October 2020

Peel-Harvey Catchment Council: Hotham-Williams River Health Assessment

2019/2020
FINAL REPORT



Hotham-Williams River Health Assessment

2019/2020 Sampling

Prepared for:

Peel-Harvey Catchment Council

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Frontispiece (left to right): Gilgie (*Cherax quinquecarinatus*) at Boraning Reserve, fyke nets set at Quindanning and dragonfly larva at Pumphreys Bridge (photos by WRM ©).

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Disclaimer

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CONTENTS

LIST OF TABLES, FIGURES & PLATES

TABLES

FIGURES

PLATES

LIST OF ACRONYMS

ANZG	Australia and New Zealand Guidelines
AUSRIVAS	Australian River Assessment System
BOM	Bureau of Meteorology
CL	Carapace Length
DBCA	Department of Biodiversity, Conservation and Attractions
DoE	Department of Environment
DGV	Default Guideline Values
DO	Dissolved Oxygen
DWER	Department of Water and Environment Regulation
EC	Electrical Conductivity
EPBC	Environment Protection and Biodiversity Conservation
FARWH	Framework for the Assessment of River and Wetland Health
FBA	Freshwater Biological Association
IUCN	International Union for Conservation of Nature
NATA	National Association of Testing Authorities
NTU	Nephelometric Turbidity Units
PHCC	Peel-Harvey Catchment Council
RAP	River Action Plan
SL	Standard Length
SWIRC	South-West Index of River Condition
TDS	Total Dissolved Solids
TN	Total Nitrogen
TP	Total Phosphorus
UWA	University of Western Australia
WRM	Wetland Research & Management

EXECUTIVE SUMMARY

The Peel-Harvey Catchment Council (PHCC) is seeking to build on its ecological information on sites in the Hotham and Williams Rivers sub-catchment of the Peel-Harvey Catchment. This report summarises the results of the spring 2019 and autumn 2020 aquatic fauna (fish, crayfish and macroinvertebrate assemblages) and water quality surveys. These were conducted to gather ecological information to use as a baseline to enable the effectiveness of rehabilitation and management actions to be measured within the Hotham and Williams Rivers.

Six sites were chosen on the Hotham and Williams river systems, with four sites on the Hotham River and two sites on the Williams River. Sampling and analysis followed South West Index of River Condition (SWIRC)[1] protocols, ensuring that methods were standardised at each site to enable direct comparison of data between sites, and enabling comparison with future assessment and monitoring of their ecological condition. SWIRC themes targeted in the current study were water quality, aquatic biota, fringing zone and physical form. The main findings of the 2019/20 surveys were:

- **Popanyinning:** SWIRC condition bands varied between severely modified to slightly modified. Water quality had the lowest score, due to high salinity within the site. A total of 18 macroinvertebrate taxa were recorded. One native fish species and one non-native fish species were recorded in the October 2019 sampling, with no native fish recorded in March 2020. The fringing vegetation zone was dense but narrow, with 50 – 74% of ground cover non-native grasses.
- **Hotham River Nature Reserve:** SWIRC condition bands varied between severely modified to slightly modified. Water quality had the lowest SWIRC score of 0, due to high salinities. A total of 17 macroinvertebrate taxa were recorded, the lowest of the six sites. Two native fish species and one non-native fish species were recorded in October 2019 sampling, no fish were recorded during the March 2020 sampling, likely due to the increase in salinity over the summer months. Fringing vegetation zone was the highest SWIRC score for this site at slightly modified.
- **Pumphreys Bridge:** SWIRC condition bands ranged from severely modified to slightly modified, with salinity scoring 0 for the water quality theme. A total of 28 macroinvertebrate taxa were recorded at the site across the two sampling events, including the odonate dragonfly *Procordulia affinis*, which is a south-west endemic species. Three native fish and one non-native fish were recorded at the site. Fringing vegetation zone was classified as substantially modified, as groundcover was dominated by non-native grasses on both the left and right banks and substantial agricultural clearing has occurred at the site.
- **Ranford Pool:** SWIRC condition bands ranged from substantially modified to slightly modified. The water quality theme had the lowest score, due to salinity levels. Along the Hotham River sites, salinity was the lowest at Ranford Pool (the most downstream site). A total of 27 macroinvertebrate taxa were recorded across the two sampling events including *Necterosoma darwini* which is a Western Australian endemic beetle. Four native fish were recorded at the site, the highest taxa richness of the four Hotham River sites. Fringing vegetation zone was classified as moderately modified and was both dense and wide across the reach, however there was minimal groundcover within the site.
- **Boraning Reserve:** SWIRC condition bands ranged from substantially modified to largely unmodified, with the water quality theme having the lowest score of 0.2, due to salinity levels. A total of 28 macroinvertebrate taxa were recorded across both sampling events, including *Symphitoneuria wheeleri* which is a Western Australian endemic caddisfly. Four native fish and

[1] https://www.water.wa.gov.au/water-topics/waterways/assessing-waterway-health/south-west-index-of-river-condition

one native crayfish were recorded at the site. Fringing vegetation zone was classified as moderately modified as it was dense and wide across most of the reach, with native shrubs and trees along the length. There was some native groundcover, although within the 10 m recorded width, this was predominantly dominated by non-native grasses.

- **Quindanning:** SWIRC condition bands ranged from moderately modified to slightly modified, with the highest overall SWIRC score for the six sites. A total of 25 macroinvertebrate taxa were recorded at the site. Three native fish and one non-native fish were recorded during the sampling events. The fringing zone theme had the lowest classification of moderately modified but was dense and wide along the reach, with all three native riparian layers (groundcover, shrubs and trees) present, although ground cover and shrub layers were heavily reduced and dominated by non-native grasses and dock.

Although SWIRC condition bands varied between sites, common themes were noted across all sites. All sites recorded salinities higher than Australia and New Zealand Guidelines 2018 (ANZG), with high levels largely a result of rising groundwater due to extensive vegetation clearing on a catchment level. All sites also recorded either a reduced groundcover layer or a groundcover layer dominated by exotic plants such as non-native grasses. Although fringing vegetation extent was high across most sites, the overall SWIRC theme score was reduced due to this.

Although widespread catchment management and lowering of groundwater levels would be needed for salinity scores to improve over time, the dataset collected will form a good baseline for future assessments to be undertaken post-rehabilitation and management.

1 INTRODUCTION

1.1 Background

The Peel-Harvey Catchment Council (PHCC) is seeking to build on its ecological information for sites within the Hotham and Williams rivers sub-catchment of the Peel-Harvey Catchment to enable effective rehabilitation and management actions. Several aquatic surveys have been conducted on the Hotham River over the past decade, with the majority between the Boddington township and the Camballing/Marradong gauging station on the Pinjarra-Williams Road, specifically by Newmont Boddington (gold mine operation). More recently, ecological investigations into sediment/water quality and aquatic fauna biodiversity within Boddington Pool, directly upstream of Lion's Weir have been conducted through the Shire of Boddington. This work was conducted by Wetland Research and Management (WRM). Prior to this, between 2002 and 2003, Murdoch University's Centre for Fish and Fisheries Research conducted studies on the fish fauna of the Hotham River (including the impact of the Lion's Weir on fish migration) and fish utilisation of the Lion's Weir Fishway (in Boddington)[2]. To WRM's and PHCC's knowledge (and after consultation with Department of Water and Environmental Regulation (DWER)), no additional river health monitoring has been conducted on the Hotham and Williams rivers apart from these studies.

The data gathered in the field and the subsequent information provided in this report will complement the Hotham-Williams River Action Plan (RAP) which was produced in 2019-20 by PHCC and Urbaqua, a not-for-profit environmental planning consultancy service. The RAP provides detailed foreshore condition ratings based on field assessments of eight sites on the Hotham and Williams Rivers, including the six sites that comprise the Hotham-Williams River Health Assessment. Furthermore, the RAP includes a desktop assessment of the 102 sub-catchments of the Hotham-Williams catchment and a detailed list of recommended management actions for ecological recovery at a site and landscape scale (Urbaqua 2020).

The Hotham and Williams rivers are two major tributaries of the Murray River, one of south west Western Australia's largest river systems. Each have their origins in the southern Wheatbelt region, an area with relatively low annual rainfall (~500 mm) that has been extensively cleared for agriculture. This has led to increased salinity levels in both the Hotham and Williams rivers, a result of secondary salinisation, where the removal of deep-rooted native vegetation has caused the water table to rise, pushing stored salts that have built-up over thousands of years to the surface and into the rivers. The major detrimental effects of salinisation on stream health include the death of riparian zone trees (with flow-on effects of stream bank destabilisation and erosion) and reductions in stream biodiversity, with "sensitive" native fish, invertebrate and plant species being replaced with invasive and/or salt-tolerant taxa. Other environmental challenges faced by the Hotham and Williams rivers include the damming of sections for recreational and agricultural use, and physical damage to river banks and vegetation where livestock access has not been restricted.

1.2 Scope of works

Through the Hotham-Williams Rivers and Tributaries' Natural Resource Management and Conservation Project, a partnership between PHCC and Newmont Boddington, one of the PHCC's main goals is to work with landowners and the community. This is to address existing natural, conservation and cultural resource management knowledge gaps of the Hotham and Williams rivers, build community capacity for future land management, and undertake research and restoration projects to protect and enhance catchment health, biodiversity and agricultural sustainability.

[2] https://researchrepository.murdoch.edu.au/id/eprint/5941/1/Hotham_River_fishway_report(Completed).pdf

In order to gather baseline ecological information to enable the effectiveness of rehabilitation and management actions to be measured, a survey of fish, crayfish and macroinvertebrate communities, along with instream and riparian habitat condition was required within the Hotham-Williams sub-catchment. As such, WRM were contracted to undertake sampling of water quality, aquatic fauna (macroinvertebrates, fish and crayfish), fringing zone vegetation and stream physical form at six locations within the Hotham-Williams sub-catchment over two sampling occasions: spring (October) 2019 and late summer/early autumn (March) 2020.

2 STUDY AREA AND SAMPLING SITES

2.1 Sampling sites

Six sites were chosen in the Hotham and Williams sub catchments for the detailed field data collection carried out as part of this River Health Assessment. Four of the sites are located on the Hotham River and two sites on the Williams River (Figure 1-4):

- Popanyinning town site, Hotham River;
- Hotham River Nature Reserve, Hotham River;
- Pumphreys Bridge, Hotham River;
- Ranford (Darminning) Pool, Hotham River;
- Boraning Reserve, Williams River; and,
- Quindanning, Williams River.

The six sites were chosen by the PHCC from the eight priority sites included in the catchment-wide Hotham-Williams River Action Plan. All of the sites were initially chosen on the basis of community and cultural value, vegetation connectivity and significance, and the presence of permanent water. In terms of the River Health Assessment, ease of access was a determining factor in the final list of sampled sites.

Table 1. Site coordinates and location descriptions

Site name	Co-ordinate location	Location Description
Popanyinning	-32.670809, 117.132125	Approximately 1km upstream of Popanyinning town site
Hotham River Nature Reserve	-32.605722, 117.091815	Approximately 800m downstream of Great Southern Highway and immediately north of Hotham River Nature Reserve
Pumphreys Bridge	-32.663597, 116.901170	Approximately 500m downstream of Old Pumphreys Bridge
Ranford (Darminning) Pool	-32.789448, 116.501196	Immediately east of Ranford Pool, 500m upstream of main recreational area
Boraning Reserve	-33.102823, 116.720224	Approximately 100m upstream of Pinjarra-Williams Road within Boraning Reserve
Quindanning	-33.046991, 116.562860	Approximately 250m downstream of the Pinjarra-Williams Road where it goes through the Quindanning town site

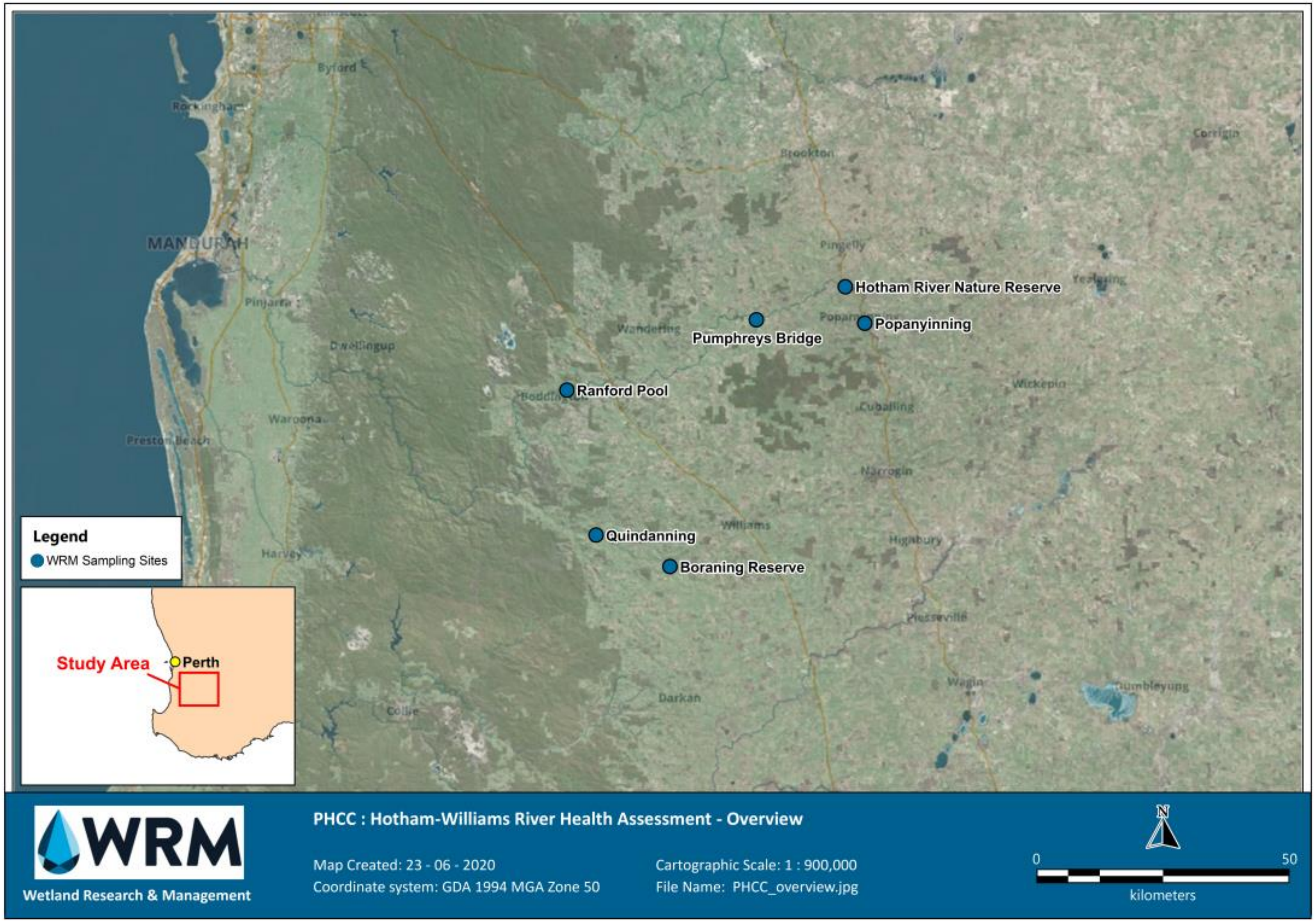


Figure 1: 2019/20 sampling locations for the Hotham-Williams River Health Assessment

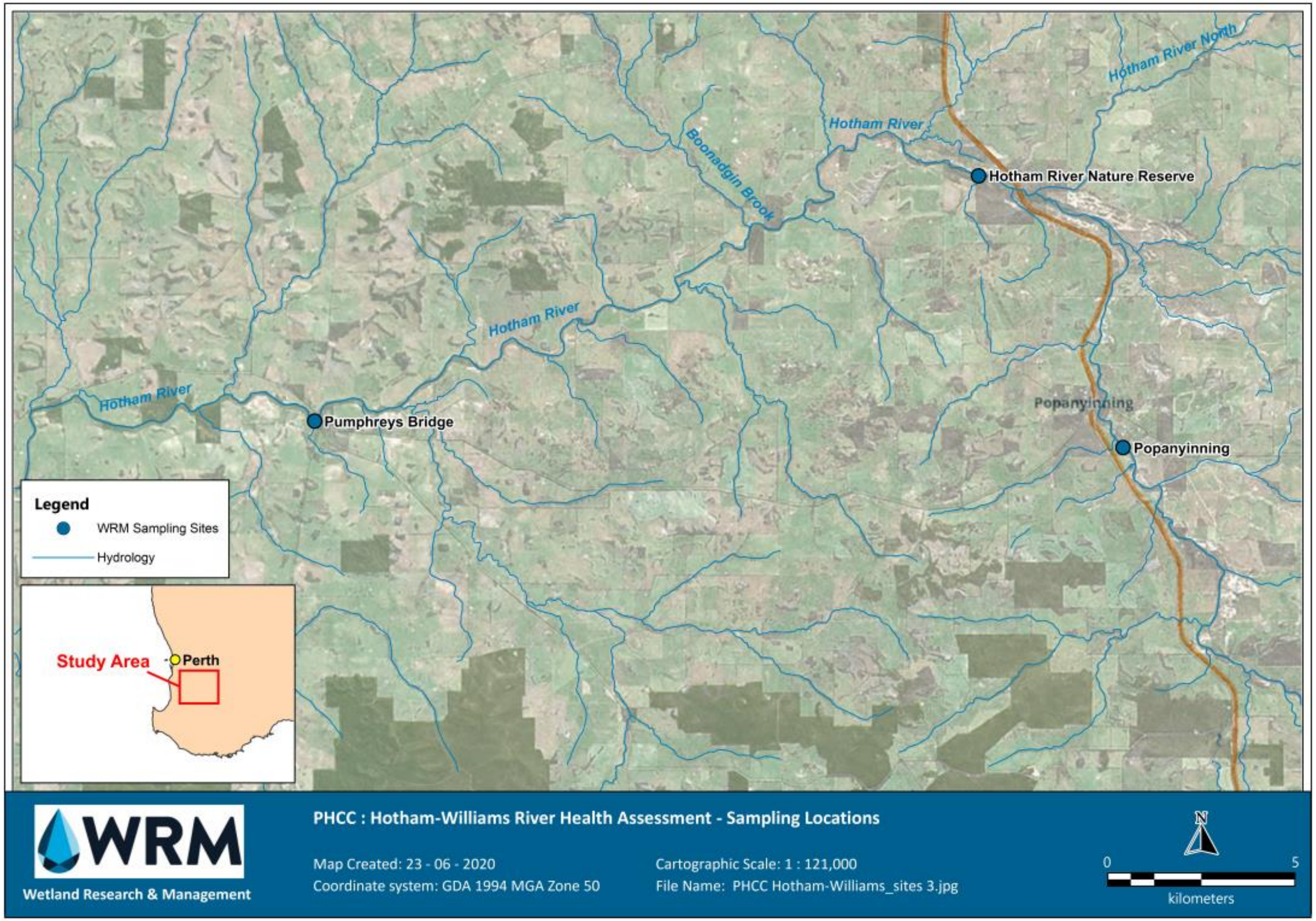


Figure 2: Location of Popanyinning, Hotham River Nature Reserve and Pumphreys Bridge sites.

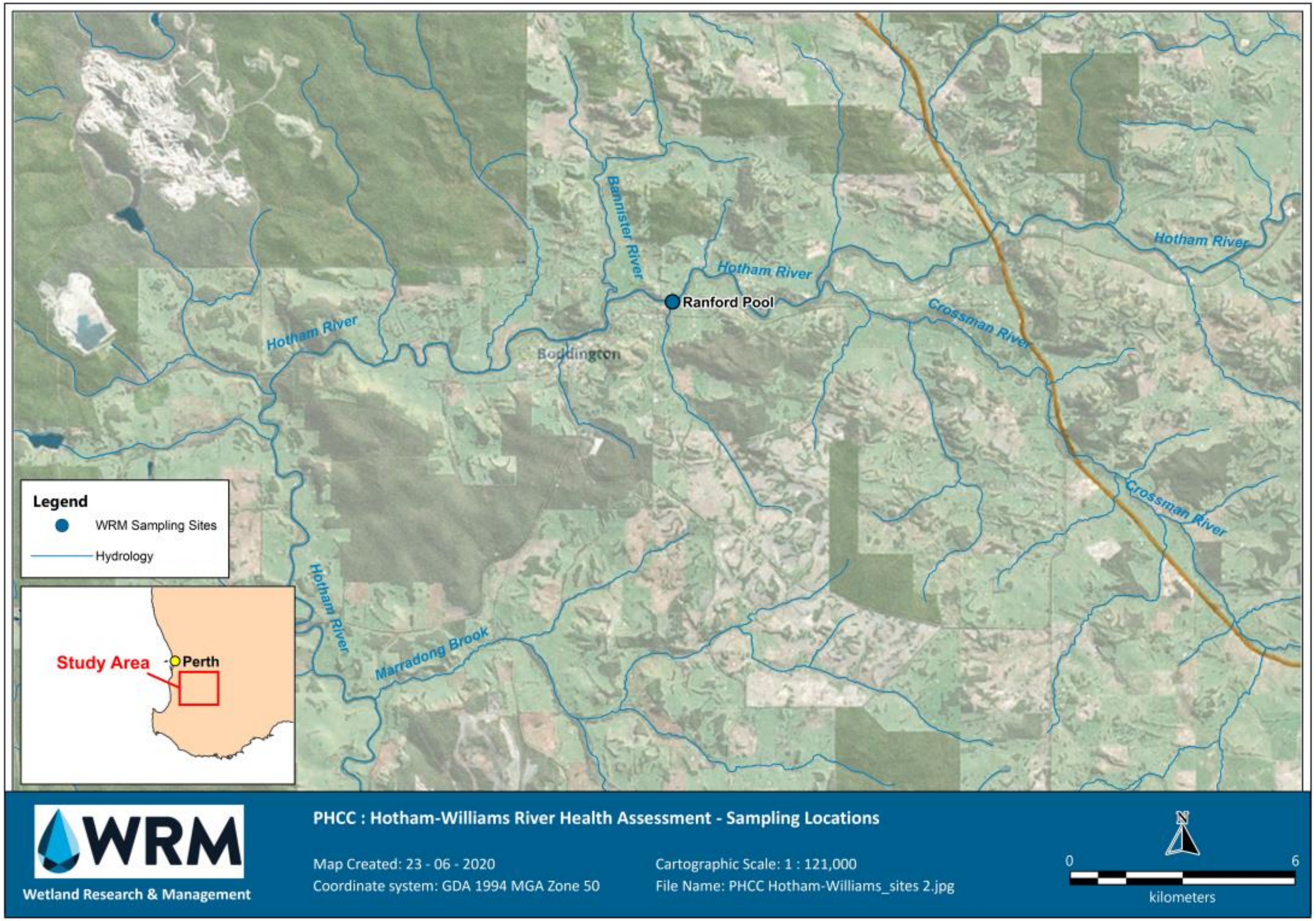


Figure 3: Location of Ranford Pool site.

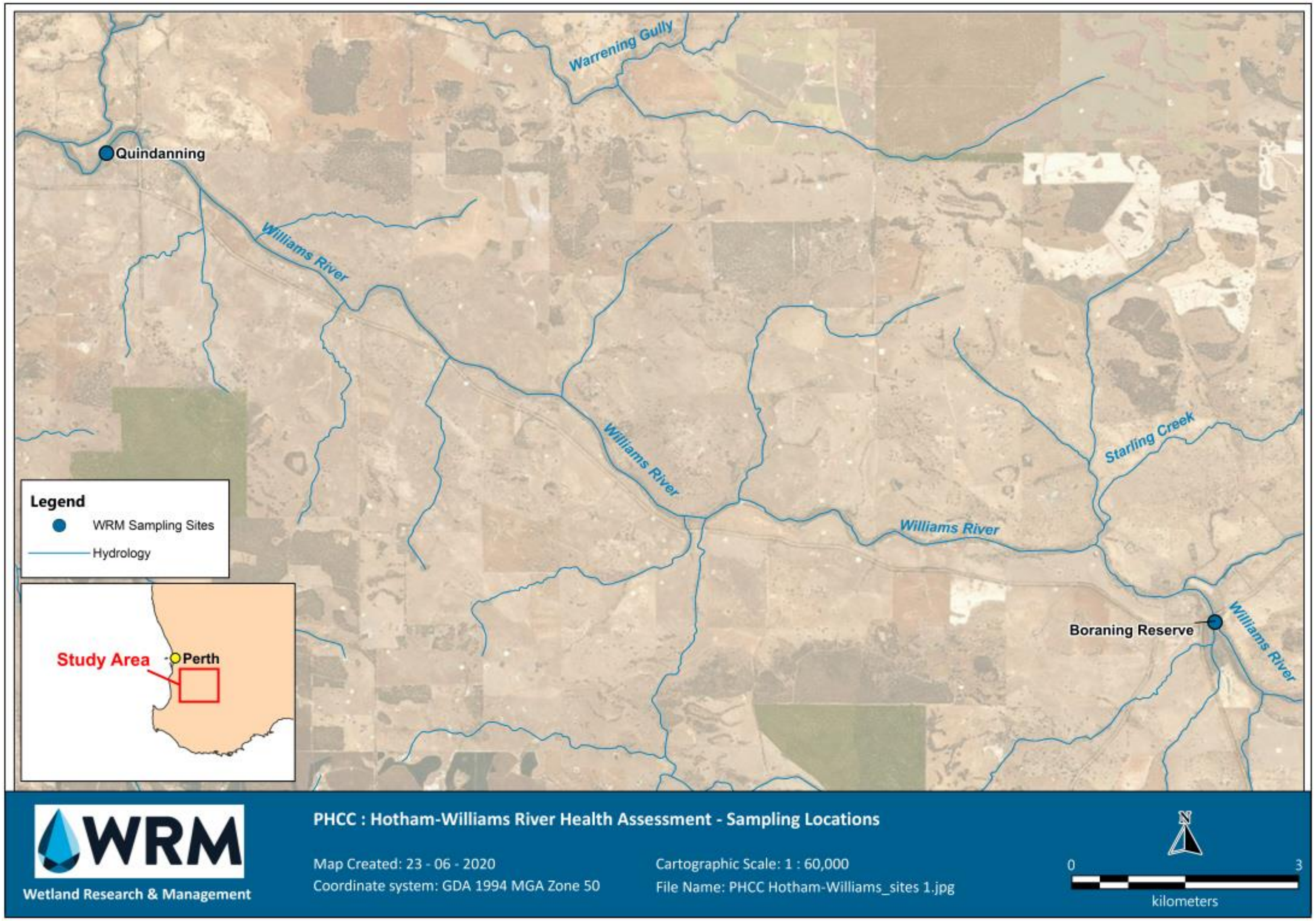


Figure 4: Location of Quindanning and Boraning Reserve sites.

2.2 Climate

The study area is located in the Murray River catchment. The region has a Mediterranean climate, with hot dry summers and cool, damp winters.

2.2.1 Rainfall

Long-term Bureau of Meteorology (BOM) rainfall data are represented by Pingelly (010626; for Popanyinning and Hotham River Nature Reserve), Caernarvon Park (010876; for Pumphreys Bridge), Boddington North (109516; for Ranford Pool) and Marradong (009575; for Boraning and Quindanning) (Figure 5). Rainfall for the Hotham and Williams Rivers catchments is highly seasonal, with the majority of precipitation occurring between June and October. Annual rainfall for the catchment varies between 430 – 710 mm.

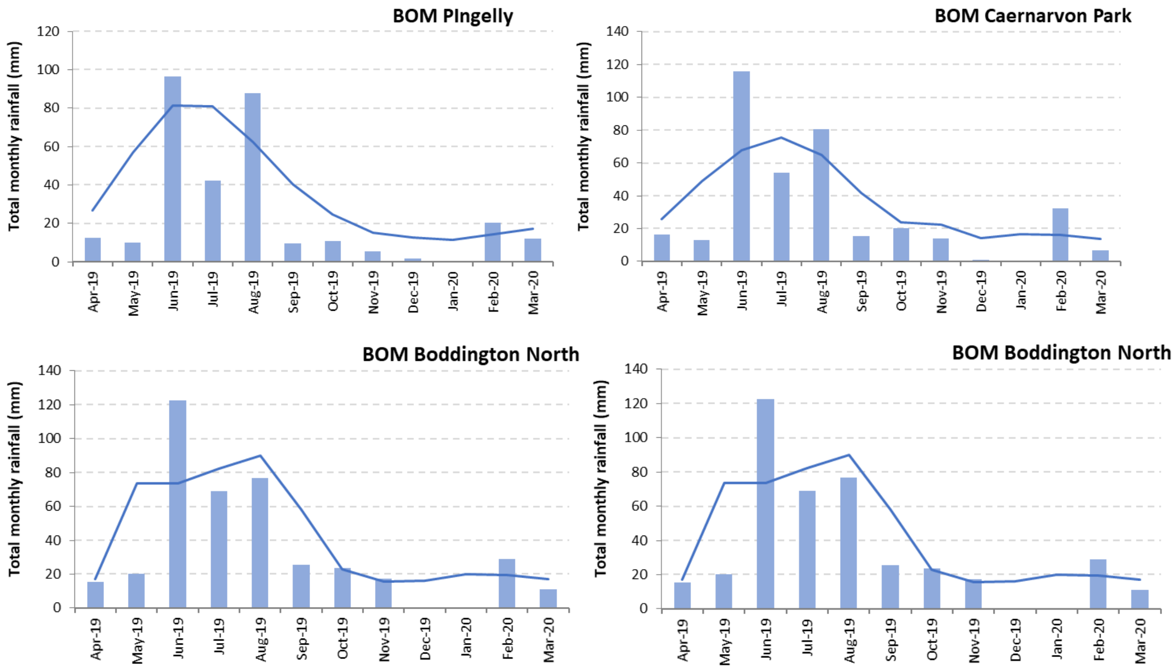


Figure 5: Total monthly rainfall (2019/20) for the four nearby gauging stations; including the long-term average monthly rainfall.

2.2.2 Streamflow

Both the Hotham and Williams Rivers are located in the Murray River catchment. The Murray River catchment drains approximately 10,142 m^2. Streamflow in the Hotham River and Williams River is highly seasonal, with flows peaking in late winter and early spring, usually ceasing by late November. When compared to long-term average data, streamflow within both the Hotham (Marradong Road Bridge) and Williams (Saddleback Road Bridge) rivers were below average for 2019-2020 (Figure 6). Although associated with rainfall, there is a slight lag between rainfall and flows due to the large soil storage capacity of the region.

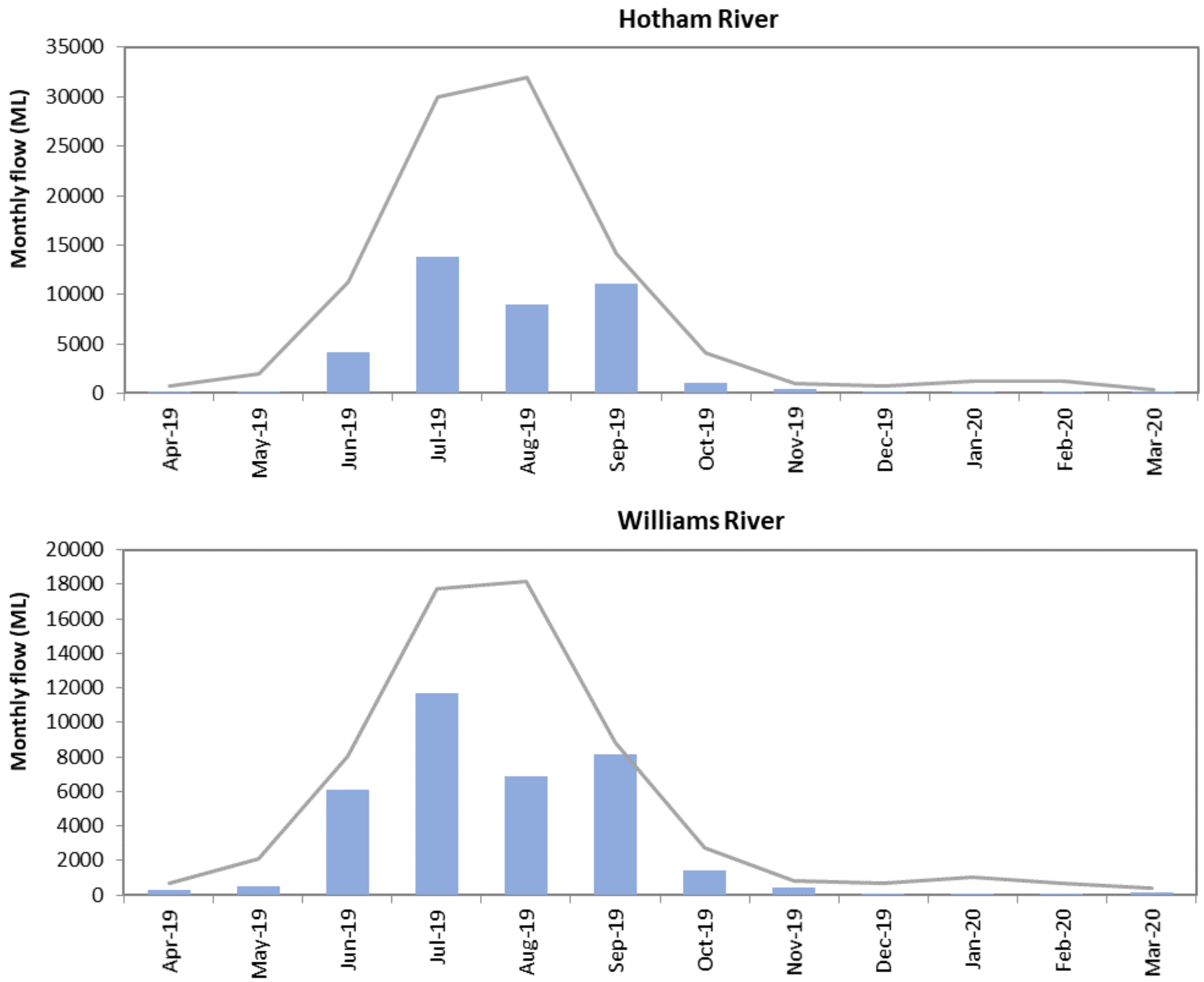


Figure 6: Total monthly streamflow (ML) (2019/20) for the Hotham River (top; Marradong Road Bridge 614224) and Williams River (bottom; Saddleback Road Bridge 614196); including the long-term average streamflow (grey line) (DWER 2020).

3 METHODS

3.1 Licences

This study was conducted under Fisheries Licence EXEM 3407 (Instruments of Exemption to the Fish Resources Management Act 1994 for Scientific Research Purposes), and DBCA Licence 08-010358-1 (Reg 27; Licence to Take Fauna for Scientific Purposes). As a condition of these licences, taxa lists and reports are required to be submitted to the respective authorities.

Surveys were undertaken in spring between the 22nd and 25th of October 2019, and autumn, between the 9th and 12th of March 2020.

3.2 Sampling methods

The South West Index of River Condition (SWIRC) is a tool developed by DWER to assess the condition of southwest WA rivers (relative to expected 'reference' condition), using a number of ecological themes and sub-themes as indicators: aquatic biota, water quality, fringing zone, physical form, hydrological change and catchment disturbance (Storer *et al.* 2011).

The SWIRC framework provides a suite of standardised methods for both collecting and analysing field and desktop data, which includes a standardised system for scoring river condition (scores range between 0 and 1, with 0 = Severely Modified, and 1 = Largely unmodified). This allows results to be compared between river systems across southwest Western Australia, but also at a site over time. The scoring system complies with the national Framework for the Assessment of River and Wetland Health (FARWH), and can be used to generate data for national comparison and reporting purposes. Detailed descriptions of SWIRC sampling methods and analysis protocols are outlined in Storer *et al.* (2011).

The sampling and analysis methods used in the current study followed SWIRC protocols, ensuring that methods were standardised at each site to enable direct comparison of data between sites, and with future assessment and monitoring of their ecological condition. SWIRC themes targeted in the current study were water quality, aquatic biota, fringing zone and physical form.

3.2.1 Water quality

A number of general water quality variables were recorded *in situ* using portable hand-held field meters, including pH, salinity (as electrical conductivity µS/cm), dissolved oxygen (% and mg/L), turbidity as Nephelometric Turbidity Units (NTU) and water temperature (°C) (Table 3).

Table 2. Water quality parameters measured *in situ.*

Parameter	*Units*
Electrical conductivity (EC)	µS/cm
Dissolved oxygen (DO)	% saturation
Dissolved oxygen (DO)	mg/L
pH	pH units
Turbidity	NTU
Water temperature	°C

Water quality was assessed against current Australian and New Zealand Guidelines 2018 (ANZG), for the protection of aquatic ecosystems, using data specific to slightly-moderately disturbed freshwater ecosystems of southwest Western Australia.

Water quality loggers (Yeo-Kal 615 and Yeo-Kal 620) were deployed at the upstream end of each site (away from fishing disturbance) at a depth of approximately 0.15 m below the water surface (probe suspended from star picket to allow the instrument to remain at a constant depth below the surface). Data were logged at 30 min intervals, over a 24-hour period to provide diurnal range of dissolved oxygen (mg/L and % saturation), temperature (^{o}C), pH, electrical conductivity (µS/cm), and total dissolved solids (mg/L).

Undisturbed water samples were collected in plastic (Nalgene) bottles at 0.1 m below the water surface for laboratory analysis of total phosphorus and total nitrogen. To reduce incidental contamination, all samples were collected with personnel wearing polyethylene gloves. Samples were kept cool in an esky while in the field, and frozen as soon as possible for subsequent transport to the ChemCentre, Bentley, WA (National Association of Testing Authorities - NATA accredited laboratory) for analysis.

3.2.2 Aquatic Biota

Macroinvertebrates

At each site, macroinvertebrate kick-sweep sampling was conducted using 250 µm mesh D-frame Freshwater Biological Association (FBA) pond net. Two macroinvertebrate samples were taken at each site on each sampling occasion: one in a macrophyte-dominated area (if present), and one in a deeper channel area. Each macroinvertebrate sweep was conducted over a period of two minutes. Each sample was washed through a 250 µm sieve to remove fine sediment, with leaf litter and other coarse debris washed into the sieve to remove attached animals and then discarded. Samples were then placed in 1L sample tubs and preserved in 70 % ethanol for transport to the WRM laboratory.

In the laboratory, macroinvertebrates were removed from samples by sorting under Leica dissecting microscopes. Collected specimens were identified to species-level, or lowest taxonomic level possible (usually genus or family level) where current taxonomy or invertebrate life stage did not allow for species level identification. In this context, "taxa" includes groups which could not be identified to species level, due to unresolved taxonomy and/or immaturity of specimens. Therefore, the total macroinvertebrate taxa richness is likely greater than reported here.

Fish and crayfish

Methods used were in accordance with SWIRC methods recommended by DWER and as described by Storer *et al*. (2011).

Fish and crayfish were surveyed using fyke nets and baited box traps, both of which are 'passive' techniques that rely on fish and/or crayfish moving into them to be caught. WRM normally use Backpack electrofishing to supplement fykes and box traps, but electrofishing could not be undertaken due to the high salinity (<1500 µS/cm) at each of the sites. Sampling methods were standardised as much as practical across habitat types to reduce the influence of sampling method on data collected.

At each site, two fyke nets and 10 baited box traps were deployed in pools for 24 hours. Fyke nets (Plate 1) and traps were set each morning, and then removed the following morning. Fyke nets comprise a dual 10 m leader/wing (7 mm mesh, 1.5 m drop) and a 5 m hooped net (75 cm diam. semi-circular opening, 10 mm mesh). Fyke nets were orientated to provide data on directional movement of fish out of the pool, *i.e.* positioned to catch fish/crayfish moving upstream out of the top of the pool, or downstream, out of the bottom end of the pool. Floating fauna platforms were placed inside each fyke net to form an air pocket in the case of any tortoises or other aquatic fauna becoming trapped.

Box traps comprised five large (21 x 47 x 60 cm, 3 mm mesh) and five small (26 x 26 x 46 cm, 20 mm mesh) traps, each baited with a mixture of cat biscuits and chicken pellets. All fish and crayfish caught were identified to species, measured for standard length[3] (SL mm, for fish; or carapace length CL mm, for crayfish), health and reproductive status recorded, and released live.

All data collected were consistent with SWIRC methodology, and were entered onto the appropriate SWIRC field data sheets as specified in the scope:

- South West Index of River Condition - Field Sheets Fish & Crayfish – Fyke Net Deployment;
- South West Index of River Condition - Field Sheets Fish & Crayfish – Box Trap Deployment;
- South West Index of River Condition - Field Sheets Fish & Crayfish – Condition of Box Traps & Fyke Nets at Collection;
- South West Index of River Condition - Field Sheets Fish & Crayfish – Supporting Information.

Records were kept of opportunistic sightings of any water rats or long-necked turtles. Turtles caught in fyke nets were measured for carapace length before being returned to the water.

3.2.3 Fringing Zone

Vegetation extent and nativeness

General observations of fringing vegetation health and extent were made at each site, using DWER SW-WA River Health Assessment Field Sheets:

- South West Index of River Condition - Field Sheets Aquatic Habitat.
- South West Index of River Condition - Field Sheets Vegetation.

This information was used to assess habitat associations for faunal assemblages to aid interpretation of any changes over time. Photographs of any defining features were taken.

3.2.4 Physical Form

Artificial channel, longitudinal connectivity & erosion

General observations of channel morphology, connectivity and erosion were made at each site, using DWER SW-WA River Health Assessment Field Sheets:

- South West Index of River Condition - Field Sheets General Site Description.
- South West Index of River Condition - Field Sheets Connectivity.
- South West Index of River Condition - Field Sheets Physical Form.

This information was used to aid interpretation of any changes over time. Photographs of any defining features were taken.

3.3 Data analysis

3.3.1 Water quality

Data were analysed descriptively, with water quality measurements and concentrations reported against ANZG 2018 Default Guideline Values (DGVs) for slightly-moderately disturbed lowland river ecosystems in southwest Australia. See Appendix 3 for the relevant list of ANZG DGVs. Logged data

[3]Standard length (SL) = tip of the snout to the posterior end of the last vertebra (*i.e.* this measurement excludes the length of the caudal fin). Carapace length (CL) = anterior tip of the rostrum to the posterior median edge of the carapace.

for temperature and dissolved oxygen plotted as diel curves (over a 24 hour period). SWIRC condition band scores for each water quality sub-index (nitrogen, phosphorus, turbidity, salinity, diel dissolved oxygen and diel temperature) were assigned using concentrations recorded at each site on each sampling occasion, based on categories defined by Storer *et al.* (2011). Sub-indices were divided into primary (salinity and diel dissolved oxygen) and secondary (total nitrogen, total phosphorus, turbidity and temperature) (Table 3-Table 8). Overall condition scores for water quality were calculated for each primary index and an average of the secondary subindices and for each site on each sampling occasion. The lowest score of the three elements (two primary and average secondary) was selected for the overall water quality index score.

Table 3. Total nitrogen (TN) sub-index categories and scores (Storer *et al.* 2011).

TN Concentration (mg/L)	Category	Score
< 0.75	Low	1.0
0.75 – 1.2	Moderate	0.8
> 1.2 – 2.0	High	0.6
> 2.0	Very high	0.4

Table 4. Total phosphorus (TP) sub-index categories and scores (Storer *et al.* 2011).

TP Concentration (mg/L)	Category	Score
< 0.02	Low	1.0
0.02 – 0.08	Moderate	0.8
> 0.08 – 0.2	High	0.6
> 0.2	Very high	0.4

Table 5. Turbidity sub-index categories and scores (Storer *et al.* 2011).

Turbidity (NTU)	Category	Score
< 5	Low	1.0
5 - 10	Moderate	0.8
> 10 - 25	High	0.6
> 25	Very high	0.4

Table 6. Diel temperature sub-index categories and scores (Storer *et al.* 2011).

Diurnal range	Score
< 4°C	0.8
> 4°C	0.4

Table 7. Diel dissolved oxygen (DO) sub-index categories and scores (Storer *et al.* 2011) (*Note:* scores for diel dissolved oxygen subindex were calculated using the length of time concentrations were in each of the below bands and was calculated using October 2019 logger data).

Band	DO concentration (mg/L)	Score
Band 1	>6	1.0
Band 2	>5 – 6	0.8
Band 3	>4 – 5	0.6
Band 4	>3 – 4	0.4
Band 5	2 – 3	0.2
Band 6	<2	0.0

Table 8. Salinity sub-index categories and scores (Storer *et al.* 2011).

Salinity (mg/L TDS)	Category	Score	Biotic tolerances
< 500	Fresh	1	Low-level impact to macroinvertebrates
500 – 1000	Marginal	1	Low level impact to macrophytes towards upper level
1000 – 1500	Marginal-brackish	0.9	Sensitive macroinvertebrates affected
1500 – 3000	High-brackish	0.8	Effects to fringing vegetation. Lethal effects to some micro/macroinvertebrates
3000 – 7000	Low-saline	0.5	Loss of species (algae, macrophytes, sensitive fish and micro/macroinvertebrates)
7000 – 14000	Mid-saline	0.2	Loss of less sensitive fish species
14000 – 35000	High-saline	0	Marron lost around 17000 mg/L
> 35000	Brine (seawater)	0	

3.3.2 Macroinvertebrates

Macroinvertebrate data were analysed descriptively based on richness, community composition and trophic structure (functional feeding groups). Conservation status of macroinvertebrate species were confirmed through reference to lists/databases such as the DBCA Threatened and Priority Fauna List, the EPBC (Federal) "Protected Matters" database, and the IUCN Red List of Threatened Species.

To calculate SWIRC macroinvertebrate sub-index scores, Western Australia autumn/spring macrophyte/channel AusRivAS (**Aus**tralian **Riv**er **A**ssessment **S**ystem) models were used to generate an AusRivAS score and condition band for each sample. The model compared the macroinvertebrate family composition at a site (observed) against the composition predicted under unimpacted or reference conditions (expected). The expected macroinvertebrate assemblage was determined by the model from a set of minimally disturbed sites that have similar physical and geographical characteristics (predictor variables). The model used the following predictor variables to determine the probability of a site belonging to a set of reference site groups: latitude, longitude, mean annual rainfall, flow velocity at time of sampling and mean annual discharge (Storer *et al*. 2011). The resultant observed/expected (O/E) score described departure from reference condition. The SWIRC macroinvertebrate sub-index scores were based on the AusRivAS scores generated (see Storer *et al*. 2011).

3.3.3 Fish and crayfish

Two indices were used to calculate the SWIRC fish and crayfish sub-index:

- Expectedness: ratio of observed expected native fish species based on species expected under minimal disturbance to the system (ratios were weighted for rare and seasonal species as per Storer *et al.* 2011).
- Nativeness: Proportion of native to non-native fish, incorporating abundance and richness.

Scores were calculated on a scale from 0 (severely modified) to 1 (largely unmodified) and sites were categorised into one of the five condition bands reflecting the degree of departure from conditions expected under minimal disturbance.

3.3.4 Fringing Zone

<u>Extent</u>

A reach was defined for each of the locations, with the sampling site in the centre of the reach. The linear length of the reach was defined based on site characteristics and associated broad variability in land use (visible in aerial photography). For example, where a site was located within a nature reserve, the start and end of the reach was defined by the boundary of the conservation area (likely no longer than 2 km).

Using a desktop approach (e.g. using Landgate "Land Monitor" vegetation extent imagery), fringing vegetation length (i.e. longitudinal continuity of vegetation along the creekline) at each reach was measured, and then expressed as a percentage of total reach length. Reference condition (pre-European) was assumed to be 100% vegetation coverage along each reach, with condition scores calculated accordingly (Storer *et al.* 2011).

Fringing vegetation width was calculated using a series of transects (overlain on the GIS imagery) extending 50 m either side of the centre of the creekline (at 90° to the creekline), with extent of continuous vegetation (in metres) from the bank measured. Average fringing vegetation width for each reach was calculated, and converted to a condition score out of one by dividing by 50 (the average width that would be obtained in a reference situation where no clearing of the fringing zone had occurred) (see Storer *et al.* 2011).

SWIRC condition scores for the fringing zone extent sub-index score were calculated as the unweighted average of the two scores (fringing zone length and width) for each reach.

Nativeness

To score the nativeness sub-index, proportion of exotic species (percentage as a portion of total vegetation cover) was assessed in the field for a 100 m linear site (i.e. 50 m on either side of the aquatic biota sampling site). Groundcover was used as the indicator for nativeness, as recommended by Storer *et al.* (2011), with assessments confined to a 10 m corridor on both banks. The proportion of exotic cover was calculated for each bank, and then an average calculated. A reference condition of 0 % exotics was used, and SWIRC scores calculated based on percentage cover of exotic species within five pre-determined condition bands (as described in Storer *et al.* 2011).

The overall fringing zone index score for each site was calculated as the unweighted average of the scores for the extent of fringing zone and nativeness sub-indices.

3.3.5 Physical Form

Artificial channel

The artificial channel sub-theme was assessed using desktop-based analysis of spatial data at a reach scale, as well as ground truthing in-field. The artificial channel SWIRC score was calculated based on the proportion of each reach mapped as artificially modified channel (e.g. if 100 % of a reach is mapped as artificially modified water course, SWIRC score was 0.0; if 50 % of a reach is mapped as an artificially modified water course, SWIRC score was 0.5, and so forth).

Longitudinal connectivity

The longitudinal connectivity sub-theme comprises four components: major dams, minor dams, gauging stations and road/rail crossings. These components and sub-theme were assessed using desktop-based analysis of spatial data at a reach scale, along with ground truthing barrier locations and sizes during field studies where possible. SWIRC scores for the longitudinal connectivity sub-index was calculated by applying a weighting to the component score (i.e. number/density of barriers) for each reach, as outlined in Storer *et al.* (2011). A weighting was assigned to components based on two factors: assumed potential for impact and confidence in source data. The greatest weighting was assigned to major dams, with reduced weightings assigned as confidence and potential for impact declines (Storer *et al*. 2011).

Erosion

The erosion sub-theme has two components: erosion extent and bank stabilisation. The components and sub-theme were assessed using data collected in-field at a site scale (i.e. over a 100 m stretch, 50 m either side of the aquatic biota sampling point).

The extent of erosion (e.g. slumping, gullying, and undercutting) observed on each bank of a site was recorded in one of four categories and given a nominal rating as described in Storer *et al.* (2011): length of bank affected 0 – 5 % (rating 4), > 5- 20 % (rating 3), 21 – 50 % (rating 2), > 50 % (rating 1). The rating for the left and right banks were averaged and the range standardised (to between 0 and 1) to give SWIRC condition scores for each site.

To calculate bank stabilisation, the percentage cover for each vegetation layer (shrubs, trees < 10 m tall, trees > 10 m tall) in the streamside zone (within 10 m of the waterline) on each bank of a site was recorded in one of five categories and given a nominal rating as described in Storer *et al.* (2011): > 75 % coverage (rating 4), > 50 – 75 % coverage (rating 3), > 10 – 50 % coverage (rating 2), 1 – 10 % coverage (rating 1), and 0 % coverage (rating 0). The rating for the left and right banks was averaged and the range standardised (to between 0 and 1) to give SWIRC condition scores for each site. The erosion sub-index SWIRC score was then calculated as the unweighted average of the erosion extent component and bank stabilisation component scores.

The three sub-index scores (longitudinal connectivity, artificial channel and erosion) were integrated into an overall physical form SWIRC score for each site using the standardised Euclidean distance equation as discussed in Storer *et al.* (2011).

4 RESULTS AND DISCUSSION

4.1 Popanyinning

The Popanyinning sampling site was located approximately 1 km upstream of the Popanyinning town site. There was a range of different in-stream habitats including submerged aquatic plants (e.g. charophytes and *Ruppia* sp.; only present in the October 2019 sampling), woody debris of two to three sizes and biological substrate present (e.g. leaves and detritus) (Plate 1; Refer to Appendix 1 for site photographs). Between 10 – 49 % of the bank length had vegetation draped in water, with stream shading covering an average stream width of 2 m. Banks were concave in shape, with a moderate slope (2+ m in bank height). Water depth varied across the site, from 0.05 - 0.49 m in channel areas, to 0.5 – 1.49 m in the deeper pools. Flow was observed in October 2019 but was in SWIRC category C (below 0.1 m/s), and no flow was observed in March 2020, with the site reduced to a small pool (see Appendix 2 for SWIRC field sheet summaries).

Plate 1. In-stream vegetation (*Ruppia* sp.) left and channel observations at Popanyinning. Photo by WRM ©

4.1.1 Water Quality

Electrical conductivity ranged from 30,700 µS/cm in October 2019 to 54,500 µS/cm in March 2020. This was above the ANZG Default Guideline Value (DGV) of 300 µS/cm (see Appendix 3 for ANZG DGVs). Salinity (as TDS (mg/L)) ranged from 20,876 mg/L in October 2019 to 37,060 mg/L in March 2020, categorising the site as highly saline in October 2019 and brine in March 2020 (Mayer 2005).

Diel dissolved oxygen ranged from 41.5 – 172.7 % in October 2019 (Table 9, Figure 7). Dissolved oxygen levels were below the lower ANZG DGV of 80 % from around 19:00 hrs in October and dropped below the threshold for most aquatic fauna, *i.e*. <60 % between 20:00 and 06:00 hrs. DO concentrations were below the threshold known to cause stress in sensitive aquatic fauna, such as smooth marron (*i.e.* <65 %) (Morrissy 1990, Merrick & Lambert 1991, Lawrence 1998, Lawrence & Jones 2002). Diel dissolved oxygen concentrations from March 2020 were unreliable and therefore not included for analysis. *In situ* dissolved oxygen in March 2020 ranged from 34.3 – 252 % (Table 9).

In October 2019, diel temperature ranged from 16.0 – 28.8 °C and in March 2020 temperature ranged from 20.4 – 27.3 °C (Table 9), with ranges exceeding the guideline value of 4 °C (Storer *et al.* 2011). The typical temperature of south western WA rivers in summer is between 15 -25 °C (DoE 2003), the upper range was exceeded on both sampling occasions.

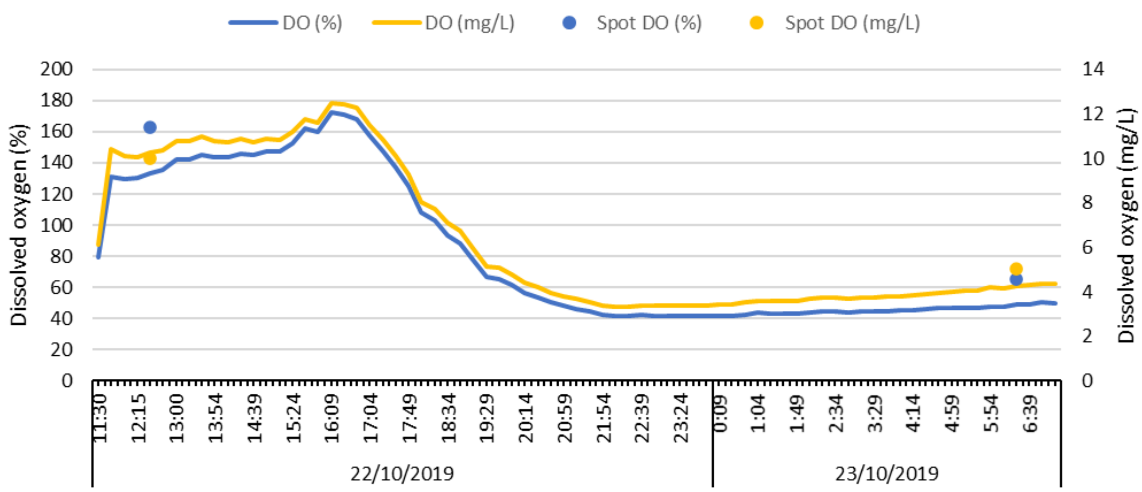
Turbidity ranged from 7.52 in October 2019 to 26.51 in March 2020, with the March sample above the DGV of 20 NTU (Table 9).

Total nitrogen and total phosphorus concentrations were below ANZG (2018) default guideline values (DGV) in October 2019 sampling but both were above the DGVs in March 2020 sampling (Table 9). The increase in concentrations is likely due to evapoconcentration within the site, with the reach reduced to an isolated pool, with flowing water no longer present by the March sampling.

Values for pH were alkaline (8.53 – 8.70) and outside of the ANZG guideline values of 6 – 8. Alkaline pH can affect fish by damaging gills and their ability to dispose of metabolic waste. High pH may also result in an increase in toxicity of other substances, such as ammonia.

Table 9. *In situ* water quality data recorded for Popanyinning in October 2019 and March 2020 at logger deployment (pm), and logger retrieval (am). Diel range and mean of temperature and dissolved oxygen levels recorded from loggers. Values in exceedance of ANZG (2018) default guidelines are highlighted in orange.

Popanyinning		Time (hrs)	Temp. (°C)	EC (µS/cm)	TDS (mg/L)	DO (%)	DO (mg/L)	pH (pH units)	Turbidity (NTU)	TN (mg/L)	TP (mg/L)
Sampled	ANZG DGV			120 - 300		80 -120		6.5 - 8.0	20	1.2	0.065
Oct-19	PM - set	12:30	25.2	30700	20876	162.5	10.02	8.7	7.52	0.94	0.006
	AM - pick up	6:30	16.2	31900	21692	65.5	5.05	8.54			
	Diel range		16.0-28.8			41.5-172.7	3.31-12.5				
	Diel mean		21			82.2	6.36				
Mar-20	PM - set	14:40	29.3	54500	37060	252	18.52	8.61	19.71	5.4	0.26
	AM - pick up	9:30	19.3	53800	36584	34.3	2.29	8.53	26.51		
	Diel range		20.4-27.3			logger failed	logger failed				
	Diel mean		23.1			logger failed	logger failed				



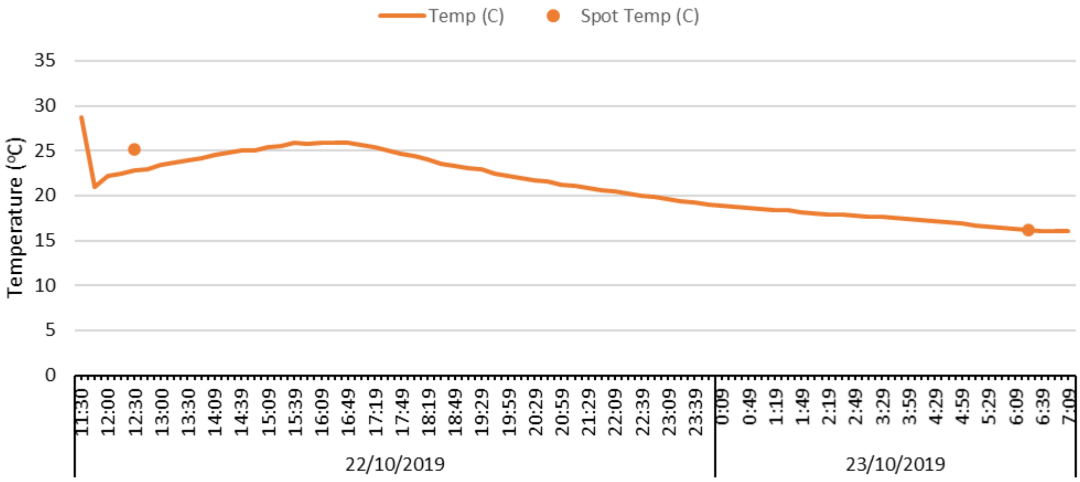


Figure 7: October 2019 logger data for dissolved oxygen (% and mg/L) top, and temperature (°C) bottom at Popanyinning.

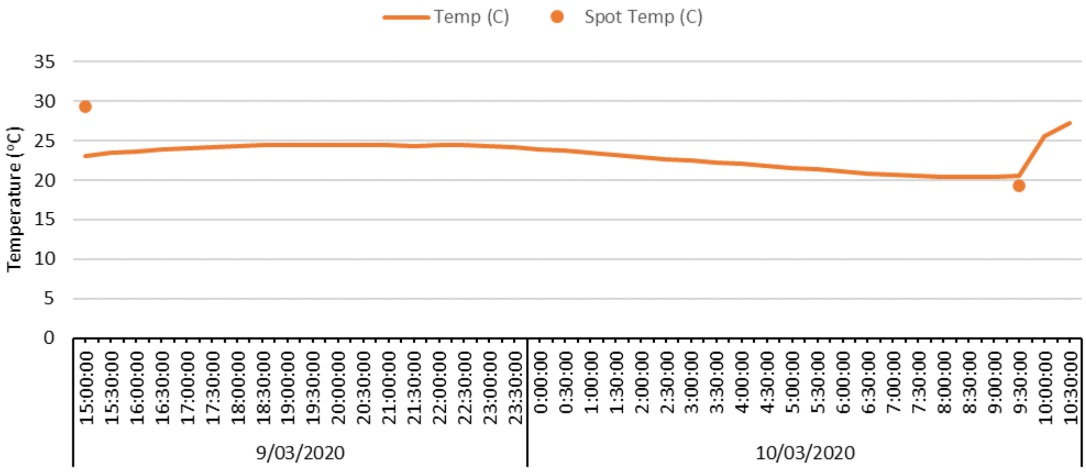


Figure 8: March 2020 logger data for temperature (°C) at Popanyinning.

4.1.2 Aquatic Biota

Macroinvertebrates

A total of 14 taxa were recorded from the channel habitat and six taxa from the macrophyte habitat in October 2019, and in March 2020 a total of six taxa were recorded from the channel habitat (no macrophyte habitat was present) (see Appendix 3), giving an overall diversity of 18 taxa.

The macroinvertebrate fauna comprised Oligochaeta (aquatic segmented worms), Odonata (dragonflies and damselflies), Coleoptera (aquatic beetles) and Diptera (two-winged fly larvae). Insecta were the dominant group in all sampling events and habitat sites. Of the insects, the best represented taxa were Coleoptera in the October 2019 channel habitat and Diptera in the 2019 macrophyte habitat as well as the 2020 channel habitat.

Table 10. Summary of higher-order macroinvertebrate taxa composition recorded from Popanyinning sites in the October 2019 and March 2020 sampling. Refer Appendix 4 for full species list.

Macroinvertebrates		Number of Taxa		
Scientific name	Common name	Channel Oct-19	Macrophyte Oct-19	Channel Mar-20
Mollusca	Freshwater snails	0	0	0
Oligochaeta	Aquatic worms	1+	0	0
Amphipoda	Amphipods	1	1	0
Decapoda	Freshwater shrimp	0	0	0
Acarina	Water mites	0	0	0
Odonata	Dragonflies and damselflies	1	0	0
Trichoptera	Caddisflies	0	0	0
Ephemeroptera	Mayflies	0	0	0
Hemiptera	True bugs	0	0	0
Coleoptera	Aquatic beetles	6+	1+	2
Diptera	Two-winged flies	5+	4+	4+
Lepidoptera	Aquatic moth larvae	0	0	0
	Total taxa richness	**14+**	**6+**	**6+**

Abundance ranged from 597 individuals in the channel habitat in October 2019 to 839 individuals in the macrophyte habitat in October 2019. All taxa recorded were common, ubiquitous species with distributions extending across Australia, and the world (cosmopolitan species).

Fish and crayfish

One native fish species (western minnow; *Galaxias occidentalis*) and one non-native fish species (mosquitofish; *Gambusia holbrooki*) were recorded at Popanyinning, with western minnow only being recorded during the October 2019 sampling. No freshwater crayfish were recorded in either sampling event. The western minnow is considered one of the most common and abundant native freshwater fish found in the south-west of Western Australia. Although minnows are a freshwater species, studies indicate that, like western pygmy perch, adult minnows can tolerate salinities up to ~14,600 mg/L (~21,000 µS/cm) (Beatty *et al*. 2008). Between sampling events, the pool had receded in size and dissolved oxygen levels were highly variable in the March 2020 sampling, dropping below the threshold for most native aquatic fauna. Salinity levels increased to more than twice the known salinity tolerance of western minnows.

A total of 36 western minnow individuals were recorded in October 2019, with size classes ranging from 31 – 70 mm (Figure 9). A total of 2521 individual mosquitofish were recorded across both sampling events, the majority recorded in March 2020 (2233 individuals). Size classes ranged from 11 – 40 mm (Figure 10), with many of the females recorded gravid (carrying young; Gambusia are live-bearers). Gambusia are short lived, with both males and females reaching sexual maturity with 4 - 6 weeks. Males live only for 3 - 6 months, attaining a maximum length of around 35 mm, whereas females may live up to 15 months growing to a length of around 60 mm (MacDonald & Tonkin 2008). Gambusia typically breed from spring through to autumn, with the ability to produce large populations in still, warm-water habitats over summer under favorable conditions, as well as having the capacity to produce up to nine broods per year (MacDonald and Tonkin 2008).

Gambusia are considered a pest because they can occur in high densities, competing with local species for food resources and space. Morgan *et al*. (1996) noted that in wetlands near Capel, Western Australia, gambusia displayed agonistic behaviour towards native species, with many individuals of native species having extensive damage to their fins, attributed to fin-nipping by gambusia. The heightened presence of gambusia may have resulted in the absence of these native species from the site.

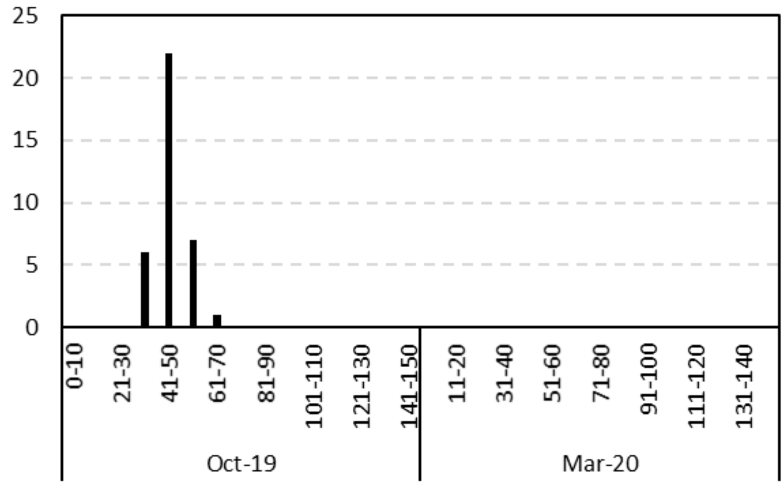


Figure 9. Length frequency (SL mm) histograms for western minnows (*Galaxias occidentalis*) recorded at Popanyinning in October 2019 and March 2020.

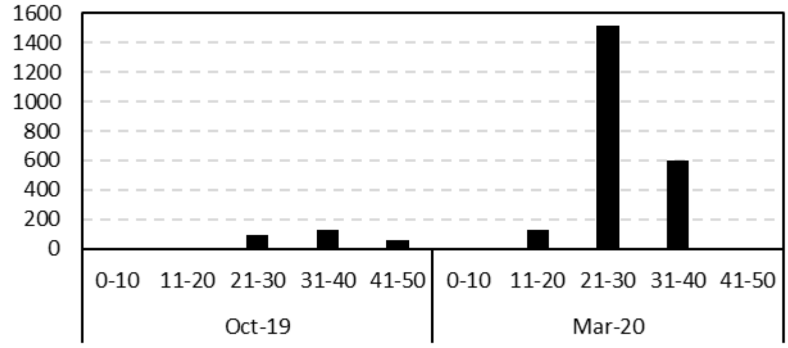


Figure 10. Length frequency (SL mm) histograms for mosquito fish (*Gambusia holbrooki*) recorded at Popanyinning in October 2019 and March 2020.

4.1.3 Fringing Zone

Extent and nativeness

The width of vegetation extent ranged from 0 – 50 m along the reach, with an average of 20.6 m. Approximately 80 % of the 1000 m reach had vegetation coverage along its length. All three riparian layers (ground cover, shrubs and trees) were present, with dominant species including samphire, salt bush and Melaleucas. The riparian zone was reduced due to human impact (i.e. clearing for agriculture). Most of the vegetation layers comprised of native species, with the exception of the ground cover layer which had 50 – 74 % of exotic species including non-native grasses and bridal creeper (*Asparagus asparagoides*).

4.1.4 Physical Form

Erosion, longitudinal connectivity, and artificial channel

Erosion extent at Popanyinning was between 0 – 4 %, with the banks stable and mostly intact, with the shrub and tree layers generally intact. No livestock access was observed during the site visits. No artificial channels were observed on site or in the desktop analysis.

No major dams were located within 40 km of the site, with a minor dam/weir located at the Popanyinning site, approximately 10 km downstream. Road and rail crossings were at a low density of 0 – 1 per kilometre.

4.1.5 SWIRC Scores

Index scores for Popanyinning varied between 0 (severely modified) and 0.78 (slightly modified) (Table 11, Figure 11). Based on the water quality index scores, the site was severely modified. This is due to the high salinity recorded at the site. The macroinvertebrate sub-index score was moderately modified and the fish and crayfish score, substantially modified. The fish and crayfish score were low, due to the presence of only one native fish species (western minnow) and one non-native fish species (mosquitofish). The fringing zone score was 0.35 (substantially modified), mainly due to fragmentation of vegetation along the reach. Although there was native vegetation present in the riparian zone, the ground cover layer comprised of 50 -74 % exotic species, within a narrow band of remaining vegetation. The physical form index score was 0.78 (slightly modified) and was the highest SWIRC score for the site.

Table 11. SWIRC scores for Popanyinning

Site	Theme	Sub-theme	Sub-theme score	SWIRC score
Popanyinning	Hydrological change	-	-	Not assessed
	Catchment disturbance	-	-	Not assessed
	Water quality	Salinity	0	0
		Diel dissolved oxygen	0.7	
		Diel temperature	0.4	
		Turbidity	0.6	
		Total nitrogen	0.4	
		Total phosphorus	0.6	
	Aquatic biota	Macroinvertebrates	0.54	0.39
		Fish & crayfish	0.23	
	Fringing zone	Extent	0.61	0.35
		Nativeness	0.1	
	Physical form	Artificial channel	1	0.78
		Longitudinal connectivity	0.82	
		Erosion	0.67	

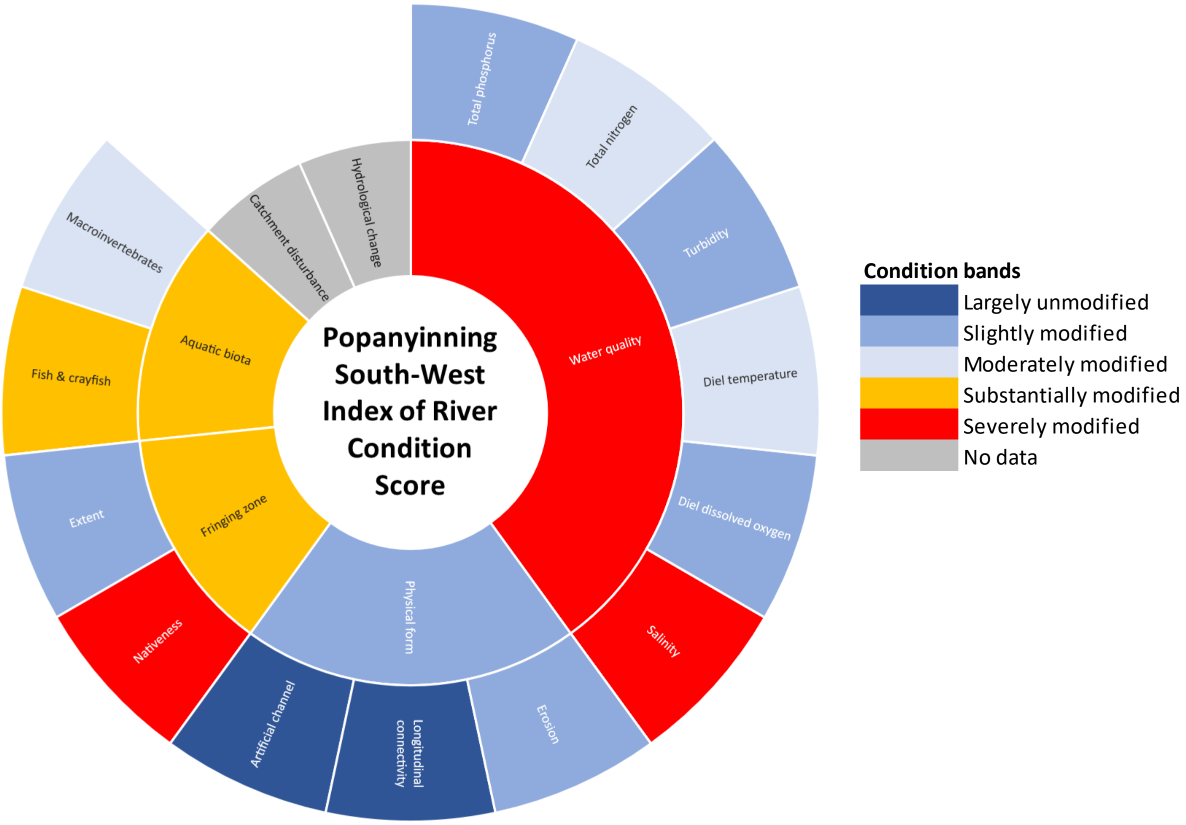


Figure 11: SWIRC condition bands for Popanyinning.

4.2 Hotham River Nature Reserve

The Hotham River Nature Reserve sampling site was located approximately 800 m downstream of the Great Southern Highway bridge. There was woody debris of two to three different sizes and submerged vegetation including charophytes and *Ruppia* sp. (only present in 2019 sampling). Four different physical substrates were present (pebble, gravel, sand and silt) and biological substrates present included leaves and detritus. Between 1 – 9 % of the bank length was covered in vegetation draped in water, with stream shading covering an average stream width of <1 m (Plate 2). Banks were convex in shape with a flat channel bottom and a steep slope (1 – 1.49 m in bank height). Water depth varied across the site, from 0.049 - 0.99 m. Flow was observed in October 2019 but was SWIRC flow category C (below 0.1 m/s), and no flow was observed in March 2020, with the site reduced to a small pool, approximately 50 m upstream from the October 2019 sampling. There was no submerged vegetation observed in the March 2020 sampling.

Plate 2. Vegetation and channel condition in 2019 (left) and 2020 (right) at Hotham River Nature Reserve Photo by WRM ©

4.2.1 Water Quality

Electrical conductivity ranged from 26,400 – 29,600 µS/cm in the October 2019 sampling to 112,800 – 115,500 µS/cm in the March 2020 sampling (Table 12). Salinity (as TDS mg/L) ranged from 20,876 mg/L in October 2019 to 37,060 mg/L in March 2020. Between the two sampling events, the salinity status at Hotham River Nature Reserve changed from highly saline to brine (Mayer *et al.* 2005). Lower rainfalls coupled with catchment clearing have likely contributed to high salinities in the upstream Hotham River sites.

Diel dissolved oxygen ranged from 35.2 – 198.5 % in October 2019 and between 23.8 – 208.5 % in March 2020 (Table 12, Figure 12, Figure 13), with ranges outside of the ANZG DGV of 80 – 120 % (ANZG 2018). Super-saturated DO occurs when net photosynthesis exceeds total oxygen consumption. Super-saturation is common in areas of high algal and macrophyte growth, and/or areas of high turbulence (e.g. riffle zones). Sites which are super-saturated during the day are likely to experience oxygen stress overnight, as respiration by plants, algae, bacteria and other aquatic fauna deplete DO, as seen with the March 2020 logger data (Figure 13). Super-saturation is also known to cause gas bubble disease in fish (Bouck 1980). Dissolved oxygen below the lower ANZG DGV was observed (Table 12). Although oxygen needs of aquatic biota differ between species and life history stage, studies have reported DO less than 50 % can cause harm to fish and macroinvertebrate populations, through reduced fecundity, decreased feeding activity, slowed larval and juvenile growth, suppressed emergence, impaired swimming ability, and death.

In October 2019, diel temperature ranged from 18.2 – 31.2 °C and in March 2020 temperature ranged from 19.0 – 32.0 °C (Table 12, Figure 12, Figure 13), with ranges exceeding the guideline value of 4 °C (Storer *et al.* 2011). The typical temperature of south western WA rivers in summer is between 15 -25 °C (DoE 2003), the upper range was exceeded on both sampling occasions likely due to minimal stream shading at the site.

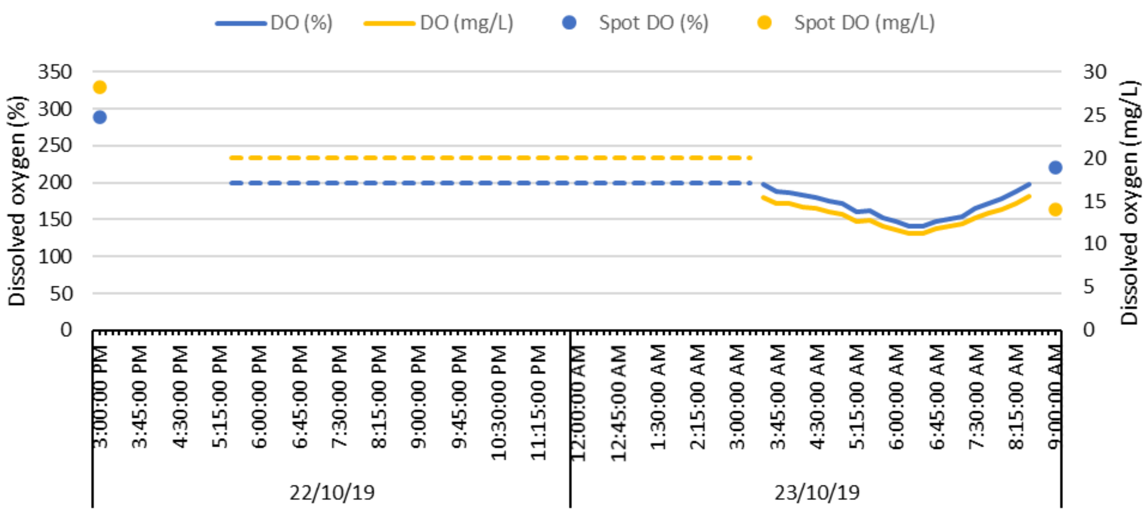
Turbidity exceeded the ANZG DGV of 20 NTU (ANZG 2018) on both sampling occasions, ranging from 26.99 NTU in October 2019 to 180.9 NTU in March 2020. The site had receded to a small pool by the March 2020 sampling, with high levels of algae and silt likely contributing to the high turbidity readings.

Total phosphorus and total nitrogen levels were both below ANZG DGV in the October 2019 sampling but had both increased to above DGVs by March 2020 (Table 12). Total nitrogen was almost 13 times the ANZG DGV and total phosphorus was almost 12 times the DGV. This could be attributed to historic pastoral and/or livestock practices and the receding pool (evapoconcentration).

Levels of pH were 8.5–9.1, and outside of the ANZG guideline values (Table 12).

Table 12. *In situ* water quality data recorded for Hotham River Nature Reserve in October 2019 and March 2020 at logger deployment (pm), and logger retrieval (am). Diel range and mean of temperature and dissolved oxygen levels recorded from loggers. Values in exceedance of ANZG (2018) DGV are highlighted in orange.

HRNR		Time	Temp.	EC	TDS	DO		pH	Turbidity	TN	TP
		(hrs)	(°C)	(µS/cm)	(mg/L)	(%)	(mg/L)	(pH units)	(NTU)	(mg/L)	(mg/L)
Sampled	ANZG DGV			120 - 300		80 -120		6.5 - 8.0	20	1.2	0.065
Oct-19	PM - set	15:00	33.3	29600	20128	288.9	28.24	9.122	26.99	1	0.007
	AM - pick up	9:30	22.9	26400	17952	220.8	14.01	9.084			
	Diel range		18.2-31.2			35.2-198.5	3.09-15.21				
	Diel mean		24.4			98.3	7.93				
Mar-20	PM - set	11:45	27.3	112800	76704	171.6	13.83	8.61	180.9	15	0.76
	AM - pick up	7:30	16.8	115500	78540	23.8	2.12	8.5	155.9		
	Diel range		19-32			23.8-208.5	0.26-8.24				
	Diel mean		25.1			124.9	4.94				



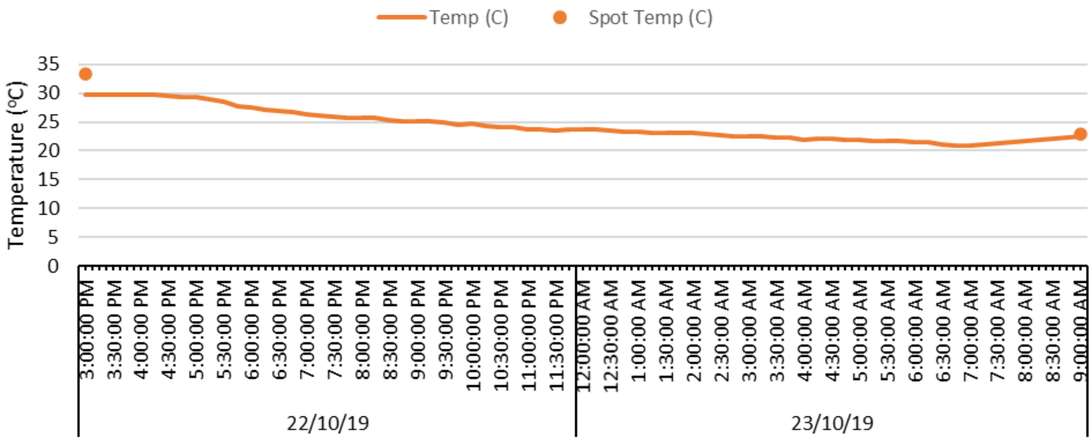


Figure 12: October 2019 logger data for dissolved oxygen (% and mg/L) top and temperature (°C) bottom at Hotham River Nature Reserve . Broken line represents maximum logger range (200%).

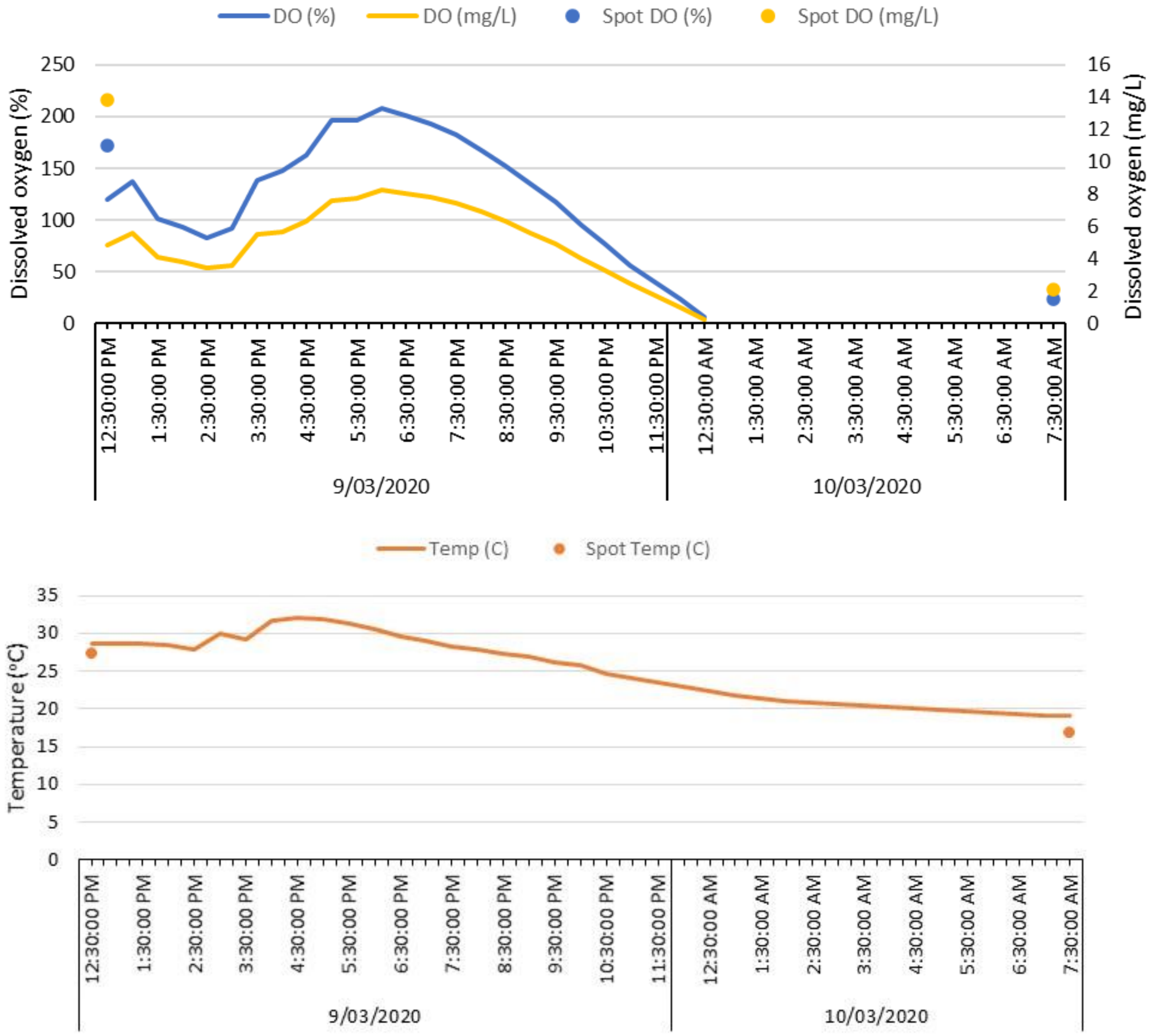


Figure 13: March 2020 logger data for dissolved oxygen (% and mg/L) top and temperature (°C) bottom at Hotham River Nature Reserve.

4.2.2 Aquatic Biota

Macroinvertebrates

A total of 12 taxa were recorded from the channel habitat and nine taxa from the macrophyte habitat in October 2019, and in March 2020 a total of seven taxa were recorded from the channel habitat (no macrophyte habitat was present) (see Appendix 3), giving an overall diversity of 17 taxa.

The macroinvertebrate fauna comprised Amphipoda (side swimmers), Odonata (dragonflies and damselflies), Coleoptera (aquatic beetles), Trichoptera (caddisflies), and Diptera (two-winged fly larvae). Insecta were the dominant group in all sampling events and habitat sites. Of the insects, the best represented taxa were Coleoptera in the October 2019 channel habitat, and Diptera in the 2019 macrophyte habitat as well as the 2020 channel habitat.

Table 13. Summary of higher-order macroinvertebrate taxa composition recorded from Hotham River Nature Reserve sites in the October 2019 and March 2020 sampling. Refer Appendix 4 for full species list.

Macroinvertebrates		Number of Taxa		
Scientific name	Common name	Channel Oct-19	Macrophyte Oct-19	Channel Mar-20
Mollusca	Freshwater snails	0	0	0
Oligochaeta	Aquatic worms	0	0	0
Amphipoda	Amphipods	1	1	0
Decapoda	Freshwater shrimp	0	0	0
Acarina	Water mites	0	0	0
Odonata	Dragonflies and damselflies	0	2+	0
Trichoptera	Caddisflies	0	0	1
Ephemeroptera	Mayflies	0	0	0
Hemiptera	True bugs	0	0	0
Coleoptera	Aquatic beetles	4+	4+	1
Diptera	Two-winged flies	7+	2+	5+
Lepidoptera	Aquatic moth larvae	0	0	0
	Total taxa richness	**12+**	**9+**	**7+**

Abundance ranged from 37 individuals in the channel habitat in March 2020 to 3252 individuals in the channel habitat in October 2019. All taxa recorded were common, ubiquitous species with distributions extending across Australia, and the world (cosmopolitan species).

Fish and crayfish

Two native fish species (Swan River goby *Pseudogobius olorum* and western minnow *Galaxias occidentalis*) and one non-native fish species (mosquitofish *Gambusia holbrooki*) were recorded at Hotham River Nature Reserve in the October 2019 sampling. No fish were recorded in the March 2020 sampling (likely due to water quality conditions at the time of sampling). No freshwater crayfish were recorded in either sampling event.

A total of 278 western minnow individuals were recorded in October 2019, with size classes ranging from 31 – 60 mm (SL) (Figure 14). A total of 20 individual mosquitofish were recorded. Size classes ranged from 11 – 60 mm (SL) (Figure 14). One Swan River goby was recorded in October 2019, with a standard length of 34 mm (Figure 14). The Swan River goby (*Pseudogobius olorum*) is a typically estuarine species that can penetrate long distances inland up secondarily salinised rivers (*e.g.* the Avon River and the Blackwood River), and even occurs in some isolated hypersaline lakes. The species only lives for about a year and is thought to be sexually mature once they have attained ~25 mm total length, usually between five and seven months of age (Gill *et al.* 1996). Although studies have shown length may not necessarily be a good reflection of age because water temperature greatly affects growth rate and hence sexual maturity (Gill *et al.* 1996). Water temperatures within the range 20 – 25 °C appear most conducive to reproductive success.

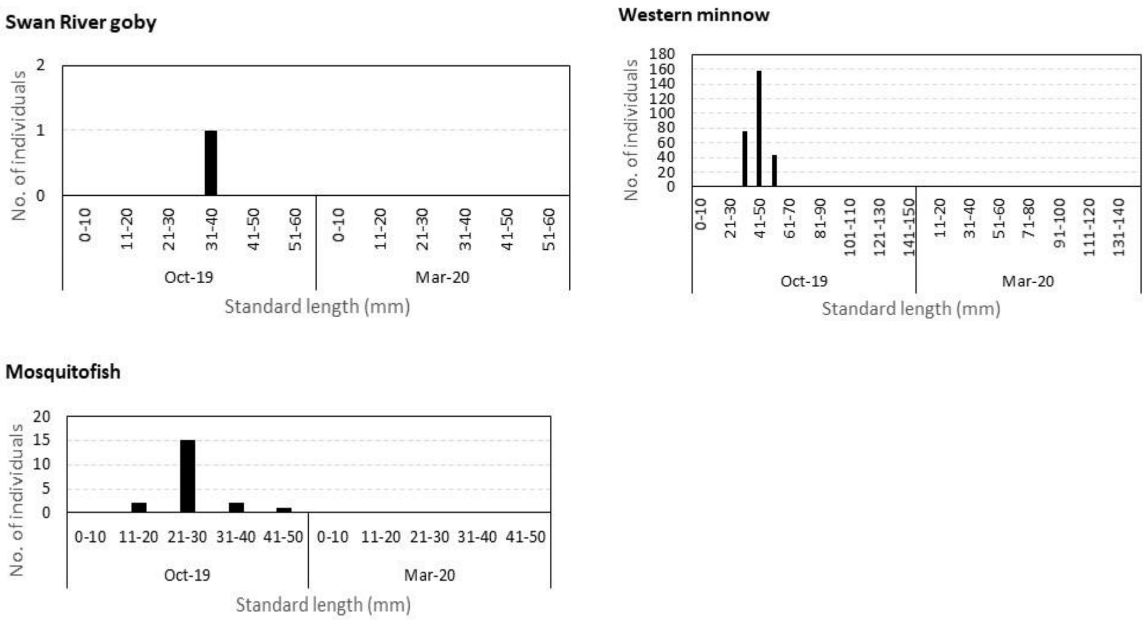


Figure 14. Length frequency (SL mm) histograms for Swan River goby (*Pseudogobius* olorum), western minnow (*Galaxias occidentalis*) and mosquitofish (*Gambusia holbrooki*) recorded for the Hotham River Nature Reserve site in October 2019 and March 2020.

4.2.3 Fringing Zone

Extent and nativeness

Vegetation extent width ranged from 19 – 50 m along the reach, with an average of 47.6 m. Approximately 60 % of the 1350 m reach had vegetation coverage along its length. All three riparian layers (ground cover, shrubs and trees) were present, with dominant species including samphire, salt bush and sedges. The riparian zone was reduced due to human impact (i.e. clearing for agriculture), with numerous dead eucalyptus trees. Most of the vegetation layers comprised of native species, with the exception of the ground cover layer which had 10 – 49 % exotic species including veldt grass.

4.2.4 Physical Form

Erosion, longitudinal connectivity, and artificial channel

Erosion extent was between 0 – 4 %, with the banks relatively stable and mostly intact, with the shrub and ground cover layers generally intact. Cattle tracks were observed during the October site visit but were minor (one track per site). No artificial channels were observed on site or in the desktop analysis.

No major dams were located within 40 km of the site, with a minor dam/weir located within the Hotham River Nature Reserve site (approximately 200 m upstream of where fish sampling was undertaken). Road and rail crossings were at a low density of 0 – 1 per kilometre.

4.2.5 SWIRC Scores

Index scores for Hotham River Nature Reserve varied between 0 (severely modified) and 0.69 (slightly modified) (Table 14, Figure 15), with most indices falling within the slightly modified to moderately modified bands. Based on the water quality index scores, the site was severely modified. This is due to the high salinity recorded at the site. Both the macroinvertebrate and fish and crayfish sub-index scores were moderately modified. The fringing zone score was 0.69 (slightly modified), and was the highest SWIRC score for the site, largely due to the condition of the nature reserve. The physical form index score was 0.67 (slightly modified).

Table 14. SWIRC scores for Hotham River Nature Reserve.

Site	Theme	Sub-theme	Sub-theme score	SWIRC score
Hotham River Nature Reserve	Hydrological change	-	-	Not assessed
	Catchment disturbance	-	-	Not assessed
	Water quality	Salinity	0	0
		Diel dissolved oxygen	0.9	
		Diel temperature	0.4	
		Turbidity	0.4	
		Total nitrogen	0.4	
		Total phosphorus	0.4	
	Aquatic biota	Macroinvertebrates	0.49	0.53
		Fish & crayfish	0.56	
	Fringing zone	Extent	0.78	0.69
		Nativeness	0.60	
	Physical form	Artificial channel	1	0.67
		Longitudinal connectivity	0.67	
		Erosion	0.54	

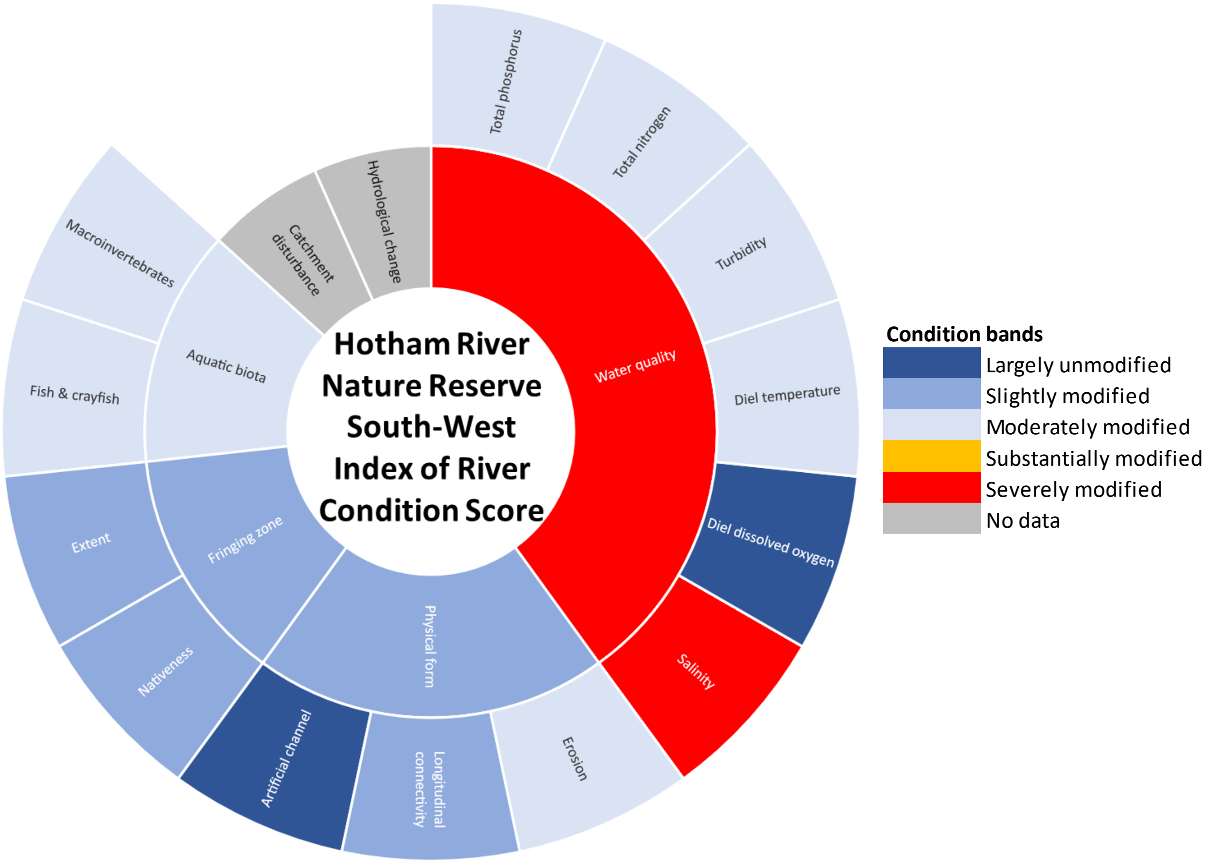


Figure 15: SWIRC condition bands for Hotham River Nature Reserve.

4.3 Pumphreys Bridge

The Pumphreys Bridge sampling site was located approximately 500 m downstream of the Pumphreys Old Bridge. There was a range of different in-stream habitats including submerged aquatic plants (e.g. charophytes, *Ruppia* sp. and overhanging couch grass), woody debris of two to three different sizes (Plate 3), and biological substrates present (e.g. leaves and detritus). Between 10 – 49 % of the bank length had vegetation draped in water, with stream shading covering an average stream width of 2 m. Banks were concave in shape, with a steep to moderate slope (0.5 – 1.5 m in bank height). Water depth varied across the site, from 0.05 - 0.49 m in the riffle and channel areas, to 0.24 – 1.49 m in the deeper pools. Flow was observed in both October 2019 and March 2020 but was within SWIRC flow category C (below 0.1 m/s). Flow in March 2020 was likely driven by groundwater, with dry sections of the river present both upstream and downstream of the site indicating subsurface flow through the riverbed alluvium.

Plate 3. Woody debris (left) and couch grass (right) at Pumphreys Bridge Photo by WRM ©

4.3.1 Water Quality

Electrical conductivity ranged from 22,100 µS/cm in October 2019 to 24,200 µS/cm in March 2020, above the ANZG DGV of 300 µS/cm (Table 15). Salinity (as TDS mg/L) ranged from 15,028 mg/L in October 2019 to 16,456 mg/L in March 2020 (Table 15), classifying the site as highly saline (Meyers *et al.* 2005).

Diel dissolved oxygen ranged from 35.2 – 200 % in October 2019 and 0.1 – 55.8 % in March 2020 (Table 15, Figure 16, Figure 17). Both sampling events recorded dissolved oxygen levels outside of the ANZG DGV (2018).

Diel temperature ranged from 16.8 – 26 °C in October 2019 and 20.8 – 23.7 °C in March 2020, with ranges exceeding the guideline value of 4 °C (Storer *et al.* 2011) in the October 2019 sampling but not in the March 2020 sampling. The typical temperature of south western WA rivers in summer is between 15 -25 °C (DoE 2003), the upper range was only exceeded in October 2019 sampling for a short period of time (3 hours) in the early to mid-afternoon (Figure 16).

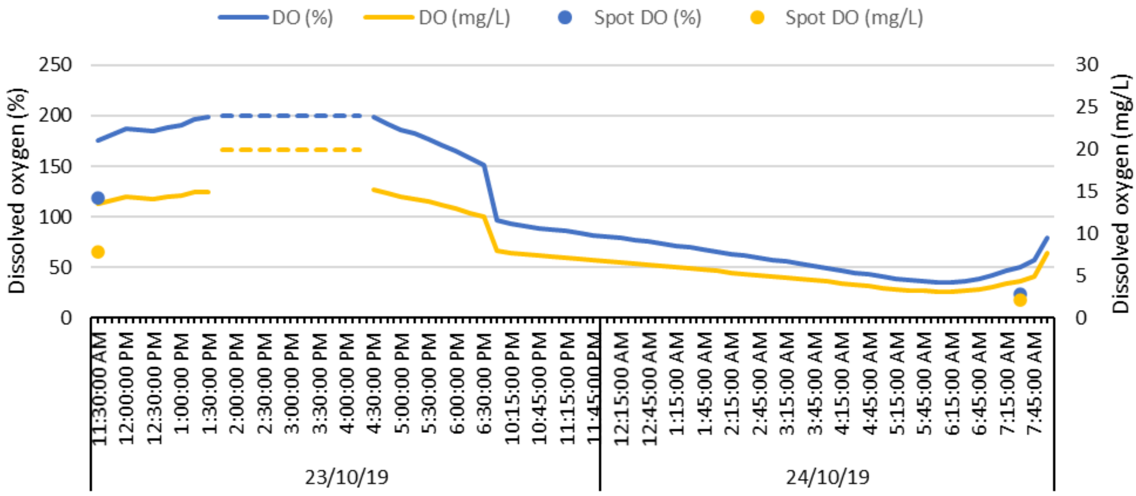
Turbidity was below the ANZG guideline value of 20 NTU on both sampling occasions, ranging from 4.6 NTU in October 2019 to 15.34 NTU in March 2020 (Table 15).

Total nitrogen and total phosphorus were below or equal to the ANZG guideline values on both sampling occasions (Table 15).

pH levels ranged between 7.9 and 8.8, and were outside of ANZG guideline values of 6 – 8 (Table 15).

Table 15. *In situ w*ater quality data recorded for Pumphreys Bridge in October 2019 and March 2020 at logger deployment (pm), and logger retrieval (am). Diel range and mean of temperature and dissolved oxygen levels recorded from loggers. Values in exceedance of ANZG (2018) default guidelines are highlighted in orange.

Pumphreys Bridge Sampled		Time (hrs)	Temp. (°C)	EC (µS/cm)	TDS (mg/L)	DO (%)	DO (mg/L)	pH (pH units)	Turbidity (NTU)	TN (mg/L)	TP (mg/L)
	ANZG DGV			120 - 300		80 -120		6.5 - 8.0	20	1.2	0.065
Oct-19	PM - set	11:30	24.3	22100	15028	149.9	9.86	8.8	4.6	0.64	0.021
	AM - pick up	7:00	17.8	22300	15164	52.4	4.93	8.6			
	Diel range		16.8-26			35.2-200	3.09-20				
	Diel mean		21.4			125.74	9.59				
Mar-20	PM - set	12:15	24.2	24100	16388	118.3	7.77	8.5	15.34	1.2	0.017
	AM - pick up	9:00	18.7	24200	16456	6.4	0.41	7.9	11.07		
	Diel range		20.8-23.7			0.1-55.8	0.01-4.25				
	Diel mean		22.5			19.2	1.48				



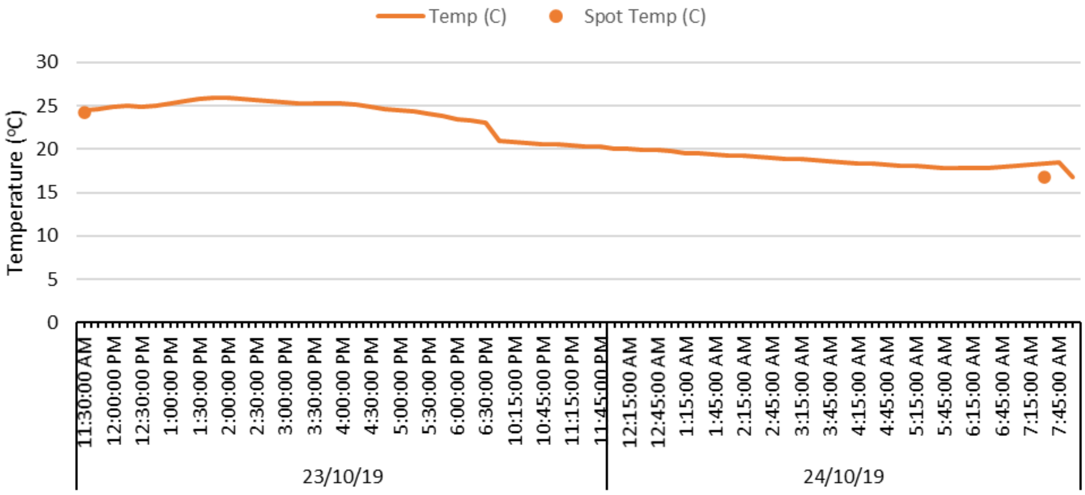


Figure 16: October 2019 logger data for dissolved oxygen (% and mg/L) top and temperature (°C) bottom at Pumphreys Bridge . Note: dotted line indicates the DO sensor was maxed at 200 % and therefore levels could be higher than this.

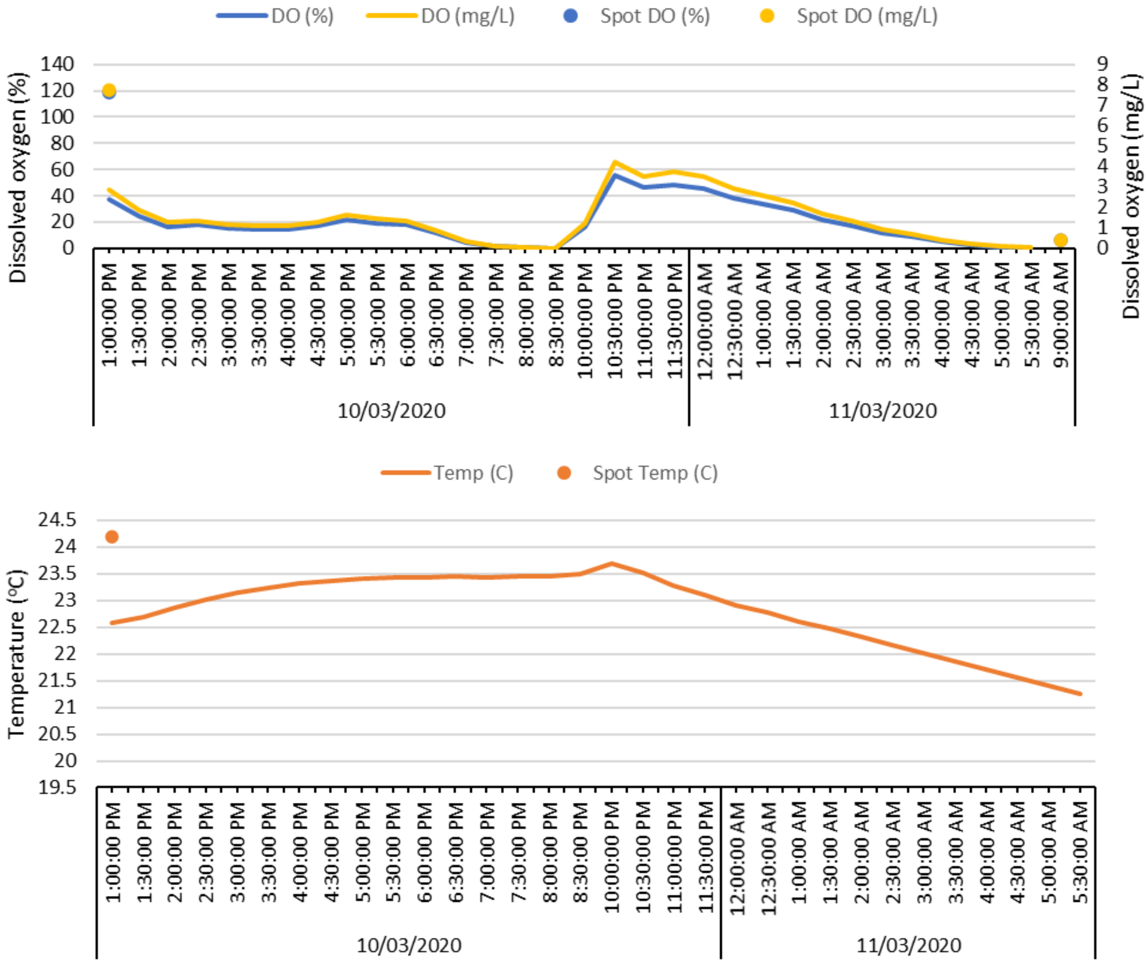


Figure 17: March 2020 logger data for dissolved oxygen (% and mg/L) top and temperature (°C) bottom at Pumphreys Bridge.

4.3.2 Aquatic Biota

Macroinvertebrates

A total of 14 taxa were recorded from the channel habitat and 20 taxa from the macrophyte habitat in October 2019. There were nine taxa recorded from the channel habitat and 15 taxa recorded in the macrophyte habitat in March 2020, giving a total of 28 taxa recorded overall.

The macroinvertebrate fauna comprised of Oligochaeta (aquatic worms), Amphipoda (side swimmers), Acarina (water mites), Decapoda (Freshwater shrimp), Odonata (dragonflies and damselflies), Coleoptera (aquatic beetles), Trichoptera (caddisflies), Diptera (two-winged fly larvae) and Lepidoptera (aquatic moth larvae). Insecta were the dominant group in all sampling events and habitat types. Of the insects, the best represented taxa were Diptera in all habitats across both sampling events. Most taxa recorded were common, ubiquitous species, with the exception of the odonate *Procordulia affinis*, which is a south-west endemic species.

Table 16. Summary of higher-order macroinvertebrate taxa composition recorded from Pumphreys Bridge sites in the October 2019 and March 2020 sampling. Refer Appendix 4 for full species list.

Macroinvertebrates		Number of Taxa			
Scientific name	Common name	Channel Oct-19	Macrophyte Oct-19	Channel Mar-20	Macrophyte Mar-20
Mollusca	Freshwater snails	0	0	0	0
Oligochaeta	Aquatic worms	1+	0	0	0
Amphipoda	Amphipods	1	1	1	1
Decapoda	Freshwater shrimp	0	0	1	1
Acarina	Water mites	0	1+	0	1+
Odonata	Dragonflies and damselflies	0	2+	0	2+
Trichoptera	Caddisflies	1+	1+	0	1+
Ephemeroptera	Mayflies	0	0	0	0
Hemiptera	True bugs	0	0	0	0
Coleoptera	Aquatic beetles	4	7	1	3
Diptera	Two-winged flies	6	7	5	5
Lepidoptera	Aquatic moth larvae	1+	1+	1+	1+
	Total taxa richness	**14+**	**20+**	**9+**	**15+**

Abundance ranged from 199 individuals in the macrophyte habitat in March 2020 to 1858 individuals in the macrophyte habitat in October 2019.

Fish and crayfish

Three native fish species (Swan River goby *Pseudogobius olorum,* south western goby *Afurcagobius suppositus* and western minnow *Galaxias occidentalis*) and one non-native fish species (mosquitofish *Gambusia holbrooki*) were recorded at Pumphreys Bridge during both sampling events. No crayfish were recorded at either sampling event.

A total of 130 Swan River gobies were recorded at Pumphreys Bridge, with 91 in October 2019 and 39 in March 2020. Size classes ranged from 11 – 60 mm SL. A total of 594 western minnow individuals were recorded, with 541 individuals in October 2019 and 53 individuals in March 2020. Size classes ranged from 31 – 150 mm (Figure 18). Two south western gobies, one in each sampling event, were recorded from Pumphreys Bridge. Standard lengths were 41 and 50 mm (Figure 18).

A total of 1503 individual mosquitofish were recorded across both sampling events, with the majority recorded in March 2020 (968 individuals). Size classes ranged from 9 – 50 mm (Figure 18), with many of the females recorded gravid (carrying young).

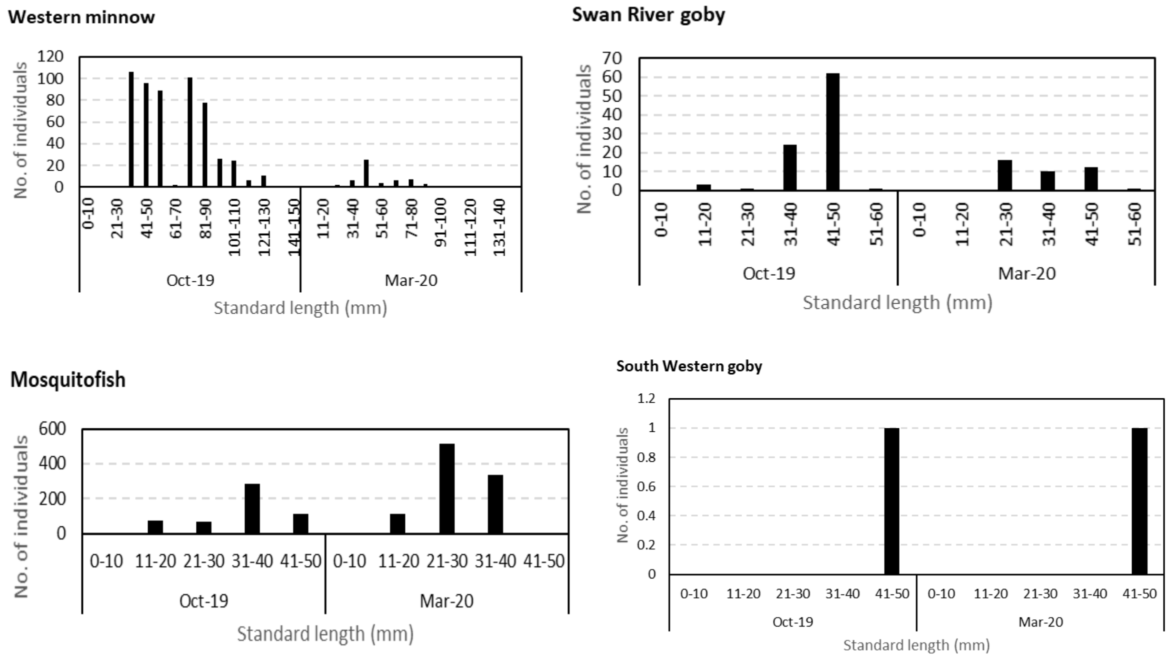


Figure 18. Length frequency (SL mm) histograms for Swan River goby (*Pseudogobius* olorum), western minnow (*Galaxias occidentalis*), south western goby (*Afurcagobius suppositus*) and mosquito fish (*Gambusia holbrooki*) recorded for the Pumphreys Bridge site in October 2019 and March 2020.

Other fauna

Three south-western snake necked turtles (*Chelodina colliei*) were recorded in the October 2019 sampling and one was recorded in the March 2020 sampling. *Chelodina colliei* is endemic to the south-west of WA and is listed on the IUCN Redlist of Threatened Species as Near Threatened (IUCN 2020), although it is not listed at 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). All captured individuals were of a size to be considered sexually mature. Clay (1981) indicates males reach sexual maturity at ≥ 130 mm carapace length (CL) and females at 160 mm CL.

4.3.3 Fringing Zone

Extent and nativeness

Vegetation extent width ranged from 0 – 50 m along the reach, with an average width of 26.7 m. Approximately 55 % of the 1163 m reach had vegetation coverage along its length. All three riparian layers (ground cover, shrubs and trees) were present although reduced due to human impact (i.e.

clearing for agriculture and stock access), with numerous dead eucalyptus trees and no recruitment of native woody vegetation present. Most of the vegetation layers comprised of native species, with the exception of the ground cover layer which had 75 – 100 % exotic species including veldt and couch grasses.

4.3.4 Physical Form

<u>Erosion, longitudinal connectivity, and artificial channel</u>

Erosion extent was between 0 – 4 %, with the banks relatively stable and mostly intact. Livestock tracks were observed during the October site visit but were minor (one track per site). No artificial channels were observed on site or in the desktop analysis.

No major dams were located within 40 km of the site, with a minor dam/weir located approximately 25 km upstream. Road and rail crossings were at a low density of 0 – 1 per kilometre.

4.3.5 SWIRC Scores

Index scores for Pumphreys Bridge varied between 0 (severely modified) and 0.75 (slightly modified) (Table 17, Figure 19). Based on the water quality index scores, the site was severely modified. This is due to the high salinity recorded. Macroinvertebrates were slightly modified, and fish and crayfish sub-index was moderately modified. The fringing zone score was 0.32 (substantially modified), due to localised clearing for agriculture, with 74 – 100 % groundcover of non-native grasses and several large, dead eucalyptus trees within the vegetation extent. The physical form index score was 0.75 (slightly modified) and was the highest SWIRC score for the site.

Table 17. SWIRC scores for Pumphreys Bridge.

<table>
<tr><th>Site</th><th>Theme</th><th>Sub-theme</th><th>Sub-theme score</th><th>SWIRC score</th></tr>
<tr><td rowspan="15">Pumphreys Bridge</td><td>Hydrological change</td><td>-</td><td>-</td><td>Not assessed</td></tr>
<tr><td>Catchment disturbance</td><td>-</td><td>-</td><td>Not assessed</td></tr>
<tr><td rowspan="6">Water quality</td><td>Salinity</td><td>0</td><td rowspan="6">0</td></tr>
<tr><td>Diel dissolved oxygen</td><td>0.5</td></tr>
<tr><td>Diel temperature</td><td>0.4</td></tr>
<tr><td>Turbidity</td><td>0.6</td></tr>
<tr><td>Total nitrogen</td><td>0.8</td></tr>
<tr><td>Total phosphorus</td><td>1</td></tr>
<tr><td rowspan="2">Aquatic biota</td><td>Macroinvertebrates</td><td>0.67</td><td rowspan="2">0.62</td></tr>
<tr><td>Fish & crayfish</td><td>0.56</td></tr>
<tr><td rowspan="2">Fringing zone</td><td>Extent</td><td>0.54</td><td rowspan="2">0.32</td></tr>
<tr><td>Nativeness</td><td>0.10</td></tr>
<tr><td rowspan="3">Physical form</td><td>Artificial channel</td><td>1</td><td rowspan="3">0.75</td></tr>
<tr><td>Longitudinal connectivity</td><td>0.90</td></tr>
<tr><td>Erosion</td><td>0.58</td></tr>
</table>

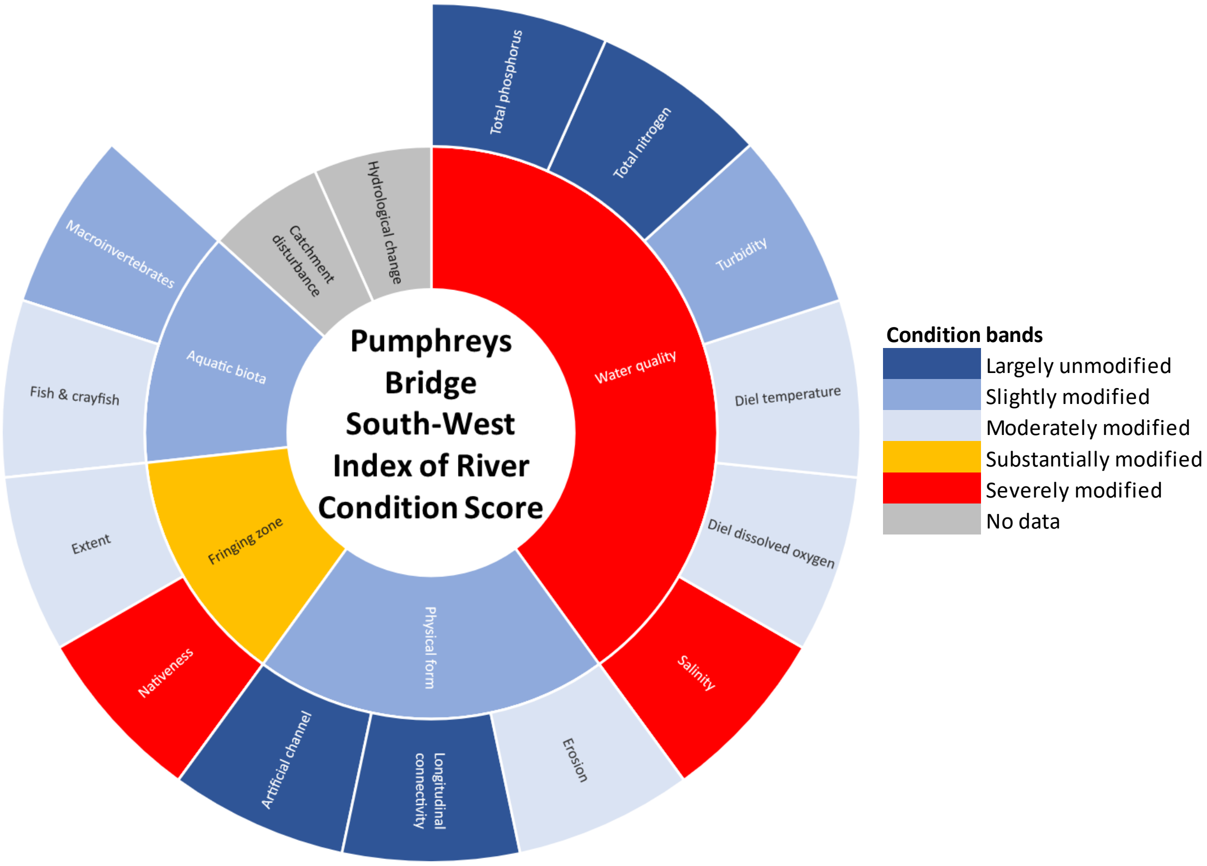


Figure 19: SWIRC condition bands for Pumphreys Bridge.

4.4 Ranford Pool

The Ranford Pool sampling site was located 500m upstream of the main pool and recreational area. There was a range of different in-stream habitats including woody debris of a variety of different sizes and biological substrates present (e.g. detritus), but no aquatic plants were present on either sampling occasion. Physical substrate comprised of pebbles, gravel, sand, and silt. Between 10 – 49 % of the bank length was undercut and another 10 – 49 % comprised of overhanging roots draped in the water, 0 % of the bank had vegetation draped in water. Stream shading covered an average stream width of 4 m (Plate 4). Banks were concave to undercut in shape, with a vertical to moderate slope (>2 m in bank height). Water depth was moderately varied across the site, from 0.5 - 0.99 m in the channel areas, to 1.5 – 2 m in the deeper pools. Flow observed in October 2019 was variable, between 0.1 – 0.6 m/s with rest areas present. Flow in March 2020 was observed but was below 0.1 m/s.

Plate 4. Stream shading and channel shape at Ranford Pool Photo by WRM ©

4.4.1 Water Quality

Electrical conductivity was 14,250 µS/cm in October 2019 and 10,550 µS/cm in March 2020 (Table 18). On both sampling occasions, results were above the ANZG DGV. Salinity (as TDS mg/L) was 9,690 in October 2019 and 7,174 in March 2020 (Table 18), classifying the site as saline (Meyer *et al.* 2005).

Diel dissolved oxygen ranged from 84.2 – 103.7 % in October and 52.2 – 94.7 % in March 2020 (Table 18, Figure 20, Figure 21). In March 2020 dissolved oxygen went below the 80 % ANZG DGV from 23:30 hrs and started to go back up from 09:00 hrs, but it did not drop below 50 % during either sampling event, which is a threshold for most aquatic species.

Diel temperatures ranged from 19.4 – 21.2 °C in October 2019 and 21.7 – 25.9 °C in March 2020 (Table 18, Figure 20, Figure 21), with ranges just exceeding the guideline value temperature change of 4 °C (Storer *et al.* 2011) in March 2020 (4.2 °C). The typical temperature of south western WA rivers in summer is between 15 - 25 °C (DoE 2003), the upper range was exceeded in the March 2020 sampling (Figure 21).

Turbidity ranged from 3.39 NTU in March 2020 to 6.60 NTU in October 2019 (Table 18) and was below the ANZG DGV of 20 NTU.

Total nitrogen and total phosphorus concentrations were below ANZG guideline values on both sampling occasions (Table 18).

pH values ranged from 7.78 to 8.4 and were within ANZG guideline values in October 2019, and outside the 6 – 8 range in March 2020 (Table 15).

Table 18. *In situ w*ater quality data recorded for Ranford Pool in October 2019 and March 2020 at logger deployment (pm), and logger retrieval (am). Diel range and mean of temperature and dissolved oxygen levels recorded from loggers. Values in exceedance of ANZG DGV (2018) are highlighted in orange.

Ranford Pool Sampled		Time (hrs)	Temp. (°C)	EC (µS/cm)	TDS (mg/L)	DO (%)	DO (mg/L)	pH (pH units)	Turbidity (NTU)	TN (mg/L)	TP (mg/L)
	ANZG DGV			120 - 300		80 -120		6.5 - 8.0	20	1.2	0.065
Oct-19	PM - set	15:00	21.9	14250	9690	93.9	6.14	7.78	6.6	0.6	0.007
	AM - pick up	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data
	Diel range		19.4-21.2			84.2-103.7	7.55-9.21				
	Diel mean		20.4			93.75	8.22				
Mar-20	PM - set	14:30	26.3	10550	7174	80.9	4.96	8.4	3.39	0.44	0.007
	AM - pick up	11:30	22.9	10500	7140	71.1	4.89	8.27	3.01		
	Diel range		21.7-25.9			52.2-94.7	4.41-7.47				
	Diel mean		23.6			74.3	6.03				

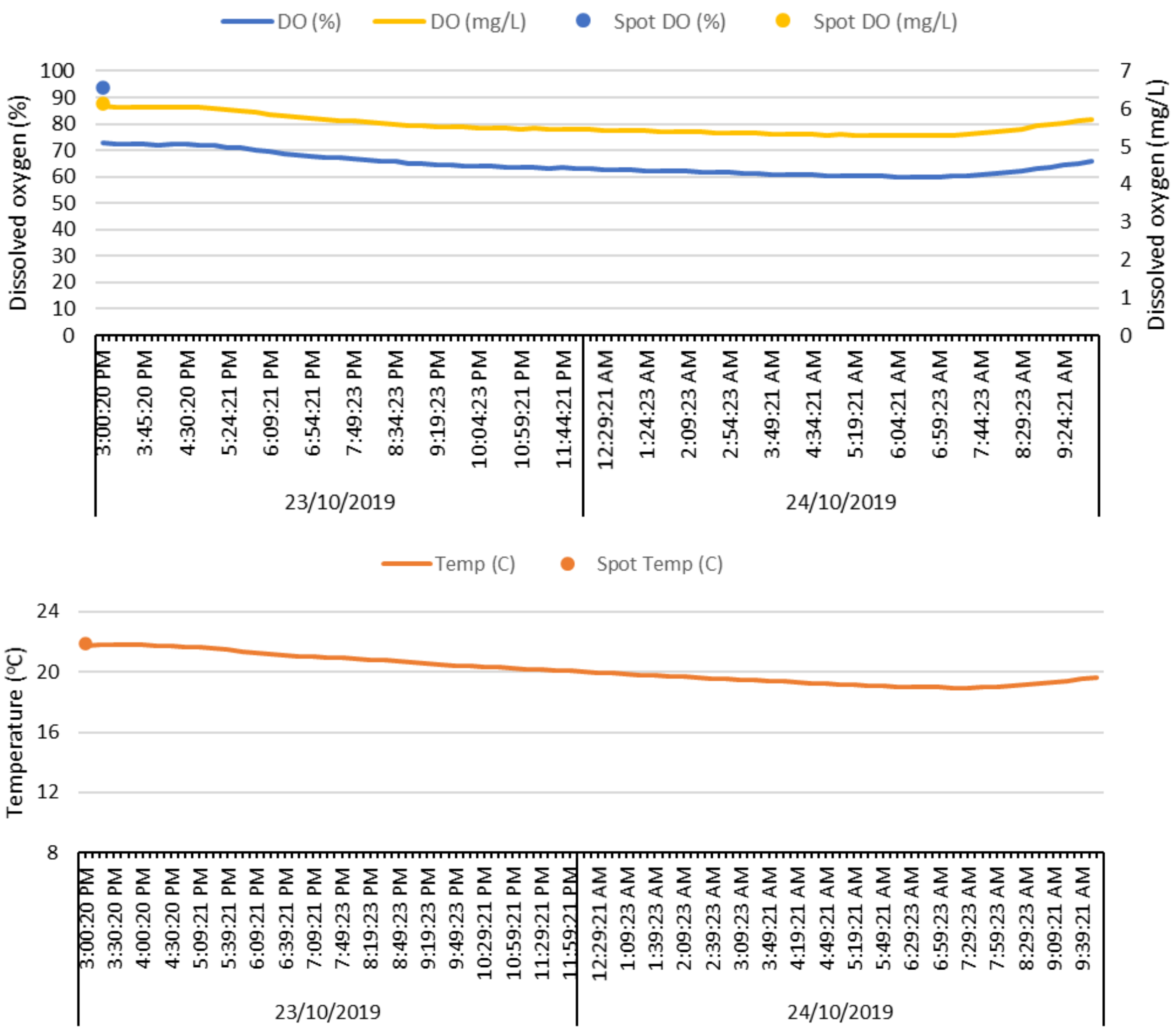


Figure 20: October 2019 logger data for dissolved oxygen (% and mg/L) top and temperature (°C) bottom at Ranford Pool.

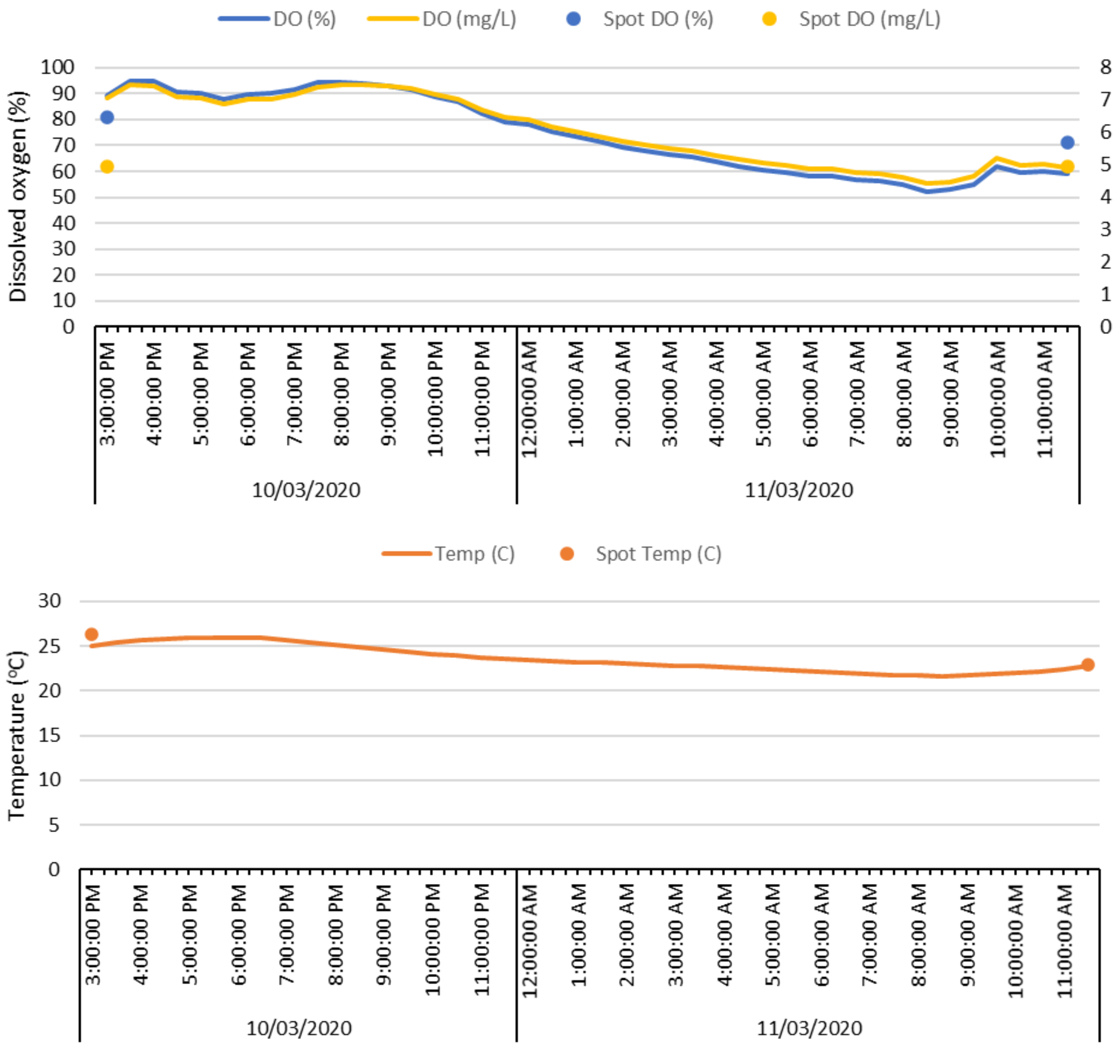


Figure 21: March 2020 logger data for dissolved oxygen (% and mg/L) top and temperature (°C) bottom at Ranford Pool

4.4.2 Aquatic Biota

Macroinvertebrates

A total of 10 taxa were recorded from Ranford Pool channel habitat in October 2019 and 22 taxa in March 2020, giving a total of 27 taxa recorded. Most taxa recorded were common, ubiquitous species with the exception of *Necterosoma darwini* which is a Western Australian endemic beetle.

The macroinvertebrate fauna comprised of Oligochaeta (aquatic worms), Amphipoda (side swimmers), Decapoda (Freshwater shrimp), Odonata (dragonflies and damselflies), Coleoptera (aquatic beetles), Trichoptera (caddisflies), Diptera (two-winged fly larvae) and one marine bivalve (*Fluviolanatus subotortus*). Insecta were the dominant group in both sampling events. Of the insects, the best represented taxa were Diptera in October 2019 and Coleoptera in March 2020 (Table 19). Abundance ranged from 199 individuals in March 2020 to 856 individuals in October 2019.

Table 19. Summary of higher-order macroinvertebrate taxa composition recorded from Ranford Pool sites in the October 2019 and March 2020 sampling. Refer Appendix 4 for full species list.

Macroinvertebrates		Number of Taxa	
Scientific name	Common name	Channel Oct-19	Channel Mar-20
Mollusca	Freshwater snails	1+	0*
Oligochaeta	Aquatic worms	0	1+
Amphipoda	Amphipods	1	1
Decapoda	Freshwater shrimp	1	1
Acarina	Water mites	0	0
Odonata	Dragonflies and damselflies	0	2+
Trichoptera	Caddisflies	1	2+
Ephemeroptera	Mayflies	0	0
Hemiptera	True bugs	0	0
Coleoptera	Aquatic beetles	0	8
Diptera	Two-winged flies	6+	7+
Lepidoptera	Aquatic moth larvae	0	0
	Total taxa richness	**10+**	**22+**

* Marine bivalve

Fish and crayfish

Four native fish species, including western minnow, Swan River goby, nightfish (*Bostockia porosa*) and western pygmy perch (*Nannoperca vittata*), and one non-native fish (mosquitofish), were recorded during the sampling events. Despite crayfish burrows being observed at the site, no crayfish were recorded during either sampling event.

A total of 17 Swan River gobies were recorded, with two in October 2019 and 15 in March 2020. Size classes ranged from 11 – 50 mm SL. A total of 180 western minnow individuals were recorded, with 169 individuals in October 2019 and 11 individuals in March 2020. Size classes ranged from 21 – 100 mm (Figure 18). One individual nightfish, at 75 mm SL was recorded in October 2019. Three western pygmy perch were recorded, both during the October 2019 sampling. Their size class ranged from 31 – 60 mm (SL).

Nightfish are widespread in the south-west of WA. They are solitary, bottom dwelling fish, and, as the name suggests, are more active during the night than during the day. Pen and Potter (1990) suggested nightfish reach approximately 56 mm total length in their first year and live for at least six years. Thorburn (1999) recorded highest densities of nightfish from finer substrate types, especially mud and fine sand.

A total of 464 mosquitofish were recorded across both sampling events, the majority recorded in March 2020 (460 individuals). Size classes ranged from 11 – 40 mm (Figure 18), with many of the females recorded gravid (carrying young).

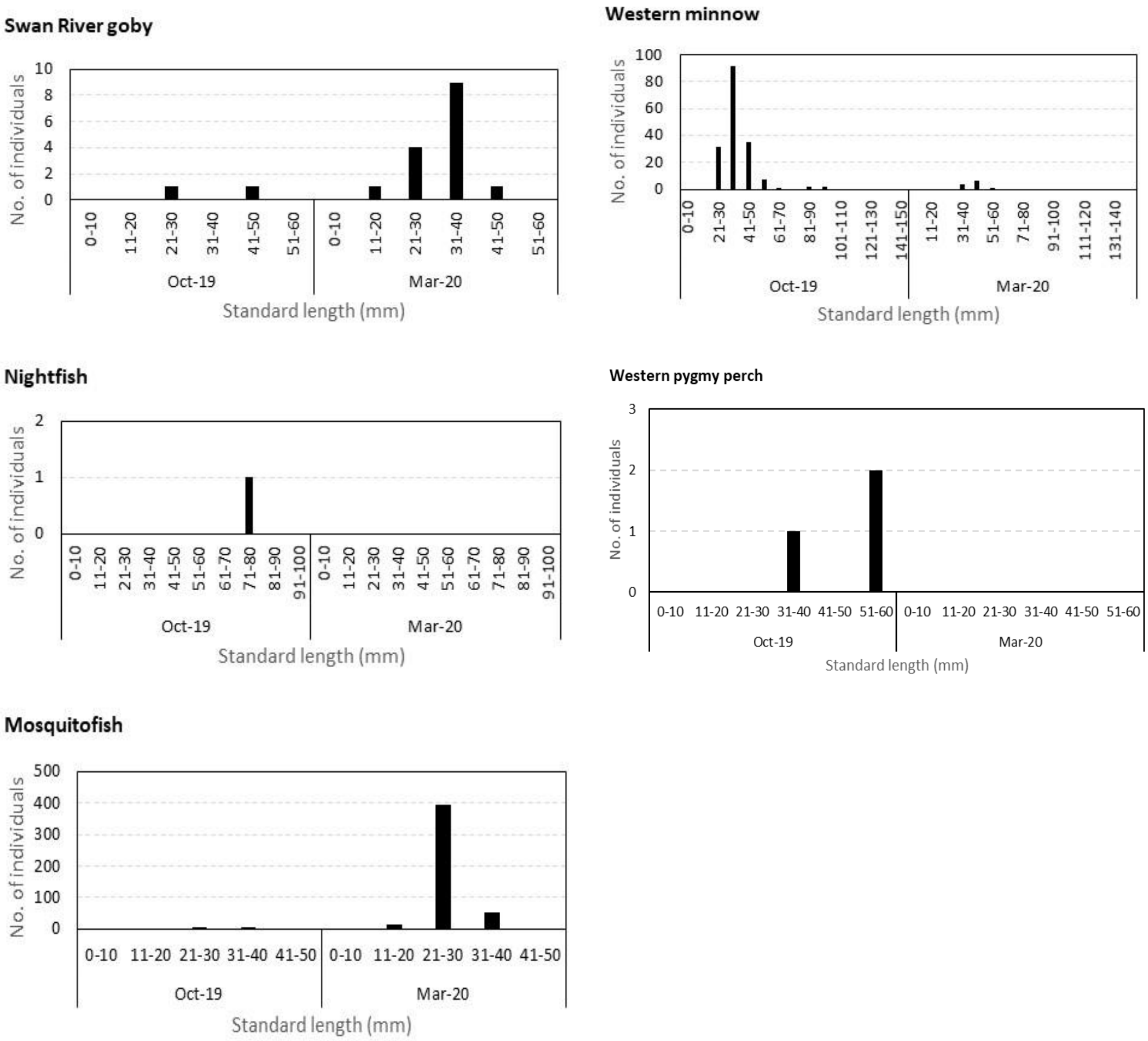


Figure 22. Length frequency (SL mm) histograms for Swan River goby (*Pseudogobius* olorum), western minnow (*Galaxias occidentalis*), nightfish (*Bostockia porosa*), western pygmy perch (*Nannoperca vittata*) and mosquito fish (*Gambusia holbrooki*) recorded at Ranford Pool site in October 2019 and March 2020.

Other fauna

Seven south western snake necked turtles were recorded from Ranford Pool in October 2019. No turtles were recorded in the March 2020 sampling.

4.4.3 Fringing Zone

Extent and nativeness

Vegetation extent width ranged from 0 – 50 m along the reach, with an average width of 43.7 m. Along the 1,030 m length, 100 % was vegetated. Three riparian layers (groundcover, shrubs and trees) were present although both the groundcover and shrub layers were reduced due to human impact (i.e. clearing for agriculture and stock access). Most of the vegetation layers comprised of native species, with the exception of the ground cover layer which had 75 – 100 % exotic species including non-native grasses.

4.4.4 Physical Form

Erosion, longitudinal connectivity, and artificial channel

Erosion extent was between 5 – 19 %, and the banks had good structural integrity. Although banks were exposed, erosion did not penetrate deeply into the bank. Livestock tracks were observed during the October site visit but were minor (one track per site). No artificial channels were observed on site or in the desktop analysis.

Boddington weir is located approximately 3.5 km downstream of the site. Road and rail crossings were at a low density of 0 – 1 per kilometre.

4.4.5 SWIRC Scores

Index scores for Ranford Pool varied between 0.2 (substantially modified) and 0.74 (slightly modified), with the majority of indices within the moderately modified to largely unmodified condition bands (Table 20, Figure 23). Based on the water quality index scores, the site was severely modified. This is due to the high salinity recorded. Both the macroinvertebrate and fish and crayfish subindices were slightly modified. The fringing zone score was 0.52 (moderately modified), due to minimal native ground cover within the site. The physical form index score was 0.74 (slightly modified) and was the highest SWIRC score for the site.

Table 20. SWIRC scores for Ranford Pool.

Site	Theme	Sub-theme	Sub-theme score	SWIRC score
Ranford Pool	Hydrological change	-	-	Not assessed
	Catchment disturbance	-	-	Not assessed
	Water quality	Salinity	0.2	0.2
		Diel dissolved oxygen	0.8	
		Diel temperature	0.4	
		Turbidity	1	
		Total nitrogen	1	
		Total phosphorus	1	
	Aquatic biota	Macroinvertebrates	0.60	0.68
		Fish & crayfish	0.76	
	Fringing zone	Extent	0.94	0.52
		Nativeness	0.10	
	Physical form	Artificial channel	1	0.74
		Longitudinal connectivity	0.67	
		Erosion	0.69	

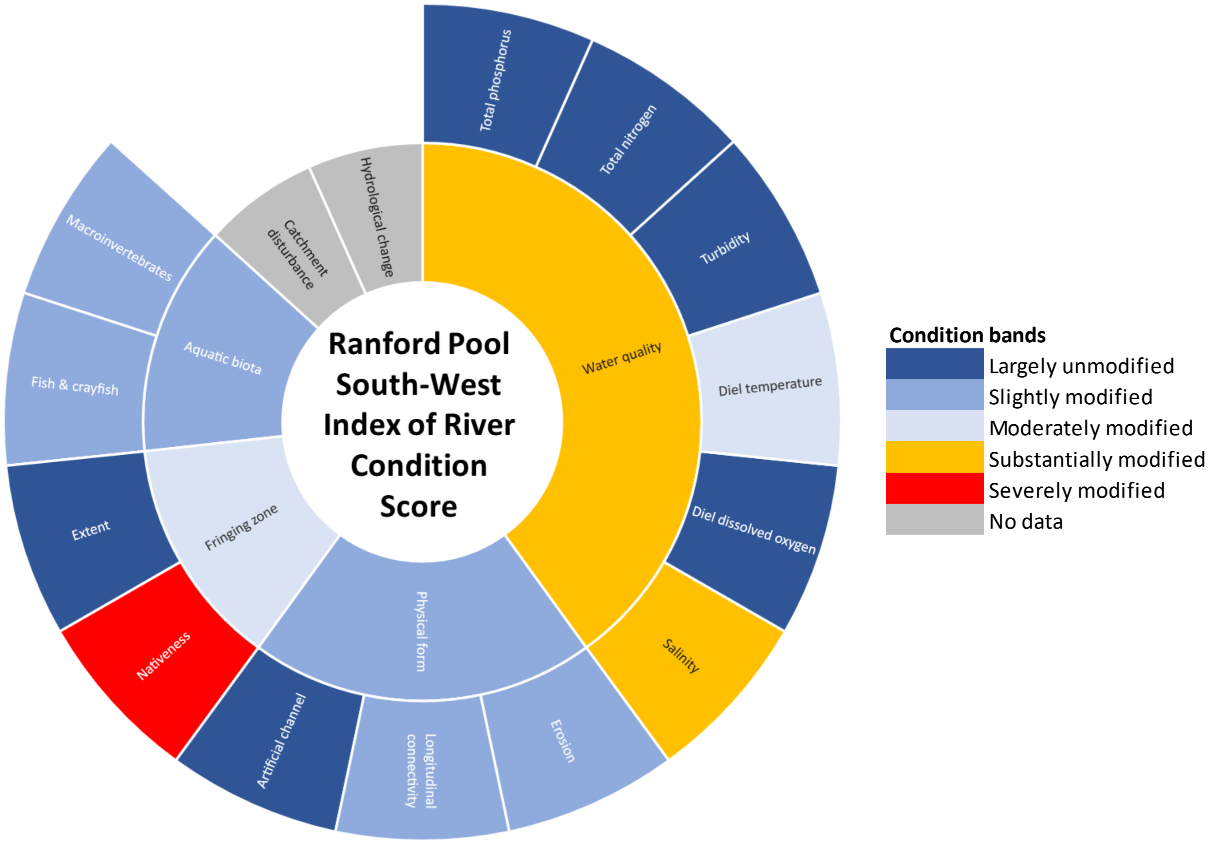


Figure 23: SWIRC condition bands for Ranford Pool.

4.5 Boraning Reserve

The Boraning Reserve site was located adjacent to the Williams River bridge on the Pinjarra-Williams Road within the Boraning Reserve. There was a range of different in-stream habitats including woody debris of a two to three sizes and biological substrates present (e.g. detritus and leaves). Physical substrate comprised of gravel and sand. Between 10 – 49 % of the bank length was undercut and another 10 – 49 % comprised of overhanging roots draped in water (Plate 5) (this was reduced to 1 – 9 % in the March sampling as water levels had receded beyond the trailing root zone). Approximately 50 - 100 % of the bank had vegetation draped in water. Stream shading covered an average stream width of 3 m. Banks were stepped in shape, with a moderate to low slope (1.5 - 2 m in bank height). Water depth was moderately varied across the site, from 0.5 – 1.5 m in the channel areas, to > 2 m in the deeper pools. Flow observed in October 2019 was variable, between 0.1 – 0.6 m/s with rest areas present. Flow in March 2020 was observed but was below 0.1 m/s.

Plate 5. Vegetation draped in water at Boraning Reserve Photo by WRM ©

4.5.1 Water Quality

Electrical conductivity ranged from 12,560 µS/cm in October 2019 to 15,210 µS/cm in March 2020 (Table 21), both sampling occasions were above ANZG guidelines. Salinity (as TDS mg/L) varied from 8,473 mg/L in October 2019 to 10,343 mg/L in March 2020, classifying the site as saline to highly saline (Meyer *et al.* 2005).

Diel dissolved oxygen ranged between 59.8 – 97.0 % in October 2019 and 66.7 – 101.9 % in March 2020 (Table 21, Figure 24, Figure 25). Both sampling events recorded dissolved oxygen levels outside of the ANZG DGV (2018), with the October sampling recording a drop in dissolved oxygen below the 60 % threshold for approximately one hour (Figure 24).

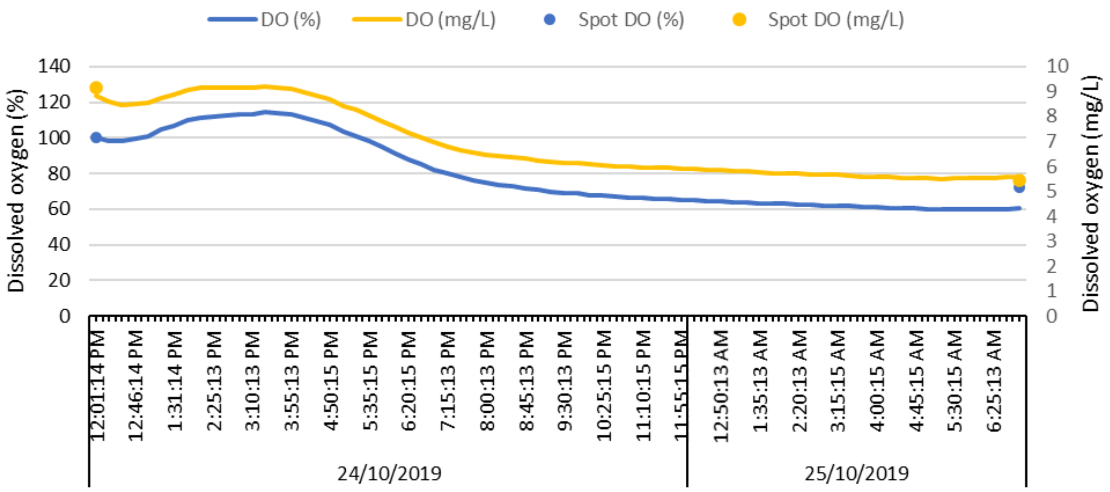
Diel temperatures ranged from 15.3 – 18.5 °C in October 2019 and 21.3 – 24.6 °C in March 2020 (Table 21, Figure 24, Figure 25). Temperature fluctuations were within the recommended change of 4 °C (Storer *et al.* 2011).

Turbidity, total nitrogen and total phosphorus were below the ANZG DGV on both sampling occasions (Table 21).

Levels of pH were within ANZG DGV in October 2019, and above the upper range in March 2020 (Table 21).

Table 21. *In situ w*ater quality data recorded for Boraning Reserve in October 2019 and March 2020 at logger deployment (pm), and logger retrieval (am). Diel range and mean of temperature and dissolved oxygen levels recorded from loggers. Values in exceedance of ANZG DGV (2018) are highlighted in orange.

Boraning Reserve Sampled		Time (hrs)	Temp. (°C)	EC (µS/cm)	TDS (mg/L)	DO (%)	DO (mg/L)	pH (pH units)	Turbidity (NTU)	TN (mg/L)	TP (mg/L)
	ANZG DGV			120 - 300		80 -120		6.5 - 8.0	20	1.2	0.065
Oct-19	PM - set	11:45	19.7	12560	8473	100.5	9.13	7.967	11.71	0.8	<0.005
	AM - pick up	7:00	17	12540	8527	72	5.46	7.89			
	Diel range		15.3-18.5			59.8-97	5.51-9.73				
	Diel mean		17.5			63.5	5.83				
Mar-20	PM - set	13:30	23.8	15210	10343	96.6	6.4	8.51	10.72	0.83	0.009
	AM - pick up	7:15	19.6	15150	10302	79.1	6.74	8.67	9.86		
	Diel range		21.3-24.6			66.7-101.9	5.56-8.14				
	Diel mean		23.1			87.8	7.07				



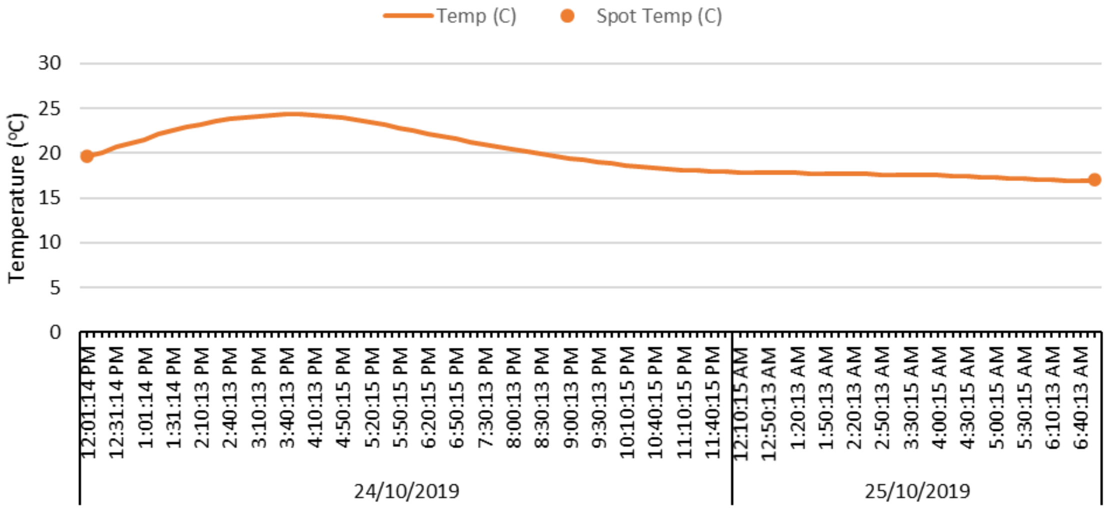


Figure 24: October 2019 logger data for dissolved oxygen (% and mg/L) top and temperature (°C) bottom at Boraning Reserve.

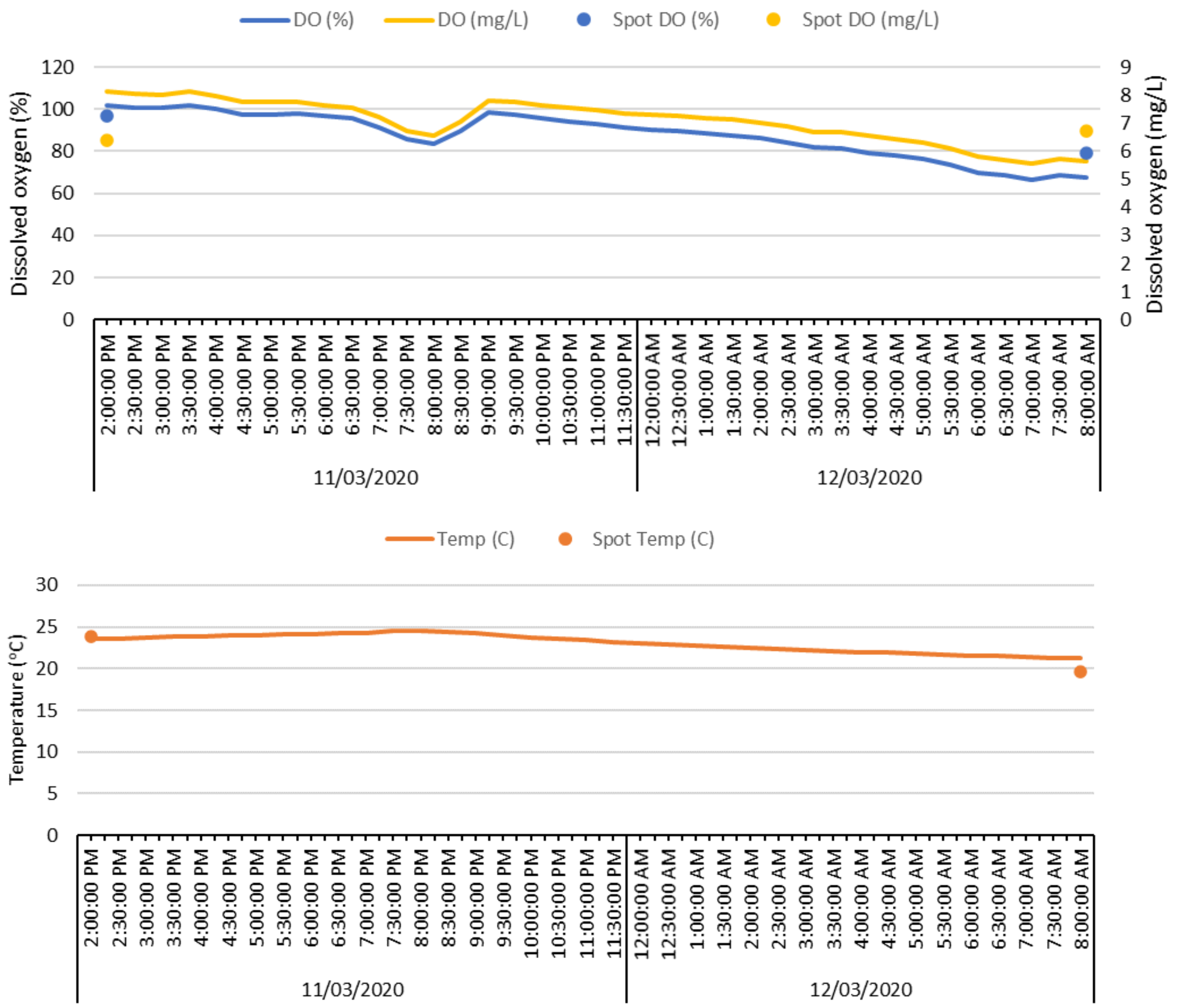


Figure 25: March 2020 logger data for dissolved oxygen (% and mg/L) top and temperature (°C) bottom at Boraning Reserve.

4.5.2 Aquatic Biota

Macroinvertebrates

A total of 13 taxa were recorded from Boraning Reserve in October 2019 and 24 taxa in March 2020, giving a total of 28 taxa recorded. Most taxa recorded were common, ubiquitous species with the exception of *Symphitoneuria wheeleri* which is a Western Australian endemic caddisfly.

The macroinvertebrate fauna comprised of Oligochaeta (aquatic worms), Amphipoda (side swimmers), Decapoda (Freshwater shrimp), Odonata (dragonflies and damselflies), Coleoptera (aquatic beetles), Trichoptera (caddisflies), Diptera (two-winged fly larvae) and Lepidoptera (aquatic moth larvae). Insecta were the dominant group in all sampling events and habitat sites. Of the insects, the best represented taxa were Diptera (Table 22). Abundance ranged from 864 individuals in March 2020 to 1,129 individuals in October 2019.

Table 22. Summary of higher-order macroinvertebrate taxa composition recorded from Boraning Reserve sites in the October 2019 and March 2020 sampling. Refer Appendix 4 for full species list.

Macroinvertebrates		Number of Taxa	
Scientific name	Common name	Channel Oct-19	Channel Mar-20
Mollusca	Freshwater snails	0	0
Oligochaeta	Aquatic worms	1+	0
Amphipoda	Amphipods	1	1
Decapoda	Freshwater shrimp	0	1
Acarina	Water mites	0	0
Odonata	Dragonflies and damselflies	2+	6+
Trichoptera	Caddisflies	2+	3+
Ephemeroptera	Mayflies	0	0
Hemiptera	True bugs	0	0
Coleoptera	Aquatic beetles	2+	4+
Diptera	Two-winged flies	4+	9+
Lepidoptera	Aquatic moth larvae	1+	0
	Total taxa richness	**13+**	**24+**

Fish and crayfish

Four native fish species, including western minnow, Swan River goby, nightfish and western pygmy perch and one non-native fish (mosquitofish), were recorded during the sampling events. One native crayfish, gilgie (*Cherax quinquecarinatus*) was recorded.

A total of six Swan River gobies were recorded, with five in October 2019 and one in March 2020. Size classes ranged from 21 – 50 mm SL. A total of 195 western minnow individuals were recorded, with 136 individuals in October 2019 and 59 individuals in March 2020. Size classes ranged from 21 – 80 mm (Figure 18). A total of 10 nightfish were recorded, seven in October 2019 and three in March 2020. Size classes ranged from 10 – 80 mm. Two western pygmy perch were recorded, both during the October 2019 sampling. They were 53 and 48 mm in standard length.

Seven gilgies were recorded, with six in the October 2019 sampling and one in March 2020 sampling. Carapace length ranged from 11 – 40 mm (Figure 26). Gilgies have a range that extends from the Moore River in the north to Bunbury in the south (Shipway 1951). They are known to exploit almost the full range of freshwater environments and can be found in habitats that range from semi-permanent swamps to deep rivers (Austin & Knott 1996). Gilgies have a well-developed burrowing ability that allows them to withstand periods of low water level by retreating into burrows until flows return. Gilgies would appear to be tolerant of salinities up to at least 18,690 µS/cm as evidenced by their presence in Warrin Creek in the upper Helena River catchment (WRM 2011).

A total of 258 mosquitofish were recorded across both sampling events, the majority recorded in October 2019 (193 individuals). Size classes ranged from 21 – 40 mm (Figure 18), with many of the females recorded gravid (carrying young).

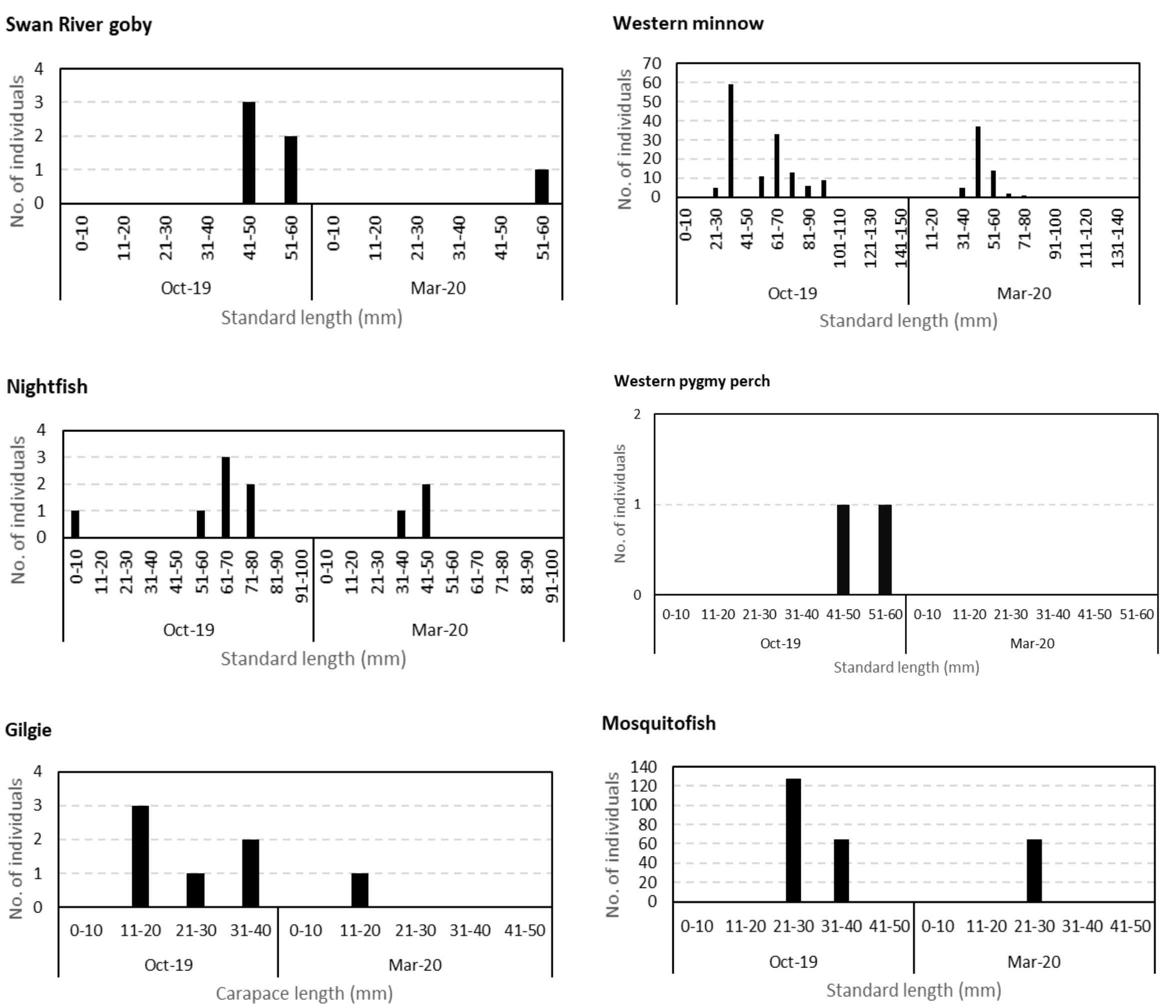


Figure 26. Length frequency (SL mm) histograms for Swan River goby (*Pseudogobius* olorum), western minnow (*Galaxias occidentalis*), nightfish (*Bostockia porosa*), western pygmy perch (*Nannoperca vittata*), gilgie (*Cherax quinquecarinatus*) and mosquitofish (*Gambusia holbrooki*) recorded at Boraning Reserve site in October 2019 and March 2020.

Other fauna

Although not recorded in the current survey, there was evidence of a water rat in a net at Boraning Reserve in March 2020. There was a hole in the cod end of the net (indicating that the water rat had escaped) and several partially consumed gilgies (only claws remained). The Australian water rat is currently listed as a Priority 4 (DBCA 2020). 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 wetland infilling and flood mitigation practices.

4.5.3 Fringing Zone

Extent and nativeness

Vegetation extent width ranged from 6 – 50 m along the reach, with an average width of 42.1 m. Along the 938 m length, 95 % was vegetated. All three native riparian layers (groundcover, shrubs and trees) were present with no obvious impacts from livestock. Most of the vegetation layers comprised of native species, with the exception of the ground cover layer which had 50 – 74 % exotic species including couch grasses and paspalum.

4.5.4 Physical Form

Erosion, longitudinal connectivity, and artificial channel

Erosion extent was between 0 – 4 %, and the banks had good structural integrity. No artificial channels were observed on site or in the desktop analysis.

No major dams were within 40 km either upstream or downstream from the site. A weir across the Williams River is present in Williams township, approximately 25 km upstream of the Boraning Reserve site. Road and rail crossings were at a low density of 0 – 1 per kilometre.

4.5.5 SWIRC Scores

Index scores for Boraning Reserve varied between 0.2 (substantially modified) and 0.82 (largely unmodified), with the majority of indices within the moderately modified to largely unmodified condition bands (Table 23, Figure 27). Based on the water quality index scores, the site was substantially modified. This is due to the high salinity recorded. The macroinvertebrate subindex was moderately modified, and fish and crayfish subindices were slightly modified, with an average for the aquatic biota index as slightly modified. The fringing zone score was 0.55 (moderately modified), due to high coverage of non-native grasses within the groundcover layer. The physical form index score was 0.82 (largely unmodified) and was the highest SWIRC score for the site.

Table 23. SWIRC scores for Boraning Reserve.

<table>
<tr><th>Site</th><th>Theme</th><th>Sub-theme</th><th>Sub-theme score</th><th>SWIRC score</th></tr>
<tr><td rowspan="15">Boraning Reserve</td><td>Hydrological change</td><td>-</td><td>-</td><td>Not assessed</td></tr>
<tr><td>Catchment disturbance</td><td>-</td><td>-</td><td>Not assessed</td></tr>
<tr><td rowspan="6">Water quality</td><td>Salinity</td><td>0.2</td><td rowspan="6">0.2</td></tr>
<tr><td>Diel dissolved oxygen</td><td>0.8</td></tr>
<tr><td>Diel temperature</td><td>0.4</td></tr>
<tr><td>Turbidity</td><td>0.6</td></tr>
<tr><td>Total nitrogen</td><td>0.8</td></tr>
<tr><td>Total phosphorus</td><td>1</td></tr>
<tr><td rowspan="2">Aquatic biota</td><td>Macroinvertebrates</td><td>0.54</td><td rowspan="2">0.63</td></tr>
<tr><td>Fish & crayfish</td><td>0.72</td></tr>
<tr><td rowspan="2">Fringing zone</td><td>Extent</td><td>0.90</td><td rowspan="2">0.55</td></tr>
<tr><td>Nativeness</td><td>0.20</td></tr>
<tr><td rowspan="3">Physical form</td><td>Artificial channel</td><td>1</td><td rowspan="3">0.82</td></tr>
<tr><td>Longitudinal connectivity</td><td>0.90</td></tr>
<tr><td>Erosion</td><td>0.71</td></tr>
</table>

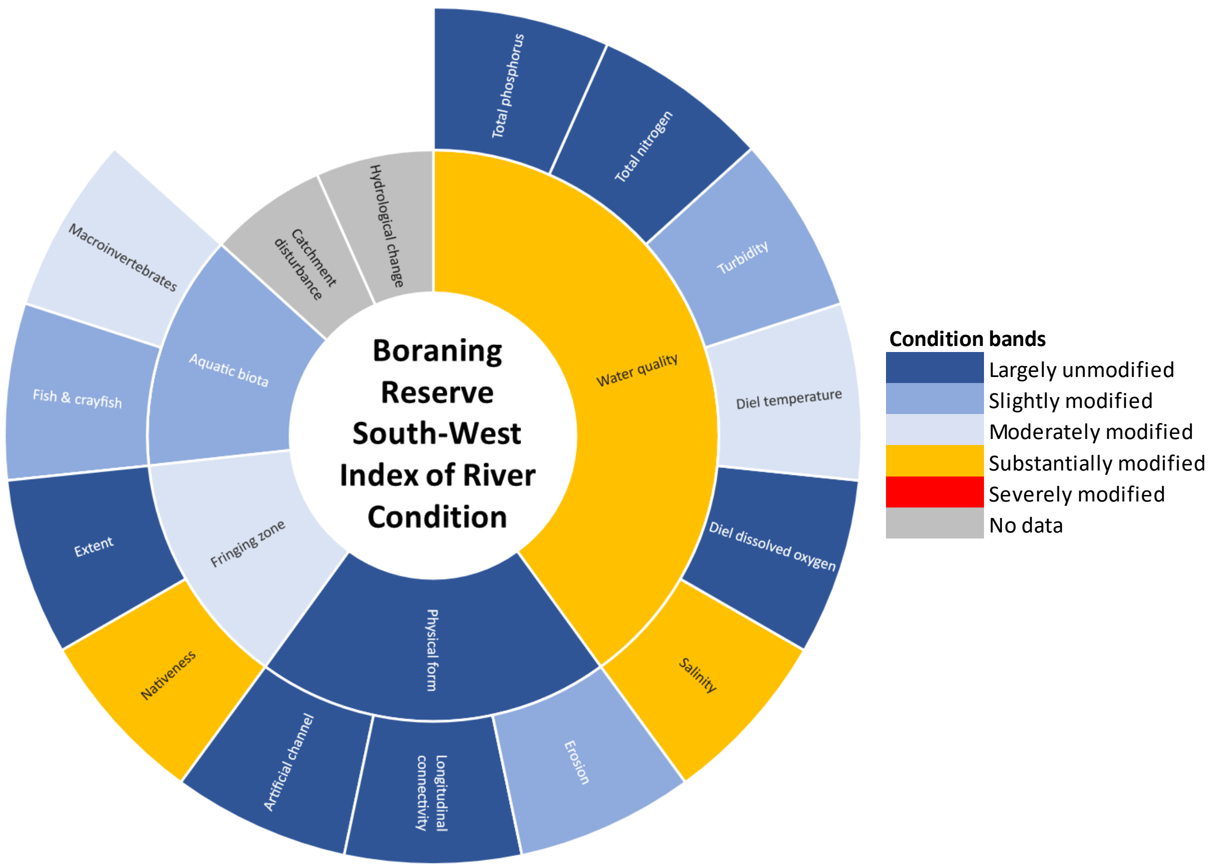


Figure 27: SWIRC condition bands for Boraning Reserve.

4.6 Quindanning

The Quindanning sampling site was located approximately 250 m downstream of the Williams River Bridge on the Pinjarra-Williams Road, within the Quindanning town site. There was a range of different in-stream habitats including woody debris of two to three different sizes and biological substrates present (e.g. detritus and leaves) but no aquatic macrophytes present. Physical substrate comprised of sand and silt. Between 1 – 9 % of the bank length was undercut and another 10 – 49 % comprised of overhanging roots draped in water (Plate 6) (this was reduced to 1 – 9 % in the March sampling as water levels had receded away from the trailing roots). Approximately 10 - 49 % of the site had vegetation draped in water. Banks were concave in shape, with a low slope (0.25 – 0.49 m in bank height). Water depth was varied across the site, from 0.25 – 2.0 m. Flow observed in October 2019 was variable, between 0.1 – 0.6 m/s with rest areas present. Flow in March 2020 was below 0.1 m/s.

Plate 6. Vegetation draped in water at Quindanning. Photo by WRM ©

4.6.1 Water Quality

Electrical conductivity ranged from 10,270 µS/cm in October 2019 to 8,890 µS/cm in March 2020 (Table 24). Electrical conductivity was above the ANZG DGV of 300 µS/cm. Salinity (as TDS mg/L) ranged from 6,984 mg/L in October 2019 to 6,045 mg/L in March 2020, classifying the site as Saline (Meyer *et al.* 2005).

Diel dissolved oxygen was not recorded in October 2019 due to logger failure. An *in situ* dissolved oxygen measurement was 96.7 %, and within ANZG DGV. Diel dissolved oxygen ranged from 52.8 – 103.8 % in March 2020 (Figure 28). Oxygen levels were below the lower ANZG DGV of 80 % from 2100 hrs and started to increase from 0830 hrs the following day.

Diel temperatures were not recorded in October 2019 but ranged from 19.2 – 24.3 °C in March 2020 (Figure 28), just exceeding the 4 °C range guideline value. Temperatures did not exceed the upper limit for south-west rivers of 25 °C, likely due to the amount of stream shading at the site.

Turbidity ranged from 21.18 NTU in October 2019 to 14.71 NTU in March 2020. Turbidity was above the ANZG DGV of 20 NTU in October 2019, but was below the guideline in March 2020.

Total nitrogen ranged from 0.5 – 0.82 mg/L and total phosphorus ranged from <0.005 – 0.011 mg/L, both were below the ANZG DGV (Table 24).

Values for pH were within ANZG DGV in October 2019, and above the upper range of 8.0 in March 2020 (Table 24).

Table 24. *In situ w*ater quality data recorded for Quindanning in October 2019 and March 2020 at logger deployment (pm), and logger retrieval (am). Diel range and mean of temperature and dissolved oxygen levels recorded from loggers. Values in exceedance of ANZG DGV (2018) are highlighted in orange.

Quindanning		Time (hrs)	Temp. (°C)	EC (µS/cm)	TDS (mg/L)	DO (%)	DO (mg/L)	pH (pH units)	Turbidity (NTU)	TN (mg/L)	TP (mg/L)
Sampled	ANZG DGV			120 - 300		80 -120		6.5 - 8.0	20	1.2	0.065
Oct-19	PM - set	14:30	21.1	10270	6984	96.7	6.72	7.98	21.18	0.5	<0.005
	AM - pick up	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data
	Diel range		logger failed			logger failed	logger failed				
	Diel mean		logger failed			logger failed	logger failed				
Mar-20	PM - set	15:00	23.9	8840	6011	104.3	7.04	8.55	14.71	0.82	0.011
	AM - pick up	8:30	19.4	8890	6045	68.9	5.42	8.17	12.69		
	Diel range		19.2-24.3			52.8-103.8	4.7-8.4				
	Diel mean		21.6			70.8	5.99				

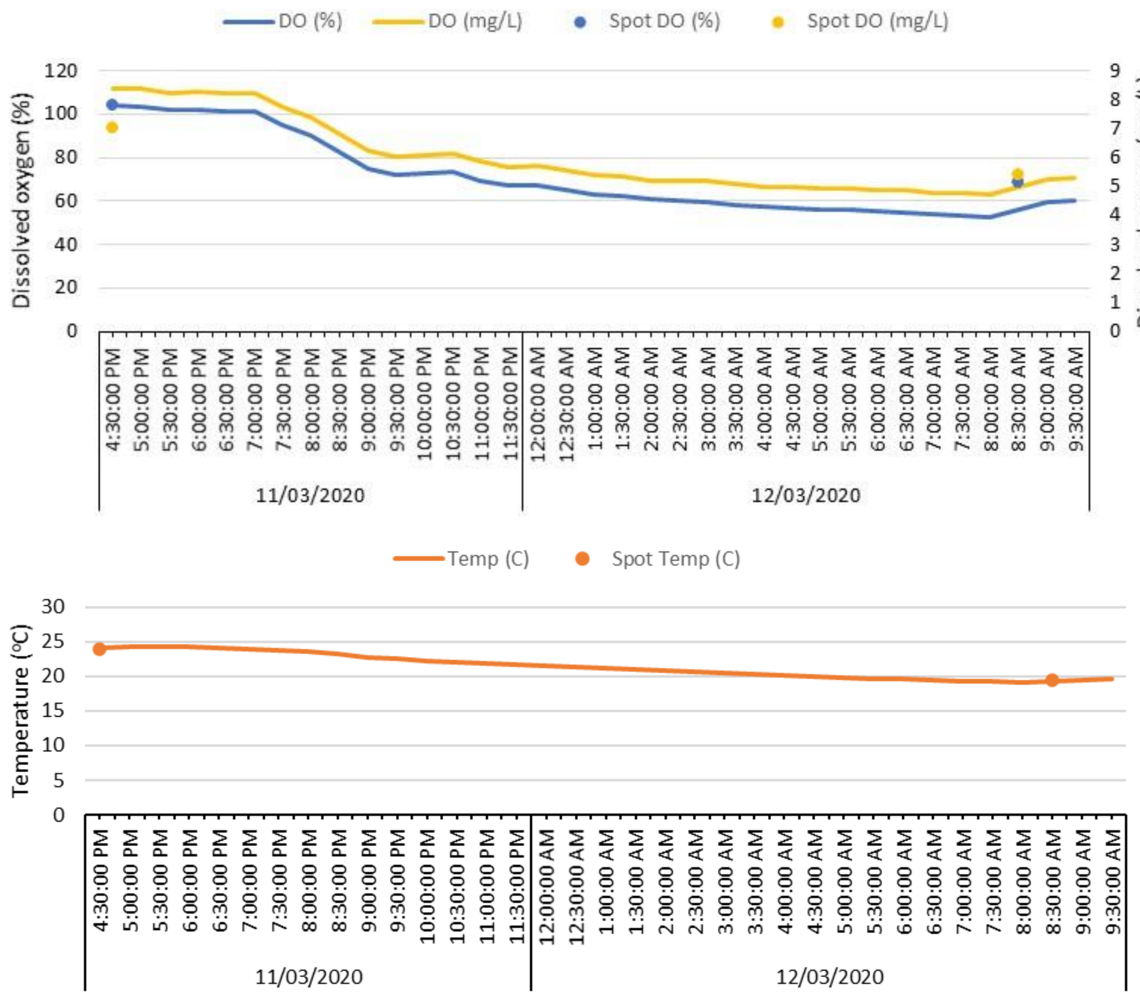


Figure 28: March 2020 logger data for dissolved oxygen (% and mg/L) top, and temperature (°C) bottom at Quindanning.

4.6.2 Aquatic Biota

A total of 17 taxa were recorded from Quindanning in October 2019 and 12 taxa in March 2020, giving a total of 25 taxa recorded. Most taxa recorded were common, ubiquitous species.

The macroinvertebrate fauna comprised of Oligochaeta (aquatic worms), Amphipoda (side swimmers), Decapoda (Freshwater shrimp), Acarina (water mites), Odonata (dragonflies and damselflies), Coleoptera (aquatic beetles), Trichoptera (caddisflies), Hemiperta (true bugs), Diptera (two-winged fly larvae) and Lepidoptera (aquatic moth larvae). Insecta were the dominant group in both sampling events. Of the insects, the best represented taxa were Diptera in both sampling events (Table 25). Abundance ranged from 202 individuals in March 2020 to 728 individuals in October 2019.

Table 25. Summary of higher-order macroinvertebrate taxa composition recorded from Quindanning in the October 2019 and March 2020 sampling. Refer Appendix 4 for full species list.

Macroinvertebrates		Number of Taxa	
Scientific name	Common name	Channel Oct-19	Channel Mar-20
Mollusca	Freshwater snails	0	0
Oligochaeta	Aquatic worms	0	1+
Amphipoda	Amphipods	1	0
Decapoda	Freshwater shrimp	1	1
Acarina	Water mites	1+	0
Odonata	Dragonflies and damselflies	1	1+
Trichoptera	Caddisflies	2+	2+
Ephemeroptera	Mayflies	0	0
Hemiptera	True bugs	2+	0
Coleoptera	Aquatic beetles	2+	2+
Diptera	Two-winged flies	7+	5+
Lepidoptera	Aquatic moth larvae	0	0
	Total taxa richness	**17+**	**12+**

Fish and crayfish

Three native fish species, including western minnow, Swan River goby and nightfish, and one non-native fish (mosquitofish), were recorded during the sampling. One native crayfish, gilgie (*Cherax quinquecarinatus*) was recorded.

A total of 95 Swan River gobies were recorded, with 60 in October 2019 and 35 in March 2020. Size classes ranged from 21 – 50 mm SL. A total of 166 western minnows were recorded, with 107 individuals in October 2019 and 59 individuals in March 2020. Size classes ranged from 21 – 110 mm (Figure 29). A total of 18 nightfish were recorded, all in October 2019. Size classes ranged from 61 – 100 mm. Seven gilgies were recorded, all in the October 2019 sampling. All were juveniles with a carapace length of 10 mm (Figure 29).

A total of 912 mosquitofish were recorded across both sampling events, the majority recorded in March 2020 (888 individuals). Size classes ranged from 11 – 40 mm (Figure 18), with many of the females recorded gravid (carrying young).

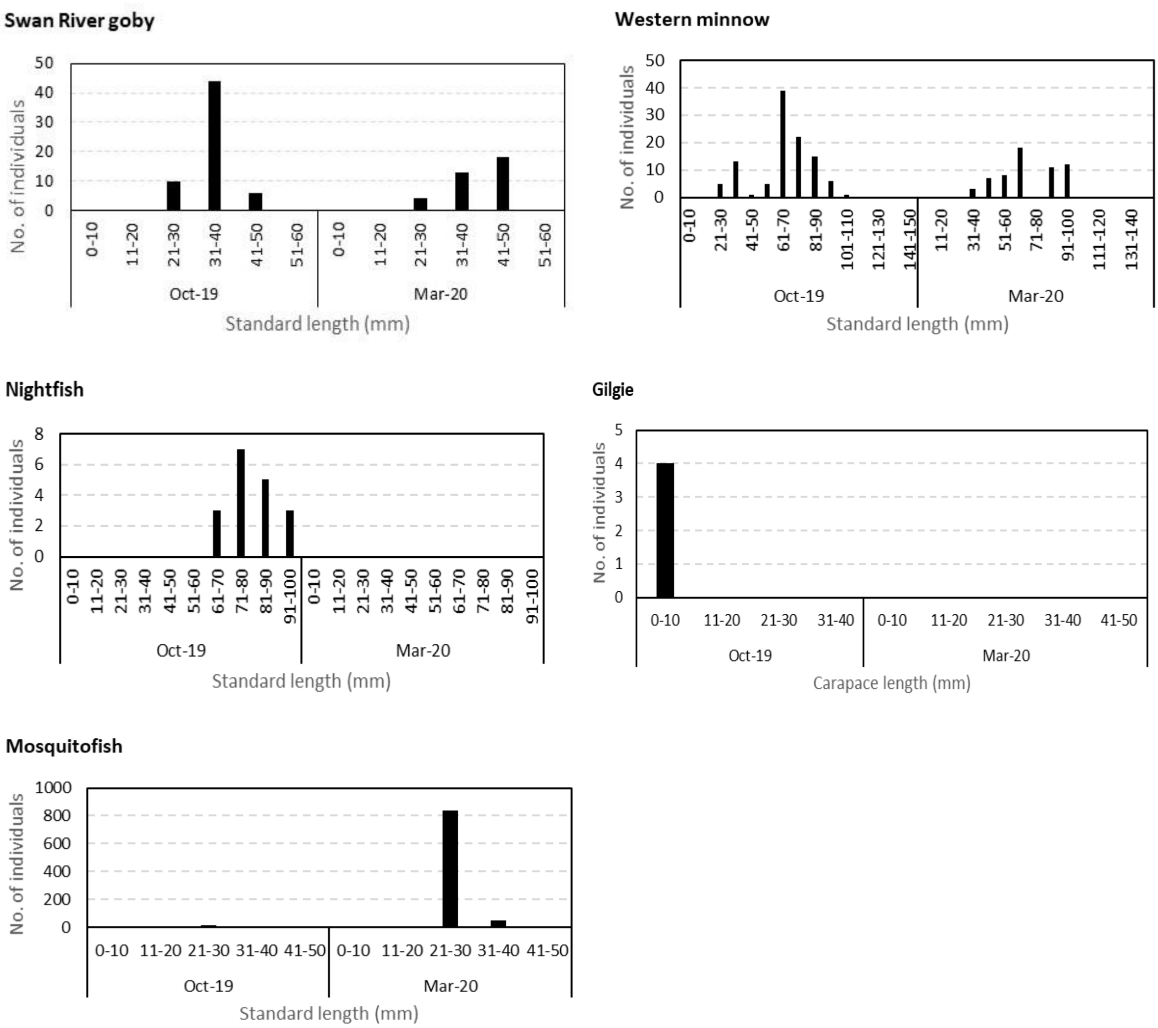


Figure 29. Length frequency (SL mm) histograms for Swan River goby (*Pseudogobius* olorum), western minnow (*Galaxias occidentalis*), nightfish (*Bostockia porosa*), gilgie (*Cherax quinquecarinatus*) and mosquitofish (*Gambusia holbrooki*) recorded at Quindanning in October 2019 and March 2020.

Other fauna

A total of 35 south-western snake necked turtles were recorded from Quindanning, with seven in October 2019 and 28 in March 2020. All individuals were of breeding size and there was a mix of both males and females.

4.6.3 Fringing Zone

Extent and nativeness

Vegetation extent width ranged from 0 – 50 m along the reach, with an average width of 36.2 m. Along the 1450 m length, 100 % was vegetated. All three native riparian layers (groundcover, shrubs and trees) were present, although ground cover and shrub layers were heavily reduced. There were no obvious impacts from livestock. Most of the vegetation layers comprised of native species, with the exception of the ground cover layer which had 75 – 100 % exotic species including couch grasses and dock.

4.6.4 Physical Form

Erosion, longitudinal connectivity, and artificial channel

Erosion extent was between 0 – 4 %, and the banks had good structural integrity. No artificial channels were observed on site or in the desktop analysis.

No major or minor dams were within 40 km either upstream or downstream of the site. Road and rail crossings were at a low density of 0 – 1 per kilometre.

4.6.5 SWIRC Scores

Index scores for Quindanning varied between 0.5 (moderately modified) and 0.78 (slightly modified), with the majority of indices within the moderately modified to largely unmodified condition bands (Table 26, Figure 30). Based on the water quality index scores, the site was moderately modified. This is due to the high salinity recorded. The macroinvertebrate and fish and crayfish subindices were both slightly modified. The fringing zone score was 0.48 (moderately modified), due to high coverage of non-native grasses and weeds within the groundcover layer. The physical form index score was 0.78 (slightly modified) and was the highest SWIRC score for the site.

Table 26. SWIRC scores for Quindanning.

Site	Theme	Sub-theme	Sub-theme score	SWIRC score
Quindanning	Hydrological change	-	-	Not assessed
	Catchment disturbance	-	-	Not assessed
	Water quality	Salinity	0.5	0.5
		Diel dissolved oxygen	0.9	
		Diel temperature	0.4	
		Turbidity	0.6	
		Total nitrogen	1	
		Total phosphorus	1	
	Aquatic biota	Macroinvertebrates	0.67	0.71
		Fish & crayfish	0.74	
	Fringing zone	Extent	0.86	0.48
		Nativeness	0.10	
	Physical form	Artificial channel	1	0.78
		Longitudinal connectivity	0.97	
		Erosion	0.63	

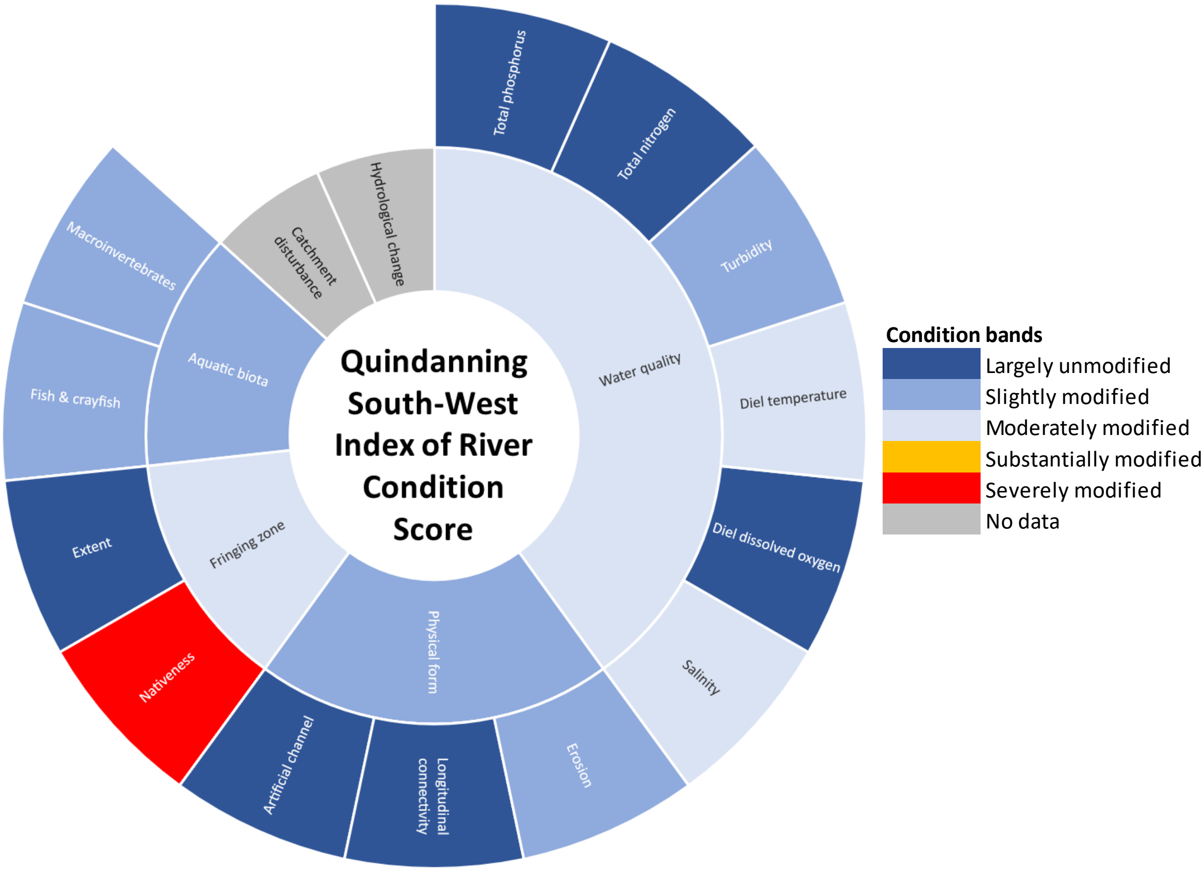


Figure 30: SWIRC condition bands for Quindanning.

5 SUMMARY AND CONCLUSIONS

The six sites provide an adequate coverage of the Hotham and Williams sub-catchments. The sites located within nature reserves, or with dense vegetation had good scores for vegetation and channel condition however, water quality still had an overbearing influence on fauna.

Stream salinity is a common problem in south-west rivers and is largely the result of rising groundwater levels due to extensive clearing (Mayer *et al.* 2005). Salinisation in the Hotham and Williams rivers was apparent at each of the six sites and is a major factor influencing the aquatic biota that can occur (Beatty *et al.* 2008), particularly in sites that experienced seasonal changes in salinity. Increased salinity levels can affect native fish recruitment success, with many larval fish showing skin, gill issues and low osmoregulatory ability with increasing salt concentrations (Hart *et al.* 1991; Beatty *et al.* 2008). Elevated salinities can cause the loss of sensitive invertebrate taxa, having an affect further down the food chain (Bunn & Davies 1992).

Four of the six expected native fish and crayfish species were recorded in the Hotham River and five of the six were recorded in the Williams River, with diversity lower in autumn than spring, likely due to salinity increases with evapoconcentration. Although present in the October 2019 sampling, western minnows were absent from the two most upstream sites (Popanyinning and Hotham River Nature Reserve) on the Hotham River in the March 2020 sampling. It is important that refuges within the system are maintained during spring and summer so that this species can recolonise these sites in winter when water levels increase. Macroinvertebrate diversity was low compared to surveys of fresher system, with a total of 67 taxa recorded across all six sites. Compared to 125 – 132 taxa recorded within jarrah forest streams (WRM 2020).

Although salinity within the catchment will be a limiting factor in the overall health of the Hotham and Williams Rivers, revegetation and weed control programs would improve the overall fringing vegetation scores for each reach. Macroinvertebrate and fish sampling provided a snapshot of the communities present. A greater understanding of the aquatic fauna and resilience of taxa within the reaches would be achieved with longer term monitoring over several years.

The dataset provides a sound baseline for assessing future response to ongoing catchment management to reduce salinities and protect streamlines through fencing for stock exclusion and revegetation. Furthermore, through the PHCC's partnership with DWER, the results of the River Health Assessment will be included on the website "Healthy Rivers South-West"[4]. This public domain managed by DWER gives people access to data and methods, and promotes the interaction, collaboration and knowledge-sharing between river users and managers.

5.1 Popanyinning

Based on SWIRC scores, Popanyinning was in slightly modified to severely modified condition, with salinity and fringing zone nativeness driving the low scores. The remaining water quality sub-themes were in moderately modified to slightly modified condition, with values for dissolved oxygen and pH outside of ANZG DGV (2018). There was a seasonal variation in salinity, with March 2020 recording values more than 16,000 mg/L higher than October 2019 values.

Overall macroinvertebrate taxa richness was 18 taxa, the second lowest richness of the six sites and was dominated by Diptera and Coleoptera. Only one native fish was recorded within the site, western minnow, which was not recorded in the March 2020 sampling. The summer increase in salinity has

[4] https://rivers.dwer.wa.gov.au/

likely caused the seasonal loss of western minnows, although it is unclear if the species had migrated downstream, or had been outcompeted by the non-native mosquitofish, which were dominant in the March 2020 sampling.

The fringing zone was characterised by a dense but narrow riparian canopy across the width and length of the site, with some native groundcover, shrubs and trees. There was a significant invasion of exotic grasses within the ground cover layer.

5.2 Hotham River Nature Reserve

Hotham River Nature Reserve SWIRC scores varied between severely modified to slightly modified, with the majority of the themes within moderately modified to slightly modified. The site was moved approximately 200 m upstream in March 2020 from the original October 2019 site, due to receding water levels and water availability. Due to the high salinity recorded at the site, the SWIRC score for water quality was 0. Salinity varied with season, with March 2020 values more than 60,000 mg/L higher than October 2019. This is likely due to evapoconcentration of salts within the site, with a salt crust visible on sediments during the March 2020 sampling. The remaining water quality sub-themes were within the moderately modified to slightly modified condition bands.

Hotham River Nature Reserve recorded a total of 17 macroinvertebrate taxa across both sampling rounds, the lowest of the six sites. Two native fish species and one non-native fish species were recorded in the October 2019 sampling with no fish recorded in the 2020 sampling. The high salinities within the system have allowed for the primarily estuarine Swan River goby to move within the river (Morgan and Beatty 2004). Fish likely moved downstream or died as salinity increased within the site over summer. The presence of the weir within the site could affect fish passage upstream when water levels are low however given the high salinity within the site, this is unlikely to be a critical factor affecting the ability for fish to persist within the reach.

The fringing vegetation zone was characterised by a dense but patchy riparian canopy across the width and length of the site, with many dead eucalyptus trees noted in the site visit. This could be due to the high groundwater salinities or the presence of dieback (*Phytophthora cinnamomi*). Groundcover was predominantly salt tolerant samphire and saltbush, with non-native grasses from surrounding cleared land.

5.3 Pumphreys Bridge

The combined SWIRC scores for Pumphreys Bridge ranged from severely modified to slightly modified, with salinity also scoring 0 for the water quality theme. The site was moved approximately 100 m downstream from the original sampling area, due to the receded water levels and water availability. There was a slight seasonal variation in salinity, with March 2020 just under 1,500 mg/l higher than October 2019 sampling. The remaining water quality sub-themes were within the slightly modified to largely unmodified condition bands, with total nitrogen and total phosphorus below ANZG DGV.

A total of 28 macroinvertebrate taxa were recorded at the site across the two sampling events, including the odonate *Procordulia affinis*, which is a south-west endemic species. Three native fish species and one non-native fish species were recorded at the site, with a higher abundance of non-native individuals in March 2020. South-western snake necked turtles were recorded at Pumphreys Bridge on both sampling occasions.

The fringing vegetation zone was sparse across both the length and width of the site, with areas cleared for agriculture on both sides of the river and numerous dead trees reducing the canopy availability. Groundcover was dominated by non-native grasses on both the left and right banks.

5.4 Ranford Pool

Condition scores for Ranford Pool ranged from substantially modified to slightly modified, with the water quality theme the lowest score of 0.2, due to the high salinity. Salinity levels decreased with the seasons, dropping 2,500 mg/L between October 2019 and March 2020. Salinity was the lowest at the Ranford Pool site along the Hotham River. With the exception of diel temperature (moderately modified), all other water quality sub-themes were within the largely unmodified condition band.

A total of 27 macroinvertebrate taxa were recorded across the two sampling events including *Necterosoma darwini* which is a Western Australian endemic beetle. Four native and one non-native fish species were recorded at the site, including nightfish and western pygmy perch which were not recorded within the upstream reaches. These two species were likely at the high end of their salinity tolerance within this site (Morgan and Beatty 2004). The presence of Boddington weir likely impedes large bodied native fish species, such as cobbler, from moving upstream into the reach. The fishway within the Boddington weir, was designed to facilitate the upstream migration of small bodied fish such as western minnow and nightfish. South-western snake necked turtles were recorded during the October 2019 sampling. No crayfish were recorded at the site, although gilgies have been recorded further downstream near the Boddington weir (WRM 2019).

The fringing vegetation zone was both dense and wide across most of the reach, with native shrubs and trees providing cover. There was minimal groundcover within the site.

5.5 Boraning Reserve

SWIRC condition scores ranged from substantially modified to largely unmodified. The water quality theme had the lowest score of 0.2, due to the high salinity levels. Salinity within the Boraning site increased by 1,870 mg/L between the two sampling events. The remaining water quality subthemes were within the moderately modified to largely unmodified condition bands.

A total of 28 macroinvertebrate taxa were recorded across both sampling events, including *Symphitoneuria wheeleri* which is a Western Australian endemic caddisfly. Four native and one non-native fish species were recorded during the sampling events. One native crayfish (gilgie), was recorded, including some juveniles.

Fringing vegetation zone was dense and wide across most of the reach, with native shrubs and trees along the length. There was some native groundcover, although within the 10 m recorded width, was predominantly dominated by non-native grasses.

5.6 Quindanning

Condition bands for the Quindanning themes ranged from moderately modified to slightly modified and had the highest overall score for the six sites. The fringing zone theme had the lowest score of 0.48, followed by water quality with a score of 0.5, due to salinity. Salinity decreased by 973 mg/L between October 2019 and March 2020, and was the freshest of the six sites. The remaining water quality sub-themes were within the moderately modified to largely unmodified condition bands.

A total of 25 taxa were recorded from both sampling events, with all species common and ubiquitous. Three native and one non-native fish were recorded, and one native crayfish was recorded during the sampling events. A total of 35 snake necked turtles were recorded over both sampling events.

Fringing vegetation was dense and wide along the reach, with all three native riparian layers (groundcover, shrubs and trees) present, although ground cover and shrub layers were heavily reduced and predominantly dominated by non-native grasses and dock.

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APPENDICES

APPENDIX 1. SITE PHOTOGRAPHS

OCT-19 **MAR-20**

Boraning

Hotham River Nature Reserve

Popanyinning

OCT-19 **MAR-20**

Pumphreys Bridge

Quindanning

Ranford Pool

APPENDIX 2. HABITAT CHARACTERISTICS

Table A2-1. Habitat characteristics – river health assessment, October 2019 (LWD – Large Woody Debris, LB – Left Bank, RB – Right Bank, BR – Boraning, RP – Ranford Pool, HRNR – Hotham River Nature Reserve, POP – Popanyinning, PB – Pumphreys Bridge, QD - Quindanning).

SITE	BR	RP	HRNR	POPO	PB	QD
DATE	24/10/2019	23/10/2019	22/10/2019	23/10/2019	23/10/2019	25/10/19
STREAM HABITAT DIVERSITY						
Channel (%)	40	20	80	50	75	50
Pool (%)	30	80	10	40	10	30
Riffle (%)	0	0	10	0	10	0
Run (%)	30	0	0	10	5	20
Aquatic plant and macroalgae (%)	10	0	40	20	70	0
LWD Diversity	2-3 different sizes	Variety of sizes	2-3 different sizes	2-3 different sizes	2-3 different sizes	2-3 different sizes
LWD Abundance	Sparse (few pieces)	Moderate	Sparse (few pieces)	Sparse (few pieces)	Sparse (few pieces)	Dense (throughout most of the site)
Roots overhanging (%)	10-49	10-49	None	1-9	1-9	10-49
Banks overhanging (%)	10-49	10-49	None	None	None	1-9
Draped bank vegetation (%)	10-49	None	1-9	10-49	10-99	10-49
Depth	Moderately varied	Moderately varied	Moderately varied	Moderately varied	Uniform	Varied
Tree overhanging (%)	15 (LB & RB)	60 (LB & RB)	N/A	2 (LB & RB)	5 (LB & RB)	75 (LB & RB)
Shrub overhanging (%)	15 (LB & RB)	N/A	<1 (LB & RB)	5 (LB & RB)	None	None
Grass overhanging (%)	15 (LB & RB)	N/A	<1 (LB & RB)	2 (LB & RB)	5 (LB & RB)	5 (LB & RB)
Physical substrate diversity	Sand	Pebble, Gravel, Sand, Silt	Pebble, Gravel, Sand, Silt	Sand, Silt	Sand, Silt	Sand, Silt
Biological substrate density (%)	N/A	N/A	N/A	N/A	N/A	N/A
Sediment deposition	None	Obvious	Obvious	Obvious	Obvious	Obvious
Sediment type	Sand	Sand, Silt	Sand	Sand, Silt	Sand	Sand, Silt
Water odours	None	None	Anaerobic	None	None	None
Water oils	None	None	None	Flecks	None	None
Turbidity	Slight	Slight	Slight	Turbid	Slight	Turbid
Tannin staining	Light tea to Dark tea	Slight	Clear	Light Tea	Light Tea	Light Tea
Algae in water column (%)	0	0	0	0	0	0
Algae on substrate (%)	0	0	0	0	0	0
Sediment plume	Small	Small to Moderate	Moderate	Moderate	Small	Moderate
Sediment oils	Absent	Absent	Absent	Absent	Absent	Absent
Sediment odours	Normal to slight	None	Anaerobic	Anaerobic	Anaerobic	Normal
VEGETATION ASSESSMENT						
Riparian Vegetation Riparian zone present	Yes	Yes	Yes	Yes	Yes	Yes
Ground layer	Yes	None	Reduced	Reduced	None	Reduced
Shrub layer	Yes	Reduced	Reduced	Reduced	Yes	Reduced
Tree layer	Yes	Yes	Reduced	Reduced	Yes	Yes

Riparian width (m)	20 (LB), 50+ (RB)	80 (LB), 50 (RB)	10 (LB & RB)	20 (LB & RB)	10 (LB & RB)	5 (LB), 50+ (RB)
Streamside Vege All						
Bare ground (%)	1-9 (LB & RB)	50-75 (LB), 1-9 (RB)	10-49 (LB & RB)	10-49 (LB & RB)	1-9 (LB & RB)	10-49 (LB & RB)
Ground cover (%)	75-100 (LB & RB)	1-9 (LB) 10-49 (RB)	10-49 (LB & RB)	75-100 (LB & RB)	75-100 (LB & RB)	1-9 (LB & RB)
Shrubs (%)	10-49 (LB & RB)	0 (LB) 1-9 (RB)	1-9 (LB & RB)	1-9 (LB & RB)	1-9 (LB & RB)	0 (LB & RB)
Trees <10m (%)	10-49 (LB & RB)	50-74 (LB & RB)	0 (LB & RB)	1-9 (LB & RB)	1-9 (LB & RB)	10-49 (LB & RB)
Trees >10m (%)	10-49 (LB & RB)	1-9 (LB & RB)	0 (LB & RB)	1-9 (LB & RB)	1-9 (LB & RB)	1-9 (LB & RB)
Streamside Vege Exotic						
Ground cover (%)	50-74 (LB & RB)	75-100 (LB & RB)	75-100 (LB & RB)	75-100 (LB & RB)	75-100 (LB & RB)	75-100 (LB & RB)
Shrubs (%)	0 (LB & RB)	0 (LB & RB)	75-100 (LB & RB)	0 (LB & RB)	0 (LB & RB)	0 (LB & RB)
Trees <10m (%)	0 (LB & RB)	0 (LB, 1-9 (RB)	0 (LB & RB)	0 (LB & RB)	0 (LB & RB)	0 (LB & RB)
Trees >10m (%)	0 (LB & RB)	0 (LB & RB)	0 (LB & RB)	0 (LB & RB)	0 (LB & RB)	0 (LB & RB)
Exotic species	Paspalum, Couch grass	Grasses	Veldt grass	Bridal creeper, Grasses	Couch grass, Veldt grass	Dock, Grasses
Streamside Vege Native.						
Recruitment evidence	Natural	None	None	None	None	Natural
Recruitment type	Trees & Shrubs	N/A	N/A	N/A	N/A	Trees
Extent of recruitment	Limited	N/A	Limited	N/A	N/A	Limited
Recruitment Health	Moderate	N/A	Poor	N/A	N/A	Moderate
Organic Litter						
Total organic litter (% cover)	10-49	1-9	1-9	1-9	1-9	1-9
Native (% cover)	75-100	75-100	1-9	1-9	10-49	1-9
PHYSICAL FORM						
Banks & Physical Form						
Erosion (%)	0-4 (LB & RB)	0-4 (LB) 5-19 (RB)	0-4 (LB & RB)	0-4 (LB & RB)	0-4 (LB & RB)	0-4 (LB & RB)
Erosion Severity	Minor (LB & RB)	Low-Mod (LB & RB)	Low-Mod (LB & RB)	Minor (LB & RB)	Low-Mod (LB & RB)	Low-Mod (LB & RB)
Bank Stability Factors	Human Access (LB) None (RB)	None	Livestock access, human access, cleared vegetation (LB & RB)	None	Human Access, Flow and Waves (LB) None (RB)	Cleared vegetation (LB & RB)
Stabilisation works	None	None	None	None	None	Fences livestock access (LB & RB)
Livestock Impact Vege	None	None	None	None	None	None
Livestock Impact Bank	None	None	None	None	None	None
Livestock Pugging	None	None	None	None	None	None
Livestock Manure	None	None	None	None	None	None
LlivestockTracks	None	None	Yes	None	None	None
FORESHORE CONDITION						
Bank and Channel Shape						
Bank Shape	Stepped	Concave	Convex	Concave	Concave	Concave
Slope	Low (10-30%) to moderate (30-60%)	Low (10-30%)	Steep (60-80%) to low (10-30%)	Moderate (30-60%)	Vertical (80-90%) to low (10-30%)	Low (1-30%)
Channel Shape	Stepped	Stepped, Flat	Flat	U-Shaped	Flat	U-Shaped

Table A2-2. Habitat characteristics – river health assessment, March 2020

SITE DATE	BR 12/3/2020	RP 11/3/2020	HRNR 9/3/2020	PB 10/3/2020	POPO 10/3/2020	QD 12/3/2020
STREAM HABITAT DIVERSITY						
Channel (%)	60	50	0	0	0	20
Pool (%)	40	50	100	100	100	80
Riffle (%)	0	0	0	0	0	0
Run (%)	0	0	0	0	0	0
Aquatic plant and macroalgae (%)	0	0	0	60	10	0
LWD Diversity	2-3 different sizes	2-3 different sizes	2-3 different sizes	Wood of Similar Size	2-3 Different sizes	Wood of Similar Size
LWD Abundance	Sparse (few pieces)	Moderate	Moderate	Sparse (few pieces)	Sparse (few pieces)	Sparse (few pieces)
Roots overhanging (%)	1-9	10-49	None	None	1-9	1-9
Banks overhanging (%)	10-49	10-49	None	10-49	None	1-9
Draped bank vegetation (%)	10-49	None	None	10-49	1-9	10-49
Depth	Moderately varied	Moderately varied	Uniform	Moderately varied	Uniform	Moderately varied
Tree overhanging (%)	40 (LB) , 20 (RB)	50 (LB), 30 (RB)	None	0 (LB), 15 (RB)	10 (LB), 5 (RB)	50 (LB & RB)
Shrub overhanging (%)	10 (LB & RB)	None	None	None	10 (LB), 20 (RB)	None
Grass overhanging (%)	90 (LB), 80 (RB)	None	None	5 (LB & RB)	2 (LB & RB)	None
Physical substrate diversity	Gravel, Sand	Bedrock, Boulders, Cobble, Pebble, Sand, Silt	Sand, Silt	Sand, Silt	Sand, Silt	Sand, Silt
Sediment deposition	None	Obvious	Obvious	None	Obvious	Not obvious
Sediment type	Sand	Sand	Silt	Sand, Silt	Silt	Sand
Water odours	None	None	Anaerobic	None	Anaerobic	None
Water oils	Slick	Slick	None	None	None	None
Turbidity	Slight	Slight	Opaque	Slight	Slight	Slight
Tannin staining	Clear to slight	Slight	Clear	Slight	Slight	Slight
Algae in water column (%)	1-9	1-9	10-49	1-9	10-49	0
Algae on substrate (%)	1-9	0	0	0	0	0
Sediment plume	Moderate	Small	Large	Moderate	Large	Small
Sediment oils	Absent	Absent	Absent	Absent	Absent	Absent
Sediment odours	Normal	None	Anaerobic	Anaerobic	Anaerobic	Normal
VEGETATION ASSESSMENT						
Riparian Vegetation Riparian zone present	Yes	Yes	Yes	Yes	Yes	Yes
Ground layer	Yes	Reduced	Yes	Reduced	Yes	No
Shrub layer	Yes	None	Yes	Reduced	Yes	No
Tree layer	Yes	Yes	Yes	Reduced	Yes	Yes
Riparian width (m)	10 (LB & RB)	10 (LB & RB)	2 (LB),3 (RB)	10 (LB & RB)	20 (LB & RB)	0.5 (LB & RB)
Streamside Vege All						
Bare ground (%)	0 (LB & RB)	50-74 (LB), 75-100 (RB)	10-49 (LB & RB)	10-49 (LB & RB)	10-49 (LB & RB)	50-74 (LB & RB
Ground cover (%)	50-74 (LB & RB)	10-49 (LB, 0 RB)	10-49 (LB & RB)	50-74 (LB & RB)	10-49 (LB & RB)	0 (LB & RB))
Shrubs (%)	10-49 (LB & RB)	0 (LB & RB)	1-9 (LB & RB)	10-49 (LB & RB)	10-49 (LB & RB)	10-49 (LB & RB)

Trees <10m (%)	1-9 (LB & RB)	10-49 (LB & RB)	10-49 (LB & RB)	1-9 (LB & RB)	1-9 (LB & RB)	10-49 (LB & RB
Trees >10m (%)	0 (LB & RB)	1-9 (LB & RB)	1-9 (LB & RB)	1-9 (LB & RB)	0 (LB & RB)	10-49 (LB & RB)
Streamside Vege Exotic						
Ground cover (%)	50-74 (LB & RB)	10-49 (LB & RB)	10-49 (LB & RB)	50-74 (LB & RB)	50-74 (LB & RB)	50-74 (LB & RB)
Shrubs (%)	None	None	None	None	None	None
Trees <10m (%)	None	10-49 (LB & RB)	None	None	None	10-49 (LB & RB)
Trees >10m (%)	None	1-9 (LB & RB)	None	None	None	10-49 (LB & RB)
Exotic species	Couch grass	Couch grass	Veldt grass	Couch grass	N/A	N/A
Streamside Vege Native.						
Recruitment evidence	Natural	None	Natural	None	None	None
Recruitment type	Trees & Shrubs	N/A	Trees	N/A	N/A	N/A
Extent of recruitment	N/A	N/A	Limited	N/A	N/A	N/A
Recruitment Health	N/A	N/A	Poor	N/A	N/A	N/A
Organic Litter						
Total organic litter (% cover)	None	10-49	10-49	1-9	1-9	50-74
Native (% cover)	None	50-74	75-100	75-100	75-100	75-100
PHYSICAL FORM						
Banks & Physical Form						
Erosion (%)	0-4 (LB & RB)	5-19 (LB & RB)	0-4 (LB & RB)	0-4 (LB & RB)	0-4 (LB & RB)	0-4 (LB & RB)
Erosion Severity	Minor (LB & RB)	Low-Mod (LB & RB)	Minor (LB & RB)	Minor (LB & RB)	Minor (LB & RB)	Minor (LB & RB)
Bank Stability Factors	None (LB & RB)	Livestock access, cleared vegetation flow and waves (LB & RB)	Feral Animals (LB & RB)	Livestock Access (LB & RB)	N/A	Livestock Access (LB & RB)
Stabilisation Works	None	None	None	None	N/A	None
Livestock Impact Vege	None	None	None	None	N/A	None
Livestock Impact Bank	None	None	None	None	N/A	None
Livestock Pugging	None	None	None	None	N/A	Yes
Livestock Manure	None	None	None	None	N/A	None
LlivestockTracks	None	yes	None	yes	N/A	Yes
FORESHORE CONDITION						
Bank and Channel Shape						
Bank Shape	Stepped	Concave	Convex	Concave	Concave	Concave
Slope	Steep (60-80%) to Moderate (30-60%)	Vertical (80-90%) to Moderate (30-60%)	N/A	N/A	N/A	Low (10-30%)
Channel Shape	Stepped	Stepped	N/A	N/A	N/A	Flat

APPENDIX 3. ANZG DEFAULT GUIDELINE VALUES (DGV) 2018 FOR THE PROTECTION OF AQUATIC SYSTEMS IN SOUTH WEST WESTERN AUSTRALIA

Table A3-1. DGV for some physical and chemical stressors for south west Western Australia for slightly disturbed ecosystems (TP = total phosphorus; FRP = filterable reactive phosphorus; TN = total nitrogen; NOx = total nitrates/nitrites; NH_3 = NH_{4+} = ammonium ion) (ANZG 2018).

	TP (mg/L)	FRP (mg/L)	TN (mg/L)	NOx (mg/L)	NH_3 (mg/L)	NH_4^+ (mg/L)	DO % saturation[2]	pH
Aquatic Ecosystem								
Upland River[1]	0.02	0.01	0.45	0.2	0.95	0.06	90	6.5 – 8.0
Lowland River[1]	0.065	0.04	1.2	0.15	0.95	0.08	80 - 120	6.6 – 8.0
Lakes and Reservoirs	0.01	0.005	0.353	0.01	0.95	0.01	90	6.5 – 8.0
Wetlands[3]	0.06	0.03	1.5	0.1	0.95	0.04	90 - 120	7.0 – 8.5[4]

[1] All values during base river flow not storm events;

[2] Derived from daytime measurements; may vary diurnally and with depth; data loggers required to assess variability;

[3] Elevated nutrients in highly coloured wetlands do not appear to stimulate algal growth;

[4] In highly coloured wetlands, pH typically ranges 4.6 – 6.5;

Table A3-2. DGV for salinity and turbidity for the protection of aquatic ecosystems, applicable to south west Western Australia (ANZG 2018).

Aquatic Ecosystem		*Comments*
Salinity	***(µs/cm)***	
Aquatic Ecosystem		
Upland & lowland rivers	120-300	Values will vary depending on geology. First flush after seasonal rain may result in temporarily high values
Lakes, reservoirs & wetlands	300-1500	Higher conductivities will occur during summer when water levels are reduced due to evaporation
Turbidity	***(NTU)***	
Aquatic Ecosystem		
Upland & lowland rivers	10-20	
Lakes, reservoirs & wetlands	10-100	Shallow lakes may have higher turbidity naturally due to wind-induced re-suspension of sediments. Lakes and reservoirs in catchments with highly dispersible soils will have high turbidity. Wetlands vary greatly in turbidity depending on the general condition of the catchment, recent flow events and the water level in the wetland.

APPENDIX 4. MACROINVERTEBRATES

Table A4-1. Macroinvertebrate taxa recorded from each site and habitat (CH = channel, MAC = macrophyte).

			Boraning		HRNR			Pumphreys Bridge				Popanynning			Quindanning		Ranford Pool	
Phylum/Class/Order	**Family**	**Lowest taxon**	**CH 19**	**CH 20**	**CH 19**	**MAC 19**	**CH 20**	**CH 19**	**MAC 19**	**CH 20**	**MAC 20**	**CH19**	**MAC 19**	**CH 20**	**CH 19**	**CH 20**	**CH 19**	**CH 20**
MOLLUSCA																		
Bivalvia																		
Cardiida	**Trapezidae**	*Fluviolanatus subtortus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Gastropoda																		
Hypsogastropoda	**Tateidae**	Tateidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
ANNELIDA																		
Oligochaeta		Oligochaeta spp.	2	0	0	0	0	3	0	0	0	2	0	0	0	2	0	3
ARTHROPODA																		
Arachnida		Acarina spp.	0	0	0	0	0	0	3	0	1	0	0	0	1	0	0	0
Malacostraca																		
Amphipoda	**Chiltoniidae**	*Austrochiltonia subtenuis*	4	2	4	4	0	4	4	1	1	4	4	0	4	0	4	2
Decapoda	**Palaemonidae**	*Palaemonetes australis*	0	3	0	0	0	0	0	2	2	0	0	0	1	3	1	2
Insecta																		
Coleoptera	**Carabidae**	Carabidae sp.	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	Dytiscidae	*Hyphydrus decemmaculatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		Lancetes lanceolatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		Megaporus howitti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		Necterosoma darwini	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		Necterosoma penicillatum	0	0	2	2	3	1	2	0	3	2	0	4	1	0	0	2
		Necterosoma spp. (L)	0	0	4	3	0	2	4	0	0	3	4	0	0	0	0	0
		Rhantus suturalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	Gyrinidae	*Aulonogyrus strigosus*	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
		Macrogyrus angustatus	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
		Macrogyrus spp. (L)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	Hydraenidae	*Ochthebius* spp.	2	1	2	1	0	0	1	0	0	0	0	0	0	2	0	0
	Hydrophilidae	*Berosus dallasae*	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0
		Berosus macumbensis	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		Berosus spp. (L)	0	0	3	2	0	1	0	2	2	0	0	0	0	0	0	0
		Coelostoma fabricii	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Enochrus sp. (L)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		Helochares percyi	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0
		Helochares spp. (L)	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	2
		Limnoxenus zealandicus	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		Limnoxenus zealandicus (L)	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Diptera	**Ceratopogonidae**	Ceratopogonidae sp. (P)	0	2	0	0	0	0	0	0	0	0	3	2	0	0	0	0
		Ceratopogoninae sp.	0	3	3	0	0	0	3	2	1	2	0	0	0	2	0	2
		Dasyheleinae sp.	0	0	0	0	2	0	0	0	0	0	0	1	0	2	0	2
	Chironomidae	Chironomidae sp. (P)	0	3	3	0	0	0	3	2	1	0	0	0	1	0	0	0
	Chironominae	Chironominae spp. (imm/dam)	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
	Chironomini	*Chironomus* aff. *alternans*	0	3	0	0	0	0	0	0	0	0	0	0	4	0	4	3
		Cladopelma curtivalva	0	0	2	2	2	3	0	3	2	0	0	0	0	0	0	0
		Dicrotendipes ?conjunctus	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
		Dicrotendipes sp. (V47)	0	0	0	0	0	4	4	0	0	0	0	0	3	0	3	0
		Kiefferulus intertinctus	0	0	0	0	0	0	0	0	0	0	0	0	0	3	4	0
	Tanytarsini	*Paratanytarsus* sp.	0	0	0	0	0	3	4	0	4	2	0	0	0	0	0	0
		Tanytarsus sp. (V6)	1	4	3	3	2	3	4	4	0	0	3	3	3	3	3	3
	Orthocladinae	*Thienemanniella* sp. (V19)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	Tanypodinae	*Larsia ?albiceps*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
		Paramerina ?levidensis	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Procladius paludicola	2	3	4	0	0	4	4	2	2	4	4	0	4	0	3	3
	Culicidae	Culicidae sp. (P)	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Empididae	Empididae sp.	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	Ephydridae	Ephydridae sp.	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0
	Muscidae	Muscidae sp.	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Simuliidae	Simuliidae sp.	2	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0
	Stratiomyidae	Stratiomyidae sp.	0	0	3	0	0	2	3	0	0	3	4	3	0	0	0	0
	Tabanidae	Tabanidae sp.	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Hemiptera	**Micronectidae**	*Micronecta annae*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
		Micronecta sp. (F)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Lepidoptera	**Crambidae**	*Elophila* sp.	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Parapoynx sp.	0	0	0	0	0	2	3	2	3	0	0	0	0	0	0	0
Odonata																		
Anisoptera		Anisoptera spp. (imm/dam)	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Corduliidae	*Procordulia affinis*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	Gomphidae	*Austrogomphus collaris*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Libellulidae	*Orthetrum caledonicum*	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		Diplacodes haematodes	2	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Zygoptera		Zygoptera spp. (imm/dam)	2	2	0	2	0	0	3	0	3	1	0	0	0	1	0	1
	Coenagrionidae	Coenagrionidae sp.	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
		Ischnura aurora	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lestidae	*Austrolestes annulosus*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	**Leptoceridae**	Leptoceridae sp.	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
		Notalina spira	3	3	0	0	1	0	0	0	0	0	0	0	1	1	3	2
		Oecetis sp.	2	2	0	0	0	2	0	0	2	0	0	0	2	1	0	3
		Symphitoneuria wheeleri	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Taxa richness	**13**	**24**	**12**	**9**	**7**	**14**	**20**	**9**	**15**	**14**	**6**	**6**	**17**	**12**	**10**	**23**

APPENDIX 5. FISH & CRAYFISH DATA

Table A5-1. Fish and crayfish catch data for October 2019

Site	Species	Common Name	# Observed	SL/CL (mm)	Sex	Gear
Boraning Reserve	*Bostockia porosa*	Nightfish	1	10		DS Fyke
Boraning Reserve	*Bostockia porosa*	Nightfish	1	59		DS Fyke
Boraning Reserve	*Bostockia porosa*	Nightfish	2	73		DS Fyke
Boraning Reserve	*Bostockia porosa*	Nightfish	2	83		DS Fyke
Boraning Reserve	*Bostockia porosa*	Nightfish	3	68		DS Fyke
Boraning Reserve	*Cherax quinquecarinatus*	Gilgie	1	15	J	US Fyke
Boraning Reserve	*Cherax quinquecarinatus*	Gilgie	1	17	J	DS Fyke
Boraning Reserve	*Cherax quinquecarinatus*	Gilgie	1	18	J	DS Fyke
Boraning Reserve	*Cherax quinquecarinatus*	Gilgie	1	22	M	DS Fyke
Boraning Reserve	*Cherax quinquecarinatus*	Gilgie	2	34	M	DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	1	26		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	1	52		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	1	89		US Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	2	38		US Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	2	63		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	2	68		US Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	2	84		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	3	38		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	3	57		US Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	3	58		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	3	88		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	4	29		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	4	60		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	4	75		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	4	78		US Fyke

Site	Species	Common Name	# Observed	SL/CL (mm)	Sex	Gear
Boraning Reserve	*Galaxias occidentalis*	Western minnow	4	92		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	5	39		US Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	5	72		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	5	91		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	6	62		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	10	64		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	13	65		US Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	21	35		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	28	34		DS Fyke
Boraning Reserve	*Gambusia holbrooki*	Mosquitofish	3	35		DS Fyke
Boraning Reserve	*Gambusia holbrooki*	Mosquitofish	5	25		US Fyke
Boraning Reserve	*Gambusia holbrooki*	Mosquitofish	20	34		DS Fyke
Boraning Reserve	*Gambusia holbrooki*	Mosquitofish	22	38		DS Fyke
Boraning Reserve	*Gambusia holbrooki*	Mosquitofish	58	24		DS Fyke
Boraning Reserve	*Nannoperca vittata*	Western pygmy perch	1	48		US Fyke
Boraning Reserve	*Nannoperca vittata*	Western pygmy perch	1	53		DS Fyke
Boraning Reserve	*Pseudogobius olorum*	Swan River Goby	1	42		DS Fyke
Boraning Reserve	*Pseudogobius olorum*	Swan River Goby	1	55		DS Fyke
Boraning Reserve	*Pseudogobius olorum*	Swan River Goby	1	58		US Fyke
Boraning Reserve	*Pseudogobius olorum*	Swan River Goby	2	48		DS Fyke
Hotham River Nature Reserve	*Galaxias occidentalis*	Western minnow	1	48		DS Fyke
Hotham River Nature Reserve	*Galaxias occidentalis*	Western minnow	1	79		DS Fyke
Hotham River Nature Reserve	*Galaxias occidentalis*	Western minnow	1	87		US Fyke
Hotham River Nature Reserve	*Galaxias occidentalis*	Western minnow	2	35		US Fyke
Hotham River Nature Reserve	*Galaxias occidentalis*	Western minnow	3	58		US Fyke
Hotham River Nature Reserve	*Galaxias occidentalis*	Western minnow	4	45		US Fyke
Hotham River Nature Reserve	*Galaxias occidentalis*	Western minnow	5	35		DS Fyke

Site	Species	Common Name	# Observed	SL/CL (mm)	Sex	Gear
Hotham River Nature Reserve	*Galaxias occidentalis*	Western minnow	5	55		US Fyke
Hotham River Nature Reserve	*Galaxias occidentalis*	Western minnow	6	36		DS Fyke
Hotham River Nature Reserve	*Galaxias occidentalis*	Western minnow	10	34		US Fyke
Hotham River Nature Reserve	*Galaxias occidentalis*	Western minnow	12	40		DS Fyke
Hotham River Nature Reserve	*Galaxias occidentalis*	Western minnow	16	60		DS Fyke
Hotham River Nature Reserve	*Galaxias occidentalis*	Western minnow	18	40		US Fyke
Hotham River Nature Reserve	*Galaxias occidentalis*	Western minnow	19	55		DS Fyke
Hotham River Nature Reserve	*Galaxias occidentalis*	Western minnow	21	41		DS Fyke
Hotham River Nature Reserve	*Galaxias occidentalis*	Western minnow	21	49		DS Fyke
Hotham River Nature Reserve	*Galaxias occidentalis*	Western minnow	22	38		DS Fyke
Hotham River Nature Reserve	*Galaxias occidentalis*	Western minnow	25	45		DS Fyke
Hotham River Nature Reserve	*Galaxias occidentalis*	Western minnow	36	50		DS Fyke
Hotham River Nature Reserve	*Gambusia holbrooki*	Mosquitofish	1	15		US Fyke
Hotham River Nature Reserve	*Gambusia holbrooki*	Mosquitofish	1	20		US Fyke
Hotham River Nature Reserve	*Gambusia holbrooki*	Mosquitofish	1	40		DS Fyke
Hotham River Nature Reserve	*Gambusia holbrooki*	Mosquitofish	1	45		US Fyke
Hotham River Nature Reserve	*Gambusia holbrooki*	Mosquitofish	2	28		US Fyke
Hotham River Nature Reserve	*Gambusia holbrooki*	Mosquitofish	2	30		DS Fyke
Hotham River Nature Reserve	*Gambusia holbrooki*	Mosquitofish	2	40		US Fyke
Hotham River Nature Reserve	*Gambusia holbrooki*	Mosquitofish	11	25		US Fyke
Hotham River Nature Reserve	*Pseudogobius olorum*	Swan River Goby	1	34		DS Fyke
Popanyinning	*Galaxias occidentalis*	Western minnow	1	37		US Fyke
Popanyinning	*Galaxias occidentalis*	Western minnow	1	44		DS Fyke
Popanyinning	*Galaxias occidentalis*	Western minnow	1	45		DS Fyke
Popanyinning	*Galaxias occidentalis*	Western minnow	1	45		US Fyke
Popanyinning	*Galaxias occidentalis*	Western minnow	1	48		DS Fyke
Popanyinning	*Galaxias occidentalis*	Western minnow	1	48		US Fyke

Site	Species	Common Name	# Observed	SL/CL (mm)	Sex	Gear
Popanyinning	*Galaxias occidentalis*	Western minnow	1	51		US Fyke
Popanyinning	*Galaxias occidentalis*	Western minnow	1	61		DS Fyke
Popanyinning	*Galaxias occidentalis*	Western minnow	3	43		DS Fyke
Popanyinning	*Galaxias occidentalis*	Western minnow	5	37		DS Fyke
Popanyinning	*Galaxias occidentalis*	Western minnow	6	51		DS Fyke
Popanyinning	*Galaxias occidentalis*	Western minnow	7	43		US Fyke
Popanyinning	*Galaxias occidentalis*	Western minnow	7	50		DS Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	1	19		US Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	6	38		DS Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	7	42		DS Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	12	26		US Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	15	24		DS Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	17	24		US Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	31	27		DS Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	61	35		DS Fyke
Pumphreys Bridge	*Afurcagobius suppositus*	South Western Goby	1	50		DS Fyke
Pumphreys Bridge	*Chelodina colliei*	South western snake necked turtle	1		F	US Fyke
Pumphreys Bridge	*Chelodina colliei*	South western snake necked turtle	2		F	DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	1	105		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	1	115		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	1	115		US Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	1	125		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	1	135		US Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	1	150		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	2	65		US Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	4	58		US Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	4	85		DS Fyke

Site	Species	Common Name	# Observed	SL/CL (mm)	Sex	Gear
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	4	120		US Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	5	55		US Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	7	75		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	8	100		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	10	40		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	10	42		US Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	10	125		US Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	16	90		US Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	18	90		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	31	45		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	36	35		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	55	55		DS Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	10	25		US Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	10	30		DS Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	15	22		DS Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	15	38		DS Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	20	35		DS Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	20	45		DS Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	30	25		DS Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	50	40		DS Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	1	28		DS Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	1	32		US Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	1	40		DS Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	1	47		US Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	1	50		US Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	1	52		US Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	2	48		US Fyke

Site	Species	Common Name	# Observed	SL/CL (mm)	Sex	Gear
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	2	50		DS Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	3	20		DS Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	3	35		US Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	4	42		US Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	6	40		US Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	11	45		US Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	13	35		DS Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	41	45		DS Fyke
Quindanning	*Bostockia porosa*	Nightfish	1	62		US Fyke
Quindanning	*Bostockia porosa*	Nightfish	1	85		US Fyke
Quindanning	*Bostockia porosa*	Nightfish	2	65		US Fyke
Quindanning	*Bostockia porosa*	Nightfish	3	80		US Fyke
Quindanning	*Bostockia porosa*	Nightfish	3	92		US Fyke
Quindanning	*Bostockia porosa*	Nightfish	4	75		US Fyke
Quindanning	*Bostockia porosa*	Nightfish	4	90		US Fyke
Quindanning	*Chelodina colliei*	South western snake necked turtle	7			DS Fyke
Quindanning	*Cherax quinquecarinatus*	Gilgie	4	10	J	US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	1	36		DS Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	1	37		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	1	38		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	1	40		DS Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	1	45		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	1	57		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	1	70		DS Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	1	74		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	1	76		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	1	90		US Fyke

Site	Species	Common Name	# Observed	SL/CL (mm)	Sex	Gear
Quindanning	*Galaxias occidentalis*	Western minnow	1	108		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	2	55		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	2	60		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	2	83		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	2	93		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	3	40		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	3	72		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	3	85		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	4	95		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	5	30		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	7	35		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	7	80		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	9	82		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	10	75		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	17	70		US Fyke
Quindanning	*Gambusia holbrooki*	Mosquitofish	1	45		US Fyke
Quindanning	*Gambusia holbrooki*	Mosquitofish	2	20		US Fyke
Quindanning	*Gambusia holbrooki*	Mosquitofish	4	35		US Fyke
Quindanning	*Gambusia holbrooki*	Mosquitofish	17	30		US Fyke
Quindanning	*Pseudogobius olorum*	Swan River Goby	2	50		US Fyke
Quindanning	*Pseudogobius olorum*	Swan River Goby	4	45		US Fyke
Quindanning	*Pseudogobius olorum*	Swan River Goby	10	30		US Fyke
Ranford Pool	*Bostockia porosa*	Nightfish	1	75		US Fyke
Ranford Pool	*Chelodina colliei*	South western snake necked turtle	1		M	DS Fyke
Ranford Pool	*Chelodina colliei*	South western snake necked turtle	2		F	DS Fyke
Ranford Pool	*Chelodina colliei*	South western snake necked turtle	4		F	DS Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	1	42		DS Fyke

Site	Species	Common Name	# Observed	SL/CL (mm)	Sex	Gear
Ranford Pool	*Galaxias occidentalis*	Western minnow	1	70		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	1	85		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	1	90		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	1	95		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	1	100		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	2	45		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	2	55		DS Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	3	38		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	5	60		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	6	35		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	7	32		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	7	50		DS Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	7	50		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	8	45		DS Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	8	48		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	10	37		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	27	40		DS Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	31	30		DS Fyke
Ranford Pool	*Gambusia holbrooki*	Mosquitofish	1	40		US Fyke
Ranford Pool	*Gambusia holbrooki*	Mosquitofish	3	25		US Fyke
Ranford Pool	*Nannoperca vittata*	Western pygmy perch	1	40		US Fyke
Ranford Pool	*Nannoperca vittata*	Western pygmy perch	1	51		US Fyke
Ranford Pool	*Nannoperca vittata*	Western pygmy perch	1	55		US Fyke
Ranford Pool	*Pseudogobius olorum*	Swan River Goby	1	30		US Fyke
Ranford Pool	*Pseudogobius olorum*	Swan River Goby	1	42		US Fyke

Table A5-2. Fish and crayfish catch data for March 2020

Site	Species	Common Name	# Observed	SL/CL (mm)	Sex	Gear
Boraning Reserve	*Bostockia porosa*	Nightfish	1	35		DS Fyke
Boraning Reserve	*Bostockia porosa*	Nightfish	2	48		DS Fyke
Boraning Reserve	*Cherax quinquecarinatus*	Gilgie	1	15	J	DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	1	43		Box Trap
Boraning Reserve	*Galaxias occidentalis*	Western minnow	1	43		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	1	52		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	1	61		US Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	1	65		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	1	72		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	2	38		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	2	45		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	2	45		US Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	2	60		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	3	40		US Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	3	42		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	9	42		US Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	11	55		DS Fyke
Boraning Reserve	*Galaxias occidentalis*	Western minnow	19	48		DS Fyke
Boraning Reserve	*Gambusia holbrooki*	Mosquitofish	1	26		Box Trap
Boraning Reserve	*Gambusia holbrooki*	Mosquitofish	2	30		US Fyke
Boraning Reserve	*Gambusia holbrooki*	Mosquitofish	12	21		Box Trap
Boraning Reserve	*Gambusia holbrooki*	Mosquitofish	12	24		DS Fyke
Boraning Reserve	*Gambusia holbrooki*	Mosquitofish	38	25		DS Fyke

Site	Species	Common Name	# Observed	SL/CL (mm)	Sex	Gear
Boraning Reserve	*Pseudogobius olorum*	Swan River Goby	1	55		DS Fyke
Boraning Reserve	*Palaemonetes australis*	Glass shrimp	10			Box Trap
Boraning Reserve	*Palaemonetes australis*	Glass shrimp	>100			DS Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	1	20		Box Trap
Popanyinning	*Gambusia holbrooki*	Mosquitofish	1	25		Box Trap
Popanyinning	*Gambusia holbrooki*	Mosquitofish	5	28		Box Trap
Popanyinning	*Gambusia holbrooki*	Mosquitofish	8	18		US Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	11	38		US Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	12	36		US Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	15	31		DS Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	32	32		US Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	45	23		DS Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	45	33		DS Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	50	15		DS Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	50	28		US Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	65	20		DS Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	70	22		US Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	75	21		US Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	81	34		DS Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	120	22		DS Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	150	31		US Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	200	23		US Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	200	30		US Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	245	30		DS Fyke
Popanyinning	*Gambusia holbrooki*	Mosquitofish	250	36		DS Fyke

Site	Species	Common Name	# Observed	SL/CL (mm)	Sex	Gear
Popanyinning	*Gambusia holbrooki*	Mosquitofish	500	28		DS Fyke
Pumphreys Bridge	*Afurcagobius suppositus*	South Western Goby	1	41		DS Fyke
Pumphreys Bridge	*Chelodina colliei*	South western snake necked turtle	1	250		US Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	1	34		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	1	36		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	1	42		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	1	47		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	1	52		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	1	53		US Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	1	68		US Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	1	75		US Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	1	79		US Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	1	81		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	1	85		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	1	86		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	2	30		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	2	41		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	2	43		US Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	2	54		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	2	61		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	3	49		DS Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	3	62		US Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	4	40		US Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	5	71		US Fyke
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	7	45		US Fyke

Site	Species	Common Name	# Observed	SL/CL (mm)	Sex	Gear
Pumphreys Bridge	*Galaxias occidentalis*	Western minnow	9	48		DS Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	1	9		Box Trap
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	1	16		US Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	1	36		US Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	1	47		Box Trap
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	2	46		DS Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	3	13		Box Trap
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	3	45		US Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	4	17		Box Trap
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	5	31		DS Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	8	21		US Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	10	21		Box Trap
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	10	31		Box Trap
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	12	30		DS Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	13	28		Box Trap
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	15	32		Box Trap
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	20	25		US Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	20	30		US Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	23	24		DS Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	30	19		Box Trap
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	30	19		DS Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	30	23		Box Trap
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	30	32		DS Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	30	32		US Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	33	21		DS Fyke

Site	Species	Common Name	# Observed	SL/CL (mm)	Sex	Gear
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	46	19		US Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	80	24		US Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	90	28		US Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	115	31		US Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	130	38		US Fyke
Pumphreys Bridge	*Gambusia holbrooki*	Mosquitofish	172	29		DS Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	1	22		US Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	1	27		US Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	1	28		US Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	1	30		DS Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	1	31		DS Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	1	36		US Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	1	38		DS Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	1	38		US Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	1	39		DS Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	1	40		DS Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	1	40		US Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	1	46		US Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	1	48		DS Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	1	54		US Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	2	24		DS Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	2	29		US Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	2	42		DS Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	2	45		US Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	2	48		Box Trap

Site	Species	Common Name	# Observed	SL/CL (mm)	Sex	Gear
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	3	23		US Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	3	28		DS Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	3	30		US Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	3	32		DS Fyke
Pumphreys Bridge	*Pseudogobius olorum*	Swan River Goby	3	42		US Fyke
Pumphreys Bridge	*Palaemonetes australis*	Glass shrimp	5			Box Trap
Pumphreys Bridge	*Palaemonetes australis*	Glass shrimp	>101			DS Fyke
Pumphreys Bridge	*Palaemonetes australis*	Glass shrimp	>11			US Fyke
Quindanning	*Chelodina colliei*	South western snake necked turtle	1	165	F	US Fyke
Quindanning	*Chelodina colliei*	South western snake necked turtle	1	185	M	US Fyke
Quindanning	*Chelodina colliei*	South western snake necked turtle	1	210	F	US Fyke
Quindanning	*Chelodina colliei*	South western snake necked turtle	1	222	M	DS Fyke
Quindanning	*Chelodina colliei*	South western snake necked turtle	1	240	M	DS Fyke
Quindanning	*Chelodina colliei*	South western snake necked turtle	1	245	M	DS Fyke
Quindanning	*Chelodina colliei*	South western snake necked turtle	1	260	M	US Fyke
Quindanning	*Chelodina colliei*	South western snake necked turtle	1	265	F	DS Fyke
Quindanning	*Chelodina colliei*	South western snake necked turtle	1	270	M	DS Fyke
Quindanning	*Chelodina colliei*	South western snake necked turtle	1	280	F	DS Fyke
Quindanning	*Chelodina colliei*	South western snake necked turtle	1	290	F	DS Fyke
Quindanning	*Chelodina colliei*	South western snake necked turtle	1	300	F	DS Fyke
Quindanning	*Chelodina colliei*	South western snake necked turtle	1	305	F	DS Fyke
Quindanning	*Chelodina colliei*	South western snake necked turtle	1	310	F	DS Fyke
Quindanning	*Chelodina colliei*	South western snake necked turtle	2	240	F	DS Fyke
Quindanning	*Chelodina colliei*	South western snake necked turtle	3	230	M	DS Fyke
Quindanning	*Chelodina colliei*	South western snake necked turtle	3	250	F	DS Fyke

Site	Species	Common Name	# Observed	SL/CL (mm)	Sex	Gear
Quindanning	*Chelodina colliei*	South western snake necked turtle	6	250	M	DS Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	1	32		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	1	33		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	1	36		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	1	42		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	1	85		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	6	45		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	6	65		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	8	60		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	10	90		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	11	68		US Fyke
Quindanning	*Galaxias occidentalis*	Western minnow	12	95		US Fyke
Quindanning	*Gambusia holbrooki*	Mosquitofish	8	25		Box trap
Quindanning	*Gambusia holbrooki*	Mosquitofish	30	25		DS Fyke
Quindanning	*Gambusia holbrooki*	Mosquitofish	50	35		US Fyke
Quindanning	*Gambusia holbrooki*	Mosquitofish	200	22		US Fyke
Quindanning	*Gambusia holbrooki*	Mosquitofish	200	30		US Fyke
Quindanning	*Gambusia holbrooki*	Mosquitofish	400	28		US Fyke
Quindanning	*Pseudogobius olorum*	Swan River Goby	1	32		US Fyke
Quindanning	*Pseudogobius olorum*	Swan River Goby	1	45		US Fyke
Quindanning	*Pseudogobius olorum*	Swan River Goby	2	34		US Fyke
Quindanning	*Pseudogobius olorum*	Swan River Goby	4	28		US Fyke
Quindanning	*Pseudogobius olorum*	Swan River Goby	4	35		US Fyke
Quindanning	*Pseudogobius olorum*	Swan River Goby	6	37		US Fyke
Quindanning	*Pseudogobius olorum*	Swan River Goby	7	48		US Fyke

Site	Species	Common Name	# Observed	SL/CL (mm)	Sex	Gear
Quindanning	*Pseudogobius olorum*	Swan River Goby	10	41		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	1	31		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	1	38		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	1	42		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	1	44		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	1	47		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	1	49		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	1	55		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	2	40		US Fyke
Ranford Pool	*Galaxias occidentalis*	Western minnow	2	50		US Fyke
Ranford Pool	*Gambusia holbrooki*	Mosquitofish	1	11		Box Trap
Ranford Pool	*Gambusia holbrooki*	Mosquitofish	1	26		Box Trap
Ranford Pool	*Gambusia holbrooki*	Mosquitofish	2	25		Box Trap
Ranford Pool	*Gambusia holbrooki*	Mosquitofish	2	35		DS Fyke
Ranford Pool	*Gambusia holbrooki*	Mosquitofish	3	40		Box Trap
Ranford Pool	*Gambusia holbrooki*	Mosquitofish	4	24		Box Trap
Ranford Pool	*Gambusia holbrooki*	Mosquitofish	5	32		US Fyke
Ranford Pool	*Gambusia holbrooki*	Mosquitofish	10	27		Box Trap
Ranford Pool	*Gambusia holbrooki*	Mosquitofish	10	36		DS Fyke
Ranford Pool	*Gambusia holbrooki*	Mosquitofish	13	19		Box Trap
Ranford Pool	*Gambusia holbrooki*	Mosquitofish	30	21		Box Trap
Ranford Pool	*Gambusia holbrooki*	Mosquitofish	30	31		Box Trap
Ranford Pool	*Gambusia holbrooki*	Mosquitofish	32	25		US Fyke
Ranford Pool	*Gambusia holbrooki*	Mosquitofish	46	27		US Fyke
Ranford Pool	*Gambusia holbrooki*	Mosquitofish	120	25		DS Fyke

Site	Species	Common Name	# Observed	SL/CL (mm)	Sex	Gear
Ranford Pool	*Gambusia holbrooki*	Mosquitofish	150	30		DS Fyke
Ranford Pool	*Pseudogobius olorum*	Swan River Goby	1	17		DS Fyke
Ranford Pool	*Pseudogobius olorum*	Swan River Goby	1	24		DS Fyke
Ranford Pool	*Pseudogobius olorum*	Swan River Goby	1	24		US Fyke
Ranford Pool	*Pseudogobius olorum*	Swan River Goby	1	26		DS Fyke
Ranford Pool	*Pseudogobius olorum*	Swan River Goby	1	29		US Fyke
Ranford Pool	*Pseudogobius olorum*	Swan River Goby	1	32		US Fyke
Ranford Pool	*Pseudogobius olorum*	Swan River Goby	1	34		US Fyke
Ranford Pool	*Pseudogobius olorum*	Swan River Goby	1	35		DS Fyke
Ranford Pool	*Pseudogobius olorum*	Swan River Goby	1	35		US Fyke
Ranford Pool	*Pseudogobius olorum*	Swan River Goby	1	37		Box Trap
Ranford Pool	*Pseudogobius olorum*	Swan River Goby	1	39		US Fyke
Ranford Pool	*Pseudogobius olorum*	Swan River Goby	1	46		US Fyke
Ranford Pool	*Pseudogobius olorum*	Swan River Goby	3	34		DS Fyke