



**Biologic**  
ENVIRONMENTAL  
SURVEY

# Sanjiv Ridge BWT Aquatic Ecology Assessment 2024

Report to Atlas Iron

16 May 2025

Document Status				
Revision No.	Author	Review / Approved for Issue	Approved for Issue to Name	Date
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2	Jess Delaney	Kim Nguyen	Larissa Byrne (Atlas)	18/03/2025
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# Executive Summary

## Background and Objectives

Atlas Iron Pty Ltd (Atlas Iron) is developing the Sanjiv Ridge Project (the Project), located approximately 33 km south of Marble Bar with plans to extend below the water table (BWT). The Coongan River flows adjacent to the Project, and various pools are known to occur within and surrounding the Project area, with several known to support obligate groundwater dependent vegetation (Woodman Environmental, 2019). Drawdown from the BWT development may impact pools influenced by groundwater and the aquatic ecology values they support. Discharge of excess groundwater may also be required, which has the potential to alter the hydrological regime and water quality in the receiving environment. Therefore, Atlas Iron contracted Biologic Environmental Survey (Biologic) to undertake a comprehensive, two season aquatic ecology survey to document baseline values within pools which may be impacted by dewatering and discharge operations (hereafter referred to as the Survey).

## Sampling Design and Methods

The sampling design included ten Study Area sites, comprising:

- Three sites on Glen Herring Creek (SR-01, SR-02, SR-03), with one additional rehydrate site sampled in the wet season (SR-01R)
- Three sites on the Coongan River (SR-04, SR-05, SR-06)
- Four sites in the Resource Area (CO-WS-10, CO-WS-12, CO-WS-14, CO-WS-16)

Five reference sites, located outside areas of potential impact, were also sampled to provide context and allow for an mBACI (multiple Before After Control Impact) statistical design. Reference sites included two on Camel Creek (SRRef-01, SRRef-02), one on Glen Herring Creek (SRRef-03) and two on Emu Creek (ECRef-04, ECRef-05).

Sampling was undertaken in April, in the post-wet season (Wet 2024), and September, in the dry season (Dry 2024). One Study Area site (SR-05) and two Reference sites (SRRef-03 and ECRef-05) were dry during the dry season. All other pools were persistent and held water over the dry season.

At sites holding surface water, a range of ecological components was sampled including water quality, aquatic macrophytes and dominant riparian flora, hyporheos fauna (invertebrate fauna residing within the hyporheic zone in the interstices between the surface and groundwater), aquatic macroinvertebrates, fish and other aquatic vertebrate fauna observed at the time of sampling. At dry sites, the riparian flora was surveyed and

sediment samples were collected and rehydration emergence trials undertaken in the Biologic laboratory.

## **Results and Discussion**

### GDEs

The Coongan River, in an area encompassing all three Study Area sites (SR-04 to SR-06), was identified in the desktop assessment (Bureau of Meteorology GDE Atlas) as having a high potential to support aquatic GDEs. The Survey supported this, especially pools at SR-04 and SR-06. These two pools recorded a high richness of GDV/GDE flora indicator taxa, including the obligate phreatophyte *Melaleuca argentea*, and supported groundwater dependent invertebrate taxa, including stygobites, in the hyporheic zone.

SR-03 on Glen Herring Creek is also considered likely to represent an aquatic GDE, or at least be partly maintained by groundwater inputs, due to high numbers of GDV/GDE indicator taxa and minimal variation in EC between seasons, suggesting some groundwater inflow. Groundwater dependent invertebrate taxa, including stygobites, were also present in the hyporheic zone at this site, suggesting groundwater connectivity through the hydrological profile.

Four permanent gorge pools with groundwater inflows were sampled in the Resource Area, with CO-WS-12, CO-WS-14 and CO-WS-16 all considered likely to represent aquatic GDEs. Surface expressions of groundwater were observed at all sites, and the riparian zones supported a high richness of GDV/GDE indicator flora species, including the obligate phreatophyte *Melaleuca argentea* at CO-SW-14 and CO-SW-16. The pools were particularly fresh, and their connection to groundwaters and persistence meant that they were buffered from evapoconcentration effects. Permanent hyporheos stygophiles were present in the hyporheic zone of CO-WS-12 and CO-WS-14, further highlighting the connection to groundwater at these sites. The remaining pool, CO-WS-10, was considered likely to be partially influenced by groundwater inflow, with aspect and shading from the gorge walls also likely attributing to the lack of evaporation and persistence of this pool.

### Habitat, Water Quality and Biota

The Study Area was found to support a rich diversity of aquatic plants and animals, including 280 invertebrate taxa (from both hyporheic and surface environments, including rehydrates), 42 macrophytes and Groundwater Dependent Vegetation (GDV)/Groundwater Dependent Ecosystem (GDE) flora indicator species, four species of freshwater fish, three frog species, and three waterbird species. Several taxa were significant and are listed on the IUCN Red List of Threatened species, or were considered potentially significant and are

restricted, known from relatively few records and/or represent new Operational Taxonomic Units (OTUs) (discussed further below).

Surface waters of Glen Herring Creek pools were generally fresh and clear, with basic pH and high total N and total P concentrations, but generally low levels of dissolved metals (except dCu). Some disturbances were noted, including impacts from cattle and the presence of invasive weeds. In-stream habitat diversity was high, and comprised high proportions of complex, heterogenous substrates such as submerged macrophytes, algae and detritus. The high habitat richness and heterogeneity supported a high richness of aquatic invertebrates, including significant and/or restricted species. Pools on Glen Herring Creek also provided important breeding and nursery grounds for western rainbowfish and spangled perch.

Water quality in the Coongan River pools was fresh, with variable DO saturation, basic pH and low turbidity. Nutrient and dissolved metal concentrations were generally low, with some exceedances (e.g. dAl, dCr and dCu). Widespread impacts from cattle grazing and trampling, as well as invasive weeds were observed throughout the Coongan River pools. In-stream habitat varied between seasons as pools receded, but was generally dominated by submerged macrophytes. A rich assemblage of riparian vegetation and aquatic invertebrates was recorded from the Coongan River pools, including significant and/or restricted species. A breeding ground for black-fronted dotterel was also present at one site (SR-05).

Pools within the Resource Area were particularly fresh, with low dissolved metal and nutrient concentrations, and few disturbances. In-stream habitat was dominated by detritus, and pools supported a notably high richness of aquatic invertebrates, including significant and/or restricted species. Richness of aquatic invertebrates recorded from two Resource Area pools were the highest recorded during the Survey, and were similar to nearby Pilbara Biologic Survey (PBS) sites that were sampled in a much wetter period (early to mid-2000s). The Resource Area pools do not support fish due to their isolated and disconnected nature, however they do provide ideal habitat for frog species.

#### Significant Taxa

Several significant and/or restricted taxa were recorded from the Study Area. These included:

- The water mites *Wandesia* sp. Biologic-ACAR028` (all Coongan River sites) and *Guineaxonopsis* sp. (Coongan River SR-06) – likely Pilbara endemics with disjunct distributions

- The clam shrimp *Ozestheria` sp.* Biologic-BRAN002` (Glen Herring Creek at SR-02 and SRRef-03, all Coongan River sites and all Emu Creek sites) – likely Pilbara endemic known from relatively few records currently
- The harpacticoid copepod *Australocamptus` sp.* Biologic-HARP099` (Coongan River SR-06) – first record of this OTU, with this genus endemic to WA
- The ostracod *Candonopsis kimberleyi* (Glen Herring Creek SR-02 and Camel Creek SRRef-02) – known from few records, most of which occur in the Kimberley
- The dragonflies *Hemicordulia koomina* (Resource Area CO-WS-14) and *Ictinogomphus dobsoni*, (Resource Area CO-WS-10 and Glen Herring Creek SRRef-03) – listed as Vulnerable and Near Threatened on the IUCN Red List of Threatened Species, respectively
- The damselfly *Eurysticta coolawanyah* (Glen Herring Creek SR-03 and SRRef-03) – listed as Vulnerable on the IUCN Red List
- The damselfly *Nososticta sp.* (Coongan River SR-04) – may represent *N. pilbara*, which is listed as Endangered on the IUCN Red List and is a DBCA Priority 2 species
- The backswimmer *Anisops nabillus* (Resource Area CO-WS-12) – disjunct distribution known from relatively few records.

The desktop assessment identified additional significant taxa that has the potential to occur within the Study Area, including:

- The herb *Stylidium weeliwolli* – DBCA listed Priority 3
- The copepod *Eodiaptomus lumholtzi* – listed as Vulnerable on the IUCN Red List
- The copepod *Parastenocaris sp.* – potentially restricted
- The amphipods Melitidae sp. and Paramelitidae sp. – potentially restricted
- The dragonfly *Austroagrion pindrina* – listed Vulnerable on the IUCN Red List
- The snake, Pilbara olive python *Liasis olivaceus barroni* - listed as Vulnerable under the WA BC Act and Federal EPBC Act

### **Summary and Considerations**

Due to the aridity of the Pilbara, rivers of the region tend to be ephemeral. Permanent surface waters, such as the those found in the Study Area, are relatively scarce in the region and restricted to springs (groundwater fed systems) and permanent pools. Such predictable sources of water have high conservation importance as they support richer faunas than ephemeral waterbodies and provide a refuge for many species during drought. The pools sampled during the Survey were found to support a variety of aquatic ecological values, including a high richness of aquatic invertebrates, groundwater dependent taxa within the hyporheic zone, GDEs, breeding and nursery habitat for fish, significant taxa, and/or new

OTUs. In particular, five pools in the Study Area were found to hold notable ecological value. These were:

1. SR-03 on Glen Herring Creek. This pool likely represents an aquatic GDE and supports high floristic richness, including high richness of GDV/GDE indicators and macrophytes. This site also recorded high numbers of Pilbara endemic and significant macroinvertebrate taxa, high spangled perch abundance, relatively high fish species richness, and provides important breeding and nursery habitat for spangled perch (and western rainbowfish, to a lesser extent).
2. SR-04 on the Coongan River. This pool likely represents an aquatic GDE and supports a high richness of GDV/GDE indicators and macrophytes. This site also recorded high macroinvertebrate richness, with several taxa constituting significant or Pilbara endemic fauna, significant hyporheic fauna, relatively high fish species richness. and provides breeding habitat for western rainbowfish.
3. SR-06 on the Coongan River. This pool likely represents an aquatic GDE and supports high numbers of significant and permanent hyporheic fauna, including a stygobitic taxon, and a high number of GDV/GDE indicator species, all of which suggest strong groundwater connectivity. This site also recorded significant macroinvertebrate fauna, a high abundance of fish, and relatively high fish species richness.
4. CO-WS-10 within the Resource Area. This pool is permanent and likely influenced by some groundwater contributions. It is currently relatively undisturbed. The pool supports high hyporheic and macroinvertebrate taxa richness, including listed odonate species, and two species of frog, with a high abundance of tadpoles recorded.
5. CO-WS-14 within the Resource Area. This pool likely represents an aquatic GDE, with permanent surface water and flow. The pool is currently relatively undisturbed and supports notable land features such as small waterfalls and a bat cave. The pool supports a high richness of High GDV/GDE indicator taxa and macrophytes, including the obligate phreatophyte *Melaleuca argentea*, notably high macroinvertebrate taxa richness, including listed odonates, and permanent hyporheic stygophiles within the hyporheic zone.

Results from the Survey provide an assessment of the baseline ecological values and health of aquatic systems within the Study Area, based on two seasons of sampling over one year. Current ANZG (2018) guidance recommends three years' sampling is required to characterise baseline conditions in aquatic ecosystems to ensure a thorough understanding of ecological value and temporal and seasonal variation. This is especially important in areas driven by highly seasonal events, such as the Study Area.

Not all of the permanent groundwater-fed pools known to occur within the Resource Area were sampled during the Survey. Given the fact that those sampled were found to support high ecological values, it is recommended that additional pools within the Resource Area are sampled prior to drawdown.

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## Glossary

<b>BOM</b>	Bureau of Meteorology
<b>DBCA</b>	Department Biodiversity, Conservation and Attractions
<b>DGV</b>	Default Guideline Value
<b>DO</b>	Dissolved oxygen
<b>DPIRD</b>	Department of Primary Industry and Regional Development
<b>EC</b>	Electrical conductivity
<b>EPBC Act</b>	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
<b>GDE</b>	Groundwater dependent ecosystem
<b>GDV</b>	Groundwater dependent vegetation
<b>GS</b>	Gauging station/s
<b>Hydrophyte</b>	A plant that grows in either partially or totally submerged in water, including waterlogged soil
<b>IUCN</b>	International Union for the Conservation of Nature
<b>LOD</b>	Limit of detection
<b>LWD</b>	Large woody debris
<b>Mesophyte</b>	A plant that grows in an environment that has a moderate supply of water. Growing in, or adapted to, a moderately moist environment
<b>PBS</b>	Pilbara Biological Survey
<b>SRE</b>	Short-range endemic
<b>WAM</b>	Western Australian Museum

# 1 Introduction

## 1.1 Background

Atlas Iron Pty Ltd (Atlas Iron) is currently in the process of developing the Sanjiv Ridge Project (the Project; formerly the Corunna Downs Project), an iron ore mine located approximately 33 km south of Marble Bar, in the Pilbara region of Western Australia (WA) (Figure 1.1). Stage 1 of the Project includes conventional open cut mining, crushing and screening methods, above the groundwater table. Stage 1 was approved in March 2020 (Ministerial Statement Number 1125), and mining commenced shortly after. Stage 2 comprises above water table mining of the Glen Herring deposit, on a range 3 km west of Stage 1, and includes three new pits, four waste rock dumps and haul road connecting to Stage 1 (Figure 1.1). Approval for Stage 2 was granted in September 2022 (Ministerial Statement Number 1197). Current Project development plans involve extending below the water table (BWT), and therefore additional environmental surveys were required to assess areas which may potentially be impacted by drawdown.

Several aquatic habitats occur within and adjacent to the Project area, including riverine pools on the Coongan River and Glen Herring Creek, as well as semi-permanent and permanent rock pools located on minor tributaries and drainages throughout the area. Several of these surface water pools are known to support obligate groundwater dependent vegetation (Woodman Environmental, 2019). Drawdown from the BWT development may impact pools influenced by groundwater and the aquatic ecology values they support. Discharge of excess groundwater may also be required, which has the potential to alter the hydrological regime and water quality in the receiving environment downstream. Therefore, Atlas Iron commissioned Biologic Environmental Survey (Biologic) to undertake a comprehensive aquatic ecology assessment in 2024, including a desktop assessment and two-season aquatic ecology survey (the Survey). The Survey focussed on pools that were considered semi-permanent or permanent, and within areas previously identified by Woodman Environmental (2019) as being at risk from groundwater drawdown impacts (based on GDV risk mapping). The area surrounding the Project and including these pools and features comprised the Study Area for the Survey (see Figure 1.1). The Survey was undertaken to document baseline aquatic values within pools of the Study Area which may be impacted by dewatering and discharge operations.

## 1.2 Scope and Objectives

The overarching objective of the Survey was to document the aquatic ecology values of pools within the Study Area which may be impacted by BWT mining, and which may need to be considered in environmental approvals. This objective was achieved through:

- A desktop assessment to compile information on any aquatic species of significance which occur, or have the potential to occur, within the Study Area
- Completion of a two-season aquatic ecology survey of pools within the Study Area, and Reference pools located elsewhere
- Identification of any significant ecological values related to aquatic fauna and their habitats within the Study Area.

### 1.3 Compliance

Native flora and fauna are protected under the *Biodiversity Conservation Act 2016* (BC Act) at the state level, and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) at a national level. Any action that has the potential to impact native fauna or flora must be approved by relevant State and / or Commonwealth departments as dictated by the state *Environmental Protection Act 1986* (EP Act) and the EPBC Act. For the purposes of Environmental Impact Assessment (EIA), relevant environmental factors defined by the EPA for aquatic ecosystems include Inland Waters, Terrestrial Fauna<sup>1</sup>, and Flora and Vegetation. With respect to Inland Waters, the EPA is primarily focused on significant ecosystems, which in the Pilbara include (but are not limited to):

- wetlands listed in the Directory of Important Wetlands in Australia (DIWA)
- wetlands protected by Environmental Protection Policies under Part III of the *Environmental Protection Act 1986*
- wild rivers, as identified by the Australian Heritage Commission and Department of Water and Environmental Regulation (DWER)
- wetland types which may be poorly represented in the conservation reserves system
- springs and pools, particularly in arid areas
- ecosystems which support significant flora, vegetation and fauna species or communities, including migratory waterbirds, bats, and subterranean fauna
- ecosystems which support significant amenity, recreation, and cultural values (EPA, 2018).

Although there is currently no technical sampling guidance available for Inland Waters, there is relevant information in the Terrestrial Fauna guidance, with respect to timing, effort and the level of survey. In addition, Biologic have a strong understanding of best practice aquatic ecology, following national ANZG (2018) guidance and similar studies undertaken by

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<sup>1</sup> The EPA defines terrestrial fauna as animals living on the land or using land (including aquatic systems) for part of their lives, and include vertebrates (freshwater fish, amphibians, reptiles, birds, and mammals) and invertebrates (EPA, 2016b).

universities and government agencies across Australia. Therefore, the Survey was undertaken in accordance with the following guidance and methods:

- Australian & New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018)
- Environmental Factor Guideline, Inland Waters (EPA, 2018)
- Environmental Factor Guideline, Flora and Vegetation (EPA, 2016a)
- Technical Guidance, Terrestrial Fauna Surveys (EPA, 2016c)
- Assessing and Managing Water Quality in Temporary Waters (Smith *et al.*, 2020)
- Best practice, including the Pilbara Biological Survey (Pinder *et al.*, 2010) and National Monitoring River Health Initiative (Choy & Thompson, 1995)
- Previous aquatic ecology surveys undertaken by Biologic for Atlas (Biologic, 2021).



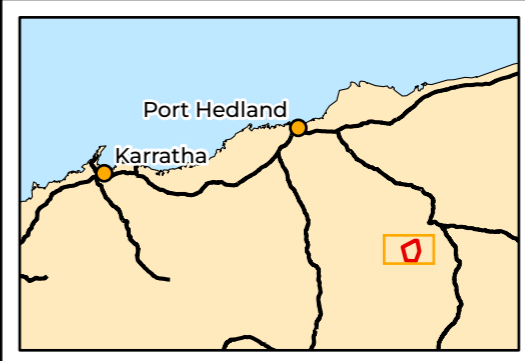
- LEGEND**
- |            |                   |                  |
|------------|-------------------|------------------|
| Study Area | Surface Hydrology | Mine Development |
| GDV Risk   | Minor             | Stage 2          |
| Local Road | Major             | Stage 1          |

**Biologic**

Scale 1:120,000

0 2 4 Km

Coordinate System: GDA 1994 MGA Zone 50  
Transverse Mercator Created: 26/02/2025



**ATLAS IRON**  
**Sanjiv Ridge BWT**  
**Aquatic Ecology Survey**

**Figure 1.1: Study Area and regional context**

## 2 Environment

### 2.1 Biogeography

The Study Area falls within the Pilbara biogeographical region as defined by the Interim Biogeographic Regionalisation of Australia (IBRA) (Thackway & Cresswell, 1995). The Study Area itself occurs within the Chichester subregion (PIL01; Figure 1.1). This subregion contains the northern section of the Pilbara Craton, comprising undulating Archaean plains of granite and basalt, interspersed with significant areas of basalt ranges (Kendrick & McKenzie, 2003). The plains of the Chichester subregion support *Acacia inaequilatera* woodland over *Triodia wiseana* grassland, with steppes of *Eucalyptus leucophloia* occurring on ranges (Kendrick & McKenzie, 2003). Drainage of the subregion occurs via several northerly flowing rivers, including the De Grey, Oakover, Nullagine, Yule and Sherlock (Kendrick & McKenzie, 2003).

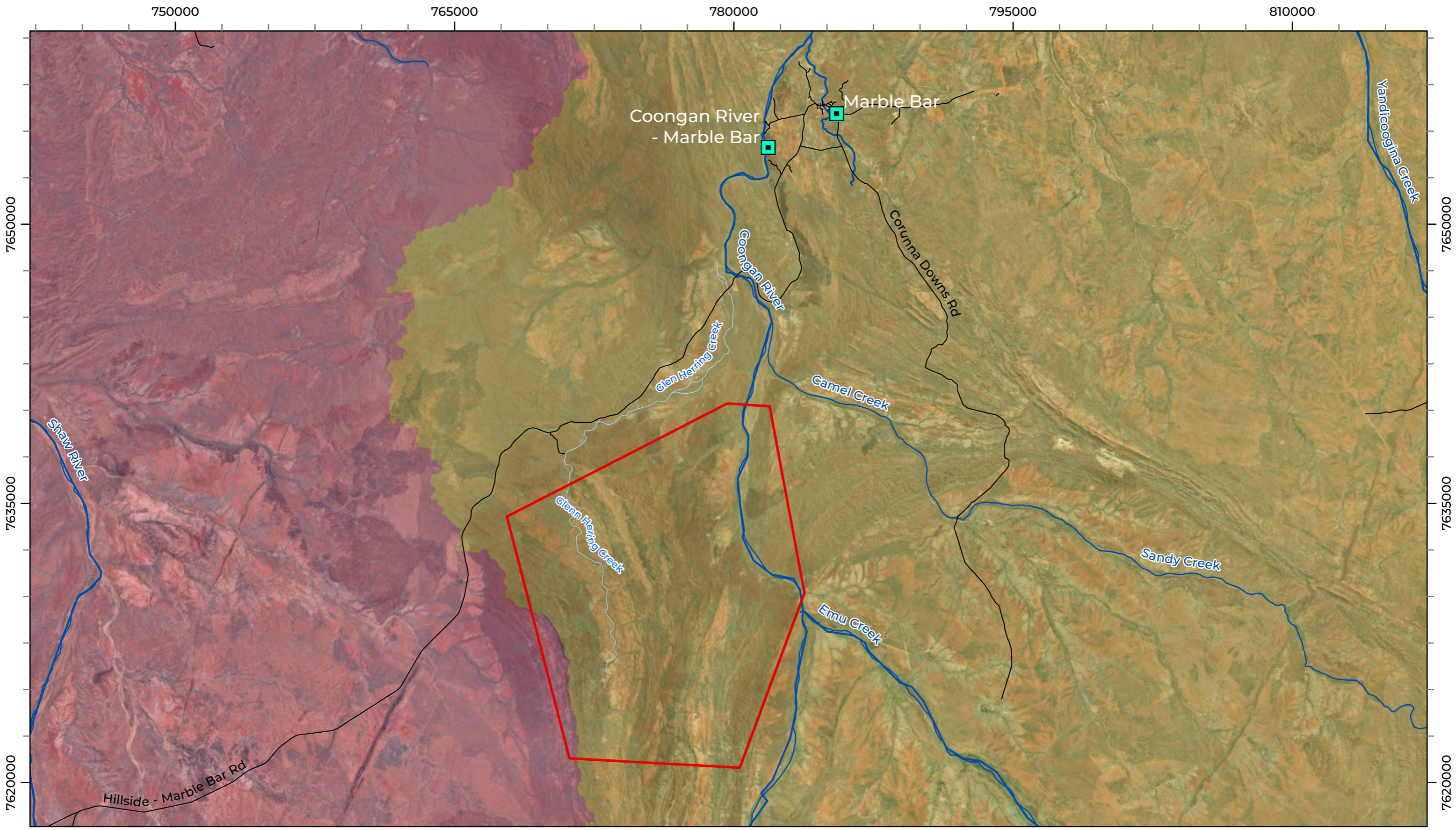
### 2.2 Hydrogeology

The Study Area occurs within the Pilbara Groundwater Province, which is characterised by discontinuous alluvium within ridges of faulted granitoid and folded greenstone rocks (Woodman Environmental, 2019). Both alluvial groundwater and fractured rock aquifer systems feed water features in the Study Area, however groundwater occurrence is often compartmentalised as the system is associated with varying degrees of permeability, controlled by structural features such as fractures, weathered zones, bedding planes, partings and joints (Woodman Environmental, 2019).

### 2.3 Hydrology


The Study Area is located in the De Grey River Basin, which covers 56,890 km<sup>2</sup> and extends over 350 km inland (Ruprecht & Ivanescu, 2000). Within this Basin, the Study Area occurs in the Coongan River catchment. The catchment covers 7,090 km<sup>2</sup> containing the Coongan River and its tributaries, which include Glen Herring Creek, Emu Creek, and Camel Creek in the vicinity of the Study Area (Figure 2.1) The Coongan River is approximately 278 km in length, and flows north, where it joins the De Grey River around 90 km downstream of the Study Area, before draining into the Indian Ocean ((DBCA, 2022);(Ruprecht & Ivanescu, 2000). The Project occurs on a raised ridge adjacent to the Coongan River with numerous pools occurring along the ridge within or near the Project Area. While recharge to these pools is primarily via rainfall infiltration, several are considered to be groundwater dependent (Atlas Iron, 2019; SRK, 2019).

Glen Herring Creek is a tributary of the Coongan River, and flows for approximately 40 km through the Study Area, to the west of Stage 2 (Figure 2.1). It joins the Coongan River approximately 10 km downstream of the Study Area. Several semi-permanent and permanent pools occur along the creek.



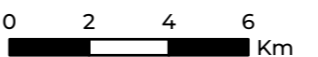
**LEGEND**

Study Area	<b>Surface Hydrology</b>	<b>Catchment</b>	Gauging Station
Local Road	Minor	Coongan River	
	Major	Shaw River	

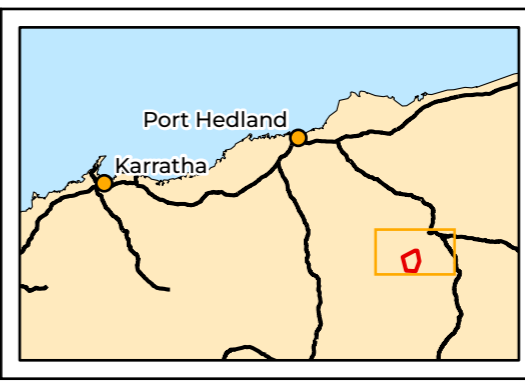


**Biologic**

Scale 1:190,000



Coordinate System: GDA 1994 MGA Zone 50  
Transverse Mercator Created: 26/02/2025



**ATLAS IRON**  
Sanjiv Ridge BWT  
Aquatic Ecology Survey

**Figure 2.1: Hydrology of the Study Area**

## 2.4 Groundwater Dependent Ecosystems (GDEs)

Groundwater-Dependent Ecosystems (or GDEs) rely on groundwater for their continued existence (BoM, 2025). GDEs can be represented by many different assemblages of biota which rely on groundwater, and as a result come in many forms. For terrestrial ecosystems there are three key types of GDE:

1. Aquatic ecosystems: that rely on the surface expression of groundwater – this includes surface water ecosystems which may have a groundwater component, such as rivers, wetlands and springs.
2. Terrestrial ecosystems: that rely on the subsurface presence of groundwater–this includes all vegetation ecosystems or Groundwater Dependent Vegetation (GDV).
3. Subterranean ecosystems: this includes cave and aquifer ecosystems (BoM, 2025).

Above-ground terrestrial GDEs are typically characterised by the presence of flora species that rely on groundwater (i.e., phreatophytes). Phreatophytes may be classified as either obligate or facultative phreatophytes depending on their reliance on groundwater:

- Obligate phreatophytes are flora species confined to habitats with access to groundwater.
- Facultative phreatophytes are flora species that can utilise groundwater to satisfy a proportion of their ecological water requirement (EWR) when it is available. However, some individuals may also satisfy their EWR by relying solely on uptake from upper unsaturated soils layers where groundwater is inaccessible (Eamus *et al.*, 2016).

## 2.5 Climate

The Pilbara region has a semi-desert to tropical climate, with relatively dry winters and hot summers. Rainfall is highly variable and mostly occurs during the summer (December to February) associated with convective thunderstorms, low pressure systems and tropical cyclones. These rainfall events generate ephemeral flows and occasional flooding in creeks and rivers (Leighton, 2004). Winter rainfall is generally lighter and the result of cold fronts moving north-easterly across the state (Leighton, 2004). Due to the nature of cyclonic events and thunderstorms, total annual rainfall in the region is highly unpredictable and individual storms can contribute several hundred millimetres of rain at one time. The average annual rainfall over the broader Pilbara area ranges from around 200 – 350 mm (predominantly in January, February and March), although rainfall may vary widely from year to year (van Etten, 2009). Temperatures vary considerably throughout the year, with average maximum summer temperatures reaching 35 °C to 40 °C and winter temperatures generally fluctuating between 22 °C and 30 °C.

The closest rainfall gauging station to the Study Area is in Marble Bar (Station Number 004106), approximately 25 km to the north (see Figure 2.1). The long-term average annual rainfall recorded from this station is 402.9 mm. Inter-annual variability in rainfall is high, with 705.4 mm recorded in 2013, and only 189 mm in 2021. Total rainfall at Marble Bar was higher than average in 2024, with 457.0 mm of rain recorded.

## 3 Desktop Assessment

### 3.1 Methods

A desktop assessment was undertaken, comprising database searches and a literature review. The purpose of the desktop assessment was to compile information on any aquatic species of significance which occur, or have the potential to occur, within the Study Area.

The significance of each species was assessed based on known distributions (disjunct or fragmented distributions, known from few records, or short-range endemics; SREs), and listing under the *Biodiversity Conservation Act 2016* (BC Act 2016), *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act 1999), International Union for Conservation of Nature (IUCN) Red List of Threatened Species, and Priority species recognised by the DBCA (see Appendix A).

#### 3.1.1 Database Searches

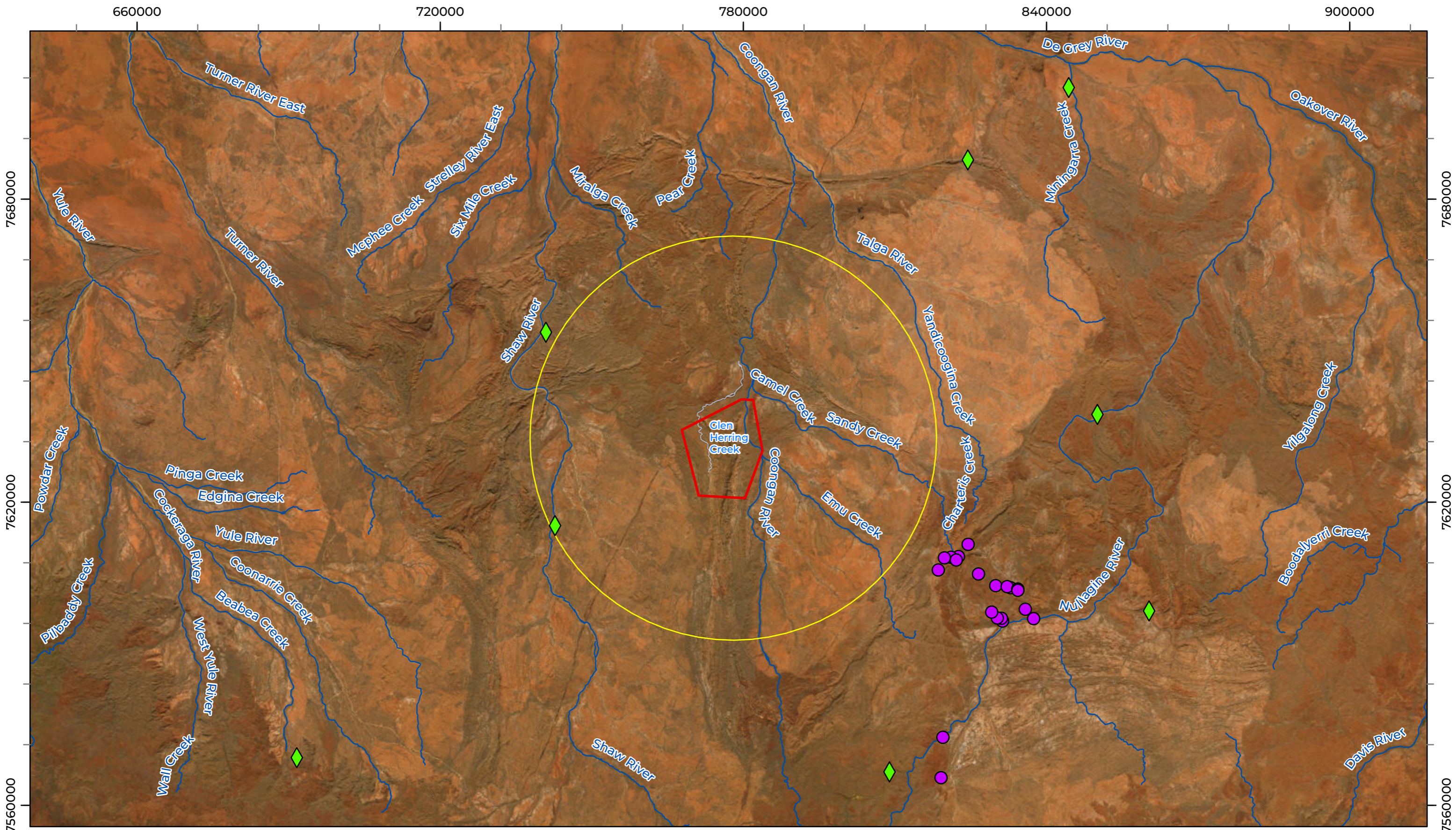
Six databases were searched for aquatic fauna records within a 40 km radius of a point centred in the Study Area (hereafter referred to as the Search Area; Table 3.1). Records of aquatic invertebrates, amphibians, waterbirds and reptiles were extracted.

Table 3.1: Details of database searches conducted





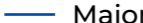

Database	Data Access/ Receival Date	Search Parameters
Department of Biodiversity, Conservation and Attractions (DBCA, 2024a)	14/06/2024	Centre point in Study Area -21.40645, 119.68158 With a 40 km buffer (comprising the Search Area)
Atlas of Living Australia (ALA, 2024)	14/06/2024	
Western Australian Museum (WAM) (WAM, 2024a) Arachnida & Myriapoda Database	26/06/2024	
WAM (2024b) Crustacea Database	26/06/2024	
WAM (2024c) Insecta Database	26/06/2024	
WAM (2024d) Mollusca Database	26/06/2024	


#### 3.1.2 Literature Review

A review of available literature relevant to the Study Area was undertaken to compile a list of aquatic fauna species previously known to occur within or near the Study Area. No studies were located which included aquatic ecology sampling within the Search Area, therefore data from previous aquatic ecology surveys within 100 km of the Study Area were included in the literature review, to provide context for the Study Area (Table 3.2 and Figure 3.1).



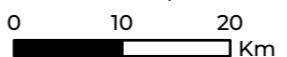
**LEGEND**

 Study Area	<b>Surface Hydrology</b>	<b>Source</b>
 Desktop Assessment Area	 Minor	 Biologic, 2021
	 Major	 Pinder et al., 2010

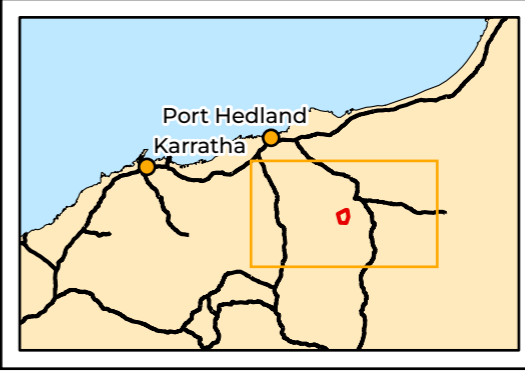


**Biologic**

Scale 1:700,000



Coordinate System: GDA 1994 MGA Zone 50  
Transverse Mercator Created: 26/02/2025



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**Sanjiv Ridge BWT**  
**Aquatic Ecology Survey**

Figure 3.1: Previous aquatic surveys conducted in the area

Table 3.2: Literature sources consulted for the desktop assessment

Survey Title	Reference	Survey Components	Closest Site to Study Area (km)
Pilbara Biological Survey (PBS)	Pinder <i>et al.</i> (2010)	Aquatic Flora, Zooplankton & Macroinvertebrates	Rocky Island Pool (30 km) Within Search Area
McPhee Creek Project: Aquatic Ecosystem Survey	Biologic (2020) Biologic (2021)	Water Quality, Zooplankton, Macroinvertebrates & Fish	WMPC-05 (48 km from the centre of the Search Area)

### 3.1.3 National GDE Atlas

The Bureau of Meteorology (BoM) developed The Groundwater Dependent Ecosystems Atlas (GDE Atlas) as a national dataset to inform groundwater planning and management. The GDE Atlas contains information about the three key types of ecosystems. Importantly, the GDE Atlas also includes the national inflow-dependent landscapes layer which is derived from remotely sensed data. This layer indicates the likelihood that a landscape is accessing water in addition to rainfall (such as soil moisture, surface water or groundwater), and generally represents a potential GDE dataset for all areas not yet studied or investigated in any detail.

The GDE mapping in the GDE Atlas comes from two broad sources:

- National assessment – national-scale analysis based on a set of rules that describe potential for groundwater/ ecosystem interaction and available geographic information systems (GIS) data.
- Regional studies – more detailed analysis undertaken by various state and regional agencies using a range of different approaches including field work, analysis of satellite imagery and application of rules/conceptual models.

The GDE Atlas was consulted to determine whether there were any potential GDEs present within the Study Area.

## 3.2 Results

### 3.2.1 Database Searches and Literature Review

The combined database search and literature review identified 604 records of aquatic fauna taxa and 60 records of groundwater dependent or aquatic flora taxa within the Search Area (Table 3.3). Of these, 541 were invertebrates. Insects accounted for over 44% of all fauna identified from the desktop assessment. Other aquatic and semi-aquatic fauna records included frogs, turtles, snakes (Pilbara olive python), and waterbirds (Table 3.3).

Table 3.3: Aquatic fauna and flora previously recorded from the Search Area

Type	Taxonomic Group	Common Name	Number of Taxa
Flora	Flora	GDV/aquatic plants	60
Invertebrate	Annelida	Segmented Worms	17
	Nematoda	Roundworm	4
	Platyhelminthes	Flatworm	3
	Arachnida	Mites	50
	Insecta	Insects	294
	Crustacea	Crustaceans	79
	Mollusca	Mollusc	12
	Cnidaria	Hydra	1
	Collembola	Springtails	1
	Rotifera	Rotifers	78
	Gastrotricha	Gastrotrich	1
	Porifera	Sponges	1
	Vertebrate	Actinopterygii	Fish
Reptilia		Turtles	1
		Snakes	1
Amphibia		Frogs	9
Aves		Waterbirds	47
		<b>Total</b>	<b>664</b>

### 3.2.2 Significant Taxa

Of the taxa identified in the desktop assessment, 33 were of significance. These taxa were either listed under international, national and/or state acts, and/or were highlighted in database search as being potentially restricted to the Search Area. These included two aquatic plants, two mites, 16 crustaceans, four insects, eight waterbirds and a snake (the Pilbara olive python *Liasis olivaceus barroni*; Table 3.4).

#### 3.2.2.1 Flora

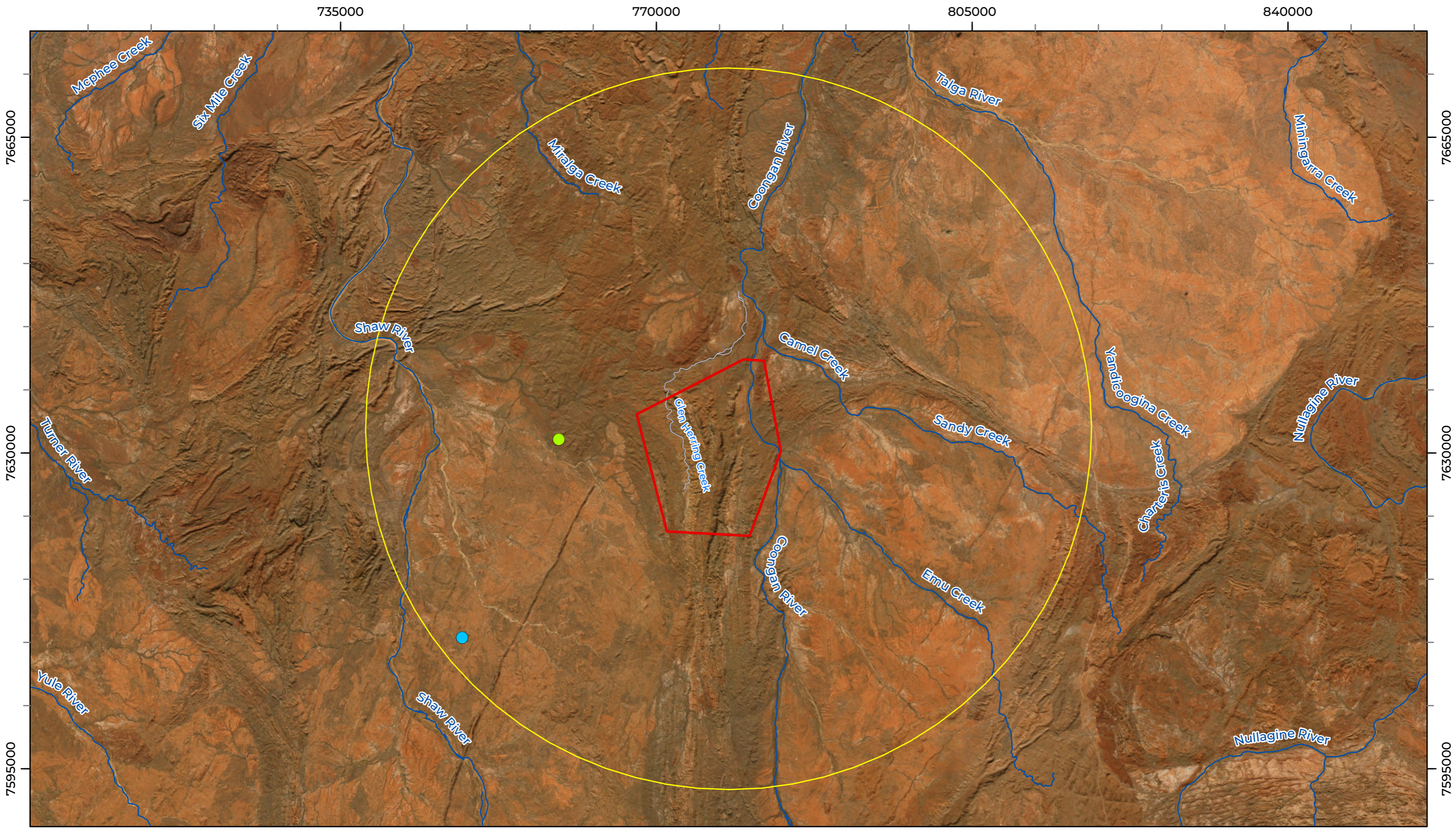
Two significant flora species were identified within the Search Area (Table 3.4 and Figure 3.2). *Stylidium weeliwollii* is an annual herb that grows predominantly in sandy soils on watercourse edges and in wet areas (DBCA, 2025b). It is listed as a Priority 3 species as it is known only from a few populations in north-west Western Australia, despite being locally abundant.

*Gymnanthera cunninghamii* is an erect shrub that predominantly grows in sandy soils. It is listed as a Priority 3 species as it is known from only a few populations in the Midwest and Pilbara (DBCA, 2025b).

Table 3.4: Significant aquatic flora and fauna occurring within or near the Search Area


Group	Family	Taxon	WA	EPBC	IUCN	Endemic to Search Area
Flora	Stylidiaceae	<i>Stylidium weeliwollii</i>	P3			
	Apocynaceae	<i>Gymnanthera cunninghamii</i>	P3			
Water mite	Hydryphantidae	<i>Wandesia</i> sp. P1 (nr <i>glareosa</i> )				Potentially restricted
	Mideopsidae	<i>Guineaxonopsis</i> sp. P1				Potentially restricted
Clam Shrimp	Cyzicidae	<i>Ozestheria</i> cf. <i>packardi</i>				Potentially restricted
Copepoda	Diaptomidae	<i>Eodiaptomus lumholtzi</i>			VU	
	Parastenocarididae	<i>Parastenocaris</i> sp.				Potentially restricted
Ostracoda	Cyprididae	Cyprididae `sp. Biologic-OSTR035`				Potentially restricted
	Cyprididae	Cyprididae `sp. Biologic-OSTR036`				Potentially restricted
	Cyprididae	Cyprididae `sp. Biologic-OSTR037`				Potentially restricted
	Cyprididae	Cyprididae `sp. Biologic-OSTR038`				Potentially restricted
	Cyprididae	Cyprididae `sp. Biologic-OSTR039`				Potentially restricted
	Cyprididae	Cyprididae `sp. Biologic-OSTR040`				Potentially restricted
	Cyprididae	Cyprididae `sp. Biologic-OSTR041`				Potentially restricted
Isopoda	Microcerberidae	Microcerberidae sp.				Potentially restricted
Amphipoda	Melitidae	Melitidae sp.				Potentially restricted
	Paramelitidae	Paramelitidae sp.				Potentially restricted
Syncarida	Bathynellidae	<i>Bathynella</i> sp.				Potentially restricted
	Parabathynellidae	<i>Atopobathynella</i> `sp. Biologic-PBAT031`				Potentially restricted
	Bathynellidae	<i>Pilbaranella</i> sp.				Potentially restricted
Insecta	Corduliidae	<i>Hemicordulia koomina</i>			VU	
	Isostictidae	<i>Eurysticta coolawanyah</i>			VU	
	Coenagrionidae	<i>Austroagrion pindrina</i>			VU	
	Gomphidae	<i>Ictinogomphus dobsoni</i>			NT	
Waterbird	Laridae	<i>Hydroprogne caspia</i>	MI	MI		
	Scolopacidae	<i>Actitis hypoleucos</i>	MI	MI		
	Scolopacidae	<i>Calidris acuminata</i>	MI	VU & MI	VU	

Group	Family	Taxon	WA	EPBC	IUCN	Endemic to Search Area
	Scolopacidae	<i>Calidris subminuta</i>	MI	MI		
	Scolopacidae	<i>Tringa glareola</i>	MI	MI		
	Scolopacidae	<i>Tringa nebularia</i>	MI	MI		
	Ciconiidae	<i>Ephippiorhynchus asiaticus</i>			NT	
	Threskiornithidae	<i>Plegadis falcinellus</i>	MI	MI		
Snake	Pythonidae	<i>Liasis olivaceus barroni</i>	VU	VU		



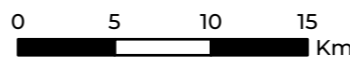
**LEGEND**

Study Area	Surface Hydrology	Significant Flora
Desktop Assessment Area	Minor	<i>Gymnanthera cunninghamii</i>
	Major	<i>Stylidium weeliwoffi</i>

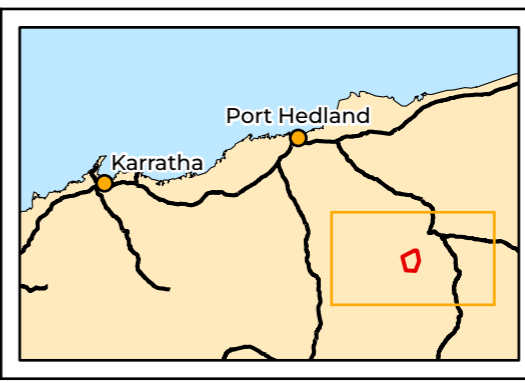


**Biologic**

Scale 1:392,000



Coordinate System: GDA 1994 MGA Zone 50  
Transverse Mercator Created: 26/02/2025



**ATLAS IRON**  
**Sanjiv Ridge BWT**  
**Aquatic Ecology Survey**

Figure 3.2: Significant flora records from the desktop assessment

### 3.2.2.2 Invertebrates

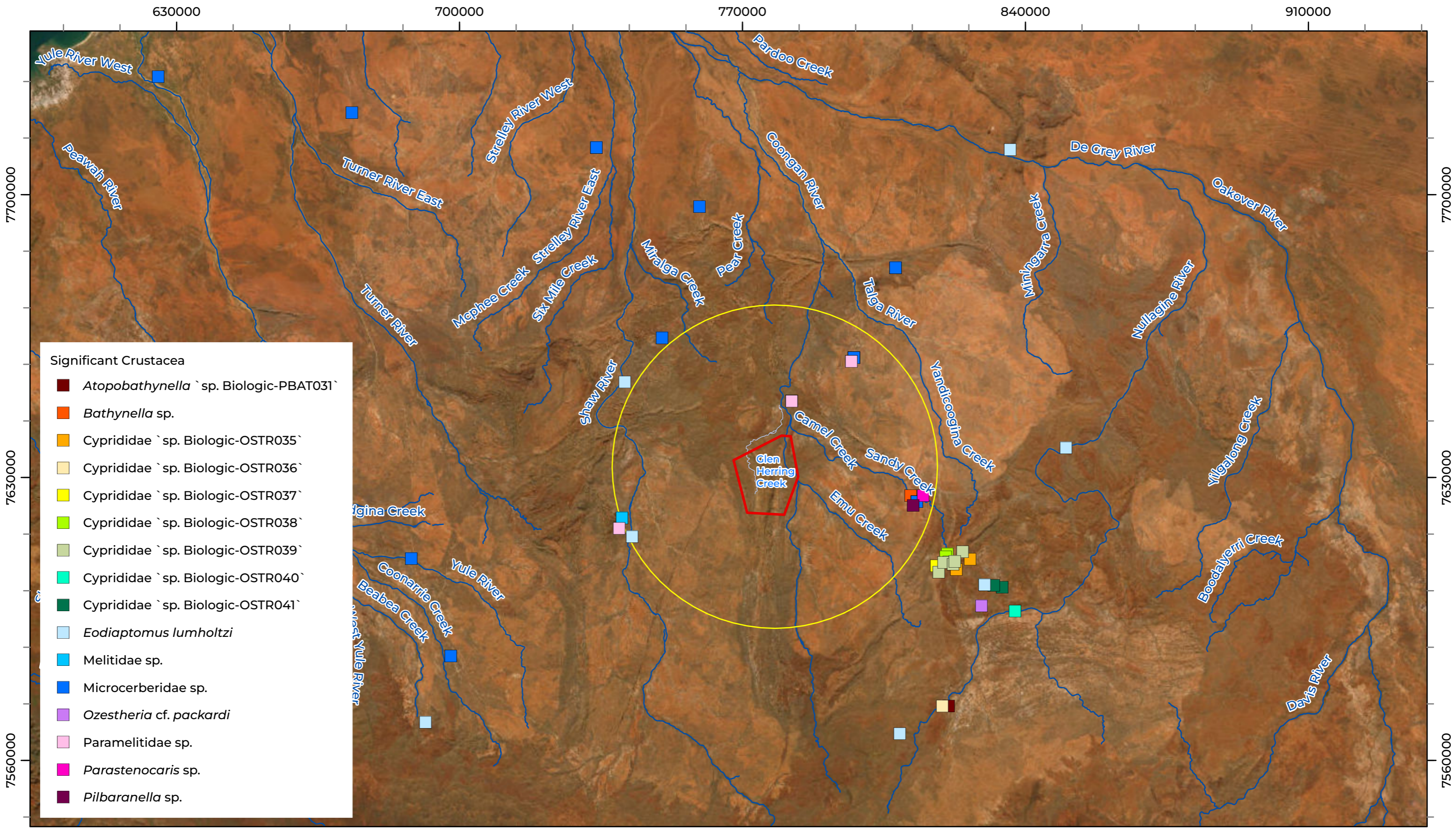
Significant invertebrates included several stygal species recorded from hyporheic zones (and in some cases surface waters) and listed odonates. Several stygal crustacean taxa with high levels of endemism were recorded within the Search Area. While these individuals are potentially restricted to the Search Area, low taxonomic resolution prevented endemism of each record from being confirmed.

Several potentially restricted crustaceans were recorded during an aquatic survey undertaken just outside the Search Area, at McPhee Creek, including ostracod OTUs from the family Cyprididae and a stygal parabathynellid (Biologic, 2021) (Figure 3.3). Whether the ostracod OTUs have a restricted range is uncertain, as there is little molecular data for related taxa in the surrounding area with which to confirm range extent. The parabathynellid, *Atopobathynella* sp. Biologic-PBAT031 has only been recorded at the one site (Figure 3.3), and was found to be more than 10.5% divergent from its closest relative (Biologic, 2021). The record is approximately 62 km from the Study Area, and based on the restricted distributions of other *Atopobathynella* species, it is not likely this OTU occurs within the Study Area.

A calanoid copepod *Eodiaptomus lumholtzi* was found to occur within the Search Area. This species is currently listed on the IUCN Red List as Vulnerable (IUCN, 2025). The listing cited its severely fragmented population, decline of mature individuals and continuing decline in area, extent and quality of habitat as justification for its listing (Reid, 1996). The listing was assessed in 1996 and numerous records are now known across the Pilbara (Figure 3.3).

Two potentially restricted water mite species, *Wandesia* sp. P1 (nr *glareosa*) and *Guineaxonopsis* sp. P1, were recorded from Minigarra Creek (> 90 km from the Study Area). Due to the large distance to the Study Area, and fact that these species have not been recorded outside a small number of fragmented locations in the Pilbara (Pinder *et al.*, 2010), it is unlikely they occur within the Study Area itself.

Four IUCN listed odonates listed were found in the database search, with *Austroagrion pindrina*, *Hemicordulia koomina*, and *Eurysticta coolawanyah* listed as Vulnerable and *Ictinogomphus dobsoni* Near Threatened. All are endemic to the Pilbara and their listing was based on being restricted to a small area and/or being known from relatively few records. Lowering water levels and habitat loss are the major threats to these species (Bush *et al.*, 2014). *Austroagrion pindrina* and *Eurysticta coolawanyah* were the only species recorded within the Search Area, although *Hemicordulia koomina* was recorded less than 2.5 km away (Figure 3.4). These species also occur at several sites within 100 km of the Study Area. Occurrence of *Ictinogomphus dobsoni* appears to be more limited, as this species was only recorded at two McPhee Creek Sites less than 10 km apart, and was not recorded at any other sites included in the database search or literature review.



**LEGEND**

- ▭ Study Area
- Desktop Assessment Area

**Surface Hydrology**

- Minor
- Major

**Biologic**

Scale 1:875,000

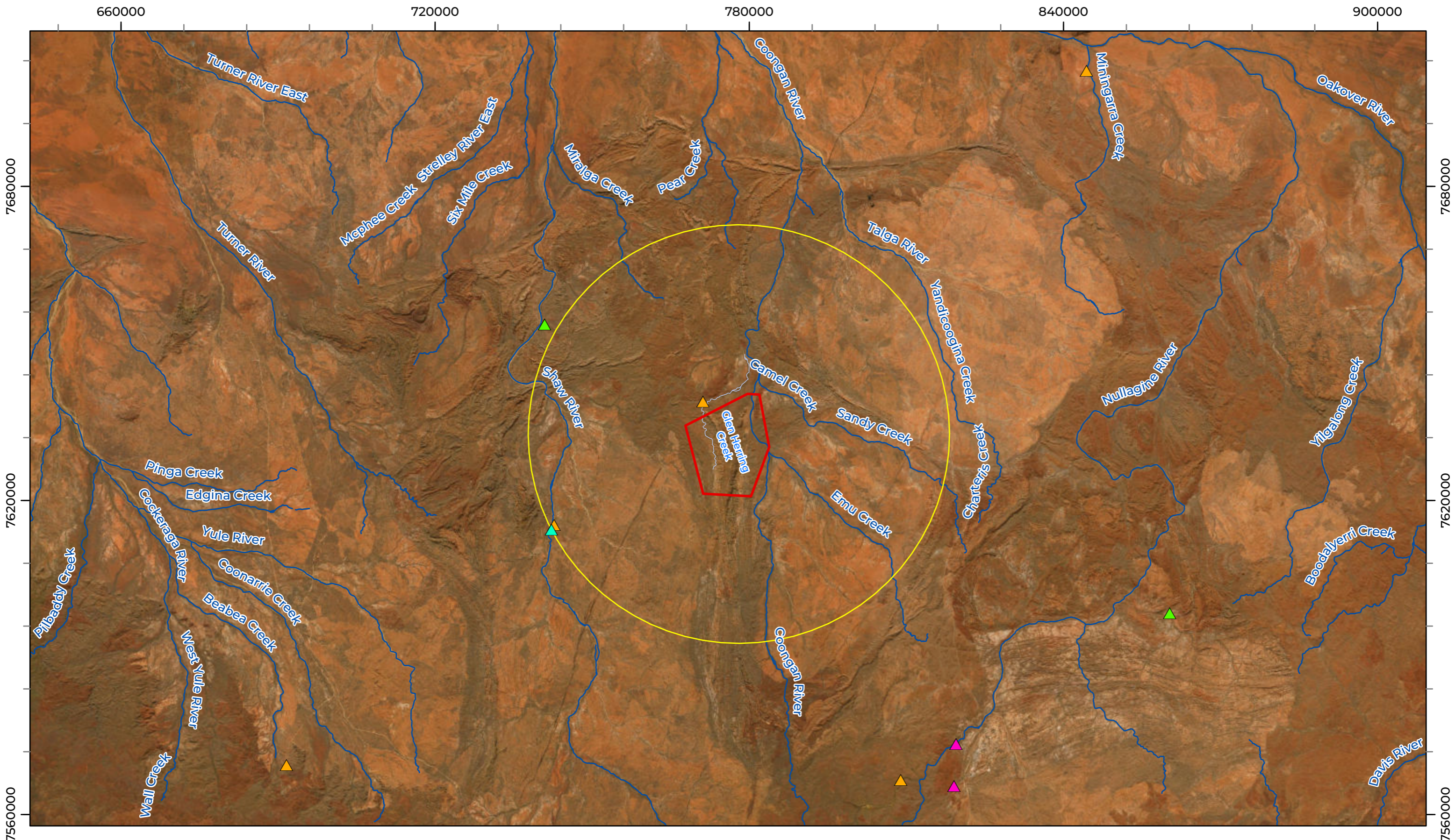
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Coordinate System: GDA 1994 MGA Zone 50 Transverse Mercator Created: 26/02/2025



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**Sanjiv Ridge BWT**  
**Aquatic Ecology Survey**

Figure 3.3: Significant Crustacea records from the desktop assessment



**LEGEND**

Study Area	Surface Hydrology	Significant Odonata
Desktop Assessment Area	Minor	<i>Austroagrion pindrina</i>
	Major	<i>Eurysticta coolawanyah</i> (Pilbara pin)
		<i>Hemicordulia koomina</i>
		<i>Ictinogomphus dobsoni</i>

**Biologic**

Scale 1:675,000

0 10 20 Km

Coordinate System: GDA 1994 MGA Zone 50 Transverse Mercator Created: 26/02/2025



**ATLAS IRON**  
**Sanjiv Ridge BWT**  
**Aquatic Ecology Survey**

Figure 3.4: Significant Odonata records from the desktop assessment

### 3.2.2.3 Vertebrates

Numerous significant waterbird species were recorded within the Search Area. The Black-necked stork (*Ephippiorhynchus asiaticus*) is listed on the IUCN Red List of Threatened species as Near-threatened (IUCN, 2025). Seven waterbird species are listed as migratory species under both the State BC act and Federal EPBC Act (Table 3.4), including the sharp-tailed sandpiper (*Calidris acuminata*) which is additionally listed as vulnerable by both the EPBC and the IUCN (IUCN, 2025). All migratory species are Matters of National Environmental Significance (MNES) under the EPBC Act. These waterbird species are generally highly mobile, thus the occurrence of these records within the Search Area (Figure 3.5) indicates they are likely to occur at water bodies within the Study Area.

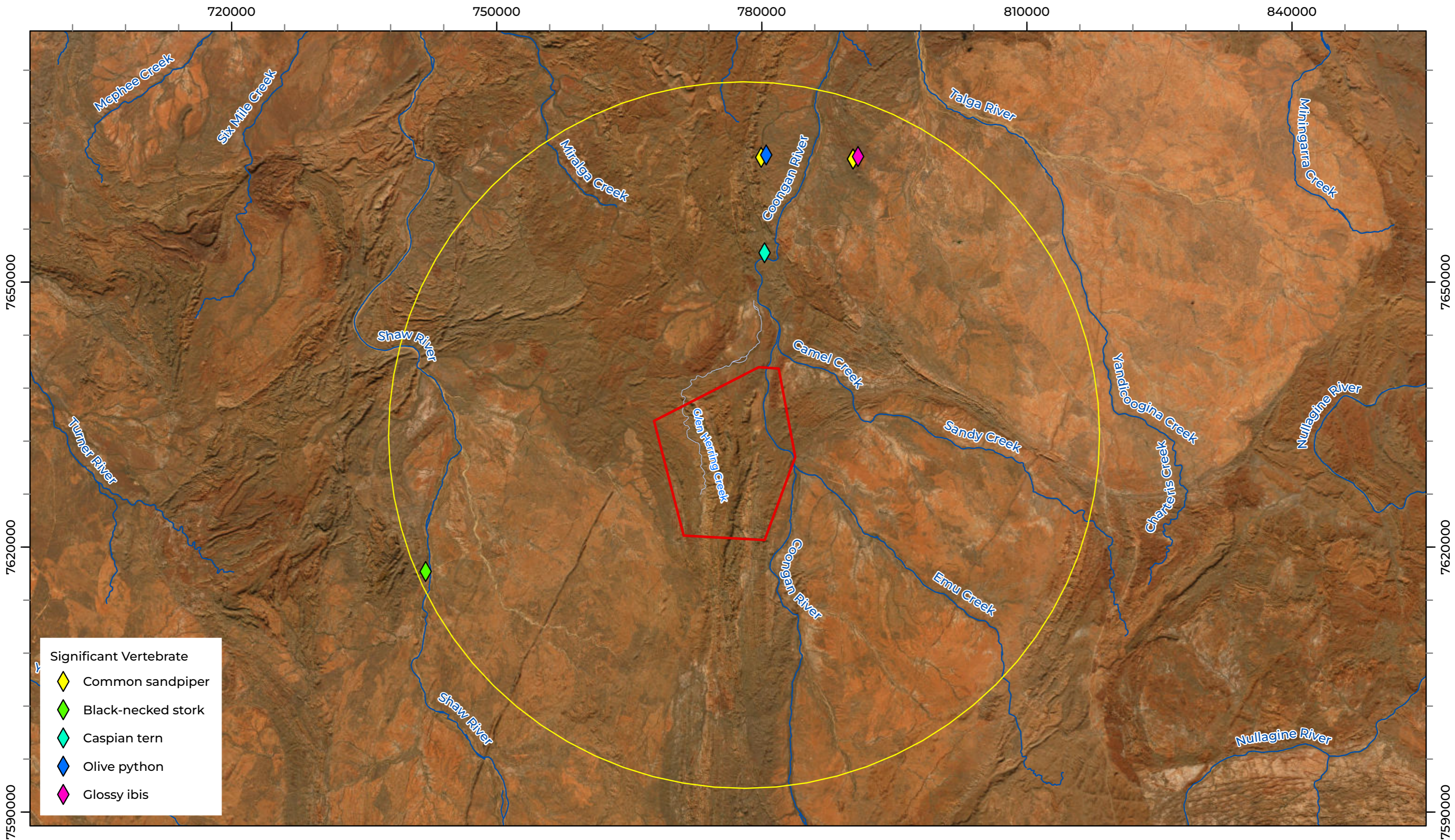
One MNES reptile species, the Pilbara olive python (*Liasis olivaceus barroni*), was also identified as occurring within the Search Area (Figure 3.5). The Pilbara olive python is restricted to the Pilbara region and can be found in gorges, waterholes and on escarpments. It is currently listed as Vulnerable on both Federal EPBC Act and State BC Act conservation lists. Threats to Pilbara olive python habitat include fire, foxes, and development of mining infrastructure.

### 3.2.3 National GDE Atlas

The GDE Atlas indicated that the Study Area overlaps with a range of different aquatic GDE areas including high, moderate, and low potential GDEs. Some areas in the Study Area were also identified as having no potential to support an aquatic GDE (BoM, 2025). The areas considered to have high potential to support an aquatic GDE are all located along the Coongan River, with this area also having a high likelihood of supporting an inflow dependent ecosystem (IDE) (IDE classification of 7). Sites sampled during the Survey (see section 4.1.4) on the Coongan River, all occur within the area identified as having a high potential of supporting an aquatic GDE. In addition, eight potential aquatic GDE pools were identified from regional studies as occurring within the Study Area, five of which are also located on the Coongan River (Figure 3.6). One of these corresponds to an aquatic site sampled during the Survey (SR-05). Two other aquatic GDEs are pools on minor tributaries which occur within 1 km to the east of Stage 2, and one occurs on Glen Herring Creek (downstream of Survey site SR-03) (Figure 3.6).


### 3.2.4 Priority Ecological Community

No Priority Ecological Communities were identified as occurring within the Study or Search Areas.



- Significant Vertebrate**
- ◆ Common sandpiper
  - ◆ Black-necked stork
  - ◆ Caspian tern
  - ◆ Olive python
  - ◆ Glossy ibis

- LEGEND**
- Study Area
  - Desktop Assessment Area
  - Surface Hydrology**
  - Minor
  - Major

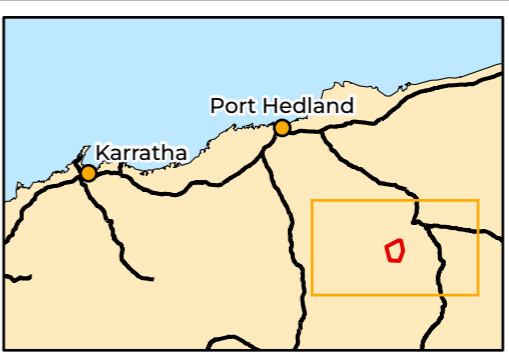


**Biologic**

Scale 1:400,000

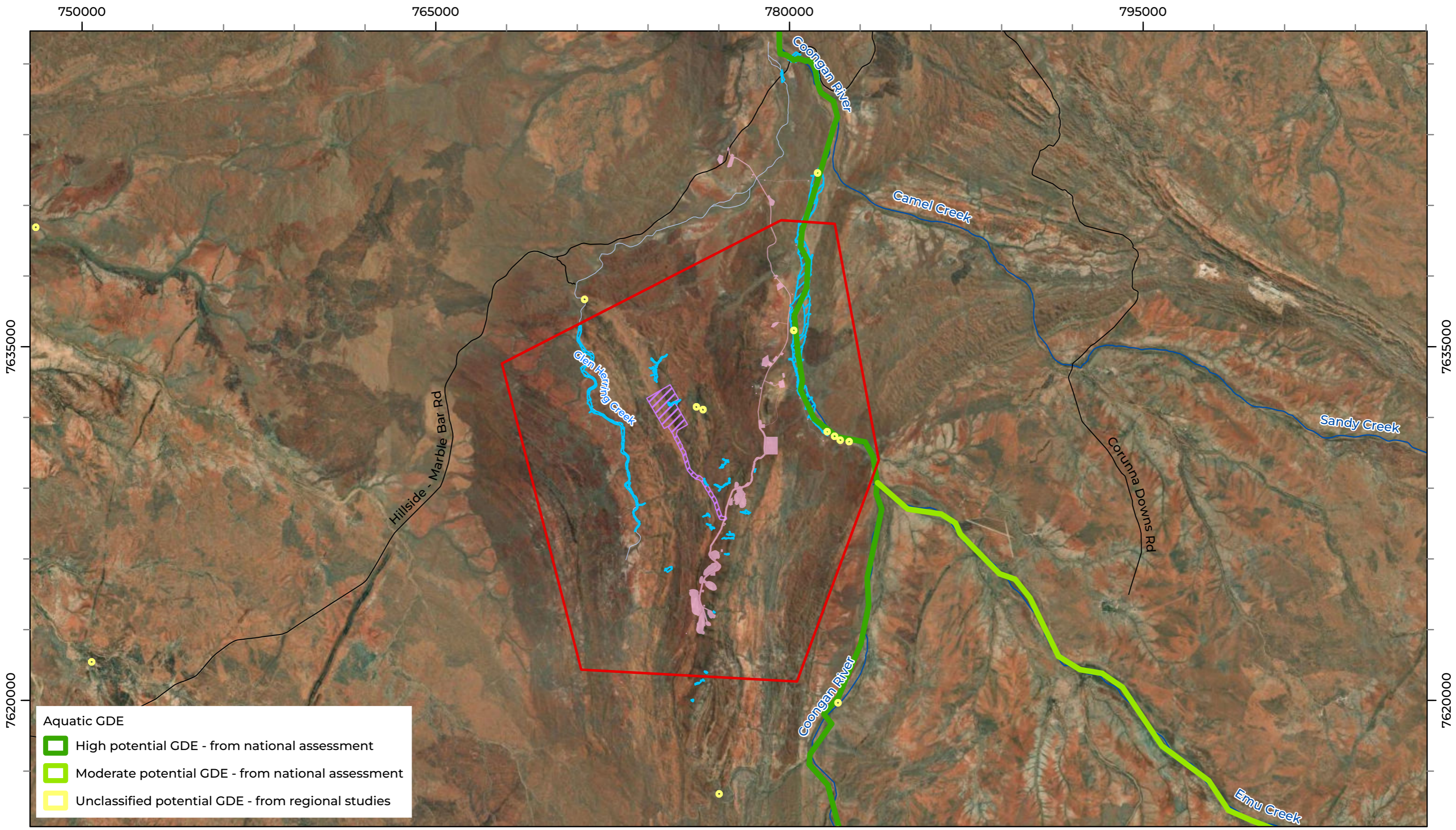
0 5 10 15 Km

Coordinate System: GDA 1994 MGA Zone 50  
Transverse Mercator Created: 26/02/2025



**ATLAS IRON**  
Sanjiv Ridge BWT  
Aquatic Ecology Survey

Figure 3.5: Significant vertebrate records from the desktop assessment



**Aquatic GDE**

- High potential GDE - from national assessment
- Moderate potential GDE - from national assessment
- Unclassified potential GDE - from regional studies

**LEGEND**

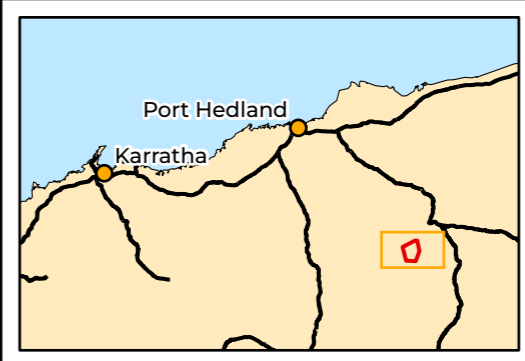
<span style="border: 1px solid red; display: inline-block; width: 15px; height: 10px;"></span> Study Area	<b>Surface Hydrology</b>	<b>Mine Development</b>
<span style="border: 1px dashed blue; display: inline-block; width: 15px; height: 10px;"></span> GDV Risk	<span style="color: blue;">—</span> Minor	<span style="background-color: pink; display: inline-block; width: 15px; height: 10px;"></span> Stage 1
<span style="border-bottom: 1px solid black; display: inline-block; width: 15px;"></span> Local Road	<span style="color: blue; font-weight: bold;">—</span> Major	<span style="background: repeating-linear-gradient(45deg, transparent, transparent 2px, purple 2px, purple 4px); display: inline-block; width: 15px; height: 10px;"></span> Stage 2

**Biologic**

Scale 1:150,000

0 2 4 6 Km

Coordinate System: GDA 1994 MGA Zone 50 Transverse Mercator Created: 26/02/2025



**ATLAS IRON**  
**Sanjiv Ridge BWT**  
**Aquatic Ecology Survey**

**Figure 3.6: Groundwater dependent ecosystems of the Study Area**

## 4 Field Survey

### 4.1 Field Methods

#### 4.1.1 Survey and Laboratory Team

Field surveys were conducted by Biologic aquatic ecologists who have extensive experience undertaking aquatic ecosystem surveys throughout the Pilbara, with a combined experience of 50 years (Table 4.1). Invertebrate and flora specimens were identified in-house by qualified zoologists and botanists. Genetic analysis was undertaken in-house on selected micro-crustacea and hyporheos specimens by experienced geneticists (Table 4.1).

Table 4.1: Survey personnel and experience

Personnel	Role	Qualification	Experience
Jess Delaney Principal Aquatic Ecologist   Manager of Aquatic Ecology	Project Management Field Survey Technical Guidance Data Analysis Reporting	BSc (Hons) Environmental Science	22 years' aquatic ecology 21 years' consulting 22 years' field survey
Kim Nguyen Senior Aquatic Ecologist	Taxonomic IDs	BSc (Hons) Conservation Biology and Management	12 years' aquatic ecology 12 years' consulting 12 years' field survey
Siobhan Paget Senior Aquatic Ecologist	Field survey Taxonomic IDs Data Analysis Reporting	BPhil (Hons) Conservation Biology and Zoology	5 years' aquatic ecology 4 years' consulting 5 years' field survey
Dr Mahabubur Rahman Aquatic Ecologist	Field survey Taxonomic IDs	PhD Environmental and Conservation Sciences MSc Fisheries Technology BSc Fisheries	11 years' aquatic ecology 2 years' consulting experience 11 years' field survey
Fintan Angel Senior Aquatic Ecologist	Field survey Taxonomic IDs	BSc Environmental Biology	10 years' aquatic ecology 10 years' consulting 10 years' field survey
Chris Hofmeester Principal Aquatic Ecologist	Taxonomic IDs	BSc (Hons) Environmental Biology	12 years' aquatic ecology 12 years' consulting 12 years' field survey
Lily Carson Aquatic Ecologist	Field survey Sample processing	BSc Environmental Science & Management	2 years' ecology 2 years' consulting 2 years' field survey
Shae Surman Graduate Aquatic Ecologist	Sample processing Reporting	BSc Zoology and Marine Science (Hons)	2 years' ecology 1 year consulting 2 years' field survey

Personnel	Role	Qualification	Experience
Vanessa Nici Senior Aquatic Ecologist	Sample processing Taxonomic IDs	BSc (Hons) Zoology and Wildlife Management	9 years' aquatic fauna 9 years' consulting 3 years' field survey
Dr Joel Huey Principal Geneticist   Manager of Molecular Systematics	Genetic analysis	PhD Molecular Ecology BSc (Hons) Environ. Science Ecology and Conservation	18 years' molecular / ecology 4 years' consulting 18 years' field survey
Dr Rachel Meissner Senior Botanist	Riparian flora IDs	PhD Environmental Science BSc Environmental Science	27 years' botany 8 years' consulting 25 years' field survey

#### 4.1.2 Survey Licences

Aquatic ecology sampling was conducted under appropriate DBCA and Department of Primary Industries and Resource Development (DPIRD) licences (Table 4.2). Animal ethics was certified under Licence U244/ 2022-2024 and Permit RW 3354/21.

Table 4.2: Licence and exemption information

Type	Licence Number	Valid	Issued To
DBCA Fauna Taking (Biological Assessment Regulation 27)	BA27001019	22/03/2024 – 21/03/2025	Jessica Delaney
DBCA Flora Taking (Biological Assessment Regulation 62)	FB62000095-2	16/05/2022 - 15/05/2025	Jessica Delaney
	FB620000704	26/06/2024 – 25/06/2027	Siobhan Paget
	FB620000703	26/06/2024 – 25/06/2027	Fintan Angel
DBCA Authorisation to Take or Disturb Threatened Flora	TFL 193-2122	21/06/2023 – 30/06/2025	Jessica Delaney
DPIRD Instrument of Exemption to the Fish Resources Management Act	250976722	20/04/2022 - 20/04/2025	Jessica Delaney
DPIRD Licence to use animals for scientific purposes	U244/ 2022-2024	01/01/2022 - 31/12/2024	Biologic

#### 4.1.3 Survey Timing, Weather and River Conditions

Survey sampling occurred over two seasons, the post-wet and dry seasons of 2024 (Wet 2024 and Dry 2024, respectively). Sampling for the Wet 2024 took place between the 18<sup>th</sup> and 24<sup>th</sup> of April 2024. The average maximum daytime temperature for April 2024 (35°C) was lower than the long-term average for the month (36.2°C; Figure 4.1). Rainfall varied considerably in the vicinity of the Study Area (Marble Bar, BoM station number 004106) in the months preceding the Wet 2024, with 171 mm recorded in March, well above the long-term average for the month (77.9 mm). However, this followed on from a notably dry period, with below

average rainfall recorded from May 2023 through to February 2024. Only 1.2 mm of rain fell in April, below the long-term average of 22.5 mm (Figure 4.1). Pools were inundated at the time of the Wet 2024 survey.

Sampling for the Dry 2024 season took place between the 13<sup>th</sup> and 18<sup>th</sup> of September 2024. The average maximum daytime temperature for September 2024 (35.1°C) was higher than the long-term average for the month (34.9°C; Figure 4.1). Total rainfall in June 2024 (31.4 mm) and August (17.8 mm) exceeded the long-term average for these months (22.4 mm and 1.3 mm, respectively). No rainfall was recorded in July 2024, less than the long-term average of 11.8 mm for the month (Figure 4.1).

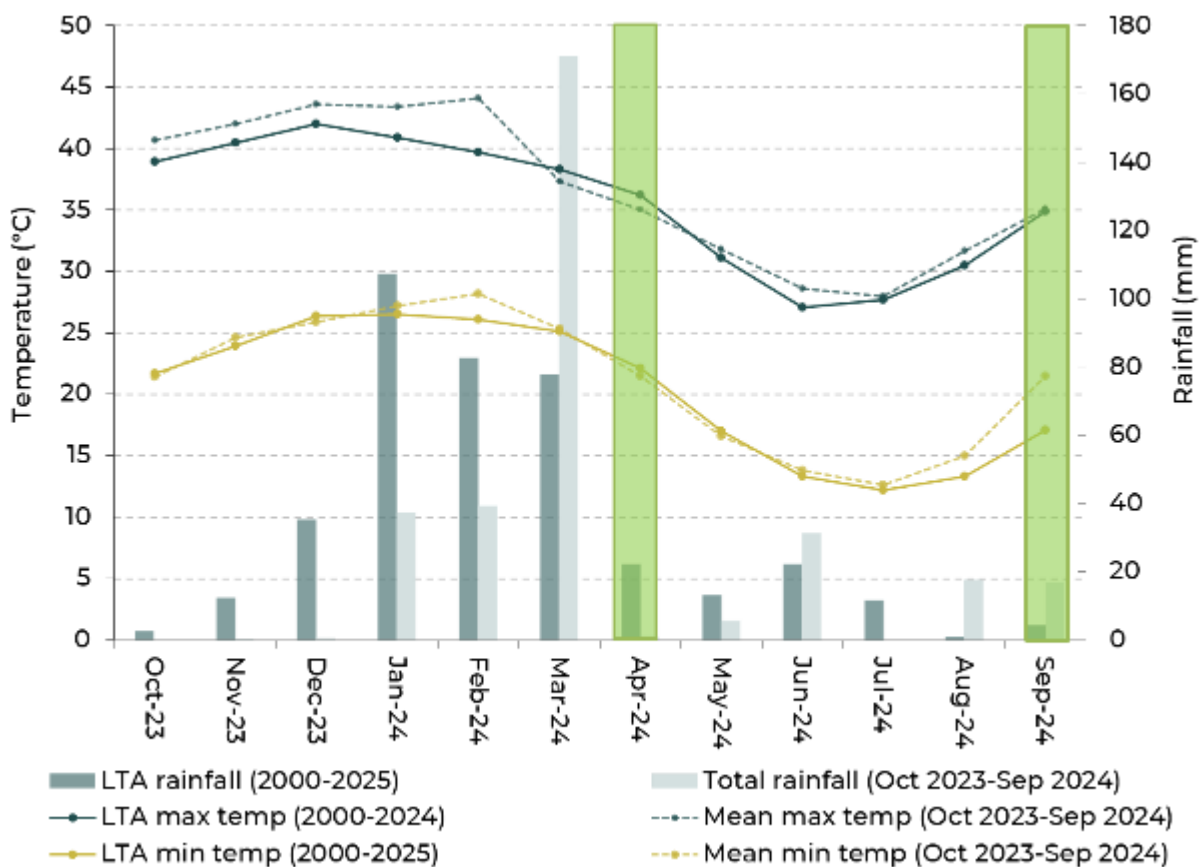


Figure 4.1: Total and long-term average monthly temperature (°C) and rainfall (mm) recorded from the Marble Bar BoM GS in the months preceding the Survey

Green bars indicate survey timing

The long-term average annual streamflow recorded from Coongan River – Marble Bar GS (streamflow station number 710204) is 130,622 ML. As rainfall data are not collected from this GS, the relationship between rainfall and streamflow in the river was examined by using rainfall data from the nearby Marble Bar BoM GS, located 4.1 km to the north-east (Figure

4.2). Total annual streamflow in the Coongan River has been below average since 2020, when a large flow was recorded coinciding with an above average annual rainfall. There does not appear to be a consistent relationship between annual rainfall and streamflow in the Coongan River, however, as years of high rainfall are not always associated with high streamflow. In recent years total rainfall has been relatively stable, with the only markedly dry year in the past decade occurring in 2021 (excluding 2016 due to incomplete rainfall data) (Figure 4.2).

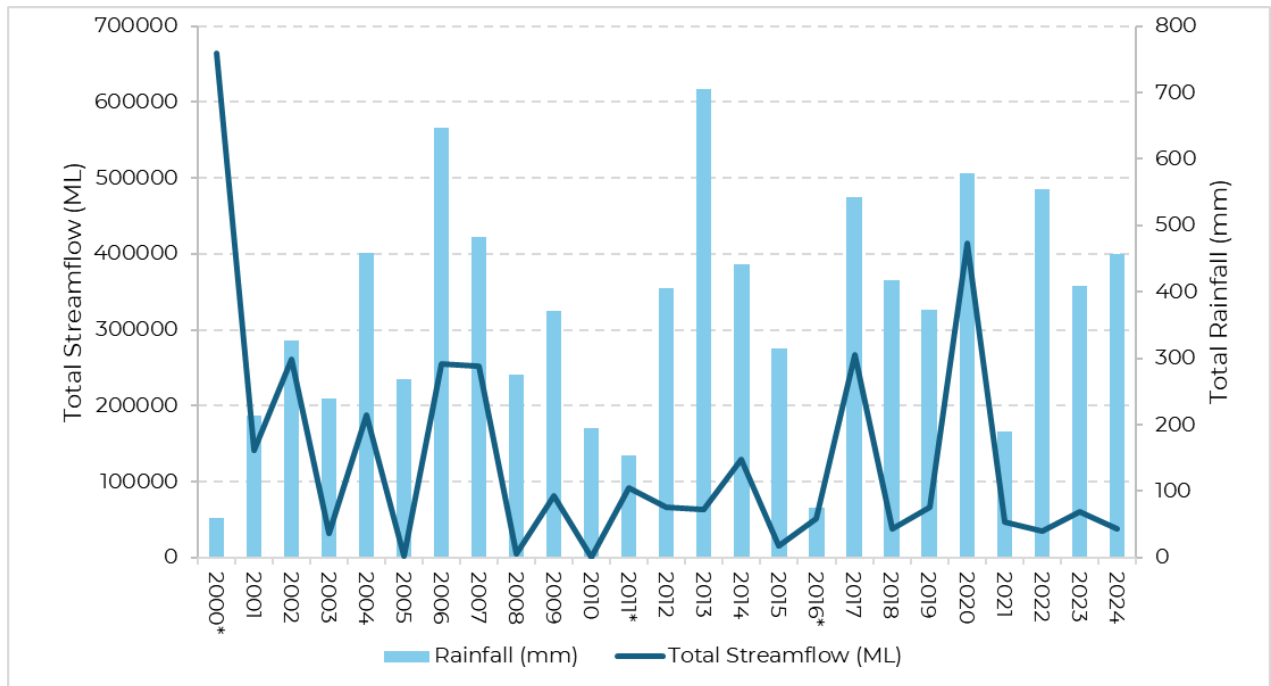


Figure 4.2: Annual rainfall (mm) and streamflow at Marble Bar – Coongan River GS

Years with incomplete rainfall totals are marked with an asterisk (\*)

#### 4.1.4 Sampling Design

The Survey followed a multiple Before After Control Impact (mBACI) design, with replicate sites located within the Study Area and control sites located elsewhere (Reference sites). Up to 16 sites were visited in each season, with 11 located within the Study Area and five Reference sites (Table 4.3 and Figure 4.3). The more persistent pools were targeted for sampling, including those in the resource area known to be dependent on groundwater (Table 4.3).

Table 4.3: Sampling site information

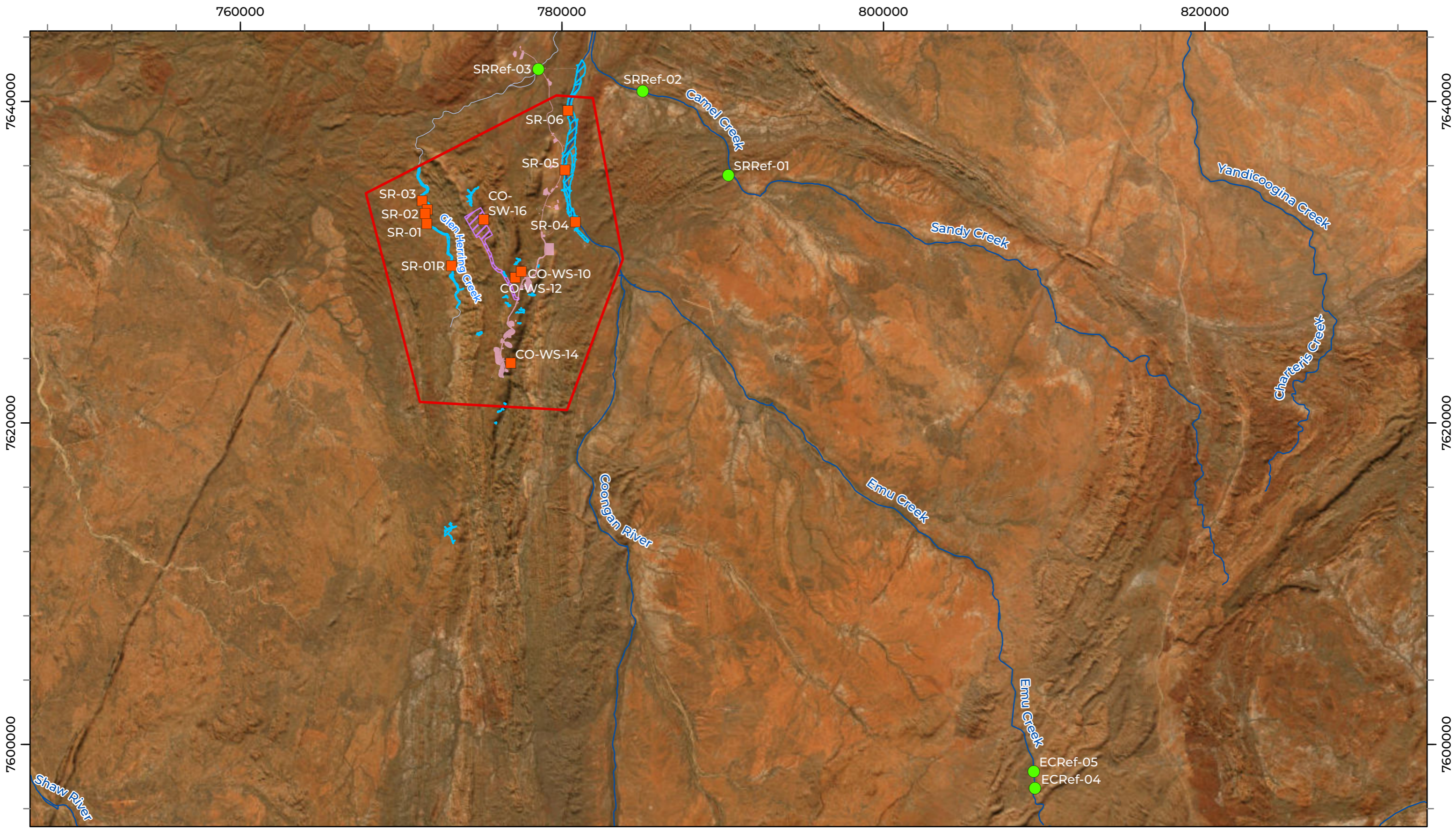
Site Type	Creek/System	Site Code	Persistence	Groundwater dependent? (Atlas, 2019)	Sampling Effort	
					Wet	Dry
Study Area	Glen Herring Creek	SR-01	Likely permanent		✓	✓
		SR-01R	Ephemeral		d^	*
		SR-02	Ephemeral		✓	
		SR-02a	Ephemeral			✓
		SR-03	Semi-permanent		✓	✓
	Coongan River	SR-04	Semi-permanent		✓	✓
		SR-05	Ephemeral		✓	d^
		SR-06	Semi-permanent		✓	✓
	Resource Area	CO-WS-10	Permanent	Yes, potential seasonal contribution	✓	✓
		CO-WS-12	Permanent	Yes, likely	✓	✓
		CO-WS-14	Permanent	Yes, likely	✓	✓
		CO- SW-16	Permanent	Not included in assessment, but likely	✓	✓
Reference	Camel Creek	SRRef-01	Ephemeral		✓	d^
		SRRef-02	Ephemeral		✓	d^
	Glen Herring Creek	SRRef-03	Permanent		✓	✓
	Emu Creek	ECRef-04	Permanent		✓	✓
		ECRef-05	Ephemeral		✓^	d^
<b>Total number full suite sites</b>					<b>15</b>	<b>11</b>
<b>Total number rehydrate sites</b>					<b>2</b>	<b>4</b>

✓ full suite of methods successfully undertaken

d^ site dry. Sediment samples collected for rehydrate-emergence trials and flora survey undertaken


✓^ full suite of methods, but very small amount of water remaining. Sediments also collected, and rehydrate-emergence trials undertaken

\* not visited



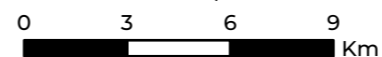
**LEGEND**

Study Area	<b>Surface Hydrology</b>	<b>Mine Development</b>	<b>Sample Site</b>
GDV Risk	Minor	Stage 1	Reference
	Major	Stage 2	Study Area

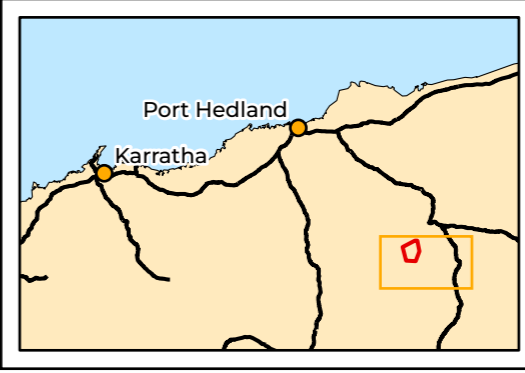


**Biologic**

Scale 1:220,000



Coordinate System: GDA 1994 MGA Zone 50  
Transverse Mercator Created: 26/02/2025



**ATLAS IRON**  
Sanjiv Ridge BWT  
Aquatic Ecology Survey

**Figure 4.3: Aquatic ecosystem sampling sites**

The reconnaissance of sampling locations was undertaken at the same time as the Wet 2024 sampling event, and as such, some sites were moved from their intended proposed location. SR-01 was dry when visited and rehydrate samples collected (SR-01R), but an inundated pool downstream was later located, and the full suite of methods was conducted there. As such, SR-01R was not visited again in the Dry 2024. In the case of SRRef-03, the proposed upstream Reference location was not able to be accessed due to other land-use in the area and locked gates preventing access. In order to sample sufficient Reference sites within the timeframe of the field survey, this site was instead sampled downstream on Glen Herring Creek. Given it is downstream of the Project Area, it is not ideal as a Reference site, and any future sampling should aim to locate a more appropriate control.

#### 4.1.5 Sampling Components and Methods

For aquatic ecology surveys, ANZG (2018) and Smith *et al.* (2020) recommend sampling multiple lines of evidence (LoE) across the pressure-stressor-ecosystem receptor (PSER) causal pathway to provide confidence in survey conclusions. Therefore, the following environmental and biological indicators were sampled during the Survey:

- Habitat assessment
- Water quality (in situ, ionic composition, turbidity, nutrients and dissolved metals)
- Macrophytes and dominant riparian vegetation
- Hyporheic fauna (Plate 4.1)
- Macroinvertebrates (including micro-crustacea)
- Rehydration trials on sediments collected from dry sites (Plate 4.2 and Table 4.3)
- Fish (Plate 4.1)
- Other vertebrate fauna recorded or observed over the course of sampling (Table 4.4).

See Appendix B for detailed descriptions of sampling methods.



Plate 4.1: Sampling the hyporheos using the Karaman-Chappuis method at SR-06 (left) and gill nets set at ERef-05 in the Wet 2024 (right; photos by Biologic ©)



Plate 4.2: Example of the rehydrate trial tank set up

Table 4.4: Description and rationale of the LoE used during the Survey

LoE	Rationale
Habitat Assessment	Qualitative assessment of features such as aquatic macrophyte beds, algae, detritus, large woody debris (LWD) and inorganic sediments provides information on the variability of aquatic habitats present at each pool, and assists in explaining patterns in distributions and aquatic fauna assemblages.
Water Quality	Sampling of parameters such as pH, dissolved oxygen (DO), salinity (or electrical conductivity; EC), turbidity, major ions, nutrients and dissolved metals in water provides a direct indication of water quality, and are key factors influencing the richness and composition of aquatic fauna and flora communities in waterways.
Macrophytes and riparian flora	Aquatic macrophytes include aquatic plants which grow either fully submerged (submerged macrophytes) or partially to fully emerged (emergent macrophytes). Aquatic macrophytes are key primary producers in aquatic ecosystems, oxygenating the water via photosynthesis, cycling nutrients, and providing habitat and a food source for aquatic animals (De <i>et al.</i> , 2019; Spoljar <i>et al.</i> , 2012; Thomaz & Cunha, 2010). Sampling of riparian flora allows for identification of species which indicate association with groundwater (GDE indicators) as well as priority flora as listed under the BC Act and the DBCA's priority flora list.
Hyporheic fauna	The hyporheic zone represents the saturated portions of streambeds, often comprising a mixture of percolating surface water and upwelling groundwater (Boulton, 2001). The interstitial spaces between sediments provide habitat for both juvenile stages of surface water fauna as well as permanent / obligate groundwater fauna (stygofauna). Presence of the latter in the hyporheic zone suggests connectivity between ground and surface waters (i.e. GDEs).
Macroinvertebrates	Aquatic macroinvertebrates, which typically include crustaceans, insects, worms and mites, are commonly used as indicators of the health of aquatic ecosystems (Chessman, 1995). They are ubiquitous, abundant and respond predictably to environmental change (Cain <i>et al.</i> , 1992; Chessman, 2003). Abrupt changes in water quality, loss of aquatic vegetation and changes to streamflow, among other factors, all influence invertebrate richness and community composition (Connolly <i>et al.</i> , 2004; Dunlop <i>et al.</i> , 2005; Nielsen <i>et al.</i> , 2003; Shrivastava, 2020).
Rehydration hatching trials	Aquatic biota of arid zones can often produce desiccation-resistant eggs or propagules (resting stages), which enable them to persist in the ecosystem even if waterbodies dry out completely. Flooding of sediments collected from dry sites under laboratory conditions (rehydration emergence trials) can induce the hatching of these resting stages, allowing assessment of aquatic ecosystem values in the absence of surface water (Smith <i>et al.</i> , 2020).
Fish	Fish complete their entire life-cycle in water, and therefore, assessment of fish species richness, abundance and life-history provide a direct indication of water quality, habitat variability, and overall ecosystem health. In particular, the presence of new recruits or juvenile fish in a pool suggests breeding conditions are optimal, driven by good water quality and ample habitat for fish.
Other fauna (direct observation)	Direct observation of other fauna during surveys provides an indication of the types of animals which utilise waterbodies on a regular or semi-regular basis. Fauna such as turtles and Pilbara olive python are top-level predators and provide an indication of the health of a waterbody.

## 4.2 Data Analysis

### 4.2.1 Water Quality

In the absence of site-specific guideline values (SSGVs) for the Study Area, water quality data were compared against the ANZG (2018) DGVs for the protection of aquatic ecosystems in the tropical north-west of Western Australia (see Appendix C for default values). For this purpose, sites sampled during the Survey were classified as lowland rivers (< 150 m elevation). DGVs are provided for a range of parameters designed to protect aquatic systems at a low level of risk but are not designed as pass or fail compliance criteria. Exceedances of DGVs provide a trigger which can be used to inform managers and regulators that changes in water quality are occurring and may need to be investigated (ANZG, 2018). As the Study Area is currently impacted by mining operations, as well as cattle and other land use activities, current data for stressors (pH, DO, EC and turbidity) were compared against DGVs for slightly-moderately disturbed ecosystems (equivalent to 95% species protection DGVs). Toxicants (nutrients and dissolved metals) were compared to the 95% toxicity DGVs, while toxicants that may bioaccumulate (i.e. dSe) were assessed against the 99% toxicity DGVs.

### 4.2.2 Macrophytes

The classification of groundwater dependant vegetation (GDV) in Western Australia lacks a clear definition or repeatable framework. As discussed in section 2.3, GDVs are known to include obligate phreatophytes such as *Melaleuca argentea* and facultative phreatophytes such as *Eucalyptus camaldulensis*. While this broadly outlines the potential for GDV, the inclusion of hydrophytic and mesophytic understory species in GDE classification systems, provides a more detailed picture of potential significance of a GDE.

To create a streamlined approach to GDV classification, Biologic has defined an assessment framework which combines botanical expertise based on years of field experience in riparian environments, published articles, presentations on GDVs, and discussion with other botanical and ecohydrological experts. This assessment framework is provided in Appendix D.

Generally, this framework defines the presence of GDV and then rates the dependence on groundwater through species composition and density cover. This dependence rating is based on a five-point scale; High, Moderate, Low, Negligible and None. The classification of 'High' indicates high soil moisture availability, very likely to be from a perennial source, as confirmed by the taxa present. Classification of 'Low' indicates soil moisture availability is more likely to be ephemeral. Negligible to None refers more to the riparian systems that would rely on surface flows to support habitat. The GDV assessment framework considers the following factors:

- The presence, density and maturity of four key indicative phreatophytes; *Melaleuca argentea* (obligate phreatophyte), *Eucalyptus camaldulensis* (facultative phreatophyte), *Eucalyptus victrix* (facultative phreatophyte to vadophyte) and *Sesbania formosa* (obligate to facultative phreatophyte)
- The presence, diversity and density of indicative hydrophytes and mesophytes and their relative reliance on groundwater (Appendix D)
- The structure of the vegetation with respect to obligate phreatophytes, facultative phreatophytes, hydrophytes and mesophytes. For example, a woodland of *Eucalyptus camaldulensis* is more dependent on groundwater presence (the woodland structure requires more groundwater for persistence) compared to scattered trees
- The presence of water bodies and an assessment of their permanence
- Broad understanding on the geology and creek morphology (i.e., presence of calcrete which may be slowly leaking groundwater into the creek).

It should be noted that a GDV unit may be assigned an overlapping rating (e.g., Moderate to Low) due to the presence of semi-mature obligate phreatophytes, increased diversity or varying densities of mesophytes and hydrophytes across the GDV unit.

#### 4.2.3 Invertebrates

All taxa recorded from hyporheic samples were classified using Boulton (2001) categories:

- Stygobite – obligate groundwater species, with special adaptations to survive such conditions such as small size, elongated body, lack of eyes, and loss of body pigmentation.
- Permanent hyporheos stygophiles - is a permanent inhabitant of the hyporheic zone.
- Occasional hyporheos stygophiles – use the hyporheic zone seasonally or during early life history stages.
- Stygoxene - species that appear rarely and apparently at random in groundwater habitats and do not have specialised adaptations for groundwater habitats.

Additionally, one further hyporheic classification was imposed:

- Possible hyporheos stygophile – likely to be hyporheos fauna, but due to taxonomic resolution or a lack of ecological information we are unable to say this with certainty.

All invertebrates collected were compared against appropriate threatened and priority species lists including the *Biodiversity Conservation Act 2016* (BC Act), the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the International Union for Conservation of Nature (IUCN), and Priority Fauna recognised by the DBCA (see Appendix D). In addition, species were assigned to one of the following conservation categories based on species' distributions:

- Cosmopolitan – species is found widely across the world.
- Australasian – species is found across Australia, New Guinea and neighbouring islands, including those of Indonesia.
- Australian endemic – species is only found in Australia.
- Northern Australia – species with distributions across the northern, tropical regions of the Australian continent.
- North-western Australia – found across northern W.A., including the Pilbara and Kimberley regions.
- Western Australian endemic – only known from W.A. (is restricted to, but is widely distributed across the state).
- Pilbara endemic - restricted to the Pilbara region of Western Australia.
- Short range endemic (SRE) – an SRE is a species occupying an area of less than 10,000 km<sup>2</sup> (Harvey, 2002). Such species have traits which make them vulnerable to disturbance and changes in habitat, and affords them high conservation value.
- Indeterminate distribution – taxon could not be assigned to one of the above, as there is currently insufficient knowledge on either its distribution or taxonomy to assess its level of endemism.

To provide regional context for richness recorded during the Survey, macroinvertebrate richness recorded from each site was compared to nearby PBS sites sampled in the early to mid-2000s (Pinder *et al.*, 2010). Histogram plots were created for the wet and dry seasons separately. PBS sites included in the comparison were:

- Coppin Gap, on a tributary of Coongan River (PSW020)
- Pelican Pool, on Nullagine River (PSW021)
- Minigarra Creek pools at Woodie Woodie, on a tributary of Coongan River (PSW061)
- Bonnie Pool, on a tributary of Nullagine River (PSW064)
- Cookes Creek Pools, on a tributary of Nullagine River (PSW065)
- Pool on Billan Ballan, on a tributary of Yule River (PSW081)
- Rocky Island Pool, on the Shaw River (PSW088)
- Panorama Spring, on a tributary of the Shaw River (PSW089).

#### 4.2.4 Fish

Analysis of population structure and age-class distribution provides a way of characterising recruitment, the health of local fish assemblages, and therefore the environmental conditions present which can support or impede recruitment. Therefore, length-frequency analysis was undertaken for three freshwater fish species which were recorded within the Study Area (spangled perch, western rainbowfish, and Pilbara tandan). This involved

classifying each species into four age classes based on body size (SL mm). Age classes were determined from the literature (Allen *et al.*, 2002; Puckridge & Walker, 1990) (Table 4.5).

In spangled perch, maturity is attained after the first year, at around 58 mm TL<sup>2</sup> for males and 78 mm TL for females. To allow for determination of age-classes (without knowing sex), size at maturity was estimated at 70 mm SL for the purposes of this study. Maximum size is ~300 mm TL. Maximum size of western rainbow is generally around 110 mm TL (Morgan *et al.*, 2002). Size at first maturity varies between river systems and sex, but for the purposes of this study was estimated to be 50 mm SL. As it is a relatively new, undescribed species, the breeding ecology of the Pilbara tandan is unknown; however, information relating to congeneric species may provide some insight. Sexual maturity in the closely related *Neosilurus hyrtlui* is attained at around 90 mm SL and they reach a maximum size of 400 mm TL (Bishop *et al.*, 2001) (see Table 4.5).

Table 4.5: Standard lengths used for age class analysis for each species

Age class	Standard Length (mm)		
	Western rainbowfish	Spangled perch	Pilbara tandan
New recruit	≤ 30	≤ 30	≤ 30
Juvenile	31-40	31-50	31-70
Sub-adult	41-50	51-70	71-90
Adult	≥ 51	≥ 71	≥ 91

#### 4.2.5 Multivariate Statistics

Patterns in macroinvertebrate assemblages were assessed using multivariate techniques in PRIMER v7 (Clarke & Gorley, 2015). Hierarchical classification and non-multidimensional scaling (nMDS) was performed to examine variation in assemblage structure. The Bray-Curtis similarity index was used to calculate coefficient similarities between samples (Bray & Curtis, 1957), with classification based on the group -average linking algorithm. The nMDS uses rank orders, and therefore can accommodate a variety of different types of data and is commonly used to interrogate biological datasets. The ordination was represented as a two-dimensional plot, grouping sites with similar composition together. The strength of the analyses was indicated by a stress value, with stress < 0.2 providing an adequate explanation of the data (Clarke & Warwick, 2001). The Similarity Profiles (SIMPROF) test was used to

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<sup>2</sup> Measurements of TL (total length) include the tail.

determine statistical significance between cluster groupings (Clarke & Gorley, 2015), with bubbles displaying these different groups superimposed on the nMDS ordination.

Finally, two-factor Analysis of Similarity (ANOSIM) was undertaken to test for significant differences in assemblages between systems (Glen Herring Creek, Coongan River, Resource Area pools, Camel Creek and Emu Creek) and seasons (Wet 2024 vs Dry 2024). One-factor ANOSIM was also conducted to test for a significant difference between site types (Study Area vs Reference).

## 4.3 Results and Discussion

### 4.3.1 Habitat Assessment

#### Glen Herring Creek

Within the Study Area, Glen Herring Creek was categorised by large semi-permanent to permanent creek pools, fringed by trees such as *Eucalyptus*, *Acacia*, *Sesbania* and *Melaleuca glomerata*, with an understorey of small shrubs, herbs, grasses and sedges. While water was persistent throughout the area, pools were generally shallow by the time of the Dry 2024 survey, with SR-02 completely dry and an alternative pool sampled approximately 150 m downstream. Glen Herring Creek was categorised by high in-stream habitat richness and complexity (6-8 microhabitats per site), consisting of open habitat and high cover of submerged macrophytes, with some algae and detritus present (Figure 4.4 and Appendix E). The creek bed primarily comprised submissive substrates, such as sand and gravel, with intermittent bedrock, boulders and clay throughout (Figure 4.4, Table 4.6). Impacts from cattle were widespread, including trampling and grazing of vegetation. Invasive weeds were also present, with buffel grass (*\*Cenchrus ciliaris*) being the most prevalent.

#### Coongan River

The Coongan River Study Area was categorised by large, but generally shallow riverine pools, fringed with a diversity of large trees such as *Eucalyptus*, *Sesbania*, mixed *Acacia* and *Melaleuca*, including the obligate phreatophyte *Melaleuca argentea*. Understorey comprised mostly herbs and grasses, with some sedges. While some persistent water occurs in the Coongan River, pools were highly receded in the Dry 2024, with SR-05 having recently dried prior to dry season sampling. The Coongan River pools supported variable in-stream habitat richness and complexity (2-9 microhabitats per site), consisting of open habitat with submerged macrophyte cover and some algae and detritus, with high root cover at SR-06 (Table 4.6). The greatest habitat richness was recorded from SR-04 in the Wet 2024 (9), though this declined in the Dry 2024 (2 habitat types). This reflected a general trend of reduced in-stream habitat complexity moving into the Dry 2024 across the Coongan River, as pools receded. Substrates were primarily submissive, with high proportions of sand and gravel (Figure 4.4 and Appendix E). Small amounts of clay were present throughout the area, likely contributing to water persistence. Impacts include cattle, vehicle tracks and a high richness of invasive weed species. Mexican poppy (*\*Argemone ochroleuca*) was particularly abundant and widespread, with thick stands present in the Dry 2024.

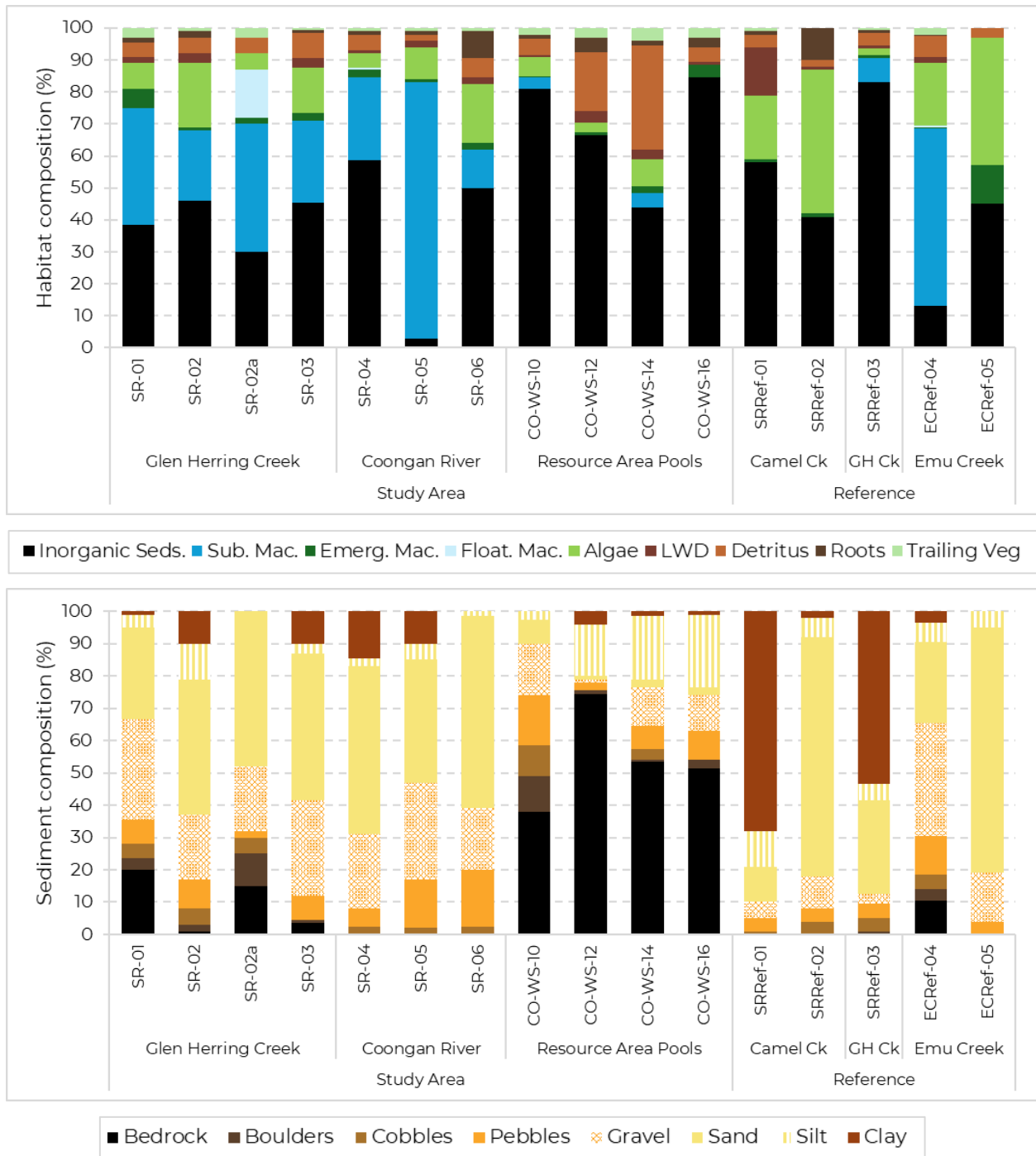





Figure 4.4: In-stream habitat (top) and sediment (bottom) composition at each site





Note – There are no native floating macrophyte species in the Pilbara. However, some submerged macrophytes (e.g. *Potamogeton*) have growth forms that provide similar habitat. Therefore in-stream vegetation cover was classified based on its functional role, rather than vegetative classification (i.e., submerged macrophyte floating on the surface of pools was classified as “floating macrophyte”).





### Resource Area Pools





The Resource Area pools were bedrock gorge pools with permanent surface water, fringed by *Ficus* and surrounded by generally thick stands of mixed *Acacia*, *Eucalyptus* and *Melaleuca argentea*. Scattered understorey included creepers, sedges, shrubs and diverse herbs. Water features suggest high ecological value and groundwater connectivity, with surface expression of groundwater observed at CO-WS-14 and CO-WS-16. Riffles and small waterfalls were observed throughout, along with a pool-side cave feature at CO-WS-14 (Table 4.6). In-stream habitat comprised open bedrock, covered in detritus, silt and gravel, typical of gorge pools (4-8 microhabitats per site; Figure 4.4). Heterogenous habitats were also present including small amounts of trailing veg, roots and algae. Some submerged macrophyte and algae was also present. The greatest habitat richness was recorded from CO-WS-10 and CO-WS-14 in the Wet 2024. Similar to other parts of the Study Area, habitat richness reduced between seasons. While invasive weeds were present, they were low in diversity and abundance. Other disturbances observed included secondary evidence of invasive predators, such as cats.




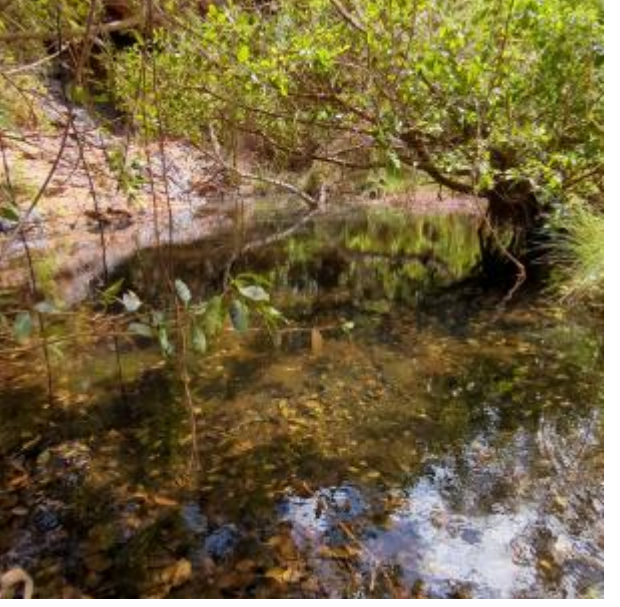
Table 4.6: Summary of the habitat assessment at each site





Site	Pool type	Site description	Wet 2024	Dry 2024
Study Area				
SR-01	Permanent creek pool	<p>Large semi-permanent creek pool</p> <p>Pool size: Wet 2024: 160 m x 16 m Dry 2024: 85 m x 15 m</p> <p>Max water depth: Wet 2024: 1.5 m Dry 2024: 1.5 m</p> <p>Riparian vegetation comprising open storey <i>Eucalyptus camaldulensis</i> over smaller trees such as <i>Melaleuca glomerata</i> and diverse <i>Acacia</i>. Multiple sedge, herb and grass species present along the waterline.</p> <p>In-stream habitat comprised of thick stands of submerged macrophyte, including <i>Potamogeton tepperi</i>, along with algae and inorganic substrates, with some emergent macrophyte, LWD, detritus and roots also present. Substrate primarily comprised of transmissive substrates, with some bedrock Disturbances include cattle and invasive weeds.</p>		
SR-01R	Ephemeral creek pool	<p>Recently dried. Many dead rainbowfish and spangled perch observed.</p> <p>Sparse riparian vegetation comprising <i>Eucalyptus camaldulensis</i>, <i>Melaleuca glomerata</i>, and <i>Acacia</i> species. Sedges, herbs, small shrubs and grasses present along the banks.</p> <p>Substrate primarily sand, gravel and clay. No disturbances observed.</p>		<p>NOT VISITED</p>





Site	Pool type	Site description	Wet 2024	Dry 2024
SR-02	Semi-permanent creek pool	<p>Long semi-permanent creek pool. In the dry season, SR-02 was dry and a shallow bedrock pool located 150 m upstream was sampled (SR-02a).</p> <p>Pool size: Wet 2024: 119 m x 20 m Dry 2024: 51 m x 7 m</p> <p>Max water depth: Wet 2024: 1.3 m Dry 2024: 0.2 m</p> <p>Open overstory of <i>Eucalyptus</i>, over <i>Melaleuca glomerata</i>, multiple <i>Acacia</i> species, <i>Sesbania cannabina</i>, <i>Atalaya hemiglauca</i> and small shrubs. Multiple sedge, herb and grass species present along the waterline.</p> <p>Habitat of both sites primarily comprised of inorganic substrate with algae and patches of thick submerged macrophyte, including <i>Potamogeton tepperi</i>. Both sites primarily comprised of sand, with gravel, silt and clay present at SR-02 and gravel, bedrock and boulders present at SR-02a. Disturbances include the presence of cattle at both sites and some invasive weeds at SR-02.</p>		
SR-03	Semi-permanent creek pool	<p>Semi-permanent creek pool, disconnecting to shallow isolated pools in the dry season</p> <p>Pool size: Wet 2024: 132 m x 26 m Dry 2024: 11 m x 5 m</p> <p>Max water depth: Wet 2024: 1.7 m Dry 2024: 0.15 m</p> <p>Open overstorey of <i>Eucalyptus</i> over smaller trees such as <i>Melaleuca glomerata</i>, multiple <i>Acacia</i> species and <i>Grevillea</i>. Multiple species of herbs, shrubs, grasses and sedges comprising the understorey and lining the banks.</p> <p>In-stream habitat primarily comprised of inorganic sediment, with algae and some detritus and thick stands of submerged macrophyte, including <i>Potamogeton tepperi</i>. Substrate primarily comprised of sand, gravel and clay. Disturbances include cattle and invasive weeds.</p>		





Site	Pool type	Site description	Wet 2024	Dry 2024
SR-04	Semi-permanent creek pool	<p>Large, semi-permanent creek pool</p> <p>Pool size: Wet 2024: 300 m x 80 m Dry 2024: 3 m x 2 m</p> <p>Max water depth: Wet 2024: 1.1 m Dry 2024: 0.35 m</p> <p>Open overstorey of <i>Eucalyptus</i> and <i>Melaleuca</i> over smaller trees such as <i>Acacia</i> and <i>Atalaya hemiglauc</i>. Thick stands of diverse sedges, with some herbs and grasses along the banks.</p> <p>In-stream habitat primarily comprised of inorganic substrate and submerged macrophyte. While submerged macrophyte was extensive in the Wet 2024, including <i>Potamogeton tepperi</i>, none was present in the receded pool in the Dry 2024.</p> <p>Substrate primarily comprised of sand with gravel, pebbles and clay. Disturbances include cattle and invasive weeds.</p>		
SR-05	Ephemeral creek pool	<p>Large, shallow creek pool with some clay</p> <p>Pool size: Wet 2024: 133 m x 35 m Dry 2024: DRY</p> <p>Max water depth: Wet 2024: 0.5 m Dry 2024: DRY</p> <p>Open overstorey of <i>Eucalyptus</i> and <i>Melaleuca</i> over smaller trees such as <i>Acacia coriacea</i> and <i>Cullen leucanthum</i>. Understorey comprised of thick stands of diverse grasses, multiple herb species such as <i>Lobelia arnhemiaca</i>, and sedges. Thick stands of Mexican poppy also present throughout the dry creekbed in the Dry 2024.</p> <p>In-stream habitat primarily comprised of thick stands of submerged macrophyte, including <i>Potamogeton tepperi</i>, with some algae in the Wet 2024. Substrate primarily comprised of sand and gravel with some clay. Disturbances include cattle and invasive weeds.</p>		

Site	Pool type	Site description	Wet 2024	Dry 2024
SR-06	Semi-permanent creek pool	<p>Semi-permanent series of long pools in sandy creek bed</p> <p>Pool size: Wet 2024: 53 m x 18 m Dry 2024: 20 m x 7 m</p> <p>Max water depth: Wet 2024: 0.6 m Dry 2024: 0.25 m</p> <p>Open overstorey of <i>Eucalyptus camaldulensis</i> and <i>Melaleuca</i> over smaller trees such as <i>Acacia</i> and <i>Atalaya hemiglauc</i>a. Understorey comprised of small shrubs and diverse herbs, including <i>Lobelia arnhemiaca</i>. Various sedge and grass species fringing the banks.</p> <p>In-stream habitat primarily inorganic substrate with submerged macrophyte and algae with some detritus and roots. Substrate primarily comprised of sand, pebbles and gravel. Disturbances include cattle, vehicle tracks and many invasive weed species.</p>		
CO-WS-10	Permanent gorge pool	<p>Permanent pool at base of waterfalls, with groundwater seeping from rockface</p> <p>Pool size: Wet 2024: 19 m x 18 m Dry 2024: 18 m x 13 m</p> <p>Max water depth: Wet 2024: 3.5 m Dry 2024: 1.8 m</p> <p>Sparse surrounding vegetation, including isolated trees of <i>Terminalia circumalata</i>, <i>Eucalyptus camaldulensis</i> and <i>Ficus brachypoda</i>. Small stands of herbs, sedges, grasses and creepers fringing the waterline and emerging from the rockface.</p> <p>In-stream habitat primarily comprised of inorganic substrate with some algae. Small amounts of <i>Chara</i> also present in-stream. Substrate primarily comprised of bedrock and boulders, with some transmissive substrates. No disturbances were observed.</p>		

Site	Pool type	Site description	Wet 2024	Dry 2024
CO-WS-12	Permanent gorge pool series	<p>Series of permanent pools with riffles over rocks. Flowing at the time of sampling in both seasons.</p> <p>Pool size: Wet 2024: 150 m x 8 m Dry 2024: 4 m x 2 m</p> <p>Max water depth: Wet 2024: 1.2 m Dry 2024: 0.5 m</p> <p>Surrounding vegetation comprised of trees such as <i>Melaleuca argentea</i> and various <i>Acacia</i>, with isolated <i>Corymbia</i> and <i>Ficus</i> over small shrubs and creepers. Thick fringing vegetation comprised of diverse sedges, including <i>Schoenus falcatus</i>, herbs and grasses.</p> <p>In-stream habitat primarily comprised of inorganic substrate with detritus and some algae. No submerged macrophyte present. Substrate primarily comprised of bedrock with some silt. Disturbances include small amounts of invasive weeds and evidence of invasive predators.</p>		
CO-WS-14	Permanent gorge pool	<p>Permanent gorge pool with waterfall next to a cave feature. Water flowing into the pool in both seasons</p> <p>Pool size: Wet 2024: 12 m x 16 m Dry 2024: 15 m x 10 m</p> <p>Max water depth: Wet 2024: 0.5 m Dry 2024: 1.3 m</p> <p>Thick surrounding vegetation comprised of an overstorey of <i>Eucalyptus victrix</i>, <i>Melaleuca argentea</i> and large <i>Ficus</i>, over smaller trees such as <i>Acacia</i> and some creepers. Banks fringed with herbs and sedges, including fields of <i>Lobelia arnhemiaca</i> and thick stands of <i>Schoenus falcatus</i> and <i>Typha domingensis</i>.</p> <p>In-stream habitat primarily comprised of inorganic substrate and detritus with some algae. Small amounts of <i>Chara</i> also present in-stream. Substrate primarily comprised of bedrock with silt, gravel and pebbles. Disturbances include invasive weeds.</p>		

Site	Pool type	Site description	Wet 2024	Dry 2024
CO-WS-16	Permanent gorge pool series	<p>Series of permanent pools and shallow riffles, with groundwater seeping from rockface. Flowing at the time of sampling in the Wet 2024.</p> <p>Pool size: Wet 2024: 130 m x 3 m Dry 2024: 100 m x 2 m</p> <p>Max water depth: Wet 2024: 0.6 m Dry 2024: 1 m</p> <p>Thick surrounding vegetation comprised primarily of <i>Eucalyptus</i>, <i>Melaleuca argentea</i>, diverse <i>Acacia</i> and <i>Adriana tomentosa</i> over smaller shrubs and creepers. Isolated <i>Ficus</i> species and <i>Corymbia</i> emerging from the rockface. Banks lined with sedges and some grasses, with thick stands of <i>Typha</i> present downstream.</p> <p>In-stream habitat primarily comprised of inorganic substrate. No submerged macrophytes present. Substrate primarily comprised of bedrock, transmissive sediments and silt. No disturbances were observed.</p>		
<b>Reference</b>				
SRRef-01	Ephemeral creek pool	<p>Long, shallow, highly turbid pool over clay</p> <p>Pool size: Wet 2024: 32 m x 7 m Dry 2024: DRY</p> <p>Max water depth: Wet 2024: 0.5 m Dry 2024: DRY</p> <p>Open overstorey of <i>Eucalyptus camaldulensis</i> over smaller trees and shrubs such as <i>Acacia</i> and <i>Melaleuca glomerata</i>. Sparse sedges, herbs and grasses present along the bank.</p> <p>In-stream habitat primarily comprised of inorganic substrate with algae and LWD. Substrate primarily comprised of clay with some sand and silt. Disturbances include cattle and some invasive weeds.</p>		

Site	Pool type	Site description	Wet 2024	Dry 2024
SRRef-02	Ephemeral creek pool	<p>Small creek pool</p> <p>Pool size: Wet 2024: 12 m x 3 m Dry 2024: DRY</p> <p>Max water depth: Wet 2024: 0.3 m Dry 2024: DRY</p> <p>Open overstorey comprised of <i>Corymbia</i>, <i>Eucalyptus camaldulensis</i> and <i>Melaleuca argentea</i> over smaller trees such as <i>Acacia</i>. Understorey comprised of sparse sedges, grasses, herbs and creepers.</p> <p>In-stream habitat primarily comprised of algae and inorganic substrate, with some roots.</p> <p>Substrate primarily comprised of sand with some gravel.</p> <p>Disturbances include cattle, some invasive weeds and vehicle tracks.</p>		
SRRef-03	Permanent pool	<p>Large, permanent turbid creek pool over clay</p> <p>Pool size: Wet 2024: 144 m x 23 m Dry 2024: 40 m x 13 m</p> <p>Max water depth: Wet 2024: 0.4 m Dry 2024: 0.5 m</p> <p>Open overstorey comprised of <i>Eucalyptus</i> over smaller trees such as a <i>Melaleuca glomerata</i> and diverse <i>Acacia</i>. Diverse sedges and grasses, with sparse herbs and creepers present along the bank.</p> <p>In-stream habitat primarily comprised of inorganic substrate and submerged macrophyte, including <i>Potamogeton tepperi</i>, though no submerged macrophyte were present in the Dry 2024.</p> <p>Substrate primarily comprised of clay and sand.</p> <p>Disturbances include cattle and invasive weeds.</p>		

Site	Pool type	Site description	Wet 2024	Dry 2024
ERef-04	Permanent creek pool	<p>Long, permanent creek pool against bedrock cliff face</p> <p>Pool size: Wet 2024: 165 m x 30 m Dry 2024: 50 m x 18 m</p> <p>Max water depth: Wet 2024: 2.5 m Dry 2024: 1.5 m</p> <p>Diverse vegetation along the bank including an overstorey of <i>Eucalyptus</i>, <i>Melaleuca glomerata</i>, <i>Atalaya hemiglauca</i> and <i>Ficus</i> over small trees and shrubs such as <i>Acacia</i>. Thick understorey comprised of notably diverse herbs, shrubs, sedges and grasses.</p> <p>In-stream habitat primarily comprised of thick stands of submerged macrophyte, including <i>Potamogeton tepperi</i>, and algae, with some inorganic substrate. Substrate primarily comprised of gravel and sand with pebbles and bedrock. Disturbances include cattle and invasive weeds.</p>		
ERef-05	Ephemeral creek pool	<p>Small pool, nearly dry in sandy creek line</p> <p>Pool size: Wet 2024: 0.2 m x 0.2 m Dry 2024: DRY</p> <p>Max water depth: Wet 2024: 0.05 m Dry 2024: DRY</p> <p>Open overstorey of <i>Eucalyptus camaldulensis</i> over diverse <i>Acacia</i>, sedges and grasses. Stands of <i>Melaleuca glomerata</i> with scattered herbs, creepers and sedges within the creekline.</p> <p>In-stream habitat primarily comprised of inorganic substrate and algae with some emergent macrophyte. Substrate primarily comprised of sand with gravel. Disturbances include cattle and some invasive weeds.</p>		

### 4.3.2 Water Quality

All raw water quality data are provided in Appendix F.

#### 4.3.2.1 In situ

EC was highly variable across the Study Area, ranging from 184  $\mu\text{S}/\text{cm}$  (CO-WS-12 in the Wet 2024) to 2,291  $\mu\text{S}/\text{cm}$  (SR-06 in the Dry 2024). Reference sites also exhibited wide-ranging EC between 240  $\mu\text{S}/\text{cm}$  (ECCRef-04 in the Wet 2024) and 1,599  $\mu\text{S}/\text{cm}$  (SRRef-01 also in the Wet 2024; Figure 4.5). While the majority of sites were fresh, two sites were brackish including SR-06 (both seasons) and SRRef-01 in the Wet 2024<sup>3</sup> (Figure 4.5). Some sites underwent evapoconcentration as waters receded in the dry season, with higher EC recorded from SR-01, SR-04, SR-06, and to a lesser extent Reference sites SRRef-03 and ECCRef-04. The transition to brackish waters is often accompanied by a marked shift in fauna assemblages, as salt-sensitive taxa are replaced by opportunistic and salt-tolerant taxa (Hart *et al.*, 1991; Horrigan *et al.*, 2005). While there was some seasonal shifts in fauna between seasons observed in the Survey (see Section 4.3.5), the degree to which salinity was influential was inconclusive. Resource Area pools were particularly fresh, and their connection to groundwaters and persistence they were buffered from evapoconcentration effects.

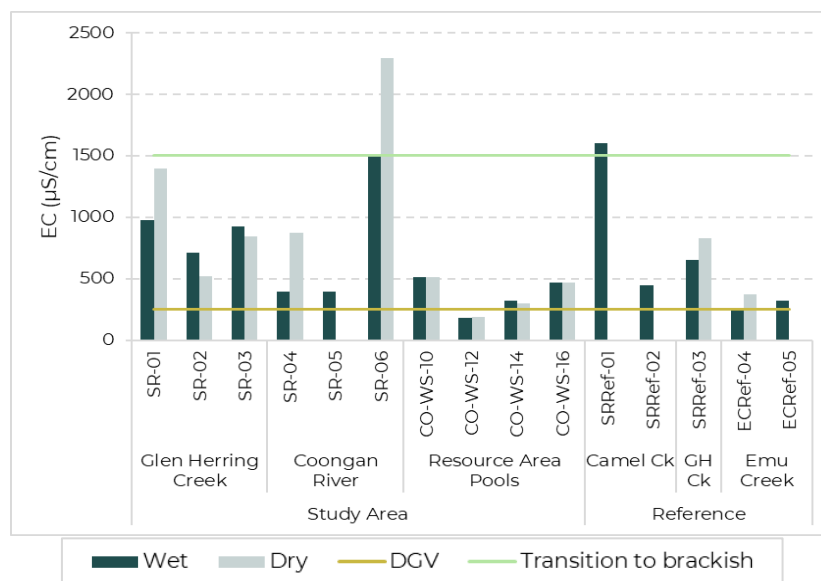


Figure 4.5: Electrical conductivity (EC  $\mu\text{S}/\text{cm}$ ) recorded during the Survey

<sup>3</sup> Salinity categories are based on the Department of Water and Regulation (DWER) classification system, where fresh/marginal < 1,000 mg/L (~1,500  $\mu\text{S}/\text{cm}$ ), brackish = 1,000 mg/L – 2,000 mg/L (~1,500  $\mu\text{S}/\text{cm}$  to 3,000  $\mu\text{S}/\text{cm}$ ), saline = 2,000 mg/L – 35,000 mg/L (~ 3,000  $\mu\text{S}/\text{cm}$  – 70,000  $\mu\text{S}/\text{cm}$ ), and hypersaline > 35,000 mg/L (> 70,000  $\mu\text{S}/\text{cm}$ ) (Mayer *et al.*, 2005).

Almost all sites recorded EC in excess of the ANZG (2018) DGV ( $> 250 \mu\text{S}/\text{cm}$ ) in both seasons, with the exception of CO-WS-12 (both seasons) and ECRRef-04 (in the Wet 2024). However, the DGV for EC is known to be conservative, and not necessarily applicable to Pilbara waters which experience wide-ranging EC. The large temporal and seasonal variability in EC within Pilbara pools is due to flushing in the wet season, and evapoconcentration of ions as surface waters recede during the dry season.

DO was also highly variable (Figure 4.6). Within the Study Area, DO ranged from 48.0 % (at SR-03 in the Dry 2024) to 197.2% (at SR-01 in the Wet 2024). DO at Reference sites varied between 5.4% (at SRRef-03 in the Dry 2024) and 166.5% (at ECRRef-04 in the Wet 2024). DO saturation fell outside ANZG (2018) DGVs ( $< 85\%$  or  $> 120\%$ ) at most sites (Figure 4.6).

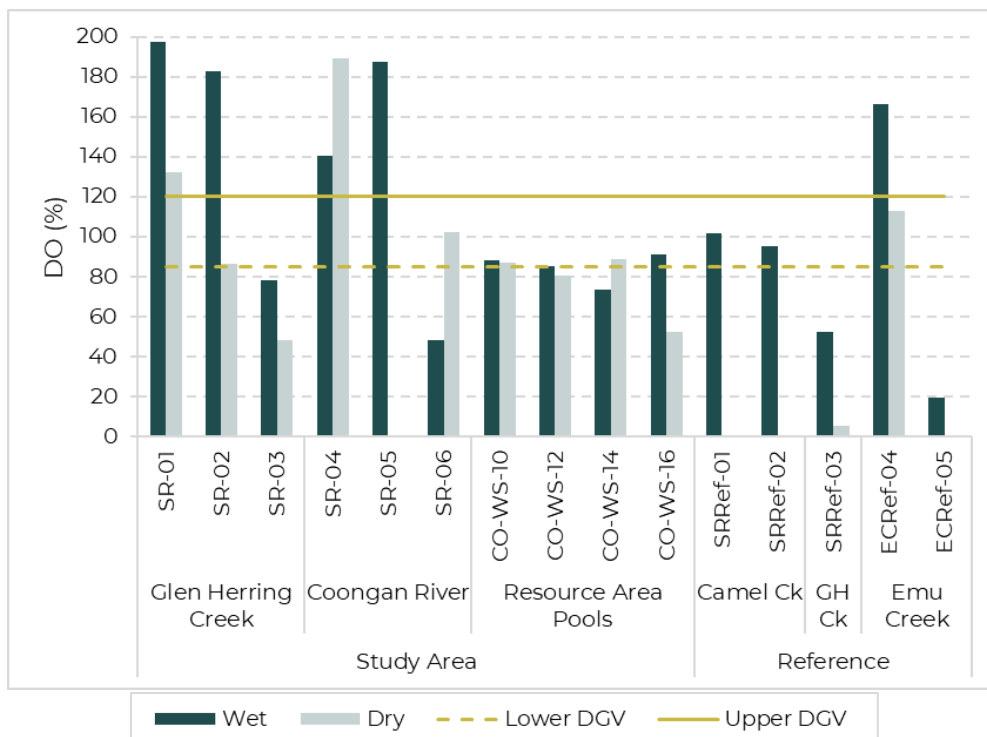


Figure 4.6: Dissolved oxygen (DO %) recorded during the Survey

In-stream DO saturation is influenced by several abiotic (flow, turbulence water temperature, water depth) and biotic factors (presence of aquatic plants, organic matter, algal blooms, respiration by aquatic fauna, decomposition by bacteria) (Andersen *et al.*, 2017; Connolly *et al.*, 2004). In the Survey, the wide variation in DO is likely due to the high abundance of submerged macrophytes and algae present in some pools, time of day that sites were sampled, and shallow water depths at some sites. DO saturation undergoes diel fluctuations, as plants aquatic undergo photosynthesis which contributes to higher DO during the day, followed by a lack of photosynthesis but continued respiration by aquatic fauna, which reduces DO overnight (Andersen *et al.*, 2017). Sites sampled from 11:00 onwards allowed for sufficient time for plants to photosynthesise, resulting in super-saturated DO at some sites

(SR-01, SR-02, SR-04, SR-05, ECRef-04), while those sampled in the early morning had reduced DO saturation (SR-03, SR-06, SRRef-03). The notably low DO recorded from Reference site SRRef-03 is likely influenced by the high turbidity at this site, reducing sunlight penetration and therefore the extent of the euphotic zone where photosynthesis can occur. The low DO recorded from ECRef-05 reflects the shallow water depth at this site.

Surface waters were slightly acidic to basic in the Study Area (6.40 at CO-WS-16 in the Dry 2024 to 10.29 at SR-05 in the Wet 2024), and basic at Reference sites (7.70 at SRRef-03 in the Dry 2024 to 9.46 at ECRef-04 in the Wet 2024; Figure 4.7). While Resource Area pools generally fell within ANZG (2018) DGVs in both seasons, almost all other Study Area sites recorded values in excess of the upper DGV (8), with the exception of SR-06. Basic waters are relatively common in Pilbara waters, especially in groundwater-fed systems (Biologic, unpub. data). High pH can be caused by photosynthesis of submerged macrophytes and algae, which when coupled with high water temperatures, results in supersaturated DO (RBI, 2004). This association between elevated pH and DO was observed in the Survey, suggesting aquatic plants are one driver of basic conditions within the Study Area.

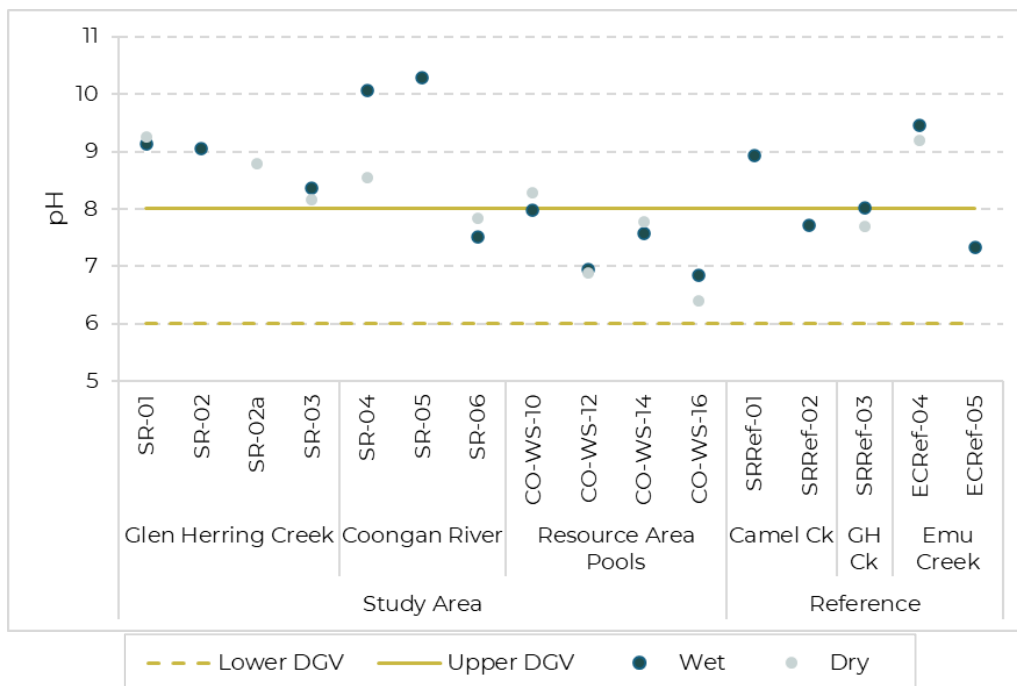


Figure 4.7: pH recorded during the Survey

#### 4.3.2.2 Ionic Composition and Alkalinity

Most Study Area sites were dominated by Na cations and HCO<sub>3</sub> anions in both seasons, though Resource Area pools tended to have more equal concentrations of Na, Ca and Mg cations and HCO<sub>3</sub> and Cl anions (Figure 4.8, Appendix F). Reference sites were also dominated by HCO<sub>3</sub> anions, but tended to have more equal concentrations of Na and Ca

cations (with the exception of SRRef-01 in the Wet 2024 and SRRef-03 in the Dry 2024, which were dominated by Na; Appendix F).

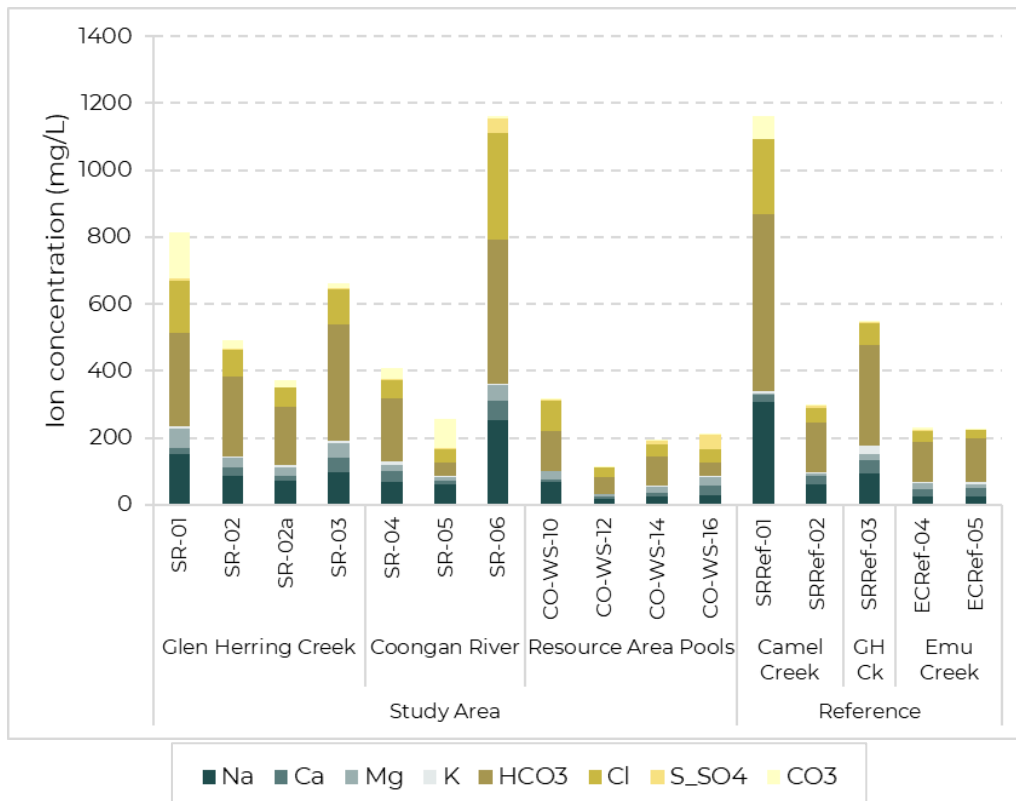


Figure 4.8: Average ion concentration recorded during the Survey. For sites sampled once for water quality, an absolute value is provided

Generally, alkalinity at both Study Area and Reference pools was relatively high ( $\geq 39$  mg/L), indicating good buffering capacity. High alkalinity is also known to reduce the toxicity effects of several dissolved metals. Resource pools recorded the lowest alkalinity levels, especially CO-WS-16, although values were still of a level to indicate good buffering capacity.

#### 4.3.2.3 Water Clarity

Turbidity recorded during the Survey was generally low, with some exceptions (Figure 4.9). SRRef-01 in the Wet 2024 and SRRef-03 in the Dry 2024 recorded notably high turbidity, 16 and 43 times the ANZG (2018) DGV, respectively. Both sites appeared highly turbid at the time of sampling, and likely reflected the clay substrate present. The effect of high turbidity on DO was observed at SRRef-03 (see 4.3.2.1).

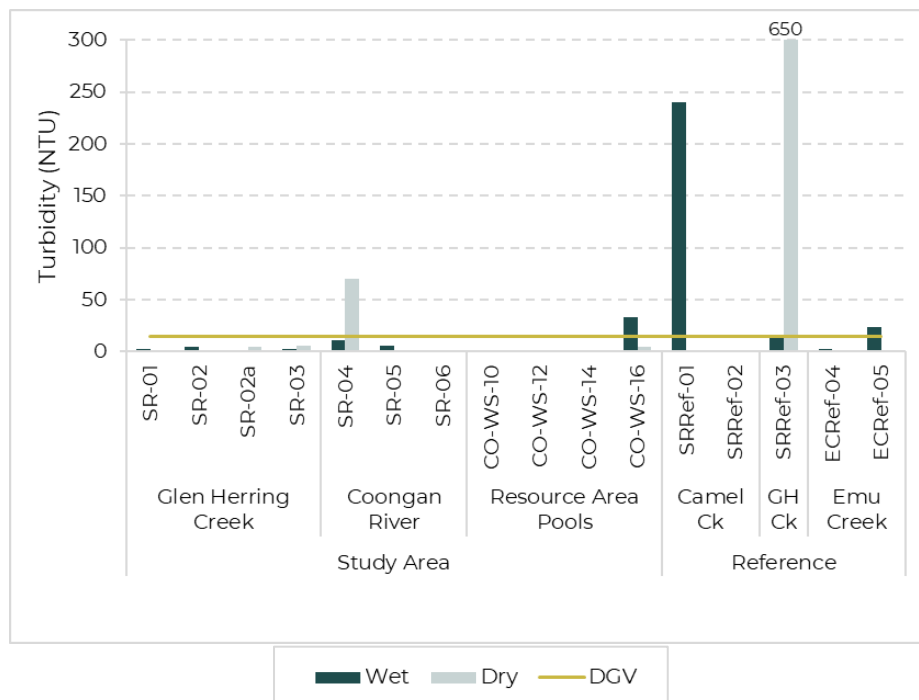


Figure 4.9: Turbidity (NTU) recorded during the Survey

#### 4.3.2.4 Nutrients

N<sub>2</sub> concentrations were below ANZG (2018) 95% toxicity DGV (0.32 mg/L at pH 8) at all Study Area sites, but there were some exceedances at Reference sites (Figure 4.10). Elevated N<sub>2</sub> was recorded from ECRef-05 (Wet 2024) and SRRef-03 (Dry 2024), with the concentration at SRRef-03 being more than twice the DGV (2.27 mg/L). High pH increases the relative amount of the more toxic un-ionised form of ammonia, contributing to greater toxicity overall (ANZECC & ARMCANZ, 2000). Therefore, ANZG (2018) provide differing 95% DGVs relevant to different pH levels. Once pH was taken into account, ECRef-05 was no longer in excess of the 95% toxicity GV, but SRRef-03 was still in exceedance (Figure 4.10). It is noted here, that ammonia toxicity is also affected by temperature, but ANZG (2018) do not provide updated 95% DGVs to account for temperature currently.

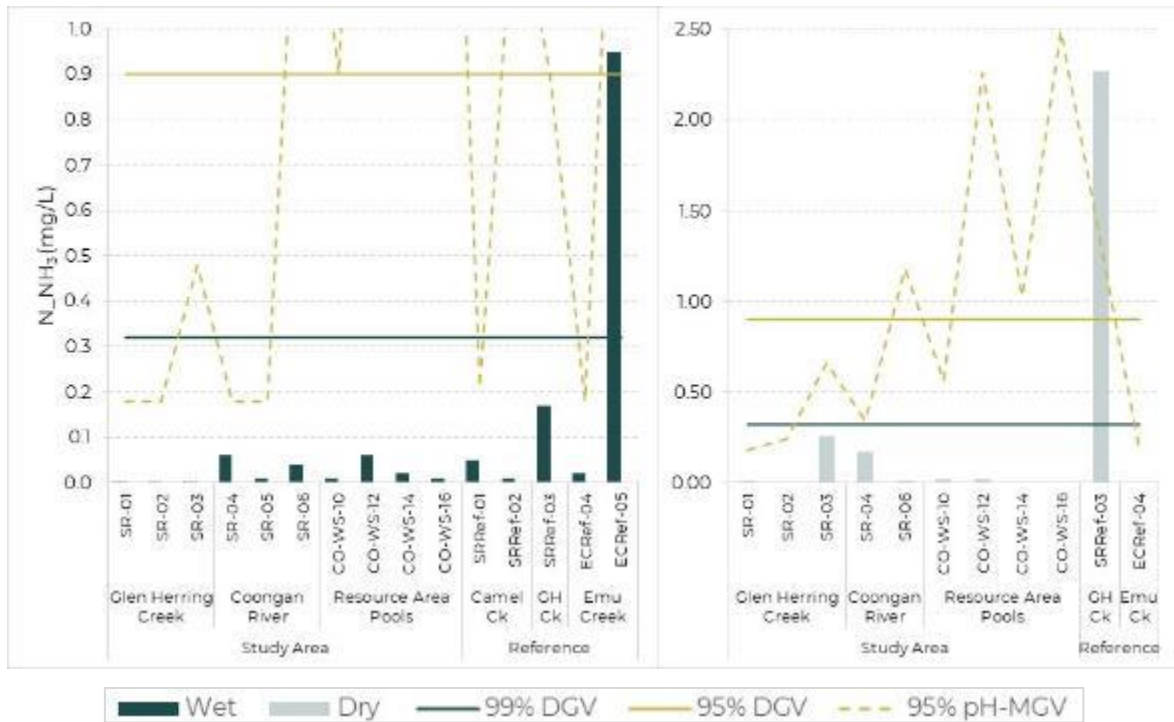


Figure 4.10: Ammonia concentrations recorded during the Survey, in comparison to ANZG DGVs at different pH levels<sup>4</sup>. Shaded bars indicate concentrations below the LOD

N-NO<sub>3</sub> concentrations were low at both Study Area and Reference sites, with several sites recording concentrations below the limit of detection (LOD). There were no exceedances of the 95% toxicity DGV recorded from any site, in either season (Appendix F).

ANZG (2018) eutrophication DGVs were exceeded at several sites. N-NO<sub>x</sub> was generally high, with most sites recording concentrations in excess of the eutrophication DGV, in at least one season. The only exceptions to this were SR-03, SR-05 and SR-06 which did not exceed the eutrophication DGV in either season (Figure 4.11). Similarly, there were multiple exceedances of the total N eutrophication DGV (0.3 mg/L) at both Study Area and Reference sites (Figure 4.11). Resource pools were the exception, consistently recording low total N concentrations across both seasons, as did Coongan River site SR-06 and Reference site SRRef-02 (Figure 4.11). Total P concentrations were elevated in comparison to the eutrophication DGV (0.01 mg/L) at almost all sites in both seasons (with the exception of CO-WS-12, CO-WS-14 and CO-WS-16 in the Wet 2024 and CO-WS-14 in the Dry 2024; Figure 4.11).

<sup>4</sup> Note that pH modified GV's were only assessed for pH up to 9.0. Therefore, for sites where pH was greater than 9.0, the GV is likely lower.

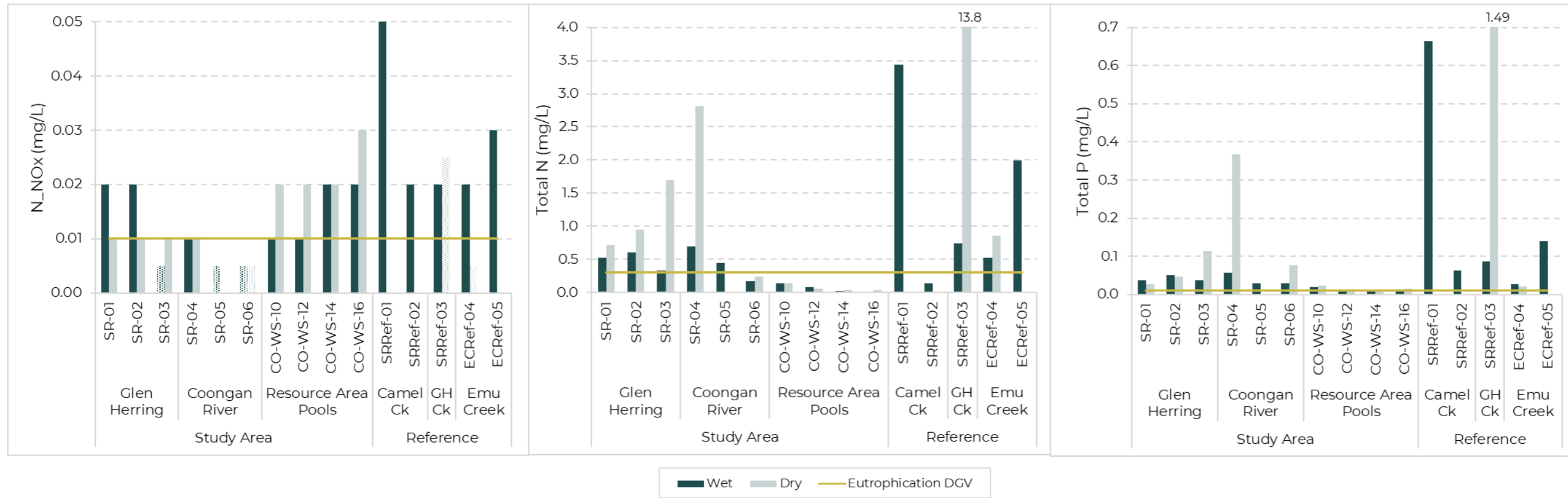


Figure 4.11: N<sub>2</sub>O<sub>x</sub>, total N and total P concentrations (mg/L) recorded during the Survey. Shaded bars indicate concentrations below the LOD

The eutrophication DGVs are designed to protect aquatic ecosystems from the effects of nuisance algal and macrophyte growth. Excessive plant growth can physically smother aquatic invertebrates, as well as deplete oxygen in the water, due to increased biological oxygen demand as plants decay and are decomposed by bacteria (Ryding & Rast, 1989). The relationship between nitrate-enrichment and enhanced algal growth in freshwaters is well documented, often resulting in very high density/ abundance, but low species richness (Camargo & Alonso, 2006; Wagenhoff *et al.*, 2011). While the idea that phosphorus (as FRP or total P) is the primary limiting factor for algal growth in freshwaters has been challenged as too simplistic (Beck & Hall, 2018; Elser *et al.*, 2007; Muhid & Burford, 2012), the fact that both total N and total P concentrations were relatively high in the Study Area under current conditions suggests that any additional nutrient inputs (such as from mining impacts associated with blasting or dewatering discharge in the future) would increase the risk of eutrophication to these pools.

#### 4.3.2.5 Dissolved Metals

Dissolved metal concentrations were generally low at both Study Area and Reference sites, in both seasons, with several analytes recording concentrations below LODs at most, if not all sites (i.e., dCd, dSe, dZn; Appendix F). In particular, Resource Area Pools tended to record very low dissolved metal concentrations (Figure 4.12). However, several dissolved metals were recorded in concentrations exceeding the 95% toxicity DGV (Figure 4.12). Generally, SRRef-01 recorded elevated dissolved metal concentrations compared to other sites, though only data from the Wet 2024 is available for this site. Elevated dissolved metals in comparison to 95% toxicity DGVs recorded from the Study Area included:

- dAl – was elevated at SR-04 and SRRef-01 in the Wet 2024. The concentration of dAl at SRRef-01 was notably high, being over 20 times the DGV (1.12 mg/L)
- dCr – was only elevated at Reference site SRRef-01 (Wet 2024), but the 99% DGV was exceeded at Study Area site SR-04 (in the Wet 2024). The toxicity of dCr is ameliorated by hardness and ANZG (2018) provide an algorithm to calculate hardness-modified guideline values (HMGVs). Even after accounting for hardness, the concentration of dCr from SRRef-01 remained in excess of the 95% HMGV (Figure 4.13)

- dCu – exceeded the 95% toxicity DGV (0.0014 mg/L)<sup>5</sup> at Study Area sites SR-01, SR-04, and SR-05, and Reference site SRRef-01 in the Wet 2024, and SR-01, SR-02, SR-03 and SRRef-03 (0.00144-0.0027 mg/L) in the Dry 2024
- dNi – was elevated in comparison to the 95% DGV (0.011 mg/L) at CO-WS-16 (0.014 mg/L) in the Wet 2024. As hardness ameliorates the toxicity of dNi, HMGVs were calculated and the concentration from CO-SW-16 was no longer in exceedance (Figure 4.13).

The current ANZG guidelines also include indicative working levels and/or low reliability triggers for some dissolved metals for which toxicity DGVs had not been prescribed previously. This includes:

- dCo (0.0014 mg/L), which was found to be elevated at CO-WS-16 (both seasons), SRRef-01 and ECRRef-05 (Wet 2024) and SRRef-03 (Dry 2024)
- dU (0.0005 mg/L), which was exceeded at SR-01, SR-04, SR-06 and SRRef-03 (in both seasons), and SR-03, SR-05, SRRef-01 and SRRef-02 (in the Wet 2024). Study Area site, in particular, recorded considerably high dU, being nearly 14 times the low reliability DGV (0.007 mg/L) in the Dry 2024.
- dV (0.006 mg/L) was elevated at SR-01 and SR-04 (both seasons) and SR-02, SR-05 and SRRef-01 (Wet 2024)
- dFe (interim indicative working level of 0.3 mg/L) was exceeded at Resource Area pool CO-WS-16 (2.20 mg/L), and Reference sites SRRef-01 (1.44 mg/L) and ECRRef-05 (0.84 mg/L) in the Wet 2024, and SR-04 (0.42 mg/L) and CO-WS-16 (1.28 mg/L) in the Dry 2024. Concentrations of dFe were notably high at CO-WS-16 and SRRef-01, being more than seven and nearly five times the interim DGV, respectively. The elevated iron concentration recorded from CO-WS-16 was unsurprising, given that an iron-rich organic floc was observed at this pool at the time of sampling.

However, due to limited chronic toxicity studies, application of the low reliability and interim DGVs should be interpreted with caution, and only used to provide context for water quality values recorded during the Survey.

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<sup>5</sup> While hardness modified guidelines exist for dCu, they are not considered sufficiently conservative to protect key sensitive aquatic species (Markich *et al.*, 2005). Therefore, dCu DGVs were not modified for hardness.



Figure 4.12: Concentrations of selected dissolved metals recorded during the Survey. Shaded bars indicate concentrations below the LOD

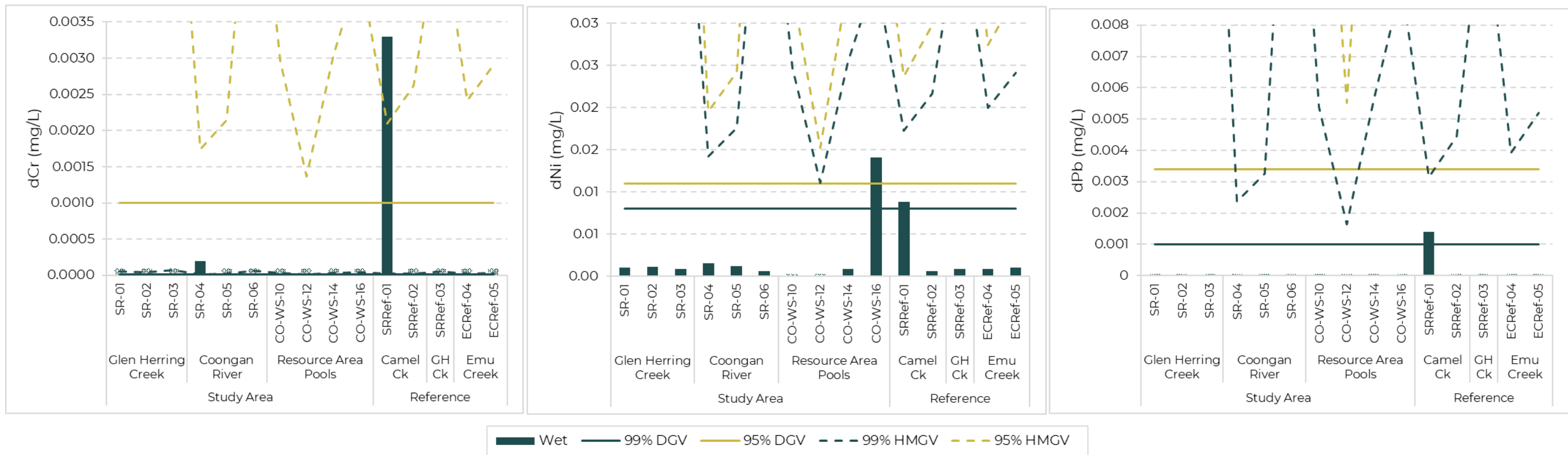


Figure 4.13: Concentrations of selected dissolved metals in comparison to HMGVs (wet season only). Shaded bars indicate concentrations below the limit of detection

Spot exceedances such as these are relatively common in Pilbara waterbodies, especially for dAl, dFe and dCu. Short-term, intermittent spikes in dissolved metal concentrations are unlikely to have adverse impacts on aquatic biota, in contrast to sustained and/or significantly increasing concentrations. These exceedances are also based on spot measurements, and do not represent total metal loads. Although the values represent dissolved concentrations, this does not necessarily translate to labile concentrations and/or the portion that is bioavailable for aquatic biota. The bioavailability of metals depends on their speciation in the aquatic environment (Campbell, 1995). Metals can be present in various forms, including the hydrated free ion, inorganic complexes, organic complexes, colloids, or suspensions (Zhao *et al.*, 2016). Care must also be taken when interpreting comparison of dCr against DGVs. Concentrations reported here relate to total dCr, but DGVs relate to dCr (VI). Cr (III) is known to be less toxic than Cr (VI), which may also bioaccumulate (ANZG, 2018). Determining the speciation of Cr in water requires additional analytical (i.e., cathodic stripping voltammetry, chromatography, ion exchange) or theoretical techniques (i.e., geochemical modelling) beyond the scope of the Survey.

### 4.3.3 Riparian Flora

#### 4.3.3.1 Macrophyte Taxa Composition and Richness

Overall floristic richness in the Study Area ranged from nine (SR-01R) to 49 (SR-03), with an average richness of 35 species. Floristic richness was greater at Reference sites, with a range from 28 (SRRef-01) to 71 (ECRef-04) and an average of 44.

Study Area sites on Glen Herring Creek and the Coongan River shared similar dominant riparian vegetation assemblages, including overstoreys of *Sesbania cannabina*, *Atalaya hemiglauca*, *Eucalyptus camaldulensis* and *Melaleuca glomerata* over *Stemodia grossa*. While Glen Herring Creek had a diversity of *Acacia* species, *Melaleuca argentea* and grasses was more common along the Coongan River, and both areas had differing herb assemblages, with *Euphorbia* spp. along Glen Herring Creek and *Ammannia* spp. and *Nellica maderaspatensis* along the Coongan River (Appendix G).

The Resource Area Pools had a distinctively different dominant riparian vegetation, with *Ficus* spp., *Melaleuca argentea* and *Clerodendrum tomentosum* prominent in the overstorey. The understorey also differed to the riverine pools, with climbers present, such as *Cucumis melo*, and herb and grass assemblages including *Flueggea virosa* and *Eriachne mucronata* (Appendix G).

The Study Area supported four submerged macrophyte species (*Chara fibrosa*, *Najas tenuifolia*, *Potamogeton tepperi* and *Vallisneria nana*) and 13 emergent macrophytes (*Bulbostylis barbata*, *Cyperus bifax*, *Cyperus difformis*, *Cyperus squarrosus*, *Cyperus*

*vaginatus*, *Eleocharis geniculata*, *Fimbristylis dichotoma*, *Schoenoplectiella laevis*, *Schoenoplectus subulatus*, *Schoenus falcatus*, *Typha domingensis* and *Marsilea hirsuta*; Figure 4.14). Three additional emergent macrophyte species were recorded from Reference sites that were not present in the Study Area, including *Cyperus iria*, *Cyperus ixiocarpus* and *Cyperus leptocarpus*.

Average macrophyte richness (emergent and submerged macrophytes) was lowest within the Resource Area (4 species), with the remaining Study Area pools and Reference sites recording an average of 6.5 species. Reference site ECRef-04 recorded the greatest richness of macrophyte species (12 species).

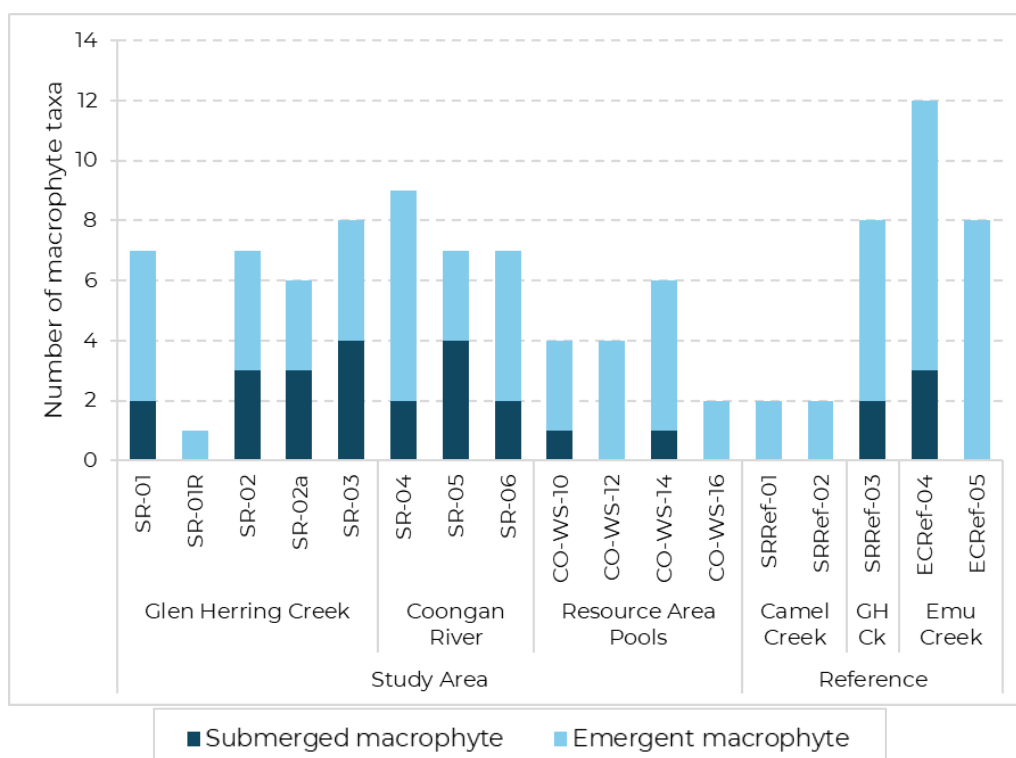


Figure 4.14: Submerged and emergent macrophyte richness recorded during the Survey

#### 4.3.3.2 Groundwater Dependent Vegetation

Sites along the Coongan River generally recorded high numbers of GDV/GDE indicator taxa (16-17 taxa), as did SR-03 on Glen Herring Creek (Figure 4.15). This included several High indicator species (3 taxa each) suggesting these sites likely have periodic or consistent groundwater connection supporting diverse and specialised vegetation adapted to GDEs. The other Glen Herring Creek Study Area sites (SR-01 and SR-02) also recorded relatively high numbers of GDV/GDE indicators (12-15 taxa), though the majority of these were Moderate to Low indicators. This suggests that in Glen Herring Creek, groundwater connectivity is highest in the vicinity of SR-03 and this connection potentially reduces as you move upstream (Figure 4.15).

Within the Resource Area, CO-WS-14 recorded the greatest number of High indicator taxa from any site sampled during the Survey (4 taxa), and, along with CO-WS-12, also supported relatively high numbers of Moderate GDV/GDE indicators (13-14 taxa; Figure 4.15). While CO-WS-10 and CO-WS-16 contained primarily Low GDV/GDE indicator taxa, the groundwater connectivity vegetative framework is used in conjunction with other features such as the presence of permanent water and surface expression. CO-WS-16 is considered likely to be groundwater dependent, given the presence of persistent, flowing water and fact that it supports mature *Melaleuca argentea*. The gorge pool at CO-WS-10 is also considered likely to be influenced by groundwater intrusion to some extent, and is likely maintained year-round by its location, with the gorge and aspect, providing shading and limited evaporation. There was no evapoconcentration recorded from surface waters at this site, with no change in EC recorded between seasons.

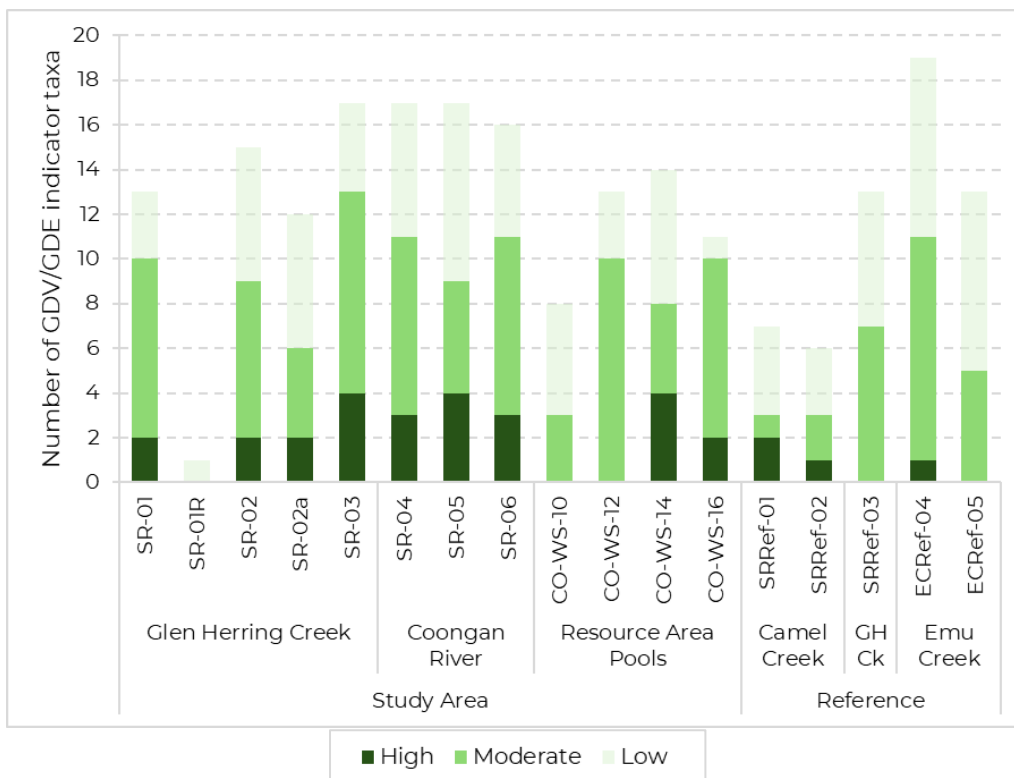


Figure 4.15: GDV/GDE indicator taxa richness recorded during the Survey

Comparatively, GDV/GDE indicator taxa richness at Reference sites was low, with surface waters at these sites also being more ephemeral. The exception was ECRRef-04 which recorded high numbers of GDV/GDE indicators, comprised primarily of Moderate indicator species (Figure 4.15).

#### 4.3.3.3 Conservation Significant Flora

Only one significant flora species was recorded, *Themeda* sp. Panorama, which is listed as a DBCA Priority 1 (DBCA, 2024b). This is a poorly known grass species, and is only known from seven locations west of Marble Bar. During the Survey, *Themeda* sp. Panorama was recorded from CO-WS-10 in the understorey adjacent to the pool.

#### 4.3.3.4 Introduced Flora

A total of 14 introduced flora species was recorded from the Study Area. The Coongan River pools and Reference sites recorded the greatest number (17 species), while Resource Pools tended to support a lower number of invasives (four species), with weeds apparently absent from CO-WS-10 and CO-WS-16 (Table 4.7). SR-06 recorded the greatest number of weeds, with seven species present.

Table 4.7: Introduced species recorded during the Survey, and their impact and invasiveness

	Lowest taxon	Study Area			Reference		
		Glen Herring Creek	Coongan River	Resource Area Pools	Camel Creek	Glen Herring Creek	Emu Creek
High Impact, Rapid Spread	* <i>Aerva javanica</i> (Kapok Bush)			X	X		
	* <i>Passiflora foetida</i> var. <i>hispida</i> (Stinking Passionflower)			X			
	* <i>Cenchrus ciliaris</i> (Buffel Grass)	X	X	X	X		X
	* <i>Cenchrus setiger</i> (Birdwood Grass)		X			X	X
	* <i>Chloris barbata</i> (Purpletop Chloris)	X	X		X		
	* <i>Cynodon dactylon</i> (Couch)		X		X		
	* <i>Echinochloa colona</i> (Awnless Barnyard Grass)		X			X	X
Low Impact, Rapid Spread	* <i>Solanum nigrum</i> (Black Berry Nightshade)		X				
Unknown Impact, Rapid Spread	* <i>Argemone ochroleuca</i> subsp. <i>Ochroleuca</i> (Mexican Poppy)	X	X		X	X	X
Unknown Impact, Unknown Spread	* <i>Physalis angulata</i> (Wild Gooseberry)		X	X			
Not Assessed	* <i>Flaveria trinervia</i> (Speedy Weed)	X					
	* <i>Lactuca serriola</i> (Prickly Lettuce)	X					
	* <i>Pseudognaphalium luteoalbum</i> (Jersey Cudweed)		X				
	* <i>Calotropis procera</i> (Rubber Bush)	X	X			X	X
	<b>Total</b>	<b>6</b>	<b>10</b>	<b>4</b>	<b>5</b>	<b>4</b>	<b>5</b>

#### 4.3.4 Hyporheic fauna

##### 4.3.4.1 Hyporheos Taxa Composition and Richness

A total of 121 invertebrate taxa was recorded from hyporheic zones of the Study Area, with 87 recorded from ten sites in the Wet 2024, and 89 recorded from nine sites in the Dry 2024. The taxonomic list included Hirudinea (leeches, one taxon), Oligochaeta (aquatic segmented worms; 12 taxa), Polychaeta (freshwater bristle worms; one taxon), Cnidaria (freshwater hydra; one taxon), Turbellaria (flat worms; one taxon), Nematoda (one taxon), Mollusca (freshwater snails; two taxa), Cladocera (water fleas; five taxa), Ostracoda (seed shrimp; nine taxa), Maxillopoda (copepods; eight taxa), Collembolla (spring tails; one taxon), Acarina (water mites; nine taxa), Coleoptera (beetles; 28 taxa), Diptera (two-winged fly larvae; 31 taxa), Ephemeroptera (mayfly larvae; two taxa), Hemiptera (aquatic true bugs; four taxa), Trichoptera (caddisfly larvae; four taxa), and Odonata (immature dragonflies; one taxon; Appendix H).

Almost three-quarters of these taxa were stygoxene (71%) and do not have specialised adaptations for groundwater habitats. Hyporheic fauna<sup>6</sup> made up the remaining taxa collected from the Study Area, with 4% being directly dependent on groundwater for their persistence (2% permanent hyporheos stygophiles and 2% stygobites). A total of 14% of taxa were occasional hyporheos stygophiles, utilising the hyporheic zone opportunistically. The percentage of stygobites recorded from the Study Area was low in comparison to a Pilbara wide study of spring sites, which recorded a total of 5% stygobites from hyporheic zones (Halse *et al.*, 2002).

Hyporheic taxa recorded from the Study Area during the Survey included:

##### Stygobites

- copepod *Australocamptus* `sp. Biologic-HARP099`
- ostracod *Candonopsis kimberleyi*

##### Permanent hyporheos stygophiles

- ostracod *Vestalenula marmonieri*
- water mites *Wandesia* `sp. Biologic-ACAR028` and *Guineaxonopsis* sp.

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<sup>6</sup> Hyporheic fauna includes stygobites, permanent hyporheos stygophiles, occasional hyporheos stygophiles and possible hyporheic taxa. Hyporheic fauna are referred to as the 'hyporheos'.

### Occasional hyporheos stygophiles

- oligochaetes *Aulophorus furcatus*, *Allonais ranauana*, *Dero nivea*, *Pristina aequisetata* and *Pristina longiseta*
- ostracods *Candonopsis* cf. *tenuis*, *Candonopsis kimberleyi*, *Cyprinotus cingalensis* and *Riocypris* cf. *fitzroyi*
- copepods *Eodiaptomus lumholtzi*, *Mesocyclops brooksi*, *Mesocyclops notius*, *Mesocyclops* sp. and *Microcyclops varicans*
- beetles *Hydraena* sp., Hydraenidae sp. (L), *Limnebius* sp., *Ochthebius* sp. and Scirtidae sp. (L).

Possible hyporheic taxa made up 11% of the taxa recorded from Study Area hyporheic zones, and included higher-level identifications for which taxa may have belonged to a stygal or hyporheos species. Such taxa included Annelida (Enchytraeidae sp., Naididae sp., *Pristina* nr. *osborni*, Phreodrilidae sp. and Aeolosomatidae sp.), Copepoda (*Mesocyclops* sp. and *Thermocyclops* sp.), Acarina (Acari sp., Trombidioidea sp. and Axonopsella sp.), Coleoptera (Hydrophilidae larvae) and Ephemeroptera (larvae).

Invertebrate richness within hyporheic zones was dominated by stygoxenes at all sites, generally followed by occasional hyporheos stygophiles (Figure 4.16). Only three stygobites were recorded during the Survey, with only recorded from any one site at a time, including Study Area sites SR-02 and SR-06, and Reference sites SRRef-02 and ECRRef-04 (Figure 4.16). Richness of groundwater dependent taxa was generally low, ranging from zero at many sites (including both Study Area and Reference sites) to three taxa at Study Area site SR-06 (Dry 2024). This was followed by two groundwater dependent taxa recorded from Study Area site SR-05 (Wet 2024; Figure 4.16). Comparatively, Reference sites recorded fewer groundwater dependent taxa, with either zero or just one taxon recorded (at SRRef-02 and ECRRef-04).

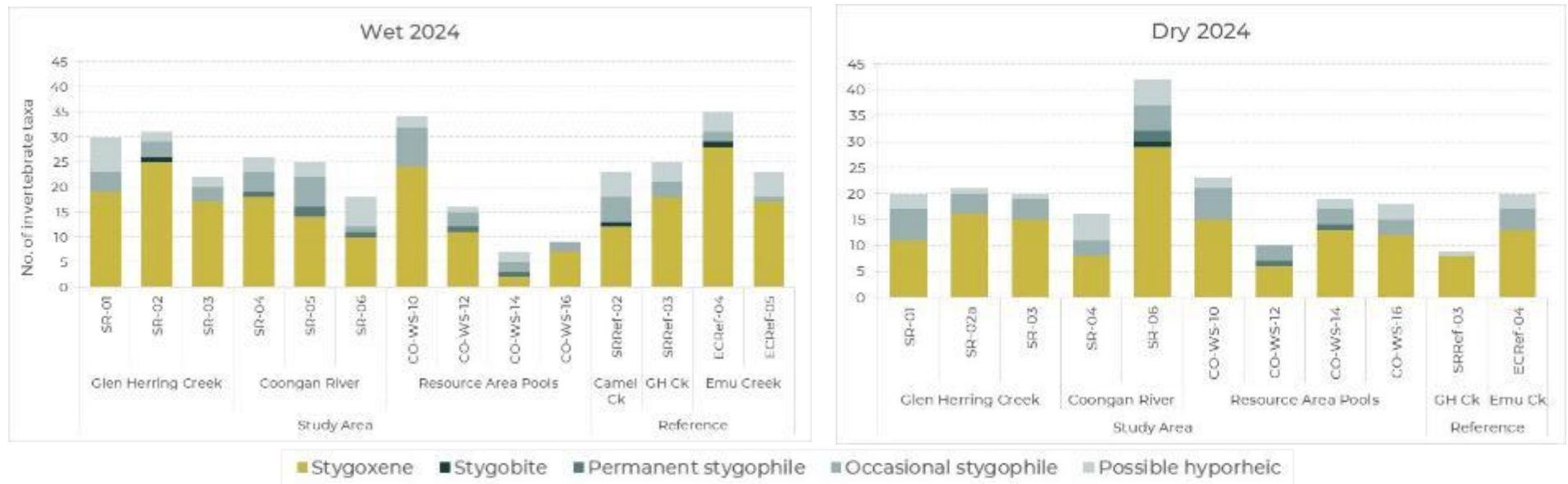


Figure 4.16: Invertebrate composition and richness recorded from hyporheic zones at each site

The presence of groundwater dependent taxa within the hyporheic zone of SR-05 and SR-06 suggests the presence of sub-surface groundwater flow in these areas. The groundwater is close to the surface, providing habitat for aquatic invertebrates within the hyporheic zone, and allowing the vertical connection from groundwater through to surface waters. In the ephemeral Coongan River, these areas would provide important refuge habitat for epigean taxa at certain times of the year. The fact that a comparatively high number of hyporheos fauna (including stygobites, permanent stygophiles, occasional stygophiles and possible hyporheic taxa) was recorded from these two sites compared to all others (11 from SR-05 in the Wet 2024 and 13 from SR-06 in the Dry 2024) suggests that this habitat is important for both stygofauna and surface water taxa. Surface water taxa are migrating vertically to exploit the hydrologic connection, potentially as a nursery to protect juveniles from predation (Bruno *et al.*, 2012; Jacobi & Cary, 1996) given the high number of larval and immature taxa present within the hyporheos. Surface water taxa are also known to utilise the hyporheic zone for protection during times of floods (Dole-Olivier & Marmonier, 1992; Edwards, 1998; Palmer *et al.*, 1992), drought (Coe, 2001; Cooling & Boulton, 1993; Hose *et al.*, 2005), and disturbance in food supplies (Edwards, 1998). In this way, the hyporheic zone enhances the resilience of the benthic community to disturbance and influences river recovery following perturbations. Hyporheic fauna have been used worldwide as an indicator of ecosystem health, especially in ephemeral creeks, with reported responses to disturbances such as metal pollution and eutrophication (Boulton, 2014; Leigh *et al.*, 2013; Moldovan *et al.*, 2013; Pacioglu & Moldovan, 2016).

#### 4.3.4.2 Significant Hyporheos Taxa

Most taxa recorded from hyporheic zones sampled during the Survey were relatively common and widespread. However, several taxa were of further interest, either due to being known from few records currently, having a disjunct distribution, or because they represent a new Operational Taxonomic Unit (OTU). This included the ostracod *Candonopsis kimberleyi*, copepod *Australocamptus* `sp. Biologic-HARP099`, and the water mite *Wandesia* `sp. Biologic-ACAR028`, all of which were recorded from the Study Area.

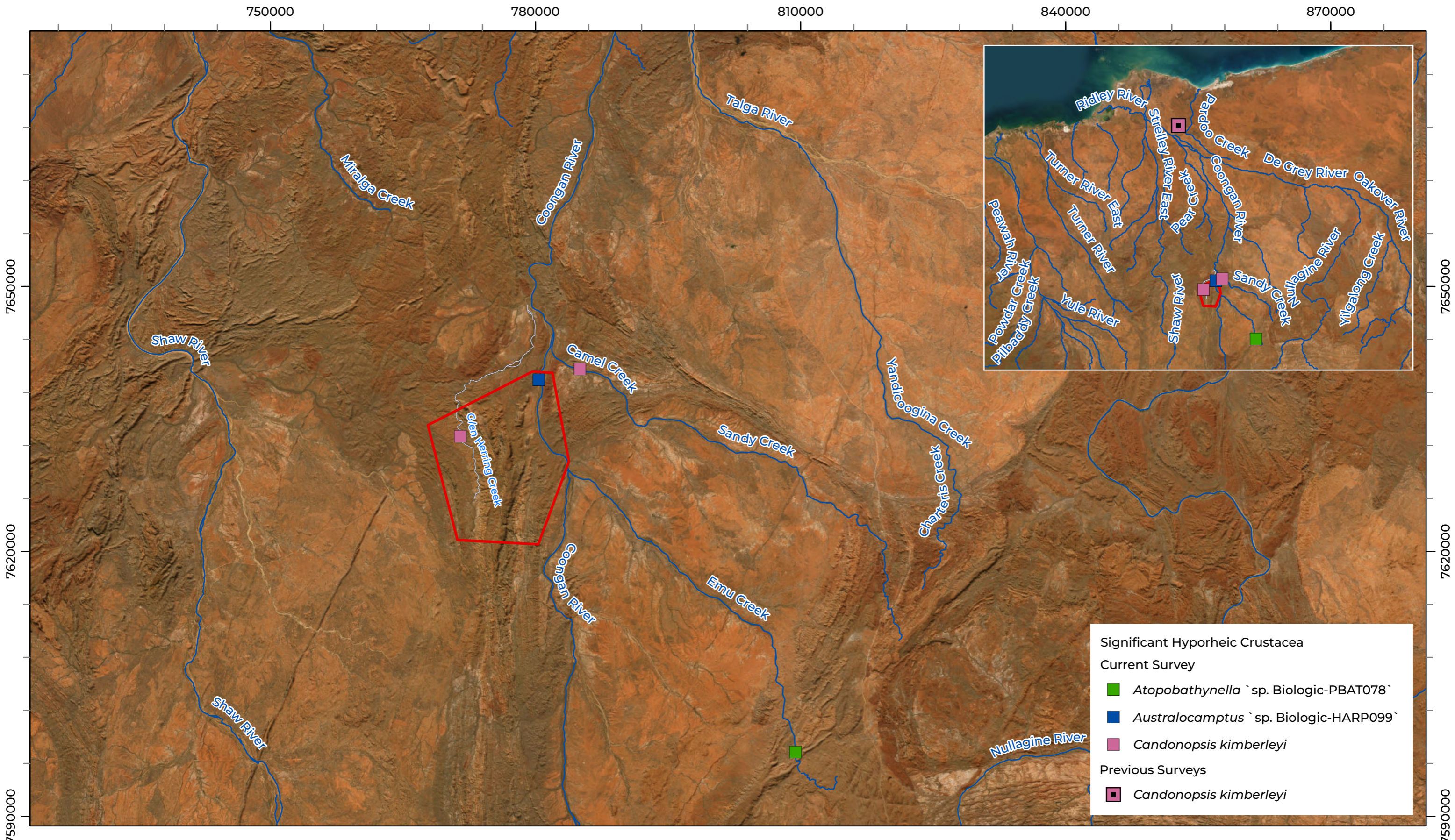
The stygobitic ostracod *Candonopsis kimberleyi* was recorded from the hyporheos of SR-02 and SRRef-02. This species is known only from few records, most of which are in the Kimberley. In the Pilbara it has been recorded from the lower De Grey catchment, approximately 115 km north-west of the Study Area (Figure 4.17).

The stygobitic copepod *Australocamptus* `sp. Biologic-HARP099` was recorded from the hyporheic zone of SR-06 on the Coongan River. This genus is endemic to Western Australia, with three described species known currently (Humphreys, 2003), none of which have records in the Pilbara (ALA, 2025). Given this and fact that the specimen did not

morphologically match the descriptions for any of the described species, molecular analysis was undertaken. The sequence was found to sit well within the *Australocamptus* genus, but it did not match any sequences within the available GenBank database, and as such, it was assigned a new OTU. This is the first record of this OTU.


The water mite *Wandesia* sp. Biologic-ACAR028` was recorded from the hyporheic zone of Study Area sites SR-04, SR-05 and SR-06. This taxon was identified using a combination of morphology and molecular analysis as the taxonomy of the *Wandesia* genus in Western Australia is poorly known and the geographic ranges of the various species have not been determined. All described species are known from the hyporheic zone of rivers in eastern Australia. One known, but undescribed morphotype, *Wandesia* sp. P1 (nr. *glareosa*), was recorded during the PBS from river pools and springs (three locations), the closest of which is Minigarra Creek pools at Woodie Woodie (Pinder *et al.*, 2010), which lies approximately 89 km north east of the Study Area (Figure 4.18). Specimens from the Survey were submitted for molecular analysis and sequences matched a previously known OTU; *Wandesia* sp. Biologic-ACAR028`. This taxon is known from one previous record, in the Upper Fortescue River catchment (Figure 4.18). It is likely the OTU is more widespread, but further morphological and molecular work is required to confirm this.

One additional stygobitic taxa with a potentially restricted distribution was recorded, but only from a Reference site (ERef-04 in the Wet 2024). This was the syncarid *Atopobathynella* sp. Biologic-PBAT078` (Figure 4.17). This taxon was morphologically identified as belonging to the genus *Atopobathynella* and submitted for molecular analysis. The sequence fit well within this genus, but it did not match any other sequences in the available genetic database (GenBank). As such, it was assigned a new operational taxonomic unit (OTU). Many Bathynellacea taxa are known to be restricted to small areas (Abrams, 2012; Coineau & Camacho, 2013), with many being known only from a single calcrete (Guzik *et al.*, 2008) and more than two-thirds of species having a known range less than 10 km (Bennelongia, 2008).



**LEGEND**

Study Area
 Surface Hydrology  
 Minor  
 Major

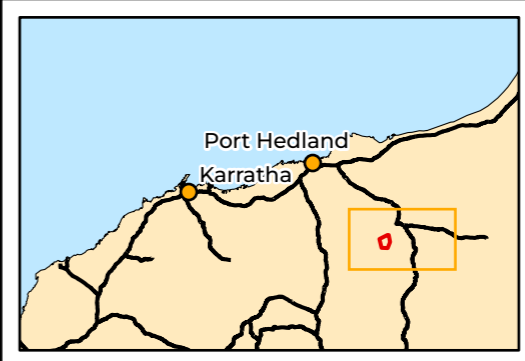


**Biologic**

Scale 1:400,000

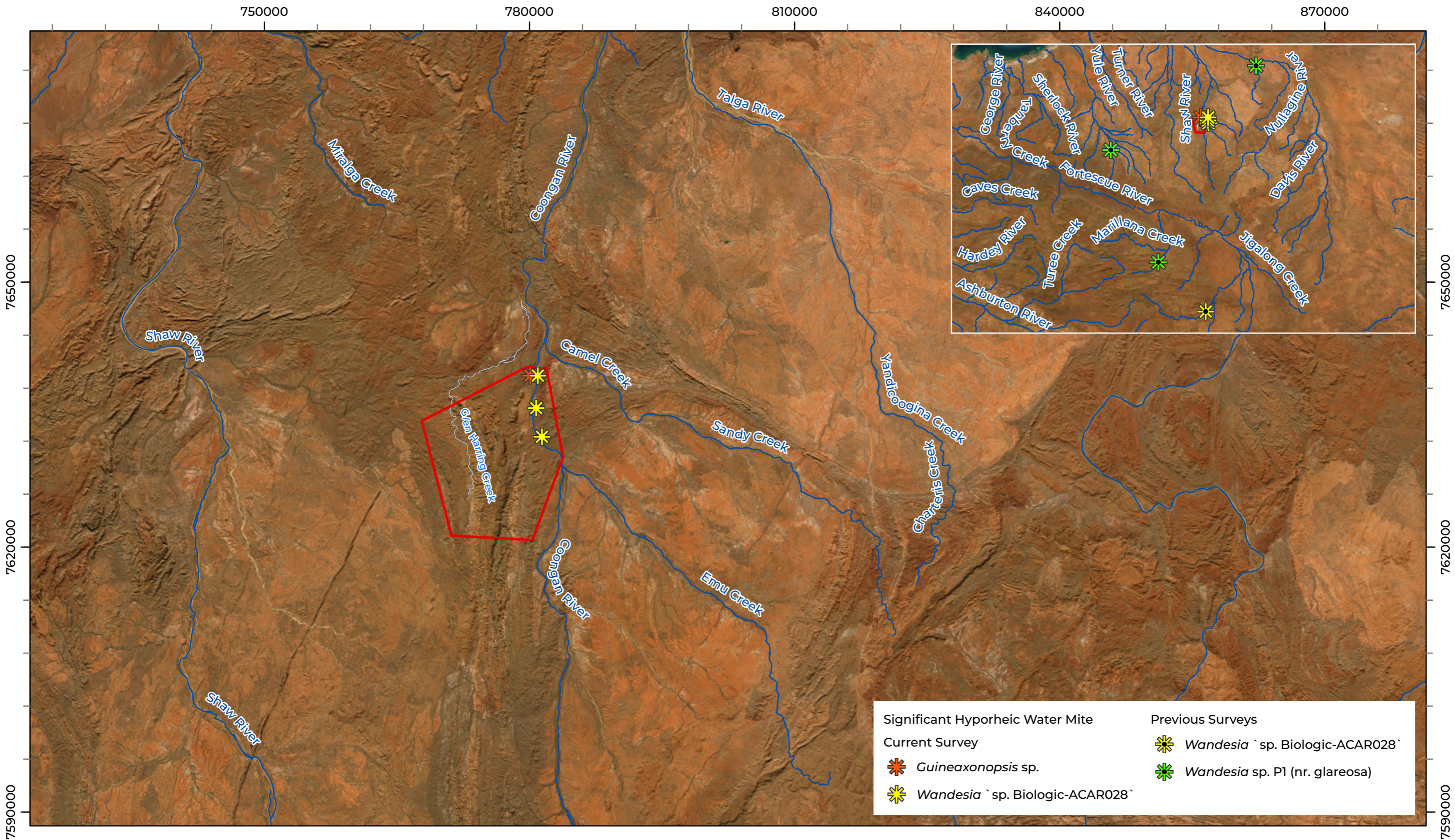
0 5 10 15 Km

Coordinate System: GDA 1994 MGA Zone 50  
Transverse Mercator Created: 26/02/2025



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**Sanjiv Ridge BWT**  
**Aquatic Ecology Survey**

Figure 4.17: Significant hyporheic Crustacea recorded during the Survey




**LEGEND**

Study Area

Surface Hydrology

— Minor

— Major

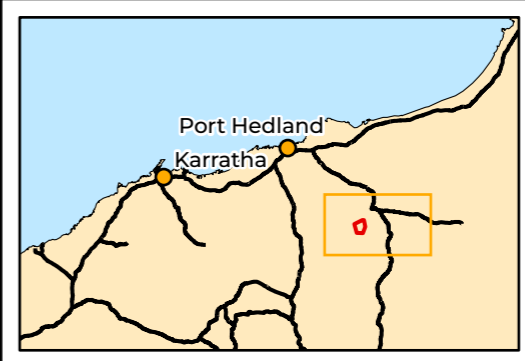


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**Sanjiv Ridge BWT**  
**Aquatic Ecology Survey**

Figure 4.18: Significant hyporheic water mites recorded during the Survey

### 4.3.5 Macroinvertebrates

#### 4.3.5.1 Macroinvertebrate Taxa Composition and Richness

A total of 259 macroinvertebrate taxa was recorded from surface waters in the Study Area, with 198 recorded from ten sites in the Wet 2024, and 204 from nine sites in the Dry 2024 (Appendix I). Taxa richness varied between sites and seasons (Figure 4.19). In the Wet 2024, the lowest macroinvertebrate richness was recorded from Resource Area pool CO-WS-16 (40 taxa) and the greatest was recorded from Resource Area pool CO-WS-14 (69 taxa). This was closely followed by Study Area site SR-04, with 68 taxa. Reference sites generally recorded slightly lower richness in the wet season, with SRRef-03 recording the highest number of taxa (64). In the Dry 2024, richness ranged from 36 (at Reference site SRRef-03) to 85 (at Reference site ECRRef-04). In the Study Area, notably high richness was recorded from Resource Area pools CO-WS-14 (83 taxa) and CO-WS-10 (81 taxa).

Of the sites which held water and were successfully sampled in both seasons, most recorded higher richness in the dry season (Figure 4.19). The exceptions to this were SR-04, CO-WS-16 and Reference site SRRef-03. Of these, the latter recorded the greatest variation, with dry season richness being just over half that recorded in the Wet 2024. The generally higher richness recorded in the dry season is likely due to the ephemerality of the creeks in the area, with aerial invertebrates likely moving to the remaining, persistent pools as others recede over the dry season. Remnant pools within ephemeral systems are known to provide important habitat during drought conditions where water quality and pool size remain suitable (Bogan *et al.*, 2019). Macroinvertebrate richness also increases with length of hydroperiod, and persistence of surface water, as pools which persist for longer periods of time allow more species to colonise, while also providing greater habitat complexity (Boulton, 1999; Pinder *et al.*, 2010; Sheldon *et al.*, 2002; Walker *et al.*, 1995).

The taxonomic composition of all Study Area sites was dominated by slow-flow, relatively tolerant taxa such as Diptera (average of 22% of taxa recorded in both seasons) and Coleoptera (average of 19% of taxa in the Wet 2024 and 24% in the Dry 2024; Figure 4.19). This was similar to Reference sites and dominance of these groups within aquatic invertebrate assemblages is commonly reported from Pilbara pools (Pinder *et al.*, 2010). One site, SR-01, recorded a notably high proportion of Ostracoda in the Wet 2024 (16% of all taxa recorded from this site). Interestingly, very few ostracods were recorded from this site in the dry season (2% of taxa). Given flowing surface waters were not present at most sites in either season (except Resource Area pools CO-WS-12, CO-WS-14 and CO-WS-16) very few species which prefer high flows were recorded from any site sampled. Families and genera known to be associated with high flows, such as Simuliidae, Ptilodactylidae, Hydropsychidae

(*Cheumatopsyche*) and Philopotamidae (*Chimarra*) (Chessman *et al.*, 2022), were not recorded during the Survey.

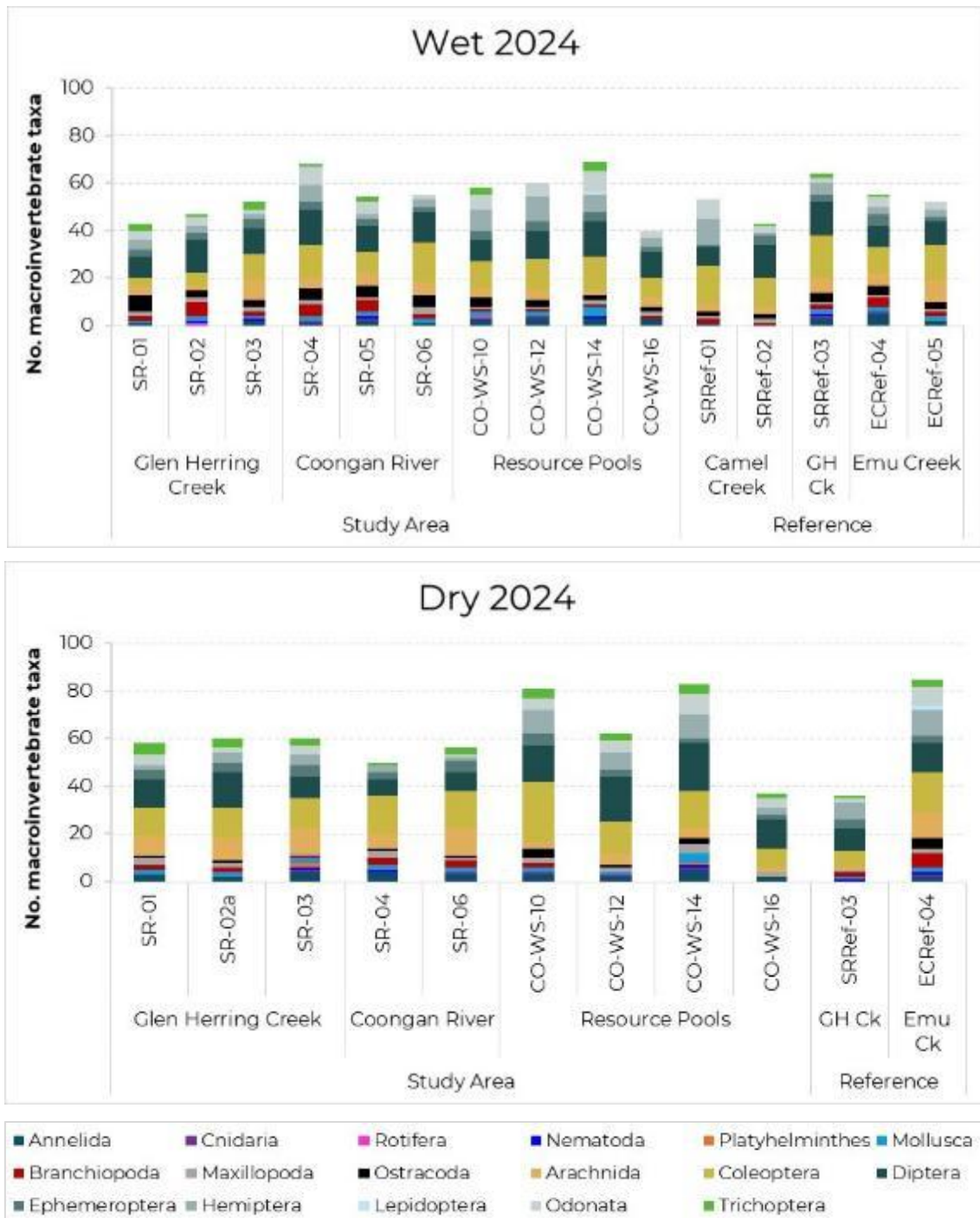


Figure 4.19: Macroinvertebrate assemblage composition recorded from each site

Of note was the relatively high richness of odonates ( $\geq$  eight taxa) recorded from several sites during the Survey, including Study Area sites SR-04 (eight taxa in the Wet 2024) and CO-SW-14 (nine taxa in both seasons), and Reference sites SRRef-01 (eight taxa in the wet) and ECRef-04 (eight taxa in the dry; Figure 4.19). During a large, broad-scale survey of aquatic

macroinvertebrates across the Pilbara, less than half of the samples collected (40%) recorded more than six odonate species (Pinder *et al.*, 2010), suggesting the richness recorded from these sites is high. The diversity and composition of odonate assemblages is known to be related to the abundance and richness of littoral zone wetland flora, extent of riparian disturbance, benthic substrate granularity and in-stream productivity (Butler & deMaynadier, 2007; Theischinger *et al.*, 2021). The high richness of odonates recorded from these was therefore likely correlated with the extensive riparian vegetation, high richness and abundance of macrophytes, and presence of GDV/GDE indicator taxa along the waterline. The exception to this was SRRef-01, which recorded low richness of macrophytes and GDV/GDE indicator taxa. In this case, the high number of odonate taxa recorded may have been related to the highly ephemeral nature of Camel Creek, and fact that there were few refuge pools available to provide habitat at this time.

#### 4.3.5.2 Significant Macroinvertebrates

Most aquatic macroinvertebrates recorded from the Study Area were common species with widespread distributions. Excluding taxa which could not be assigned a distribution status due to insufficient information or taxonomy (juveniles/damaged specimens), most taxa had broad distributions, extending across Australia (41%), northern Australia (21%), Australasia (7%) or the world (cosmopolitan species; 14%). A total of 4% were endemic to WA, 1% were northern WA species, and 12% were restricted to the Pilbara region. No introduced species were recorded.

Twenty-one macroinvertebrate taxa that are restricted to the Pilbara or are listed for conservation significance were recorded across all sites and seasons. Of these, 18 were found within the Study Area. All sites recorded at least one restricted or significant taxon, in at least one season, except CO-WS-16 (Figure 4.20). The greatest number of restricted or significant taxa was recorded from Study Area site SR-04 and Reference site SRRef-03, both of which recorded six taxa, followed by SR-03, SR-05 and ECRRef-05, each with five taxa in one season (Figure 4.20).

None of the macroinvertebrate species recorded are listed as significant under the BC Act or EPBC Act, or are recognised as Priority Fauna. However, several taxa recorded from the Study Area were of further interest, either due to being listed internationally under the IUCN Red List of Threatened Species, having disjunct distributions or being known from relatively few records. These taxa are discussed further below.

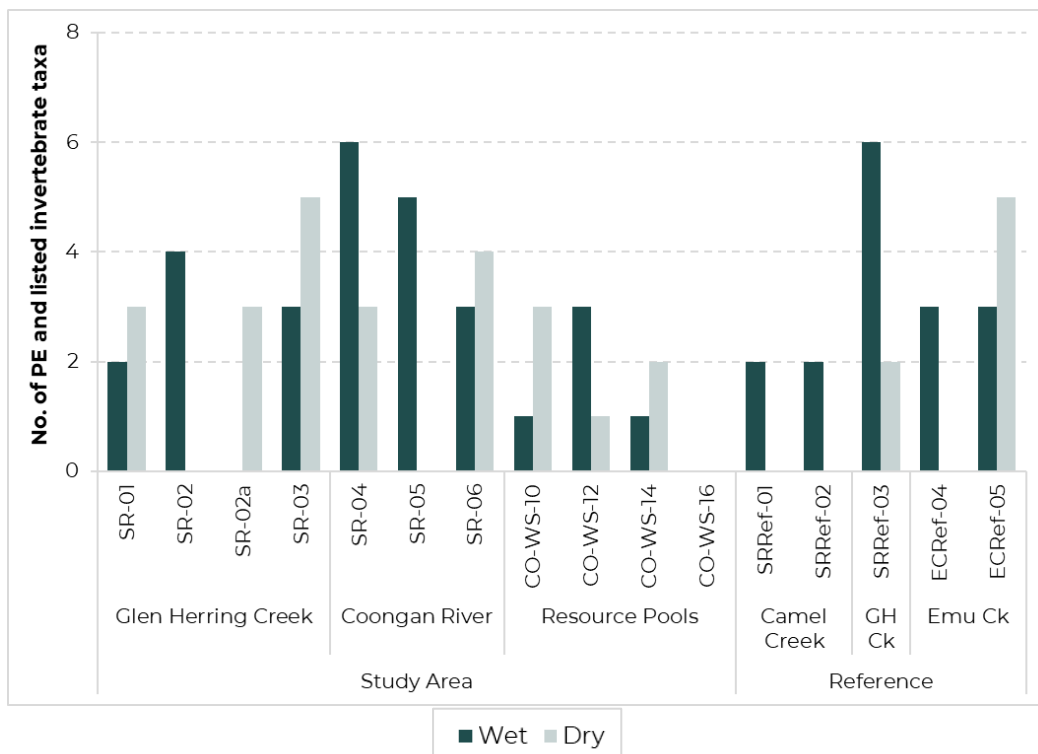


Figure 4.20: Pilbara endemic (PE) and listed macroinvertebrate taxa richness from each site

### Clam shrimp

A clam shrimp recorded from four Study Area sites (SR-02, SR-04, SR-05 and SR-06) and three Reference sites (SR-Ref-03, ERef-04 and ERef-05) was morphologically identified as belonging to the genus *Ozestheria*. The *Ozestheria* genus was described in 2015, after being transferred from *Caenestheriella*, and is known only from Australia. The one species known to occur in the Pilbara, *Ozestheria packardi*, has a large distribution and exhibits high morphological variability. A large number of lineages are known, with studies indicating *O. packardi* represents a complex of at least 14 species (Rogers, 2020; Schwentner *et al.*, 2015). Specimens were therefore submitted for molecular analysis and sequences found to match a previously recorded OTU; *Ozestheria* `sp. Biologic-BRAN002`. This OTU has been recorded from the Harding River, Cane River, Red Hill Creek, and Fortescue River (Biologic unpub. data; Figure 4.21). *Ozestheria* `sp. Biologic-BRAN002` was more than 13.9% divergent from its closest relative in the genetic database, *Caenestheria lustraria*, which occurs in central Australia (in the southern Northern Territory, western QLD, and northern areas of South Australia) (ALA, 2025).

750000

780000

810000

840000

870000

7650000

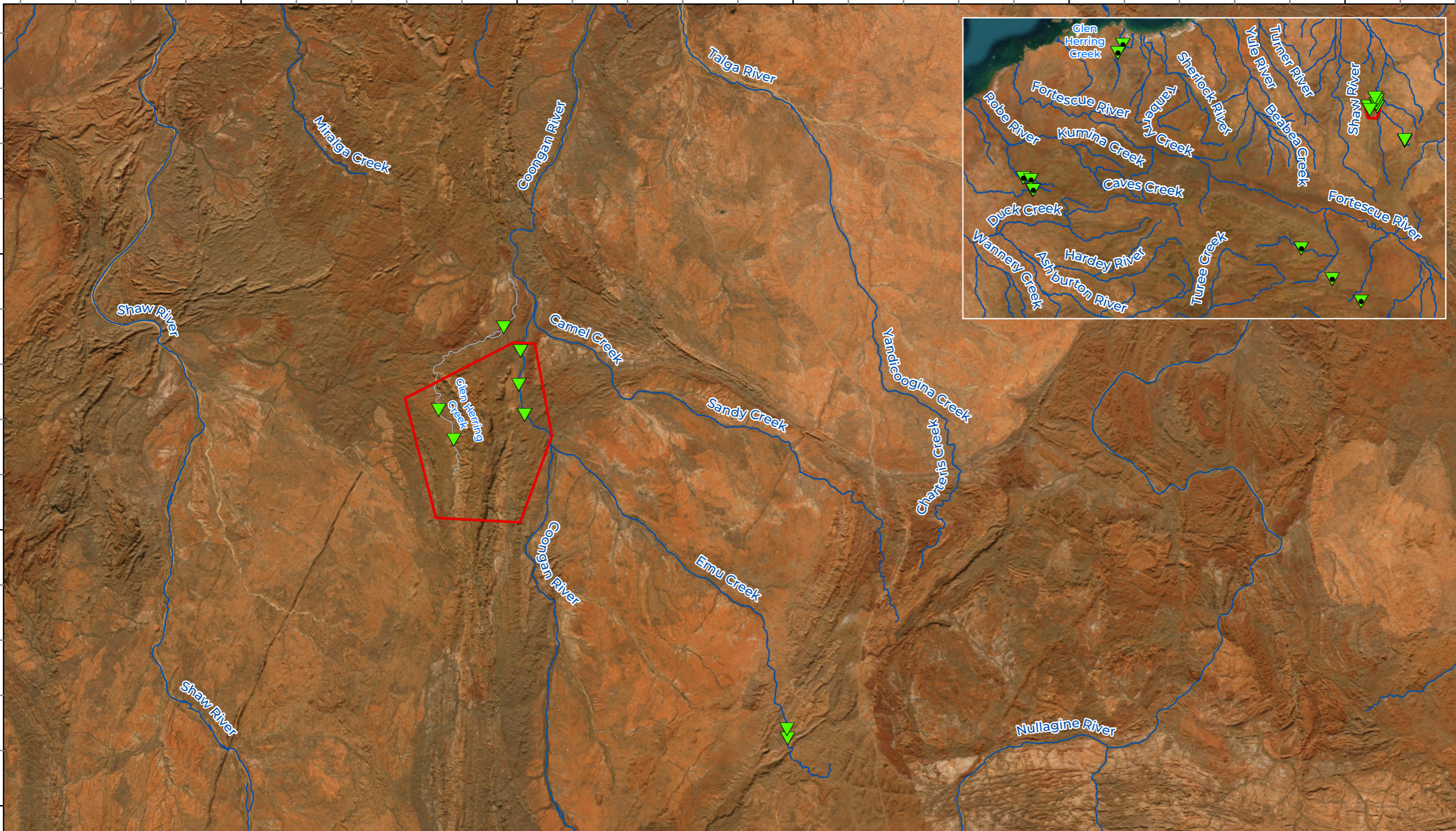
7620000

7590000

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LEGEND

Study Area

Surface Hydrology

Significant Clam Shrimp

Minor

Current Survey

Major

*Ozestheria* sp. Biologic-BRAN002

Previous Surveys

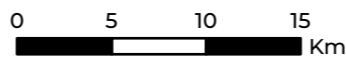
*Ozestheria* sp. Biologic-BRAN002



**Biologic**



Scale 1:400,000



Coordinate System: GDA 1994 MGA Zone 50  
Transverse Mercator Created: 26/02/2025



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**Aquatic Ecology Survey**

Figure 4.21: Significant *Ozestheria* clam shrimp recorded during the Survey

### Backswimmer

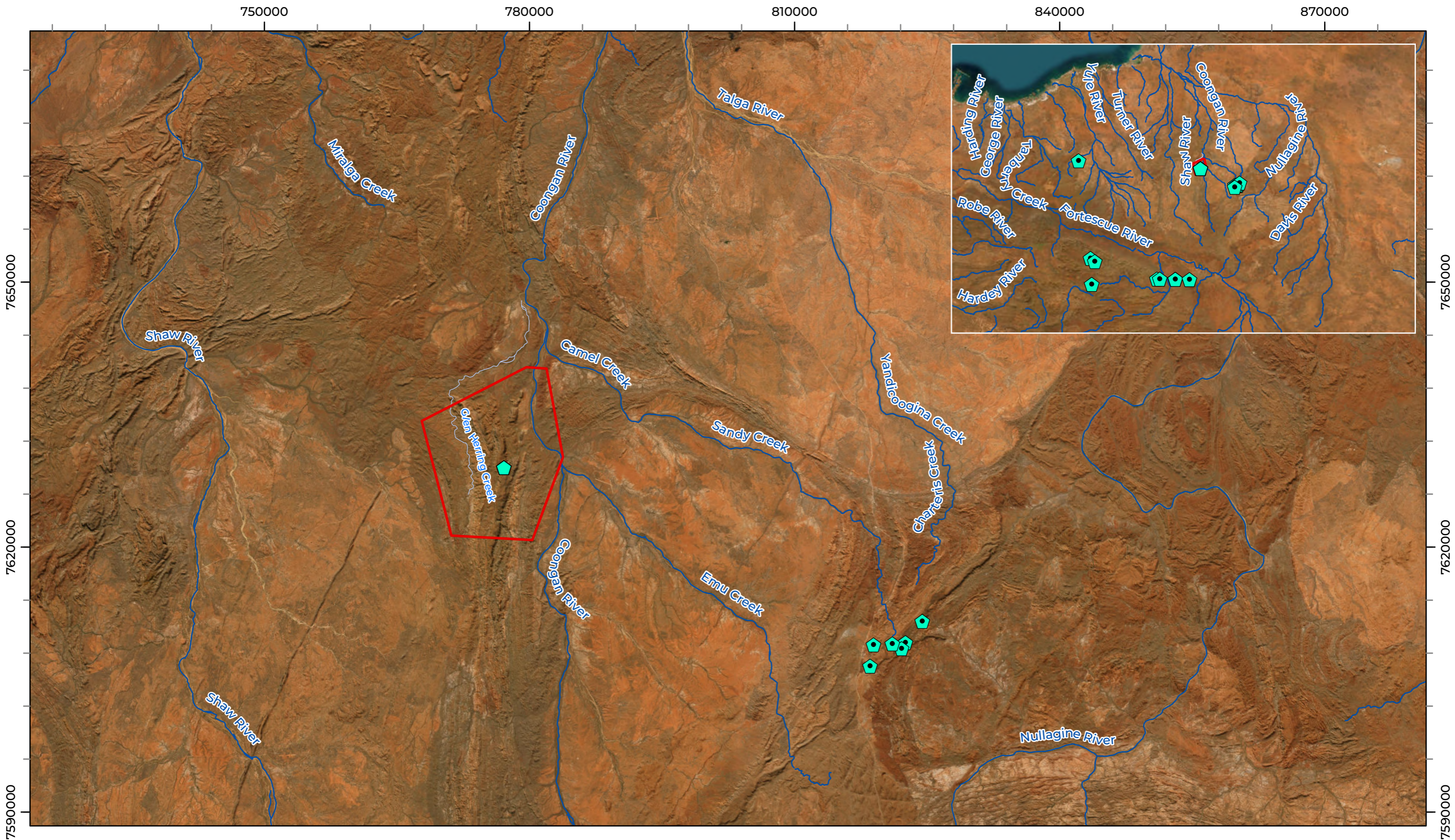
The collection of the backswimmer (Hemiptera), *Anisops nabillus*, is of interest as the species is relatively uncommonly recorded. During the Survey, one individual was recorded from CO-WS-12 in the Wet 2024 (Figure 4.22). The species is endemic to the Pilbara, but it has a highly disjunct distribution and is known from relatively few records across the region. It was recorded from only three locations during the PBS, including Desert Queen Baths (Rudall River NP), Watrara Creek Pool (Rudall River NP) and Harding River Pool at Millstream (Pinder *et al.*, 2010). Since this time, *A. nabillus* has been recorded from Koodaideri Spring, Duck Creek, Kalamina Gorge, Marillana Creek, Weeli Wollie Creek and Turee Creek (ALA, 2025) (Figure 4.22).

### Odonates

Five odonates listed on the IUCN Red List of Threatened Species were recorded during the Survey, four of which were recorded in the Study Area (Figure 4.23). These were *Hemicordulia koomina*, *Ictinogomphus dobsoni*, *Eurysticta coolawanyah* and *Nososticta* sp. The Pilbara emerald *Hemicordulia koomina* was recorded from Resource Area pool CO-WS-14. This species is listed on the IUCN Redlist as Vulnerable (IUCN, 2025). Its listing was based on it being known from only five sites in the Pilbara. Although the listing was updated in 2016, the update did not take into account grey literature records. Including known locations reported during the PBS (Pinder *et al.*, 2010), and sites known by the authors, *H. koomina* likely occurs at more than 15 sites across the Pilbara. The IUCN listing did indicate that its maximum known extent of occurrence based on five locations was 6,504 km<sup>2</sup> (Dow, 2019b); however, Bush *et al.*, (2014) provided a much greater estimate of the current extent of suitable habitat (119,416 km<sup>2</sup>). This species is still relatively rare and not commonly recorded. Major threats to this species are lowering water levels from groundwater abstraction and climate change, coupled with its severely fragmented distribution (IUCN, 2025).

The Pilbara tiger *Ictinogomphus dobsoni* was recorded from surface waters of CO-WS-10 and Reference site SRRef-03 (Figure 4.23). This species is listed as Near Threatened by the IUCN (2025) based on its record from less than ten locations. This is despite the fact that during the PBS undertaken between 2003 and 2006, *I. dobsoni* was recorded from 16 locations across the Pilbara (Pinder *et al.*, 2010). Where present, the Pilbara tiger can occur in high local abundances (Dow, 2017).

The Pilbara pin damselfly *Eurysticta coolawanyah* was recorded from SR-03 and SRRef-03. This species is listed as Vulnerable on the IUCN Red List, and like *H. koomina*, the listing was based on it being known from less than five locations (IUCN, 2025). It similarly has since been recorded from numerous locations in the Pilbara, albeit in low numbers and with a disjunct distribution (Figure 4.23).



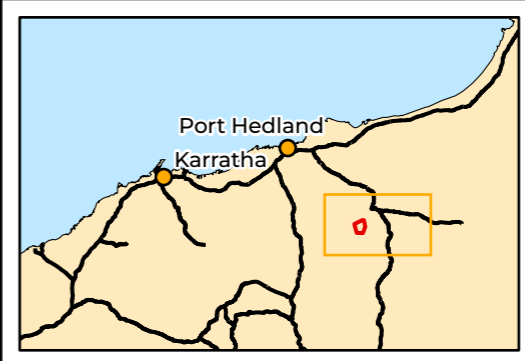
**LEGEND**

Study Area	<b>Surface Hydrology</b>	<b>Significant <i>Anisops</i></b>
	Minor	Current Survey
	Major	<i>Anisops nabillus</i>
		Previous Surveys
		<i>Anisops nabillus</i>

**Biologic**

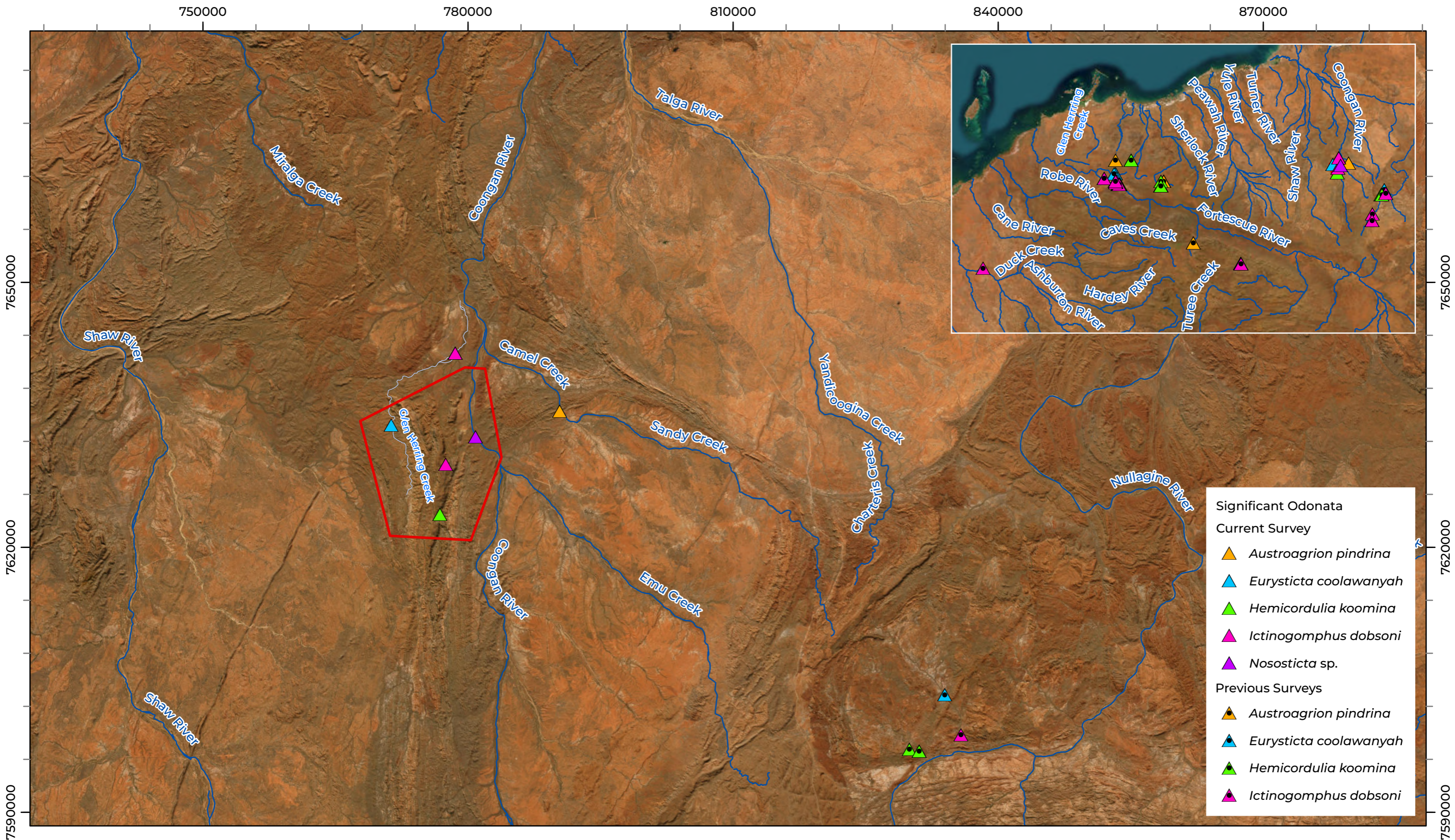
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Coordinate System: GDA 1994 MGA Zone 50  
Transverse Mercator Created: 26/02/2025



**ATLAS IRON**  
**Sanjiv Ridge BWT**  
**Aquatic Ecology Survey**

Figure 4.22: Significant *Anisops* recorded during the Survey




**LEGEND**

Study Area

Surface Hydrology

— Minor

— Major

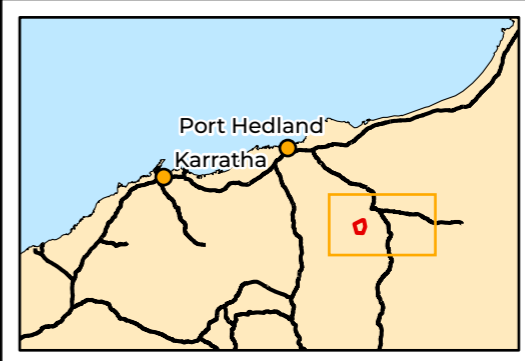


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Coordinate System: GDA 1994 MGA Zone 50  
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**ATLAS IRON**  
**Sanjiv Ridge BWT**  
**Aquatic Ecology Survey**

Figure 4.23: Significant Odonata recorded during the Survey

An immature threadtail, *Nososticta* sp., was recorded from SR-04 in the Wet 2024 (Figure 4.23). As the specimen was immature it could not be identified to species, and may be *Nososticta pilbara* or *Nososticta liveringa*. The former is listed as Endangered on the IUCN Red List (IUCN, 2025) and as a Priority 2 species by DBCA (2025a). The Pilbara threadtail is known from relatively few, fragmented records, most of which occur in and around Millstream National Park. In comparison, *Nososticta liveringa* is relatively common and broadly distributed across northern WA with records into the Northern Territory. Larvae are unknown for this species, so it is not possible to identify aquatic larvae to this species.

#### 4.3.5.3 Macroinvertebrate Comparison with Other Studies

Macroinvertebrate richness recorded during the Survey was compared to the closest eight PBS sites sampled between 2003 and 2006 (Figure 4.24). Generally, richness recorded from the Study Area was comparable to PBS sites, although some PBS sites recorded considerably high richness, especially in the dry season (i.e., Coppin Gap and Pelican Pool). It must be noted that these sites were sampled following a notably wet period in the late 1990s/early 2000s, when systems in the Pilbara were regularly flushed and surface water pools remained inundated for longer periods. Even so, richness recorded from several Study Area sites including SR-04 and CO-SW-14 in the wet season, and CO-SW-10 and CO-SW-14 in the dry season, recorded greater richness than several PBS sites, indicating relatively high richness at a more broad scale at these sites. Similar to the Survey, greater richness was recorded during the dry season at PBS sites, further highlighting the importance of persistent, refuge pools in the arid and ephemeral landscape (Figure 4.24).

#### 4.3.5.4 Patterns in Macroinvertebrate Assemblage Structure

Patterns were evident in the nMDS ordination of all macroinvertebrate samples collected during the Survey. Resource Area pools separated from all riverine pool samples, and generally showed limited seasonal variation (Figure 4.25 and Figure 4.26). In comparison, the riverine pools were more strongly influenced by seasonal change, with most wet season samples significantly separating from the dry (significant SIMPROF clusters; Figure 4.26). SR-04 and Reference sites SRRef-01 and SRRef-03 separated from other riverine pools in ordination space. Overall, there was a significant difference in macroinvertebrate assemblages between systems (Two-factor ANOSIM;  $R = 0.59$ ,  $p < 0.001$ ), with the high  $R$  value indicating strong separation. There was also a significant difference in assemblages between seasons ( $R = 0.33$ ,  $p = 0.009$ ), although the low  $R$  suggests the groups weren't well separated, which was largely due to the limited seasonal variation within Resource Area pools. There was no significant difference in assemblage structure between the Study Area pools and Reference sites (ANOSIM;  $R = 0.16$ ,  $p = 0.073$ ).

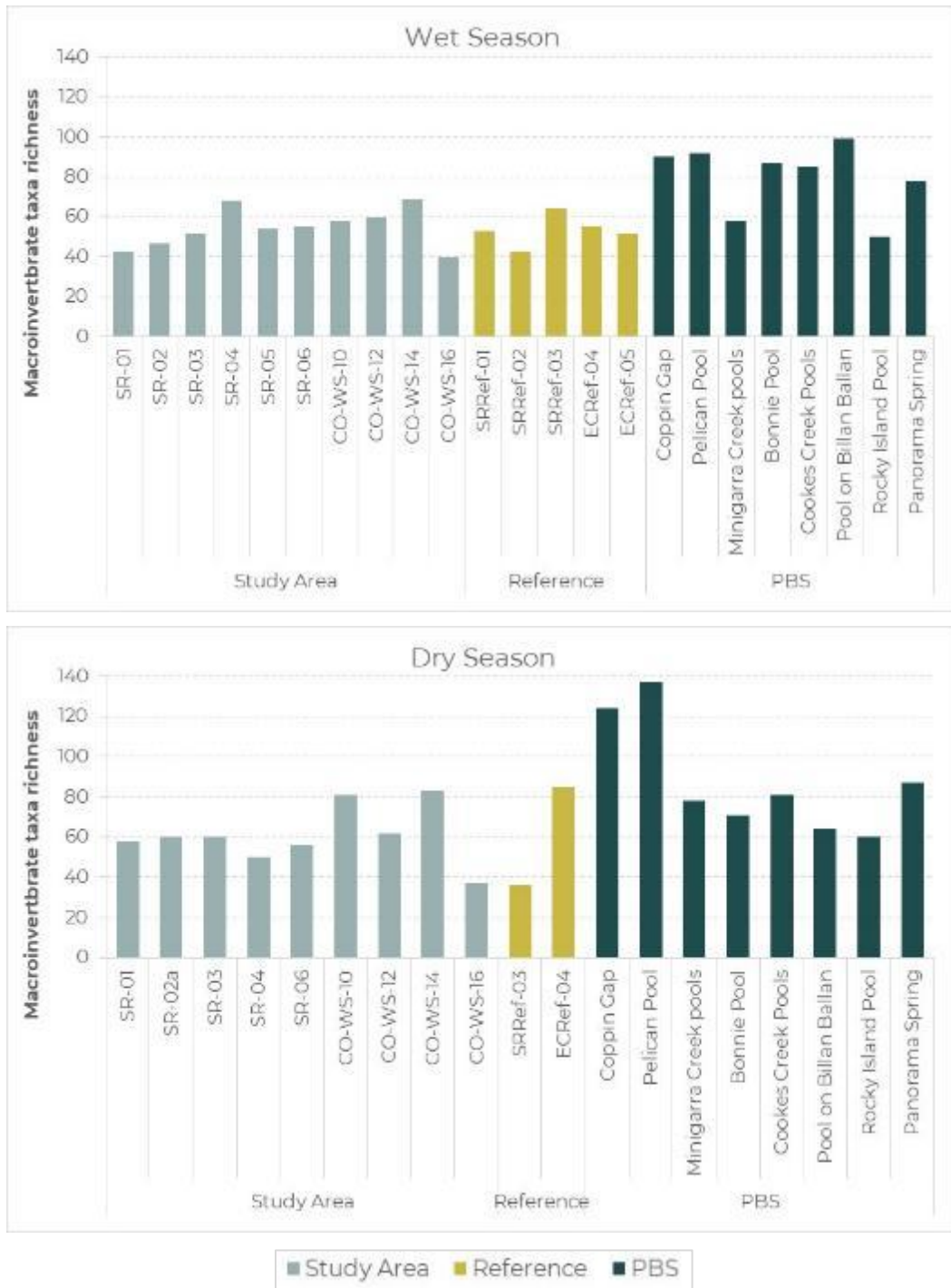


Figure 4.24: Macroinvertebrate richness compared to the PBS

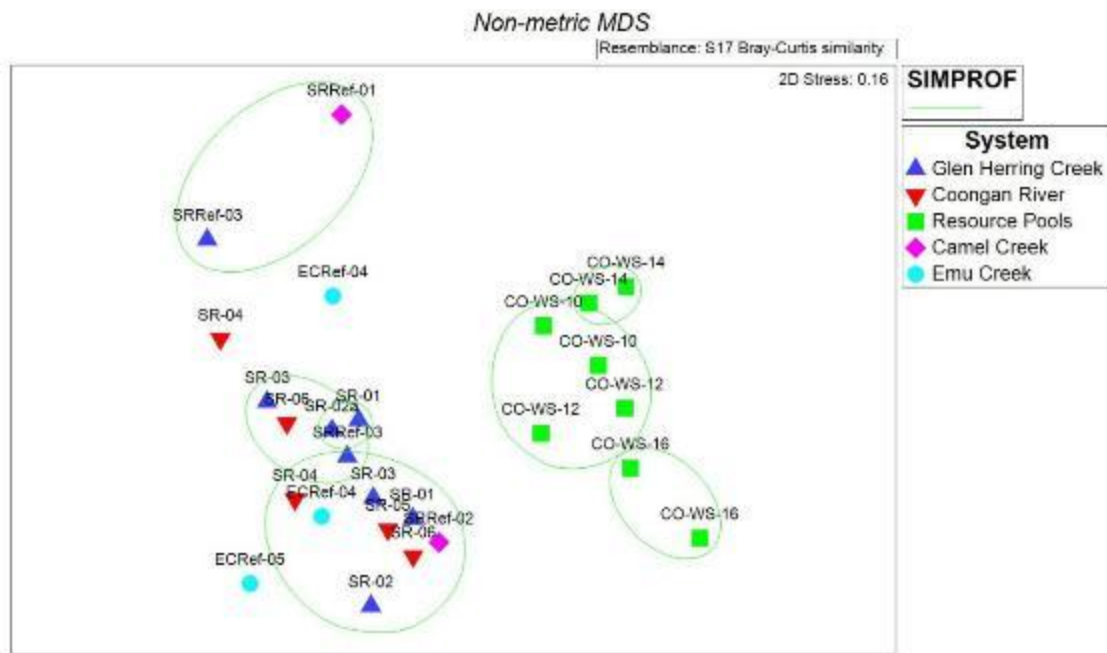


Figure 4.25: nMDS of macroinvertebrate assemblages, with samples identified by system. Green circles indicate significantly separate SIMPROF cluster groups.

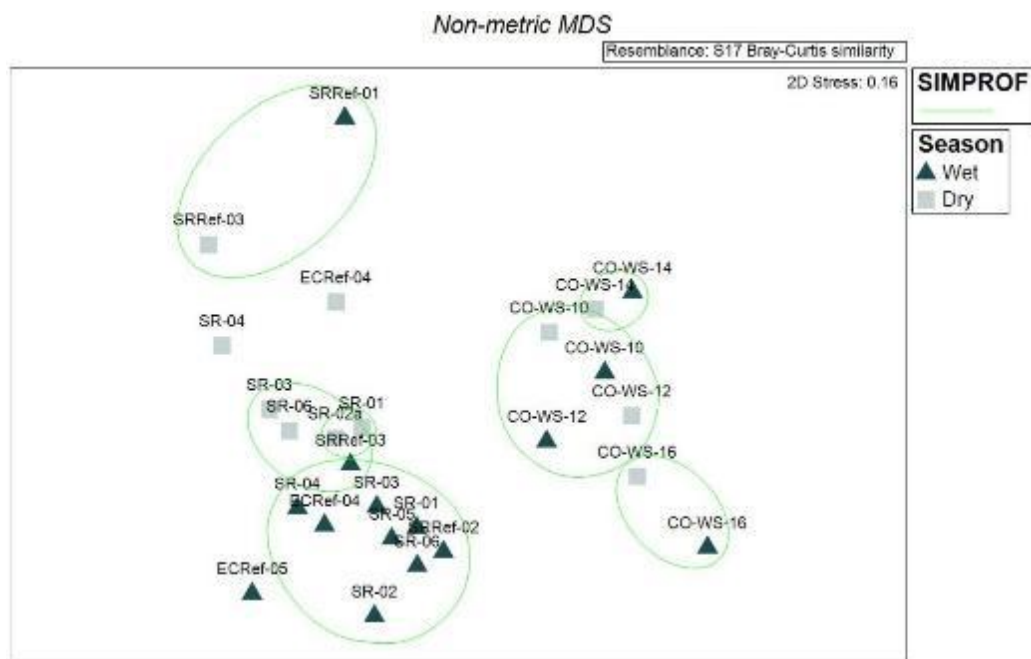


Figure 4.26: nMDS of macroinvertebrate assemblages, with samples identified by season. Green circles indicate significantly separate SIMPROF cluster groups.

### 4.3.6 Rehydration Emergence Trials

Sediments for rehydration-emergence trials were collected from two sites in the Wet 2024 and four sites in the Dry 2024. The sediments collected in the Wet 2024 included pools that had recently dried (SR-0-1R), or were imminently about to dry (ECCRef-05). Given an alternative SR-01 site was located, SR-01R was not resampled for rehydrates in the Dry 2024. While a small pool was present at ECCRef-05 in the Wet 2024, sampling was affected by the shallow water depths, and therefore sediments were also collected. Sediments collected in the dry included those from one Study Area site (SR-05) and three Reference sites (SRRef-01, SRRef-03 and ECCRef-05).

#### 4.3.6.1 Water Quality

Water quality within the rehydrate trial tanks generally reflected values present within surface waters in the Study Area, when holding water, and were considered conducive to emergence of fauna. EC ranged from 828  $\mu\text{s}/\text{cm}$  (ECCRef-05, W2) to 1,201  $\mu\text{s}/\text{cm}$  (ECCRef-05 W1) in the Wet 2024 and 602  $\mu\text{s}/\text{cm}$  (ECCRef-05, W2) to 6,422  $\mu\text{s}/\text{cm}$  (SRRef-01, W1; see Appendix J). Most sites recorded EC indicative of freshwaters, and within the range of EC recorded in the field. SRRef-01 recorded higher EC than other rehydration trials, with a minimum EC of 1,042  $\mu\text{s}/\text{cm}$ . Towards the end of W1, water was saline within this tank. In the W2, water was fresh to slightly brackish, as salts stored in the sediments declined. This reflected conditions within surface waters at SRRef-01 when inundated (EC in the field - 1,599  $\mu\text{s}/\text{cm}$  in the Wet 2024).

pH during rehydration trials ranged from slightly acidic at 6.57 (SRRef-01, Dry 2024 W2) to basic at 8.92 (ECCRef-05, Wet 2024 W1). In general, all sites tended to be basic throughout the trial, with spot records of acidic to circum-neutral pH. This reflects pH recorded in the field, which similarly tended towards basic.

DO saturation and temperature were maintained in trials tanks to be similar to the field and within a range appropriate for the emergence of invertebrate fauna. DO was relatively stable, ranging from 62.1% (SR-01-R, Wet 2024 W1) to 100.3% (ECCRef-05, Wet 2024 W2), as was temperature (20.0°C ECCRef-05, Wet 2024 W1, to 25.9°C SRRef-01, Dry 2024 W2). Both DO and water temperatures were within the ranges recorded in the field.

#### 4.3.6.2 Rehydrate Invertebrate Taxa Composition and Richness

The rehydration trials were productive, yielding over 3,000 individuals and 22 invertebrate taxa from Study Area sediments across both seasons. A total of seven taxa emerged from one Study Area site in the Wet 2024, and 16 taxa emerged from one Study Area site in the Dry 2024. Across both seasons and wetting phases (W1 and W2), taxa that emerged from Study Area sediments included Turbellaria (flatworms), Rotifera (rotifers), Nematoda

(roundworms), Cladocera (water fleas), Conchostraca (clam shrimp), Ostracoda (seed shrimp), Collembolla (spring tails) and Diptera (two-winged flies) (Appendix K and Figure 4.27).

Between sites (and within individual wetting phases), invertebrate taxa richness varied from three (at SR-01R Wet 2024 W2, and SRRef-02; Dry 2024 W2) to 14 (SR-05 Dry 2024 W1; Figure 4.27). Crustacea, including water fleas, seed shrimp and copepods was the dominant group within each trial, with remaining groups comprising a minor proportion of the emergent invertebrate assemblages (Figure 4.27). This is consistent with other studies, where crustaceans make up a large proportion of the invertebrate assemblage in temporary waters due to their ability to produce desiccation resistant propagules (also known as resting stages) capable of withstanding long periods of drought (Rossi *et al.*, 2013; Timms, 1993).

Invertebrate taxa emerged in both wetting phases (W1 and W2) at all sites in both seasons (Figure 4.27). Generally greater numbers of taxa emerged in W1 in comparison to W2 (Figure 4.27), but W2 added five taxa in the Wet 2024 which did not emerge in W1, and four taxa in the Dry 2024 that did not emerge in W1 (Appendix K). This highlights the importance of conducting two wetting phases during rehydration trials, to capture the hatching potential of all resting eggs present in the sediment, considering the bet-hedging strategy employed by temporary wetland specialist invertebrates (Simovich & Hathaway, 1997). Bet-hedging is a survival technique in invertebrates, whereby a proportion of resting eggs do not hatch during a rehydration event (Hairston *et al.*, 1985). This strategy is crucial for enhancing resilience to unpredictable and fluctuating environmental conditions (Simovich & Hathaway, 1997).

The emergence trials added eight taxa to the list of invertebrate taxa recorded from the Study Area (taxa not retrieved from the macroinvertebrate and hyporheic samples). These included the Cladocera *Alona* sp., *Simocephalus australiensis*, *Macrothrix* sp. and *Moina micrura*, the Ostracoda *Cyprretta* sp. Biologic-OSTR016, Cyprididae sp. Biologic-OSTR136, and *Heterocypris* sp., and the Collembolla *Symphyleona* sp. Sediment rehydration was effective in retrieving species from ephemeral pools within the Study Area that would otherwise be impossible to sample.

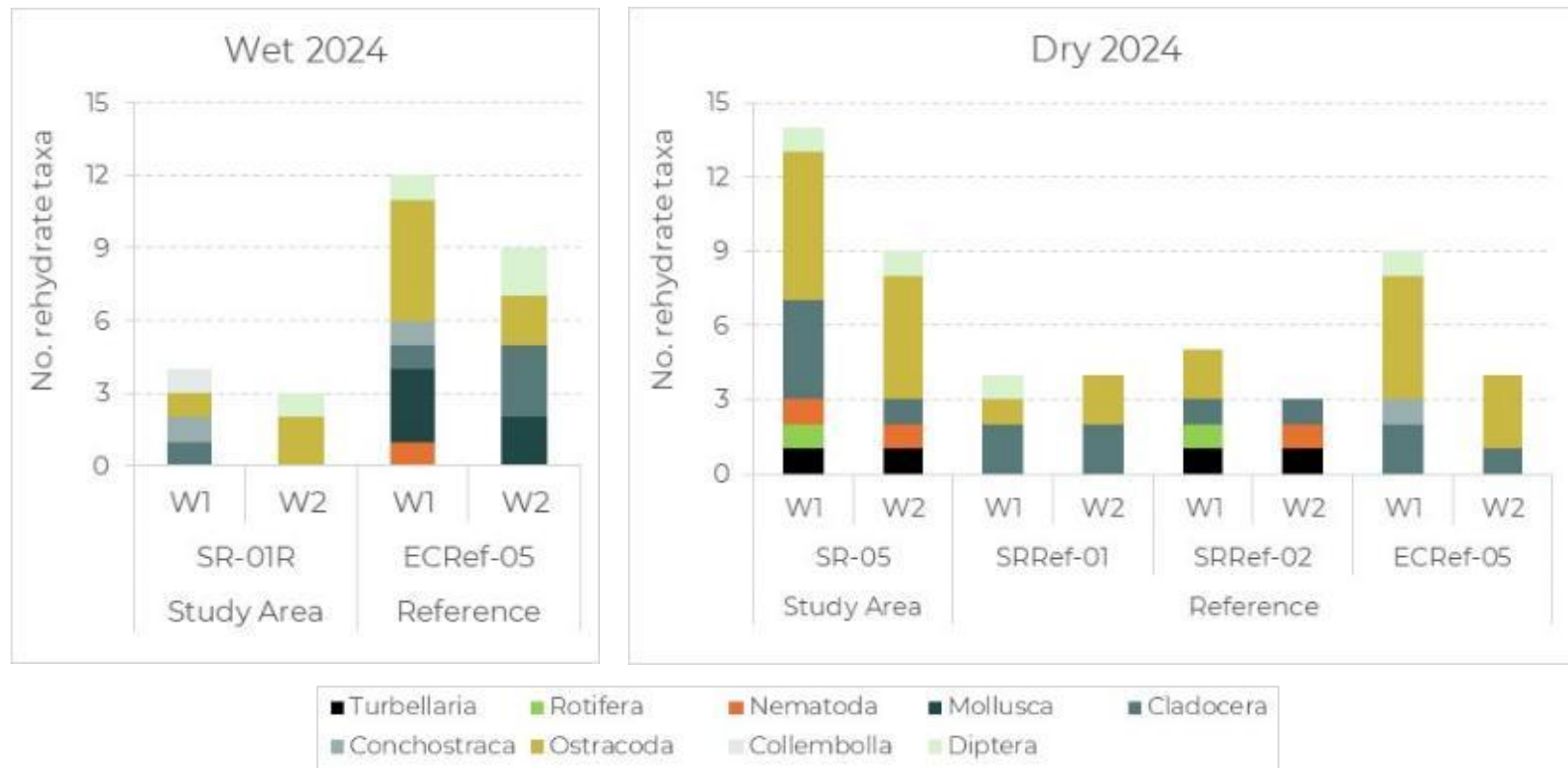


Figure 4.27: Richness and composition of invertebrates recorded during rehydration trials in each season

#### 4.3.6.3 Significant Emergent Taxa

Most invertebrates that emerged from Study Area sediment were common, ubiquitous species. The only exceptions included an ostracod OTU which did not match any sequences in the available database and the *Ozestheria* sp. Biologic-BRAN002` clam shrimp that was also recorded from surface waters (see section 4.3.5.2 for further information). The ostracod Cyprididae sp. Biologic-OSTR136` was recorded from SR-05 sediments collected in the Dry 2024, as well as Reference site sediments from SRRef-01, and *Ozestheria* sp. Biologic-BRAN002` emerged from Study Area sediments at SR-01R collected in the Wet 2024 (see Figure 4.21).

#### 4.3.7 Fish

##### 4.3.7.1 Fish Species Composition and Richness

Four freshwater fish species were recorded during the Survey, all of which were recorded in the Study Area: western rainbowfish *Melanotaenia australis* (Melanotaeniidae), Pilbara tandan *Neosilurus* sp.<sup>7</sup> (Plotosidae), spangled perch *Leiopotherapon unicolor* (Terapontidae) and Pilbara bony bream (*Nematalosa* sp.<sup>7</sup>) (Table 4.8). The low species richness is not unexpected given the aridity of the Pilbara and generally low diversity of freshwater fish species across the region (Allen *et al.*, 2002; Masini, 1988; Morgan *et al.*, 2014). Despite the low diversity known from the Pilbara, the region does support high endemism in freshwater fishes (56%) (Morgan *et al.*, 2014).

Fish were recorded from most sites sampled Study Area, with the exception of all the Resource Area pools. The absence of fish from these pools is likely due to the isolated and disconnected nature of the pools, coupled with the presence of waterfalls within gorge systems, limiting the movement of fish. Fish were also recorded from most Reference sites, with the exception of SRRef-01. The highest richness of freshwater fish was recorded from SR-01 and SR-04, both of which supported all four species (Table 4.8). All sites with fish recorded both western rainbowfish and spangled perch. While SR-01R was dry at the time of sampling, recently deceased fish were present, indicating the pool is connected to others on Glen Herring Creek, and that it had recently dried prior to sampling.

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<sup>7</sup> The *Neosilurus* catfish and *Nematalosa* bream from the Pilbara are both known to be genetically distinct to the described species *Neosilurus hyrtlui* and *Nematalosa erebi* (Unmack 2013). The Pilbara taxa are therefore currently known as *Neosilurus* sp. And *Nematalosa* sp. until further taxonomic work have been undertaken and descriptions made.

Table 4.8: Abundance of freshwater fish recorded during the Survey

Type	System	Site	Spangled perch ( <i>Leiopotherapon unicolor</i> )		Western rainbowfish ( <i>Melanotaenia australis</i> )		Pilbara tandan ( <i>Neosilurus</i> sp.)		Pilbara bony bream ( <i>Nematalosa</i> sp.)		Abundance		Richness	
			Wet 24	Dry 24	Wet 24	Dry 24	Wet 24	Dry 24	Wet 24	Dry 24	Wet 24	Dry 24	Wet 24	Dry 24
Study Area	Glen Herring Creek	SR-01	168	41	133	271	1	0	9	6	311	318	4	3
		SR-02	145	-	29	-	0	-	0	-	174	-	2	-
		SR-02a	-	58	-	39	-	0	-	5	-	102	-	3
		SR-03	208	91	154	41	0	3	0	0	362	135	2	3
	Coongan River	SR-04	22	11	93	137	0	1	223	0	338	149	3	3
		SR-05	32	-	202	-	0	-	0	-	234	-	2	-
SR-06		470	28	119	355	31	5	0	0	620	388	3	3	
Reference	Camel Creek	SRRef-02	35	-	67	-	7	-	0	-	109	-	3	-
	Glen Herring Creek	SRRef-03	72	14	88	18	0	0	0	0	160	32	2	2
	Emu Creek	ECRef-04	120	0	185	5	0	0	0	0	305	5	2	1
		ECRef-05	24	-	122	-	0	-	0	-	146	-	2	-
<b>Abundance</b>			<b>1,296</b>	<b>243</b>	<b>1,192</b>	<b>866</b>	<b>39</b>	<b>9</b>	<b>232</b>	<b>11</b>	<b>2,759</b>	<b>1,129</b>		

Generally, pH values between 6.5 and 9.0 are considered optimal for most freshwater fish and other aquatic organisms, with pH greater than 9.0 leading to some physiological stress in freshwater fish, resulting in reduced growth and reproduction (Marium *et al.*, 2023). Two Coongan River sites, SR-04 and SR-05, recorded pH greater than 10.0, where spangled perch abundance was notably low compared to SR-06 (also on the Coongan River). However, there was no obvious difference in the abundance of western rainbowfish or bony bream between Coongan River sites, suggesting that these fish populations are adapted to the highly basic conditions. It is likely that freshwater fish at these sites are persisting at the upper limit of their pH tolerance and therefore may be vulnerable to further increases to pH.

#### 4.3.7.2 Abundance

A total of 3,888 freshwater fish was recorded during the Survey, with 2,759 recorded in the Wet 2024 (2,039 from the Study Area and 720 from Reference sites) and 1,129 recorded in the Dry 2024 (1,092 from the Study Area and 37 from Reference sites; Table 4.8). SR-06 recorded the greatest abundance of fish in both seasons (620 in the Wet 2024 and 388 in the Dry 2024). The lowest abundance was recorded from Reference site SRRef-02 in the Wet 2024 (109 individuals) and ECRRef-04 in the Dry 2024 (five individuals). Reference sites generally recorded lower richness compared to the Study Area, with no Pilbara bony bream recorded from any Reference sites.

Spangled perch were the most abundant fish in the Wet 2024 (1,296 individuals), followed by western rainbowfish (1,192 individuals). This abundance was inverse in the Dry 2024, with western rainbowfish more abundant (866 individuals) than spangled perch (243 individuals). Bony bream were the next most abundant species (243 individuals across both seasons), followed by Pilbara tandan (48 individuals across both seasons; Table 4.8).

#### 4.3.7.3 Length-Frequency Analysis

##### Western rainbowfish

In the Study Area, new recruits and juveniles constituted the greatest proportion of western rainbowfish recorded in the wet season (57% and 33% respectively), while juveniles and sub adults were dominant in the Dry 2024 (50% and 46%, respectively; Figure 4.28). A similar trend was seen for Reference sites in the Wet 2024, with 51% new recruits and 46% juveniles in the Wet 2024 (Figure 4.28). The high numbers of new recruits in the Wet 2024 at all Study Area sites indicates good levels of breeding and recruitment. Although, western rainbowfish typically have multiple spawning events throughout the year, taking advantage of the intermittent rainfall and streamflow (Beesley, 2006), the low rainfall recorded between seasons in 2024, meant that breeding and recruitment only occurred following the wet season rains and stream flows. Reference site SRRef-02 was the exception, where no new

recruits were recorded during the Wet 2024. A greater number of juveniles and sub-adults being present within the Study Area populations in the Dry 2024 was unsurprising, as the fish matured from the recruitment events in the wet season.

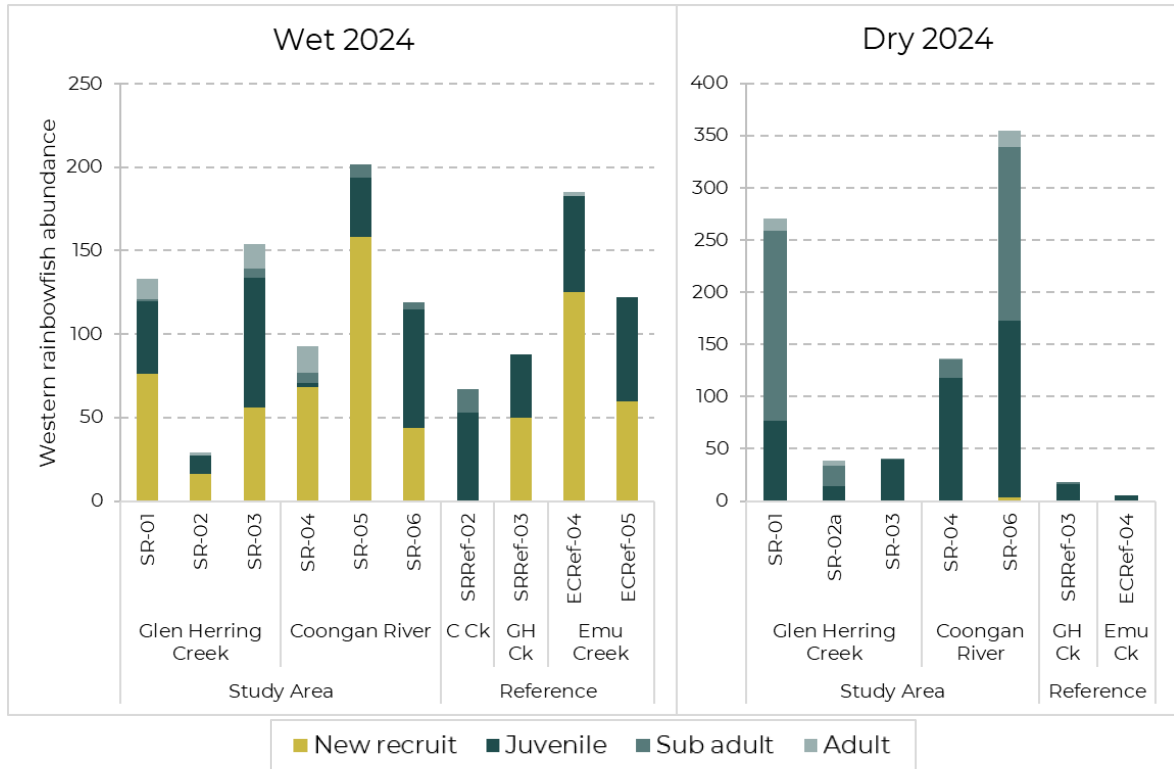


Figure 4.28: Western rainbowfish age-class abundances recorded in each season

### Spangled perch

Juveniles constituted the greatest proportion of spangled perch in the Study Area, in both the Wet 2024 and Dry 2024 (53% and 60% respectively; Figure 4.29). In the Wet 2024, new recruits were also common (36% of individuals from the Study Area). In particular, Glen Herring Creek pools provide valuable breeding and nursery habitat for spangled perch, with a notably high proportion of new recruits recorded in the wet season (59%). The shallow, low flow channel, with high submerged macrophyte cover likely provides protection and suitable habitat. Spangled perch are bottom spawners, with eggs dispersed over the substrate but more concentrated among vegetation in shallow margins (Beumer, 1979).

Age-classes at Reference sites were generally similar to the Study Area, with new recruits dominant in the Wet 2024 (58%), followed by juveniles (37%) and juveniles most prevalent in the Dry 2024 (50%; Figure 4.29). Unlike the Study Area, Reference sites recorded a relatively high proportion of sub-adults in the Dry 2024 (35%; Figure 4.29).

The low numbers of new recruits present in the dry season is expected as spangled perch are known to breed during the wet season, between late November and March (Beesley,

2006). Spawning in spangled perch generally coincides with flooding events, and several spawning events will occur each wet season (Beesley, 2006; Morgan *et al.*, 2002). At this time, new recruits and juveniles have the greatest chance of survival owing to the greater persistence of water and habitat, increased ecosystem productivity, and availability of food resources (Beesley, 2006). Triggers for spawning likely include rising water levels and increased turbidity, and in laboratory experiments, longer photo-period and higher water temperatures were also correlated with increased spawning (Beumer, 1979).

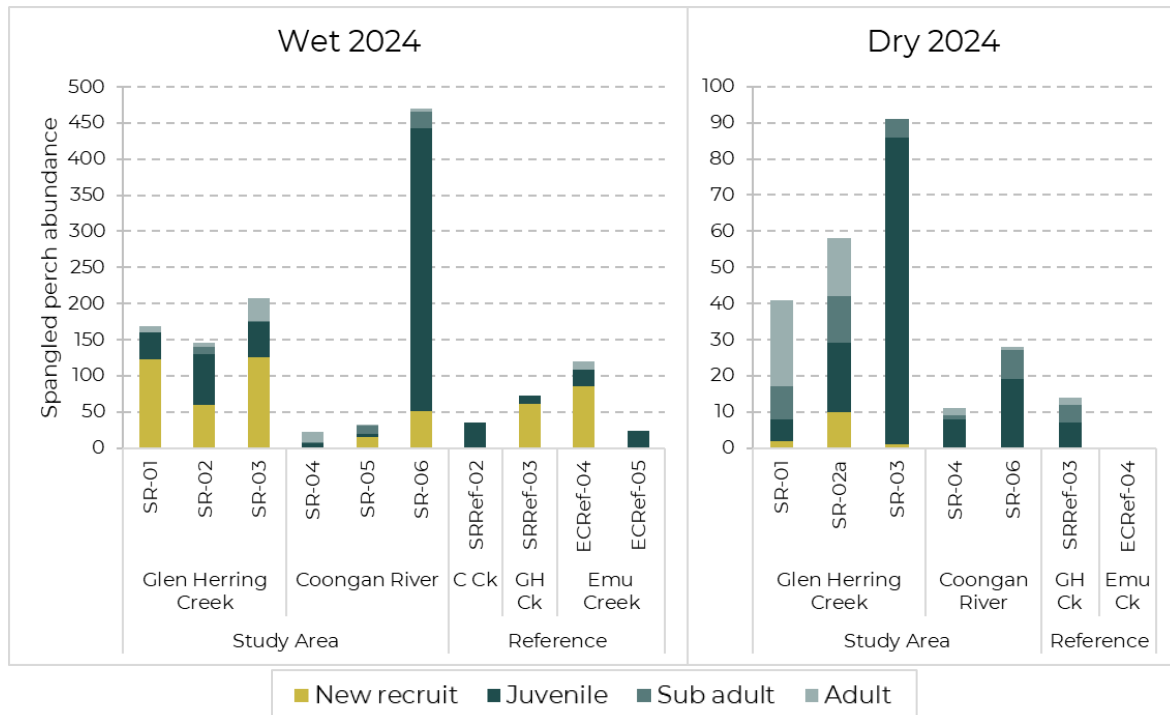


Figure 4.29: Spangled perch age-class abundances recorded in each season

### Pilbara tandan

Pilbara tandan were generally less common and were recorded from three sites across both seasons. Pilbara tandan are cryptic, utilising habitats such as rock overhangs and root matter which are difficult to sample using traditional gill and seine fishing methods. Therefore, the numbers captured likely under-represent the true population. The population that was recorded predominantly comprised juveniles in the Wet 2024 (95%), both in the Study Area and at Reference sites, with high numbers recorded from SR-06 (Figure 4.30). New recruits were present at SR-06 in the wet season. In northern populations of the closely related *Neosilurus hyrtlii*, breeding occurs early in the wet season in shallow, sandy/gravelly areas of the upper reaches of creeks (Allen *et al.*, 2002), suggesting this habitat is present at SR-06.

In the Dry 2024, sub-adults and adults constituted most of the fish caught (56% and 33%, respectively), with no Pilbara tandan recorded from Reference sites at this time (Figure 4.30).

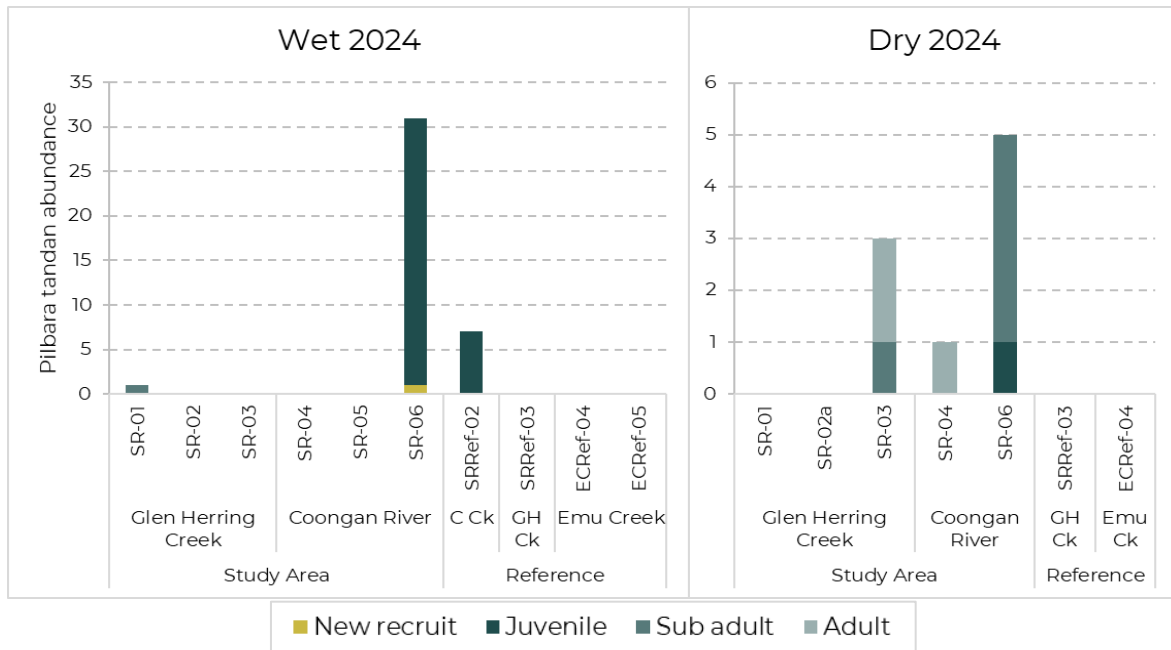


Figure 4.30: Pilbara tandan age-class abundances recorded in each season

### Pilbara bony bream

Pilbara bony bream were recorded in high numbers in the Wet 2024, though the majority of individuals were caught from one site (SR-04), with none recorded at Reference sites. This species is a schooling fish, and therefore when captured, it tends to be in high abundance. The population primarily comprised adults in both the Wet 2024 (89%) and Dry 2024 (73%; Figure 4.31). Juveniles were recorded in the Dry 2024 (27%; Figure 4.31).

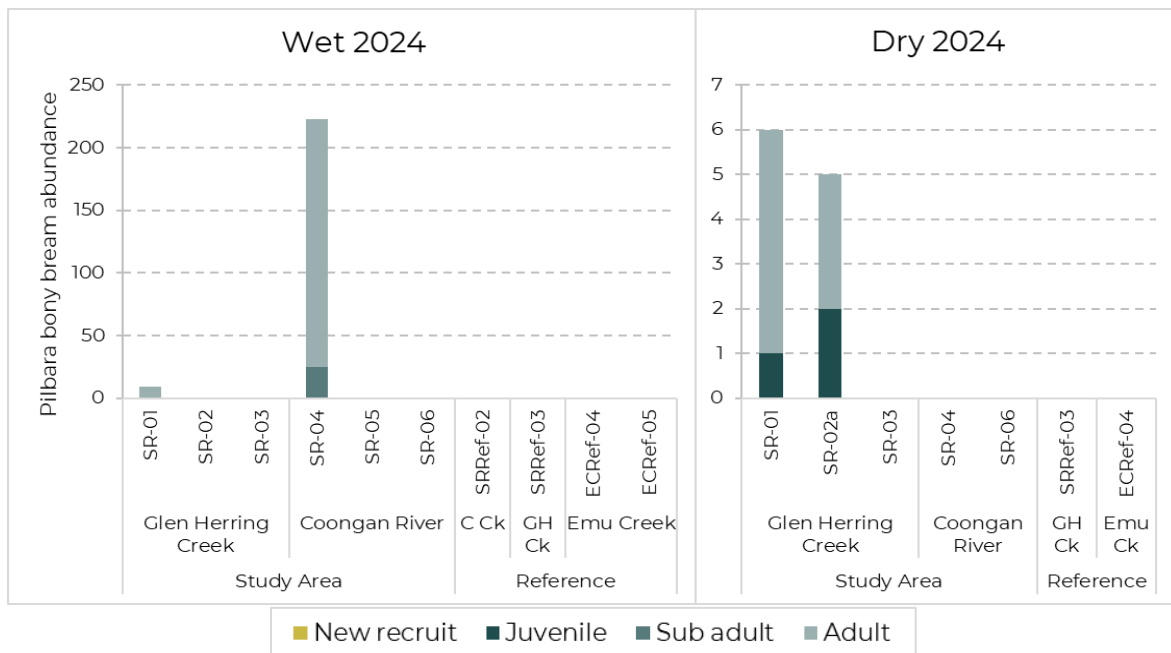


Figure 4.31: Pilbara bony bream age-class abundances recorded in each season

### 4.3.8 Other Aquatic Fauna

#### 4.3.8.1 Frogs

Tadpoles and frogs were observed both within the Study Area and at Reference sites, in both seasons. Tadpoles were observed at SR-01, CO-WS-10, CO-WS-12, CO-WS-14, ECRRef-04 and ECRRef-05 in the Wet 2024, with particularly high abundances observed at CO-WS-10 (~40 individuals). These were identified as *Uperoleia glandulosa* (glandular toadlet) at CO-WS-12 and ECRRef-05, with individuals at other sites being too immature to identify. Tadpoles were also present at CO-WS-16 in the Dry 2024. Two species of adult frog, *Litoria rubella* (desert tree frog) and *Cyclorana maini* (Main's frog), were recorded from CO-WS-10, SRRef-01, SRRef-02 and ECRRef-05. *Litoria rubella* was also recorded at ECRRef -05, where particularly high numbers were observed (~50 individuals). All three species are common, although *Uperoleia glandulosa* is restricted to the north of the Pilbara, while *L. rubella* and *C. maini* are more widespread across northern Australia.

#### 4.3.8.2 Waterbirds

Three species of waterbird were observed during the Survey. Black-fronted dotterels (*Charadrius melanops*) were observed at SR-02 and SRRef-03, in both seasons, and SR-05 in the Wet 2024. Nesting behaviour was observed at SR-05 in the wet season, and chicks was present at this time, indicating this site represents a breeding ground for black-fronted dotterels (Plate 4.3). Black-fronted dotterels are common and widespread, occurring near shallow freshwater throughout Australia (Morcombe, 2003).



Plate 4.3: Black-fronted dotterel chicks observed at SR-05 in the Wet 2024

Pacific black ducks (*Anas superciliosa*) were recorded from SR-04 (Wet 2024) and ECRRef-04 (both seasons) and little pied cormorants (*Microcarbo melanoleucos*) were recorded at SR-04 in the Wet 2024. Both species are common and widespread.

The low occurrence of waterbirds across the Study Area is not surprising. Given the high mobility of most bird species, adequate surveying for waterbirds is challenging under a bi-yearly sampling design. Further, optimum survey timing for aquatic invertebrates and fish (March-May and September-November 3 weeks post-rainfall) is partially misaligned to that of bird surveys (March-early July). However, waterbird surveys were not the primary objective of the Survey, with opportunistic observations recorded to provide additional information on the ecology of pools within the Study Area, particularly where breeding sites are present.

## 5 Conclusion

### 5.1 Main Findings

Results from the Survey provide an assessment of the baseline ecological values and health of aquatic systems within the Study Area, which may be impacted by dewatering drawdown associated with BWT mining in the future. Over both seasons, a total of 280 invertebrate taxa was recorded from the Study Area, from both hyporheic and surface environments (including rehydrates), as well as 42 macrophytes and GDV/GDE flora indicator species, four species of freshwater fish, three frog species, and three waterbird species. Several significant, listed (IUCN), or restricted taxa were recorded, or were considered likely to occur in the Study Area from the desktop assessment (Table 5.1).

The desktop assessment identified the Coongan River, in an area encompassing all three Study Area sites (SR-04 to SR-06), as having a high potential to support aquatic GDEs. Results from the Survey support the notion that these pools are influenced by groundwater flows, especially SR-04 and SR-06, including:

- the high number of GDV/GDE flora indicator taxa recorded from both sites, including four High indicator species
- both sites support the obligate phreatophyte *Melaleuca argentea*
- groundwater dependent invertebrate taxa are present within the hyporheic zone of both sites, including stygobites at SR-06.

SR-03 on Glen Herring Creek is also considered likely to represent an aquatic GDE, or at least be partly maintained by groundwater inputs, because it recorded:

- High numbers of GDV/GDE indicator taxa, including several High indicator species
- Minimal variation in EC between seasons, suggesting some groundwater inflow reducing evapoconcentration effects.

Surface waters of Glen Herring Creek pools were generally characterised by fresh, clear waters, with basic pH and high total N and total P concentrations, but generally low levels of dissolved metals (except dCu, dU and dV; Table 5.2). There were some disturbances noted in the area, including impacts from cattle and the presence of invasive weeds. In-stream habitat diversity was high, and comprised high proportions of complex, heterogenous substrates such as submerged macrophytes, algae and detritus, which provide habitat for a wide range of aquatic biota. In the three pools sampled, this biodiversity included a total of 164 aquatic invertebrate taxa (across both surface and hyporheic habitats), including nine significant or restricted species, one stygobitic species present in the hyporheic zone, 24 macrophytes and GDV/GDE flora indicator species, four freshwater fish species, tadpoles and the black-fronted dotterel (Table 5.2). Fish populations included high proportions of new recruits of western

rainbowfish and spangled perch, indicating conditions conducive to breeding. SR-01 and SR-03 represent important breeding and nursery grounds for these species.

Water quality in the Coongan River pools was characterised by fresh waters, with variable DO saturation, basic pH and low turbidity. Nutrient concentrations were generally low in comparison to toxicity DGVs, but total N and total P exceeded eutrophication DGVs at some sites. While dissolved metal concentrations were generally low in the Coongan River, there were some exceedances of 95% toxicity DGVs, including dAl, dCr and dCu. In-stream habitat varied between seasons but was dominated by submerged macrophyte cover in the wet season (Table 5.3). Widespread impacts from cattle grazing and trampling were observed throughout the area, as well as vehicle tracks/human access and invasive weeds.

The Coongan River sites sampled supported a rich assemblage of aquatic invertebrates with 178 taxa recorded (across both surface and hyporheic habitats), including 13 significant or restricted species, and groundwater dependent taxa within the hyporheos which included one stygobitic species. The riparian zone recorded a high richness of GDV/GDE flora indicator species, with a total of 29 macrophytes and GDE indicator taxa recorded. Vertebrates using Coongan River pools included four freshwater fish and three waterbird species, with a black-fronted dotterel nesting site recorded at SR-05 (Table 5.3). Chicks were present at this nesting site in the Wet 2024.

Four permanent gorge pools with groundwater inflows were sampled in the Resource Area, with CO-WS-12, CO-WS-14 and CO-WS-16 all considered likely to represent aquatic GDEs. Surface expressions of groundwater were observed at all sites, and the riparian zones supported a high richness of GDV/GDE indicator flora species (25 macrophyte and GDE indicator species), including the obligate phreatophyte *Melaleuca argentea* at CO-SW-14 and CO-SW-16. The pools were particularly fresh, and their connection to groundwaters and persistence meant that they were buffered from evapoconcentration effects and recorded minimal change in EC between seasons (Table 5.4). These Resource Area pools were also highlighted by Atlas Iron (2019) as likely being groundwater dependent.

The Resource Area pools supported a notably high richness of aquatic invertebrates. In total, across both hyporheic and surface water habitats, 193 invertebrate taxa were recorded, including eight potentially significant or restricted species and a high richness of odonates. Permanent hyporheos stygophiles were present in the hyporheic zone of CO-WS-12 and CO-WS-14, highlighting the connection to groundwater at these sites. These gorge pools did not support fish due to their isolated and disconnected nature, coupled with the presence of waterfalls within gorge systems, limiting the movement of fish. However, the Resource Area pools supported three species of frog (Table 5.4).

Overall, five pools in the Study Area were considered to hold notably high ecological value for the region. These included:

### **Glen Herring Creek**

#### SR-03

- Likely represents an aquatic GDE
- Greatest overall floristic richness (along with SR-06, 48 taxa)
- Highest richness of High and Moderate GDV/GDE indicator species
- Supports a high number of Pilbara endemic and significant macroinvertebrate species (including the IUCN listed damselfly *Eurysticta coolanwanyah*)
- All four species of freshwater fish recorded (one of few to record the Pilbara tandan)
- Provides important breeding and nursery habitat for spangled perch (and western rainbowfish to a lesser extent).

### **Coongan River**

#### SR-04

- Likely represents an aquatic GDE
- Highest total number of GDV/GDE indicator taxa (17 taxa)
- Supports the obligate phreatophyte *Melaleuca argentea*
- Highest richness of macrophytes (nine taxa) from the Study Area
- Relatively high macroinvertebrate richness, comparable to several nearby PBS sites that were sampled during a much wetter period (early 2000s)
- Greatest number of Pilbara endemic and potentially significant taxa in the Wet 2024, including *Ozestheria* `sp. Biologic-BRAN002`, *Wandesia* `sp. Biologic-ACAR028` and *Nososticta* sp.
- Supports four species of fish and provides breeding habitat for western rainbowfish.

#### SR-06

- Likely represents an aquatic GDE
- Greatest floristic richness overall (along with SR-01, 48 taxa)
- A high number of GDV/GDE indicator species (16 taxa), many of which were High-Moderate indicators
- Supports the obligate phreatophyte *Melaleuca argentea*
- Groundwater dependent fauna present within the hyporheic zone, including stygobites and potentially restricted species (*Australocamptus* `sp. Biologic-HARP099` and *Wandesia* `sp. Biologic-ACAR028` and *Guineaxonopsis* sp.)
- Highest abundance of fish recorded.

## **Resource Area Pools**

### CO-WS-10

- Permanent pool with some contribution by groundwater inflow
- Supports the highest richness of invertebrate taxa within the hyporheic zone recorded during the Survey, suggesting the hydrological connection between surface waters and groundwater provides an important refuge for epigeal taxa at certain times of year
- Notably high macroinvertebrate richness, comparable to nearby PBS sites that were sampled during a much wetter period (early 2000s)
- Supports *Ictinogomphus dobsoni* listed on the IUCN Red List as Near Threatened
- Two species of frog
- One of two sites in the Study Area with no apparent impacts or disturbances noted (along with CO-WS-14).

### CO-WS-14

- Permanent pool with surface flow
- Likely represents an aquatic GDE
- Notable land features including small waterfalls and a bat cave
- Highest number of High GDV/GDE indicator species
- Supports the obligate phreatophyte *Melaleuca argentea*
- Greatest macrophyte richness of all the Resource Area pools
- Notably high macroinvertebrate richness, comparable to nearby PBS sites that were sampled during a much wetter period (early 2000s). Represented the highest richness recorded during the Survey
- Supports *Hemicordulia koomina* listed on the IUCN Red List as Vulnerable
- One of two sites in the Study Area with no apparent impacts or disturbances noted (along with CO-WS-10).

Due to the aridity of the Pilbara, rivers of the region tend to be ephemeral. Permanent surface waters, such as the those found in the Study Area (CO-WS-10, CO-WS-12, CO-WS-14, CO-WS-16, and SR-01), are relatively scarce in the region and restricted to springs (groundwater fed systems) and permanent pools. Such predictable sources of water have high conservation importance as they support richer faunas than ephemeral water-bodies and provide a refuge for many species during drought (Halse *et al.*, 2002; Kay *et al.*, 1999).

Table 5.1: Significant species known, or likely to occur, in the Study Area, including the Survey and database search records

Red text indicates the taxon is likely to occur in the Study Area from the desktop assessment

Type	Taxon	Sites recorded		Likely to Occur in the Study Area (from desktop)	Significance/Listing/Distribution
		Study Area	Reference sites		
Flora	Themeda sp. Panorama	CO-WS-10			DBCA Priority 1
	<i>Styloidium weeliwolli</i>			✓	DBCA Priority 3
Water mite	<i>Wandesia</i> sp. Biologic-ACAR028`	SR-04, SR-05, SR-06			Poorly known genus Potentially restricted OTU known only from Study Area and Upper Fortescue River catchment
	<i>Guineaxonopsis</i> sp.	SR-06			Unresolved taxonomy, but species within this genus tend to be relatively restricted
Clam shrimp	<i>Ozestheria</i> sp. Biologic-BRAN002`	SR-02, SR-04, SR-05, SR-06	SRRRef-03, ECRRef-04, ECRRef-05		OTU has a fragmented distribution and is known from few records Currently known from the Study Area, Harding River, Red Hill Creek, Cane River, and Marillana Creek
	<i>Eodiaptomus lumholtzi</i>			✓	Vulnerable – IUCN Red List
Copepoda	<i>Parastenocaris</i> sp.			✓	Unresolved taxonomy (genus level), but species within this genus can have restricted distributions
	<i>Australocamptus</i> sp. Biologic-HARP099`	SR-06			Genus endemic to WA First record of this OTU
	<i>Candonopsis kimberleyi</i>	SR-02	SRRRef-02		Known from only a few records, most of which occur in the Kimberley. Recorded in the lower De Grey catchment in the Pilbara ~115km from the Study Area
	<i>Melitidae</i> sp.			✓	Potentially restricted. Further taxonomic resolution required.
Amphipoda	<i>Paramelitidae</i> sp.			✓	Potentially restricted. Further taxonomic resolution required.
	<i>Atopobathynella</i> sp. Biologic-PBAT078`		ECRRef-04		Only record of this OTU, potential to occur in the Study Area
Odonates	<i>Hemicordulia koomina</i>	CS-WS-14			Vulnerable – IUCN Red List
	<i>Eurysticta coolawanyah</i>	SR-03	SRRRef-03		Vulnerable – IUCN Red List
	<i>Austroagrion pindrina</i>			✓	Vulnerable – IUCN Red List
	<i>Ictinogomphus dobsoni</i>	CS-WS-10	SRRRef-03		Near Threatened – IUCN Red List
	<i>Nososticta</i> sp.	SR-04			May be <i>Nososticta pilbara</i> , listed as Endangered by the IUCN Red List and as a Priority 2 species by DBCA
Backswimmers	<i>Anisops nabillus</i>	CO-WS-12			Species rarely recorded, disjunct distribution
Snake	<i>Liasis olivaceus barroni</i>			✓ (suitable habitat within Resource Area pools)	Vulnerable – WA BC Act and Federal EPBC Act

Table 5.2: Summary of aquatic habitat, condition and values in Glen Herring Creek within the Study Area

Habitat and Hydrology	Water Quality	Flora	Invertebrate Fauna	Vertebrate Fauna	Overall Condition
<ul style="list-style-type: none"> <li>Large permanent to semi-permanent creek pools</li> <li>SR-03 may constitute a permanent pool that is supported by groundwater</li> <li>Groundwater connection appears highest in the northern area (downstream) and potentially reduces moving upstream</li> <li>High in-stream habitat richness, including complex, heterogenous substrates with which to support aquatic fauna</li> </ul>	<ul style="list-style-type: none"> <li>Generally fresh (EC higher in the dry at SR-01, likely due to evapoconcentration), basic and clear waters</li> <li>Ionic composition dominated by Na and HCO<sub>3</sub></li> <li>Relatively high concentrations of total N and total P, exceeding eutrophication DGVs (except SR-03)</li> <li>Generally low concentrations of dissolved metals, with one ANZG (2018) 95% toxicity DGV exceedances (dCu)</li> </ul>	<ul style="list-style-type: none"> <li>Flora indicating groundwater connection at SR-03 (relatively high GDV/GDE indicator taxa richness, including High indicator species)</li> <li>Emergent macrophytes present at all sites</li> <li>Relatively abundant submerged macrophytes</li> </ul>	<ul style="list-style-type: none"> <li>Generally richness of groundwater dependent taxa in the hyporheic zone, but one stygobitic taxon recorded from SR-02</li> <li>Macroinvertebrate taxa richness was moderate, but lower than the Resource Area pools</li> <li>9 significant invertebrate taxa recorded from hyporheic zones and surface waters</li> </ul>	<ul style="list-style-type: none"> <li>A total of 4 fish species recorded, with all present at SR-01</li> <li>Important breeding and nursery habitat for western rainbowfish and spangled perch</li> <li>Black-fronted dotterel recorded at SR-02</li> </ul>	<ul style="list-style-type: none"> <li>Impacts from cattle grazing and trampling along the banks and in-stream, some elevated nutrient inputs</li> <li>Several species of invasive weeds, with buffel grass the most abundant</li> </ul>

Table 5.3: Summary of aquatic habitat, condition and values in the Coongan River within the Study Area

Habitat and Hydrology	Water Quality	Flora	Invertebrate Fauna	Vertebrate Fauna	Overall Condition
<ul style="list-style-type: none"> <li>Sites sampled were typically large riverine pools</li> <li>Some water persistence but water levels generally reduced by the Dry 24</li> <li>All sites located in area identified as having a high potential to support aquatic GDEs (BoM, 2025)</li> <li>SR-05 identified as a potential aquatic GDE pool (BoM, 2025)</li> <li>Creek beds generally comprised transmissive substrates such as sand and gravel, with some clay</li> <li>In-stream habitat richness was variable, but generally dominated by open substrate and submerged macrophyte cover, with some algae</li> </ul>	<ul style="list-style-type: none"> <li>Generally fresh (though SR-06 was brackish), with variable DO, basic pH and low turbidity</li> <li>EC increase at SR-04 and SR-06 in the dry season, likely due to evapoconcentration</li> <li>Ionic composition dominated by Na and HCO<sub>3</sub></li> <li>Low N<sub>2</sub>NO<sub>x</sub>, but some exceedances of eutrophication DGVs for total N (SR-04 and SR-05) and total P (all sites)</li> <li>Generally low concentrations of dissolved metals, but with some exceedances of 95% toxicity DGVs (i.e., dAl, dCr and dCu)</li> </ul>	<ul style="list-style-type: none"> <li>Relatively high GDV/GDE indicator taxa richness, with several High indicator species at each site. This likely indicate high levels of groundwater connection at these sites.</li> <li>Emergent and submerged macrophytes present at all sites</li> </ul>	<ul style="list-style-type: none"> <li>Permanent stygophiles present at every site in the wet season, albeit absent from all sites except for SR-06 in the dry season. SR-06 recorded the highest richness of groundwater dependent species in the Study Area in the dry season</li> <li>High macroinvertebrate taxa richness, particularly at SR-04 in the wet season (68 taxa)</li> <li>Notably high richness of odonates at SR-04</li> <li>13 significant invertebrate taxa recorded from hyporheic zones and surface waters</li> </ul>	<ul style="list-style-type: none"> <li>A total of 4 fish species recorded, with all present at SR-04</li> <li>Pilbara bony bream highly abundant at SR-04</li> <li>Pacific black ducks and Little pied cormorants recorded at SR-04</li> <li>Black-fronted dotterels recorded at SR-05. Nesting site observed in the wet season, with chicks present</li> </ul>	<ul style="list-style-type: none"> <li>Widespread impacts from cattle grazing and trampling, vehicle tracks and invasive weeds</li> <li>High richness of invasive weed species, with Mexican poppy particularly abundant</li> </ul>

Table 5.4: Summary of aquatic habitat, condition and values in the Resource Area Pools

Habitat and Hydrology	Water Quality	Flora	Invertebrate Fauna	Vertebrate Fauna	Overall Condition
<ul style="list-style-type: none"> <li>Permanent gorge pools</li> <li>Aquatic GDEs present at CO-WS-12, CO-WS-14, CO-WS-16 based on GDV/GDE indicator flora and water quality and information provided in (Atlas Iron, 2019)</li> <li>Surface expression of groundwater observed at CO-WS-14 and CO-WS-16</li> <li>CO-WS-10 likely to be influenced by groundwater inputs, but maintained by aspect and lack of evaporation</li> <li>Substrates primarily bedrock</li> <li>In-stream habitat dominated by open inorganic substrates, with some submerged macrophytes and algae present.</li> </ul>	<ul style="list-style-type: none"> <li>Generally, fresh, consistent and adequate DO, basic and clear waters</li> <li>Except slightly acidic at CO-WS-16 (Dry 2024)</li> <li>Turbidity slightly elevated at CO-WS-16</li> <li>Pools buffered from evapoconcentration effects in the dry season due to groundwater connection and persistence of surface water</li> <li>Ionic composition had relatively equal concentrations of Na, Ca, Mg, HCO<sub>3</sub> and Cl</li> <li>Low N_NOx concentrations but elevated total N and total P in comparison to eutrophication DGVs</li> <li>Generally low dissolved metal concentrations, with some ANZG DGV exceedances (i.e., dNi, dCo, dFe)</li> </ul>	<ul style="list-style-type: none"> <li>CO-WS-14 supported several High GDV/GDE indicator species</li> <li>Other sites (except CO-WS-10) contained a relatively high richness of Moderate/Low species</li> <li>Low macrophyte richness, with submerged macrophytes only present at CO-WS-10 and CO-WS-14</li> <li>One significant species, <i>Themeda</i> sp. Panorama recorded from CO-WS-10</li> </ul>	<ul style="list-style-type: none"> <li>Relatively low hyporheic richness compared to Glen Herring Creek and Coongan River pools</li> <li>Permanent stygophiles only recorded at CO-WS-12 and CO-WS-14</li> <li>Notably high macroinvertebrate taxa richness at CO-WS-14 and CO-WS-10, with 83 and 81 taxa recorded, respectively</li> <li>High richness of odonates recorded at CO-WS-14</li> <li>8 significant invertebrate taxa recorded from hyporheic zones and surface waters</li> </ul>	<ul style="list-style-type: none"> <li>No fish recorded from the Resource Area pools</li> <li>CO-WS-10 supports <i>Litoria rubella</i> and <i>Cyclorana maini</i> frogs</li> <li>CO-WS-12 supports <i>Uperoleia glandulosa</i></li> <li>Tadpoles present at all sites</li> </ul>	<ul style="list-style-type: none"> <li>Some invasive weeds present, but with low richness and abundance, especially compared to Glen Herring Creek and Coongan River pools</li> <li>Secondary evidence of invasive predators such as cats at CO-WS-12</li> </ul>

## 5.2 Final Remarks

This report provides one year of bi-annual aquatic ecology data relevant to the Study Area. The ANZG (2018) guidelines recommend a weight of evidence approach to aquatic monitoring, which includes sampling of biological indicators and water quality parameters. For ecosystems driven by highly seasonal events (e.g. tropical creeks and rivers), multiple surveys provide the most comprehensive representation of aquatic biodiversity. In cases where monitoring may be required in future to assess potential impacts from development/s, it is important that the baseline dataset captures the natural seasonal and temporal variation characteristic of the area. ANZG (2018) recommends sampling over a period of at least three years to develop an appropriate biological dataset to cover the range in natural variability present within the aquatic ecosystem. Bi-annual sampling is recommended in tropical and semi-tropical regions due to the high variation experienced in these systems seasonally and temporally. This baseline dataset would then enable statistical analysis to be undertaken in the future, to assess whether any adverse biological change is mine-related, or whether it is more likely due to climate-change, or represents natural stochastic variation.

Not all of the permanent groundwater-fed pools known to occur within the Resource Area were sampled during the Survey. Given the fact that those sampled were found to support high ecological values, it is recommended that additional pools within the Resource Area are sampled prior to drawdown to assess their current condition and values, and allow an assessment of potential impacts to be undertaken.

In the case of water quality, surface waters in the Pilbara rarely meet DGVs naturally, as was the case in the Study Area. Spot measurements recorded in the Wet 2024 and Dry 2024 indicated that baseline water quality was elevated in a number of analytes in comparison to ANZG (2018) DGVs at some sites. Such analytes included EC, DO, pH, N<sub>2</sub>O, total N, total P, dAl and dCu). The ANZG (2018) DGVs are intended to be applied to systems for which there are no baseline data or where baseline data are insufficient to adequately describe the natural or existing seasonal fluctuations in water quality. In cases where water quality naturally and consistently exceed DGVs, as is the case here, ANZG (2018) recommend that GVs be 'tailored' to local conditions through the development of SSGVs. Therefore, to reduce the risk of compliance issues associated with changes to water quality from future development, it is recommended that SSGVs be derived for major analytes such as pH, EC, DO and turbidity, as well as nutrients and dissolved metals. ANZG (2018) recommend that SSGVs should be based on at least two years of monthly monitoring data.

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## Appendix A: Conservation Status Codes

## International Union for Conservation of Nature

Category	Definition
<b>Extinct (EX)</b>	A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
<b>Extinct in the Wild (EW)</b>	A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
<b>Critically Endangered (CR)</b>	A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (see Section V), and it is therefore considered to be facing an extremely high risk of extinction in the wild.
<b>Endangered (EN)</b>	A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Section V), and it is therefore considered to be facing a very high risk of extinction in the wild.
<b>Vulnerable (VU)</b>	A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see Section V), and it is therefore considered to be facing a high risk of extinction in the wild.
<b>Near Threatened (NT)</b>	A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future
<b>Data Deficient (DD)</b>	A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases, great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

## Environment Protection and Biodiversity Conservation Act 1999

Category	Definition
<b>Extinct (EX)</b>	Taxa not definitely located in the wild during the past 50 years.
<b>Extinct in the Wild (EW)</b>	Taxa known to survive only in captivity.
<b>Critically Endangered (CE)</b>	Taxa facing an extremely high risk of extinction in the wild in the immediate future.
<b>Endangered (EN)</b>	Taxa facing a very high risk of extinction in the wild in the near future.
<b>Vulnerable (VU)</b>	Taxa facing a high risk of extinction in the wild in the medium-term future.
<b>Migratory (MG)</b>	Consists of species listed under the following International Conventions: Japan-Australia Migratory Bird Agreement (JAMBA) China-Australia Migratory Bird Agreement (CAMBA) Convention on the Conservation of Migratory Species of Wild animals (Bonn Convention).

## Biodiversity Conservation Act 2016

Category	Definition
<b>CR</b>	Rare or likely to become extinct, as <i>critically endangered</i> fauna.
<b>EN</b>	Rare or likely to become extinct, as <i>endangered</i> fauna.
<b>VU</b>	Rare or likely to become extinct, as <i>vulnerable</i> fauna.
<b>EX</b>	Being fauna that is presumed to be extinct.
<b>MI</b>	Birds that are subject to international agreements relating to the protection of migratory birds.
<b>CD</b>	Special conservation need being species dependent on ongoing conservation intervention. (Conservation Dependant)
<b>OS</b>	In need of special protection, otherwise than for the reasons pertaining to Schedule 1 through to Schedule 6 Fauna. (Other specially protected species.

## Department of Biodiversity, Conservation and Attractions Priority codes

Category	Definition
<b>Priority 1 (P1)</b>	Taxa with few, poorly known populations on threatened lands.
<b>Priority 2 (P2)</b>	Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.
<b>Priority 3 (P3)</b>	Taxa with several, poorly known populations, some on conservation lands.
<b>Priority 4 (P4)</b>	Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection but could be if present circumstances change.

## Appendix B: Detailed Sampling Methods

## Habitat Assessment

Habitat characteristics were recorded at each site to provide information on the variability of aquatic habitat present, and to assist in explaining patterns in aquatic faunal assemblages. Habitat characteristics recorded included percent cover by inorganic sediment, submerged macrophyte, floating macrophyte, emergent macrophyte, algae, large woody debris (LWD), detritus, roots, and trailing vegetation. Substrate composition included percent cover by bedrock, boulders, cobbles, pebbles, gravel, sand, silt, and clay. Maximum water depth was measured with a graduated pole.

## Water Quality

Water quality variables were recorded in situ with a portable YSI Pro Plus multimeter. Undisturbed water samples were taken for laboratory analyses of ionic composition, nutrients, dissolved metals, and turbidity. All water quality analyses were undertaken by Australian Laboratory Services (ALS), a National Association of Testing Authorities (NATA) accredited chemical analysis laboratory. Water quality variables measured were:

- In situ – pH, dissolved oxygen (DO; % and mg/L), electrical conductivity (EC;  $\mu\text{S}/\text{cm}$ ), water temperature ( $^{\circ}\text{C}$ ) and redox potential (mV)
- General ions and others - calcium (Ca), potassium (K), magnesium (Mg), sodium (Na), bicarbonate ( $\text{HCO}_3$ ), chloride (Cl), sulfate ( $\text{SO}_4$ ), sulfur (S), carbonate ( $\text{CO}_3$ ), alkalinity and hardness (all mg/L)
- Water clarity – turbidity (NTU) and total suspended solids (TSS; mg/L)
- Nutrients – nitrogen nitrate ( $\text{N}_{\text{NO}_3}$ ), nitrogen oxides ( $\text{N}_{\text{NO}_x}$ ), nitrogen ammonia ( $\text{N}_{\text{NH}_3}$ ), total nitrogen (total N) and total phosphorus (total P) (all in mg/L)
- Dissolved metals – aluminium (dAl), arsenic (dAs), boron (dB), barium (dBa), cadmium (dCd), cobalt (dCo), chromium (dCr), copper (dCu), iron (dFe), manganese (dMn), molybdenum (dMo), nickel (dNi), lead (dPb), selenium (dSe), uranium (dU), vanadium (dV) and zinc (dZn) (all mg/L).

Samples collected for dissolved metals were filtered through 0.45  $\mu\text{m}$  MF-Millipore™ nitrocellulose filters in the field. Nutrient samples were filtered by ALS in the laboratory as part of their analytical methods. Following best practice and to minimise any potential for contamination, all water samples were collected using clean Nalgene sample bottles, and clean/new filters and syringes (Ahlers *et al.*, 1990; Batley, 1989; Madrid & Zayas, 2007). All water quality sampling equipment was stored in polyethylene bags, and samplers wore polyethylene gloves whilst sampling water quality. All water samples were kept on ice in an esky whilst in the field, and either refrigerated (ions, dissolved metals, nutrients, general

water), or frozen (total nutrients) as soon as possible for subsequent transport to the ALS laboratory.

### Macrophytes and Dominant Riparian Vegetation

Macrophytes (submerged and emergent) and dominant riparian vegetation specimens were collected from each site, where present. Submerged macrophytes were hand collected and placed in sample containers with sufficient water from the site to ensure the collected material did not dry out or degrade. Roots, stem and flowering/fruitlet bodies from emergent and riparian sedges and rushes were hand collected, ensuring sufficient material to allow confident identification. The emergent and riparian flora samples were assigned a unique number and pressed in the field. All specimens collected were processed as per WA Herbarium guidelines and identified in the Biologic laboratory

### Hyporheic Fauna

At each site, the hyporheic zone was sampled using the Karaman-Chappuis (Karaman) method (Chappuis, 1942; Karaman, 1935). This involved digging a hole (approximately 20 cm deep, 40 cm diameter) in alluvial sediments adjacent to the water's edge (see Plate 4.1). The hole was swept at three-time intervals with a modified 110  $\mu$ m mesh plankton net; (i) immediately once it had filled with water, (ii) after approximately 30 minutes, and (iii) then again at the completion of sampling at that site. The net was thoroughly cleaned between sites to avoid cross contamination. Although Bou-Rouch (Bou, 1974) sampling has widely been used to sample the hyporheic zone, the Karaman method has been found to be more effective, with a greater diversity of taxa collected (Canton & Chadwick, 2000; Strayer & Bannon-O'Donnell, 1988).

Hyporheic samples were preserved in 95% ethanol in the field and returned to the Biologic laboratory where they were stored in the freezer prior to processing. Hyporheos<sup>8</sup> fauna were removed by sorting under a low power dissecting microscope. Specimens were identified in-house to the lowest possible level (genus or species level) and enumerated to log<sub>10</sub> scale abundance classes (i.e., 1 = 1 individual, 2 = 2 - 10 individuals, 3 = 11 - 100 individuals, 4 = 101-1000 individuals, 5 = >1000). Molecular analysis was used to complement morphological taxonomy for identification of some of the more difficult groups, such as ostracods, syncarids, and

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<sup>8</sup> Surface water species utilising the hyporheic zone for protection against perturbations in the river environment and obligate groundwater species, are collectively known as hyporheos fauna (Brunke & Gonser, 1997).

amphipods. Molecular analysis methodology is provided in the accompanying Molecular Report (Biologic, 2024).

### **Macroinvertebrates**

At each site, two different nets and mesh sizes were used to sample the macroinvertebrates and smaller micro-crustacea taxa (Cladocera, Copepoda and Ostracoda). Micro-crustacea were sampled by a gentle sweep with a 53 µm plankton tow net over an approximate 30 m distance at each site, taking care not to disturb the benthos or sweep through algae. For macroinvertebrates, all aquatic microhabitats within each site were sampled with a 250 µm mesh D-net, including open water, macrophyte beds, large woody debris (LWD), leaf litter and edge habitat. The kick-sweep method was used in open areas and along edge habitat, whereby the sediments were vigorously disturbed (kicked), and the water column immediately swept with the dip net. Each macroinvertebrate sample was washed through a 250 µm sieve to remove fine sediment and leaf litter was removed by hand. This micro-crustacea collection was carefully combined with the macroinvertebrate sample and preserved in 95% ethanol in the field before being transported to the Biologic laboratory for processing. The sieve and both nets were thoroughly cleaned between sites to avoid cross contamination.

In the laboratory, sorting was conducted under a low power dissecting microscope. Specimens were identified to the lowest possible level (genus or species level) and enumerated to the log<sub>10</sub> scale abundance classes. All macroinvertebrate groups were identified using in-house expertise.

### **Rehydrate Emergence Trials**

Sediments were collected from dry sites to enable rehydration and emergence trials to be conducted in the Biologic laboratory. This included 2 sites in the Wet 2024 (SR-0-1R and ECRRef-05) and 4 in the Dry 2024 (SR-05, SRRef-01, SRRef-03, ECRRef-05). The aim of these trials was to obtain information on the types of resident fauna the Study Area pools support by identifying those which emerge from desiccation-resistant resting stages following inundation and rehydration. This provides information on aquatic ecology values in the absence of surface water.

In the field, sediment samples were collected from areas with low elevation in relation to surrounding topography, i.e., areas that likely hold water after a rainfall event. Approximately 2 kg of surficial sediment was collected from the top 5-10 mm, and samples placed in labelled, breathable calico bags. Each sample was kept in a cool, dark place.

In the Biologic laboratory, each sediment sample was rehydrated in tanks flooded with 7 L of dechlorinated filtered water (see Plate 4.2). Rehydration was undertaken in a controlled

temperature room maintained at a temperature comparable to conditions in the field at the time of collection, with a 12-hour light/12-hour dark cycle. Samples were examined every 24 to 48 hours for emergent fauna for up to 58 days after rehydration, or until no new fauna emerged. As cues for emergence and colonisation rates are different for different species, samples were allowed to dry after 28 days and re-wetted, to simulate a second flooding event. Animals were fed algal pellets for the duration of the emergence trials. Water quality was measured every few days over the course of the trial to ensure the water temperature and DO were appropriate for emergence/germination.

Emergent fauna was identified to species level (where possible) under high-powered magnification, and abundance recorded on the  $\log_{10}$  abundance scale. The conservation status of emergent taxa was determined. Macrophytes which germinated did not grow to sufficient size to allow identification before the rehydration trials were complete, and therefore were recorded as Macrophyte sp.

## Fish

Fish sampling included a variety of methods to collect as many species and individuals as possible. Methods included light-weight fine mesh gill nets (10 m net, with a 2 m drop, using 10 mm, 13 mm, 19 mm and 25 mm stretched mesh) set across the creek/pool, seine netting (10 m net, with a 2 m drop and 6 mm mesh), fyke nets (comprising two 10 m leaders/wings of 4–6 mm mesh, 1.5 m drop, and a 5 m long funnel supported by a series of hoops), and direct observation. The seine was deployed in shallow areas with little vegetation or LWD, and up to three seine hauls were undertaken per site.

Fyke nets were used to complement other methods and were set in at least two pools in the Study Area (SR-04 and SR-05) and one Reference site (SRRef-01). Fyke nets were set overnight with the leader wings perpendicular to the bank, and floats placed in the cod end to provide an airspace for turtles and any other air-breathing fauna, as required by DSEWPaC (2011). Fish were identified in the field and standard length (SL<sup>9</sup>) measured. All fish were released alive to the site where they were collected.

## Other Aquatic Fauna

Other vertebrate fauna (i.e., turtles, olive pythons, frogs) recorded using any of the methods above, or observed over the course of the Survey, were recorded for each site.

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<sup>9</sup> Standard length (SL) - measured from the tip of the snout to the posterior end of the last vertebra or to the posterior end of the midlateral portion of the hypural plate (i.e., this measurement excludes the length of the caudal fin).

## Appendix C: Default ANZG (2018) water quality guidelines

Default trigger values for some physical and chemical stressors for tropical Australia for slightly disturbed ecosystems (TP = total phosphorus; FRP = filterable reactive phosphorus; TN = total nitrogen; NOx = total nitrates/nitrites; NH4+ = ammonium).

Aquatic Ecosystem	Analyte						
	TP	FRP	TN	NOx	NH4 <sup>+</sup>	DO	pH
Units	mg/L	mg/L	mg/L	mg/L	mg/L	% saturation	
Upland River <sup>e</sup>	0.01	0.005	0.15	0.03	0.006	90-120	6.0-7.5
Lowland River <sup>e</sup>	0.01	0.004	0.2-0.3 <sup>h</sup>	0.01 <sup>b</sup>	0.01	85-120	6.0-8.0
Lakes	0.01	0.005	0.35 <sup>c</sup>	0.01 <sup>b</sup>	0.01	90-120	6.0-8.0
Wetlands <sup>3</sup>	0.01-0.05 <sup>g</sup>	0.05-0.025 <sup>g</sup>	0.35-1.2 <sup>g</sup>	0.01	0.01	90 <sup>b</sup> -120 <sup>b</sup>	6.0-8.0

b = Northern Territory values are 0.005mg/L for NO<sub>x</sub>, and < 80 (lower limit) and >110% saturation (upper limit) for DO;  
 c = this value represents turbid lakes only. Clear lakes have much lower values;  
 e = no data available for tropical WA estuaries or rivers. A precautionary approach should be adopted when applying default trigger values to these systems;  
 f = dissolved oxygen values were derived from daytime measurements. Dissolved oxygen concentrations may vary diurnally and with depth. Monitoring programs should assess this potential variability;  
 g = higher values are indicative of tropical WA river pools;  
 h = lower values from rivers draining rainforest catchments.

Default trigger values for salinity and turbidity for the protection of aquatic ecosystems, applicable to tropical systems in Australia (ANZECC & ARMCANZ, 2000).

Salinity	(µs/cm)	Comments
Aquatic Ecosystem		
Upland & lowland rivers	20-250	Conductivity in upland streams will vary depending on catchment geology. The first flush may result in temporarily high values
Lakes, reservoirs & wetlands	90-900	Higher conductivities will occur during summer when water levels are reduced due to evaporation
Turbidity	(NTU)	
Aquatic Ecosystem		
Upland & lowland rivers	2-15	Can depend on degree of catchment modification and seasonal rainfall runoff
Lakes, reservoirs & wetlands	2-200	Most deep lakes have low turbidity. However, shallow lakes have higher turbidity naturally due to wind-induced re-suspension of sediments. Wetlands vary greatly in turbidity depending on the general condition of the catchment, recent flow events and the water level in the wetland.

Guideline values for toxicants at alternative levels of protection (in mg/L).

Chemical		Guideline values for freshwater mg/L			
		Level of protection (% species)			
		99%	95%	90%	80%
<b>Metals and metalloids</b>					
Aluminium	pH > 6.5	0.027	0.055	0.08	0.15
Aluminium	pH < 6.5	ID	ID	ID	ID
Arsenic (As III)		0.001	0.024	0.094 <sup>c</sup>	0.36 <sup>c</sup>
Arsenic (AsV)		0.0008	0.013	0.042	0.14 <sup>c</sup>
Boron		0.34	0.94	0.150	0.250
Cadmium	H	0.00006	0.0002	0.0004	0.0008 <sup>c</sup>
Chromium (Cr III)	H	ID	ID	ID	ID
Chromium (Cr IV)		0.00001	0.001 <sup>c</sup>	0.006 <sup>A</sup>	0.04 <sup>A</sup>
Cobalt	K	ID	ID	ID	ID
Copper		0.001	0.0014	0.0018 <sup>c</sup>	0.0025 <sup>c</sup>
Iron	G	ID	ID	ID	ID
Lead	H	0.001	0.0034	0.0056	0.0094 <sup>c</sup>
Manganese		1.2	1.9 <sup>c</sup>	2.5 <sup>c</sup>	3.6 <sup>c</sup>
Mercury (inorganic)	B	0.00006	0.0006	0.0019 <sup>c</sup>	0.0054 <sup>A</sup>
Mercury (methyl)		ID	ID	ID	ID
Molybdenum	K	ID	ID	ID	ID
Nickel	H	0.008	0.011	0.013	0.017 <sup>c</sup>
Selenium (Total)	B	0.005	0.011	0.018	0.034
Selenium (SeIV)	B	ID	ID	ID	ID
Uranium	K	ID	ID	ID	ID
Vanadium	K	ID	ID	ID	ID
Zinc	H	0.0024	0.008 <sup>c</sup>	0.015 <sup>c</sup>	0.031 <sup>c</sup>
<b>Non-metallic inorganics</b>					
Ammonia	D	0.32	0.9 <sup>c</sup>	1.43 <sup>A</sup>	2.3 <sup>A</sup>
Chlorine	E	0.0004	0.003	0.006 <sup>A</sup>	0.013 <sup>A</sup>
Nitrate	J	1.0	2.4	3.4 <sup>c</sup>	17 <sup>A</sup>

**Notes:**

Most guideline values listed here for metals and metalloids are *High Reliability* figures, derived from field or chronic NOEC data (see 3.4.2.3). Exceptions are *Moderate Reliability* for freshwater Al (pH>6.5) and Mn.

Most non-metallic inorganics are *Moderate Reliability* figures, derived from acute LC50 data (see section 3.4.2.3). The exception is *High Reliability* for freshwater ammonia.

A = Figure may not protect key test species from acute toxicity (and chronic) (Section 8.3.4.4).

B = Chemicals for which possible bioaccumulation and secondary poisoning effects should be considered (Section 8.3.3.4)

C = Figure may not protect key test species from chronic toxicity (this refers to experimental chronic figures or geometric mean for species) - check Section 8.3.7 for spread of data and its significance.

D = Ammonia as total ammonia as [N-NH<sub>3</sub>] at pH 8. For changes in DV with pH refer to Section 8.3.7.2

E = Chlorine as Total Chlorine, as [Cl]; see Section 8.3.7.2

F = Figures protect against toxicity and do not relate to eutrophication issues. Refer to Section 3.3 if eutrophication is a concern.

G = There were insufficient data to derive a reliable guideline value for iron. The current Canadian guideline level is 0.3 mg/L which could be used as an interim working level. However, further data are required to establish a figure appropriate for Australian waters.

H = Chemicals for which algorithms have been provided in table 3.4.3 to account for the effects of hardness. The values have been calculated using a hardness of 30 mg/L CaCO<sub>3</sub>. These should be adjusted to the site-specific hardness (see Section 3.4.3).

J = Figures relate to toxicity (not eutrophication). The ANZECC & ARM CANZ (2000) DGVs for nitrate have been found to be erroneous (ANZG, 2018). In the absence of updated values, ANZG (2018) suggest reference is made to current New Zealand nitrate toxicity guidelines, specifically the 'Grading' GVs published in the 'Updating Nitrate Toxicity Effects on Freshwater Aquatic Species' report (NIWA, 2013). These New Zealand Grading DGVs for N-NO<sub>3</sub> are provided above.

K = There was insufficient chronic toxicology data to derive a reliable guideline. Therefore a low reliability trigger is currently used.

## Appendix D: Biologic GDV Assessment Framework

Table 1: Site considerations for GDV rating assessment

Rating	General site features	Key/most common indicator species and density		
		Phreatophytic/Riparian	Mesophytic	Hydrophytic
High	<p>Presence of mature obligate phreatophytes (i.e., <i>Melaleuca argentea</i>) with permanent to semi-permanent water bodies present.</p> <p>A high diversity and density of mesophytic and hydrophytic taxa.</p> <p>Pooling present; evidence of seepage</p>	<p><b>Abundant:</b></p> <ul style="list-style-type: none"> <li>• <i>Eucalyptus camaldulensis</i></li> <li>• <i>Melaleuca argentea</i></li> </ul> <p><b>Present:</b></p> <ul style="list-style-type: none"> <li>• <i>Sesbania formosa</i></li> </ul>	<p><b>Abundant to Common:</b></p> <ul style="list-style-type: none"> <li>• <i>Melaleuca</i> species</li> <li>• <i>Ficus aculeata</i></li> </ul> <p><b>Present:</b></p> <ul style="list-style-type: none"> <li>• <i>Acacia ampliceps</i></li> <li>• <i>Cullen leucanthum</i></li> <li>• <i>Ficus virens</i></li> <li>• <i>Imperata cylindrica</i></li> <li>• <i>Myoporum monatanum</i></li> <li>• <i>Samolus</i> species</li> </ul>	<p><b>Abundant to Common:</b></p> <ul style="list-style-type: none"> <li>• <i>Potamogeton</i> species</li> <li>• <i>Sonchus hydrophyllus</i></li> </ul> <p><b>Present:</b></p> <ul style="list-style-type: none"> <li>• <i>Juncus krausii</i></li> <li>• <i>Livistona alfredii</i></li> <li>• <i>Lobelia arnhemiaca</i></li> <li>• <i>Samolus</i> sp. Millstream</li> </ul>
Moderate	<p>Presence of mature facultative phreatophytes (with potential for semi-mature to young obligate phreatophytes).</p> <p>Semi-permanent water bodies may be present. A moderate diversity and density of mesophytic and hydrophytic taxa.</p> <p>+/- Pooling present or evidence of pools; +/- evidence of seepage</p>	<p><b>Abundant:</b></p> <ul style="list-style-type: none"> <li>• <i>Eucalyptus victrix</i></li> <li>• <i>Sesbania cannabina</i></li> </ul> <p><b>Common:</b></p> <ul style="list-style-type: none"> <li>• <i>Eucalyptus camaldulensis</i></li> <li>• <i>Melaleuca argentea</i></li> </ul>	<p><b>Abundant:</b></p> <ul style="list-style-type: none"> <li>• <i>Melaleuca glomerata</i></li> </ul> <p><b>Common to Present:</b></p> <ul style="list-style-type: none"> <li>• <i>Melaleuca</i> species</li> <li>• <i>Ficus aculeata</i></li> <li>• <i>Plumbago zeylanica</i></li> <li>• <i>Atalaya hemiglauca</i></li> <li>• <i>Dodonaea lanceolata</i></li> <li>• <i>Gymnanthera cunninghamii</i></li> <li>• <i>Adriana tomentosa</i></li> <li>• <i>Tinospora smilacina</i></li> </ul>	<p><b>Abundant:</b></p> <ul style="list-style-type: none"> <li>• <i>Ammannia baccifera</i></li> <li>• <i>Chara</i> species</li> <li>• <i>Najas</i> species</li> <li>• <i>Typha domingensis</i></li> </ul> <p><b>Present:</b></p> <ul style="list-style-type: none"> <li>• <i>Cyperus</i> species</li> <li>• <i>Potamogeton</i> species</li> <li>• <i>Samolus repens</i></li> <li>• <i>Schenkia</i> species</li> <li>• <i>Schoenoplectus subulatus</i></li> <li>• <i>Sonchus hydrophyllus</i></li> </ul>

Rating	General site features	Key/most common indicator species and density		
		Phreatophytic/Riparian	Mesophytic	Hydrophytic
Low	<p>Scattered presence of facultative and/or presence of mature vadophytic (i.e. <i>Eucalyptus victrix</i>).</p> <p>Ephemeral to semi-permanent water bodies may be present. Low diversity and density of mesophytic and hydrophytic taxa.</p>	<p><b>Abundant to Common:</b></p> <ul style="list-style-type: none"> <li>• <i>Acacia citrinoviridis</i></li> <li>• <i>Acacia coriacea</i> subsp. <i>pendens</i></li> <li>• <i>Eucalyptus victrix</i></li> <li>• <i>Stylobasium spathulatum</i></li> </ul> <p><b>Present:</b></p> <ul style="list-style-type: none"> <li>• <i>Acacia sclerosperma</i></li> <li>• <i>Eucalyptus camaldulensis</i></li> <li>• <i>Eucalyptus xerothermica</i></li> <li>• <i>Melaleuca argentea</i></li> <li>• <i>Sesbania cannabina</i></li> <li>• <i>Terminalia circumalata</i></li> </ul>	<p><b>Abundant to Common:</b></p> <ul style="list-style-type: none"> <li>• <i>Cyprus vaginatus</i></li> <li>• <i>Eulalia aurea</i></li> <li>• <i>Stemodia grossa</i></li> </ul> <p><b>Present:</b></p> <ul style="list-style-type: none"> <li>• <i>Abutilion amplum</i></li> <li>• <i>Melaleuca glomerata</i></li> <li>• <i>Plumbago zeylanica</i></li> <li>• <i>Atalaya hemiglauca</i></li> </ul>	<p><b>Present:</b></p> <ul style="list-style-type: none"> <li>• <i>Ammannia baccifera</i></li> <li>• <i>Chara species</i></li> <li>• <i>Fimbristylis microcarya</i></li> <li>• <i>Marsilea exarata</i></li> <li>• <i>Marsilea hirsuta</i></li> <li>• <i>Mysiophyllum species</i></li> <li>• <i>Najas species</i></li> <li>• <i>Schoenoplectiella laevis</i></li> <li>• <i>Typha domingensis</i></li> <li>• <i>Wahlenbergia tumidifruca</i></li> </ul>
Negligible	<p>Minor to medium flowlines and drainage areas. Mostly inflow dependent species. Riparian species (i.e., <i>Acacia tumida</i> var. <i>pilbarensis</i>) are prevalent and dominant.</p>	<p>No groundwater indicator species present or not present at the density that would indicate presence of soil moisture. Mostly mature vadophytic taxa, with riparian tree species (i.e., <i>Eucalyptus xerothermica</i>, <i>Corymbia hamersleyana</i>). High diversity of Riparian species abundant and common.</p>		
None	<p>Minor flowlines. Occurs on upland habitats (i.e., hummock grassland on stony hills and slopes) that are highly unlikely to have to access to or be reliant on groundwater presence.</p>	<p>None present. Riparian species may be abundant, common and present.</p>		

Please Note: 'Present' refers to any cover density, though is usually 0.1%; 'Common' is cover density from 0.2% to 10%; 'Abundant' is 11% cover density and higher.

Table 2: Comprehensive list of riparian taxa and their GDV rating for assessment

Family	Taxon	Classification	High	Moderate	Low	Negligible
Amarantaceae	<i>Alternanthera denticulata</i>	Riparian				Present
	<i>Alternanthera nana</i>	Riparian				Present
	<i>Alternanthera nodiflora</i>	Riparian				Present
	<i>Amaranthus cuspidifolius</i>	Riparian				Present
Apocynaceae	<i>Gymnanthera cunninghamii</i>	Mesophyte		Common/Present		
Arecaceae	<i>Livistona alfredii</i>	Hydrophyte	Present			
Asteraceae	<i>Centipeda minima</i>	Riparian				Present
	<i>Centipeda minima</i> subsp. <i>minima</i>	Riparian				Common
	<i>Flaveria trinervia</i>	Riparian				Present
	<i>Pluchea dentex</i>	Riparian				Present
	<i>Pluchea rubelliflora</i>	Riparian				Present
	<i>Sonchus hydrophyllus</i>	Hydrophyte	Common	Present		
Boraginaceae	<i>Ehretia saligna</i> var. <i>saligna</i>	Riparian				Present
Campanulaceae	<i>Lobelia arnhemiaca</i>	Hydrophyte	Present			
	<i>Wahlenbergia tumidifructa</i>	Hydrophyte			Present	
Caryophyllaceae	<i>Polycarpaea longiflora</i>	Riparian				Present
Characeae	<i>Chara</i> species	Hydrophyte		Abundant	Present	
Combretaceae	<i>Terminalia circumalata</i>	Phreatophyte			Present	Present
Convolvulaceae	<i>Ipomoea muelleri</i>	Riparian				Present
	<i>Polymeria ambigua</i>	Riparian				Present
Cyperaceae	<i>Cladium procerum</i>	Hydrophyte	Present			
	<i>Cyperus leptocarpus</i>	Hydrophyte			Present	
	<i>Cyperus polystachyos</i>	Hydrophyte		Present		
	<i>Cyperus</i> species	Hydrophyte		Present		

Family	Taxon	Classification	High	Moderate	Low	Negligible
	<i>Cyperus vaginatus</i>	Mesophyte		Abundant/Common	Common/Present	
	<i>Eleocharis dulcis</i>	Hydrophyte	Present			
	<i>Eleocharis geniculata</i>	Hydrophyte		Present		
	<i>Eleocharis pallens</i>	Hydrophyte		Present		
	<i>Eleocharis sphacelata</i>	Hydrophyte	Present			
	<i>Eleocharis spiralis</i>	Hydrophyte	Present			
	<i>Fimbristylis cephalophora</i>	Hydrophyte	Present			
	<i>Fimbristylis feruginea</i>	Hydrophyte	Present			
	<i>Fimbristylis littoralis</i>	Hydrophyte	Present			
	<i>Fimbristylis microcarya</i>	Hydrophyte			Present	
	<i>Fimbristylis sieberiana</i>	Hydrophyte	Present			
	<i>Fuirena ciliaris</i>	Hydrophyte		Present		
	<i>Machaerina juncea</i>	Hydrophyte	Present			
	<i>Machaerina rubiginosa</i>	Hydrophyte	Present			
	<i>Schoenoplectiella laevis</i>	Hydrophyte			Present	
	<i>Schoenoplectus subulatus</i>	Hydrophyte		Present		
	<i>Schoenus falcatus</i>	Hydrophyte	Abundant	Common		
	<i>Schoenus punctatus</i>	Hydrophyte	Present			
Elatinaceae	<i>Bergia ammannioides</i>	Riparian				Present
Eriocaulaceae	<i>Eriocaulon cinereum</i>	Hydrophyte	Present			
Euphorbiaceae	<i>Adriana tomentosa</i>	Mesophyte		Present		
Fabaceae	<i>Acacia ampliceps</i>	Mesophyte	Present			
	<i>Acacia citrinoviridis</i>	Phreatophyte			Abundant/Common	
	<i>Acacia coleii</i> var. <i>ileocarpa</i>	Riparian				Common
	<i>Acacia coriacea</i> subsp. <i>pendens</i>	Phreatophyte			Common	

Family	Taxon	Classification	High	Moderate	Low	Negligible
	<i>Acacia monticola</i>	Riparian				Present
	<i>Acacia monticola</i>	Riparian				Common
	<i>Acacia pyrifolia</i>	Riparian				Common
	<i>Acacia pyrifolia</i> var. <i>pyrifolia</i>	Riparian				Common
	<i>Acacia sclerosperma</i>	Phreatophyte			Present	
	<i>Acacia sericophylla</i>	Phreatophyte			Present	
	<i>Acacia tumida</i>	Riparian				Present
	<i>Acacia tumida</i> var. <i>pilbarensis</i>	Riparian				Common
	<i>Afrohybanthus aurantiacus</i>	Riparian				Present
	<i>Cajanus pubescens</i>	Riparian				Present
	<i>Crotalaria medicaginea</i> var. <i>neglecta</i>	Riparian				Present
	<i>Crotalaria novae-hollandiae</i>	Riparian				Present
	<i>Cullen leucanthum</i>	Mesophyte	Present			
	<i>Petalostylis labicheoides</i>	Riparian				Common
	<i>Rhynchosia bungarensis</i>	Mesophyte			Present	
	<i>Sesbania cannabina</i>	Phreatophyte		Abundant	Present	
	<i>Sesbania formosa</i>	Phreatophyte	Present			
	<i>Tephrosia rosea</i> var. Fortescue creeks (M.I.H. Brooker 2186)	Riparian				Present
	<i>Vigna lanceolata</i> var. <i>lanceolata</i>	Riparian				Present
Gentianaceae	<i>Schenkia australis</i>	Hydrophyte		Present		
	<i>Schenkia clementii</i>	Hydrophyte		Present		
Haloragaceae	<i>Myriophyllum</i> species	Hydrophyte			Present	
Hydrocharitaceae	<i>Najas</i> species	Hydrophyte		Abundant	Present	
Juncaceae	<i>Juncus krausii</i>	Hydrophyte	Present			

Family	Taxon	Classification	High	Moderate	Low	Negligible
Lamiaceae	<i>Clerodendrum floribundum</i> var. <i>angustifolium</i>	Riparian				Present
Lythraceae	<i>Ammannia baccifera</i>	Hydrophyte		Abundant	Present	
	<i>Ammannia multiflora</i>	Hydrophyte			Present	
Malvaceae	<i>Abutilon amplum</i>	Mesophyte		Common	Present	
	<i>Abutilon</i> sp. Dioicum (A.A. Mitchell PRP 1618)	Riparian				Common
	<i>Gossypium sturtianum</i>	Mesophyte		Present		
	<i>Lawrencia glomerata</i>	Mesophyte		Present		
Marsileaceae	<i>Marsilea exarata</i>	Hydrophyte			Present	
	<i>Marsilea hirsuta</i>	Hydrophyte			Present	
Menispermaceae	<i>Tinospora smilacina</i>	Mesophyte		Present		
Moraceae	<i>Ficus aculeata</i>	Mesophyte	Common	Present		
	<i>Ficus brachypoda</i>	Riparian				Present
	<i>Ficus geniculata</i>	Mesophyte	Present			
	<i>Ficus virens</i>	Mesophyte	Present			
	<i>Ficus virens</i> var. <i>dasycarpa</i>	Mesophyte	Present			
Myrtaceae	<i>Eucalyptus camaldulensis</i>	Phreatophyte	Abundant	Common	Present	
	<i>Eucalyptus camaldulensis</i> subsp. <i>refulgens</i>	Phreatophyte	Abundant	Common	Present	
	<i>Eucalyptus victrix</i>	Phreatophyte		Abundant	Common	
	<i>Eucalyptus xerothermica</i>	Riparian			Present	Present
	<i>Melaleuca alsophila</i>	Mesophyte	Abundant	Present		
	<i>Melaleuca argentea</i>	Phreatophyte	Abundant	Common	Present	
	<i>Melaleuca bracteata</i>	Mesophyte		Present		
	<i>Melaleuca glomerata</i>	Mesophyte		Abundant	Present	

Family	Taxon	Classification	High	Moderate	Low	Negligible
	<i>Melaleuca lasiandra</i>	Mesophyte		Present		
	<i>Melaleuca linophylla</i>	Mesophyte		Abundant/present		
	<i>Melaleuca nervosa</i>	Mesophyte	Abundant			
	<i>Melaleuca xerophila</i>	Mesophyte		Common		
Nyctaginaceae	<i>Commicarpus australis</i>	Mesophyte		Present		
Nymphaea	<i>Nymphaea pubescens</i>	Hydrophyte	Present			
	<i>Nymphaeaceae</i> species.	Hydrophyte	Present			
	<i>Nymphoides indica</i>	Hydrophyte	Present			
Orobanchaceae	<i>Striga curviflora</i>	Hydrophyte		Present		
Papaveraceae	<i>Argemone ochroleuca</i> subsp. <i>ochroleuca</i>	Riparian				Present
Passifloraceae	<i>Passiflora foetida</i> var. <i>hispida</i>	Riparian				Present
Phyllanthaceae	<i>Fleuggea virosa</i> subsp. <i>melanthesoides</i>	Mesophyte		Present		
	<i>Kirganelia baccata</i>	Mesophyte		Common/Present		
	<i>Nellica maderaspatensis</i>	Riparian				Present
	<i>Notoleptopus decaisnei</i> var. <i>orbicularis</i> (A.B. Craig 428)	Riparian				Present
Plantaginaceae	<i>Stemodia grossa</i>	Mesophyte			Abundant	
Plumbaginaceae	<i>Muellerolimon salicorniaceum</i>	Mesophyte		Present		
	<i>Plumbago zeylanica</i>	Mesophyte		Common	Present	
Poaceae	<i>Cenchrus ciliaris</i>	Riparian				Common
	<i>Cenchrus setiger</i>	Riparian				Common
	<i>Chrysopogon fallax</i>	Riparian				Present
	<i>Cymbopogon ambiguus</i>	Riparian				Present
	<i>Cymbopogon obtectus</i>	Riparian				Present

Family	Taxon	Classification	High	Moderate	Low	Negligible
	<i>Cynodon dactylon</i>	Riparian				Present
	<i>Eragrostis tenellula</i>	Riparian				Present
	<i>Eriachne mucronata</i>	Riparian				Common
	<i>Arundo donax</i>	Hydrophyte	Present			
	<i>Elytrophorus spicatus</i>	Hydrophyte			Present	
	<i>Eragrostis surreyana</i>	Mesophyte		Present		
	<i>Eulalia aurea</i>	Mesophyte			Abundant	
	<i>Imperata cylindrica</i>	Mesophyte	Present			
	<i>Leptochloa digitata</i>	Riparian				Present
	<i>Phragmites karka</i>	Hydrophyte	Present			
	<i>Pseudoraphis spinescens</i>	Hydrophyte		Present		
	<i>Sporobolus virginicus</i>	Hydrophyte	Present			
	<i>Themeda triandra</i>	Riparian				Common
Polygonaceae	<i>Duma florulenta</i>	Mesophyte		Present		
Potamogetonaceae	<i>Potamogeton species</i>	Hydrophyte	Abundant	Present		
	<i>Potamogeton tepperi</i>	Hydrophyte	Abundant	Present		
Primulaceae	<i>Samolus repens</i>	Hydrophyte		Present		
	<i>Samolus</i> sp. Millstream	Hydrophyte	Present			
	<i>Samolus</i> species.	Mesophyte	Present			
Pteridaceae	<i>Acrostichum speciosum</i>	Hydrophyte	Present			
	<i>Adiantum capillus-veneris</i>	Hydrophyte	Present			
	<i>Ceratopteris thalictroides</i>	Hydrophyte	Present			
	<i>Pteris vittata</i>	Hydrophyte	Present			
Ruppiaceae	<i>Ruppia polycarpa</i>	Hydrophyte		Present		
Sapindaceae	<i>Atalaya hemiglauca</i>	Mesophyte		Common	Present	

Family	Taxon	Classification	High	Moderate	Low	Negligible
	<i>Dodonea lanceolata</i>	Mesophyte		Common		
Scrophulariaceae	<i>Myoporum montanum</i>	Mesophyte	Present			
Solanaceae	<i>Physalis angulata</i>	Riparian				Present
Stylidiaceae	<i>Stylidium fluminense</i>	Hydrophyte		Present		
	<i>Stylidium weeliwolli</i>	Hydrophyte	Present			
Surianaceae	<i>Stylobasium spathulatum</i>	Phreatophyte			Common	Present
Thelypteridaceae	<i>Ampelopteris prolifera</i>	Hydrophyte	Present			
Typhaceae	<i>Typha domingensis</i>	Hydrophyte		Abundant	Present	

Please Note: 'Present' refers to any cover density, though is usually 0.1%; 'Common' is cover density from 0.2% to 10%; 'Abundant' is 11% cover density and higher.

## Appendix E: Habitat Assessment Raw Data

Percentage cover of each in-stream habitat type. NB: Inorganic sed. = inorganic sediment, Sub. Mac = submerged macrophyte, Emerg. Mac. = emergent macrophyte and Trailing Veg. = trailing vegetation

### Wet 2024

Type	System	Site	Inorganic Seds.	Sub. Mac.	Emerg. Mac.	Float. Mac.	Algae	LWD	Detritus	Roots	Trailing Veg
Study Area	Glen Herring Creek	SR-01	37	33	2	0	16	2	4	3	3
		SR-02	46	22	1	0	20	3	5	2	1
		SR-03	49	13	1	0	25	3	6	2	1
	Coongan River	SR-04	24	53	5	1	9	2	3	2	2
		SR-05	3	80	1	0	10	2	2	1	1
		SR-06	40	4	3	0	36	4	7	4	2
	Resource Area Pools	CO-WS-10	87	2	1	0	2	1	5	1	1
		CO-WS-12	78	0	2	0	6	2	7	4	1
		CO-WS-14	48	4	1	0	2	4	35	3	3
		CO- SW-16	84	0	3	0	0	2	4	6	1
Reference	Camel Creek	SRRef-01	58	0	1	0	20	15	4	1	1
		SRRef-02	41	0	1	0	45	1	2	10	0
	Glen Herring Creek	SRRef-03	71	15	1	0	2	2	6	2	1
	Emu Creek	ECRef-04	9	44	1	1	36	2	5	1	1
		ECRef-05	45	0	12	0	40	0	3	0	0

### Dry 2024

Type	System	Site	Inorganic Seds.	Sub. Mac.	Emerg. Mac.	Float. Mac.	Algae	LWD	Detritus	Roots	Trailing Veg
Study Area	Glen Herring Creek	SR-01	40	40	10	0	0	2	5	0	3
		SR-02a	30	40	2	15	5	0	5	0	3
		SR-03	42	38	4	0	3	3	10	0	0

Type	System	Site	Inorganic Seds.	Sub. Mac.	Emerg. Mac.	Float. Mac.	Algae	LWD	Detritus	Roots	Trailing Veg
	Coongan River	SR-04	93	0	0	0	0	0	7	0	0
		SR-06	60	20	1	0	1	0	5	13	0
	Resource Area Pools	CO-WS-10	75	5	0	0	10	0	5	2	3
		CO-WS-12	55	0	0	0	0	5	30	5	5
		CO-WS-14	40	5	3	0	15	2	30	0	5
		CO-WS-16	85	0	5	0	0	0	5	0	5
Reference	Glen Herring Creek	SRREF-03	95	0	1	0	2	0	2	0	0
	Emu Creek	ECRef-04	17	67	0	0	3	2	8	0	3

Percentage cover of each in-stream substrate types

### **Wet 2024**

Type	System	Site	Bedrock	Boulders	Cobbles	Pebbles	Gravel	Sand	Silt	Clay
Study Area	Glen Herring Creek	SR-01	10	2	4	10	32	32	8	2
		SR-02	1	2	5	9	20	42	11	10
		SR-03	2	2	0	10	19	41	6	20
	Coongan River	SR-04	0	0	4	8	30	44	5	9
		SR-05	0	0	2	15	30	38	5	10
		SR-06	0	0	5	30	18	44	3	0
	Resource Area Pools	CO-WS-10	46	2	9	16	17	5	5	0
		CO-WS-12	64	2	0	5	2	2	17	8
		CO-WS-14	47	1	2	14	19	5	9	3
		CO- SW-16	48	0	0	18	22	5	5	2

Type	System	Site	Bedrock	Boulders	Cobbles	Pebbles	Gravel	Sand	Silt	Clay
Reference	Camel Creek	SRRef-01	0	0	1	4	5	11	11	68
		SRRef-02	0	0	4	4	10	74	6	2
	Glen Herring Creek	SRRef-03	0	0	3	6	6	18	10	57
	Emu Creek	ECRef-04	6	2	4	14	30	30	10	4
		ECRef-05	0	0	0	4	15	76	5	0

### **Dry 2024**

Type	System	Site	Bedrock	Boulders	Cobbles	Pebbles	Gravel	Sand	Silt	Clay
Study Area	Glen Herring Creek	SR-01	30	5	5	5	30	25	0	0
		SR-02a	15	10	5	2	20	48	0	0
		SR-03	5	0	0	5	40	50	0	0
	Coongan River	SR-04	0	0	1	3	16	60	0	20
		SR-06	0	0	0	5	20	75	0	0
	Resource Area Pools	CO-WS-10	30	20	10	15	15	10	0	0
		CO-WS-12	85	0	0	0	0	0	15	0
		CO-WS-14	60	0	5	0	5	0	30	0
CO-WS-16		55	5	0	0	0	0	40	0	
Reference	Glen Herring Creek	SRREF-03	0	2	5	3	0	40	0	50
	Emu Creek	ECRef-04	15	5	5	10	40	20	2	3

## Appendix F: Water Quality Raw Data

**Wet 2024**

Highlighted cells refer to the values which are in excess of: ■ > 99% ANZG (2018) DGV, ■ > the 95% DGV, ■ > a low reliability trigger or interim indicative working level. All values are mg/L unless otherwise stated

Analyte	ANZG DGV		Glen Herring Creek			Coongan River			Resource Area				Camel Creek		Glen Herring	Emu Creek	
	99% DGV	95% DGV	SR-01	SR-02	SR-03	SR-04	SR-05	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-01	SRRef-02	SRRef-03	ECRef-04	ECRef-05
Temperature (°C)			25.46	26.10	22.30	26.08	27.25	22.80	22.58	25.97	19.77	24.30	26.79	28.57	21.19	24.10	18.95
EC (µS/cm)		250	977	715	927	393	394	1497	516	184	319	468	1599	445	656	240	324
pH (pH units)		6-8	9.13	9.05	8.37	10.06	10.29	7.52	7.98	6.94	7.57	6.85	8.93	7.72	8.01	9.46	7.33
Redox (mV)			42.7	52.2	206.6	11.5	17.7	187.7	17.7	4.8	19.9	-38.5	13.9	18.1	-21.1	19.5	-28.9
DO (%)		85-120	197.2	182.7	78.2	140.2	187.7	48.5	88.1	85.1	73.8	91.0	101.8	95.5	52.4	166.5	19.2
Turbidity (NTU)		15	2.9	4.6	2.7	11.0	5.5	1.4	0.6	0.6	0.6	33.0	240.0	1.8	14.0	3.1	24.0
TSS			6	13	7	8	6	4	<1	<1	<1	<1	116	<1	12	3	58
Alkalinity			374	264	407	115	130	361	113	48	89	39	593	147	311	100	129
Hardness			250	174	326	59	76	298	113	44	117	174	74	97	216	88	110
Na			124.0	87.0	96.4	66.7	59.4	194.0	67.0	19.5	23.9	28.1	307.0	61.7	67.3	19.4	25.0
Ca			23.0	25.8	57.1	12.1	11.7	50.6	8.2	3.8	11.3	30.8	20.4	23.4	52.0	18.4	25.9
Mg			46.7	26.7	44.5	6.9	11.3	41.7	22.4	8.3	21.6	23.7	5.5	9.4	20.9	10.3	10.9
K			6.4	5.8	5.1	1.0	2.4	4.0	2.3	0.9	1.6	3.9	7.7	4.1	4.9	5.7	6.4
HCO <sub>3</sub>			301	238	389	64	42	361	113	48	89	39	526	147	302	86	129
Cl			123	81	110	51	39	261	92	25	35	33	225	45	38	17	26
S <sub>2</sub> O <sub>4</sub>			7.00	2.43	6.10	3.87	3.67	34.70	6.60	0.21	10.20	44.30	1.43	3.83	2.23	1.89	1.18
CO <sub>3</sub>			72	26	18	51	87	<1	<1	<1	<1	<1	67	<1	8	13	<1
dAl	0.027	0.055	0.008	0.014	<0.005	0.066	0.017	<0.005	<0.005	<0.005	<0.005	<0.005	1.12	<0.005	0.042	0.015	0.023
dAs	0.001	0.024	0.0015	0.0015	0.0008	0.0027	0.0014	0.0012	<0.0002	<0.0002	<0.0002	0.0002	0.0140	0.0020	0.0011	0.0013	0.0014
dB	0.340	0.940	0.285	0.220	0.197	0.133	0.114	0.314	0.211	0.094	0.090	0.086	0.412	0.095	0.140	0.069	0.047
dBa			0.0287	0.0436	0.0515	0.0152	0.0048	0.0508	0.0171	0.0075	0.0057	0.0370	0.0310	0.0192	0.0718	0.0268	0.0664
dCd	0.00006	0.0002	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
dCo	0.0014*		0.0002	0.0003	0.0002	0.0007	0.0004	0.0004	<0.0001	<0.0001	0.0001	0.0031	0.0016	0.0003	0.0006	0.0002	0.0018
dCr	0.00001	0.001	<0.0002	<0.0002	<0.0002	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0033	<0.0002	<0.0002	<0.0002	<0.0002
dCu	0.001	0.0014	0.00148	0.00124	0.00044	0.00285	0.00166	0.00030	0.00021	<0.00005	<0.00005	<0.00005	0.00585	0.00017	0.00052	0.00066	0.00017
dFe	0.300*		0.012	0.033	0.012	0.136	0.072	0.042	0.014	0.111	0.078	2.200	1.440	0.022	0.103	0.058	0.842
dMn	1.2	1.9	0.0046	0.0126	0.1800	0.0150	0.0062	0.1010	0.0016	0.0072	0.1910	0.8110	0.0611	0.0681	0.1690	0.0048	2.9900
dMo	0.034*		0.0009	0.0007	0.0006	0.0028	0.0020	0.0057	0.0002	<0.0001	<0.0001	<0.0001	0.0096	0.0014	0.0007	0.0008	0.0006
dNi	0.008	0.011	0.0010	0.0011	0.0009	0.0015	0.0012	0.0006	<0.0005	<0.0005	0.0009	0.0141	0.0088	0.0006	0.0009	0.0009	0.0010
dPb	0.001	0.0034	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0014	<0.0001	<0.0001	<0.0001	<0.0001
dSe	0.005	0.011	0.0002	<0.0002	<0.0002	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0007	<0.0002	<0.0002	0.0002	<0.0002
dU	0.0005*		0.00056	0.00036	0.00068	0.00076	0.00083	0.00454	<0.00005	<0.00005	<0.00005	<0.00005	0.00452	0.00071	0.00071	0.00026	0.00018
dV	0.006*		0.0095	0.0063	0.0026	0.0142	0.0082	0.0028	0.0006	<0.0001	<0.0001	<0.0001	0.0109	0.0032	0.0023	0.0014	0.0005
dZn	0.0024	0.008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001
N <sub>2</sub> NH <sub>3</sub>	0.32	0.9	<0.01	<0.01	<0.01	0.06	0.01	0.04	0.01	0.06	0.02	0.01	0.05	0.01	0.17	0.02	0.95
N <sub>2</sub> NO <sub>3</sub>	1	2.4	0.02	0.02	<0.01	0.01	<0.01	<0.01	0.01	0.01	0.02	0.02	0.05	0.02	0.02	0.02	0.03
N <sub>2</sub> NO <sub>x</sub>		0.01	0.02	0.02	<0.01	0.01	<0.01	<0.01	0.01	0.01	0.02	0.02	0.05	0.02	0.02	0.02	0.03
Total N		0.3	0.52	0.61	0.33	0.7	0.45	0.17	0.14	0.08	0.02	<0.01	3.44	0.14	0.74	0.53	1.99
Total P		0.01	0.036	0.050	0.036	0.056	0.029	0.029	0.020	0.010	0.009	0.010	0.663	0.062	0.086	0.028	0.139

\* indicates the DGV is a low reliability trigger or interim/indicative working level

**Dry 2024**

Highlighted cells refer to the values which are in excess of: ■ > 99% ANZG (2018) DGV, ■ > the 95% DGV, ■ > a low reliability trigger or interim indicative working level. All values are mg/L unless otherwise stated

Analyte	ANZG DGV		Glen Herring Creek			Coongan River		Resource Area				Glen Herring	Emu Creek
	99% DGV	95% DGV	SR-01	SR-02	SR-03	SR-04	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-03	ECRef-04
Temperature (°C)			25.3	23.5	20.7	29.3	25.3	21.9	23.9	18.8	21.7	22.2	17.6
EC (µS/cm)		250	1397	521	846	876	2291	513	188	296	471	831	372
pH (pH units)		6-8	9.25	8.79	8.16	8.55	7.83	8.28	6.89	7.78	6.40	7.70	9.19
Redox (mV)			136.1	132	97	97.3	132.6	32	62.6	56	-13	-90.9	40.8
DO (%)		85-120	132.2	86.6	48.0	189.4	102.4	86.8	80.4	88.7	52.5	5.4	113.0
Turbidity (NTU)		15	2.0	4.7	6.2	70.0	1.4	0.4	1.2	0.4	4.5	650.0	0.9
TSS			4	8	10	51	4	<1	4	<1	3	379	3
Alkalinity			469	197	321	324	512	122	55	85	43	295	160
Hardness			299	142	237	265	390	122	50	108	167	137	151
Na			181.0	70.6	98.0	69.2	309.0	67.5	18.4	22.0	28.5	120.0	32.7
Ca			13.7	13.9	29.4	49.9	66.4	9.6	4.2	10.8	28.8	27.3	20.5
Mg			64.4	26	39.8	34.1	54.5	23.8	9.6	19.6	23	16.8	24.2
K			6.3	8.5	9.9	18.7	4.6	2.2	0.5	1.3	3.1	47.2	5.8
HCO <sub>3</sub>			261	175	307	312	498	122	55	85	43	295	153
Cl			186	55	101	61	376	90	30	39	45	96	49
S <sub>SO4</sub>			7.03	0.65	1.85	1.70	49.70	4.83	0.27	10.00	42.30	3.43	1.51
CO <sub>3</sub>			208	22	14	13	14	<1	<1	<1	<1	<1	7
dAl	0.027	0.055	0.010	0.030	0.030	0.022	<0.005	<0.005	<0.005	<0.005	<0.005	0.017	0.006
dAs	0.001	0.024	0.0016	0.0011	0.0010	0.0030	0.0021	<0.0002	<0.0002	<0.0002	<0.0002	0.0022	0.0012
dB	0.340	0.940	0.36	0.167	0.216	0.144	0.496	0.197	0.084	0.089	0.086	0.273	0.104
dBa			0.0454	0.0504	0.0868	0.129	0.0616	0.0154	0.0113	0.0039	0.0306	0.128	0.0468
dCd	0.00006	0.0002	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
dCo	0.0014*		0.0003	0.0004	0.0006	0.0014	0.0003	<0.0001	<0.0001	<0.0001	0.0015	0.0018	0.0003
dCr	0.00001	0.001	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
dCu	0.001	0.0014	0.0019	0.0023	0.0014	0.0005	0.0002	0.0002	<0.00005	<0.00005	<0.00005	0.0027	0.0003
dFe	0.300*		0.01	0.05	0.038	0.415	0.044	0.007	0.061	0.037	1.28	0.229	0.073
dMn	1.2	1.9	0.007	0.038	0.180	1.320	0.089	0.001	0.055	0.150	0.442	0.269	0.007
dMo	0.034*		0.0010	0.0007	0.0006	0.0021	0.0095	0.0002	<0.0001	<0.0001	<0.0001	0.0023	0.0010
dNi	0.008	0.011	0.0009	0.0013	0.0017	0.0030	<0.0005	<0.0005	<0.0005	0.0009	0.0048	0.0034	0.0011
dPb	0.001	0.0034	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001
dSe	0.005	0.011	0.0002	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0003	<0.0002
dU	0.0005*		0.00071	0.00024	0.00050	0.00114	0.00693	<0.00005	<0.00005	<0.00005	<0.00005	0.00362	0.00044
dV	0.006*		0.0068	0.0016	0.0021	0.0062	0.0029	0.0006	<0.0001	<0.0001	<0.0001	0.0034	0.0006
dZn	0.0024	0.008	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
N <sub>NH3</sub>	0.32	0.9	0.01	<0.01	0.26	0.17	0.01	0.02	0.02	<0.01	<0.01	2.27	<0.01
N <sub>NO3</sub>	1	2.4	0.01	0.01	0.01	0.01	<0.01	0.02	0.02	0.02	0.03	<0.05	<0.01
N <sub>NOx</sub>		0.01	0.01	0.01	0.01	0.01	<0.01	0.02	0.02	0.02	0.03	<0.05	<0.01
Total N		0.3	0.72	0.95	1.7	2.81	0.24	0.14	0.06	0.04	0.04	13.8	0.85
Total P		0.01	0.028	0.046	0.115	0.368	0.076	0.024	0.011	0.010	0.016	1.490	0.022

\* indicates the DGV is a low reliability trigger or interim/indicative working level

## Appendix G: Riparian Flora Raw Data

Class/Order	Family	Lowest taxon	Glen Herring Creek					Coongan River			Resource Area				Camel Creek		Glen Herring Creek	Emu Creek	
			SR-01	SR-01R	SR-02	SR-02a	SR-03	SR-04	SR-05	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-01	SRRef-02	SRRef-03	ECRef-04	ECRef-05
<b>CHAROPHYCEAE</b>																			
<b>Charales</b>	<b>Characeae</b>	<i>Chara fibrosa</i> ^^↓	X		X	X	X		X	X	X		X					X	
<b>MAGNOLIOPSIDA</b>																			
<b>Apiales</b>	<b>Araliaceae</b>	<i>Trachymene oleracea</i> subsp. <i>oleracea</i>											X						
<b>Asterales</b>	<b>Asteraceae</b>	<i>Blumea tenella</i>											X	X				X	
		<i>Centipeda minima</i>						X								X	X	X	
		* <i>Flaveria trinervia</i>	X																
		* <i>Lactuca serriola</i>	X																
		<i>Pluchea dentex</i> ^	X				X	X		X		X		X		X	X	X	
		<i>Pluchea rubelliflora</i> ^							X					X					
		* <i>Pseudognaphalium luteoalbum</i>								X									
		<i>Pterocaulon sphacelatum</i>														X			
		<i>Streptoglossa decurrens</i>												X					
	<b>Campanulaceae</b>	<i>Lobelia arnhemiaca</i> ^^							X	X			X						
		<i>Wahlenbergia tumidiflora</i> ^							X	X								X	
	<b>Capparaceae</b>	<i>Capparis spinosa</i> subsp. <i>nummularia</i>								X		X							
	<b>Cleomaceae</b>	<i>Arivela viscosa</i>	X		X	X	X	X	X	X	X		X		X		X	X	
	<b>Goodeniaceae</b>	<i>Goodenia lamprosperma</i>							X						X				
<b>Caryophyllales</b>	<b>Aizoaceae</b>	<i>Trianthema glossostigmum</i>							X					X					
		<i>Trianthema triquetrum</i>												X					
	<b>Amaranthaceae</b>	* <i>Aerva javanica</i>											X		X				
		<i>Amaranthus undulatus</i>					X	X	X	X	X							X	
		<i>Alternanthera nodiflora</i>	X		X	X		X	X							X	X	X	
		<i>Gomphrena cunninghamii</i>				X											X		
		<i>Ptilotus clementii</i>				X													
		<i>Ptilotus obovatus</i>											X					X	
	<b>Caryophyllaceae</b>	<i>Polycarpaea longiflora</i>											X						
	<b>Chenopodiaceae</b>	<i>Dysphania plantaginella</i>							X										
	<b>Droseraceae</b>	<i>Drosera</i> sp.									X								
	<b>Molluginaceae</b>	<i>Glinus lotoides</i> ^						X											
		<i>Glinus oppositifolius</i> var. <i>keenanii</i>																X	
	<b>Nyctaginaceae</b>	<i>Boerhavia coccinea</i>	X		X	X	X			X									
	<b>Portulacaceae</b>	<i>Calandrinia</i> sp.								X								X	
		<i>Calandrinia tepperiana</i>							X									X	
		<i>Portulaca oleracea</i>						X											
<b>Cucurbitales</b>	<b>Cucurbitaceae</b>	<i>Austrobryonia pilbarensis</i>														X			
		<i>Cucumis melo</i>									X	X	X						
		<i>Cucumis variabilis</i>									X								
<b>Euasterids</b>	<b>Boraginaceae</b>	<i>Ehretia saligna</i> var. <i>saligna</i>											X	X				X	

Class/Order	Family	Lowest taxon	Glen Herring Creek					Coongan River			Resource Area				Camel Creek		Glen Herring Creek	Emu Creek	
			SR-01	SR-01R	SR-02	SR-02a	SR-03	SR-04	SR-05	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-01	SRRef-02	SRRef-03	ECRef-04	ECRef-05
		<i>Trichodesma zeylanicum</i>												X			X		
<b>Fabales</b>	<b>Fabaceae</b>	<i>Acacia ampliceps</i> <sup>^^</sup>	X		X	X	X	X		X			X	X					
		<i>Acacia bivenosa</i>										X						X	
		<i>Acacia citrinoviridis</i> <sup>^</sup>											X						
		<i>Acacia colei</i>									X	X	X			X	X	X	
		<i>Acacia coriacea</i> subsp. <i>pendens</i> <sup>^</sup>	X		X	X	X	X	X						X	X	X	X	
		<i>Acacia monticola</i>															X		
		<i>Acacia monticola</i> x <i>trachycarpa</i>											X						
		<i>Acacia orthocarpa</i>																X	
		<i>Acacia pruinocarpa</i>								X									
		<i>Acacia pyrifolia</i>	X		X	X	X	X		X		X	X	X	X	X	X	X	
		<i>Acacia trachycarpa</i>	X		X	X	X	X		X				X	X	X	X	X	
		<i>Acacia tumida</i> var. <i>pilbarensis</i>		X								X	X	X				X	
		<i>Cajanus cinereus</i> <sup>^</sup>				X						X	X						
		<i>Cullen leucanthum</i> <sup>^^</sup>							X										
		<i>Indigofera ?hirsuta</i>																X	
		<i>Indigofera linnaei</i>																X	
		<i>Indigofera monophylla</i>																X	
		<i>Indigofera trita</i> subsp. <i>Trita</i>												X					
		<i>Petalostylis labicheoides</i>				X					X			X	X				
		<i>Rhynchosia minima</i>		X			X					X		X					
		<i>Senna glutinosa</i> subsp. <i>glutinosa</i>										X		X					
		<i>Senna notabilis</i>											X		X			X	
		<i>Sesbania cannabina</i> <sup>^^</sup>	X		X	X	X	X	X	X		X		X	X			X	
		<i>Tephrosia rosea</i> var. <i>clementii</i>																X	
		<i>Tephrosia rosea</i> var. Fortescue creeks (M.I.H. Brooker 2186)										X	X						
		<i>Vigna lanceolata</i> var. <i>lanceolata</i>							X	X					X			X	
<b>Gentianales</b>	<b>Apocynaceae</b>	* <i>Calotropis procera</i>					X	X		X						X			
	<b>Gentianaceae</b>	<i>Schenkia clementii</i> <sup>^^</sup>								X									
	<b>Rubiaceae</b>	<i>Dolichocarpa crouchiana</i>				X													
		<i>Scleromitron galioides</i>										X							
		<i>Synaptantha tillaeacea</i>										X							
<b>Lamiales</b>	<b>Byblidaceae</b>	<i>Byblis pilbarana</i>										X							
	<b>Lamiaceae</b>	<i>Clerodendrum floibundum</i>										X						X	
		<i>Clerodendrum tomentosum</i> subsp. <i>Lanceolatum</i>										X	X	X					
	<b>Oleaceae</b>	<i>Jasminum didymum</i> subsp. <i>lineare</i>																X	
	<b>Plantaginaceae</b>	<i>Stemodia grossa</i> <sup>^</sup>	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	
<b>Laurales</b>	<b>Lauraceae</b>	<i>Cassytha</i> sp.			X													X	

Class/Order	Family	Lowest taxon	Glen Herring Creek					Coongan River			Resource Area				Camel Creek		Glen Herring Creek	Emu Creek	
			SR-01	SR-01R	SR-02	SR-02a	SR-03	SR-04	SR-05	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-01	SRRef-02	SRRef-03	ECRef-04	ECRef-05
<b>Malpighiales</b>	<b>Elatinaceae</b>	<i>Bergia ammannioides</i> <sup>^</sup>					X												
		<i>Bergia pedicellaris</i> <sup>^</sup>																	X
	<b>Euphorbiaceae</b>	<i>Adriana tomentosa</i> <sup>^^</sup>											X	X					
		<i>Euphorbia australis</i> var. <i>subtomentosa</i>	X		X	X	X		X					X		X		X	X
		<i>Euphorbia biconvexa</i>													X	X		X	
		<i>Euphorbia careyi</i>												X					
		<i>Euphorbia trigonsperma</i>	X		X	X	X		X	X			X				X	X	X
	<b>Passifloraceae</b>	<i>*Passiflora foetida</i> var. <i>hispida</i>											X	X					
	<b>Phyllanthaceae</b>	<i>Flueggea virosa</i> subsp. <i>melanthesoides</i> <sup>^^</sup>	X		X		X	X			X	X	X	X			X	X	
		<i>Nellica maderaspatensis</i>	X		X		X	X	X	X	X					X		X	X
<i>Notoleptopus decaisnei</i> var. <i>orbicularis</i> (A.B. Craig 428)															X				
<b>Violaceae</b>	<i>Afrohybanthus aurantiacus</i>	X		X		X			X								X		
<b>Malvales</b>	<b>Malvaceae</b>	<i>Corchorus incanus</i>		X	X	X	X	X		X				X	X	X		X	X
		<i>Gossypium australe</i>					X											X	
		<i>Hibiscus austrinus</i>														X			
		<i>Hibiscus goldsworthii</i>												X					
		<i>Sida rohlenae</i> subsp. <i>rohlenae</i>																X	
		<i>Sida</i> sp. articulation below (A.A. Mitchell PRP 1605)												X	X				
		<i>Sida</i> sp. Shovelanna Hill (S. van Leeuwen 3842)																X	
		<i>Triumfetta chaetocarpa</i>															X		
		<i>Triumfetta clementii</i>		X			X							X		X			
		<i>Waltheria indica</i>															X		
	<i>Waltheria virgata</i>																X		
<b>Myrtales</b>	<b>Combretaceae</b>	<i>Terminalia circumalata</i> <sup>^</sup>										X							
	<b>Lythraceae</b>	<i>Ammannia baccifera</i> <sup>^^</sup>			X		X			X			X						
		<i>Ammannia multiflora</i> <sup>^</sup>	X		X		X	X	X				X				X	X	X
		<i>Rotala diandra</i>																	X
	<b>Myrtaceae</b>	<i>Corymbia flavescens</i>											X		X				
		<i>Corymbia hamersleyana</i>														X			
		<i>Corymbia</i> sp.											X						
		<i>Eucalyptus camaldulensis</i> <sup>^^</sup>	X		X	X	X	X	X	X	X			X	X	X	X	X	X
		<i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i>															X		
		<i>Eucalyptus victrix</i> <sup>^^</sup>				X	X	X	X					X			X	X	
<i>Melaleuca argentea</i> <sup>^^</sup>								X	X	X		X	X	X		X			
	<i>Melaleuca glomerata</i> <sup>^^</sup>	X		X	X	X	X	X	X					X		X	X	X	
	<b>Onagraceae</b>	<i>Ludwigia perennis</i> <sup>^</sup>														X	X		
<b>Proteales</b>	<b>Proteaceae</b>	<i>Grevillea pyramidalis</i>					X												
		<i>Grevillea wickhamii</i>											X	X	X				
<b>Ranunculales</b>	<b>Menispermaceae</b>	<i>Tinospora smilacina</i> <sup>^^</sup>					X						X					X	
	<b>Papaveraceae</b>	<i>*Argemone ochroleuca</i> subsp. <i>ochroleuca</i>					X	X	X	X						X	X	X	

Class/Order	Family	Lowest taxon	Glen Herring Creek					Coongan River			Resource Area				Camel Creek		Glen Herring Creek	Emu Creek			
			SR-01	SR-01R	SR-02	SR-02a	SR-03	SR-04	SR-05	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRRef-01	SRRRef-02	SRRRef-03	ECRRef-04	ECRRef-05		
<b>Rosales</b>	<b>Moraceae</b>	<i>Ficus aculeata</i> <sup>^^</sup>										X	X	X							
		<i>Ficus brachypoda</i>									X	X	X	X					X		
<b>Santalales</b>	<b>Loranthaceae</b>	<i>Amyema sanguinea</i>																	X		
	<b>Santalaceae</b>	<i>Santalum lanceolatum</i>						X													
<b>Sapindales</b>	<b>Sapindaceae</b>	<i>Atalaya hemiglauca</i> <sup>^^</sup>	X		X	X	X	X	X	X	X	X		X	X	X	X	X	X		
		<i>Dodonaea lanceolata</i> var. <i>lanceolata</i> <sup>^^</sup>								X				X		X					
<b>Saxifragales</b>	<b>Haloragaceae</b>	<i>Gonocarpus ephemerus</i> <sup>^</sup>																	X		
<b>Solanales</b>	<b>Convolvulaceae</b>	<i>Bonamia pannosa</i>																	X		
		<i>Bonamia pilbarensis</i>																			
		<i>Duperreya commixta</i>							X												
		<i>Evolvulus alsinoides</i>																		X	
		<i>Ipomoea muelleri</i>								X			X					X		X	
		<i>Ipomoea polymorpha</i>																		X	
		<i>Polymeria ambigua</i>																			
		<i>Polymeria mollis</i>																			
		<b>Solanaceae</b>	<i>Nicotiana benthamiana</i>																		
		<i>*Physalis angulata</i>																			
		<i>Solanum diversiflorum</i>																			
		<i>*Solanum nigrum</i>																			
<b>LILIOPSIDA</b>																					
<b>Alismatales</b>	<b>Hydrocharitaceae</b>	<i>Najas tenuifolia</i> <sup>^^↓</sup>					X		X	X								X	X		
		<i>Potamogeton tepperi</i> <sup>^^↓</sup>	X		X	X	X	X	X									X	X		
		<i>Vallisneria nana</i> <sup>↓</sup>						X													
<b>Poales</b>	<b>Cyperaceae</b>	<i>Bulbostylis barbata</i> <sup>^†</sup>	X																		
		<i>Cyperus bifax</i> <sup>^†</sup>	X						X	X	X	X	X		X				X		
		<i>Cyperus cunninghamii</i>													X		X				
		<i>Cyperus difformis</i> <sup>^†</sup>													X						
		<i>Cyperus hesperius</i>													X		X				
		<i>Cyperus iria</i> <sup>^†</sup>																	X	X	
		<i>Cyperus ixiocarpus</i> <sup>^†</sup>																		X	
		<i>Cyperus leptocarpus</i> <sup>^†</sup>																		X	
		<i>Cyperus squarrosus</i> <sup>^†</sup>	X		X	X	X	X	X			X						X	X	X	
		<i>Cyperus vaginatus</i> <sup>^^†</sup>	X		X	X	X	X	X	X	X		X		X	X	X	X	X	X	
		<i>Eleocharis geniculata</i> <sup>^^†</sup>										X	X	X	X						
		<i>Fimbristylis dichotoma</i> <sup>^†</sup>									X								X	X	
		<i>Schoenoplectiella laevis</i> <sup>^†</sup>									X								X	X	
<i>Schoenoplectus subulatus</i> <sup>^^†</sup>	X		X			X	X			X						X					
<i>Schoenus falcatus</i> <sup>^^†</sup>													X	X							

Class/Order	Family	Lowest taxon	Glen Herring Creek					Coongan River			Resource Area				Camel Creek		Glen Herring Creek	Emu Creek	
			SR-01	SR-01R	SR-02	SR-02a	SR-03	SR-04	SR-05	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-01	SRRef-02	SRRef-03	ECRef-04	ECRef-05
	<b>Poaceae</b>	<i>*Cenchrus ciliaris</i>	X		X		X	X	X	X			X		X	X	X	X	
		<i>*Cenchrus setiger</i>							X										X
		<i>*Chloris barbata</i>	X				X			X					X				
		<i>Chrysopogon fallax</i>		X															
		<i>Cymbopogon ambiguus</i>	X								X	X		X					X
		<i>*Cynodon dactylon</i>						X	X	X					X				
		<i>Dactyloctenium radulans</i>	X		X		X											X	X
		<i>Dichanthium sericeum</i> subsp. <i>humilius</i>							X										
		<i>Diplachne fusca</i> subsp. <i>fusca</i>	X						X										
		<i>*Echinochloa colona</i>							X								X	X	X
		<i>Enneapogon lindleyanus</i>	X																
		<i>Enteropogon ramosus</i>													X		X	X	
		<i>Eragrostis ?setifolia</i>											X						
		<i>Eragrostis cummingii</i> ^	X		X								X					X	X
		<i>Eragrostis elongata</i> ^															X	X	
		<i>Eragrostis tenellula</i> ^	X				X	X	X	X		X					X	X	X
		<i>Eragrostis tenuifolia</i>				X													
		<i>Eriachne benthamii</i>			X		X		X	X									X
		<i>Eriachne mucronata</i>	X				X			X	X	X		X				X	
		<i>Eriachne tenuiculmis</i>	X		X	X			X								X	X	X
		<i>Eulalia aurea</i> ^			X				X	X							X		X
		<i>Leptochloa digitata</i> ^							X										
		<i>Themeda</i> sp. Panorama (P1)									X								
		<i>Themeda triandra</i>		X													X	X	X
		<i>Triodia</i> sp.			X		X						X		X			X	X
	<b>Typhaceae</b>	<i>Typha domingensis</i> ^^↑											X	X					
<b>Polypodiales</b>	<b>Pteridaceae</b>	<i>Cheilanthes sieberi</i> subsp. <i>sieberi</i>										X							
<b>Salvinales</b>	<b>Marsileaceae</b>	<i>Marsilea hirsuta</i> ^↑↓		X	X	X	X	X	X	X						X	X	X	X
		<b>Overall taxa richness</b>	<b>38</b>	<b>9</b>	<b>35</b>	<b>30</b>	<b>47</b>	<b>38</b>	<b>43</b>	<b>47</b>	<b>19</b>	<b>41</b>	<b>36</b>	<b>36</b>	<b>28</b>	<b>31</b>	<b>37</b>	<b>71</b>	<b>52</b>

## Appendix H: Hyporheic Fauna Taxonomic List

**Wet 2024**

Values are log abundances (i.e., 1=1 individual, 2 = 2-10, 3 = 11-100, 4 = 101-1000).

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River			Resource Area				Camel Creek	Glen Herring	Emu Creek	
			SR-01	SR-02	SR-03	SR-04	SR-05	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-02	SRRef-03	ECRef-04	ECRef-05
<b>ANNELIDA</b>																
	<b>Hirudinida</b>	Hirudinea sp.							1							
	<b>Oligochaeta</b>	Oligochaeta sp.			3	3							3	3		3
	Tubificida	Naididae						2								
		Naididae sp.	1						2	2						
		<i>Pristina aequiseta</i>								3	3					
		<i>Pristina leidyi</i>								3						
		<i>Pristina longiseta</i>	1	3	3	3	3		3		2	3	3	2		
		<i>Pristina nr. osborni</i>	2						2					2		2
	Phreodrilidae	Phreodrilidae sp.	2			3	2	1			3	2		3	3	3
	Polychaeta	Aeolosomatidae	2													
		Aeolosomatidae sp.	2													
<b>CNIDARIA</b>																
	<b>Hydrozoa</b>															
	Anthoathecata	Hydridae												1	3	
		Hydra sp.														
<b>PLATYHELMINTHES</b>																
	<b>Turbellaria</b>	Turbellaria sp.														1
<b>NEMATODA</b>																
		Nematoda sp.	3			1	3		1	1				2	3	2
<b>MOLLUSCA</b>																
	<b>Gastropoda</b>															
	Hygrophila	Planorbidae	1	1					1							
		Gyraulus sp.														
<b>ARTHROPODA</b>																
	<b>Crustacea</b>															
	<b>Branchiopoda</b>															
	Diplostraca	Chydoridae							3							
		Chydoridae sp.		2									1			
		<i>Leberis</i> sp.		1	2					2						
		Daphniidae								3						
		Ilyocryptidae				1									1	
		Macrothricidae												2		
	<b>Ostracoda</b>															
	Podocopida	Candonidae						1	3				4		2	
		<i>Candonopsis cf. tenuis</i>														
		<i>Candonopsis kimberleyi</i>		2									3			
		Cyprididae		1	2											1
		<i>Cypricercus</i> sp.	3	1	2								3	2		4

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River			Resource Area				Camel Creek	Glen Herring	Emu Creek	
			SR-01	SR-02	SR-03	SR-04	SR-05	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-02	SRRef-03	ECRef-04	ECRef-05
		<i>Cyprinotus cingalensis</i>	3			2										
		<i>Riocypris cf. fitzroyi</i>							2							
		<i>Stenocypris major</i>				2	1		2						3	
	Darwinulidae	<i>Vestalenula marmonieri</i>					1			2	2					
	Ilyocypridae	<i>Ilyocypris australiensis</i>	1			3									2	
<b>Maxillopoda</b>																
	Cyclopoida	Cyclopidae							2							
		<i>Ectocyclops phaleratus</i>							2							
		<i>Mesocyclops brooksi</i>							2							
		<i>Mesocyclops notius</i>	2	3	2		1			1		3	3			
		<i>Microcyclops varicans</i>	5	3	2	2	1	3	3	2	2	4	3	4	2	
		<i>Thermocyclops</i> sp.	2										2			
<b>Malacostraca</b>																
	Bathynellacea	Parabathynellidae														2
		<i>Atopobathynella</i> `sp. Biologic-PBAT078`														
<b>Hexapoda</b>																
<b>Collembola</b>																
	Symphyleona															
		Symphyleona sp.	2	2			1	1						1	3	1
<b>Arachnida</b>																
		Acari sp.	3	3			1	2	2		2	3		2	1	
	Mesostigmata	Mesostigmata sp.	1				1					2			1	
	Sarcoptiformes	Oribatida sp.			1	3				3		2				
	Trombidiformes	Trombidioidea sp.	2					1								
		Halacaridae								2						
		Hydrachnidae				1										
		Hydryphantidae				2	1	2								
		<i>Wandesia</i> `sp. Biologic-ACAR028`														
<b>Insecta</b>																
	Coleoptera	Carabidae						1								
		Carabidae sp.														
		Carabidae sp. (L)				1										
		Dytiscidae											1			
		<i>Allodessus bistrigatus</i>											2			
		<i>Bidessini</i> sp. (L)														
		<i>Copelatus irregularis</i>							3							
		<i>Limbodessus compactus</i>							2							
		<i>Sternopriscus</i> sp. (L)													1	
		Hydraenidae							4							
		Hydraenidae sp. (L)				2	1					1			2	
		Hydrophilidae							2							
		? <i>Agraphydrus</i> sp. (L)														
		<i>Berosus</i> sp. (L)		2											2	
		<i>Enochrus deserticola</i>		1											1	
		<i>Enochrus</i> sp. (L)		2											1	
		<i>Helochaers</i> sp. (L)											1		2	

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River			Resource Area				Camel Creek	Glen Herring	Emu Creek	
			SR-01	SR-02	SR-03	SR-04	SR-05	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-02	SRRef-03	ECRef-04	ECRef-05
		Hydrophilidae sp.			2			2								1
		Hydrophilidae sp. (L)		3		3	2	2				2		2		2
		<i>Paracymus</i> sp. (L)										1				
		<i>Paracymus spenceri</i>										1				
	Ptiliidae	Ptiliidae sp.				1										
	Scirtidae	Scirtidae sp. (L)							4							
	Staphylinidae	Staphylinidae sp.														1
Diptera	Ceratopogonidae	Ceratopogonidae sp. (P)				3	1	1	1			1	2		2	3
		Ceratopogoninae sp.	5	3	4	4	3	3	3	2	4	3	3	3	4	4
		<i>Dasyhelea</i> sp.			2				2	2		3			3	
		Forcipomyiinae sp.							2							
	Chironomidae	Chironomidae sp. (P)	2	2										1	2	
		<i>Chironomus</i> aff. <i>alternans</i>			3				1							
		<i>Cladopelma curtivalva</i>	2	3	2										2	
		<i>Cladotanytarsus</i> sp.	3	3	3	2	2	2					2	3	3	
		<i>Cryptochironomus griseidorsum</i>	1			1			1							2
		<i>Dicrotendipes</i> sp. `CA1`		2			3									
		<i>Larsia ?albiceps</i>	2	2	4		2			1				1	2	2
		<i>Microchironomus</i> sp.												2		
		<i>Nilotanypus</i> sp.						3	3			3				
		<i>Paramerina</i> sp. 1		3			2									
		<i>Paraskusella</i> sp. K2	2	2											2	
		<i>Polypedilum nubifer</i>							1							
		<i>Polypedilum watsoni</i>	5	2	2		2	2		1		1		2	3	3
		<i>Procladius</i> sp.	4	4	4		3			1					3	3
		Tanypodinae sp.				2			3	2		1	3		3	
		<i>Tanytarsus</i> sp.	2	3	3	2	2		2	2			2		3	2
		<i>Thienemanniella</i> sp.														2
	Culicidae	Culicidae sp.							2					1		
	Dolichopodidae	Dolichopodidae sp.		1	2	2						2				
	Ephydriidae	Ephydriidae sp.		2		1								2	2	
	Muscidae	Muscidae sp.	1		2		1	3						2		2
	Psychodidae	Psychodidae sp.			2										2	
	Stratiomyidae	Stratiomyidae sp.									1					
	Tipulidae	Tipulidae sp.	2			4										
Ephemeroptera		Ephemeroptera sp.			1								2			
	Baetidae	Baetidae sp.												2	2	
		<i>Cloeon</i> sp.												1		
	Caenidae	Caenidae sp.		2										1		2
Hemiptera	Hebridae	Hebridae sp.	2													
	Pleidae	<i>Paraplea brunni</i>				1										

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River			Resource Area				Camel Creek	Glen Herring	Emu Creek	
			SR-01	SR-02	SR-03	SR-04	SR-05	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-02	SRRef-03	ECRef-04	ECRef-05
	Veliidae	<i>Nesidovelia</i> sp.							1							
Corixoidea		Corixoidea sp.												2		
Odonata																
Anisoptera		Anisoptera sp.		1						1						
Trichoptera	Hydroptilidae	<i>Orthotrichia</i> sp.							1							
	Leptoceridae	Leptoceridae sp.													1	
		<i>Oecetis</i> sp.		1												
		<b>Taxa richness</b>	<b>30</b>	<b>31</b>	<b>22</b>	<b>26</b>	<b>25</b>	<b>18</b>	<b>34</b>	<b>16</b>	<b>7</b>	<b>9</b>	<b>23</b>	<b>25</b>	<b>35</b>	<b>23</b>

**Dry 2024**

Values are log abundances (i.e., 1=1 individual, 2 = 2-10, 3 = 11-100, 4 = 101-1000).

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River		Resource Area				Glen Herring	Emu Creek
			SR-01	SR-02	SR-03	SR-04	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-03	ECRef-04
<b>ANNELIDA</b>													
<b>Oligochaeta</b>													
		Oligochaeta sp.	2									2	3
	Tubificida	Enchytraeidae										3	
		Naididae							1				
		<i>Chaetogaster</i> sp.			3								
		<i>Dero nivea</i>			2								
		<i>Pristina aequiseta</i>	2						2				3
		<i>Pristina leidyi</i>						2	3				3
		<i>Pristina longiseta</i>	3		2	3	2	3		2	2		
		<i>Pristina</i> nr. <i>osborni</i>						3					
	Phreodrilidae	Phreodrilidae sp.				3	2					2	3
<b>Polychaeta</b>	Aeolosomatidae	Aeolosomatidae sp.		3	3								
<b>CNIDARIA</b>													
<b>Hydrozoa</b>													
	Anthoathecata	Hydridae			2		2	2					
<b>PLATYHELMINTHES</b>													
<b>Turbellaria</b>													
		Turbellaria sp.	2										
<b>NEMATODA</b>													
		Nematoda sp.		1	1	1						2	1
<b>MOLLUSCA</b>													
<b>Gastropoda</b>													
	Hygrophila	Lymnaeidae	1	2	2		3						2
		Planorbidae	2		2		3						
<b>ARTHROPODA</b>													
<b>Crustacea</b>													
<b>Branchiopoda</b>													
	Diplostraca	Ilyocryptidae											1
<b>Ostracoda</b>													
	Podocopida	Candonidae	1	3									3
		Cyprididae						1					
		Darwinulidae							1	2			
		Ilyocypridae		2				3					
<b>Maxillopoda</b>													
	Calanoida	Diaptomidae								1			

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River		Resource Area				Glen Herring	Emu Creek
			SR-01	SR-02	SR-03	SR-04	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRRef-03	ECRef-04
Cyclopoida	Cyclopidae	<i>Ectocyclops phaleratus</i>						2			3		
		<i>Mesocyclops brooksi</i>						2					
		<i>Mesocyclops notius</i>		3				3					
		<i>Mesocyclops</i> sp.				2							
		<i>Microcyclops varicans</i>	2	3		2	3		2	2	3		2
		<i>Thermocyclops</i> sp.				2		2		3	2		
Harpacticoida	Canthocamptidae	<i>Australocamptus</i> `sp. Biologic-HARP099`					1						
<b>Hexapoda</b>													
<b>Collembola</b>													
Symphyleona		Symphyleona sp.		2	1		2						
<b>Arachnida</b>		Acari sp.				2							
Mesostigmata		Mesostigmata sp.		2						2			2
Sarcoptiformes		Oribatida sp.					1	3	3				
Trombidiformes		Trombidioidea sp.	1			1	2						
	Aturidae	<i>Axonopsella</i> sp.					1						
	Halacaridae	Halacaridae sp.					1		1	2	1		
	Hydryphantidae	<i>Wandesia</i> `sp. Biologic-ACAR028`					3						
	Mideopsidae	<i>Guineaxonopsis</i> sp.					1						
<b>Insecta</b>													
Coleoptera	Carabidae	Carabidae sp.	2										
	Dytiscidae	<i>Copelatus irregularis</i>						2					
		<i>Hydroglyphus grammopterus</i>				2	2						
		<i>Hydroglyphus orthogrammus</i>					2						
		<i>Limbodessus compactus</i>							1				
	Hydraenidae	<i>Hydraena</i> sp.				1		3					
		Hydraenidae sp. (L)	1	2			3						2
		<i>Limnebius</i> sp.			2		2						
		<i>Ochthebius</i> sp.	3		3								
	Hydrochidae	<i>Hydrochus obsкуроaeneus</i>									1		
		<i>Hydrochus</i> sp. (L)	3	1			3				1		2
	Hydrophilidae	<i>Agraphydrus coomani</i>					1						
		<i>Agraphydrus coomani</i> (L)				2							
		<i>Berosus</i> sp. (L)					2						
		<i>Enochrus deserticola</i>					1						
		<i>Helochares</i> sp. (L)		2	3		2						
		Hydrophilidae sp. (L)	1					2		1			
		<i>Laccobius</i> sp. (L)					3						
		nr. <i>Anacaena</i> sp.						1					

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River		Resource Area				Glen Herring	Emu Creek
			SR-01	SR-02	SR-03	SR-04	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-03	ECRef-04
		<i>Paracymus spenceri</i>			2								
	Limnichidae	Limnichidae sp. B	2										
	Noteridae	<i>Notomicrus tenellus</i>		1									
	Ptiliidae	Ptiliidae sp.					3						
	Scirtidae	Scirtidae sp. (L)						3		2	3		
Diptera	Ceratopogonidae	Ceratopogonidae sp. (P)	2			3	3	1				2	2
		Ceratopogoninae sp.	4	3	3	3	3	2	2	3	3	3	4
		<i>Dasyhelea</i> sp.		2				2		3			2
		Forcipomyiinae sp.								1	2		
	Chironomidae	<i>Cladotanytarsus</i> sp.			2								
		<i>Coelopynia pruinosa</i>			1								
		<i>Cryptochironomus griseidorsum</i>					3						
		<i>Larsia ?albiceps</i>						1			2		
		nr. <i>Gymnometriocnemus</i> sp.								1			
		Orthocladiinae sp.								2			
		<i>Paramerina</i> sp. 1		3				3	1		2		
		<i>Paraskusella</i> sp. K2	2	2									
		<i>Polypedilum nubifer</i>								1		2	
		<i>Polypedilum watsoni</i>									3		
		<i>Procladius</i> sp.		2			3		2				
		<i>Stenochironomus watsoni</i>						1					
		<i>Tanytarsus</i> sp.			3	2	3	2	2		1		
	Culicidae	Culicidae sp.										1	
	Dolichopodidae	Dolichopodidae sp.		2				2		2	2		2
	Ephydriidae	Ephydriidae sp.	2							2		2	
	Muscidae	Muscidae sp.		1	1								
	Psychodidae	Psychodidae sp.				2	1					2	2
	Sciaridae	Sciaridae sp.								2			
	Stratiomyidae	Stratiomyidae sp.								2			
	Tipulidae	Tipulidae sp.		1		1	3			2	2	1	1
Ephemeroptera	Baetidae	Baetidae sp.											1
	Caenidae	Caenidae sp.	1		2		3						1
Hemiptera	Micronectidae	<i>Micronecta annae</i>						1					
Trichoptera	Ecnomidae	<i>Ecnomus pilbarensis</i>						2					
	Leptoceridae	<i>Oecetis</i> sp. Pilbara 4			3		2						
		<b>Taxa richness</b>	<b>20</b>	<b>21</b>	<b>20</b>	<b>16</b>	<b>41</b>	<b>23</b>	<b>10</b>	<b>19</b>	<b>18</b>	<b>9</b>	<b>20</b>

## Appendix I: Macroinvertebrate Taxonomic List

**Wet 2024**

Values are log abundances (i.e., 1=1 individual, 2 = 2-10, 3 = 11-100, 4 = 101-1000).

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River			Resource Pools				Camel Creek		Glen Herring	Emu Creek	
			SR-01	SR-02	SR-03	SR-04	SR-05	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRef-01	SRef-02	SRef-03	ECRef-04	ECRef-05
<b>ANNELIDA</b>																	
	<b>Hirudinida</b>	Hirudinea sp.							3	2							
	<b>Oligochaeta</b>	Oligochaeta sp.			1				2			3					2
	Tubificida	Naididae										3					
		<i>Allonais paraguayensis</i>															
		<i>Allonais pectinata</i>										2					1
		<i>Allonais ranauana</i>							2				1				
		<i>Aulophorus furcatus</i>						2					2			2	
		<i>Dero nivea</i>															1 3
		<i>Nais communis</i>															2
		<i>Pristina longiseta</i>	2		2			2	2			1			1		2
	Phreodrilidae	Phreodrilidae sp.				2						1	2				1
	<b>Polychaeta</b>	Aelosomatidae															2
<b>CNIDARIA</b>																	
	<b>Hydrozoa</b>																
	Anthoathecata	Hydridae				1	3				3					2	3
<b>ROTIFERA</b>																	
		Rotifera sp.		3					3								
<b>NEMATODA</b>																	
		Nematoda sp.		2	3			2				2				2	
<b>MOLLUSCA</b>																	
	<b>Gastropoda</b>																
	Hygrophila	Lymnaeidae		3		3	4	3		1	3				2	2	3
		Planorbidae										3					
		<i>Glyptophysa</i> sp.							3		3						
		<i>Gyraulus</i> sp.	2	3	2	3	3	3	3	3	4				2	2	2
<b>ARTHROPODA</b>																	
	<b>Crustacea</b>																
	<b>Branchiopoda</b>																
	Diplostraca																
	Cladocera	Cladocera sp.									1	2	1		1		
		Chydoridae		2		2	2										1
		<i>Leberis</i> sp.		2		2	2							2			
		Daphniidae							4								
		<i>Simocephalus expinosus</i>	3	4	2	3	3	1									

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River			Resource Pools				Camel Creek		Glen Herring	Emu Creek	
			SR-01	SR-02	SR-03	SR-04	SR-05	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRRef-01	SRRRef-02	SRRRef-03	ECRef-04	ECRef-05
	Ilyocryptidae	<i>Ilyocryptus</i> sp.														2	
	Macrothrichidae	<i>Macrothrix</i> sp.		3	3								2			2	1
	Moinidae	<i>Moina</i> sp.											3				
	Sididae	<i>Latonopsis australis</i>	1	3		2	3										
Conchostraca	Cyzicidae	<i>Ozestheria</i> `sp. Biologic-BRAN002`		2		1	1	2							1	1	3
<b>Maxillopoda</b>																	
Calanoida	Diaptomidae	<i>Eodiaptomus lumholtzi</i>						1						2			
Cyclopoida	Cyclopidae	<i>Ectocyclops phaleratus</i>										2					
		<i>Mesocyclops brooksi</i>					4										
		<i>Mesocyclops darwini</i>									4		4				
		<i>Mesocyclops notius</i>	3	4	4	3		2	4	3	3			4	4		
		<i>Microcyclops varicans</i>	2	3	3	2		2								3	4
		<i>Thermocyclops</i> sp.										1					
<b>Ostracoda</b>																	
Podocopida																	
	Cyprididae	<i>Bennelongia tirigie</i>	2					2							1		3
		<i>Cypretta</i> `sp. Biologic-OSTR015`		3	3	2	2										
		<i>Cypretta</i> sp.	2				1		3		4				2	3	
		<i>Cypretta</i> `sp. Biologic-OSTR138`								3							
		<i>Cypricercus</i> sp.	3						3								
		Cyprididae `sp. Biologic-OSTR018`		3	3	2								2		2	2
		Cyprididae `sp. Biologic-OSTR135`								2							
		Cyprididae `sp. Biologic-OSTR136`											4				
		<i>Cypridopsis</i> sp.	1		2							2					
		<i>Cyprinotus cingalensis</i>	1					3					3				
		<i>Hemicypris</i> sp.				2											
		<i>Heterocypris</i> sp.											1				
		<i>Ilyodromus</i> sp.	2														
		<i>Riocypris</i> cf. <i>fitzroyi</i>		1			2	2		2	4	2			2	2	
		<i>Sarscypridopsis aculeata</i>						3							3		
		<i>Stenocypris major</i>				3	2	2	3							3	4
	Ilyocypridae	<i>Ilyocypris australiensis</i>	2			2	2										
	Notodromadidae	<i>Newnhamia fenestrata</i>							3								
<b>Arachnida</b>																	
Araneae	Pisauridae	<i>Dolomedes</i> sp.						2		1	2						
Mesostigmata		Mesostigmata sp.			2												
Trombidiformes		Acari sp.	3	2	3	2	2		3	3		2	3	2	3	3	3
		Trombidioidea sp.										1					
	Arrenuridae	<i>Arrenurus (Arrenurus)</i> sp.			2	2											3

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River			Resource Pools				Camel Creek		Glen Herring	Emu Creek	
			SR-01	SR-02	SR-03	SR-04	SR-05	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRRef-01	SRRRef-02	SRRRef-03	ECRRef-04	ECRRef-05
		<i>Arrenurus (Brevicadaturus) sp.</i>						2									
		<i>Arrenurus (Dividuracarus) sp.</i>			2		1										3
		<i>Arrenurus (Megaluracarus) sp.</i>			2												3
		<i>Arrenurus (Truncaturus) sp.</i>						2									
		<i>Arrenurus sp.</i>	1					2		1						2	3
	Eylaidae	<i>Eylais sp.</i>												1		1	
	Halacaridae	Halacaridae sp.										1					
	Hydrachnidae	<i>Hydrachna sp.</i>						2									
	Hydrodromidae	<i>Hydrodroma sp.</i>	1											1			
	Limnesiidae	<i>Limnesia maceripalpis</i>			2												
		<i>Limnesia parasolida</i>	2			2		1					1			2	3
		<i>Limnesia sp. `solida group`</i>		1	3	2	2	1	3	2	4	2			2	2	3
	Oxidae	<i>Oxus sp.</i>			2												
	Unionicolidae	<i>Neumania sp.</i>					1						3	1	2		3
		<i>Recifella sp.</i>					1								2		3
		Unionicolidae `sp. Biologic-ACAR043`											4				
<b>Insecta</b>																	
Coleoptera	Dytiscidae	<i>Allodessus bistrigatus</i>											2		1		
		<i>Bidessini sp. (L)</i>				1						1					
		<i>Copelatus irregularis</i>										1					
		<i>Cybister sp. (L)</i>						1									
		<i>Cybister tripunctatus</i>						2	2	2			2	1			
		<i>Eretes australis</i>						3					2	2			
		<i>Eretes sp. (L)</i>									1						
		<i>Hydaticus daemeli</i>						3	1	2	1						
		<i>Hydroglyphus godeffroyi</i>					2	1									1
		<i>Hydroglyphus grammopterus</i>			2	3	3	3					3	3	4	3	2
		<i>Hydroglyphus orthogrammus</i>	2	3	2	3		3	1				2	2	3	3	2
		<i>Hydrovatus sp. (L)</i>								1	2						
		<i>Hyphydrus elegans</i>									2				2		
		<i>Hyphydrus lyratus</i>			1	2	1	1					3	1	3	2	
		<i>Hyphydrus sp. (L)</i>							1		3		1				
		<i>Laccophilus sp. (L)</i>											2				
		<i>Limbodessus compactus</i>					1		1	2							1
		<i>Necterosoma regulare</i>				1											
		<i>Neobidessodes denticulatus</i>				2								2			
		<i>Onychohydrus sp. (L)</i>									2						
		<i>Sternopriscus goldbergi</i>				1											

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River			Resource Pools				Camel Creek		Glen Herring	Emu Creek	
			SR-01	SR-02	SR-03	SR-04	SR-05	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-01	SRRef-02	SRRef-03	ECRef-04	ECRef-05
		<i>Tiporus giuliani</i>						2									
		<i>Tiporus</i> sp.		2				2		1							
		<i>Tiporus</i> sp. (L)						2	1								
		<i>Tiporus tambreyi</i>				3	2	2									
	Gyrinidae	<i>Dineutus australis</i>		4				3	2			2	4				
		<i>Dineutus australis</i> (L)										2					
		Gyrinidae sp.			3							3				4	
		<i>Macrogyrus angustatus</i>							1								
		<i>Macrogyrus gibbosus</i>								3							
	Halipidae	<i>Halipus pilbaraensis</i>					1							2			
	Hydraenidae	<i>Hydraena</i> sp.	1		2			1	3	2	2	3	3	2	2	3	3
		<i>Ochthebius</i> sp.				2						3					
	Hydrochidae	<i>Hydrochus burdekinensis</i>												2			2
		<i>Hydrochus interioris</i>	2		1	3		2					2	3	2	2	3
		<i>Hydrochus macroaquilonius</i>				1							1	2			2
		<i>Hydrochus obscuroaeneus</i>			1	3	1	1	2	2	2	3	2		3	1	
		<i>Hydrochus</i> sp. P1						1						2			3
	Hydrophilidae	<i>Agraphydrus coomani</i>					2						2				
		<i>Berosus australiae</i>												1			
		<i>Berosus dallasi</i>		1	2	1		3					2	3	2	2	
		<i>Berosus pulchellus</i>										1					
		<i>Berosus</i> sp. (L)				2										1	
		<i>Enochrus deserticola</i>								2							2
		<i>Enochrus eyrensis</i>									1	1					
		<i>Helochares</i> sp. (L)			2			1	1					2	1		
		<i>Helochares tatei</i>			1												2
		Hydrophilidae sp.		1													
		Hydrophilidae sp. (L)			2												2
		<i>Laccobius matthewsi</i>					1							1			2
		nr. <i>Anacaena</i> sp.														1	
		<i>Paracymus spenceri</i>						1	1			2		2			2
		<i>Regimbartia attenuata</i>						1		2							
		<i>Sternolophus australis</i>							3	2	1	2	2				
	Scirtidae	Scirtidae sp. (L)									2	1					
Diptera	Ceratopogonidae	Ceratopogonidae sp. (P)		2				1			1	1					1
		Ceratopogoninae sp.	2	3	3	3	3	3	2	3	2	3	3	3	3	3	4
		<i>Dasyhelea</i> sp.						2		2	2		2	3			2
		Forcipomyiinae sp.						1		1		2					
	Chironomidae	<i>Ablabesmyia hilli</i>				2	2	2	2	2	3		3			1	
		Chironomidae sp. (P)	2		3	2	2			2	3	1	2		3	2	

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River			Resource Pools				Camel Creek		Glen Herring	Emu Creek	
			SR-01	SR-02	SR-03	SR-04	SR-05	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-01	SRRef-02	SRRef-03	ECRef-04	ECRef-05
		Chironominae sp.						2					2				
		<i>Chironomus</i> aff. <i>alternans</i>								3	1	4	2	3			
		<i>Cladotanytarsus</i> sp.	3	3		2	3						2	3	2	2	
		<i>Coelopynia pruinosa</i>		2		2	2							2			
		<i>Cryptochironomus griseidorsum</i>				2								2			
		<i>Dicrotendipes jobetus</i>											2	2			1
		<i>Dicrotendipes</i> sp. `CA1`	2	3	3	3	4	3		2		2	2	3	3		
		<i>Harnischia</i> sp.				2											
		<i>Kiefferulus intertinctus</i>			2						4						
		<i>Larsia ?albiceps</i>	3	3	3	3	4	3	3	3			3	3	3	3	4
		<i>Nanocladius</i> sp.	2	2	2	2	2						2	2			
		<i>Paramerina</i> sp. 1		3	3				3								
		<i>Paramerina</i> sp. 2									4						
		<i>Polypedilum (Pentapedilum) leei</i>							2		4			2			
		<i>Polypedilum watsoni</i>		3						1	4	2				2	2
		<i>Procladius</i> sp.	3	3	4	3	4	3	2		4	2	3	3	4	3	4
		<i>Stenochironomus watsoni</i>							2	2	3	2					
		<i>Tanytarsus</i> sp.	2	4	4	2	4	3	4	3	4	3		3	2	2	2
	Culicidae	Culicidae sp.	2	1	2	3	2	2	2	2	2	3	4	2	1		
		Culicidae sp. (P)		1		2				1			4				
	Ephydriidae	Ephydriidae sp.			1	2		2					3	2			2
	Psychodidae	Psychodidae sp.		3													
	Stratiomyidae	Stratiomyidae sp.						2			1						
Ephemeroptera	Baetidae	Baetidae sp.	3	4	4		4	3	4	3	3	1		3	3	3	2
		<i>Cloeon</i> sp.		3													
		<i>Cloeon</i> sp. Red Stripe	2		3	4	4	2	3	3	2		4	3	3	2	
	Caenidae	Caenidae sp.	2		2		2		4	2		1		2	2		
		<i>Tasmanocoenis</i> sp.									3		2				
		<i>Tasmanocoenis</i> sp. M		1		2							2		2	4	
		<i>Tasmanocoenis</i> sp. P/arcuata			2	2			2	2	3				2		
Hemiptera	Belostomatidae	<i>Diplonychus eques</i>									2						
Corixoidea		Corixoidea sp.		2	3		2						3				2
	Corixidae	<i>Agraptocorixa parvipunctata</i>								1							
		<i>Agraptocorixa</i> sp.											2				
		Corixidae sp.	2							3					3	2	
	Micronectidae	<i>Micronecta annae</i>				3											1
		<i>Micronecta paragoga</i>				2			1								
		<i>Micronecta</i> sp.		2		2							3				1
		<i>Micronecta virgata</i>											3				

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River			Resource Pools				Camel Creek		Glen Herring	Emu Creek	
			SR-01	SR-02	SR-03	SR-04	SR-05	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-01	SRRef-02	SRRef-03	ECRef-04	ECRef-05
	Gelastocoridae	<i>Nerthra</i> sp.															1
	Gerridae	Gerridae sp.	3	4	3	2	3	3		1		1		2	3		
		<i>Limnogonus fossarum gilguy</i>	1					1		2			1		2		1
		<i>Limnogonus</i> sp.										2					
	Nepidae	<i>Laccotrephes tristis</i>							2	1							
	Notonectidae	<i>Anisops hackeri</i>				1							3				
		<i>Anisops nabillus</i>								1							
		<i>Anisops nasutus</i>											3				
		<i>Anisops</i> sp.							2	2	2		3				
		<i>Anisops stali</i>											3				
		<i>Enithares woodwardi</i>							2		2						
		Notonectidae sp.							4	2	3		4				
	Pleidae	<i>Paraplea brunni</i>	1			3		1	1	1	3				1		
	Veliidae	<i>Microvelia oceanica</i>				1											
		<i>Nesidovelia australiensis</i>							1			1					
		<i>Nesidovelia herberti</i>							1								
		<i>Nesidovelia peramoena</i>									2						
		<i>Nesidovelia</i> sp.										3					
		Veliidae sp.							2	3	3	2			2		
Lepidoptera	Crambidae	Acentropinae sp.										1					
Odonata																	
Anisoptera		Anisoptera sp.	2	1			2	2	3	3	4	4	2	1			
	Aeshnidae	<i>Adversaeschna brevistyla</i>											1				
		Aeshnidae sp.				2			1				1				
		<i>Hemianax papuensis</i>							2	2	2						
	Corduliidae	<i>Hemicordulia koomina</i>									2						
		<i>Hemicordulia tau</i>		1	2		2						1		2	1	
	Gomphidae	<i>Austroepigomphus (Xerogomphus) gordonii</i>				1											
	Libellulidae	<i>Diplacodes bipunctata</i>				2							2			2	
		<i>Diplacodes haematodes</i>	2	1		2				2							3
		<i>Diplacodes</i> sp.										1					
		<i>Orthetrum caledonicum</i>	1			2	1			2	2		1			2	3
		<i>Orthetrum migratum</i>							1		2						
		<i>Tramea</i> sp.					2			2	2		2	1			
	Lindeniiidae	<i>Ictinogomphus dobsoni</i>							2								
Zygoptera		Zygoptera sp.	2	2	1		2	3	3	3	4	3		3			1
	Coenagrionidae	<i>Agrion sp.</i>				2											1
		<i>Austroagrion pindrina</i>											1				
		<i>Austroagrion</i> sp.									2						
		<i>Ischnura aurora</i>									3						

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River			Resource Pools				Camel Creek		Glen Herring	Emu Creek	
			SR-01	SR-02	SR-03	SR-04	SR-05	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-01	SRRef-02	SRRef-03	ECRef-04	ECRef-05
		<i>Pseudagrion aureofrons</i>				1											
	Isostictidae	<i>Eurysticta coolawanyah</i>													2		
	Platycnemididae	<i>Nososticta</i> sp.				1											
Trichoptera	Ecnomidae	Ecnomidae sp.	2					2		1							
		<i>Ecnomus pilbarensis</i>	1				1						1	2			
		<i>Ecnomus</i> sp.			1												
	Hydroptilidae	<i>Orthotrichia</i> sp.						3		1						1	
	Leptoceridae	Leptoceridae sp.			3			2		2							
		<i>Oecetis</i> sp.					2										
		<i>Oecetis</i> sp. Pilbara 4	2	2	3	3									3		
		<i>Triplectides ciuskus seductus</i>								2							
		<b>Taxa richness</b>	<b>43</b>	<b>47</b>	<b>52</b>	<b>68</b>	<b>54</b>	<b>55</b>	<b>58</b>	<b>60</b>	<b>69</b>	<b>40</b>	<b>53</b>	<b>43</b>	<b>64</b>	<b>55</b>	<b>52</b>

**Dry 2024**

Values are log abundances (i.e., 1=1 individual, 2 = 2-10, 3 = 11-100, 4 = 101-1000).

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River		Resource Pools				Glen Herring	Emu Creek
			SR-01	SR-02a	SR-03	SR-04	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-03	ECRef-04
<b>ANNELIDA</b>													
	<b>Hirudinida</b>	Hirudinea sp.						2					
	<b>Oligochaeta</b>												
	Tubificida	Naididae							4				
		<i>Allonais paraguayensis</i>											
		<i>Allonais pectinata</i>									3		
		<i>Allonais ranauana</i>	1								1		
		<i>Aulophorus furcatus</i>						2					
		<i>Dero nivea</i>			3	4							1
		Naidinae sp.	2	2	3	4							
		<i>Nais variabilis</i>									1		
		<i>Pristina aequiseta</i>			4	3	1	2	3	1			1
		<i>Pristina longiseta</i>	3	1	3	3		2		3	2		
	Phreodrilidae	Phreodrilidae sp.						1			2		
<b>CNIDARIA</b>													
	<b>Hydrozoa</b>												
	Anthoathecata	Hydridae			3		1	2	3	2			2
<b>NEMATODA</b>													
		Nematoda sp.			2	3				3		1	1
<b>PLATYHELMINTHES</b>													
	<b>Trematoda</b>	Trematoda sp.			2								
	<b>Turbellaria</b>	Turbellaria sp.			1					2			
<b>MOLLUSCA</b>													
	<b>Gastropoda</b>												
	Hygrophila	Lymnaeidae			4	2	4				3	1	4
		Planorbidae									3		
		<i>Glyptophysa</i> sp.						3		3			
		<i>Gyraulus</i> sp.	3	3	4	2	4	3	3	3			4
<b>ARTHROPODA</b>													
	<b>Crustacea</b>												
	<b>Branchiopoda</b>												
	Diplostraca												
	Cladocera	Cladocera sp.						2					
	Chydoridae	Chydoridae sp.						1					2

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River		Resource Pools				Glen Herring	Emu Creek
			SR-01	SR-02a	SR-03	SR-04	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRRef-03	ECRef-04
		<i>Leberis</i> sp.						1					
	Daphniidae	<i>Ceriodaphnia</i> sp.						2					4
		<i>Simocephalus expinosus</i>		3			1						5
		<i>Simocephalus</i> sp.	4										
	Ilyocryptidae	<i>Ilyocryptus</i> sp.				2							
	Macrothrichidae	<i>Macrothrix</i> sp.			2								
	Moinidae	<i>Moina</i> sp.										5	2
	Sididae	<i>Latonopsis australis</i>	4	3		4							4
		Sididae sp.				4						4	
Conchostraca	Cyzicidae	<i>Ozestheria</i> `sp. Biologic-BRAN002`											1
<b>Maxillopoda</b>													
Calanoida	Diaptomidae	<i>Eodiaptomus lumholtzi</i>				5							
Cyclopoida	Cyclopidae	<i>Ectocyclops phaleratus</i>							3		3		
		<i>Mesocyclops brooksi</i>	3	3				3					
		<i>Mesocyclops darwini</i>				4				4			5
		<i>Mesocyclops notius</i>	4	3	5	4	4	3	3	4	4	5	4
		<i>Microcyclops varicans</i>	4							3			
		<i>Paracyclops fimbriatus</i>								3			
<b>Ostracoda</b>													
Podocopida	Candonidae	<i>Candonopsis cf. tenuis</i>				2							2
	Cyprididae	<i>Bennelongia</i> sp.					2						
		<i>Cypridopsis</i> sp.											4
		<i>Ilyodromus</i> sp.	3	1									
		<i>Riocypris cf. fitzroyi</i>								4			
		<i>Stenocypris major</i>						3					3
		<i>Ilyodromus</i> `sp. Biologic-OSTR014`						2					
		Cyprididae sp.						3					
		<i>Cypretta</i> sp.							2	3			2
	Notodromadidae	<i>Newnhamia fenestrata</i>						4					
<b>Arachnida</b>													
Araneae	Pisauridae	<i>Dolomedes</i> sp.								1			
Sarcoptiformes		<i>Oribatida</i> sp.							2				
Trombidiformes		Acari sp.	3	3	3	2	2				2	1	4
	Anisitsiellidae	<i>Rutacarus</i> sp.							1				
	Arrenuridae	<i>Arrenurus (Brevicadaturus)</i> sp.							1				
		<i>Arrenurus (Dividuracarus)</i> sp.		2									
		<i>Arrenurus (Megaluracarus)</i> sp.	3	3	3								3
		<i>Arrenurus</i> sp.	2	3	3		1						3
	Eylaidae	<i>Eylais</i> sp.	3				1	2		3			3

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River		Resource Pools				Glen Herring	Emu Creek		
			SR-01	SR-02a	SR-03	SR-04	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-03	ECRef-04		
	Halacaridae	Halacaridae sp.							1						
	Hydrachnidae	<i>Hydrachna</i> sp.								3			3		
	Hydrodromidae	<i>Hydrodroma</i> sp.			3		1	3							
	Hydryphantidae	<i>Pseudohydryphantes</i> sp.											3		
	Hygrobatidae	<i>Coaustraliobates minor</i>	3	2	3		1						3		
	Limnesiidae	<i>Limnesia maceripalpis</i>		2	3		1								
		<i>Limnesia parasolida</i>		2	3	2	1						3		
		<i>Limnesia</i> sp. `solida group`	3	3	4	3	2	3	2	4	2		3		
	Oxidae	<i>Oxus</i> sp.													
	Pionidae	<i>Piona cumberlandensis</i>											3		
		<i>Piona</i> nr. <i>australiana</i>			3										
	Unionicolidae	<i>Neumania</i> sp.		2		2	1								
		<i>Recifella</i> sp.	3		3	2	1						3		
		<i>Unionicola</i> sp.	3			1									
<b>Insecta</b>															
Coleoptera	Dytiscidae	<i>Allodessus bistrigatus</i>			3									3	
		<i>Bidessini</i> sp. (L)							1						
		<i>Cybister</i> sp. (L)												3	
		<i>Cybister tripunctatus</i>	2	1				2		1	1				
		<i>Eretes australis</i>										2		1	
		<i>Hydaticus consanguineus</i>							1	1					
		<i>Hydaticus daemeli</i>							3	2	2	1			
		<i>Hydroglyphus grammopterus</i>			4	4	3								3
		<i>Hydroglyphus leai</i>		1											
		<i>Hydroglyphus orthogrammus</i>	3	2	4	3	3	3	3	1			8		3
		<i>Hydrovatus opacus</i>						2			1				
		<i>Hydrovatus</i> sp. (L)						2			1				
		<i>Hyphydrus elegans</i>		2	3	3			1		1				
		<i>Hyphydrus lyratus</i>	2	3	4	3	3						3		3
		<i>Hyphydrus</i> sp. (L)	1												3
		<i>Laccophilus sharpi</i>								1					3
		<i>Limbodessus compactus</i>								2			1		
<i>Limbodessus occidentalis</i>			1												
<i>Necterosoma regulare</i>			1												
<i>Neobidessodes denticulatus</i>					3										
<i>Platynectes decempunctatus</i> var. <i>decempunctatus</i>								2							
<i>Rhantus</i> sp. (L)						1									
<i>Tiporus giuliani</i>								3		1					

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River		Resource Pools				Glen Herring	Emu Creek
			SR-01	SR-02a	SR-03	SR-04	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-03	ECRef-04
		<i>Tiporus lachlani</i>						1		2			
		<i>Tiporus</i> sp.						3		1			
		<i>Tiporus</i> sp. (L)						3					
		<i>Tiporus tambreyi</i>			3	3	3					3	
	Gyrinidae	<i>Dineutus australis</i>	2									4	
		Gyrinidae sp.						4					
		<i>Macrogyrus gibbosus</i>								2			
		<i>Macrogyrus</i> sp. (L)						1					
	Halipidae	<i>Halipus pilbaraensis</i>		1	1								
		<i>Halipus</i> sp. (L)										1	
	Hydraenidae	<i>Hydraena</i> sp.		1	2	3	2	3	2	2		1	
		<i>Limnebius</i> sp.			2	2	1	2			1	1	
		<i>Ochthebius</i> sp.			2	2					1	1	
	Hydrochidae	<i>Hydrochus burdekinensis</i>	1										
		<i>Hydrochus interioris</i>	2	2				1	2				
		<i>Hydrochus macroaquilonius</i>	2	2				1	1			1	
		<i>Hydrochus obscuroaeus</i>						2	2	2	2		
		<i>Hydrochus</i> sp. (L)	1										
		<i>Hydrochus</i> sp. P1	1					1					
	Hydrophilidae	<i>Agraphydrus coomani</i>				1							
		<i>Anacaena horni</i>				1		2		2	1		
		<i>Berosus dallasi</i>		2	2	3	3				2	4	
		<i>Coelostoma fabricii</i>						1					
		<i>Enochrus deserticola</i>						2	2				
		<i>Helochares</i> sp. (L)		1	2	1		1	2		1		
		<i>Helochares tatei</i>	1					1					
		<i>Laccobius matthewsi</i>				1							
		<i>Paracymus pygmaeus</i>						2			1		
		<i>Paracymus</i> sp. (L)	1										
		<i>Paracymus spenceri</i>				1		2				1	
		<i>Regimbartia attenuata</i>							1	2			
		<i>Sternolophus australis</i>						3	2	3	2		
		<i>Sternolophus immarginatus</i>						1					
		<i>Sternolophus marginicollis</i>			2					1			
	Noteridae	<i>Neohydrocoptus subfasciatus</i>									1		
	Scirtidae	Scirtidae sp. (L)							1	3	2		
Diptera	Ceratopogonidae	Ceratopogonidae sp. (P)	2						2			2	
		Ceratopogoninae sp.	3	3	2	2	2	2	4	4	3	3	
		<i>Dasyhelea</i> sp.		2				1	4	2		1	
		Forcipomyiinae sp.		1					1	1			

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River		Resource Pools				Glen Herring	Emu Creek
			SR-01	SR-02a	SR-03	SR-04	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-03	ECRef-04
	Chironomidae	<i>Ablabesmyia hilli</i>		2				3		3			
		Chironomidae sp. (P)	2	3	2	2	2	2	3	3	2		2
		<i>Chironomus</i> aff. <i>alternans</i>				4				4	3	2	4
		<i>Cladopelma curtivalva</i>		3		4						2	2
		<i>Cladotanytarsus</i> sp.	3	2	4		3	2					
		<i>Coelopynia pruinosa</i>	3	1	4							4	
		<i>Cryptochironomus griseidorsum</i>					3						
		<i>Dicrotendipes</i> sp. `CA1`	3	2	4			2	4				
		<i>Larsia ?albiceps</i>	4	3	4			3	3	4	3		4
		<i>Nanocladius</i> sp.	2	3									
		nr. <i>Parametrioconemus</i> sp.							2	4	2		
		<i>Paramerina</i> sp. 1	3	1			3	3	4	4	2		3
		<i>Paratendipes</i> sp. K1								3			
		<i>Polypedilum nubifer</i>			3			2			3		
		<i>Polypedilum</i> sp.							4	3			
		<i>Polypedilum watsoni</i>						2		3	2		
		<i>Procladius</i> sp.	4	3	4	4	4	2	4	4	2	4	4
		<i>Rheocricotopus</i> sp.							2	3			
		<i>Stenochironomus watsoni</i>						3	2	3			
		<i>Tanytarsus</i> sp.	3	3	4		4	3	4	4	3		4
		<i>Thienemanniella</i> sp.							2				
	Culicidae	Culicidae sp.	2	3		2		2	3	3	3	3	4
		Culicidae sp. (P)							1	1			
	Dolichopodidae	Dolichopodidae sp.							1				
	Ephydriidae	Ephydriidae sp.									1	1	
	Simuliidae	Simuliidae sp.							3				
	Stratiomyidae	Stratiomyidae sp.						1		2			1
	Syrphidae	Syrphidae sp.				1							
	Tabanidae	Tabanidae sp.						3		2			1
Ephemeroptera	Baetidae	Baetidae sp.			4	2	2	3	2		3	2	
		<i>Cloeon fluviatile</i>	2	1				2					
		<i>Cloeon</i> sp. Red Stripe	3	3	3	2	2	3	2	4	2	2	5
	Caenidae	Caenidae sp.			4		2				1		
		<i>Tasmanocoenis</i> sp.						2	2				
		<i>Tasmanocoenis</i> sp. M	2	2	3		1						4
		<i>Tasmanocoenis</i> sp. P/arcuata	4	3	4	1	1	2		3	1		4
Hemiptera	Belostomatidae	<i>Diplonychus eques</i>								2			
	Corixidae	Corixidae sp.	3	2	4	1		2			2		4
	Gerridae	<i>Limnogonus fossarum gilguy</i>		1									2

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River		Resource Pools				Glen Herring	Emu Creek
			SR-01	SR-02a	SR-03	SR-04	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRRef-03	ECRef-04
	Hebridae	<i>Hebrus axillaris</i>						1					
	Hydrometridae	<i>Hydrometra</i> sp.							1				
	Mesoveliidae	<i>Mesovelia</i> sp.											2
	Micronectidae	<i>Austronecta bartzarum</i>											3
		<i>Micronecta annae</i>			3							2	4
		<i>Micronecta paragoga</i>						2					
		<i>Micronecta</i> sp.			3							3	4
	Nepidae	<i>Laccotrepes tristis</i>						1					
	Notonectidae	<i>Anisops elstoni</i>								1			
		<i>Anisops hackeri</i>					1						3
		<i>Anisops</i> sp.						2	1	2		2	3
		<i>Anisops stali</i>										2	
		<i>Enithares woodwardi</i>							2	1			
		Notonectidae sp.						3	2	3	1	1	4
	Pleidae	<i>Paraplea brunni</i>	2	2	2	2	2	1		2		2	4
	Veliidae	<i>Nesidovelia australiensis</i>						2	2	1			
		<i>Nesidovelia peramoena</i>								1			
		<i>Nesidovelia</i> sp.		1				2	2	2	3		
		Veliidae sp.						2	3	3	3		1
Lepidoptera	Crambidae	<i>Parapopynx</i> sp.											1
		Acentropinae sp.											1
Odonata													
Anisoptera		Anisoptera sp.	2						3	3	3		1
	Aeshnidae	<i>Hemianax papuensis</i>								2			
	Corduliidae	<i>Hemicordulia tau</i>			2			1					
	Gomphidae	<i>Austroepigomphus (Xerogomphus) gordonii</i>			1		1			2			
	Libellulidae	<i>Diplacodes bipunctata</i>											2
		<i>Diplacodes haematodes</i>						2		2	1		2
		<i>Orthetrum caledonicum</i>			2							2	
		<i>Orthetrum migratum</i>							3	2	2		
		<i>Orthetrum</i> sp.						1		3			
		<i>Tremea</i> sp.						3	2				
	Lindenidae	<i>Ictinogomphus dobsoni</i>										1	
Zygoptera		Zygoptera sp.	2						2	3	2		3
	Coenagrionidae	<i>Agriocnemis</i> sp.		2				2					3
		<i>Ischnura aurora</i>	1						1	3			3
		<i>Ischnura heterosticta</i>											2
		<i>Pseudagrion aureofrons</i>	1	2									
		<i>Pseudagrion microcephalum</i>								3			
		<i>Xanthagrion erythroneurum</i>											3

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek			Coongan River		Resource Pools				Glen Herring	Emu Creek
			SR-01	SR-02a	SR-03	SR-04	SR-06	CO-WS-10	CO-WS-12	CO-WS-14	CO-WS-16	SRRef-03	ECRef-04
	Isostictidae	<i>Eurysticta coolawanyah</i>			1								
Trichoptera	Ecnomidae	<i>Ecnomus pilbarensis</i>	3	2	3		2	3	3	4			1
	Hydroptilidae	<i>Hellyethira</i> sp.	2	2			1			2			
		<i>Orthotrichia</i> sp.	2	2				2		2			
	Leptoceridae	Leptoceridae sp.							2		1		
		<i>Oecetis</i> sp.						2					
		<i>Oecetis</i> sp. Pilbara 4	4	3	4	2	2					2	2
		<i>Triplectides ciuskus seductus</i>	2		2			2		4			3
	Polycentropodidae	Polycentropodidae sp.							2		1		
		<b>Taxa richness</b>	<b>58</b>	<b>60</b>	<b>60</b>	<b>50</b>	<b>56</b>	<b>81</b>	<b>62</b>	<b>83</b>	<b>37</b>	<b>36</b>	<b>85</b>

## Appendix J: Rehydrate Water Quality Raw Data

### **Wet 2024**

Highlighted cells (■) refer to the values which are in excess the 95% DGV.

Site	Statistic	Temp (°C)		pH		EC (µs/cm)		DO %	
		W1	W2	W1	W2	W1	W2	W1	W2
SR-01-R	Min	20.4	20.5	7.65	7.83	1095	840	62.1	87.9
	Max	24.91	22.1	8.88	8.25	1193	908	92	99.5
	Mean	23.671	21.6	8.115	8.06	1150.9	879.571	77.9778	93.9333
	SE	0.52963	0.20702	0.10288	0.0581	11.6509	8.75828	3.52754	1.91305
ECRef-05	Min	20	20.3	7.72	7.87	1073	828	66.5	90.3
	Max	24.33	21.8	8.92	8.27	1201	879	90.5	100.3
	Mean	23.223	21.3143	8.094	8.09857	1148.7	859.429	75.5444	94.4333
	SE	0.50334	0.19448	0.1061	0.05663	13.8348	7.97871	2.84288	1.70874

### **Dry 2024**

Highlighted cells (■) refer to the values which are in excess the 95% DGV.

Site	Statistic	Temp (°C)		pH		EC (µs/cm)		DO %	
		W1	W2	W1	W2	W1	W2	W1	W2
SR-05	Min	21.1	21.1	7.67	6.96	751	719	75	91.7
	Max	23.8	23.8	8.22	8.46	1004	830	95.6	94.3
	Mean	22.9727	22.9727	8.06	7.79	931.273	786.4	84.68	93.1167
	SE	0.22847	0.22847	0.04927	0.22776	23.1847	12.5876	2.67685	0.46577
SRRef-01	Min	21.4	22.9	8.5	6.57	4246	1042	76.8	85.2
	Max	24	25.9	8.78	8.74	6422	1371	99.9	93.9
	Mean	23.1182	23.75	8.67909	7.945	5860.73	1260.7	88.24	89.5333
	SE	0.21943	0.36765	0.02725	0.28758	205.109	33.984	3.0897	1.33832
SRRef-02	Min	21.3	22.7	7.68	7.01	657	604	76.1	90.9
	Max	23.7	25.8	8.09	8.44	795	686	98.3	94.4
	Mean	23	23.66	7.94091	7.713	756.091	657	87.44	93.0167
	SE	0.20976	0.36914	0.03981	0.1991	13.3092	7.81878	2.65167	0.64674
ECRef-05	Min	21.6	22.7	7.5	6.97	645	602	72.4	84.8
	Max	23.7	25.6	7.8	7.95	760	648	93.4	93.6
	Mean	22.9909	23.59	7.64364	7.507	726.273	636.7	82.25	89.4
	SE	0.18412	0.35291	0.0289	0.14376	10.2052	4.12054	2.81919	1.25778

## Appendix K: Rehydrate Fauna Taxonomic List

**Wet 2024**

Values are log abundances (i.e., 1=1 individual, 2 = 2-10, 3 = 11-100, 4 = 101-1000).

Phylum/Class/Order	Family	Lowest taxon	Glen Herring Creek		Emu Creek	
			SR-01R		ECCRef-05	
			W1	W2	W1	W2
<b>NEMATODA</b>		Nematoda sp.			3	
<b>MOLLUSCA</b>						
<b>Gastropoda</b>						
	Hygrophila	Lymnaeidae			1	
		Planorbidae			3	2
		<i>Cyraululus</i> sp.			3	3
<b>ARTHROPODA</b>						
<b>Crustacea</b>						
<b>Branchiopoda</b>						
	Diplostraca					
	Cladocera	Chydoridae				3
		<i>Alona</i> sp.				2
		<i>Leberis</i> sp.				2
		Macrothricidae			5	4
		Moinidae	3			
		<i>Moina micrura</i>				
	Conchostraca	Cyzicidae	2			
		<i>Ozestheria</i> `sp. Biologic-BRAN002`				
		Limnadiidae			1	
		<i>Limnadopsis pilbarensis</i>				
<b>Ostracoda</b>						
	Podocopida	Cyprididae		3		2
		<i>Cypretta</i> `sp. Biologic-OSTR016`				



**Dry 2024**

Values are log abundances (i.e., 1=1 individual, 2 = 2-10, 3 = 11-100, 4 = 101-1000).

Phylum/Class/Order	Family	Lowest taxon	Coongan River		Camel Creek				Emu Creek	
			SR-05		SRRef-01		SRRef-02		ECRef-05	
			W1	W2	W1	W2	W1	W2	W1	W2
<b>PLATYHELMINTHES</b>										
<b>Turbellaria</b>		Turbellaria sp.	2	2			3	3		
<b>ROTIFERA</b>		Rotifera sp.	3				2			
<b>NEMATODA</b>		Nematoda sp.	3	2				2		
<b>MOLLUSCA</b>										
<b>Gastropoda</b>										
	Hygrophila	Lymnaeidae								
		Planorbidae								
		<i>Bullastra vinosa</i>								
		<i>Bayardella</i> sp.								
		<i>Gyraulus</i> sp.								
<b>ARTHROPODA</b>										
<b>Crustacea</b>										
<b>Branchiopoda</b>										
	Diplostraca									
	Cladocera	Chydoridae								
		<i>Leberis</i> sp.	3	4		1	4	3		
		Daphniidae sp.			2					
		<i>Simocephalus australiensis</i>	3							

Phylum/Class/Order	Family	Lowest taxon	Coongan River		Camel Creek				Emu Creek	
			SR-05		SRRef-01		SRRef-02		ECCRef-05	
			W1	W2	W1	W2	W1	W2	W1	W2
		<i>Ilyocryptus</i> sp.							1	
	Macrothrichidae	<i>Macrothrix</i> sp.	3						4	4
	Moinidae	<i>Moina</i> sp.			2	2				
		<i>Latonopsis australis</i>	3							
Conchostraca	Limnadiidae	<i>Limnadopsis pilbarensis</i>							1	
<b>Ostracoda</b>										
	Podocopida	Cyprididae							2	
		<i>Cyprretta</i> `sp. Biologic-OSTR047`					2		4	3
		<i>Cyprretta</i> sp.	4	2					2	
		<i>Cypricercus</i> sp.	3				2			
		Cyprididae `sp. Biologic-OSTR136`		3	3					
		<i>Cyprinotus cingalensis</i>	1	1						
		<i>Hemicypris</i> sp.				4				
		<i>Ilyodromus</i> sp.	1							
		<i>Riocypris</i> cf. <i>fitzroyi</i>	2	2		1			3	3
		<i>Stenocypris major</i>	3	3					4	3
<b>Insecta</b>										
	Diptera	Ceratopogonidae		1						
		Psychodidae	2		1				1	
		<b>Taxa richness</b>	<b>14</b>	<b>9</b>	<b>4</b>	<b>4</b>	<b>5</b>	<b>3</b>	<b>9</b>	<b>4</b>