10

AQUATIC ECOLOGY

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SUPPLEMENTARY REPORT TO THE EIS

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10 Aquatic Ecology

10.1 Objectives

This chapter summarises findings from the supplementary aquatic ecology assessment provided in the Aquatic Ecology Technical Report (Appendix H) of the SREIS.

The supplementary assessment was undertaken to determine any revised potential impacts the Project may have on aquatic ecological values as a result of changes to the project description and updates to relevant State or Commonwealth legislation. Additionally, this report provides extended discussion around particular submissions made following the public consultation stage of the EIS.

10.2 Summary of Aquatic Ecology Studies for the EIS

This section provides an overview of the aquatic ecological impact assessment completed for the EIS (Aquatic Ecology Technical Report (Appendix O)) and the main conclusions from that assessment. The assessment identified and described aquatic ecology values within the Project development area through desktop research and field surveys in selected areas.

The EIS desktop study incorporated a detailed literature review and searches of government and non-government databases to inform the location of possible field survey sites and to broadly characterise the existing aquatic environment. Survey site selection was refined through field reconnaissance and consideration of physical and ecological factors. Targeted aquatic field surveys were undertaken during the late 2012 wet season at 15 locations considered representative of the aquatic environment across the Project area. Of the sites surveyed, 13 were located within the Fitzroy Basin whilst two suitable sites were identified and surveyed within the Burdekin Basin. Each survey site was sampled and surveyed for the following:

- Physico-chemical water quality parameters;
- Aquatic flora (macrophytes);
- Fish assemblages;
- Aquatic macroinvertebrates and macrocrustaceans; and
- Turtles.

Data from the field surveys was described and included information such as aquatic flora and fauna species abundance and richness. Results from the desktop review and field surveys were used to summarise existing aquatic environmental values and discuss the sensitivity of these values to change.

10.2.1 Aquatic Ecosystems

Aquatic ecosystems within the Project area (both the Fitzroy and Burdekin catchments) were assessed to be in moderately good health. Macroinvertebrate assemblages from pool beds and edge habitats were comparable and both assemblages were found to be typical of ecosystems exposed to low to moderate disturbance typical of land use in the area. The desktop and field investigations did not reveal any macroinvertebrate species (including crustaceans) of conservation value.

Fish assemblages within the Project area were relatively species poor and were dominated by a small number of taxa. The Mackenzie River was found to have the greatest number of fish species (13) recorded during a single survey. No fish species listed under State or Commonwealth legislation were recorded during field studies. However, three recorded fish species are endemic to the Fitzroy River Basin and are therefore of conservation significance, including:

- *Macquaria ambigua oriens* (golden perch);
- *Scleropages leichardtii* (southern saratoga); and
- *Scortum hilli* (leathery grunter).

No turtle species of conservation significance were recorded during the field surveys. Two species identified during desktop searches are considered possible occurrences, particularly within the upper reaches of the Mackenzie River which is known habitat to both species, including:

- *Rheodytes leukops* (Fitzroy River turtle); and
- *Elseya albagula* (southern snapping turtle).

Potential impacts from Project activities (construction, operation and decommissioning), identified by the Aquatic Ecology Technical Report (Appendix O) of the EIS included:

- Degradation of water quality and smothering of benthic habitat from erosion and sediment transport processes;
- Loss of riparian or aquatic vegetation;
- Contamination of waterways resulting from fuel, oil or chemical spills;
- Altered surface water hydrology; and
- Spread and proliferation of aquatic pest species.

Commitments relating to minimising impacts to ecological values were developed and outlined in the Aquatic Ecology chapter (Section 16) and Draft Environmental Management Plan (Appendix Z) of the EIS. These commitments are still relevant to the Project and this SREIS. Commitments made during the EIS were reviewed and incorporated into the potential impact and mitigation measures identified in Section 10.6 and Section 10.7 below. The EIS outlines that the application of buffers around riparian zones and the strategic timing of unavoidable works within buffer zones during the dry season is the primary means by which protection for aquatic ecology values will be achieved. Residual impacts associated with Project activities were determined and are outlined in Section 10.8.

10.3 Regulatory Framework

The Aquatic Ecology Technical Report (Appendix O) of the EIS details the Commonwealth and State legislation, policy and guidelines relevant to the Project. A review has been undertaken to determine if any changes have been made to legislation, policy and guidelines since release of the EIS, and what impact these changes may have on approvals or environmental permitting for the Project.

10.3.1 Queensland Government

The following Queensland Acts and guidelines were reviewed as part of the EIS:

- *Environmental Protection Act 1994*;
- *Fisheries Act 1994* and relevant legislation:
  - Fisheries Regulation 2008;
  - Fisheries (Freshwater) Management Plan 1999; and
  - Fish Habitat Management Operational Policy (FHMOP 008) 2009;
- *Nature Conservation Act 1992* (NC Act);
- *Land Protection (Pest and Stock Route Management) Act 2002*; and
- Draft Code of Environmental Compliance for Level 2 Petroleum Activities.

No Project-relevant changes to these Acts or guidelines have been identified.

10.3.2 Commonwealth Government

Commonwealth legislation reviewed as part of the EIS was restricted to the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). No Project-relevant changes to this Act have been identified.

10.3.3 Non-statutory Mechanisms

The following non-statutory mechanisms were reviewed as part of the EIS:

- Establishing environmental values and water quality objectives for the Fitzroy Basin Waters (2010);
- Fish Water Quality Guidelines for Fitzroy Freshwaters 2011 (Department of Environment and Resource Management (DERM) (now EHP));
- Fitzroy River Sub-basin Environmental Values and Water Quality Objectives 2011 (DERM);
- Isaac River Sub-basin Environmental Values and Water Quality Objectives 2011 (DERM); and
- Mackenzie River Environmental Values and Water Quality Objectives 2011 (DERM).

No Project-relevant changes to these guidelines have been identified.

10.4 Project Description Changes Relevant To Aquatic Ecology

A conceptual description of the Project was prepared to inform the EIS. This initial project description formed the basis for which initial baseline environmental studies were undertaken and guided the impact assessment studies conducted.

Since publication of the EIS for public comment in Q1 2013, Arrow's field development plan and conceptual design for the Project has advanced. This progression is the result of ongoing exploration activities that have improved Arrow's understanding of the gas resource, and the progress of Arrow's planning process.

Table 10-1 below details the changes to the project description relevant to aquatic ecology since the release of the EIS. This is an excerpt of the Project changes presented in the Project Description chapter (Section 3, Table 3-1) of the SREIS that relate to potential changes in impact extent on aquatic ecology values. The particular changes are discussed further in Section 10.6 of this report.

Table 10-1 Project Description Changes Relevant to Aquatic Ecology

EIS Project Description	Description of Change (in Supplement)
Production facility locations were assumed to be located somewhere near the centre of each development area (**17** in total) of **12 km radius**.	The number of development (or drainage) areas has increased to **33** in total, however; each of these drainage areas now represent an approximate **6 km radius** catchment area for gathering well production (gas and water), and distributing to surface production facilities located at or near the centre of drainage area.
Up to **6,625 production wells** were expected to be drilled throughout the Project area over the approximate 40 year Project life to maintain gas supply to the LNG plant.	Approximately **4,000 production wells** will be drilled throughout the Project area over life of the Project (approximately 40 years) to maintain gas feed to the LNG plant.
Total associated water volume to be extracted over the life of the Project is estimated at approximately **264,300 ML (over 40 years)** Average production = **7 GL/a** Peak production = **10 GL/a**	Estimated total water produced will be **153,000 ML (average over 36 years)** Average production = **4.25 GL/a** Peak production = **10.4 GL**
The term integrated processing facility (IPF) was used in the EIS to describe the facility that would contain both gas compression and processing equipment and also a water treatment facility (WTF). The EIS presented the following dam sizes (per WTF): • Aggregation dam – 600 ML; • Treated water dam – 600 ML; and • Brine dam (x2) – 960 ML.	For the SREIS, the term 'IPF' is no longer considered and the WTFs will be co-located with the two central gas processing facility (CGPFs) with the potential of a third WTF to be constructed near Blackwater at later stages of the Project. As part of the SREIS reference case and for planning purposes, the following preliminary dam sizing (per WTF) has been adopted (based on a nominal facility throughput of 20 ML/d): • Associated water storage (feed) dam – up to 400 ML (providing a minimum of 20 days storage); • Clear (treated) water dam – 600 ML; and • Brine storage dam(s) – 1,800 ML.

10.4.1 Disposal of CSG Water

Disposal of CSG water may be necessary when beneficial use options are not economically and technically feasible, or in the case of residual volumes which are those volumes of CSG water that cannot be feasibly managed through beneficial use due to operational, technical, environmental or economic constraints. The EIS disposal options included discharge to watercourses, injection into suitable formations and discharge to the ocean. However, the conceptual development of the Project has progressed and ruled out injection to suitable formations and discharge to the ocean, see sections below.

10.4.1.1 Discharge of CSG Water to Watercourses

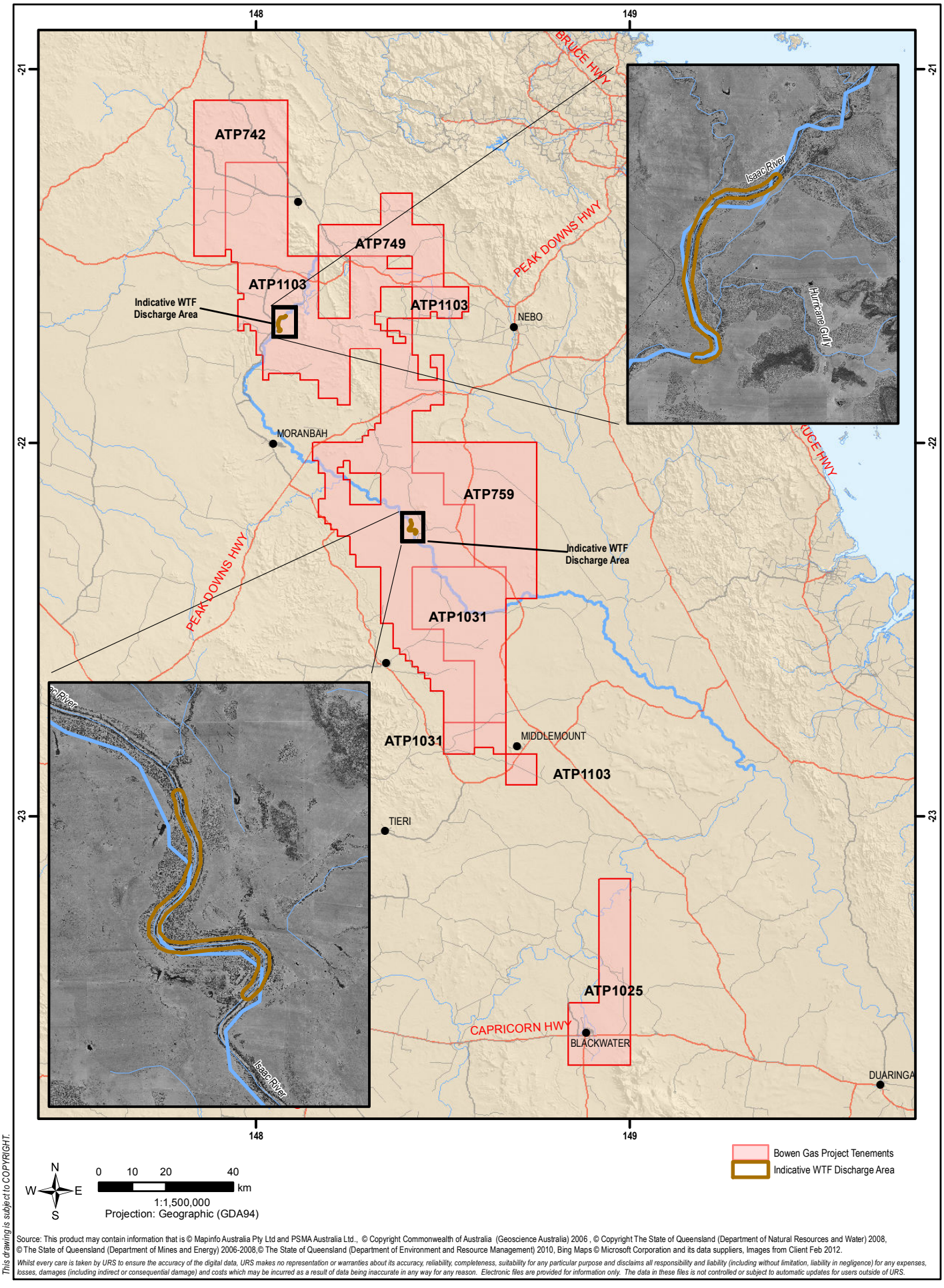
Management of residual volumes via discharge to a watercourse may be necessary to ensure that CSG production can continue during times where:

- Constraints to supply for beneficial use occur;
- Unforeseen events occur such as significant weather events;
- Operational upset conditions necessitate discharge; and
- The structural and operational integrity of dams is at risk.

Discharge to watercourses would occur within environmental flow requirements and in accordance with the relevant approval. The Surface Water chapter (Section 8) of the SREIS outlines environmental flow conditions in which discharge of CSG water would occur.

The study areas identified to characterise the values of the Isaac River focused on target reaches associated with potential discharge of CSG water. Figure 10-1 depicts reaches of the Isaac River relevant to this report.

The potential impacts to aquatic ecological values from the project description changes listed above, as well as potential discharge of CSG water to watercourses, are addressed in Section 10.6. Site specific assessment will be undertaken as part of the site specific environmental approvals process once the site selection is finalised.



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BOWEN GAS PROJECT SREIS

STUDY AREAS FOR POTENTIAL WATER TREATMENT FACILITY LOCATIONS

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AQUATIC ECOLOGY

Figure: **10-1**

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10.5 Updates to EIS Findings

10.5.1 Submission Responses

Submissions received during the public consultation stage of the EIS suggested that the occurrence of wetlands within the Project area and associated impacts from Project activities were not adequately assessed in the EIS (Submission issues 190, 192, 193 and 194).

Submissions received also raised queries regarding the number of sampling sites used to derive baseline conditions for aquatic ecosystems (Submission issue 229). Issue 229 also states that "No commitment to conduct site-specific impact assessments where disposal to watercourses is to occur appears in the EIS".

Additionally, Submission issues 229 and 230 raise queries regarding the sensitivity of species to changes in water quality or flow as a result of Project activities. Submission issue 230 states "Significant impacts to aquatic ecosystems may occur when severe impacts occur on species that are not necessarily listed as endangered, threatened or vulnerable".

The responses to these submissions are provided in the Submission Responses chapter (Section 21) of the SREIS. Additional discussion is provided below.

10.5.2 Wetlands

Submissions outlined a recommendation for a revised assessment of impacts on wetlands within the Project area. This section presents the results of the revised desktop review of publically available data sets and GIS mapping layers associated with wetlands, including:

- Queensland Wetland Mapping version 3;
- Ramsar Convention on Wetlands;
- Directory of Important Wetlands in Australia;
- Map of referable wetlands;
- DERM report on Aquatic Conservation Assessments (ACA), using AquaBAMM, for the non-riverine and riverine wetlands of the Great Barrier Reef catchment (Rollason and Howell, 2012); and
- Wetlandinfo.

The review of the above sources initially identified 109 riverine and 423 non-riverine wetlands incorporating a range of wetland types (described below), varying in ecological value. These wetlands incorporate riverine systems such as the Isaac River and non-riverine wetlands (lacustrine and palustrine wetlands) which range from modified dams to vegetated swamps.

Wetlands within the Project area are mapped and/or listed within numerous data sources (listed above) and, may occur more than once across the data sets. However, the ACAs of the Fitzroy and Burdekin catchments encompass all wetlands identified from other datasets (such as referable wetlands). For this reason, particular attention was applied to this dataset, with recognition of other datasets given due to differing legislative purpose.

The analysis of wetland mapping identified that of the above listed wetlands, 66 riverine and 191 non-riverine wetlands occur within the Project gas drainage areas (focus areas for field development). Of

these wetlands identified within gas drainage areas, 14 riverine and 29 non-riverine wetlands are identified of high or very high ecological value under EHP's AquaBAMM classification, Given the above, an assessment of the identified wetlands within the Project area (Section 10.5.2.1 through to Section 10.5.2.4) and gas drainage areas (Section 10.5.2.5) is outlined below. The potential impacts on these wetlands was assessed (Section 10.6.1) and mitigation measures from the EIS reviewed (Section 10.7).

Wetlands identified as supporting very high or high ecological value during the revised desktop review have been incorporated into Arrow's Risk Based Management Framework and Constraints Mapping. This will ensure that wetlands within the Project area are identified during the preliminary planning stages allowing for avoidance and mitigation management measures to be applied.

The results of the impact assessment identified no residual significant impacts on wetlands and associated aquatic values following the application of mitigation measures such as the use of buffers (from construction) and ground-truthing surveys.

Wetlands within the Project area and associated gas drainage areas are presented below.

10.5.2.1 Queensland Wetland Mapping

The Queensland EHP defines wetlands as (EHP, 2013):

> *"…areas of permanent or periodic/intermittent inundation, with water that is static or flowing fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed 6 metres. To be a wetland the area must have one or more of the following attributes:*
>
> - *at least periodically the land supports plants or animals that are adapted to and dependent on living in wet conditions for at least part of their life cycle, or*
> - *the substratum is predominantly undrained soils that are saturated, flooded or ponded long enough to develop anaerobic conditions in the upper layers, or*
> - *the substratum is not soil and is saturated with water, or covered by water at some time."*

A review of publically available wetland mapping layers identified the presence of lacustrine, palustrine and riverine wetlands. These are defined below:

- Lacustrine wetlands - are large, open, water-dominated systems (for example, lakes) larger than eight hectares. This definition also applies to modified systems (for example, dams), which are similar to lacustrine systems (for example, deep, standing or slow-moving waters).
- Palustrine wetlands - are primarily vegetated non-channel environments of less than eight hectares. They include billabongs, swamps, bogs, springs, soaks etc, and have more than 30% emergent vegetation.
- Riverine wetlands - are all wetlands and deepwater habitats within a channel. The channels are naturally or artificially created, periodically or continuously contain moving water, or connecting two bodies of standing water.

With respect to above, the following number of wetlands are mapped within the Project area:

- 454 lacustrine wetlands;
- 411 palustrine wetlands; and

— 109 riverine wetlands.

These wetlands are captured in a range of wetland mapping and conservation assessment tools such as AquaBAMM and the Map of Referable Wetlands.

10.5.2.2 Ramsar Convention and the Directory of Important Wetlands in Australia

A search of wetlands listed under legislation and/or international agreements was undertaken and include the Ramsar Convention on Wetlands and the Directory of Important Wetlands in Australia.

Lake Elphinstone is listed on the Directory of Important Wetlands and occurs adjacent to the Project area (approximately 100 m). No wetlands listed under the Ramsar convention or Directory of Important Wetlands in Australia are mapped within the Project area. A detailed impact assessment for potential impacts on Lake Elphinstone with regard to groundwater outside of the Project area is outlined in the Groundwater Technical Report (Appendix E) of the SREIS.

10.5.2.3 Map of Referable Wetlands

EHP has undertaken a comprehensive mapping exercise for wetlands of high ecological significance (HES) and general ecological significance across Queensland. Statutory protection of these wetlands falls under the State Development Assessment Provisions (Module 11) which seeks to ensure that development is planned, designed, constructed and operated so as to not cause harm to the hydrology of wetlands in wetland protection areas that protect matters of national and state environmental significance including the outstanding universal values of the Great Barrier Reef (GBR).

Within the Project area, 37 wetlands categorised as having high ecological significance are mapped. These wetlands are regarded as GBR wetland protection areas. Of these wetlands, 24 are mapped within the Project's gas drainage areas.

As detailed above, the referable wetlands have been identified using AquaBAMM. Given this, the location of wetlands and the associated potential impacts are equivalent to that identified below from review of the ACAs for the Fitzroy and Burdekin catchments.

10.5.2.4 Aquatic Conservation Assessments

ACAs undertaken using the AquaBAMM methodology for the Fitzroy and Burdekin Catchments were reviewed. AquaBAMM is a decision support tool that utilises existing information and expert input to assess conservation value in aquatic ecosystems (Clayton *et al.,* 2006). It uses a robust and easily accessible analysis of ecological or conservation values associated with a catchment that is useful for subcatchment and regional planning (Clayton *et al.,* 2006). It is applicable in freshwater riverine, freshwater non-riverine and estuarine wetlands (Clayton *et al.,* 2006).

The method is based on a review of national and international literature but tailored towards the local situation and a thorough assessment of data availability (Clayton et al., 2006). It uses a database platform for data storage, manipulation and values assessment and outputs directly to a GIS platform for result presentation and interpretation. The output is an ACA for the study area. Details on how wetlands are assessed comparatively are provided in the Aquatic Ecology Technical Report (Appendix H) of the SREIS.

Once a wetland has been assessed, an Aqua score or conservation category is determined. Conservation categories are detailed below in Table 10-2.

Table 10-2 AquaBAMM ACA Wetland Conservation Categories

Conservation Value Category	Definition[1]
Very High	These wetlands have very high values across all criteria (aquatic naturalness, catchment naturalness, diversity and richness, threatened species, special features and representativeness), or they have very high representativeness values in combination with very high aquatic naturalness, catchment naturalness or threatened species values. They may also be wetlands nominated by an expert panel for their very high special feature values, regardless of values across other criteria.
High	These wetlands are mainly those that have very high aquatic naturalness or representativeness values in combination respectively with very high/high threatened species values or very high diversity and richness values. Other combinations of very high or high values amongst the criteria may also indicate one of these wetlands.
Medium	These wetlands have varied combinations of high and medium values amongst the criteria.
Low	These wetlands have limited aquatic and catchment naturalness values. They have varied combinations of medium and low values amongst the other criteria.
Very Low	These wetlands have very limited or no aquatic and catchment naturalness values and they lack any other known significant value. They may also be wetlands that are largely data deficient.

1 – Definitions obtained from Clayton *et al*. (2006)

As well as scoring and categorising wetlands, the ACAs of the Fitzroy and Burdekin catchments identify and describe other aquatic values typical of the catchments, including:

- Special features and priority ecosystems;
- Aquatic species richness riverine and non-riverine wetlands;
- Aquatic flora and fauna recognised as priority wetland species; and
- Migratory fauna regarded as priority wetland species.

Aquatic species richness and priority aquatic species are outlined in the Aquatic Ecology Technical Report (Appendix H) of the SREIS. Special features and priority ecosystems within the Fitzroy and Burdekin Catchments which occur downstream of the Project are also outlined in the Aquatic Ecology Technical Report (Appendix H) of the SREIS and include:

- Lake Elphinstone;
- Denison Creek and Funnel Creek; and
- Isaac River where it joins with the Mackenzie River.

The above wetlands occur outside the Project area boundary. Thus, the potential for direct impacts on these priority ecosystems from activities such as land clearing is unlikely. However, downstream impacts on the identified values, particularly the riverine systems (Isaac River, Denison Creek and Funnel Creek) may occur. General mitigation measures outlined in the EIS and in Section 10.7 will minimise impacts from the Project on these ecosystems.

Wetlands Mapped Within the Project Area

The ACAs of the Fitzroy and Burdekin catchments have identified a number of wetlands within the Project area across all wetland ecological categories (Rollason and Howell, 2012). Table 10-3 below details the number of wetlands within each wetland ecological category within both riverine and non-riverine wetland types. Figure 10-2 depicts the wetlands within the Project area.

Table 10-3 Riverine and Non-riverine Wetlands within the Project Area

ACA Wetland Ecological Category	Riverine	Non-Riverine
Very High	8	10
High	18	38
Medium	77	290
Low	4	-
Very Low	2	85
Total	**109**	**423**

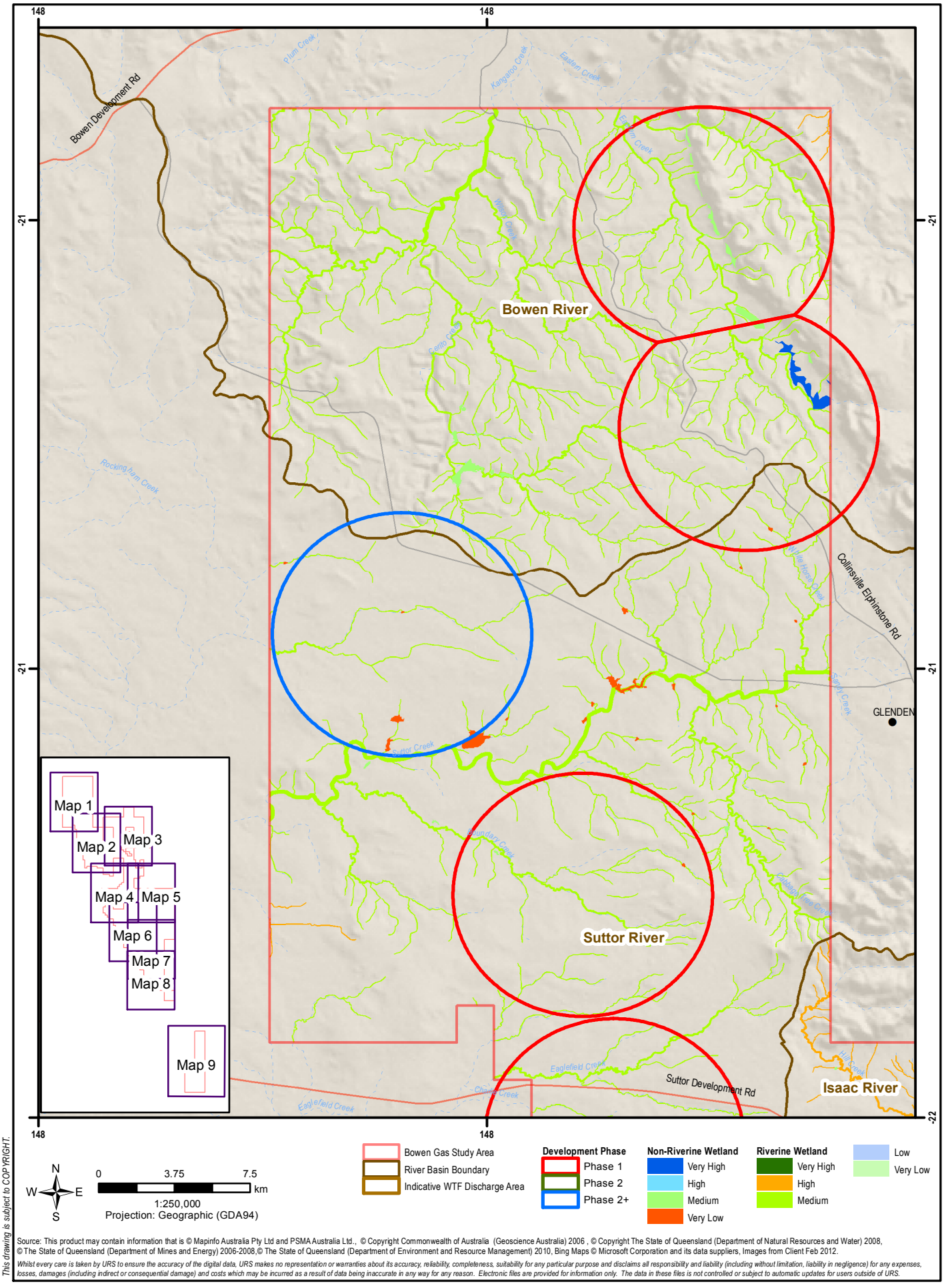
As detailed in Table 10-3 above, non-riverine wetlands regarded as having very high (10 total) or high (38 total) ecological value are mapped within the Project area. This equates to approximately 11% of wetlands. These wetlands are of conservation value and incorporate referable wetlands which are mapped as wetland protection areas (e.g. regarded as wetlands with high ecological significance).

Non-riverine wetlands which are scored as having medium ecological value (290 wetlands) comprise 68% of the total non-riverine wetlands within the Project area. These wetlands are defined as wetlands which have varied combinations of high and medium values. Medium ecological value wetlands are not mapped as wetland protection areas on a map of referable wetlands.

Within the Project area, 85 low or very low non-riverine wetlands of ecological significance are mapped. These wetlands have limited or no aquatic and catchment values and lack other known significant values.

Within the Project area, riverine wetlands mapped as having very high or high ecological value total 8 and 18 respectively. Similarly to non-riverine wetlands, medium value riverine wetlands comprise 62% of mapped wetlands within the Project area.

As detailed in Table 10-3 above, very high and high ecological valued wetlands support a range of aquatic values, including conservation significant species, high species diversity and richness, as well as high aquatic naturalness. Given this, the potential impact on these wetlands versus wetlands of medium ecological value or lower, have potential to be greater in significance. The potential impact on wetlands is detailed in Section 10.6.1, the mitigation measures and subsequent potential residual impacts are outlined in Section 10.7 and Section 10.8 respectively.



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BOWEN GAS PROJECT SREIS

WETLANDS AND DEVELOPMENT PHASES MAP 1

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AQUATIC ECOLOGY

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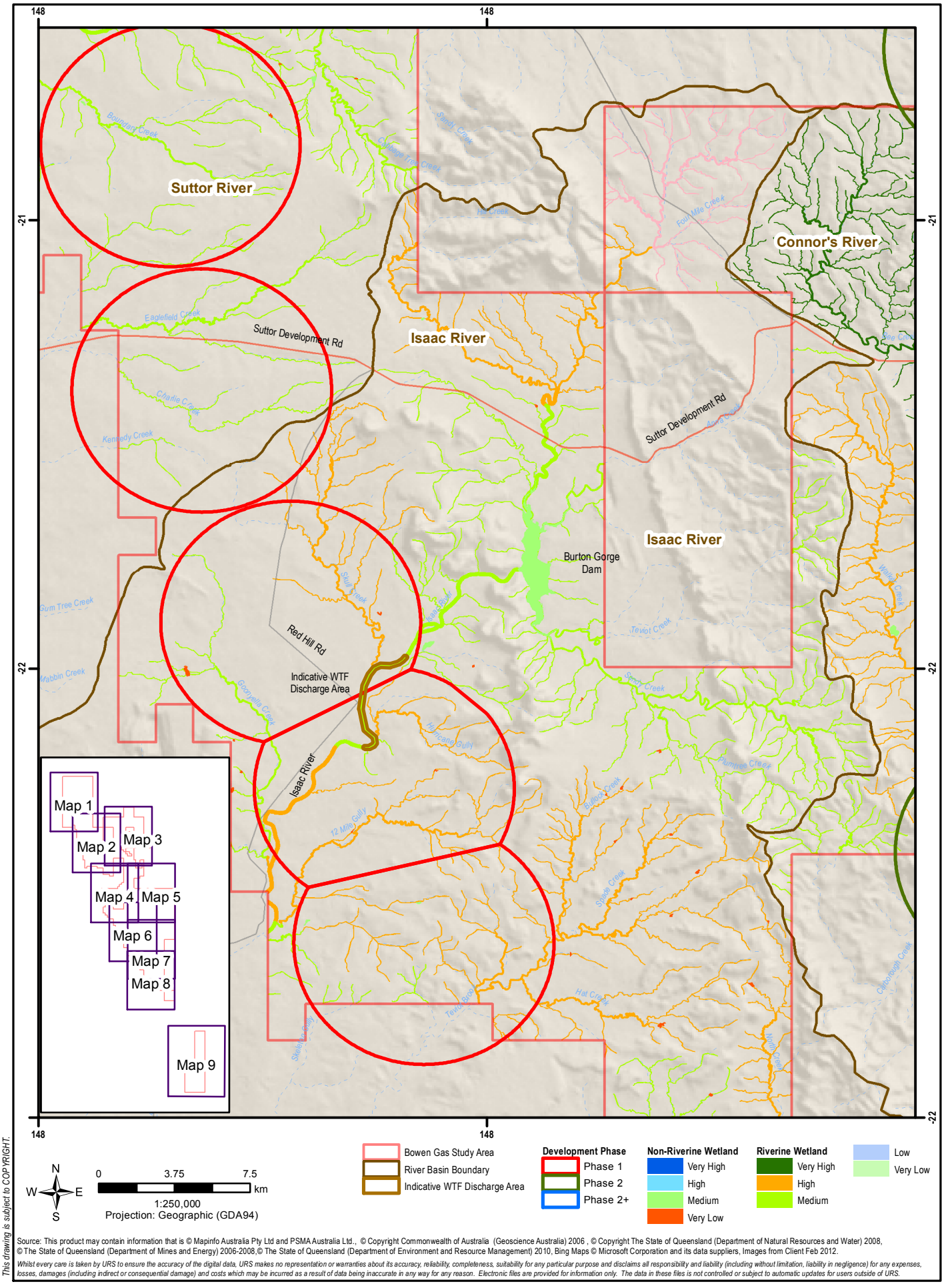

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BOWEN GAS PROJECT SREIS

WETLANDS AND DEVELOPMENT PHASES MAP 2

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AQUATIC ECOLOGY

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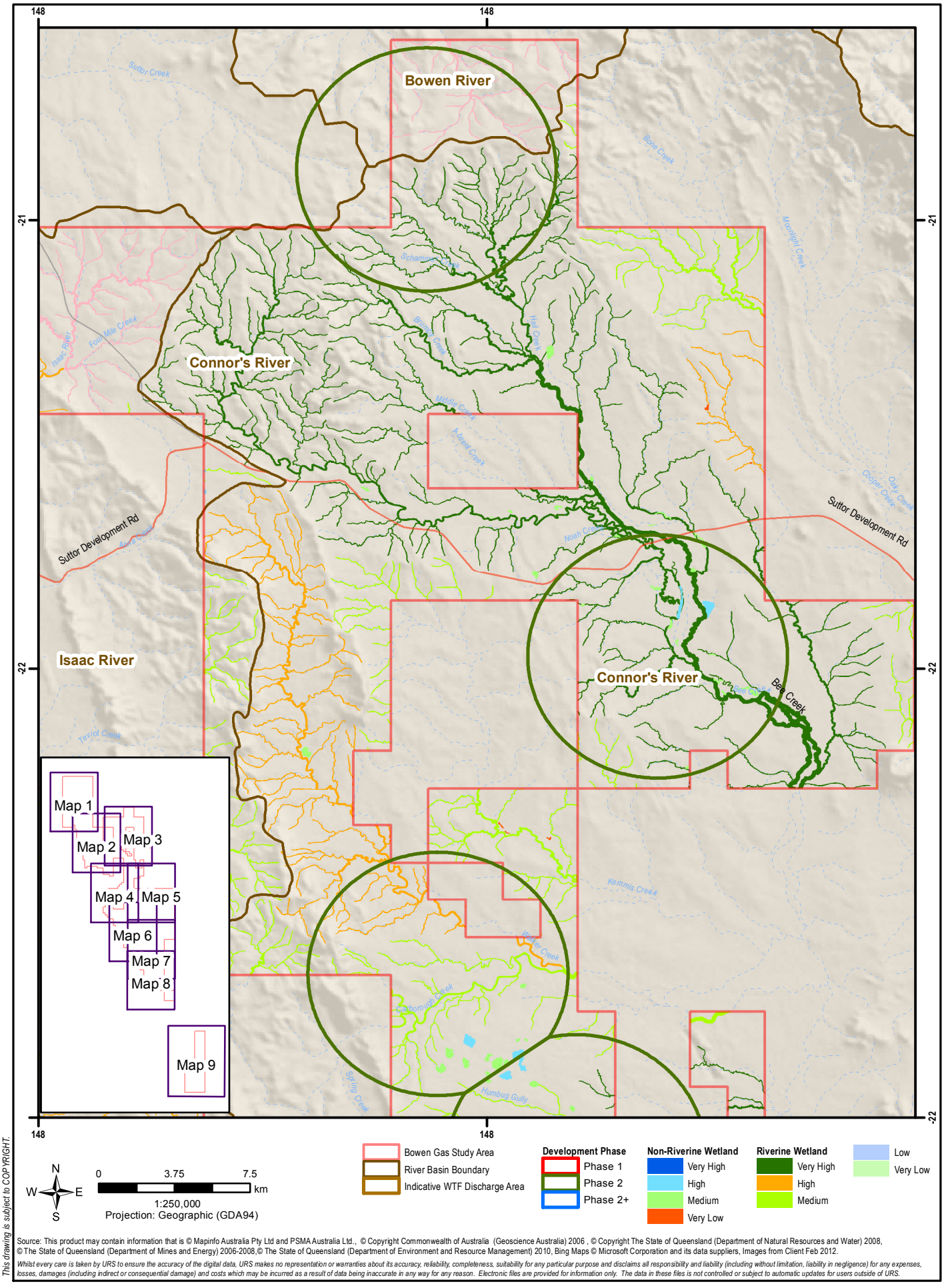

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BOWEN GAS PROJECT SREIS

WETLANDS AND DEVELOPMENT PHASES MAP 3

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AQUATIC ECOLOGY

Figure: 10-2

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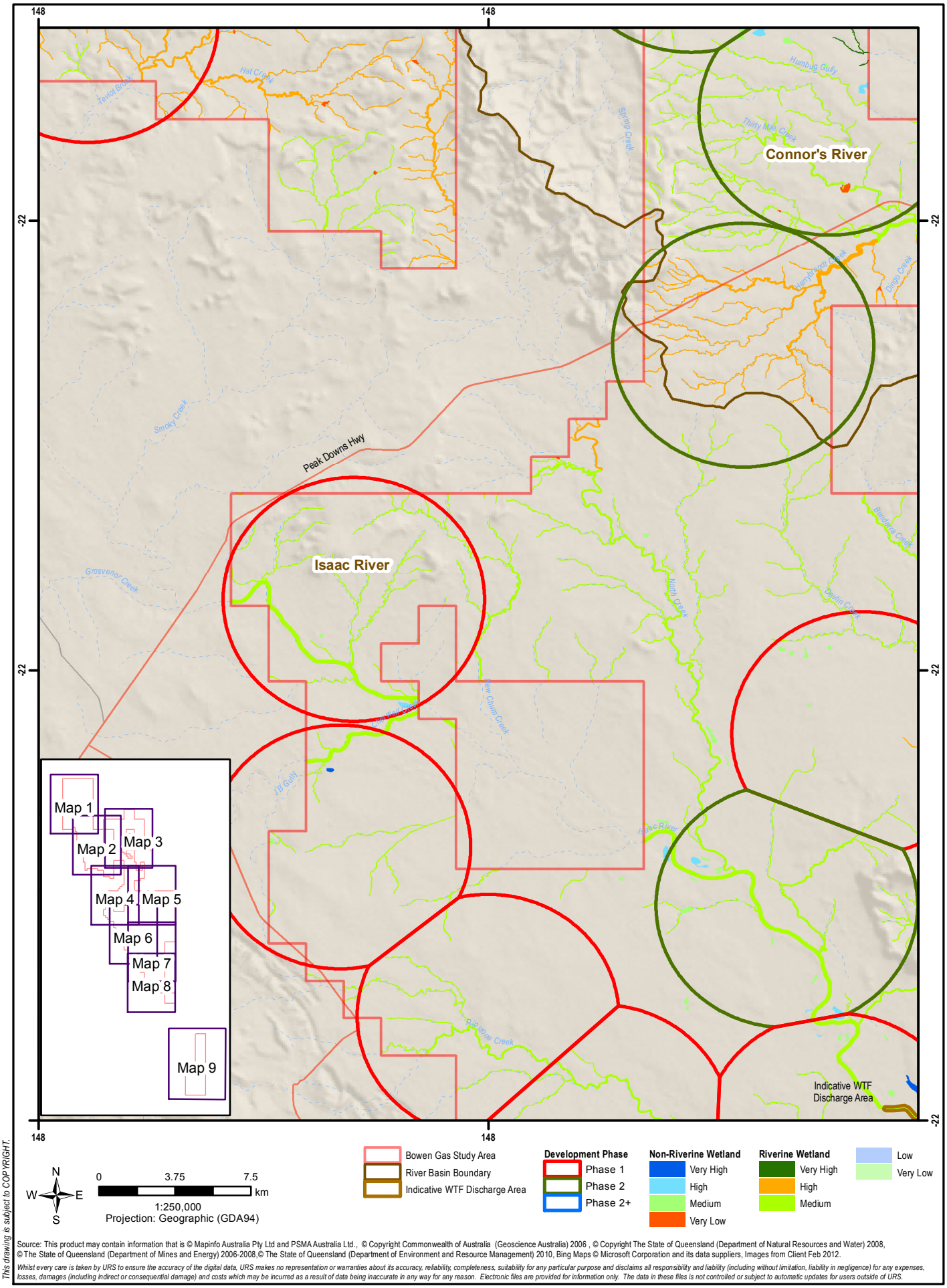

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BOWEN GAS PROJECT SREIS

WETLANDS AND DEVELOPMENT PHASES MAP 4

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AQUATIC ECOLOGY

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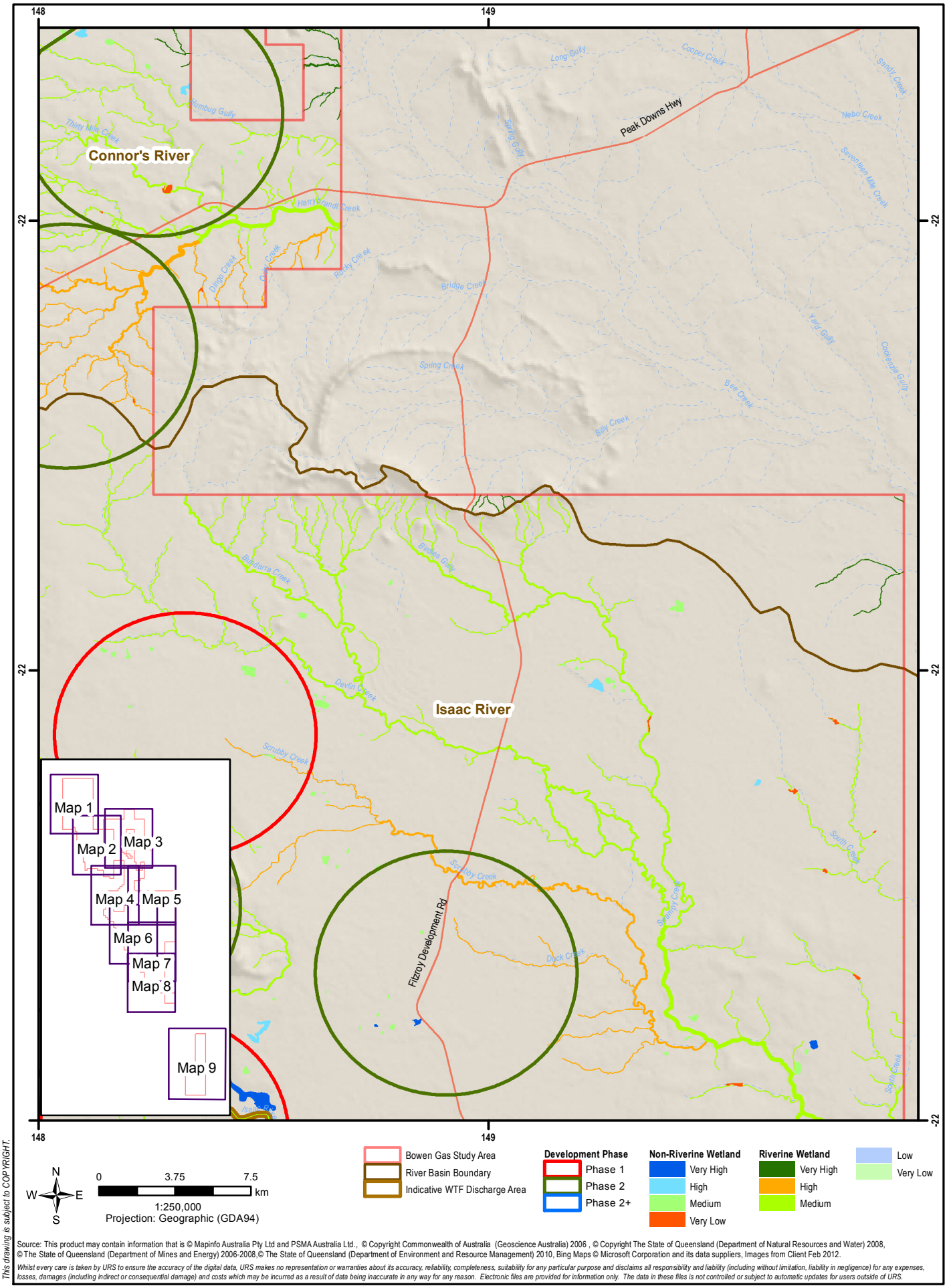

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BOWEN GAS PROJECT SREIS

WETLANDS AND DEVELOPMENT PHASES MAP 5

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AQUATIC ECOLOGY

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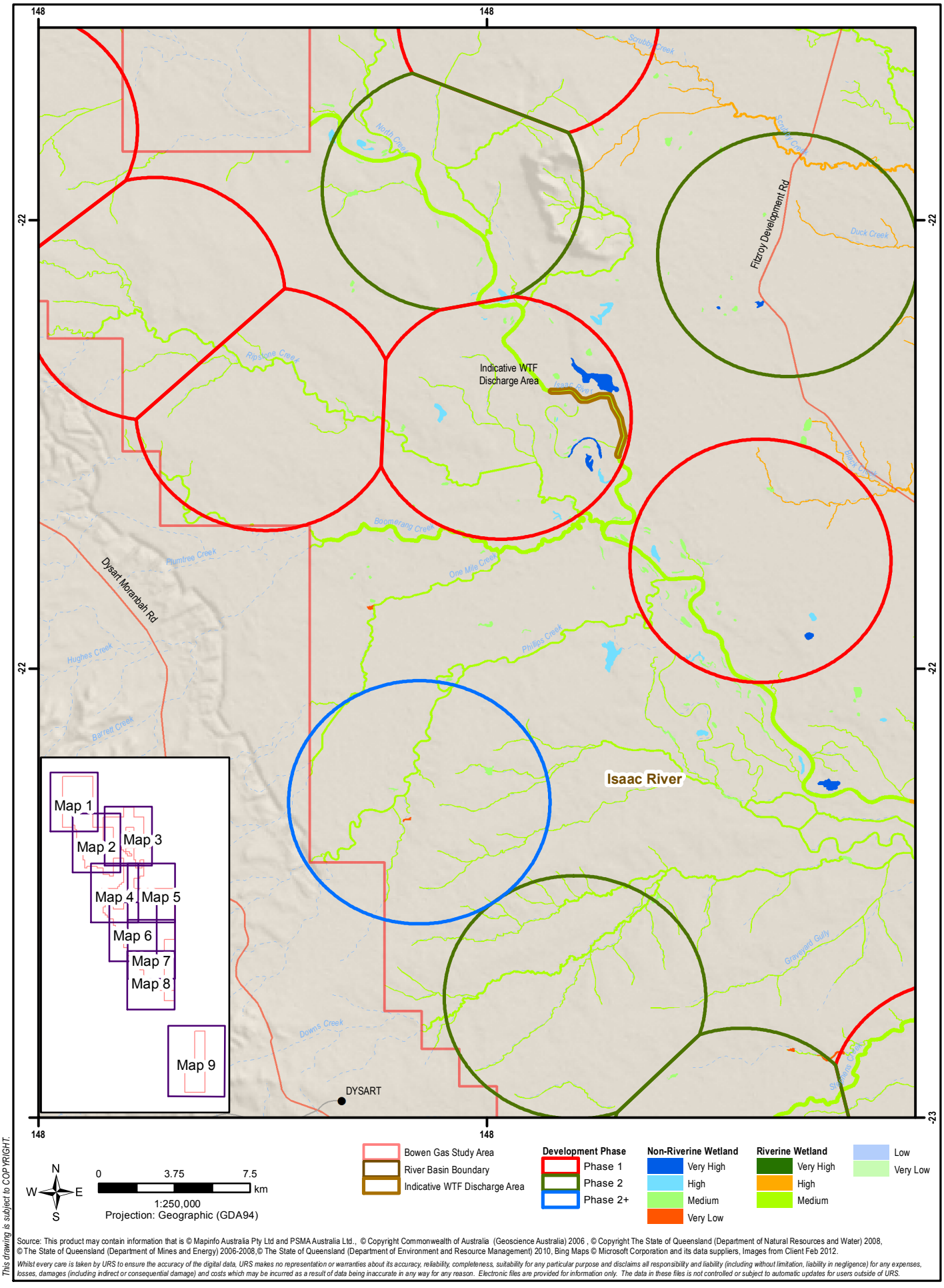

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BOWEN GAS PROJECT SREIS

WETLANDS AND DEVELOPMENT PHASES MAP 6

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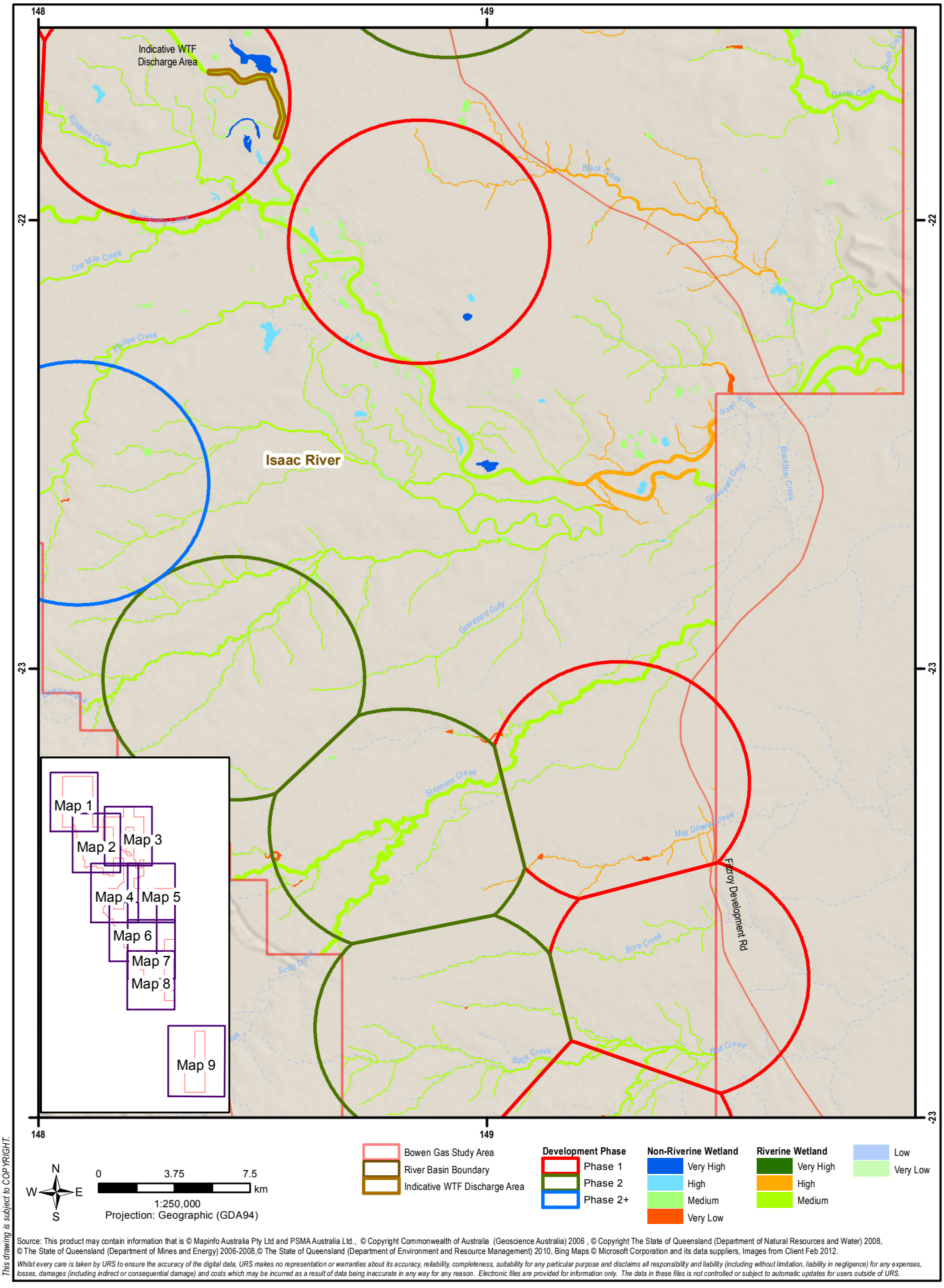

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WETLANDS AND DEVELOPMENT PHASES MAP 7

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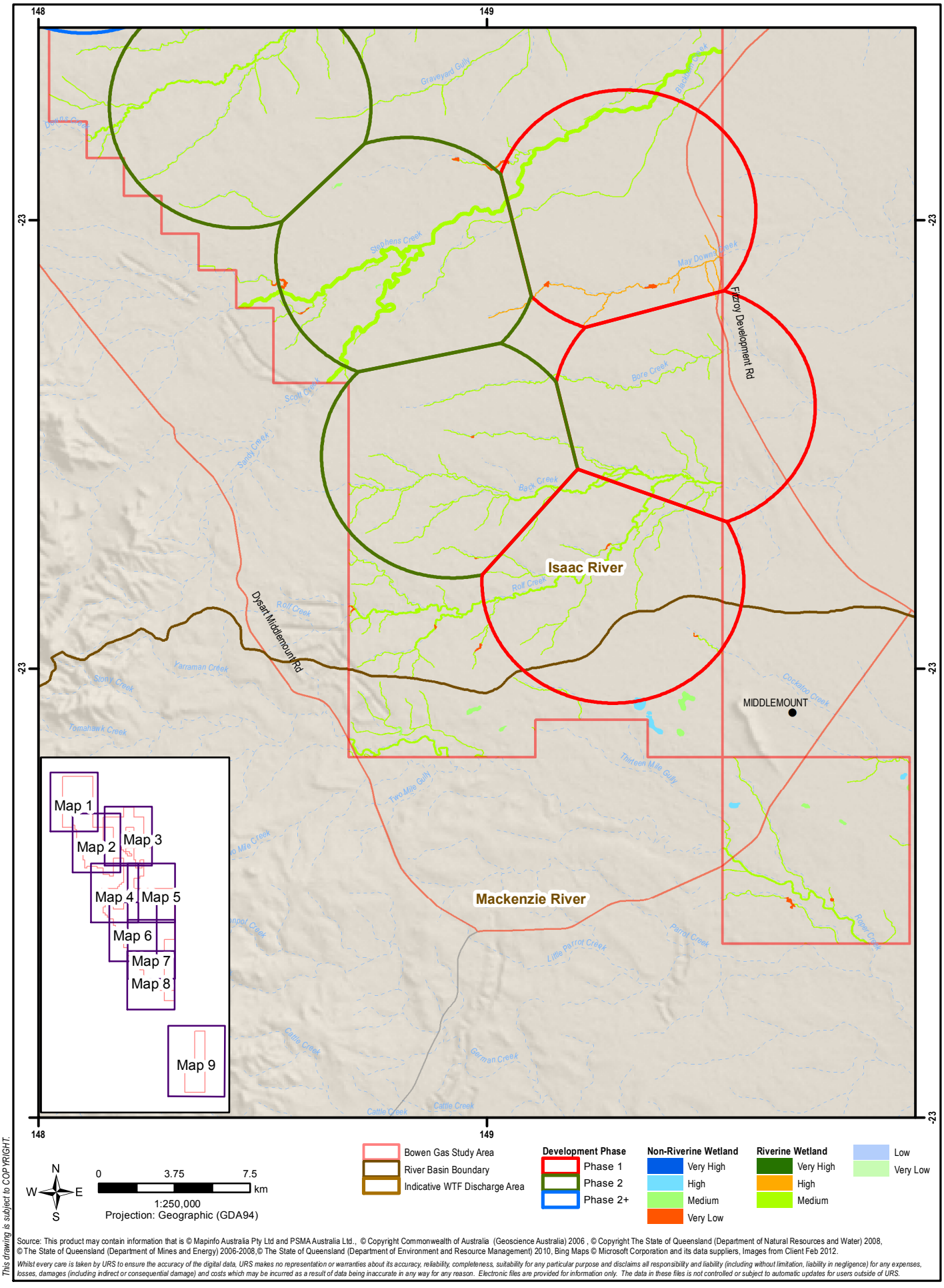

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BOWEN GAS PROJECT SREIS

WETLANDS AND DEVELOPMENT PHASES MAP 8

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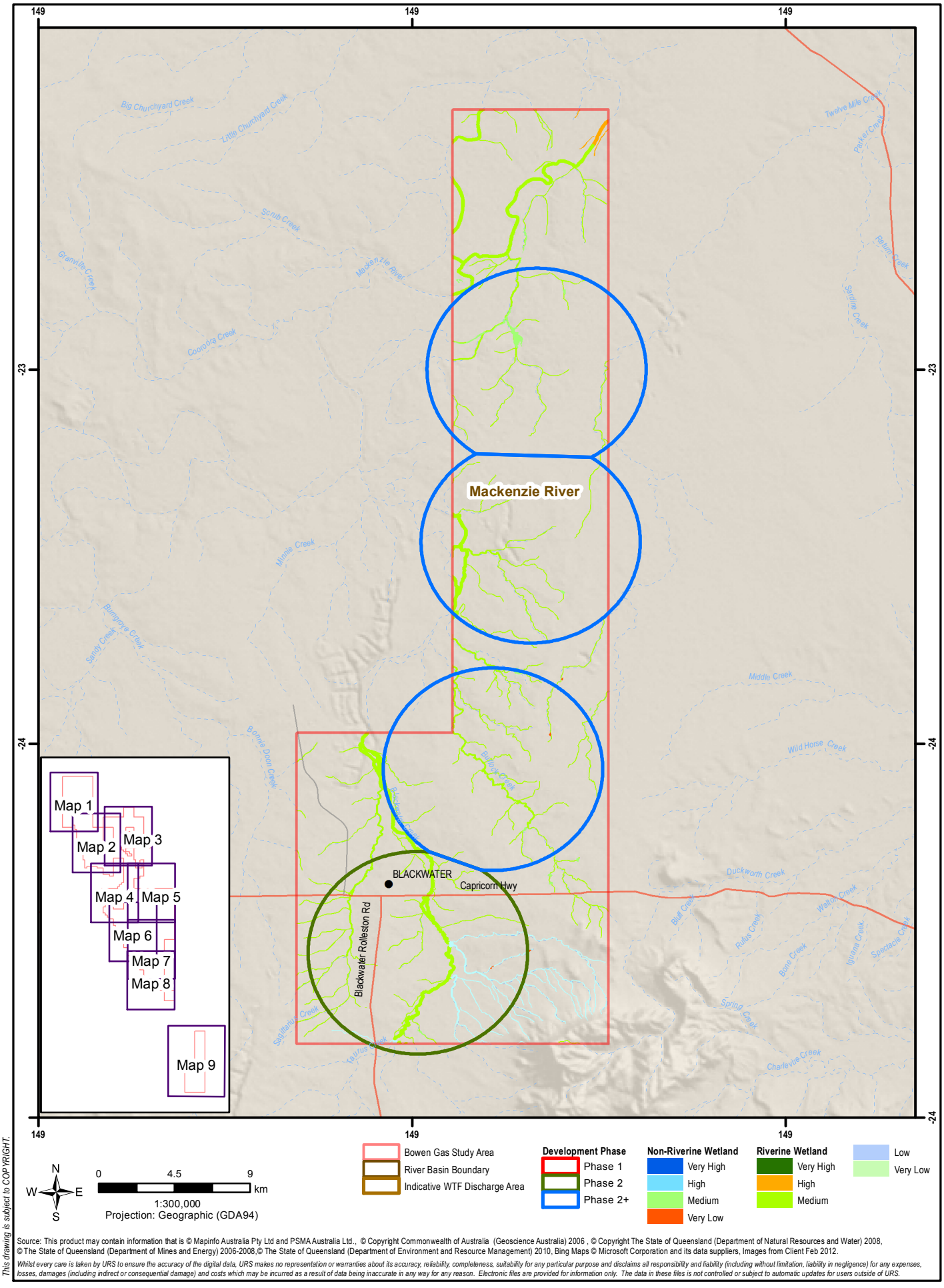

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BOWEN GAS PROJECT SREIS

WETLANDS AND DEVELOPMENT PHASES MAP 9

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AQUATIC ECOLOGY

Figure: 10-2

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10.5.2.5 Current Field Development Planning

Field development planning has advanced since preparation of the EIS, with the overall Project development area now being separated into 33 smaller drainage areas. Each drainage area is a 6 km radius catchment area for gathering well production (gas and water) to surface production facilities located at or near the centre of the circle. Each of these centrally located surface production facilities is an FCF. The indicative locations of gas drainage areas are shown in Figure 10-2.

The application of the drainage area approach has allowed for a refined analysis of the number of wetlands potentially affected by the Project. The focus of development will occur within the drainage area, although there may be impacts beyond the drainage area boundary.

Thirty-three indicative drainage areas are located across the Project tenements. These have been scheduled for development across three distinct Phases: 1, 2 and 3.

Given the above, the number of ACA wetlands mapped within the 33 drainage areas is outlined in Table 10-4 below. Of these wetlands, 24 are mapped as referable wetlands of HES.

Table 10-4 Wetlands Mapped within the Proposed Drainage Areas

ACA Wetland Ecological Category	Riverine	Non-Riverine
Very High	4	8
High	10	21
Medium	49	134
Low	1	-
Very Low	2	28
Total	**66**	**191**

10.5.3 Proposed WTF Development Area (Moranbah)

At the time of this report, site specific data relating to the ecological characterisation of the Isaac River and associated environmental values for potential WTF discharge areas were unavailable. Numerous regionally specific studies have been reviewed to gain an appreciation of the reach of waterway in the area of the proposed WTF localities.

Field assessments undertaken during the EIS coupled with data published in numerous other EIS investigations and monitoring studies, provide useful information to generally characterise the reaches of the Isaac River within the footprint of the proposed WTF development areas. This information, although not site specific, allows for an understanding of the site conditions in order to estimate preliminary potential impacts from future development. The results of the literature review are provided in Sections 10.5.3.1 to 10.5.3.5.

10.5.3.1 Description of the Isaac River and Habitat

The Isaac River is an ephemeral stream with a mobile sand bed. Instream habitat generally consists of intermittent pools and runs, with edgewaters providing habitat during flows. Substrate is dominated by coarse sand, with leaf litter forming the base of most pools. Few permanent pools exist, although

natural rock formations do exist that provide semi-permanent habitat to aquatic species. URS (2011) describes the Isaac River as homogeneous throughout the Moranbah region with little natural variation. Localised differences in habitat may occur.

10.5.3.2 Fish

The Aquatic Ecology Technical Report (Appendix O) of the EIS undertook a survey of 15 sites across the Project area. Of the sampling effort from the EIS, two sampled sites correlate with the two study areas identified in this supplementary report to characterise the values of the Isaac River associated with potential WTF localities.

Sample site AQ10A is located slightly upstream of the northern survey reach of the Isaac River, and sample site AQ16 is located slightly downstream of the southern survey reach of the Isaac River associated with potential WTF localities.

Similarly, aquatic biodiversity data collected as a part of the BHP Billiton Mitsubishi Alliance (BMA) Red Hill Mining Lease EIS focused on the Isaac River (and tributaries) close to the study areas of the Isaac River associated with the potential northern WTF locality.

Additionally, numerous other monitoring studies undertaken by URS (2013) and WBM Oceanics (2005) also detail fish species observed in this area. Fish species documented to occur within the potential WTF localities are provided in Table 10-5 below.

No fish species recorded during recent published reports are listed as threatened. A total of ten fish species were recorded within the vicinity of the northern reach of the Isaac River associated with the potential WTF locality. Similarly, ten fish species were recorded at the site close to the potential WTF locality near the southern reach area of the Isaac River study site. As shown above in Table 10-6, the community structure of the two sites is similar, differing by three species. It is expected that all fish species identified above will occur at both locations during periods of flow given the habitat features of the Isaac River are typically homogenous within the Moranbah region.

A study undertaken by WBM Oceanics (2001 and 2005) in a tributary upstream of Moranbah provides evidence that Western carp gudgeon (*Hyseleotris klunzingeri*) may also be present in the vicinity of the northern Isaac river reach associated with the potential WTF locality. Their presence in the Isaac River may be limited, as spawning sites are highly vulnerable to elevated or erratic flow regimes (Pusey *et al*., 2004). *Hypseleotris sp1* and *Scortum hilii* were also noted in the 2005 fish survey. Pusey *et al*. (2004) also indicates that a further three species, Barred grunter (*Amniataba percoides*), Mouth almighty (*Gossamia aption*) and Flathead gudgeon (*Philypnodon grandiceps*) may also be present in the study area as their spatial range overlaps the area.

Ecosure (2012) note the difference in both species diversity and abundance with seasonal flow regime in the Isaac River. Surveys conducted in October 2012 (early wet) and April 2013 (late wet) shows a decrease in species diversity, although an increase in relative abundance. For example, a total of two *Oxyeleotris lineolata* individuals were captured in the October 2012 sampling event, while 117 individuals were collected in the April 2013 sampling event.

Table 10-5 Fish Species Observed at Relevant Survey Sites Associated with the Potential WTF Localities

Species	Common Name	Bowen Gas Project EIS*		BMA Red Hill Mining Lease EIS
		WTF1*	WTF2**	WTF1***
Ambassis agasizzii	Olive perchlet	✓	✓	✓
Craterochephalus stercusmuscarum	Fly-specked hardyhead	-	✓	-
Hypseleotris sp1	Midgley's carp gudgeon	-	✓	-
Leiopotherapan unicolor	Spangled perch	✓	✓	✓
Macquaria ambigua oriens	Golden perch	✓	✓	-
Melanotaenia splendida splendida	Eastern rainbowfish	✓	✓	✓
Mogurnda adspersa	Purple-spotted gudgeon	✓	-	✓
Nematalosa erebi	Bony bream	✓	✓	✓
Neosilurus hytilii	Hyrtle's tandan	✓	✓	✓
Oxyeleotris lineolata	Sleepy cod	✓	-	✓
Porochilus rendahli	Rendahl's catfish	✓	✓	-
Scortum hilii	Leathery grunter	✓	✓	-

* Data collated from site AQ10A (Aquatic Ecology Technical Report (Appendix O) of the EIS)
** Data collated from site AQ16 (Aquatic Ecology Technical Report (Appendix O) of the EIS)
*** Data collated from Isaac River sites – during late wet season (BMA Red Hill Mining Lease EIS Appendix K)

Water Quality Tolerance

Different fish species display a range of water quality tolerances, often dependent upon localised conditions (Pusey *et al*., 2004). The Aquatic Ecology Technical Report (Appendix H) of the SREIS provides water quality ranges for sites within close vicinity of the northern and southern reaches of the Isaac River associated with the potential WTF localities and water quality tolerances of the fish listed in Table 10-5 above.

In general, the water quality encountered within the northern and southern reaches of the Isaac River during the EIS and BMA Red Hill Mining Lease EIS was well within the tolerance ranges for most fish species; however the following exceptions are identified:

- Eastern Rainbowfish (*Melanotaenia splendida*): pH and electrical conductivity recorded during the EIS slightly exceeds the maximum tolerance value; and
- Sleepy Cod (*Oxyeleotris lineolata*): electrical conductivity recorded during the EIS greatly exceeds the maximum tolerance value.

10.5.3.3 Macroinvertebrates

The literature review identified that macroinvertebrates within the northern reach of the Isaac River varied depending on stream flow (high or low) and macrophyte availability. Field sampling from the

EIS identified 18 taxa whilst sampling during the Red Hill Mining Lease EIS identified 28 taxa from a similar area. OE50 Signal scores assigned to the northern reach are considered moderate, achieving an AusRivAS modelling banding of B. This infers that the site may be slightly impacted as fewer taxa were observed than were expected to occur under reference conditions.

Macroinvertebrate sampling undertaken for the EIS in the vicinity of the southern reach of the Isaac River associated with the potential WTF locality indicates similar results to that reported for upstream. Seasonal variation in macroinvertebrate taxa appears to occur at this site. No other data could be obtained to verify these results.

A summary of macroinvertebrate sampling undertaken within the Project area is provided in the Aquatic Ecology Technical Report (Appendix H) of the SREIS.

10.5.3.4 Turtles

Turtles were assessed as a part the EIS, although no sites were examined on the Isaac River. No other studies were identified as a part of this review. The Fitzroy River turtle (*Rheodytes leukops*) is listed as Vulnerable under both the NC Act and EPBC Act. Whilst not observed during past surveys of the proposed development area, the species may occur in the wider region and is listed by EHP (2010) as occurring in the Fitzroy River tributaries, such as the Isaac River.

The species requires flowing streams and permanent waterbodies for survival. Given the Isaac River is ephemeral, it does not provide suitable core habitat for this species within the Project areas.

Suitable habitat for this species is found to the south-east of the Project area where permanent flowing water exists downstream. Potential habitat mapping and a species profile and impact assessment for the Fitzroy River turtle is provided in the MNES report (Appendix J) of the SREIS.

Further information on the Fitzroy River turtle is provided in Aquatic Ecology Technical Report (Appendix H) of the SREIS. Additionally, potential habitat mapping within the Project area, a profile, and significant impact assessment on this species is provided in the MNES Report (Appendix J) of the SREIS.

10.5.3.5 Aquatic Flora

Data relating to aquatic flora present within the northern and southern reaches of the Isaac River associated with the potential WTFs is limited. To characterise the flora assemblages likely to be present, a summary of the data provided in the EIS is presented below.

The EIS identifies two species of macrophyte observed during the field surveys of 2012 and 2013. *Juncus sp* (Common Rush) was observed at sample site AQ10A, close to the northern reach of the Isaac River associated with the potential WTF locality. URS (2011) in their ecological assessment suggests *Lomandra longifolia* (Lomandra) is also quite widespread through this area. One macrophyte species *Phragmites australis* (Common Reed) was observed at the downstream AQ16 sample site, close to southern reach of the Isaac River associated with the potential WTF locality.

No conservation significant species were recorded. Priority aquatic flora are outlined in Aquatic Ecology Technical Report (Appendix H) of the SREIS.

10.6 Potential Impacts

An assessment of the potential impacts to the aquatic environment arising from proposed activities was completed during the EIS process. The EIS assessment outlined standard operational measures that will be taken to minimise the potential impacts identified at the time. In the interim, the proposed activities associated with the Project have been refined, and greater detail is available in relation to the arrangement of project infrastructure, expected peak flows for produced water, and designed water treatment capacity across the Project area.

Thus, the purpose of the SREIS aquatic ecology impact assessment is to provide further detail for impacts and mitigation measures, as well as addressing any knowledge gaps identified during the legislative review or public submission stage since the EIS. The discussions of mitigation measures within this section contain some references to earlier management options outlined in the EIS documentation; notably the Aquatic Ecology Technical Report (Appendix O) and the Surface Water Technical Report (Appendix N).

The key changes to the proposed Project activities, applied since the EIS, that may potentially contribute to the following impacts on the aquatic environment within the Project area include:

- Change in size / distribution of project infrastructure footprints;
- Greater certainty around ‘field water treatment / storage’ facilities;
- Brine management options have been assessed further by Arrow (since the EIS) and a preferred option has been identified;
- Marked reduction in Project lifecycle water production (reduction of 123 GL of produced water over project lifecycle) and number of wells (approximately 2,500 wells less than at EIS stage); and
- Drainage areas (which form the basis for field development staging) have been reduced in area (now a 6 km radius), and approximately doubled in number (now 33 drainage areas); drainage areas are now spread out more evenly both temporally and spatially across the Project area.

Table 10-6 below outlines the changes in potential impacts on aquatic values from the changes in Project activities listed above. Typically, impacts have been reduced on a regional scale, i.e. a reduction in the number of wells and associated infrastructure across the Project area. However, the inclusion of multi well pads may result in increased potential impacts on a local scale when compared against the EIS scenario.

These activities, their potential associated impacts to the existing aquatic environment are discussed further below and summarised in Table 10-6. Applicable mitigation measures and residual impacts are presented in Sections 10.7 and 10.8 below.

Table 10-6 SREIS Impact Assessment Summary

Project Component	EIS Scenario (2012)	SREIS Scenario (2014)	Associated Potential Impacts	Key Changes in Degree of Potential Impact	Applicable Mitigation Measures
Drainage areas	• 17 'catchment areas' of up to 12 km radius, over approximately 8,000 km^2 Project area.	• 33 'drainage areas' of up to 6 km radius, over approximately 8,000 km^2 Project area.	• Alteration of flows and flow paths; • Degradation of aquatic habitats from erosion and sediment mobilisation; and • Potential release of contaminants to watercourses (adverse effects on aquatic habitats).	• Reduction in size of each drainage area, but increase in number of drainage areas; contributing to an overall reduction in the intensity of development on a regional scale; and • May result in increased localised impacts compared with EIS scenario.	• Mitigation measures outlined in the Aquatic Ecology chapter (Section 16.6) and Aquatic Ecology Technical Report (Appendix O, Section 6) of the EIS still apply.
Production wells	• 6,625 production wells drilled over 40 years; and • Single well pads only.	• Approximately 4,000 production wells drilled throughout the Project area over life of the Project (up to 40 years); and • Some multi-well pads of up to 6 wells each.	• Alteration of flows and flow paths; and • Degradation of aquatic habitats from erosion and sediment mobilisation.	• Reduced intensity of development on a regional scale, however the introduction of multi-well pads may increase the degree of potential localised impact and risk to aquatic ecosystems.	• Mitigation measures outlined in the Aquatic Ecology chapter (Section 16.6) and Aquatic Ecology Technical Report (Appendix O, Section 6) of the EIS still apply.

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Project Component	EIS Scenario (2012)	SREIS Scenario (2014)	Associated Potential Impacts	Key Changes in Degree of Potential Impact	Applicable Mitigation Measures
Linear infrastructure	• Pipeline gathering network required to connect each well pad to gas compression infrastructure; and • Associated roads and access tracks for wells and pipelines.	• Overall net reduction in area required gathering network; and • Net reduction in area of associate roads and access tracks.	• Alteration of flows and flow paths; • Degradation of aquatic habitats from erosion and sediment mobilisation; and • Removal of riparian vegetation.	• Net reduction in total area for gathering network infrastructure including pipelines, access tracks and roads. Reduced intensity at a regional and local scale.	• Mitigation measures outlined in the Aquatic Ecology chapter (Section 16.6) and Aquatic Ecology Technical Report (Appendix O, Section 6) of the EIS still apply.
Gas compression infrastructure	• Four integrated gas and water processing facilities of 800 x 250 m area, with dams up to 1 km^2 in area; and • One FCF per drainage area, with a footprint of up to 200 m x 250 m.	• Two CGPFs located near Peak Downs and Red Hill; and • One FCF per drainage area (skid-based, modular design with footprint up to 200 m x 380 m in area).	• Alteration of flows and flow paths; and • Degradation of aquatic habitats from erosion and sediment mobilisation.	• Reduced footprint and number of gas processing facilities; and • Larger footprint area for FCFs.	• Mitigation measures outlined in the (Aquatic Ecology chapter (Section 16.6) and Aquatic Ecology Technical Report (Appendix O, Section 6) of the EIS still apply.

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Project Component	EIS Scenario (2012)	SREIS Scenario (2014)	Associated Potential Impacts	Key Changes in Degree of Potential Impact	Applicable Mitigation Measures
Water treatment facilities	• Maximum dam footprint 0.6 km^2; • FCFs will most likely be of skid-based modular construction; and • IPFs may have peak flows of between 15-30 ML/d of field produced water, allowing that some areas will produce more water than others.	• Water Transfer Stations in field (pumping and surge tanks); typically associated with an FCF; • One WTF associated with each CGPF. Feed dams, treated water dams, and brine storage facilities will be located at each WTF; • WTF1: Peak flow capacity of 12.9 ML/d; • WTF2: Peak flow capacity of 20 ML/d; • Raw water can be transferred between WTFs (concept only); and • Modular water treatment / storage units at FCFs (such as oily water reclamation systems) can treat up to 5-20 ML/d of produced water.	• Release of treated and untreated CSG water to surface watercourses (potential adverse effects on aquatic habitats); • Uncontrolled release of contaminated water to grade and/or watercourses due to spills (from water gathering lines; trucks transporting wastewater and treated water from water transfer stations); and • Reduced risk of adverse impacts to aquatic values, with fewer discharge points (a function of having fewer WTFs).	• Reduction in number of WTFs, but retained a similar treatment capacity to that proposed for the EIS scenario; • 40% reduction in maximum area for WTF dams, potentially decreasing the overall impact of WTF construction / operation; and • Potentially lower risk of uncontrolled release to surface waters, due to reduced number of discharge locations.	• Mitigation measures outlined in the Aquatic Ecology chapter (Section 16.6) and Aquatic Ecology Technical Report (Appendix O, Section 6) of the EIS still apply; and • Section 9.2.2.4 of the Surface Water Technical Report (Appendix N) of the EIS specifically applies to any releases from WTFs to the receiving environment, along with information outlined in the Surface Water Quality Technical Report (Appendix F, Sections 9.1 and 9.2) of the SREIS.

While this chapter specifically addresses the aquatic ecology aspects of any likely impacts related to activities described in the updated Project description, these studies are considered together and in a holistic manner with Project impacts related to surface water quality and hydrology and geomorphology (refer to the Surface Water Technical Report (Appendix F) and Hydrology and Geomorphology Technical Report (Appendix G) of the SREIS. The different and inter-relating aspects that determine river health such as water quality, river hydrology, geomorphology and aquatic ecology were assessed in order to protect all environmental values associated with the Isaac River. This holistic approach was utilised in the assessment of impacts associated with potential discharges of CSG water. This interrelationship is depicted in Figure 10-3.

10.6.1 Potential Impact on Wetlands

The EIS identified a number of potential impacts on aquatic values, typically associated with construction activities, such as vegetation clearing and site levelling. Similarly to the EIS, these activities have potential to impact on wetlands, and include:

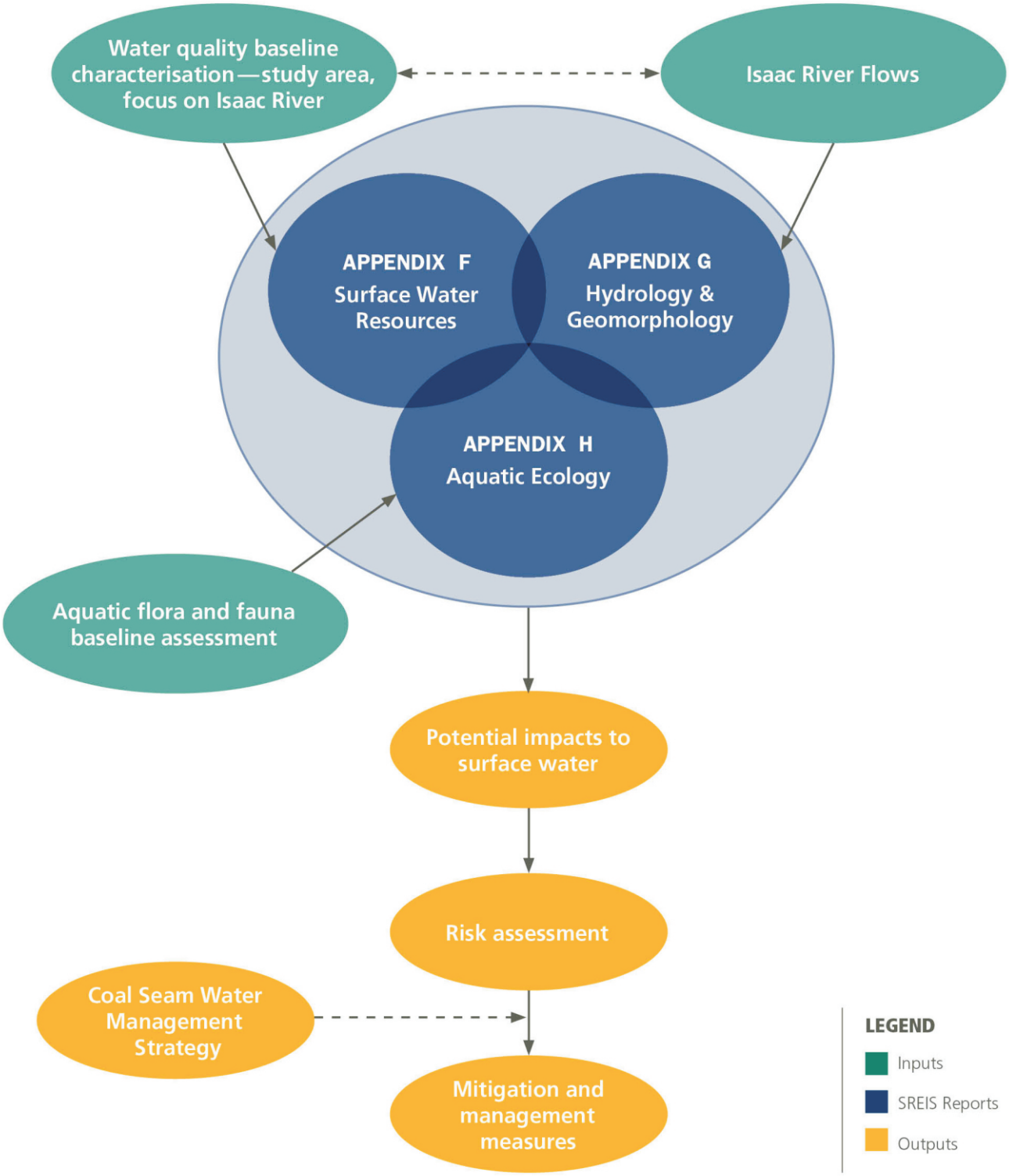
- Site clearing and levelling;
- Construction of access tracks;
- Use of vehicles / plant / machinery near wetlands and waterways;
- Waste management;
- Gathering systems;
- Drilling operations; and
- Altered surface hydrology.

The potential impacts on wetlands from the above activities are consistent with the impacts detailed in the EIS on aquatic ecosystems, including:

- Degradation of water quality and smothering of benthic habitat from erosion and sediment transport processes;
- Reduction in aquatic biodiversity;
- Loss of riparian or aquatic vegetation;
- Contamination of wetlands and waterways resulting from fuel, oil or chemical spills;
- Altered surface water hydrology; and
- Spread and proliferation of pest species.

The application of mitigation measures outlined in the Aquatic Ecology chapter (Section 16.6) and Aquatic Ecology Technical Report (Appendix O, Section 6) of the EIS and the buffer zones to be applied to wetlands using Arrow's risk based framework as detailed in the Constraints Mapping report (Appendix BB) of the EIS and summarised in Section 10.7.1 of this report, will ensure impacts on wetlands are minimised.

General mitigation measures associated with protecting aquatic values and committed to by Arrow during the EIS will further reduce the environmental impacts on wetlands and aquatic habitat. These mitigation measures are also presented in Section 10.7.



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BOWEN GAS PROJECT SREIS

OVERVIEW OF IMPACT ASSESSMENT PROCESS FOR THE SURFACE WATER ENVIRONMENT

URS

AQUATIC ECOLOGY TECHNICAL REPORT

Figure: 10-3

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10.6.2 Potential Impacts to the Isaac River

The Aquatic Ecology Technical Report (Appendix O, Section 5) of the EIS details the general impacts to aquatic ecology values at a broader scale, and encompasses the greater Project development area. This report presents the potential impacts on aquatic values identified from the desktop investigation. The potential impacts from construction and operation of large infrastructure such as the CGPFs and WTFs may also be revised once site specific investigations have taken place.

As detailed in Section 10.4.1, the discharge of residual volumes of CSG water into adjacent watercourses may be necessary to ensure that coal seam production can continue during times where:

- Constraints to supply for beneficial use occur;
- Unforeseen events occur such as significant weather events;
- Operational upset conditions necessitate discharge; and
- The structural and operational integrity of dams is at risk.

Discharge to watercourses would occur within environmental flow requirements and in accordance with the relevant approval. The discharge rates, timing, frequency and duration of CSG water releases that will be considered as part of the EA process will address a number of variables including stream flows, stream water quality and CSG water quality. Under these circumstances, CSG water discharges would have insignificant impacts on the surface water receiving environment.

The potential impacts associated with the discharge of CSG water into watercourses are detailed below (Table 10-7), and are assessed for the following scenarios:

- Uncontrolled release of untreated CSG water;
- Uncontrolled release of treated CSG water;
- Uncontrolled release of both treated and untreated CSG water;
- Controlled release of untreated CSG water;
- Controlled release of treated CSG water; and
- Controlled release of both treated and untreated CSG water.

The potential impacts associated with the construction of the large infrastructure (CGPFs and WTFs) i.e. removal of aquatic or riparian vegetation, were addressed in the Project's EIS with no additional impacts identified during this assessment. As such, Table 10-7 only addresses the potential impacts on the aquatic environment from the discharge of CSG water. Further site specific assessments will be undertaken as part of the environmental authority approvals process.

An environmental flow (Spells) analysis was undertaken in conjunction with the aquatic technical report; the results are presented in the Hydrology and Geomorphology chapter (Section 9.3) and Hydrology and Geomorphology Technical Report (Appendix G) of the SREIS. Spells analysis provides an indication of the low and high flow regime under certain climatic conditions at a particular location within a catchment, using the available data record. The potential impact from the discharge of CSG water on hydrology and surface waters (and thus the receiving aquatic environment) can then be assessed. The potential impacts detailed in Table 10-7 below, has incorporated results from the Spells analysis, as applied to potential impacts on relevant aquatic ecological values.

Table 10-7 Impact Assessment for CSG Water Release Scenarios on the Isaac River

CSG Water Release Scenario	Contributing Factor	Potential Impacts	Magnitude of Impact	Significance of Impact
Uncontrolled release of *untreated* CSG water	Flooding (dams over capacity; inundation of infrastructure)	• Slight increase in receiving environment salinity, although unlikely to exceed receiving environment 80th percentile value of 428 µS/cm as Isaac River flows will likely be at greater than 75th percentile flow volume for flooding to occur; and • Salt tolerances of fish are presented in Appendix B of the Aquatic Ecology Technical Report (Appendix H) of the SREIS. All fish presented have tolerance to salt higher than the 80th percentile of the Isaac River. Increased salinity in receiving environment is thus likely to have a low to negligible impact on fish. However other aquatic flora and fauna with reduced tolerance to high salinity may be impacted.	Low	Low
	Dam failure	• During periods of low flow, sudden release of large volumes of CSG water will be outside of the natural flow regime; • Potential inundation of riparian margins not usually inundated during dry season; • Transport of large quantities of sediment and large woody debris downstream disturbing existing aquatic habitat (i.e. smothering of benthic habitat); and • During periods of high flow, there may be a slight increase in salinity within the receiving environment which may impact on aquatic fauna. However it is unlikely to exceed Isaac River 80th percentile value of 428 µS/cm. Salt tolerances of fish are presented in Appendix B of the Aquatic Ecology Technical Report (Appendix H) of the SREIS. All fish presented have tolerance to salt higher than the 80th percentile of the Isaac River. Increased salinity in the receiving environment is thus likely to have a low to negligible impact on fish. However other aquatic flora and fauna with reduced tolerance to high salinity may be impacted.	Moderate	Moderate
	WTF operational emergency	• Similar impacts to those listed above for dam failure.	Moderate	Moderate

CSG Water Release Scenario	Contributing Factor	Potential Impacts	Magnitude of Impact	Significance of Impact
Uncontrolled release of *treated* CSG water	Flooding (dams over capacity; inundation of infrastructure)	• Decrease in salinity within receiving environment (due to dilution). Greatest impact would be to hydrology, with an increase in water level and discharge; • Potential inundation of riparian margins areas; and • May result in mobilisation of sediment within the channel near discharge location, with transport of sediment 'slug' downstream resulting in degradation of downstream aquatic habitat.	Low	Low
	Dam failure	• During periods of low flow, sudden release of large volumes will be outside of the natural flow regime; • Potential inundation of riparian margins and floodplain areas not usually inundated during dry season; exacerbation of high water level during wet season resulting in degradation of downstream aquatic habitat; • Alteration of biological triggers e.g. fish spawning triggered by flood flows, and or uniformity in water temperature; and • Physical disturbance of aquatic habitat / substrate at the point of discharge.	Moderate	Moderate
	WTF operational emergency	• Similar impacts to those listed above for dam failure.	Moderate	Moderate
Uncontrolled release of both *treated and untreated* CSG water	Flooding (dams over capacity; inundation of infrastructure)	• Potential water quality impacts resulting from combined sources (higher salinity of treated CSG water, combined with large volumes of both streams) could be difficult to interpret; • Possible Increase salinity in the receiving environment (depending on ratio of untreated to treated CSG water). However, should flooding occur, overspills are likely to be quickly diluted in the receiving environment; • Potential inundation of riparian margins and floodplain areas; and • May result in mobilisation of sediment within channel near discharge location, with transport of sediment 'slug' downstream resulting in degradation of downstream aquatic habitat.	Low	Low
	Dam failure	• This event is considered to be highly unlikely (i.e. for more than one dam to fail on site at the same time), however if it did occur there may be the following impacts:	High	High

CSG Water Release Scenario	Contributing Factor	Potential Impacts	Magnitude of Impact	Significance of Impact
		— During periods of low flow, sudden release of large volumes (greater than annual volumes listed in the Surface Water Technical Report (Appendix F, Table 7-3 or Table 7-4) of the SREIS will be outside of the natural flow regime; — Potential inundation of riparian margins and floodplain areas not usually inundated during dry season; exacerbation of high water level during wet season; — Mobilisation and transport of large quantities of sediment and large woody debris downstream; — Physical disturbance of aquatic habitat/substrate at the point of discharge; and — During periods of high flow, there may be a slight increase in salinity within the receiving environment, however it is unlikely to exceed Isaac River 80th percentile value of 428 µS/cm.		
	WTF operational emergency	• This event is considered to have a higher probability of occurrence than for dam failure in the same scenario. It is more likely to be able to be moderated or controlled using emergency engineering solutions. However, the same impacts as listed for dam failure (above) would apply, albeit at a reduced extent.	Moderate	Moderate
Controlled release of untreated CSG water	Release according to environmental authority conditions (where beneficial use is not appropriate / available)	• Controlled release of untreated CSG water would only occur at levels governed by the environmental authority. As such the discharge rates, timing, frequency and duration of CSG water releases that will be considered as part of the EA process will address a number of variables including stream flows, stream water quality and CSG water quality. Under these circumstances, CSG water discharges would have insignificant impacts on the Surface Water receiving environment; and • The potential impact on aquatic ecology from CSG water discharge under EA conditions is considered low to negligible.	Low	Low to negligible

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CSG Water Release Scenario	Contributing Factor	Potential Impacts	Magnitude of Impact	Significance of Impact
Controlled release of *treated* CSG water	Release according to environmental authority conditions (where beneficial use is not appropriate / available)	• Controlled release of treated CSG water would only occur at levels governed by the environmental authority. As such the discharge rates, timing, frequency and duration of CSG water releases that will be considered as part of the EA process will address a number of variables including stream flows, stream water quality and CSG water quality. Under these circumstances, CSG water discharges would have insignificant impacts on the Surface Water receiving environment. • The potential impact on aquatic ecology from CSG water discharge under EA conditions is considered low to negligible.	Low	Low to negligible
Controlled release of both *treated and untreated* CSG water	Release according to environmental authority conditions (where beneficial use is not appropriate/available)	• Controlled release of treated and untreated CSG water would only occur at levels governed by the environmental authority. As such the discharge rates, timing, frequency and duration of CSG water releases that will be considered as part of the EA process will address a number of variables including stream flows, stream water quality and CSG water quality. Under these circumstances, CSG water discharges would have insignificant impacts on the Surface Water receiving environment. • The potential impact on aquatic ecology from CSG water discharge under EA conditions is considered low to negligible.	Low	Low to negligible

10.7 Mitigation Measures

10.7.1 Risk Based Framework

The risk based framework outlined in the Framework Approach chapter (Section 7) and the associated Constraints Mapping report (Appendix BB) of the EIS identifies the Project activities allowed to be undertaken within or near environmental values based on the inherent level of constraint.

As identified above, wetlands vary in ecological value, thus also vary in the level of constraint. Given this, surface water constraints are detailed below in Table 10-8 below. The Constraints Mapping report (Appendix BB) of the EIS outlines Project activities which can be undertaken within the differing levels of constraint.

Table 10-8 Surface Water Constraints

Sensitivity	Surface Water Value
No Go Zone	Within mapped wetlands, including: • Referable wetlands of High Ecological Significance; and • Non-riverine wetlands mapped as having high or very high ecological value in the GBR AquaBAMM report.
High	Within Watercourses.
	Within Waterways.
Moderate	Within 100 m of springs*.
	Within 200 m of mapped wetlands*, including: • Referable wetlands of High Ecological Significance; and • Non-riverine wetlands mapped as having high or very high ecological value in the GBR AquaBAMM report.
	Wetlands not shown on the map of referable wetlands*, including non-riverine wetlands mapped as having medium, low or very low ecological value in the GBR AquaBAMM report.
	Within 200 m of lakes*.
	Within 50 m of 1st and 2nd order waterways and watercourses*.
	Within 100 m of 3rd and 4th order waterways and watercourses*.
	Within 100 m of 5th order and above waterways and watercourses*.
Low	Nil.

* Buffers outlined above are indicative based on the current regulatory conditions and may be subject to change in the future

10.7.2 Wetland Mitigation Measures

The EIS committed to the adoption of riparian buffer zones [Commitment B196] along all watercourses with the exception of required creek crossings. The size of buffers is as defined by current regulatory conditions and level of constraint identified in the Project's constraints mapping as outlined in the

Environmental Framework chapter (Section 7), and detailed in Constraints Mapping (Appendix BB) of the EIS.

The application of buffers around non-riverine wetlands will reduce the impact from Project activities on these ecosystems. A 200 m buffer will be implemented around referable wetlands mapped as having HES. This buffer is consistent with guidelines supplied in the *State Development Assessment Provisions, Module 11: Wetland protection and wild river areas*. Non-riverine wetlands not mapped on the map of referable wetlands, but considered to support very high to high ecological value (as identified by the ACAs for the Fitzroy and Burdekin Catchment) will also have a 200 m buffer implemented.

It is recognised that wetlands of medium ecological value (Section 10.5.2.4) have potential to support aquatic values of conservation significance. To assist in mitigating impacts on these wetlands, pre-clearing surveys will be undertaken prior to development to quantify the presence of EVNT species or habitats. Following further field survey and revised mapping, possible habitat may be revised to "habitat known" or can be revised to areas in which the absence of EVNT habitat is known. This is consistent with commitments B132 and B155 as presented in the EIS (refer to Table 10-9).

The application of buffers and preclearance surveys as well as the general Project mitigation commitments listed in Table 10-9 below will minimise impacts on wetlands, with the aim that:

- Project activities are not undertaken within a wetland or within a wetland protection area;
- Adequate buffers are applied to wetlands of very high and high ecological significance;
- The existing surface water hydrological regime of the wetland protection area is maintained;
- The existing groundwater hydrological regime of the wetland protection area is protected;
- Development adjacent to the wetland protection area does not result in measurable change to the quantity or quality of stormwater entering the wetland;
- Vegetation clearing within the wetland or wetland buffer is avoided where possible;
- Wetland vegetation is retained where possible; and
- Construction activities do not introduce or exacerbate the occurrence of exotic flora and/or fauna.

10.7.3 Impact Mitigation for Construction and Operation of WTFs

An analysis of the project description changes potentially affecting aquatic ecology and an assessment of potential impacts as a result of the proposed development of the WTFs has been undertaken (Section 10.6.2). Generic mitigation and avoidance measures stipulated in the EIS remain relevant to mitigation of the impacts detailed in Section 10.6.2.

Project commitments to avoid and reduce significance of potential impacts assessed in this chapter are presented in Table 10-9 below. New and revised commitments are also presented below in Table 10-10. This update has resulted either from changes made to the project description since the EIS was finalised and the decision to further clarify the intent of a commitment (e.g., through the consolidation of similar commitments to avoid inconsistent wording).

A full list of all Project commitments, including those that remain unchanged from the EIS, and details of those that have changed, are detailed in the Commitments Update (Appendix O) of this SREIS.

Table 10-9 Project Commitments to Avoid and Reduce Significance of Impacts to Aquatic Ecology Values

Number	Commitment
B094	Inspect at risk erosion and sediment control measures following significant rainfall events to ensure effectiveness of measures is maintained.
B115	Use existing roads and designated access tracks, where practicable.
B172	Design washdown facilities to ensure that runoff is contained on site and does not transfer weed seeds, spores or infected soils to adjacent areas. Treat or dispose of washdown solids in a registered landfill.
B180	When sourcing maintenance materials, ensure that such materials as bedding sand, topsoil, straw bales and sand bags are brought to site only after it is ascertained that the materials are not contaminated with weeds and plant or animal pathogens. Request a weed hygiene declaration form from the supplier where there is possible risk of contamination in products.
B191	Develop a declared weed and pest management plan in accordance with the Petroleum Industry – Pest Spread Minimisation Advisory Guide (Biosecurity Queensland, 2008). Undertake species-specific management for identified key weed species at risk of spread through Project activities (mesquite, parthenium, African lovegrass and lippia). Increase weed control efforts in areas particularly sensitive to invasion. The pest management plan should include, as a minimum, training, management of pest spread, management of pest infestations and monitoring effectiveness of control measures.
B194	The use of vehicles and machinery near waterways will be avoided wherever possible and expected to be minimal.
B195	CSG water received from the field and brine concentrate will be managed in dams adjacent to WTFs.
B196	Buffer zones will be adopted for Project activities (with the exception of required creek crossings), in different areas of constraint, as defined by the project's constraints mapping (outlined in Section 7 and detailed in Constraints Mapping (Appendix BB) of the EIS). The buffers outlined below are indicative based on the current regulatory conditions; however these may be subject to change in future. The buffers that will be implemented for the project will be in line with the regulatory requirements at the time of implementation. Indicative buffers at this time include: • In areas mapped as high constraint a buffer of 100 m, measured from the bank edge, will be adopted during all phases of the Project, with a further 100 m constrained to low impact activities For areas mapped as moderate constraint, the following buffer zones, measured from the bank edge, will be adopted during all phases of the Project: • a riparian buffer of 50 m width on either side of first and second order streams.
B198	Construction of access tracks will be kept to a minimum, with the use of existing tracks and roads preferred wherever possible.
B199	Tracks will be restricted in riparian zones and durations of impacts minimised, except in the immediate vicinity of creek crossings.
B200	Where waterway crossings are unavoidable, measures will be taken to ensure that the movement of aquatic species is not impacted.
B201	During the design and construction of waterway crossings, care will be taken to minimise the footprint of the structure and to avoid unnecessary disturbance to stream beds and banks.
B202	Construction that will potentially affect waterways will occur during dry months (periods of low rainfall and low flow) where possible. The use of machinery and vehicles on stream beds and banks will be avoided wherever possible.
B203	Where the gathering line crosses waterways ensure that the trenching is perpendicular to the creek.

Number	Commitment
B204	Where practical the width of the easement would also be narrowed at these points, further reducing impacts on stream banks, beds and riparian zones by restricting the area of waterway that would be disturbed.
B205	Where possible trenching within or in the vicinity of watercourses would occur during the drier months of the year, which will reduce the potential for water quality decline as a result of sediment mobilisation.
B207	A Water Management Plan, Erosion and Sediment Control Plan, and Waste Management Plan will be designed to avoid or minimise the potential impacts of Project.
B208	Limit the use of herbicides in the vicinity of watercourses or within riparian zones. Use non-toxic, non-persistent (i.e., biodegradable) herbicides to treat weeds, except on properties where organic or biodynamic farming is practiced, for which the method of weed treatment is to be agreed with the landowner.
B209	Monitoring where required will be undertaken including water quality, aquatic macroinvertebrates, fish, and other aquatic / semi-aquatic fauna.
B210	A sampling program will be undertaken if discharge or emergency release is required.
B211	The reporting of monitoring analysis results would include both standalone and cumulative interpretation to provide for a comprehensive understanding of significant change, if any, over time.
B212	Environmental auditing processes would include both internal and external audit components to ensure consistency and compliance with the regulatory framework.
B213	Inspections will be carried out on an incident basis to determine potential impacts to aquatic environments resulting from pollution events; or potential pollution events.
B214	Where a discharge triggers a mandatory incident procedure that includes the need for point-source assessment, at a minimum, water quality would be assessed at the point source, as well as downstream of that point to the estimated downstream limit of impact.
B215	Routinely monitor buffer zones and Project footprint using satellite imagery.
B216	Visually inspect physical form and monitor hydrology, turbidity and pH upstream and downstream of crossings immediately prior to, during and after construction of watercourse crossings.
B217	Routinely inspect for pest flora and evidence of pest fauna species within Project disturbed areas.
B218	Monitoring where required will be undertaken including water quality, aquatic macroinvertebrates, fish, and other aquatic/semi-aquatic fauna.
B219	Routinely inspect spill containment controls and spill response kits.
B220	Minimise watercourse crossings, where practicable, during route selection. Where required, select crossing locations to avoid or minimise disturbance to aquatic flora, waterholes, watercourse junctions and watercourses with steep banks.
B221	Construct watercourse crossings in a manner that minimises sediment release to watercourses, stream bed scouring, obstruction of water flows and disturbance of stream banks and riparian vegetation (i.e., the crossing location will be at a point of low velocity, and straight sections will be targeted, with the pipeline or road orientated as near to perpendicular to water flow as practicable).
B222	Ensure flumes used to construct watercourse crossings are suitably sized to maintain flows and enable fish passage. Protect the bed of the watercourse from scouring at the site of the downstream discharge of any flumes or pipes.
B223	If diversion of watercourse flows using pumps is required, screen the pump intakes with mesh to protect aquatic life.
B224	Where appropriate, design ground disturbance works to minimise the need for cut-and-fill

Number	Commitment
	earthworks.
B225	Avoid transport of equipment across watercourses unless an appropriate crossing that minimises disturbance to the watercourse bed and banks and to riparian vegetation is available.
B226	Design watercourse crossings to enable passage of flows resulting from a 1 in 100 year average recurrence interval flood event, as a minimum.
B227	Design gathering lines and tracks to avoid watercourses, drainage lines and riparian areas (particularly permanent watercourses or perennial aquatic habitat), where practicable.
B228	Design the width of the pipeline RoWs to be narrower at watercourse crossings,where practicable.
B229	Co-locate pipelines into one watercourse crossing corridor, where practicable.
B230	Plan construction and maintenance activities to minimise movement of plant and equipment between properties or areas with weed infestations.
B231	Identify declared weeds during the preconstruction clearance survey.
B232	Store stockpiled, cleared vegetation away from watercourses or drainage lines.
B233	Backfill and rehabilitate excavations, particularly pipeline trenches and drilling sumps. Conduct backfilling in a manner that will promote successful rehabilitation, including capping of exposed subsoil with topsoil and replacement of the land surface to preconstruction levels to reduce trench subsidence and concentration of flow. Mounding of soils to allow for settling may be required in some areas. However, in laser-levelled paddocks, this may not be practicable, and backfilling should be carried out in consultation with the landowner.
B345	Incorporate into an emergency response plan or water management plan procedures for the controlled discharge of CSG water.
B391	Onsite waste storage areas will be developed in accordance with industry practice and relevant waste management regulations.

Table 10-10 Revised Mitigation Commitments Associated with Aquatic Ecology

Number	Revised Commitments	Rationale
B172	Design wash down facilities to ensure that runoff is contained on site and does not transfer weed seeds, spores or infected soils to adjacent areas.	Amended to clarify intent
B194	Minimise exposure of vehicles and machinery to waterways wherever possible during construction.	Amended to clarify intent
B195	CSG water produced from the field and brine concentrate will be transferred to purpose built dams.	Amended to clarify intent
B196	Buffer zones will be adopted for Project activities (with the exception of required creek crossings), in different areas of constraint, as defined by the project's constraints mapping (outlined in Section 7 and detailed in Constraints Mapping (Appendix BB of the EIS).	Amended to clarify intent

10.8 Residual Impacts

Residual impacts on aquatic ecology values from Project activities were outlined in the Aquatic Ecology chapter (Section 10) of the EIS. Within the EIS, the potential impacts from Project activities (also listed in Section 10.6.1 above) and specific avoidance and mitigation measures are described.

The potential residual impacts on aquatic values, with consideration given to the project description changes, were reviewed. A summary of residual impacts on aquatic values following the application of mitigation measures are outlined in Table 10-11 below.

As presented in Table 10-11, the consideration of mitigation measures has minimised the potential for impact on the aquatic environment, particularly those associated with erosion and sedimentation impacts (during the construction phase). Sedimentation of aquatic habitats such as wetlands and waterways, presents the greatest risk to aquatic ecosystems through the degradation of habitat and potential introduction of contaminants, both potentially impacting water quality. However, the application of measures such as constraint buffers around sensitive locations (i.e. referable wetlands) coupled with industry standard erosion and sedimentation management practices will reduce the potential impacts on these systems.

The residual impacts on aquatic values within the reaches of the Isaac River associated with the WTF localities are still considered moderate given the magnitude of specific release scenarios such as the uncontrolled release of untreated CSG water.

Table 10-11 Residual Impacts to Aquatic Values Potentially Arising from Project Activities

Project Component	Associated Potential Impacts	Applicable Mitigation Measures	Residual Impact	Magnitude of Residual Impact	Significance of Residual Impact
Drainage areas	• Alteration of flows and flow paths; • Degradation of aquatic habitats from erosion and sediment mobilisation; • Improper disposal of wastes from construction and operations activities; and • Potential release of contaminants to watercourses (adverse effects on aquatic habitats).	• Those listed in Section 10.7 of this report; • Mitigation measures outlined in the Aquatic Ecology chapter (Section 16.6) and Aquatic Ecology Technical Report (Appendix O, Section 6) of the EIS still apply; and • Mitigation measures outlined in the Surface Water Technical Report (Appendix N, Sections 9.2.2.1, 9.2.2.2 and 9.2.2.3) of the EIS still apply.	• Potential release of sediment and contaminated water to aquatic ecosystems if management controls fail (for example, sediment fence is washed away).	Low	Low
Production wells	• Alteration of flows and flow paths; and • Degradation of aquatic habitats from erosion and sediment mobilisation.	• Those listed in Section 10.7 of this report; • Mitigation measures outlined in the Aquatic Ecology chapter (Section 16.6) and Aquatic Ecology Technical Report (Appendix O, Section 6) of the EIS still apply; and • Mitigation measures outlined in the Surface Water Technical Report (Appendix N, Sections 9.2.2.1, 9.2.2.2 and 9.2.2.3) of the EIS still apply.	• Potential exists for localised impacts on aquatic ecosystems. For example, larger volumes of sediment may be mobilised from larger multi-well pads. Resulting in localised impacts on aquatic ecosystems (i.e. reduced water quality and possible	Low	Low to negligible

Project Component	Associated Potential Impacts	Applicable Mitigation Measures	Residual Impact	Magnitude of Residual Impact	Significance of Residual Impact
			smothering of benthic habitat).		
Linear infrastructure	• Alteration of flows and flow paths; and • Degradation of aquatic habitats from erosion and sediment mobilisation.	• Those listed in Section 10.7 of this report; • Mitigation measures outlined in the Aquatic Ecology chapter (Section 16.6) and Aquatic Ecology Technical Report (Appendix O, Section 6) of the EIS still apply; and • Mitigation measures outlined in the Surface Water Technical Report (Appendix N, Sections 9.2.2.1, 9.2.2.2 and 9.2.2.3) of the EIS still apply.	• Whilst a reduced area of disturbance from the EIS, potential exists for localised impacts on aquatic ecosystems. In particular, the potential release of sediment into waterways and watercourses where pipeline and road crossings occur.	Low	Low to negligible
Gas compression infrastructure	• Alteration of flows and flow paths; and • Degradation of aquatic habitats from erosion and sediment mobilisation.	• Those listed in Section 10.7 of this report; • Mitigation measures outlined in the Aquatic Ecology chapter (Section 16.6) and Aquatic Ecology Technical Report (Appendix O, Section 6) of the EIS still apply; and • Mitigation measures outlined in the Surface Water Technical Report (Appendix N, Sections 9.2.2.1, 9.2.2.2 and 9.2.2.3) of the EIS still apply.	• Potential exists for localised impacts on aquatic ecosystems. For example, larger volumes of sediment may be mobilised from larger multi-well pads. Resulting in localised impacts on aquatic ecosystems (i.e. reduced water quality and possible smothering of benthic habitat).	Low	Low to negligible
Water treatment facilities					
Uncontrolled release of *untreated* CSG water	• Potential adverse effects on surface water quality and thus receiving	• Those listed in Section 10.7 of this report; • Mitigation measures outlined in the Aquatic Ecology chapter (Section 16.6) and Aquatic	• Uncontrolled release of large volumes of untreated CSG water during times of low flow will have the	Moderate	Moderate

Project Component	Associated Potential Impacts	Applicable Mitigation Measures	Residual Impact	Magnitude of Residual Impact	Significance of Residual Impact
	aquatic environments; and • Transport of large quantities of sediment and large woody debris downstream disturbing existing aquatic habitat (i.e. smothering of benthic habitat).	Ecology Technical Report (Appendix O, Section 6) of the EIS still apply; • Mitigation measures outlined in the Surface Water Technical Report (Appendix N, Sections 9.2.2.1, 9.2.2.2 and 9.2.2.3) of the EIS still apply; and • Section 9.2.2.4 of the Surface Water Technical Report (Appendix N) of the EIS specifically applies to any releases from WTFs to the receiving environment, along with information outlined in Sections 9.1 and 9.2 of the same report.	following potential impacts: — During periods of high flow, potential residual impact to aquatic habitat (e.g. large woody debris) by flushing or degradation (e.g. smothering of benthic habitat); and — During periods of no flow, minimal direct residual impact on aquatic fauna (e.g. fish due to the likely absence of most aquatic species during low flow conditions. Secondary residual impacts on aquatic fauna may occur by the removal and/ or degradation of aquatic habitat.		
Uncontrolled release of *treated* CSG water	• Dilution of receiving environment water resulting in decreased salinity (high flow conditions); and • Sedimentation and/or removal of aquatic habitat.		• Residual impact from uncontrolled release of CSG water (treated) will have greatest impact on aquatic habitat through removal or degradation processes.	Moderate	Moderate

Project Component	Associated Potential Impacts	Applicable Mitigation Measures	Residual Impact	Magnitude of Residual Impact	Significance of Residual Impact
Uncontrolled release of both *treated and untreated* CSG water	• Potential water quality impacts from combined sources including increase salinity; and • Loss or degradation of aquatic habitat.		• Residual impact from uncontrolled release of CSG water (treated and untreated) will have greatest impact on aquatic habitat through removal or degradation processes.	Moderate	Moderate
Controlled release of *untreated* CSG water	• Increase of water level as governed by EA conditions.		• Increased water level and flow volume in receiving environment.	Low	Low to negligible
Controlled release of *treated* CSG water	• Release according to environmental authority conditions (where beneficial use is not appropriate / available).		• Increased water level and flow volume in receiving environment.	Low	Low to negligible

10.9 Monitoring and Reporting

Monitoring and reporting will follow the frameworks set out in the EIS. The EIS monitoring recommendations detailed below will be complimented by the surface water values monitoring program outlined in the Surface Water Technical Report (Appendix F) of the SREIS.

10.9.1 Water Quality Monitoring During Construction and Operation

Commitments identified in the EIS which encompass the mitigation and monitoring detailed above include:

- A Water Management Plan, Erosion and Sediment Control Plan, and Waste Management Plan will be designed to avoid or minimise the potential impacts of Project [B207];
- Monitoring, where required, will be undertaken including water quality, aquatic macroinvertebrates, fish, and other aquatic / semi-aquatic fauna [B209];
- A sampling program will be undertaken if discharge or emergency release is required [B210];
- The reporting of monitoring analysis results will include both standalone and cumulative interpretation to provide for a comprehensive understanding of significant change, if any, over time [B211];
- Where a discharge triggers a mandatory incident procedure that includes the need for point-source assessment, at a minimum, water quality would be assessed at the point source, as well as downstream of that point to the estimated downstream limit of impact [B214];
- Routinely inspect for pest flora and evidence of pest fauna species within Project disturbed areas [B217]; and
- Incorporate into an emergency response plan or water management plan procedures for the controlled discharge of CSG water [B345].

10.9.2 Release of Treated CSG Water to Natural Watercourses

The release of treated CSG water to natural watercourses is discussed in detail in Surface Water Technical Report (Appendix F) of the SREIS.

10.10 Conclusion

The supplementary assessment of aquatic values reviewed Project description changes and updates to relevant State or Commonwealth legislation since the submission of the EIS. This review identified new potential impacts from the proposed development as well as provided mitigation measures. Submission responses made following the public consultation stage of the EIS were also addressed.

The assessment outlined above, identified new potential impacts associated with the potential for discharge of CSG water. Target areas for potential water discharge locations were identified within reaches of the Isaac River associated with the potential localities of WTF facilities. A literature review of these areas was undertaken and aquatic values described.

Section 10 Aquatic Ecology

The assessment of aquatic values within the Isaac River describes the river as typically homogeneous throughout the Moranbah region with little natural variation. Instream habitat generally consists of intermittent pools and runs, with edgewaters providing habitat during flows. Twelve fish species have been previously recorded within the river near the reaches of the Isaac River as potential discharge areas.

No fish of conservation significance were identified. The water quality tolerance of fish recorded within the Isaac River was reviewed with water quality encountered at the sites being well within the tolerance ranges for most fish species.

Macroinvertebrate sampling undertaken during existing studies determined that the discharge locations achieved a AusRivAS modelling band of B, inferring that the discharge locations are slightly impacted and support fewer taxa than would be expected under reference conditions.

The Fitzroy River turtle was identified during the literature review as possibly occurring. However, review of habitat preferences and habitat within the Isaac River suggest this species is highly unlikely to occur given the absence of permanent flowing water, Suitable habitat for this species is found to the south-east of the Project area where permanent flowing exists downstream. Potential habitat mapping and a species profile and impact assessment for the Fitzroy River turtle is provided in the MNES report (Appendix J) of the SREIS.

EIS Submission responses recommended further review of wetlands within the Project area. A revised review of wetland values was undertaken using a range of literature sources and GIS analysis.

Wetlands within the Project area include referable wetlands of high ecological significance. The number and location of wetlands within the Project area are detailed in Section 10.5.2.4. The potential impacts identified from changes to the project description were reviewed. The reduction in infrastructure resulted in a reduction in impact intensity of development on a regional scale. However, an increase in localised potential impacts may occur.

The potential impacts resulting from the discharge of CSG water was also assessed against a range of scenarios, including the release of treated and untreated water during controlled or uncontrolled conditions.

Whilst the uncontrolled release of both untreated and/or treated CSG water is an unlikely occurrence, the impact assessment identified that the uncontrolled release of untreated and/or treated CSG water pose the greatest risk to the aquatic values through loss and degradation of habitat. However, the application of mitigation measures determined that residual impacts are reversible and temporary with a resulting moderate significance.