APPENDIX C ATTACHMENTS LIST (WRM 2019)

Biota. (2019b). *Bunbury Outer Ring Road Southern Section Targeted Fauna Assessment.* Unpublished report prepared for Main Roads Western Australia.

BORR IPT. (2019a). *Bunbury Outer Ring Road Southern Section Vegetation and Flora Study.* Unpublished report prepared for Main Roads Western Australia.

Brad Goode & Associates. (2012). *Aboriginal Heritage Survey Report of the Proposed Bunbury Outer Ring Road Stage 2, Western Australia*. Unpublished report prepared for GHD Pty Ltd on behalf of Main Roads Western Australia.

Main Roads WA. (2018). *Environmental Policy*.

WRM. (2019). *Bunbury Outer Ring Road Southern Investigation Area: Targeted Conservation Significant Aquatic Fauna Survey*. Unpublished report prepared for BORR IPT on behalf of Main Roads Western Australia.

BUNBURY OUTER RING ROAD SOUTHERN INVESTIGATION AREA: TARGETED CONSERVATION SIGNIFICANT AQUATIC FAUNA SURVEY

NOVEMBER 2018 SAMPLING
FINAL REPORT

September 2019



Study Team

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Disclaimer

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Frontispiece (left to right): Southern 1; the south-western snake-necked turtle *Chelodina colliei*; and, Southern 4 (all photos by WRM© /November 2018).

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EXECUTIVE SUMMARY

The Bunbury Outer Ring Road (BORR) is a planned Controlled Access Highway linking the Forrest Highway and Bussell Highway. BORR will be a high standard route for access to the Bunbury Port and facilitate proposed development to the east of the City of Bunbury. BORR provides an effective bypass of Bunbury for inter-regional traffic. The BORR Project comprises three sections:

- BORR Northern Section – Forrest Highway to Boyanup-Picton Road
- BORR Central Section – Boyanup-Picton Road to South Western Highway, an existing four kilometre (km) section which was completed in May 2013, along with a three km extension of Willinge Drive southwards to South Western Highway
- BORR Southern Section – South Western Highway (near Bunbury Airport) to Bussell Highway.

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

In November 2018, six sites were sampled which lie within the BORR Southern Section investigation area, 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.

No fish or Carter's freshwater mussels were recorded during the November 2018 survey of the Southern Section investigation area. The black-stripe minnow *Galaxiella nigrostriata* was recorded from site Northern 9 (WRM unpub. data), which is the southern-most site in the BORR Northern and Central Section investigation area. This site is in close proximity to Southern 1 and 2 and surface water at the three sites is likely connected during periods of high rainfall. The lack of Carter's mussels from this area was likely due to the highly ephemeral nature of wetlands sampled (Klunzinger *et al*. 2012). Using motion sensor cameras and visual observations, no Australian water rats were recorded from any sites.

1 INTRODUCTION

1.1 Background

The Bunbury Outer Ring Road (BORR) is a planned Controlled Access Highway linking the Forrest Highway and Bussell Highway. BORR will be a high standard route for access to the Bunbury Port and facilitate proposed development to the east of the City of Bunbury. BORR provides an effective bypass of Bunbury for inter-regional traffic. The BORR Project comprises three sections:

- BORR Northern Section – Forrest Highway to Boyanup-Picton Road
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- BORR Southern Section – South Western Highway (near Bunbury Airport) to Bussell Highway.

The Commissioner of Main Roads Western Australia (Main Roads) is proposing to construct and operate the southern section of the BORR Project ("The Proposal"). The BORR Southern Section includes the construction and operation of 10.5 km of freeway standard, dual carriageway southwest of South Western Highway (south of Bunbury Airport) to Bussell Highway and a 3 km regional distributor from Bussell Highway at Centenary Road southeast to a grade separated interchange at the western end of Lillydale Road. The project includes associated bridges, interchanges, local road modifications and other infrastructure including, but not limited to, drainage basins, drains, culverts, lighting, noise barriers, fencing, landscaping, road safety barriers and signs. The BORR Southern Section connects the Northern and Central sections of the BORR (from Forrest Highway) to Bussell Highway.

The Proposal is located 160 - 168 km south of Perth, mainly within the Shire of Capel including the localities of Gelorup, North Boyanup and Statham with some overlap into neighbouring localities (College Grove, Usher and Dalyellup). A small part of the project occurs in the City of Bunbury.

The north-eastern end of the BORR Southern Section will join with the southwest end of the BORR Central section, southwest of South Western Highway, approximately 8 km southeast of Bunbury CBD. The northwest end of the Proposal (regional distributor) at Bussell Highway is approximately 7 km south of Bunbury and the southernmost point of the project (on Bussell Highway adjacent to Capel Golf Course), is approximately 15 km south of Bunbury CBD.

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, dissolved oxygen (DO), Electrical Conductivity (EC) and temperature), habitat assessments, motion sensor camera trapping, and observations of other fauna (if present) at seven sites,
- 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 Western Australia 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),
- Threatened and 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 nigrostriata*; Plate 2) is currently listed as Endangered (Schedule 2 of the Wildlife Conservation Specially Protected Fauna Notice 2018), Endangered under the Federal EPBC Act (1999), and Lower Risk/Near Threatened (IUCN Redlist 2018). The black-stripe minnow is capable of aestivating (burrowing) in 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 is 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 BORR Southern Alternate development area, also recorded a population of black-stripe minnow near Gelorup. 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 urban and rural development during the previous 100 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 isolated populations near Perth (Ellen Brook catchment) and 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 seven consecutive days, between the 20^{th} and 29^{th} November 2018.

Aquatic fauna sampling by WRM is consistent with methodology used 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 seven potential sites where aquatic fauna of conservation significance may occur. During the on-ground survey, one of the sites (Southern 7) was dry, making a total of six sites surveyed. Southern 7 comprises a small patch of remnant native vegetation (~12 ha) surrounding by cleared farmland, immediately adjacent to an area of seasonal dampland listed as a multiple use wetland by DBCA Swan Coastal Plain geomorphic wetland classification mapping. Aerial imagery reveals that the site or adjacent wetland area does not fill (to sufficient levels to allow for aquatic fauna sampling) following winter rains, with the nearest frequently wetted area a modified drainage channel and excavated farm dam outside of the proposed BORR alignment.

See Figures 1 to 5 and Table 1 for site locations.

Table 1. Survey sites sampled in November 2018. GPS in UTMs (Zone 50).

Southern alignment	GPS		
Site	Zone	Easting	Northing
Southern 1	50	376273	6304494
Southern 2	50	376199	6304342
Southern 3	50	376089	6304316
Southern 4	50	375225	6304694
Southern 5	50	375287	6303605
Southern 6	50	375302	6302271
Southern 7	50	374522	6301181

3.2 Targeted aquatic fauna survey

3.2.1 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. 10 quadrats were deployed at each site.

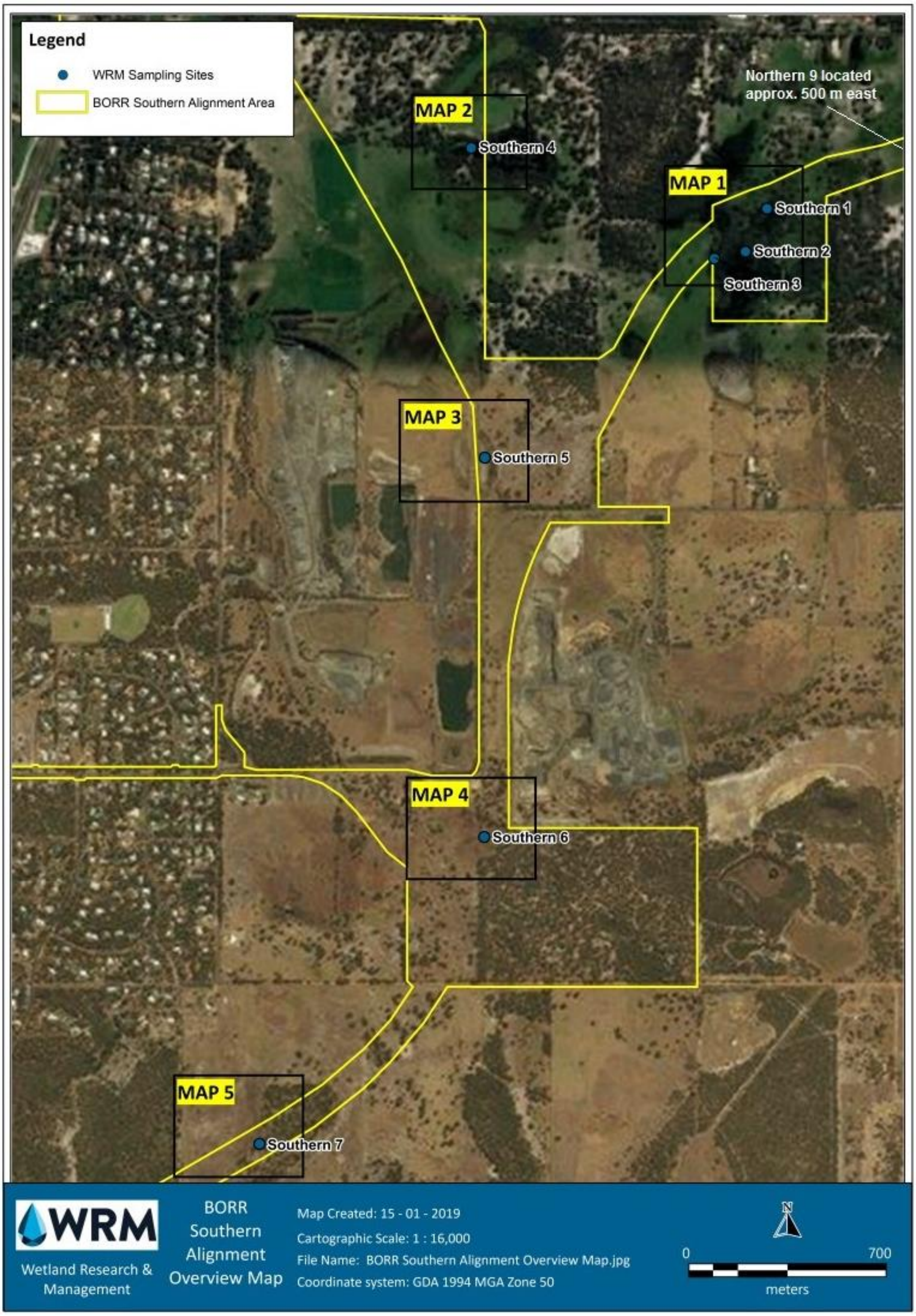

Figure 1. Map of the study area, showing aquatic sampling sites.

Figure 2. Map of Southern 1, 2 and 3.

Figure 3. Map of Southern 4.

Figure 4. Map of Southern 5.

Figure 5. Map of Southern 6.

3.2.2 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. Unbaited box traps were positioned to create a barrier to fish.

Shallower water depths with dense vegetation where fyke nets could not effectively be 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.

Plate 4. Fyke nets set within a wetland.

3.2.3 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.

3.2.4 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).

3.2.5 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.

3.2.6 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 variable between wetlands, with pH slightly acidic to basic (6.88 to 8.95), dissolved oxygen low to extremely high (33.4% to 243.0%), and water temperatures relatively warm (18.8 ºC to 29.7 ºC; Table 2).

One site was fresh (Southern 6), four sites were brackish (Southern 1, 2, 3 and 4) and one was saline (Southern 5), as defined by the DoE (2003)[1], with EC ranging from 510 µs/cm (at Southern 6) to 9,420 µs/cm (at Southern 5). Salinity toxicity differs between aquatic species, however most adult Australian freshwater fish can tolerate salinities up to 14,000 µs/cm (Hart *et al.* 1990). Earlier life stages of fish may be more susceptible to increased salinity as EC can affect osmoregulatory ability (Beatty *et al.* 2011). Elevated salinity may not only cause mortality but also negatively affect biological performance of fishes and decrease sperm viability (Harris 1986). pH at Southern 5 (8.95) and Southern 6 (8.56) was marginally greater than the default ANZECC/ARMCANZ (2000) guideline value (GV) for the protection of slightly/moderately disturbed wetland ecosystems in the southwest of Western Australia (pH 6 – 8). Elevated pH at Southern sites 5 and 6 was can likely be attributed to the clearing of native riparian vegetation surround these wetlands; pH is known to increase with higher water temperatures, higher aquatic macrophyte and algal densities (causing higher dissolved oxygen levels) and lack of organic material (e.g. leaf litter and detritus) (DEC 2012), all of which are likely to occur when riparian vegetation is removed from a wetland.

One site recorded DO under the lower ANZECC/ARMCANZ (2000) GV (90%); Southern 4 (33.4%). 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). Three sites recorded super-saturated DO, in excess of the upper ANZECC/ARMCANZ (2000) GV (120%); Southern 3 (145.5%), Southern 5 (243.0%) and Southern 6 (205.2%). 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).

Table 2. *In situ* water quality results from all sites sampled in November 2018.

Site	Date	Temp°C	Cond (µs/cm)	pH	DO%	DO mg/L
				ANZECC GV		
				6.0-8.0	90-120%	
Southern 1	21/11/2018	21.2	1913	7.52	92.2	8.05
Southern 2	21/11/2018	21.2	1913	7.52	92.2	8.05
Southern 3	21/11/2018	29.7	2350	7.48	145.5	11.96
Southern 4	22/11/2018	18.8	2000	6.88	33.4	3.34
Southern 5	22/11/2018	23.9	9420	8.95	243	18.71
Southern 6	20/11/2018	27.4	510	8.56	205.2	17.6

[1] 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).

4.2 Habitat

Southern sites 1, 2, 3 and 4 were surrounded by large areas of native riparian vegetation (mainly *Melaleuca* spp.) with habitat representative of natural wetland areas (although there was some evidence of excavation for agricultural purposes at Southern 4). Southern sites 5 and 6 were mostly cleared of riparian vegetation with habitat considered degraded due to landuse practices (farmland, with Southern 5 also adjacent to a large sand mine). In terms of aquatic habitat, all sites had some submerged macrophyte (ranging from 10% coverage at Southern 4, to 70% coverage at Southern 6) and emergent macrophyte (ranging from 2% at Southern 3 to 20% at Southern 1 and 2), and a diversity of other in-stream habitat types including large woody debris (LWD), detritus, floating macrophyte and/or trailing vegetation (see Plate 5). All sites sampled had predominantly sand substrate.

Southern 1

Southern 2

Southern 3

Southern 4

Southern 5

Southern 6

Plate 5. Site photographs from Southern 1, 2, 3, 4, 5 and 6 at the time of sampling in November 2018.

4.3 Fish

No fish were recorded during the aquatic fauna survey in November 2018.

4.3.1 Black-stripe minnow

Although no black-stripe minnows were captured during the survey, there were similarities in habitat and physio-chemical water properties between Southern 1, 2 and 3 and sites where black-stripe minnows were found during surveys conducted in the adjacent BORR Northern and Central Section during November 2018 (WRM unpub. data). Galeotti (2013) found that black-stripe minnows can occur across a range of water quality parameters, with no significant correlation between species occurrence and physio-chemical properties. Little is known about the salinity tolerances for the black-stripe minnow, although they have been recorded at salinities up to 3,330 µs/cm (WRM unpub. data). It is unlikely that this would be a limiting factor for their distribution in the Southern Section investigation area except at Southern 5 (where EC was 9,420 µs/cm).

Furthermore, it is considered likely that black-stripe minnows could occur at Southern 1, 2 and 3, given the proximity of these sites to Northern 9 (where black-stripe minnows were recorded in November 2018 (WRM unpub. data)), and the likelihood of connectivity between these three sites during periods of heavy rainfall and high inundation. Surveys conducted within the Kemerton Nature Reserve (approx. 25 km north of Southern 1) have shown that black-stripe minnow populations will disperse in years of high rainfall, and although recorded continuously in some of the wetlands, were only recorded intermittently in others (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 still within 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). The survey conducted in November 2018 may have been timed slightly too late to capture them as waters were receding at the time of survey. Aestivation cues for the species are currently unknown.

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 has 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 University, pers. comm.). 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.

4.4 Other fauna

4.4.1 Turtles

A total of 11 south-western snake-necked turtles, *Chelodina colliei*[2] (Plate 6), were caught within the study area; from Southern 1, 2, 3 and 4. *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 6. South-western snake-necked turtle recorded from Northern 8.

South-western snake-necked turtles captured during the current study ranged in size from 50 mm CL to 200 mm CL. Of the 11 turtles recorded, four were female, five were male and two were juvenile. Five 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 27 native decapod crustaceans (freshwater crayfish) were recorded during the survey, all gilgies (*Cherax quinquecarinatus*). Gilgies were recorded at all sites except Southern 6. This species is

[2] 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*).

not listed for conservation significance, but is a south-west endemic, and has inland ranges that have been reduced due to salinisation (Morgan *et al*. 2011).

4.4.3 Carter's freshwater mussel

Despite extensive survey effort, no Carter's freshwater mussels were recorded at any of the sites. This is likely due to the ephemeral nature of the sites sampled, and lack of creeklines within the investigation area for survey (Klunzinger *et al.* 2012).

4.4.4 Australian water rat

No Australian water rats were recorded on any of the motion sensor cameras set up at each of the wetlands. A midden consisting of crustacean remains was observed at Southern 5 (Plate 7). However, it could not be confirmed whether this belonged to a water rat or another species (e.g. a herron or other wading bird).

Plate 7. Midden consisting of crustacean remains at Southern 5.

5 CONCLUSIONS

A targeted aquatic fauna survey was completed within the Southern investigation area for the proposed Bunbury Outer Ring Road in November 2018. *In situ* water quality and habitat was generally good across sites Southern 1, 2, 3, and 4, which were found to support native crayfish and turtles. Habitat and water quality at Southern 5 and 6 was considered more degraded, mostly due to the previous clearing of native riparian vegetation at these sites.

The black-stripe minnow *Galaxiella nigrostriata* was not recorded during the survey, however it was recorded from Northern 9 (WRM unpub. data) during concurrent surveys conducted for the BORR Northern and Central Section. This site is in close proximity to the northern-most sites of this survey (i.e. within 500 m of Southern 1 and 2), with these wetlands possibly connected during periods of high rainfall. EC at Southern 1 and Southern 2 was marginally brackish but not likely to preclude black-stripe minnows from inhabiting these sites. 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 known from Northern 9 (see WRM 2019). No western mud minnows were recorded, and it is considered unlikely they would occur in the study area given their preference for headwater stream habitats (as opposed to ephemeral wetlands).

Carter's freshwater mussels were not recorded at any sites within the Southern Section investigation area, this is likely due to the ephemeral nature of wetlands sampled and lack of creeklines in the area for survey (Klunzinger *et al*. 2012).

No Australian water rats were recorded at any of the sites surveyed, however, it is still considered possible that this species occurs at wetlands within the study area, given the presence of suitable wetland habitat and prey in the form of crayfish at each wetland.

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