPG00662213	\$5,444,659
TOTAL FA		\$105,473,313

Source: Santos GLNG Plan of Operations, September 2013.

20 Definitions

Abbreviation	Description
AGE	Australian Groundwater and Environmental Consultants Pty Ltd
AHD	Australian Height Datum
Air NEPM	NEPM for Ambient Air Quality
Air Toxics NEPM	NEPM for Air Toxics
APLNG	Australia Pacific LNG
ATP	Authority to Prospect
APPEA	Australian Petroleum Production and Exploration Association
APIA	Australian Pipeline Industry Association
AR4	Fourth Assessment Report
ARI	Average Recurrence Interval
AWAF	Associated Water Amendment Facility
BAMM	Biodiversity Assessment and Mapping Methodology
BoM	Bureau of Meteorology
BPA	Biodiversity Planning Assessment
BUA	Beneficial Use Approval
CE	Critically Endangered
CFMP	Chemical and fuel management plan
CH ⁴	Methane
CHRC	Central Highlands Regional Council
CSG	Coal seam gas
CSRM	Centre for Social Responsibility in Mining
CSWS	Coal seam water management strategy
CO	Carbon monoxide
CO ² e	Carbon dioxide equivalent
COPC	Chemicals of Potential Concern
Constraints protocol	GFD Project environmental protocol for constraints planning and field development
DAMP	Decommissioning and abandonment management plan
DEHP	Department of Environment and Heritage Protection
DFRC	Drilling Fluid Recycling Centres
DIDO	drive in/drive out
DNRM	Department of Natural Resources and Mines
DO	Dissolved Oxygen
EA	Environmental Authority
EC	Electrical Conductivity

Abbreviation	Description
ECP	Emergency Environmental Incidents
EHS	Environmental hazard standards
EHSMS	Environment, health and safety management standards
Draft EM Plan	Environmental management plan
EIS	Environmental Impact Statement
EP Act	<i>Environmental Protection Act 1994</i>
EP Reg	<i>Environmental Protection Regulation 2008</i>
EPBC Act	<i>Environmental Protection and Biodiversity Conservation Act 1999</i>
EPP Air	<i>Environmental Protection (Air) Policy 2008</i>
EPP Noise	<i>Environmental Protection (Noise) Policy 2008</i>
EPP Waste	<i>Environmental Protection (Waste Management) Policy 2000</i>
EPP Water	<i>Environmental Protection (Water) Policy 2009</i>
ERA	Environmentally Relevant Activity
ESA	Environmentally Sensitive Area
ESCMP	Erosion and sediment control management plan
ESP	Exchangeable Sodium Percentage
Expert Panel	Expert Panel for Major Coal Seam Gas Projects
FA	Financial Assurance
FMP	Fauna management plan
GAB	Great Artesian Basin
GABCC	Great Artesian Basin Coordinating Committee
GAP ROP	GAB Resource Operation Plan
GFD Project	GLNG Gas Field Development Project
GDE	Groundwater Dependent Ecosystem
GDMMP	Ground deformation monitoring and management plan
GFL	Gas field locality
GHG	Greenhouse gas
GIS	Geographical Information System
GLNG	Gladstone Liquefied Natural Gas
GPF	gas processing facility
GTP	Gas Transmission Pipeline
GWP	Global Warming Potential
ha	hectare
HDPE	High-Density Polyethylene
HSMS	Health and safety hazard standards
IAS	Initial Advise Statement

Abbreviation	Description
IPCC	Intergovernmental Panel on Climate Change
IRTM	Interactive Resource Tenure Map
kg	kilogram
km	kilometre
km ²	square kilometres
KP	Kyoto Protocol
L _{Aeq}	Equivalent continuous noise level
L _{A90} dBA	Noise level (in decibels – A weighted) exceeded for 90 percent of the measurement period
L _{Aeq(1hour)} dBA	Equivalent continuous (or ‘average’) noise level (in decibels – A weighted) over a measurement period
LRMP	Land release management plan
LGA	Local Government Area
LHR	Local Heritage Register
LNG	Liquefied Natural Gas
LP Act	Land Protection (Pest and Stock Route Management) Act 2002
LULUCF	Land Use, Land Use Change and Forestry
µg/m ³	micrograms per cubic metre
m	metre
ML	Megalitres
MNES	Matters of National Environmental Significance
mm	millimetres
MSES	Matters of State Environmental Significance
MtCO _{2e}	Million tonnes of carbon dioxide equivalent
Mtpa	Million tonnes per annum
NEPM	National Environment Protection Measure
NGER Act	<i>National Greenhouse and Energy Reporting Act 2007</i>
NHL	National Heritage List
NICH	Non-Indigenous Cultural Heritage
NMP	Noise management plan
NO _x	Oxides of nitrogen
NPI	National Pollutant Inventory
NRM	Natural Resource Management
OGIA	Office of Groundwater Impact Assessment
P&G Act	<i>Petroleum and Gas (Production and Safety) Act 2004</i>
PAA	Priority Agricultural Area
PALU	Priority Agricultural Land Use

Abbreviation	Description
Petroleum Act	<i>Petroleum Act 1923</i>
PFL	Petroleum facility licence
PL	Petroleum Lease
PM	Particulate Matter
PPL	Petroleum Pipeline Licence
ppm	parts per million
PWMP	Pest and weed management plan
QHR	Queensland Heritage Register
QNT	Queensland Branch of the National Trust of Australia
RE	Regional Ecosystem
REMP	Receiving Environmental Monitoring Program
RFCHC	Request for Cultural Heritage Clearance
RL	Reduced Level
RMS	Rehabilitation management strategy
RNE	Register of the National Estate
ROC	Reverse Osmosis Concentrate
ROP	Reverse Osmosis Plant
SDPWO	State Development and Public Work Organisation
SCL	Strategic Cropping Land
SEWPaC	Department of Sustainability, Environment, Water, Population and Community (<i>superseded by DoE</i>)
SIMP	Social impact monitoring plan
SMUs	Soil Mapping Units
SO ₂	Sulfur dioxide
SSBV	State Significant Biodiversity Values
SSMP	Significant species management plan
STP	Sewage Treatment Plant
Surat CMA	Surat Cumulative Management Area
tCO ₂ e	Tonnes of carbon dioxide equivalent
TEC	Threatened Ecological Communities
TEG	Triethylene glycol
ToR	Terms of Reference
TJ/day	Terajoules per day
TMR	Department of Transport and Main Roads
UNFCCC	United Nations Framework Convention on Climate Change
UWIR	Underground Water Impact Report
VOC	Volatile Organic Compound

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Abbreviation	Description
WHL	World Heritage List
WMP	Waste management plan
WoNS	Weeds of National Significance
WRI	World Resource Institute
WBCSD	World Business Council for Sustainable Development
WCM	Walloon Coal Measures

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