



# INDOPACIFIC

*Environmental*

## FORTESCUE RIVER AQUATIC FAUNA SURVEY 2021-2022



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## EXECUTIVE SUMMARY

Indo Pacific Environmental was commissioned by BHP Western Australia Iron Ore (BHP) to conduct a two-season field assessment of the aquatic fauna and habitats in a 140 km section of the upper Fortescue River catchment. Seventeen and eighteen sites were surveyed using a variety of methods in the dry season (October) 2021 and wet season (May) 2022, respectively. Various water quality parameters were recorded as part of the assessment. Numerous values of parameters including electrical conductivity (EC), dissolved oxygen (%), pH, total nitrogen (TN), total phosphorus (TP) and NO<sup>x</sup> were found to be in exceedance of ANZG (2018) guidelines values at a majority of sites surveyed in both seasons. However, these results are consistent with the results of previous surveys in the study area and common throughout the Pilbara, with water quality parameters being associated with catchment geology, time of sampling and land use (primarily livestock access to waterbodies). In stream habitat characterisation found the majority of sites in 2021 and 2022 attained a moderate rating, with some sites scoring a poor rating due to heavy impact from pastoral disturbances including clearing and cattle grazing.

Ninety-nine microinvertebrate taxa, 40 hyporheic taxa, 34 sediment rehydration taxa and 221 macroinvertebrate taxa were recorded during the current study, with a majority being considered widespread and common throughout Northern Australia, Australia and Australasia. Regarding significant invertebrate fauna, a limited number of taxa recorded were considered Western Australian endemic or Pilbara endemic species although all were considered widespread within their respective regions. Furthermore, none of these species are afforded protection under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or *Western Australian Biodiversity Conservation Act 2016* (BC Act).

Three native fish species were recorded throughout the study area in both seasons including *Neosilurus hyrtlii*, *Leiopotherapon unicolor* and *Melanotaenia australis*. These species commonly occur throughout the Pilbara and are typical species found within the Fortescue River catchment (Morgan *et al.* 2014; Morgan and Gill 2004). The native turtle *Chelodina steindachneri* was also recorded from a number of sites throughout the study area. In relation to the vertebrate aquatic fauna encountered, none are listed under the EPBC and BC Acts. Two introduced species (*C. quadricarinatus* and *P. latipinna*) were recorded at multiple sites during both dry and wet seasonal surveys. Both species have been previously recorded throughout the study area during previous surveys, suggesting that these species have established sustainable populations. Localised impacts of these invasive species are difficult to determine, however there has been no discernible change in native taxa encountered to date.

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# 1 INTRODUCTION

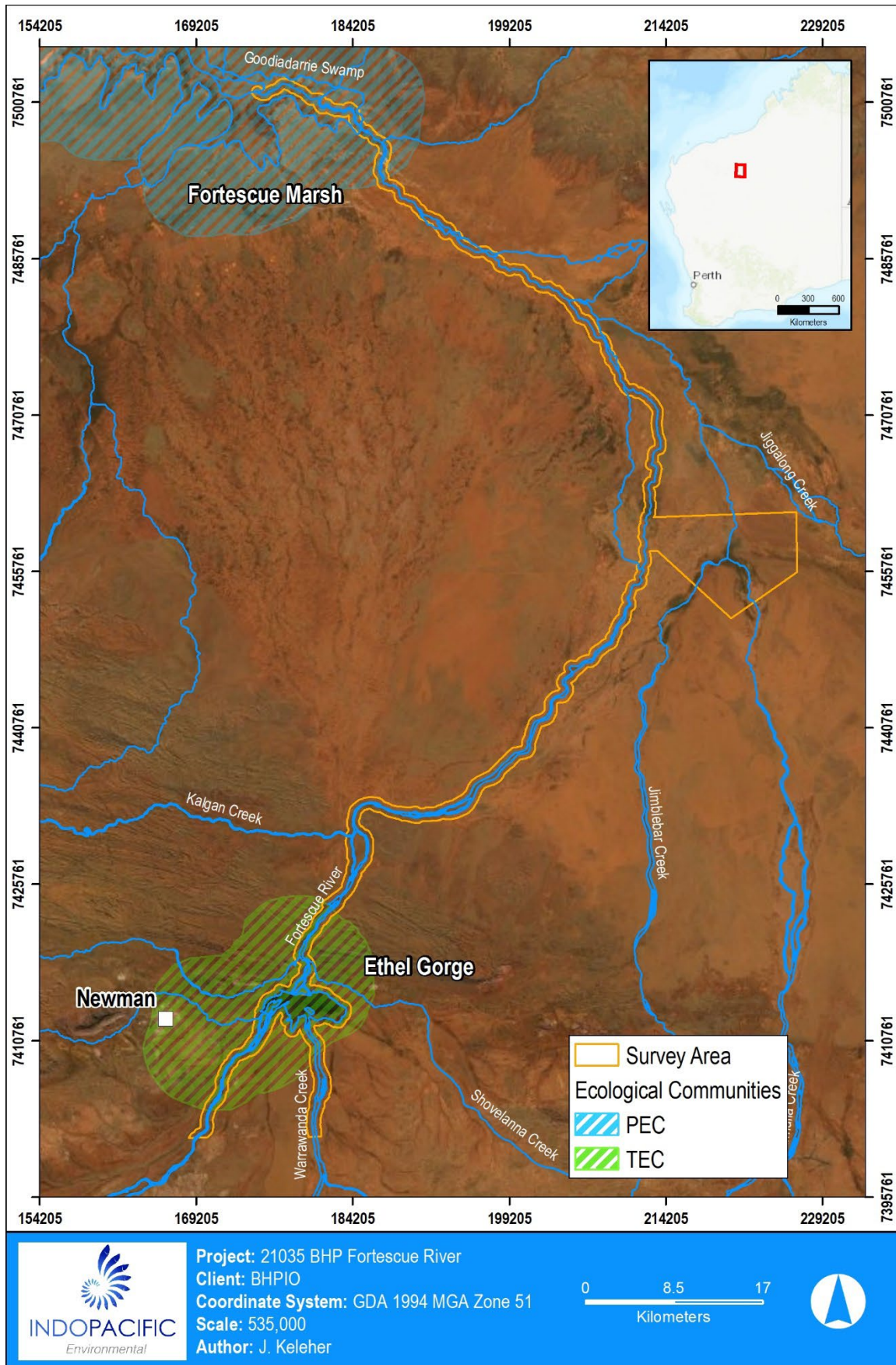
## 1.1 Background

In 2021, BHP Western Australian Iron Ore (BHP) commissioned Indo-Pacific Environmental (IPE) to undertake a two-season field assessment of aquatic fauna and habitats occurring in the upper reach of the Fortescue River catchment. Specifically, the study area was located approximately 7 - 90 km from Newman in the East Pilbara region of Western Australia, and encompassed the upper Fortescue River main channel, Ophthalmia Dam and the lower reach of Warrawanda Creek (Figure 1). This area is comprised of active/non-active Geoscience tenure, mining operational areas and pastoral leases. Whilst the current assessment did not aim to assess any specific proposed development or operational aspect of BHP, information on the current ecological condition of the study area may be used to guide relevant future environmental approvals or the management of operations within the region.

## 1.2 Project Aims and Objectives

The aquatic fauna baseline assessment aimed to assess the current ecological condition of the upper Fortescue River. The specific objectives for the assessment were to:

- Determine the presence or likely presence of listed or threatened aquatic species or ecological communities through the review of previous surveys and relevant databases;
- Systematically sample aquatic fauna in the dry and wet seasons, in the study area, with priority given to aquatic fauna which is considered to be of 'significance';
- Conduct habitat and water quality assessments at each sampling location;
- Provide an inventory of aquatic taxa collected; and
- Report the conservation status of recorded aquatic fauna.



**Figure 1.** Extent of the study area in addition to identified Priority Ecological Communities (PEC) and Threatened Ecological Communities (TEC).

## 2 METHODS

### 2.1 Guidance and Sampling Approach

Field surveys were undertaken in accordance with BHP procedures and relevant Environmental Protection Authority (EPA) guidance documentation, in addition to employing methods and general sampling approaches in alignment with the following:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018);
- BHPBIO Biological Survey Spatial Data Requirements, Version 11.0 (SPR-IEN-EMS-015) (BHPBIO 2020);
- BHPBIO Aquatic Fauna Assessment Methods, Version 2.0 (0098594) (BHPBIO 2020);
- EPA Guidance No. 20, Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (EPA 2009);
- EPA Position Statement No. 3, Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002);
- EPA Technical Guidance – Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA 2020);

### 2.2 Database Searches and Literature Review

A comprehensive literature review and database search was conducted by Indo-Pacific Environmental (2022) to support previous aquatic survey works in the study area. This review was undertaken to determine if conservation significant fauna or habitats occurred within the 140 km survey area. Multiple databases were utilized and are listed below. In addition to databases, available literature including reports, journals, books and other relevant publications were reviewed. The existing literature review was utilised in this study, with any relevant updates in significant faunal or habitat occurrences recorded. Additional sources of literature were also incorporated.

- Protected Matters Search Tool (Department of Agriculture, Water and the Environment (DAWE)),
- NatureMap (Western Australian Government Department of Parks and Wildlife and Western Australian Museum),
- Freshwater Fish Distribution in Western Australia (Western Australian Government Department of Fisheries),
- Threatened and Priority Ecological Communities (Western Australian Government Department of Parks and Wildlife), and
- Threatened and Priority Fauna List (Western Australian Government Department of Parks and Wildlife).

## 2.3 Licences

The field survey was conducted under a Section 7 Exemption (No. 2799) obtained from the Department of Primary Industries and Regional Development (DPIRD) - Fisheries per Section 7 (1) and (2) (e) of the *Fish Resources Management Act 1994* (FRM Act).

## 2.4 Sampling Team, Design and Sites

The Pilbara region has a semi-arid climate typified by a dry season (July to November) and a wet season (December to June) with highly variable rainfall, generally associated with cyclonic events and isolated thunderstorms (Sudmeyer 2016). Dry season sampling was conducted by Dr Dean Thorburn and Emma Thillainath between the 26<sup>th</sup> and 31<sup>st</sup> of October 2021. Wet season sampling was conducted by Dr Dean Thorburn and William Pragnell Fleming between the 6<sup>th</sup> and 14<sup>th</sup> of May 2022 after moderate rainfall in February (73 mm), March (31.8 mm) and April (4.2 mm) (Newman Aero weather station 7176). Methodologies followed closely those outlined in the BHP 'Aquatic Fauna Assessment Methods' (Document number: 0098594).

As the majority of the Fortescue River within the study area is typically dry towards the end of the dry season, permanent or semi-permanent pools previously identified by Indo-Pacific Environmental (2017a, 2017b, 2019) were targeted during the dry season survey. These sites were again visited during the wet season to provide a seasonal data set. Five sites were located within Ophthalmia Dam due to its size, and three sites were situated immediately downstream of the dam where the introduced *Poecilia latipinna* (Sailfin Molly) has previously been recorded as they hold water throughout the year. Nineteen sites in total were sampled over the course of the two seasons. Seventeen sites were visited during the dry season survey, with 13 of those sites found to contain adequate surface water for the full suite of survey methods to be used (Table 1; Appendix 1). Visual records were made at an opportunistic site (OPDS5) in 2021 due to the presence of *P. latipinna*. While attempts were made to access sites Salty Pool and Fortescue River Upstream, permission to do so was not available during the 2021 dry season survey. During the wet season, 18 sites were visited and surveyed, with adequate surface water available at 17 sites allowing for the full suite of survey methods. Sites which hyporheic samples could not be collected was due to the presence of clay, which limited water exchange.

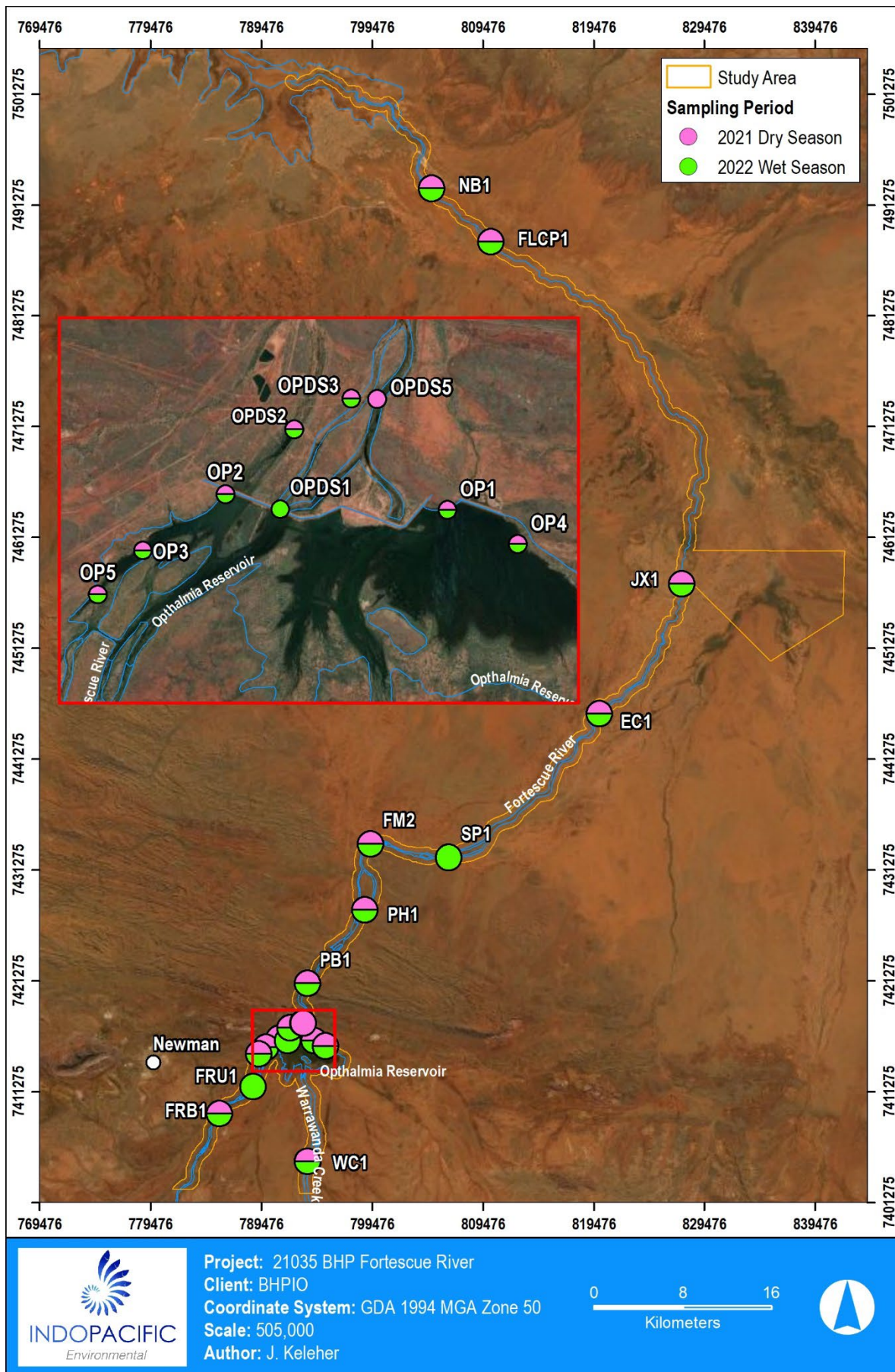


Figure 2. Locations of sites surveyed during the 2021 dry season and 2022 wet season.

**Table 1.** Summary of sites surveyed during the 2021 dry season and 2022 wet season and the ecological components sampled (Sed. = sediment for rehydration, AQI = Aquatic invertebrates, AQVC = Aquatic vertebrates and crustaceans, Hab. = habitat assessment and WQ = water quality).

Reach	Site	Site Code	Coordinates (UTM)			Samples Collected - Dry 2021					Samples Collected - Wet 2022				
			Zone	Easting	Northing	Sed.	AQI	AQVC	Hab.	WQ	Sed.	AQI	AQVC	Hab.	WQ
Fortescue River Upstream of Ophthalmia Dam	Warrawanda Creek	WC1	50	793649	7405007	✓	No surface water present				✓	No surface water present			
	Fortescue Bridge	FRB1	50	785693	7409303	✓	No surface water present				✓	✓	✓	✓	✓
	Fortescue River Upstream of Dam	FRU1	50	788721	7411747	Not surveyed					✓	No surface water present			
Ophthalmia Dam	Ophthalmia Dam 1	OP1	50	794235	7415892	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Ophthalmia Dam 2	OP2	50	791061	7416115	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Ophthalmia Dam 3	OP3	50	789880	7415311	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Ophthalmia Dam 4	OP4	50	795241	7415402	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Ophthalmia Dam 5	OP5	50	789240	7414682	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ophthalmia Dam Downstream	Ophthalmia Dam Downstream 1	OPDS1	50	791846	7415900	x	x	x	✓	✓	✓	✓	✓	✓	✓
	Ophthalmia Dam Downstream 2	OPDS2	50	792044	7417043	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Ophthalmia Dam Downstream 3	OPDS3	50	793205	7417484	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Ophthalmia Dam Downstream 5	OPDS5				Visual records of vertebrates					Not surveyed				
Fortescue River Downstream of Ophthalmia Dam	Pool B	PB1	50	793627	7421050	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Pool H	PH1	50	798796	7427698	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Fortescue Mid	FM2	50	799331	7433652	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Salty Pool	SP1	50	806377	7432417	Not surveyed					✓	✓	✓	✓	✓
	Ethel Creek	EC1	51	205192	7445894	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Jigalong Road Crossing	JX1	51	212136	7457923	✓	No surface water present				✓	✓	✓	✓	✓
	Fortescue LCP	FLCP1	51	193677	7488051	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Nullagine Bridge	NB1	50	804814	7492780	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

## 2.5 Water Quality Assessment

A range of water quality parameters were measured at sites with viable surface water present (Table 2). Physiochemical parameters were measured *in situ* using a portable hand-held Yellow Springs Instruments (YSI) field meter. Undisturbed water samples were also collected for laboratory analysis in line with the Western Australian River Assessment System (AUSRIVAS) Sampling and Processing manual protocols (van Looij 2009). Water samples were kept on ice while in the field and refrigerated as soon as possible, before being transported to the NATA-accredited Australian Laboratory Services (ALS) in Perth, Western Australia. Water samples were analysed for multiple nutrients, anions and cations with the results being compared to the relevant Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) Default Guideline Values (DGVs). For riverine sites, DGVs for lowland rivers in tropical Australia were adopted, whilst DGVs for Lakes, reservoirs and wetlands in tropical Australia were adopted for sites located within Ophthalmia Dam.

**Table 2.** Water quality parameters measured in the 2021 dry season and 2022 wet season.

Physiochemical <i>in situ</i>	Laboratory Analysis	
pH (H <sup>+</sup> )	Turbidity (NTU)	Hardness (as CaCO <sub>3</sub> )
Temperature (°C)	Ammonia (N-NH <sub>3</sub> )	Chloride (Cl)
Electrical conductivity (µS/cm)	Nitrogen oxides (N-NO <sub>x</sub> )	Calcium (Ca)
Dissolved oxygen (%)	Nitrogen total (N-total)	Magnesium (Mg)
Dissolved oxygen (ppm)	Phosphorus total (P-total)	Sodium (Na)
Salinity (PSU)	Alkalinity (as CaCO <sub>3</sub> )	Potassium (K)
	Total suspended solids (TSS)	

## 2.1 Qualitative Habitat Assessment

A qualitative habitat assessment was undertaken at all sites with surface water present. This assessment approach was adapted from the Western Australia AUSRIVAS sampling and processing manual (van Looij 2009) and enables consistent documentation of available instream habitat, substrate composition, bank structure and disturbances (Table 3). This information was incorporated into the Waters and Rivers Commissions habitat of rivers and creeks assessment (Water and Rivers Commission 2000) to rate the overall stream habitat of each site.

**Table 3.** Habitat characteristics recorded in the 2021 dry season and 2022 wet season.

Site measurements	Habitat Area (% Cover)	Sediment Substrate (% Cover)	Disturbances (Ranked 0-3)
Habitat Type	Mineral Substrate	Bedrock	Pastoral Use
Site Length (m)	Emergent Macro	Boulders (>256 mm)	Frequent Fire
Site Width (m)	Submerged Macro	Cobbles (64-256 mm)	Mining Exploration
Depth (m)	Floating Macro	Pebbles (16 - 64 mm)	Road/ Access Track
Velocity (cm/s)	Algal Cover	Gravel (4 - 16 mm)	Rubbish/ Litter
	Detritus	Sand (1 - 4 mm)	Weed Invasion
	Veg. draped in water	(Silt (<1 mm)	Other
	Root mats	Clay	None Discernible
	Woody Debris >10cm		Local Erosion

## 2.2 Sediment Collection and Rehydration of Invertebrates

At each sample site, 500 g of sediment was collected from the top 5-10 mm surface sediments. Areas that appeared to have held water previously, indicated by historic waterline markings and low elevation, with fine sediments and distinct crusts were targeted for collection. Samples were transported to the Indo-Pacific Environmental laboratory, where 100 g of each sediment sample were rehydrated in a plastic container with 300 ml of deionised water. Rehydration occurred under controlled conditions, with the temperature maintained at 25°C and a 12 hour light/12 hour dark cycle. Samples were examined for emerging fauna periodically for at least six weeks after rehydration. Emergent fauna collected were categorised and identified. Samples were sent to Dr Russell Shiel (University of Adelaide) for additional identification to species level (where possible) under high-powered magnification, and abundances were recorded using a log<sub>10</sub> abundance scale (i.e. 1 = 1 individual, 2 = 2 - 10 individuals, 3 = 11 – 100 individuals, 4 = 101-1,000 individuals, etc.) as outlined under the BHP BIO aquatic fauna assessment methods document (0098594) and adapted from the Western Australia AUSRIVAS sampling and processing manual (van Looij 2009).

## 2.3 Microinvertebrate Fauna

Microinvertebrate samples were collected by sweeping a with a 53 µm mesh plankton net over a distance of approximately 15 m in the water column. Samples were preserved in 70% ethanol and sent to Dr Russell Shiel (University of Adelaide) for identification. The first 200-300 individuals obtained from an agitated sample decanted into a 125 mm<sup>2</sup> gridded plastic tray were identified to the lowest taxon possible. The tray was also scanned for additional taxa for identification and recorded as 'present'. This method is widely used and accepted (Shiel and Tan 2013; WRM 2009-2018) to determine the presence/absence of microcrustacean taxa in addition to determining the proportional microinvertebrate assemblage composition at each site. Microinvertebrate specimens were sent to Dr Russell Shiel (University of Adelaide) for identification to the lowest taxon possible.

## 2.4 Hyporheic Fauna

Hyporheic sampling was conducted using the Karaman-Chappuis method (Delamare Deboutteville 1960). In particular, a hole ~20 cm deep and 40 cm in diameter was dug in the dry stream bed adjacent to the water's edge and left to inundate. After filling, the water column was swept with a modified 110 µm mesh plankton net and was swept again after 30 minutes. Samples were preserved in 70% ethanol and transported to the Indo-Pacific Environmental laboratory for identification. Extracted macroinvertebrate specimens were identified to the lowest taxon possible. All taxa recorded from hyporheic samples were categorised, based on habitat affinity, using the functional classifications of Boulton (2001).

## 2.5 Macroinvertebrate Fauna

In alignment with AUSRIVAS methodologies (van Looij 2009), macroinvertebrates were collected using a 250 µm sweep net over a liner 10 m sampling area. Edge habitats and riffle habitats (when present) were targeted separately at each site to maximise the diversity of taxa collected. Each sample was washed and

decanted to remove fine sediment, while debris was washed by hand in a 250 µm sieve to remove attached macroinvertebrates, and then discarded. Samples were preserved in 70% ethanol and transported to the Indo-Pacific Environmental laboratory for identification and enumeration. Macroinvertebrate fauna were identified to the lowest possible level and enumerated using a log<sub>10</sub> abundance scale (i.e., 1 = 1 individual, 2 = 2 - 10 individuals, 3 = 11 – 100 individuals, 4 = 101-1,000 individuals, etc.). This method of reporting abundances has been adapted from the Western Australia AUSRIVAS sampling and processing manual (van Looij 2009) and is widely used in aquatic fauna assessments.

## **2.6 Vertebrate Aquatic Fauna**

To comprehensively assess vertebrate aquatic fauna within the study area, a broad sampling regime was used to account for the variable nature of the habitat present and to ensure the recording of all aquatic species present. Survey methods used at each site are presented in Table 4 and included electrofishing equipment, fyke nets, seine nets, baited opera house traps and the collection of visual records.

### *2.6.1 Electrofishing*

To gather data on the presence and abundance of cryptic species or sample complex habitats, electrofishing was conducted using a Smith-Root Model LR24 battery-powered backpack electrofisher. While electrofishing, current and voltage settings were adjusted with the aim of stunning fish only. Stunned fish were kept alive in a bucket of freshly collected water to recover before being identified, measured and released.

### *2.6.2 Fyke Nets*

A pair of fyke nets (one facing upstream and one facing downstream) were deployed overnight to capture the dawn, dusk and nocturnal movement periods of both highly mobile and cryptic aquatic species including fish, decapod crustaceans and reptiles. Each fyke net was 11.2 m total width, including two 5 m wings, one 1.2 m wide mouth, a depth of 0.8 m and a length of 5 m, all comprised of 2 mm woven mesh, that was set to fish the entire water column. The mouth of the net is held open by a rigid aluminium frame, which was secured in place with star pickets. The wings of each net were secured to the nearest bank in order to channel fauna into the mouth of the fyke net. In order to minimise the risk of drowning amphibians and aquatic reptiles, the end of the net (the bunt) was tied up above the waterline.

### *2.6.3 Seine Nets*

Where applicable, seine nets of five or 10 m lengths comprising of 2 mm woven mesh were used to target fauna species and juveniles. Up to four seine net replicates were conducted at each site when possible. In general, seine nets were walked out from the shore, stretched parallel to shore and hauled shoreward. Fauna captured in the seine net was identified, measured and released.

#### 2.6.4 Baited Opera House Trap

To target decapod crustaceans, a baited opera house trap was deployed in close proximity to each fyke net site overnight. The entry size into each trap is restricted to exclude larger air-breathing fauna (e.g., turtles) and mitigate the risk of drowning fauna. Native fauna captured was identified, measured and released, with all invasive decapod crustaceans humanely euthanised in accordance with DPIRD-Fisheries guidelines.

#### 2.6.5 Identification and Measurement

All specimens captured during the survey were identified to species level and counted in the field. At each site, a sub-sample of each species was measured to the nearest millimetre as total length (TL) for fish, orbital carapace length (OCL) for crustaceans and straight-line carapace length (SCL) for turtles. All native species were released alive at the site of capture. However, introduced fish or crustacean species captured were euthanised in accordance with DPIRD-Fisheries exemption conditions by placement in an ice slurry as per Barker *et al.* (2009).

**Table 4.** Summary of fauna collection methods utilised at each site within the study area sampled during the 2021 dry season and 2022 wet season (Micro: microinvertebrate sampling, Hypo: hyporheic sampling, Macro: macroinvertebrate sampling, Sed: rehydration. E: electrofisher, F: fyke net, S: seine net, T: trap, V: visual records).

Site Code	2021 Dry Season									2022 Wet Season								
	Sed	Micro	Hypo	Macro	E	F	S	T	V	Sed	Micro	Hypo	Macro	E	F	S	T	V
WC1	✓									✓								
FRB1	✓									✓	✓	✓	✓					
FRU1										✓								
OP1	✓	✓		✓		✓		✓		✓	✓	✓	✓		✓		✓	
OP2	✓	✓		✓		✓		✓		✓	✓		✓		✓		✓	
OP3	✓	✓		✓		✓		✓		✓	✓	✓	✓		✓		✓	
OP4	✓	✓	✓	✓		✓		✓		✓	✓	✓	✓		✓		✓	
OP5	✓	✓		✓		✓		✓		✓	✓	✓	✓		✓		✓	
OPDS1										✓	✓		✓					✓
OPDS2	✓	✓		✓		✓		✓		✓	✓		✓		✓		✓	
OPDS3	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓		✓		✓	
OPDS5									✓									
PB1	✓	✓	✓	✓		✓		✓		✓	✓	✓	✓		✓		✓	
PH1	✓	✓	✓	✓		✓		✓		✓	✓	✓	✓		✓		✓	
FM2	✓	✓	✓	✓		✓		✓		✓	✓	✓	✓		✓		✓	
SP1										✓	✓	✓	✓	✓	✓	✓		
EC1	✓	✓	✓	✓		✓		✓		✓	✓	✓	✓		✓		✓	
JX1	✓									✓	✓	✓	✓	✓	✓		✓	
FLCP1	✓	✓		✓		✓		✓		✓	✓		✓		✓			
NB 1	✓	✓		✓		✓		✓		✓	✓		✓		✓		✓	

## 2.7 Survey Limitations

The EPA (2020) outlines several potential limitations to fauna surveys. The current assessment provides a snapshot of water quality, habitat and faunal condition within the study area over a wet and dry season. However, whilst the assessment allows for a seasonal comparison, noting the dynamic and ephemeral nature of the system, temporal comparisons should consider influential factors outside the scope of this assessment (e.g., historic flows and external impacts from other operations).

Regarding invertebrate identification, total taxa richness contains groups of taxa (e.g., Nematoda indet. sp. indet.) which could not be identified to species level due to the specimen being incompatible (juvenile or damaged) with current taxonomic keys or the lack of available published taxonomic framework. Therefore, the total taxa recorded is likely an underestimate of the true richness of the survey area. Hyporheic taxa categorisation must also be treated with a degree of caution as classification into groups is based upon current available life history information which is limited for many of the taxa discussed. Regarding sediment rehydration taxa richness, this is also likely an underestimate of total diversity due to the unique parameters required for many taxa to emerge. A summary of the survey limitations encountered during the current assessment are presented in Table 5.

**Table 5.** Survey limitations and constraints.

Limitation	Applicability to this survey
Availability of data and information	Taxonomy of aquatic fauna (macroinvertebrate fauna, fish etc.) throughout the region is relatively well documented, with a number of survey results and data available. While some macroinvertebrate and microinvertebrate fauna taxonomic resolution remains a constraint of the current study to some degree, engagement of a taxonomic expert (Dr Russell Shiel) meant that relatively few taxa remained unidentified and as such this was considered a minor limitation.
Timing, weather and season	The timing of each survey was adequate, with sampling in the dry season capturing remnant pools and sampling during the wet season capturing wet season flows and discharge from Ophthalmia Dam. No adverse weather was encountered in either season. These factors were considered to represent a minor limitation of the study, noting that dry season conditions in Homestead Creek and the Fortescue River would typically be dry.
The proportion of fauna identified/recorded/collected	An adequate snapshot of faunal assemblage composition across the study area was derived from the current assessment, with both cosmopolitan as well as regionally endemic species recorded from across the study area.
Access issues and remoteness	The dry season survey experienced some site access issues, however alternative sites to complete the sampling design requirements were sampled in place of these inaccessible sites. The use of an appropriate alternative survey site was not considered to be a limitation of the current study.
Completeness of the survey	Both field surveys (dry season 2021 and wet season 2022) were completed, with a good spread of sites across both seasons (proposed and accepted by BHP) being sampled successfully.

### 3 RESULTS AND DISCUSSION

#### 3.1 Database Searches and Literature Review

Database searches for significant communities occurring within the vicinity of the study area identified one PEC and one TEC (Figure 1). The PEC, the Fortescue Marsh, is listed as Priority 1 and exists in the northern section of the study area. The Fortescue Marsh has been afforded this status as it is the largest ephemeral wetland in the Pilbara region, supporting ecologically important waterbirds, floral assemblages and a diverse range of restricted aquatic and terrestrial invertebrates (Pinder *et al.* 2017; DBCA 2018).

The TEC identified was the Ethel Gorge aquifer stygobiont community, which occurs within the southern section of the study area (DBCA 2021). This TEC is categorised as “endangered” and has been endorsed by the Western Australian Minister for Environment as the following WA criteria for TECs have been met (DEC 2013; DBCA 2018):

(B) Current distribution is limited

(ii) There are few occurrences, each of which is small and/or isolated and all or most occurrences are very vulnerable to known threatening processes.

While Ethel Gorge is known to support a diverse, locally endemic stygofauna community, there is no direct or indirect interaction with the study area.

The Protected Matters Search Tool and NatureMap Database search found no records of aquatic vertebrates or larger invertebrate species of significance within the 140 km long study area or its vicinity (15 km to 20 km). A list of the aquatic fauna studies, identified during the literature review, which have been conducted in the waters of the upper Fortescue River and in the vicinity of the current study area and their key findings are provided in Table 6. Numerous studies have been undertaken within the upper Fortescue River, resulting in several Pilbara endemic taxa or potentially significant taxa (i.e., macroinvertebrate species which have limited geographical distribution or about which little is known) being recorded. Although *Leiopotherapon aheneus* (Fortescue Grunter), a significant species (listed as Priority 4), is known to occur within the Fortescue River catchment (Morgan *et al.* 2004; Morgan *et al.* 2014), it has not been recorded within the upper Fortescue River catchment or the study area despite numerous surveys occurring in the region (Table 6). As such, no aquatic fauna species of significance afforded protection under either the Federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or Western Australian *Biodiversity Conservation Act 2016* (BC Act) have been recorded within the upper Fortescue River or the study area.

**Table 6.** Summary of publicly available aquatic fauna studies in the upper Fortescue River catchment, including aquatic vertebrate studies.

Reference	Survey name	Sites	Sampling Components	Seasonal Conditions	Key Biological findings	Significant / Restricted Fauna
Morgan and Gill (2004)	Fish fauna in inland waters of the Pilbara (Indian Ocean) Drainage Division of Western Australia — Evidence for three subprovinces.	16 sites on the Fortescue River with one site in the upper Fortescue	Water quality, fish	Between December 2000 and November 2002	Species diversity was higher within the lower reaches of the Fortescue River. The listed <i>Leiopotherapon aheneus</i> was only recorded from the lower reaches whilst two common species were recorded from the upper Fortescue site.	No significant fauna was recorded in the upper reaches of the Fortescue River.
Streamtec (2004)	Aquatic Ecosystems of the Upper Fortescue River Catchment for BHP Billiton Iron Ore.	12 sites in the upper Fortescue River catchment	Water quality, aquatic invertebrates, fish, turtles	Dry season and wet season	125 macroinvertebrates, three fish species and one turtle species were recorded.	Two undescribed aquatic invertebrate species; <i>Boongurrus</i> sp. (dytiscid beetle) and <i>Haliplus</i> sp. (haliplid beetle).
WRM (2009)	Hope Downs 4 Aquatic Ecosystem Surveys Dry Season Sampling 2008	24 sites in Coondiner Creek, Mindy Creek, Kalgan Creek	Water quality, aquatic invertebrates, fish	Dry season	Three fish species, 102 microinvertebrate taxa and 188 macroinvertebrate taxa.	<i>Nososticta pilbara</i> (Pilbara threadtail) is listed as a Priority 2, located ~35 NE of Ophthalmia Dam.
Pinder <i>et al.</i> (2010)	An Arid Zone Awash with Diversity: Patterns in the Distribution of Aquatic Invertebrates in the Pilbara Region of Western Australia.	100 waterbodies throughout the Pilbara region including Innawally Pool	Water quality, aquatic invertebrates, macrophytes	Autumn and spring with a few ephemeral sites sampled in late summer after flooding.	High diversity of invertebrate species (>1000), most of which were widespread.	Flowing springs (Millstream/Karijini National Parks), ephemeral wetlands (Fortescue Marsh) and freshwater claypans supported rare and/or restricted elements.
WRM (2011)	Yandicoogina: Aquatic Management Report. Unpublished report by Wetland Research and Management Iron Ore	Desktop review of studies conducted throughout the Upper Fortescue catchment.	Water quality, aquatic invertebrates, fish	Dry season and wet season	27 microinvertebrate taxa, 115 macroinvertebrate taxa, three fish species and one turtle species recorded	No significant species recorded

Reference	Survey name	Sites	Sampling Components	Seasonal Conditions	Key Biological findings	Significant / Restricted Fauna
WRM (2013)	Baseline Aquatic Survey of the Fortescue Marsh Wet Season 2012	11 sites within the Fortescue Marsh, three within the lower extent of the study area	Water quality, aquatic invertebrates, fish	Wet season	Two fish species, 109 microinvertebrate and 98 macroinvertebrate taxa recorded. The majority of macroinvertebrates were common.	A limited number of potentially significant (at the time) microinvertebrates as only known from the Fortescue Marsh, however, none were listed
Morgan <i>et al.</i> (2014)	Field Guide to the Freshwater Fishes of Western Australia's Pilbara Province	Summation of publications and unpublished data of sites throughout the "Pilbara Province", including a number of sites on the Fortescue River.		Dry season and wet season	16 native freshwater fish species are known from the "Pilbara Province", nine of which are endemic. Four introduced fish and three introduced freshwater crayfish are known from the "Pilbara Province".	No significant species known for the upper Fortescue River.
MWH (2016)	Ophthalmia Dam Aquatic Fauna Survey Aquatic Ecology.	16 aquatic sites within Ophthalmia Dam and eight sites within the upper Fortescue River Catchment	Water quality, algae, macrophytes aquatic invertebrates, fish, frogs, turtles	Dry season and wet season	The total number of species recorded comprised 46 algae, nine macrophytes, 146 aquatic invertebrates, 27 hyporheic fauna, two fish, three frog and one turtle species.	Five potentially significant aquatic invertebrate taxa were identified however rare or restricted elements of Pilbara invertebrate communities are typically associated with permanent springs, ephemeral wetlands and freshwater claypans.
Ecologia and Indo-Pacific Environmental (2017a)	Fortescue River Aquatic Fauna Survey BHPBIO	Seven aquatic sites, including five downstream of Ophthalmia Dam and two upstream.	Water quality, habitat, aquatic invertebrates, fish, frogs, turtles.	Wet season only (March 2017)	A total of 1777 individual macroinvertebrates collected from 99 taxa, three native and one introduced fish species, two amphibians and a reptile were recorded.	No significant or restricted fauna was recorded.

Reference	Survey name	Sites	Sampling Components	Seasonal Conditions	Key Biological findings	Significant / Restricted Fauna
Ecologia and Indo-Pacific Environmental (2017b)	Innawally Pool Aquatic Survey BHPBIO	Seven aquatic sites, including five downstream of Ophthalmia Dam and two upstream.	Water quality, habitat, aquatic invertebrates, fish, frogs, turtles.	Dry season and wet season	A total of 4000 individual macroinvertebrates collected from 110 taxa, three native and one introduced fish species, three amphibians and a reptile were recorded.	No significant or restricted fauna was recorded.
Pinder <i>et al.</i> (2017)	Wetland biodiversity patterning along the middle to upper Fortescue valley (Pilbara: Western Australia) to inform conservation planning	Invertebrate sampling within the middle and upper Fortescue valley	Water quality, habitat, aquatic invertebrates.	Dry season and wet season	No large aquatic fauna of significance or introduced species were identified within the upper Fortescue. Notes a recent record an introduced freshwater crayfish ( <i>Cherax quadricarinatus</i> ) from a tributary of the lower Fortescue River (Weelumurra Creek).	No Significant species recorded.
WRM (2017)	Marillana Creek Aquatic Fauna Survey 2017	One site on upper Fortescue, rest on other sub-catchments of the Fortescue marsh	Water quality, habitat, aquatic invertebrates, fish,	Dry season and wet season	56 macro taxa identified and two native fish species	No significant species recorded although a stygal water mite recorded may be a potential SRE.
Indo-Pacific Environmental (2018)	Memorandum: Survey of the aquatic fauna in the Fortescue River and Ophthalmia Dam	Five sites within the upper Fortescue River below Ophthalmia Dam and 24 sites within the Dam	Fish and aquatic fauna	Dry season conditions	Four fish, one turtle and one freshwater crayfish species were recorded. No significant species recorded. One introduced fish species ( <i>Poecilia latipinna</i> ) and one introduced freshwater crayfish ( <i>Cherax quadricarinatus</i> ) recorded.	No significant or restricted fauna was recorded during the survey.

Reference	Survey name	Sites	Sampling Components	Seasonal Conditions	Key Biological findings	Significant / Restricted Fauna
Thorburn <i>et al.</i> (2018)	Introduction of an alien fish species in the Pilbara region of Western Australia	Nine sites on the Fortescue River and Warrawanda Creek	Fish and aquatic fauna	Dry season and wet season	One introduced fish species ( <i>Poecilia latipinna</i> ) was recorded.	No significant species recorded.
Indo-Pacific Environmental (2019)	Sailfin Molly eDNA survey of the Fortescue River and its tributaries, 2019	Samples were collected from seven known Permanent or semi-permanent pools on the Fortescue River and its tributaries between Ophthalmia Dam and the headwaters of the Fortescue Marsh	Fish and aquatic fauna	Dry season	Native species recorded included three fish, one amphibian and one turtle species. One introduced fish freshwater crayfish species was recorded.  In addition, five genera of macroinvertebrates were recorded.	No significant species recorded.
Indo-Pacific Environmental (2022)	Survey of the aquatic fauna in the Fortescue River and Ophthalmia Dam	Samples were collected from 12 and 17 sites in the dry and wet season 2020 and 2021.	Fish and aquatic fauna	Dry and wet season	Three native fish species, one invasive fish and one invasive crayfish. 164 Macroinvertebrate taxa recorded.	Two ICUN Red Listed odonates listed as 'vulnerable'. Pilbara endemic copepod <i>Parastenocaris jane</i> , First record of Cladocera <i>Coronatella cf. rectengula</i> in Australia.
Indo-Pacific Environmental (2022)	Ob32 surplus water - homestead creek aquatic fauna survey 2021	Eleven and seven site surveyed during the wet and dry season 2021	Fish and aquatic fauna	Dry and wet season	Three native fish species and one invasive crayfish.	Four Pilbara endemic macroinvertebrates

## 3.2 Water Quality

Surface water quality parameters varied spatially (between sites) and temporally (between seasons) (Figures 3 and 4; Appendix 2). The varying parameters are associated with flow events in relation to the time of sampling, land use and surrounding geology (ANZECC 2000; Junk *et al.* 1989; Pinder *et al.* 2010).

### 3.2.1 Electrical Conductivity

In general, electrical conductivity (EC) was marginally higher at survey sites during the dry season. This is typical of Pilbara aquatic systems and generally the result of evapoconcentration (ANZECC 2000). During the 2021 dry season survey, EC was similar across most sites excluding OPDS3 and FLCP1 (Figure 3), which both displayed markedly higher EC values, likely explained by increased evaporation rates at these sites. During the 2022 wet season survey, EC was also broadly comparable between most sites. However, EC was vastly higher at OPDS3 and somewhat higher at OPDS2. These sites are located directly downstream of Ophthalmia dam.

In comparison to lower DGVs (ANZG 2018) for lowland rivers and reservoirs, all river and dam sites during 2021 and 2022 surveys exceeded lower DGVs for EC (Figure 3). All riverine sites across both surveys exceeded upper DGVs for EC, while reservoir upper DGVs were only exceeded at two sites during the 2021 dry season survey (Figure 3; Appendix 2). The highest dry season EC of 2233  $\mu\text{S}/\text{cm}$  was recorded at FLCP1, while the highest wet season EC of 2073  $\mu\text{S}/\text{cm}$  was recorded at OPDS3. These sites were also highest in the respective seasonal surveys in 2020 and 2021 (Indo Pacific Environmental 2022). Salinities below 3800  $\mu\text{S}/\text{cm}$  are classified as freshwater, with aquatic diversity declining in Pilbara freshwater systems occurring at salinities above 2244  $\mu\text{S}/\text{cm}$ , of which no sites exceeded in both seasonal surveys. (Pusey *et al.* 2014; Pinder *et al.* 2010). Freshwater systems may experience little ecological stress at conductivity values lower than 1500  $\mu\text{S}/\text{cm}$  (Hart *et al.* 1991; Horrigan *et al.* 2005; Butler 2008), which was evident at the majority of sites in 2021 and 2022 (Figure 3). Therefore, it is apparent that any encountered EC values are not likely affecting aquatic faunal communities at any site during both 2021 and 2022 surveys.

### 3.2.2 Dissolved Oxygen

Percentage saturation of dissolved oxygen (DO%) varied between both site and season, ranging from 34.4 % at OPDS1 to 134.5% at OPDS3 in the 2021 dry season and between 41.5% at FRB1 and 128.5% at OPDS2 during the 2022 wet season survey (Figure 3). The high degree of variability in DO% is likely explained by a number of factors, including the time of day the measurement was taken and the surface area to volume ratios for oxygen exchange. The presence of macrophytes, algae and turbulence from flow events and wind can increase dissolved oxygen readings, while the presence of organic matter and concurrent decomposition may lower dissolved oxygen levels (Junk *et al.* 1989). It is also apparent that increased turbidity may limit oxygen input from macrophytes due to limited photosynthesis. (ANZECC 2000). OPDS2 is an example of site with large coverage of aquatic macrophytes and low turbidity likely resulting in elevated dissolved oxygen readings. (Figure 3).

DO% was below the respective DGVs at FRB1, OP5, OPDS1 and during both seasons surveyed. OP2, FM2, EC1 and NB1 were below the DGV for DO% during the dry season survey. It is understood that detrimental effects to aquatic biota may occur DO% levels below 50% (Butler *et al.* 1970; Connolly *et al.* 2004; EIFAC 1973; Flint *et al.* 2015). DO% levels below 50% occurred at sites OP2 and OPDS1 during the dry season and site FRB1 during the wet season (Figure 3). As FRB1 was an isolated pool, the low DO% is not unexpected. However, a DO% of <50% recorded from Ophthalmia Dam at OP2 is surprising considering the large size of the water body. All other sites surveyed in Ophthalmia Dam were above 50% DO.

### 3.2.3 pH

pH was generally seen to be marginally higher at sites surveyed during the dry season survey (Figure 3). All sites surveyed during both seasons were considered circumneutral (pH = 6.0 – 8.0) or alkaline (pH>8.0), with values varying irrespective of proximity to Ophthalmia Dam. Although many sites exceeded relevant DGVs (upper DGV of 8.0), it is apparent that alkaline values are typical of the catchment area and likely product of the hard alkaline red soils present. Similar results have been obtained from varying studies (EPA 1988; MWH 2016), with values ranging between 7.0 to 10.2 recorded by Pinder *et al.* (2010). The circumneutral to alkaline pH values recorded are a product of local geology and are unlikely to detrimentally effect present aquatic biota.

### 3.2.4 Turbidity

Turbidity was only measured during wet season sampling with the majority of sites having values within the respective upper DGVs (Figure 3; ANZG 2018). Turbidity exceeded upper DGVs at two sites, FLCP1 and NB1, with NTU values of 33.26 and 124 respectively. The increased turbidity at these sites was attributed to these sites being susceptible to disturbances, primarily cattle use and grazing which was present at both of these sites (Table 7).

### 3.2.5 Nutrients

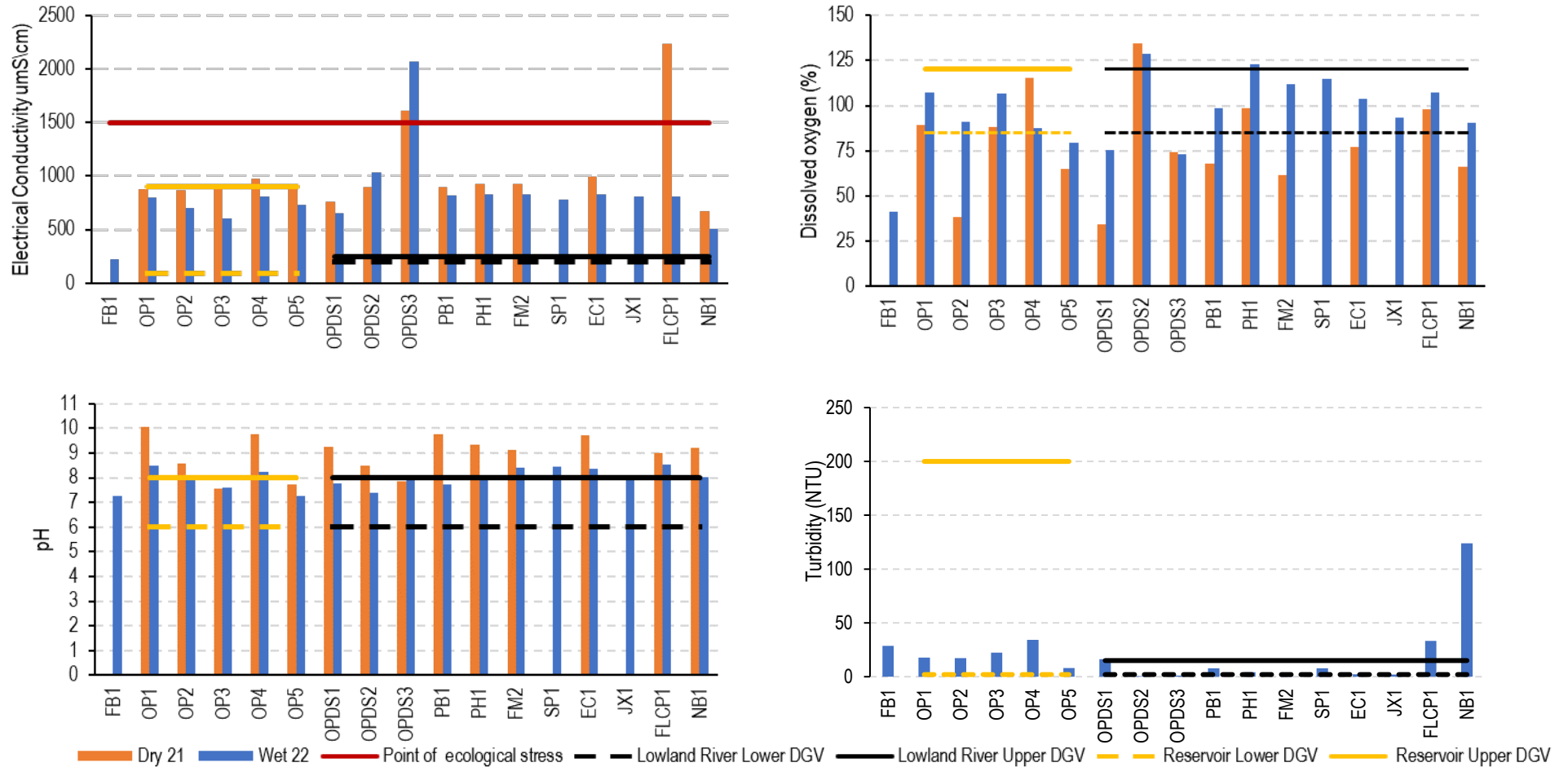
During the 2021 dry season, both total nitrogen (TN) and total phosphorus (TP) slightly exceeded DGVs at the majority of sites (Figure 4). However, site FLCP1 recorded significantly higher values of TN and TP during the dry season. Similar results were evident during wet season sampling, with most sites slightly exceeding ANZG DGVs. NO<sub>x</sub> concentrations at the majority of sites during both seasonal surveys were below ANZG DGVs, with exceptions at one site in 2021, and three sites in 2022 (Figure 4). Although most sites exceeded ANZG DGVs, due to the consistency of values displayed in both seasonal surveys it is likely that these values are representative of natural nutrient concentrations in the catchment and not cause for concern. The significantly increased TN and TP concentrations at FLCP1 during the 2021 survey is likely attributed to unrestricted livestock access in the area (Table 7) which is often associated with elevated nutrient concentrations (MWH 2016).

### 3.1 In-stream Habitat Characterisation

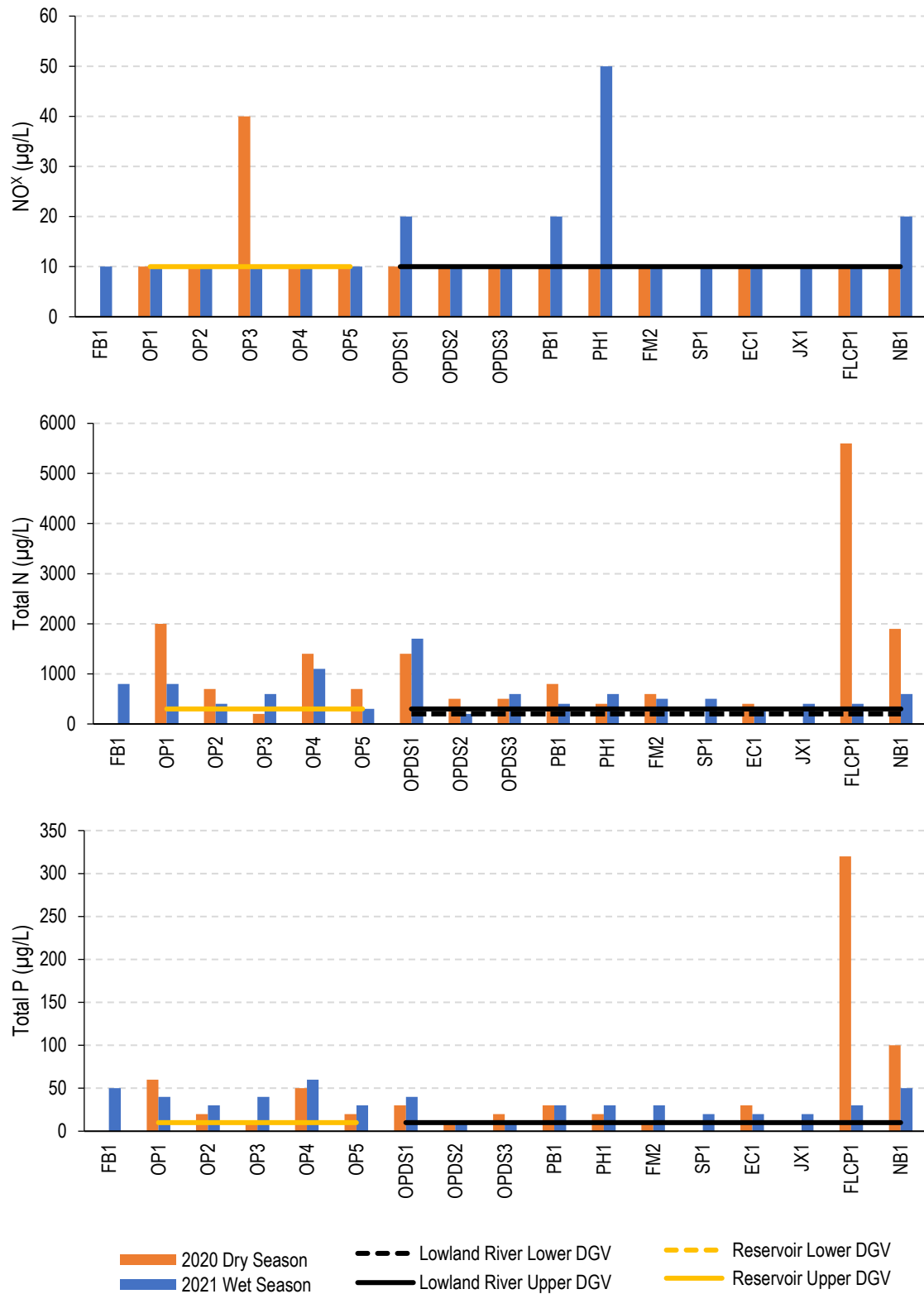
The majority of sites within Ophthalmia Dam and those immediately downstream were dominated by clay and silt, while riverine sites were largely characterised as sandy, gravelly channels (Figure 5.). In stream structure was primarily mineral substrate, however algal and root matt cover appeared to increase in the 2022 wet season at multiple sites (Figure 5.). Primary land use at the majority of sites was pastoral, with evidence of cattle present at most sites (Appendix 3).

The Water and Rivers Commission method of stream habitat rating determined that the majority of sites received a moderate rating due to low presence of emergent vegetation and reduced riparian zones dominated by Eucalypts and invasive grasses (Table 7; Appendix 1). Sites which received a poor rating was primarily due to minimal presence of emergent vegetation, little instream structure, and were generally highly impacted by cattle resulting in degraded bank structure and riparian zones.

All habitats surveyed are typical of those in the wider Pilbara region, although due to dewatering or dam seepage, many sites throughout the Fortescue River either permanently inundated or inundated for an extended period. The presence of semi-permanent water contrasts the natural “wet-dry” flow regimes seen in many freshwater systems in the Pilbara region; which likely allows fauna species which require permanent water to persist during the dry season.



**Figure 3.** Electrical conductivity ( $\mu\text{S}/\text{cm}$ ), dissolved oxygen (%), pH (H+) and turbidity (NTU) values recorded from sites surveyed within the study area during the 2021 dry season and 2022 wet season with corresponding tropical Australia Default Guideline Values (DGV) from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) also displayed. N.B. In instances where a value is missing, the site was either dry or inaccessible at the time of the survey.



**Figure 4.** Nutrient concentrations (µg/L) recorded from sites surveyed within the study area during the 2021 dry season and 2022 wet season with corresponding tropical Australia Default Guideline Values (DGV) from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018).

**Table 7.** The stream habitat rating of each site during the dry and wet season derived using the Waters and Rivers Commissions habitat of rivers and creeks assessment (Water and Rivers Commission 2000; Appendix A). Definitions of ratings are provided below. N.B. sites that were dry or inaccessible during a season are highlighted grey.

Site Code	2021 Dry Season						2022 Wet Season					
	Emergent Veg.	Mid and Upper Bank Veg.	In-stream habitat	Flow Conditions	STREAM HABITAT RATING		Emergent Veg.	Mid and Upper Bank Veg.	In - stream habitat	Flow Conditions	STREAM HABITAT RATING	
WB1	Dry				-	-	Dry				-	-
FRB1	Dry				-	-	1	2	2	2	7	Poor
OP1	2	2	2	2	8	Poor	2	3	2	2	9	Poor
OP2	3	3	4	2	12	Moderate	3	3	4	2	12	Moderate
OP3	2	2	2	2	8	Poor	2	3	2	2	9	Poor
OP4	2	3	2	2	9	Poor	2	3	2	2	9	Poor
OP5	3	4	4	3	14	Good	3	4	4	3	14	Good
OPDS1	2	3	4	2	11	Moderate	2	3	4	2	11	Moderate
OPDS2	2	3	4	3	12	Moderate	3	3	4	3	13	Moderate
OPDS3	4	3	5	4	16	Good	4	3	5	4	16	Good
PB1	3	4	3	4	14	Good	3	4	3	4	14	Good
PH1	2	4	3	4	13	Moderate	3	4	3	4	14	Good
FM2	2	4	3	3	12	Moderate	2	4	3	3	12	Moderate
SP1	Dry				-	-	3	3	3	4	13	Moderate
EC1	3	3	3	2	11	Moderate	3	4	4	4	15	Good
JX1	Dry						3	3	4	5	15	Good
FLCP1	1	2	2	2	7	Poor	1	2	2	2	7	Poor
NB1	2	3	4	2	11	Moderate	2	3	4	3	12	Moderate

#### Definitions

Score	Rating	Condition
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17 - 20	Excellent	Site in virtually natural condition with excellent habitat value
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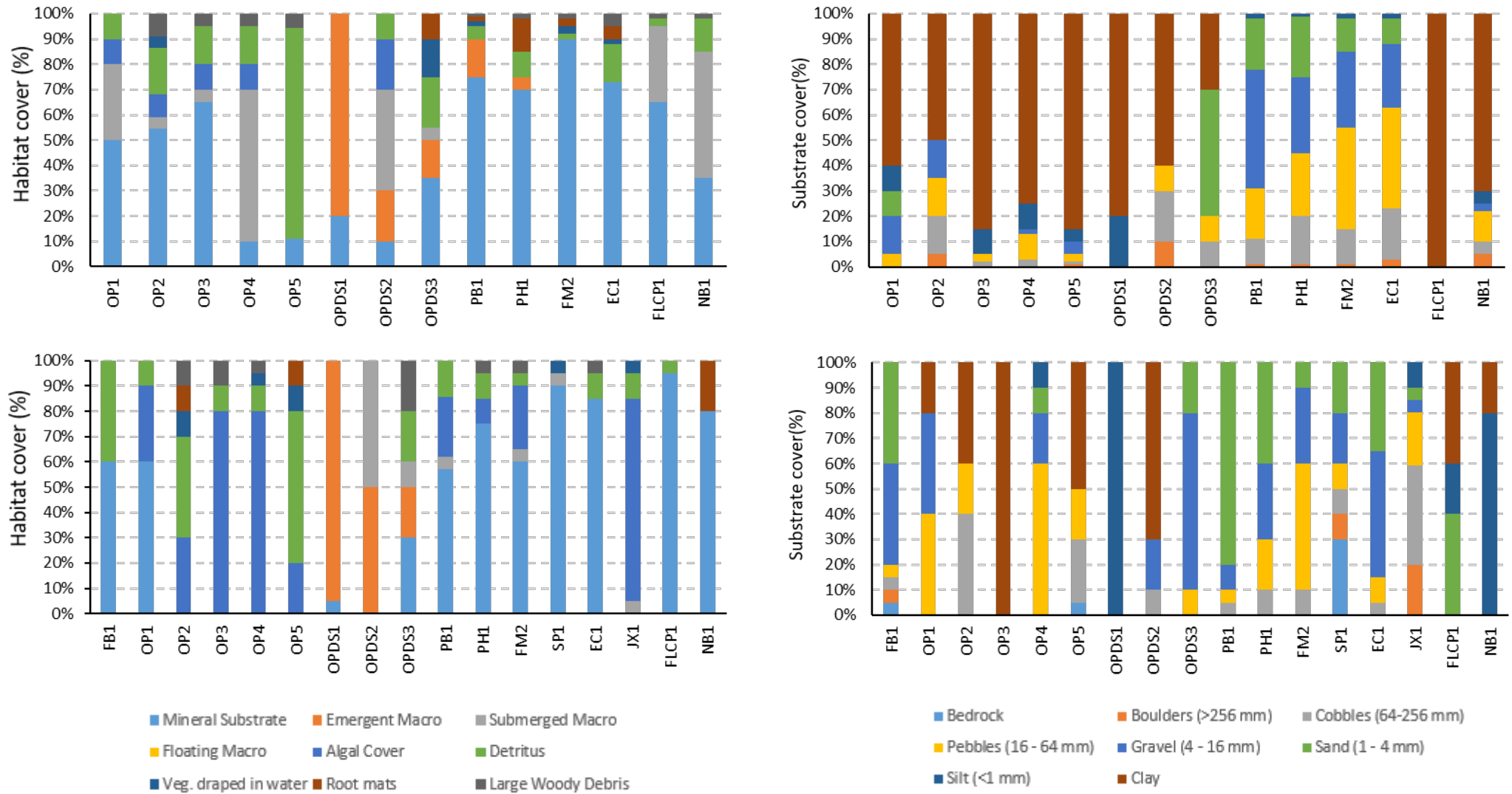
14 - 16	Good	Site is in natural condition with some weed invasion, localised disturbance or habitat infilling/sedimentation
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10 - 13	Moderate	Some alteration from the natural state, moderate habitat value
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7 - 9	Poor	Significant alterations from the natural state, reduced habitat value
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4 - 6	Very Poor	Very degraded. Little available habitat
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2021 Dry Season

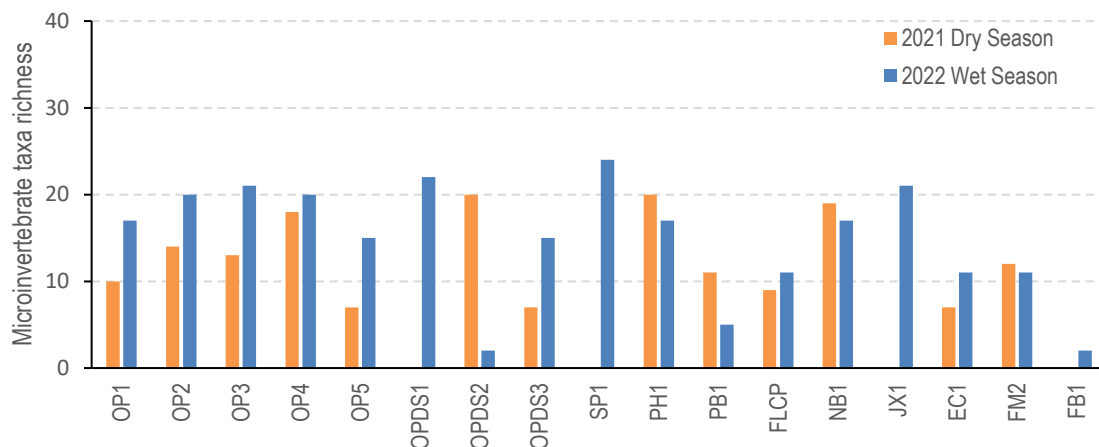


**Figure 5.** Plots of substrate compositions (left column) and habitat compositions (right column) showing percentage cover (%) at each site.

### 3.2 Microinvertebrate Fauna

#### 3.2.1 Taxonomic Composition

A total of 99 microinvertebrate taxa were recorded during the 2021 and 2022 seasonal surveys (Appendix 4). Of these, 67 were recorded in the dry season, while 77 were recorded in the wet season. In the 2021 dry season, microinvertebrate richness was greatest at sites OPDS2 and PH1 (20 taxa), while the greatest diversity (24 taxa) during the 2022 wet season survey was recorded at site SP1 (Figure 6). Site FRB1 recorded very low microinvertebrate richness with only two taxa recorded in the wet season. This site has historically recorded very low richness (Indo-Pacific Environmental 2022) and is likely explained by this site being highly ephemeral (i.e., very temporary) and existing as an isolated remnant pool of rainwater. Despite having the greatest microinvertebrate diversity in the 2021 dry season, OPDS2 recorded a very low richness (i.e., two taxa) during the 2022 Wet. Overall, the microinvertebrate community composition aligns with previous years monitoring (Indo-Pacific Environmental 2022).



**Figure 6.** The total number of microinvertebrate taxa recorded (taxa richness) from each site sampled during the 2021 dry season and 2022 wet season survey. N.B. instances where no taxa were recorded were not surveyed during that season.

Microinvertebrate fauna consisted of Cladocera (water fleas), Copepoda, Ostracoda (seed shrimp), Protista (Amoebozoa, Bryozoa) and Rotifera; which are typical major microinvertebrate groups found within aquatic systems in the Pilbara (Pinder *et al.* 2010). Rotifers were the most diverse taxa group in both seasonal surveys, followed by Cladocera (Table 8). Overall, diversity was comparable between seasons for the majority of groups except Rotifera, in which 6 more species were present in 2022. Rotifer diversity is understood to be influenced by seasonal variation in tropical aquatic systems, with overall diversity increasing during periods of high rainfall and connectivity (Casanova *et al.* 2009).

**Table 8.** Major microinvertebrate groups recorded from the study area during the dry 2021 and wet 2022 season.

	2021 Dry	2022 Wet
Cladocera	14	15
Copepoda	8	8
Ostracoda	7	7
Protista	8	10
Rotifera	30	37
<b>Total number of taxa</b>	<b>67</b>	<b>77</b>

### 3.2.2 Scientific significance of microinvertebrate fauna

Overall, the majority of microinvertebrate taxa recorded during both seasons were common species with cosmopolitan or Australasian distributions, with no listed species recorded in either season. One species of copepod (*Mesocyclops brooksi*) is considered an Australian endemic species, but is understood to be well distributed throughout the country (Halse *et al.* 2002).

One undescribed species of Rotifer (*Lecane* 'bulloid' sp. indet.) which has been recorded in previous years study (Indo-Pacific Environmental 2022) was again recorded at multiple sites in both wet and dry seasons. This undescribed species is understood to be a part of a complex of varying *Lecane* species, which differs from other lecanids due to its increased size and unique morphology (Dr Hendrik Segers, Royal Belgian Institute of Natural Sciences, pers. comm.). *Lecane* 'bulloid' was recorded from PH1 in dry 2021 and from OP4, OPDS3, SP1, PH1, JX1, EC1 and FM2 in wet 2022 (Appendix 4). An unidentified species of *Parastenocaris* (*Parastenocaris* sp. indet) was recorded at site FM2 in 2021 dry. Parastenocarid copepods are stygobiont species and do not typically occur in surface water samples (Karanovic, Cho and Lee 2012). The occurrence of a stygobiont species is unusual, but could be explained by hyporheic exchange between surface water and groundwater in the surrounding area.

## 3.3 Hyporheic Fauna

Viable hyporheic samples were not able to be collected from multiple sites during the 2021 dry and 2022 wet season surveys due to limited hyporheic zones existing and the presence of clay dominated substrates (which limit the inundation of water). In total, hyporheic fauna samples were collected from six sites in 2021 dry and 12 sites in the 2022 wet season survey (Table 4).

### 3.3.1 Taxonomic Composition

A total of 40 taxa were recorded across both seasonal surveys, with 18 species recorded in 2021 dry and 28 species in the 2022 wet season (Appendix 5). Hyporheic taxa richness over both seasons ranged between 12 taxa at OP1 in the 2022 wet season, to only two taxa at OP3 also during the 2022 wet season survey. When split into functional hyporheic categories (Boulton 2001), fauna categorised as stygobionts

(i.e., taxa that are not specialised for groundwater habitats) were the most prominent, totalling 67% of taxa in 2021 dry and 57% of taxa in 2022 wet. Occasional hyporheos stygophile fauna (i.e., taxa that are found in both hyporheic groundwater and surface water habitats) were less prominent in the dry season (accounting for 11% of total taxa) than in the wet season (making up 36% of total taxa recorded). Stygobites (i.e., taxa adapted to living in groundwater environments) accounted for 22% of hyporheic fauna diversity in the 2021 dry season compared to 7% in 2022 wet season. Fauna considered hyporheic (either occasional hyporheos stygophiles or stygobites) recorded in the study area are listed below.

### Occasional Hyporheos Stygophile

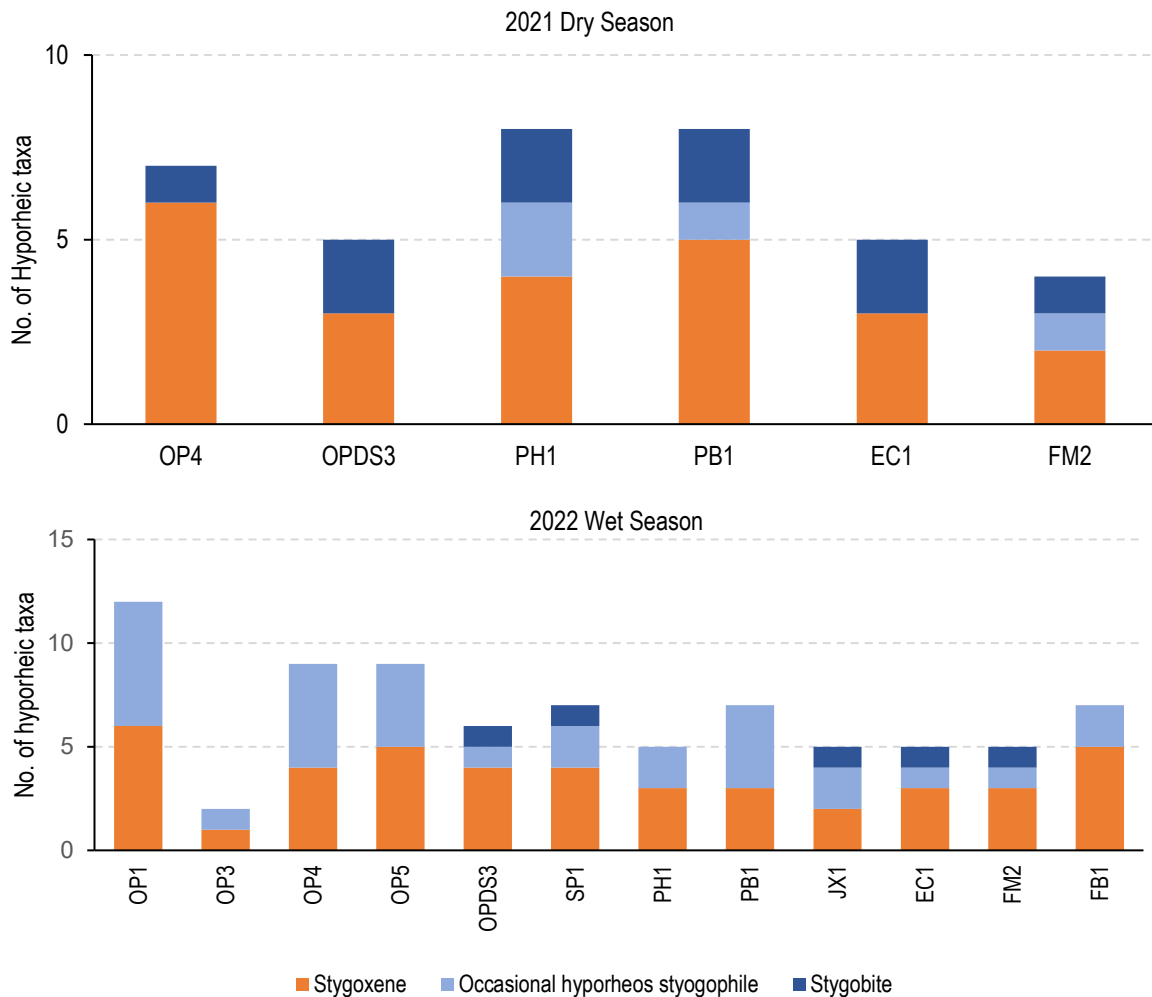
- Cladocera: *Karualona karua*
- Copepoda: Calanoida indet. sp. nauplii, Cyclopoida indet. sp. nauplii, *Ectocyclops phaleratus*, *Mesocyclops brooksi*, *Mesocyclops notius*, *Mesocyclops* sp. indet., *Microcyclops varicans* and *Thermocyclops decipiens*
- Oligochaeta: Naididae indet. sp. indet.
- Ostracoda: Ostracoda indet. sp. indet (juv) and Ostracoda indet. sp. indet.

### Stygobite

- Copepoda: *Parastenocaris jane*
- Ostracoda: *Candonopsis* cf. *tenuis*, *Candonopsis novaezealandiae* and *Vestalenula marmonieri*

#### 3.3.2 Scientific significance of hyporheic fauna

No significant fauna categorised as occasional hyporheos stygophiles were recorded during sampling, with all taxa displaying cosmopolitan or Australia wide distributions. It is apparent that stygobite fauna, particularly from the Pilbara region can have highly restricted distributions (Halse *et al.* 2014). One species recorded in both seasonal surveys, *Parastenocaris jane*, is considered a Pilbara endemic taxon. Although endemic to the Pilbara, *P. jane* is understood to be widespread throughout the region (Bennelongia 2013; WRM 2018). *Parastenocaris jane* has also been recorded at multiple sites upstream and downstream of the Ophthalmia Dam in previous years study (Indo-Pacific Environmental, 2022). The three stygobite Ostracod species recorded in the survey area do not have restricted distributions, with *C. tenuis* and *C. novaezealandiae* present Australia wide and *V. marmonieri* distributed throughout Australasia (Halse *et al.* 2002; Halse *et al.* 2014).



**Figure 7.** Taxonomic composition of hyporheic fauna recorded from each site during the 2021 dry season and 2022 wet season surveys, categorised using Boulton's (2001) hyporheic categories.

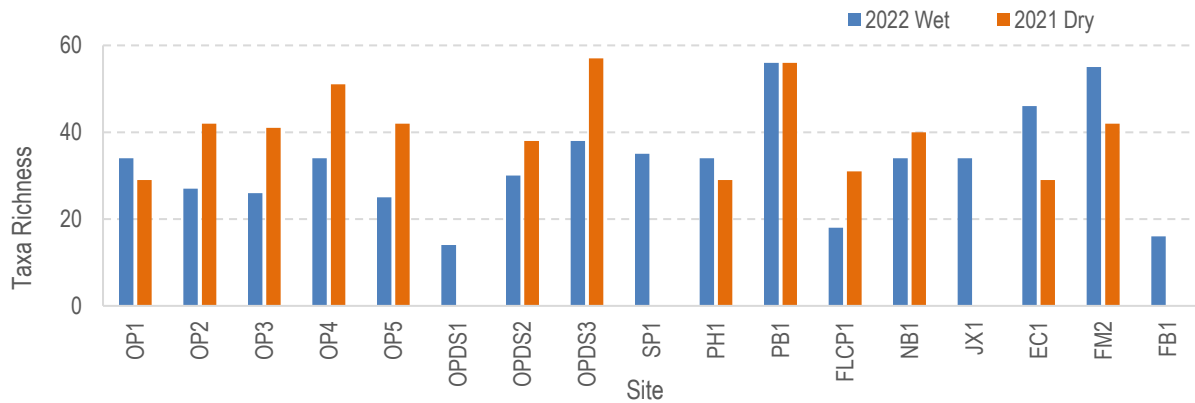
### 3.4 Macroinvertebrate Fauna

#### 3.4.1 Taxonomic Composition

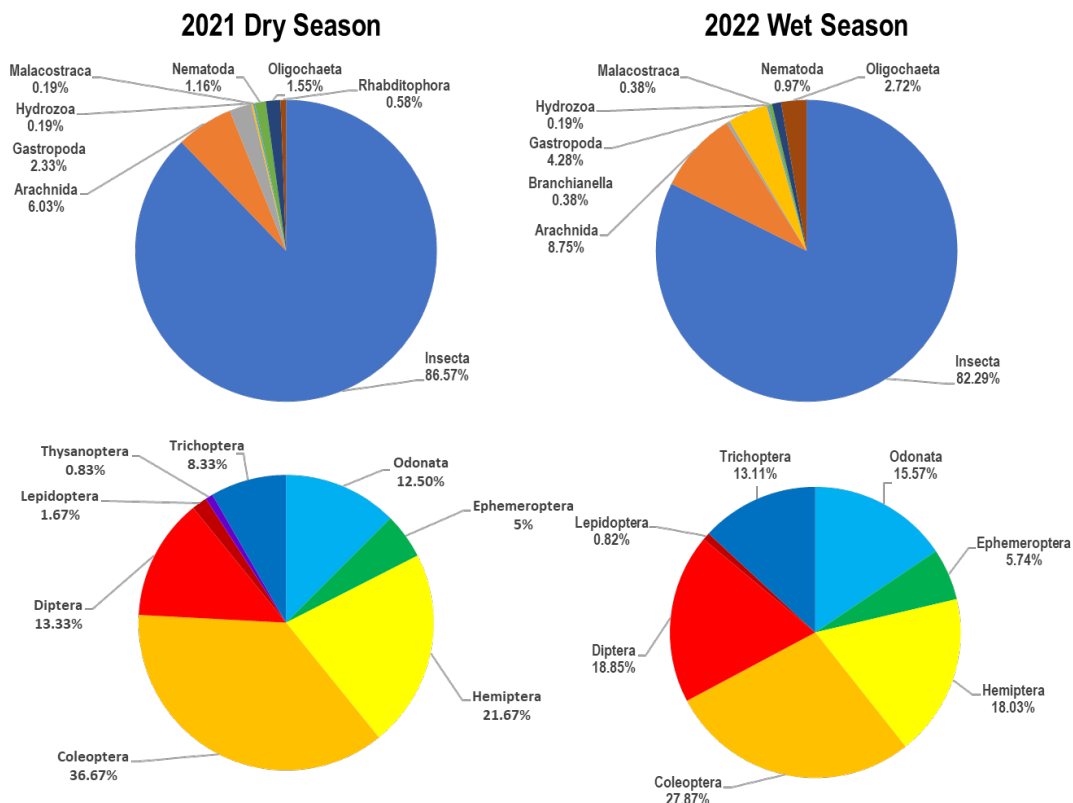
A total of 221 taxa were recorded over both seasons, with 144 taxa recorded during the 2021 dry survey and 152 taxa recorded in the 2022 wet survey (Appendix 6). The highest taxa richness was recorded from OPDS3 in 2021 with 57 taxa present whilst Pool B recorded the highest taxa richness in 2022 with 56 taxa present (Figure 8). Conversely, the lowest richness in 2021 was recorded at OP1, EC1 and Pool H with 29, whilst OPDS1 recorded the lowest richness in 2022 with 14 taxa present (Figure 8).

Taxonomic composition of both seasons was broadly comparable, with both 2021 dry season and 2022 wet season macroinvertebrate samples primarily composed of the group Insecta (86.57% and 82.30% respectively) followed by Arachnida and Gastropoda (Figure 9). Coleoptera were the most diverse insect order during dry and wet season surveys, (27.87% and 36.67% of species richness, respectively) (Figure 9). Diptera and hemiptera also accounted for much of the taxa richness in both 2021 and 2022 seasonal surveys (Diptera accounting for 18.85% in 2021 and 13.33% in 2022, Hemiptera accounting for 18.03%

in 2021 and 21.67 % in 2022). The remaining insect taxa also shared comparable richness, with the only notable difference between seasonal surveys being the lack of Thysanoptera specimens in 2022. The majority of taxa recorded from both seasonal surveys are considered common with widespread distributions throughout Australia and Australasia.



**Figure 8.** The total number of macroinvertebrate taxa recorded (taxa richness) from each site sampled during the 2021 dry season and 2022 wet season survey. N.B. instances where no taxa were recorded were not surveyed during that season.



**Figure 9.** Pie graphs displaying the classes of macroinvertebrate occurrences recorded during the 2021 dry season (top left) and 20212 wet season (top right) surveys, in addition, macroinvertebrate groups within the class Insecta recorded during the 2021 dry season (bottom left) and 2022 wet season (bottom right) surveys.

### 3.4.2 Scientific significance of macroinvertebrate fauna

Four significant species of Odonate were recorded within the study area, including *Eurysticta coolawanyah* (Pilbara Pin Dragonfly), *Hemicordulia koomina* (Pilbara Emerald), *Austroagrion pindrina* (Pilbara Billabongfly) and *Agriocnemis kunjina* (Pilbara Wisp). *Eurysticta coolawanyah* was the only species present in both the 2021 dry season and 2022 wet season surveys, with the remaining species only present in the 2022.

All these taxa are considered endemic to the Pilbara region and listed as Vulnerable on the ICUN Red List (Dow 2019; Dow 2019; Dow 2017; Dow 2017), however, the ICUN Red List has no legislative power in Australia, affording no protection under the EPBC Act or BC act for any of the species mentioned. All species are listed as vulnerable primarily due to their restricted or unknown range, but are also vulnerable to impacts associated with groundwater abstraction resulting in habitat degradation. Despite their listing as vulnerable due to their limited range, a review by Bush *et al.* (2014) suggested that *E. coolawanyah*, *H. koomina* and *A. pindrina* have ranges exceeding 100 000 km<sup>2</sup>, which aligns with widespread records of these species occurring throughout the Pilbara (DEC 2009; CSIRO 2015; Pinder *et al.* 2010). *Agriocnemis kunjina* is the only species with an estimated range under 10 000km<sup>2</sup> (Bush *et al.* 2014).

**Table 9.** Numbers of individuals of Pilbara endemic macroinvertebrate species recorded during the 2021 dry season and 2022 wet season survey.

Survey Period	Species	OP1	OP4	OP5	OPDS2	OPDS3	PB1	FM2	SP1	EC1	NB1
2021 Dry Season	<i>Eurysticta coolawanyah</i>	-	-	-	-	5	-	-	-	-	-
2022 Wet Season	<i>Hemicordulia koomina</i>	1	-	1	-	-	-	-	-	-	-
	<i>Eurysticta coolawanyah</i>	-	-	-	-	-	-	-	-	-	8
	<i>Austroagrion pindrina</i>	-	2	-	-	-	-	-	-	-	-
	<i>Agriocnemis kunjina</i>	-	-	-	1	1	3	1	1	2	-

### 3.5 Sediment Rehydration

A total of 34 taxa were recorded from sediment rehydration samples collected during the 2021 dry season, consisting of seven rotifers, one copepod, 17 cladocera, seven ostracoda, one bryozoan and one platyhelminth. Taxa richness ranged from 0 (i.e., no taxa hatched in sample) at sites OP2, OP4 and OPDS3 to 14 at Pool H (Appendix 7a). The absence of taxa in roughly 20% of samples may be explained by the opportunistic nature of sediment rehydration sampling and the tendency for samples to become anoxic during the rehydration process due to the presence of large quantities of organic matter. Only seven taxa were hatched from samples collected in the 2022 wet season survey including one cladocera, three ostracoda, two collembola and one nematode. Taxa richness ranged from 0 (at the majority of sites) to four at sites OP4 and OP2 (Appendix 7b).

Sediment hatching trials during wet seasonal surveys have historically had limited success (Indo-Pacific Environmental 2022), with multiple factors potentially explaining reduced hatching rates. Ideal rehydration trials require dry sediments with no organic matter from areas that have been recently inundated. Elevated water levels in wet season conditions limit the amount of viable sediment available for collection, resulting in sediment collection in dry areas where sediments are likely infrequently inundated. It is apparent that sediment rehydration although beneficial to dry season surveys is of less use during wet season surveys.

### 3.5.1 Scientific significance of emergent taxa

The majority of taxa hatched were species that are common and have been previously recorded in the Pilbara in sediment rehydration or microinvertebrate sweep samples. Although less diverse than microinvertebrate sweeps, there were nine taxa including an undescribed species of cladocera (*Rak* sp. indet.) that were only recorded in sediment rehydration samples, suggesting that hatching trials can complement microinvertebrate sweeps if viable sediments are present.

## 3.6 Other Fauna

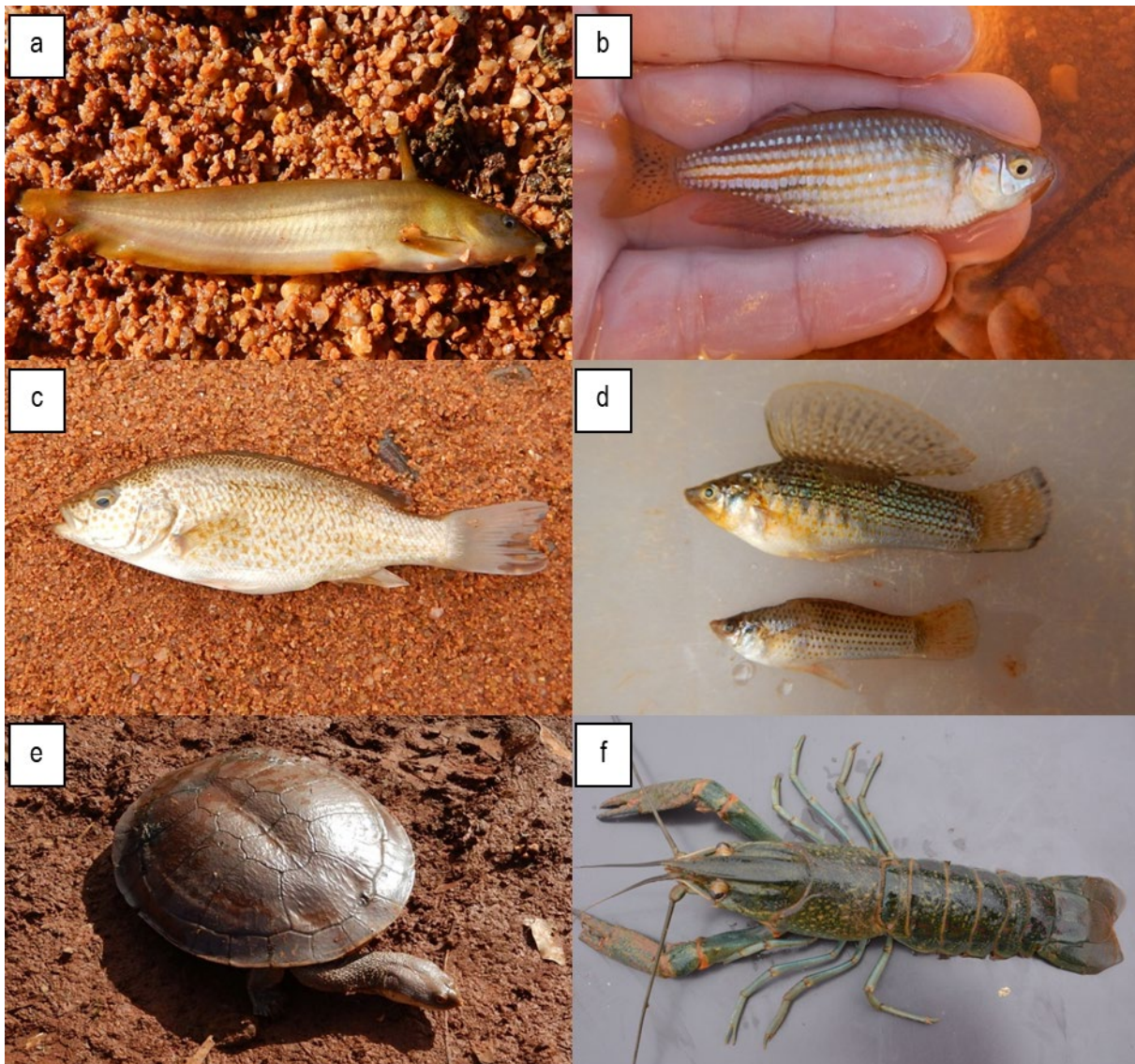
A total of five vertebrate species, comprising three native fish species, one introduced fish species and one reptile species, were recorded during both seasons (Plate 1). The introduced crustacean *Cherax quadricarinatus* was also recorded at multiple sites within the survey area. All native fish and reptile species recorded are widely distributed within the Pilbara region, with most also occurring more broadly throughout Australian inland waters (Cogger 2014, Doughty *et al.* 2011, Morgan *et al.* 2014, Morgan and Gill 2004). No specimens caught were considered significant species afforded protection under Western Australian State or Federal legislation.

### 3.6.1 Fish

Three native fish species *Leiopotherapon unicolor* (Spangled Perch), *Melanotaenia australis* (Western Rainbowfish) and *Neosilurus hyrtlilii* (Hyrtl's Tandan) were recorded during the survey. These species are common throughout north-western Australia including the Pilbara region (Allen *et al.* 2002, Morgan *et al.* 2014). The low number of fish species caught in this survey is typical of the diversity found in the upper Fortescue River catchment and aligns with the Morgan and Gill (2004) and Morgan *et al.* (2009), which highlighted the low diversity of the upper Fortescue in comparison to the lower Fortescue River and associated drainage basins. This low diversity is attributed to the arid climate, ephemeral nature and sporadic flow periods of Pilbara aquatic systems. (Allen *et al.* 2002). The introduced species *Poecilia latipinna* (Sailfin Molly) was also recorded during both seasons, being first recorded within the region in 2017 (Indo-Pacific Environmental 2017a).

A total of 5368 fish were recorded during the 2021 dry season survey, with *L. unicolor* the most abundant, accounting for 73.5% (n=3883) of individuals (Table 10). This species was also the most widespread, occurring at 12 of the 13 sites surveyed (Table 10). *Neosilurus hyrtlilii* was the second most abundant, accounting for 16.13% (n=852) of individuals and present at 8 sites. *M. australis* was less abundant, accounting for 10.37% (n=548) of total fish abundance. Although the least abundant native fish, *M.*

*australis* was very widespread, present at 11 sites in total. *Poecilia latipinna* was the least abundant fish, accounting for 1.5% of total fish abundance, and was only visually recorded at one site.



**Plate 1.** Aquatic fauna recorded within the study area; a) *Neosilurus hyrtlui*, b) *Melanotaenia australis*, c) *Leiopotherapon unicolor* d) *Poecilia latipinna*, e) *Chelodina steindachneri* and f) *Cherax quadricarinatus*.

In relation to the wet season survey, 3262 fish were recorded with *L. unicolor* and *N. hyrtlui* being the two most abundant species, representing 47.2% (n=1541) and 42.9% (n=1400) of total fish recorded, respectively (Table 10). These species were also the most widespread, with *L. unicolor* occurring at 14 sites and *N. hyrtlui* at 11 sites. The notable reduction in the number of *L. unicolor* captured during the wet season may be explained by the spawning behavior of *L. unicolor*, which are known to spawn later in the year (i.e., around the time of the 2021 survey) (Llewellyn, 1973). The large numbers of new recruits, evident in the 2021 age-class structure composition also suggest that *L. unicolor* may have spawned several weeks prior to the 2021 dry season survey (Figure 10). The abundance of *N. hyrtlui* was also seen to be higher during the wet season survey. This may potentially be explained by the behavioral adaptation

of the species to form dense congregations to avoid predation and spawn (Morgan and Gill, 2004), This may explain the high number encountered at site JX1, where 994 individuals were recorded. The remaining species, *M. australis* and *P. latipinna*, were less abundant, accounting for 9.7% (n=317) and <0.1% (n=4) of the total fish composition. Similar to 2021, *M. australis* was widespread, being found at 10 sites, whilst *P. latipinna* was only found at three sites, all of which were located downstream of Ophthalmia Dam in relatively close proximity (OPDS1, OPDS3 and PB1). *Melanotaenia australis* was present in very similar distribution and abundance between 2021 dry and 2022 wet season surveys. Although total abundance of *P. latipinna* was distinctly lower in 2022, the distribution appears to be more widespread, being recorded at four sites downstream of the Ophthalmia Dam.

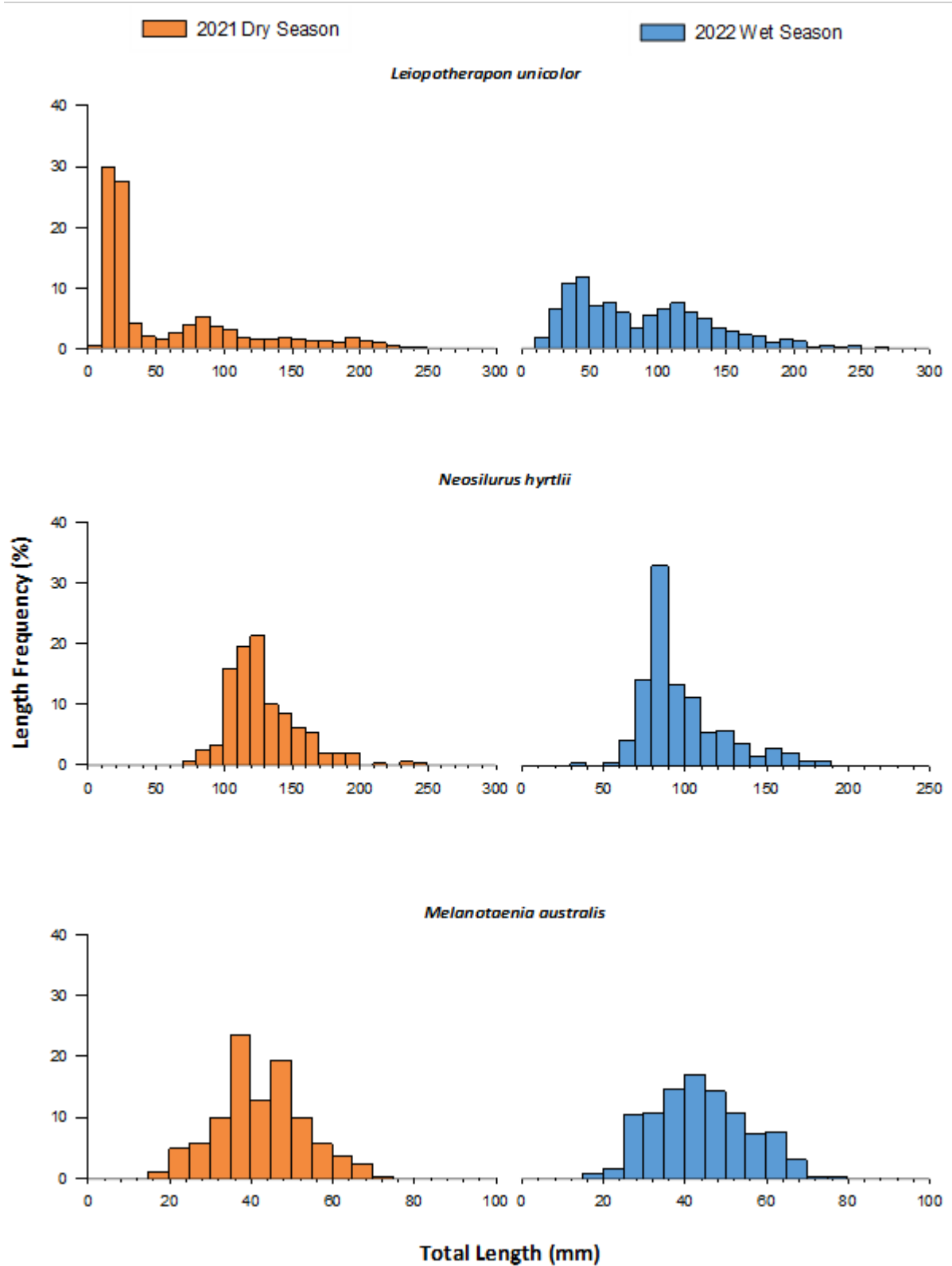
**Table 10.** The total number of aquatic fauna recorded at each site sampled during the 2021 dry season and 2022 wet season survey using all survey methods. N.B. Introduced species have been highlighted red, sites not surveyed during a season are highlighted grey and (\*) indicates visual occurrence only.

Site Code	2021 Dry Season						2022 Wet Season					
	<i>Chelodina steindachneri</i>	<i>Leiopotherapon unicolor</i>	<i>Melanotaenia australis</i>	<i>Neosilurus hyrtii</i>	<i>Poecilia latipinna</i>	<i>Cherax quadricarinatus</i>	<i>Chelodina steindachneri</i>	<i>Leiopotherapon unicolor</i>	<i>Melanotaenia australis</i>	<i>Neosilurus hyrtii</i>	<i>Poecilia latipinna</i>	<i>Cherax quadricarinatus</i>
WC1												
FRB1												
OP1		325	19	21			50	7	5		3	
OP2		143		341		61	3	106	143	240	36	
OP3		86	17	139		35	4	67	24	18	26	
OP4		504	24	231				82	1	30	3	
OP5	3	42	332	105		34	1	227		2	27	
OPDS1										1*		
OPDS2	3						4					
OPDS3		93	17	13		149		28	33	7	2	
OPDS5*		125*	55*	1*	85*							
PB1		29	5	1		7		38	6		1	
PH1		135	2					6	8		2	
FM2		342	2					38		3	21	
SP1								242		82	2	
EC1		1187	5					120	86	18	35	
JX1								152	5	994	71	
FLCP1							8	169	3		35	
NB1	5	872	70					216	1	1	24	
<b>Total Number</b>	<b>11</b>	<b>3883</b>	<b>548</b>	<b>852</b>	<b>85*</b>	<b>286</b>	<b>20</b>	<b>1541</b>	<b>317</b>	<b>1400</b>	<b>4</b>	<b>365</b>
<b>Sites Recorded</b>	<b>3</b>	<b>12</b>	<b>11</b>	<b>8</b>	<b>1</b>	<b>5</b>	<b>5</b>	<b>14</b>	<b>11</b>	<b>11</b>	<b>3</b>	<b>14</b>

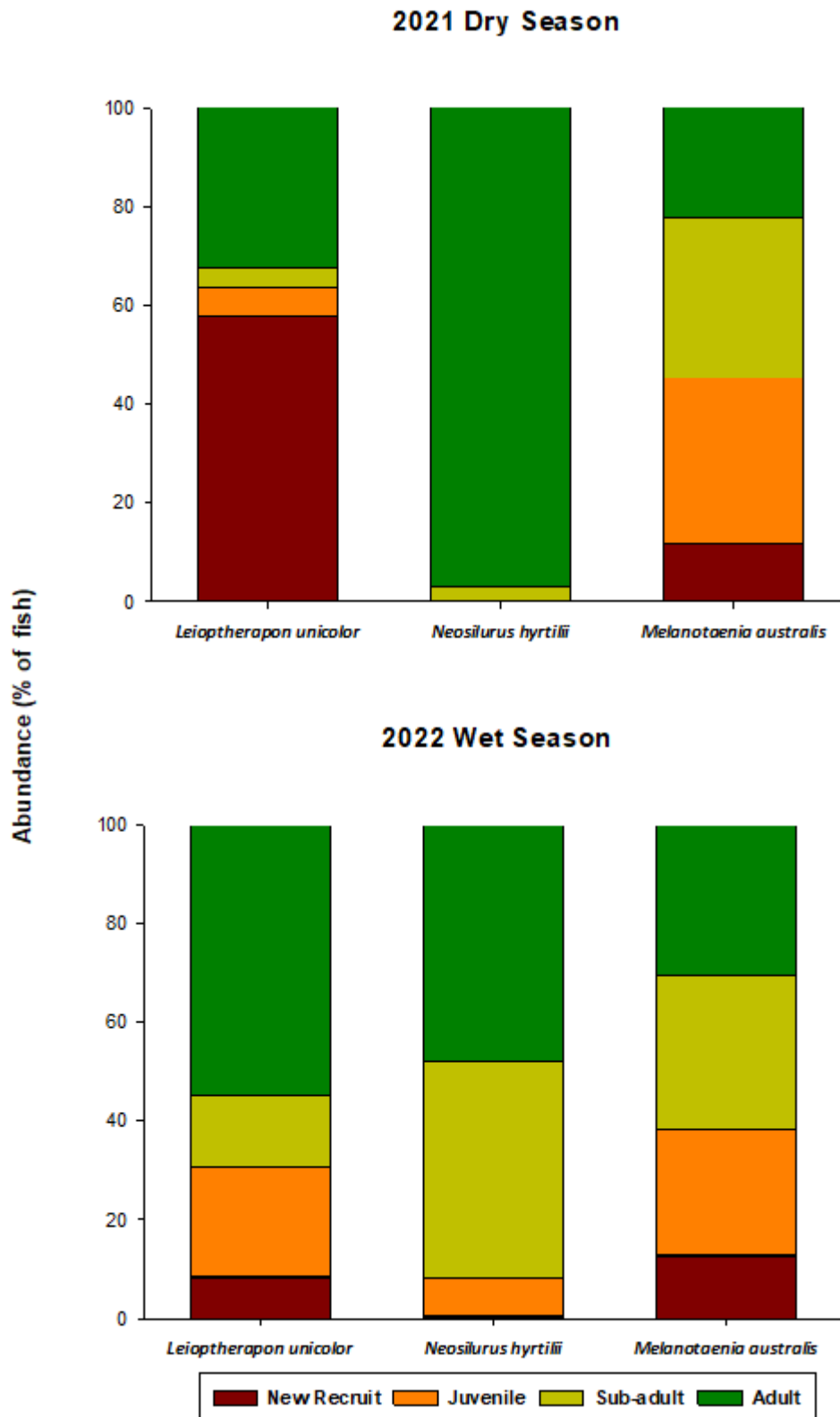
Length-frequency data of all native fish species and population structure age classes were attained from available literature (Beesley 2006; Bishop *et al.* 2001; Lake 1971) and visually presented (Figures 10 and Figure 11). *P. latipinna* was not included due to the limited amount of length data available from both 2021 dry and 2022 wet season surveys. For all three native fish species, multiple size classes were present in

both seasonal surveys, suggesting that populations are self-sustaining. *Leiopotherapon unicolor* displayed a greater composition of new recruits in the 2021 dry season, while *N. hyrtlilii* were primarily composed of adults in the 2021 dry season, with an increase in juveniles and sub-adults in the later 2022 wet season survey. Both these results are aligned with previous surveys (Indo Pacific Environmental 2022) and relevant literature (Llewellyn 1973) which state that environmental cues, primarily water temperature, are understood to trigger spawning of fish in Australian riverine systems. *Leiopotherapon unicolor* are known to spawn when water temperatures exceed 20°C, whilst *N. hyrtlilii* spawn when water temperatures exceed 26°C (Llewellyn 1973; Allen *et al.* 2002; Lintermans 2007; Morgan *et al.* 2014, Orr and Milward 1984; Allen *et al.* 2002), with these behaviours apparent in survey results (Figure 12). *Leiopotherapon unicolor* appear to have spawned close to the 2021 dry survey while water temperatures are warming and may explain the high number of new recruits at the time of survey. *Neosilurus hyrtlilii* appeared to spawn in between the seasonal surveys when water temperatures would have been highest (BOM 2021), explaining the presence of both juvenile and sub-adults and some new recruits during the 2022 wet season survey, which were not found in the 2021 dry survey.

In regards to *P. latipinna*, the species was present at a single site in 2021 and at multiple sites in 2022. The distribution of *P. latipinna* during the current study appeared to be limited to sites immediately downstream of Ophthalmia Dam, however previous surveys have found the species occurring further downstream (Indo-Pacific Environmental, 2018; Indo-Pacific Environmental, 2022). Regarding the influence on native fish populations, at the majority of sites where *P. latipinna* were recorded, all three species of native fish were present in comparable abundances to sites where *P. latipinna* was absent. This suggests that in their current abundance *P. latipinna* appear to be coexisting with native fish populations. Despite this, literature suggests that *P. latipinna* are potentially capable of adversely effecting native fish populations through habitat modification and degradation (Corfield *et al.* 2008). If *P. latipinna* populations did increase within the Fortescue River catchment, adverse effects on native fish communities may become more apparent. Invasive *P. latipinna* are also understood to influence native macroinvertebrate communities (Corfield *et al.* 2008). In 2021 comparisons between invertebrate richness and *P. latipinna* could not be made as no invertebrate sample was taken at OPDS5, the only site which the species was present. In the 2022 dry season survey, invertebrate richness at sites where *P. latipinna* were present (OPDS1, OPDS3 and Pool B) were amongst the highest recorded the data attained in that year (Appendix 6.) This suggests that in their current population, *P. latipinna* appear to be having no discernible effect on local macroinvertebrate communities. However much like native fish communities, if populations of *P. latipinna* increase in the future, adverse effects on invertebrate assemblages may become more evident.



**Figure 10.** Combined length frequency plots of each fish species recorded from all sites within the study area during the 2021 dry season and 2022 wet season survey.



**Figure 11.** Combined age-class structures of native fish species recorded from all sites within the study area during the 2021 dry season (top) and 2022 wet season (bottom) survey.

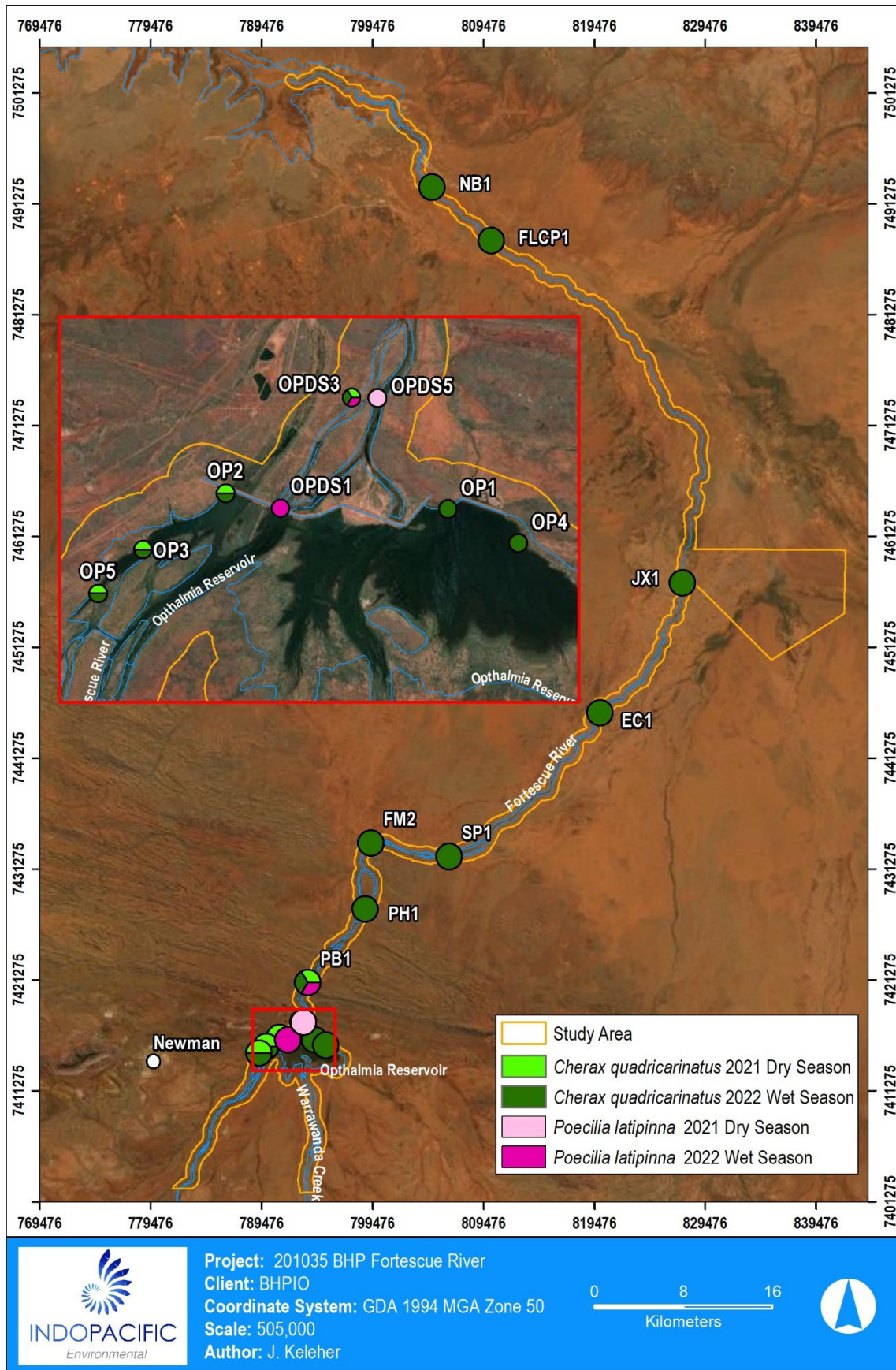
### 3.6.1 Reptiles

*Chelodina steindachneri* is the only freshwater turtle that occurs in the Pilbara bioregion (Cogger 2014). A total of 11 individuals were recorded from three sites during the 2021 dry season survey, while 20 individuals were recorded from five sites in the 2022 wet season survey (Table 10). Straight-line carapace lengths recorded were between 130-210mm in the dry season and between 110-180mm in the wet season. The higher abundance encountered during the wet season is likely explained by the greater amount of water present at that time. In addition, *C. steindachneri* is known to aestivate through dry periods or when water levels are receded (Georges *et al.* 1993; Kuchling 1988). Peak breeding activity also occurs during the wet season (Legler and Georges 1993), which may also explain the higher activity and spread of *C. steindachneri* during the 2022 survey.

### 3.6.2 Freshwater Crayfish

The introduced *C. quadricarinatus* (Redclaw Crayfish) has been recorded in Pilbara waterbodies since 2013, and has rapidly increased in abundance and distribution throughout the region since that time (Pinder *et al.* 2019). The first recorded occurrence in the Fortescue River catchment was in Ophthalmia Dam in 2018 (Indo-Pacific Environmental 2018) and has since become widespread in both the dam and associated tributaries of the Fortescue River (Indo-Pacific Environmental, 2022). In total, 286 individuals were recorded from five sites during the 2021 dry season survey, whilst 365 individuals were recorded from 14 sites in the 2022 wet season survey (Table 10). The distribution of *C. quadricarinatus* in both seasonal surveys was comparable to studies undertaken in previous years, however the number of individuals recorded in the 2021 dry season was higher in comparison to previous dry season surveys (i.e., 286 individuals in 2021 vs 87 individuals in 2020).

The presence of *C. quadricarinatus* at the majority of survey sites assessed in 2022, in comparison to only one site in 2018 (Indo-Pacific environmental 2018), indicates the species has established a robust population over a widespread area in the upper Fortescue River catchment in under four years. *Cherax quadricarinatus* has demonstrated an ability to rapidly colonise areas during periods of flow and connectivity. Ecological impacts of *C. quadricarinatus* in the Pilbara are undetermined, although small scale studies suggest that invasive freshwater crayfish can potentially alter macroinvertebrate community assemblages and reduce macrophyte cover (Pinder *et al.* 2019). It is difficult to assess the current impacts of *C. quadricarinatus* in the Ophthalmia Dam and Fortescue River at this point, however as the species density and distribution increases changes are likely to become evident. Indeed, additional monitoring would be beneficial to gain an increased understanding of the ecological impact of the species in the upper Fortescue River catchment.



**Figure 12.** Distribution of the introduced aquatic fauna during the 2021 dry season and 2022 wet season survey.

## 4 CONCLUSIONS

This study builds on previous surveys of aquatic fauna undertaken in the upper Fortescue River and provides additional insight into the diversity present and the utilisation of habitat. The section of the Fortescue River assessed is highly seasonal with a large amount of the river channel typically drying out during the dry season. However, in recent years atypical volumes of water has been present in the Fortescue River downstream of Ophthalmia Dam during the dry season as a result of water being released from the dam. It is understood that the release of water from the Ophthalmia Dam occurs to maintain the dam wall integrity as well as during the wet season after large rainfall events. As water was being released near the time of current survey, typical riverine conditions were not apparent at sites below Ophthalmia Dam. As such results collected during the dry season component of the current survey may not represent a typical 'dry season' scenario. However, considering it is likely that water will continue to be discharged from the dam the attained results may be representative of the conditions to be encountered in future surveys.

Varying water quality parameters were seen to be in exceedance of ANZG guidelines (2018) at the majority of sites during both seasons; including electrical conductivity (EC), dissolved oxygen (%), pH, total nitrogen (TN), total phosphorus (TP) and NO<sub>x</sub>. However, this result is consistent with previous survey work undertaken in the same part of the Fortescue River catchment, with water quality parameters being associated with Pilbara catchment geology, time of sampling and land use (primarily livestock access to waterbodies).

In stream habitat assessments found that the majority of sites scored a moderate rating, with multiple sites being classified as 'poor'. This was primarily due to sites being impacted by cattle or lacking in stream habitat and structure at the time of each survey. All habitats assessed were typical of those in the Fortescue River catchment, although the altering of typical "wet-dry" flow regimes in the catchment caused by dewatering throughout the year potentially provides habitat for aquatic fauna which would usually perish in the dry season.

Of the 100 microinvertebrate taxa, 40 hyporheic taxa, 34 sediment rehydration taxa and 221 macroinvertebrate taxa recorded, the majority were considered widespread and common throughout Northern Australia, Australia and Australasia. Regarding significant macroinvertebrate fauna, a limited number of taxa recorded were considered Pilbara endemic. Four odonate species (*E. coolawanyah*, *H. koomina*, *A. pindrina* and *A. kunjina*) recorded are currently listed on the ICUN red list as "Vulnerable", although this listing has no legislative relevance under the EPBC or BC acts. *Agrioncnemis kunjina* was the only species recorded with an estimated range under 10 000km<sup>2</sup>, with all other Odonata estimated to have ranges exceeding 100 000km<sup>2</sup>. The majority of microinvertebrate fauna collected were widespread and considered typical of the Pilbara region. Unusually, one Parastenocarid copepod (*Parastenocaris* sp. indet.) was found in surface microinvertebrate sweeps, but is likely explained by hyporheic interaction between surface water and ground water. One Pilbara endemic species, *P. jane*, was recorded in hyporheic samples in both seasons. Although endemic to the Pilbara, the species is considered

widespread throughout the region. No Western Australian or Pilbara Endemic species were recorded in the sediment emergent samples, although 9 taxa unique to hatching trials including one undescribed species of Cladocera (*Rak. sp. indet*) were recorded.

All native vertebrate fauna recorded were well distributed throughout the survey area during both wet and dry seasons. The three native fish species recorded (*N. hyrtlii*, *L. unicolor* and *M. australis*) are very common throughout the Pilbara and are typical species found within the Fortescue River catchment (Morgan *et al.* 2014; Morgan and Gill 2004). One species of aquatic reptile (*C. steindachneri*) was recorded in both seasonal surveys and is also widespread and a species typically encountered in the Fortescue River catchment. No native vertebrate species recorded were listed under the EPBC and BC Acts. Two introduced species (*C. quadricarinatus* and *P. latipinna*) were recorded at multiple sites during both dry and wet seasonal surveys. Both species have been previously recorded throughout the study area suggesting that these species have established self-sustaining populations. Noting the spatial distribution and abundance of these species, eradication of either would be extremely difficult. Localised impacts of both invasive species are difficult to determine, but currently do not appear to be detrimentally affecting the ecology within the survey area. However, as *C. quadricarinatus* and *P. latipinna* populations increase, further monitoring may help determine if native aquatic fauna or habitat is affected by these introduced species.

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## **APPENDICES**

**Appendix 1. Photographs taken at sites surveyed during the 2021 dry season and 2022 wet season.**





2021 dry season	2022 Wet Season
<p data-bbox="209 264 304 304"><b>OPDS1</b></p> <p data-bbox="432 443 552 477">No Photo</p>	
<p data-bbox="209 734 304 775"><b>OPDS2</b></p> 	
<p data-bbox="209 1171 304 1211"><b>OPDS3</b></p> 	
<p data-bbox="209 1630 264 1671"><b>PB1</b></p> 	

2021 dry season	2022 Wet Season
<p><b>PH1</b></p>  A photograph of a river in a dry season. The water is shallow and brown, with exposed banks of red soil and sparse, dry vegetation. A yellow label 'PH1' is in the top left corner.	 A photograph of the same river in a wet season. The water is deep, clear, and reflects the sky. The banks are lush with green grass and trees. A yellow label 'PH1' is in the top left corner.
<p><b>FM2</b></p>  A photograph of a river in a dry season. The water is shallow and brown, with exposed banks of red soil and sparse, dry vegetation. A yellow label 'FM2' is in the top left corner.	 A photograph of the same river in a wet season. The water is deep, clear, and reflects the sky. The banks are lush with green grass and trees. A yellow label 'FM2' is in the top left corner.
<p><b>SP1</b></p> <p>Inaccessible</p>	 A photograph of a river in a wet season. The water is deep, clear, and reflects the sky. The banks are lush with green grass and trees. A yellow label 'SP1' is in the top left corner.
<p><b>EC1</b></p>  A photograph of a river in a dry season. The water is shallow and brown, with exposed banks of red soil and sparse, dry vegetation. A yellow label 'EC1' is in the top left corner.	 A photograph of the same river in a wet season. The water is deep, clear, and reflects the sky. The banks are lush with green grass and trees. A yellow label 'EC1' is in the top left corner.



**Appendix 2a. In situ water quality results. Highlighted cells indicate exceedance of DGVs in the ANZG 2018 Guidelines**

Survey Period	Reach	Site	Conductivity	Dissolved Oxygen		pH	Salinity	Temperature	
			µS/cm	(ppm)	(%)	(+)	(PSU)	(°C)	
2021 Dry Season	Lakes, reservoir and wetlands DGVs		90-900	-	90-120	6-8	-	-	
	Ophthalmia Dam	OP1	881	7.32	89.3	10.08	0.43	22.98	
		OP2	892	6.56	38.6	8.6	0.42	27.29	
		OP3	863	6.33	88.4	7.55	0.43	28.56	
		OP4	971	8.63	115.2	9.77	0.48	27.2	
		OP5	924	5.01	65.2	7.74	0.45	26.8	
	Lowland River DGVs		20-250	-	85-120	6-8	-	-	
	Ophthalmia Dam Downstream	OPDS1	761	2.71	34.4	9.27	0.37	23.77	
		OPDS2	901	9.9	134.5	8.51	0.44	27.53	
		OPDS3	1607	5.48	74.1	7.85	0.91	26.79	
	Fortescue River Downstream of Ophthalmia Dam	NB1	647	4.81	66.1	9.2	0.32	29.49	
		FM2	928	4.99	61.5	9.15	0.46	22.99	
		PB1	900	5.48	67.7	9.76	0.44	23.38	
		PH1	927	7.32	98.4	9.34	0.45	27.8	
		EC1	994	5.8	77.2	9.71	0.49	27.35	
		FLCP1	2233	6.48	97.8	9	1.12	34.9	
	2022 Wet Season	Lowland River DGVs		20-250	-	85-120	6-8	-	-
		Upstream of Ophthalmia Dam	FRB1	226	3.55	41.5	7.25	0.11	20.21
		Lakes, reservoir and wetlands DGVs		90-900	-	90-120	6-8	-	-
Ophthalmia Dam		OP1	804	9.05	107.1	8.49	0.39	21.09	
		OP2	699	7.36	91.1	7.9	0.34	23.77	
		OP3	604	9.27	106.9	7.61	0.38	19.15	
		OP4	810	7.25	87.6	8.26	0.4	20.03	
		OP5	734	6.43	79.2	7.25	0.36	21.48	
Lowland River DGVs		20-250	-	85-120	6-8	-	-		
Ophthalmia Dam Downstream		OPDS1	650	6.26	75.6	7.77	0.32	20.46	
		OPDS2	1033	10.8	128.5	7.41	0.51	21.01	
		OPDS3	2073	6.13	73.4	7.88	1.06	21.59	
Fortescue River Downstream of Ophthalmia Dam		PB1	816	8.53	98.6	7.75	0.4	19.01	
		PH1	828	10.74	123.1	8.01	0.41	19.74	
		FM2	826	9.51	111.9	8.42	0.41	21.09	
		SP1	777	9.7	114.5	8.45	0.41	21.92	
		EC1	829	8.75	104	8.37	0.41	21.01	
		JX1	813	8.09	93.4	8.06	0.4	19.67	
		FLCP1	805	9.03	107	8.53	0.4	21.15	
	NB1	502	7.92	90.6	8.01	0.24	18.64		

**Appendix 2b.** Laboratory results of nutrient and alkalinity concentrations, and turbidity. Highlighted values indicate exceedances of the corresponding tropical Australia Default Guideline Values (DGV) from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018).

Survey Period	Reach	Site	Turbidity	Ammonia as N	Nitrite + Nitrate as N (N_NOx)	Total Nitrogen	Total Phosphorus	Alkalinity (CaCO <sub>3</sub> )
			NTU	ug/L	ug/L	ug/L	ug/L	mg/L
		Reporting Limit	15	10	10	10	10	1
2021 Dry Season	Lakes, reservoir and wetlands DGVs		2–200	-	10	350	10	-
	Ophthalmia Dam	OP1	-	<10	<10	2000	60	141
		OP2	-	10	<10	700	20	212
		OP4	-	10	<10	1400	50	141
		OP5	-	20	<10	700	20	230
	Lowland River DGVs		2–15	-	10	200–300	10	-
	Ophthalmia Dam Downstream	OPDS1	-	20	<10	1400	30	166
		OPDS2	-	30	<10	500	<10	248
		OPDS3	-	<10	<10	500	20	528
	Fortescue River Downstream of Ophthalmia Dam	NB1	-	10	<10	1900	100	142
		FM2	-	<10	<10	600	10	138
		PB1	-	20	<10	800	30	141
		PH1	-	20	<10	400	20	142
		EC1	-	20	<10	400	30	148
		FLCP1	-	50	<10	5600	320	115
	2022 Wet Season	Lowland River DGVs		2–15	-	10	200–300	10
Upstream of Ophthalmia Dam		FRB1	28.7	220	<10	800	50	109
Lakes, reservoir and wetlands DGVs		2–200	-	10	350	10	-	
Ophthalmia Dam		OP1	17.83	<10	<10	800	40	176
		OP2	17.21	10	<10	400	30	206
		OP3	22.32	20	<10	600	40	229
		OP4	34.15	30	<10	1100	60	177
		OP5	8.16	40	<10	300	30	241
Lowland River DGVs		2–15	-	10	200–300	10	-	
Ophthalmia Dam Downstream		OPDS1	16.33	150	20	1700	40	183
		OPDS2	0.47	20	<10	200	<10	287
		OPDS3	0.99	40	<10	600	10	572
Fortescue River Downstream of Ophthalmia Dam		PB1	7.82	20	20	400	30	182
		PH1	4.1	10	50	600	30	185
		FM2	2.03	30	<10	500	30	185
		SP1	7.75	30	<10	500	20	90
	EC1	2.14	30	<10	300	20	180	
	JX1	1.97	10	<10	400	20	174	
	FLCP1	33.26	50	<10	400	30	163	
	NB1	124	20	20	600	50	101	

**Appendix 2c.** Laboratory results of total suspended solids (TSS), hardness and ionic analyte concentrations (mg/L).

Season Year	Reach	Site	TSS	Hardness as CaCO <sub>3</sub>	Ions				
					Chloride	Calcium	Magnesium	Sodium	Potassium
		Reporting Limit	5	1	1	1	1	1	1
2021 Dry Season	Ophthalmia Dam	OP1	19	246	192	16	50	87	11
		OP2	<5	278	133	29	50	70	9
		OP4	<5	252	204	15	52	89	12
		OP5	<5	293	138	25	56	75	10
	Ophthalmia Dam Downstream	OPDS1	<5	267	137	23	51	81	10
		OPDS2	<5	264	145	35	43	88	4
		OPDS3	<5	240	288	40	34	294	12
	Fortescue River Downstream of Ophthalmia Dam	NB1	11	146	146	19	24	90	13
		FM2	<5	248	201	20	48	90	11
		PB1	<5	244	194	17	49	90	11
		PH1	<5	249	194	19	49	91	11
		EC1	<5	267	208	31	46	96	12
		FLCP1	52	390	649	69	53	253	31
2022 Wet Season	Upstream of Ophthalmia Dam	FRB1	37	83	7	25	5	12	4
	Ophthalmia Dam	OP1	6	249	129	37	38	68	12
		OP2	7	244	80	40	35	53	8
		OP3	74	274	92	44	40	59	8
		OP4	58	251	132	38	38	68	12
		OP5	12	290	86	47	42	56	8
	Ophthalmia Dam Downstream	OPDS1	<5	209	102	36	29	63	10
		OPDS2	<5	342	166	58	48	91	6
		OPDS3	<5	271	372	46	38	337	16
	Fortescue River Downstream of Ophthalmia Dam	PB1	10	251	130	38	38	71	12
		PH1	<5	249	135	37	38	72	12
		FM1	<5	249	135	37	38	72	12
		SP1	19	119	58	18	18	34	5
EC1		<5	240	138	32	39	74	12	
JX1		<5	236	138	32	38	74	12	
FLCP1		16	216	146	27	36	79	13	
NB1		10	126	84	24	16	53	11	

**Appendix 3.** Habitat factors recorded for qualitative habitat assessment based on AUSRIVAS methods of sites surveyed for aquatic fauna in the Fortescue River in October 2021 and May 2022.

2021 Dry Season															
Habitat component	Attribute	OP1	OP2	OP3	OP4	OP5	OPDS1	OPDS2	OPDS3	PB1	PH1	FM2	EC1	FLCP1	NB1
<b>Site Measures</b>	Habitat Type	Dam	Dam	Dam	Dam	Dam	Toe Seep	Isolated Pool	Isolated Pool	Riffle/ Isolated Pool	Riffle	Riffle/ Isolated Pool	Channel/ Isolated Pool	Isolated Pool	Isolated Pool
	Site Length (m)	40	40	40	100	40	5	150	50	80	1000	1000	1000	50	150
	Site Width (m)	10	10	10	100	10	3	50	100	20	10	20	-	8	15
	Depth (m)	0.6	0.8	0.5	0.5	0.6	0.2	1.2	1.8	0.5	0.5	1.0	1.5	0.5	0.6
	Velocity (cm/s):	0	0	0	0	0	0.1	0	0	0	2	0	0	0	0
<b>Habitat Area (% Cover)</b>	Mineral Substrate	50	50	65	10	10	20	10	35	75	70	90	73	65	35
	Emergent Macro	0	0	0	0	0	80	20	15	15	5	0	0	0	0
	Submerged Macro	30	5	5	60	0	0	40	5	0	0	0	0	30	50
	Floating Macro	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Algal Cover	10	10	10	10	0	0	20	0	0	0	0	0	0	0
	Detritus	10	20	15	15	85	0	10	20	5	10	2	15	3	13
	Veg. draped in water	0	5	0	0	0	0	0	15	2	0	3	2	0	0
	Root mats	0	0	0	0	0	0	0	10	2	13	3	5	0	0
	Large Woody Debris	0	10	5	5	5	0	0	0	1	2	2	5	2	2
<b>Sediment Substrate (% Cover)</b>	Bedrock	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Boulders (>256 mm)	0	5	0	0	1	0	10	0	1	1	1	3	0	5
	Cobbles (64-256 mm)	0	15	2	3	1	0	20	10	10	19	14	20	0	5
	Pebbles (16 - 64 mm)	5	15	3	10	3	0	10	10	20	25	40	40	0	12
	Gravel (4 - 16 mm)	15	15	0	2	5	0	0	0	47	30	30	25	0	3
	Sand (1 - 4 mm)	10	0	0	0	0	0	0	50	20	24	13	10	0	0
	Silt (<1 mm)	10	0	10	10	5	20	0	0	2	1	2	2	0	5
	Clay	60	50	85	75	85	80	60	30	0	0	0	0	100	70
<b>Disturbances (0= None, 1= Some, 2= Moderate, 3= High)</b>	Cattle Grazing	0	1	0	1	0	2	1	1	1	0	0	2	3	3
	Frequent Fire	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	Mining Exploration	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Road/ Access Track	0	1	1	0	2	2	1	0	1	0	0	1	0	1
	Rubbish/ Litter	2	1	3	1	1	0	0	0	0	0	0	2	0	1
	Weed Invasion	0	0	1	0	1	3	1	0	1	0	0	0	0	0
	Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	None Discernible	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Local Erosion	1	0	0	0	0	3	0	2	1	1	2	0	0	2	

2022 Wet Season																		
Habitat component	Attribute	FRB1	OP1	OP2	OP3	OP4	OP5	OPDS1	OPDS2	OPDS3	PB1	PH1	FLCP2	FM2	SP1	EC1	JX1	NB1
Site Measures	Habitat Type	Isolated Pool	Dam	Dam	Dam	Dam	Dam	Toe Seep	Isolated Pool	Isolated Pool	Isolated Pool	Isolated Pool	Channel	Channel	Channel	Channel	Channel	Channel
	Site Length (m)	60	40	40	40	40	40	5	100+	80	40	100	100+	100+	100+	100	60	70
	Site Width (m)	10	10	10	10	10	10	2	50	30	40	10	25	30	90	80	30	30
	Depth (m)	0.4	0.6	1.1	0.6	1.0	0.6	0.7	1	1.5	0.4	0.5	1.0	0.6	0.7	0.8	0.6	0.9
	Velocity (cm/s):	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0.5	0.5	0.5	0.45	0
Habitat Area (% Cover)	Mineral Substrate	60	60	0	0	0	0	5	0	30	60	75	95	60	90	85	0	80
	Emergent Macro	0	0	0	0	0	0	95	50	20	0	0	0	0	0	0	0	0
	Submerged Macro	0	0	0	0	0	0	0	50	10	5	0	0	5	5	0	5	0
	Floating Macro	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Algal Cover	0	30	30	80	80	20	0	0	0	20	10	0	25	0	0	80	0
	Detritus	40	10	40	10	10	60	0	0	20	15	10	5	5	5	10	10	0
	Veg. draped in water	0	0	10	0	5	10	0	0	0	0	0	0	0	0	0	5	0
	Root mats	0	0	10	0	0	10	0	0	0	0	0	0	0	0	0	0	20
	Large Woody Debris	0	0	10	10	5	0	0	0	20	0	5	0	5	0	5	0	0
Sediment Substrate (% Cover)	Bedrock	5	0	0	0	0	5	0	0	0	0	0	0	0	30	0	0	0
	Boulders (>256 mm)	5	0	0	0	0	0	0	0	0	0	0	0	0	10	0	20	0
	Cobbles (64-256 mm)	5	0	40	0	0	25	0	10	0	5	10	0	10	10	5	40	0
	Pebbles (16 - 64 mm)	5	40	20	0	60	20	0	0	10	5	20	0	50	10	10	20	0
	Gravel (4 - 16 mm)	40	40	0	0	20	0	0	20	70	10	30	0	30	20	50	5	0
	Sand (1 - 4 mm)	40	0	0	0	10	0	0	0	20	80	40	40	10	20	35	5	0
	Silt (<1 mm)	0	0	0	0	10	0	100	0	0	0	0	20	0	0	0	10	80
	Clay	0	20	40	100	0	50	0	70	0	0	0	40	0	0	0	0	20
Disturbances (0= None, 1= Some, 2= Moderate, 3= High)	Cattle Grazing	1	1	1	1	0	1	2	1	1	1	1	3	0	2	2	1	1
	Frequent Fire	1	1	1	1	0	1	1	0	1	0	1	0	0	0	1	0	0
	Mining Exploration	0	2	1	1	2	1	2	2	2	1	1	0	1	0	1	0	0
	Road/ Access Track	3	2	1	1	2	2	3	2	2	1	1	1	1	1	2	3	2
	Rubbish/ Litter	3	2	1	3	1	2	0	0	2	0	0	0	0	0	2	3	2
	Weed Invasion	1	1	1	1	0	1	0	0	1	1	0	0	1	0	0	1	1
	Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	None Discernible	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Local Erosion	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

**Appendix 4.** Microinvertebrate taxa list of 2021 dry season and 2022 wet season surveys. Values are total abundances.

2021 Dry Season			OP1	OP2	OP3	OP4	OP5	OPDS2	OPDS3	EC1	PB1	PH1	FM2	FLCP1	NB1
Phylum/Class/Order	Family	Lowest Taxon													
<b>AMOEOBOZOA</b>															
	<b>Arcellinida</b>	Arcellidae	<i>Arcella discoidea</i>	-	-	-	-	3	-	-	-	-	-	-	-
			<i>Arcella megastoma</i>	-	-	-	7	-	-	-	-	-	-	-	-
		Centropyxidae	<i>Centropyxis ecomis</i>	-	-	-	20	-	-	-	-	12	-	-	-
		Diffugiidae	<i>Diffugia lacustris</i>	-	-	-	-	-	-	-	-	12	-	-	-
		Lesquereusiidae	<i>Netzelia corona</i>	-	-	-	20	-	-	-	-	-	-	-	-
			<i>Lesquereusia spiralis</i>	-	-	-	-	-	13	-	-	4	-	-	-
	<b>Heterotruchida</b>	Stentoridae	<i>Stentor amethystinus</i>	-	143	-	-	-	-	-	-	-	-	-	-
<b>ROTIFERA</b>															
	<b>Bdelloidea</b>		Bdelloidea indet. sp. indet.bdelloid (lg)	-	-	-	-	5	-	-	-	-	-	-	-
			Bdelloidea indet. sp. indet.bdelloid (sm)	-	-	-	-	5	-	-	-	181	4	-	-
	<b>Monogononta</b>	Asplanchnidae	<i>Asplanchna brightwelli</i>	-	-	-	-	-	-	-	-	-	-	1000	5000
		Brachionidae	<i>Anuraeopsis fissa</i>	-	-	-	-	-	111	-	-	-	-	-	5000
			<i>Brachionus angularis</i>	-	-	-	-	-	-	-	-	-	-	6000	-
			<i>Brachionus bidens</i>	-	-	-	-	-	-	-	-	-	-	7500	25000
			<i>Brachionus budapestinensis</i>	-	-	-	-	-	-	-	-	-	-	1250	5000
			<i>Brachionus calyciflorus</i>	-	-	-	-	-	-	-	-	-	-	250	5000
			<i>Brachionus dichotomus</i>	-	-	-	-	-	-	-	-	-	-	-	5000
			<i>Brachionus falcatus</i>	-	-	-	-	-	-	-	-	-	-	-	5000
			<i>Keratella procurva</i>	1348	5429	256	262	100	3	-	50000	100	1470	2	10000
		Euchlanidae	<i>Euchlanis dilatata</i>	-	-	-	-	-	-	-	-	-	1	-	5000
		Flosculariidae	<i>Sinatherina</i> sp. indet. (colony)	-	-	-	-	-	-	-	-	48	-	-	-
		Hexarthridae	<i>Hexarthra intermedia</i>	-	143	-	-	-	-	-	-	-	-	-	350000
		Lecanidae	<i>Lecane bulla</i>	-	-	-	-	-	16	-	-	48	1	-	5000
			<i>Lecane 'bulloid'</i> n. sp. indet.	-	-	-	-	-	-	-	-	60	-	-	-
			<i>Lecane homemanni</i>	-	-	-	-	-	-	-	4	-	-	-	-
			<i>Lecane ludwigii</i>	-	-	-	-	5	-	-	-	-	-	-	-
			<i>Lecane luna</i>	-	-	-	-	-	-	-	-	12	2	-	-
			<i>Lecane obtusa</i>	-	-	-	-	-	-	-	-	24	-	-	-
			<i>Lecane unguitata</i>	-	-	-	-	-	-	-	-	12	1	-	-
		Lepadellidae	<i>Colurella</i> sp. indet.	-	-	-	-	-	-	-	-	12	-	-	-
		Mytilinidae	<i>Mytilina ventralis</i>	-	-	-	-	-	-	-	-	24	-	-	-
		Proalidae	<i>Proales</i> sp. indet.	-	-	-	-	13	-	-	-	-	-	-	-
		Synchaetidae	<i>Polyarthra</i> sp. indet.	-	1143	-	20	-	-	-	-	-	-	1250	25000
			<i>Synchaeta pectinata</i>	-	-	-	-	-	-	-	-	-	-	250	-
		Testudinellidae	<i>Testudinella patina</i>	43	-	-	-	-	-	-	-	12	-	-	-
		Trochosphaeridae	<i>Filinia pejeri</i>	-	-	-	-	-	-	-	-	-	-	-	5000

2021 Dry Season															
Phylum/Class/Order	Family	Lowest Taxon	OP1	OP2	OP3	OP4	OP5	OPDS2	OPDS3	EC1	PB1	PH1	FM2	FLCP1	NB1
BRYOZOA		<i>Filinia terminalis</i>	-	-	-	-	-	-	-	-	-	-	-	25500	-
		<i>Filinia longiseta</i>	-	-	-	-	-	-	-	-	-	-	-	-	10000
		Bryozoa indet. sp. indet.	-	-	-	-	-	-	-	-	-	12	-	-	-
ARTHROPODA															
CRUSTACEA															
BRANCHIOPODA															
	Diplostraca														
	Cladocera	Chydoridae													
		<i>Alona rigidicaudis</i>	-	-	-	40	-	3	-	-	-	-	-	-	-
		<i>Anthalona harti</i> subsp. <i>occidentalis</i>	-	-	-	-	-	3	-	-	-	-	-	-	-
		<i>Armatalona macrocopa</i>	-	-	-	-	-	-	111	-	4	-	-	-	-
		<i>Dunhevedia crassa</i>	-	-	23	7	-	-	-	-	-	24	2	-	-
		<i>Leberis diaphanus</i>	-	-	-	7	-	-	-	-	-	72	12	-	-
		<i>Leydigia cf. australis</i>	-	143	-	-	-	-	-	-	-	-	-	-	-
		Daphniidae													
		<i>Ceriodaphnia cornuta</i>	174	-	23	-	100	-	111	2857	4	-	2	-	-
		<i>Ceriodaphnia dubia</i>	739	286	116	81	-	3	-	15714	-	-	-	-	-
		<i>Daphnia carinata</i>	913	143	-	-	-	-	-	98571	4	1	2	-	-
		<i>Daphnia projecta</i>	-	-	-	-	-	-	-	-	-	12	-	-	-
		<i>Simocephalus heilongjiangensis</i>	-	-	-	-	-	8	-	-	-	-	-	-	-
		Macrothricidae													
		<i>Macrothrix spinosa</i>	-	714	-	-	-	-	-	-	-	-	-	-	-
		Sididae													
		<i>Diaphanosoma excisum</i>	-	-	-	-	-	-	-	-	-	-	-	-	5000
		<i>Latonopsis australis</i>	-	-	-	7	-	-	-	-	-	-	-	-	-
MAXILLOPODA															
	Calanoida														
		Calanoida indet. sp. indet. nauplii	-	714	884	7	600	-	-	-	-	-	-	-	255000
		Diatomidae													
		<i>Eodiaptomus lumholtzi</i>	174	714	558	13	2800	5	-	1429	-	-	-	-	25000
		Cyclopoida													
		Cyclopoida indet. sp. nauplii	5304	19000	2767	725	16500	296	22111	167143	28	12	-	12250	760000
		Cyclopidae													
		<i>Mesocyclops brooksi</i>	-	143	-	67	-	8	111	-	4	-	-	-	-
		<i>Microcyclops varicans</i>	-	714	23	-	-	-	-	1429	-	-	-	-	-
		<i>Thermocyclops decipiens</i>	217	-	70	-	-	3	111	-	-	12	-	-	-
		<i>Tropocyclops cf. prasinus</i>	-	-	-	-	100	-	111	-	-	-	-	-	-
		Harpacticoida													
		Parastenocarididae													
		<i>Parastenocaris</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	2	-	-
OSTRACODA															
	Podocopida														
		Cyprididae													
		Ostracoda indet. sp. indet. (juv.)	43	143	47	20	-	3	-	-	-	-	-	-	-
		<i>Cyprretta</i> sp. indet.	-	-	23	-	-	3	-	-	4	-	-	-	-
		<i>Ilyodromus</i> sp. indet.	-	-	-	7	-	-	-	-	-	-	-	-	-
		<i>Stenocypris</i> sp. indet.	-	-	23	-	100	-	-	-	-	-	-	-	-
		Darwinulidae													
		<i>Vestalenula marmonieri</i>	-	-	-	7	-	-	-	-	8	-	1	-	5000
		Lymnocytheridae													
		<i>Limnocythere</i> sp. indet.	43	-	23	20	-	19	-	-	56	-	-	-	-
		Notodromadidae													
		<i>Newnhamia fenestrata</i>	-	-	-	-	-	3	-	-	-	-	-	-	-
		<b>Total Taxa Richness</b>	<b>10</b>	<b>14</b>	<b>13</b>	<b>18</b>	<b>7</b>	<b>20</b>	<b>7</b>	<b>7</b>	<b>11</b>	<b>20</b>	<b>12</b>	<b>9</b>	<b>19</b>

2022 Wet Season			OP1	OP2	OP3	OP4	OP5	OPDS1	OPDS2	OPDS3	SP1	PH1	PB1	FLCP1	NB1	JX1	EC1	FM2	FRB1
<b>CILIOPHORA</b>																			
Heteritrichida	Stentoridae	<i>Stentor amethystinus</i>	-	-	-	-	-	-	-	4	-	-	-	-	-	5	-	-	-
<b>AMOEBOZOA</b>																			
<b>Tubulinea</b>																			
Arcellinida	Acrelidae	<i>Arcella discoides</i>	-	-	-	-	-	-	-	2	-	6	-	-	-	32	6	-	-
		<i>Arcella</i> sp. indet. (sm)	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
	Centropyxidae	<i>Centropyxis ecornis</i>	-	165	303	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Diffugiidae	<i>Diffugia australis</i>	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-
		<i>Diffugia</i> sp. indet.	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
	Lesquereusiidae	<i>Lesquereusia spiralis</i>	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-
	Netzelidae	<i>Netzelia corona</i>	-	-	-	-	384	-	-	-	-	-	-	-	-	-	-	-	-
		<i>Netzelia tuberculata</i>	-	-	-	-	-	-	-	-	-	-	-	-	384	-	-	-	-
<b>ROTIFERA</b>																			
<b>Bdelloidea</b>																			
		Bdelloidea indet. sp. indet.bdelloid (sm)	-	-	-	-	-	-	-	2	-	4	-	-	-	90	28	3	-
		Bdelloidea indet. sp. indet. bdelloid (med.)	-	-	606	-	-	-	-	-	1	6	-	-	-	149	-	-	-
		Bdelloidea indet. sp. indet.bdelloid (lg)	-	-	303	136	-	384	-	-	-	-	-	-	-	-	-	-	-
	Asplanchnidae	<i>Asplanchna brightwelli</i>	250	-	-	136	-	192	-	-	-	-	-	-	-	-	-	-	-
		<i>Anuraeopsis coelata</i>	-	987	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		<i>Anuraeopsis fissa</i>	2254	1152	13036	1084	-	-	-	-	1152	-	-	-	-	-	-	-	-
		<i>Brachionus angularis</i>	10518	165	-	19245	-	1152	-	-	-	-	-	-	-	-	-	-	-
		<i>Brachionus bidens</i>	-	-	303	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		<i>Brachionus calyciflorus</i>	1503	-	-	136	-	2112	-	-	-	-	-	-	-	-	-	-	-
		<i>Brachionus dichotomus</i>	-	10862	7882	-	384	2496	-	-	-	-	-	16	-	-	-	-	-
		<i>Brachionus falcatus</i>	1002	2469	4244	136	1152	2112	-	2	-	-	-	64	768	-	-	-	-
		<i>Brachionus quadridentatus</i>	-	165	-	-	-	576	-	-	-	-	-	-	-	-	-	-	-
		<i>Keratella procurva</i>	-	165	303	-	-	384	-	-	-	-	48	384	-	-	-	-	-
		<i>Keratella tropica</i>	15527	3785	10004	2440	768	4416	-	2	-	-	-	384	-	-	-	-	-
		<i>Plationus patulus</i>	-	-	-	271	-	192	-	-	-	-	-	-	-	-	-	-	-
	Conochilidae	<i>Conochilus dossuarius</i>	-	-	-	-	-	192	-	-	-	-	-	-	-	-	-	-	-
		<i>Conochilus natans</i>	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
	Euchlanidae	<i>Dipleuchlanis propatula</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	16	-	-	-
		<i>Euchlanis dilatata</i>	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
		<i>Euchlanis meneta</i>	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
	Flosculariidae	<i>Sinantherina</i> sp. indet. (colony)	-	-	-	136	-	-	-	-	-	-	-	-	-	-	-	-	-
	Gastropodidae	<i>Ascomorpha</i> cf. <i>saltans</i>	-	-	-	-	-	-	-	-	-	-	-	16	-	-	-	-	-
	Hexarthridae	<i>Hexarthra intermedia</i>	-	-	-	-	-	-	-	-	-	-	-	48	-	-	-	-	-
		<i>Hexarthra mira</i>	-	2469	2728	-	768	576	-	2	-	-	-	224	-	-	-	-	-
	Lecanidae	<i>Lecane bulla</i>	-	-	-	-	-	-	-	-	5	-	-	-	-	42	11	-	-
		<i>Lecane</i> 'bulloid' n. sp. indet.	-	-	-	136	-	-	-	2	12	2	-	-	-	96	6	3	-
		<i>Lecane unguitata</i>	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-
		<i>Lecane</i> (M.) sp. A	-	-	-	-	-	-	-	-	-	-	-	-	-	27	-	-	-

2022 Wet Season			OP1	OP2	OP3	OP4	OP5	OPDS1	OPDS2	OPDS3	SP1	PH1	PB1	FLCP1	NB1	JX1	EC1	FM2	FRB1	
Phylum/Class/Order	Family	Lowest Taxon																		
			Lecane ( <i>M.</i> ) sp. B	-	-	-	-	-	-	-	-	-	-	-	-	-	16	-	-	-
		Lindiidae	<i>Lindia torulosa</i>	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
		Notommatidae	<i>Monommata</i> sp. indet.	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
		Synchaetidae	<i>Polyarthra</i> sp. indet.	-	-	-	271	-	192	-	-	-	-	-	-	-	-	-	-	-
			<i>Synchaeta pectinata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	-
		Testudinellidae	<i>Testudinella amphora</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	106	6	-	-
		Trichotriidae	<i>Macrochaetus</i> sp. indet.	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-
		Trochosphaeridae	<i>Filinia longiseta</i>	250	1810	6063	-	-	1344	-	-	2	-	-	-	16	1152	-	-	-
			indet. contr. rotifer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	37	-	-
<b>BRYOZOA</b>		Bryozoa indet. sp. Indet.	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
<b>ARTHROPODA</b>																				
<b>CRUSTACEA</b>																				
	<b>BRANCHIOPODA</b>																			
	<b>Diplostraca</b>																			
	<b>Cladocera</b>	Chydoridae	Chydoridae indet. sp. indet.	-	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	
			<i>Alona rigidicaudis</i>	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-		
			<i>Anthalona harti occidentalis</i>	-	-	-	-	-	-	-	3	-	-	-	-	5	-	2		
			<i>Armatalona macrocopa</i>	-	165	-	-	-	-	2	-	-	-	-	384	-	-	-		
			<i>Chydorus</i> cf. <i>sphaericus</i>	250	-	303	-	-	-	-	9	-	-	-	-	5	-	-		
			<i>Coronatella rectangula</i>	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-		
			<i>Ephemeroporus barroisi</i>	-	-	-	-	-	-	-	-	4	-	-	-	5	-	-		
			<i>Karualona karua</i>	-	-	-	-	-	-	-	-	-	-	-	-	6	2	-		
		Daphniidae	<i>Ceriodaphnia cornuta</i>	1002	165	303	136	7296	1152	-	2	-	-	16	1536	5	-	-		
			<i>Ceriodaphnia dubia</i>	-	-	-	-	384	-	-	-	-	-	-	-	-	-	-		
			<i>Simocephalus heilongjiangensis</i>	-	-	-	-	-	-	-	-	4	-	-	-	-	-	2		
		Macrotrichidae	<i>Macrothrix spinosa</i>	-	-	303	-	-	-	-	-	2	-	-	-	-	-	-		
			<i>Macrothrix</i> sp. indet.	-	165	-	136	384	-	-	-	-	-	-	-	5	6	-		
		Moinidae	<i>Moina micrura</i>	-	-	-	-	-	-	-	-	-	-	-	384	-	-	-		
		Sididae	<i>Diaphanosoma excisum</i>	250	165	1213	136	1152	192	-	-	15	-	-	112	1152	-	-		
<b>MAXILLIPODA</b>																				
	<b>Calanoida</b>	Calanoida indet. sp. indet. nauplii	501	1317	3032	-	40704	192	-	-	-	10	-	-	21120	-	-	-		
		Diaptomidae	<i>Eodiaptomus lumboltzi</i>	501	165	606	271	3456	1152	-	2	-	-	1	16	10368	-	-		
	<b>Cylopoida</b>	Cylopoida indet. sp. nauplii	16278	7570	10004	2846	17280	15936	6	239	69	-	1	2624	33792	419	1069	2	964	
		<i>Mesocyclops brooksi</i>	-	-	303	-	-	-	-	-	-	-	-	-	-	-	-	-		
		<i>Mesocyclops notius</i>	-	-	-	136	384	2496	-	-	-	-	-	-	768	-	-	-		
		<i>Microcyclops varicans</i>	-	-	-	-	-	-	-	-	3	2	-	-	-	-	6	-		
		<i>Thermocyclops decipiens</i>	1503	165	303	136	2304	576	-	-	-	2	-	-	3072	-	-	-	75	
		<i>Tropocyclops</i> cf. <i>prasinus</i>	-	-	-	-	768	-	-	-	-	-	-	-	-	-	-	-		

2022 Wet Season			OP1	OP2	OP3	OP4	OP5	OPDS1	OPDS2	OPDS3	SP1	PH1	PB1	FLCP1	NB1	JX1	EC1	FM2	FRB1
<b>OSTRACODA</b>		Ostracoda indet. sp. indet.	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-
		Ostracoda indet. sp. indet. (juv.)	-	-	-	136	-	-	-	2	-	14	2	-	384	11	6	7	-
	<b>Podocopida</b>	Cypridae	250	-	303	136	-	192	-	2	48	8	1	-	384	-	-	2	-
		<i>Cypretta</i> sp. indet.	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
		<i>Ilyodromus</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		<i>Stenocypris major</i>	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-
		Dawrinulidae	-	-	-	-	-	-	-	109	1	12	-	-	-	5	-	8	-
		Limnocytheridae	250	165	-	-	-	-	1	-	23	14	1	-	384	5	-	10	-
		<i>Limnocythere</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		<b>Total Taxa Richness</b>	<b>17</b>	<b>20</b>	<b>21</b>	<b>20</b>	<b>15</b>	<b>22</b>	<b>2</b>	<b>15</b>	<b>24</b>	<b>17</b>	<b>5</b>	<b>11</b>	<b>17</b>	<b>21</b>	<b>11</b>	<b>11</b>	<b>2</b>

**Appendix 5.** Hyporheic taxa list for 2021 dry and 2022 wet season surveys. Values are log<sub>10</sub> abundance categories, where 1= 1 individual, 2 = 2-10 individuals, 3 = 11-100, 4 = 101-1000 etc. Hypo Categories denote the following; X = stygoxene, O = Occasional hyporheos stygophile and S = stygobite.

2021 Dry Season										
Phylum/Class/Order	Family	Lowest Taxon	Hypo Category	OP4	OPDS3	EC1	PB1	PH1	FM2	
<b>ARTHROPODA</b>										
<b>CRUSTACEA</b>										
<b>BRANCHIOPODA</b>										
	<b>Diplostraca</b>	Chydoridae	Chydoridae indet. sp. indet.	X	2	-	-	-	-	
			<i>Dunhevedia crassa</i>	X	-	-	-	2	-	
			<i>Ephemeroporus barroisi</i>	X	-	-	-	-	2	
			<i>Karualona karua</i>	O	-	-	-	-	2	
		Daphniidae	<i>Ceriodaphnia cornuta</i>	X	-	-	2	-	1	
			<i>Ceriodaphnia dubia</i>	X	2	-	-	-	-	
			<i>Daphnia carinata</i>	X	1	-	3	-	2	
<b>MAXILLOPODA</b>										
<b>Copepoda</b>										
	<b>Calanoida</b>	Diaptomidae	<i>Eodiaptomus lumholtzi</i>	X	1	-	-	-	-	
	<b>Cyclopoida</b>		Cyclopoida indet. sp. nauplii	X	1	3	2	3	3	
		Cyclopidae	<i>Eucyclops</i> sp. indet.	X	-	1	-	-	-	
			<i>Microcyclops varicans</i>	O	-	-	-	1	1	
	<b>Harpacticoida</b>	Canthocamptidae	Canthocamptidae indet A	X	-	-	-	2	-	
			Canthocamptidae indet B	X	-	-	-	2	-	
		Parastenocarididae	<i>Parastenocaris jane</i>	S	-	-	3	-	3	
<b>OSTRACODA</b>										
	<b>Podocopida</b>	Candonidae	<i>Candonopsis</i> cf. <i>tenuis</i>	S	-	1	-	2	-	
		Cyprididae	<i>Candonocypris novaezelandiae</i>	S	1	-	-	-	-	
		Darwinulidae	<i>Vestalenula marmonieri</i>	S	-	2	2	3	3	
		Limnocytheridae	<i>Limnocythere</i> sp. indet.	X	1	2	-	2	-	
			<b>Total Taxa Richness</b>	<b>18</b>	<b>7</b>	<b>5</b>	<b>5</b>	<b>8</b>	<b>8</b>	<b>4</b>

2022 Wet Season																
Phylum/Class/Order	Family	Lowest Taxon	Hypo Category	OP1	OP3	OP4	OP5	OPDS3	SP1	PH1	PB1	JX1	EC1	FM2	FRB1	
<b>ROTIFERA</b>																
	<b>Bdelloidae</b>	Asplanchnidae	<i>Brachionus calyciflorus</i>	X	1	-	-	-	-	-	-	-	-	-	-	
			<i>Brachionus falcatus</i>	X	1	-	-	-	-	-	-	-	-	-	-	
<b>ANNELIDA</b>																
	<b>OLIGOCHAETA</b>		Naididae indet. sp. indet.	O	2	-	-	-	-	2	2	3	2	3	2	-
<b>ARTHROPODA</b>																
<b>CRUSTACEA</b>																
<b>BRANCHIOPODA</b>																
<b>Diplostraca</b>																
	<b>Cladocera</b>	Daphniidae	<i>Ceriodaphnia cornuta</i>	X	1	-	2	5	-	-	-	-	-	-	-	
			<i>Ceriodaphnia dubia</i>	X	-	-	-	5	-	-	-	-	-	-	-	
		Macrotrichidae	<i>Macrothrix</i> sp. indet.	X	-	-	1	-	-	-	-	-	-	-	-	
		Sididae	<i>Diaphanosoma excisum</i>	X	2	-	-	5	-	-	-	-	-	-	-	
<b>MAXILLIPODA</b>																
	<b>Calanoida</b>		Calanoida indet. sp. nauplii	O	3	-	2	6	-	-	-	-	-	-	-	
		Diaptomidae	<i>Eodiaptomus lumholtzi</i>	X	3	-	3	6	-	-	-	-	-	-	-	
	<b>Cyclopoid</b>		Cyclopoida indet. sp. nauplii	O	4	2	3	6	-	1	2	1	2	-	-	2
		Cyclopidae	<i>Ectocyclops phaleratus</i>	O	-	-	-	-	2	-	-	-	-	-	-	
			<i>Mesocyclops brooksi</i>	O	-	-	-	-	-	-	-	2	-	-	-	
			<i>Mesocyclops notius</i>	O	3	-	1	4	-	-	-	-	-	-	-	
			<i>Mesocyclops</i> sp. indet.	O	-	-	-	-	-	-	-	-	-	-	1	
			<i>Thermocyclops decipiens</i>	O	3	-	2	4	-	-	-	-	-	-	-	
	<b>Harpactacoid</b>	Parastenocarididae	<i>Parastenocaris jane</i>	S	-	-	-	-	-	-	-	2	-	-	-	
<b>OSTRACODA</b>																
			Ostracoda indet. sp. indet. (juv.)	O	1	-	-	-	-	-	-	1	-	-	-	
			Ostracoda indet. sp. indet.	O	-	-	2	-	-	-	-	-	-	-	-	
		Darinulidae	<i>Vestalenula marmonieri</i>	S	-	-	-	-	2	1	-	-	2	3	-	

2022 Wet Season																
Phylum/Class/Order	Family	Lowest Taxon	Hypo Category	OP1	OP3	OP4	OP5	OPDS3	SP1	PH1	PB1	JX1	EC1	FM2	FRB1	
<b>CHELICERATA</b>																
<b>ARACHNIDA</b>																
<b>Trombidiformes</b>	Aturidae	Aturidae indet. sp. indet.	X	-	1	-	-	-	-	2	-	-	-	-	1	
	Hydrachnidae	<i>Hydrachna</i> sp. indet.	X	-	-	-	-	-	-	-	1	-	-	-	-	
<b>Sarcoptiformes</b>	Oribatida	Oribatida indet. sp. indet.	X	1	-	-	-	2	2	-	-	2	1	-	-	
<b>HEXAPODA</b>																
<b>INSECTA</b>																
<b>Ephemeroptera</b>		Ephemeroptera indet. sp. indet.	X	-	-	-	3	-	1	-	1	-	-	1	2	
<b>Coleoptera</b>	Dytiscidae	Dytiscidae indet. sp. indet.	X	-	-	-	-	1	-	-	-	-	-	-	-	
<b>Diptera</b>	Ceratopogonidae	Ceratopogonidae indet. sp. indet.	X	-	-	-	-	3	3	3	-	3	3	3	3	
	Chaboridae	Chaoboridae indet. sp. indet.	X	-	-	-	-	2	-	-	-	-	-	-	-	
	Chironomidae	Chironomidae indet. sp. indet.	X	-	-	1	-	-	3	2	2	-	2	2	3	
<b>COLLEMBOLA</b>		Collembola indet. sp. indet.	X	-	-	-	-	-	-	-	-	-	-	-	1	
<b>Total Taxa Richness</b>			<b>28</b>	<b>12</b>	<b>2</b>	<b>9</b>	<b>9</b>	<b>6</b>	<b>7</b>	<b>5</b>	<b>7</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>7</b>	

**Appendix 6a.** Macroinvertebrate taxa list recorded during the 2021 dry season. Values are log<sub>10</sub> abundance categories, where 1= 1 individual, 2 = 2-10 individuals, 3 = 11-100, 4 = 101-1000 etc.

Phylum/Class/Order	Family	Lowest taxon	EC1	FLCP1	FM2	NB1	OP1	OP2	OP3	OP4	OP5	OPDS2	OPDS3	PB1	PH1
<b>CNIDARIA</b>															
<b>HYDROZOA</b>															
	<b>Anthoathecata</b>	Hydridae	<i>Hydra</i> sp. indet.	-	-	-	-	-	-	-	-	3	-	-	-
<b>PLATYHELMINTHES</b>															
<b>TURBELLARIA</b>															
	<b>RHABDITOPHORA</b>	Temnocephalidae	Temnocephalidae sp. indet.	-	-	-	-	-	-	-	-	-	1	2	1
<b>NEMATODA</b>															
			Nematoda indet. sp. indet.	2	2	-	-	2	1	1	3	-	-	-	-
<b>MOLLUSCA</b>															
<b>GASTROPODA</b>															
	<b>Hygrophila</b>	Lymnaeidae	<i>Bullastra vinosa</i>	-	-	-	-	3	-	-	3	-	4	2	1
		Planorbidae	<i>Ferrissia petterdi</i>	-	-	-	-	-	2	1	-	2	-	-	-
			<i>Gyraulus</i> sp. indet.	1	-	-	-	2	-	-	2	-	-	-	1
<b>ANNELIDA</b>															
<b>OLIGOCHAETA</b>															
			Oligochaeta indet. sp. indet.	3	-	4	-	-	2	1	-	-	2	2	2
			Naididae indet. sp. indet.	-	-	2	-	-	-	3	2	-	2	-	3
<b>ARTHROPODA</b>															
<b>CHELICERATA</b>															
<b>ARACHNIDA</b>															
	<b>Mesostigmata</b>		Mesostigmata indet. sp. Indet	-	-	1	-	-	1	-	-	-	-	-	-
	<b>Sarcoptiformes</b>		Oribatida indet. sp. indet	-	1	1	2	-	-	-	-	-	1	-	-
	<b>Trombidiformes</b>	Arrenuridae	<i>Arrenurus</i> sp. indet	-	2	-	-	-	-	-	-	-	-	2	-
		Hydrachnidae	Hydrachnidae indet. sp. indet	-	-	-	5	-	-	-	-	-	2	-	-
		Hydrodromidae	<i>Hydrodroma</i> sp. indet	3	2	-	2	-	-	-	-	-	-	-	-
		Hygrobatidae	Hygrobatidae indet. sp. indet	-	-	2	1	-	1	-	-	3	-	3	-
		Limnesiidae	Limnesiidae indet. sp. indet	-	1	-	-	2	2	1	-	3	1	3	1
		Pionidae	Pionidae indet. sp. indet.	-	-	2	-	-	-	-	-	2	-	-	-

Phylum/Class/Order	Family	Lowest taxon	EC1	FLCP1	FM2	NB1	OP1	OP2	OP3	OP4	OP5	OPDS2	OPDS3	PB1	PH1
	Unionicolidae	Unionicolidae indet. sp. indet.	-	2	-	1	-	-	1	-	-	-	3	-	-
<b>CRUSTACEA</b>															
<b>Malacostraca</b>	Parastacidae	<i>Cherax quadricarinatus</i>	-	-	-	-	-	1	-	-	-	-	-	-	-
<b>HEXAPODA</b>															
<b>INSECTA</b>															
<b>Odonata</b>															
<b>Anisoptera</b>		Anisoptera indet. sp. indet.	-	-	1	-	3	1	1	1	1	3	3	2	3
	Aeshnidae	<i>Hemianax papuensis</i>	-	-	-	-	-	-	-	1	-	-	-	-	-
	Libellulidae	<i>Diplacodes bipunctata</i>	-	-	-	-	2	-	2	1	1	-	-	1	-
		<i>Diplacodes haematodes</i>	-	-	-	2	-	-	2	-	1	-	2	1	-
		<i>Orthetrum caledonicum</i>	-	-	-	1	-	1	1	1	2	-	-	1	-
		<i>Tremea</i> sp. indet.	-	-	-	-	-	-	-	-	-	3	-	-	-
		<i>Zyxomma elgneri</i>	-	-	-	-	-	-	-	-	2	-	-	-	-
	Macromiidae	<i>Macromia</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	2	-	-
<b>Zygotera</b>		Zygotera indet. sp. indet. (imm./dam.)	-	3	-	3	3	1	2	3	2	3	3	2	2
	Coenagrionidae	<i>Agriocnemis</i> sp. indet.	-	-	-	1	-	1	-	-	1	-	3	-	-
		<i>Agriocnemis rubescens</i>	-	-	-	1	-	-	-	2	-	-	3	1	-
		<i>Ischnura aurora</i>	-	3	-	-	3	-	1	3	1	3	-	-	-
		<i>Ischnura heterosticta</i>	-	3	-	-	-	-	-	2	-	-	-	-	-
	Corduliidae	<i>Hemicordulia tau</i>	-	-	-	-	1	-	-	-	-	-	-	-	-
	Isostictidae	<i>Eurysticta coolawanyah</i>	-	-	-	-	-	-	-	-	-	-	2	-	-
<b>Ephemeroptera</b>		Ephemeroptera indet. sp. indet.	-	-	-	-	-	4	3	3	-	3	4	3	4
	Baetidae	Baetidae indet. sp. indet.	2	3	3	4	4	3	4	3	3	3	4	3	4
		<i>Cloeon</i> sp. Red Stripe	-	3	4	4	4	3	4	4	3	3	4	4	4
		<i>Offadens</i> sp. G1WA2	-	-	-	-	-	-	-	-	-	-	-	4	-
	Caenidae	Caenidae indet. sp. indet.	2	-	4	2	4	3	4	3	3	1	4	4	3
		<i>Tasmanocoenis</i> sp. M	-	-	-	-	-	-	3	2	-	-	3	-	-
		<i>Tasmanocoenis</i> sp. P/arcuata	1	-	-	1	3	3	3	2	3	-	3	4	3
<b>Hemiptera</b>															
	Belostomatidae	<i>Diplonychus</i> sp. indet.	-	-	-	-	1	2	2	2	1	2	1	-	-
	Corixoidea	Corixoidea indet. sp. indet.	-	-	-	-	-	-	-	1	-	2	-	-	-
	Corixidae	Corixidae indet. sp. indet.	-	-	1	-	-	-	-	-	-	-	-	2	-
		<i>Agraptocorixa</i> sp. indet.	-	2	-	-	-	-	-	-	-	-	-	-	-
		<i>Agraptocorixa parvipunctata</i>	-	2	-	2	-	-	-	-	-	-	-	-	-
	Gerridae	Gerridae indet. sp. indet. (imm./dam.)	-	-	1	-	-	-	2	-	-	-	-	1	-

Phylum/Class/Order	Family	Lowest taxon	EC1	FLCP1	FM2	NB1	OP1	OP2	OP3	OP4	OP5	OPDS2	OPDS3	PB1	PH1
		<i>Rhagadotarsus anomalus</i>	-	-	-	-	-	-	2	-	-	-	-	-	-
	Hebridae	<i>Merragata hackeri</i>	-	-	-	-	-	-	-	-	-	2	1	-	-
	Mesoveliidae	<i>Mesovelia</i> sp. indet.	-	-	-	2	-	-	-	-	-	-	2	-	-
		<i>Mesovelia</i> sp. indet. (F/imm.)	-	-	-	1	-	-	-	2	-	-	-	-	-
		<i>Mesovelia vittigera</i>	-	-	-	-	-	-	-	2	-	-	-	-	-
	Micronectidae	Micronectidae indet. sp. indet. (imm./dam.)	1	-	-	-	3	-	4	2	-	-	2	3	-
		<i>Micronecta</i> sp. indet. (F/imm.)	2	4	2	4	4	4	4	2	4	-	2	3	-
		<i>Micronecta annae</i>	2	4	2	4	4	4	4	2	4	-	2	3	-
		<i>Micronecta paragoga</i>	-	-	-	-	-	-	-	-	-	1	-	-	-
		<i>Micronecta virgata</i>	-	4	-	-	-	-	-	-	-	-	-	-	-
		<i>Austronecta</i> sp. indet.	-	-	-	-	-	-	-	-	3	-	-	-	-
		<i>Austronecta micra</i>	-	-	-	-	-	4	3	-	3	-	-	-	-
	Nepidae	<i>Ranatra diminuta</i>	-	-	-	-	-	-	2	-	-	-	2	-	-
	Notonectidae	Notonectidae indet. sp. indet. (F/imm.)	-	4	2	4	2	2	-	4	2	2	-	3	-
		<i>Anisops</i> sp. indet.	-	4	-	3	2	2	2	4	2	2	-	2	1
		<i>Anisops hackeri</i>	-	4	-	3	-	1	2	3	2	-	-	-	-
		<i>Anisops nasutus</i>	-	-	-	-	-	-	1	-	-	-	-	-	-
		<i>Anisops thienemanni</i>	-	3	-	-	-	-	-	-	-	-	-	-	-
		<i>Enithares woodwardi</i>	-	-	-	-	-	-	-	-	-	2	-	-	-
	Pleidae	<i>Paraplea</i> sp. indet.	3	-	2	4	4	4	3	4	2	1	4	2	-
	Veliidae	Veliidae indet. sp. indet. (dam/imm.)	-	-	-	-	-	1	2	-	1	1	1	1	-
		<i>Nesidovelia peramoena</i>	-	-	-	-	-	-	-	-	-	2	1	-	-
<b>Coleoptera</b>	Dytiscidae	<i>Allodessus bistrigatus</i>	2	2	2	-	-	-	-	-	2	-	-	2	-
		<i>Bidessini</i> sp. indet. (L)	3	-	1	-	-	-	-	-	-	-	-	-	2
		<i>Copelatus nigrolineatus</i>	-	-	-	-	-	-	-	-	-	-	-	2	-
		<i>Cybister</i> sp. indet. (L)	-	-	-	2	-	-	-	2	-	-	-	1	-
		<i>Eretes australis</i>	-	1	-	1	-	-	-	-	-	-	-	-	-
		<i>Eretes</i> sp. indet. (L)	2	-	-	-	-	-	-	-	-	-	-	-	-
		<i>Hydroglyphus grammopterus</i>	-	-	-	-	-	2	-	-	-	-	2	2	-
		<i>Hydroglyphus leai</i>	2	-	-	2	3	3	-	2	2	2	2	2	-
		<i>Hydroglyphus orthogrammus</i>	2	-	1	-	-	-	-	-	2	-	2	3	2
		<i>Hyphydrus elegans</i>	1	-	2	-	-	2	-	-	2	-	-	2	1
		<i>Hyphydrus lyratus</i>	2	-	2	-	-	2	1	-	2	-	-	3	-
		<i>Hyphydrus</i> sp. indet. (L)	3	-	1	-	-	-	-	-	-	-	-	2	2
		<i>Laccophilus sharpi</i>	-	-	-	-	-	-	-	1	-	-	-	-	-

Phylum/Class/Order	Family	Lowest taxon	EC1	FLCP1	FM2	NB1	OP1	OP2	OP3	OP4	OP5	OPDS2	OPDS3	PB1	PH1
		<i>Laccophilus</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	-	2	-
		<i>Limbodessus compactus</i>	-	-	-	-	-	2	-	1	2	-	-	-	-
		<i>Necterosoma regulare</i>	-	-	-	-	3	-	-	2	2	-	3	-	-
		<i>Necterosoma</i> sp. indet. (L)	-	-	-	-	-	-	-	-	-	-	-	2	-
		<i>Neobidessodes denticulatus</i>	-	-	-	-	-	3	-	-	3	-	2	3	-
		<i>Platynectes</i> sp. indet. (L)	2	-	-	-	-	-	-	-	-	-	-	-	-
		<i>Rhantus</i> sp. indet. (L)	-	-	1	-	-	-	-	-	-	-	-	-	-
		<i>Rhantus suturalis</i>	-	-	1	-	-	-	-	-	-	-	-	-	-
		<i>Sternopriscus multimaculatus</i>	-	2	-	-	-	-	-	-	-	-	-	2	-
	Gyrinidae	<i>Macrogyrus</i> sp. indet. (L)	3	-	-	-	-	-	-	-	-	-	-	-	-
		<i>Dineutus australis</i>	-	-	-	-	-	-	-	1	-	-	-	2	-
	Hydraenidae	<i>Hydraena</i> sp. indet. (L)	1	-	-	-	-	-	-	-	-	-	-	-	-
		<i>Hydraena</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	-	1	-
		<i>Limnebius</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	2	-	-
		<i>Ochthebius</i> sp. indet.	-	-	-	-	-	1	-	2	-	-	2	-	-
	Hydrochidae	<i>Hydrochus</i> sp. indet.	2	-	-	-	-	-	-	-	-	1	3	-	-
	Hydrophilidae	nr. <i>Anacaena</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	1	-	-
		<i>Berosus dallasae</i>	-	-	-	1	-	-	-	2	-	-	-	-	-
		<i>Berosus pulchellus</i>	-	2	-	-	-	-	-	-	-	-	-	-	-
		<i>Berosus</i> sp. indet. (L)	-	-	-	-	-	-	-	-	-	-	-	1	-
		<i>Chaetarthria nigerrima</i>	-	-	-	-	-	-	-	-	-	-	1	-	-
		<i>Enochrus esuriens</i>	-	-	-	-	-	-	-	-	-	-	2	-	-
		<i>Enochrus</i> sp. indet. (L)	-	-	1	-	-	-	-	-	-	-	-	-	-
		<i>Helochaes</i> sp. indet. (L)	-	-	-	-	-	-	-	1	-	1	2	2	-
		<i>Helochaes tatei</i>	-	-	-	-	-	1	-	-	-	-	1	-	-
		<i>Laccobius billi</i>	-	-	-	-	-	-	-	-	-	-	2	-	-
		<i>Paracymus spenceri</i>	-	-	-	-	-	1	-	-	-	1	-	-	-
		<i>Regimbartia attenuata</i> (L)	-	-	-	-	-	-	-	-	-	-	-	1	-
		<i>Sternolophus</i> sp. indet. (L)	-	-	-	1	-	-	-	-	-	-	-	-	-
	Limnichidae	Limnichidae indet. sp. indet.	-	-	-	1	-	-	-	-	-	-	-	-	-
	Spercheidae	<i>Spercheus</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	-	1	-
	<b>Diptera</b>	Ceratopogonidae	2	4	3	5	2	4	3	2	2	3	4	3	2
		Ceratopogoninae indet. sp. indet. (P)	-	-	2	-	-	-	-	-	-	-	1	-	1
		<i>Dasyhelea</i> sp. indet.	-	-	1	-	-	-	-	-	-	2	2	-	-
	Chaoboridae	Chaoboridae indet. sp. indet.	1	-	-	-	-	-	-	-	-	-	-	-	-

Phylum/Class/Order	Family	Lowest taxon	EC1	FLCP1	FM2	NB1	OP1	OP2	OP3	OP4	OP5	OPDS2	OPDS3	PB1	PH1	
	Chironomidae	Chironomidae indet. sp. indet. (P)	-	1	3	2	2	2	2	2	3	2	3	3	4	
		Chironominae indet. sp. indet.	4	4	4	5	4	4	4	3	4	4	4	4	4	4
		Orthoclaadiinae indet. sp. indet.	-	-	3	-	-	-	1	2	2	-	2	4	4	4
		Tanypodinae indet. sp. indet.	1	4	4	5	4	4	4	4	4	4	4	4	4	4
	Culicidae	Culicidae indet. sp. indet. (P)	-	-	-	2	-	-	-	-	-	-	-	-	-	-
		<i>Aedes</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	1	-	-	-
		<i>Anopheles</i> sp. indet.	-	-	3	-	-	-	-	1	-	-	-	-	2	2
		<i>Culex</i> sp. indet.	-	-	2	2	-	-	-	-	-	-	-	-	-	-
	Simuliidae	Simuliidae indet. sp. indet.	-	-	2	-	-	-	-	-	-	-	-	-	4	3
		Simuliidae indet. sp. indet. (P)	-	-	-	-	-	-	-	-	-	-	-	-	2	-
	Stratiomyidae	Stratiomyidae indet. sp. indet.	-	-	-	-	-	-	-	-	-	-	-	3	-	-
	Tabanidae	Tabanidae indet. sp. indet.	-	-	1	-	-	-	-	-	-	-	-	-	-	2
	Thaumaleidae	Thaumaleidae indet. sp. indet.	-	-	2	-	-	-	-	-	-	-	-	-	-	-
	<b>Lepidoptera</b>	Crambidae	Acentropinae indet. sp. indet.	1	-	1	-	-	-	-	-	-	-	-	-	1
<i>Parapoynx</i> indet. sp. indet.			-	2	-	3	3	-	-	4	-	-	-	-	-	-
<b>Thysanoptera</b>		Thysanoptera indet. sp. indet.	-	-	-	-	-	1	-	1	-	1	-	-	-	
<b>Trichoptera</b>	Ecnomidae	<i>Ecnomus</i> sp. indet.	-	-	-	2	2	2	2	2	2	3	1	3	-	
	Hydropsychidae	<i>Cheumatopsyche wellsae</i>	-	-	-	-	-	-	-	-	-	-	-	2	-	
	Hydroptilidae	<i>Hellyethira</i> sp. indet.	-	-	-	1	-	-	-	-	-	-	2	-	-	
		<i>Orthotrichia</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	2	-	-	
	Leptoceridae	Leptoceridae indet. sp. indet. (imm./dam.)	1	-	2	2	-	-	1	1	1	-	-	-	-	-
		<i>Leptocerus atsou</i>	-	-	-	-	-	-	1	-	-	-	-	-	-	-
		<i>Oecetis</i> sp. indet.	-	2	2	-	2	2	-	3	-	-	2	-	2	
		<i>Triaenodes</i> sp. indet.	-	-	-	-	-	-	1	-	-	-	-	-	-	-
		<i>Tripletides ciuskus</i> subsp. <i>seductus</i>	-	2	2	2	-	2	-	2	1	-	2	2	2	
	Philopotamidae	<i>Chimarra</i> sp. AV17	-	-	-	-	-	-	-	-	-	-	-	-	1	
<b>Total Taxa Richness</b>		<b>144</b>	<b>29</b>	<b>31</b>	<b>42</b>	<b>40</b>	<b>29</b>	<b>42</b>	<b>41</b>	<b>51</b>	<b>42</b>	<b>38</b>	<b>57</b>	<b>56</b>	<b>29</b>	

**Appendix 6b.** Macroinvertebrate taxa list recorded during the 2022 wet season. Values are log<sub>10</sub> abundance categories, where 1= 1 individual, 2 = 2-10 individuals, 3 = 11-100, 4 = 101-1000 etc.

Phylum/Class/Order	Family	Lowest taxon	OP1	OP2	OP3	OP4	OP5	OPDS1	OPDS2	OPDS3	SP1	PH1	PB1	FLCP1	NB1	JX1	EC1	FM2	FRB1	
<b>CNIDARIA</b>																				
<b>HYDROZOA</b>																				
	<b>Anthoathecata</b>	Hydridae	<i>Hydra</i> sp.indet.	-	-	-	-	-	4	2	-	-	-	-	-	-	2	-	-	
<b>NEMATODA</b>			Nematoda indet. sp. indet.	4	2	-	3	-	-	-	-	2	1	2	-	2	2	-	-	
<b>PLATYHELMINTHES</b>																				
<b>TURBELLARIA</b>																				
			Turbellaria indet. sp. indet.	-	-	-	-	-	4	-	2	-	-	-	4	-	-	-	-	
<b>GASTROPODA</b>																				
	<b>Hygrophila</b>	Lymnaeidae	<i>Austropeplea lessoni</i>	2	-	-	3	-	1	2	2	2	3	3	-	-	-	3	-	
		Planorbidae	<i>Ferrissia petterdi</i>	-	1	-	-	-	-	-	2	-	-	1	-	-	2	-	-	
			<i>Gyraulus</i> sp. indet.	3	-	-	2	-	-	-	1	2	3	3	-	-	1	4	-	
			<i>Glytophysa</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	
			Planorbidae indet. sp. indet.	-	-	-	4	-	-	-	-	-	-	-	-	-	-	1	-	
<b>ANNELIDA</b>																				
	<b>OLIGOCHAETA</b>		Oligochaeta indet. sp. indet.	3	3	3	2	-	2	-	4	3	2	3	3	4	2	2	4	-
			Naididae indet. sp. indet.	4	-	-	4	-	-	2	3	2	2	3	-	5	-	2	2	-
<b>ARTHROPODA</b>																				
<b>CHELICERATA</b>																				
<b>ARACHNIDA</b>																				
	<b>Sarcoptiformes</b>		Oribatida indet. sp. indet	-	-	4	-	-	-	-	2	-	-	-	-	2	-	2	-	
	<b>Trombidiformes</b>		Trombidiformes indet. sp. indet. (imm.)	-	-	-	-	2	-	-	-	-	-	-	-	-	-	1	-	
		Arrenuridae	Arrenuridae indet. sp. indet.	2	1	2	-	3	2	2	2	-	2	1	-	1	1	-	-	
		Aturidae	Aturidae indet. sp. indet.	-	-	-	4	-	-	1	-	-	-	-	-	-	-	2	-	
		Hydrodromidae	<i>Hydrodroma</i> sp. indet.	2	-	-	1	-	-	-	-	-	1	2	2	1	-	1	-	
		Hydryphantidae	Hydryphantidae indet. sp. indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	
		Hydrachnidae	<i>Hydrachna</i> sp. indet.	4	-	4	-	4	-	-	2	1	-	1	-	-	-	-	-	
		Hygrobatidae	Hygrobatidae indet. sp. indet.	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	
		Limnesiidae	Limnesiidae indet. sp. indet.	1	-	3	-	2	-	1	-	2	-	1	1	2	3	3	3	
		Mideopsidae	Mideopsidae indet. sp. indet.	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	
		Oxidae	<i>Oxus</i> sp. indet.	-	1	1	-	2	-	-	-	-	-	-	-	-	-	-	-	
		Unionicolidae	Unionicolidae indet. sp. indet.	-	2	2	-	-	-	2	2	-	-	-	-	2	2	2	-	

Phylum/Class/Order	Family	Lowest taxon	OP1	OP2	OP3	OP4	OP5	OPDS1	OPDS2	OPDS3	SP1	PH1	PB1	FLCP1	NB1	JX1	EC1	FM2	FRB1
<b>CRUSTACEA</b>																			
	<b>Malacostraca</b>	Parastacidae	<i>Cherax quadricarinatus</i>	-	2	-	-	-	-	-	-	-	-	-	2	-	-	-	-
	<b>Branchiopoda</b>	Cyzicidae	<i>Caenestheriella packardi</i>	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
			<i>Caenestheriella</i> sp. indet. (imm.)	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
<b>HEXAPODA</b>																			
	<b>COLLEMBOLA</b>		Collembola indet. sp. indet.	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
	<b>INSECTA</b>																		
	<b>Odonata</b>		Odonata indet. sp. indet.	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
	<b>Anisoptera</b>																		
		Aeshnidae	Aeshnidae indet. sp. indet.	-	1	-	-	-	-	-	-	-	3	-	-	-	-	-	-
			<i>Anax</i> sp. indet. (imm)	-	-	-	-	-	-	-	-	2	-	-	-	-	-	3	-
			<i>Anax papuensis</i>	-	-	-	1	-	-	2	2	1	1	2	-	-	-	2	-
		Corduliidae	Corduliidae indet. sp. indet. (imm)	-	-	-	-	-	-	-	-	3	-	3	-	-	-	-	-
			<i>Hemicordulia</i> sp. indet.	-	-	-	-	2	-	-	-	3	-	-	-	2	-	-	-
			<i>Hemicordulia koomina</i>	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
			<i>Hemicordulia tau</i>	-	1	-	1	1	-	-	-	2	2	2	-	3	2	-	1
		Libellulidae	Libellulidae indet. sp. indet. (imm.)	-	-	-	-	-	3	2	-	-	-	-	-	-	2	2	-
			<i>Diplacodes bipunctata</i>	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
			<i>Orthetrum caledonicum</i>	-	1	-	-	-	-	2	-	2	1	-	1	2	2	1	-
			<i>Tramea</i> sp. indet.	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
	<b>Zygoptera</b>																		
		Coengrionidae	Coengrionidae indet. sp. indet. (imm.)	-	-	-	-	-	3	1	2	-	-	-	-	-	-	-	-
			<i>Argiocnemis kunjina</i>	-	-	-	-	-	1	1	1	-	2	-	-	-	2	1	-
			<i>Argiocnemis rubescens</i>	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
			<i>Austroagrion pindrina</i>	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
			<i>Ischnura aurora</i>	2	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
			<i>Pseudagrion aureofrons</i>	-	-	-	-	-	-	1	-	-	1	-	1	-	-	-	-
		Isostictidae	Isostictidae indet. sp. indet. (imm.)	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
			<i>Eurysticta coolawanyah</i>	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
	<b>Ephemeroptera</b>																		
		Baetidae	Ephemeroptera indet. sp. indet.	4	-	-	-	-	-	2	-	2	2	-	-	-	-	2	-
			Baetidae indet. sp. indet.	3	3	3	4	3	-	4	3	4	3	3	3	3	3	4	3
			<i>Cloeon</i> sp. Red Stripe	3	4	4	4	3	-	4	4	-	2	4	3	2	3	3	3
			<i>Offadens</i> sp. indet. (dam/imm.)	-	-	-	3	-	-	-	-	3	-	-	3	-	-	-	-

Phylum/Class/Order	Family	Lowest taxon	OP1	OP2	OP3	OP4	OP5	OPDS1	OPDS2	OPDS3	SP1	PH1	PB1	FLCP1	NB1	JX1	EC1	FM2	FRB1	
Hemiptera	Caenidae	Caenidae indet. sp. indet.	3	-	-	-	-	-	-	3	3	-	4	-	-	-	3	-	-	
		<i>Tasmanocoenis</i> sp. indet.	-	-	-	-	-	-	-	-	-	4	-	-	-	4	4	-	3	-
		<i>Tasmanocoenis</i> sp. M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
		<i>Tasmanocoenis arcuata</i>	1	-	-	-	-	-	-	-	2	3	4	3	2	2	3	3	2	-
	Belostomatidae	<i>Diplonychus eques</i>	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
		<i>Lethocerus distinctifemur</i>	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
	Corixidae	Corixidae indet. sp. indet.	4	-	2	4	4	-	-	-	2	1	-	-	-	-	-	2	-	-
		<i>Agraptocorixa parvipunctata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
	Gerridae	<i>Limnogonus</i> sp. indet. (imm.)	-	1	-	-	-	-	-	-	-	-	-	2	-	-	-	1	3	-
		<i>Limnogonus fossarum</i> subsp. <i>gilguy</i>	-	1	-	-	2	2	-	-	-	-	-	-	-	-	2	1	2	-
		<i>Rhagadotarsus anomalus</i>	1	2	-	-	-	-	-	-	-	1	-	-	-	-	-	2	-	-
	Mesoveliidae	<i>Mesovelia hackeri</i>	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		<i>Mesovelia hungerfordi</i>	-	-	1	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
		<i>Mesovelia vittigera</i>	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-
	Micronectidae	<i>Micronecta</i> sp. indet. (F/imm.)	4	4	3	3	3	-	3	-	2	-	2	-	4	-	3	2	-	-
		<i>Micronecta annae</i>	4	4	3	3	3	-	-	-	2	2	3	2	3	3	-	4	3	-
		<i>Micronecta gracilis</i>	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		<i>Micronecta halei</i>	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Nepidae	<i>Ranatra occidentalis</i>	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-
	Notonectidae	<i>Anisops</i> sp. indet.	-	-	-	3	-	-	-	-	-	-	-	1	-	-	-	-	-	-
<i>Anisops hackeri</i>		1	-	-	2	-	-	2	-	-	-	-	2	-	-	-	-	-	-	
<i>Notonectidae</i> indet. sp. indet.		-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	
Pleidae	<i>Paraplea</i> sp. indet.	2	2	3	3	2	-	1	-	-	-	-	2	-	2	2	2	2	-	
	<i>Paraplea brunni</i>	1	2	3	3	3	-	1	-	2	1	2	-	2	2	2	2	3	2	
Veliidae	<i>Microvelia</i> sp. indet. (F/imm.)	-	-	-	-	-	-	-	-	3	-	2	2	-	-	-	-	1	-	
	<i>Microvelia australiensis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	
	<i>Microvelia herberti</i>	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	
Coleoptera	Dytiscidae	Dytiscidae indet. sp. indet. (dam.)	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	
		Dytiscidae indet. sp. indet. (L)	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
		<i>Austrodytes plateni</i>	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
		Bidessini sp. indet. (L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
		<i>Cybister</i> sp. indet. (L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
		<i>Cybister tripunctatus</i>	-	-	-	1	-	-	3	-	-	-	-	-	-	1	-	-	-	-

Phylum/Class/Order	Family	Lowest taxon	OP1	OP2	OP3	OP4	OP5	OPDS1	OPDS2	OPDS3	SP1	PH1	PB1	FLCP1	NB1	JX1	EC1	FM2	FRB1
		<i>Eretes australis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
		<i>Hydroglyphus daemeli</i>	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
		<i>Hydroglyphus godeffroyi</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
		<i>Hydroglyphus grammopterus</i>	-	-	-	-	-	-	-	-	1	2	-	-	1	-	-	-	-
		<i>Hydroglyphus leai</i>	1	-	-	-	1	-	-	2	2	1	-	-	3	2	-	-	-
		<i>Hydroglyphus orthogrammus</i>	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
		<i>Hyphidrus</i> sp. indet. (L)	-	-	-	-	-	-	-	-	1	2	1	-	-	-	1	1	2
		<i>Hyphidrus decemmaculatus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
		<i>Hyphidrus elegans</i>	-	-	-	-	-	-	-	-	1	2	-	1	1	-	1	2	-
		<i>Hyphidrus lyratus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3	-
		<i>Limbodessus compactus</i>	-	1	-	-	-	-	1	3	-	-	-	-	-	-	2	-	-
		<i>Necterosoma</i> sp. indet. (L)	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	-
		<i>Necterosoma regulare</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1
		<i>Neobidessodes denticulatus</i>	-	-	-	-	1	-	-	-	-	3	-	-	-	-	-	-	-
		<i>Platynectes decempunctatus</i> var. <i>decempunctatus</i>	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
		<i>Rhantus</i> sp. indet. (L)	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
		<i>Rhantus</i> sp. indet.	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
		<i>Sternopriscus multimaculatus</i>	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Gyrinidae	<i>Dineutus australis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
	Hydraenidae	<i>Hydraena</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
		<i>Hydraena</i> sp. indet. (L)	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
	Hydrophilidae	<i>Berosus</i> sp. indet. (L)	2	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-
		<i>Berosus</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
		<i>Berosus dallasae</i>	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	1	1
		<i>Berosus pulchellus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
		<i>Hydrochus</i> sp. indet.	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	3
		<i>Paracymus</i> sp. indet. (L)	-	-	2	-	-	-	-	-	-	-	-	-	-	1	-	2	-
		<i>Regimbartia attenuata</i>	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Diptera																			
	Ceratopogonidae	<i>Austroconops</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	2	-	-	1	1	2	-
		Ceratopogoninae indet. sp. indet.	2	2	2	-	2	-	-	4	2	3	3	3	4	1	2	2	2
		Ceratopogoninae indet. sp. indet. (P)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-
		<i>Dasyhelea</i> sp. indet.	-	-	-	-	-	-	1	2	1	-	1	-	-	-	-	-	-
		Forcipomyiinae indet. sp. indet.	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-

Phylum/Class/Order	Family	Lowest taxon	OP1	OP2	OP3	OP4	OP5	OPDS1	OPDS2	OPDS3	SP1	PH1	PB1	FLCP1	NB1	JX1	EC1	FM2	FRB1
	Chaoboridae	Chaoboridae indet. sp. indet.	-	-	2	-	4	4	-	-	-	-	-	-	-	-	-	-	-
	Chironomidae	Chironominae indet. sp. indet. (A)	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
		Chironominae indet. sp. indet.	3	3	4	4	3	3	4	3	3	3	4	4	5	3	4	3	4
		Chironominae indet. sp. indet. (P)	3	-	1	2	-	-	-	-	-	-	-	1	-	2	3	-	2
		Orthoclaadiinae indet. sp. indet.	-	2	2	-	-	-	-	2	-	-	3	-	-	2	3	2	-
		Tanypodinae indet. sp. indet.	2	2	4	4	3	2	4	4	3	3	4	4	4	3	4	4	-
		Tanypodinae indet. sp. indet. (P)	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	Culicidae	Culicidae indet. sp. indet. (P)	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
		<i>Aedes</i> sp. indet.	-	-	-	-	-	-	1	-	-	-	2	-	2	-	-	1	-
		<i>Anopheles</i> sp. indet.	-	-	-	1	-	-	-	-	-	-	1	-	2	-	-	1	-
		<i>Culex</i> sp. indet.	-	-	2	-	-	-	-	-	-	-	2	-	-	-	-	2	-
		<i>Culex</i> sp. indet. (P)	-	-	2	-	-	-	-	-	-	-	1	-	-	-	-	-	-
	Dolichopodidae	Dolichopodidae indet. sp. indet.	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	Empididae	Empididae indet. sp. indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
	Ephydriidae	Ephydriidae indet. sp. indet.	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	Muscidae	Muscinae indet. sp. indet.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-
	Simuliidae	Simuliidae indet. sp. indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	-	-
	Tabanidae	Tabanidae indet. sp. indet.	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
<b>Lepidoptera</b>																			
	Pyralidae	Pyralidae indet. sp. indet. (L)	-	-	1	-	-	-	-	2	-	2	2	-	-	-	-	-	-
<b>Trichoptera</b>																			
	Ecnomidae	<i>Ecnomina</i> sp. indet. (imm.)	-	-	-	-	-	-	-	-	-	-	2	-	-	1	-	-	-
		<i>Ecnomina</i> sp. AV14	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
		<i>Ecnomus pilbarensis</i>	-	-	-	1	-	-	-	1	1	2	2	1	-	-	2	2	-
		<i>Ecnomus</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
	Hydropsychidae	<i>Cheumatopsyche wellsae</i>	-	-	-	-	-	-	-	-	-	-	3	-	-	3	2	2	-
		<i>Cheumatopsyche</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-
		<i>Smicrophylax</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
	Hydroptilidae	Hydroptilidae indet. sp. indet. (imm.)	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
		<i>Orthotrichia</i> sp. indet.	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Leptoceridae	<i>Leptocerus</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-
		<i>Oecetis</i> sp. indet.	2	1	-	-	-	-	1	1	2	2	1	3	2	-	2	1	-
		<i>Trianodes</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
		<i>Triplectides australicus</i>	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Phylum/Class/Order	Family	Lowest taxon	OP1	OP2	OP3	OP4	OP5	OPDS1	OPDS2	OPDS3	SP1	PH1	PB1	FLCP1	NB1	JX1	EC1	FM2	FRB1
		<i>Triplectides ciuskus</i> subsp. <i>seductus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
		<i>Triplectides</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
	Philopotamidae	<i>Chimarra</i> sp. AV17	-	-	-	-	-	-	-	1	-	2	-	-	-	3	2	-	-
		<i>Chimarra</i> sp. AV18	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
<b>Total Taxa Richness</b>		<b>152</b>	<b>34</b>	<b>27</b>	<b>26</b>	<b>34</b>	<b>25</b>	<b>14</b>	<b>30</b>	<b>38</b>	<b>35</b>	<b>34</b>	<b>56</b>	<b>18</b>	<b>34</b>	<b>34</b>	<b>46</b>	<b>55</b>	<b>16</b>

**Appendix 7a.** Sediment rehydration taxa list from the 2021 dry season. Values represent log abundance where 1=1 individual, 2 = 2-10 individuals, 3=11-100, 4=101-1000 etc.

Phylum/Class/Order	Family	Lowest Taxon	WC1	FRB1	OP1	OP3	OP5	OPDS2	EC1	JX1	PB1	PH1	FM2	FLCP1	NB1
<b>BRYOZOA</b>		Bryozoa indet. sp. indet.	-	-	-	-	-	-	-	-	1	1	-	-	-
<b>PLATYHELMINTHES</b>															
<b>TURBELLARIA</b>		Turbellaria indet. sp. indet.	-	-	-	-	-	-	-	1	-	-	-	3	2
<b>ROTIFERA</b>															
	<b>Bdelloidea</b>	Bdelloidea indet. sp. indet. bdelloid (lg)	-	-	-	-	-	2	-	-	-	1	-	-	2
		Bdelloidea indet. sp. indet. bdelloid (sm)	-	-	-	-	-	-	-	-	-	1	-	-	-
	<b>Monogononta</b>														
	Euchlanidae	<i>Euchlanis dilatata</i>	2	-	-	-	-	-	-	-	-	-	-	2	-
	Hexarthridae	<i>Hexarthra mira</i>	-	-	-	-	-	-	-	-	-	-	-	2	-
	Lecanidae	<i>Lecane bulla</i>	1	-	-	-	-	-	-	-	-	-	-	3	-
		<i>Lecane nitida</i>	-	-	-	-	-	-	-	-	-	2	-	-	-
	Flosculariidae	<i>Sinantherina</i> sp. indet. (colony)	-	-	-	-	3	-	-	-	-	-	-	-	-
<b>ARTHROPODA</b>															
<b>CRUSTACEA</b>															
<b>BRANCHIOPODA</b>															
<b>Diplostraca</b>															
<b>Cladocera</b>	Chydoridae	<i>Alona rigidicaudis</i>	-	-	3	-	2	3	3	-	3	3	-	-	3
		<i>Anthalona harti</i> subsp. <i>occidentalis</i>	-	-	-	-	-	-	3	-	-	-	-	-	-
		<i>Armatalona macrocopa</i>	-	2	-	2	3	-	2	-	-	3	-	-	-
		Chydoridae indet. sp. indet.	-	-	-	-	-	-	-	-	-	3	-	-	-
		<i>Chydorus</i> cf. <i>sphaericus</i>	-	-	3	-	-	-	-	-	-	-	-	-	-
		<i>Ephemeroporus barroisi</i>	4	-	-	-	-	-	-	-	2	1	-	-	-
		<i>Karualona karua</i>	-	-	-	-	4	-	-	-	3	3	-	-	-
		<i>Leberis diaphanus</i>	-	-	-	-	-	3	-	-	-	-	-	-	4
		<i>Rak</i> sp. indet.	2	-	-	-	-	-	-	-	-	-	-	-	-
	Daphniidae	<i>Ceriodaphnia cornuta</i>	-	-	-	-	-	1	-	1	-	-	-	2	-
		<i>Ceriodaphnia dubia</i>	-	-	-	-	-	-	-	2	-	2	-	-	-
		<i>Ceriodaphnia</i> sp. indet.	-	-	-	-	-	-	-	3	-	-	-	-	-
		<i>Daphnia carinata</i>	-	-	-	-	-	-	-	-	-	-	-	-	2
		<i>Simocephalus heilongjiangensis</i>	3	-	-	-	-	-	-	-	-	-	-	-	-
	Macrotrichidae	<i>Macrothrix</i> sp. indet.	-	-	-	-	4	-	-	-	-	4	-	4	-
	Monidae	<i>Moina micrura</i>	-	2	-	-	-	-	-	-	-	4	-	-	-
	Sididae	<i>Diaphanosoma excisum</i>	-	-	-	-	-	-	-	-	-	-	-	-	2
<b>MAXILLOPODA</b>															
<b>Copepoda</b>		<i>Calanoida</i> indet. sp. indet. nauplii	-	-	-	-	-	-	-	-	-	-	-	1	-
<b>OSTRACODA</b>		Ostracoda indet. sp. indet. (juv.)	-	-	3	4	-	-	-	-	-	2	-	1	-

Phylum/Class/Order	Family	Lowest Taxon	WC1	FRB1	OP1	OP3	OP5	OPDS2	EC1	JX1	PB1	PH1	FM2	FLCP1	NB1	
Podocopida	Cyprididae	<i>Cypretta</i> sp. indet.	2	3	2	3	3	2	-	-	3	3	2	-	2	
		<i>Cypridopsis</i> sp. indet.	1	-	-	2	-	-	-	-	-	-	-	-	-	-
		<i>Riocypris</i> sp. indet.	1	-	-	3	-	-	-	-	-	-	-	-	-	-
		<i>Stenocypris major</i>	1	-	-	3	-	-	-	-	-	-	-	-	-	2
		<i>Stenocypris</i> sp. indet.	-	-	-	-	-	-	-	-	-	-	-	-	1	-
		<i>Limnocythere</i> sp. indet.	2	-	3	-	2	2	2	2	-	-	-	1	2	-
	Limnocytheridae															
<b>Total Taxa Richness</b>		<b>34</b>	<b>10</b>	<b>3</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>6</b>	<b>4</b>	<b>4</b>	<b>5</b>	<b>14</b>	<b>2</b>	<b>10</b>	<b>8</b>	

**Appendix 7b.** Sediment rehydration taxa list from the 2022 wet season. Values represent log abundance where 1=1 individual, 2 = 2-10 individuals, 3=11-100, 4=101-1000 etc.

Phylum/Class/Order	Family	Lowest Taxon	OP2	OP3	OP4	OP5	FM2
NEMATODA		Nematoda indet. sp. indet.	-	-	-	-	1
ARTHROPODA							
	CRUSTACEA						
	BRANCHIOPODA						
	Diplostraca						
	Cladocera	Macrotrichidae	-	3	2	1	3
		<i>Macrothrix</i> sp. indet.					
	OSTRACODA						
	Podocopida	Cyprididae	1	-	-	-	-
		<i>Cypridopsis</i> sp. indet.	1	-	-	-	-
		<i>Stenocypris</i> sp. indet.	-	-	2	-	-
		Ostracoda indet. sp. indet. (dam.)	-	-	2	-	-
HEXAPODA							
	COLLEMBOLA						
		Dicyrtomidae	1	-	1	-	-
		Isotomidae	3	-	2	2	-
		Dicyrtomidae indet. sp. indet.					
		Isotomidae indet. sp. indet.					
<b>Total Taxa Richness</b>		<b>7</b>	<b>4</b>	<b>1</b>	<b>4</b>	<b>2</b>	<b>2</b>