16. AQUATIC ECOLOGY

This chapter provides a summary of the aquatic ecological values within and surrounding the project development area and an assessment of the potential for these values to be affected by direct and indirect impacts associated with the construction, operation and decommissioning phases of the project. For the detailed findings of the project's aquatic ecology impacts, refer to Appendix J, Aquatic Ecology Impact Assessment. Environmental protection objectives have been developed and the avoidance, mitigation and management measures to achieve these objectives, identified. The residual impact assessment assumes that the proposed avoidance, mitigation and management measures have been applied.

The health of aquatic ecosystems is dependent on the water quality of surface water and any groundwater systems that discharge to the watercourse. Interconnections between groundwater and surface water systems provide potential pathways for contaminated groundwater to leak or flow to surface water features and cause impacts on aquatic flora and fauna. Ecosystems of the Condamine River are considered to be groundwater-dependent in areas where the Condamine Alluvium aquifer discharges to the Condamine River. While this process is interpreted to be limited (Barnett & Muller, 2008; Hillier, 2010), it is an important interaction between groundwater and surface water in the project development area. Shallow aquifers in the project development area are also recharged predominantly from surface drainage, in particular from the main branch of the Condamine River (Huxley, 1982; SKM, 1999). These interconnections need to be taken into consideration in the planning and monitoring of project activities. Groundwater and surface water resources are detailed in Chapter 14, Groundwater, and Chapter 15, Surface Water.

Semi-aquatic mammals, amphibians, reptiles, avifauna, wetland birds and riparian vegetation have been addressed in Chapter 17, Terrestrial Ecology.

Matters of national environmental significance identified through the aquatic ecology impact assessment have also been presented in Attachment 3, Matters of National Environmental Significance.

16.1 Legislative Context

The following legislation, policy, guidelines and guidance documents are relevant to identifying values and providing guidance for avoidance, mitigation and management of impacts to aquatic ecology.

***Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act).** This Commonwealth act provides for the protection of matters of national environmental significance, which includes listed aquatic species and Ramsar sites.

***Environmental Protection Act 1994* (Qld) (EP Act).** The objective of the EP Act is to protect Queensland's environment by promoting ecologically sustainable development. The Environmental Protection Regulation 2008 provides a mechanism to enforce the EP Act and allows for an assessment of the risk that an environmentally relevant activity poses to environmentally sensitive areas (ESAs).

***Nature Conservation Act 1992* (Qld).** The objective of this act is to protect native wildlife, which includes individual species of plants and aquatic animals, in addition to habitats and ecosystems. The Department of Environment and Resource Management (DERM) administers the act and approval is required to interfere with species listed under the Nature Conservation (Wildlife) Regulation 2006 (Qld). This act places threatened species into different categories, i.e., extinct in

the wild, endangered, vulnerable, near threatened and least concern in recognition of how threatened they are and what action needs to be taken to protect them. For threatened species, there are a range of management and recovery actions to ensure their ongoing survival in the wild.

Fisheries Act 1994 **(Qld).** This act provides for the management, use and protection of fisheries resources in Queensland. The main purpose of the act is to provide for the use, conservation and enhancement of the community's fisheries resources and fish habitats in a way that seeks to apply and balance the principles of ecologically sustainable development. In the event that Arrow needs to establish waterway barriers during watercourse crossings, approval must be sought under the Fisheries Act. The Fisheries (Freshwater) Management Plan 1999 under this act lists noxious species.

Water Act 2000 **(Qld)**. This act provides the framework to deliver sustainable water planning, allocation management and supply processes to ensure the improved security of water resources. The project lies within the region covered by the Water Resource (Condamine and Balonne) Plan 2004.

Sustainable Planning Regulation 2009. The Water Resource (Condamine and Balonne) Plan sets a requirement for the taking of, or interfering with, overland flow; therefore, such activities need an operational works approval under schedule 3, table 4 of Sustainable Planning Regulation 2009.

Land Protection (Pest and Stock Route Management) Act 2002 **(Qld).** This act lists declared aquatic plants and provides a framework for the management of pest animals and weeds. The species targeted for control by the act are those with the potential to cause serious economic, environmental or social impacts.

Environmental Protection (Water) Policy 2009 (EPP Water). This policy sits under the EP Act and governs the discharge of wastewater to land, surface water and groundwater. The EPP Water sets water quality objectives to provide guidance to protect environmental values. The values for aquatic ecology are closely related to those of groundwater and surface resources, which are detailed in Chapter 14, Groundwater, and Chapter 15, Surface Water.

State Planning Policy for Healthy Waters 4/10. This policy is intended to ensure that development is planned, designed, constructed and operated to manage stormwater and wastewater in ways that protect water environmental values specified in the EPP Water.

Queensland Water Quality Guidelines 2009 (DERM 2009d). These guidelines provide a framework for assessing water quality in Queensland through the setting of water quality objectives.

Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000). These guidelines provide a methodology for assessing water quality through comparison with guidelines derived from local reference values.

Regional Vegetation Management Code for Brigalow Belt and New England Tablelands Bioregions (DERM, 2009e). The code has been prepared in accordance with provisions set out in the *Vegetation Management Act 1999* (Qld) and applies to significant projects under the *State Development and Public Works Organisation Act 1971*. Although petroleum activities are exempt from the requirement to obtain approval to clear native vegetation under the Vegetation Management Act and the project has not been declared a significant project, the guidance of the

code has been used to ensure best practice techniques are undertaken to maintain aquatic ecological values.

IUCN Red List of Threatened Species (IUCN, 2011). The Fitzroy river turtle (*Rheodytes leukops*) has been assessed by the Australasian Reptile and Amphibian Specialist Group and is recognised internationally as vulnerable under the IUCN Red List of Threatened Species.

16.2 Assessment Methods

The aquatic ecology baseline assessment comprised a desktop study and a field survey to gain an understanding of and describe the existing environment. The significance approach was used to undertake the assessment of impacts.

16.2.1 Desktop Study

The study commenced with an intensive review of existing data and information of aquatic ecology for the study area, which includes the project development area as well as surrounding drainage basins (Figure 16.1). The desktop study involved a detailed literature review and searches of the following government, non-government databases and other sources:

- Protected Matters Search Tool (EPBC Act), including a 5-km additional search buffer surrounding the project development area. The coordinates searched can be found in the EPBC referral (No. 2010/5344), available on the DSWEPAC website, and also within the Terrestrial Ecology Assessment Report (Appendix K). The Matters of National Environmental Significance (Attachment 3) also provides more information on the EPBC Protected Matters Searches.
- Aquatic Conservation Assessment, 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, 2010g).
- The Murray Darling Basin Commission for sources of fish data over a range of time spans in the Condamine and Weir rivers drainage basins.
- A review of recreational fishing clubs, associations and values within the area.

Database searches were undertaken to determine whether any aquatic flora, fauna or areas protected under existing legislation occur near or within the project development area.

Surface water quality is one indicator of aquatic ecosystem health and historical data and information were obtained from a variety of sources. Further information is provided in Chapter 15, Surface Water.

Data collected through the desktop and field survey were interpreted using modeling, univariate and multivariate statistical analysis. A sensitivity analysis of aquatic ecosystem values was performed and the magnitude of potential impacts associated with project activities assessed. The method for applying sensitivity criteria and rankings is described in detail in Section 3.10, Impact Assessment, of Appendix J, Aquatic Ecology Impact Assessment.

16.2.2 Field Survey

Potential survey sites for aquatic ecosystems were identified through the desktop study. As the precise location of production facilities and associated infrastructure was unknown, potential sampling sites were selected to provide a representative sample of aquatic ecosystems in the study area which corresponded with the project development area.

A preliminary list of potential sampling sites across the study area was prepared based on land-use, and waterway and catchment characteristics. Areas that may contain significant aquatic ecosystem values such as high value wetlands or critical habitat for listed aquatic species were identified.

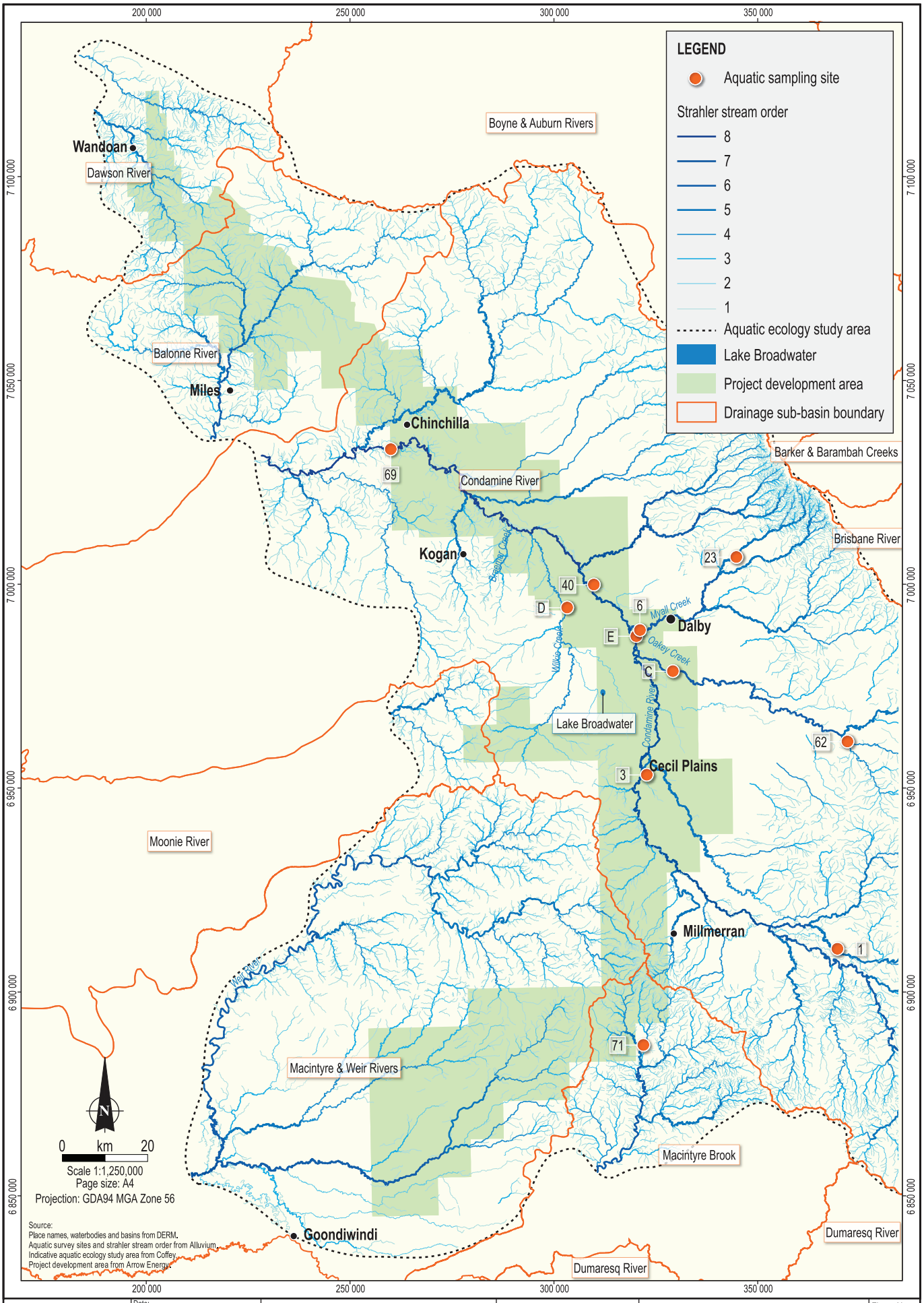
Waterways were characterised in the desktop study based on physical and ecological features to ensure that all waterway types were adequately represented in the sampling program. Factors considered in detail during site selection include:

- Drainage basin and catchment land-use.
- The proportion of flowing and still water bodies within the study area.
- Hydrological factors e.g., permanently flowing or intermittently flowing waterways.
- Stream order and location in relation to other waterways e.g., above or below the point where two or more watercourses meet.
- Salinity (dissolved salt content).
- Suitability of habitat for aquatic ecology sampling and accessibility during wet season flows.

Desktop assessment identified 73 sites that were potentially suitable for ground truthing the aquatic ecology desktop study findings. Many of these sites were relatively similar in terms of key attributes such as habitat type, altitude, land use and climate, indicating that a representative subset of sites could be sampled without significant loss of information.

A field reconnaissance trip was undertaken to assess all 73 sites on the basis of the above criteria. Ground truthing identified 11 of the 73 sites as being representative of the ecological conditions of the study area with regard to human, climatic and physical influences on aquatic ecology. Further details of the site selection process are provided in Section 3.3, Field Surveys, of Appendix J, Aquatic Ecology Impact Assessment.

The 11 sites selected for field assessment are identified in Figure 16.1. Field surveys were completed in November 2009 (early wet season) and May 2010 (post wet season) to capture variation in waterway conditions. Details of field survey sites are presented in Table 16.1.



coffey environments	Date: 02.11.2011 MXD: 7040AC_04_GIS056_v1_4 File Name: 7040_04_F16.01_GIS_GL	Arrow Energy Surat Gas Project	arrowenergy go further	Aquatic ecology field survey sites and study area	Figure No: 16.1

Table 16.1 Field survey site locations and survey descriptions

Site	Watercourse	Hydrology	Dominant Substrate	Reach Hydrology	Survey Type
1	Condamine River at Karrara Road	Permanent/semi-permanent	Bedrock	Run, pool, riffle	Flora, fish, macroinvertebrate, water quality
3	Condamine River at Cecil Plains	Permanent/semi-permanent	Sand	Pool	Flora, fish, reptile, macroinvertebrate, water quality
6	Westbrook Creek at the Moonie Highway	Permanent/semi-permanent	Silt/clay	Pool	Flora, fish, macroinvertebrate, water quality
23	Myall Creek at Irvingdale	Permanent/semi-permanent	Silt/clay	Pool	Flora, fish, macroinvertebrate, water quality
40	Braemar Creek at Kogan Road	Ephemeral	Sand	Pool	Flora, fish, macroinvertebrate, water quality
62	Gowrie Creek at Oakey–Pittsworth Road	Permanent/semi-permanent	Sand, silt/clay	Run, pool, riffle	Flora, fish, macroinvertebrate, water quality
69	Condamine River at Chinchilla Weir	Permanent/semi-permanent	Bedrock, sand	Pool	Flora, fish, reptile, macroinvertebrate, water quality
71	Bringalilly Creek at Heckles Road	Ephemeral	Sand	Pool	Flora, fish, macroinvertebrate, water quality
C	Oakey Creek at Cecil Plains Road	Permanent/semi-permanent	Silt/clay	Pool	Flora, fish, macroinvertebrate, water quality
D	Wilkie Creek at end of Theten Road	Permanent/semi-permanent	Sand	Run, pool, riffle	Flora, fish, reptile, macroinvertebrate, water quality
E	Condamine River at Louden Weir	Permanent/semi-permanent	Silt/clay	Pool	Flora, fish, reptile, macroinvertebrate, water quality

A risk based approach to site selection was applied. The field reconnaissance trip clarified that many of the 73 sites were homogenous in terms of biophysical attributes such as altitude, land use and climate. This indicated that a representative subset of sites could be sampled without a significant loss of information. The 11 sites were considered representative of aquatic systems across the entire study area. Appendix J (Aquatic Ecology Impact Assessment) provides more information.

The aquatic ecology survey sites were sampled and surveyed during November 2009 and May 2010 for the following:

- Water quality parameters including measurement of temperature, dissolved oxygen, electrical conductivity, turbidity and pH.
- Aquatic flora (macrophytes) to provide a visual assessment of the species present and watercourse health.

- Aquatic fauna (fish), using a combination of either fine-mesh (6 mm) fyke nets, fine-mesh seine nets, baited traps or backpack electrofishing. The surveys aimed to provide details of the abundance and diversity of species. All fish survey methods were non-lethal and all native fish were returned unharmed to the water.
- Aquatic fauna (reptiles), using modified fyke nets and opera-house turtle nets baited with oily fish to concurrently sample fish and turtles within weirs and pools.
- Aquatic fauna (macroinvertebrates), using standard field protocols outlined in the Australian Rivers Assessment System (AusRivAS) Queensland field manual (DNRM, 2001). The surveys aimed to provide details of invertebrate assemblages at the sites, which could be compared to reference sites to provide an indication of the health and diversity of the aquatic ecosystems.

Sediment samples were taken at seven of the sites and tested for a range of parameters, including petroleum hydrocarbons, nutrients and metals.

Nine of the eleven field survey sites were permanent/semi-permanent watercourses within the study area. This approach was considered appropriate given that permanent/semi-permanent watercourses provide dry season refuge for aquatic biota and are more likely to contain less resilient species, communities or habitats than ephemeral systems.

Several watercourses such as the ephemeral streams that drain into the Dawson and Weir rivers drainage basins were dry at the time of sampling and were not able to be sampled for aquatic flora or fauna.

16.3 Existing Environment and Environmental Values

This section describes the general characteristics of the aquatic environment, identifies environmentally sensitive areas, and describes the water quality, sediment, and aquatic flora and fauna (fish, reptiles, macroinvertebrates) within and around the project development area. Values of the existing aquatic environment are described.

16.3.1 General Aquatic Ecology Characteristics

Aquatic ecosystems within the study area are diverse with permanent, semi-permanent and highly seasonal lotic (flowing water) and lentic (non-flowing water) environments represented in four drainage basins (Condamine-Culgoa Drainage Basin, Fitzroy Drainage Basin, Border Rivers Drainage Basin and Moonie Drainage Basin (see Figure 15.2, Chapter 15)). Figure 16.1 shows the sub-basin boundaries within these drainage basins.

Numerous watercourses were identified within the study area, including the Condamine River itself. Several wetlands are located in the study area along with numerous smaller creeks and drainage lines, many of which are known to be ephemeral. Aquatic Conservation Assessment using AquaBAMM identified wetlands in 67% of riverine catchments and 68% of non-riverine catchments as being of low to medium value. Wetlands alongside the Condamine River were identified as ranging from high to very high value.

Permanent and semi-permanent watercourses within the project development area are typically slow flowing and meandering during the dry season, with periods of higher flow during the wetter months. Ephemeral streams may experience short periods of high flow but also undergo long periods of low or zero flow during which time the streams become a series of waterholes or dry out completely. There are a number of storages and weirs throughout the region, and flows in the major river systems are highly regulated.

In general, the aquatic environments within the project development area are moderate to highly disturbed as a result of many decades of modification to terrestrial environments and altered drainage basin processes.

Permanent and Semi-permanent Watercourses

Permanent and semi-permanent watercourses within the project development area include the Condamine River, Wilkie Creek, Oakey Creek and Braemar Creek. These systems contain water year round, although in many cases they are reduced to series of isolated pools during the dry season.

Recreational fishers frequent the permanent and semi-permanent watercourses, as evidenced by the multiple fishing clubs and stocking associations operating within the project development area. Most fishing takes place on private properties or where there is public road access to the watercourses. Recreational fisheries within the project development area are considered an asset that requires protection. There are no commercial fisheries or fishing assets within the project development area or other areas that might potentially be affected.

Development and agricultural land use has resulted in the disturbance of the permanent and semi-permanent watercourses and their ecosystems. The disturbance ranges from minimal to highly disturbed. However, these ecosystems still provide good-quality aquatic habitat that are known to support a relatively diverse range of aquatic species including fish, turtles and invertebrates. In general, the permanent and semi-permanent watercourses have uniform aquatic flora, fauna and macroinvertebrate communities across the project development area, as described below.

Ephemeral Watercourses

A high proportion of the ephemeral systems within the project development area are unnamed first- or second-order systems that flow for very limited periods each year. The simplest of these systems are often little more than drainage lines through agricultural or forested areas, although the more substantial watercourses hold water for longer periods of time and have slightly higher habitat value for aquatic fauna.

These systems ranged from being moderately disturbed by existing land use activities to being highly disturbed agricultural drainages.

In general, the ephemeral watercourses within the project development area are not unique on a local or regional scale. These ecosystems contain no formal conservation status, no species, habitat or aquatic communities of special conservation significance, no fisheries values and no eco-tourism potential. They provide marginal aquatic habitat due to the short periods during which they contain water, lack of connectivity to larger, permanent watercourses and minimal spawning/nursery habitat.

Ephemeral watercourses are likely to be opportunistically utilised by aquatic fauna and flora that are tolerant of significant disturbance events and which can adapt to rapidly colonise and regenerate when conditions are suitable.

16.3.2 Environmentally Sensitive Areas

DERM has identified and mapped Category A and Category B ESAs, which are governed under the Environmental Protection Regulation 2000 and include, but are not limited to, national and conservation parks, forest reserves and international agreement areas.

Lake Broadwater Conservation Park (see Figure 16.1) is located within the project development area and is classified as a Category A ESA. This site is likely to be seasonally inhabited by some aquatic species for foraging or spawning. These species potentially include the EPBC Act-listed Murray cod (*Maccullochella peelii peelii*). The site is important in maintaining hydrological and ecological processes and filtering water, sediment and other pollutants.

The Narran Lakes Nature Reserve (in northern New South Wales) is listed as a site of international importance under the Ramsar Convention. The site is the terminal wetland of the Narran River, which is fed by the Condamine River. The Condamine River drains a substantial part of the project development area. Located approximately 75 km northwest of Walgett and 50 km northeast of Brewarrina, Narran Lake provides habitat for migratory species and is of cultural significance to Indigenous people. The wetland is located some 500 km by river from the project development area.

The Fitzroy River and its tributary, the Dawson River, drain the north part of the project development area. The Fitzroy River flows to the sea southeast of Rockhampton. Its mouth is 50 km south of the Ramsar wetlands of the Shoalwater and Corio Bays Area. The site comprises five major estuarine and marine environments, which represent the largest area in central east Queensland containing representative coastal, subcoastal, aquatic landscapes and ecosystems. The wetland complex is more than 500 km by river from the project development area.

Due to the expansive distances between the project development area and the Narran Lakes Nature Reserve and the Shoalwater and Corio Bays Area wetlands, it is unlikely project-related activities will impact on these sites. Consequently, the assessment did not include these sites. Attachment 3, Matters of National Environmental Significance provides more information.

16.3.3 Water Quality

A summary of in-situ water quality measurements across the field survey sites during November 2009 surveys and May 2010 surveys is provided in Table 16.2 and Table 16.3 respectively. ANZECC (2000) guidelines are provided where available for each parameter. Full water quality and sediment data for each site is provided in Appendix D to Appendix J, Aquatic Ecology Impact Assessment.

Table 16.2 Summary of in-situ water quality results across all sites during November 2009 surveys

Parameter	Unit	Mean	Maximum	Minimum	Standard Deviation	Standard Error	ANZECC Guideline
Temperature	˚C	25.6	31.0	23.0	2.9	0.9	N/A
pH	N/A	7.2	8.3	6.0	0.8	0.3	6.5 – 8.0
Dissolved oxygen	% saturation	62.0	118.0	14.0	30.5	3.4	90 – 100
Dissolved oxygen	mg/L	5.1	9.1	1.8	2.4	0.7	N/A
Electrical conductivity	µs/cm	499.2	1211.0	76.7	685.0	216.5	125 - 2200
Turbidity	NTU	295.9	661.0	14.0	239.8	75.8	6 - 50

Table 16.3 Summary of in-situ water quality results across all sites during May 2010 surveys

Parameter	Unit	Mean	Maximum	Minimum	Standard Deviation	Standard Error	ANZECC Guideline
Temperature	˚C	14.9	20.1	11.5	2.5	0.8	N/A
pH	N/A	7.3	8.5	6.6	0.5	0.2	6.5 – 8.0
Dissolved oxygen	% saturation	59.6	101.0	22.0	26.3	7.9	90 – 100
Dissolved oxygen	mg/L	6.1	10.4	2.1	2.7	0.8	N/A
Electrical conductivity	µs/cm	373.5	1247.0	156.6	337.1	101.6	125 - 2200
Turbidity	NTU	203.6	540.0	41.0	168.6	50.8	6 - 50

Water quality results are summarised as follows:

- Temperature ranged from 11.5˚C to 31.0˚C, with warmer temperatures in the November sampling season.
- pH ranges were outside ANZECC guidelines for all sites except for sites 3 and 62 in the November 2009 sampling season, and sites 1, 23 and 62 in the May 2010 season.
- Dissolved oxygen ranges were outside ANZECC guidelines for all sites except site 1 in the May 2010 sampling season.
- Electrical conductivity readings varied with highly elevated salinity levels at site 62 and site C.
- Turbidity readings were relatively high across the study area and exceeded ANZECC guidelines for all sites except sites 3 and 62 in the November 2009 sampling season, and sites 1, 23 and 62 in the May 2010 season.

Field survey results indicate that physico-chemical surface water quality for a number of parameters was often outside of the ANZECC (2000) guidelines, reflecting drainage basin land use and disturbance. Lack of flow at sample sites and the presence of algal blooms at some sites were noted as factors contributing to poor water quality.

Analysis of sediment samples was also carried out, and is summarised as follows:

- Petroleum hydrocarbon levels were less than the analytical detection limit at all field survey sites.
- Total nitrogen levels varied across the sites with markedly elevated levels at sites C and 40.
- Phosphorus levels varied across the sites and were highest at site C with elevated levels also present at site 6.
- Of 11 metals tested for, only nickel exceeded ANZECC guidelines, at sites C and 6. Other metals were below analytical detection limits or only present at low levels.

Results indicate that sites C and 6 are affected by the pollutants tested for, to a higher degree than other field survey sites.

The diversity and health of aquatic ecology species is strongly influenced by water quality within the watercourses in which they reside. Chapter 15, Surface Water, provides a detailed description

of the existing surface water systems (including a description of Strahler stream orders) and a more detailed assessment of surface water quality within the project development area.

16.3.4 Aquatic Flora Species

Aquatic flora in the permanent and semi-permanent watercourses is dominated by emergent and floating taxa. There is an absence of submerged aquatic flora due to the relatively high turbidity, which prevents light penetration and reduces the potential for submerged species to grow.

Field surveys identified 23 species of native aquatic flora. No nationally significant aquatic flora listed under the EPBC Act nor any aquatic flora species of state significance listed under the Nature Conservation Act were identified. Although no significant species were listed, aquatic flora represent important habitat for many aquatic fauna species.

Three introduced aquatic flora species were found, although none was listed under the Land Protection (Pest and Stock Route Management) Act. The species identified include:

- Umbrella sedge (*Cyperus eragrostis*), which is a native of South America and is a tufted perennial sedge. Although it is introduced, the species assists in stabilising earth banks and provides habitat for aquatic biota. It was located during field surveys but not found to be present in dense populations.
- Curled dock (*Rumex crispus*), which is a native of Europe and is a noxious weed in agricultural areas. It is a prolific plant that thrives in seasonal wetlands and was recorded at eight sites during the field surveys. At these sites, however, it was not present in large numbers.
- Barnyard grass (*Echinochloa crus-galli*), which is a native of Europe. It was recorded only at the Oakey Creek site (site C) and Myall Creek (site 23) during the surveys. It is a very prolific seed producer and should be considered a threat to aquatic ecosystems in the region.

16.3.5 Aquatic Fauna Species (Fish and Reptiles)

The desktop study searched databases to determine which fish and reptile species were likely to exist in the area, and targeted field surveys further clarified their existence. The desktop study revealed that 20 native fish species and 3 introduced species were likely to be found in permanent and semi-permanent watercourses within the project development area. Of these 23 species, 17 were recorded either within and/or immediately adjacent to the project development area during the field surveys. The desktop study also identified that a number of species of turtle were likely to be found within the project development area. During the field surveys, 46 turtles from 2 species were caught within and/or immediately adjacent to the project development area.

The fish and aquatic reptile species in the project development area are generally resilient species that tolerate a wide range of conditions. However, the desktop study identified seven fish species known or likely to be present within the project development area that are considered to be potentially and/or locally threatened and are of conservation interest as they are not very resilient to change. These are not currently listed under state legislation and include:

- Dwarf flathead gudgeon (*Philypnodon maculates).*
- Eel-tailed catfish (*Tandanus tandanus*). Verified during field surveys.
- Mountain galaxias (*Galaxias olidus*).
- Purple-spotted gudgeon (*Mogurnda adspersa*). Verified during field surveys outside project development area (Plate 16.1).

Photo: Tim Howell

Plate 16.1
Purple-spotted gudgeon
(Mogurnda adspersa)

Photo: Tim Howell

Plate 16.2
Bony bream
(Nematalosa erebi)

Photo: Tim Howell

Plate 16.3
Goldfish
(Carasius auratus)

- Rendahls tandan (*Porochilus rendahli*). Verified during field surveys.
- River blackfish (*Gadopsis marmoratus*). Verified during field surveys outside project development area.
- Silver perch (*Bidyanus bidyanus*). Verified during field surveys.

The Murray cod (*Maccullochella peelii peelii*), which is listed as vulnerable under the EPBC Act, was not recorded during field surveys. The species is known to exist in the area and was identified during the database search. Despite not appearing in the field surveys, there could potentially be remnant populations of wild fish present and it is known to be stocked as a recreational species.

Oakey Creek (site C) provides habitat for the purple-spotted gudgeon and river blackfish (potentially threatened, locally significant species now very scarce within the region). These species were recorded approximately 48 km upstream of the project development area in a tributary of Oakey Creek (Gowrie Creek).

The two most abundant native fish taxa found during field surveys were the carp gudgeons (*Hypseleotris* species complex) and bony bream (*Nematalosa erebi*) (Plate 16.2), both of which are widespread and abundant throughout most of the Murray-Darling Basin. Total fish abundance and species richness varied between sites across the project development area. Species richness ranged from a single species at site 23 (Myall Creek) to 10 species at site 3 (Condamine River). While these species richness values are low relative to coastal fish communities, they are typical of the lowland zones of the Murray-Darling portion of the Surat Basin, where fish assemblages are species poor and are dominated by a small number of taxa.

The total fish count at each site varied substantially between a single specimen recorded at site 23 (Myall Creek), and 1,090 fish recorded at site C (Oakey Creek). The high number of fish recorded from site C was largely composed of schooling juvenile common carp (*Cyprinus carpio*). The abundance of all other fish species was relatively low.

The only species with recreational or commercial fishing significance recorded during field surveys were golden perch (*Macquaria ambigua*) and eel-tailed catfish (*Tandanus tandanus*).

Three introduced species of fish were found during field surveys. The species were as follows:

- Mosquito fish (*Gambusia holbrooki*).
- Common carp (*Cyprinus carpio*).
- Goldfish (*Carasius auratus*) (Plate 16.3).

The mosquito fish and common carp are listed as noxious species under the Fisheries (Freshwater) Management Plan 1999.

Field survey results for turtles, identified that the most numerous species was the Macquarie turtle (*Emydura macquarii*), with 37 individuals collected from 3 sites (sites 3, D and E). Several specimens of Macquarie turtle appeared to be subspecies. None of the potential subspecies that are likely to be found within the project development area is considered threatened. Other species found during the surveys included the broad-shelled turtle (*Chelodina expansa*), with nine individuals caught at four sites (sites 3, 69, D and E).

The Fitzroy River turtle (*Rheodytes leukops*) is listed as vulnerable under the EPBC Act and the state Nature Conservation Act and recognised internationally as vulnerable under the IUCN's red list of threatened species (IUCN, 2011). The species was not recorded during field surveys;

however, the database search indicates it could potentially be present within the northernmost section of the project development area within the Fitzroy River Drainage Basin.

16.3.6 Aquatic Fauna Species (Macroinvertebrates)

Assessment of the macroinvertebrate species present in a watercourse gives an indication of the overall health of the watercourse, based on varying species-specific tolerances to pollution.

The AusRivAS method uses regional models to statistically compare the following:

- Observed invertebrate assemblages at field survey sites with those expected to occur at comparable but relatively pristine reference sites. This comparison provides an indication of which species assemblages are currently present compared to those that would be expected if water quality was pristine.
- Values allocated to each macroinvertebrate family based largely upon their sensitivity to pollution. The presence or absence of macroinvertebrate families provides an indicator of long-term water quality at a site.

AusRivAs risk bands are determined based on modelled scores for each field survey site. Risk bands are defined as follows:

- **Band X.** This shows that the field survey site has greater biological diversity than the reference sites. More macroinvertebrate families are found than expected and there is the potential as being a biodiversity 'hot-spot' or mild organic enrichment. There is a continuous irrigation flow in a normally intermittent stream.
- **Band A.** This shows that the biodiversity of the field survey site is similar to the reference sites. An expected number of families within the range are found at 80% of the reference sites.
- **Band B.** Biodiversity is significantly reduced at the field survey sites. There are fewer macroinvertebrate families than expected. There is potential impact either on water or habitat quality resulting in a loss of families.
- **Band C.** Biodiversity of the field survey site is severely impaired. Many fewer macroinvertebrate families than expected are found. There is a loss of families from substantial impairment of expected biota caused by water or habitat quality.
- **Band D.** Biodiversity of the field survey site is extremely impaired. Few of the expected macroinvertebrate families and only the hardy, pollution tolerant families remain. There is severe impairment.

Habitats selected for sample include pool (relatively 13, stationary or very slow flowing water) and edge (along the bank where there is no current). Table 16.4 provides AusRivAs risk bands based on modelled scores for each field survey site.

Table 16.4 AusRivAS risk bands for combined data from November 2009 and May 2010 for field survey sites

Site	Habitat	Band
1	Pool	C
	Edge	B
3	Pool	C
	Edge	B

Table 16.4 AusRivAS risk bands for combined data from November 2009 and May 2010 for field survey sites (cont'd)

Site	Habitat	Band
6	Pool	C
	Edge	B
23	Pool	C
	Edge	C
40	Pool	C
	Edge	C
62	Edge	B
69	Pool	C
	Edge	C
71	Pool	C
	Edge	B
C	Pool	B
	Edge	B
D	Pool	C
	Edge	B
E	Pool	C
	Edge	B

Macroinvertebrate results for all sites fall between bands B (biodiversity significantly reduced) and C (biodiversity severely impaired), meaning that fewer macroinvertebrate families were present than expected. Macroinvertebrate populations are indicative of watercourses that are significantly degraded due to impacted water or habitat quality. Sites 23 and 40 were distinct from other survey sites, being dominated by chironomid (non-biting midge) larvae, a family that is particularly tolerant of poor water quality. Analysis of macroinvertebrates indicates a high degree of similarity in the composition of populations between sampling sites across the project development area, irrespective of drainage basin or catchment land use.

Macroinvertebrate communities were typically characteristic of watercourses experiencing significant impacts through anthropogenic processes such as water extraction and agricultural land use.

No crustacean species of conservation or commercial significance were indicated by the desktop surveys and no specific surveys for crustacean species were undertaken. However, the giant freshwater prawn (*Macrobrachium* spp.) was observed in significant numbers across most sampling sites during electrofishing and seine netting operations, as were yabbies (*Cherax destructor*). Freshwater shrimps (*Atyidae* spp.) were very common across the sites. Microcrustaceans such as daphnia (*Cladocera* spp.) and copepods (*Calanoida* spp., *Cyclopoida*, spp.) were present in macroinvertebrate samples at most sites across the project development area. The collection of yabbies is likely to be a minor recreational pursuit.

16.3.7 Environmental Values

Aquatic ecosystems in the region include ESAs, permanent and semi-permanent watercourses, and ephemeral watercourses. A unique portion of Oakey Creek (upstream of site C) has also

been described below due to the potential presence of an extremely limited distribution of locally threatened fish.

The existing aquatic ecology environment identified within the project development area comprises unique characteristics. These characteristics dictate the overarching value of each aquatic ecology environment and formed the basis of an assessment from which the sensitivity of the value was determined. Based on the desktop and field studies, the key existing environments relating to aquatic ecology are summarised in Table 16.5 together with the sensitivity of the aquatic ecology value. The method of applying sensitivity criteria and rankings is described in detail in Section 3.10, Impact Assessment, of Appendix J, Aquatic Ecology Impact Assessment.

Table 16.5 Sensitivity of the value of the existing environment

Existing Environment	Characteristics Contributing to the Value	Sensitivity of the Value
Lake Broadwater Conservation Park	• High degree of ecological intactness. • Valuable aquatic habitat, in particular, for: – National and state listed aquatic fauna species of significance, including the Murray cod. – Locally significant species. • Provision of important ecological processes for maintaining and filtering water quality, sediment and other pollutants.	High
Oakey Creek (upstream of site C)	• Provision of habitat for locally threatened species (*Mogurnda adspersa* and *Gadopsis marmoratus*). The tolerance of these species to disturbance and the replacement potential is very low. • Valuable aquatic habitat.	High
Permanent and semi-permanent watercourses (excluding Lake Broadwater Conservation Park and upstream of Oakey Creek site C)	• Valuable aquatic habitat, in particular, for: – National and state listed aquatic fauna species of significance, including the Murray cod (*Maccullochella peelii peelii*) and Fitzroy river turtle (*Rheodytes leukops*). – Locally significant species (for both conservation and recreation), such as river blackfish (*Gadopsis marmoratus*), golden perch (*Macquaria ambigua*) and silver perch (*Bidyanus bidyanus*). • Species diversification: aquatic ecosystems (unique at a local scale), ranging from minimally disturbed to highly disturbed, contain many areas of good quality aquatic habitat that are known to support a relatively diverse range of aquatic species, including fish, turtles and invertebrates. • Spawning habitat for aquatic species is present but does not represent critical spawning habitat. • Deeper pools and remnant waterholes providing refuge for a range of aquatic species, and these communities 'seed' populations when wet season flows provide connectivity between watercourses. • Habitat for longer-lived species (than those from ephemeral systems), which are less likely to recolonise following disturbance (hence there is greater possibility of these species or communities becoming locally extinct).	Moderate
Ephemeral watercourses	• Marginal aquatic habitat.	Low

16.4 Issues and Potential Impacts

The significance of potential impacts on the aquatic ecological values has been assessed using the sensitivity of the value and the magnitude of the potential impact (as described in Chapter 7, Impact Assessment Method. Potential impacts to aquatic ecological values from project activities include:

- Erosion and sediment transport.
- Decline in water quality and increased algal blooms.
- Introduction and spread of exotic species.
- Reduced movement of aquatic biota.
- Habitat loss, modification or fragmentation.

Assessment of impacts to terrestrial ecology, including riparian habitat, is provided in Chapter 17, Terrestrial Ecology. Activities with the potential to cause these adverse impacts on aquatic ecological values during the construction, operation and decommissioning phases of the project are described below.

16.4.1 Construction

The primary construction activity that could impact aquatic ecological values is the construction of road and pipeline watercourse crossings. Watercourse crossings will involve:

- Removal of riparian vegetation thereby exposing the ground surface and increasing its susceptibility to increased sedimentation in watercourses and erosion. Disturbance to watercourse banks can also destroy turtle and frog habitat.
- Earthworks and vehicle movement within the watercourse, leading to potential scouring of the bed and banks and subsequent sedimentation (with the potential for sedimentation to smother benthic fauna).
- The installation of temporary watercourse diversions which could create an instream barrier and disrupt the hydrology and the flow of the watercourse.

Further construction activities that could adversely impact the aquatic ecology include accidental spills or release of construction waste near or in watercourses causing contamination. Terrestrial earthworks during well site, pipeline and production facility construction could also cause sedimentation and the spread of exotic species.

16.4.2 Operation

During operations, the following project activities could impact upon aquatic ecological values:

- Use of herbicides during maintenance of wellheads, production facility sites and pipeline easements.
- Accidental spills or release of waste or sanitary wastewater near or in watercourses.
- Emergency discharge of coal seam gas water into watercourses during periods of prolonged rainfall when the dams have reached maximum capacity, potentially leading to streambed erosion and changes in water chemistry affecting aquatic flora and fauna.
- Use of vehicles for maintenance activities on access tracks potentially causing sedimentation and the spread of exotic species.
- The performance of culverts installed on production facility access tracks.

16.4.3 Decommissioning

During decommissioning, the following could impact on aquatic values:

- Accidental spills near or in watercourses.
- Use of vehicles for decommissioning activities on access tracks causing sedimentation and the spread of exotic species.

16.5 Environmental Protection Objectives

The environmental protection objectives for aquatic ecology are:

- To avoid or minimise adverse impacts to the aquatic ecology within ESAs, permanent and semi-permanent watercourses and ephemeral watercourses.
- To control the introduction or spread of new or existing exotic aquatic flora or fauna species.

16.6 Avoidance, Mitigation and Management Measures

Avoidance, mitigation and management measures have been proposed to achieve the identified environmental protection objectives.

The primary means by which avoidance is achieved is through design and site selection. Arrow's environmental framework focuses on early identification of sensitive locations that should be avoided by project activities, as described within Chapter 8, Environmental Framework. Arrow will manage potential impacts on Lake Broadwater Conservation Park (Category A ESA) through implementation of the relevant buffer proposed in Table 16.6. [C156].

Note that the only directly relevant sensitive area for aquatic ecology is Lake Broadwater Conservation Park, a Category A ESA; however, the proposed buffers for all category ESAs are provided for completeness. Regional ecosystems (REs) are defined under the *Vegetation Management Act 1999* (Qld) and are discussed in more detail within Chapter 17, Terrestrial Ecology.

Table 16.6 Proposed buffer distances from the ESA boundary

ESA Category	Proposed Activities within the ESA	Proposed Activities within 200 m of the ESA Boundary	Proposed Activities within a Secondary Protection Zone*
Category A	None	Low impact activities	Limited petroleum activities within 800 m of the primary protection zone.†
Category B: excluding regional ecosystems with 'endangered' status	Low impact activities	Low impact activities	Limited petroleum activities within 300 m of the primary protection zone.†
Category B: regional ecosystems with an 'endangered' status	Limited petroleum activities	Limited petroleum activities	Only limited petroleum activities within 300 m of the primary protection zone.†
Category C: excluding regional ecosystems with an 'of concern' status, state forests and timber reserves	Low impact activities	Low impact activities	Limited petroleum activities within 300 m of the primary protection zone.†

Table 16.6 Proposed buffer distances from the ESA boundary (cont'd)

ESA Category	Proposed Activities within the ESA	Proposed Activities within 200 m of the ESA Boundary	Proposed Activities within a Secondary Protection Zone*
Category C: regional ecosystems with an 'of concern' status, state forests and timber reserves	Limited petroleum activities	Limited petroleum activities	Limited petroleum activities within 300 m of the primary protection zone.†

* ESA buffers (derived from the guidelines under the EP Act, Model Conditions for Level 1 Environmental Authorities for Coal Seam Gas Activities) will be applied unless the activity occurs in pre-existing cleared areas or significantly disturbed land within the buffer and no reasonable or practicable alternatives exist.

† The primary protection zone is considered to be within 200 m of the ESA boundary.

The following definitions are used to describe acceptable project activities in relation to ESA buffers:

- **Low Impact Activities**. These activities include the limited prescribed activities that do not result in the clearing of native vegetation, cause disruption to soil profiles through earthworks or excavation or result in significant disturbance to land. Examples of such activities include, but are not limited to, soil surveys, topographic, cadastral and ecological surveys and traversing land by car or foot via existing access tracks or routes.
- **Limited Petroleum Activities.** Such activities include well sites not exceeding 1 ha of disturbance and multi-well sites not exceeding 1.5 ha of disturbance, geophysical surveys, ecological geological surveys, gathering/flow pipelines from a wellhead to the initial production facility, supporting access tracks and communication and powerlines necessary for the undertaking of petroleum activities. The definition excludes construction of dams, borrow pits, production facilities and construction camps.

16.6.1 Erosion and Sediment Transport

The following mitigation and management measures have been developed to address the potential impact of erosion and sediment transport on aquatic ecology, in accordance with best practice erosion and sediment controls for building and construction sites (IECA, 2008):

- Where appropriate, design ground disturbance works to minimise the need for cut-and-fill earthworks. [C183]
- Design gathering lines and tracks to avoid watercourses, drainage lines and riparian areas (particularly permanent watercourses or perennial aquatic habitat), where practicable. [C191]
- Avoid the use of vehicles and machinery in the vicinity of or within watercourses and riparian zones, wherever practicable. [C181]
- Minimise the disturbance footprint and vegetation clearing. [C020]
- Develop an erosion and sediment control plan and install and maintain appropriate site-specific controls. [C034]
- Confine project traffic to designated roads and access tracks, where practicable. [C033]
- Design watercourse crossings to enable passage of flows resulting from a 1 in 100 year average recurrence interval flood event, as a minimum. [C184]

16.6.2 Decline in Water Quality and Increased Algal Blooms

A decline in downstream surface water quality would result largely from mobilisation of sediment during construction as well as potential spills, herbicide use or accidental release of sanitary wastewater (which is rich in nutrients and slightly higher in temperature and could cause algal blooms).

Measures to minimise water quality and algal bloom impacts include:

- Install and maintain diversion drains to divert clean surface water runoff around production facilities and away from construction areas. [C024]
- Plan construction of watercourse crossings to occur during periods of low rainfall and low flow, when practicable. [C161]
- 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). [C157]
- 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. [C066]
- 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. [C036]
- Ensure appropriate spill response equipment, including containment and recovery equipment, is available on site. [C037]
- 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. [C069]
- Carry out corrective actions immediately upon the identification of any contamination of soil or groundwater that has occurred as a result of project activities. [C038]
- Complete excavation, remediation, characterisation and validation activities in response to the identification of contamination that may have occurred as a result of project activities. [C043]
- 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. [C199]
- Apply appropriate international, Australian and industry standards and codes of practice for the handling of hazardous materials (such as chemicals, fuels and lubricants). [C035]
- 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). [C048]
- 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. [C182]

16.6.3 Introduction of Aquatic Weeds

Aquatic weeds may be introduced when crossing the watercourses, or by vehicle washdown runoff. Management measures to minimise the introduction of exotic aquatic weeds include:

- Identify declared weeds during the preconstruction clearance survey. [C193]
- 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. [C188]
- Plan construction and maintenance activities to minimise movement of plant and equipment between properties or areas with weed infestations. [C189]
- 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. [C179]
- 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. [C190]
- 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. [C187]
- Wash down vehicles and equipment that have potentially been in contact with weeds before entering new work sites. [C099]
- Do not wash down vehicles in watercourses. [C180]

16.6.4 Reduced Movement of Aquatic Biota

In-stream barriers to the movement of fish and other biota could result from watercourse crossing during the construction of roads and pipelines. Measures to maintain in-stream biota movement include:

- Obtain all relevant permits required under the *Fisheries Act 1994* (Qld), including permits for construction of waterway barriers or disturbance of fish habitat. [C192]
- If diversion of watercourse flows using pumps is required, screen the pump intakes with mesh to protect aquatic life. [C198]
- 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. [C196]

16.6.5 Habitat Loss, Modification or Fragmentation

Site clearing during construction activities of the wells, pipeline and facilities will be the main cause of habitat loss; however, Arrow does not plan to construct well sites or production facilities near aquatic ecosystems. To minimise habitat loss, modification or fragmentation Arrow will:

- 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. [C152]
- Co-locate pipelines into one watercourse crossing corridor, where practicable. [C186]
- Design the width of the pipeline ROWs to be narrower at watercourse crossings, where practicable. [C185]
- 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). [C195]
- Store stockpiled, cleared vegetation away from watercourses or drainage lines. [C197]
- 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. [C071]
- 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. [C194]

16.7 Residual Impacts

The avoidance, mitigation and management measures outlined above will avoid adverse impacts to, or reduce the severity of, the magnitude of potential impacts on aquatic ecological values. The significance of residual impacts associated with project activities are described below.

16.7.1 Erosion and Sediment Transport

Erosion and sediment transport are predominantly caused by site clearance activities during construction. Avoidance and mitigation measures will be implemented to minimise impacts from erosion and sediment transport into the watercourses.

The intactness of the Lake Broadwater Conservation Park is of high value; therefore no clearing or levelling will occur within 200 m of Lake Broadwater Conservation Park. This subsequently eliminates direct impacts on this ecosystem. The magnitude of indirect residual impacts on Lake Broadwater from sediment transport will be low with implementation of mitigations measures, resulting in a residual impact significance of **moderate**.

Buffer zones restricting project activities will be maintained around watercourses. These buffers combined with mitigation measures reduce the magnitude of impacts to moderate for permanent, semi-permanent watercourses and ephemeral watercourse values will be reduced to low. The

overall significance of residual impacts will be **low** for permanent and semi-permanent watercourses and **negligible** for ephemeral watercourses.

16.7.2 Decline in Water Quality and Increased Algal Blooms

A decline in water quality would result largely from mobilisation of sediment during construction as well as potential spills, herbicide use or accidental release of sanitary wastewater (causing algal blooms).

Key mitigation measures to minimise potential impacts to water quality include buffer zones, limiting discharges to watercourses, erosion controls, spill containment and response and restricted use of herbicides. The potential for algal blooms will be reduced by locating onsite sanitary wastewater treatment away from watercourses or by transporting sanitary waste to municipal sewage treatment plant off site.

Magnitude of potential impacts will reduce to low and the significance of residual impacts will be **moderate** for Lake Broadwater, **low** for permanent and semi-permanent watercourses and **negligible** for ephemeral watercourses.

16.7.3 Introduction of Aquatic Weeds

The most likely construction activities to introduce aquatic weeds will be those conducted directly in watercourses (i.e., watercourse crossings). The magnitude of the impact can be reduced to low with the wash down of equipment and effective management of weeds.

Residual impact significance is considered **moderate** for Lake Broadwater, **low** for permanent and semi-permanent watercourses and **negligible** for ephemeral watercourses.

16.7.4 Reduced Movement of Aquatic Biota

The creation of physical or velocity barriers to the movement of aquatic organisms may result from in-stream construction of the pipeline and roads. With the installation of appropriately sized road culverts and pipeline flumes, as well as compliance with relevant permit conditions under the Fisheries Act, the magnitude of impact will decrease to low, resulting in a residual impact significance of **moderate** for Lake Broadwater, **low** for permanent and semi-permanent watercourses and **negligible** for ephemeral watercourses.

16.7.5 Habitat Loss, Modification or Fragmentation

As no project activities will occur in Lake Broadwater Conservation Park or Oakey Creek (upstream of site C), direct impacts on aquatic habitat will not occur; however, indirect impacts are possible. The presence of buffers around these sites will reduce the potential for, and magnitude of, indirect impacts.

Aquatic habitat loss and the modification of watercourses will be managed predominantly through minimising the project footprint.

The magnitude of impact following implementation of mitigation measures decreases to low, thereby reducing residual indirect impact significance to **moderate** for Lake Broadwater, and residual direct impact significance to **low** for permanent and semi-permanent watercourses and **negligible** for ephemeral watercourses.

16.7.6 Summary of Residual Impacts

Table 16.7 summarises the potential impacts prior to mitigation, along with proposed mitigation and management measures and the subsequent residual impacts, assuming implementation of proposed mitigation and management measures.

Table 16.7 Summary of aquatic ecology impact assessment

Cause of Potential Impacts	Existing Environment	Values Sensitivity	Premitigated Impact		Summary of Mitigation Measures	Residual Impact	
			Magnitude	Significance		Magnitude	Significance
Erosion and Sediment Transport Causing Changed Flow Patterns, High Turbidity or Smothering of Benthic Aquatic Habitat							
Construction • Site clearance and levelling resulting in mobilisation of sediment into watercourses. • Watercourse crossings resulting in stream-bed scouring, stream-bank erosion and riparian habitat loss.	Lake Broadwater and Oakey Creek (upstream of site C)	High	Moderate	High	• Use appropriate buffer zones around Lake Broadwater Conservation Park. • Design ground disturbance works to minimise need for cut-and-fill earthworks. • Design gathering lines and tracks to avoid watercourses where practicable. • Avoid use of vehicles in or near watercourses, where practicable. • Minimise disturbance footprint and vegetation clearing. • Develop an erosion and sediment control plan and install and maintain appropriate structures at work sites. • Confine project traffic to designated roads and access tracks, where practicable. • Design watercourse crossings as a minimum to enable passage of a 1 in 100 year ARI flood event.	Low	Moderate
Operations • Failure of sediment and erosion control measures.	Permanent and semi-permanent watercourses	Moderate	Moderate	Moderate		Low	Low
Decommissioning • Vehicle movement across the project development area for decommissioning activities could cause erosion and sediment runoff into watercourses.	Ephemeral watercourses	Low	Moderate	Low		Low	Negligible

Table 16.7 Summary of aquatic ecology impact assessment (cont'd)

Cause of Potential Impacts	Existing Environment	Values Sensitivity	Premitigated Impact		Summary of Mitigation Measures	Residual Impact	
			Magnitude	Significance		Magnitude	Significance
A Decline in Water Quality and Increased Algal Blooms							
Construction • Runoff from pipeline and road construction activities causing increased sediment. • Accidental spills or release of construction waste (including fuel, chemicals or waste water) near watercourses. • Sedimentation or contamination of watercourses caused by pipeline watercourse crossings. **Operations** • Use of herbicides during maintenance of well pads, facility sites and pipeline easements. • Accidental spills or release of waste (including fuel, chemicals or waste water) near watercourses. • Altered surface water hydrology from emergency discharge of water resulting in increased flows in ephemeral streams and altered water quality. • Sedimentation or contamination of watercourses caused by runoff from well pads and facility sites.	Lake Broadwater and Oakey Creek (upstream of site C)	High	Moderate	High	• Use appropriate buffer zones around Lake Broadwater Conservation Park. • Install and maintain diversion drains to divert clean surface water runoff around facilities and construction areas. • Plan watercourse crossings to target dry periods, where practicable. • Implement a 100-m buffer zone from the high bank of all watercourses. • Discharge water from project activities at a rate that will not result in erosion (use energy dissipation structures if required). • Develop and implement emergency response and spill response procedures. • Ensure appropriate spill response equipment is available on site. • Develop procedures for the controlled discharge of coal seam gas water under emergency conditions. • Carry out corrective actions immediately upon identification of contaminated soil. • Use herbicides away from watercourses and use non-toxic, biodegradable herbicides. • Use appropriate standards for handling hazardous materials.	Low	Moderate
	Permanent and semi-permanent watercourses	Moderate	Moderate	Moderate		Low	Low
	Ephemeral watercourses	Low	Moderate	Low		Low	Negligible

Table 16.7 Summary of aquatic ecology impact assessment (cont'd)

Cause of Potential Impacts	Existing Environment	Values Sensitivity	Premitigated Impact		Summary of Mitigation Measures	Residual Impact	
			Magnitude	Significance		Magnitude	Significance
A Decline in Water Quality and Increased Algal Blooms (cont'd)							
Decommissioning • Accidental spills near or in watercourses.	Ephemeral watercourses	Low	Moderate	Low	• Use appropriate standards for the design and installation of infrastructure used for storage of hazardous materials. • Locate portable toilet facilities at appropriate distances from watercourses. • Manage disposal of grey water through licensed contractors.	Low	Negligible
Introduction of Exotic Aquatic Flora Species							
Construction • Trenching and pipeline watercourse crossings and vehicle movement across the project development area could introduce new weeds or spread existing weeds.	Lake Broadwater and Oakey Creek (upstream of site C)	High	Low	Moderate	• Use appropriate buffer zones around Lake Broadwater Conservation Park. • Identify weeds during the preconstruction clearance survey. • Develop a weed and pest management plan. • Minimise movement of plant and equipment between properites with weed infestations. • Ensure all relevant personnel are aware of the location of weed infestations in the vicinity of the work area. • Ensure materials brought to site are not contaminated with weeds. Acquire a weed hygiene declaration form from the supplier of materials such as sand, straw bales, etc., if used.	Low	Moderate
Operations • Vehicle movement across the project development area could introduce new weeds or spread existing weeds. • Altered surface water hydrology from emergency discharge of water resulting in transferring of weeds from one area to another.	Permanent and semi-permanent watercourses	Moderate	Moderate	Moderate		Low	Low
	Ephemeral watercourses	Low	Moderate	Low		Low	Negligible

Table 16.7 Summary of aquatic ecology impact assessment (cont'd)

Cause of Potential Impacts	Existing Environment	Values Sensitivity	Premitigated Impact		Summary of Mitigation Measures	Residual Impact	
			Magnitude	Significance		Magnitude	Significance
Introduction of Exotic Aquatic Flora Species (cont'd)							
Decommissioning • Vehicle movement across the project development area for decommissioning activities could introduce new weeds or spread existing weeds.	Ephemeral watercourses	Low	Moderate	Low	• Design washdown facilities to ensure runoff is contained on site and does not transfer weeds to adjacent areas. • Wash down vehicles and equipment that has potentially come into contact with weeds. • Segregate weeds removed from designated work sites from all other materials (to allow to decompose).	Low	Negligible
Reduced Aquatic Biota Movement or Feeding Patterns							
Construction • Temporary diversion of watercourses during construction of pipeline watercourse crossings creating an in-stream barrier and/or disruption of hydrology and flow. **Operations** • Altered surface water hydrology from emergency discharge of water resulting in velocity barrier increased flows in ephemeral streams and altered water quality.	Lake Broadwater and Oakey Creek (upstream of site C)	High	Low	Moderate	• Use appropriate buffer zones around Lake Broadwater Conservation Park. • Obtain and comply with all relevant permits required under the Fisheries Act. • Construct watercourse crossings with suitable flumes and the pumps will be screened mesh, if required.	Low	Moderate
	Permanent and semi-permanent watercourses	Moderate	Low	Low		Low	Low
	Ephemeral watercourses	Low	Low	Negligible		Low	Negligible

Table 16.7 Summary of aquatic ecology impact assessment (cont'd)

Cause of Potential Impacts	Existing Environment	Values Sensitivity	Premitigated Impact		Summary of Mitigation Measures	Residual Impact	
			Magnitude	Significance		Magnitude	Significance
Habitat Loss, Modification or Fragmentation							
Construction • Temporary diversion of watercourses during construction of pipeline watercourse crossings creating an in-stream barrier and/or disruption of hydrology and flow. • Removal of riparian vegetation and excavation of road and pipeline watercourse crossings. **Operations** • Altered surface water hydrology from emergency discharge of water resulting in velocity barrier increased flows in ephemeral streams and altered water quality.	Lake Broadwater and Oakey Creek (upstream of site C)	High	Moderate	High	• Use appropriate buffer zones around Lake Broadwater Conservation Park. • Minimise watercourse crossings, where practicable. • Minimise the width of pipeline ROWs, where practicable. • Construct watercourse crossings to minimise sediment release to watercourses. • Store stockpiled vegetation away from watercourses or drainage lines. • Backfill and rehabilitate excavations, particularly pipeline trenches and drilling sumps. • Avoid transport of equipment across watercourses unless an appropriate crossing.	Low	Moderate
	Permanent and semi-permanent watercourses	Moderate	Moderate	Moderate		Low	Low
	Ephemeral watercourses	Low	Moderate	Low		Low	Negligible

16.8 Inspection and Monitoring

Inspection and monitoring of avoidance, mitigation and management measures will be implemented to ensure the residual impacts continue to be low throughout the lifetime of the project. Inspection will be undertaken regularly to ensure mitigation measures are effective and monitoring will be undertaken to demonstrate achievement of the environmental objectives.

Inspection and monitoring measures include:

- Inspect erosion and sediment control measures following significant rainfall events to ensure effectiveness of measures is maintained. [C505]
- Visually inspect physical form and monitor hydrology, electrical conductivity, turbidity and pH upstream and downstream of crossings immediately prior to, during and after construction of watercourse crossings. [C507]
- Routinely inspect for pest flora and evidence of pest fauna species within project disturbed areas. [C508]
- Routinely monitor buffer zones and project footprint using satellite imagery. [C509]
- Routinely visually inspect physical form integrity and measure or monitor as appropriate, macroinvertebrates, flow, electrical conductivity, turbidity, total suspended solids, pH, dissolved metals and total petroleum hydrocarbons. Inspection and monitoring will be conducted in accordance with relevant guidelines upstream and downstream of authorised locations where water is discharged directly to a watercourse. [C531]
- Routinely inspect spill containment controls and spill response kits. [C516]