Emu Swamp Supplementary Environmental Impact Statement –

Aquatic Ecology Assessment 2013

Prepared for:

Sinclair Knight Merz on behalf of Southern Downs Regional Council

frc environmental

PO Box 2363, Wellington Point QLD 4160
Telephone: + 61 3286 3850
Facsimile: + 61 3821 7936

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Summary

Background

The proposed Emu Swamp Dam Project is located on the Severn River, 15 km south-west of Stanthorpe and 5 km north of Ballandean, in south-east Queensland. In 2007, an Environmental Impact Statement (EIS) was prepared for the Dam by Southern Downs Regional Council and submitted to the Coordinator-General. Feedback on the EIS provided by the Department of Sustainability, Environment, Water, Population and Communities and the Queensland Department of Environment and Heritage Protection requested further information regarding the aquatic ecology of the Project area.

This report provides:

- an assessment of aquatic habitat, aquatic plants, fish and platypus in the Project area
- a discussion of the extent of aquatic habitat and aquatic plants in the Project area
- an assessment of potential impacts of the Project on aquatic ecology within and downstream of the proposed dam
- potential mitigation measures to reduce impacts, and
- recommendations for on-going monitoring, including performance measures, if required.

Aquatic habitat, aquatic plants, fish and platypus were surveyed at thirteen sites upstream, within and downstream of the proposed dam from 9 to 15 September 2013 .

Aquatic Habitat

Aquatic habitat was similar upstream, within and downstream of the proposed dam. It is capable of supporting aquatic flora and fauna, but has been affected by historical clearing of riparian vegetation and numerous weirs that restrict the passage of aquatic fauna.

Aquatic Plants

The specie richness and percent cover of aquatic plants was generally low. No rare, threatened or vulnerable species under the EPCB Act or NCWR, or noxious weed or weeds of significance, were observed in the vicinity of the Project.

Fish and Platypus

Fish communities in the vicinity of the Project are poor, with low diversity, abundance and recruitment. Carp gudgeon were the most abundant and widespread species during all surveys in the area. Murray cod, which are protected under the EPBC Act are present in the area.

Platypus are present upstream and downstream of the proposed dam, but are not abundant.

Risk Assessment

Aquatic flora and fauna in the proposed Project area may be affected by:

- the operation and maintenance of vehicles and other equipment during construction
- works including vegetation clearing, earthworks, quarrying and sand extraction during construction
- inundation and operation of the dam
- obstruction of flow and passage by the dam, and
- changes to the flow regime downstream of the dam.

Of the potential impacts identified, the inundation and operation of the dam, obstruction of flow and passage by the dam and changes to the downstream flow regime may have the greatest impact on aquatic ecology. These potential impacts of these, and other Project activities, can be minimised where mitigation measures are implemented.

Overall, the risk assessment indicates that there will only be a slight impact to aquatic habitat, aquatic plants, fish and platypus if mitigation measures are implemented. Monitoring might be required during construction and operation to confirm the absence of direct impacts key species and assess overall impacts to aquatic ecology.

1 Introduction

1.1 Background

The proposed Emu Swamp Dam Project (the Project) is located on the Severn River, 15 km south-west of Stanthorpe and 5 km north of Ballandean, in south-east Queensland (SKM 2008) (Figure 1.1).

An Environmental Impact Statement (EIS) was prepared for the Project in 2007 and released for public comment in 2008.

Submissions on the EIS provided by the Queensland Department of Agriculture and Fisheries (DAFF), the Queensland Department of Environment and Heritage Protection (EHP), and the Department of Sustainability, Environment, Water, Population and Communities (SEWPAC) requested further information regarding the aquatic ecology. Specifically, these agencies required further information on:

- the type, condition and proportion of aquatic habitat in the Project area, including habitat adjacent to the river
- aquatic plant communities, including rare and vulnerable species
- fish communities and fish passage in non-drought conditions and the potential impacts of the Project on fish passage
- the distribution and abundance of platypus in the Project area
- potential impacts to aquatic ecology
- cumulative impacts, and
- performance measures for aquatic flora and fauna, and the development of a monitoring program.

The EIS presented two options for Project: an Urban Water Supply Dam; and a Combined Urban and Irrigation Dam. SDRC have resolved to prepare a Supplementary EIS for the Combined Urban and Irrigation Dam option. The Combined Urban and Irrigation Dam has a storage capacity of 10 500 ML, a full supply level of 738 m AHD, with an associated inundation area of 196 ha (Figure 1.2). The maximum height of the dam wall will be 19.8 m for the combined urban and irrigation dam.

This report has been prepared for Sinclair Knight Merz (SKM) on behalf of Southern Downs Regional Council for the Supplementary EIS. It provides an assessment of the potential impacts of the proposed Emu Swamp Dam on aquatic habitat, aquatic plants, fish and platypus.

1.2 Project Area

The proposed dam site is on the Severn River, between Fletcher Road and Emu Swamp Road in the Stanthorpe Downs Regional Council. The Severn River is in the Granite Belt catchment, which is part of the Border Rivers Drainage Basin and Murray-Darling River System. The Granite Belt catchment is approximately 1 300 km^2 and includes the Broadwater, Cannon Creek, Quart Pot Creek, Four Mile Creek, Accommodation Creek and the Severn River. Cannon Creek and Four Mile Creek are tributaries of the Broadwater and Quart Pot Creek, which converge to form the Severn River west of Stanthorpe. The Severn River flows south-west and joins with Pike Creek to become the Dumaresq River then becomes the Macintyre River and Barwon River before flowing into New South Wales. Accommodation Creek is a tributary that flows into the Severn River approximately 12 km downstream of the proposed dam site.

Land use in the upper areas of the Granite Belt catchment comprises state forest and agriculture, while a large portion of the Accommodation Creek sub-catchment is in Girraween National Park. There are 26 barriers on the Severn River between the confluence of the Broadwater and Quart Pot Creek and Nundubbermere Falls, which are approximately 33 km downstream of the proposed dam site. Most of these barriers are private use weirs; their locations and heights were provided in Section 7 of the EIS.

For the purposes of this report, the Project area refers to the dam site, the dam storage, the Severn River approximately 25 km upstream of the dam site and the Severn River to approximately 17 km downstream of the dam site.

1.3 Objectives

This report provides a response to the submissions received for the EIS, and includes:

- an assessment of aquatic habitat, aquatic plants, fish and platypus in the Project area
- a discussion of the extent of aquatic habitat and aquatic plants in the Project area
- an assessment of potential impacts of the Project on aquatic ecology within and downstream of the proposed dam
- potential mitigation measures to reduce impacts, and
- recommendations for on-going monitoring, including performance measures, if required.

A conservative approach has been taken with respect to potential impacts and their mitigation.

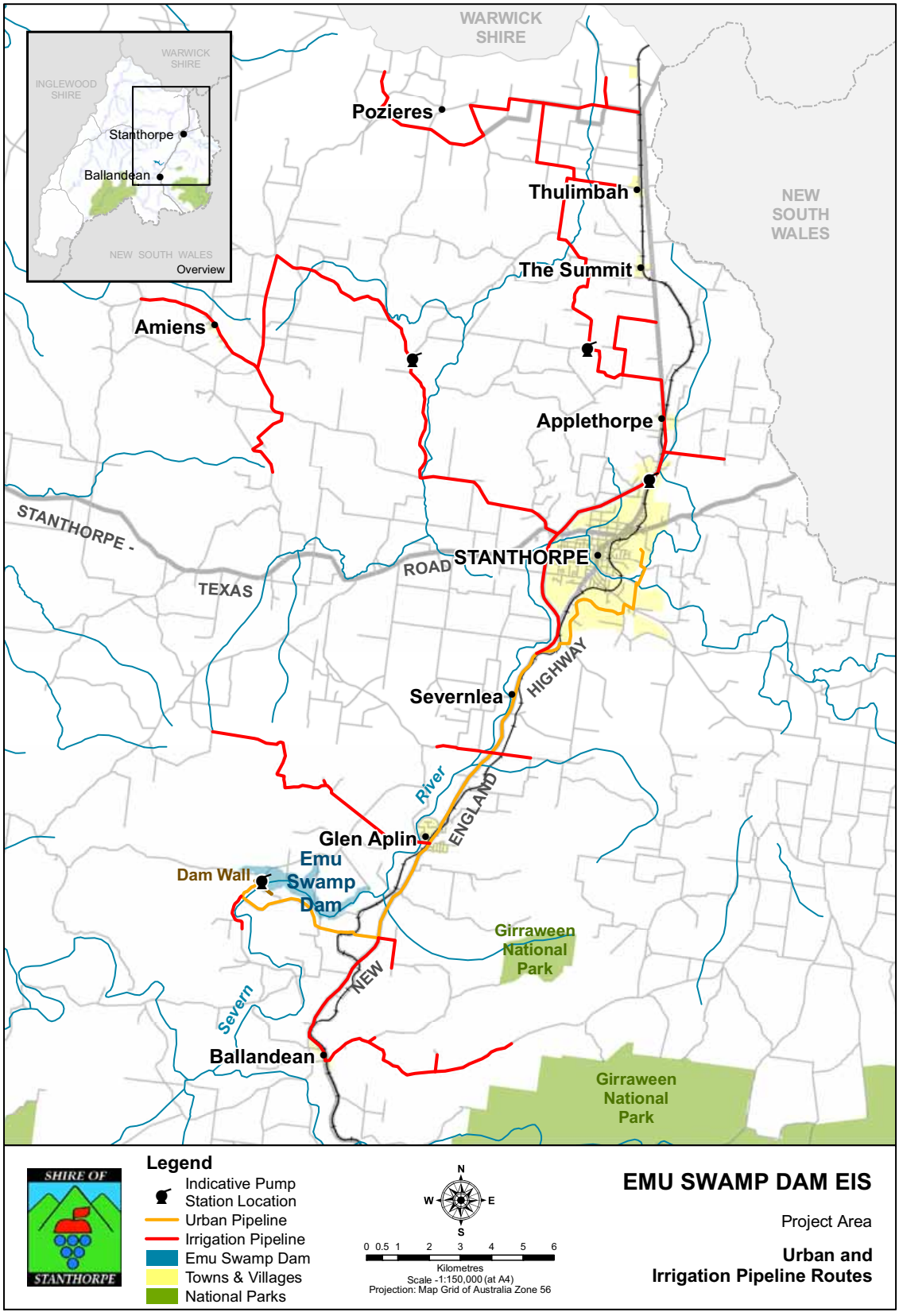

Figure 1.1 Location of Emu Swamp Dam Project.

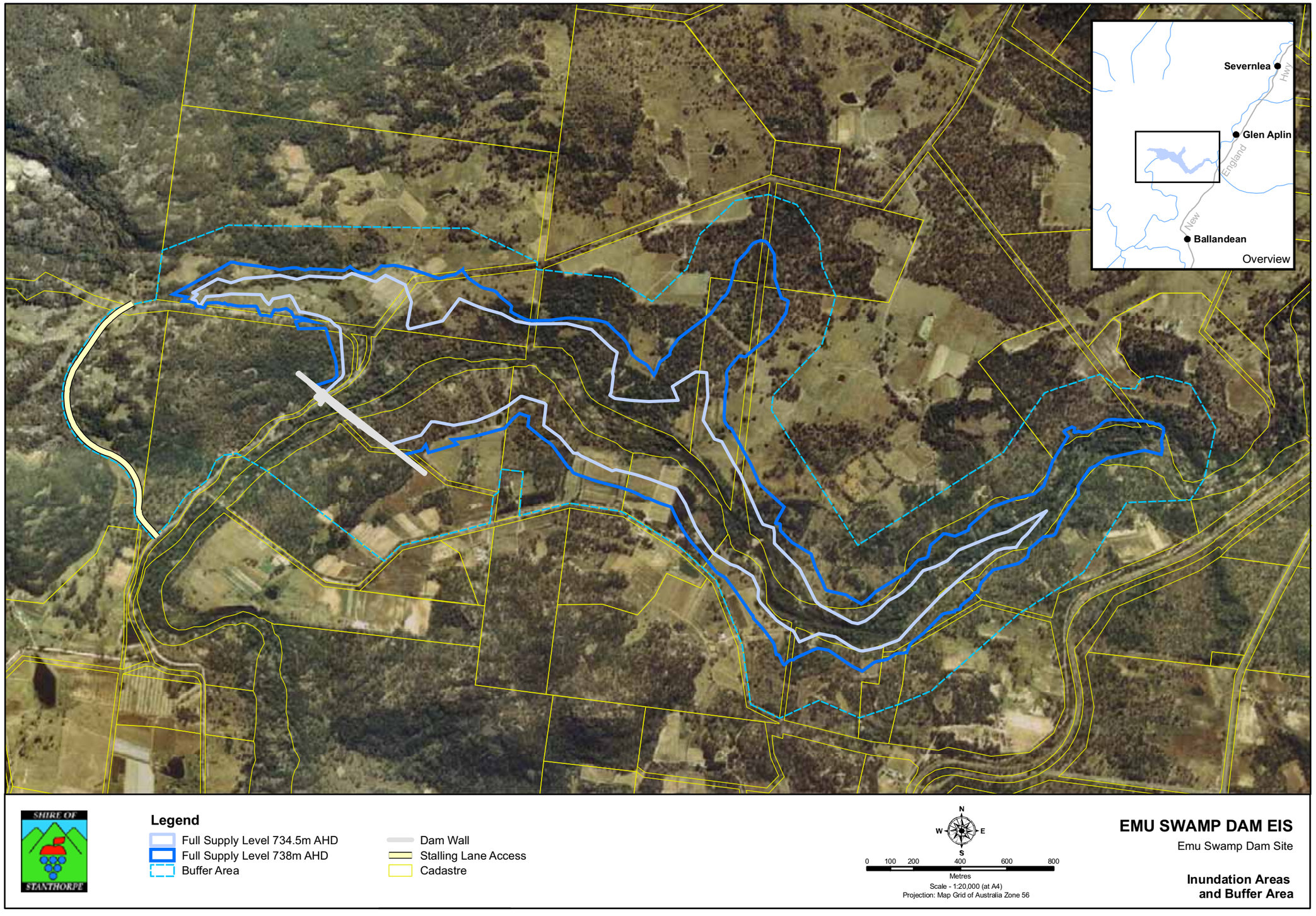

Figure 1.2 Full supply levels for proposed dam options.

2 Legal Framework

The legislation applicable to the Project was described in Section 1 of the EIS. As such, only changes to relevant legislation are discussed in this report.

2.1 *Environment Protection & Biodiversity Conservation Act 1999*

Any actions that are likely to have a significant impact on a matter of national environmental significance are subject to assessment under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* [1] (EPBC Act) approval process. Matters of national environmental significance were revised in 2013 to include water resources (in relation to coal seam gas and large coal mining development). This revision is not applicable to the Project.

The Project was determined to be a controlled action under the EPBC Act, with controlling provisions Sections 18 and 18a: Listed threatened species and communities. One threatened fish species occurs in the vicinity of the Project: the Murray cod (*Maccullochella peelii*). The Murray cod was discussed in the EIS, however information regarding its ecology has also been provided in Appendix D of this report. The Murray cod is endemic to the Murray-Darling River System and native to the Severn River downstream of Nundubbermere Falls; this species may have been introduced above Nundubbermere Falls by early settlers.

No rare or threatened aquatic plant species under the EPBC Act are known to occur in the vicinity of the Project.

2.2 *Nature Conservation Act 1992*

Native plant and animal species are protected in Queensland under the *Nature Conservation Act 1992*; extinct in the wild, endangered, vulnerable, near threatened and least concern species are listed in the Nature Conservation (Wildlife) Regulation 2006 (NCWR). No listed endangered, vulnerable, or near threatened fish or aquatic plant species under the NCWR are in the vicinity of the Project.

[1] Act no. 91 of 1999 as amended, prepared on 19 February 2012 taking into account amendments up to Act No. 46 of 2011. Prepared by the Office of Legislative Drafting and Publishing, Attorney General's Department, Canberra.

2.3 *Queensland Environmental Protection Act 1994*

The Queensland *Environmental Protection Act 1994* (EP Act) is the key legislation for environmental management and protection in Queensland. The environmental values (EVs) of waterways in Queensland are protected under the EP Act and the subordinate Environmental Protection (Water) Policy 2009 (EPP Water). No EVs have been prescribed for the Granite Belt catchment under the EPP Water, however draft EVs have been developed by the Queensland Murray Darling Committee and are currently undergoing community consultation.

2.4 *Queensland's Fisheries Act 1994*

All waters of the state are protected against degradation by direct or indirect impact under section 125 of the *Fisheries Act 1994* (Fisheries Act) [2]. If litter, soil, a noxious substance, refuse or other polluting matter is on land (including the foreshore and non-tidal land), in waters, or in a fish habitat, and it appears to the Chief Executive that the polluting matter is likely to adversely affect fisheries resources or a fish habitat, the Chief Executive of the Department of Agriculture, Fisheries and Forestry may issue a notice requiring the person suspected of causing the pollution to take action to redress the situation.

Waterway Barriers

The construction and raising of a waterway barrier works that will inhibit the movement of fish is regulated under the *Fisheries Act 1994* (Fisheries Act) and the *Sustainable Planning Act 2009* (SPA), and therefore requires a self-assessable evaluation to determine if the works that will be conducted require development approval. All self-assessable evaluations that do not meet the requirements as described in the Fisheries Queensland's Codes for Self-assessable Development are subject to the development approval process.

The special GIS layer created by Fisheries Queensland (Appendix A – Map 130402WB) was used to confirm the risk category associated with this project. The risk categories are characterised by a combination of stream order, stream slope, flow regime, number of fish species present and fish swimming ability. Five categories have been created (Table 2.1).

[2] Reprint No. 7 as in force on 5 May 2011. Reprint prepared by the Office of the Queensland Parliamentary Council.

In accordance with these categories, the Project is in the purple zone, which represents a major risk of impact, and a development approval will be required for the dam.

Table 2.1 Assessment requirements for minor works (DAFF 2013).

Waterway zoning colour	Risk of impact	Development type			
		Bed-level crossing	Culvert crossing	Low impact dam / weir	Temporary works
green	low	self-assessable	self-assessable	self-assessable	self-assessable
amber	moderate	self-assessable	self-assessable	development approval	self-assessable
red	high	self-assessable	self-assessable	development approval	self-assessable
purple	major	self-assessable	development approval	development approval	self-assessable
grey (estuarine / marine)	major	development approval	development approval	development approval	self-assessable

If development approval is given, the Chief Executive of Department of Agriculture, Fisheries and Forestry (DAFF) must be satisfied that movement of fish across the waterway barrier works will be adequate. The Fisheries Queensland group within DAFF assesses whether or not an approval should be issued, and whether a fishway should be built with the structure.

To assess the requirements for a fishway on a proposed structure, the following issues are considered:

- Are there fish in the waterway that need to move across the site of the waterway barrier works?
- Are there habitats upstream and / or downstream of the proposed works that the fish need to move into?
- What are the effects of existing barriers (natural or man-made) upstream or downstream of the site of the waterway barrier works?
- Will the drown-out characteristics of the proposed waterway barrier works allow adequate fish passage? and

- Can a fishway be incorporated into the proposed works?

When a fishway is required, Queensland Fisheries have developed a standard design process that ensures that both biologists and engineers are involved in developing the fishway design. Once the fishway is built, monitoring is required to confirm that the fishway is effective, or to identify any adjustments needed.

Non-indigenous Fish

Under the Fisheries Regulation 2008, non-indigenous fish are fish living in an area where they are not naturally found. A non-indigenous fish can be a native Australian species or a species that is not native to Australia (i.e. exotic). Some exotic non-indigenous fish can be kept without a permit as long as they cannot escape into the local waterways.

Of the species known in the upper reaches of the Queensland section of the Border Rivers catchment, there are three exotic non-indigenous species:

- mosquitofish (*Gambusia holbrooki*)
- goldfish (*Carassius auratus*), and
- red fin perch (*Perca fluviatilis*) (Davies et al. 2012).

Declared Noxious Fish

Declared noxious species are listed under the Fisheries Regulation 2008[3]. Declared noxious fish cannot be kept, hatched, reared or sold, and must be destroyed if caught. They must not be returned to the water in any form, and cannot be used as bait (alive or dead). Mosquitofish are a declared noxious fish.

Fisheries Regulation 2008

The Fisheries Regulation 2008 defines the regulatory rights and allocation requirements associated with disturbing and / or removing Queensland's fisheries resources. It

[3] Reprint No. 2G, Reprinted as in force on 1 January 2010. Reprint prepared by the Office of the Queensland Parliamentary Council.

superseded the Fisheries (Freshwater) Management Plan 1999, which was repealed in March 2010. The Fisheries Regulation 2008 regulates the catching and taking of fish in specific waters and the catching and taking of specific fish species. Fish that may occur in the vicinity of the Project, and that are protected by the Fisheries Regulation 2008 are shown in Table 2.2.

Table 2.2 Fish species regulated by the Fisheries Regulation 2008 that may occur in the Project area.

Regulated Fish	**Regulated By**	**Regulated Form, Gender, Number, Size, Volume or Weight**	**Regulated Persons and Prohibited Activities Involving Regulated Fish**
freshwater catfish (*Tandanus tandanus*)	size	less than 35 cm	a person taking or possessing the fish
Murray cod (*Maccullochella peeli*)	number	more than 2	a person taking or possessing the fish in the waters of the Murray-Darling Drainage Division
	size	less than 60 cm or more than 110 cm	a) a person taking the fish in the waters of the Murray-Darling Drainage Division b) a person possessing the fish in the waters mentioned in a)
river blackfish (*Gadopsis marmoratus*)	–	–	a person taking or possessing the fish
southern purple-spotted gudgeon (*Mogurnda adspersa*)	number	more than 20	a person taking or possessing the fish

2.5 *Queensland's Land Protection (Pest and Stock Management) Act 2002*

Declared Weeds

The *Land Protection (Pest and Stock Route Management) Act 2002* (the Land Protection Act) [4] provides a framework for improved management of weeds, pest animals and the stock route network. Declared noxious weeds in Queensland are listed under the Land Protection (Pest and Stock Route Management) Regulation 2003[5].

Class 1 declared pests are uncommon in Queensland, and if introduced, are likely to have adverse economic, environmental or social impacts. Class 1 pests established in Queensland must be eradicated from the state.

Class 2 and 3 declared pests are established in Queensland and have, or could have, an adverse economic, environmental or social impact. Landowners must take all reasonable steps to keep their land free from Class 2 pests. Landowners are not required to remove Class 3 pests, unless their land is next to an area of environmental significance.

Weeds of National Significance

Weeds of National Significance is a list of 32 weeds as endorsed by the Agricultural and Resource Management Council of Australia and New Zealand, Australia and New Zealand Environment and Conservation Council and Forestry Ministers. Weeds of National Significance are determined by their invasiveness, impacts, potential for spread, and socio-economic and environmental values. While the listing of Weeds of National Significance is outside the legislative framework, it provides a useful condition assessment tool.

Aquatic plants that are declared weeds are:

- Hymenachne (*Hymenachne amplexicaulis*)
- water hyacinth (*Eichhornia crassipes*) and
- salvinia (*Salvinia molesta*).

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[4] Reprint No. 4A. Reprinted as in force on 2 March 2012. Prepared by the Office of the Queensland Parliamentary Counsel.

[5] Reprint No. 5A. Reprinted as in force on 28 May 2012. Prepared by the Office of the Queensland Parliamentary Counsel.

Of these plant species, salvinia may occur in the vicinity of the Project area. Water hyacinth and salvinia are Class 2 declared pest plants under the Land Protection Act (DAFF 2012).

2.6 *Queensland's Water Act 2000*

The purpose of the *Water Act 2000* (Water Act) [6] is to provide for the sustainable management of water and other resources. Permits will be required for the project in relation to the current riverine protection provisions.

The Border Rivers Water Resource Plan (WRP) was amended in July 2007 to support interstate trading of water allocations. The Border Rivers Resource Operations Plan (ROP) was approved in March 2008 and amended in May 2011.

2.7 *Queensland's Sustainable Planning Act 2009*

The *Integrated Planning Act 1997* (IPA), as described in the EIS, was replaced by the *Sustainable Planning Act 2009*, however it still incorporates the Integrated Development Assessment System (IDAS), and is relevant to the Project.

Integrated Development Assessment System: Referable Wetlands

EHP has an advice agency role for wetlands under the IDAS and schedules of the Sustainable Planning Regulation 2009[7]. These wetlands are identified as Wetland Protection Areas on maps of referable wetlands. There are no Wetland Protection Areas in the vicinity of the Project.

2.8 Wetlands of National, State or Regional Significance

Lacustrine (i.e. lakes) and riverine systems (e.g. river and creek channels) have been mapped in the vicinity of the Project in EHP's wetland mapping program (Appendix A –

[6] Reprint No. 8F, Reprinted as in force on 2 March 2012. Reprint prepared by the Office of the Queensland Parliamentary Council.

[7] Reprint No. 2. Reprinted as in force on 2 March 2012. Prepared by the Office of the Queensland Parliamentary Counsel.

Map 130402RW); however, no mapped lacustrine wetlands are within the proposed dam full supply level, and those mapped downstream comprise a private weir on the Severn River and farm dams. No palustrine (e.g. swamps) wetlands are in the vicinity of the Project.

2.9 Native Fish Strategy for the Murray-Darling Basin 2003–2013

The Native Fish Strategy for the Murray-Darling Basin 2003–2013 (the Native Fish Strategy) is part of the Integrated Catchment Management Policy Statement for the Murray-Darling Basin, and targets the causes and symptoms of declining native fish species. Its focus is on long-term rehabilitation rather than restoration and the strategy's vision is that the Murray-Darling Basin sustains viable fish populations and communities throughout its rivers. To achieve this vision, 13 objectives have been established:

1. to repair and protect key components of aquatic and riparian habitats important for sustaining native fish populations
2. to rehabilitate and protect the natural functioning of wetlands and floodplain habitats for native fish; and revive the links between terrestrial ecosystems, wetlands and rivers
3. to improve key aspects of water quality that affect native fish
4. to modify flow regulation practices to facilitate native fish rehabilitation
5. to provide adequate passage for native fish throughout the Basin
6. to devise and implement recovery plans for threatened native fish species and communities
7. to create and implement management plans for all non-threatened native fish species and communities
8. to control and manage carp and other alien fish species effectively
9. to increase understanding of fish diseases and parasites, and to protect native fish from such threats
10. to manage fisheries in a sustainable manner
11. to protect the natural species composition, population structure, genetic integrity and diversity of native fish communities from the adverse effects of human interventions into native fish movements and restocking
12. to ensure native fish populations are not threatened from aquaculture, and

13. to ensure community and partner ownership and support for and understanding of the Native Fish Strategy.

The Project could counteract these objectives through changes to aquatic habitat, fish passage and flow that may have impacts on native fish species and communities in the Severn River. Where appropriate mitigation measures and offsets are implemented, the Native Fish Strategy objectives can be maintained.

3 Methods

3.1 Survey Design

Survey Timing

Aquatic habitat, aquatic plants, fish and platypus were surveyed from 9 to 15 September 2013.

The weather was fine to overcast during the survey. Air temperatures in Stanthorpe (the closest available weather station - 041095) ranged from approximately 1.2°C overnight, to 26.5°C during the day, whilst daily rainfall ranged between 0 and 0.6 mm (BOM 2013).

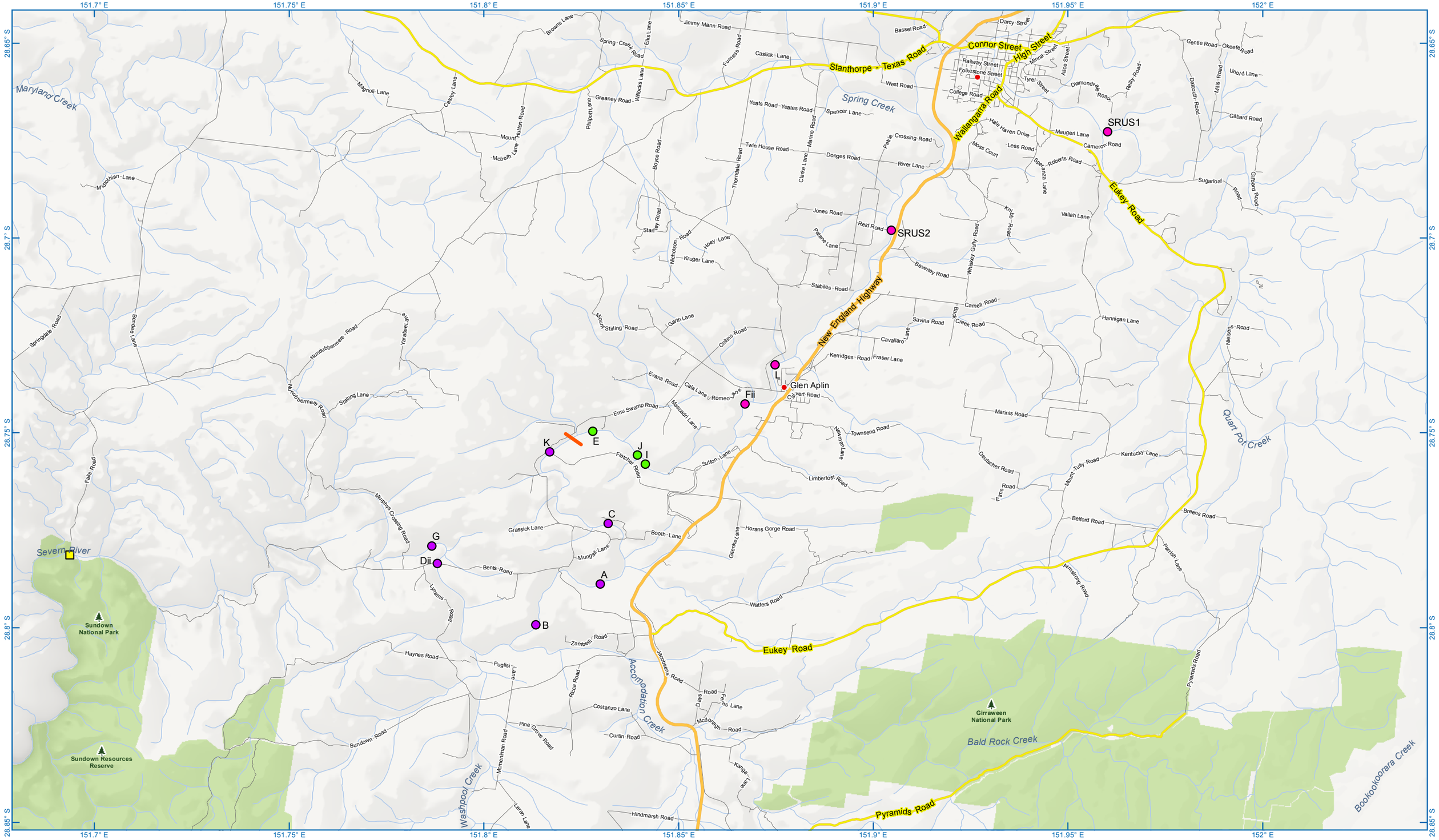
Survey Sites

Thirteen sites were surveyed:

- four sites upstream of the proposed dam full supply level
- three sites within the proposed dam full supply level, and
- six sites downstream of the proposed dam (Table 3.1 and Map 130402SMb).

Table 3.1 Site location details.

Site	Easting	Northing	Description
Upstream of the Proposed Dam Full Supply Level			
SRUS1	6827831.938	398403.0025	Approximately 25 km upstream of the proposed dam site
SRUS2	6824976.938	393000.9976	Approximately 14 km upstream of the proposed dam site
L	390118	6821121	Approximately 7 km upstream of the proposed dam site
Fii	389376	6820006	Approximately 5.5 km upstream of the proposed dam site
Within the Proposed Dam Full Supply Level			
I	386835	6818211	Approximately 2.1 km upstream of the proposed dam site
J	386753	6818469	Approximately 1.8 km upstream of the proposed dam site
E	385571	6819198	Approximately 0.5 km upstream of the proposed dam site
Downstream of the Proposed Dam			
K	384494	6818591	Approximately 1.6 km downstream of the proposed dam site
C	385977	6816579	Approximately 4.7 km downstream of the proposed dam site
A	385802	6814846	Approximately 7.6 km downstream of the proposed dam site
B	384199	6813675	Approximately 10.2 km downstream of the proposed dam site
Dii	381710	6815393	Approximately 15.3 km downstream of the proposed dam site
G	381568	6815888	Approximately 16.4 km downstream of the proposed dam site



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PO Box 2363
Wellington Point
Q 4160 Australia

P 07 3286 3850
E info@frcenv.com.au
www.frcenv.com.au

Emu Swamp Supplementary Environmental Impact Statement – Turtle Survey

Map 130402AE:
Aquatic ecology survey sites

SOURCES

Document Path: Y:\Projects\2013\130402_SKM_Emu_Swamp_Turtles\Mapping\Workspaces\130402AE_AqEco_sitemap_13-09-20_CF.mxd

LEGEND

Aquatic Ecology Survey Sites
- Upstream of the Proposed Dam FSL
- Within the Proposed Dam FSL
- Downstream of the Proposed Dam
- Proposed Dam Site
- Watercourse

Road Network
- Highway
- Main Road
- Local Road

Protected Area
- National Park
- Nundubbermere Falls

N

SCALE

0 1 2 4
Kilometres

Scale: 1:100,000 @ A3

PROJECTION
Coordinate System: GCS GDA 1994
Datum: GDA 1994
Units: Degree

DATE
2013-09-30

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3.2 Aquatic Habitat

Habitat Condition

The condition of in-stream habitat at each site was assessed based on the Australian River Assessment System (AUSRIVAS) protocol described in the Queensland *AUSRIVAS Sampling and Processing Manual* (DNRM 2001), including the following parameters:

- water depth and velocity
- reach environs (land immediately next to the riparian zone)
- bank erosion
- substrate composition (silt / clay, sand, pebble, cobble and boulder)
- channel diversity (pool, riffle, run etc.)
- in-stream habitat (in-stream vegetation, large woody debris and substrate characteristics), and
- physical barriers to fish passage.

Habitat Bioassessment Scores

Habitat bioassessment score datasheets (DNRM 2001) were used to numerically score nine criteria, which were then allocated to one of four categories (excellent, good, moderate and poor). The sum of the numerical rating from each category produced an overall habitat condition assessment score (Table 3.2). According to this system sites with scores:

- >110 were considered to be in excellent condition
- between 75 and 110 were considered to be in good condition
- between 39 and 74 were considered to be in moderate condition, and
- ≤38 were considered to be in poor condition.

Table 3.2 Habitat bioassessment scores used to derive overall condition categories.

Habitat category	Category score range			
	Excellent	**Good**	**Moderate**	**Poor**
bottom substrate / available cover	16–20	11–15	6–10	0–5
embeddedness	16–20	11–15	6–10	0–5
velocity / depth category	16–20	11–15	6–10	0–5
channel alteration	12–15	8–11	4–7	0–3
bottom scouring & deposition	12–15	8–11	4–7	0–3
pool / riffle, run / bend ratio	12–15	8–11	4–7	0–3
bank stability	9–10	6–8	3–5	0–2
bank vegetative stability	9–10	6–8	3–5	0–2
streamside cover	9–10	6–8	3–5	0–2
Total Score for the Site	**111–135**	**75–110**	**39–74**	**0–38**

Water Quality Measured In Situ

Water quality was measured in situ at each site. A Hydrolab QUANTA multi-parameter water quality probe was used to measure:

- water temperature
- pH
- electrical conductivity, and
- dissolved oxygen.

Turbidity was measured in situ at all sites using a HACH 2100Q portable turbidity meter.

The Hydrolab QUANTA meter was calibrated daily and the HACH 2100Q was calibrated at the beginning and end of the surveys.

Results were compared to the Australian and New Zealand National Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000) for slightly to moderately disturbed aquatic ecosystems in south-east Australia (upland rivers) and the Queensland Water Quality Guidelines (DERM 2009).

Table 3.3 Trigger values for water quality parameters measured in situ.

Parameter	Units	Trigger Value
dissolved oxygen	% saturation	90 – 110
pH	pH units	6.5 – 7.5
electrical conductivity [a]	µS/cm	325
turbidity	NTU	2 – 25

[a] based on the 75th percentile value for electrical conductivity from the Queensland Water Quality Guidelines Maranoa-Balonne-Border Rivers salinity zones

3.3 Aquatic Plants

Aquatic Plant Survey

Background

Aquatic plants are valuable components of the ecosystem as they:

- are primary producers, providing food for other organisms
- oxygenate the water and sediment
- provide habitat for freshwater fauna, including fish and macroinvertebrates
- can help regulate water flow, and
- can stabilise riverbanks and streams.

The distribution and abundance of each species of aquatic plant reflects the ecological condition of the site. For example a high concentration of phytoplankton (algae in the water column) is indicative of high nutrient content, and a high abundance of exotic weeds is indicative of disturbance to the area. Low abundance or species richness may indicate the site is infrequently inundated, while the presence of submerged attached species indicates that a site is likely to be commonly inundated.

Some aquatic plants that require permanent standing or flowing water are species of conservation significance, such as artesian milfoil (*Myriophyllum artesium*), and could be indicators of an impact.

Aquatic Plants in Standing or Flowing Water

Aquatic plants in standing or flowing water include algae, ferns and flowering plants. Algae are simple plants without true roots, leaves or flowers. They include microscopic single celled plants and larger multi-celled plants that have stem-like and leaf-like structures such as *Chara*. Ferns are vascular plants that reproduce by spores, aquatic ferns include species such as *Azolla* and Nardoo (*Marsilea drummondii*). Flowering plants include monocotyledons (grasses and grass-like plants with one cotyledon) and dicotyledons (herbaceous and woody plants with two cotyledons).

Aquatic plants in standing or flowing water are grouped into four broad classes of growth habit (Table 3.4). The presence of abundant and / or diverse aquatic plant communities containing species from these various classes indicates that permanent (or near-permanent) water is likely at the site.

Some species can grow in one or more of these growth habits, for example water fern (*Ceratopteris thalictroides*) can be free floating or submerged. Some species require temporary periods of drying to reproduce, and some species such as spike rushes (*Juncus* sp*., Eleocharis* sp.) and spiny mudgrass (*Pseudoraphis spinescens*) that grow as emergents in standing or flowing water are also common in drier areas adjacent to water (e.g. stream banks or dry stream beds).

Table 3.4 Growth habits of aquatic plants in standing or flowing water.

Class of Aquatic Plant	Description
Submerged	Submerged aquatic plants are rooted in the bed of the stream or wetland, with leaves totally covered by water most of the time. Some species may have underwater flowers, whereas other species may require water levels to decrease to trigger flowering and have flowers above the water level. Examples of submerged aquatic plants include milfoils (*Myriophyllum* spp.), ribbon weed (*Vallisneria* sp.), ottelia (*Ottelia alismoides*), pondweeds (*Potamogeton* spp.) and hornworts (*Ceratophyllum* spp.).
Attached floating	Attached floating aquatic plants are rooted in the bed of the stream or wetland, with leaves typically floating on top of the water. Flowers are usually above the water. Examples of attached floating aquatic plants include water lilies (*Nymphaea* spp., *Nelumbo* sp., *Ottelia ovalifolia*), frogbit (*Hydrocharis dubia*), *Triglochin* spp., and floating heart (*Nymphoides* spp.).
Free floating	Free-floating plants float on top of the water, or in the water column, with roots trailing into the water column. Flowers are typically above the water. Examples of free-floating aquatic plants include *Azolla* spp., thin duckweed (*Spirodela punctate*) and tiny duckweed (*Wolffia*

Class of Aquatic Plant	Description
	angusta). Several declared weeds are free floating species, including *Salvinia molesta* and water hyacinth (*Eichhornia crassipes*).
Emergent	Emergent plants are rooted in the bed of the stream or wetland, with leaves and flowers above the water. Examples of emergent aquatic plants include spike rushes (*Juncus* spp.), *Eleocharis* spp., sedges (*Cyperus* spp.), bulrush (*Typha* spp.), *Persicaria* spp., frogsmouth (*Philydrum lanuginosum*), *Monochoria cyanea*, water primrose (*Ludwigia* spp.). Emergent weed species including *Hymenachne acutigluma* and para grass (*Brachiaria mutica*).

Other Aquatic Plants

Aquatic plants are also commonly found in areas adjacent to standing or flowing water, or in areas that are currently dry but have recently contained water. This includes plants in the ground stratum such as grasses (e.g. swamp rice grass, *Leersia hexandra*), grass-like plants (*Cyperus* spp., *Juncus* spp. and *Eleocharis* spp.), and herbaceous species (e.g. *Persicaria* spp., *Marsilea* spp.).

Survey Methods

Aquatic plants were surveyed using methods similar to those outlined in the *River and Riparian Land Management Technical Guideline* (Dixon et al. 2006). Aquatic plants were assessed along two 100 x 10 m belt transects at each site: one transect in the water (in-stream) and one transect on the bank (on bank). Both transects were parallel to the water's edge. At each site, in each transect, aquatic plants were identified and the following recorded:

- species richness
- growth form of each species (submerged, free-floating, attached-floating or emergent)
- total percent cover (% of substrate [bed / bank] covered by each species), and
- whether the plant was native or exotic to Australia.

Aquatic plant species were identified in the field, where practical. Representative specimens were collected for identification in the frc environmental laboratory or by the Queensland Herbarium, if required.

The *Census of Queensland Flora 2010* (Queensland Herbarium 2010) was used to classify aquatic vegetation as native or exotic.

3.4 Aquatic Vertebrates

Fish

Fish communities were surveyed using a combination of electrofishing and baited traps, where water levels were suitable (Table 3.5). All available habitats (e.g. pool, riffle, run and bend) were fished at each site. Electrofishing was conducted using a Smith-Root LR-24 backpack electrofisher in shallow water in accordance with the Australian Code of Electrofishing Practice 1997. Where there was sufficient water, five small (2 mm mesh size) baited traps were set at each site for a minimum of two hours.

To avoid the re-capture of fish, all caught fish were kept in an aerated nally bin filled with water, on the shore, until the last trap was retrieved.

The life-history stage, abundance and apparent health of every fish caught were recorded and fish were returned to the water. Specimens that were unable to be identified in the field were euthanised and returned to the laboratory for identification. The sampling of fishes was conducted under General Fisheries Permit No. 153223 and Animal Ethics Approval No. CA 2012/02/593 issued to frc environmental.

Data Analysis

Fish communities at each site were assessed for the:

- species richness (the number of species caught at a site)
- total abundance (total number of individuals caught at a site)
- abundance of each life-history stage (total number of adult, intermediate and juvenile fish caught at each site)
- abundance of exotic species (species listed under the Fisheries Regulation 2008), and
- abundance of listed species.

Listed species were determined from those listed under the EPBC Act or the NCWR.

Platypus

Platypus were surveyed at each site using timed observational surveys at dusk and / or dawn (Table 3.6). Surveys were conducted from a canoe, where water depth allowed, or from the bank at shallow sites. Surveys conducted using a canoe were timed for an hour over a distance of up to 1 km. Surveys conducted from the bank were timed for 30 minutes over a distance of up to 500 m. The number of platypus observed and the abundance by size (small, medium, large) were recorded. Brief searches of the banks were undertaken at each site for platypus burrows.

Table 3.5 Electrofishing and net efforts at each site.

Site	Method	Habitat	Date	Time In	Time Out	Settings	Effort
Upstream of the Proposed Dam Full Supply Level							
SRUS1	small bait traps (5)	pool	15/09/13	0615	0830	–	11.25 h
	boat electrofishing			0630	0730	1000 V 60 Hz 100%	1208 s
SRUS2	small bait traps (5)	pool	13/09/13	0800	1800	–	50 h
	backpack electrofishing			1030	1230	200 V 30 Hz 60 ms	1201 s
L	small bait traps (5)	pool	9/09/13	1225	1825	–	30 h
	backpack electrofishing			1030	1130	200 V 30 Hz 60 ms	660 s
Fii	small bait traps (5)	pool	11/09/13	0700	1600	–	45 h
	backpack electrofishing			1030	1200	150 V 30 Hz 60 ms	1200 s
Within the Proposed Dam Full Supply Level							
I	small bait traps (5)	pool	12/09/13	0845	1545	–	35 h
	boat electrofishing			0745	0845	1000 V 60 Hz 100%	1249 s
J	small bait traps (5)	pool	12/09/13	0700	1700	–	50 h
	backpack electrofishing			1200	1300	160 V 30 Hz 60 ms	1209 s
E	small bait traps (5)	pool	10/09/13	1100	1600	–	25 h
	backpack electrofishing			1115	1230	200 V 30 Hz 60 ms	1202 s

Site	Method	Habitat	Date	Time In	Time Out	Settings	Effort
Downstream of the Proposed Dam							
K	small bait traps (5)	pool	10/09/13	1000	1700	–	35 h
	backpack electrofishing			0840	0954	200 V 30 Hz 60 ms	1207 s
C	small bait traps (5)	pool	9/09/13	1300	1630	–	17.5 h
	boat electrofishing			1300	1330	500 V 60 Hz 100%	1277 s
A	small bait traps (5)	pool	13/09/13	0930	1600	–	32.5 h
	boat electrofishing			0745	0840	1000 V 60 Hz 100%	1219 s
B	small bait traps (5)	pool	11/09/13	0830	1630	–	40 h
	boat electrofishing			0725	0800	1000 V 60 Hz 100%	1200 s
Dii	small bait traps (5)	pool	14/09/13	0700	1600	–	45 h
	backpack electrofishing			1000	1115	160 V 30 Hz 60 ms	1201 s
G	small bait traps (5)	pool	14/09/13	0910	1710	–	40 h
	boat electrofishing			0745	0900	1000 V 60 Hz 100%	1219 s

Table 3.6 Platypus search effort at each site.

Site	Dawn Effort (mins)	Dusk Effort (mins)
Upstream of the Proposed Dam Full Supply Level		
SRUS1	30	–
SRUS2	30	30
L	60	60
Fii	60	60
Within the Proposed Dam Full Supply Level		
I	60	55
J	30	45
E	30	30
Downstream of the Proposed Dam		
K	60	60
C	60	60
A	50	50
B	60	60
Dii	60	60
G	55	60

4 Aquatic Habitat

4.1 Habitat Condition

Aquatic habitat was similar throughout the Project area; a detailed description of the aquatic habitat at each site is provided in Table 4.1. The reach environs at most sites had been moderately disturbed by human activities including historical vegetation clearing, cropping and grazing, and private weirs.

The width of the riparian zone was generally narrow (1–15 m) at all sites except at sites L (upstream of the proposed dam), and K and C (downstream of the proposed dam), where it was 20 m or wider. Eucalypt, melaleuca and / or casuarina trees dominated the riparian vegetation at all sites, along with native grasses and shrubs. In general, riparian vegetation was semi-continuous to continuous, except at site SRUS2, upstream of the proposed dam, and site A, downstream of the proposed dam. Riparian vegetation at these sites was scattered or clumped due to historical clearing.

Banks were moderately stable to stable at all sites due to extensive riparian vegetation and substantial areas of bedrock and boulders.

Substrate composition was varied at all sites, but typically dominated by bedrock, boulders and sand (Figure 4.1). Composition at site SRUS2, upstream of the proposed dam, differed slightly from all other sites as it was dominated by cobbles and sand, with few other substrate types present.

Channel diversity was divided between sites dominated by weir pools and sites with a combination of flow types (e.g. shallow and / or deep, flowing and / or still). Sites in weir pools included:

- site Fii, upstream of the proposed dam
- site I, within the proposed dam full supply level, and
- sites C, A and G, downstream of the proposed dam site.

The downstream end of site K was also in the upstream extent of a weir pool. These weirs, along with other weirs identified throughout the area in the EIS, restrict fish passage in periods of low and moderate / average flow. That is, fish passage is currently restricted upstream of and within the proposed full supply level, and downstream of the proposed dam site, except in periods of high flow. Nundubbermere Falls, which is approximately 33 km downstream of the proposed dam site and approximately 2.5 m high, also represents a natural impediment to fish passage in the Severn River, particularly during low or moderate / average flow (Figure 4.2).

There were no natural off-stream wetlands in the area; some farm dams were present downstream of the proposed dam site.

In-stream habitat at most sites comprised scattered large and small woody debris, and some detritus, overhanging vegetation and trailing bank vegetation. There were in-stream emergent aquatic plants at sites L and Fii (upstream of the proposed dam), I and E (within the proposed dam, and C, A and B (downstream of the proposed dam). Submerged aquatic plants were also present in-stream at sites L, I, C and A.

The results of the 2013 habitat assessment are consistent with the EIS surveys and literature review, which found that riparian vegetation, woody debris, in-stream habitat diversity and macrophyte growth were generally good in the vicinity of the Project, but that weir pools had affected the aquatic habitat at a number of locations (Ecology Management 2007; SKM 2008).

Habitat assessment for the Sustainable Rivers Audit (SRA) (Davies et al. 2012) indicated that the riparian vegetation condition and physical form of the waterways in the Montane zone of the Border Rivers Valley (which incorporates the Severn River) differed from the predicted reference condition. This was primarily due to a decreased abundance in riparian vegetation compared to the reference condition. Assessment for the SRA indicated that approximately 57% of the Montane riparian zone was cleared or non-native, and dominated by eucalypt open forests. However, this assessment is based on satellite imagery and historical vegetation mapping, rather than site surveys.

The SRA assessment of the physical form of the waterways indicated an increase in floodplain sediment deposition, channel width and channel depth. Channel form and channel and floodplain dynamics were considered similar to reference condition.

The SRA assessment of hydrology also indicated altered hydrology in the main waterways in the Montane zone, with high over bank floods, flow seasonality, and low and zero flow events differing from the reference condition. In the Severn River this is likely associated with the high number of weirs present, as described in the EIS.

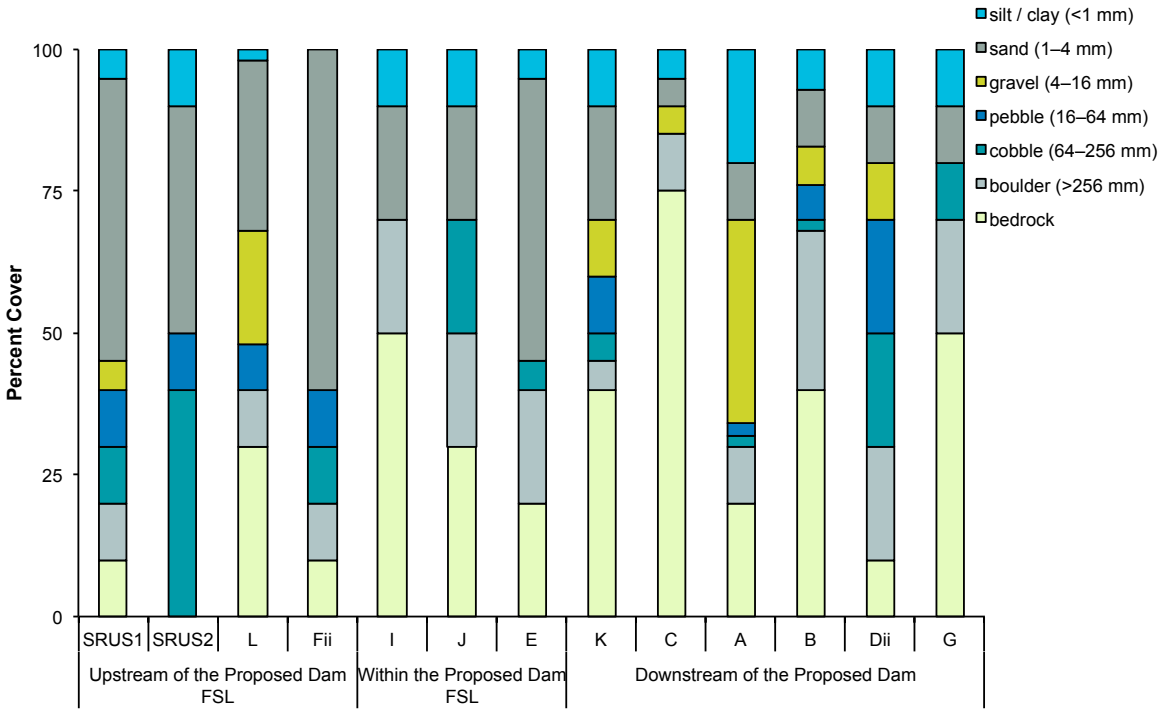

Figure 4.1 Substrate composition at each site.

Figure 4.2

Nundubbermere Falls in high flow [8]

[8] Photo by Michael Jeffries, 2009.

Table 4.1 Detailed description of aquatic habitat at each site.

Site	Description	Photographs
Upstream of the Proposed Dam Full Supply Level		
Site SRUS1	***General Description*** This site comprised a mildly sinuous and braided channel, with an average wetted width of 10 m and an average depth of 1.5 m. The right bank was sloping and low (0.2 m), and the left bank was steep to vertical and low (0.5 m). Both banks were stable. The riparian zone was ~3–5 m wide on each bank, with continuous vegetation dominated by casuarina and eucalypt trees and some shrubs. There was some shading of the river and trailing bank vegetation. In-stream habitat comprised shallow and deep pool, with scattered woody debris, detritus and tree roots. The bed substrate was dominated by sand, with some bedrock, gravel, boulders, cobbles and pebbles. ***Fish Passage*** There were no barriers to fish passage at this site.	 View downstream  View downstream of side channel  View upstream  Large woody debris

Site	Description	Photographs
Site SRUS2	***General Description*** This site comprised a mildly sinuous channel, with an average wetted width of 10 m and an average depth of 1 m. The left bank was sloping and low (0.5 m), and the right bank was steep and concave (0.8 m). Both banks were moderately stable. The riparian zone was ~1 m wide on each bank, with vegetation dominated by trees and grasses with some shrubs. Riparian vegetation was regularly spaced or in occasional clumps. There was little overhanging vegetation shading the river. In-stream habitat comprised shallow pool, with large woody debris, some detritus and isolated trailing bank vegetation. The bed substrate was dominated by cobbles and sand, with some pebbles and silt / clay. ***Fish Passage*** There were no barriers to fish passage at this site.	 View upstream  View of downstream left bank  View downstream  Tree roots overhanging into water

Site	Description	Photographs
Site L	***General Description*** This site comprised a mildly sinuous channel, with an average wetted width of 10 m and an average depth of 0.4 m. The banks were sloping and low (0.5 m), and stable. The riparian zone was ~20 m wide on each bank, with vegetation dominated by melaleuca and eucalypt trees and grasses with some shrubs. In-stream habitat comprised shallow pool and runs, with isolated woody debris, some detritus and beds of emergent aquatic plants. The bed substrate was dominated by bedrock and sand, with some gravel, boulders and pebbles. ***Fish Passage*** Fish passage may be restricted at this site during periods of low flow due to sand deposits and bedrock constricting flow in some areas.	 View upstream  View of upstream right bank.  View downstream  Extensive reeds in shallow water

Site	Description	Photographs
Site Fii	***General Description*** This site comprised a mildly sinuous channel, with an average wetted width of 6 m and a bank full width of ~25 m. The average depth was 1 m. The banks were sloping and low (0.5 m), and moderately stable. There was some minor bank erosion. The riparian zone was ~10 m wide on each bank, with vegetation dominated by shrubs and melaleuca and eucalypt trees. In-stream habitat comprised a shallow pool, with scattered woody debris, emergent plants, and detritus. The bed substrate was dominated by sand, with some bedrock, boulders, cobble and pebbles. ***Fish Passage*** Fish passage was unrestricted within the reach surveyed, but a private weir upstream of the reach would restrict passage except in high flow.	 View upstream  View of downstream right bank  View downstream  Extensive woody debris

Site	Description	Photographs
Within the Proposed Dam Full Supply Level		
Site I	***General Description*** This site comprised a weir pool with an average width of 20 m and an average depth of approximately 2 m. The banks were sloping on the left bank and steep on the right bank vertical, with an average height of 0.5 to 0.8 m. Both banks were stable. The riparian zone was ~5 m on each bank, with vegetation dominated by eucalypt trees, shrubs and grass. In-stream habitat included large woody debris, overhanging vegetation, boulders, and isolated areas of submerged and emergent aquatic plants. The bed substrate was dominated by bedrock and boulders, with some sand and silt / clay. ***Fish Passage*** Fish passage within the reach surveyed was unrestricted, however there was a weir at the downstream end of the site that would restrict fish passage except during high flow events.	 View upstream  View of downstream left bank  View downstream  Extensive *Typha orientalis* in channel

Site	Description	Photographs
Site J	***General Description*** This site comprised a mildly sinuous channel with an average width of 5 m and an average depth of 1 m. The average bank full width was 20 m. The banks were sloping, low (0.5 m), and stable. The riparian zone was ~10 m wide on each bank. Melaleuca trees dominated riparian vegetation, with some shrubs and grasses. In-stream habitat included shallow and deep pools and shallow runs, with extensive woody debris, detritus, undercut banks and overhanging vegetation. The bed substrate was varied, with some bedrock, boulder, cobble, sand and silt / clay. ***Fish Passage*** Fish passage at this site was restricted by a private weir upstream. In low to moderate flow fish would not be able to pass the weir. Fish passage would be possible during high flow events.	 View downstream  View upstream in side channel  View upstream  Scoured bank and woody debris

Site	Description	Photographs
Site E	***General Description*** Site comprised an irregular channel, with an average width of 3 m and a maximum width of 10 m. A man made rock wall formed a pool in the middle of the site. The banks were sloping and low (0.5m). The banks were moderately stable. The riparian zone was ~5m wide on each bank. Melaleuca and eucalypt trees and shrubs dominated the riparian vegetation, with some grasses also abundant. In-stream habitat comprised shallow pools, runs and riffles, with sand bars. There was some detritus and little woody debris. There were isolated patches of emergent aquatic plants in-stream. The bed substrate was dominated by sand, with some bedrock and boulder. Overall disturbance was low. ***Fish Passage*** A man-made rock wall at this site would restrict fish passage for all fish during periods of low flow, and for large fish in periods of moderate / average flow. There would be no restrictions to fish passage during periods of high flow.	 View downstream  View downstream from upper end of reach  Small riffle at downstream end of reach  Man-made rock wall at site

Site	Description	Photographs
Downstream of the Proposed Dam		
Site K	***General Description*** This site comprised an irregular channel with an average width of 15 m and an average depth of 1 m. There was a road crossing through the middle of this site and a weir at the downstream end. The banks were sloping to vertical, and low (0.5 m). Banks were undercut, but stable. The riparian zone was ~30 m wide on the left bank and ~20 m wide on the right bank. Melaleuca and eucalypt trees dominated riparian vegetation, with some shrubs and grasses. In-stream habitat included shallow and deep pools, runs and riffles, with some woody debris, detritus, undercut banks and overhanging vegetation. The bed substrate was dominated by bedrock and sand, with some boulders, cobble, pebble, gravel and silt / clay. ***Fish Passage*** During periods of low flow fish passage at this site would be restricted by the culvert at the road crossing and bars in the channel. A private weir also restricts fish passage at the downstream end of this site in low to moderate / average flow.	 View downstream in September  Culvert in middle of site  View upstream in May  View upstream in September

Site	Description	Photographs
Site C	***General Description*** This site comprised a large weir pool with an average width of 25 m and an average depth of more than 2 m. The banks were gently sloping, low (0.5 m high), and stable. The riparian zone was ~20 m on each bank, with vegetation dominated by eucalypt and callistemon trees, with shrubs and grasses. In-stream habitat consisted of a deep pool with isolated woody debris, scattered detritus and beds of submerged plants. Reeds lined the banks in many areas. The bed substrate was dominated by bedrock and boulders, with some gravel, sand and silt / clay. ***Fish Passage*** Fish passage was unrestricted through the reach surveyed, but limited by a weir at the downstream end of the site. Fish passage is only possible at this site in high flow.	 View downstream  Weir at downstream end of reach  View upstream  Downstream of weir

Site	Description	Photographs
Site A	***General Description*** This site comprised a weir pool with an average width of 43 m, and a bank full width of approximately 70 m. The average depth was approximately 1 m. The banks were gently sloping, low (<1 m), and stable. The riparian zone was ~5 m on the left bank and ~10 m on the right bank. Grasses and discontinuous eucalypts and melaleucas dominated the riparian vegetation. There were areas of cleared on both banks for grazing and cropping. In-stream habitat consisted of a pool with no visible flow, large beds of ribbonweed and scattered woody debris. The bottom substrate was dominated by bedrock, gravel and silt / clay, with some boulder, sand, cobbles and pebbles. ***Fish Passage*** Fish passage at this site was restricted by a weir at the downstream end of the reach surveyed. Passage would only be possible past this weir in periods of high flow.	 View upstream  Weir at downstream end of reach  View downstream  Extensive reeds and grasses along bank

Site	Description	Photographs
Site B	***General Description*** This site comprised a wide irregular channel, with an average wetted width of 30 m (minimum 3 m and maximum 57 m). The average depth was approximately 1.2 m. The banks were low (0.5 m) and gently sloping to steep. The banks were stable, with no undercut areas. The riparian zone was ~15 m wide on each bank. Melaleuca, eucalypt and callistemon trees dominated the riparian vegetation, with some shrubs and grasses. In-stream habitat included shallow and deep pools with areas of shallow runs and cascades. There was abundant detritus, some algal growth, isolated woody debris and no submerged vegetation. The bed substrate was dominated by bedrock and boulders, with some finer sediments. ***Fish Passage*** Upstream fish movement at this site may be restricted for some fish due to a bedrock shelf with a drop of approximately 0.8 m. Extensive bedorck through the site would restrict fish movement upstream and downstream during periods of low flow.	 View downstream  Bedrock shelf restricting flow  View upstream  Extensive bedrock at site

Site	Description	Photographs
Site Dii	***General Description*** Site comprised a irregular channel, with an average wetted width of 4 m and a bank full width of 15 m. The average water depth was 0.5 m. The banks were gently sloping to vertical and low (0.5 m). The banks were moderately stable. The riparian zone was ~5 m on the left bank and ~10 m on the right bank. Melaleuca and casuarina trees and shrubs dominated the riparian vegetation. In-stream habitat comprised shallow and deep pools, with runs and undercut banks. There was scattered large and small woody debris, and no in-stream aquatic vegetation. The bed substrate was dominated by boulders, cobble and pebble, with some bedrock, gravel, sand and silt / clay. A road crossing with a culvert was in the centre of this site. ***Fish Passage*** During periods of low flow fish passage at this site would be restricted by the road culvert and gravel bars. There is also a private weir approximately 700 m upstream of the reach surveyed that restricts fish passage in low to moderate / average flow.	 View upstream  Tree roots on bank  View downstream  Culvert at site

Site	Description	Photographs
Site G	***General Description*** This site comprised a weir pool with an average width of 18 m and an average depth of more than 2 m. The banks were sloping to steep and an average height of 1 m. Both banks were stable. The riparian zone was approximately 3 m on the left bank and 10 m on the right bank. Eucalypt and casuarina trees and shrubs dominated the riparian vegetation, with some grasses. In-stream habitat was a deep pool with some woody debris and detritus. There were no in-stream aquatic plants. The bed substrate was dominated by bedrock, with some boulders, cobble, sand and silt / clay. ***Fish Passage*** Fish passage at this site was restricted by a private weir. Fish movement past the weir would only be possible during periods of high flow.	 View downstream  Weir at downstream end of reach  View upstream  Woody debris downstream of weir

4.2 Habitat Bioassessment Scores

Condition of aquatic habitat was moderate to good at all of the sites (Figure 4.3). With the exception of site G, aquatic habitat condition was generally better at sites within and downstream of the proposed dam than at sites upstream of the proposed full supply level. Compared to sites with high bioassessment scores, sites with lower habitat bioassessment scores typically had:

- lower in-stream diversity and available cover
- areas of historically cleared riparian vegetation, and
- more deposition of fine sediments (sand and silt / clay).

Sites with high bioassessment scores typically had:

- a variety of in-stream habitat and available cover
- intact riparian vegetation, dominated by native species
- a range of flow habitats (i.e. shallow and deep pools, runs and riffles), and
- stable banks.

These results are consistent with the EIS and State of the Rivers (SOR) assessments.

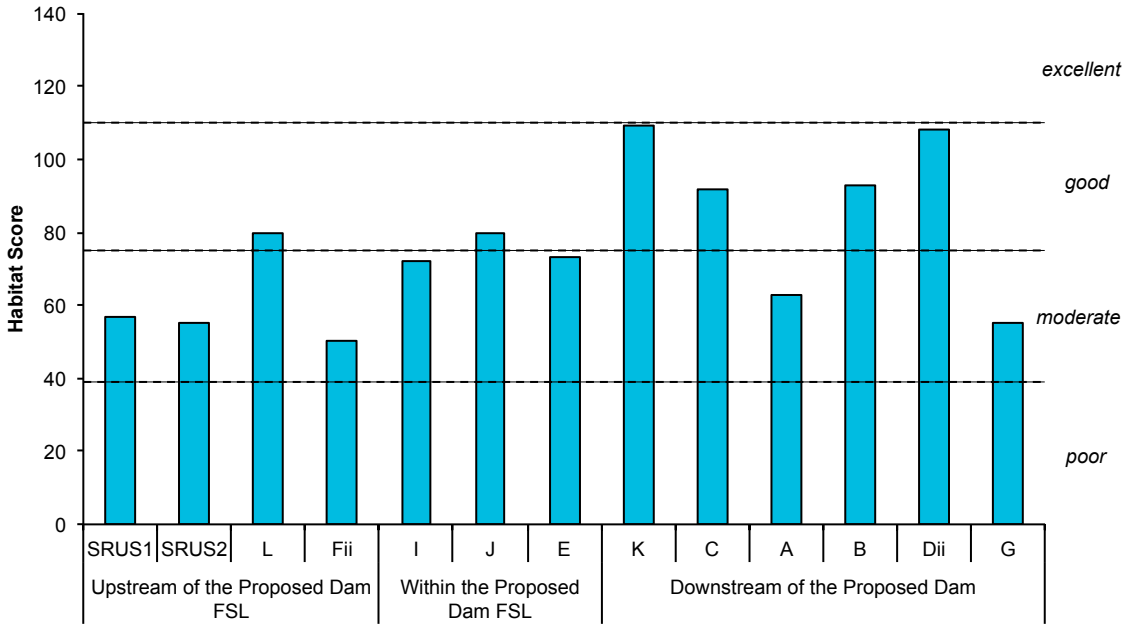

Figure 4.3 Habitat Bioassessment Score at each site.

4.3 In Situ Water Quality

Water Temperature

There is no ANZECC & ARMCANZ guideline for water temperature. Surface water temperature ranged from 12.6ºC to 19.2ºC (Figure 4.4). These temperatures were generally lower than in the EIS, however water temperature at any given site may reflect the:

- season
- time of day
- size and depth of the water body
- prevailing weather conditions
- flow, and
- riparian cover.

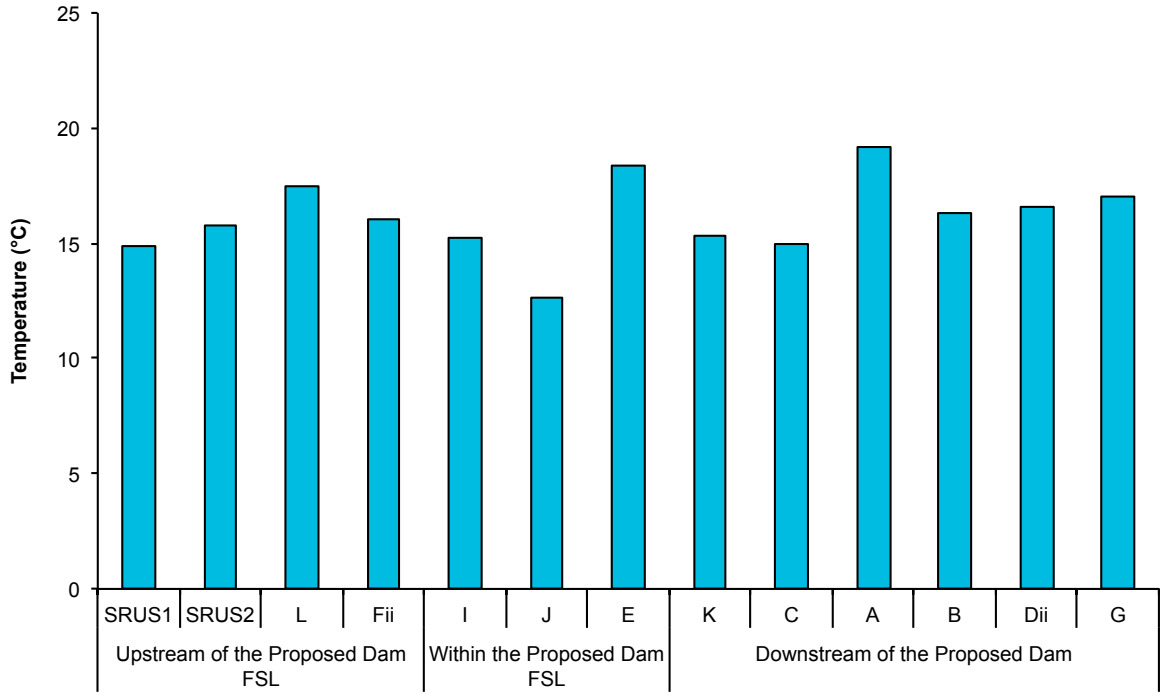

Figure 4.4 Water temperature at each site.

pH

The pH was outside the ANZECC & ARMCANZ guideline trigger value at all sites except:

- SRUS1, upstream of the proposed dam full supply level
- J, in the proposed dam full supply level, and
- K, downstream of the proposed dam site (Figure 4.5).

These results are generally lower than those during the EIS, where pH was in the 7 to 9 range. The lower pH in 2013 may be associated with different flow conditions between the surveys. Potential causes of higher pH at sites L and C were not apparent during the survey, but might be associated with local geology and / or local land use.

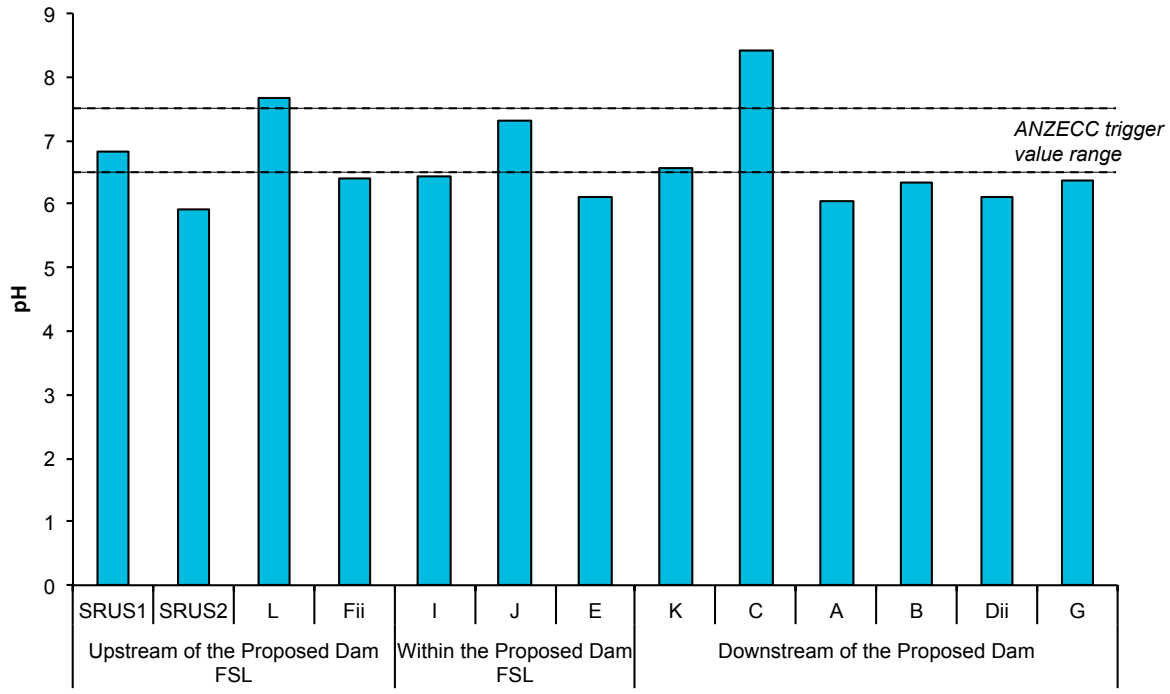

Figure 4.5 pH at each site.

Electrical Conductivity

Electrical conductivity was below the ANZECC & ARMCANZ guidelines trigger level at all sites except:

- SRUS1 and L, upstream of the proposed dam full supply level, and
- C, downstream of the proposed dam site.

These results are generally consistent with the EIS. Potential causes of higher electrical conductivity at sites SRUS1 and C were not apparent during the survey, but might be associated with local geology and / or local land use.

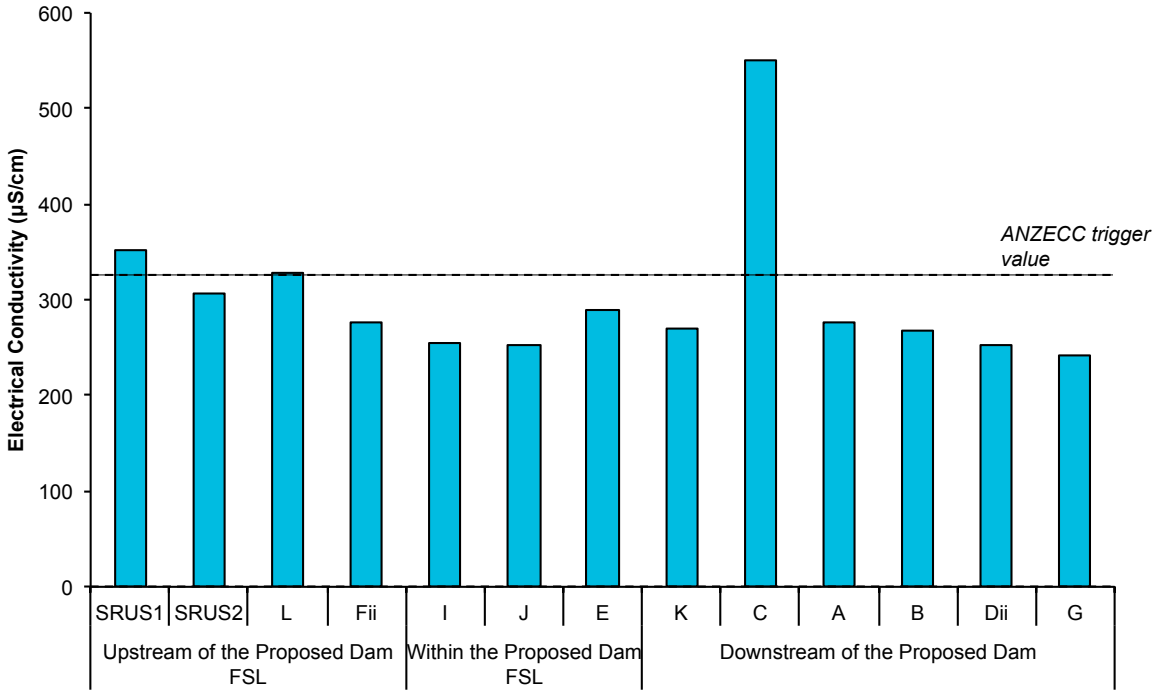

Figure 4.6 Electrical conductivity at each site.

Dissolved Oxygen

The percent saturation of dissolved oxygen was within the ANZECC & ARMCANZ trigger value range at all sites except:

- SRUS1, SRUS2 and L, upstream of the proposed dam full supply level
- J and E, within the proposed dam full supply level, and
- Dii, downstream of the proposed dam site (Figure 4.7).

These results are consistent with the EIS, during which dissolved oxygen varied considerably.

The percent saturation of dissolved oxygen can vary considerably and is likely to reflect the:

- time of day measurements were taken (plants photosynthesise during the day, producing oxygen)
- photosynthetic rates of algae and aquatic plants (which are affected by light availability and temperature)
- rate of oxygen uptake by micro-organisms in the water associated with decomposing organic matter, and
- amount of surface mixing at a monitoring point (caused by flows, wind and bird activity).

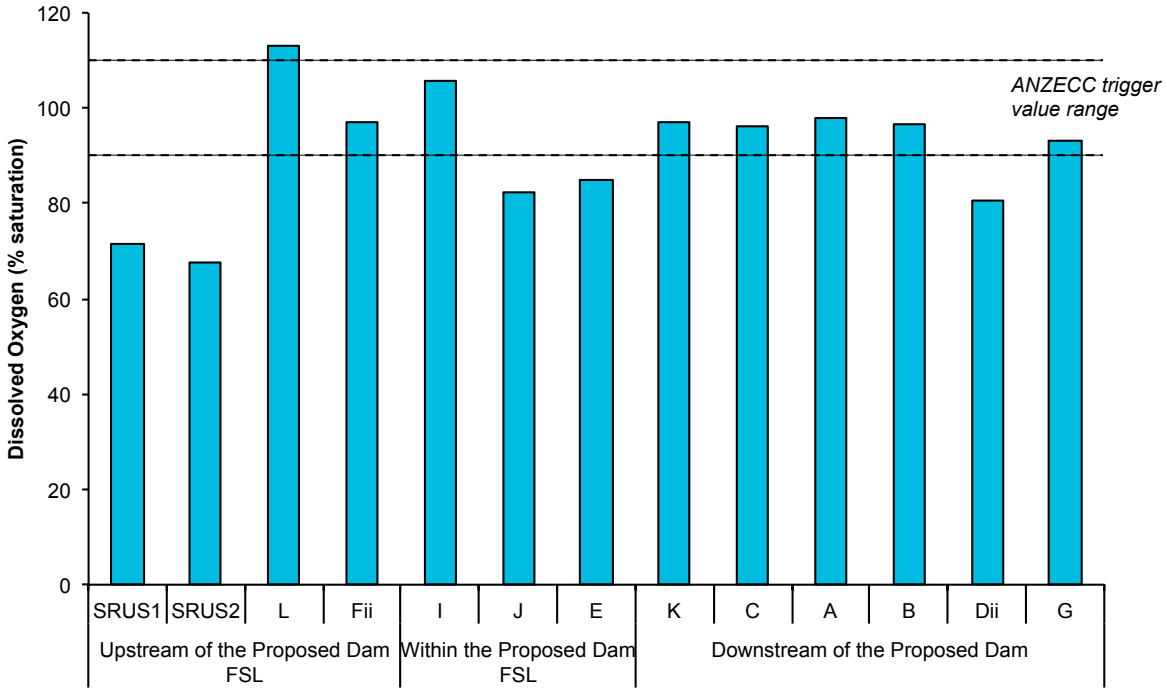

Figure 4.7 Percent saturation of dissolved oxygen at each site.

Turbidity

The turbidity was below the ANZECC & ARMCANZ trigger value at all sites (Figure 4.8). These results are consistent with the EIS.

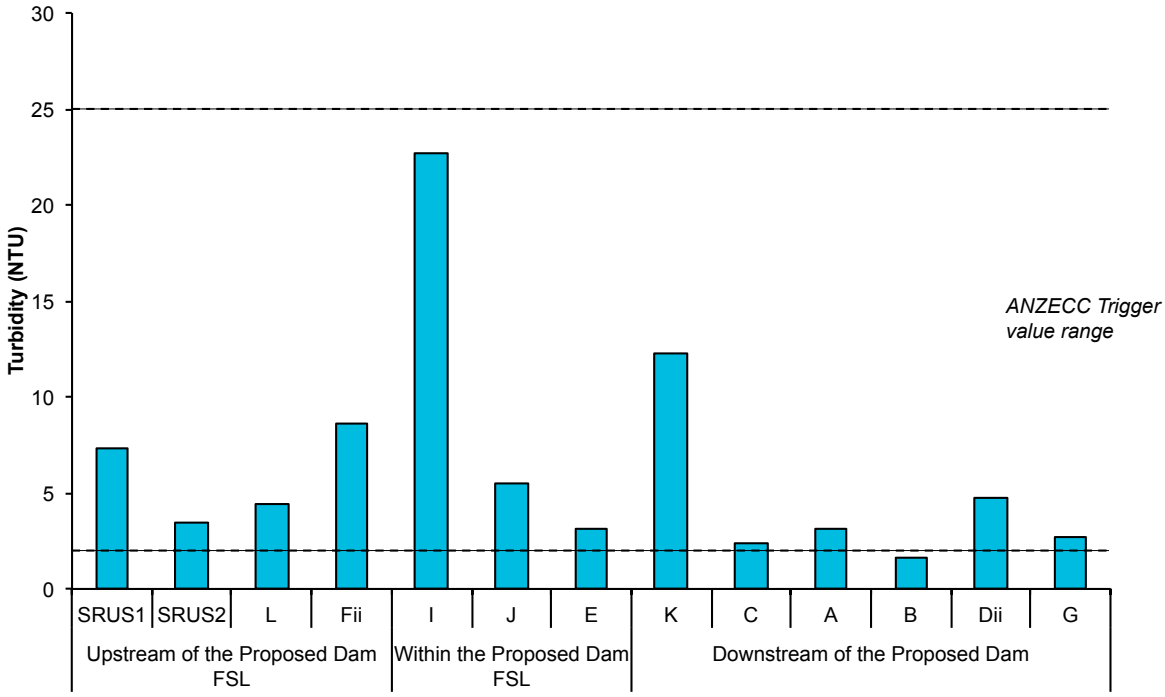

Figure 4.8 Turbidity at each site.

5 Aquatic Plants

A total of 13 species of aquatic plants were recorded in the survey area (Table 5.1 and Table 5.2). Nine species were recorded on the bank and nine species were recorded in-stream. Aquatic plants were recorded on the bank at all sites surveyed and in-stream at all sites except SRUS2 and Dii.

No rare, threatened or vulnerable aquatic plant species under the EPBC Act and NCWR were observed during the survey. No declared noxious weeds or weeds of significance were observed during the survey.

In-stream aquatic plant species richness was highest at site L (five species) and site B (five species), and lowest at sites SRUS2 and Dii (no species). Aquatic plant species richness on the bank was similar at all sites; there were three or four species on the bank at all sites except I, K and C, where there were only two species.

Percent cover of in-stream aquatic plants was highest at site L (13.2% mean aquatic plant cover) and percent cover of aquatic plants on the bank was highest at site Fii (14.8% mean aquatic plant cover). Percent cover of aquatic plants on the bank was lowest at site B.

Aquatic plants with an emergent growth form were the most abundant (i.e. had the highest cover) and most widespread (i.e. recorded at more sites). Common taxa included:

- common reed (Figure 5.1)
- common rush (Figure 5.2), and
- broad leaved cumbungi (Figure 5.3).

There was one floating species, red azolla, at site C (Figure 5.4), and two submerged species:

- ribbonweed, at sites L, C, A, B and G (Figure 5.6), and
- water milfoil, at site L.

Fewer aquatic plants were observed during the 2013 survey than in the EIS. With the exception of nardoo, all aquatic plants observed in 2013 were present during the EIS surveys. The results of the 2013 and EIS surveys are consistent with the SOR. During the SOR surveys only submerged and emergent aquatic plants were found in the Severn River catchment, and the percent cover of aquatic plants was typically low (Johnson D.P. 2004).

Table 5.1 Percent cover of aquatic plants in-stream.

Species Name	Common Name	Growth Form	Upstream of the Proposed Dam FSL				Within the Proposed Dam FSL			Downstream of the Proposed Dam					
			SRUS1	SRUS2	L	Fii	I	J	E	K	C	A	B	Dii	G
Azolla filiculoides	red azolla	F	–	–	–	–	–	–	–	–	0.1	–	–	–	–
Juncus usitatus	common rush	E	0.1	–	1.6	–	0.2	0.1	–	–	–	–	–	–	–
Ludwigia peploides	water primrose	E	–	–	–	–	–	–	–	–	–	–	0.3	–	–
Myriophyllum aquaticum	water milfoil	S	–	–	0.2	–	–	–	–	–	–	–	–	–	–
Persicaria hydropiper	water pepper	E	–	–	–	–	–	–	–	–	–	–	–	–	0.1
Persicaria sp.	smartweed	E	–	–	–	–	–	–	–	–	–	–	0.2	–	–
Phragmites australis	common reed	E	0.5	–	9	0.1	–	–	0.2	0.8	–	1	0.1	–	–
Typha orientalis	broad-leaved cumbungi	E	–	–	1.5	–	1.5	–	–	–	4.1	1	0.3	–	–
Vallisneria nana	ribbonweed	S	–	–	0.9	–	–	–	–	–	0.2	0.8	0.1	–	0.5
		Total Cover	**0.6**	**–**	**13.2**	**0.1**	**1.7**	**0.1**	**0.2**	**0.8**	**4.4**	**2.8**	**1**	**–**	**0.6**

Table 5.2 Percent cover of aquatic plants on the bank.

Species Name	Common Name	Growth Form	Upstream of the Proposed Dam FSL				Within the Proposed Dam FSL			Downstream of the Proposed Dam					
			SRUS1	SRUS2	L	Fii	I	J	E	K	C	A	B	Dii	G
Cyperus difformis	rice flat-sedge	E	–	–	0.2	–	–	–	–	0.6	–	–	–	–	0.3
Cyperus eragrostis	drain flat-sedge	E	0.3	0.1	–	–	–	0	–	–	–	–	0	–	–
Juncus usitatus	common rush	E	6.1	3.6	7.3	8.2	0.9	6.1	6.6	4.2	1.1	1.3	1	1.7	3.1
Ludwigia peploides	water primrose	E	–	–	–	–	–	–	–	–	–	–	0.4	0.2	–
Marsilea drummondii	nardoo	E	–	–	–	–	–	–	0.1	–	–	–	–	–	–
Persicaria hydropiper	water pepper	E	–	–	–	–	–	0.9	–	–	–	–	–	0.8	0.1
Phragmites australis	common reed	E	0.6	3.8	–	5.2	–	–	0.5	–	–	3.6	–	–	–
Rumex crispus	curled dock	E	–	1	0.9	1.4	1.1	1.3	1.2	–	–	0.8	–	1	0.9
Typha orientalis	broad-leaved cumbungi	E	–	–	0.5	–	–	–	–	–	2.1	0.2	–	–	–
		Total Cover	**7**	**8.5**	**8.9**	**14.8**	**2**	**8.3**	**8.4**	**4.8**	**3.2**	**5.9**	**1.4**	**3.7**	**4.4**

Figure 5.1

Common reed at site K

Figure 5.2

Common rush at site J

Figure 5.3

Broad leaved cumbungi at site B

Figure 5.4

Red azolla at site C

Figure 5.5

Ribbonweed at site B

Figure 5.6

Water milfoil at site G

6 Aquatic Vertebrates

6.1 Fish

A total of five species of fish were caught in the survey: three native species and two exotic species (Table 6.1). No species listed under the EPBC Act or NCWR were caught. Carp gudgeons were the most widespread and abundant fish species during the survey (Figure 6.1). Mosquitofish, which are a noxious pest, were also abundant at site J, within the proposed dam full supply level.

Fish species richness was low at all sites (Figure 6.2). A maximum of three species was caught at site E, within the proposed dam, however only two of these species were native. Only one fish species, carp gudgeon, was caught at site SRUS1 (upstream of the proposed dam full supply level), and at sites C, A, B and Dii (downstream of the proposed dam site). Of the sites where two fish species were caught, only sites F, I and G had no exotic species.

Fish communities were dominated by adult and intermediate life stages at all sites (Figure 6.3). Only juvenile carp gudgeons were caught at sites SRUS1 and L, upstream of the proposed dam full supply level, and at sites A and Dii, downstream of the proposed dam. Due to the fast growth rates (i.e. maturation periods within 12 months) of most of species caught, this is the expected distribution of life history stages. That is, most species breed in autumn and summer, so in September most juveniles have developed to later life-history stages. However, the SRA survey in 2008 found that recruitment of native species was considered very low in the Montane zone compared to other zones in the Border Rivers Valley (Davies et al. 2012).

The results of the 2013 survey are consistent with the EIS (Table 6.3). Five fish species were caught in 2013 compared to six fish species during the EIS. Of these species, goldfish were caught in 2013 but not during the EIS, and Murray cod and silver perch were caught during the EIS, but not in 2013. Carp gudgeons were the most abundant and widespread species in both surveys. Mosquitofish were also abundant and widespread during the EIS, but were less so in 2013. Water levels were lower during the EIS surveys, which may have resulted in increased fish abundance in restricted areas, compared to 2013 when more water likely increased connectivity and fish dispersal.

Fish populations assessed in the Montane zone of the Border Rivers Valley for the SRA were classified as being in poor to very poor condition (Davies et al. 2012) (Appendix B). Seven native species and three exotic species were caught during this survey, however only two of seven sites in the Montane zone were within the vicinity of the Severn River.

The species caught are shown in Table 6.3. Gambusia were the dominant exotic species in the SRA survey.

Figure 6.1

Carp gudgeon at site A

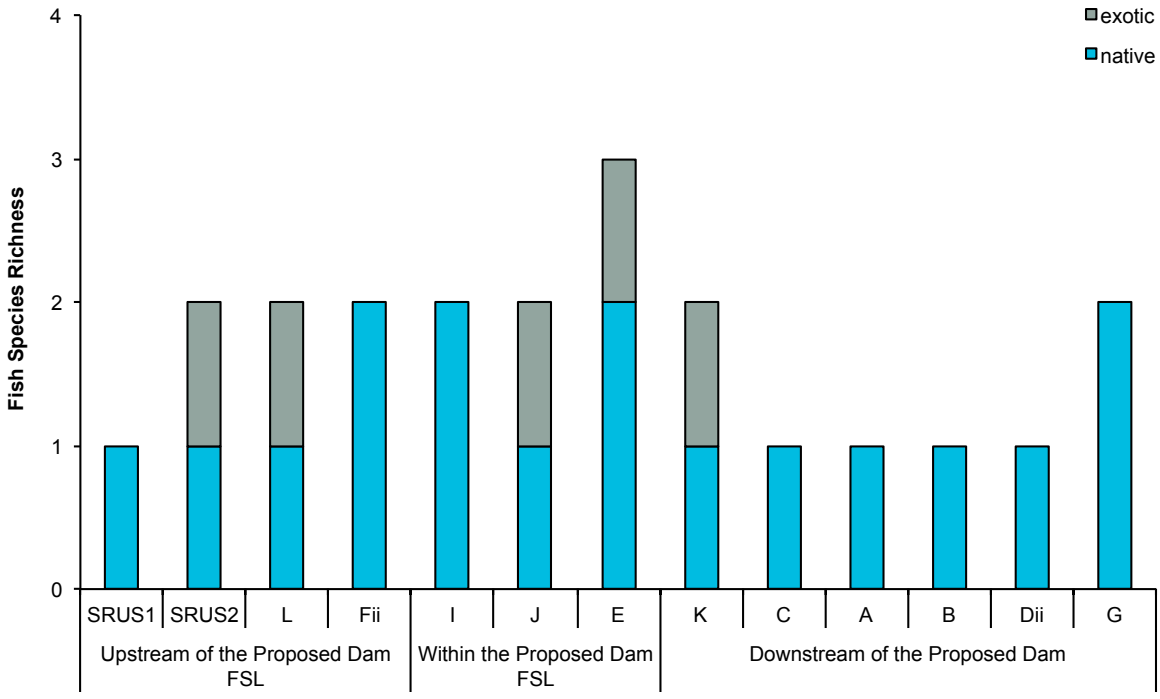

Figure 6.2 Fish species richness at each site.

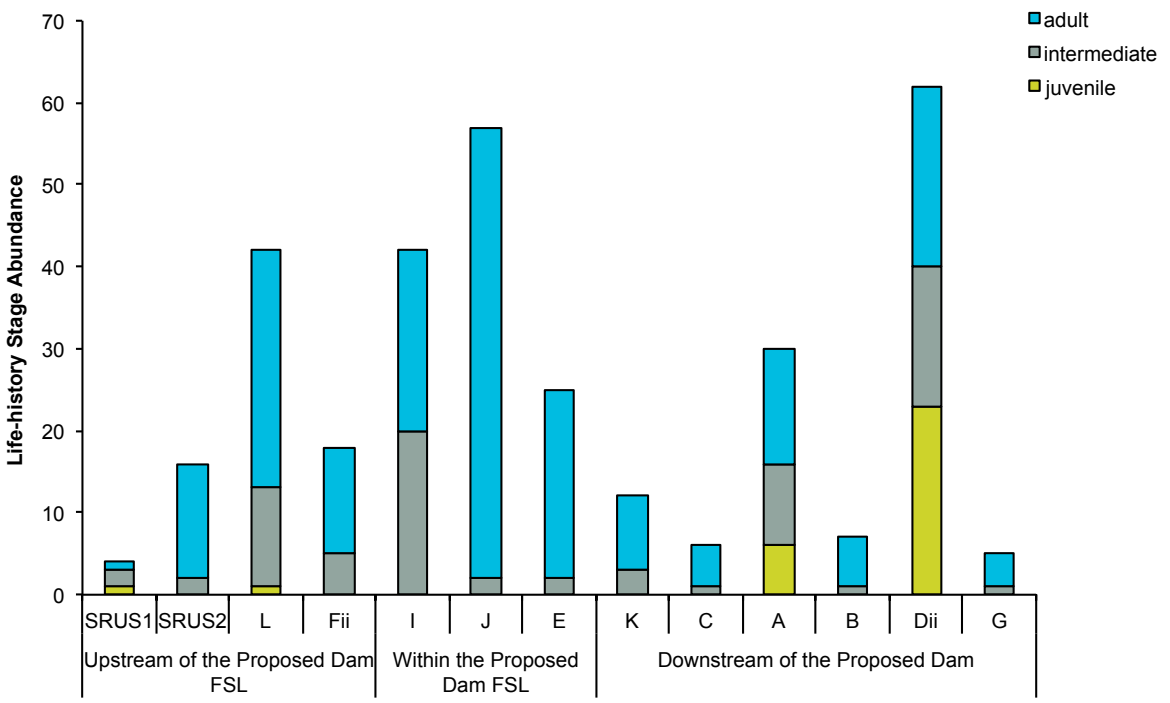

Figure 6.3 Fish abundance by life history stage at each site.

Table 6.1 Fish species caught in the survey.

Species	Common Name	Native / Exotic	Upstream of the Proposed Dam FSL				Within the Proposed Dam FSL			Downstream of the Proposed Dam					
			SRUS1	SRUS2	L	Fii	I	J	E	K	C	A	B	Dii	G
Carassius auratus	goldfish	exotic	–	1	–	–	–	–	–	–	–	–	–	–	–
Gambusia holbrooki	mosquitofish	exotic	–	–	4	–	–	35	11	1	–	–	–	–	–
Hypseleotris sp.	carp gudgeon	native	4	15	38	17	41	22	12	11	6	30	7	62	4
Macquaria ambigua	yellow belly	native	–	–	–	–	1	–	–	–	–	–	–	–	1
Tandanus tandanus	freshwater catfish	native	–	–	–	1	–	–	2	–	–	–	–	–	–
	Total Species Richness		**1**	**2**	**2**	**2**	**2**	**2**	**3**	**2**	**1**	**1**	**1**	**1**	**2**
	Total Abundance		**4**	**16**	**42**	**18**	**42**	**57**	**25**	**12**	**6**	**30**	**7**	**62**	**5**

Table 6.2 Fish species caught in the Sustainable Rivers Audit, EIS and supplementary EIS surveys.

Species	Common Name	Native / Exotic	Sustainable Rivers Audit 2008	EIS 2006 - 2007	Supplementary EIS 2013
Carassius auratus	goldfish	exotic	✔	✔	✔
Gambusia holbrooki	mosquitofish	exotic	✔	✔	✔
Hypseleotris sp.	carp gudgeon	native	✔	✔	✔
Macquaria ambigua	yellow belly	native	✔	✔	✔
Tandanus tandanus	freshwater catfish	native	✔	✔	✔
Retropinna semoni	Australian smelt	native	✔		
Galaxias olidus	mountain galaxias	native	✔		
Mogurnda adspersa	southern purple-spotted gudgeon	native	✔		
Perca fluviatilis	redfin perch	exotic	✔		
Maccullochella peelii	Murray cod	native	✔	✔	
Bidyanus bidyanus	silver perch	native		✔	

Ecology of Fish in the Project Area

Each of the fish species in the survey area requires some physical in-stream habitat for shelter or for reproduction. A variety of physical aquatic habitat (e.g. woody debris and substrate diversity) also supports diverse macroinvertebrate communities, which are prey to many of the fish in the survey area. Most of the species caught can tolerate a broad range of water quality conditions (Table 6.3). A detailed description of the ecology of each fish species caught in 2013 is provided in Appendix C.

6.2 Platypus

A total of 3 platypus were observed during the survey: one each at sites Fii (upstream of the proposed dam full supply level), K and C (downstream of the proposed dam site). The platypus at site K was large, while the platypus at site F was medium in size. The size of the platypus at site C could not be determined.

Table 6.3 Fish species caught and the range of water quality conditions in which they are known to occur.

Family *Latin Name*	**Common Name**	**Water Temp. (ºC)**	**Dissolved Oxygen (mg/L)**	**pH**	**Electrical Conductivity (µS/cm)**	**Turbidity (NTU)**
Cyprinidae						
Carassius auratus	goldfish	–	–	–	–	–
Eleotridae						
Hypseleotris sp.[b]	common carp gudgeons	8.4–31.7	0.6–12.8	4.8–9.1	19.5–5380	0.5–65
Percichthyidae						
Macquaria ambigua	yellowbelly	4–35	3–15	7.1–7.8	224–3000	–
Plotosidae						
Tandanus tandanus	freshwater catfish	8.4–33.6	0.3–17.1	4.8–9.1	19.5–3580	0.2–250
Poeciliidae						
Gambusia holbrooki	mosquitofish	–	–	–	–	–

7 Summary of Aquatic Ecological Values

Overall, the condition of aquatic ecology in the vicinity of the Project is moderate to poor. Aquatic habitat is similar upstream, within and downstream of the proposed dam, and is generally in moderate to good condition. It is capable of supporting aquatic species, but has been affected by historical clearing of riparian vegetation and numerous weirs that restrict fish passage.

Aquatic plant communities in the area are dominated by emergent and submerged species. Percent cover of aquatic plants on the bed and banks was generally low. No rare, threatened or vulnerable species under the EPBC Act or NCWR were present in the vicinity of the Project. No noxious weed or weeds of significance were observed.

Fish communities in the vicinity of the Project are poor, with low diversity, abundance and recruitment. Carp gudgeon were the most abundant and widespread species during all surveys in the area. Mosquitofish, a noxious species, were also abundant and widespread. No threatened or vulnerable species were caught during the 2013 survey, however Murray cod were caught in the EIS and SRA surveys.

Platypus are present upstream and downstream of the Project, but they were not abundant during the survey.

8 Potential Impacts and Mitigation Measures

Construction and operation activities associated with the proposed dam have the potential to affect aquatic ecology through:

- the operation and maintenance of vehicles and other equipment
- vegetation clearing and earthworks during construction
- quarrying and sand extraction during construction
- inundation of the dam
- dam operation
- obstruction of flow and passage by the dam, and
- changes to the flow regime.

The aquatic ecology attributes that could be impacted by these activities include:

- aquatic habitat (including riverine and lacustrine wetland (farm dams) habitats)
- aquatic plants (not species of conservation significance)
- fish (including a species of conservation significance), and
- turtles (discussed in a separate technical report).

The assessment of impacts is based on the legislative framework and description of the existing environment. A description of potential impacts of the Project activities on aquatic ecology and the associated mitigation measures is provided below. A summary and risk assessment is provided in Section 6.

8.1 Operation and Maintenance of Vehicles and Other Equipment

Fuel Spills

Both diesel and petrol are toxic to aquatic flora and fauna at relatively low concentrations. A spill of either may impact aquatic flora and fauna directly, or indirectly through changes in water quality or the loss of food sources. However, the risk will be low if a high level of control that meets required standards is implemented, and drainage of refuelling and maintenance areas is directed into contained areas away from the river. Spilt fuel is most likely to enter the river via an accidental spill on nearby roads or when there are

construction activities adjacent to river. A significant fuel spill to the river (in the order of tens or hundreds of litres) is likely to have a locally significant impact on aquatic flora and fauna, with the quantity spilt and the volume of water in the river being the most significant factors influencing significance of the impact.

Water that is used for dust suppression and in the concrete batch plants has the potential to introduce contaminants, such as cement residues and hydrocarbons into waterways through runoff from the site. Increases in pH may occur if significant quantities of concrete slurry used to build the dam wall mixes with the storage water. Any such increase might impact aquatic flora and fauna.

Risks associated with the spillage of fuels and other contaminants can be substantially reduced, if not eliminated, where:

- vehicle maintenance areas, portable refuelling stations and storage of fuels, oils and batteries are situated within bunded areas, designed and constructed in accordance with Australian Standards
- all spills of contaminants over 20 litres are reported to the Environmental Officer (or delegated person) for follow up action, and
- appropriate spill containment kits are available, and used for the cleanup of spills in the field. The kits should contain equipment for clean up of both spills on land or in dry creek beds, and spills to water.

Litter and Waste

With appropriate controls in place, such as bunded storage areas and direction of runoff to a contaminated water management system, the risk to aquatic ecosystems from litter and spilt waste from the Project area is likely to be very low.

8.2 Vegetation Clearing and Earthworks During Construction

There is potential for soil erosion and sedimentation in the river following vegetation clearing and earthworks, particularly during periods of intense rainfall. This could lead to impacts on aquatic flora and fauna via increased turbidity and contaminant levels in the river, and the alteration of preferred habitats. There may also be direct impacts to aquatic habitat and flora and fauna.

Increased Turbidity

Vegetation clearing and / or earthworks have the potential to increase sediment run-off to creeks and increase turbidity. Increased turbidity may negatively impact aquatic fauna, as highly turbid water reduces respiratory and feeding efficiency (Karr & Schlosser 1978) cited in (Russell & Hales 1993). Increased turbidity may also adversely affect submerged aquatic plants because light penetration (required for photosynthesis) is reduced. Reduced light penetration can also lead to a reduction in temperature throughout the water column (DNR 1998).

Turbidity was low in the vicinity of the Project; however, based on the published tolerances of the species caught, the animal communities of the survey area are capable of living in more turbid waters. Small increases in turbidity would therefore be unlikely to have a significant impact on aquatic ecology; however, significant, prolonged increases in turbidity could adversely impact the health, feeding and breeding ecology of some species of fish.

Input of Nutrients or Other Contaminants

Aquatic fauna could also be impacted by nutrients or other contaminants washed into the waterways with the sediment. Nutrient inputs can lead to algae or aquatic plant blooms. During the day, as the algae photosynthesises, these blooms can produce a high percent saturation of dissolved oxygen. However, at night, there is a net consumption of oxygen as the algae continue to respire. This can cause the percent saturation of dissolved oxygen to be reduced very low during the night and early morning, which is harmful to fauna.

Input of nutrients or other contaminants into the waterways would impact on aquatic plants and animals. Where the spill is a one-off occurrence, communities may be impacted, but would be expected to recover over time. Chronic inputs of nutrients or contaminants to the waterways would be expected to have longer-term detrimental impacts on flora and fauna.

Nutrient / contaminant-laden run-off is likely to be low where best practice stormwater and erosion control measures are implemented.

Aquatic Habitat

Vegetation clearing and earthworks may decrease the amount of habitat available for aquatic fauna. All habitats under the dam wall will be lost to aquatic fauna upon commencement of construction.

Aquatic animals use a variety of in-stream and off-stream structures for habitat, including:

- large and small woody debris
- bed and banks
- detritus
- tree roots
- boulders
- undercut banks, and
- in-stream overhanging and trailing bank vegetation.

All of these habitat types were found in the survey area. In-stream habitat is an important as it:

- provides shelter from temperature, current and predators
- contributes organic matter to the system, and
- is important for successful reproduction.

The deposition of fine sediments can decrease in-stream bed roughness and habitat diversity. A decrease in habitat available for aquatic fauna could lead to a decline in the abundance and diversity of fish communities, and also potentially impact on dependent predators (e.g. birds, reptiles and small mammals).

The impacts of disturbance to habitat during the construction phase will be highly localised and are considered acceptable in both a local and regional context, given the expected relatively small disturbance footprint. As aquatic habitat is similar throughout the Project area, a decrease in habitat associated with earthworks and vegetation clearing during construction is likely to represent a only small proportion of the habitat available for flora and fauna. The risk of sedimentation in waterways from vegetation clearing and earthworks will be reduced where:

- an erosion and sediment control management plan is developed and implemented
- sediment dams are constructed prior to vegetation clearing and earthworks

- vegetation clearing and earthworks are done in stages, and
- clearing and earthworks for construction of the dam is done in the dry season.

Flora and Fauna

In-stream works will have an impact on aquatic flora and fauna through direct disturbance. Direct impacts to aquatic fauna will be minimised where fauna are relocated from the work area prior to disturbance. Translocation should be in accordance with QPIF fish salvage guidelines (DPI&F 2004), which recommend that:

- fish from the waterway be captured using a variety of methods (seine netting, electrofishing, cast nets and set traps)
- translocation should be done in the cooler months if possible, to minimise stress to the fish
- fish should be removed before water flow is isolated from the channel, and
- fish should be handled, transported, and released so as to minimise damage to the fish (e.g. handle with wet hands, hold fish correctly etc.).

Vibration, noise and sudden changes in pressure from drilling and blasting of the diversion channel have the potential to impact on aquatic fauna, though mobile fauna such as fish and turtles would be expected to move away from the area. Blasting will occur at the dam site and in the quarry, very close to, or in, the river. Direct impacts to fauna will be minimised where fauna are relocated prior to disturbance.

Other physical disturbance will occur during vegetation clearance within the inundation area because trees and shrubs will be felled in riparian zones. It is recommended that vegetation not be felled into the water so that it can be both easily removed but also so that the process causes minimal disturbance to the river / creek. Fauna from these areas do not need to be relocated as they would be expected to move of their own volition as the water storage fills.

8.3 Quarrying and Sand Extraction During Construction

Quarry and sand extraction areas are located in the inundation area of the proposed dam, parallel to the river. The potential impacts of quarrying and sand extraction are similar to those described for vegetation clearing and earthworks in section 8.2, and similar mitigation measures should be applied.

8.4 Inundation of the Dam

During the filling phase, existing habitats will be inundated as the dam begins to fill. The ecosystems within the inundation water will change from riverine (lotic) to lake (lentic) habitats. Initially, the lotic ecosystems will fill to bank full widths as if in flood, but then the area above the banks will be gradually inundated until the dam is at full supply level. The length of the filling phase is dependent on the rate of inflow, and the inundation area may fill during a single flood event or it may take several years.

Aquatic Habitat

The inundation of the dam will result in the loss of pool, run, glide, backwater, riffle and cascade habitat along approximately 4.4 km of the Severn River. Coarse sediment (boulders, cobbles, pebbles and gravel) present within the inundation area will likely be smothered in fines and sands once the inundation area is filled (as suspended fine sediments are likely to settle out of the water column in the relatively still waters of the inundation area). However, the aquatic habitat in the Severn River is similar throughout the Project area (i.e. upstream of, within, and downstream of the proposed dam site). The distance from the confluence of the Broadwater and Quart Pot Creek (i.e. the headwaters of the Severn River) to the downstream extent of the Project area (as defined in this report) is approximately 34.5 km, and field surveys indicate that aquatic habitat is similar throughout this area. As such, the inundation will result in the loss of approximately 12.8% of aquatic habitat in this section of the Severn River, but is highly unlikely to result in the loss of any unique aquatic habitat that supports aquatic flora and fauna.

The fish species recorded within the water storage area are not habitat specialists. That is, no species are expected to be lost from the dam due to the changes in habitat type. However, there will be a shift in community composition due to the expected changes in habitat and sediment type. The increased extent of shallow margins may provide ideal habitat for several species, particularly if they are colonised by macrophytes as was predicted. For example, gudgeons and catfish prefer habitats that include macrophytes (Allen et al. 2002). Most species recorded in the study area have previously been recorded in habitats with a variety of substrates (Appendix C). However, the shift in substrate composition may result in the loss of spawning habitat for species that deposit eggs on gravel surfaces or hard surfaces, such as freshwater catfish.

There are no mapped farm dams or wetlands in the proposed dam inundation area; however, there is one on-stream lacustrine wetland (a weir pool) and three off-stream lacustrine wetlands (farm dams) downstream of the proposed dam. These will not be affected by the inundation of the proposed dam.

Water Quality

Water quality is likely to change as the dam fills and the greatest risk to fauna is likely to be low levels of dissolved oxygen in deepest part of the inundation area. The storage may also become stratified periodically, resulting in warm surface waters and cool deeper waters. Rapid changes of temperature during a 'roll over' event (where cool deep waters upwell to the surface) may be detrimental to fish and platypus; however, the likelihood of this occurring is low where water quality at the surface and at depth is monitored, and operation of the dam promotes mixing through the water column. Decreases in dissolved oxygen levels are also possible during such events. Water quality issues will be minimised during inundation if there is a balance between removal of vegetation from the inundation area prior to filling in order to minimise de-oxygenation, and leaving some in place to minimise erosion during filling or to serve as habitat in the operational storage. Ecological impacts would be minimised if the storage filled rapidly and could reach its "mature" operational state as quickly as possible.

The inundation area will provide a stable pool habitat for aquatic fauna. While the length of riverine sections will decrease and there will be an increase in deep inhospitable areas, there may be a net increase in diversity of habitat because of that offered by the over-bank areas in the tributaries. The stability and potential diversity of the habitat created by the dam may result in an increase in fish abundance and diversity in the inundation area (frc environmental 2008). The inundation area is unlikely to be suitable for platypus, as they prefer water depths of 5 m or less for optimal foraging; however, platypus have been observed in dam storages (e.g. Paradise Dam on the Burnett River).

8.5 Dam Operation

Water will exit the dam through a multi-level off-take structure, through a fishway, or over the spillway during periods of high flow. The multi-level off-take structure will allow water to be withdrawn from a range of depths or fill levels, ensuring that high quality water is available. Potential impacts to aquatic flora and fauna that may result from the operation of the off-take structures include changes to water quality in the downstream environment and entrapment of fauna in the off-take works.

Water Outlets

Potential impacts to fauna that may result from the operation of the off-take structures include entrapment of fauna in the off-take and outlet works. Screens covering the multi-level off-take would direct large fish towards the fishway entrance, but fish small enough

to fit through the screens (such as gudgeons and juveniles) may enter the multi-level off-take. These fish may survive if returned to the river with environmental flows, but they will die if diverted to the pumping station. However, these species are unlikely to be in the deep open water areas where the off-take will be located.

While the effects of fauna overtopping weirs and spillways is poorly understood, some fish have been observed dying after overtopping weirs during large flow events (Clay 1995; Hamann et al. 2004). Factors affecting survival are the height of the spillway, whether it is stepped or smooth and the size of the animal. Mortality is thought to be the result of impact forces and shearing against the concrete spillway and may be reduced where the spillway is stepped. Spillway-associated losses would not be likely to have a significant impact on the populations of commonly occurring species of fish

Fauna near the stilling basin may also be injured by water and debris coming over the spillway. Some fish may be attracted to flows at the base of the spillway during overtopping events. Impacts to aquatic fauna will be reduced if the spillway and energy dissipation devices are constructed such that fish are prevented from entering the stilling basin from downstream. Any stabilisation works required on river banks downstream from the dam should aim to provide habitat as well as perform their engineering function.

Water Quality

Downstream of the dam, the key water quality parameters that may be affected are dissolved oxygen, turbidity, temperature, and nutrient concentration. The quality of the water received downstream will depend on whether the impoundment is stratified, whether there are blue-green algae blooms in the impoundment, and the location of release valves. Water released from the dam may be low in dissolved oxygen and harmful to aquatic fauna if taken from deep within the dam. Surface waters of the dam will have a higher concentration of dissolved oxygen due to the action of phytoplankton and macrophytes, unless surface waters may become temporarily hypoxic (low in oxygen) after change in stratification or after extensive microbial decomposition (e.g. rotting vegetation). After filling and stabilising, sediments will drop out of suspension and as such, the dam will act as a trap for sediments and nutrients. Impacts to downstream water quality will be mitigated if water quality in the dam and the source of releases are managed.

Aquatic habitat

During operation of the dam there is expected to be some overhanging vegetation along the margins of the water storage area at full supply level, though the likely ratio of this habitat compared with open water with no canopy cover will be substantially reduced. When water levels are below full supply level there will be little overhanging vegetation except where the storage remains in a former stream channel and surviving riparian vegetation can still perform that function or where deep areas abut existing forest. Appropriate material could be salvaged for use as 'large woody debris' fish habitat in the inundation area.

Tree and shrub vegetation provides shading to channels and aquatic habitat such as snags and overhanging vegetation. Snags provide resting, sheltering and foraging habitat for aquatic fauna. Substrate diversity and a variety of aquatic habitat such as woody debris also support more diverse and abundant macroinvertebrate communities, which are prey for many of the fish found in the study area. Each of the native fish species that may occur in the water storage area require in-stream habitat to provide shelter or for reproduction (Appendix C).

The dam will provide less diversity of physical habitat, hence it is important to re-create some through the strategies such as placing snags in relatively (<5 m) shallow water and not clearing to full supply level to provide structural diversity.

8.6 Obstruction of Flow and Passage

Dams create barriers that prevent or impede movement (i.e. general movement through a waterway) and migration (i.e. movement for a specific purpose such as reproduction) of aquatic fauna, including fish and platypus, in waterways. A dam wall is, without mitigation, a complete barrier to upstream fauna movement and an almost complete barrier to downstream movement. During construction the construction site will also represent a barrier to aquatic fauna. Many of the native fish in Queensland waterways migrate upstream and downstream and between different habitats during particular stages of their life cycle. Fish passage is already restricted in the Severn River in the vicinity of the Project by weirs and, if unmitigated, the dam will further restrict fish movement and migration in the catchment.

During construction, impacts from the obstruction of flow and passage can be mitigated through the use of a diversion channel to connect the river upstream and downstream of the construction site. Removal of the larger aquatic fauna before construction begins, as described in section 8.2, will also mitigate potential impacts during construction.

The impediment to passage from the dam wall has the potential to affect fish migration and breeding, isolate fish populations and, in the long-term, could decrease genetic diversity in populations upstream and downstream of the dam. However, fish communities in the vicinity of the Project are generally poor and Murray cod have typically been caught downstream of the proposed dam site; therefore, with the installation of a fishway, it is considered unlikely that the dam will lead to the isolation of important fish populations.

A fishway has been included in the design to accommodate both movement direction and is intended to service the needs of other fauna, including turtles. The design of the facility will be finalised following further consultation with relevant agencies and experts, and in general accordance with the process provided by Queensland Fisheries. However, the concept design is for a fishlock arrangement, similar to that installed on Ned Churchward Weir located on the Burnett River near Albionville, which will operate such that at least the current opportunity for movement is maintained.

The dam will affect fish species differently, depending on their need to migrate and their ability to navigate fishways. Most of the fish caught move throughout the freshwater reaches of rivers over the course of their lifetimes. The timing of these migrations in Australian fishes is often unpredictable. In some species, migrations occur during periods of low flow, while others migrate in response to periods of high flow, either upstream or downstream. The use of fish locks by fish within a particular family or even genus is not always consistent. Therefore, generalisations made about the behaviour of related groups of fishes may not be accurate.

Fish locks and fish lift structures are likely to provide adequate passage for most fish species present, if they are appropriately designed, maintained in working order, monitored and fine-tuned to improve performance. Platypus have also been known to use fish locks (DEEDI 2012). Impediments to fish movement at the dam wall will be reduced by constructing fishway structures that (from Stuart et al. 2007):

- use an impassable downstream barrier to direct fish away from the spillway towards the fish lock opening, or have a downstream entrance near the spillway to allow the passage of larger fish attracted to large flows
- have upstream structures that direct fish migrating downstream towards the lock
- can vary attraction flows in accordance with river flows
- can operate over a range of head and tailwater levels
- use high quality water (surface) as attractant provided with little turbulence
- provide attractant flows and lock cycles for fish migrating downstream

- use a sloping lock chamber rather than a follower cage to encourage exit from the lock
- are maintained in working order, monitored and fine-tuned to improve performance
- are remotely operated and functional year round, and
- reduce the chances of fish migrating upstream passing back over the spillway.

Restrictions to fish passage and associated impacts (e.g. decreased recruitment) may be offset where fish habitat movement is enhanced by:

- restoration of passage at existing barriers through the removal and / or installation of fishways at existing weirs in the Project area
- habitat restoration and / or protection in the Project area, and
- allocation of water specifically to enhance aquatic habitat downstream of the dam.

8.7 Changes to the Flow Regime

The proposed dam may change the current flow regime in the river by reducing flow in the river downstream of the dam site and altering the timing, frequency and size of seasonal flow events. The number of weirs downstream of the dam site could also exacerbate any decrease in flow downstream of the proposed dam. Potential impacts associated with a change in the existing flow regime may include: a decrease in the persistence of and connectivity between some pool – run / riffle habitat sequences; a reduction in the availability and suitability of aquatic habitat for native flora and fauna; and altered migratory or breeding cues for some aquatic fauna (particularly fish). However, the proposed release regime from the dam includes environmental releases and modelling indicates the decrease in water depth will be small.

Environmental flows from the dam will comprise a release equivalent to the inflow, up to 30 ML/day, in order to maintain the natural flow regime for low flows and the ephemeral nature of the Severn River. For example, if 8 ML/day enters the storage then 8 ML/day will be released downstream, but if flow greater than 30 ML/day enters the storage then 30 ML/day will be released downstream. Modelling for the SEIS indicates that the dam will spill for 46 days of the year, with an average of 0.4 of a year (i.e. 4-5 months) between spills. The average duration of spills is predicted to be 14 days. The proposed combination of environmental releases and spills will contribute to maintaining a flow regime consistent with the current flow regime and will mitigate impacts to flora and fauna. In particular, the combination of low flow releases and high spills are expected to provide suitable conditions to trigger migration and reproduction in aquatic fauna.

Modelling undertaken for the SEIS indicates that between the proposed dam site and the confluence of the Severn River and Accommodation Creek, changes to the stream flow would only represent a decrease in water depth of up to 100 mm. This change in water depth is unlikely to have a substantial impact on the availability and suitability of aquatic habitat, except during periods of very low flow, in areas not within existing weir pools. Loss of habitat during periods of low flow will be mitigated by the proposed environmental releases. Impacts to aquatic habitat, flora and fauna from altered flows, are therefore expected to be minimal, as habitat persistence and connectivity downstream of the dam will be maintained.

Changes to the downstream flow regime could potentially affect the downstream lacustrine wetlands (farm dams) through a decrease in the depth and persistence of water in these reservoirs. However, based on the proposed release regime and water modelling, this is considered unlikely to occur, and if the combined urban and irrigation dam is developed, supply from the proposed dam may supplement any loss of water in the farm dams.

9 Risk Assessment

9.1 Methods

Based on the outcomes of a literature review and field surveys for the EIS and supplementary EIS, potential impacts to aquatic habitat, aquatic plants, fish and platypus have been identified. The value of these aquatic ecology attributes in the Project area was identified, along with the magnitude of each potential impact to these attributes, and defined in accordance with the criteria outlined in Table 9.1 and Table 9.2.

Risks to aquatic habitat, aquatic plants, fish and platypus as a result of the Project have been assessed based on the determined value and magnitude of impact. Table 9.3 illustrates how the significance of a potential impact was derived.

Table 9.1 Value criteria for aquatic ecology attributes.

Value	Definition
very high	· an internationally important site (e.g. Ramsar wetland, or a site considered worthy of such designation) · a regularly occurring population of an internationally important species · a nationally designated site (e.g. Wetland of National Significance) · smaller areas of habitat which are essential for maintaining the viability of a larger whole area of national significance · areas of habitat that may support nationally important species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). · aquatic species or communities listed under the EPBC Act
high	· habitat of state significance (e.g. wetlands of high ecological significance in the Great Barrier Reef catchments) · aquatic species or communities listed under Queensland's *Nature Conservation Act 1992* · aquatic habitat, species or communities that are rare or have a high conservation priority species within Queensland. · aquatic species or communities that are considered 'iconic' species within Queensland or Australia (e.g. platypus)

Value	Definition
medium	· aquatic habitat or site designated by a local authority as having local conservation status · aquatic habitat or species that has importance at a catchment-scale, e.g. refuge habitat or fish breeding habitat
low	· aquatic habitat not specifically protected under state or national legislation, but that supports native aquatic flora and fauna · common or widespread aquatic species or communities within the region that are not specifically protected under state or national legislation and that are relatively tolerant of a wide range of environmental conditions
negligible	· common or widespread aquatic habitat within the region that is highly disturbed and rarely supports aquatic flora and fauna · highly disturbed aquatic communities, e.g. that are affected by pollution or invasion of exotic species

Table 9.2 Thresholds for magnitude of impact for aquatic ecology receptors.

Magnitude of Change	Definition
major	· permanent or long-term effect on the extent or integrity of a habitat, a species or a community · likely to result in a direct effect on a habitat or a species, including mortality of a high value species that affects the viability of the population · likely to threaten the sustainability or conservation status of a habitat, a species or a community · if beneficial, likely to enhance the sustainability or conservation status of a habitat, a species or a community
moderate	· permanent or long-term effect on the extent or integrity of a habitat, a species or a community · likely to result in direct effect on a habitat or a species that does not affect the viability of the population · unlikely to threaten the sustainability of a habitat, a species or a community · if beneficial, likely to enhance the sustainability of a habitat, a species or a community

Magnitude of Change	Definition
minor	· medium or short-term reversible effect on a habitat, a species or a community · may be a small but measurable indirect impact on an aquatic habitat or on a native aquatic species or community · will not threaten the sustainability of a significant habitat, species or native aquatic community
negligible	· no direct impact to an aquatic habitat or a species · short-term and reversible indirect effect on habitat that is unlikely to lead to impacts on habitat integrity or a native aquatic community
no change	· no direct or indirect impacts to aquatic ecology

Table 9.3 Matrix used to estimate the significance of potential impacts after mitigation.

Significance of Effect		Magnitude of Change				
		Major	**Moderate**	**Minor**	**Negligible**	**No change**
Attribute Value	**Very high**	Very Large	Large/Very Large	Moderate/ Large	Slight	Neutral
	High	Large/Very Large	Moderate/ Large	Slight/ Moderate	Slight	Neutral
	Medium	Moderate/ Large	Moderate	Slight	Neutral/ Slight	Neutral
	Low	Slight/ Moderate	Slight	Neutral/ Slight	Neutral/ Slight	Neutral
	Negligible	Slight	Neutral/ Slight	Neutral/ Slight	Neutral	Neutral

Note: Shaded boxes indicate a significant effect in terms of environmental impact assessment. Where a choice of two impact significance descriptors is available, only one should be chosen. This allows for professional judgement and discrimination in assessing impacts.

9.2 Impact Assessment

Table 9.4 shows the risk assessment for potential impacts to aquatic habitat, aquatic plants, fish and platypus in the Project area. Based on the impact assessment presented above, the following activities have the potential to result in impacts to aquatic flora and fauna without mitigation and management:

- fuel and contaminant spills to the river, affecting water quality
- works such as vegetation clearing, earthworks, quarrying and sand extraction, resulting in decreased available habitat, and
- construction, inundation and operation of the dam, leading to habitat loss and decline in habitat suitability, a reduction in food sources and isolation of populations.

Once mitigation measures are implemented, all residual impacts on aquatic habitat, aquatic plants, fish and platypus are considered to be slight, except in relation to the restriction of passage in the river. The restriction of passage has moderate residual impact for Murray cod and platypus using the impact assessment methodology; however, the restriction of passage is unlikely to threaten the sustainability of these species in the region.

The residual impacts classified as slight are not considered to be significant impacts in accordance with the impact assessment methodology described in Section 9.1.

Table 9.4 Summary of the potential impacts of the Emu Swamp Dam Project on aquatic ecology, the relevant mitigation and management measures and the residual risk.

Aquatic Ecology Attribute by Value Criteria	Potential Impact	Mitigation / Management Protocol	Objective	Magnitude of Change After Mitigation	Residual Impact
Very High					
Listed threatened or near-threatened species – Murray cod	· increased turbidity and sedimentation, and input of nutrients or other contaminants associated with the soil from works including vegetation clearing, earthworks, quarrying and sand extraction	· an erosion and sediment control plan is developed and implemented during works and operation · sediment dams are constructed before works begin · works occur in the dry season, if possible	no increase in turbidity or general decline in water quality	negligible	slight
	· loss of in-stream habitat from works including vegetation clearing, earthworks, quarrying and sand extraction	· fauna are translocated from in-stream areas directly affected by works by qualified professionals before work begins	no direct or indirect impacts to listed threatened or near-threatened species	negligible	slight
	· loss of in-stream habitat from dam inundation	· maintain riparian vegetation and in-stream woody debris along dam margins	no change to Murray cod population	negligible	slight
	· restriction of passage and isolation of populations by the dam wall and during construction	· inclusion of fishlock on dam, with screens to re-direct large fauna towards the fishlock and away from off-takes · maintain passage for aquatic fauna during construction using diversion channels · improvement of fish movement across existing weirs	no change to Murray cod population	minor	moderate
	· loss of in-stream habitat due to a changed flow regime downstream of the dam	· managed environmental releases and spills to maintain connectivity and flow regime consistent with current conditions	no reduction in the number of existing pool-run/riffle sequences or connectivity	negligible	slight
	· improved conditions for exotic species from dam inundation and a changed flow regime downstream of the dam.	· management plan to control exotic and pest species such as mosquitofish and goldfish within and downstream of the dam.	no increase in the populations of exotic or pest species	negligible	slight
	· reduction in food sources from changed water quality and flow conditions.	· managed environmental releases and spills to maintain connectivity and flow regime consistent with current conditions · management plan for water quality in the storage and environmental releases	no direct or indirect impacts to Murray cod	negligible	slight
High					
iconic aquatic and protected aquatic species – platypus, river blackfish,	· increased turbidity and sedimentation, and input of nutrients or other contaminants associated with the soil from works including vegetation clearing, earthworks, quarrying and sand extraction	· an erosion and sediment control plan is developed and implemented during works and operation · sediment dams are constructed before works begin · works occur in the dry season, if possible	no overall decrease in water quality	negligible	slight

Aquatic Ecology Attribute by Value Criteria	Potential Impact	Mitigation / Management Protocol	Objective	Magnitude of Change After Mitigation	Residual Impact
southern purple-spotted gudgeon, freshwater catfish	· loss of in-stream and riparian habitat from works including vegetation clearing, earthworks, quarrying and sand extraction	· fauna are translocated from in-stream areas directly affected by works by qualified professionals before work begins · riparian vegetation is preserved and maintained, where possible	no direct or indirect impacts to iconic and protected species	negligible	slight
	· loss of in-stream and riparian habitat from dam inundation	· fauna are translocated from in-stream areas directly affected by works by qualified professionals before work begins	no change to populations of iconic and protected species	negligible	slight
	· restriction of passage and isolation of populations by the dam wall and during construction	· inclusion of fishlock on dam, with screens to re-direct large fauna towards the fishlock and away from off-takes · maintain passage for aquatic fauna during construction using diversion channels · improvement of fish movement across existing weirs	no change to populations of iconic and protected species	minor	moderate
	· loss of in-stream habitat due to a changed flow regime downstream of the dam	· managed environmental releases and spills to maintain connectivity and flow regime consistent with current conditions	no reduction in the number of existing pool-run/riffle sequences or connectivity	negligible	slight
	· improved conditions for exotic species from dam inundation and a changed flow regime downstream of the dam.	· management plan to control exotic and pest species such as goldfish within and downstream of the dam.	no increase in the populations of exotic or pest species	negligible	slight
	· reduction in food sources from changed water quality and flow conditions.	· managed environmental releases and spills to maintain connectivity and flow regime consistent with current conditions · management plan for water quality in the storage and environmental releases	no change to populations of iconic and protected species	negligible	slight
Medium - Low					
all aquatic habitat, flora and fauna in the Severn River	· increased turbidity and sedimentation, and input of nutrients or other contaminants associated with the soil from works including vegetation clearing, earthworks, quarrying and sand extraction	· an erosion and sediment control plan is developed and implemented during works and operation · sediment dams are constructed before works begin · works occur in the dry season, if possible	no overall decrease in water quality	negligible	slight
	· loss of in-stream and riparian habitat from works including vegetation clearing, earthworks, quarrying and sand extraction	· fauna are translocated from in-stream areas directly affected by works by qualified professionals before work begins	minimise direct impacts to fauna	negligible	slight
	· loss of in-stream and riparian habitat from dam inundation	· maintain riparian vegetation and in-stream woody debris along dam margins	maintain riparian and in-stream habitat in margins of dam	moderate	slight

Aquatic Ecology Attribute by Value Criteria	Potential Impact	Mitigation / Management Protocol	Objective	Magnitude of Change After Mitigation	Residual Impact
	· restriction of passage and isolation of populations by the dam wall and during construction	· inclusion of fishlock on dam, with screens to re-direct large fauna towards the fishlock and away from off-takes · maintain passage for aquatic fauna during construction using diversion channels · improvement of fish movement across existing weirs	minimise restriction of passage in river	moderate	slight
	· loss of in-stream due to a changed flow regime downstream of the dam	· managed environmental releases and spills to maintain connectivity and flow regime consistent with current conditions	no reduction in the number of existing pool-run/riffle sequences or connectivity	negligible	neutral
	· improved conditions for exotic species from dam inundation and a changed flow regime downstream of the dam.	· management plan to control exotic and pest species such as goldfish within and downstream of the dam.	no increase in the populations of exotic or pest species	negligible	slight
	· reduction in food sources from changed water quality and flow conditions.	· managed environmental releases and spills to maintain connectivity and flow regime consistent with current conditions · management plan for water quality in the storage and environmental releases	minimise changes to flow regime and water quality	negligible	slight

10 Cumulative Impacts

Cumulative impacts of the Project on aquatic ecosystems were considered in relation to the surrounding land uses and other major projects underway or planned in the local area.

The lands in the vicinity of the Project are predominately used for agricultural activities, dominated by grazing and cropping, with some rural and urban residential areas (Henderson 2000; Johnson D.P. 2004). Numerous weirs, as described in the EIS, are also located on the Severn River in the vicinity of the Project. These activities have the potential to affect, or have affected, aquatic ecology through vegetation clearing, earthworks, water extraction, application of fertilisers and/or pesticides, and water impoundment and flow regime modification.

The proposed dam represents a substantial impact to fish passage and the flow regime in the Severn River, However, where the appropriate mitigation measures are in place, including a fishway, it is considered unlikely that the Project will result in a significant increase in cumulative adverse impacts on aquatic ecosystems when compared to the existing impacts expected from existing river regulation and on-going regional agricultural activities.

To mitigate cumulative impacts associated with fauna passage, a survey will be undertaken of the existing privately owned weirs upstream and downstream of the proposed dam and a team of specialist ecologists in consultation with Queensland Fisheries will develop concept designs to improve fish passage at existing weirs. This team will engage with the weir owners and make the concept designs available and a demonstration fishway will be constructed at one of the existing weirs, with the owner's permission, as part of the Project.

11 Monitoring Requirements

The monitoring of aquatic ecosystems is recommended to:

- monitor the impacts of the proposed dam on downstream aquatic ecology
- monitor the impacts on threatened, near-threatened and iconic species
- monitor the efficacy of the fishway
- inform the continual improvement of the dam's operations, and
- trigger the requirement for remedial action should an impact be detected.

The monitoring program should be designed to detect changes to both the physical environment and to plant and animal communities of the waterways and focus on aquatic habitat and key species indicators.

The monitoring should include:

- a comparison of the condition of aquatic ecology in the Severn River upstream of, within and downstream of the proposed dam
- an assessment of impacts, if any, to key aquatic species and aquatic habitat (including a comparison of fish populations upstream, within and downstream of the dam)
- recommendations for monitoring and management of impacts, if any
- a statistically-robust, quantitative design in order to reliably describe background condition and detect impacts
- be approved by the administering authority before implementation, and
- be implemented by qualified aquatic biologists.

The monitoring program for key aquatic species should be designed and implemented by an appropriately qualified professional, and consider:

- completion of at least two baseline surveys before commissioning works, and at least two surveys after works begin (with the need for further surveys to be determined based on the results)
- survey of fauna using equipment appropriate to the conditions at each site

- the life-history stage (juvenile, intermediate, adult) of each species, along with the apparent health of individuals, and
- the richness, total abundance, abundance of key species, with statistical analyses where appropriate.

General Fisheries and Animal Ethics permits will be required to complete the monitoring.

12 Conclusions and Recommendations

Overall, aquatic ecological condition in the vicinity of the Project is moderate to poor. Aquatic habitat is similar upstream, within and downstream of the proposed dam. It is capable of supporting aquatic species, but has been affected by historical clearing of riparian vegetation and numerous weirs that restrict the passage of aquatic fauna. The percent cover of aquatic plants was generally low. No rare, threatened or vulnerable species under the EPBC Act or NCWR, or noxious weed or weeds of significance, were observed in the vicinity of the Project. Fish communities in the vicinity of the Project are poor, with low diversity, abundance and recruitment. Carp gudgeon were the most abundant and widespread species during all surveys in the area. Murray cod, which are protected under the EPBC Act are present in the area. Platypus are present upstream and downstream of the proposed dam, but are not abundant.

Aquatic flora and fauna in the proposed Project area may be affected by:

- the operation and maintenance of vehicles and other equipment during construction
- works including vegetation clearing, earthworks, quarrying and sand extraction during construction
- inundation and operation of the dam
- obstruction of flow and passage by the dam, and
- changes to the flow regime downstream of the dam.

Of the potential impacts, the inundation and operation of the dam, obstruction of flow and passage by the dam and changes to the downstream flow regime may have the greatest impact on aquatic ecology. Potential impacts of these, and other Project activities, can be minimised where mitigation measures are implemented.

Overall, the risk assessment indicates that there will only be a slight impact to aquatic habitat, aquatic plants, fish and platypus if mitigation measures are implemented. Impacts will be further mitigated where offset management measures to enhance fish passage and aquatic habitat are undertaken within the Project area. Monitoring is recommended during construction and operation to confirm the absence of direct impacts key species and assess overall impacts to aquatic ecology. Fauna salvage and relocation is also recommended where in-stream works will have a direct disturbance on aquatic flora and fauna.

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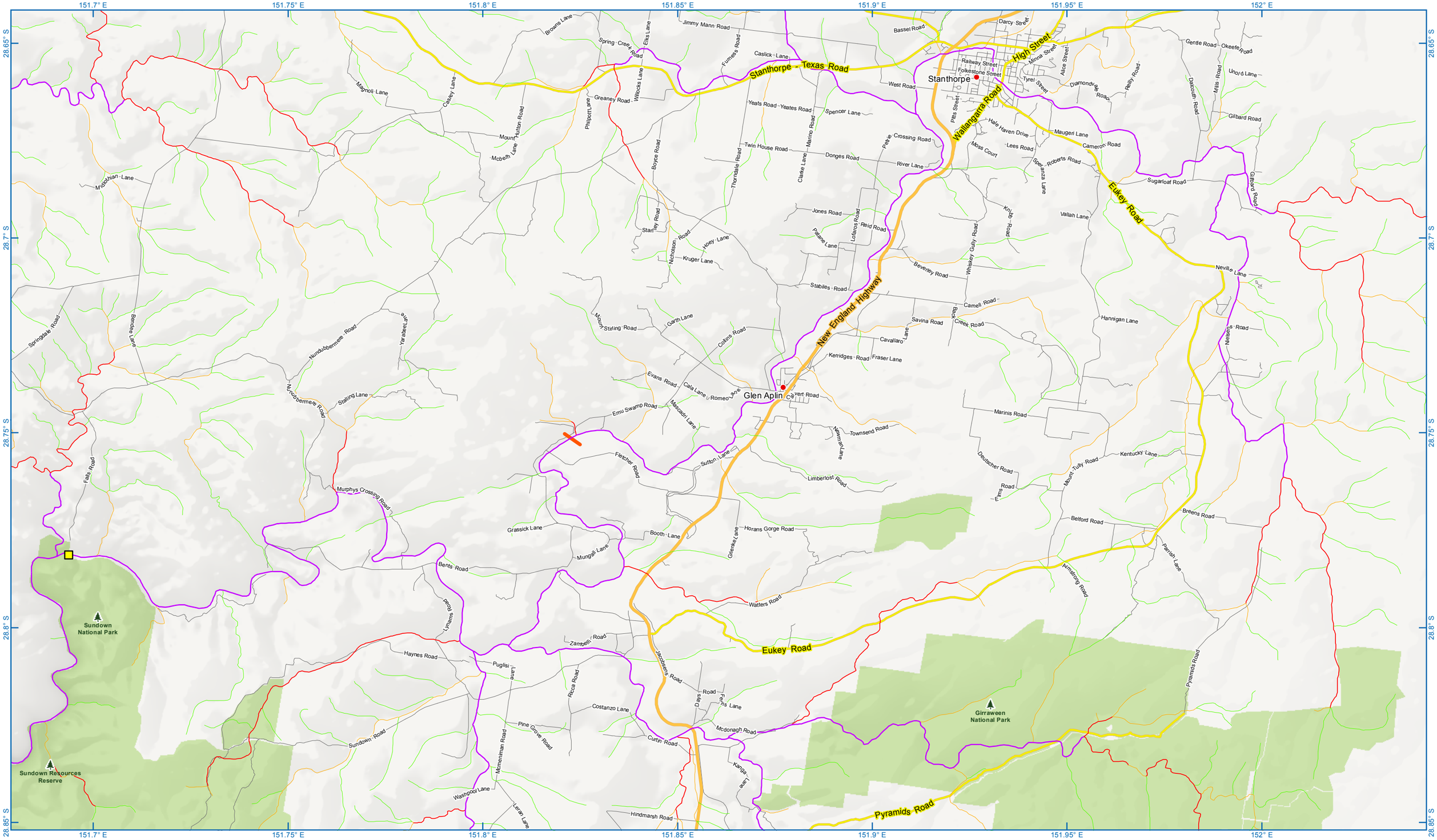
Appendix A Legislation Maps



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PO Box 2363
Wellington Point
Q 4160 Australia

P 07 3286 3850
E info@frcenv.com.au
www.frcenv.com.au

Emu Swamp Supplementary Environmental Impact Statement – Turtle Survey

Map 130402WB: Waterway barrier works

SOURCES

Document Path: Y:\Projects\2013\130402_SKM_Emu_Swamp_Turtles\Mapping\Workspaces\130402WB_waterway_barrier_13-09-20_CF.mxd

LEGEND

- Proposed Dam Site

Waterway Barrier Works

- 1 - Low
- 2 - Moderate
- 3 - High
- 4 - Major

Road Network

- Highway
- Main Road
- Local Road

Protected Area

- National Park
- Nundubbermere Falls

N

SCALE

0 1 2 4
Kilometres

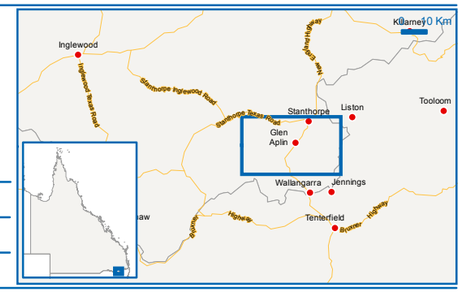
Scale: 1:100,000 @ A3

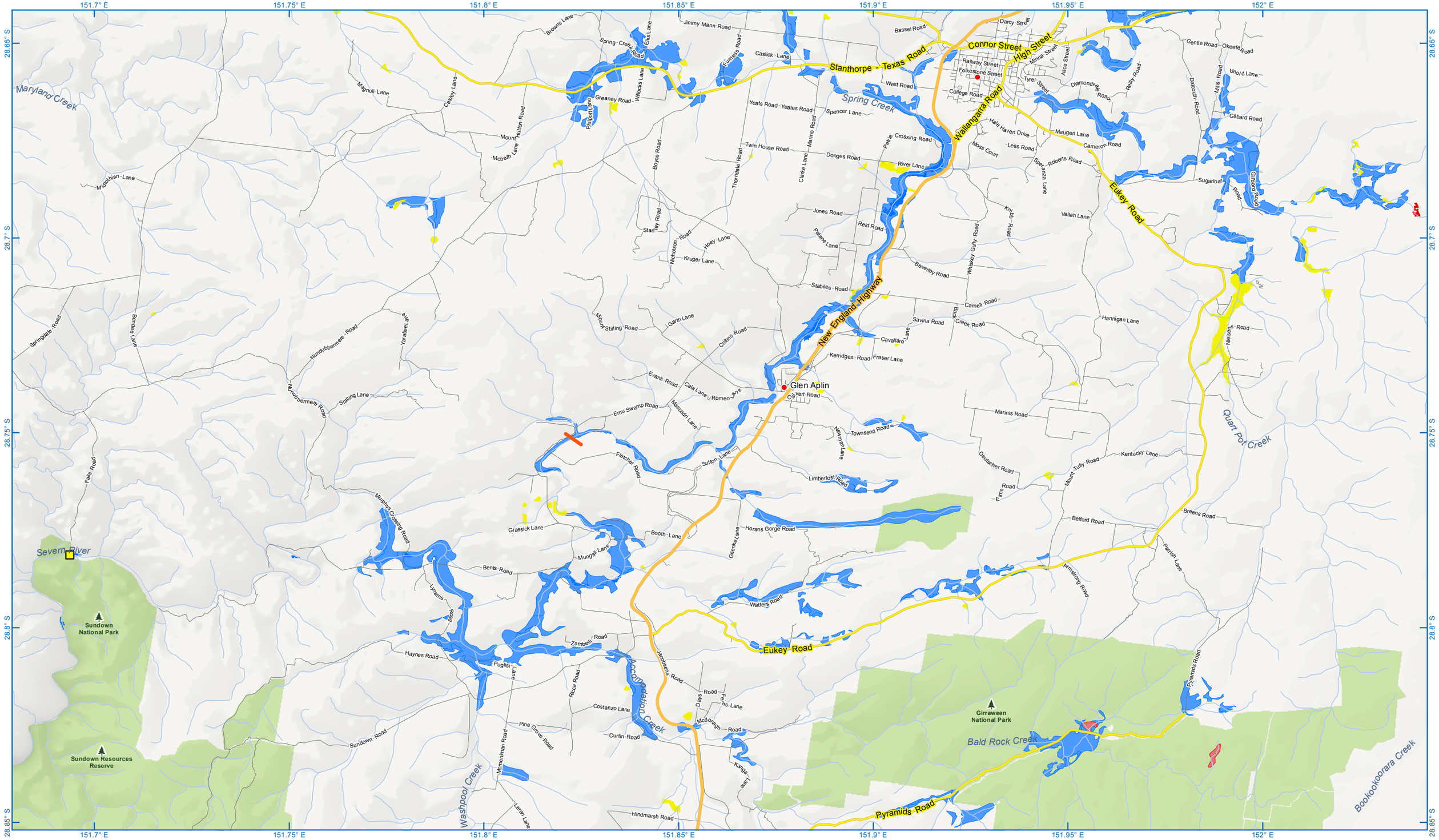
PROJECTION
Coordinate System: GCS GDA 1994
Datum: GDA 1994
Units: Degree

DATE
2013-09-20

DRAWN BY
CF

VERSION
01





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PO Box 2363
Wellington Point
Q 4160 Australia

P 07 3286 3850
E info@frcenv.com.au
www.frcenv.com.au

Emu Swamp Supplementary Environmental Impact Statement – Turtle Survey

Map 130402WL: Mapped wetlands

SOURCES

Document Path: Y:\Projects\2013\30402_SKM_Emu_Swamp_Turtles\Mapping\Workspaces\130402WL_wetlands_13-09-20_CF.mxd

LEGEND

- Proposed Dam Site
- Watercourse

Mapped Wetlands

- Riverine Waterbody
- Riverine RE
- Lacustrine Waterbody
- Palustrine Waterbody
- Palustrine RE

Road Network

- Highway
- Main Road
- Local Road

Protected Area

- National Park
- Nundubbermere Falls

N

SCALE

0 1 2 4
Kilometres

Scale: 1:100,000 @ A3

PROJECTION
Coordinate System: GCS GDA 1994
Datum: GDA 1994
Units: Degree

DATE
2013-09-20

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VERSION
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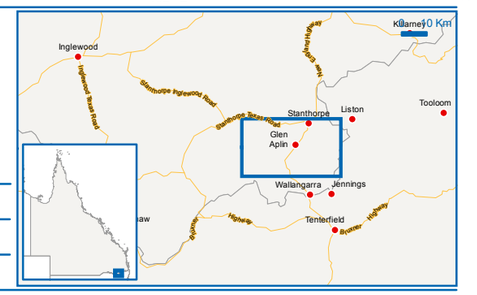

Appendix B Ecology of Fish Species Caught

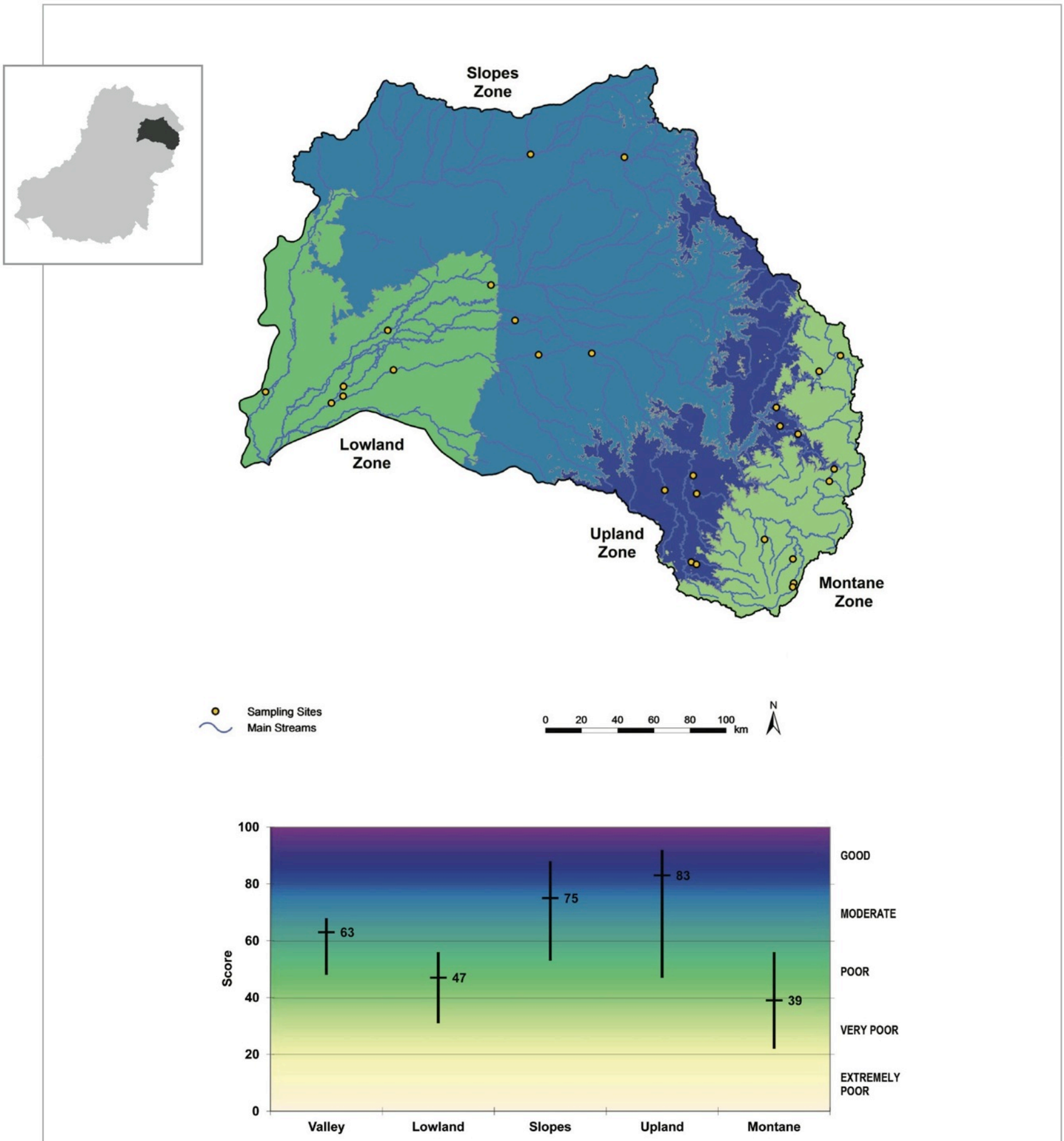

Figure BRD 2: Border Rivers Valley map with sampling sites and zones coloured by SRA Fish Index (SR–FI) scores.

Graph shows mean SR–FI scores as horizontal bars and 95% confidence limits as vertical bars.

Source: Davies et al. 2012

Appendix C Ecology of Fish Species Caught in 2013

Carp Gudgeon

Carp gudgeons (*Hypseleotris* spp.) include undescribed *Hypseleotris* species that readily hybridise (many in a hemiclonal fashion), together with the firetail gudgeon (*Hypseleotris galii*) and the western carp gudgeon (*Hypseleotris klunzingeri*). Firetail gudgeons are known to hybridise with the undescribed taxa and cannot be phylogenetically distinguished from them on the basis of genetic data. While the western carp gudgeon is a valid species, identification of this species requires a microscope, which is not practical in field surveys. The western carp gudgeon has a similar distribution and ecological role as the undescribed carp gudgeons, and so has been grouped with these taxa.

Carp gudgeons occur in many of Queensland's coastal drainages and have been recorded as far north as the Tully-Murray Swamps and as far south as the Hunter River, in central New South Wales (Pusey et al. 2004). Carp gudgeons are a benthic species typically found near aquatic vegetation and woody debris (Allen et al. 2002) in a variety of habitats including large waterbodies (e.g. rivers, lakes, dams and weirs), streams and associated floodplain habitats (Allen et al. 2002; Pusey et al. 2004). Carp gudgeons can generally tolerate a wide range of environmental conditions including:

- pH from 4.4 to 8.9
- electrical conductivity up to 4123 µS/cm, and
- water temperature up to 31.2 ºC (Pusey et al. 2004).

Freshwater Catfish

Freshwater catfish (*Tandanus tandanus*) is commonly found throughout the Murray-Darling Basin, except in cooler parts of southern tributaries (DPI 2008). It is rare in natural riverine habitats but can be found in farm dams throughout inland New South Wales and southern Queensland. Freshwater catfish prefer sluggish or still waters of rivers, creeks and billabongs. Spawning takes place from late spring until mid-summer following complex courtships, usually in nests up to 200 cm in diameter, built of pebbles or gravel. One of the parents guards the fertilised eggs and aerates the eggs by fanning them with its tail. Freshwater catfish are generally bottom feeders, and eat molluscs, crustaceans, insect larvae and small fishes. This species is susceptible to localised disturbances such as water pollution because of its small home ranges.

Yellowbelly

The golden perch (*Macquaria ambigua*) is commonly found throughout the Murray-Darling Basin, except at higher altitudes and above large barriers (e.g. dams). The Golden Perch is commonly found in riverine habitats; it prefers warm, slow-moving reaches; and it can be found in flooded lakes or impoundments. As a solitary species, it prefers cover, such as woody debris, and usually undergoes long upstream breeding migrations (Allen et al. 2002; Pusey et al. 2004).

Golden perch are tolerant of a wide range of environmental conditions, including a concentration of dissolved oxygen as low as 3 µg/L and water temperatures up to 35 ºC; it is typically found in turbid waters (Pusey et al. 2004). This species has a carnivorous diet of terrestrial and aquatic invertebrates, crustaceans and fish. Golden perch spawn in spring and summer and can move upstream, sometimes huge distances, to spawning sites in a similar way to silver perch (Pusey et al. 2004, Allen et al., 2002).

Goldfish

The goldfish (*Carassius auratus*) was introduced to Australia in the 1860s for the aquarium trade. This species can tolerate a wide range of temperatures and low oxygen, and it typically inhabits still or low-flowing waters. Native to eastern Asia, this species is now well established in the Murray-Darling Basin and is common throughout New South Wales and Victoria (Allen et al. 2002).

Mosquitofish / Eastern Gambusia

The mosquitofish (*Gambusia holbrooki*) is a widespread and abundant species whose numbers are in plague proportions in some areas of Australia. It is commonly found in all states of Australia including coastal drainages of New South Wales; however, it is native to north and central America and was introduced into Australia as a mosquito control measure that has proven to have minimal effect (Allen et al. 2002). They prefer warm, still waters and are typically found shoaling at the edges of streams and lakes (Allen et al. 2002). Mosquitofish have a large reproductive output and have broad environmental tolerances, which gives them a potential competitive advantage over native species (DPI 2000). Mosquitofish are declared noxious in Queensland under the Fisheries Act.

Appendix D Ecology of Murray Cod

Murray cod are found in a range of warm-water habitats in the waterways of the Murray Darling Basin (DEWHA June, 2003). This species can be found in a variety of habitats, including slow-flowing turbid waters as well as fast-moving and clear waters in upstream reaches (Allen et al. 2002). However, it prefers deeper-water habitats around in-stream habitat structures such as boulders, logs, undercut banks and overhanging vegetation (Allen et al. 2002). In-stream woody debris is particularly important to this species, with adults establishing home 'territories' around a particular snag (DEWHA June, 2003). Murray cod are predators that feed on a variety of prey items, including macrocrustaceans and other fish (including the introduced carp and goldfish) (DEWHA June, 2003). This species migrates up to 120 km upstream during spring and early summer to spawn during flood events when water temperatures exceed 15ºC ((Kearney & Kildea 2001; Hydrobiology 2010)), with adults then returning to their home territory (DEWHA June, 2003).

Spawning is not solely correlated with flow, it occurs under a range of flow conditions (Humphries 2005; Koehn & Harrington 2006; Koehn 2009). Larval numbers are at their highest in reduced flows after a high flow event, possibly due to washout from nests, and strong year classes are typically recorded in years following high flow events (Humphries 2005; Koehn & Harrington 2006). However, the spawning season also appears to be influenced by other environmental cues such as season, annual rhythms, temperature, day length or moon phases (Humphries 2005; Koehn & Harrington 2006).

Juvenile Murray cod are obligate and active drifters that can choose their location in the water column and are rarely caught outside their preferred habitat (Humphries 2005). Once outside of the nest, juvenile Murray cod drift downstream for 5-7 days, with their rate of growth and development linked to temperature (Humphries 2005).

Murray cod typically occur throughout the Murray-Darling Basin in all but the upper tributaries of river systems, (DEWHA June, 2003). There have been serious declines in numbers due to habitat loss and declines in water quality (Kearney & Kildea 2001).