APPENDIX F

# Aquatic Fauna survey (WRM 2020)

BORR Team

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

## August 2019 SAMPLING FINAL REPORT

WRM Wetland Research & Management

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## Disclaimer



## Document history

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Frontispiece (left to right): Fyke net set at South 1; Black-stripe minnow (*Galaxiella nigrostriata*); and, South 8 (all photos by WRM© /August 2019).

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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. The 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.

The BORR alignment passes through areas characterised by creeklines and wetlands. As part of the approvals process, it was necessary to document the ecological values of these creeklines and wetlands, and determine if they support any listed aquatic fauna species of conservation significance; namely, the black-stripe minnow, Carter's freshwater mussel and Australian water rat / rakali.

In late-November 2018, WRM completed a targeted aquatic fauna survey of seven wetlands within the southern investigation area. The survey didn't record any of the above conservation significant species. However, the black-stripe minnow is known to occur in wetlands adjacent to the area surveyed, having been recorded in several wetlands during surveys of the BORR north/central investigation area in 2018 and 2019 (WRM 2019b; WRM 2019 in prep.) and a survey of an alternate southern alignment in 2018 (WRM 2019a). Due to the high mobility of black-stripe minnows, and the relatively late timing of the sampling, in November 2018, with wetlands receding and minnows likely in preparation for summer aestivation, it was postulated that black-stripe minnows could occur in the southern investigation area but not recorded in the 2018 sampling. As such, WRM was requested to conduct a second targeted survey for black-stripe minnow at a more appropriate time, in winter 2019, along with targeted surveys for Carter's freshwater mussel and Australian water rat / rakali. To better understand the local extent of each species, locations both within and adjacent to the investigation area were sampled.

Black-stripe minnows were recorded at two of the five wetland sites that were holding water at the time of sampling, with the presence of black-stripe minnow at site "South 8" representing the first record of the species within the southern investigation area. The second site to record black-stripe minnows, site "South 11", occurs outside but adjacent to the southern investigation area boundary. As in November 2018, no Carter's freshwater mussel or Australian water rat were recorded during the August 2019 survey.

# 1 INTRODUCTION

## 1.1 Background

The Commissioner of Main Roads Western Australia (Main Roads) is proposing to construct and operate the southern section of the Bunbury Outer Ring Road project (BORR; see Figure 1). The BORR is a planned Controlled Access Highway linking the Forrest and Bussell Highways and will provide a high standard route for access to the Bunbury Port and will facilitate 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 and GHD.

The proposed BORR alignment ("southern investigation area") passes through or adjacent to a number of creeklines and wetlands. As part of the approval process, it is necessary to document the ecological values of these ecosystems, and determine if they support any aquatic fauna species of conservation significance. Based on species' distributions and habitat present, the creeklines and wetlands were deemed likely to support two State, Federally and internationally listed species:

- Carter's freshwater mussel (*Westralunio carteri*); Vulnerable (EPBC Act 1999), Vulnerable (BC Act 2016, Schedule 3 of the Wildlife Conservation Specially Protected Fauna Notice 2019), Vulnerable (IUCN Redlist 2020),
- Black-stripe minnow (*Galaxiella nigrostriata*); Endangered (EPBC Act 1999), Endangered (BC Act 2016, Schedule 2 of the Wildlife Conservation Specially Protected Fauna Notice 2019), Endangered (IUCN Redlist 2020),
- Australian water rat / rakali (*Hydromys chrysogaster*); Priority 4 (P4) under the BC Act 2016.

In late-November 2018, WRM undertook a targeted aquatic fauna survey of seven wetlands within the southern investigation area. The 2018 survey did not record any of the above conservation significant species. However, the black-stripe minnow is known from the area, having been recorded in several wetlands during surveys of the BORR northern and central and southern alternate alignment investigation areas in 2018 and 2019 (WRM 2019a, 2019b, 2019 in prep.). Due to the high mobility of the black-stripe minnows, and the relatively late timing of the sampling in November 2018, with wetlands receding and minnows likely in preparation for summer aestivation, it was postulated that black-stripe minnows could occur in the southern investigation area and were not recorded due to the lateness of the 2018 sampling. As such, WRM were requested to conduct a second targeted survey for black-stripe minnow in winter 2019, along with targeted surveys for Carter's freshwater mussel and Australian water rat / rakali. To better understand the local extent of each species, locations both within and adjacent to the investigation area were sampled.

## 1.2 Scope of works

The scope of works for the winter 2019 targeted conservation significant aquatic fauna survey were:

- Targeted sampling of black-stripe minnow, Carter's freshwater mussel and Australian water rat, *in situ* water quality (pH, DO, EC & temperature), habitat assessments, and observations of other fauna (if present),
- an assessment of the conservation status of aquatic fauna recorded,
- preparation of a detailed technical report of all findings,
- updated mapping of Carter's freshwater mussel distribution, and
- provision of a detailed memo with strategies to manage, monitor and mitigate direct and indirect impacts to Carter's freshwater mussel, water rat and black-stripe minnow within the study area.

# 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. To assess the conservation significance of aquatic fauna a range of sources were referenced, including:

- Nationally threatened Fauna listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act 1999),
- Threatened and Priority Fauna in Western Australia under the *Biodiversity Conservation (BC) Act 2016* (as listed on the Department of Biodiversity, Conservation and Attractions Threatened and Priority Fauna List (DBCA 2020)),
- Threatened Fauna under the IUCN Redlist of Threatened Species (IUCN 2020), and
- Conservation status of Australian Fishes List (Australian Society for Fish Biology 2016).

Three species of conservation significance were specifically targeted during this survey; the black-stripe minnow, the Carter's freshwater mussel and the Australian water rat / rakali. Information on each species is outlined below.

## 2.1 Black-stripe minnow

The black-stripe minnow (*Galaxiella nigrostriata*; Plate 1) is currently listed as Endangered nationally (EPBC Act 1999) and at a State level in Western Australia (Schedule 2 of the Wildlife Conservation Specially Protected Fauna Notice 2018), as well as Endangered at an international level (IUCN Redlist 2020). The black-stripe minnow is capable of aestivating (burrowing) into soils to survive drying habitat and therefore tends to inhabit wetlands that dry over summer, appearing in pools within hours following first rains (Morgan *et al*. 2011). Interestingly, it does not have any specific anatomical or physiological adaptations to aid aestivation, and is assumed to survive either within moist soils or within crayfish burrows that contain water through dry periods. It appears that most individuals 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 now rare throughout its distribution. Its main distribution lies within the Warren sub-region, where numerous populations are found between Albany and Augusta. However, there are isolated populations on the Swan Coastal Plain, including Lake Chandala (near Gingin), Melaleuca Park (north of Perth), and wetlands within the Kemerton Nature Reserve (north of Bunbury) (Morgan *et al*. 1998, Allen *et al.* 2002). In addition to the above occurrences on the Swan Coastal Plain, a survey by WRM in October 2018 of the BORR southern alternate investigation area recorded a population of black-stripe minnows in Gelorup (WRM 2019a). 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 hundred years has had a significant impact on the extent of this species. As such, their biggest threat is further loss of suitable habitat through urbanisation and rural development.

**Plate 1.** Black-stripe minnow, photo WRM ©.

## 2.2 Carter's freshwater mussel

Carter's freshwater mussel (*Westralunio carteri*; Plate 2) is currently listed as Vulnerable on state (Schedule 3; DBCA 2020), national (EPBC Act 1999), and international (IUCN Redlist 2020) conservation lists. This species occurs in greatest abundance in slower flowing riverine habitats with stable sediments and low salinity. The lifecycle involves an obligate parasitic 'larval' stage, known as glochidia, which attach to host fish for several weeks to complete their development (Beatty *et al*. 2010). The glochidia aids with the distribution of this species, with individuals being dispersed by migrating fish.

Carter's freshwater mussel is endemic to the South West Coast Drainage Division, where it is the only native 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. Water extraction and rainfall reductions also appear to have a negative effect on populations (Klunzinger *et al*. 2012).

**Plate 2.** Carter's freshwater mussels, photo by WRM ©.

## 2.3 Australian water rat / rakali

The Australian water rat (*Hydromys chrysogaster*; Plate 3) is currently listed as a Priority 4 species in the State of Western Australia (DBCA 2019). 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. The study was also conducted under Department of Biodiversity, Conservation and Attractions (DBCA) Fauna Taking (Biological Assessment) Licence BA27000105. As a condition of this licence, a fauna return including taxa lists and locations, is required upon project completion.

Sampling was undertaken by Senior Aquatic Ecologist Mel Tucker and Aquatic Ecologist Alex Hickling over four consecutive days; 26th to 29th August 2019.

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), 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

A desktop assessment identified a total of 15 potential sites where black-stripe minnow and/or water rats were likely to occur within or adjacent to the southern investigation area, based on previous records and habitat similarities. Due to site restrictions around access to private property, only ten sites were able to be accessed for the 2019 survey. Carter's freshwater mussels prefer flowing riverine/creekline ecosystems, none of which intersect the southern investigation area. However, all sites in the 2019 survey were sampled for freshwater mussels as a precaution. Due to site conditions at the time of sampling (i.e. dryness), only five of the ten remaining sites were sampled during the August 2019 survey (Table 1, Figure 1). Table 1 and Figure 1 also denote November 2018 targeted aquatic fauna sampling locations. Note that several sites originally surveyed in November 2018 were re-sampled in August 2019 (Table 1). As mentioned previously, sites located both within and outside of the investigation area were surveyed, in order to provide information of the local extent of conservation significant species for environmental impact assessment and species management (Figure 1).

**Table 1.** Summary of all targeted aquatic fauna sampling locations within and adjacent to the southern investigation area, August 2019 and November 2018 (bold indicates within investigation boundary). Notes on habitat suitability for black-stripe minnow are provided from the November 2018 survey.

| Southern targeted wetlands: Black-stripe minnow, Carter's mussel and water rat | | | | |
|---|---|---|---|---|
| Site name | Easting | Northing | Sampling event | Suitable black-stripe minnow habitat? |
| **South 1a*** | **376114** | **6304518** | **August 2019** | - |
| South 1b* | 376140 | 6304187 | August 2019 | - |
| South 2 | 377098 | 6303455 | August 2019 | Dry at time of sampling |
| South 6a | 373750 | 6301742 | August 2019 | Dry at time of sampling |
| South 6b | 373937 | 6301460 | August 2019 | Dry at time of sampling |
| **South 7a** | **373580** | **6300453** | August 2019 | Dry at time of sampling |
| South 7b | 373393 | 6300385 | August 2019 | Dry at time of sampling |
| **South 8** | **373640** | **6300410** | August 2019 | - |
| South 10 | 375552 | 6299955 | August 2019 | - |
| South 11 | 373613 | 6299275 | August 2019 | - |
| | | | | |
| **Southern 1*** | **376273** | **6304494** | November 2018 | Yes – seasonal wetland, intact riparian vegetation |
| **Southern 2*** | **376199** | **6304342** | November 2018 | Yes – seasonal wetland, intact riparian vegetation |
| **Southern 3*** | **376089** | **6304316** | November 2018 | Yes – seasonal wetland, intact riparian vegetation |
| Southern 4 | 375225 | 6304694 | November 2018 | No – excavated wetland on farmland |
| Southern 5 | 375287 | 6303605 | November 2018 | No – highly degraded, brackish wetland |
| **Southern 6** | **375302** | **6302271** | November 2018 | No – excavated wetland on farmland |
| **Southern 7** | **374522** | **6301181** | November 2018 | No – no surface water present |

**Note: 2019 sites South 1a and 1b are within of the same large wetland as 2018 sites Southern 1, 2 and 3.*


**Figure 1.** Summary of all target aquatic fauna sampling locations within and adjacent to the southern investigation area, in November 2018 (purple) and August 2019 (orange).

## 3.2 Survey methods

### 3.2.1 Black-stripe minnow

A number of methods were used at each site to effectively collect as many species/individuals as possible and increase the likelihood of recording the conservation significant black-stripe minnow or any additional listed species, such as the western mud minnow (*Galaxiella munda*). Fish sampling methods included beach seine netting, dip netting, baited box traps, and fyke netting.

A minimum of three (depending on wetland size) fyke nets comprising a double 10 m leader/wing (4 - 6 mm mesh, 1.5 m drop) and a 5 m hoop were set at each site overnight. Fyke nets were set at a 45° angle to the bank to create a complete barrier to fish passage at each site. A custom-made floating fauna platform was placed at the cod (closed)-end (closest to the bank) to provide an air space and resting stage for air-breathing fauna such as freshwater turtles, frogs and water rats that might be retained. A minimum of five baited fine mesh box traps (26 x 26 x 36 cm, 3 mm mesh) were deployed overnight at each site, each baited with a mixture of cat biscuits and chicken pellets.

Dip nets (500 mm x 500 mm opening x 450 mm deep and 3 mm mesh) were used in areas that were shallow and dense with vegetation. Dip nets were swept through the water, encompassing a variety of different habitat types.

Where habitat complexity and water depth allowed, replicate seine netting was used. Each seine (10 m net, with a 2 m drop and 6 mm mesh) was deployed in shallow areas where there was little vegetation or large woody debris to obstruct the "looping" action of the net. A minimum of two seine hauls were conducted at each site where seining was possible.

Due to site access restrictions, and proximity to the road (increased chance of vandalism of fishing gear), only box traps could be set at site South 10.

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, which reflects breeding and recruitment success. 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.

[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).

**Plate 4.** Fyke net set, August 2019

### 3.2.2 Carter's freshwater mussel

Visual observations for live mussels (or evidence of dead mussels) at each site were made. A fine-toothed rake was used to comb through wetland sediments in order to uncover any buried mussels.

### 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 in-stream 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. Notes on riparian vegetation and geomorphology of each wetland were also made during the survey.

### 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

Sites South 2, 6a, 6b, 7a and 7b were dry at the time of sampling. *In situ* water quality across wetlands holding surface water was characterised by slightly acidic to slightly basic pH (6.89 to 7.98), low to good dissolved oxygen levels (52.2% to 108.8%), and moderate temperatures (15.2 °C to 26.4 °C; Table 2). Two sites were considered fresh, and two sites were considered brackish as defined by the DoE (2003)[2], with conductivity ranging from 1391 µs/cm (at South 11) to 2630 µs/cm (at South 10) (Table 2). EC values were above the ANZG (2018) default guideline range for slightly disturbed wetlands in the southwest of Western Australia (300 – 1500 µS/cm) at South 1a, South 1b and South 11 (pH 6.89; Table 2). pH was below the default guideline values (DGVs) (ANZG 2018) for the protection of slightly/moderately disturbed wetland ecosystems in the southwest of W.A. (pH 7 – 8.5) at South 10 (Table 2). However, highly coloured (tannin stained) wetlands such as these can be naturally acidic, due to the microbial breakdown of organic matter (leaf litter and woody debris). As such, the pH values recorded at South 10 is considered normal.

Two sites recorded DO saturation less than the lower DGV (90%); South 10 (64.4%) and South 11 (52.2%). 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).

**Table 2.** *In situ* water quality results from all sites sampled in August 2019, with default ANZG (2018) water quality guideline values.

| | Date | Temp°C | Cond (µs/cm) | pH | DO% | DO mg/L |
|---|---|---|---|---|---|---|
| **ANZG guidelines – wetlands** | | | **300 - 1500** | **7 – 8.5*** | **90 - 120** | |
| South 1a | 26/08/2019 | 26.4 | 1517 | 7.78 | 108.8 | 8.51 |
| South 1b | 27/08/2019 | 20.6 | 2020 | 7.98 | 102.8 | 9.54 |
| South 2 (dry) | 28/08/2019 | - | - | - | - | - |
| South 6a (dry) | 28/08/2019 | - | - | - | - | - |
| South 6b (dry) | 28/08/2019 | - | - | - | - | - |
| South 7a (dry) | 28/08/2019 | - | - | - | - | - |
| South 7b (dry) | 28/08/2019 | - | - | - | - | - |
| South 8 | 28/08/2019 | 22.2 | 1427 | 7.60 | 92.2 | 7.70 |
| South 10 | 27/09/2019 | 15.2 | 2630 | 6.89 | 64.4 | 6.60 |
| South 11 | 27/08/2019 | 17.2 | 1391 | 7.13 | 52.2 | 4.95 |

* ANZG recognises that pH can typically range between 4.5 and 6.5 in highly coloured wetlands, such as those in the study area.

## 4.2 Habitat

Sites South 1a and 1b are located with an extremely large seasonal wetland (over 24 hectares) that has a large area of intact native riparian vegetation, is fenced entirely and has minimal human/livestock disturbance. Site South 8 is part of a small watercourse/wetland chain that flows in

[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 ANZG (2018).

a westerly direction following heavy rains, however, there is little intact riparian vegetation at this site (cleared farmland). South 10 is part of a large wetland either side of Ken Bell Road and has a large area of intact riparian vegetation. South 11 is part of a large wetland that floods Jilley Road following high rainfall and appears to be part of the same wetland chain as that of South 8. All five wetland sites had a diverse range of instream habitat types including large woody debris, emergent macrophyte, trailing vegetation, submerged macrophyte and detritus (see Plate 4). All sites had a sand substrate and percentage of riparian cover ranged from 20 – 90%.

**South 1a**

**South 1b**

**South 8**

**South 10**

**South 11**

**Plate 5.** Site photographs from South 1a, 1b, 8, 10 and 11 at the time of sampling in August 2019.

## 4.3 Black-stripe minnow

### 4.3.1 Abundance and population structure

A total of five black-stripe minnow (Plate 6) were recorded during the August 2019 survey; one individual (39 mm) was recorded from site South 8 (within the southern investigation area), and four individuals (between 35 and 40 mm) were recorded from site South 11 (adjacent the southern investigation area). Introduced mosquitofish (*Gambusia holbrooki*) and goldfish (*Carassius auratus*) were also recorded at South 8. The black-stripe minnows recorded were displaying breeding colours (i.e. two distinctive lateral black stripes bordering a narrow band of orange; Plate 6), with some of the females recorded as gravid (carrying eggs).

**Plate 6.** Black-stripe minnow, *Galaxiella nigrostriata* in breeding colours (photo by WRM ©).

### 4.3.2 Distribution of black-stripe minnow within and adjacent to the BORR southern investigation area

Targeted surveys for black-stripe minnow in November 2018 and August 2019 revealed that the black-stripe minnow is present at wetlands both within, and adjacent to, the southern investigation area (Figure 2). However, distribution appears restricted to a small water course (wetland chain) that flows westwards from South 8 across Jilley Road. These wetlands appear to be hydrologically linked to the chain of wetlands in Gelorup where black-stripe minnows were found by WRM in 2018 as part of aquatic fauna surveys of the BORR southern alternate alignment investigation area (WRM 2019a, Figure 3), though these wetlands would likely only connect up during periods of high rainfall and flooding.

Black-stripe minnows were not recorded at Southern 1, 2 and 3 (2018) or South 1 (a & b) (2019), despite extensive survey effort in both November 2018 and August 2019. The habitat and conditions at this wetland (large, tannin-stained wetland with large areas of intact riparian vegetation) are similar to sites that black-stripe minnow were recorded in at nearby wetlands (e.g. wetlands North 2, North 5 and Northern 9; Figure 3) during surveys of the BORR northern and central investigation area. It is considered likely that South 1 once supported black-stripe minnows, however the population may have become isolated and subsequently died out due to land clearing practices. Given the close proximity of South 1 to other wetlands that support black-stripe minnow (Figure 3), and the high mobility of the species, it is possible that colonisation/recolonisation would occur at South 1 after a large rainfall event and the wetlands become connected.

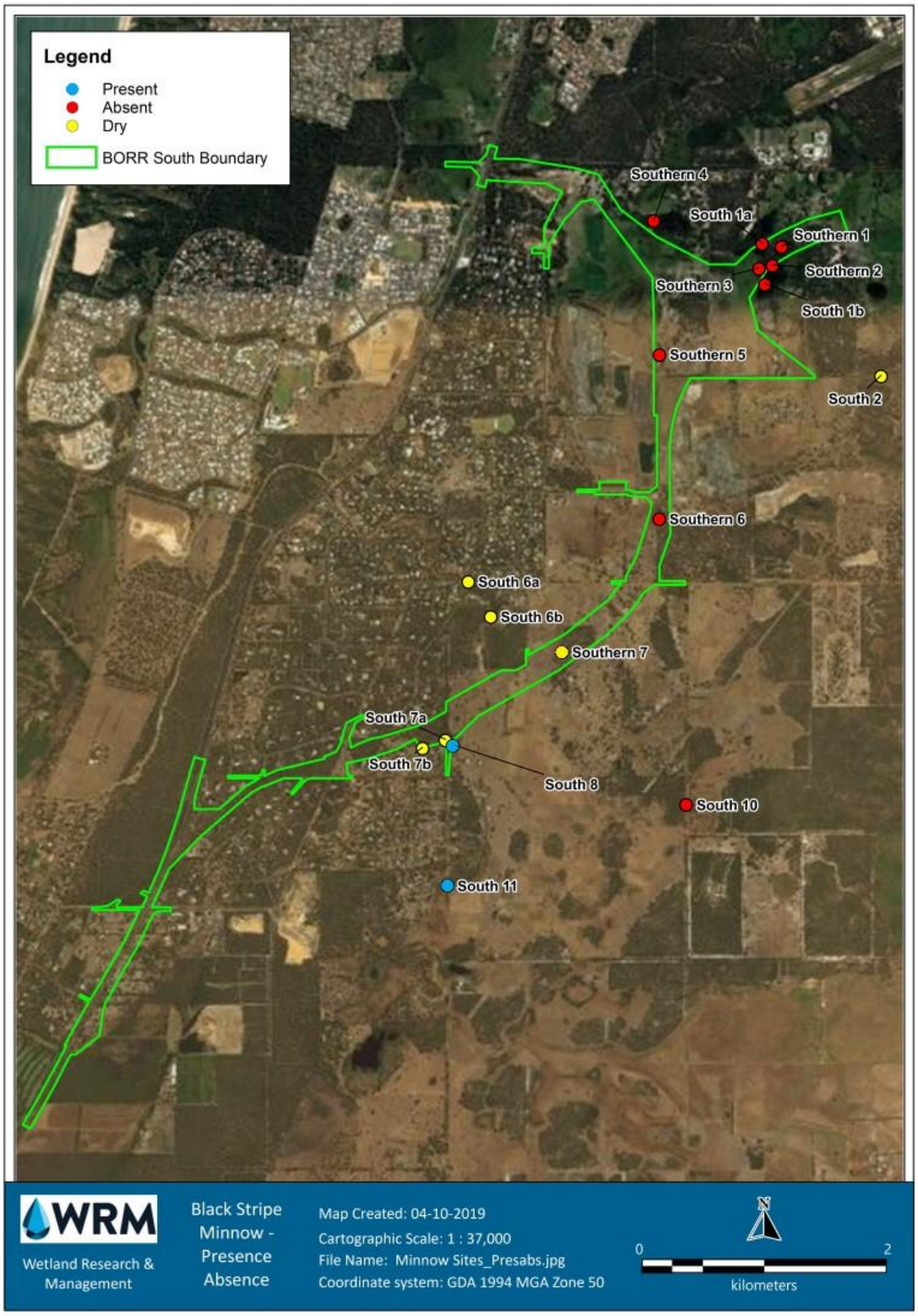


**Figure 2.** Summary of black-stripe minnow presence and absence within and adjacent to the southern investigation area (November 2018 and August 2019 records provided).

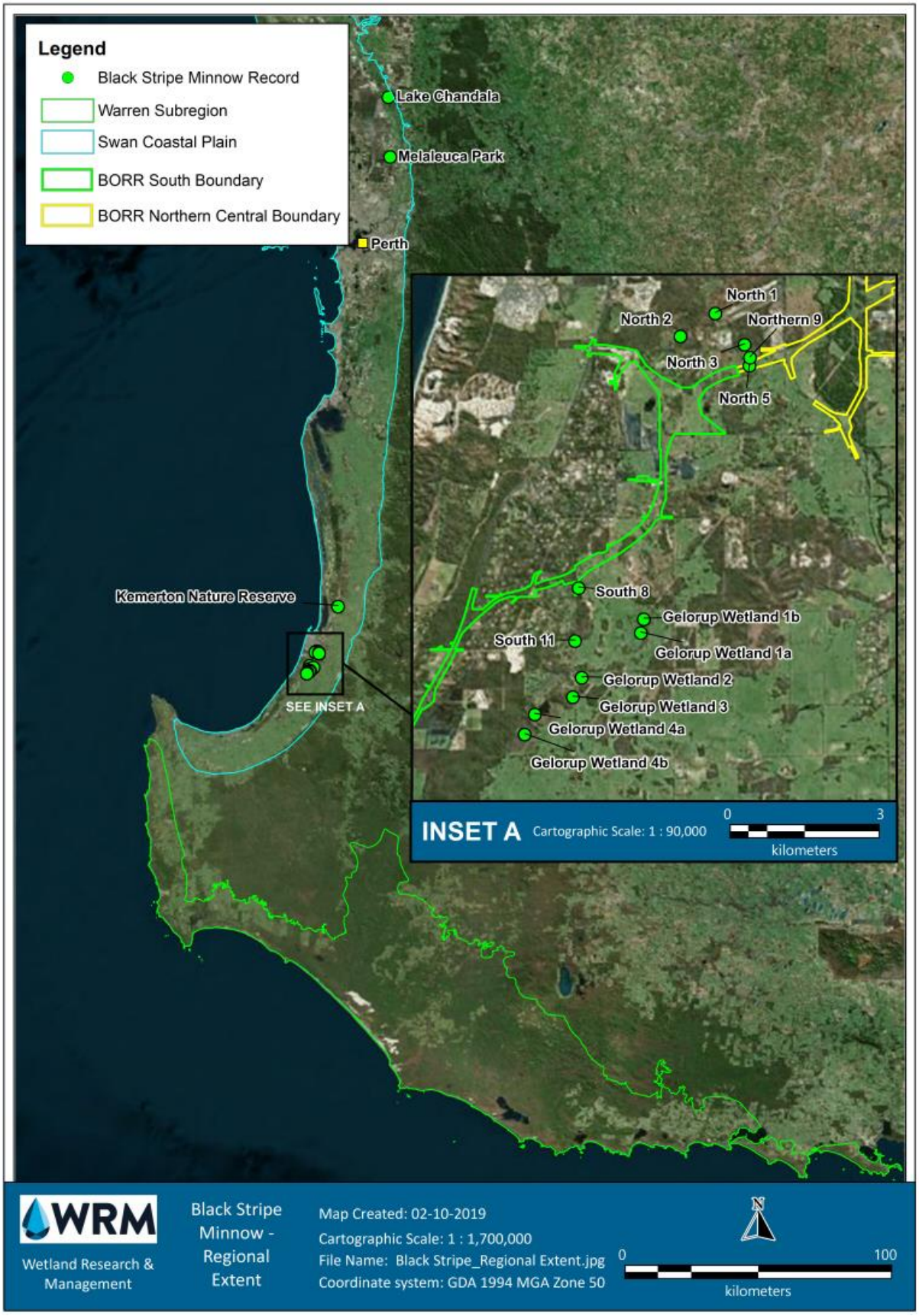


**Figure 3.** Regional distribution of black-stripe minnow. Note that the majority of populations are found in the Warren sub-region (green outlined area; individual sites not shown), but only four are known from the Swan Coastal Plain (blue outlined area), including that discovered during BORR aquatic fauna surveys.

### 4.3.3 Regional distribution of black-stripe minnow, with notes on water quality and habitat preferences

The majority of black-stripe minnow populations are confined to peat flat wetlands of the Warren sub-region between Augusta and Albany in the extreme south-west corner of W.A. (Figure 3), though three isolated populations exist between Bunbury and Gingin on the Swan Coastal Plain (Lake Chandala *ca.* 55 km north-east of Perth, Melaleuca Park *ca.* 30 km north-east of Perth, and Kemerton Nature Reserve *ca.* 130 km south of Perth), intimating its historically-wider distribution (Figure 3). The discovery of black-stripe minnow during 2018 and 2019 surveys of the BORR southern investigation area, as well as nearby wetlands in the northern central investigation area (WRM 2019b, WRM 2019 in prep.) and the BORR southern alternate alignment investigation area (WRM 2019a, Table 3, Figure 3), extends the distribution of this species on the Swan Coastal Plain approximately 30 km south.

Black-stripe minnows 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). However, individual populations appear to be sensitive to sudden, localised changes in water quality variables (Knott *et* al. 2002). Little is known about the salinity tolerances for the black-stripe minnow, although the authors have previously recorded them in wetlands with salinity levels above 3330 µS/cm (Table 3). Table 3 outlines all the known water quality variables reported for sites where black-stripe minnows have been recorded in Western Australia.

**Table 3.** *In situ* water quality results from all sites with positive black-stripe minnow records (Green text highlights lowest of the range, orange text highlights highest of the range).

| Reference | Site Code | Temp °C | Cond (µS/cm) | pH | DO (%) |
|---|---|---|---|---|---|
| Current study | Gelorup (South 8) | 17.2 | 1391 | 7.13 | 52.2 |
| Current study | Gelorup (South 11) | 22.2 | 1427 | 7.60 | 92.2 |
| WRM (2019 in prep.) | Manea Park (North 1) | 12.7 | 1878 | 7.35 | 55.6 |
| WRM (2019 in prep.) | Manea Park (North 2) | 13.2 | 672 | 6.59 | 52.2 |
| WRM (2019 in prep.) | Manea Park (North 3) | 16.2 | 1306 | 6.89 | 83.2 |
| WRM (2019 in prep.) | North Boyanup (North 5) | 19.3 | 1005 | 6.67 | 127.2 |
| WRM (2019b) | North Boyanup (Northern 9) | 26.1 | 3360 | 7.70 | 109.7 |
| WRM (2019a) | Gelorup (Wetland 1a&b) | 22.0-25.0 | 983-1422 | 6.51-6.67 | 28.7-95.5 |
| WRM (2019a) | Gelorup (Wetland 2) | 21.1 | 855 | 6.68 | 170.8 |
| WRM (2019a) | Gelorup (Wetland 3a&b) | 19.0-22.7 | 365-596 | 6.52-6.62 | 57.7-103.9 |
| WRM (2019a) | Gelorup (Wetland 4a&b) | 18.8 | 278 | 6.42 | 49.5 |
| Knott *et al.* (2002) | Melaleuca Park | 12.8-17.0 | 3060-5000 | 3.3-5.0 | 40.0-70.0 |
| Galeotti (2013) | Swan Coastal Plain | 19.6±0.6 | 960±150 | 5.4±0.3 | 71±4.2 |
| Galeotti (2013) | Warren sub-region | 16.2±0.5 | 350±0.40 | 5.2±0.3 | 61±1.7 |

## 4.4 Carter's freshwater mussel

Carter's freshwater mussels were not recorded in the southern investigation area in either the November 2018 or September 2019 surveys. Carter's freshwater mussel are considered unlikely to occur in the southern investigation area, as they prefer flowing riverine/creekline habitats (as opposed to the seasonal wetlands), none of which intersect the southern investigation area.

## 4.5 Australian water rat / rakali

No Australian water rats were recorded on any of the motion sensor camera traps deployed in August 2019, nor was there any evidence of water rats (e.g. the presence of middens). Similarly, no water rats were recorded from the southern investigation area in November 2018, however, a feeding midden was discovered at Southern 5 (Figure 1), potentially belonging to a water rat. Although not recorded in either 2018 or 2019 surveys, it is still considered likely that water rats could occur in the southern investigation area, as the species is widely distributed across the south west of W.A., and a number of suitable wetland habitats exist for water rats in the investigation area, with intact riparian zones, good water quality and prey species such as freshwater crayfish.

## 4.6 Other fauna

### 4.6.1 Turtles

One south-western snake-necked turtle, *Chelodina colliei*[3], was observed within the investigation area; from South 1 (Plate 7). The south-western snake necked turtle was also recorded from South 1 in the November 2018 survey, including mature males and females as well as juveniles (WRM 2019b). (Plate 7). *Chelodina colliei* is endemic to the south-west of W.A. and is listed on the IUCN Redlist of Threatened Species as Near Threatened (IUCN 2020), although not listed on a state or national level. 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 for up to six months to avoid drought in seasonal waterbodies (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).

[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*).

**Plate 7.** South-western snake-necked turtle recorded from Northern 8 (November 2018 survey).

### 4.6.2 Crustaceans

Two species of decapod crustacean (freshwater crayfish) were recorded during the August 2019 survey. Both were native species, gilgie (*Cherax quinquecarinatus*) and koonac (*Cherax preissii*); and were recorded from South 1 and 8. Neither of these species are listed for conservation significance, although both are south-west W.A. endemics, and have inland ranges that have been reduced due to salinisation (Morgan *et al*. 2011).

# 5 CONCLUSIONS

A targeted aquatic fauna survey was completed within, and adjacent to, the southern investigation area for the Bunbury Outer Ring Road in August 2019 to supplement an initial targeted survey in November 2018. A total of five seasonal wetland sites were surveyed for the black-stripe minnow (listed as Endangered under the federal EPBC Act 1999, State BC Act 2016 and IUCN Redlist 2020); one within the investigation area, three just outside but adjacent to the investigation area, and one closer to populations recorded in October 2018 (outside of the investigation area). Surveys were also conducted for Carter's freshwater mussel (listed as Vulnerable under the EPBC Act 1999 and the BC Act 2016) and Australian water rat / rakali (listed as a P4 species under the BC Act 2016), however none were found in the investigation area.

Black-stripe minnows were recorded at two of the five sites, with the presence of black-stripe minnows at site South 8 representing the first record of the species within the southern investigation area. The discovery of this population (along with the previous discovery by WRM of a population at wetlands in Gelorup as part of BORR southern alternate alignment surveys) extends the Swan Coastal Plain distribution of black-stripe minnow approximately 30 km further south. It should also be considered, that due to the current known spatial separation between black-stripe minnow populations on the swan Coastal Plain, that they could be different genetically distinct populations, this would need to be confirmed through further investigations.

Loss of habitat, including habitat degradation and fragmentation is one of the most critical potential impacts to black-stripe minnow in the investigation area. 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). Currently, information on aestivation duration, timing and physiological tolerances for the black-stripe minnow is unknown, however changes to water inundation extent and duration could alter the length of aestivation, thus adversely impacting reproduction and recruitment success.

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