CONTENTS

13. AQUATIC FAUNA 13-1

13.1. Description of environmental values 13-1

13.1.1. Legislative framework 13-1

13.1.2. Methodology 13-3

13.1.3. Dam and surrounds 13-6

13.1.4. Pipeline 13-33

13.1.5. Associated infrastructure 13-39

13.1.6. Estuarine and marine 13-39

13.2. Potential impacts and mitigation measures 13-42

13.2.1. Dam and surrounds 13-42

13.2.2. Pipeline 13-58

13.2.3. Associated infrastructure 13-59

13.2.4. Impact assessment and residual risks 13-60

13.3. Cumulative impacts 13-65

13.4. Summary 13-67

TABLES

Table 13-1 State and Commonwealth conservation status of conservationally significant species that may occur within and immediately downstream (within the Dawson River) of the Project area (DEWHA, 2008; Limpus *et al.*, 2007) 13-2

Table 13-2 State and Commonwealth conservation status of conservationally significant species that may occur downstream (Fitzroy River and Estuary / Marine environment) of the Project area (DEWHA, 2008; Limpus *et al.*, 2007) 13-2

Table 13-3 Sites surveyed for aquatic fauna during the 2007 / 2008 pre-wet and post-wet season surveys 13-4

Table 13-4 Number of taxa recorded by the DNRW at long term monitoring sites within the Dawson sub-catchment (adapted from data provided by DNRW, 2008) 13-14

Table 13-5 Number of taxa recorded within the dam and surrounds study area (adapted from data provided by Ecowise 2008a and 2008b) 13-14

Table 13-6 Most abundant taxa within the dam and surrounds study area 13-15

Table 13-7 Common freshwater macroinvertebrate taxa that show a preference for particular habitat types (as indicated by presence and / or high abundance) in the catchment 13-17

Table 13-8 Fish species recorded in the study area, Dawson sub-catchment, Mackenzie sub-catchment and Fitzroy sub-catchment13-19

Table 13-9 Presence of macrocrustaceans in the study area 13-22

Table 13-10 Total abundance of freshwater turtle species (pre-wet season EIS baseline survey) 13-25

Table 13-11 Total abundance of freshwater turtle species (targeted Fitzroy River turtle Survey – 2010) 13-25

Table 13-12 Total abundance of freshwater turtle species (targeted Fitzroy River turtle Survey – 2011) 13-25

Table 13-13 Fish recorded in the pipeline study area 13-37

Table 13-14 Catch and fishing data of the various fisheries in the Fitzroy River estuary area (commercial catch grids R29 and R30) in 2005 (DPI & F, 2007a) 13-40

Table 13-15 Risk assessment – construction 13-61

Table 13-16 Risk assessment – operation 13-63

FIGURES

Figure 13-1 Location of sites surveyed for aquatic fauna during the 2007/2008 baseline surveys (source: Ecowise, 2008) 13-5

Figure 13-2 Daily flow at Nathan Gorge during period of typical climatic conditions – full entitlement only (1930-1940) 13-7

Figure 13-3 The Fitzroy Basin, showing the location of dams and weirs 13-8

Figure 13-4 Percent coverage of large woody debris habitat (A), percent bank coverage of tree root habitat (B), percent bank coverage of overhanging vegetation (C) and substrate type coverage (D) recorded at each site 13-10

Figure 13-5 Glebe Weir at very low water levels, showing the channel bar plain on the Dawson River upstream of the weir (site 4); Cockatoo Creek to the left 13-11

Figure 13-6 Wetlands in the vicinity of the proposed Nathan Dam site 13-13

Figure 13-7 Macroinvertebrate taxonomic richness (A) and abundance (B) (mean ± SE) in the dam and surrounds study area during the pre- and post-wet season baseline surveys 13-16

Figure 13-8 Recorded presence of the Fitzroy River turtle (*Rheodytes leukops*) in the Fitzroy Basin (adapted from Limpus *et al.*, 2007; frc environmental 2009; DERM, 2011) 13-27

Figure 13-9 Recorded presence of the white throated snapping turtle (*Elseya albagula*) in the Fitzroy Basin (adapted from Limpus *et al.*, 2007; frc environmental 2009; DERM, 2011) 13-28

Figure 13-10 Mean taxonomic richness (± SE) (A) and mean abundance (± SE) (B) of macroinvertebrates in the four habitat types present at sites to be crossed by the pipeline 13-36

13. AQUATIC FAUNA

13.1. Description of environmental values

This section addresses Section 3.3.5 of the ToR and discusses the aquatic fauna (macroinvertebrates, fish, aquatic reptiles and aquatic mammals) present or likely to be present within the Project area at any time throughout the year.

13.1.1. Legislative framework

13.1.1.1. Environment Protection and Biodiversity Conservation Act 1999

Controlling provisions for the Project under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) relate to listed threatened species, and a number of marine-related provisions.

The Fitzroy River turtle (*Rheodytes leukops*) is listed as vulnerable under the EPBC Act. A deceased record is located downstream of Glebe Weir within the Project area. Live records and nests have been recorded in Theodore Weir, approximately 75 km downstream of the proposed dam site. It is considered likely that this species is present in the Project area (Section 13.1.3.4).

A number of species listed as threatened, migratory or marine species are also likely to occur downstream of the Project area (Table 13-1). Potential impacts to these species are discussed in Section 13.2.

Impacts to the GBRWHA and the Shoalwater and Corio Bays Area Ramsar site (which provide important habitat to a range of fauna species) are also regulated under the EPBC Act (Section 13.2.1.1).

13.1.1.2. Queensland Environmental Protection Act 1994

The environmental values of waterways in Queensland are protected under the Queensland *Environmental Protection Act 1994* (EP Act) and the subordinate *Environmental Protection (Water) Policy 2009* (EPP Water). The aquatic fauna of the study areas and downstream waters contribute to the environmental values (biological integrity and ecological interactions) of these waterways (Section 13.2.1.2).

13.1.1.3. Queensland Fisheries Act 1994

The primary objective of the Queensland *Fisheries Act 1994* (Fisheries Act) is to provide for the use, conservation and enhancement of the communities' fisheries resources and fish habitats. As it relates to the Project, environmental values protected under the Act are:

- fish habitats;
- fish movement and migration (i.e. regulation of waterway barriers); and
- commercial, recreational and indigenous fishing.

13.1.1.4. Queensland Nature Conservation Act 1992

The Fitzroy River turtle (*Rheodytes leukops*) is protected as 'vulnerable' under the Queensland *Nature Conservation Act 1992* (NC Act) - as listed under the *Nature Conservation (Wildlife) Regulation 2006* (NC Reg), subordinate legislation under the NC Act). The White throated snapping turtle *(Elseya albagula)* is listed as Least Concerned (LC) under the *NC Reg.* and has been recorded within the Project area.

A range of species listed as threatened under the NC Act are also likely to occur downstream of the Project area (Table 13-1 and Table 13-2).

Table 13-1 State and Commonwealth conservation status of conservationally significant species that may occur within and immediately downstream (within the Dawson River) of the Project area (DEWHA, 2008; Limpus *et al.*, 2007)

Species	Common Name	NC Act*	EPBC Act**
Chelidae			
Rheodytes leukops	Fitzroy River turtle	V	V
Elseya albagula	white throated snapping turtle	LC	-

Table 13-2 State and Commonwealth conservation status of conservationally significant species that may occur downstream (Fitzroy River and Estuary / Marine environment) of the Project area (DEWHA, 2008; Limpus *et al.*, 2007)

Species	Common Name	NC Act*	EPBC Act**
Balaenidae			
Balaenoptera acutorostrata	minke whale	LC	C
Balaenoptera edeni	Bryde's whale	LC	M, C
Balaenoptera musculus	blue whale	LC	E, M, C
Eubalaena australis	southern right whale	LC	E, M, C
Balaenopteridae			
Megaptera novaeangliae	humpback whale	V	V, M, C
Dermochelyidae			
Dermochelys coriacea	leatherback turtle	E	E, M, O
Chelidae			
Rheodytes leukops	Fitzroy River turtle	V	V
Elseya albagula	white throated snapping turtle	LC	-
Cheloniidae			
Chelonia mydas	green turtle	V	V, M, O
Caretta caretta	loggerhead turtle	E	E, M, O
Eretmochelys imbricata	hawksbill turtle	V	V, M, O
Lepidochelys olivaceae	olive Ridley turtle	E	E, M, O
Natator depressa	flatback turtle	V	V, M, O
Crocodylidae			
Crocodylus porosus	estuarine crocodile	V	M
Dugongidae			
Dugong dugon	dugong	V	M, O
Delphinidae			
Delphinus delphis	common dolphin	LC	C

Species	Common Name	NC Act*	EPBC Act**
Grampus friseus	Risso's dolphin	LC	C
Lagenorhynchus obscurus	dusky dolphin	LC	M, C
*Orcaella heinsohni****	Australian snubfin dolphin	NT	M, C
Orcinus orca	killer whale	LC	M, C
Stenella attenuata	spotted dolphin	LC	M, C
Sousa chinensis	Indo-Pacific	NT	M, C
	humpback dolphin		M, C
Tursiops aduncus	spotted (inshore) bottlenose dolphin	LC	M, C
Tursiops truncatus	bottlenose dolphin	LC	C
Muridae			
Xeromys myoides	water mouse	V	V

13.1.1.5. Queensland Water Act 2000

The Queensland *Water Act 2000* (Water Act) is the overarching piece of legislation under which the Water Resource (Fitzroy Basin) Plan 1999 is implemented. The Water Act specifies that all rights to the use, flow and control of water in Queensland are vested in the State.

13.1.1.6. Water Resource (Fitzroy Basin) Plan 1999

The *Water Resource (Fitzroy Basin) Plan 1999* (WRP) makes provision for 'environmental water requirements for natural ecosystems'. No specific reference to aquatic fauna is made, however, aquatic fauna play an integral role in maintaining the health and ecosystem function of aquatic ecosystems.

The WRP has a 10 year review cycle and a Draft WRP has been released for public comment. . Further information on the review process including objectives and timeline is provided in Chapter 14.

13.1.2. Methodology

In order to describe the environmental values related to aquatic fauna the following was undertaken:

- the regulatory instruments noted above were reviewed;
- the literature available on the area and the catchment was sourced and reviewed; and
- baseline surveys were conducted (for detailed description of the sampling program and methods adopted refer to Appendix 12-A).

Two baseline field surveys were conducted in the dam and surrounds study area to describe the aquatic fauna present in the freshwater habitats that may be affected by the Project (encompassing sites upstream of, within, and downstream of the proposed water storage area). These included a pre-wet season survey (26th November to the 3rd December 2007) (Appendix 12-A); a post-wet season survey (17^{th} to the 24^{th} June 2008) (Appendix 12-B). The location of all sites relative to the proposed water storage are listed in Table 13-2 and displayed in Figure 13-1.

Further targeted surveys for the Fitzroy River Turtle were undertaken in October 2008 (Ecowise), October 2010 (frc environmental), and Sept-October 2011 (Appendix 12-C, Appendix 13-B and Appendix 13-C).

Sampling methods to capture turtles included:

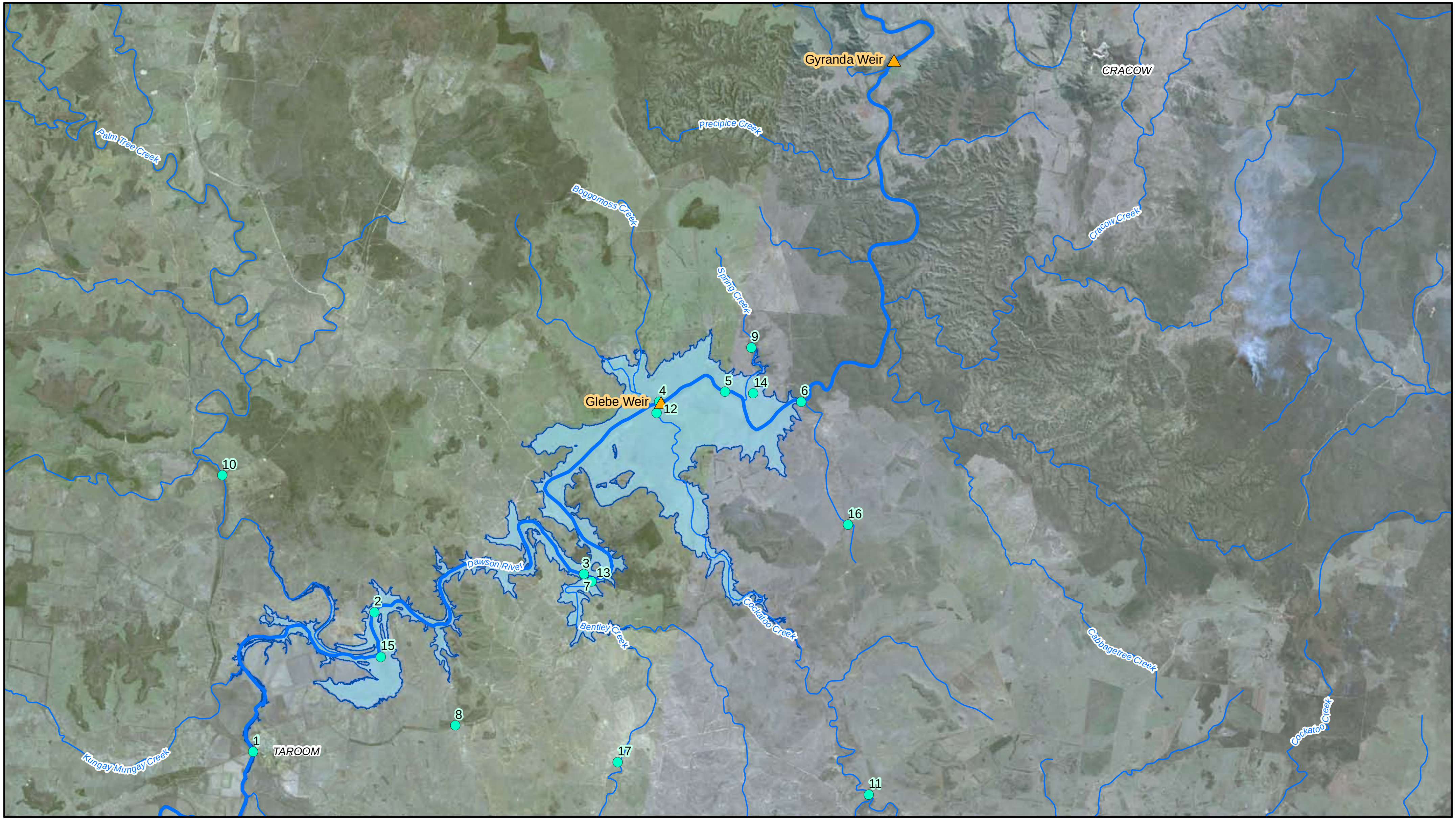
- Dip netting;
- Seine netting;
- Snorkel (conditions permitting);
- Spotlighting;
- Pole camera; and
- Muddling.

For the pipeline study area, one field survey (in the post-wet season, 27th to the 31st of October 2008) was undertaken to describe the aquatic fauna present in the freshwater habitats crossed by the pipeline route (Appendix 12-D).

Table 13-3 Sites surveyed for aquatic fauna during the 2007 / 2008 pre-wet and post-wet season surveys

Site	Channel Name	Location	Survey Completed	
			Pre-Wet	Post-Wet
1	Dawson River	Upstream of proposed water storage	×	✓
2	Dawson River	Within proposed water storage	✓	✓
3	Dawson River	Within proposed water storage	×	✓
4	Dawson River	Within current Glebe Weir pool	✓	✓
5	Dawson River	Within proposed water storage	×	✓
6	Dawson River	Downstream of proposed water storage	×	✓
7	Dawson River	Within current Gyranda Weir pool	×	✓
8	Blackboy Creek	Upstream of proposed water storage	✓	✓
9	Spring Creek	Upstream of proposed water storage	×	✓
10	Palm Tree Creek	Upstream of proposed water storage	×	×
11	Cockatoo Creek	Upstream of proposed water storage	✓	×
12	Cockatoo Creek	Within current Glebe Weir pool	✓	✓
13	Bentley Creek	Within current Glebe Weir pool	×	✓
18	Cockatoo Creek	Within proposed water storage	✓	×

Note: Sites 14 to 17 did not hold sufficient water to undertake water quality or aquatic fauna surveys.



LEGEND

- Aquatic Fauna Site Locations
- Weir
- Major Watercourse
- Watercourse
- Full Supply Level (183.5 m AHD)

Projection: GDA94 Zone 56

Figure 13-1

0 1.5 3 6
Kilometres

N

Scale 1:300,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Location of sites surveyed for aquatic fauna during the 2007/2008 baseline surveys (source: Ecowise, 2008)

13.1.3. Dam and surrounds

13.1.3.1. Aquatic habitat

- Distribution of waterbody types

The last State of the Rivers (SoR) report (Telfer, 1995) for the Dawson sub-catchment separates the Dawson River into three sections: Upper Dawson River; Regulated Dawson River; and Lower Dawson River. The water storage for the proposed Nathan Dam is situated within the lower section of the Upper Dawson River and the upper section of the Regulated Dawson River. Generally, the SoR report indicates that this length of the Dawson River is characterised by very low to low channel diversity with pool habitat representing 88% of sites surveyed with some riffle habitat (present at between 19% and 38% of sites surveyed).

Results from the 2007/2008 EIS baseline surveys support the SoR report findings indicating relatively low channel diversity throughout the Project area. Isolated pools were observed to be the dominant waterbody type (Appendix 12-A). At the time of the baseline surveys, most of the tributary sites were dry, or partially dry with only pool habitat available. Sites within the Glebe Weir water storage (site 4 on the Dawson River and site 12 on Cockatoo Creek) were also characterised by pool habitat with little variation in depth and few bends to provide habitat diversity. Run, glide and riffle habitat was rare throughout the study area, although each of these habitats were found at site 2 (Dawson River, upstream of the Glebe Weir water storage).

Like all river systems, flows within the Dawson River influence the types of aquatic habitats available to aquatic fauna. Discussed in Section 14.1.4.4, stream-flow records from gauge stations within and downstream of the dam, reflect that during typical climatic conditions, this section of the Dawson River is characterised by considerable climatic variability, comprising large flow pulses with periods of low flow between events (Figure 13-2). During times of peak flow all waterways within the Project area would be in flood. For short periods of time whilst water levels are subsiding, run and riffle habitats may occur at some of the sites surveyed (based on observations of substrate characteristics, Section 12.1.3.1).

As reflected in the SoR (1995) and baseline surveys, the construction of weirs on the Dawson River has altered aquatic habitat, increasing the amount of lacustrine (pool) habitat in the river. The weirs located on the Dawson River are (from upstream to downstream): Glebe Weir; Gyranda Weir; Orange Creek Weir; Theodore Weir; Moura Weir; and Neville Hewitt Weir (Figure 13-3).

Downstream of the confluence of the Dawson and Mackenzie rivers, the Eden Bann Weir on the Fitzroy River creates on-stream lacustrine habitat (EPA, 2008a). Similarly, the Fitzroy Barrage, near Rockhampton, prevents tidal inundation, and also creates lacustrine habitat for approximately 50 km upstream of the barrage.

Channel diversity is relatively low in the Fitzroy River downstream of the Dawson River, and is dominated by pools and runs. During the wet season, there are riffle habitats that connect the deeper pools, though these tend to dry up during the dry season (Limpus *et al.*, 2007). Similar to the Dawson River, there are off-stream palustrine and lacustrine wetlands (typically farm dams) on the floodplains of the Fitzroy River (EPA, 2008a).

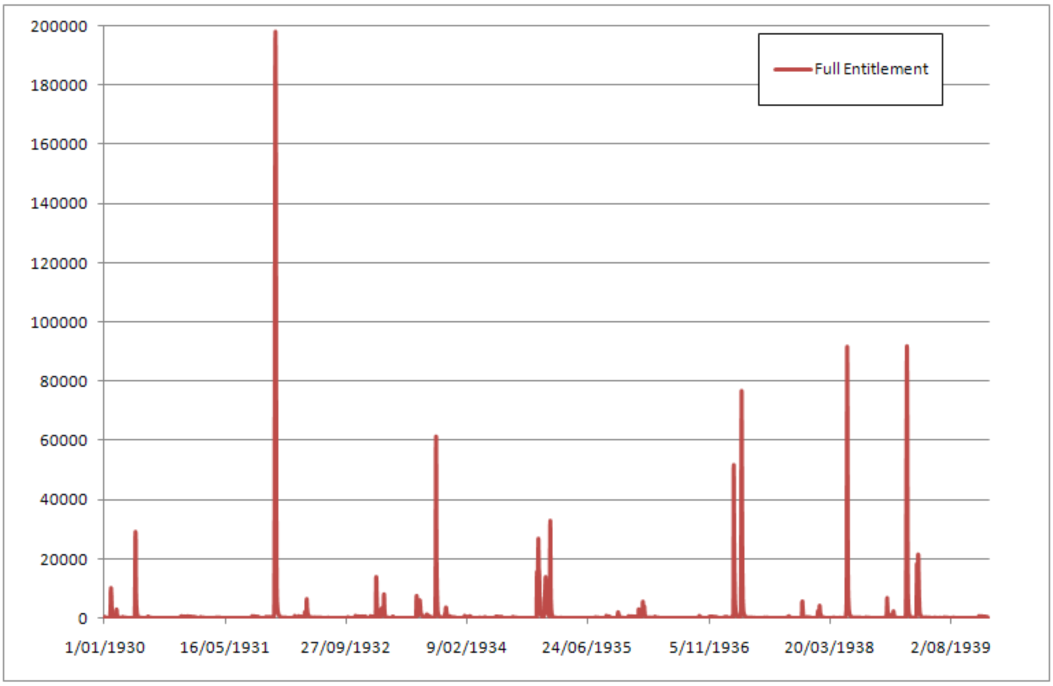


Figure 13-2 Daily flow at Nathan Gorge during period of typical climatic conditions – full entitlement only (1930-1940)

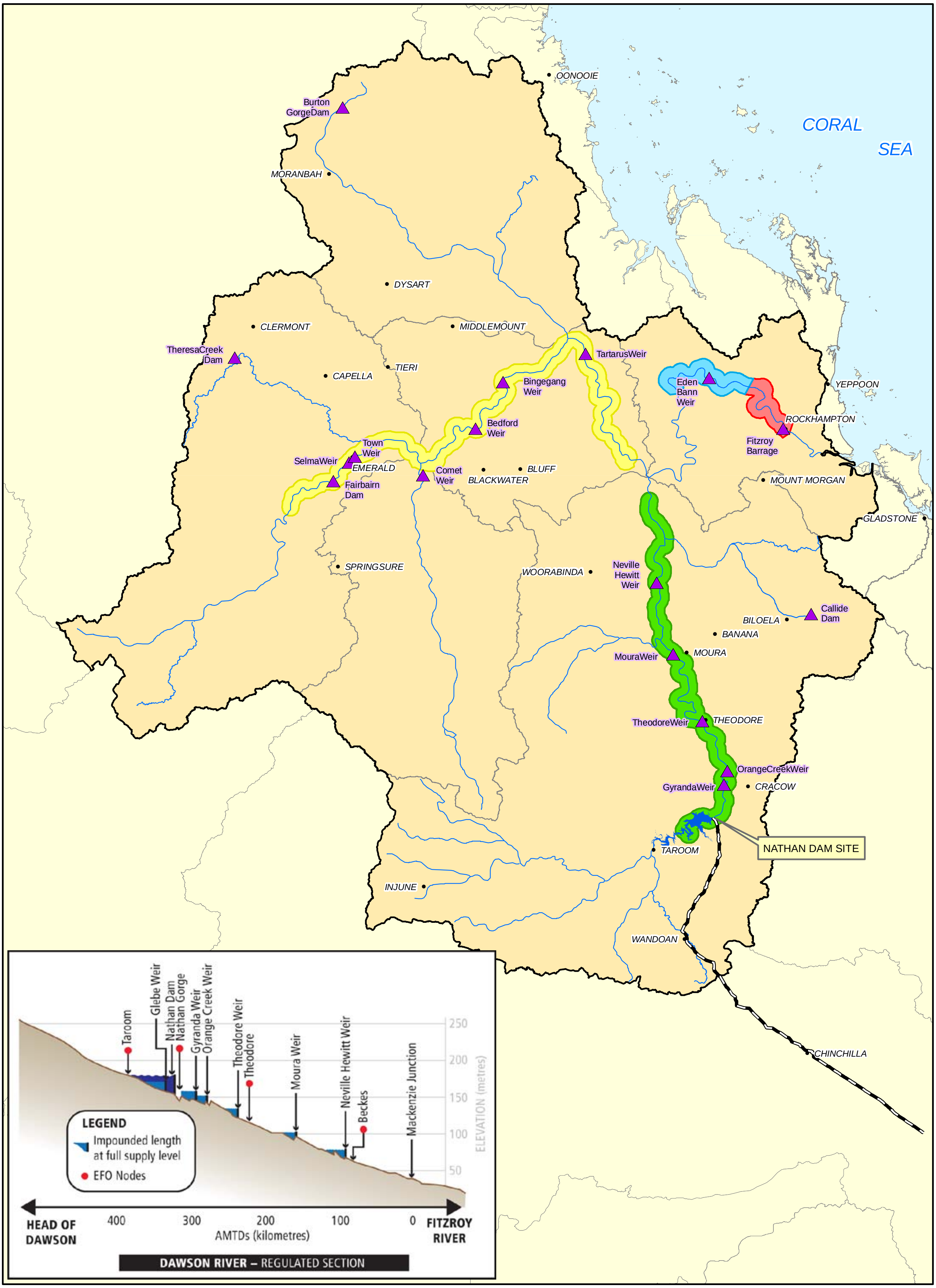
Note: The Full Entitlement scenario incorporates all water resource development within the catchment which existed at the time the model was developed, i.e. all dams, weirs, off stream storages, associated water infrastructure and all water entitlements. It assumes full utilisation of all existing water entitlements regardless of the actual degree of utilisation. This provides information on the committed entitlements and represents the approved level of water resource use in the catchment. The Full Entitlement model is the base case for the assessment of the impacts of approved levels of development against the WRP specified objectives.

- Presence of snag habitats

Large woody debris (LWD) provides important habitat to aquatic fauna. There was little LWD recorded throughout the study area, except in the Glebe Weir water storage (Sites 4 and 11) during the pre-wet season, where there were numerous inundated trees (Figure 13-4 (A)). There was no LWD recorded at this site during the post-wet season surveys, which is likely to be a result of increased water levels obscuring the visibility of the submerged trees. Many of the drowned trees within the upper water storage of Glebe Weir remain standing.

Tree root habitat coverage was low throughout the survey area (Figure 13-4 (B)). Coverage was generally similar at each site between the pre- and post-wet season.

Other habitat types along the edges of waterways in the study area included terrestrial debris, submerged tree roots; and some rock faces/boulders/cobbles. The Dawson River (Site 1), Blackboy Creek (Site 8), Spring Creek (Site 9) and Bentley Creek (Site 13) were the only sites that had overhanging banks.



LEGEND

- Localities
- Weir Locations
- Proposed Pipeline
- Major Watercourses
- Full Supply Level (185.3 m AHD)
- Fitzroy Basin

Supplemented Water Supply Scheme

- Nogoa Mackenzie
- Dawson Valley
- Lower Fitzroy
- Fitzroy Barrage

Projection: GDA94

Figure 13-3

0 20 40 80
Kilometres
N

Scale 1:3,000,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

The Fitzroy Basin, showing the location of dams and weirs

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- Presence of overhanging vegetation habitat

Results from the SoR for the Dawson sub-catchment indicate that in the 'upper Dawson' overhanging vegetation was present at 75% of banks surveyed, occupying 39.2% of total bank lengths. Overhanging vegetation was present at 91% of banks surveyed in the 'regulated Dawson' (Glebe Weir – Baralaba), but occupied only 19.1% of total bank length (SoR, 1995).

During the pre and post-wet season surveys, overhanging vegetation (within 1 m of the water's surface) coverage was generally less than 10% throughout the survey area (Figure 13-4 (C)). Higher levels of overhanging vegetation were, however, recorded at Site 1 (approximately 15%) and Site 5 (approximately 40%) during the post-wet season survey. The fact that no overhanging vegetation was recorded at Site 1 or Site 5 during pre-wet season surveys indicates seasonal variability in overhanging vegetation cover – likely explained by comparatively elevated water levels during the post-wet season surveys, resulting in a higher point on the bank being surveyed.

- Presence of sand and gravel bars

Bed and bar condition ratings from the SoR report ranged from unstable to very stable within the Project area. Field observations and aerial photograph interpretation undertaken as part of the Nathan Dam EIS (Chapter 14) similarly indicate that the bed and banks of the Dawson River from upstream of Taroom downstream into Nathan Gorge are generally stable. Nevertheless, there are minor areas of erosion and sedimentation as is expected in dynamic stream systems.

Bars were observed upstream and within the proposed water storage in the pre-wet season; however, several bars were absent in the post-wet season, having been either inundated or washed downstream. During the pre-wet season survey, braided channels, bars and mid-channel islands and bars were each relatively common features across the study area. Bar formation was almost always observed in association with obstructions such as the Glebe Weir, fallen logs, bridges or fords (Plate 13-1); or observed in association with high flow deposits.

- Sediment type

Sediment type varied across the study area (Figure 13-4 (D)). A high proportion of sand and silt was found at most sites, particularly downstream of the water storage (site 16), within current weir pools (sites 4 and 12) and within the proposed water storage on tributaries (sites 15 and 18).

Coarse sediment (cobbles, pebbles and gravel) was more prevalent at sites upstream of the proposed water storage (sites 8 and 11) and within the proposed water storage on the main channel (site 2) than at sites downstream of the proposed dam.

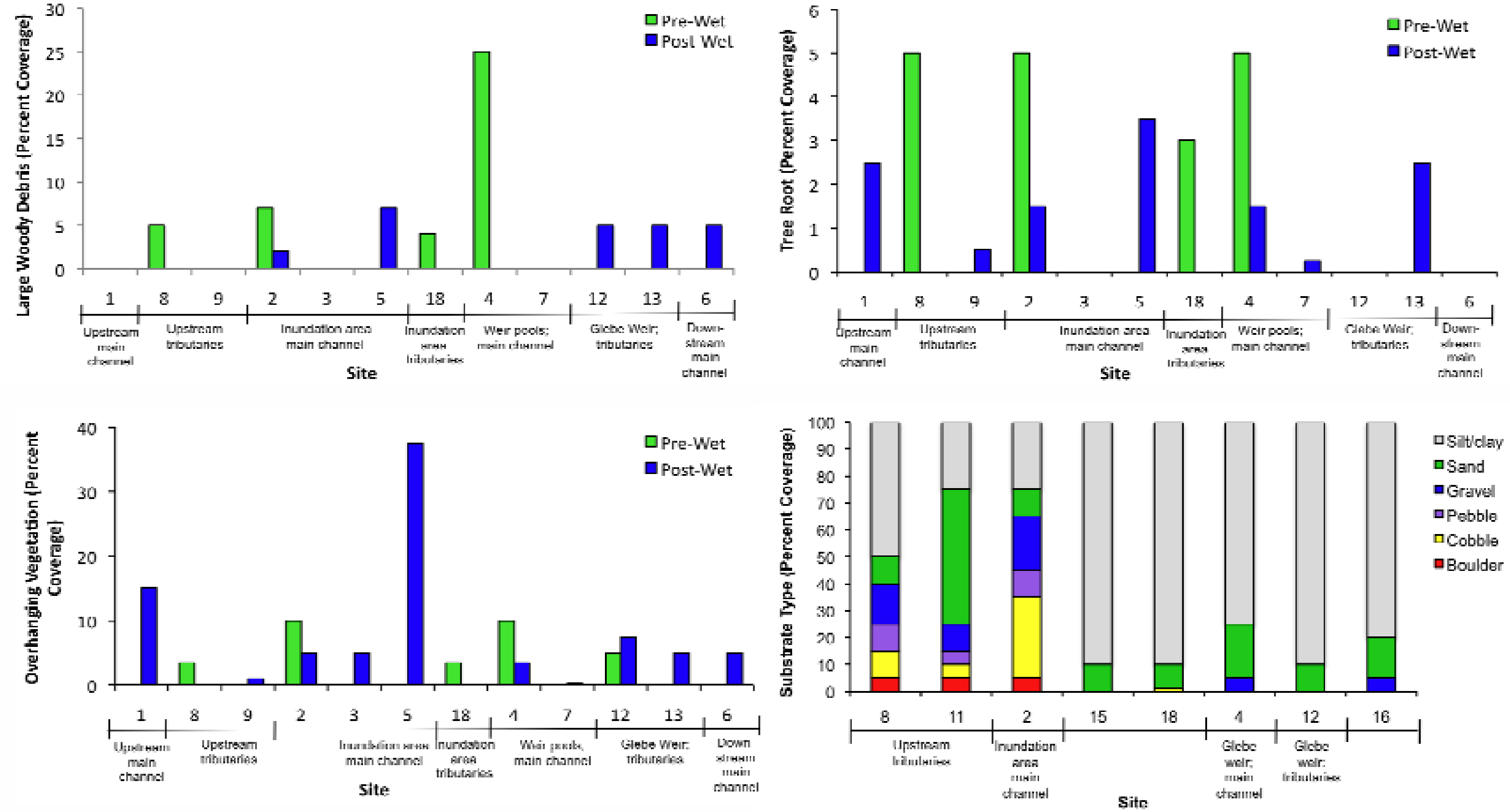


Figure 13-4 Percent coverage of large woody debris habitat (A), percent bank coverage of tree root habitat (B), percent bank coverage of overhanging vegetation (C) and substrate type coverage (D) recorded at each site

Figure 13-5 Glebe Weir at very low water levels, showing the channel bar plain on the Dawson River upstream of the weir (site 4); Cockatoo Creek to the left

River profile

Channel width varied across the sites surveyed, but on average channels were typically less than 30 m wide, except at sites within the current weir pools. The Dawson River at Site 4 and Cockatoo Creek at Site 12, both within the Glebe Weir impoundment, were up to six times the average channel width of the natural channel.

During the pre-wet season survey the water was typically less than 1 m deep across all the sites surveyed, except in the Dawson River in the Glebe and Gyranda weirs where it was approximately 10 m at the deepest point.

Average wetted width was typically less than 10 m in the tributaries, however, this was much higher in Cockatoo Creek in the Glebe weir pool. The average wetted widths were generally higher in the post-wet season survey than in the pre-wet season survey due to increased water levels.

Upper and lower bank heights and widths were generally consistent upstream of and within the proposed water storage.

Floodplain wetlands

A map of wetlands within Nathan Dam footprint and surrounds is presented in Figure 13-6. Existing wetlands within the Nathan Dam full supply level (FSL) water storage are artificial riverine wetlands (created by the construction of Glebe Weir) and palustrine wetlands (wetlands dominated by persistent emergent vegetation where water in the deepest part of the basin is less than 2 m deep); predominantly ‘tree swamps’ (Melaleuca/Eucalypt), although very small patches of ‘grass swamp’ also occur. Palustrine wetlands (both tree and grass swamps) and small artificial wetlands (farm dams) are also found abundantly outside of the water storage, along with several floodplain lakes.

Water quality overview

A full description of water quality within the Project area is provided in Chapter 16. Generally, water quality within the Project area is characterised by:

- temporally variable but spatially similar turbidity levels, in excess of the QWQG (2009) value of 25 NTU;
- high nutrient concentrations in excess of QWQG (2009) guideline values;
- electrical conductivity (EC) concentrations occasionally in excess of the QWQG (2009) value of 340 μS/cm;
- pH levels bordering on and slightly above the QWQG (2009) value of 7.5; and,
- temporally and spatially variable dissolved oxygen (DO) concentrations below the QWQG (2009) minimum value of 90% saturation, with the rare stratification and supersaturation event noted to occur in Glebe Weir.

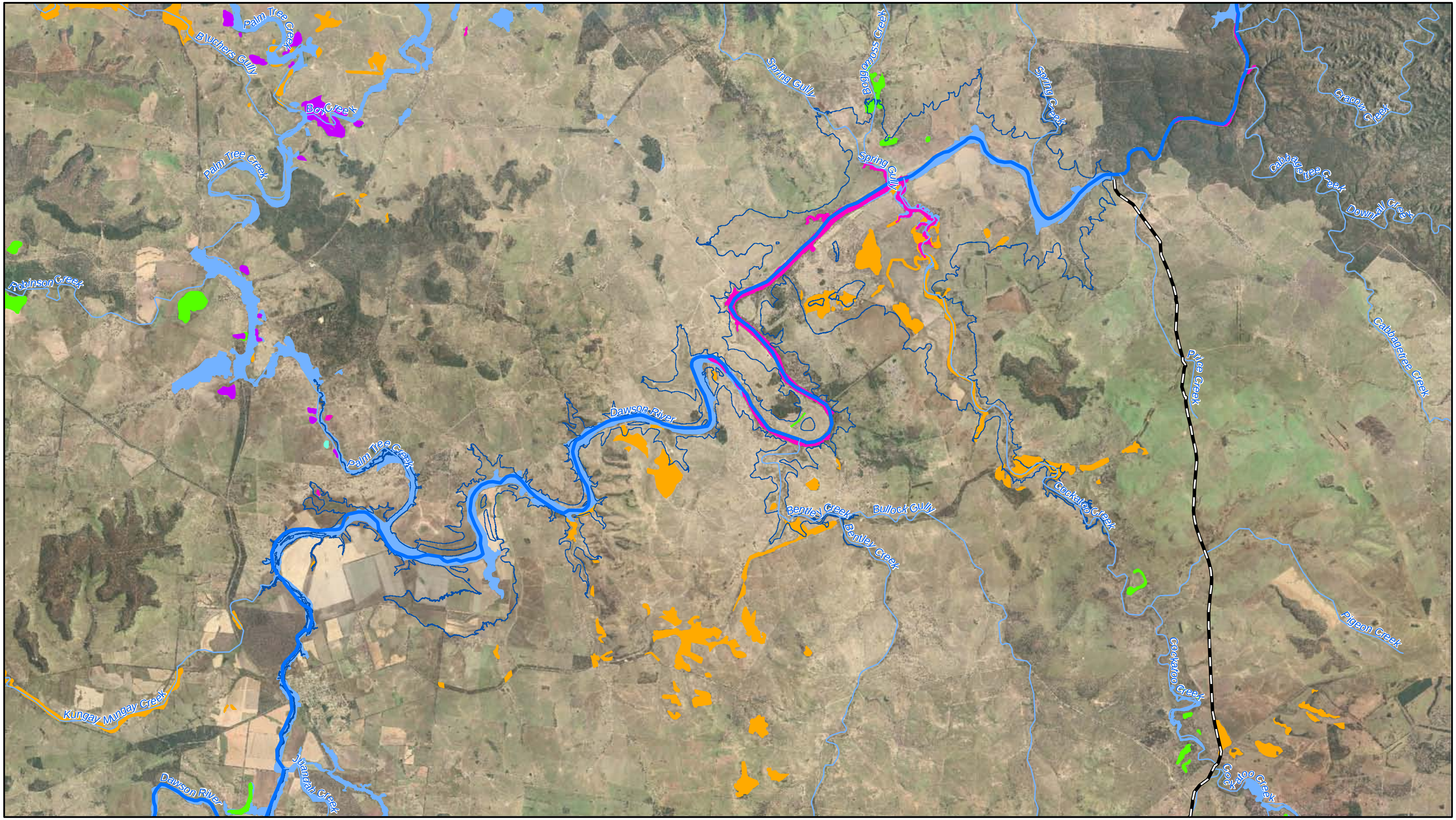
Water quality within the Project area is subject to seasonal variation of flow. Generally, increased flow is associated with decreases in EC, metal and nutrient concentrations and increased turbidity, pH and DO.

Aquatic flora overview

A full description of aquatic flora within the Project area is provided in Chapter 12. Of the 18 species of macrophytes recorded from the Project area, the majority (15) are categorised as ‘emergent’ macrophytes, with few (3) floating species and no submerged species. Generally, aquatic flora communities within the Project area are relatively depauperate compared to other areas of the Fitzroy Basin (Arthington *et al.,* 1992; Duivenvoorden, 1992), with only 2-5 species of macrophyte occurring at any site.

No introduced or exotic species inhabit the Project area. The only protected species known to inhabit the study area is *Myriophyllum artesium*, which has been recorded in Sandy Creek a tributary of Cockatoo Creek approximately 20 km upstream (east) of the water storage and 12 km from the pipeline corridor.

Phytoplankton species richness and abundance is generally low in the Fitzroy Basin (Negus, 2007). However, cyanobacteria (blue-green algae) blooms regularly occur, particularly in late winter to summer (Noble *et al.*, 1997). Since November 2001, no cyanobacteria blooms have been recorded in the Glebe, Theodore or Neville Hewitt Weirs, however low levels (< 20,000 cells/mL) have been occasionally recorded in Moura Weir.



LEGEND

- Major Watercourse
- Watercourse
- Full Supply Level (183.5m AHD)

Wetlands

- Coastal/Sub-coastal floodplain grass, sedge and herb swamps
- Coastal/Sub-coastal floodplain lakes
- Coastal/Sub-coastal floodplain tree swamps (Melaleuca/ Eucalypt)
- Coastal/Sub-coastal non-floodplain tree swamps (Melaleuca/Eucalypt)
- Coastal/Sub-coastal non-floodplain (spring) swamps
- Coastal/Sub-coastal non-floodplain soil lakes
- Artificial/Highly modified wetlands)
- Riverine

Projection: GDA94 Zone 56

Figure 13-6

0 1.5 3 6
Kilometres

N

Scale 1:200,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Wetlands in the vicinity of the proposed Nathan Dam site

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13.1.3.2. *Macroinvertebrates*

- Diversity, distribution and abundance

Sixty-six macroinvertebrate taxa have previously been recorded from the Dawson River at the Nathan Dam site, Glebe Weir tailwater, and Boolburra crossing by the Department of Natural Resources and Water (DNRW) (Table 13-3) (DNRW, 2008). A higher number of taxa (91) were sampled in the study area during baseline field surveys for this Project (Table 13-4). The number of taxa collected from bed and riffle habitat types was comparable between DNRW and baseline results. The number of taxa collected from edge habitat, however, was notably higher during the baseline surveys. Observed differences in the number of taxa collected during DNRW and baseline surveys, may be a result of increased sampling effort (in terms of the number of sites and habitats surveyed).

Table 13-4 Number of taxa recorded by the DNRW at long term monitoring sites within the Dawson sub-catchment (adapted from data provided by DNRW, 2008)

DNRW Site		Edge	Bed	Riffle	Total
Nathan Dam	(site #: 1303013)	46	n/a	31	57
Glebe Weir Tailwater	(site #: 130345A)	21	18	6	28
Boolburra Crossing	(site #: 1303005)	44	24	21	50
Total		57	33	37	66

Table 13-5 Number of taxa recorded within the dam and surrounds study area (adapted from data provided by Ecowise 2008a and 2008b)

Site	Edge	Bed	Riffle	Tree Root	Macrophyte	Total
Upstream main channel	25	n/a	n/a	n/a	n/a	25
Upstream tributaries	38	12	n/a	26	n/a	47
Water storage main channel	48	15	31	32	18	64
Water storage tributaries	23	9	n/a	16	n/a	27
Weir pools; main channel	29	11	n/a	16	12	39
Glebe Weir; tributaries	39	3	n/a	17	26	52
Downstream main channel	29	n/a	n/a	21	n/a	33
Total	74	32	31	53	42	91

n/a – habitat type not present

Across the DNRW sites, 50% of macroinvertebrate abundance was accounted for by 11 taxa, dominated by non-biting midge larvae (Chironominae and Orthocladiinae), mayfly larvae (Caenidae), and caddisfly larvae (Leptoceridae). Conversely within the study area, 50% of the abundance was accounted for by only three taxa. Similar to the DNRW sites, non-biting midge larvae (Chironominae) was the most abundant taxa in the study area, however, water fleas (Cladocera) and biting midge larvae (Ceratopogonidae) were also abundant (Table 13-5).

Table 13-6 Most abundant taxa within the dam and surrounds study area

Order/Class	Taxa	Total Number	Total Abundance (%)	Cumulative Abundance (%)
Diptera	Chironominae	6775	22.3	22.3
Cladocera	unidentified	5540	18.2	40.5
Diptera	Ceratopogonidae	4528	14.9	55.4
Copepoda	unidentified	2510	8.3	63.7
Diptera	Simulidae	1631	5.4	69.0
Ephemeroptera	Caenidae	1530	5.0	74.1
Diptera	Orthocladiinae	1398	4.6	78.7

Analysis used to interpret macroinvertebrate data are described in Appendix 12-A. Within the study area, macroinvertebrate community composition supported by riffle habitat was found to be different to those communities inhabiting other habitat types Community composition in bed, edge, tree root and macrophyte habitats were similar to each other.

Within the study area, average taxonomic richness and abundance generally increased between the pre- and post-wet season in all habitats (Figure 13-8). Taxonomic richness and abundance was generally similar throughout the study areas. Generally, richness and abundance of macroinvertebrates was higher and more variable in habitats that had greater complexity (e.g. edges, tree roots, riffles and macrophyte habitat). Overall, mean taxonomic richness was lowest in bed habitats, and in particular at sites that had deeper pools.

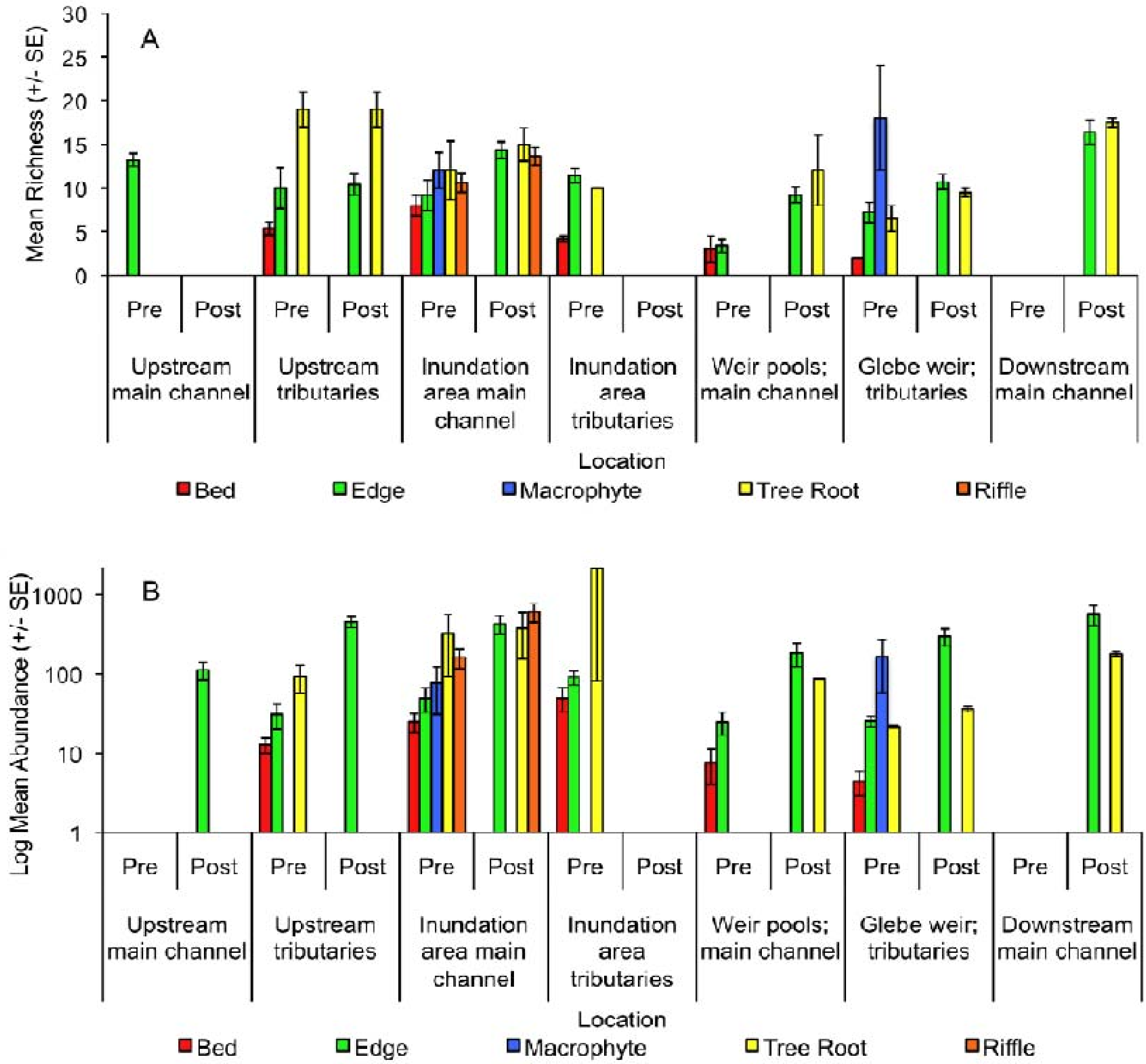


Figure 13-7 Macroinvertebrate taxonomic richness (A) and abundance (B) (mean ± SE) in the dam and surrounds study area during the pre- and post-wet season baseline surveys

- **Listed threatened or migratory species or otherwise significant species or populations**

No macroinvertebrate taxa listed as threatened or migratory, or otherwise significant species or populations, have been recorded from, or are likely to occur in, the study area or downstream.

- **Commercial and recreational fisheries species**

Freshwater fisheries target macroinvertebrates such as mussels, yabbies and prawns. Fisheries are discussed in detail in Section 13.2.3.3.

Introduced and exotic Species

No introduced or exotic macroinvertebrate taxa have been recorded from the study area or downstream.

Habitat requirements, life history characteristics and sensitivity to change

Freshwater macroinvertebrate species have differing habitat requirements and tolerances to environmental change. Macroinvertebrate communities are commonly distributed along a gradient of nutrients, metals, hydrocarbons and other contaminants. Elevated levels of these of these contaminants can alter macroinvertebrate community structure by reducing the abundance of sensitive taxa, reducing community diversity and species richness, and shifting trophic group structure (Pearson and Rosenberg, 1978; Rossi, 2003).

The freshwater macroinvertebrates recorded within the catchment and study area generally have opportunistic life histories and a relatively wide tolerance of environmental conditions and change (Table 13-6). Within the study area, most taxa were recorded from more than one habitat type, although the abundance of some taxa differed consistently between habitats, indicating a preference for particular habitat types.

Table 13-7 Common freshwater macroinvertebrate taxa that show a preference for particular habitat types (as indicated by presence and / or high abundance) in the catchment

Order/Class	Taxa	Presence	Preference
Cladocera	-	all habitats except riffle	tree root
Coleoptera	Dytiscidae	all habitats except riffle	edge and tree root
Coleoptera	Hydrophillidae	all habitats except riffle	edge
Copepoda	-	all habitats	edge
Diptera	Ceratopogonidae	all habitats	edge and riffle
Diptera	Chironominae	all habitats	edge and riffle
Diptera	Orthocladiinae	all habitats	edge and riffle
Diptera	Simulidae	all habitats except bed	riffle
Ephemeroptera	Caenidae	all habitats	riffle
Gastropoda	Hydrobiidae	edge and tree root	edge
Gastropoda	Physidae	edge, macrophyte and tree root	macrophyte
Hemiptera	Corixidae	all habitats except riffle	macrophyte
Hemiptera	Mesovellidae	edge, macrophyte and tree root	macrophyte
Hemiptera	Notonectidae	all habitats except riffle	tree root
Hemiptera	Veliidae	edge, macrophyte and tree root	tree root
Ostracoda	-	all habitats except bed	edge
Trichoptera	Hydropyschidae	bed and riffle	riffle
Trichoptera	Leptoceridae	all habitats	edge

13.1.3.3. Fish and fisheries

Diversity, distribution and abundance

A total of 36 species of fish from 20 families have been recorded in the freshwater reaches of the Fitzroy Basin (Table 13-7). Many of the fish found in the Fitzroy Basin are native to intermittent and ephemeral systems of central and western Queensland, and move up and downstream, and between different habitats at particular stages of their lifecycle (Cotterell and Jackson, 1998; Marsden and Power, 2007, Appendix 13-A). Most of the species present in the basin are potadromous (complete entire life cycle in freshwater), with only six amphidromous species (move freely between freshwater and saltwater during their life cycle) and four catadromous species (live in freshwater and migrate to saltwater to spawn) (Marsden and Power, 2007).

Within the study area, 19 species from 11 families (total of 750 individual fish) were caught during the pre- and post-wet season baseline surveys, with the greatest number of fish species recorded within the proposed water storage during the post-wet season survey (Table 13-7). All of the species found in the present study area are potadromous, however, environmental conditions in Australian rivers are extremely variable, and fish may need to move up and downstream to avoid deteriorating water quality and the drying of reaches (Kennard, 1997; Freshwater Fisheries Advisory, 1996).

A number of species previously recorded from the Fitzroy Basin were not caught during this study; four species (bullrout (*Notesthes robusta*), swamp eel (*Ophisternon sp*.), speckled goby (*Redigobius bikolanus*) and striped or sea mullet (*Mugil cephalus*)) are not expected to occur in the study area as they are typically found in the lowland reaches of river basins and/or estuaries (Pusey *et al.*, 2004). The distribution of migratory species in the upper reaches of the Dawson sub-catchment has been reduced due to the construction of impoundments on the lower Dawson River (Pusey *et al.*, 2004, Marsden and Power, 2007). Therefore, species which are known to move or migrate (including between estuarine and freshwater systems) such as barramundi (*Lates calcarifer*); oxeye herring (*Megalops cyprinoides*); long-finned eel (*Anguilla reinhardtii*); longtom (*Strongylura kreftii*); snub-nosed garfish (*Arramphus sclerolepis*); and Pacific blue eye (*Pseudomugil signifer*) may be restricted from the study area due to the weirs present along the Dawson River, a number of which are not fitted with fishways. Banded grunter (*Amniataba percoides*) and sooty grunter (*Hephaestus fuliginosus*) are introduced to the Fitzroy Basin, and their absence in the study area indicates that they may have not been stocked there.

Within the study area, the most dominant families were gudgeons (Eleotridae, (at least) five species), eel-tailed catfishes (Plotosidae, three species), and grunters (Terapontidae, two species). The most abundant species was bony bream (*Nematalosa erebi*) accounting for 54% of the total catch. Spangled perch (*Leiopotherapon unicolor)* was the second most abundant species accounting for 14% of the total catch.

A greater number of species were caught in the study area during the post-wet season (19 species) than during the pre-wet season survey (10 species) (Table 13-7). Many of the species caught during the post-wet season were also likely to be present during the pre-wet season, however, differences in the types of species caught may be related to lower sampling effort (both number of sites sampled and fishing effort) during the pre-wet season survey.

Table 13-8 Fish species recorded in the study area, Dawson sub-catchment, Mackenzie sub-catchment and Fitzroy sub-catchment

Family	Common Name	Upstream		Storage Area		Glebe Weir		Downstream		Gyranda Weir		Presence in River System		
species		**pre**	**post**	**pre**	**post**	**pre**	**post**	**pre**	**post**	**pre**	**post**	**Dawson**	**Mackenzie**	**Fitzroy**
Ambassidae														
Ambassis agassizii	Agassiz's glassfish		✓								✓	✓	✓	✓
Anguillidae														
Anguilla reinhardtii	long-finned eel											✓	✓	✓
Antherinidae														
Craterocephalus stercusmuscarum	fly-specked hardyhead										✓	✓	✓	✓
Apogonidae														
Glossamia apron	mouth almighty											✓	✓	✓
Ariidae														
Arius graeffei	fork-tailed catfish											✓	✓	✓
Belonidae														
Strongylura kreftii	longtom											✓	✓	✓
Centropomidae														
Lates calcarifer	barramundi												✓	✓
Clupeidae														
Nematolosa erebi	bony bream		✓		✓	✓	✓	✓			✓	✓	✓	✓
Cyprinidae														
*Carassius auratus**	goldfish				✓		✓				✓	✓		✓
Eleotridae														
Hypseleotris compressa	empire gudgeon											✓	✓	✓
Hypseleotris klunzingeri	western carp gudegon		✓		✓	✓						✓	✓	✓
Hypseleotris sp. 1	Midgley's gudgeon			✓	✓							✓	✓	✓
Hypseleotris spp.	carp gudgeons		✓		✓		✓		✓					
Mogurnda adspersa	purple spotted gudgeon		✓									✓	✓	✓
Oxyeleotris lineolata	sleepy cod					✓	✓	✓			✓	✓	✓	✓

Family *species*	Common Name	Upstream		Storage Area		Glebe Weir		Downstream		Gyranda Weir		Presence in River System		
		pre	post	pre	post	pre	post	pre	post	pre	post	Dawson	Mackenzie	Fitzroy
Philypnodon grandiceps	flathead gudgeon				✓							✓		✓
Gobiidae														
Redigobius bikolanus	speckled goby													✓
Hemirhamphidae														
Arramphus sclerolepsis	snub-nosed garfish												✓	✓
Megalopidae														
Megalops cyprinoides	oxeye herring													√
Melanotaeniidae														
Melanotaenia s splendida	eastern rainbow fish		✓		✓	✓	✓				✓	✓	✓	✓
Mugilidae														
Mugil cephalus	stripped mullet													✓
Osteoglossidae														
Scheropages leichardti	southern saratoga				✓		✓				✓	✓	✓	✓
Percichthyidae														
Macquria ambigua oriens	goldern perch		✓		✓		✓				✓	✓	✓	✓
Plotosidae														
Neosilurus ater	black catfish													✓
Neosilurus hyrtlii	Hyrtl's tandan		✓	✓	✓	✓	✓					✓	✓	✓
Porochilus rendahli	Rendahl's catfish				✓	✓						✓		✓
Tandanus tandanus	eel-tailed catfish				✓	✓						✓	✓	✓
Poecillidae														
*Gambusia holbrooki**	mosquitofish			✓	✓		✓				✓	✓	✓	✓
*Poecilia reticulata**	guppy												✓	✓
Pseudomugilidae														
Pseudomugil signifer	pacifi blue eye											✓		✓
Scorpaenidae														
Notesthes robusta	bullrout													✓

Family *species*	Common Name	Upstream		Storage Area		Glebe Weir		Downstream		Gyranda Weir		Presence in River System		
		pre	post	pre	post	pre	post	pre	post	pre	post	Dawson	Mackenzie	Fitzroy
Synbranchidae														
Ophisternon sp.	swamp eel												✓	✓
Terapontidae														
Amniataba percoides	banded grunter											✓	✓	✓
Bidyanus bidyanus	silver perch**													✓
Hephaestus fuliginosus	sooty grunter**												✓	✓
Leiopotherapon unicolor	spangled perch	✓	✓		✓		✓				✓	✓	✓	✓
Scortum hillii	leathery grunter		✓		✓		✓					✓	✓	✓
Total		**1**	**10**	**4**	**16**	**6**	**11**		**1**		**10**	**25**	**26**	**36**

1 Berguis and Long, 1999; Marsden *et al.* 2005; this study

2 Berguis and Long, 1999; Marsden and Power 2007; frc environmental, 2008

3 Berguis and Long, 1999; Puesy *et al.*, 2004; Marsden and Power, 2007

* Exotic

** Introduced species

Macrocrustaceans

Three macrocrustacean taxa were captured during surveys (Table 13-8). *Macrobrachium australiense*, the common Australian river prawn, was captured throughout survey areas and, despite not being captured in upstream sites during the pre-wet season survey, are likely to occur at these sites. Freshwater shrimps (likely *Caridina sp*. and *Paratya australiensis*) and yabbies (likely *Cherax depressus*, the orange-fingered yabby) were captured throughout the study area.

Table 13-9 Presence of macrocrustaceans in the study area

Family	Common Name	Upstream		Storage Area		Glebe Weir		Downstream		Gyranda Weir	
Species		**pre**	**post**	**pre**	**post**	**pre**	**post**	**pre**	**post**	**pre**	**post**
Atyidae											
Paratya australiensis	freshwater shrimp	✓	✓	✓	✓	✓					
Caradina sp.	freshwater shrimp										
Palaemonidae											
Macrobrachium australiense	Macrobrachium		✓	✓	✓	✓	✓		✓		✓
Parastacidae											
Cherax depressus	orange fingered yabby	✓	✓	✓		✓					

1 During the post-wet season survey, atyid shrimps were not recorded during fishing; this data represents macroinvertebrate samples, which were only identified to family level.

Listed threatened or migratory species, and otherwise significant species

Scheropages leichardti (southern saratoga), *Scortum hillii* (leathery grunter) and the subspecies of golden perch (*Macquaria ambigua oriens*) were found within and upstream of the existing weir pools on the main Dawson River channel. These species are endemic to the Fitzroy Basin (Pusey *et al.*, 2004; Marsden and Power, 2007), however, they are not listed as rare or threatened under Commonwealth or State legislation.

Recreational fisheries

Few studies have described the extent of recreational fishing within the region. Recreational fishers are likely to target a number of species, although fishing activity would be largely restricted to deeper water habitats such as the Glebe Weir impoundment (Long, 1992). The waters of Gyranda Weir are closed to fishing and much of the Dawson River within the Project area is bound by private property.

Commercial fisheries

A commercial fishery for juvenile and adult marbled eels (*Anguilla reinhardtii*) operates in the Fitzroy basin (DPI&F, 2008). Juvenile eels may be collected at, or downstream of, the Eden Bann Weir and up to 200 m either side of the mouth of the Fitzroy River. They may also be collected in tributaries downstream of the Eden Bann Weir for a distance of 1 km upstream of the confluence. Juvenile eels are then grown out in aquaculture facilities. Adult eels may be collected from impoundments (private and public). In 2007, fewer than five boats operated in the Fitzroy basin and due to privacy provisions, no specific information relating to the fishery in the Fitzroy basin is available. In 2007, the commercial eel fishery in Queensland was worth approximately $220,000 for adult eels. No value estimates were available for juvenile eels; however, in 2007 approximately 2,166,770 juvenile eels were harvested in Queensland. As of August 2008, there were 31 licences for adult eels and 13 licences for juvenile eels in Queensland.

Fish stocking programs

The Queensland DPI&F has undertaken a number of stocking programs over recent years in the dams and rivers within the Fitzroy Basin under the Queensland Government Freshwater Recreational Enhancement Program between 1987-1992 (Long, 1992) and later between 2003 and 2007 (data courtesy of DPI&F 2008). Stocking efforts were limited to native fish species targeted by recreational fishers (including barramundi, golden perch, silver perch, saratoga and sleepy cod), and typically limited to water storages (dams and weirs) within the region (Long, 1992; Anderson and Howland, 1997).

No fish have been stocked into the Dawson River near Taroom in recent years, although 27,500, 50,000 and 2,500 golden perch fingerlings were stocked into the Glebe Weir impoundment in the 2005/06, 2004/05, and 2003/04 financial years, respectively (data courtesy of DPI&F, 2008).

Introduced and exotic species

Two exotic species, mosquitofish (*Gambusia holbrooki*) and goldfish, (*Carassius auratus*) were recorded in the study area. In particular, these species were found at sites in the main river channel within the proposed water storage, and in the existing Glebe and Gyranda weir pools. Mosquitofish are a declared noxious species under the Fisheries Regulation (2008). While silver perch and sooty grunter have been translocated to the Fitzroy Basin; nether species have been recorded in the study area.

Habitat requirements, life history characteristics and sensitivity to change

The habitat preferences, diet and migrations of each of the fish species known in the region (including the timing of critical movements of these fishes) are described in detail in Appendix 13-A. In-stream habitat, such as woody debris provides critical structural complexity for the native fish species found in the study area, providing shelter from predators and areas for reproduction. Woody debris and a range of substrate types also support diverse macroinvertebrate communities, which are prey for many of the fish found in the study area.

Most species captured in the study area can tolerate a large range of water quality conditions and are unlikely to be affected by substantial changes in water quality. For example, spangled perch, golden perch, carp gudgeons, eastern rainbowfish and eel-tailed catfish can tolerate environmental conditions characterised by low dissolved oxygen levels, high conductivity and relatively high turbidity. In contrast, species such as bony bream, sleepy cod, glassfish, leathery grunter and fly-specked hardyhead, which have narrower water quality tolerances, may be affected by large fluctuations in the water quality. However, further work is required to assess the full range of water quality tolerance limits for many fish, as these are often based on field observations and many species are likely to have much wider tolerance limits (Pusey *et al.*, 2004).

Most of the species recorded in the study area were found in both the Glebe and Gyranda weir pools and riverine (pool and run) habitat. However, hardyheads were only recorded in the Gyranda Weir pool, and purple-spotted gudgeons were not recorded in weir pool habitat.

- Movement and migration

Many of the fish known in the region are native to intermittent and ephemeral systems of central and western Queensland, and move up and downstream, and between different habitats, at particular stages of their lifecycle (Cotterell and Jackson, 1998; Marsden and Power, 2007) (Appendix 13-A). Environmental conditions in Australian rivers are extremely variable, and fish may need to move up and downstream to avoid deteriorating water quality and the drying of reaches (Kennard 1997; Freshwater Fisheries Advisory, 1996). Stimuli for movement may include small and large discharge events and changes in water temperature (Appendix 13-A). Under existing conditions, fish movement is restricted by numerous existing instream weirs many of which do not have fish passage structures.

13.1.3.4. Aquatic reptiles - turtles

- Diversity, distribution and abundance

Six species of turtle have been described from the Fitzroy Basin (Limpus *et al.*, 2007). These are: *Emydura macquarii krefftii* (Kreft's river turtle); *Chelodina longicollis* (eastern long neck turtle); *Chelodina expansa* (broad-shelled river turtle); *Wollumbinia latisternum* (sawshelled turtle); *Elseya albagula* (white throated snapping turtle) and *Rheodytes leukops* (Fitzroy River turtle).

Emydura macquarii krefftii, Wollumbinia latisternum and Elseya albagula have been recorded in the vicinity of Glebe Weir, of which, Kreft's river turtle is noted to be the most abundant (Hyder Environmental, 1999).

The mortality of turtles has been noted at Glebe Weir in recent years, with turtles being caught on the trash filters during water releases (Johnson, 2007, cited in Limpus *et al.*, 2007). The following turtles were reported dead at the weir in October 2003:

- 2 *Elseya albagula*;
- 2 *Chelodina longicollis*;
- 17 *Emydura macquarii krefftii*; and
- 2 *Chelodina expansa*.

Chelodina longicollis has been observed in farm dams upstream of the proposed water storage, in the upper catchment of the Dawson River (Limpus *et al.*, 2007). *Emydura macquarii krefftii, Elseya albagula and Wollumbinia latisternum* have been recorded from spring-fed creeks in the upper Dawson catchment (Limpus *et al.*, 2007).

During the November 2007 EIS baseline survey, only *Emydura macquarii krefftii* were observed within the dam and surrounds study area. Adults were captured in the Glebe Weir impoundment at sites 4 and 12 (Table 13-9). No evidence of turtle nesting was observed during this baseline surveys. No turtles were captured in traps or observed alive during the August 2008 EIS baseline survey, although two unidentified decomposing turtle carcasses were observed on the banks of the Dawson River upstream of the water storage at Site 1. No Fitzroy River turtle (*Rheodytes leukops)* were located during the three targeted turtle surveys however *Elseya albagula, Emydura macquarii krefftii* and *Chelodina expansa* were observed within the storage area (Table 13-11 and Table 13-12).

Table 13-10 Total abundance of freshwater turtle species (pre-wet season EIS baseline survey)

Latin name	Common name	Site						
		2[1]	4	8[1]	11[2]	12[3]	15[2]	16[2]
Emydura macquarii krefftii	Krefft's river turtle	–	11	–	–	1	–	–

1 nil captured

2 dry site

3 observed during electrofishing

Table 13-11 Total abundance of freshwater turtle species (targeted Fitzroy River turtle Survey – 2010)

Latin name	Common name	Site				
		3	4	5	8	9
Emydura krefftii	Krefft's river turtle	7	–	–	–	1
Chelodina expansa	broad-shelled river turtle	–	1	–	–	–
Chelodina longicollis	eastern long neck turtle	–	–	–	1	–
Elseya albagula	white throated snapping turtle	–	–	2	–	–

Table 13-12 Total abundance of freshwater turtle species (targeted Fitzroy River turtle Survey – 2011)

Latin name	Common name	Site			
		5	6	7	8
Emydura krefftii	Krefft's river turtle	2	2	5	3
Elseya albagula	white throated snapping turtle	–	–	1	–

Listed threatened or migratory species, and otherwise significant species

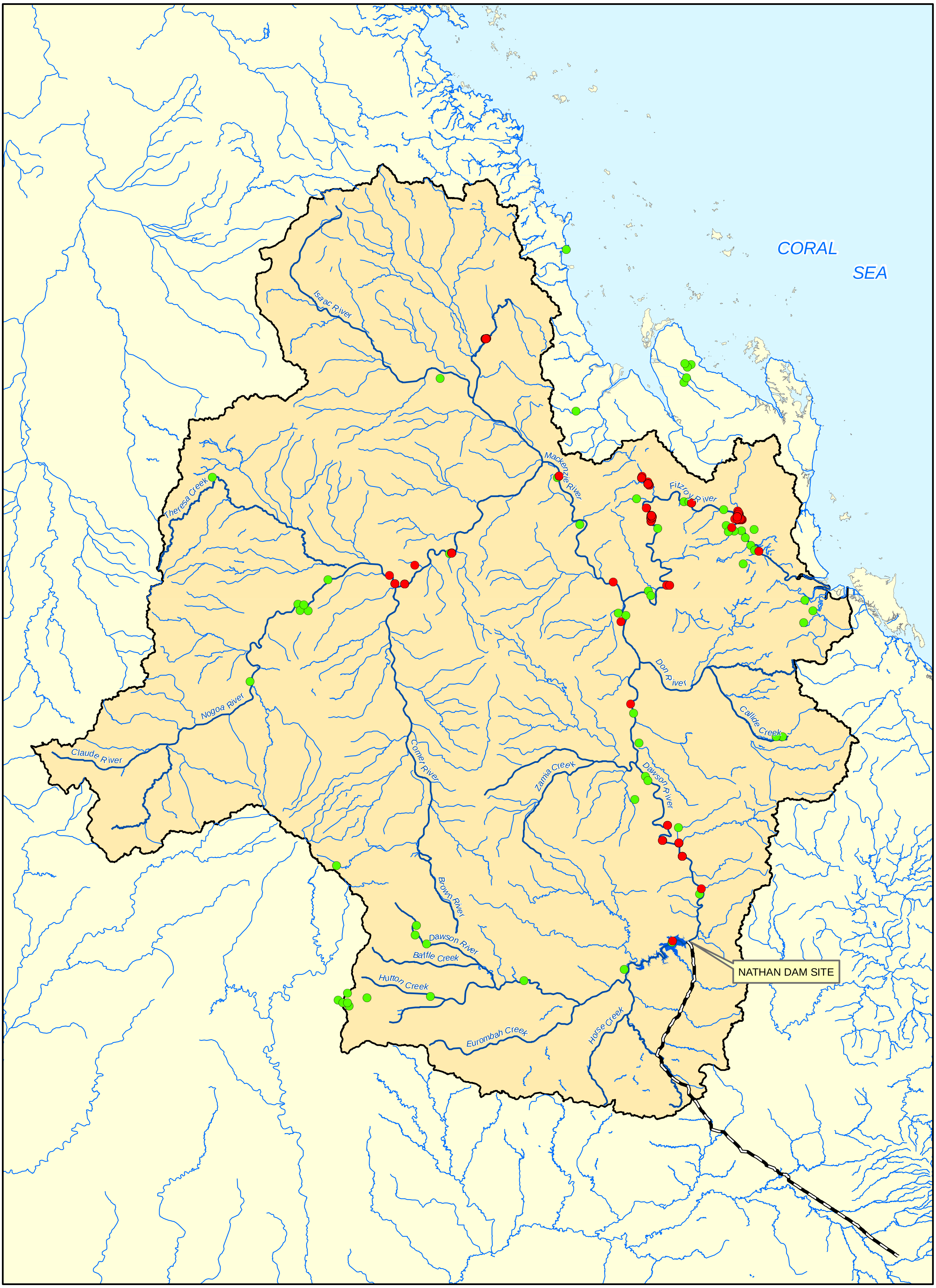
The Fitzroy Basin has high conservation value with respect to freshwater turtles, due to the high degree of biodiversity endemism (Limpus *et al.*, 2007).

Fitzroy River turtle

The Fitzroy River turtle (*Rheodytes leukops*) is listed as 'vulnerable' both in Queensland (under the NC Act) and nationally (under the EPBC Act). The Fitzroy River turtle was not recorded within or upstream of the dam during the baseline surveys or by EPA during surveys in year 2006 (Limpus *et al.*, 2007). A deceased Fitzroy River turtle has been recorded downstream of Glebe Weir, within the Project area. There are also records of the Fitzroy River turtle in the Dawson River at the Theodore Weir, approximately 75 km downstream of the proposed dam (Limpus *et al.*, 2007). Known sites in the Fitzroy Basin that are inhabited by this species are displayed in Figure 13-8. The figure also shows the sites which have been surveyed but where no Fitzroy River turtles have been found. Such a result applies to all sites above the proposed Nathan Dam site.

White throated snapping turtle

The white-throated snapping turtle (*Elseya albagula*) was first described in 2006 (Thomson *et al.*, 2006); previously it had been regarded as a form of the more common and widely distributed northern snapping turtle (*Elseya dentata*). This species is listed as 'least concern' under the NC Act but has been identified as a high priority for conservation in the former EPA's species prioritisation framework. It has been recorded within the study area, upstream of the proposed water storage, and a carcass has been recorded at Glebe Weir. Known sites in the Fitzroy Basin that are inhabited by this species are displayed in Figure 13-9. The figure also shows the sites which have been surveyed but where no white throated snapping turtles have been found.



LEGEND

- Proposed Pipeline
- Major Watercourse
- Watercourse
- Full Supply Level (185.3 m AHD)
- Fitzroy Basin

Turtle Survey Sites - *Rheodytes leukops* (DERM 2011)

- Recorded Presence
- No Recorded Presence

Projection: GDA94

Figure 13-8

0 20 40 80
Kilometres

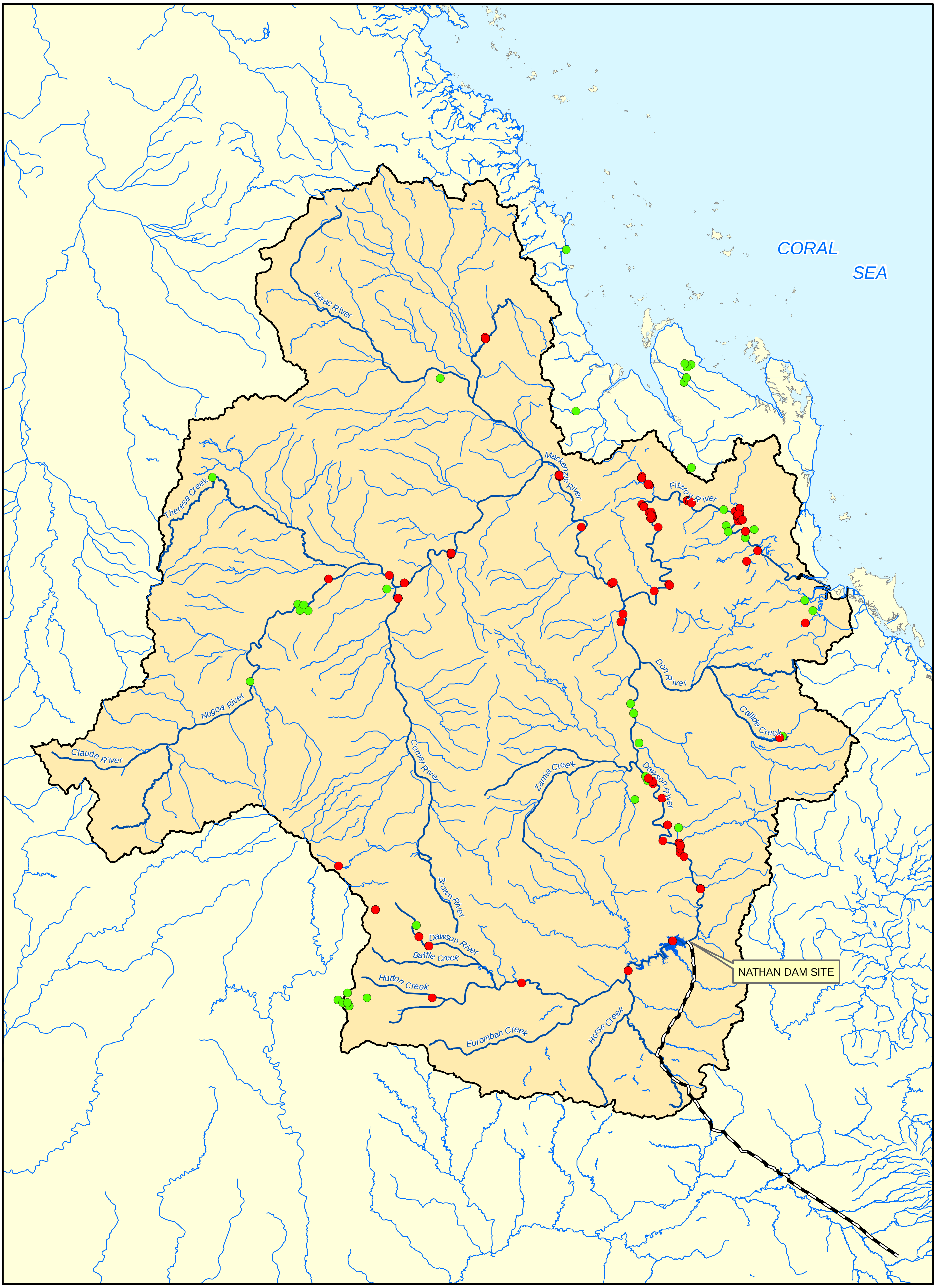
N

Scale 1:3,000,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Recorded presence of the Fitzroy River turtle *(Rheodytes leukops)* in the Fitzroy Basin (adapted from Limpus *et al.*, 2007; frc environmental 2009; DERM, 2011)



LEGEND

- Proposed Pipeline
- Major Watercourse
- Watercourse
- Full Supply Level (185.3 m AHD)
- Fitzroy Basin

Turtle Survey Sites - *Elseya albagula* (DERM 2011)

- Recorded Presence
- No Recorded Presence

Projection: GDA94

Figure 13-9

0 20 40 80
Kilometres

N

Scale 1:3,000,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Recorded presence of the white throated snapping turtle *(Elseya albagula)* in the Fitzroy Basin (adapted from Limpus *et al.*, 2007; frc environmental 2009; DERM, 2011)

I:\QENV2\Projects\QE40192\400 - Nathan - Spatial\ArcMXD\Figures\130_AquaticFauna\Figure_13-9_WhiteThroated_Snapping_Turtles_Elseya.mxd Produced: 22/06/2011

Introduced and exotic species

All six species of turtle known to inhabit the Fitzroy Basin are native.

Habitat requirements and life history characteristics

Fitzroy River turtle

Little information is available on the abundance and life history of *R. leukops* across its greater distribution. *R. leukops* occurs in flowing rivers with large deep pools with rocky, gravelly or sand substrate, connected by shallow riffles (DEWHA 2008). Riffle zones are an important habitat for *R. leukops*, with the home ranges of individuals typically overlapping these habitats (Tucker *et al.* 2001), possibly due to increased foraging success in these habitats (Legler & Cann 1980).

Under low flow events, or as riffle zones become seasonally ephemeral (i.e. dry completely), *R. leukops* retreat to deeper sections of pool habitats, or even isolated waterholes, adjacent to riffle zones (Limpus *et al.* 2007, Tucker *et al.,* 2001). As riffle zones throughout most of the range of the Fitzroy River turtle, including in the Dawson River, are likely to be ephemeral, this species should not be considered to be a riffle zone specialist; rather, they exploit this habitat to forage for abundant food sources such as benthic invertebrates and algae during the wet season and early dry season (Limpus *et al.* 2007). This allows the turtles to take up nutrients and build fat reserves for the dry season, which is essential for preparing to breed (Limpus *et al.* 2007). Therefore, while large, slow flowing pools can support populations of the Fitzroy River turtle, they are likely to have a lower carrying capacity than reaches containing riffle zones (Limpus *et al.* 2007).

Nesting in *R. leukops* occurs between September and December (Limpus *et al.* 2007). In areas where it has been studied, there has been a poor recruitment of juveniles into the population in recent years, and the population consists primarily of ageing adults (Limpus *et al.* 2007). However, it should be noted that the population of Fitzroy River turtles in the shallow and slow-flowing Fitzroy Barrage impoundment is a well-functioning population, with several nesting banks available (Limpus *et al* 2007, frc environmental 2007b). Conversely, populations at other sites in the Fitzroy River downstream of the study area, are not functioning as well, and reproductive success is low (Limpus *et al.* 2007).

White throated snapping turtle

Within the greater Fitzroy, Burnett and Mary River catchments, *E albagula* has been recorded almost exclusively in close association with permanent flowing stream reaches, typically characterised by a sand-gravel substrate with submerged rock crevices, undercut banks and/or submerged logs and fallen trees (Hamann *et al.*, 2007). Within the Fitzroy and Mary River catchments, *E. albagula* is regularly associated with areas of high shade, including submerged logs and overhanging riparian vegetation, during the day; and shallow riffle zones at night (Hamann *et al.*, 2007). Capture records suggest that *E. albagula* is rarely found in reaches without such refuge (Hamann *et al.*, 2007).

Similar to *R. leukops*, *E. albagula* is able to use cloacal ventilation to undertake long dives in productive shallow flowing waters to feed upon plant material (macrophytes, algae and fallen material from the riparian zone) during the wet season possibly in order to build energy reserves for reproduction, and retreats to pools during the dry season (Limpus *et al.*, 2007). Across its distribution, individuals have been recorded from both shallow flowing pools and in deeper, slow flowing pools of at least 6 m depth (Hamann *et al.*, 2007). It has been recorded in high densities at the Ned Churchward Weir on the Burnett River (Hamann *et al.*, 2007) and the best-functioning population in the Fitzroy River is located in the Fitzroy Barrage impoundment (Limpus *et al.*, 2007). They have also been recorded from the existing Eden Bann Weir impoundment (Limpus *et al.*, 2007). Individual populations of *E. albagula* tend to be localised around suitable nesting habitats (frc environmental, 2007b, Hamann *et al.* 2007).

E. albagula has not been recorded from man-made water bodies isolated from flowing streams, such as farm dams or sewage treatment plants, suggesting that *E. albagula* does not move extended distances over dry land (Hamann *et al.*, 2007). *E. albagula* breeding and nesting occurs during autumn and spring, while hatching occurs during spring through to summer, a pattern consistent with that of many tropical zone turtles (Hamann *et al.*, 2007). Egg production and nesting occurs during March to September, coinciding with generally low temperatures, low rainfall and declining river heights (Hamann *et al.*, 2007). Low density of juvenile and young immature turtles have been observed in studies in the Fitzroy River system and across the species' greater distribution (frc environmental, 2007b, Hamann *et al.*, 2007). Low numbers of juvenile and immature turtles are considered to be a function of poor hatchling survival, thought to be related to egg predation by natural (goanna, dingo, etc.) and introduced (fox, pig, etc.) predators as well as the trampling of eggs by cattle access to creek banks where the eggs are laid (Hamann *et al.*, 2007).

Other turtles

The other freshwater turtle species found in the Fitzroy Basin are more generalist species, with generalised diets and a decreased reliance on well-oxygenated waters and riffle zones (Limpus *et al.*, 2007). These species are more often found in impoundments.

Movement and migration

Freshwater turtles typically move between habitats in the order of tens of kilometres apart (but they may be displaced in the order of hundreds of kilometres) (Limpus *et al.*, 2007). Movement is likely to occur in conjunction with the drying of habitats during the dry season, with turtles moving into large pools, which act as dry season refuge habitat (Limpus *et al.*, 2007). This is particularly likely to be the case for cloacal ventilating species, which use riffle habitats for foraging during the wet season when the river is flowing, and move into refuge habitats as riffle zones dry up. Water infrastructure such as dams and weirs, as well as non-water infrastructure such as road crossings, can impede the up and downstream movement of freshwater turtles.

13.1.3.5. Aquatic reptiles - crocodiles

Estuarine crocodiles are classified as 'vulnerable' under the NC Act and as a migratory species under the EPBC Act. Anecdotal evidence supports the presence of estuarine crocodiles in the lower reaches of the Dawson River near Baralaba (Shift Miner Magazine, 2010). No evidence of crocodiles was found in the study area during baseline surveys and it is considered unlikely that they would inhabit the Dawson River within the proposed water storage. .

13.1.3.6. *Aquatic mammals*

- Diversity, distribution and abundance

No aquatic mammals were noted during the present surveys; although anecdotal evidence from landowners suggests that platypus (*Ornithorhynchus anatinus*) occur in the Dawson River and tributaries in the Taroom region.

- Listed threatened or migratory species, and otherwise significant species

Whilst platypus are common throughout most of their range, they are considered vulnerable as they are dependent on river systems for survival, and major or prolonged disturbance of these systems could lead to a reduction in their distribution (Grant, 1995). Platypus are listed as ‘Least Concern’ species under the NC Act; they are not listed under the EPBC Act.

- Introduced and exotic species

There are no known introduced or exotic aquatic mammals in the Fitzroy Basin.

- Habitat requirements, life history and movement and migration

Platypus are likely to move along rivers to find suitable habitat, and are known to cross shallow or dry riffle zones between pools (Grant and Temple-Smith, 1993). Platypus are found in highly modified streams with no riparian vegetation flowing through agricultural land, in artificial dams, and in forested habitats with dense riparian vegetation (Fanning *et al.*, 1997). They eat a variety of macroinvertebrates and require access to riffle and pool habitats when feeding, and to firm banks for the construction of burrows and the nest used for rearing young (Grant, 1991). These banks are very important from November to March, when the females suckle their young inside the burrows (Grant, 1991). Platypus develop nest sites relative to water levels, and may therefore be affected by the construction of water infrastructure, and the resulting unseasonal or irregular flows that may arise (DNR, 1998).

13.1.3.7. *Existing impacts to aquatic faunal communities*

- Water-resource development

Impoundments such as weirs and dams are found throughout the Fitzroy Basin. Barriers typically trap debris and restrict flow during flow events, resulting in aggradation of sediments behind the barrier (DNR, 1998). This aggradation of sediments and the creation of lacustrine habitat reduce the habitat diversity within the affected reach. A reduction in habitat diversity can affect the diversity of aquatic fauna compared with the natural state. Surveys throughout the Fitzroy Basin have found reduced macroinvertebrate abundance in impoundments compared with riverine sites (Noble *et al.*, 2007; Duivenvoorden *et al.*, 2003). Weir impoundments have been found to increase the area of suitable habitat for generalist, potamodromous fish such as southern saratoga (Berghuis and Long, 1999) and bony bream (Marsden and Power, 2007), but are not optimal habitat for other species that prefer riverine habitats, such as golden perch (Marsden and Power, 2007).

Stocking of predatory fish in impoundments, recreational boating and fishing activities and mortality in relation to water infrastructure (such as trash filters on dams and weirs, and being swept over dams and weirs) also impacts upon aquatic faunal communities, particularly fish and turtles (Limpus *et al.*, 2007).

Barriers also restrict aquatic fauna movement and migration in the Fitzroy Basin, affecting the number and type of fish found both upstream and downstream of the obstruction (Taylor and Jones, 2000; Berghuis and Long, 1999). Barriers can also impact on aquatic fauna species that do not require migration for breeding or that have a wide habitat preference, by fragmenting populations as recruitment and movement between populations is restricted (Limpus *et al.,* 2007, Marsden and Power, 2007). Barriers in the lower Fitzroy Basin have probably reduced the occurrence of a number of species within the study area (Section 13.2.3.7).

With respect to changes to flow conditions within the Dawson River, the modelled flow duration curves show that the flow regime is highly impacted by existing development and flow regulation. The most upstream reporting station, Nathan Gorge shows that low flows have been impacted, and that the river regularly experiences periods of no flow in the Full Entitlement scenario. In the Pre-development scenario, the cease to flow point of baseflow was 94 % of the time during the simulation period (Chapter 14).

Further downstream along the Dawson River all flows, with the exception of infrequent high flow events, have been reduced in the Full Entitlement scenario, as shown in Figure 14-7 and Figure 14-8. In Figure 14-8 at Beckers, the impact of flow regulation can be seen on low flows which are artificially maintained within the river, while in the Pre-development scenario, flows are only present for 86 % of the simulation period.

At the downstream end of the Dawson River (Figure 14-9), the pattern of flow is observed to be similar between the Full Entitlement and Pre-development scenario – with the stepped and uneven nature of flow (caused by operation of the various weirs) observed in the flow duration curves produced for Nathan Gorge (Figure 14-5), Theodore (Figure 14-6) and Beckers (Figure 14-7), no longer present. This is largely due to inflows from the Don River which has a relatively undeveloped catchment. Despite the similarity in the pattern of Pre-development and Full Entitlement flows, the actual degree of impact to flows at the end of the Dawson River is greater in the Full Entitlement scenario.

Non-water resource development

Development which is not related to water resources has negatively impacted on aquatic habitat and aquatic fauna populations throughout the Fitzroy Basin through:

- riparian vegetation clearing, which can lead to the loss of in-stream woody debris habitat, bank erosion and sedimentation, and a reduced input of detrital material;
- broad acre land clearing, which alters rainfall runoff relationships and leads to an increase in erosion and sediment transport;
- stock access to waterways, which can result in altered habitat and increased erosion and sedimentation;
- agricultural (including grazing and cropping), industrial (including mining) and urban land uses which have resulted in increased suspended sediment, nutrient and pesticide levels in the waters of the Fitzroy Basin. These are carried to the Fitzroy Estuary and Great Barrier Reef during flood flows;
- introduction of exotic flora and fauna species, which can negatively impact on native populations;
- turtle nest disturbance and predation by feral pigs;
- direct disturbance or removal of habitat;

- impacts from overfishing; and
- entanglement of aquatic fauna in fishing gear and rubbish items.

Based on the results of literature review and field survey, the magnitude of such impacts within the study area appears comparable with other developed catchments in the Fitzroy Basin.

13.1.3.8. Estimation of natural condition

Both water-resource and non-water resource development are likely to have affected the composition of aquatic fauna communities in the study area. Species that undertake migrations may be constrained and population sizes of some species such as the Pacific blue-eye have been reduced throughout the catchment (Marsden and Power, 2007). The distribution and abundance of barramundi and sea mullet within the Fitzroy Basin has decreased significantly following the construction of the barrage and other impoundments (Taylor and Jones, 2000). As a specific example, a number of such species were not caught in the study area (such as barramundi, oxeye herring, long-finned eel, longtom, snub-nosed garfish and Pacific blue eye). In contrast, species that do not require reproductive migrations (potamodromous species) or specific instream habitats, such as bony bream, appear to be less affected by the construction of instream barriers (Marsden and Power, 2007). Bony bream are generalist species that can eat both aquatic plants and algae, as well as detrital material (Pusey *et al.*, 2004), which may have enabled successful adaptations to changes in the availability of certain riverine habitats after weir construction. Within the Glebe Weir water storage, bony bream were abundant and dominated the fish community, yet this was not the case in riverine habitats up and downstream of the weir.

Macroinvertebrate communities in the Glebe Weir pool were generally less diverse than those in riverine habitat, suggesting that the construction of this weir resulted in the loss of some taxa that have a preference for non-pool habitat such as riffles, for example blackfly and caddisfly larvae. The construction of weirs may have also led to a reduction in the diversity of turtle communities, or a shift towards community dominance by generalist species such as the Krefft's river turtle, in the study area, given that a greater diversity of turtles has been recorded upstream and downstream.

In the context of the Fitzroy Basin, the likely degree of alteration of aquatic fauna communities from the natural state is considered to range from low to moderate depending upon position within the catchment. Within major water storages (Glebe and Gyranda Weir's) or immediately downstream of sewerage effluent discharge the degree of alteration would be considered high, whilst un-impounded sections which are not highly regulated would be considered low. Due to significant changes in flow regime caused by the construction of several weirs, the regulated section of the Dawson River may be considered to support the most highly modified ecosystems within the Fitzroy Basin, with the exception of those present at the Fitzroy Barrage.

13.1.4. Pipeline

This section describes the aquatic fauna communities within the pipeline survey area. The pipeline route was surveyed in January 2009 and the sampling sites are described in full in Appendix 12-C. A map of the proposed pipeline route is presented in Chapter 2, Figures 2-2a, 2-2b, 2-2c, 2-2d and 2-2e. Discussions of habitat requirements, life history characteristics, and movement and migration of aquatic fauna found or likely to be found in the pipeline study area is discussed in Section 13.1.3. The pipeline commences in the Dawson catchment but primarily traverses tributaries of the Condamine River.

Overall, crossings constitute a relatively small total area of the waterway being crossed, with much of the habitat crossed by the pipeline consisting of intermittent dry areas. Similar to watercourses in the dam and surrounds study area in the pre-wet season, smaller watercourses (Juandah, L Tree, Jingi Jingi and Jimbour Creeks) contained only shallow, intermittent or ephemeral pools and an ephemeral flow regime, while larger watercourses (Dogwood, Columboola, Rocky, Cooranga and Myall Creeks, and the Condamine River) had perennial pools at least 1 m deep. It is likely that during periods of flow, there are run, riffle and backwater habitats in some of these waterways, similar to those observed in the Dawson River in the dam and surrounds study area. Two Mile Creek was dry at the time of survey.

Although the Condamine River was included in the baseline survey, it should be noted that the pipeline will not cross the Condamine River.

13.1.4.1. Aquatic habitat

- **Distribution of waterbody types**

The majority of waterways crossed by the pipeline are intermittent or ephemeral, first or second order streams, characterised by a series of small, disconnected pools. This finding is supported by the results from the baseline survey, during which only pool habitat was observed (Appendix 12-C).

- **Presence of snag habitats**

Large woody debris coverage varied from 0-45% and was dominated by individual logs and log jams.

- **Presence of overhanging vegetation habitat**

Overhanging vegetation covered some of the channel at most sites, except Juandah Creek (site P1) and Two Mile Creek (site P2). Overhanging vegetation coverage ranged between 0-80%, and was highest at Columboola Creek (site P6).

- **Presence of sand and gravel bars**

Sandy bars were observed at L Tree Creek (site P3) and Myall Creek (site P11), in the form of side/irregular bars and islands). The bars observed at Myall Creek may provide nesting habitat for turtles during the dry season, when the bars are not inundated, however, there was no evidence of turtle nesting (tracks or excavation marks) during the survey. Turtles are not expected to utilise the bars observed in L Tree Creek for nesting due to the relatively small size of the waterway.

- **Sediment type**

Sediments at most sites were dominated by silt/clay; Two Mile Creek (site P2) sediments were solely made up of silt/clay). In contrast, Juandah Creek (site P1) sediment was dominated by sand, while at L Tree Creek (site P3) 80% of the sediment was comprised of sand, gravel, pebbles and cobbles.

- River profile

Average channel width was < 40 m at most sites, except Jingi Jingi Creek (site P5) where it was 200 m. Average wetted width was < 30 m at all sites. Average lower bank width varied from 1-4 m wide, while average upper bank width varied from 3–15 m. Average lower bank height ranged from 0.3-2.3 m high, while average upper bank height ranged from 0.5-10 m.

- Floodplain wetlands

No floodplain wetlands were surveyed in the pipeline study area.

13.1.4.2. Macroinvertebrates

Macroinvertebrate surveys were collected at only four of the eleven sites visited during the baseline survey. No sample was collected at the Condamine River site.

Thirty six taxa (1,018 individuals) were recorded in the pipeline study area. Communities were dominated by non-biting midges (sub-families Chironominae and Tanypodinae), biting midges (family Ceratopogonidae), freshwater shrimps (family Atyidae) and caddis fly (Family Leptoceridae).

Mean taxonomic richness of bed habitats ranged between 2.2 and 7 families (Figure 13-10(a)). It was highest at Juandah Creek (site P1) and lowest at Cooranga Creek (site P9). Rocky Creek (site P7) was the only site noted to support all four habitat types (bed, edge, macrophyte and tree root); richness was highest in macrophyte habitat and lowest in bed habitat.

Mean abundance (total number of individuals captured) of bed habitats ranged between 3.8 and 52.3 individuals (Figure 13-10(b)). Abundance was highest at Juandah Creek (P1) and lowest at Cooranga Creek (site P9). At Rocky Creek (site P7) abundance was highest in macrophyte habitat and lowest in bed habitat.

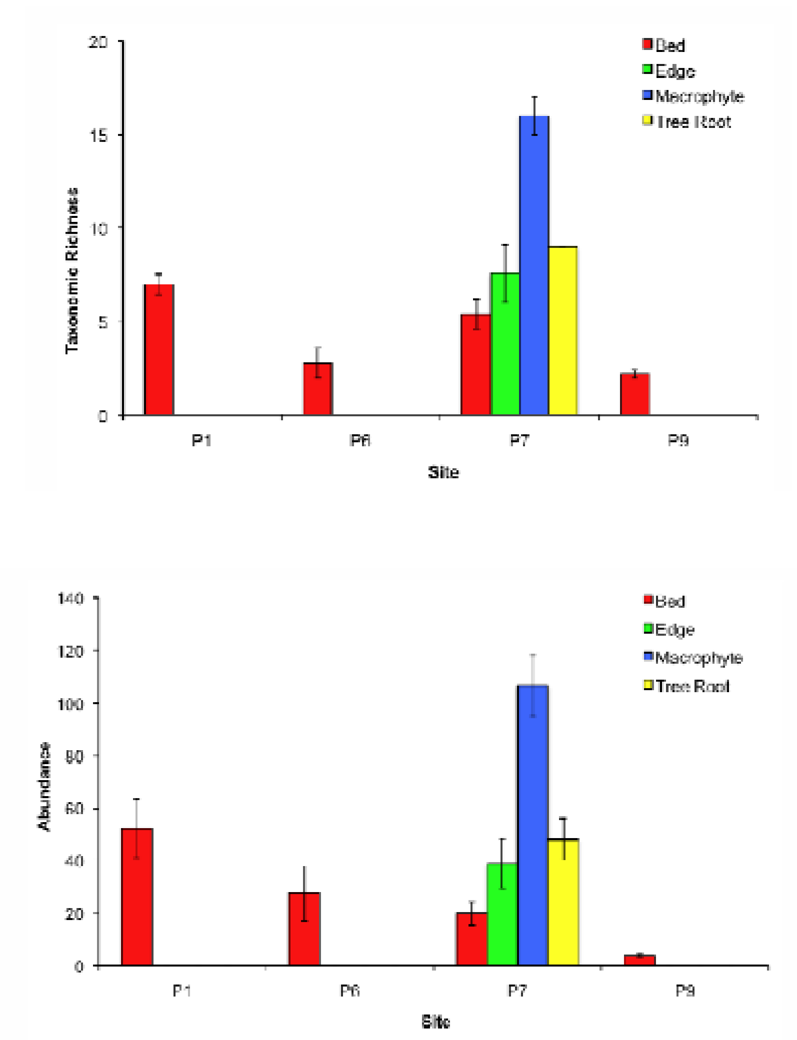


Figure 13-10 Mean taxonomic richness (± SE) (A) and mean abundance (± SE) (B) of macroinvertebrates in the four habitat types present at sites to be crossed by the pipeline

13.1.4.3. Fish and fisheries

- Community composition and richness

Fourteen species from eleven families (2,918 individuals) were recorded in the pipeline study area (Table 13-10). Communities were dominated by gudgeons (family Eleotridae, two species), spangled perch (family Terapontidae) and mosquito fish (family Poeciliidae). The most abundant species were mosquito fish (*Gambusia holbrooki*), accounting for 31% of the catch; midgley's / western carp gudgeon (*Hypseleotris sp*.), accounting for 23% of the catch; and spangled perch (*Leiopotherapon unicolor*), accounting for 12% of the catch.

All 14 species were captured in the Condamine River catchment. Spangled perch (*Leioptherapon unicolor*) was the only species captured at Juandah Creek (site P1; the only site within the Fitzroy catchment surveyed). Of all the sites surveyed, communities were most diverse and abundant at Rocky Creek (site P8), with twelve species and 1,061 individuals captured at this site. Diversity and abundance was lowest at Juandah Creek (site P1).

Listed threatened or migratory species, or otherwise significant species

No listed rare or threatened, or noteworthy species were observed in the pipeline study area.

Fisheries

Within the pipeline study area, recreational fishing is likely to be primarily conducted by local residents, due to the remote location and lack of large waterbodies such as dams. There are no known commercial fisheries in the pipeline study area.

There are several fish stocking programs managed by stocking groups in the Condamine catchment. Golden perch (*Macquaria ambigua*), silver perch (*Bidyanus bidyanus*) and Murray cod (*Maccullochella peelii*) are stocked into several waterways, including Chinchilla, Miles and Dalby weirs.

Introduced and exotic species

Two exotic species were captured in the Condamine River catchment: goldfish (*Carassius auratus*); carp (*Cyrpinus carpio*) and mosquito fish (*Gambusia holbrooki*). Carp and mosquito fish are declared as noxious species in Queensland under the Fisheries Regulation (2008). No exotic species were recorded at Juandah Creek.

13.1.4.4. Aquatic reptiles - turtles

Eleven Macquarie turtles (*Emydura macquarii macquarii*) were captured in the Condamine River catchment. Turtles were captured at Rocky Creek, the Condamine River and Myall Creek, sites P7, P8 and P11, respectively. No turtles were recorded in the Fitzroy catchment during the pipeline aquatic flora survey, however, the absence of barriers to movement and the presence of preferred habitat suggests it is likely that they are present.

Table 13-13 Fish recorded in the pipeline study area

Family	**Common Name**	**Condamine River Catchment**					**Fitzroy River Catchment**
species		**P6**	**P7**	**P8**	**P9**	**P11**	**P1**
Ambassidae							
Ambassis agassizii	Agassiz's glassfish	√	√				
Antherinidae							
Craterocephalus stercusmuscarum	fly-specked hardyhead		√				
Clupeidae							
Nematolosa erebi	bony bream		√	√		√	
Cyprinidae							
*Carassius auratus**	goldfish		√				
Cyprinus carpio	carp			√		√	

Family *species*	Common Name	Condamine River Catchment P6	P7	P8	P9	P11	Fitzroy River Catchment P1
Eleotridae							
Hypseleotris galii	firetail gudgeon	√	√	√		√	
Hypseleotris sp.	Midgley's/western carp gudegon	√ √	√ √	√ √	√ √	√ √	
Melanotaeniidae							
Melanotaenia duboulayi	crimson spotted rainbow fish		√			√	
Percichthyidae							
Macquria ambigua oriens	goldern perch		√	√			
Plotosidae			√				
Neosilurus hyrtlii	Hyrtl's tandan	√					
Tandanus tandanus	eel-tailed catfish		√				
Poecillidae							
*Gambusia holbrooki**	mosquitofish	√	√	√	√	√	
Retropinnidae							
Reteropinna semoni	Australian smelt		√				
Terapontidae							
Leiopotherapon unicolor	spangled perch		√	√	√	√	√
Total		√	√	√	√	√	√

13.1.4.5. Aquatic reptiles - crocodiles

The saltwater crocodile (*Crocodylus porosus*) and the freshwater crocodile (*Crocodylus johnstoni*) are highly unlikely to occur in the study area.

13.1.4.6. Aquatic mammals

No aquatic mammals were noted in the study area, although platypus may occur.

13.1.4.7. Existing impacts and estimation of natural condition

Though all sites surveyed have weirs and/or are downstream of them, only the Rocky Creek (P7) and Condamine River (P8) sites are directly impacted by water infrastructure. The Rocky Creek site is in the headwaters of a weir at the junction of Rocky and Charleys Creeks, which it is believed was originally constructed to supply water to Chinchilla. The Condamine River site is in the headwaters of Chinchilla Weir.

Non-water resource development has impacted on all sites and all are adjacent to major roads. Nevertheless, the Rocky Creek (P7), Condamine River (P8), Cooranga Creek (P9), and Myall Creek (P11) sites have been impacted to a greater extent because of the higher intensity of agricultural land use around the sites and/or upstream.

The above factors, together with modification of habitats at the sites and the introduction of exotic species, means that they are appreciably different from their natural condition.

13.1.5. Associated infrastructure

The description of aquatic fauna values within the dam and surrounds or pipeline is equally applicable to the associated infrastructure for those Project components, particularly the resource extraction sites.

13.1.6. Estuarine and marine

The risk of impacts to estuarine and marine fauna communities from the Project is low. As such, the descriptions and impact assessment for estuarine and marine fauna are brief and commensurate with the associated risks.

13.1.6.1. Macroinvertebrates

Macrobenthic invertebrate communities in the Fitzroy estuary are generally low in abundance (Currie and Small, 2005). Surveys conducted in 2001 found 49 benthic species from 16 sites within the estuary extending into Keppel Bay (Currie and Small, 2005). Polychaetes, crustaceans, molluscs, and echinoderms were the main groups found. Bivalves were the most abundant taxa (77%), whilst filter feeders were the most common trophic group in the subtidal zone, and deposit feeding polychaete worms were most common in the intertidal areas (Currie and Small, 2005).

Many of the islands in Keppel Bay are surrounded by fringing reefs. These reefs have high coral cover (60 to 70%). Fast growing branching *Acropora* species are the dominant form in many of these areas, but there are also plate corals and small massive corals (GBRMPA, 2007).

The invertebrate fauna that occur in the Fitzroy estuary are greatly influenced by salinity. After continuous freshwater inflow, marine fauna disappear and are eventually replaced by freshwater fauna, particularly in the upper estuary (Sheaves, 2005). Macroinvertebrate communities in the upper estuary typically have low diversity but high abundance. Conversely, communities closer to the mouth of the estuary have low abundance and high diversity, with species composition that is less affected by flood events. Species composition in both the upper and lower estuary is typical of the region (Sheaves, 2005).

The reefs in Keppel Bay are affected by flooding and bleaching events (GBRMPA, 2007). There is a clear distinction between benthic communities close to the Fitzroy River and those offshore. Inshore reefs have a significantly lower cover of hard corals (though not a lower species richness of hard corals), higher cover of macroalgae and lower densities of hard coral recruits than reefs further offshore (Prange *et al.*, 2007).

13.1.6.2. Fish and fisheries

Part of the Fitzroy River estuary is a Type A Declared Fish Habitat Area (DPI & F, 2008). The fisheries species that this area is designated to protect are: barramundi; banana prawns; king salmon; blue salmon; sea mullet; grunter; shark; and mud crab. The habitat values protected are: extensive saltpans; saline grasslands fed by mangrove lined creeks; closed mangrove forests of mixed species; mud and sand flats; rocky headlands; and brackish lagoons (DPI & F, 2008).

In the Fitzroy estuary and along the Central Queensland Coast there are several commercial fisheries for barramundi, (*Lates calcarifer*) mullet (*Mugil cephalus*), king salmon (*Polydactylus macrochir*), blue salmon (*Eleutheronema tetradactylum*), and crustacean species such as banana prawns (*Penaeus spp.*) and mud crabs (*Scylla spp.*) (Quinn and

Garrett, 1992). The commercial fisheries in the inshore areas adjacent to the Fitzroy estuary were worth more than $2,439,500 in 2005 (Table 13-13).

Table 13-14 Catch and fishing data of the various fisheries in the Fitzroy River estuary area (commercial catch grids R29 and R30) in 2005 (DPI & F, 2007a)

Fishery	Tonnes	Boats	Days	GVP (AUD)
Line	2.7	5	58	$16,400
Net	186.2	72	1,762	$965,400
Pot - Mud Crab	73.2	58	3394	$762,000
Trawl – Beam	53.8	33	1367	$480,800
Trawl – Other	>23.5	<23	>147	$>214,900
Total	**339.4**	**<191**	**6728**	**>$2,439,500**

13.1.6.3. Aquatic reptiles – Turtles

Six species of turtle are found in the Great Barrier Reef: green turtles (*Chelonia mydas*), hawksbill turtles (*Eretmochelys imbricata*), loggerhead turtles (*Caretta caretta*), flatback turtles (*Natator depressus*), Olive Ridley turtles (*Lepidochelys olivacea*), and leatherback turtles (*Dermochelys coriacea*). All six species are classified as either 'endangered' or 'vulnerable' under the NC Act and EPBC Act (Table 13-1). These turtles are likely to occur in the coastal waters offshore of the mouth of the Fitzroy River. However, the Fitzroy River estuary is unlikely to provide appropriate habitat for any of these species, and flatback turtles are the only species that have been recorded in the estuary (EPA, 2008b).

Marine turtle species are vulnerable to changes in their habitat, such as water quality. For example, fibropapillomatosis disease is common amongst turtles in some areas, and may be related to high industrial or agricultural runoff (Kirkwood and Hooper, 2004). The diet of marine turtles depends on the species, but includes seagrass, mangrove propagules, and benthic and pelagic invertebrates. They are therefore also vulnerable to the secondary impacts of changes in water quality to their foraging habitat (e.g. the loss of seagrass or changes in benthic invertebrate community structure); particularly for the more 'inshore species' such as green and loggerhead turtles, which maintain a small foraging home range that is heavily influenced by discharges from river systems.

Marine turtles are generally highly migratory, moving between feeding grounds and rookeries, with both males and females undertaking migrations of up to 3,000 km (Environment Australia, 2003). Regionally, there are several important rookeries, including Mon Repos, to the south of the Burnett River mouth, and the islands of the Capricorn Bunker group of the Great Barrier Reef, offshore from the Fitzroy River mouth (EPA, 2007b). Green and loggerhead turtles are migratory, in term of breeding, although they tend to maintain small home ranges, ~10–15 km of coastline, within their foraging grounds (C. Limpus, 2007 [Queensland Parks and Wildlife Service], pers. comm.). Turtle movements within foraging grounds are likely to be related to food availability and environmental factors such as the tide cycle as they can only feed in intertidal areas when the water depth is between 0.5–1 m over the seabed) (Bell, 2003).

13.1.6.4. Aquatic reptiles – other

Estuarine crocodiles are classified as 'vulnerable' under the NC Act and as a migratory species under the EPBC Act. Anecdotal evidence supports the presence of estuarine crocodiles in the lower reaches of the Dawson River near Baralaba (Shift Miner Magazine, 2010).

13.1.6.5. Marine mammals

Around 30 species of whale and dolphin have been identified along the Great Barrier Reef (GBRMPA, 2007). Dwarf minke whales (*Balaenoptera acutorostrata*), humpback whales (*Megaptera novaeangliae*), and inshore bottlenose dolphins (*Tursiops aduncus*) are the most commonly sighted species.

The Indo-Pacific humpback dolphin (*Sousa chinensis*) has been observed on rare occasions in the Fitzroy River estuary. It is regarded as an inshore species because it found in shallow waters, often near river mouths, and is rarely sighted more than 1 km off shore.

The Australian snubfin dolphin (*Orcaella heinsohni*), a recently described species, formally *Orcella brevirostris*, has been recorded along the Capricorn Coast. Its distribution is currently being mapped and it is possible that an isolated population of this species may be found at the mouth of the Fitzroy River (Rodney and Christensen, 2006). There have also been rare sightings of false killer whales (*Pseudorca crassidens*) (Rodney and Christensen, 2006).

Cetaceans are highly mobile species, though not all species are considered to be migratory. For example, Indo-pacific humpback dolphins appear to occupy a home range in inshore waters. Population distribution appears to be directly impacted by features such as water depth and habitat type, and indirectly by the distribution of prey (fish) (e.g. Jaquet and Whitehead, 1996; Benson *et al.*, 2002). Cetaceans that undertake predictable migrations include the minke whale and humpback whale, which migrate along the east coast of Australia during the winter and spring months to reproduce. Breeding and resting grounds for humpback whales include Hervey Bay to the south of the Fitzroy River mouth and the Whitsundays to the north; they are not known to 'stopover' in the vicinity of the Fitzroy River mouth (Environment Australia, 2002).

Dugongs (*Dugong dugon*) are found throughout the Great Barrier Reef in shallow, tropical and sub-tropical waters. Dugong abundance along the southern Great Barrier Reef is generally sparse relative to the abundance in the northern parts of the reef. This is likely to be due to the small area of inshore seagrass and the relatively small size of individual meadows (Marsh *et al.*, 2002). Although there are no reports of dugongs near the Fitzroy estuary (EPA, 2008b), Shoalwater Bay is considered to be the most important dugong habitat in the Great Barrier Reef south of Cooktown. The Fitzroy River enters the sea about 100 km south of Shoalwater Bay (Schaffelke *et al.*, 2001).

Dugongs feed almost exclusively on seagrass, and principally inhabit seagrass meadows (Lanyon and Morris, 1997; Preen, 1992; Preen *et al.*, 1995). Dugongs are very variable in their movement patterns; some are sedentary and others move hundreds of kilometres in a few days (Marsh *et al.*, 1989; Sheppard *et al.*, 2006), although dugongs are generally considered to inhabit a home range. The reasons behind dugong movements are poorly understood but it appears that they may be in response to environmental variables such as temperature, water levels, salinity (Sheppard *et al.*, 2006), water quality (Schaffelke *et al.*, 2001) and foraging for seagrass (Marsh *et al.,* 2002; Marsh and Penrose, 2001; Sheppard *et al.*, 2006). Calving is likely to occur in shallow, specialised areas that are not associated with seagrass beds, and typically occurs from September to November inclusive (Marsh, 1989).

The water mouse or false water-rat (*Xeromys myoides*) is also found in the region. The water mouse has only been recorded within fringing mangroves in the high intertidal zone dominated by *Ceriops tagal* or *Bruguiera* spp. (Van Dyck *et al.*, 2007). They forage in mangrove forests at night during a low tide. In daylight hours, or when it cannot forage, the water mouse will retreat to its nest, located anywhere from the reed/sedge zone to the mangrove zone (Van Dyck and Janetzki, 2004).

13.2. Potential impacts and mitigation measures

13.2.1. Dam and surrounds

13.2.1.1. Construction

Impacts of the Project on aquatic fauna during the construction phase are likely to occur within and downstream of any construction areas that directly disturb stream beds or nearby land. As such, most impacts are likely to occur on a relatively local scale at specific work sites such as road bridges or the dam wall. It is assumed that best practice site management will be employed and the direct impact of individual site works will be relatively minor. However as there are many construction sites and some are far more significant than others in terms of extent of disturbance (the dam wall area with coffer dams etc), secondary impacts such as sedimentation and turbidity may be significant and are dealt with collectively.

Impacts on aquatic fauna during the construction phase fall into the following categories:

- direct physical disturbance;
- temporary barriers and the diversion channel;
- water extraction;
- water quality;
- mosquito and biting midge;
- modification of habitat or flow conditions; and
- fish passage barriers.

Many of the mechanisms of impact are similar to those for aquatic plants and the same mitigation measures apply.

Direct physical disturbance

All aquatic fauna habitats between and under the coffer dams and the dam construction area will be lost to aquatic fauna upon commencement of construction. From this stage the habitats will be isolated from the river and will constitute a construction site. The diversion channel will connect to the river both upstream and downstream of the coffer dams and construction of the links will disturb the banks of the watercourse.

Direct impacts to aquatic fauna will be minimised where the proposed fauna relocation plan (Section 2.4.1.1) includes provisions to remove larger aquatic fauna (fish, turtles, platypus) from the work area prior to disturbance. Macroinvertebrates present in the area will essentially be lost, however any crayfish or shrimp captured in nets will be relocated along with the larger fauna. Translocation will be in accordance with QPIF fish salvage guidelines (DPI&F 2004), which recommend that:

- fish from the waterway to be diverted be captured using a variety of methods (seine netting, electrofishing, cast nets and set traps);
- where possible, translocation should be done in the cooler months if possible, to minimise stress to the fish;
- fish should be removed from the existing channel 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.).

To ensure minimal impact, specialist advice will be sought with regards to turtle capture and relocation strategies. Similarly, specialist advice will also be sought with regard to the Platypus (Chapter 11). The task of translocation will be significant as the length of pool impacted is over 500 m. Once dewatering of the area commences and pools are lowered, a significant effort will again be required to capture and relocate stranded fauna.

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. Significant impacts are unlikely unless blasting occurs very close to, or in, the river though this is currently not envisaged.

Other physical disturbance will occur during vegetation clearance within the water storage because trees and shrubs will be felled in riparian zones except those within 1.5 m vertical of FSL. 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 will not be relocated as they would be expected to move of their own volition as the water storage fills.

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.

Temporary barriers and the diversion channel

Unmitigated, the coffer dams on the Dawson River will represent significant barriers to fauna movement until they are removed at the end of construction. A diversion channel however is planned for use during the construction phase. The diversion will comprise a deep excavation into the sandstone bedrock and will have a 20% chance of its capacity being exceeded during the dry season. It is an engineering structure designed as a temporary means of allowing the river to continue to flow during construction while keeping the work site dry. It is not designed specifically as a means to allow fauna movement, though this will potentially be possible. The structure will not be in place long enough to justify full creation of riverine habitat within the channel however it will be constructed to facilitate passage by fauna, including fish, by the addition of some habitat features such as boulders or logs. The channel will adequately allow water, sediment and organic material to pass unhindered downstream.

Poor water quality can also represent a barrier and this is discussed below.

Water extraction

During dam wall construction, clean water will be sourced from Dawson River upstream of the construction site. This may impact aquatic fauna in the river by reducing water levels (and therefore available habitat for fauna). If there is rapid draw down of water, fish eggs can become stranded out of the water and cease to develop. The severity of this impact depends on the volume of water to be extracted, flow in the river at the time, water level, and size of the extraction pool. The Fitzroy ROP currently includes approaches to pool drawdown that minimise the potential for such impacts and it is recommended that similar approaches be adopted here. The main strategy would be to not completely drain pools and to only take water from significant pools.

Unmitigated, another potential impact of water extraction is that fauna may become trapped in the inlet pipe if approach velocities exceed the swimming capability of the fauna present. Floating booms and a mesh cage around the pipe will be used to significantly minimise this risk. Depending on the size of the mesh attached to the booms, some small fish may swim through the mesh. The loss of fauna due to entrapment would not be likely to have a significant impact on commonly occurring species of fish.

Water for dust suppression or wash down will drawn for the dewatering process and sedimentation basins and essentially recycled on site following the principle of separation of clean and dirty water.

Water quality

Vegetation clearing and earthworks may cause a temporary increase in the suspended sediment loads entering adjacent and downstream waterways. Unmanaged, this can result in increased turbidity and smothering of benthic habitat. High turbidity is directly harmful to some aquatic fauna, as fine suspended sediments in the water column can clog the gills of fish and filter feeding invertebrates, preventing respiration (breathing). Visual foragers can have trouble feeding in turbid water. Turbidity can also indirectly impact fauna by reducing the amount of light entering the water, which inhibits the growth of aquatic flora (Chapter 12).

As outlined in Section 2.4.3.7, Sunwater commit to a sedimentation and erosion control plan that will be detailed in the Environmental Management Plan prior to construction and submitted to the relevant regulating authority as part of future applications for project approvals. The sediment and erosion control plan will be designed in accordance with guidelines such as those specified by the International Erosion Control Association (IECA) to significantly reduce the potential for additional sediment to enter watercourses.

The major mitigation strategy for dry or low flow periods is to isolate the dam construction area between the coffer dams and direct runoff from works areas to the internal sediment basins. The diversion channel transfers clean upstream water around the site, passing through to the downstream environment. Sediment will be generated within the diversion channel during its early operation and also when the capacity of the diversion channel is exceeded during flood flows such that the excess flows will pass through the original river channel and the work site. In these types of events, the coffer dams will serve to retard flows and capture some sediment but it will not be possible to significantly reduce the sediment load in larger flow events. Suspended sediment levels in the local watercourses are naturally high at these times but will be temporarily further elevated downstream of the construction site.

Uncontrolled wastewater from a range of construction activities has the potential to introduce contaminants such as cement residues, hydrocarbons or detergents into waterways through runoff from the site. Consistent with standard environmental practices, wastewater from activities such as concrete batch plants, workshops and ablutions facilities will be captured within appropriately designed bunding established around the particular activity. Each of these waste sources will be appropriately treated prior to re-use or disposal at licensed facilities. Waste-water from washing of dam foundations will be captured within the bunds established around the dam wall construction area. Diverted to settling ponds, this particular waste-water will then be treated as necessary prior to reuse for activities such as dust suppression. If waste-water is to be discharged then the quality will be checked to ensure it is within acceptable criteria prior to discharge (Chapter 16 and Chapter 20). Those criteria will be determined in conjunction with approval authorities.

Fuels and oils required for the operation of construction machinery only present a risk to aquatic fauna if spills enter watercourses. Both diesel and petrol are toxic to fauna at relatively low concentrations. A significant fuel spill to any of the waterways in the study area (in the order of tens or hundreds of litres) is likely to have a significant impact on fauna, with the quantity spilt and rate of stream flow being the most influential factors on the length of stream impacted.

Risks associated with the spillage of fuels and other contaminants will be substantially reduced, if not eliminated, where the mitigation measures outlined in the EMP are implemented (Chapter 29). The likelihood of spills or runoff from potentially high risk sites reaching a watercourse is relatively low because the risk areas are within the construction site, which is isolated from the river. Further, spill kits for contaminated material will be provided at each transfer and storage location for use in the event of any spillages or leaks. Spills associated with traffic accidents as vehicles travel to and from the site is a low risk. These mitigation measures are reflected in the EMPs developed for the Project (Chapter 29).

Potential for mosquito and biting midge breeding sites

Mosquito eggs are laid in mud or on vegetation associated with shallow pooled water, and hatch when water levels rise (e.g. with the incidence of rainfall). The larvae and pupae of most species take at least 6 days to develop. Within the study area, creeks, dams, stock water troughs and other areas of standing water currently have the potential to provide breeding habitat for mosquitoes and biting midges.

Construction and operational activities that result in pooled water may provide an increase in mosquito and biting midge breeding habitat in the Project area. An increase in the population of mosquitoes and biting midge has the potential to impact on human health. Opportunities exist to minimise the breeding of mosquitoes and biting midges on site through appropriate education, control, and engineering.

Minimisation of breeding habitat during construction

The creation of mosquito breeding habitat will be minimised through:

- minimising the area of standing water, and ensuring drainage within 4 days where practical;
- profiling to ensure sufficient drainage;
- routinely grading incidental depressions and holes that may hold standing water;
- regularly clearing drainage lines to ensure that water continues to flow; and

- constructing dams and water storages intended to contain stormwater and wastewater with steep edges, to minimise the extent of shallow water, which can provide breeding habitat.

Control of biting insect populations during operation

The margins of the dam will provide ideal breeding habitat for some species of mosquito and biting midge. Control of biting insect populations can be achieved through the development and implementation of a biting insect management plan for the Project.

Native fish that colonise the dam such as Agassiz's glassfish (*Ambassis agassizii*), eastern rainbowfish (*Melanotaenia splendida*) and carp gudgeons (*Hypseleotris* spp.) prey on mosquito and biting midge larvae. Native fish populations will control mosquito populations to an extent.

Additionally, the application of larvicides (which kill developing larvae) can also be used to control mosquitoes if necessary. Two larvicides are commonly used: *Bacillus thuringiensis israelensis* (Bti), a bacterial larvicide; and a methoprene-based hormone regulator. These larvicides are relatively target-specific, and are appropriate for use in the Project area. Complaints by Project employees or recreational users should primarily determine the requirement for application of larvicides in targeted breeding habitats. Given the low number of staff at the dam and the expected concentration of recreational users at the provided facilities, such controls are unlikely to be used in the majority of the water storage area. It is also preferable that measures which prevent mosquito bites are used, such as insect screens on buildings and personal insect repellent.

Extent and importance of habitats to be lost

Waterbody type and sediments

Inundation of the water storage area will change part of a river and several major streams into a lake. The Dawson River and the major tributaries in the water storage area are characterised by run and pool habitat, with occasional glide, backwater, and riffle habitat. Isolated pools of the river and tributaries within the water storage area, along with those in other parts of the catchment, provide refuge habitat for aquatic fauna in the dry season.

During operation of the dam, approximately 75.2 km of the Dawson River will be inundated along with 90.8 km of other major streams. The current coarse sediment (boulders, cobbles, pebbles and gravel) will likely be smothered in fines and sands, once the water storage area is filled though some will remain in the shallow delta areas where streams enter the storage.

These changes are likely to impact on species that have a strong preference towards coarse substrate, shallow depths and flowing water for resting, sheltering and foraging. Although most macroinvertebrates are found in a variety of habitats, many taxa have a preference for one specific habitat type; for example, hydropsychic caddisfly larva and simuliid blackflies prefer riffle habitat and coarse substrates (Section 13.1.3). Most fish are found in a variety of habitats; although some fish prefer shallow flowing habitats (e.g. eastern rainbowfish) and some have specific breeding requirements (e.g. gudgeons deposit eggs on substrate, often hard surfaces like rocks or logs). Riffle-pool sequences are thought to be of particular importance to freshwater turtles (particularly *E. albagula* and *R. leukops*), however, riffle zones throughout most of the range of the *E. albagula* and *R. leukops* are likely to be ephemeral, short lived and account for only a minor portion of the total habitat. As such, *E. albagula* and *R. leukops* should not be considered riffle zone specialists (Section 13.1.3). Irrespective, the vast majority of habitat to be flooded following construction of Nathan Dam is existing pool habitat.

Snag habitats and overhanging vegetation habitat

During construction, trees and shrubs will be cleared to FSL within the water storage area, except in the riparian zone of tributaries and the main channel, which will be cleared to within 1.5 m (vertical) of FSL, or where significant vegetation is near FSL. In this case it will be left in place as it may survive for some time, depending on inundation frequency and duration, though it will eventually die. At FSL inundation will extend considerable distances up a number of tributaries but will remain within the original channel, with its original riparian vegetation. When water levels are below FSL overhanging vegetation is likely to be restricted to areas 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, such as directly north of the dam wall on the Dawson River. During vegetation clearing, appropriate material will be salvaged for use as 'large woody debris' fish habitat in the water storage area or diversion channel.

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 (Section 13.2.3.2). Each of the native fish species that may occur in the water storage area require in-stream habitat to provide shelter or for reproduction (Section 13.2.3.3).

The dam will provide less diversity of physical habitat; hence it is important to re-create some through the proposed strategies of snags placed in relatively shallow water (< 5 m) and not clearing LWD including existing tree trunks to FSL to provide structural diversity.

Sand and gravel bars and banks

Following construction of Nathan Dam, existing sand and gravel bars within the water storage will be lost. At FSL sand/gravel bars are not expected to occur within the water storage, however, lower water levels (as expected during the dry (pre-wet) season) may expose sand/gravel bars in the shallower margins of the storage. The temporary, seasonal nature of such bars would thus mimic that observed during baseline surveys of the region – which noted that whilst bars were common during pre-wet season surveys, they were relatively uncommon during the post-wet season (likely due to flows washing them away).

Following the construction of Nathan Dam, the increased permanence of flows occurring between Nathan Dam and Gyranda Weir, particularly those occurring throughout the dry (pre-wet) season – which is traditionally characterised by no to very-low flow – may reduce the formation of sand/gravel bars in this section of the river. The pattern of bar formation downstream of Gyranda Weir is expected to remain relatively unchanged.

Sand bars and banks currently within the water storage may provide nesting habitat for a number of turtle species although no nests were identified during baseline surveys.

- Filling phase impacts

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 FSL. The length of the filling phase is dependent on the rate of inflow, and the water storage area may fill during a single flood event or it may take several years.

As discussed in Chapter 12 and Chapter 16, water quality is likely to be temporarily degraded as the dam fills. The greatest risk to fauna is likely to be low levels of dissolved oxygen in the water storage area, which could impact on fauna populations and potentially lead to fish kills. The impacts of the expected increased turbidity on aquatic fauna were discussed earlier in this section.

The approach to minimising water quality problems in this phase is based on achieving a balance between removal of vegetation from the water storage 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. An operational strategy for the filling phase cannot be finalised until detailed design however will be developed with the aim of maximising the potential for a rapid fill while not impacting on existing downstream water users.

13.2.1.2. Operations

- Fauna community expected to develop within the water storage area

During operation of the dam, the water storage area will provide lentic habitat that will be dominated by open water (pelagic habitat), with littoral and benthic habitat. The water storage will have a long perimeter, one significant island at FSL and a range of depths. The total area of the water storage will be significantly greater than that of the watercourses which were inundated. At FSL inundation will extend considerable distances up a number of tributaries but will remain within the original channel, with its original riparian vegetation. This will increase the amount of deep pool habitat and the connectivity between habitats in these reaches.

The majority of macroinvertebrate species recorded within the study area are not habitat specialists. Therefore, few species are expected to be lost from the dam, other than riffle zone specialists such as blackfly larvae (Simuliidae) and some caddisflies (such as Hydropsychidae and Philorheithridae). No macroinvertebrate species not previously found in the study area are expected to colonise the dam; rather, species are likely to colonise from upstream habitats, and are expected to be similar in composition to the communities currently found in bed, edge and macrophyte habitat, depending on the specific habitat found in different areas of the dam. Taxa colonising the bed habitat in deeper sections of the dam are likely to be least diverse, as is naturally the case.

Similar to macroinvertebrates, the fish species recorded within the water storage area are not habitat specialists. That is, no species are expected to be lost 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 predicted in Chapter 12. For example, gudgeons and catfish prefer habitats that include macrophytes (Allen *et al.,* 2002). Macrophytes also provide spawning habitat for many species that are known in the region, for example Agassiz's glassfish, western carp gudgeons, Pacific blue eye and rainbowfish.

Most species recorded in the study area have previously been recorded in habitats with a variety of substrates (Figure 16-A). However, the shift in substrate composition may have a negative impact on some species that are typically associated with rocky substrates, such as marbled eels and sooty grunter. It may also result in the loss of spawning habitat for species that deposit eggs on gravel surfaces or hard surfaces, such as eel-tailed catfish, gudgeons (purple spotted, Midgley's carp, and flathead), and sleepy cod.

The water storage will provide a stable habitat for aquatic fauna. While the length of riverine sections will decrease there will be an increase in overall wetted area. While the depth of some areas of the water storage will become unsuitable to some aquatic fauna under certain fill conditions, there may be a net increase in diversity of habitat because of that offered by the over-bank areas in the tributaries. Large open water areas will favour pelagic species.

Inundation of riffle-pool habitat has the potential to reduce the area of foraging and nesting habitat for turtles, including *E. albagula* and *R. leukops*. However, both *E. albagula* and *R. leukops* are known to occur in existing impoundments on the Fitzroy River, where only flooded pool habitats are available and banks on the edges of the water storage area are used for nesting (Limpus *et al,.* 2007; frc environmental, 2008). Therefore, the water storage area is likely to be used by these species, along with the others that have been recorded in the study area (Section 13.2.3.4). Ensuring structural habitat remains and is placed within the shallower margins will significantly enhance the potential utility of the storage. Similar to other impoundments in the Fitzroy Basin, turtle communities in the water storage area are likely to be dominated by *Emydura macquarii krefftii.*

Crocodiles were not found in the water storage area and are not expected to colonise the dam. Platypus is discussed in Section 11.1.3.

□ Effects of variations in water level of the water storage

The FSL of the dam is 183.5 m AHD and the minimum operating level (MOL) is 170.0 m AHD. The dam level is expected to fluctuate between FSL and MOL approximately 94% of the time. During operation, the water level of the water storage area will fluctuate less rapidly than in natural streams, simply because of its larger capacity and surface area. The pattern of fluctuations typical to normal, wet and dry periods is described in Section 12.2.1.2. Generally, there are expected to be no apparent baseflow trends or long periods of sustained flow, with rapid infilling over a short period of time as inflows occur, followed by a period of gradual drawdown. During wetter periods the water level fluctuations over a year, other than the short lived flood peaks, tend to be less than about 1 m while in more normal periods that fluctuation increases to about 2 m. During drought it can be over 10 m. In steeper edge areas of the storage the smaller levels of change will have little effect on the available habitat but in low gradient areas a small vertical change can mean that the water's edge may retreat significantly from the riparian zone, exposing the soft bed of the shallow margin.

Steady or steadily reducing water levels, particularly in drought periods, is predicted to promote the growth of emergent macrophytes, and will provide habitat for aquatic fauna. However, during the refilling phase, high water in the water storage area will cause emergent macrophytes to die off. This will result in decomposing vegetative matter; releasing nutrients and reducing dissolved oxygen concentrations. These conditions, if severe enough, can cause fish kills.

Increases in the water level may also inundate turtle nests along the banks, though these are often inundated by natural flooding.

Operational impact of in-stream structures

Water offtakes

There are four routes for water to exit the dam during operation: through a multi-level off take structure; through the fishway; through the turtleway or over the spillway when the volume in storage exceeds FSL. Water to be used in downstream and environmental flows and water destined for Dalby will be sourced from the same multi-level offtake (Chapter 2). This structure will allow offtake from a range of depths or fill levels, ensuring that the highest quality water is available for environmental flows. Water from the offtake will be diverted to the downstream outlet works where it will be discharged into the river through a number of outlet conduits with facilities to regulate and control flow through each.

Potential impacts to fauna that may result from the operation of the offtake structures include entrapment of fauna in the offtake and outlet works. Screens covering the multi-level offtake will direct large fish and turtles towards the fishway entrance. However, fish small enough to fit through the screens (such as gudgeons, hardyheads, glassfish, and juveniles) may enter the multi-level offtake. Some of 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 area occupied by the offtake. The design of the screens at the off-take towers and the location of the off-take in relation to the fish way will be discussed with Fisheries Qld during consultation on finalising the fishway design.

Spillway operation

The spillway will be 200–300 m in width and will be approximately 23.5 m above the stilling basin. While the effects of fauna overtopping weirs and spillways is poorly understood, some fish and turtles have been observed dying after overtopping weirs during large flow events (Clay 1995). Mortality is thought to be the result of impact forces and shearing against the concrete spillway. Factors affecting survival are the height of the spillway, whether it is stepped or smooth and the size of the animal. Turtles and fish are the animals most likely to be near the spillway, and suffer mortality as a result of going over the spillway. The spillway has been designed to be smooth and thus, turtles will be unable to climb over and into the spillway. Additionally, the aquatic habitat near the dam wall will likely be less utilised by turtles due to the depth of the water. 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.

Energy dissipation devices

If the dissipation device is not appropriately designed, it may result in a velocity barrier in the Dawson River for fish and turtles, preventing upstream migration to the fishway. Other potential impacts include entrapment of fauna in the stilling basin and subsequent damage from floods or debris and increased predation.

Impacts to aquatic fauna will be reduced through spillway and energy dissipation devices which will be constructed such that fish and turtles are prevented from entering the stilling basin from downstream and being injured by floodwaters and debris coming over the spillway. Any stabilisation works required on river banks downstream from the dam will aim to provide habitat as well as perform their engineering function.

Proposed fauna transfer devices

The dam wall is, without mitigation, a complete barrier to upstream fauna movement and an almost complete barrier to downstream movement. A fishway has been included in the preliminary design to accommodate both movement directions and is intended to service the needs of other fauna, including turtles. The detailed design of the facility will be finalised following further consultation with relevant agencies and experts, and in general accordance with the process provided by QPIF. The concept design is for a lift and lift arrangement, which will operate such that at least the current opportunity for movement is maintained. In effect the current proposed operational strategy will provide greater opportunity for movement in terms of times that the river flows, because it overcompensates slightly in the low flow range, largely through releases through the fishway. The apparatus can also operate from minimum operating volume, meaning there is very little limit on the operational range of the fishway.

The dam will affect fish species differently, depending on their need to migrate and their ability to navigate fishways. Most of the fish fauna captured surrounding the dam footprint are expected to be potamodromous; i.e. they 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. Provided that suitable breeding habitat exists on either side of an obstruction, the impacts of the obstruction are less severe to populations of potamodromous fish than they are to species of catadromous fish. Catadromous fish, such as barramundi and marbled eels, migrate from freshwater to saltwater for breeding and cannot reproduce if obstructed. Some of the fish from the vicinity of the dam are likely to be amphidromous; i.e. they migrate interchangeably from fresh to salt waters, but not specifically to breed.

Fish lift structures are likely to provide adequate passage for most fish species present, if they are designed to mitigate the limitations of previous structures, maintained in good working order, monitored and fine-tuned to improve performance.

Impediments to fish movement at the dam wall will be reduced by constructing fishway structures (largely from Stuart *et al.* 2007). The intent of the structure design will be to:

- use an impassable downstream barrier to direct fish away from the spillway towards the fishway 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 fishway;
- vary attraction flows as river flows vary;
- operate over a range of head and tailwater levels;
- use high quality water (surface) as attractant provided with little turbulence;
- provide attractant flows and fishway cycles for fish migrating downstream; and
- use a sloping chamber rather than a follower cage to encourage exit from the fishway.

They should also be:

- maintained in working order, monitored and fine-tuned to improve performance;

- remotely operated and can be functional at any time of year; and
- reduce the chances of fish migrating upstream passing back over the spillway.

If the impoundment water in the dam turns over, there may be a physico-chemical barrier to upstream fish migration despite use of the multi-level offtake.

With respect to turtle movement, fishways have traditionally been less successful in providing adequate passage for turtles, which move within rivers to access feeding and / or breeding habitat. Turtles prefer to walk upstream rather than use fishways and are unlikely to use the fishway in significant numbers. A turtleway has been included as a design feature of the dam and will accommodate the upstream and downstream movement of turtles past the dam wall (Chapter 2).

The fishway and the spillway stilling basin will be designed with the aim of maximising potential movement while reducing the potential for physical damage. DERM turtle experts have been consulted and this consultation will continue to ensure maximum potential benefits are identified and achieved.

It should be noted that while the fauna transfer devices on Nathan Dam will incorporate the best technology available, the numerous weirs downstream on the Dawson River, and at Glebe Weir, do not have such devices so the change in net impact on fauna movement within the Dawson River system will be relatively minor.

Changes to flow regime and associated factors downstream

Flow regime

Section 28.5 provides a detailed assessment of potential impacts to aquatic fauna of national environmental significance (Fitzroy River turtle). The following section presents statistics describing the broader flow regime of the Pre-development, Full Entitlement (current development) and 'With Dam' scenarios. There will be a range of impacts on the flow regime along the Dawson River due to the operation of Nathan Dam. The impacts of the dam decrease with distance downstream from the dam, as flow from additional tributaries enters the river.

Impacts to the flow regime directly downstream of the dam (at Nathan Gorge) can be summarised as follows:

- low flows – the low flow range (0 to 70 ML/d) will return to near pre-development levels due to the low flow release strategies adopted;
- medium flows – the medium flow range (70 to 30,000 ML/d) will be moderately reduced in the ranges of 70 to 200 ML/d and 1,500 to 30,000 ML/d. The flow range between 200 to 1,500 ML/d will be slightly increased towards predevelopment levels;
- high flows - the high flow range (flows over 30,000 ML/d) will not change significantly;
- overall flow volume – the overall flow volume (on an annual basis) will decrease;

The Project will have minimal impacts on flow regimes in the Fitzroy River, downstream of the Dawson River.

The dam Impacts from changes in flow regimes will be more pronounced immediately downstream of the dam. The closest streamflow gauge to the dam site is the Nathan Gorge gauge, 8.1 km downstream of the dam. The streamflow record shows that flow at the Nathan Gorge gauge occurs in large flow pulses, with periods of low flow between events

(Figure 13-2). Modelling shows that this general pattern of large flow pulses and low flows will continue with the dam in place.

The modelled flow duration curves show that the dam at Nathan Gorge, and at all downstream locations on the Dawson River in the 'With Dam' scenario, the flow regime will more closely simulate natural flows than the present Full Entitlements scenario for low flow periods. This includes all flows with a daily flow exceedance of greater than 41% at Nathan and at similar exceedances downstream. This is due to flows released for Low Flow, Fishway and Turtleway operation, the seasonal baseflow release and flows released to maintain downstream storage volumes.

Low to medium flows, in the 70 to 200 ML/d range, are moderately impacted in the 'With Dam' scenario at Nathan Gorge. However, downstream of Nathan Gorge flows in this range are not as highly impacted. This flow range is substantially increased downstream of Theodore, primarily due to the seasonal baseflow release and releases to Moura Weir from Theodore Weir.

Medium to high flows, in the 1,500 to 30,000 ML/d range, are moderately impacted in the 'With Dam' scenario. (This range generally covers flushing flows through to half bankfull flows in this reach.) This is particularly evident at Nathan Gorge as these flows are generally captured by the dam; however, these impacts decrease at downstream locations.

Flows above 30,000 ML/d usually occur as part of a large flood event, when the dam receives enough inflow to fill. The larger flows therefore pass through the storage with minimal loss of volume.

By the end of the Dawson River the flow regime has moved closer to pre-development in the 48-94 percentile flow range, although a slight decrease is evident in the mid to high range. The former is primarily due to inflows from the Don River catchment. The impacts of the dam on flows in the Lower Fitzroy River are not perceptible, mainly due to inflows from the Nogoa-Mackenzie catchment.

Water quality and connectivity

When assessing the potential risks to water quality and connectivity as a result of changed flow conditions, two environmental indicators have been used. These are the 10 cm and 30 cm above the cease to flow (CTF) level. The 10 cm flow provides an indicator of riffle flows, while the 30 cm flow provides an indicator of stream connectivity and potential for fish and other fauna movement. Flow depths of 10 cm and 30 cm above CTF levels are equivalent to flows of 9.0 and 48.5 ML/d, respectively throughout the 2 km reach of the Dawson River between the wall of Nathan Dam and the headwaters of Gyranda Weir. The operational strategy encompasses a low flow environmental release which mirrors the dam inflows, up to a maximum release of 50 ML/d.

With known nesting sites for the Fitzroy River turtle located within Theodore Weir (Limpus pers. comm.), an assessment of flows within the unimpounded section of the Dawson River between Orange Creek Weir and Theodore Weir was undertaken (Chapter 28). This assessment focused on flows associated with the maintenance of water quality, access and maintenance of foraging habitat and potential for unseasonal flood of nesting banks. Results from this assessment indicate that:

- riffle forming flows will most likely increase in the months of the turtle nesting season, with this trend continuing in all months except April and May where a small reduction in the 10 cm flows is possible;

- a similar trend is noted for the 30 cm flows which facilitate movement between pools. Seasonal water demands create good connectivity during the nesting season with slight reductions in autumn and winter.
- no unseasonal flooding of turtle nesting banks is expected; and
- overall, Nathan Dam is not expected to decrease the quality, abundance or availability of potential downstream habitat for the Fitzroy River turtle or white throated snapping turtle.

Other key water quality parameters that may be affected by the dam include dissolved oxygen, turbidity, temperature, and nutrient concentration. The quality of the water received downstream from a dam is dependent on whether the impoundment is stratified, whether there are blue-green algal blooms in the impoundment, and existing management measures to manage the release of water, such as the location of offtake valves. While rapid changes of temperature during an overturn event (where cool deep waters upwell to the surface) have been known to be detrimental or fatal to aquatic fauna, as discussed in Section 16.2.1, hydrological analysis (Chapter 14) and evidence from other storages in the Fitzroy Basin (Section 16.1.4) suggest that strong stratification is not likely, except in periods of prolonged drought. Such conditions might occur once in approximately 20 years. Regular monitoring to detect the potential for blue-green algal outbreaks however will be undertaken and standard management measures implemented in the case of a breakout.

Regardless of if and when stratification of the storage may occur, a multi-level offtake will allow warm surface waters rich in oxygen to be used as environmental flows at a range of fill levels.

After filling and stabilising, sediments will drop out of suspension and the dam will act as a trap for sediments and nutrients. Trapping of sediments is not likely to have a substantial impact on the ecology of downstream waters given the suspended sediment and nutrient loads entering downstream reaches from diffuse catchment runoff (Chapter 14). Changes in water quality in the freshwaters downstream of the confluence with the Mackenzie River are unlikely, due to catchment influences having a greater impact on water quality than releases from the dam. As the changes in the volume of flows, seasonal patterns, and frequency of high flows to the Fitzroy estuary as a result of the Nathan Dam will be minimal (Chapter 14), changes to water quality in the estuary, including a reduction in salinity due to reduced flows, are highly unlikely. Therefore, no significant impacts to estuarine or marine fauna are predicted.

Extent and importance of downstream wetlands to be impacted by reduced flooding

Downstream of the dam, there are several off-stream wetlands and channels that are connected to the main channel of the Dawson River during floods. None of these, however, are listed as significant on the EPA database or Directory of Important Wetlands in Australia.

The Water Resource Plan (WRP) includes Environmental Flow Objectives (EFOs) for floodplain zones. The closest EFO node with this objective is Node 2 (Dawson River at Beckers). The floodplain zone statistic compares the number of events which inundate floodplain habitats under a development scenario to the number of events which would have occurred under pre-development conditions. A floodplain flow release is made from the dam in order to supplement flood flows at EFO node 2 (Dawson River at Beckers) for the floodplain zone statistic EFO. The release occurs when the dam is at or above FSL and inflows to the dam are between 20,000 ML/d and 140,000 ML/d, reflecting a likely flood event at Beckers. The release is limited to 19,870 ML/d, the maximum capacity of outlet 2.

There will be no discernable impacts to flow in the Fitzroy River or downstream (**Chapter 14**), and Nathan Dam is not expected to impact on water quality, the location of the salt wedge or sediment input to the Fitzroy Estuary (**Chapter 16**). Therefore no significant impacts on estuarine and marine fauna inhabiting the GBRWHA and the Shoalwater and Corio Bays Area Ramsar site are expected.

Habitat structure

Scouring of sediments downstream from the dam wall may be expected to occur between the Nathan Dam wall and the headwaters of Gyranda Weir, due to the sediment trapping effect of the dam. This effect may be limited by bed and bank rock outcropping along the channel, however, geotechnical studies conducted at the dam wall indicate that significant vertical scour may occur due to the fact that the bed is comprised of a mixture of sands and clay (**Chapter 14**). Given that the Dawson River has an oversupply of sediment compared with pre-development conditions, this represents a return to a more natural state.

Flow duration curves (**Chapter 14**) indicate that downstream channel contraction and stabilisation is not likely to occur between the Nathan Dam wall and the headwaters of Gyranda Weir, due to little impact to flows above 10,000 ML/d (flows upward of 14,500 are considered important for maintaining in-channel features, whilst flows upwards of 33,800 ML/d are considered important for maintaining overall channel dimensions (**Chapter 14**)).

Flow duration curves also indicate that, following construction of Nathan Dam, an increase in the frequency of riffle forming flows (9 ML/d) will occur immediately downstream of Gyranda Weir, with this increase becoming minor at Beckers and negligible by the end of the Dawson River. An increase in flows of this range should not be viewed as a negative impact as it represents a shift in the flow regime towards conditions occurring prior to regulation of the Dawson River. The expected increase of flows in this range should therefore be considered to benefit aquatic habitat structure.

Overall, little impact to habitat structure is expected downstream of Nathan Dam, with potential impacts largely mitigated by the highly regulated nature of the Dawson River between Taroom and it's junction with the Fitzroy River.

Effects on species of conservation significance

The only species of conservation significance within the area potentially impacted by the Project are the Fitzroy River turtle (*Rheodytes leukops*) and the white-throated snapping turtle (*Elseya albagula*). The Fitzroy River turtle has not been formally recorded in the study area, however it is likely to be present. The white-throated snapping turtle has been captured in the study area (Limpus *et al.*, 2007). Both turtles are known to occur in existing impoundments on the Fitzroy River as well as in the Dawson River at Theodore Weir (approximately 128 km downstream of Glebe Weir (Limpus *et al.*, 2007)). Populations of both species are higher in the lower or mid-reaches of the Fitzroy Basin, with the core of the Fitzroy River turtle population in the barrage, an area which will be unaffected by any aspect of the Project.

Populations of these species immediately downstream of the dam are not likely to be significantly impacted as changes to flows are not expected to significantly alter the habitat structure or water quality characteristic of this reach.

Environmental strategies proposed to ensure minimal impact to the Fitzroy River turtle and the white-throated snapping turtle are presented below. The strategies incorporate commitments already made in the Description of Project as well as items based on previous advice from Col Limpus, a DERM turtle expert. SunWater is committed to continue consultation with DERM, SEWPaC and Fisheries Queensland in regards to mitigation measures proposed. The mitigation strategies are:

- capture and translocation of fauna within the construction footprint prior to works commencing;
- provision for aquatic fauna passage at all temporary and permanent watercourse crossings;
- provide snag habitat in shallow areas on the edge of the storage and in in-flowing tributaries by not clearing within 1.5 m vertical of FSL and through placement of snags salvaged during clearing of the impoundment area;
- use of a smooth spillway;
- design and orientate screens and filters on intakes to prevent turtles being attracted to the intakes and trapped;
- reduce mortality and injury to turtles during passage over impoundment structures during over-topping events by providing a 'soft landing' e.g. a deep stilling basin;
- reduce death and injury of turtles aggregated at or within the downstream side of outlet structures by reducing the velocity of high volume water release events and excluding turtles from outlet structures that produce high velocities;
- discourage turtles from climbing unsafe locations on impoundments by, for example, having an overhanging, smooth surface at least 1m high immediately below the structure lip;
- increase in the rate of release of water from outlet structures gradually in order to prevent physical damage to turtles;
- restrict the stocking of fish which prey upon turtles (particularly hatchlings) in the impoundment (This is SunWater's preferred position but stocking is controlled by DEEDI);
- reduce the incidence of death and injury to turtles from boat strike, propeller cuts and fishing activities (SunWater will provide informational signage at the boat ramps);
- maintain flows downstream that 'mimic' the natural characteristics, particularly the post winter and base flows as determined by the WRP;
- manage terrestrial and aquatic weeds in the storage area, the flood margin and riparian rehabilitation area to prevent them from blocking access to suitable nesting habitat for turtles;
- monitor the changes in nesting banks downstream from infrastructure and, where necessary, rehabilitate nesting banks that have not rejuvenated as a result of reduced flood flows (SunWater commits to find nesting banks at Theodore Weir and then to sponsor this monitoring and rehabilitation (the latter if shown to be necessary),in that area);
- manage riverine sand mining so that it does not negatively impact on turtle nesting banks (The Project does not propose sand mining in the Dawson River). SunWater will source materials from licensed providers; and
- manage the terrestrial zone around the impoundment to reduce loss of turtle eggs from predation by feral and native animals and avoid damage to nesting habitat from trampling by stock to increase nesting opportunities and the recruitment of hatchlings into the river (the Project includes management of the flood margin and riparian rehabilitation area. This includes reduced grazing and management to control weeds and feral animals).

In summary, once the above strategies are implemented it is suggested that while impacts to Fitzroy River turtle are possible they are likely to be few. With the exception of a single anecdotal record within the water storage area, no Fitzroy River turtles have been reported within the Project area. The habitat value of the storage itself will be maximised as far as practical, by the proposed mitigation strategies and the Project's riparian zone and environmental offset strategy. Downstream flow regime impacts can be effectively mitigated by adherence to the environmental flow objectives of the Water Resource Plan. SunWater suggests that the residual impacts are minor and acceptable.

SunWater commits to monitor the impacts and the effectiveness of mitigation strategies. Final design of the monitoring program will be developed in consultation with DERM and SEWPaC. Monitoring will include:

- recording the sex and number of individuals moved, and where they were moved to, during translocation from the construction area (most appropriate relocation sites will be confirmed with DERM turtle experts). Individuals will be pit tagged using DERM approved techniques;
- annual population surveys will be undertaken during the nesting season in areas upstream of the water storage area which supports suitable habitat, within the water storage and downstream as far as Theodore Weir to assess the population and the likelihood of nesting (using non-invasive ultrasound techniques). All individuals captured will be pit tagged. Results will be assessed with respect to the monitored flow regime, dam water levels, fishway and turtleway evaluations and changes over time;
- if nesting is observed within the dam catchment, the nests will be protected from predators using mesh cages (as used in the Fitzroy Barrage and Mary River) and the site will be inspected for evidence of hatching at the appropriate time;
- use of the fishway and turtleway will be monitored and reported; and
- offtakes, outlet structures and the spillway will be inspected for evidence of injury or death caused to turtles and any such observations will be reported to DERM. If evidence suggests that design of the screens, stilling basin or outlet structures can be improved to avoid or minimise such instances, feasible and practical modifications will be undertaken as a corrective action.

SunWater suggests that if the monitoring programs do not detect the species within the water storage, or do not find nesting banks in particular areas after a reasonable period, say five years, then SunWater's sponsorship of such monitoring should cease.

There is a general belief that traditional fish transfer devices do not adequately cater for turtles. However, the most recent monitoring data from Paradise Dam on the Burnett River (QPIF 2009) shows that the upstream fishway is catering for significant numbers of some turtle species. Irrespective, the Nathan Dam proposal includes a specific turtleway. The transfer device will include pit tag readers to easily monitor turtle movement.

Effects on commercial and recreational fisheries

As there is no local commercial fishery and limited recreational use, negative impacts will be negligible. However, there will very likely be positive impacts as many species encountered during surveys are targeted by recreational fishers and recreation areas with boat ramps will be provided at the storage. Water storages are often stocked with large predatory fish species (e.g. golden perch and grunters) to promote their recreational fishing values. If the Nathan Dam were stocked with these species, opportunities for recreational freshwater fishing in the region would be enhanced, although as they are already present, stocking may not be necessary.

No discernable impacts to the timing and magnitude of flows to the Fitzroy estuary are expected (Chapter 14); therefore, the dam is not predicted to impact on estuarine, coastal or offshore fisheries.

Potential for introduction or increase of translocated, exotic and noxious fauna

Silver perch (*Bidyanus bidyanus)* and sooty grunter *(Hephaestus fuliginosus)* are considered to be translocated species in the Fitzroy Basin and may establish within Nathan Dam; however, their impact on smaller, native fishes is likely to be minimal.

Two exotic species, mosquitofish (*Gambusia holbrooki*) and goldfish (*Carassius auratus*)) were recorded in the study area. They will certainly inhabit the dam but their impact upon aquatic ecosystems is not expected to increase relevant to the current situation.

It is acknowledged that there is risk of transfer of exotic fish species into the water storage area on boats using the storage, when used as live bait by fishers or simply through release of aquarium fish into the storage by members of the public. As a whole, live fish need to be transferred along with a mate (or carrying already fertilised eggs), the risk of translocation/introduction of exotic fish species not already occurring within the Dawson River (and tributaries) is thus considered low. SunWater will provide signage regarding this issue at the recreation areas.

13.2.2. Pipeline

Construction of the pipeline between the dam and Dalby has the potential to impact surrounding aquatic fauna and habitat through:

- the direct loss of fauna and aquatic habitat at waterway crossings;
- changes to water quality, flow regime, erosion and sedimentation surrounding pipeline crossings;
- runoff from works areas leading to turbidity increases in waterways; and
- fuel and oil spills.

13.2.2.1. Potential impacts and mitigation measures

Without appropriate management, vegetation clearing and/or sediment disturbance can result in erosion, which can in turn increase turbidity and reduce available aquatic fauna habitat. As with the potential impacts upon aquatic flora communities (Section 12.2.2), the overall potential impact of placement of the pipeline on aquatic fauna communities is considered low, as crossings constitute a relatively small total area of the creek and much of the habitat consists of intermittent dry areas with occasional intermittent or perennial pools.

After pipeline crossings have been constructed, the newly formed bed and banks will be appropriately stabilised and rehabilitated to prevent scour. On this basis, impacts from the placement of the pipeline would be ecologically negligible. Opportunities to mitigate the potential impacts of waterway crossings are provided in Section 12.2.2 and below. The critical feature is to minimise riparian zone clearing in the first place and to rehabilitate as much of the easement as possible.

As per the Project Description, it will be important to undertake crossings in the dry season and to rehabilitate before significant flows occur.

The pipeline route is generally straight and traverses several hills, and will adopt standard procedures for drainage control to direct runoff from the easement onto vegetated areas and not directly into watercourses unless it cannot be avoided.

Vehicles involved in the construction and maintenance of the pipeline could impact on aquatic habitat or water quality should a fuel or oil spill occur within a waterway. The risk associated with this activity is considered low as works will be undertaken during dry conditions to limit the potential for dispersal. Emergency spill equipment will be on hand at all times to capture and contain any potential spillages.

Operation of the pipeline (i.e. the act of pumping water from one location to another) has the potential to translocate aquatic fauna. That is, organisms may be drawn into the pipeline at the dam and transferred along its length to the receiving environment. However, the consequences of transfer of aquatic fauna are considered to be negligible as the only two exotic species recorded in the Project area (mosquitofish (*Gambusia holbrooki*) and goldfish, (*Carassius auratus*)) are already well established within the Condamine catchment (DPI, 2008). Irrespective, it is unlikely that they would survive transport through the pipeline and pump stations or would be able to survive in the most likely discharge location, which would be a scour point on generally dry ground.

General mitigation measures for the installation of the pipeline presented in Chapter 12 are applicable to preventing or minimising impacts to aquatic fauna. The construction of temporary creek crossings during the construction of the pipeline will further minimise disruption of fish passage where:

- the crossing structures at each site follow the recommendations presented in Chapter 12;
- culverts used for temporary crossings are designed in accordance with QPIF guidelines to allow fauna passage (Section 13.2.3.1); and
- culverts are removed when pipeline construction is complete, and the riparian vegetation is rehabilitated.

Operational phase impacts of the pipeline relate primarily to the discharges at scour or pigging points when the line is flushed. This releases water and associated biofilm. The discharge is initially to an energy dissipation pit which then overflows to the surrounding ground and either soaks in or evaporates. Discharge areas will not be near watercourses in order to minimise the impact on water quality in any nearby pools. It is possible that the discharges could contain aquatic flora or fauna but it is unlikely that they would survive transport through the pipeline and pump stations or would be able to survive in the discharge location.

13.2.3. Associated infrastructure

13.2.3.1. Potential impacts and mitigation measures

Clay borrow pits for construction will, in some locations directly remove materials from a watercourse, therefore removing habitat. Each site will also require disturbance of the riparian zone for the access track or tracks plus clearing of stockpile and works areas on nearby land. These impacts will be localised and, assuming extraction is from a dry bed and a high standard of sediment and erosion control is undertaken, will be relatively minor. All such sites will be within the water storage so the temporary impacts noted here will be superseded by inundation.

All roadworks will be constructed in accordance with applicable guidelines and aim not to act as a barrier to fauna movement or to block the downstream transport of natural debris. If temporary isolation of the work site is required and fauna salvage is necessary it will be conducted in accordance with the procedures discussed previously.

The temporary bridging required in order to construct the pipeline in significant streams is designed to allow flow and so will mitigate significant issues.

Issues related to construction camps are primarily associated with sediment and runoff control and the treatment of wastewater. Given the procedures outlined in Chapter 2 and the location of camps not directly adjacent to a watercourse, so significant impacts would not be expected.

Mitigation measures for associated infrastructure are consistent with those presented for the dam and pipeline in Sections 13.2.1 and 13.2.2.

13.2.4. Impact assessment and residual risks

The methodology used for risk assessment and management is discussed in Section 1.8.

This section assesses the risks relevant to aquatic fauna and summarises the mitigation measures proposed to minimise those risks. Where significant residual risks remain after mitigation, offsets are described where practicable.

Risks associated with construction and operation phases of the Project are presented in Table 13-15 and Table 13-14, respectively. The definition of consequence and likelihood is presented in Chapter 26. The risk assessment is of the Project as described in Chapter 2, in which SunWater has already incorporated a range of risk reduction and mitigation measures.

Based on this assessment, the following conclusions can be made:

- while there may be a small reduction in diversity of aquatic fauna communities (associated with a reduction in habitat diversity) in the water storage area, implementation of mitigation measures to minimise this loss will reduce the risk to as low as reasonably practicable; and
- feasible mitigation actions are described in Sections 13.2.1, 13.2.2 and 13.2.3, and these will be reflected in the Environmental Management Plans and/or the Proponent Commitments.

Based on this risk assessment, the impacts relevant to aquatic fauna can be effectively managed and the residual risks are acceptable.

Table 13-15 Risk assessment – construction

Hazards	Factors	Impacts	Project Description Controls & Standard Industry Practice	Risk with controls			Additional Mitigation Measures	Mitigation effectiveness	Residual risk		
				C	L	Current risk			C	L	Mitigated risk
Physical impacts to fauna and / or habitat during construction and water extraction.		Reduction in diversity and abundance of aquatic fauna communities.	Removal and translocation of larger aquatic fauna from isolated areas. Screening and floating booms with a cage around intake pipes. Aquatic fauna and habitat present in the water storage area remain within the Project area and are well represented within catchment.	Minor	Likely	Medium			Minor	Likely	Medium
Degraded downstream water quality during dam and pipeline construction (including earthworks, cleaning and grouting).	Impact will increase in severity following rainfall events.	Temporary reduction in diversity and abundance of aquatic fauna communities.	Implementation of sediment and erosion control plan including routine monitoring.	Moderate	Possible	Medium			Moderate	Possible	Medium

Hazards	Factors	Impacts	Project Description Controls & Standard Industry Practice	Risk with controls			Additional Mitigation Measures	Mitigation effectiveness	Residual risk		
				C	L	Current risk			C	L	Mitigated risk
Creating mosquito and biting midge breeding sites.	Construction and operational activities that result in pooled water will potentially provide an increase in mosquito and biting midge breeding habitat in the study area. The margins of the dam may provide suitable breeding habitat. Native fish species will reduce impact	Potentially problematic for the health of human occupants within proximity to impacted area (including construction workers).	Minimisation of likelihood through an effective mosquito and biting midge management plan	Minor	Possible	Medium			Minor	Possible	Medium
Restriction of fauna passage	Physical and possible water quality barrier .	Temporary, localised reduction in diversity and abundance.	Construction of a diversion channel	Minor	Possible	Medium			Minor	Possible	Medium
Degraded water quality within water storage during first filling phase	Rate of filling	Temporary, localised reduction in diversity and abundance.	Vegetation clearing strategy	Minor	Possible	Medium			Minor	Possible	Medium

Table 13-16 Risk assessment – operation

Hazards	Factors	Impacts	Project Description Controls & Standard Industry Practice	Risk with controls			Additional Mitigation Measures	Mitigation effectiveness	Residual risk		
				C	L	Current Risk			C	L	Mitigated risk
Impacts to aquatic fauna movement / migration due to the dam wall.	If the fishway and turtleway do not perform as designed, the dam wall will become a barrier to aquatic fauna movement. If the energy dissipation device is not appropriately designed, it may result in a velocity barrier in the Dawson River for fish and turtles.	Reduction in diversity of fish and turtle species.	Designing and maintaining the fishway and turtleway following consultation with relevant agencies and experts. Ensuring correct design of energy dissipation device. The fishway and turtleway are expected to allow fauna movement.	Moderate	Unlikely	Medium	Incorporate knowledge from continuing monitoring of this and other structures and including the Fitzroy River turtle turtleway project.	Moderate	Minor	Unlikely	Low
Reduction in diversity of aquatic fauna habitat.	Creation of the water storage area.	Reduction in diversity of aquatic fauna communities within the water storage.	Salvaging aquatic fauna habitat (e.g. trees) to be used as large woody debris habitat in the dam. Rock spalls will similarly be used. Large areas of aquatic fauna habitat present in the water storage area remain within the Project area and are well represented within catchment.	Minor	Absolute	Medium			Minor	Absolute	Medium
Change in aquatic fauna habitat downstream of the water storage area.	Change in flow regime.	Reduction in diversity or shift in composition of aquatic fauna communities downstream of Nathan Dam. Potential risk to water quality.	Operational flow regime, multi level offtake, minimise water level fluctuations and monitoring program. Large areas of aquatic fauna habitat present downstream of the water storage area remain within the Project area and are well represented within catchment. water storage area	Minor	Possible	Medium			Minor	Possible	Medium

Hazards	Factors	Impacts	Project Description Controls & Standard Industry Practice	Risk with controls			Additional Mitigation Measures	Mitigation effectiveness	Residual risk		
				C	L	Current Risk			C	L	Mitigated risk
Temporary reduction in abundance of fish and turtle populations due to entrapment in water offtake structures.	This hazard only exists for fauna small enough to fit through screens on intake structures.	Temporary reduction in abundance of fish and turtle populations due to mortality	Screens over intake structures Consultation with relevant experts to ensure potential hazard is minimised.	Minor	Unlikely	Low	Listed in detail on page 55-56.	Significantly	Minor	Unlikely	Low
Introduction/translocation of exotic fauna species within dam and surrounds waterways.	Two translocated and two exotic species have been recorded within the water storage. Recreational fisherman may accidentally/ unknowingly introduce /translocates species.	Reduction in diversity of native aquatic fauna communities.	Implementation of awareness/education campaign (posting of sign, etc.)	Moderate	Unlikely	Medium			Moderate	Unlikely	Medium
Negative impacts upon fauna and flora inhabiting downstream estuarine and marine ecosystems.	Deterioration of water quality, flow or sediment regime	Reduction in diversity and/or altered structure, of flora and fauna communities inhabiting downstream estuarine and marine ecosystems.	The closest estuarine receiving system is situated approximately 650 km downstream. Multi-level offtake tower will ensure only water of appropriate quality will be released downstream. Compliance with mandatory environmental flow objectives (EFOs) will ensure that downstream flow regime is maintained.	Minor	Rare	Low			Minor	Rare	Low

13.3. Cumulative impacts

Due to the highly regulated nature of the Dawson River (including the existing Glebe Weir) the cumulative impact upon aquatic fauna within the Dawson sub-catchment and the wider Fitzroy Basin, associated specifically with the construction of Nathan Dam is considered to be low. There are no other known water related projects which would impact on aquatic fauna within the Dawson River. Other construction related projects could impact on water quality but those presently known are either on very small tributaries or are in the Condamine catchment.

The cumulative impacts of existing and proposed (Connors River Dam, Nathan Dam and Lower Fitzroy Weirs water infrastructure on flows in the Fitzroy Basin were modelled (Chapter 14). Each of these developments is in the early approvals phase and requires a full business case to be developed and approved before they can proceed. It is not assured that they will all progress. The performance of the Cumulative Impacts scenarios was assessed against the WRP environmental flow objectives: seasonal baseflow, first post winter flow and medium to high flows (Chapter 14).

The WRP environmental flow objectives are met under the Cumulative Impacts scenario in most cases, and where they are not met initially, operational strategies will be revised to ensure that they are met (at least in the case of mandatory flow objectives) (Chapter 14). Therefore, the assessment of impacts to movement and migration cues for fauna in the Fitzroy River (i.e. downstream of the confluence of the Dawson River, and in the reaches affected by the proposed weirs) is consistent with that described for the Connors Dam; i.e. no major disruption of cues or impacts to estuarine and coastal fisheries productivity are expected due to the cumulative impacts of proposed water infrastructure.

Construction of the proposed water infrastructure will result in a greater proportion of lacustrine (pool) habitat in the Fitzroy Basin, at the expense of habitat such as runs, glides, riffle and backwater. This is likely to result in a reduction in biodiversity and a shift in community composition in the affected reaches, and a reduction in the extent of these habitat types within the Fitzroy Basin. However, the cumulative impacts of these developments are not expected to result in an overall reduction in aquatic fauna diversity in the Fitzroy Basin (through for example, regional extinctions).

With respect to potential cumulative impacts on the Fitzroy River turtle relating to movement, SunWater will implement a multi-tiered management approach with respect to turtle passage as follows:

- installation of an effective turtle bypass, specifically designed to facilitate movement of turtles past the dam wall;
- development and implementation of a rigorous monitoring program for turtles, and an adaptive response program where identified outcomes are not being met;
- fishway design which explicitly takes account of the needs of turtles;
- intake tower screen design that prevents turtles entering the system; and
- barrier design that prevents turtles entering downstream release areas where they might be injured by high flow velocities.

While it is considered very likely that effective transfer will result from the design outlined above, SunWater suggests that if monitoring shows this is not the case, effective short term transfer and genetic mixing could be achieved by simple catch and carry techniques. The technique can also be used for other turtle species. In the longer term the results from SunWater sponsored programs noted below could be incorporated into the modification of turtle transfer devices, if required. SunWater does not anticipate that such actions will be necessary but is committing to the long term success of turtle movement processes at Nathan Dam and is prepared to undertake the necessary actions to ensure that success.

SunWater will provide an environmental offset. The direct offset for this Project is suggested as protection and management of sections of river and riparian zone downstream from the dam which may support the species. This would need to be negotiated and agreed with the landowner/s. Management measures would include reduction of grazing pressure, weed control and feral animal control. It is suggested that further survey be directed in this region to identify areas of greatest utility to the species, particularly nesting areas, and that these be the target of management actions. The environmental offset strategy for the Project includes the need to find and secure suitable Order 5/6 stream watercourse vegetation (to meet State requirements) as well as habitat for the Boggomoss Snail. SunWater aims to achieve this as far as possible in the area immediately downstream of the dam. This will be of direct benefit to the Fitzroy River turtle and the aim is to co-locate these offsets. An Order 5/6 offset relates to protection of a 200 m wide strip of riparian zone either side of the river and SunWater aims to obtain as much of this offset as possible between the dam and Theodore.

The SunWater Board and shareholding ministers have also approved a commitment of $4 M from the dividend reinvestment scheme toward design, construction and monitoring of turtle transfer systems. The approved project will place emphasis on Fitzroy River turtles. It is envisaged that an existing weir which currently has no facility for passage will be fitted with alternative designs and the designs will then be modified depending on results of monitoring. It is currently envisaged that Tartrus Weir on the Mackenzie River will be targeted as it is known to represent a significant barrier and DERM turtle research team members have observed Fitzroy River Turtles congregating in the rock pools downstream. DERM turtle experts will assist with the process and Central Queensland University will be invited to participate by way of postgraduate research projects. It is expected that the Project, which has commenced, will continue over approximately two years. The results will be used to inform the design of turtle transfer facilities on any future dams or weirs and enable informed retrofitting to existing structures. The Project has direct links to the "Overcoming the barriers – fishways" component of the approved regional NRM body (Fitzroy Basin Association) investment plan.

SunWater is the proponent or joint proponent for three projects in the Fitzroy catchment (Connors River Dam, Nathan Dam and Lower Fitzroy Weirs) and each of these projects is likely to have residual impacts on the Fitzroy River Turtle after implementation of all mitigation strategies. Each is likely to offer direct offsets in or near its area of impact as has been done for Nathan Dam above. SunWater recognises the potential for cumulative impacts on the species. SunWater suggests that a catchment wide research and monitoring program, linked to the necessary monitoring associated with each project, should be implemented. It is only relatively recently that night time sampling techniques using spotlighting have been shown to be an effective means of finding the species. Coupled with a sparse geographic sampling effort over the years as a result of limited funding, SunWater suggests that a systematic survey using the now recognised most useful techniques, is highly likely to significantly increase the known range of the species and the estimates of population density. The recent photographic evidence of a specimen from Glebe Weir as well a new records below Orange Creek Weir increases the range by 100 river kilometres from Theodore Weir and it is very likely that the species will be found in between these locations and possibly upstream of the Glebe Weir pool, though repeated surveys (sampling has often been in difficult conditions) have failed to locate it. Similarly a review of Figure 4.2 in Limpus *et al* (2007) for example, suggests there are no known occurrences between Cardowan and a point near where the Mackenzie River joins the Dawson River, a distance of over 250 river kilometres. This is considered highly unlikely as the species is known to exist both upstream and downstream and only two sites have historically been sampled in this long stretch of river.

SunWater proposes to commit $100,000 per annum per constructed project for a period of five years to this program. The design of the program would be formulated via discussion with SEWPaC, DERM and relevant researchers. It is intended to link the funding to the "Biodiversity and Vegetation" component of the existing FBA regional NRM plan and to Central Queensland University research programs in order that the SunWater seed funding can be used to leverage further funding or in-kind support, thereby substantially increasing the scope of the Project. The "Biodiversity and Vegetation" component of the regional NRM plan includes Fitzroy River Turtle as a focus species and community engagement in turtle conservation, primarily through Greening Australia and other volunteers protecting nest sites in certain downstream areas, has been very successful. For example it was suggested that approximately 90% of nests are predated if protection by volunteers is not undertaken.

SunWater suggests that the research should be directed at both ecological parameters (distribution, abundance, location of nesting areas, etc.) and at practical means to reduce the impact of existing structures. As SunWater manages a number of existing structures in the system, such knowledge will be very useful with respect to possible adjustment of the operational regimes in order to reduce incidental impacts to turtles. Limpus *et al* (2007, page 16-17) suggested that with such a catchment wide approach "it will be possible to reverse the negative impact of not only the new infrastructure developments but to also compensate for the cumulative impacts".

13.4. Summary

This section has assessed the potential impact of the Project on aquatic fauna within the Dawson River catchment and greater Fitzroy Basin. This assessment showed that:

- as no significant flow, water quality or sediment regime changes are predicted in the estuary or nearshore environments as a result of the Project, no impacts are predicted on fauna in those locations, including in the GBRWHA and the Shoalwater and Corio Bays Area Ramsar site;
- potential impacts associated with the Project can be effectively managed and mitigated through Environmental Management Plans for erosion and sediment control, dam construction and operations (including factors such as rehabilitation of habitat in the water storage area and effective design of the fishway), and rehabilitation of both temporary and permanent creek crossings; and implementation of best-practice fuel-handling and storage;
- as proposed water infrastructure in the Fitzroy Basin (i.e. Connors River Dam, Nathan Dam and Lower Fitzroy Weirs) will be operated to provide ecologically critical environmental flows, and will be fitted with effective fishways and turtle transfer mechanisms, the cumulative impacts of this water infrastructure to aquatic fauna are expected to be minimal and acceptable;
- the aquatic fauna community in the dam and surrounds study area is diverse and comprised primarily of common and widespread taxa. Although composition of aquatic fauna communities is expected to shift towards those species preferring pool habitat, the diversity of aquatic fauna communities is not expected to decrease;
- only one species protected under State or Commonwealth legislation is expected to be present in the dam and surrounds study area. The Fitzroy River turtle was not recorded during the baseline surveys, however, effective breeding populations are noted to be present in weir pools elsewhere in the Fitzroy Basin. As key flows responsible

for the maintenance of water quality, foraging habitat and habitat connectivity are not anticipated to change significantly following construction of Nathan Dam, and movement past the dam wall will be facilitated via the construction of a turtleway, the potential for significant impact on this species is considered low;

- the white-throated snapping turtle was recorded in the study area and is listed as 'least concern' under the NC Act, and has been identified as a high priority for conservation in the DERM's species prioritisation framework. The known habitat preferences of this species suggest that this species will be able to establish within the Nathan Dam water storage. Additionally, movement past the dam wall will be facilitated via the construction of a turtleway. Accordingly, the risk of impact upon this species following the construction of Nathan Dam is considered to be low;
- two exotic (*Gambusia holbrooki* and *Carassius auratus*) and two translocated (*Bidyanus bidyanus* and *Hephaestus fuliginosus)* fish species were recorded in the study area. However, the risks of transfer, or introduction of new species, are low;
- physical disturbance at construction sites and as a result of inundation has the potential to directly impact fauna causing mortality. The scale of the impact area within the local region is not likely to be significant and the DPIF Fish salvage guidelines will be utilised to minimise any potential impacts;
- the water storage will be colonised by most of the native species that inhabited the river and streams though the proportional abundance will change. Given likely good water quality, relatively low probably of significant stratification and turnover and only occasional major level long term water level changes, the lake is expected to be productive and to support a diverse native fauna;
- no commercial fishery exists in the area or is reliant upon breeding from the area;
- a fishway will be provided and will have a broad operational range. It is expected to be suited to a wide range of species;
- the preliminary operational strategy maintains the downstream flows in accordance with the WRP and ecosystem requirements. In conjunction with use of the multi-level offtake, the Project is expected to deliver suitable water quality and flows; and
- based on this risk assessment, the impacts relevant to aquatic fauna can be effectively managed and the residual risks are acceptable.