BORR Team

APPENDIX F

Bunbury Outer Ring Road Northern and Central Investigation Area: Targeted Conservation Significant Aquatic Fauna Survey (WRM 2019)

BUNBURY OUTER RING ROAD NORTHERN AND CENTRAL INVESTIGATION AREA: TARGETED CONSERVATION SIGNIFICANT AQUATIC FAUNA SURVEY

NOVEMBER 2018 SAMPLING

FINAL REPORT

April 2019



Study Team

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Disclaimer

Document history

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Frontispiece (left to right): Northern 1; Carter's freshwater mussel (*Westralunio carteri*); and, Northern 7 (all photos by WRM© /November 2018).

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EXECUTIVE SUMMARY

The Commissioner of Main Roads Western Australia (Main Roads) is proposing to construct and operate the Northern and Central sections of the Bunbury Outer Ring Road project (Figure 1). The BORR is a planned Controlled Access Highway linking the Forrest Highway and Bussell Highway and will provide a high standard route for access to the Bunbury Port and facilitating proposed development to the east of the city of Bunbury. The completed BORR will also provide an effective bypass of Bunbury for inter-regional traffic. Project development of the BORR is being conducted through the BORR Integrated Project Team (IPT) which is composed of Main Roads, GHD and BG&E.

A desktop study identified a number of potential habitats for aquatic fauna within the northern and central BORR investigation area, including a number of wetlands of varying sizes/extents and a number of creeklines/river systems. The overarching objective of the survey was to determine the occurrence of any aquatic fauna considered to be of conservation significance within these systems. Wetland Research & Management (WRM) was sub-contracted by the BORR Team to undertake this survey.

In November 2018, 12 sites which lie within the northern and central BORR investigation area were sampled, with four species of conservation significance being targeted:

- Carter's freshwater mussel (*Westralunio carteri*); Vulnerable (Schedule 3 of the Wildlife Conservation Specially Protected Fauna Notice 2018), Vulnerable (International Union for Conservation of Nature (IUCN) Redlist 2018), Vulnerable (Environment Protection and Biodiversity Conservation (EPBC) Act 1999),
- Black-stripe minnow (*Galaxiella nigrostriata*); Endangered (Schedule 2 of the Wildlife Conservation Specially Protected Fauna Notice 2018), Lower Risk/Near Threatened (IUCN Redlist 2018), Endangered (EPBC Act 1999), Endangered (Australian Society of Fish Biology (ASFB 2016),
- Western mud minnow (*Galaxiella munda*); Vulnerable (Schedule 3 of Wildlife Conservation Specially Protected Fauna Notice 20178), Lower Risk/Near Threatened (IUCN Redlist 2018), and
- Australian water rat (*Hydromys chrysogaster*); Priority 4 (Department of Biodiversity Conservation and Attractions (DBCA) 2018).

Habitat assessments and *in-situ* water quality measurements were also made in conjunction with the aquatic fauna survey, as well as observations of any other freshwater fauna at each site (Table 1).

A total of 926 individual fish were caught during the current study, including seven native and two introduced species. One black-stripe minnow was recorded (site Northern 9), and Carter's freshwater mussels were present at four sites.

Other native aquatic fauna recorded included:

- Freshwater cobbler *Tandanus Bostocki* (North Creek 2, North Creek 5), south-western goby *Afurcagobius suppositus* (Northern 3, North Creek 1), Swan River goby *Pseudogobius olorum* (Northern 3, Northern 5, North Creek 1, North Creek 2), western minnow *Galaxias occidentalis* (Northern 3, North Creek 1, North Creek 2, North Creek 5), nightfish *Bostockia porosa* (North Creek 1, North Creek 5) and western hardyhead *Leptatherina wallacei* (North Creek 1)
- Two freshwater crayfish: smooth marron *Cherax cainii* (North Creek 2) and gilgie *Cherax quinquecarinatus* (Northern 5, North Creek 1, North Creek 5)
- the south-western snake-necked turtle *Chelodina colliei* (Northern 1, Northern 5, Northern 8 and North Creek 2).

Aside from the black-stripe minnow, none of the native fish species recorded are listed on any state, national or international conservation lists, although all except the Swan River goby and western minnow are south-west endemic. The south-western snake necked turtle is protected under the provisions of the *Biodiversity Conservation Act 2016*, and is listed on the IUCN Redlist of Threatened Species as Near Threatened.

Three introduced species were recorded, including the mosquitofish *Gambusia holbrooki* (Northern 3, 5, 8 and North Creek 1 and 5), goldfish *Carassius auratus* (Northern 5), and the yabby *Cherax destructor* (Northern 5).

Table 1. Freshwater fauna recorded at northern and central investigation area sites in November 2018.

Species	Site									
	Northern 1	Northern 3	Northern 5	Northern 8	Northern 9	North Creek 1	North Creek 2	North creek 3	North Creek 4	North Creek 5
Black-stripe minnow					✓					
Freshwater cobbler							✓			✓
Nightfish						✓				✓
South-western goby		✓				✓				
Swan River goby		✓				✓	✓			✓
Western hardyhead						✓				
Western minnow		✓				✓	✓			✓
Goldfish			✓							
Mosquitofish		✓	✓	✓		✓				✓
Yabby			✓							
Marron							✓			
Gilgie			✓			✓				✓
Carter's freshwater mussel							✓	✓	✓	✓
Snake-necked turtle	✓		✓	✓			✓			

1 INTRODUCTION

1.1 Background

The Commissioner of Main Roads Western Australia (Main Roads) is proposing to construct and operate the Northern and Central sections of the Bunbury Outer Ring Road project (Figure 1). The BORR is a planned Controlled Access Highway linking the Forrest Highway and Bussell Highway and will provide a high standard route for access to the Bunbury Port and facilitating proposed development to the east of the city of Bunbury. The completed BORR will also provide an effective bypass of Bunbury for inter-regional traffic. Project development of the BORR is being conducted through the BORR Integrated Project Team (IPT) which is composed of Main Roads, GHD and BG&E.

The overarching objective of the survey was to determine the occurrence of any aquatic fauna considered to be of conservation significance within the proposed investigation area. Based on species' distributions and habitat present, the wetlands of interest could provide habitat for State, Federally and internationally listed species including:

- Carter's freshwater mussel (*Westralunio carteri*); Vulnerable (Schedule 3 of the Wildlife Conservation Specially Protected Fauna Notice 2018), Vulnerable (IUCN Redlist 2018), Vulnerable (EPBC Act 1999),
- Black-stripe minnow (*Galaxiella nigrostriata*); Endangered (Schedule 2 of the Wildlife Conservation Specially Protected Fauna Notice 2018), Lower Risk/Near Threatened (IUCN Redlist 2018), Endangered (EPBC Act 1999), Endangered (Australian Society of Fish Biology (ASFB 2016),
- Western mud minnow (*Galaxiella munda*); Vulnerable (Schedule 3 of Wildlife Conservation Specially Protected Fauna Notice 2018), Lower Risk/Near Threatened (IUCN Redlist 2018), and
- Australian water rat (*Hydromys chrysogaster*); Priority 4 (DBCA 2018).

As such, these species were specifically targeted by WRM in the November 2018 survey.

1.2 Scope of works

The scope of works for the targeted conservation significant aquatic fauna survey were:

- systematic sampling of aquatic fauna, *in situ* water quality (pH, DO, EC & temperature), habitat assessments, motion sensor camera trap recordings, and observations of other fauna (if present),
- an assessment of the conservation status of aquatic fauna recorded, and
- preparation of a detailed technical report of all findings.

2 SPECIES OF CONSERVATION SIGNIFICANCE

Aquatic ecosystems in the south-west of the state support a diverse range of taxa with different local, regional, national and international distributions, and therefore taxa vary in their conservation status depending upon their distribution and evolutionary origins. The conservation significance of aquatic fauna recorded was assessed by referring to:

- Threatened Fauna under the IUCN Redlist of Threatened Species (IUCN 2018),
- Scheduled Fauna listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act 1999),
- Priority Fauna recognised by the Department of Biodiversity, Conservation and Attractions (DBCA 2018), and
- Conservation status of Australian Fishes List (Australian Society for Fish Biology 2016).

Four species of conservation significance were specifically targeted during this survey. Information on each species is outlined below.

2.1 Carter's freshwater mussel

Carter's freshwater mussel (*Westralunio carteri*; Plate 1) is currently listed as Vulnerable on state (Schedule 2; DBCA 2018), national (EPBC Act 1999), and international (IUCN Redlist 2018) conservation lists. This species occurs in greatest abundance in slower flowing waters with stable sediments and low salinity. The lifecycle involves an obligate parasitic stage, glochidia, which attach to host fish for several weeks to complete their development (Beatty *et al*. 2010).

Carter's freshwater mussel is endemic to the South West Coast Drainage Division, where it is the only freshwater mussel to be found. The distribution of this species is from the Moore River in the north, to the south coast, west of Esperance (Klunzinger *et al*. 2010). Carter's freshwater mussel is threatened by secondary salinisation, as well as sedimentation. Reservoir dewatering and rainfall reductions also appear to have a negative effect on populations (Klunzinger *et al*. 2012).

Plate 1.Carter's freshwater mussels, photo by WRM ©.

2.2 Black-stripe minnow

The black-stripe minnow (*Galaxiella nigrostriatal*; Plate 2) is currently listed as Endangered (Schedule 2 of the Wildlife Conservation Specially Protected Fauna Notice 2018), Lower Risk/Near Threatened (IUCN Redlist 2018) and Endangered under the Federal EPBC Act (1999). The black-stripe minnow is capable of aestivating (burrowing) into soils to survive dry summers and will appear in pools within hours following first rains. Interestingly, it does not have any specific anatomical, physiological, or behavioural adaptations to aid aestivation, and presumably survives within moist soils or crayfish burrows that contain water through the dry season. Most fish only live for one year, dying shortly after spawning (Morgan *et al*. 2011).

The black-stripe minnow is endemic to south-western Australia and rare throughout its distribution. Its main distribution lies within 100 km of the coast, between Albany and Augusta, with isolated populations known from further north, including Lake Chandala (Gingin), Melaleuca Park (Perth), and wetlands within the Kemerton Nature Reserve (Bunbury) (Morgan *et al*. 1998, Allen *et al.* 2002). A survey by WRM in October 2018 within the southern alternate development area, also recorded a population of black-stripe minnows near Gelorup (WRM 2019 – refer to our southern alternate investigation area final report). They are restricted to shallow, tannin stained, ephemeral pools and are most common in waterbodies of peat flats (Morgan and Gill 2000). It is thought that the populations on the Swan Coastal Plain are remnants of a once wider distribution (Morgan *et al.* 1998), suggesting that the loss of habitat caused by massive urban and rural development during the previous hundred years has had a significant impact on this species. As such, their biggest threat is loss of suitable habitat through urbanisation and rural development.

Plate 2. Black-stripe minnow, photo WRM ©.

2.3 Western mud minnow

The western mud minnow (*Galaxiella munda*) is currently listed as Vulnerable (Schedule 3 of Wildlife Conservation Specially Protected Fauna Notice 2018) and Lower Risk/Near Threatened (IUCN Redlist 2018). Adults live close to riparian vegetation in streams and open water of pools that are tannin stained and acidic (pH 3 – 6). The lifecycle of the western mud minnow typically lasts for one year (Morgan *et al*. 1998).

The western mud minnow is restricted in its distribution, from Margaret River to Albany, with an isolated population in Gingin. This species is most common in headwaters of major rivers and in shallow pools connected to streams (Morgan *et al*. 1998). The western mud minnow is threatened by salinisation, land clearing and the introduction of exotic fish species such as mosquitofish (Morgan *et al*. 1998).

2.4 Australian water rat

The Australian water rat (*Hydromys chrysogaster*; Plate 3) is currently listed as a Priority 4 (DBCA 2018). Water rats are adapted to semi-aquatic life with broad, partially webbed feet and water repellent fur (Scott and Grant 1997). They are opportunistic feeders, often preying on large aquatic invertebrates, fish, mussels and crustaceans.

The Australian water rat is distributed across a range of habitats from permanent water bodies to lowland streams, with the highest abundances associated with permanent wetlands (Scott and Grant 1997). Threats to their distribution include swamp reduction and flood mitigation practices.

Plate 3. Australian water rat, *Hydromys chrysogaster* (photo taken and provided by Bert and Bab Wells)

3 METHODS

This study was conducted under Department of Primary Industries and Regional Development (DPIRD) Fisheries Licence EXEM 2483 (*Instruments of Exemption to the Fish Resources Management Act 1994* for Scientific Research Purposes). As a condition of this licence, taxa lists and reports are required to be submitted to DPIRD.

Sampling was undertaken over four consecutive days, 23rd to 26th November 2018.

Aquatic fauna sampling by WRM is consistent with methodology used by others in similar surveys across Australia (i.e. Cheal *et al.* 1993, Storey *et al.* 1993, Edward *et al.* 1994), including the sampling of wetlands of the SCP by Murdoch University (Davis *et al.* 1993) and the National Monitoring River Health Initiative (Department of Environment Sport and Territories *et al*. 1994).

3.1 Sampling sites

Assessment of aerial images identified a total of 11 potential sites where aquatic fauna of conservation significance may occur. During the on-ground survey, one of the sites (Northern 4) was dry. In lieu of this site, two additional sites were sourced (North Creek 3 and North Creek 4) however, only *in situ* water quality, habitat assessment and visual observations of any fauna were undertaken at the two additional sites. In total, 12 sites were surveyed; five creek/river sites and seven wetlands.

See Figures 1 to 9 and Table 1 for site locations.

Table 2. Survey sites sampled in November 2018. GPS in UTMs (Zone 50).

Northern and central investigation area		GPS		
Site	Creek/river system	Zone	Easting	Northing
North Creek 1	Collie River	50	385502	6314612
North Creek 2	Preston River	50	379297	6303282
North Creek 3	Collie River tributary	50	383993	6315508
North Creek 4	Millars Creek	50	385167	6311922
North Creek 5	Ferguson River	50	377008	6307549
Northern 1		50	384148	6318099
Northern 2		50	384684	6317630
Northern 3		50	385589	6314505
Northern 4		50	381911	6308024
Northern 5		50	381206	6307767
Northern 7		50	379056	6304461
Northern 8		50	379387	6305074
Northern 9		50	377037	6304974

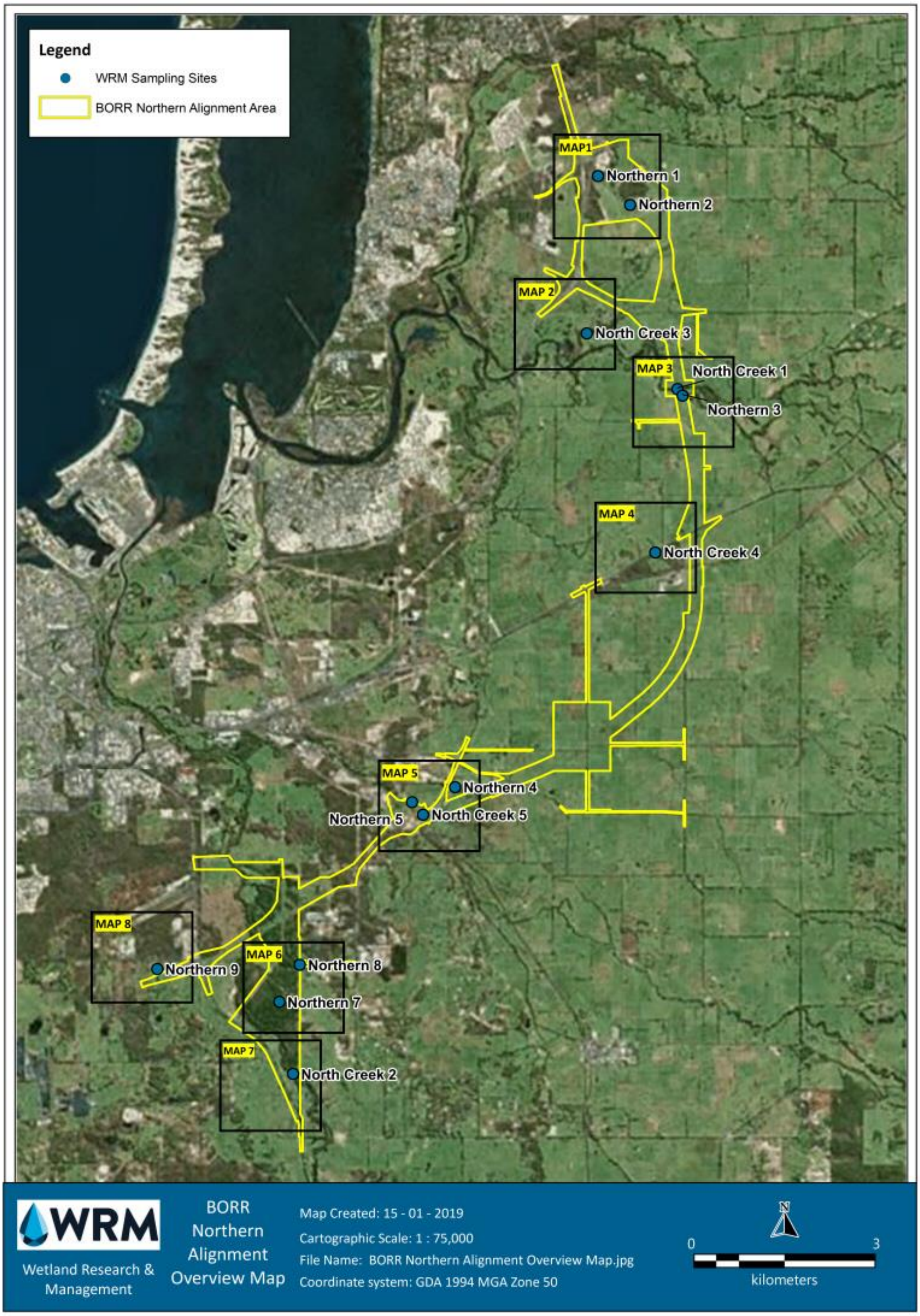

Figure 1. Map of the study area, showing aquatic sampling sites.

Figure 2. **Map of Northern 1 and 2.**

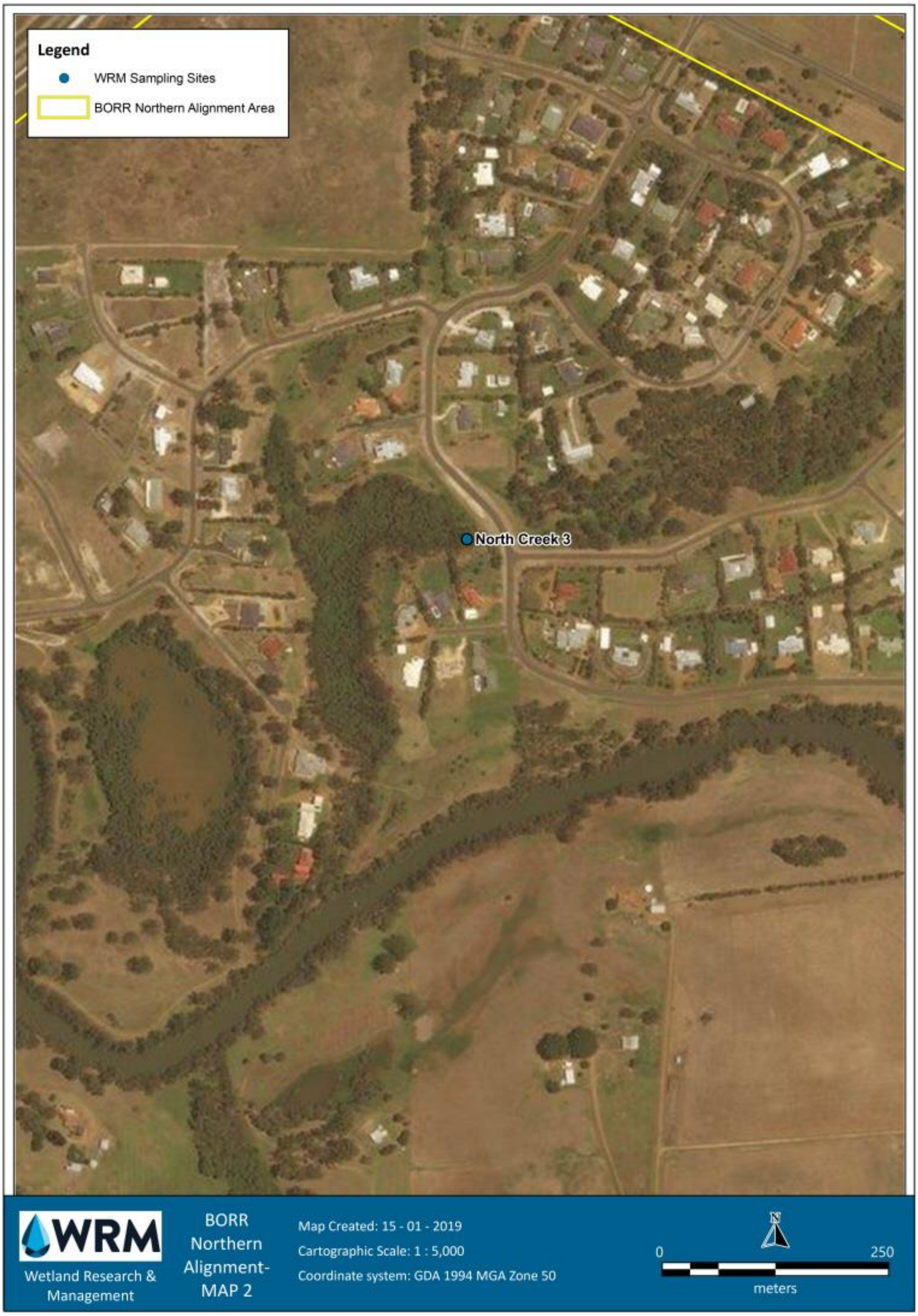

Figure 3. Map of North Creek 3.

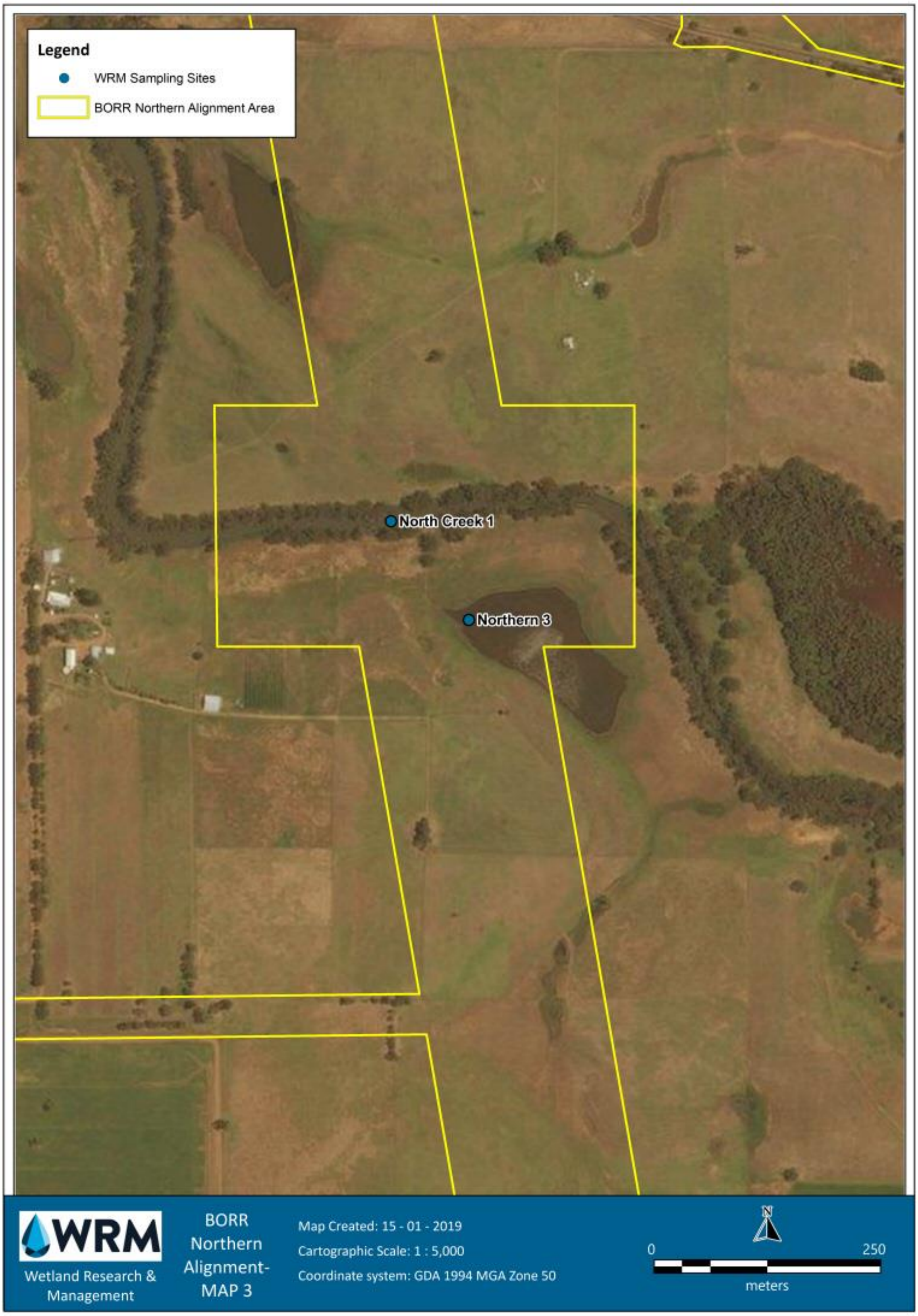

Figure 4. Map of North Creek 1 and Northern 3.

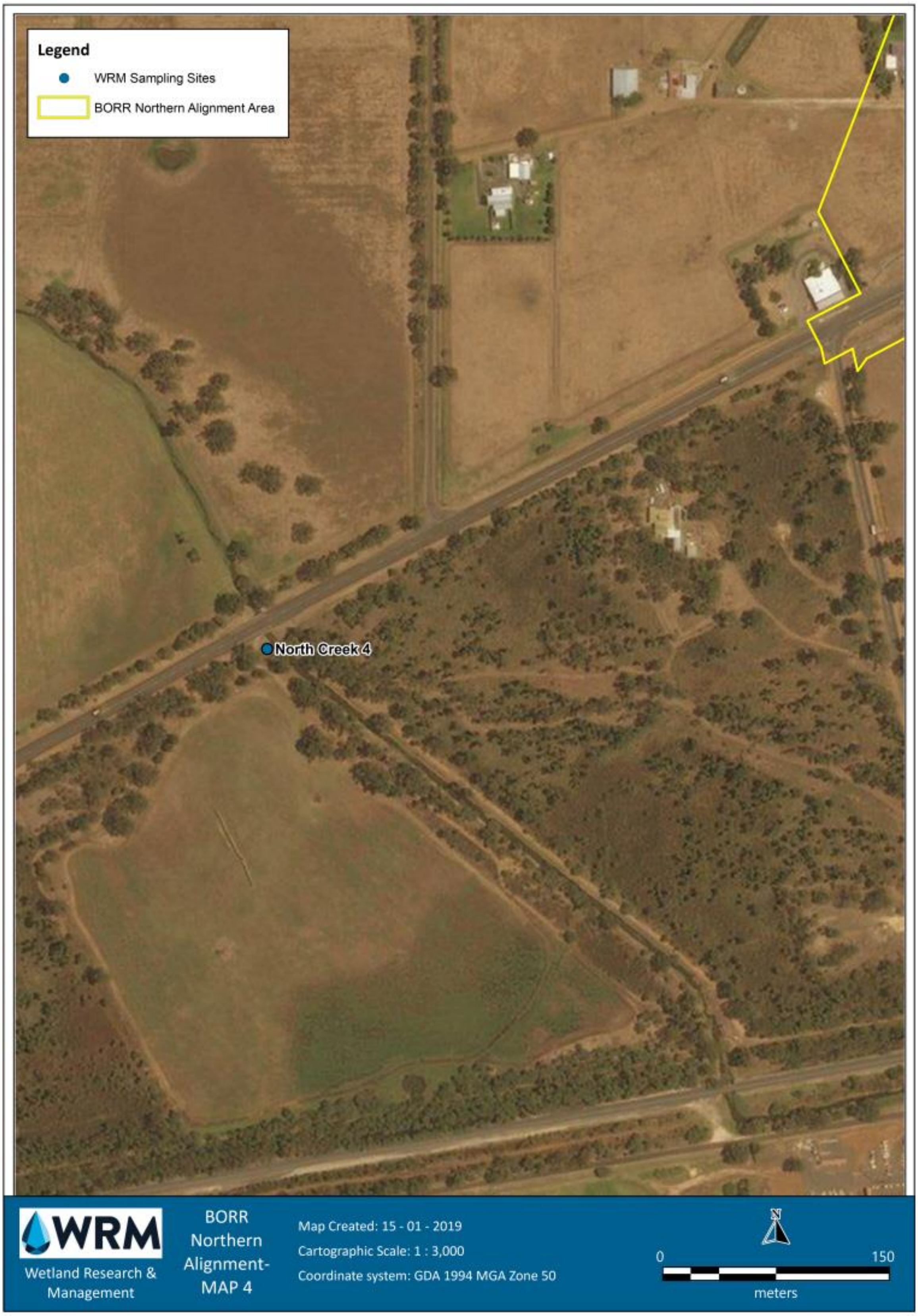

Figure 5. **Map of North Creek 4.**

Figure 6. **Map of Northern 4, Northern 5 and North Creek 5.**

Figure 7. **Map of Northern 7 and 8.**

Figure 8. Map of North Creek 2.

Figure 9. Map of Northern 9.

3.2 Targeted aquatic fauna survey

3.1.1 Carter's freshwater mussel

At each site, the benthos within randomly placed 1 m^2 quadrats was intensively surveyed by hand collection, rake, dip net and sieves. Approximately 10 quadrats per site were surveyed.

3.1.2 Black-stripe minnow and western mud minnow

A number of fish sampling methods were used at each site in order to collect as many species and individuals as possible. Methods included dip nets, trawl nets, seine nets, fyke nets and box traps.

A minimum of three fyke nets, comprising a single or double 10 m wing (4 - 6 mm mesh, 1.5 m drop) and a 5 m hooped net were set overnight at each site. A float was placed at the cod-end to provide an air space for freshwater turtles and water rats (Plate 4).

A minimum of five baited box traps were set overnight at each site, depending on the habitat available. Shallower water depths with dense vegetation where fyke nets could not be effectively set, were sampled using seine, trawl and/or dip nets. The number of trawls was dependent on habitat availability and the number of fish captured.

All fish were identified in the field following nomenclature of Allen *et al.* (2002) and standard length (SL mm)[1] measured. The measurement of fish provided information on population structure, breeding and recruitment. In order to comply with conditions of the Fisheries Exemption, any introduced species that were caught were not returned to the environment. Condition 8 of the exemption states: "*All species of fish, other than known introduced species, shall be immediately returned to their natural environment with the least possible injury*." Therefore, introduced fish were euthanised humanely in an ice slurry. All other fish and aquatic fauna (crayfish, frogs, turtles) were returned alive to the water.

Plate 4. Fyke nets set within Northern 2

[1] Standard length - measured from the tip of the snout to the posterior end of the last vertebra or to the posterior end of the midlateral portion of the hypural plate (i.e. this measurement excludes the length of the caudal fin).

3.1.3 Australian water rat

A minimum of two motion sensor cameras were deployed overnight at each site, positioned towards the ground/water body to target water rats. Each camera was baited with universal bait, a mixture of oats, sardines and peanut butter. Cameras were set on high sensitivity, with bursts of three images with no or short delay periods.

Visual surveys were also conducted at each site for evidence of water rat presence. This included the observation of feeding middens. Photographic evidence was taken of any visual signs of water rat presence.

3.1.4 Water quality

In situ water quality data were recorded using portable WTW and TPS field meters. Variables recorded included pH, dissolved oxygen (DO; % and mg/L), electrical conductivity (EC; µS/cm) and water temperature (°C).

3.1.5 Habitat

Details of habitat characteristics were recorded from each site. WRM has specific worksheets for this task so that recordings between sites remain as comparable as possible. Habitat characteristics recorded included percent cover by inorganic sediment, submerged macrophyte, floating macrophyte, emergent macrophyte, algae, large woody debris, detritus, roots and trailing vegetation. Details of substrate composition were also recorded and included percent cover by bedrock, boulders, cobbles, pebbles, gravel, sand, silt and clay.

3.1.6 Opportunistic sightings

Freshwater crayfish were sampled using the methods described above for fish fauna, specifically, dip netting, box traps and fyke nets. Crayfish were identified to species, carapace length measured (CL mm), and sex noted. Opportunistic records of any turtle or frog species observed whilst sampling were also made, with turtles sexed and measured for carapace (shell) length. Turtles are often captured using sampling methods designed for fish (especially fyke netting). Opportunistic survey of frog species included identification of:

- any adults seen while sampling for aquatic fauna, and
- species identified from mating calls.

4 RESULTS AND DISCUSSION

4.1 Water quality

4.1.1 *In situ*

In situ water quality was generally good and characterised by acidic to basic pH (5.99 to 8.70), extremely low to very high dissolved oxygen (6.2% to 264.0%), and warm temperatures (18.0 °C to 27.0 °C; Table 2). Most sites were fresh to brackish, with one saline site as defined by the DoE (2003)[2] (Northern 3) with conductivity ranging from 304 µs/cm (at Northern 1) to 6010 µs/cm (at Northern 3).

pH was within the default ANZECC/ARMCANZ (2000) guidelines values (GVs) for the protection of slightly/moderately disturbed wetland ecosystems in the southwest of W.A. (pH 6 - 8) at all sites except Northern 3 and North Creek 4. pH from Northern 3 (5.99) was only slightly below the lower default GV, while that from North Creek 4 (8.70) was in excess of the upper default GV (Table 2). However, the pH recorded from these sites is considered natural, and not likely to negatively impact resident aquatic fauna.

Likewise, four sites recorded DO saturation less than the lower ANZECC/ARMCANZ (2000) guideline value (GV; 90%); North Creek 3 (24.3%), Northern 1 (76.8%), Northern 2 (69.3%) and Northern 7 (6.2%). While the oxygen needs of aquatic biota differ between species and life history stage, values less than 50% saturation are known to result in chronic responses in macroinvertebrates and fish (Butler *et al.* 1970, Davis 1975, Alabaster and Lloyd 1982). The DO recorded from Northern 7 was highly anoxic and would undoubtedly affect the aquatic fauna that could reside there. Three sites recorded super-saturated DO, in excess of the upper ANZECC/ARMCANZ (2000) GV (120%); North Creek 4 (184%), Northern 5 (264.0%) and Northern 8 (202.3%). Super-saturation occurs when net photosynthesis exceeds total oxygen consumption, and is common in areas of high algal and macrophyte growth, and/or areas of high turbulence. Sites which have high day-time DO are likely to experience oxygen stress overnight, as respiration by plants, algae, bacteria and other aquatic fauna deplete DO. Super-saturation is also known to cause gas bubble disease in fish (Bouck 1980).

[2] Fresh defined as < 1500 µS/cm, Brackish = 1500 – 4500 µS/cm, Saline = 4500 – 50,000 µS/cm, Hypersaline > 50,000 µS/cm (DoE 2003). Classifications were presented as TDS (mg/L) in DoE (2003) so a conversion factor of 0.68 was used to convert to conductivity µS/cm as recommended by ANZECC/ARMCANZ (2000).

Table 3. *In situ* water quality results from all sites sampled in November 2018.

Site	Date	Temp°C	Cond (us/cm)	pH	DO%	DO mg/L
				ANZECC GV		
				6.0-8.0	90-120%	
North Creek 1	25/11/2018	18.8	2120	6.67	97.7	9.2
North Creek 2	23/11/2018	20.4	650	6.79	84.1	7.7
North Creek 3	24/11/2018	19.1	2480	6.99	24.3	2.1
North Creek 4	24/11/2018	25.4	2860	8.70	184.9	15.1
North Creek 5	24/11/2018	18.0	2050	7.37	95.8	9.0
Northern 1	25/11/2018	20.7	304	6.14	76.8	6.8
Northern 2	25/11/2018	19.4	669	6.83	69.3	6.4
Northern 3	25/11/2018	23.8	6010	5.99	106.1	9.1
Northern 5	24/11/2018	27.0	1865	7.31	264.0	20.3
Northern 7	23/11/2018	21.5	345	6.45	6.2	0.5
Northern 8	23/11/2018	25.0	645	6.66	202.3	16.6
Northern 9	23/11/2018	26.1	3360	7.70	109.7	9.0

4.2 Habitat

Habitat type varied between sites from ephemeral wetlands and small creeks, through to fairly major river systems such as the Preston and Collie River. Three sites had a percentage of submerged macrophyte (5% at Northern 3, 8 and 9), and all sites had a diversity of instream habitat types including large woody debris (LWD), emergent macrophyte, detritus, floating macrophyte and/or trailing vegetation (see Plates 5 to 6). All sites sampled were predominantly sand substrate.

Northern 1

Northern 2

Northern 3

Northern 5

North Creek 5

Northern 7

Plate 5. **Site photographs from Northern 1, 2, 3, 5, North Creek 5 and Northern 7 at the time of sampling in November 2018.**

Northern 8

Northern 9

North Creek 1 (Collie River)

North Creek 2 (Preston River)

North Creek 3 (trib. of the Collie River)

North Creek 4 (Millars Creek)

Plate 6. Site photographs from Northern 8, 9 and North Creek 1, 2 3 and 4 at the time of sampling in November 2018.

4.3 Fish

4.3.1 Species composition and abundance

A total of 926 individual fish were caught from seven sites during the current study, including seven native and two introduced species (Table 3). One black-stripe minnow (*Galaxiella nigrostriata*; Plate 7) was recorded at Northern 9. This site was sampled slightly north of the investigation boundary, as it was the only area with surface water deep enough to sample effectively. It would connect to the water within the investigation area during periods of high rainfall, and has likely only been isolated recently (wet sediments were still present at the time of sampling). Other native fish recorded from the northern BORR investigation area included freshwater cobbler (*Tandanus bostocki*), south-western goby (*Afurcagobius suppositus*), Swan River goby (*Pseudogobius olorum*), western minnow (*Galaxias occidentalis*), nightfish (*Bostockia porosa*) and western hardyhead (*leptatherina wallacei*). None of these species are listed on any state, national or international conservation lists, although all except the Swan River goby and western minnow are south-west endemic. Introduced mosquitofish (*Gambusia holbrooki*) were recorded from Northern 3, Northern 5, Northern 8, North Creek 1 and North Creek 5, and goldfish (*Carassius auratus*) from Northern 5 (Plate 8; see section 4.3.3 for further information on the impacts of introduced fish to native species).

No fish were recorded from Northern 1, 2 or 7.

Table 4. Fish caught during the aquatic fauna survey, November 2018.

		Site							
		Northern 3	Northern 5	Northern 8	Northern 9	North Creek 1	North Creek 2	North Creek 5	Total
Native	Black-stripe minnow	0	0	0	1	0	0	0	**1**
	Freshwater cobbler	0	0	0	0	0	20	12	**32**
	Nightfish	0	0	0	0	1	0	2	**3**
	South-western goby	1	0	0	0	11	0	0	**12**
	Swan River goby	115	0	0	0	8	1	154	**278**
	Western hardyhead	0	0	0	0	30	0	0	**30**
	Western minnow	1	0	0	0	16	5	115	**137**
Introduced	Goldfish	0	1	0	0	0	0	0	**1**
	Mosquitofish	5	275	200	0	1	0	1	**482**
	Total	**122**	**276**	**200**	**1**	**67**	**26**	**284**	**976**

Plate 7. Black-stripe minnow, *Galaxiella nigrostriata* in breeding colours (photo by WRM ©).

Goldfish

Mosquitofish

Plate 8. Introduced fish recorded in November 2018.

4.3.2 Conservation listed species

The black-stripe minnow that was recorded at Northern 9, measured only 26 mm (SL). This individual was most likely an early 2018 recruit, and indicates that breeding occurs within this wetland. Although no other black-stripe minnows were recorded during the sampling effort, a number of sites showed similar habitat and water quality characteristics to the October 2018 survey (i.e. Northern 1, 7, 8 and 9). Galeotti (2013) found that black-stripe minnows can occur across a range of wetland characteristics, with no significant correlation to physio-chemical water properties. Little is known about the salinity tolerances for the black-stripe minnow, although they were recorded at a salinity of 3330 us/cm (Northern 9). It is unlikely that this would be a limiting factor for their distribution in the northern and central investigation area except at Northern 3 (where EC was 6010 us/cm).

4.3.3 Introduced species

Introduced species can adversely impact native fish fauna through interference competition, increased predation or the introduction of disease. Introduced fish can often displace native species from their preferred habitat, or even replace them in entire systems (Arthington and Lloyd 1989, Kailola *et al.* 1999).

Mosquitofish (*Gambusia holbrooki*) were introduced to freshwaters around Perth in 1936 (Mees 1977) in an attempt to control mosquitoes. Through intentional introduction and natural dispersal, they are now widespread and abundant in streams, wetlands and reservoirs throughout the southwest (Morgan *et al*. 1998), dominating the fish fauna in lowland areas (Pusey *et al*. 1989). Mosquitofish have been implicated in the decline of several small native species in Australian waters (Myers 1975, Arthington and Lloyd 1989). This species is known to nip the fins of other fish (Lloyd 1990) and this behaviour has been implicated in the decline and altered distribution of black-stripe minnows, and other native fish, in south-western Australia (Gill *et al*. 1999). Fin-nipping can lead to secondary bacterial and fungal infections which results in death (Faragher and Lintermans 1997). Goldfish were introduced in Australia in the 1860s as an ornamental fish (Allen *et al*. 2002), with fish most likely being released into the system as unwanted pets. Adults are omnivorous, consuming organic detritus, plant matter and aquatic invertebrates. Goldfish have the potential to prey on the eggs, larvae and adults of native fishes, as well as competing with native fish for space and food (Morgan and Beatty 2007). The release of goldfish into natural waterways should be discouraged.

4.4 Other fauna

4.4.1 Turtles

A total of 74 south-western snake-necked turtles, *Chelodina colliei*[3], were caught within the investigation area; from Northern 1, 5, 8 and North Creek 2 (Plate 9). *Chelodina colliei* is endemic to the south-west of W.A. and is protected under the provisions of the *Wildlife Conservation Act 1950*. It is also listed on the IUCN Redlist of Threatened Species as Near Threatened (IUCN 2018). This species is restricted to the south-west of Western Australia, between the Hill River in the north, Blackwood River in the south, and east to the Sussetta River (Cann 1998). Throughout this range, snake-necked turtles are known to occur in both permanent and seasonal habitats, including rivers, lakes, farm dams, swamps, damplands and natural and constructed wetlands (Balla 1994, Guyot and Kuchling 1998). They can migrate relatively long distances overland if local conditions deteriorate (Dr Gerald Kuchling, UWA, pers. comm.) and can aestivate to avoid drought in seasonal waterbodies for up to five to six months (Kuchling 1988, 1989). Since their diet includes tadpoles, fish, and aquatic invertebrates, south-western snake-necked turtles only eat when open water is present. In permanent waters, this species has two nesting periods (September-October and December-January), but in seasonal systems, nesting will only occur in spring. Females can travel inland as far as 1 km to find appropriate nesting sites at this time (Clay 1981, Kuchling 1998). They generally nest in sandy soils, and eggs take up to two hundred days to hatch. The main threats to these turtles are road deaths during movement in the nesting season and predation by feral animals (Bencini and Turnbull 2012).

Plate 9. South-western snake-necked turtle recorded from Northern 8.

South-western snake-necked turtles captured during the current study ranged in size from 40 mm CL to 270 mm CL. Of the 74 turtles recorded, 36 were female, 24 were male and 14 were juvenile. Thirty were of size to be considered sexually mature. Clay (1981) indicates males reach sexual maturity at ≥ 130 mm CL and females at 160 mm CL.

4.4.2 Crustaceans

A total of 20 native decapod crustaceans (freshwater crayfish) were recorded during the survey, 15 smooth marron (*Cherax cainii*) and five gilgies (*Cherax quinquecarinatus*); from Northern 5, North Creek 1, North Creek 2 and North Creek 5. Neither of these species are listed for conservation

[3] This species was referred to as *Chelodina oblonga* in the past. However, there was some debate over species names and distributions. In 2013, the ICZN handed down its decision on nomenclature, with *C. colliei* given to the south-western snake-necked turtle, and *C. oblonga* given to the northern snake-necked turtle (previously *C. rugosa*).

significance, although both are south-west endemics, and have inland ranges that have been reduced due to salinisation (Morgan *et al*. 2011). One introduced species, the yabby (*Cherax destructor)* was recorded at Northern 5. This species is extremely adaptable to site conditions and is capable of burrowing down to the water table to survive dry conditions (Morrissy *et al.* 1984). It is also more tolerant than native species of extremes in temperature (Morrissy 1990), hypoxia (Morrissy *et al.* 1984, Holdich and Lowery 1988), and salinity. Since its introduction, the yabby has proven to be a highly successful invasive species and is spread throughout much of the southwest of the state (Lynas *et al.* 2004, 2007a). It has a highly aggressive nature and the potential for the yabby to out-compete native species has been well documented (Lynas *et al*. 2004, 2006, 2007a, 2007b). Due to their considerable negative impact on native freshwater species there are restrictions on the farming and movement of yabbies in Western Australia.

4.4.3 Carter's freshwater mussel

Carter's freshwater mussels were recorded from North Creek 2, North Creek 3, North Creek 4 and North Creek 5. Carter's freshwater mussel is the only species of freshwater mussel found in south-western Australia. Mussels filter large volumes of water, thereby removing nutrients and detritus from the water column. They are also a food source for water birds, freshwater crayfish and water rats (Morgan *et al.* 2011). It is sensitive to high salinity, with mortality known to occur at 4000 μS/cm (Bailey *et al.* 2002). These mussels have an early larval phase that is parasitic on the gills of native freshwater fish. Fish appear to be essential for completion of their life cycle.

4.4.4 Motion sensor cameras

No Australian water rats were recorded on any of the motion sensor cameras set up at each of the wetlands. There was also no evidence of middens observed at any of the sites.

5 POTENTIAL IMPACTS

Two species of high conservation significance were recorded from the northern and central investigation area; the black-stripe minnow and Carter's freshwater mussel. As wetlands outside the development envelope were not part of the current scope, and exact details of the proposal are not known (i.e. whether all wetlands within the development envelope will be impacted as part of the construction, or whether impacts to these wetlands will be indirect through changes to water quality and habitat), a traditional impact assessment was not possible. However, some general comments are made below regarding tolerances and potential impacts from development within the investigation envelope.

5.1 Black-stripe minnow

There has been a considerable decline in the number of known extant populations and the geographical distribution of the black-stripe minnow, largely due to climate change and habitat loss (Ogston *et al.* 2016). Increasing water temperatures and reduced rainfall have resulted in altered hydrology and water quality of ephemeral wetlands in the south-west. Species distribution modelling indicated the presence of black-stripe minnow in southern wetlands is influenced by lower temperatures, pH and an increase in connectivity between pools (Ogston *et al.* 2016). Currently, information on aestivation duration, timing and physiological tolerances for the black-stripe minnow are unknown, however changes to water inundation extent and duration could alter the length of aestivation, thus adversely impacting reproduction and recruitment success.

Survival of aestivating individuals in summer will likely depend upon soil moisture profiles which will be influenced by the extent of groundwater drawdown. To determine threshold levels, it is necessary to know dependence of aestivating fish on soil moisture, and depth to moisture, during summer. These will be affected by the extent of groundwater drawdown. Unlike some aestivating frog species, black-stripe minnows do not build a cocoon to aestivate, but rather they survive in the wet mud within the bed of the wetland (Howard Gill (Murdoch Uni, pers. com.). As such, the depth to moisture within wetland sediments is important to the survival of this species. Specifics relating to the depth and duration of aestivation for this species are not currently known, with further research required in this area generally. Given their short, one-year lifecycle (Ogston *et al.* 2016), declines in groundwater levels as well as reductions in surface flows are highly likely to adversely affect this species.

Black-stripe minnows are known to inhabit tannin stained, vegetated wetlands of approximately 300 mm deep with a pH range of 3 – 8 (Galeotti *et al.* 2008). Other than these general observations, and anecdotal information, little is known about the preferred physio-chemical water properties of their habitats, with no correlations found between physio-chemical variables measured in wetlands across the south-west (Galeotti 2013).

Surveys conducted within the Kemerton region have shown that black-stripe minnow populations will disperse in years of high rainfall and black-stripe minnows were declared extinct in one of the pools, only to be recorded in subsequent surveys (MBS Environmental 2009). Due to the high mobility of the species and increased connectivity between wetlands in wetter years, it is possible that black-stripe minnows have migrated between wetlands and are likely more abundant and widespread in the local area. It is also possible that seasonal fluctuations of presence/abundance of black-stripe minnows may occur, with the highest activity occurring between late June/early July and late September/early October (Smith *et al.* 2002).

Ultimately, altering the hydrological regime and extent of inundation is likely to have a considerable effect on black-stripe minnow populations, however, key parameters of their biology and ecology still

need to be investigated to determine the potential impact. This includes surveying the extent of populations in nearby wetlands and ascertaining population connectivity, including sites outside of the proposed development area, that would indicate the maintenance of these local populations should habitat within the BORR development envelope be lost. It is suggested any further surveys are timed for earlier in the season to ensure maximum activity and increase likelihood of their capture. An overall reduction in seasonal wetlands, as well as a reduction in the connectivity between inundated areas, will likely affect populations of the black-stripe minnow.

5.2 Carter's freshwater mussel

Freshwater mussels are sensitive to environmental variables, such as salinity, nutrients and sedimentation (Klunzinger *et al.* 2012). Declines in mussel populations are due principally to a decline in quality of habitat resulting from secondary salinisation, seasonal water availability and increases in total nitrogen concentration. Physical disturbance of river beds and potential increases in turbidity and resuspension of organic material into the water column, could result in burying of individuals and would likely have a negative impact on freshwater mussel populations.

Mussels utilise fish to complete development and as a dispersal mechanism. Barriers to upstream movement of fish may also restrict gene flow between mussel populations, limit upstream-downstream recruitment of mussels, restrict distributions and prevent recolonisation. Though Carter's freshwater mussel may be common locally in some areas, many populations are in decline due to habitat fragmentation or secondary salinisation (Morgan *et al.* 2012).

6 CONCLUSIONS

A targeted aquatic fauna survey was completed within the northern and central investigation area for the Bunbury Outer Ring Road in November 2018. *In situ* water quality was generally good across all sites, aside from some notably low (anoxic) and high (saturated) dissolved oxygen values. A diversity of instream habitats were present, which were found to support a range of fauna including native fish, mussels, crayfish and turtles.

One individual black-stripe minnow *Galaxiella nigrostriata,* a species of state, national and international significance was recorded at Northern 9. This study represents the second record of the black-stripe minnow in the local area, with the first record being from within the BORR Southern Section alternate investigation area (WRM 2019). Prior to this, the closest known population was at Kemerton Nature Reserve (north of Bunbury). As the land is owned privately, no previous surveys have been undertaken on these properties prior to the alternative investigation area survey in October 2018. The current survey also represents the fourth remnant population on the Swan Coastal Plain (together with the population/s from the alternate investigation area wetlands). Galeotti *et al.* (2010) suggest that other remnant populations may still exist, with many undiscovered suitable habitats located on private property. Any development within the survey area resulting in the clearing of vegetation, or removal or alteration of habitat through draining, infilling, and changes to hydrology or water quality may potentially affect the local population of the species.

Carter's freshwater mussels were only recorded at creek sites, this is likely due to the ephemeral nature of wetlands (Klunzinger *et al*. 2012). Disturbances to river beds where mussels are found, could have a negative impact on populations. Studies have shown that mussels can be translocated from site where disturbance will occur and successfully relocated (Beatty *et a.* 2017).

Using motion sensor cameras and visual observations, no Australian water rats were recorded at any of the sites.

7 REFERENCES

Alabaster JS, Lloyd R (1982) Water quality criteria for freshwater fish. 2nd edition. pp. 127-142. London, England: Butterworth Scientific.

Allen GR, Midgley SH, Allen M (2002) *Field Guide to the Freshwater Fishes of Australia.* Western Australian Museum, Perth WA.

ANZECC/ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australia and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand. Paper No. 4. Canberra. http://www.deh.gov.au/water/quality/nwqms/index.html

Arthington AH, Lloyd L (1989) Introduced Poeciliidae in Australia and New Zealand. [In] G.K. Meffe and F.F. Snelson (eds). Evolution and Ecology of Livebearing Fishes (Poeciliidae). Prentice-Hall, New York. pp 333 – 348.

Australian Society of Fish Biology (2016) Conservation Status of Australian Fishes. http://www.asfb.org.au/commitees/threatened-species-committee/

Balla S (1994) Wetlands of the Swan Coastal Plain Volume 1: Their Nature and Management. Water Authority of Western Australia, and the Western Australian Department of Environmental Protection.

Beatty SJ, Morgan DL, Klunzinger M, Lymbery AJ (2010) Aquatic microfauna of Ellen Brook and the Brockman River: Freshwater refuges in a salinised catchment. A report to Ellen Brockman Integrated Catchment Group.

Beatty S, Ma L, Morgan D, Lymbery A (2017) Baseline assessment of Carter's Freshwater Mussel, *Westralunio carteri*, at proposed bridge construction site on the Lower Vasse River. A report to Strategen Environmental.

Bencini R, Turnbull A (2012) Monitoring a population of the Western Australian oblong turtle (*Chelodina oblonga*) at Lake Mabel Talbot, progress report 2012. School of Animal Biology, The University of Western Australia, Perth.

Bouck GR (1980) Etiology of Gas Bubble Disease. *Transactions of the American Fisheries Society* **109**: 703-707.

Butler B, Doudoroff P, Shumway DL (1970) Dissolved oxygen requirements of freshwater fishes. FAO Fisheries Technical Paper No. 86, 291 pp.

Cann J (1998) *Australian Freshwater Turtles*. Beumont Publishing, Singapore.

Cheal F, Davis J, Growns J, Bradley J, Whittles F (1993) The influence of sampling method on the classification of wetland macroinvertebrate communities. *Hydrobiologia* **257**: 47-56.

Clay B (1981) Observations on the breeding biology and behaviour of the long-necked tortoise *Chelodina oblonga. Journal of the Royal Society of Western Australia* **4**: 27-32.

Davis JC (1975) Minimal dissolved oxygen requirements of aquatic life with emphasis on Canadian species: A review. *Journal of Fisheries Research Board of Canada* **32**: 2295-2332.

Davis JA, Rosich RS, Bradley JS, Growns JE, Schmidt LG, Cheal F (1993) *Wetlands of the Swan Coastal Plain Volume 6: Wetland Classification on the Basis of Water Quality and Invertebrate Community Data*. Murdoch University and the Water Authority of Western Australia.

Department of Biodiversity, Conservation and Attractions (2018). Threatened and Priority Fauna List. October 2018.

Department of Environment Sport and Territories, Land and Water Resources – Research and Development Corporation, Commonwealth Environment Protection Authority (1994) National River Processes and Management Program: Monitoring River Health Initiative. River Bioassessment Manual, Version 1.0. February 1994.

Edward DHD, Gazey P, Davies PM (1994) Invertebrate community structure related to physico-chemical parameters of permanent lakes of the south coast of Western Australia. *Journal of the Royal Society of Western Australia* **77**: 51-63.

Faragher RA, Lintermans M (1997) Alien fish species from the New South Wales Ricers Survey. [In] Harris JH, Gerhke PC (eds) Fish and Rivers in Stress: The NSW Rivers Survey, New South Wales Fisheries and CRC for Freshwater Ecology, pp 201-223.

Galeotti DM, McCullogh CD, Lund MA (2008) Current state of knowledge of the black-stripe minnow *Galaxiella nigrostriatal* (Pisces: Galaxiidae) in Western Australia. Centre for Ecosystem Management report 2008-12.

Galeotti DM (2013) *Metapopulation theory explains black-stripe minnow (Pisces: Galaxiidae, Galaxiella nigrostriata) distribution in seasonal wetlands in south-western Western Australia*. Retrieved from https://ro.ecu.edu/theses/708

Gill HS, Hambleton SJ, Morgan DL (1999) Is *Gambusia holbrooki* a major threat to the native freshwater fishes of south-western Australia? [In] Seret B and Sore JY (eds) *Proceeding 5th Indo-Pacific Fish Conference, Noumea, 3-8 November 1997*. pp 79-87.

Guyot G, Kuchling G (1998) Some ecological aspects of populations of oblong turtles *Chelodina oblonga* in the suburbs of Perth (Western Australia) [In] *Le Bourget Du Lac*, Miaud C and Guyetant G (eds) Societas Europacea Herpetologica, France, pp. 173-181.

Hart B, Bailey, Edwards P, Hortle K, James K, McMahon A, Meredith C, Swadling K (1991) A review of salt sensitivity of Australian freshwater biota. *Hydrobiologia* **210**: 105-144.

Holdich DM, Lowery RS (eds) (1988) Freshwater crayfish: biology, management and exploitation. Croom Helm London, UK.

IUCN (2018) IUCN Red List of Threatened Species. Version 2017.3. www.iucnredlist.org Downloaded on the 25th of January 2018.

Kailola PJ, Arthington AH, Woodland DJ, Zalucki DJ (1999) Non-native finfish species recorded in Australian waters. [In] Arthington AH, Kailola PJ, Woodland DJ, Zalucki DJ (eds). *Provision of baseline environmental data relevant to an evaluation of quarantine risk potentially associated with the importation to Australia of ornamental finfish*. Australian Quarantine and Inspection Service, Canberra.

Klunzinger MW, Beatty SJ, Morgan DL, Lymbery R, Thomson GJ, Lymbery AJ (2010) Discovery of a host fish species for glochidia of *Westralunio carteri* Iredale, 1934 (Bivalvia: Unionoida: Hyrridae). *Journal of the Royal Society of Western Australia* **94**: 19-23.

Klunzinger MW, Beatty SJ, Morgan DL, Lymbery AJ, Pinder AM, Cale DJ (2012) Distribution of *Westralunio carteri* Iredale 1934 (Bivalvia: Unionoida: Hyriidae) on the south coast of southwestern Australia, including new records of the species. *Journal of the Royal Society of Western Australia* **95**: 77-81.

Kuchling G (1988). Gonadal cycles of the Western Australian long-necked turtles *Chelodina oblonga* and *Chelodina steindachneri* (Chelonia: Chelidae). *Records of the Western Australian Museum* **14**: 189-198.

Kuchling G (1989). Assessment of ovarian follicles and oviducal eggs by ultra-sound scanning in live freshwater turtles, *Chelodina oblonga*. *Herpetologica* **45**:89-94.

Lloyd L (1990) Native Fishes as alternatives to the exotic fish, *Gambusia* for insect control. [In] Introduced and translocated fishes and their ecological effects. Pollard DA (ed) pp. 115-122 Bureau of Rural Resources Proceedings No. 8 (Australian Government Publishing Service, Canberra).

Lynas J, Lindhjem P, Storey AW, Knott B (2004) Is the yabby, *Cherax destructor* (Parastacidae) in Western Australia an ecological threat? *Freshwater Crayfish* **14:** 37–44.

Lynas J, Storey AW, Armstrong K, Prince J, Knott B (2006) Invasion by the exotic crayfish, *Cherax destructor* Clark (Parastacidae) into habitats of local crayfish near Perth, Western Australia. *Freshwater Crayfish* **15:** 176–188.

Lynas J, Storey AW, Knott B (2007a) Introductions and spread of freshwater crayfish (Parastacidae) in Western Australia, and the potential for displacement of indigenous species. [In] Gherardi F (ed) *Biological Invaders in Inland Waters: Profiles, Distribution and Threats*. Springer. Chapter 31, 577-596.

Lynas J, Storey AW, Knott B (2007b) Aggressive interactions between three species of freshwater crayfish of the genus *Cherax* (Decapoda: Parastacidae). *Marine and Freshwater Behaviour and Physiology* **40**: 105-116.

Maglio VJ, Rosen DE (1969) Changing preference for substrate colour by reproductively active mosquitofish *Gambusia affinis* (Baird and Girard) (Poeciliidae: Atheriniformes). *American Museum of Novitates* **2397**: 1-39.

McDowall RM (1996) *Freshwater Fishes of South-Eastern Australia*. Reed Books pp 247.

Mees GF (1977) The status of *Gambusia affinis* (Baird and Girard) in south-western Australia. *Records of the West Australian Museum* **6:** 27-31.

Milton DA, Arthington AH (1983) Reproductive biology of *Gambusia affinis* holbrooki Baird & Girard, *Xiphophorus hellerii* (Gunther) and *X. maculatus* (Heckel) (Pisces: Poeciliidae) in Queensland, Australia. *Journal of Fish Biology* **23**: 23–41.

Morgan DL, Gill HS, Potter IC (1998) Distribution, identification and biology of freshwater fishes in south-western Australia. *Records of the Western Australian Museum*. Supplement No. 56. Western Australian Museum, Perth.

Morgan DL, Gill HS (2000) Fish associations within the different inland habitats of lower south-western Australia. *Records of the Western Australian Museum* **20**: 31-37.

Morgan DL, Beatty SJ (2007) Feral goldfish (*Carassius auratus*) in Western Australia: a case study from the Vasse River. *Journal of the Royal Society of Western Australia* **90***:* 151-156.

Morgan DL, Beatty SJ, Klunzinger MW, Allen MG, Burnham QF (2011) *A field guide to freshwater fishes, crayfishes and mussels of southwestern Australia*. SERCUL and Freshwater Fish Group, Perth WA.

Morrissy NM, Caputi N, House RR (1984) Tolerance of marron (*Cherax tenuimanus*) to hypoxia in relation to aquaculture. Aquaculture **41:** 61–74.

Myers GS (1975) *Gambusia*, the fish destroyer. Australian Zoologist **13:** 102.

Ogston G, Beatty S, Morgan D, Pusey B, Lymbery A (2016) Living on burrowed time: Aestivating fishes in south-western Australia face extinction due to climate change. *Biological Conservation* **195:** 235-244.

Paull, DJ (2008) Southern brown bandicoot. In Van Dyck S and Strahan R (Eds.). *The Mammals of Australia*. Reed New Holland, Sydney.

Pusey BJ, Storey AW, Davies PM, Edward DHD (1989) Spatial variation in fish communities of two south-western Australian river systems*. Journal of the Royal Society of Western Australia* **71**: 69-75.

Scott A, Grant T (1997) Impacts of water management in the Murray-Darling Basin on the platypus (*Ornithorhynchus anatinus*) and the water rat (*Hydromys chrysogaster*). CSIRO Land and Water Technical Report 23/97.

Storey AW, Halse SA, Shiel RJ (1993) Aquatic invertebrate fauna of the Two Peoples Bay area, southwestern Australia. *Journal of the Royal Society of Western Australia* **76**: 25-32.