10. AQUATIC ECOLOGY

This chapter of the supplementary report to the EIS (SREIS) summarises the findings of the supplementary aquatic ecology assessment undertaken to address updates to the project description made since the Surat Gas Project Environmental Impact Statement (EIS) (Coffey Environments, 2012b) was finalised.

The Supplementary Aquatic Ecology Assessment, prepared by AMEC Environment and Infrastructure Australia Pty Ltd (AMEC), is provided in Appendix 8. The study supplements the Aquatic Ecology Impact Assessment presented in Appendix J of the EIS, the main findings of which are summarised in Chapter 16 of the EIS. The study and this chapter also presents the aquatic ecology findings of the preliminary environmental flows assessment, conducted by Alluvium and attached as Appendix 7, Supplementary Surface Water Assessment Part C – Preliminary Environmental Flows Assessment.

The revised project description is provided in Chapter 3, Project Description; however, aspects relevant to aquatic ecology are also discussed in this chapter.

Matters of national environmental significance identified through the supplementary aquatic ecology assessment and presented in this chapter are also presented in Attachment 1, Matters of National Environmental Significance.

In addition to the study findings, a list of topics raised in submissions is presented, with responses to all issues provided in Part B, Chapter 19, Submission Responses, and Chapter 20, Response to DERM Submission. An updated commitments list is also provided, showing new and updated commitments as a result of this study.

Geomorphology, hydrology and water quality are detailed in Chapter 9, Surface Water. Semi-aquatic mammals, amphibians, reptiles, avifauna, wetland birds and riparian vegetation have been addressed in Chapter 11, Terrestrial Ecology.

10.1 Studies and Assessments Completed for the EIS

This section provides a summary of the aquatic ecology studies completed for the Surat Gas Project EIS and the main conclusions from that assessment.

Aquateco Pty Ltd (Aquateco) was engaged to conduct the aquatic ecology impact assessment, and the findings of the study are presented in Appendix J of the EIS. The aquatic ecology impact assessment undertaken as part of the EIS comprised a desktop study and field surveys of representative sites within and surrounding the project development area. Aquatic ecological values were identified for permanent, semi-permanent and ephemeral watercourses; and an assessment was conducted of the potential for these values to be affected by direct and indirect impacts associated with project activities.

The desktop study comprised an intensive review of existing data and information of aquatic ecology for the project development area, as well as surrounding drainage basins. The study included a detailed literature review and searches of the following government and non-government databases and other sources:

- Protected Matters Search Tool. The coordinates searched can be found in the EPBC referral (No. 2010/5344), available on the DSWEPAC website, and also within Appendix K of the EIS.

- Aquatic Conservation Assessments where AquaBAMM is used to assess the conservation and ecological value of wetland systems within the Condamine Basin, based on a series of national and international criteria including naturalness, diversity and richness, threatened species and ecosystems, priority species and ecosystems, special features, connectivity and representativeness (Clayton et al., 2008).
- Wildlife Online Database (DERM, 2010h).
- The Murray Darling Basin Commission for sources of fish data over a range of time spans in the Condamine and Weir rivers catchments.
- A review of recreational fishing clubs, associations and values within the area.

The regional surface water environment was found to be represented by four drainage basins, all of which intersect the project development area: Condamine-Balonne Basin (Condamine River and Balonne River sub-basin), Fitzroy Basin (Dawson River sub-basin), Border Rivers Basin (Macintyre and Weir rivers and Macintyre Brook sub-basins), and Moonie Basin (Moonie River sub-basin). The Condamine-Balonne, Border Rivers, and Moonie basins form part of the Murray-Darling drainage division, while the Fitzroy Basin is part of the North-East Coast drainage division.

A field reconnaissance trip was undertaken to assess 73 sites identified through the desktop assessment as being potentially suitable for ground truthing. A total of 11 sites were field surveyed as they were considered to be representative of the ecological conditions of the study area with regard to human, climatic and physical influences on aquatic ecology. Permanent watercourses represented nine of the sites surveyed, and ephemeral watercourses represented two of the sites. Several watercourses, including ephemeral watercourses that drain into the Dawson River and Macintyre and Weir rivers sub-basins, were dry at the time of sampling and were not sampled for aquatic flora and fauna.

The field surveys were completed in November 2009 (early wet season) and May 2010 (post wet season) to allow a comparison of variation in watercourse condition.

Field surveys identified 23 species of native aquatic flora and 14 species of native fish. No nationally significant aquatic flora or fauna listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) or any aquatic flora or fauna species of state significance listed under the *Nature Conservation Act 1992* (Qld) were identified. The field surveys also identified three introduced aquatic flora species and three introduced aquatic fauna species, with two of the fauna species listed under the *Land Protection (Pest and Stock Route Management) Act 2002* (Qld).

Site-specific assessments of the impact of project infrastructure on aquatic ecology values were not undertaken because the location of infrastructure was not known. However, impacts of the project activities required to construct, operate and maintain project infrastructure were known from existing operations and formed the basis for the assessment. The EIS also presented a qualitative discussion on discharge of coal seam gas water under emergency conditions during high-flow events.

The likely key impacts identified in the EIS as a result of the project related to erosion and sediment transport; decline in water quality and increased algal blooms; introduction of aquatic weeds; reduced movement of aquatic biota; and habitat loss, modification or fragmentation.

Conceptual layouts of production facilities and typical arrangements of gathering systems, high-pressure pipelines, production wells and access tracks were used to identify and assess the

impacts by evaluation of the sensitivity of aquatic ecosystems to change. The sensitivity of the aquatic ecosystems to change was the basis for the magnitude of impact and the mitigation measures proposed to manage the impacts.

The EIS found that the implementation of the proposed mitigation measures reduced the overall significance of residual impacts to low for permanent and semi-permanent watercourses and negligible for ephemeral watercourses for each of the identified potential impacts.

Mitigation and management measures proposed by Aquateco were presented as commitments in the EIS (Attachment 8, EIS Commitments Summary). The commitments presented in the EIS are listed in Table 10.1.

Table 10.1 Aquatic ecology commitments presented in the EIS

No.	Commitment
C020	Minimise the disturbance footprint and vegetation clearing.
C024	Install and maintain diversion drains to divert clean surface runoff water around production facilities and away from construction areas.
C033	Confine project traffic to designated roads and access tracks, where practicable.
C034	Develop an erosion and sediment control plan and install and maintain appropriate site-specific controls.
C035	Apply appropriate international, Australian and industry standards and codes of practice for the handling of hazardous materials (such as chemicals, fuels and lubricants).
C036	Develop and implement emergency response and spill response procedures to minimise any impacts that could occur as a result of releases of hazardous materials or any loss of containment of storage equipment.
C037	Ensure appropriate spill response equipment, including containment and recovery equipment, is available on site.
C038	Carry out corrective actions immediately upon the identification of any contamination of soil or groundwater that has occurred as a result of project activities.
C043	Complete excavation, remediation, characterisation and validation activities in response to the identification of contamination that may have occurred as a result of project activities.
C048	Apply appropriate international, Australian and industry standards and codes of practice for the design and installation of infrastructure associated with the storage of hazardous materials (such as chemicals, fuels and lubricants).
C066	Discharge water from project activities at a rate and location that will not result in erosion. Install additional erosion protection measures, including energy dissipation structures, at discharge outlets.
C069	Incorporate into an emergency response plan or water management plan procedures for the controlled discharge of coal seam gas water under emergency conditions. Procedures will include water balance modelling, weather monitoring and forecasting, stream flow data, notification and reporting.
C071	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.
C099	Wash down vehicles and equipment that have potentially been in contact with weeds before entering new work sites.
C152	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.

Table 10.1 Aquatic ecology commitments presented in the EIS (cont'd)

No.	Commitment
C156	Manage potential impacts on Lake Broadwater Conservation Park (Category A ESA) through implementation of the relevant buffer proposed in Table 2.
C157	Implement a 100-m buffer zone from the high bank of all watercourses to ensure that no development or clearance occurs within these buffers (other than construction of watercourse crossings for roads, pipelines and discharge infrastructure and associated stream monitoring equipment).
C161	Plan construction of watercourse crossings to occur during periods of low rainfall and low flow, when practicable.
C179	Ensure all relevant personnel are made aware of the location and extent of weed infestations in the vicinity of the work area and the risks involved in moving from one site or property to another.
C180	Do not wash down vehicles in watercourses.
C181	Avoid the use of vehicles and machinery in the vicinity of or within watercourses and riparian zones, wherever practicable.
C182	Locate self-contained portable toilet facilities at designated work sites at appropriate distances from watercourses, ensuring that they are accessible to all operations personnel and are regularly maintained. Dispose of sewage and greywater from toilet facilities via a chemical treatment system or transport to a municipal sewage plant using a licensed contractor.
C183	Where appropriate, design ground disturbance works to minimise the need for cut-and-fill earthworks.
C184	Design watercourse crossings to enable passage of flows resulting from a 1 in 100 year average recurrence interval flood event, as a minimum.
C185	Design the width of the pipeline ROWs to be narrower at watercourse crossings, where practicable.
C186	Co-locate pipelines into one watercourse crossing corridor, where practicable.
C187	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.
C188	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.
C189	Plan construction and maintenance activities to minimise movement of plant and equipment between properties or areas with weed infestations.
C190	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.
C191	Design gathering lines and tracks to avoid watercourses, drainage lines and riparian areas (particularly permanent watercourses or perennial aquatic habitat), where practicable.
C192	Obtain all relevant permits required under the Fisheries Act 1994 (Qld), including permits for construction of waterway barriers or disturbance of fish habitat.
C193	Identify declared weeds during the preconstruction clearance survey.
C194	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.

Table 10.1 Aquatic ecology commitments presented in the EIS (cont'd)

No.	Commitment
C196	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.
C197	Store stockpiled, cleared vegetation away from watercourses or drainage lines.
C198	If diversion of watercourse flows using pumps is required, screen the pump intakes with mesh to protect aquatic life.
C199	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 practised, for which the method of weed treatment is to be agreed with the landowner.
C505	Inspect erosion and sediment control measures following significant rainfall events to ensure effectiveness of measures is maintained.
C507	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.
C508	Routinely inspect for pest flora and evidence of pest fauna species within project disturbed areas.
C509	Routinely monitor buffer zones and project footprint using satellite imagery.
C516	Routinely inspect spill containment controls and spill response kits.
C531	Routinely visually inspect physical form integrity, macroinvertebrates, flow, turbidity, total suspended solids, pH, dissolved metals and total petroleum hydrocarbons upstream and downstream of authorised locations where water is discharged directly to a watercourse.

10.2 Study Purpose

The supplementary aquatic ecology assessment was undertaken to address updates to the project description, to provide additional information made available since publication of the EIS, and to incorporate legislative updates that may impact on the management of aquatic ecology. A summary of relevant information is presented in the following sections.

The purpose of the aquatic ecology assessment was to:

- Describe general aquatic ecology values of the properties now identified for locating project infrastructure.
- Further characterise the aquatic ecology environment in the Dawson River and the Macintyre and Weir rivers sub-basins (these sub-basins were dry at the time that sampling was conducted for the EIS).
- Provide a detailed description of the aquatic ecology values in watercourses proposed to receive discharges of coal seam gas water from two water treatment facilities and to identify the potential impacts and mitigation measures from the discharge to the receiving environment.

10.2.1 Project Description Updates

Updates to the project description presented in the EIS that have the potential to change or refine the EIS aquatic ecology impact assessment are described below.

Field Development Concept

A field development concept based on five development regions was presented in the EIS. The field development concept has evolved and is now based on 11 drainage areas. Each drainage area is defined by the production wells and associated water and gas gathering network required to service a central gas processing facility (CGPF). The CGPFs have been identified by the drainage area in which they will be built e.g., CGPF2 is located in drainage area 2 (DA2). The number of CGPFs has been reduced from the 12 described in the EIS to 8, and the number of water treatment facilities has been reduced from the 6 described in the EIS to 2. The water treatment facilities will be co-located with CGPF2 and CGPF9.

Project Development Area

Since publication of the EIS, Arrow has relinquished parcels of land as a result of ongoing exploration and improved knowledge of the coal seam gas reserves. The revised project development area (shown in Figure 9.1) has changed the extent of basins and sub-basins (as described in Chapter 15 of the EIS) within the project development area. The updated extents are summarised in Table 10.2.

Table 10.2 Updated drainage divisions, basins and sub-basins within the project development area

Drainage Division	Basin	Sub-basin	Percentage of the Project Development Area within the Sub-basin (%)	Project Development Area as a Percentage of the Sub-basin (%)
Murray-Darling	Condamine-Balonne	Balonne River	17.23	2.74
		Condamine River	61.01	12.24
	Border Rivers	Macintyre Brook	1.5	2.12
		Macintyre and Weir Rivers	12.42	4.91
	Moonie	Moonie River	0.98	0.40
North-East Coast	Fitzroy	Dawson River	6.86	0.82

Siting of Facilities

Arrow has identified four properties on which CGPF2, CGPF7, CGPF8 and CGPF9 will be located. A fifth property located in drainage area 9 has been identified by Arrow for a temporary workers accommodation facility (TWAF) identified as TWAF F. It is intended that all properties identified for major facilities will be either owned by Arrow or leased under a long-term arrangement. The exact siting of the facilities on each property is still being investigated.

Consequently, this assessment has focused on identifying and assessing the site-specific impacts of development across each of these five properties, not at a specific location within each property. In this chapter the properties will be referenced by the CGPF or TWAF to be developed on the property e.g., CGPF2 property and TWAF F property. The findings of this study and environmental constraints identified in the EIS and updated as part of the SREIS process will inform the final siting of infrastructure on the properties.

Figure 9.1 presented in Chapter 9, Surface Water shows the location of the properties identified to site the CGPFs, TWAF F and the water treatment facilities.

Capacity of Water Treatment Facilities

The EIS stated that the six water treatment facilities would have a capacity of 30 to 60 ML/d each. The updated project description proposes only two water treatment facilities that will have larger capacities. The northern water treatment facility, co-located with CGPF2, will potentially treat approximately 35 ML/d of coal seam gas water. The southern water treatment facility, co-located with CGPF9, will potentially treat approximately 90 ML/d of coal seam gas water.

Both facilities will discharge coal seam gas water to nearby watercourses under normal operations and emergency situations to manage variations in seasonal conditions and for distribution to existing and new water users for beneficial use and injection to a suitable aquifer. These discharges will occur as required and will be within prescribed limits, to be determined by subsequent investigations that will support the applications for an environmental authority or environmental authority amendment.

10.2.2 Additional Information

The EIS was unable to assess watercourses within the Dawson River and Macintyre and Weir rivers sub-basins due to unfavourable weather conditions resulting in the watercourses being dry during the period of assessments. The aquatic ecology assessment for the SREIS includes sites in the Dawson River and Macintyre and Weir rivers sub-basins to provide further information on the aquatic values in these areas.

10.2.3 Legislative Update

Legislation, policies and guidelines related to the protection of aquatic ecological values in the project development area are described in Chapter 16 of the EIS. The SREIS aquatic ecology study considered two additional documents that are described below.

- **Coal Seam Gas Water Management Policy 2012**. This policy replaces Queensland's Coal Seam Gas Water Management Policy 2010, that was developed to provide direction on the treatment and disposal of coal seam gas water and of the role the government wants to play in facilitating greater beneficial use. The updated policy presents a hierarchy of the methods to be employed by coal seam gas operators to manage coal seam gas water and saline waste.
- **Healthy Headwaters Coal Seam Gas Water Feasibility Study** (DSITIA, 2012). This three year study, carried out by the Queensland Government and funded by the Commonwealth, consisted of nine activities to address sustainability and adjustment issues in the Queensland section of the Murray-Darling Basin by analysing the opportunities and risks and practicality of using coal seam gas water. Activity 4, stream ecosystem health response to coal seam gas water release, was reviewed to understand the relevance of aquatic ecology values in the project development area. The documents for Activity 4 also provided information on the potential impacts to environmental values and water quality of receiving systems of coal seam gas discharge and identified potential hazards with different flow regimes.

Reports released since the submission of the EIS outline species of conservation significance under the Aquatic Conservation Assessments (Fielder et al., 2011; Inglis & Howell, 2009a, b) and Back On Track species prioritisation framework (DERM, 2010b). These reports highlighted several new species of local significance, which were considered in the supplementary aquatic ecology assessments.

10.3 Study Method

The supplementary aquatic ecology study comprised a desktop assessment and field surveys of the Dawson River and Macintyre and Weir rivers sub-basins and the receiving environments of the two proposed potential discharge locations identified to be released from the CGPF2 and CGPF9 properties. A visual inspection was undertaken at the CGPF7, CGPF8 and TWAF F properties to identify the presence of aquatic ecosystems. Figure 10.1 shows the location of the aquatic ecology sites sampled in the Dawson River and Macintyre and Weir rivers sub-basins, the sites sampled for the two proposed receiving environments of discharge, and the properties inspected in relation to the project development area. A preliminary environmental flows assessment and an impact assessment was also conducted for the discharge of coal seam gas water to the receiving environments.

10.3.1 Desktop Assessments

The supplementary aquatic ecology assessment included a desktop review of the information sources utilised in the EIS to capture any updates, as well as a review of additional sources identified following submission of the EIS. These key information sources were reviewed in relation to the project development area (or within a 10-km radius of survey sites situated outside of the project development area).

The sources reviewed in addition to those in the EIS were:

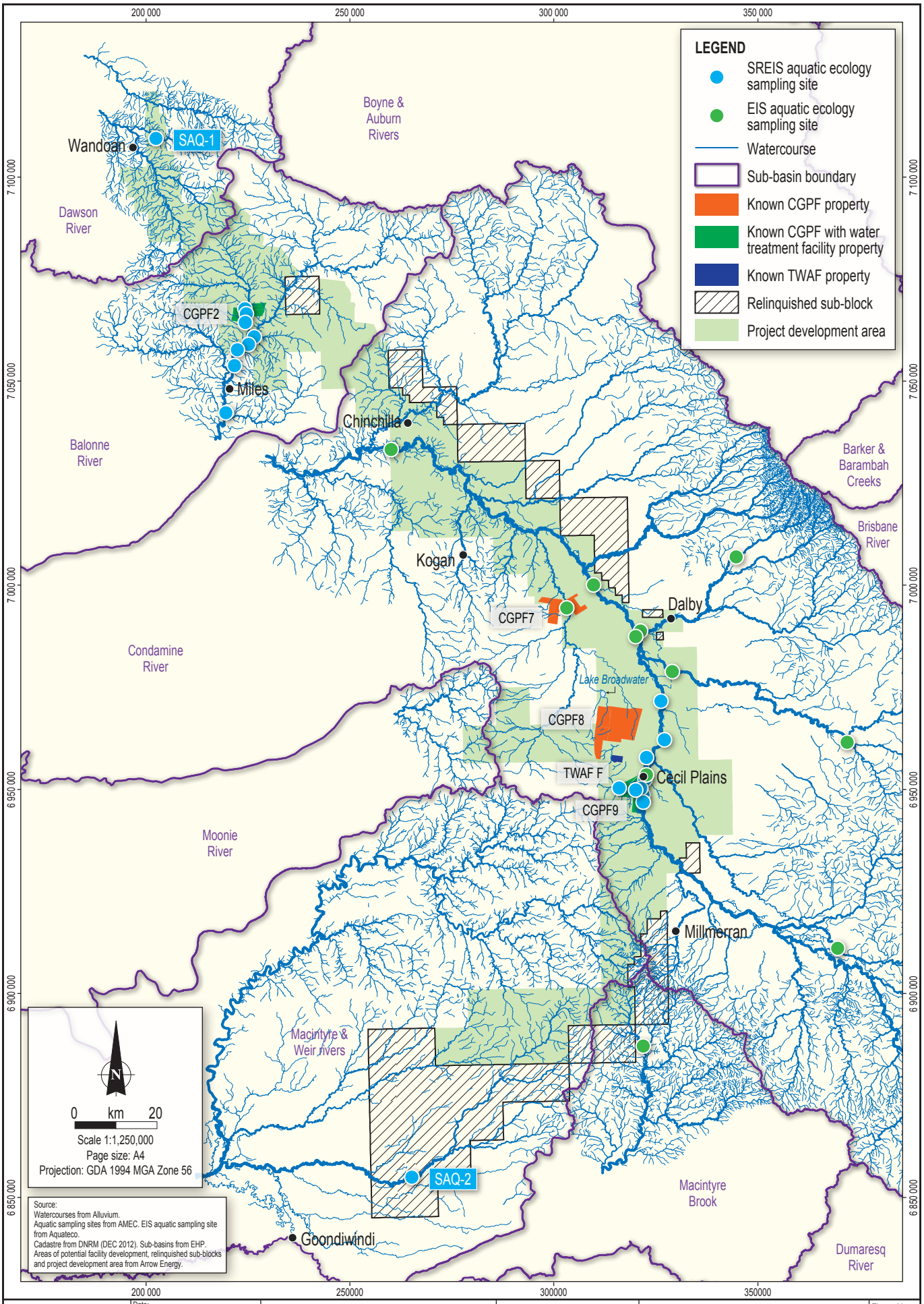
- Aquatic Conservation Assessments (ACAs) for the riverine and non-riverine wetlands of the Queensland Murray-Darling Basin (Fielder et al., 2011) and ACAs for the riverine and non-riverine wetlands of the Great Barrier Reef catchment (Inglis & Howell, 2009a, b). An ACA provides baseline wetland conservational and ecological information. ACAs also incorporate the identification of ‘priority’ species for conservation purposes.
- Results from the Back on Track species prioritisation framework (Back on Track) for the Condamine Natural Resource Management (NRM) region (DERM, 2010b), Border Rivers Maranoa-Balonne NRM region (DERM, 2010a) and Fitzroy NRM region (DERM, 2010c). Back on Track aims to identify priority threatened species that require conservation and suggests recovery actions for species in each region.
- Information on species ecology such as distribution and habitat requirements, using a variety of sources specific to fish, reptiles, invertebrates and water plants.

10.3.2 Field Surveys

The aquatic ecology sites were sampled and surveyed during February, March and May 2013, in accordance with methods employed for the EIS surveys. The sites sampled in May were within 250 m of the sites sampled during February and March (see Figure 10.1). Exact coordinates for all sites can be found in Appendix 8, Supplementary Aquatic Ecology Assessment.

The surveys at CGPF7, CGPF8 and TWAF F were limited to visual inspections. The aim was to describe the aquatic ecology values at these sites and to identify potentially sensitive areas that should be considered in future development at these properties.

A single site located on Weringa Creek (SAQ-1) (see Figure 10.1) was selected to represent the Dawson River sub-basin within the project development area. One site was considered adequate as only a small portion of the project development area is within the sub-basin, the tributaries are highly ephemeral and aquatic habitat is relatively uniform.



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File Name: 7040_12_F10.01_GIS_HB

Arrow Energy

Surat Gas Project

arrow energy go further

Sites sampled and properties inspected for the aquatic ecology assessment

Figure No: 10.1

The relinquishment of tenements by Arrow means that only a small portion of the project development area now intersects the Macintyre and Weir rivers sub-basin. A single site located on Commoron Creek (SAQ-2) (see Figure 10.1) was selected to represent this sub-basin. Whilst this site is located outside the project development area, it will still serve to characterise aquatic ecosystems potentially impacted by project activities. These habitats are downstream of project activities and could be impacted through modifications to water quality and/or flows.

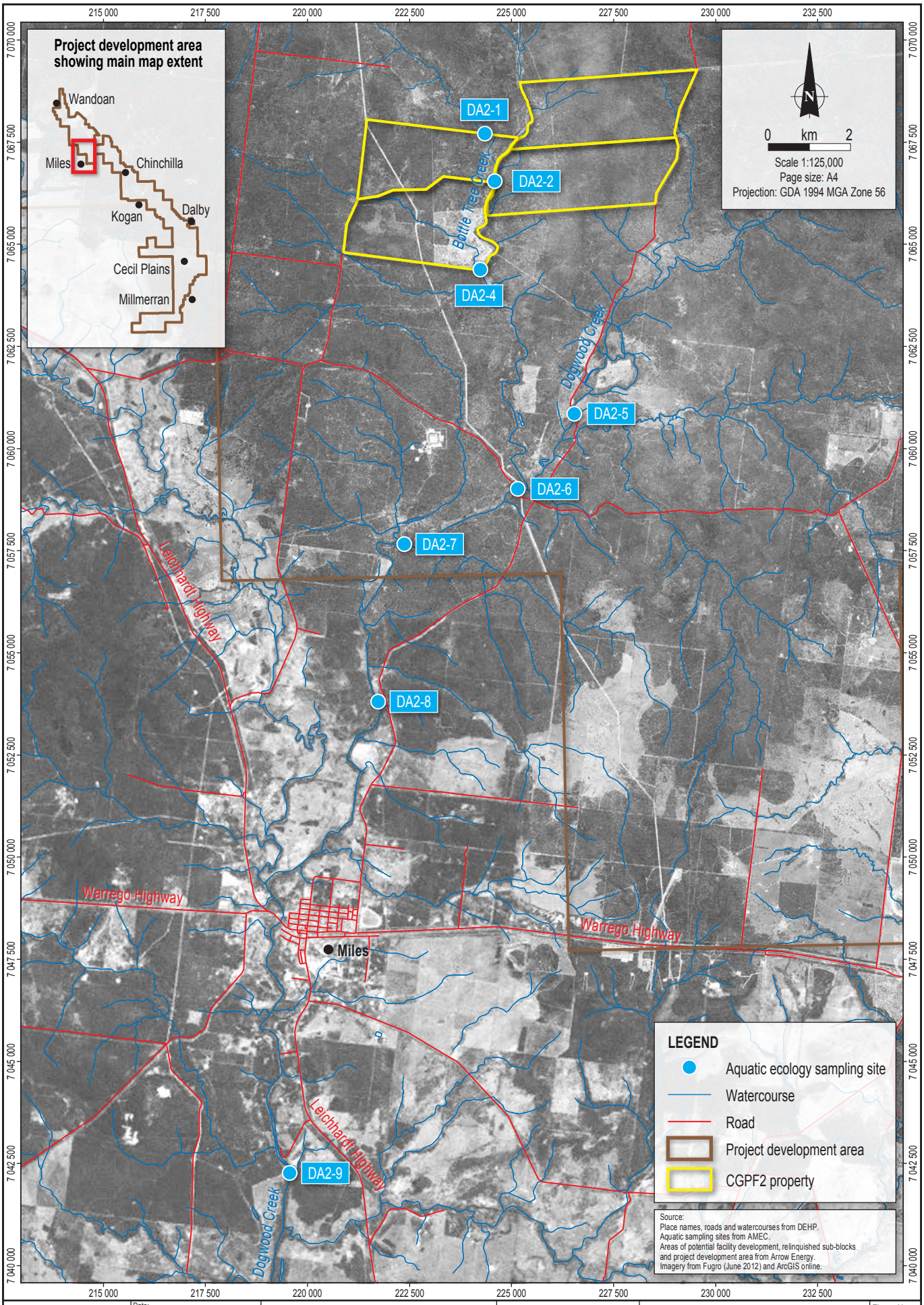
The identification of property locations for the water treatment facilities enabled detailed investigations to be carried out of the watercourses potentially affected by coal seam gas water discharges.

The two key watercourses within the receiving environment of potential discharge from the CGPF2 property water treatment facilities are Bottle Tree Creek and Dogwood Creek. Treated or untreated coal seam gas water was assumed to be discharged into Bottle Tree Creek which is the watercourse that runs through the CGPF2 property. Eight survey sites were inspected to characterise the aquatic values of the receiving system, with three sites on Bottle Tree Creek and five on Dogwood Creek. Figure 10.2 provides an overview of the sites inspected in CGPF2.

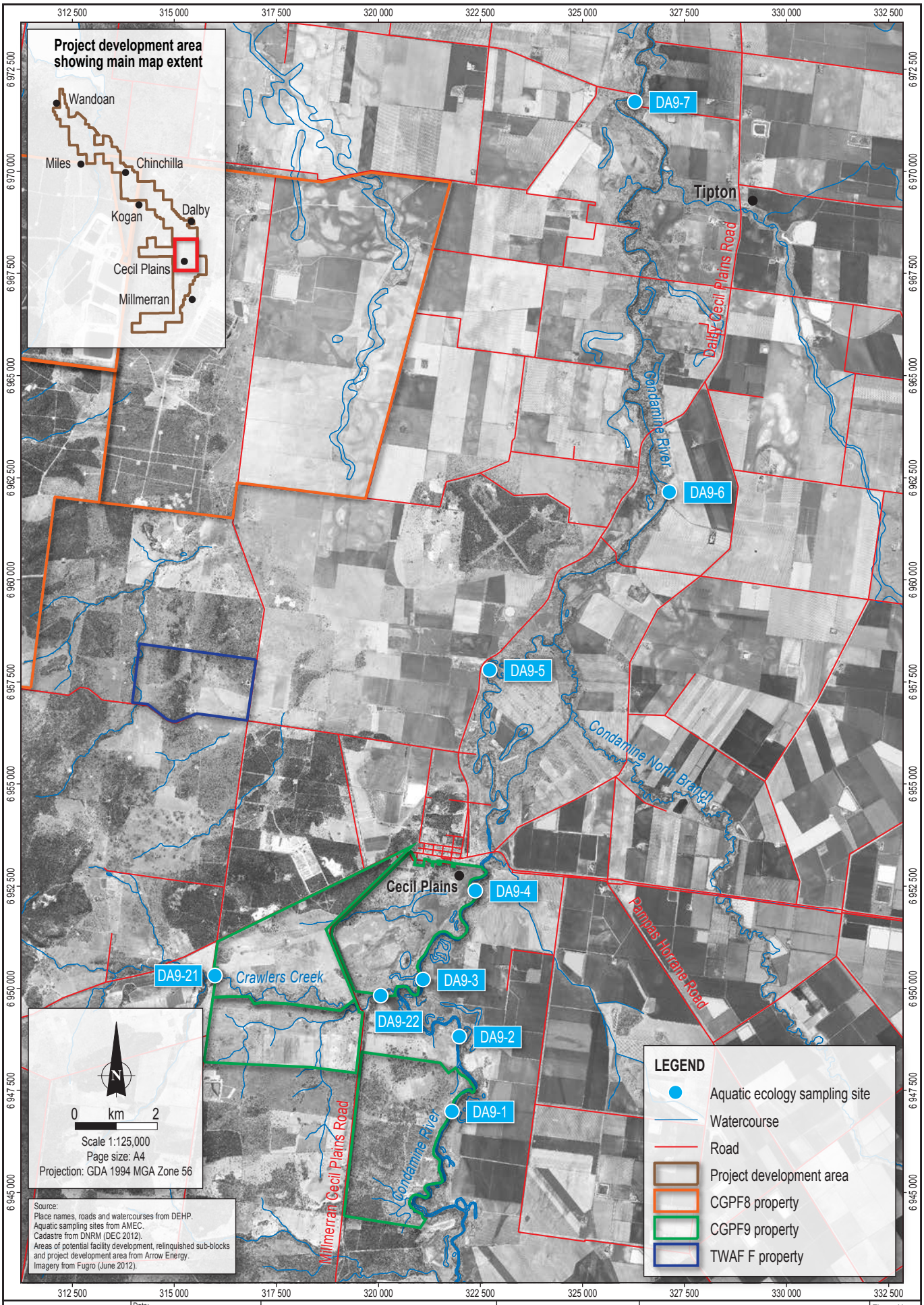
The two key watercourses of the receiving environment of the CGPF9 property are the Condamine River and its first-order tributary, Crawlers Creek. Nine survey sites were identified to characterise the aquatic values of the receiving system, with seven sites on the Condamine River and two on Crawlers Creek. Figure 10.3 identifies the aquatic ecology sites surveyed in CGPF9.

Surveys undertaken for the aquatic ecology assessment included the following:

- *Water quality.* Water quality was sampled in accordance with the DERM Monitoring and Sampling Manual 2009 (DERM, 2010f) to provide context for interpreting aquatic ecology values and to represent the water quality conditions at the time sampled. In-situ water quality parameters were measured for water temperature, pH, dissolved oxygen, electrical conductivity and turbidity. A fuller description of water quality values in the receiving environment watercourses is provided in Appendix 6, Supplementary Surface Water Assessment Part B – Water Quality.
- *Aquatic habitat.* Qualitative visual inspections of watercourses were carried out to identify and assess value of physical habitat such as reach habitat, substrate, riparian zones and woody debris and other aquatic values and potentially sensitive areas.
- *Macrophytes.* At each site, aquatic flora was assessed visually over the 100 m survey reach to identify emergent, floating and submerged macrophytes.
- *Fish and turtles.* Surveys were conducted in accordance with the DERM Monitoring and Sampling Manual 2009 (DERM, 2010f). Fish sampling techniques were electrofishing by boat or backpack, fyke netting and box trapping. The turtle surveys used modified fyke nets or opera house turtle nets.
- *Other vertebrates.* Incidental sitings and by-catch of aquatic vertebrates other than fish and turtles were recorded at each site. Information for other vertebrates found in riparian environments is provided in Appendix 9, Supplementary Terrestrial Ecology Assessment.



coffey environments	Date: 18.06.2013 MXD: 7040AE_12_GIS031_v1_1 File Name: 7040_12_F10.02_GIS_HB	Arrow Energy Surat Gas Project	arrow energy go further	Aquatic ecology sites inspected within the receiving environment of the CGPF2 property	Figure No: 10.2



coffey environments	Date: 18.06.2013 MXD: 7040AE_12_GIS032_v1_3 File Name: 7040_12_F10.03_GIS_HB	Arrow Energy Surat Gas Project	arrow energy go further	Aquatic ecology sites inspected within the receiving environment of the CGPF9 property	Figure No: 10.3

- *Macroinvertebrates.* Surveys were conducted in accordance with the DERM Monitoring and Sampling Manual 2009 (DERM, 2010f) and the Queensland Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual 2001 (DERM, 2001). Edge, pool and riffle habitats were sampled where possible. Samples from each habitat were live picked in the field, preserved in 70% ethanol and delivered to *Stream Macroinvertebrate Identifications* for sorting, taxonomic identification and enumeration. Macroinvertebrate surveys were undertaken in May for all sites to meet with the timing requirements for AUSRIVAS sampling. Two indices were calculated, PET Richness to assess the changes in habitat condition and water quality based on the total number of families present (Plecoptera, Ephemeroptera and Trichoptera) and SIGNAL2 to assign a grade between 1 (most tolerant) and 10 (most sensitive) that is plotted against taxa richness.

The location of field survey sites and the surveys undertaken at each site are summarised in Table 10.3. Detailed descriptions of the surveys undertaken at each site are provided in Appendix 8, Supplementary Aquatic Ecology Assessment.

Table 10.3 Aquatic ecology field survey site locations and survey descriptions

Survey Site	Basin	Dominant Substrate	Dominant Reach Hydrology	Surveys Undertaken	Date Completed
Additional Dawson and Macintyre and Weir Rivers Sub-basins					
SAQ-1	Fitzroy	Silt/clay	Pool (sandy)	Water quality, aquatic habitat, macrophytes, fish and turtles, other vertebrates and macroinvertebrates.	February and May 2013
SAQ-2	Border Rivers	Silt-clay	Pool (sandy)	Water quality, aquatic habitat, macrophytes, fish and turtles, other vertebrates and macroinvertebrates.	May 2013
CGPF2 Receiving Environment of Potential Discharge					
DA2-1	Condamine-Balonne	Bedrock	Pool (rocky)	Water quality, aquatic habitat, macrophytes, fish and turtles, other vertebrates and macroinvertebrates.	February and May 2013
DA2-2	Condamine-Balonne	Sand	Run	Water quality, aquatic habitat, macrophytes, fish and turtles, other vertebrates and macroinvertebrates.	February and May 2013
DA2-4	Condamine-Balonne	Sand	Pool (sandy)	Water quality, aquatic habitat, macrophytes, fish and turtles, other vertebrates and macroinvertebrates.	February and May 2013
DA2-5	Condamine-Balonne	Sand	Run	Water quality, aquatic habitat, macrophytes, fish and turtles, other vertebrates and macroinvertebrates.	February and May 2013
DA2-6	Condamine-Balonne	Sand	Run	Water quality, aquatic habitat, macrophytes, fish and turtles, other vertebrates and macroinvertebrates.	February and May 2013
DA2-7	Condamine-Balonne	Sand	Run, pool (sandy)	Water quality, aquatic habitat, macrophytes, fish and turtles, other vertebrates and macroinvertebrates.	February and May 2013

Table 10.3 Aquatic ecology field survey site locations and survey descriptions (cont'd)

Survey Site	Basin	Dominant Substrate	Dominant Reach Hydrology	Surveys Undertaken	Date Completed
CGPF2 Receiving Environment of Potential Discharge (cont'd)					
DA2-8	Condamine-Balonne	Silt-clay/sand	Pool (sandy)	Water quality, aquatic habitat, macrophytes, fish and turtles, other vertebrates and macroinvertebrates.	May 2013
DA2-9	Condamine-Balonne	Silt-clay/sand	Pool (sandy)	Water quality, aquatic habitat, macrophytes, fish and turtles, other vertebrates and macroinvertebrates.	May 2013
CGPF9 Receiving Environment of Potential Discharge					
DA9-1	Condamine-Balonne	Silt/clay	Pool (sandy)	Water quality, aquatic habitat, macrophytes, fish and turtles, other vertebrates and macroinvertebrates.	March and May 2013
DA9-2	Condamine-Balonne	Silt/clay	Pool (sandy)	Water quality, aquatic habitat, macrophytes, fish and turtles, other vertebrates and macroinvertebrates.	March and May 2013
DA9-3	Condamine-Balonne	Silt/clay	Pool (sandy)	Water quality, aquatic habitat, macrophytes, fish and turtles, other vertebrates and macroinvertebrates.	March and May 2013
DA9-4	Condamine-Balonne	Silt/clay	Pool (sandy)	Water quality, aquatic habitat, macrophytes, fish and turtles, other vertebrates and macroinvertebrates.	March and May 2013
DA9-5	Condamine-Balonne	Silt/clay	Pool (sandy)	Water quality, aquatic habitat and macrophytes.	March and May 2013
DA9-6	Condamine-Balonne	Silt/clay	Pool (sandy)	Water quality, aquatic habitat and macrophytes.	March and May 2013
DA9-7	Condamine-Balonne	Silt/clay	Pool (sandy)	Water quality, aquatic habitat and macrophytes.	March and May 2013
DA9-21	Condamine-Balonne	Silt/clay	Pool (sandy)	Water quality, aquatic habitat, macrophytes, fish and turtles, other vertebrates and macroinvertebrates.	March and May 2013
DA9-22	Condamine-Balonne	Silt/clay	Pool (sandy)	Water quality, aquatic habitat, macrophytes, fish and turtles, other vertebrates and macroinvertebrates.	March and May 2013
Properties					
CGPF7	Condamine-Balonne	Not assessed	Not assessed	Qualitative visual survey.	February 2013
CGPF8	Condamine-Balonne	Not assessed	Not assessed	Qualitative visual survey.	February 2013
TWAF F	Condamine-Balonne	Not assessed	Not assessed	Qualitative visual survey.	February 2013

10.3.3 Preliminary Environmental Flows Assessment

A preliminary environmental flows assessment based on a spells analysis (Appendix 7, Supplementary Surface Water Assessment Part C – Preliminary Environmental Flows Assessment) was carried out to determine the rate, duration and frequency of flows from the planned discharges that would not adversely affect the receiving environments of the CGPF2 and CGPF9 properties. The assessment focused on surface water attributes such as geomorphology and hydrology, water quality, aquatic ecology and riparian vegetation and included a literature review, spells analysis and a workshop with technical specialists and professionals (also see Chapter 9, Surface Water).

The resulting preliminary environmental flows assessment defined the existing flow regime for Dogwood Creek and the Condamine River taking into account different climatic conditions. The spells analysis was carried out for Dogwood Creek using data from the flow gauge at Gil weir and is considered to be representative of its tributary, Bottle Tree Creek. The potential impacts from coal seam gas water discharges on the natural flow regimes were identified together with the potential risks and opportunities associated with the discharge of coal seam gas water. Potential options for managing the discharges were also identified.

The outcomes of the preliminary environmental flows assessment were used in the aquatic ecology assessment of coal seam gas water discharges.

10.3.4 Impact Assessment Method

The potential impacts of the project on aquatic ecology values were assessed in the EIS using the significance assessment method described in Chapter 7 and Chapter 16 of the EIS. The SREIS assessment draws on both extensive desktop investigations and field investigations to provide further definition through a qualitative assessment of the sensitivity of aquatic ecosystems and species. Detailed information on this assessment method is provided in Appendix 8, Supplementary Aquatic Ecology Assessment.

10.4 Study Findings

The findings of the desktop assessment, field surveys and additional assessment of impacts of coal seam gas water discharges on aquatic ecology values are described below.

10.4.1 Desktop Study

No additional threatened communities or flora or fauna species were identified as occurring in the project development area through the desktop review other than those identified in the EIS. Detailed information on the distribution, habitat and threats to matters of national environmental significance aquatic species is presented in Attachment 1, Matters of National Environmental Significance.

The desktop assessment identified two additional pest species of significance as potentially occurring within the project development area. Aquatic weeds salvinia (*Salvinia molesta*) and hymenachne (*Hymenachne amplexicaulis*) are declared as Class 2 pests under the *Land Protection (Pest and Stock Route Management) Act 2002* and listed as Weeds of National Significance.

The outcomes of the desktop study for ACA and Back on Track species are summarised below.

Aquatic Conservation Assessments

The results of the ACAs are described in terms of basins. The CGPF2, CGPF7, CGPF8 and TWAF F properties are located within the Condamine River sub-basin, which forms part of the Condamine-Balonne Basin. The CGPF2 property is located within the Balonne River sub-basin, which also forms part of the Condamine-Balonne Basin. The site SAQ-1 is located within the Dawson River sub-basin, which forms part of the Fitzroy Basin, while site SAQ-2 is located within the Macintyre and Weir rivers sub-basin, which forms part of the Border Rivers Basin.

The extensive literature review of the ACAs regarding flora identified 20 priority flora species in the riverine and non-riverine wetlands of the Condamine-Balonne Basin, 15 species in the Border Rivers Basin and 31 species in the Fitzroy Basin.

Literature reviews of the ACA regarding fauna identified three invertebrate species, eight species of fish, one aquatic mammal and one turtle priority species within the Condamine-Balonne Basin, as well as two invertebrate species, seven species of fish, one aquatic mammal and one turtle priority species in the Border Rivers Basin. A further 2 invertebrate species, 11 species of fish and 1 turtle priority species were identified in the Fitzroy Basin. While the platypus (*Ornithorhynchus anatinus*) was identified in the ACA searches, it is addressed in Chapter 11, Terrestrial Ecology.

The desktop reviews of ACAs also identified one exotic invertebrate species and 11 exotic fish species as potentially occurring in both the Border Rivers and Condamine-Balonne basins and one exotic invertebrate and six exotic fish species potentially occurring in the Fitzroy Basin.

The literature review found that the rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) are unlikely to occur within the project development area, as it is outside the environmental tolerances of these species.

Semi-aquatic amphibians, reptiles and avifauna are addressed separately in Chapter 11, Terrestrial Ecology.

Back on Track

Back on Track aims to identify priority threatened species that require conservation and suggests recovery actions for identified species in each region. Actions for Biodiversity documents are prepared as part of Back on Track for each of the 14 natural resource management (NRM) regions within Queensland.

No macrophytes were identified for the study area during the desktop review of Back on Track Actions for Biodiversity documents.

The Condamine NRM region Actions for Biodiversity document identified one ‘critical’ priority freshwater aquatic species, the Murray cod (*Maccullochella peelii peelii*) (DERM, 2010b) as occurring in the region.

In the Border Rivers Maranoa-Balonne NRM region, the Murray cod is listed as a ‘critical’ priority aquatic species and the Bell’s turtle (*Wollumbinia belli*) is listed as a ‘high’ priority aquatic species (DERM, 2010a, b).

Bell’s turtle is unlikely to occur in the project development area as this species has a very restricted distribution. The species is only known to occur in the headwaters of the Namoi and Gwydir rivers (west of Armidale in New South Wales) and in Bald Rock Creek (in southeast Queensland).

In the Fitzroy NRM region, the ornate rainbowfish (*Rhadinocentrus ornatus*), Fitzroy River turtle (*Rheodytes leukops*) and white-throated snapping turtle (*Elseya albagula*) were identified as 'high' priority freshwater species. The Fitzroy River turtle and the white-throated snapping turtle have the potential to occur in the project development area that falls within the Fitzroy NRM region. Records of the Fitzroy River turtle, however, occur well downstream of the project development area.

Literature reviews identified the ornate rainbowfish as locally common, but highly restricted in its distribution, with the species occurring in a narrow strip of coastal freshwater streams from Rockhampton to Coffs Harbour. This species is considered unlikely to occur in the project development area. Further detail on the potential for the identified species to occur in the project development area is provided in Appendix 8, Supplementary Aquatic Ecology Assessment.

10.4.2 Aquatic Values of CGPF7, CGPF8 and TWAF F Properties

Wilkie Creek is situated on the CGPF7 property, which is about 25 km northwest of the town of Dalby. Wilkie Creek intersects the property and was surveyed and aquatic values were described in detail in the EIS (site D, Chapter 16 of the EIS). Adjacent to Wilkie Creek, in the central portion of the property, are several billabongs. Inspection of the assemblages of the submerged and floating aquatic flora suggests that these billabongs are likely to be semi-permanent in nature and therefore likely to support aquatic ecosystems of significance. The property is also intersected on its western portion by two smaller watercourses, which contained water at the time of assessment but are considered highly ephemeral and of low sensitivity.

The CGPF8 property is situated approximately 26 km south-southwest of the town of Dalby. Examination of aerial photography showed that the western section of the property is situated in the catchment above Lake Broadwater. The lake is highly sensitive and is a Category A Environmentally Sensitive Area. The central and eastern portions of the property drain into the Wilkie Creek subcatchment. Minimal areas of standing water were observed across the property despite the recent periods of high rainfall. No direct evidence of aquatic values of significance was observed.

The TWAF F property is situated approximately 35 km south-southwest of the town of Dalby and approximately 10 km south of the CGPF8 property, within the Wilkie Creek subcatchment. The property is intersected by two small watercourses, with the larger watercourse running parallel to the western boundary of the TWAF F property. The smaller watercourse passes across the southeast corner of the TWAF F property, forming a confluence with a drainage line at the corner of the property. Both watercourses contained water at the time of inspection; however, it is likely that they remain dry for most of the year with potentially a few remnant pools remaining.

All three properties were identified as having the potential for the occurrence of Murray cod, which is listed under the EPBC Act as a nationally significant fish species.

Aquatic ecology values in the CGPF7 and TWAF F properties have a low sensitivity, with watercourses identified in both properties as being predominately dry throughout the year. While the aquatic ecology values within the CGPF8 property were identified as low, part of the western side of the property is situated in the catchment feeding the highly sensitive Lake Broadwater and a wetland named 'Longswamp' in the eastern portion of the property. Activities within the CGPF8 property could impact indirectly on the aquatic values of the lake and this wetland through changes in upstream water quality and flows.

Mitigation measures in the EIS to reduce the impacts associated with project activities during the construction, operational and decommissioning phases are adequate to manage the predicted

impacts of project activities on aquatic values on these properties. These measures include commitments that reduce the risk of sediment or other potential pollutants entering watercourses that flow into Lake Broadwater.

10.4.3 Characterisation of the Dawson River and Macintyre and Weir Rivers Sub-basins

The aquatic ecology environment in the Dawson River and the Macintyre and Weir rivers sub-basins are described below.

Dawson River Sub-basin (Weringa Creek)

Site SAQ-1 is situated on Weringa Creek, a small, low-order, semi-permanent watercourse within the Dawson River sub-basin of the Fitzroy Basin. Surface water persists as a series of semi-connected and disconnected pools, separated by areas of dry streambed, for the majority of the hydrological cycle. Streamflow in the watercourse occurs for a brief period following heavy and sustained rainfall and typically occurs during the wet season.

The hydrologic conditions existing at site SAQ-1 have naturally shaped assemblages of aquatic flora and fauna that are typically low in diversity and seasonally variable. Most species recorded during the aquatic ecology surveys have broad habitat requirements and are generally tolerant of a wide range of conditions (hydrological, water quality and physical habitat).

One macrophyte species was recorded at site SAQ-1, spiny-head mat-rush (*Lomandra longifolia*), and has no conservation significance.

Five species of fish were recorded at site SAQ-1:

- Agassiz's glassfish (*Ambassis agassizii*).
- Carp gudgeons (*Hypseleotris* species complex).
- Eastern rainbowfish (*Melanotaenia splendida splendida*).
- Eel-tailed catfish (*Tandanus tandanus*).
- Spangled perch (*Leiopotherapon unicolor*).

These species are not considered priority species within the Dawson River sub-basin and have no conservation significance.

The only turtle species recorded at this site, the eastern long-necked turtle (*Chelodina longicollis*), is not a priority species in the Dawson River sub-basin and is not listed under relevant legislation.

No macroinvertebrate taxa of conservation significance were recorded at site SAQ-1.

Macintyre and Weir Rivers Sub-basin (Commoron Creek)

Site SAQ-2 is situated on Commoron Creek, a small, low-order, ephemeral watercourse within the Macintyre and Weir rivers sub-basin of the Border Rivers Basin. The site was dry at the time of sampling as there were no significant rainfall events prior to the sampling period and this small, ephemeral watercourse only contains water during and immediately after such events.

Although dry at the time of sampling, site SAQ-2 would support sandy pool habitat and shallow run habitat during the wet season.

Five macrophyte species was recorded at site SAQ-2:

- Sedge (*Cyperus spp.*).
- Common rush (*Juncus usitatus*).
- Tassel sedge (*Carex fascicularis*).

- Tall spike-rush (*Eleocharis sphacelata*).
- Para grass (*Urchola mutica*).

Of these, para grass is an introduced species but is not listed as a 'declared pest' under the *Land Protection (Pest and Stock Route) Management Act 2002.*

Sampling of macroinvertebrates, fish and other vertebrates at this site could not be completed due to the dry conditions in May 2013. The habitat assessment indicates that aquatic assemblages would be similar to those found in ephemeral watercourses in other sub-basins within the project development area.

Potential Impacts and Management Measures

Project activities proposed for the Dawson River and Macintyre and Weir Rivers sub-basins and the associated potential impacts are consistent with those described in the EIS. The further characterisation of the aquatic ecology values in these sub-basins does not change the significance of potential impacts and the mitigation measures presented in the EIS remain valid.

10.4.4 CGPF2 and CGPF9 - Coal Seam Gas Water Discharge Impact Assessment

The impacts of emergency discharge from water treatment facilities (to maintain the integrity of the water storage dams) were assessed in the EIS. This section presents the findings of the aquatic ecology assessment of operational discharges to watercourses from the CGPF2 and CGPF9 properties.

CGPF2 Property Receiving Environment

The general characteristics, aquatic flora and fauna species, macroinvertebrates and water quality are described below for the receiving environment watercourses.

General Characteristics

The watercourses in the receiving environment of CGPF2, Bottle Tree Creek and Dogwood Creek, are small and ephemeral. Surface water does not persist for the majority of the hydrological cycle and remnant waterholes are unlikely to persist, even in small numbers. Stream flow within these watercourses occurs for a brief period following heavy and sustained rainfall and typically occurs during the wet season. When surface water does persist, aquatic habitat is largely characterised by a series of disconnected and semi-connected recessional waterholes. The far downstream reaches of Dogwood Creek are regulated by Gil Weir (see Appendix 8, Supplementary Aquatic Ecology Assessment, Section 3.4.2 for further discussion regarding classification of watercourses).

Water Quality

A summary of in-situ water quality measurements taken during the February and March 2013 surveys at the CGPF2 receiving environment watercourses (from sites DA2-1, DA2-2, DA2-4, DA2-5, DA2-6 and DA2-7) is provided in Table 10.4. These results represent the water quality condition at the sampling time and assist in interpretation of the aquatic ecology sampling results. Detailed water quality data from sites DA2-8 and DA2-9 (surveyed in May) are described in the addendum report to Appendix 8, Supplementary Aquatic Ecology Assessment. Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000) (ANZECC (2000) guidelines) are provided where available for each parameter.

Table 10.4 Summary of in-situ water quality results in the CGPF2 receiving environment

Parameter	Units	Mean	Maximum	Minimum	Standard Deviation	Standard Error	ANZECC (2000)*
Temperature	ºC	24.89	26.90	22.50	1.64	0.62	NA[†]
pH	pH units	6.52	7.05	6.08	0.31	0.12	6.5 to 8.0
Electrical conductivity	µS/cm	196.29	345.00	133.00	73.23	27.68	125 to 2,200
Dissolved oxygen	% saturation	48.20	75.52	19.90	19.96	7.55	90 to 110
Turbidity	NTU[§]	550.49	1,000.00[**]	9.40	429.87	162.48	6 to 50

*Default values from ANZECC (2000) guidelines for 'south-east Australia' 'slightly to moderately disturbed' 'lowland streams' adopted.

[†]NA denotes absence of ANZECC (2000) guidelines for this parameter.

[§]Nephelometric turbidity units.

**Actual measurement exceeded this value but could not be recorded due to instrumentation calibration limit.

The results were compared to the ANZECC (2000) guidelines value range for all sites including DA2-8 and DA2-9:

- No trends were apparent in the data (excluding turbidity) with respect to location (i.e., upstream or downstream of proposed discharge locations).
- Water temperature was spatially variable throughout sites and was likely to be a result of the variation in the time of day sampling and the level of canopy cover at each site.
- pH was neutral to slightly acidic and was within the ANZECC (2000) guidelines value range at two of the sites. Sites that were outside of the ANZECC (2000) guidelines value range were less than 0.5 of a pH unit below.
- Electrical conductivity was within the ANZECC (2000) guidelines value range at all sites except for DA2-9 that was surveyed in May.
- Dissolved oxygen levels varied widely throughout the sites, with levels below the ANZECC (2000) guidelines value range at all sites.
- Turbidity levels exceeded the ANZECC (2000) guidelines value range at all sites in the Dogwood Creek catchment. A trend of increased turbidity with distance downstream was apparent between sites DA2-1 and DA2-6.

The detailed water quality results for each site are provided in Appendix 8, Supplementary Aquatic Ecology Assessment.

Aquatic Flora Species

The diversity at each site sampled ranged from two to six species in Bottle Tree Creek and Dogwood Creek. A total of eight macrophytes were recorded with seven being of the emergent growth form and one, a floating growth form, salvinia *(Salvinia molesta*). This species is introduced and is listed as a Class 2 declared pest under the *Land Protection (Pest and Stock Route Management) Act 2002*.

The absence of submerged macrophytes, as well as the low diversity of emergent and floating macrophyte species, is attributed to the ephemeral nature of the watercourses. The high degree of spatial and temporal habitat variability and difficult growing conditions means that ephemeral watercourses usually provide poor habitat for macrophytes. Ephemeral watercourses usually

consist of macrophyte assemblages that are low in diversity, relatively tolerant, of the emergent growth form and are commonly found throughout a wide geographical region.

Aquatic Fauna Species (Fish and Turtles)

The total fish species diversity identified within Bottle Tree Creek and Dogwood Creek was 14 species. Twelve species are described here as three positively identified species of carp gudgeons were grouped as one and labelled as *Hypseleotris* species complex. These species are:

- Western carp gudgeon (*Hypseleotris klunzingeri*).
- Midgely's carp gudgeon (*Hypseleotris species 1*).
- Murray-Darling carp gudgeon (*Hypseleotris species 4*).

The diversity at each site sampled ranged from four to eight species. Site DA2-8 supported the lowest species diversity. Site DA2-5 is situated on Dogwood Creek upstream of its confluence with Bottle Tree Creek and is not expected to receive coal seam gas water. This site supported the highest species diversity and contained the highest substrate complexity, with five types (bedrock, cobble, pebble, sand and silt/clay), two more than any other site sampled in the CGPF2 receiving environment.

Two species of conservation significance were collected:

- Murray cod (*Maccullochella peelii peelii*) which is listed as 'vulnerable' under the EPBC Act and as a 'critical' priority Back on Track species within the Condamine-Balonne Basin.
- Agassiz's glassfish (*Ambassis agassizii*) which is listed as an ACA Priority species within the Condamine-Balonne Basin.

A single specimen of Murray cod was collected, from site DA2-5; and Agassiz's glassfish was collected in low abundance at sites DA2-4 and DA2-7.

Three introduced species recorded and listed as a noxious species under the *Fisheries Act 1994* (Qld) were:

- European carp (*Cyprinus carpio*).
- Goldfish (*Carassius auratus*).
- Mosquitofish (*Gambusia holbrooki*).

While the goldfish and European carp were present in relatively low abundance, the mosquitofish was the most abundant fish species recorded.

Other fish species recorded that are not of conservation significance include:

- Australian smelt (*Retopinna semoni*).
- Bony bream (*Nematalosa erebi*).
- Golden perch (*Macquaria ambigua*).
- *Hypseleotris* species complex.
- Hyrtl's tandan (*Neosilurus hyrtlii*).
- Murray River rainbowfish (*Melanotaenia fluviatilis*).
- Spangled perch (*Leiopotherapon unicolor*).

No consistent patterns were obvious between the findings for fish species diversity and corresponding abiotic (physical habitat and water quality) and biotic (fish and macrophytes) findings.

Figure 10.4 illustrates the relative abundance of fish collected during the assessment of the receiving environment watercourses in CGPF2.

The total fish count varied between 8 specimens recorded at site DA2-8 and 340 fish recorded at DA2-1. Of the eight sites surveyed, *Hypseleotris* species complex was the most abundant species at five sites, with mosquitofish the most abundant species at the remaining three sites.

Two species of turtle were collected, the broad-shelled turtle (*Chelodina expansa*) and the eastern long-necked turtle (*Chelodina longicollis*). The broad-shelled turtle is classified as an ACA Priority species within the Condamine-Balonne Basin. The eastern long-necked turtle has no conservation significance.

Macroinvertebrates

No macroinvertebrates of conservation significance were recorded within the receiving environment watercourses of the CGPF2 property. A summary of the macroinvertebrate findings for the CGPF2 watercourses is provided in Table 10.5.

Table 10.5 Macroinvertebrate data univariate analysis results for watercourses on the CGPF2 property

		Site							
	Habitat	DA2-1	DA2-2	DA2-4	DA2-5	DA2-6	DA2-7	DA2-8	DA2-9
Taxa Richness*	Edge	28	22	28	28	28	30	30	32
	Pool bed	11	15	16	13	14	10	18	17
PET Richness^	Edge	4	4	5	4	5	4	5	3
	Pool bed	3	4	4	4	2	3	3	2
SIGNAL2~	Edge	3.72	3.21	3.58	3.48	3.30	3.50	3.37	3.21
	Pool bed	4.00	4.17	4.14	4.27	3.83	4.30	3.67	3.64

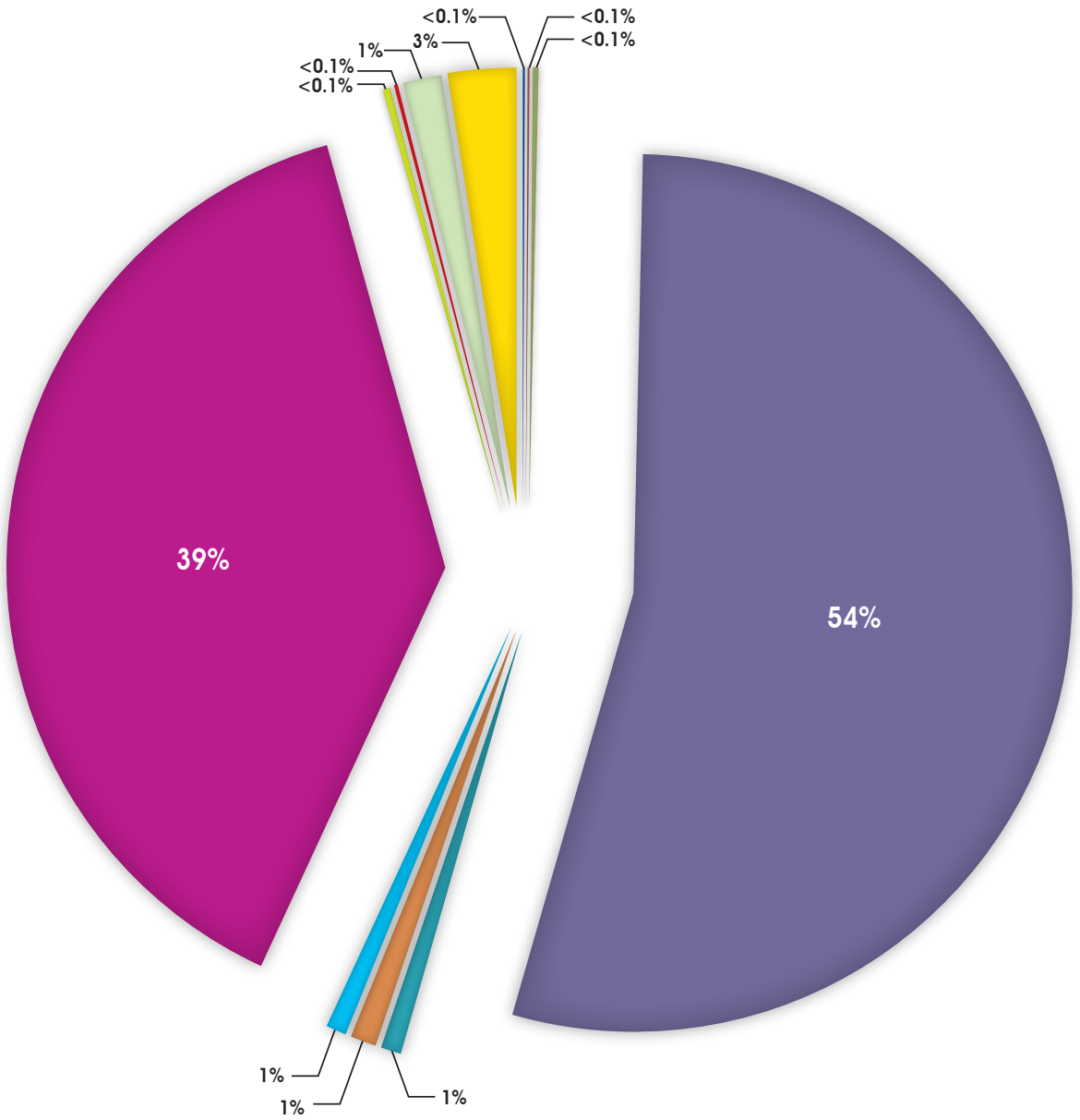
*Taxa richness refers to the number of different taxa contained in a sample.

^Some groups of aquatic macroinvertebrates are more sensitive to changes in the aquatic environment than others. Three orders of aquatic insects, the Plecoptera (stoneflies), Ephemeroptera (mayflies) and Trichoptera (caddisflies) (PET) are the most sensitive to changed conditions and are often used as an indicator of ecosystem health.

~ SIGNAL2 is a biotic index based on pollution sensitivity values (grade numbers) derived from published and unpublished information on macroinvertebrate tolerance to pollutants. Each taxa in a sample is assigned a grade between 1 (most tolerant) and 10 (most sensitive).

Taxa richness (number of taxa) was higher in edge habitat than pool bed habitat for most sites. The exception was site DA2-2 where the diversity of taxa in edge habitat appears to increase slightly with increasing distance downstream. Overall, a total of 54 taxa were collected from the survey sites. Macro-crustaceans were widespread and found in abundant numbers throughout the sites, with three of the four families of Australian freshwater decapod collected.

PET richness was low with edge habitat ranging from three to five and pool bed habitat ranging from two to four. Pool bed habitat generally had higher average SIGNAL2 scores ranging from 3.63 to 4.30 while edge habitat ranged from 3.21 to 3.50. These scores indicate the presence of macroinvertebrate families that are tolerant of a wide range of water quality parameters and are typical of ephemeral and disturbed systems.



Legend	Species name	Numbers
	Murray cod *(Maccullochell a peelii peelii)*	1
	European carp *(Cyprinus carpio)**	1
	Goldfish *(Carassius auratus)**	3
	Mosquitofish *(Gambusia holbrooki)**	796
	Agassiz's glassfish *(Ambassis agassizii)*	11
	Australian smelt *(Retropinna semoni)*	14
	Bony bream *(Nematalosa erebi)*	11
	Carp gudgeons *(Hypseleotris spp.)^*	540
	Golden perch *(Macquaria ambigua)*	4
	Hyrtl's tandan *(Neosilurus hyrtlii)*	2
	Murray River rainbowfish *(Melanotaenia fluviatilis)*	21
	Spangled perch *(Leiopotherapon unicolor)*	37
Total count		1471

Note:
* Denotes introduced species.
^ Denotes Hypseleotris species complex).

coffey environments

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Arrow Energy
Surat Gas Project

arrow energy go further

Relative abundance of fish collected at the receiving environment of the CGPF2 property

Figure No: **10.4**

The results returned by AUSRIVAS were outside the range of the models due to limited reference sites available for calibration of the models. This situation is not uncommon for ephemeral systems in southern and central Queensland. Consequently, AUSRIVAS results are not presented here.

CGPF9 Property Receiving Environment Watercourses

The general characteristics, aquatic flora and fauna species, macroinvertebrates and water quality are described below for the receiving environment watercourses.

General Characteristics

The major watercourse for the CGPF9 receiving environment is the Condamine River. The river is a high-order, semi-permanent watercourse that contains permanent pools as a result of the presence of the Cecil Plains weir. A proposed area of discharge from the water treatment facility on the CGPF9 property is situated upstream of the Cecil Plains weir, within the area of permanent surface water.

Crawlers Creek is the other key watercourse on the CGPF9 property and is characterised as a small, ephemeral, first-order tributary of the Condamine River. Streamflow within this watercourse occurs for a brief period following heavy and sustained rainfall and typically occurs during the wet season. Immediately following periods of streamflow, surface water persists for a short time as a series of semi-connected and disconnected pools, separated by areas of dry stream bed. For the majority of the hydrological cycle, surface water does not persist. During periods of high rainfall, water from the Condamine River could back up into Crawlers Creek.

Water Quality

A summary of in-situ water quality measurements taken during the March 2013 surveys at the CGPF9 receiving environment watercourses (from sites DA9-1, DA9-2, DA9-3, DA9-4, DA9-21 and DA9-22) is provided in Table 10.6. These results represent the water quality condition at the sampling time and assist in interpretation of the aquatic ecology sampling results. ANZECC (2000) guidelines are provided where available for each parameter.

Table 10.6 Summary of in-situ water quality results in the CGPF9 receiving environment

Parameter	Units	Mean	Maximum	Minimum	Standard Deviation	Standard Error	ANZECC (2000)*
Temperature	ºC	23.15	24.60	22.50	0.77	0.29	NA[†]
pH	pH units	7.09	7.61	6.47	0.42	0.16	6.5 to 8.0
Electrical conductivity	µS/cm	327.50	366.00	224.00	56.88	21.50	125 to 2200
Dissolved oxygen	% saturation	65.05	78.20	40.40	14.77	5.58	90 to 110
Turbidity	NTU[§]	98.80	113.00	62.80	18.15	6.86	6 to 50

*Default values from ANZECC (2000) guidelines for 'south-east Australia' 'slightly to moderately disturbed' 'lowland streams' adopted.

[†]NA denotes absence of ANZECC (2000) guidelines for this parameter.

[§]Nephelometric turbidity units.

The results were compared to the ANZECC (2000) guidelines value range for all sites including DA9-5 and DA9-7:

- For all water quality parameters recorded, excluding turbidity, no trends in results were discernible with respect to location (i.e., upstream or downstream of the Cecil Plains weir).

- Water temperature was spatially variable throughout sites most likely a result of the variation in the time of day sampling occurred and the level of canopy cover at each site. DA9-5 and DA9-7 were sampled in May and found to be between 5 and 6 degrees colder.
- pH was within the ANZECC (2000) guidelines value range at all sites except DA9-1, which was slightly below the range.
- Electrical conductivity was within the ANZECC (2000) guidelines value range and was comparable between sites.
- Dissolved oxygen levels varied widely, with levels below the ANZECC (2000) guidelines value range at all sites.
- Turbidity levels exceeded the ANZECC (2000) guideline values range at all sites, and no trends in results were apparent with respect to location.

Full water quality details for each site are provided in Appendix 8, Supplementary Aquatic Ecology Assessment.

Aquatic Flora Species

The diversity at each site ranged from three to five species. All eight macrophyte species recorded were of the emergent growth form, with two species of note, the shiny nardoo (*Marsilea mutica*), listed as an ACA Priority species within the Condamine-Balonne Basin, and the umbrella sedge (*Cyperus eragrostis*) listed as an exotic species.

The macrophyte assemblages data may be an underestimate of the typical diversity levels as these assemblages are susceptible to removal by high-flow events. Two high-flow events occurred in the watercourses on this property within the two months preceding the surveys.

The environmental conditions in the receiving environment watercourses included high water turbidity and fluctuating water levels, which are generally not conducive for macrophytes of submerged and floating growth forms and usually inhibit the establishment of such species. A low diversity of emergent macrophyte species was observed and is likely to be due to the moderate to extensive rates of bank erosion and stock access through the riparian zone.

Aquatic Fauna Species (Fish and Turtles)

The total fish species diversity identified was 12 species of fish. Eleven species are described here as two positively identified species of gudgeons have been grouped and labelled as *Hypseleotris* species complex. These species are:

- Western carp gudgeon (*Hypseleotris klunzingeri*).
- Murray-Darling carp gudgeon (*Hypseleotris species 4*).

Two species of conservation significance were collected during field surveys of the CGPF9 receiving environment watercourses:

- Murray cod (*Maccullochella peelii peelii*), which is listed as ‘vulnerable’ under the EPBC Act and as a ‘critical’ priority Back on Track species within the Condamine-Balonne Basin.
- Eel-tailed catfish (*Tandanus tandanus*), which is listed as an ACA Priority species within the Condamine-Balonne Basin.

Murray cod was collected in low abundance from sites DA9-1 and DA9-2, and a single specimen of the eel-tailed catfish was collected at site DA9-1. Despite the relatively low abundance of Murray cod during surveys, suitable habitat does exist in the Condamine River and as such,

sections of the Condamine River within the receiving environment watercourses of the CGPF9 property should generally be considered to support the Murray cod. Crawlers Creek is not expected to contain suitable habitat for the Murray cod, due to its ephemeral nature and comparatively small size.

Two introduced species recorded and listed as a noxious species under the *Fisheries Act 1994* (Qld) were the European carp (*Cyprinus carpio*) and the Mosquitofish (*Gambusia holbrooki*).

Both species were widespread throughout the receiving environment at a moderate to low abundance.

Other fish species recorded that are not of conversation significance were:

- Australian smelt (*Retopinna semoni*).
- Bony bream (*Nematalosa erebi*).
- Golden perch (*Macquaria ambigua*).
- *Hypseleotris* species complex.
- Hyrtl's tandan (*Neosilurus hyrtlii*).
- Murray River rainbowfish (*Melanotaenia fluviatilis*).
- Spangled perch (Leiopotherapon unicolor).

Figure 10.5 illustrates the relative abundance of fish collected in the CGPF9 receiving environment watercourses.

The species diversity sampled at each site ranged from five to seven species. No consistent patterns were apparent between fish species diversity and corresponding abiotic (physical habitat and water quality) and biotic (fish, macrophytes and reptiles) findings. A general decline in species richness as sites approached the Cecil Plains weir was observed, with species richness slightly decreasing between sites DA9-1 and DA9-3, and then remaining constant between sites DA9-3 and DA9-4.

Total abundance ranged from 43 individuals collected at site DA9-3 to 117 individuals collected at site DA9-4. Individuals of bony bream and the *Hypseleotris* species complex accounted for the majority of total abundance within the Condamine River sub-basin. European carp was the most abundant species recorded at site DA9-21, while the *Hypseleotris* species complex was the most abundant species recorded at site DA9-22. Both of these sites are situated on Crawlers Creek.

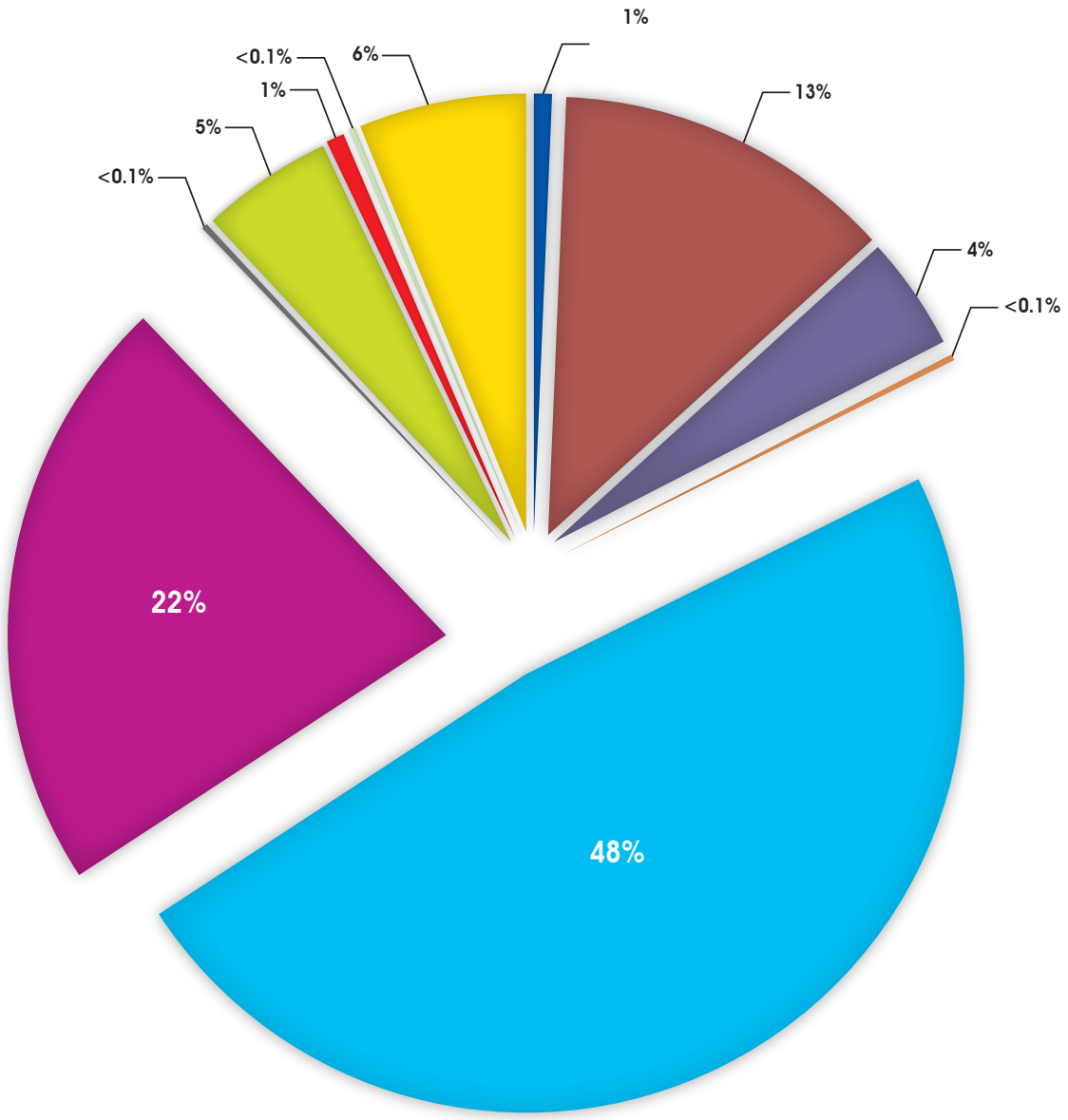
The Murray River turtle (*Emydura macquarii macquarii*) was the only species of turtle collected. This species is not of conservation significance and is generally expected to be common throughout the Condamine River sub-basin.

While not recorded in the SREIS surveys, suitable habitat for the broad-shelled turtle is generally present throughout sections of the Condamine River, and this species was recorded in the EIS surveys.

Macroinvertebrates

No macroinvertebrates of conservation significance were recorded within the receiving environment watercourses of the CGPF9 property. A summary of the macroinvertebrate findings is provided in Table 10.7 for three parameters.

Pool bed habitat data was not collected at four sites within the CGPF9 receiving environment watercourses due to water depth and associated safety concerns.



Legend	Species name	Numbers
	Murray cod *(Maccullochell a peelii peelii)*	3
	European carp *(Cyprinus carpio)**	57
	Mosquitofish *(Gambusia holbrooki)**	19
	Australian smelt *(Retropinna semoni)*	1
	Bony bream *(Nematalosa erebi)*	218
	Carp gudgeons *(Hypseleotris spp.)^*	100
	Eel-tailed catfish *(Tandanus tandanus)*	1
	Golden perch *(Macquaria ambigua)*	22
	Hyrtl's tandan *(Neosilurus hyrtlii)*	3
	Murray River rainbowfish *(Melanotaenia fluviatilis)*	1
	Spangled perch *(Leiopotherapon unicolor)*	28
Total count		453

Note:
* Denotes introduced species.
^ Denotes Hypseleotris species complex).

coffey environments

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Relative abundance of fish collected at the receiving environment of the CGPF9 property

Figure No: **10.5**

Taxa richness ranged from 12 to 32 in the edge habitat while pool bed habitat ranged from 7 to 16. The diversity of edge habitat was lower on the Condamine River sites than those of Crawlers Creek. The presence of Cecil Plain weir is a major determinant of community structure in these watercourses. A total of 49 taxa were collected with one exotic family, Physidae (freshwater snail) found at a single site. Macro-crustaceans were widespread and found in abundant numbers throughout the sites, with three of the four families of Australian freshwater decapod collected.

Table 10.7 Macroinvertebrate data univariate analysis results CGPF9 property

		Site							
	Habitat	DA9-1	DA9-2	DA9-3	DA9-4	DA9-5	DA9-7	DA9-21	DA9-22
Taxa Richness*	Edge	18	15	12	14	20	21	31	32
	Pool bed	–	–	–	–	10	16	7	9
PET Richness^	Edge	3	4	3	2	4	4	3	3
	Pool bed	–	–	–	–	3	5	0	1
SIGNAL2~	Edge	2.94	4.00	3.55	3.23	3.37	3.65	3.07	2.93
	Pool bed	–	–	–	–	3.67	4.06	3.80	3.38

*Taxa richness refers to the number of different taxa contained in a sample.

^Some groups of aquatic macroinvertebrates are more sensitive to changes in the aquatic environment than others. Three orders of aquatic insects, the Plecoptera (stoneflies), Ephemeroptera (mayflies) and Trichoptera (caddisflies) (PET) are the most sensitive to changed conditions and are often used as an indicator of ecosystem health.

~ SIGNAL2 is a biotic index based on pollution sensitivity values (grade numbers) derived from published and unpublished information on macroinvertebrate tolerance to pollutants. Each taxa in a sample is assigned a grade between 1 (most tolerant) and 10 (most sensitive).

PET richness ranged from 2 to 4 for edge habitat and 0 to 5 for pool bed habitat. SIGNAL2 scores decreased closer to the Cecil Plains weir, with the exception of DA9-1. Overall macroinvertebrate communities were diverse and in ‘good’ condition. The communities are generally representative of those occurring in semi-permanent waterways throughout the region that are experiencing only minor impacts from anthropogenic sources (including agriculture).

The results returned by AUSRIVAS were outside the range of the models due to limited reference sites available for calibration of the models. This situation is not uncommon for ephemeral systems in southern and central Queensland. Consequently, AUSRIVAS results are not presented here.

Sensitivity of the Receiving Environment

Table 10.8 summarises the sensitivity of the aquatic ecology values of the receiving environment watercourses in the CGPF2 and CGPF9 properties to coal seam gas water discharges.

Table 10.8 Summary of sensitivity of the receiving environments to potential discharge

Sensitivity	**CGPF2 Receiving Environment (Dogwood Creek and Bottle Tree Creek)**	**CGPF9 Receiving Environment (Condamine River and Crawlers Creek)**
Conservation status	*Moderate* Watercourse not listed as of state, national or international significance. One EPBC-listed species (Murray cod) is known to occur. Contains moderate to marginal fishery values and is a state and local ecotourism destination.	*Moderate* Watercourse not listed as of state, national or international significance. One EPBC-listed species (Murray cod) is known to occur. Contains moderate to marginal fishery values and is a state and local ecotourism destination.

Table 10.8 Summary of sensitivity of the receiving environments to potential discharge (cont'd)

Sensitivity	CGPF2 Receiving Environment (Dogwood Creek and Bottle Tree Creek)	CGPF9 Receiving Environment (Condamine River and Crawlers Creek)
Intactness	*High* A largely undisturbed ephemeral aquatic system with naturally limited passage for aquatic fauna and limited spawning or nursery opportunities.	*Moderate* A moderately disturbed aquatic system. An important movement corridor with nursery and spawning habitat potential.
Uniqueness	*Low* Not unique on a regional, national or international scale in terms of biota, communities or processes.	*Low* Not unique on a regional, national or international scale in terms of biota, communities or processes.
Resistance to change	*Moderate* Moderately tolerant and adaptive aquatic communities.	Moderate Moderately tolerant and adaptive aquatic communities.
Recovery potential	*Moderate* Communities likely to exhibit moderate to good recovery following disturbance.	*Moderate* Communities likely to exhibit moderate to good recovery following disturbance.

Potential Impacts

The potential impacts, on aquatic ecology values, of discharges of treated or untreated coal seam gas water from water treatment facilities located on the CGPF2 and CGPF9 properties into the respective receiving environment watercourses include:

- Changes in the composition of aquatic assemblages as a result of changes in the timing and magnitude of discharges.
- Changes in the aquatic community composition as a result of potentially altered water chemistry and physical characteristics (e.g., turbidity, pH, tannic acids, temperature, dissolved oxygen, ionic composition, and macro- and micronutrients).
- Changes in the geomorphological processes that create or assist in the formation of habitat for aquatic assemblages, particularly those supporting species of conservation significance (e.g., ephemeral cycles, deep pools and undercut banks).
- Creation of conditions that could facilitate the establishment or spread of pest species (e.g., the change to higher base flows in other regions of the Murray-Darling is thought to have provided more favourable conditions for carp than for native fish species).
- Changes in the health of aquatic ecosystems through the introduction of exotic species from discharging coal seam gas water that has originated from a dam colonised by exotic species and transferred through water gathering lines to the discharge point.

The potential impacts of discharges are restricted to the operations (during or between discharge releases) and the decommissioning phases (when the watercourses return to pre-existing flow conditions) of the project.

Potential impacts on aquatic ecosystems will depend on the scale of the change in flow conditions and characteristics of the receiving environment watercourses. The aquatic ecology assessment considered the potential impacts on aquatic values of coal seam gas water discharges for

conditions of low flow and high flow in the receiving watercourses. The two scenarios assessed were:

- *Low flow conditions*: Includes cease to flow (no flow), and low flow freshes (flow that is exceeded on 20% of days during the low flow season).
- *High flow events*. Includes high flow freshes (flow exceeded on 5% of days during the high flow season) and bankfull flow (occurring on average every two years).

The low flow season is characterised by extended periods of low flow or periods of no flow, with shorter infrequent periods of high flow (freshes) caused by small localised rainfall events. For Dogwood Creek (CGPF2 receiving environment) this season is from December to February and from March to October for the Condamine River (CGPF9 receiving environment).

The high flow season is typically characterised by a higher base flow with frequent, sometimes extended periods of higher flow from more widespread rainfall events. For Dogwood Creek this season is from December to February and from November to February for the Condamine River.

The magnitude was assessed of potential impacts, on aquatic ecology values, of discharging coal seam gas water to the receiving watercourses on the CGPF2 and CGPF9 properties under low flow conditions and during high flow events. The outcomes of the assessment are presented in Table 10.9.

Table 10.9 Magnitude of impact on the receiving environment watercourses in the CGPF2 and CGPF9 properties

Impact	Magnitude	
	Discharge during High Flow Events	**Discharge during Low Flow Conditions**
Geographic extent of impact	Low • Discharge diluted during high natural flows. • High flows mask extent of discharge.	*High* • Bottle Tree Creek: discharge impacts could extend at least as far as Gil Weir (30 km downstream). • Condamine River: semi-permanent system; discharge impacts could extend downstream at least as far as 20 km downstream.
Duration of impact	*Low* • Proportional to the periods of high flow; duration likely to be up to several weeks for a given flow period.	*High* • Initial impact period is for the operational life of the project (35 years). • Secondary impacts will occur when discharges cease and the ecosystem re-equilibrates (indeterminable time frame).
Severity	*Low* • Potential for minor, short-term impacts on aquatic communities.	*High* • Changes in flow regime and water chemistry are likely to have a significant impact on aquatic community abundance and diversity especially in the highly ephemeral Bottle Tree Creek.

Overall, discharges under high flow events will have a significance of impact of low. No additional mitigation measures are proposed for discharge of coal seam gas water during high flow events. Under low flow conditions, the discharge of coal seam gas water will have a significance of impact of high. Mitigation and management measures to reduce the significance of impacts under low flow conditions are discussed below.

Mitigation and Management Measures

Preliminary discharge guidelines have been developed to reduce the impacts of coal seam gas water discharges to watercourses located in the CGPF2 and CGPF9 properties. The guidelines were developed based on the findings of the literature review, a review of the spells analysis and through technical professional discussions which drew on previous experience in other comparable aquatic systems (including the Murray-Darling Basin).

A preliminary guideline of a 20% deviation from the current flow conditions was developed for discharges of coal seam gas water. Extended periods of sustained low flow would also be maintained (including no flow). A deviation of 20% from the existing flow regimes is possible without causing adverse impacts to geomorphology, hydrology, water quality, aquatic ecology and riparian vegetation.

The preliminary guideline will be used to develop a discharge strategy that specifies parameters for the discharge of coal seam gas water including the volumes, timing and duration of discharges. A detailed environmental flows assessment will be carried out to further characterise the aquatic values of the receiving environment watercourses. Key ecological processes, natural flow regimes, the timing of discharges, and the ecology of priority species will be considered. The results of planned aquatic ecology and water quality monitoring will also inform the development of the strategy.

Other management measures presented in the EIS (as commitments) remain relevant to reducing the impacts of coal seam gas water discharges.

The discharge of coal seam gas water under a preliminary guideline of a 20% deviation to current flow conditions has a **moderate** significance of impact.

Summary of Residual Impacts

The significance of residual impacts (i.e., those that will remain following the implementation of proposed mitigation and management measures) of the discharge of treated or untreated coal seam gas water for the receiving environment watercourses is presented in Table 10.10. The assessment assumes discharges occur either during high flow events; or during low flow conditions, where discharges deviate from current flows by 20%.

Table 10.10 Summary of residual impact assessment on watercourses receiving coal seam gas water on the CGPF2 and CGPF9 properties

Property/ Watercourse	Scenario	Sensitivity	Magnitude	Residual Impact
CGPF2 Bottle Tree Creek	Discharge during high flow events	Moderate	Low	Low
	Discharge during low flow with a 20% deviation from current flow conditions	Moderate	Moderate	Moderate
CGPF9 Condamine River	Discharge during high flow events	Moderate	Low	Low
	Discharge during low flow with a 20% deviation from current flow conditions	Moderate	Moderate	Moderate

Cumulative Assessment of Discharge

The assessment of cumulative impacts of the Surat Gas Project is presented in Chapter 28 of the EIS. Cumulative impacts on surface water values are further discussed in Chapter 9, Surface Water. The influence of other planned and existing discharges into watercourses proposed to

receive coal seam gas water from the Arrow properties will be considered through the development of the discharge strategy.

10.5 Conclusion

The aquatic ecology assessment identified general aquatic values at the CGPF7, CGPF8 and TWAF F properties, provided further characterisation of the aquatic environment in the Dawson River and Macintyre and Weir rivers sub-basins and included an assessment of impact on the receiving environment watercourses of the discharge of coal seam gas water from facilities located on the CGPF2 and CGPF9 properties.

Aquatic values, potential impacts, and the mitigation measures to reduce the impacts associated with project activities on the CGPF7, CGPF8 and TWAF F properties are consistent with those presented in the EIS.

Overall, aquatic habitat (hydrological conditions, water quality, physical characteristics and macro- and microhabitat availability), flora and fauna at site SAQ-1 located on Weringa Creek and SAQ-2 located on Commoron Creek, were assessed as being representative of local and regional conditions characteristic of aquatic ecosystems occurring within the Dawson River and Macintyre and Weir rivers sub-basins.

The prevailing hydrologic conditions throughout the receiving environment watercourses at the CGPF2 property have naturally shaped assemblages of aquatic flora and fauna that are typically low in diversity and seasonally variable. Most species recorded during the aquatic ecology surveys have broad habitat requirements and are generally tolerant of a wide range of conditions (hydrological, water quality and physical habitat).

Assemblages of aquatic flora and fauna at the CGPF9 receiving environment are low in diversity. The lack of diverse aquatic habitat in these watercourses is not conducive to varied assemblages, despite the comparatively increased permanence of water in the Condamine River. Assemblages in Crawlers Creek are generally restricted to a low number of generalist species, possessing a broad set of habitat requirements, due to the prevailing hydrologic conditions of the watercourse.

Four fish species of conservation significance were identified during the field surveys. The Murray cod, listed as vulnerable under the EPBC Act, was found within both the CGPF2 and CGPF9 receiving environment watercourses. Two species listed as ACA priority species were identified with the Agassiz's glassfish recorded at the CGPF2 receiving environment and the eel-tailed catfish recorded at the CGPF9 receiving environment. Three introduced fish species were identified including the European carp, goldfish and the mosquito fish. One introduced macrophyte species, salvinia, was recorded at the CGPF2 receiving environment and is listed as a Class 2 declared past under the *Land Protection (Pest and Stock Route Management) Act 2002*.

The macroinvertebrate assemblages identified in the CGPF2 watercourses are typical of ephemeral and disturbed systems and have relatively low diversity. Macroinvertebrate assemblages identified in the CGPF9 property watercourses are typical of semi-permanent waterways throughout the region, are relatively diverse, and in 'good' condition (with only minor impacts from anthropogenic sources). No macroinvertebrates of conservation significance were identified.

The potential impact on aquatic ecosystems of discharging treated or untreated coal seam gas water to the watercourses in the CGPF2 and CGPF9 receiving environments is low during periods

of high flow events and moderate during periods of low flow conditions with a 20% deviation from existing flows.

10.6 Issues Raised in Submissions

Submissions on the EIS raised a range of issues relating to aquatic ecology. The issues fall into broad topics, which are listed below:

- Aquatic fauna, including stygofauna.
- Aquatic weeds and pests.
- Buffer distances.
- Commitments.
- Environmentally sensitive areas.
- Further characterisation of existing environment, i.e., ephemeral watercourses.
- Legislative requirements.
- Movement of aquatic biota.
- Project infrastructure impacts, such as dams, discharge points, and the potential ocean outfall pipeline.
- Relationship with terrestrial ecology and the interconnectedness with aquatic ecology.
- Spill containment and remediation.
- Study method.

The topics list is provided to give an idea of the types of issues that have been raised in relation to aquatic ecology and for which responses have been provided under the heading 'Aquatic Ecology' in Part B, Chapter 19 and also in Chapter 20, Response to DERM Submission.

10.7 Commitments Update

Four commitments have been updated to reflect current legislative requirements, incorporate expert advice provided through the SREIS process and to address the changes to the project description (Table 10.11).

The full list of commitments, including those that remain unchanged from the EIS and details on those that have changed, is provided in Attachment 4, Commitments Update.

Table 10.11 Commitments update: aquatic ecology

No.	Commitment	Revised/New
C034	Develop an erosion and sediment control plan and install and maintain appropriate site-specific controls, established on the basis of the sensitivity of the surrounding environment.	Expanded to capture expert advice provided in supplementary assessment.
C156	Manage potential impacts on Lake Broadwater Conservation Park (Category A ESA) through implementation of relevant buffers in accordance with legislative requirements at the time of development in this region.	Commitment updated to reflect Queensland Government review of buffers.
C157	Arrow will implement a buffer zone from the high bank of all watercourses to prevent development or clearance occurring within the buffer (other than construction of watercourse crossings for roads and pipelines, discharge infrastructure and associated stream monitoring equipment). Determine the buffer zone distance in accordance with the legislative requirements at the time of development or through preconstruction clearance surveys.	Commitment updated to reflect Queensland Government review of buffers.

Table 10.11 Commitments update: aquatic ecology (cont'd)

No.	Commitment	Revised/New
C498	Develop a strategy for the discharge of coal seam gas water to watercourses in accordance with relevant legislation. The strategy will incorporate a water quality monitoring program with locations upstream and downstream of the discharge point to inform site specific water quality objectives. A detailed environmental flows assessment informed by water quality monitoring data and an aquatic ecology monitoring program will inform the discharge strategy. Periodic inspections of the physical form and hydrology of the watercourse are to be incorporated in the strategy to monitor geomorphic performance.	Revised to account for changes to the project description and to encompass commitments C175, C526 and C527 in one place.