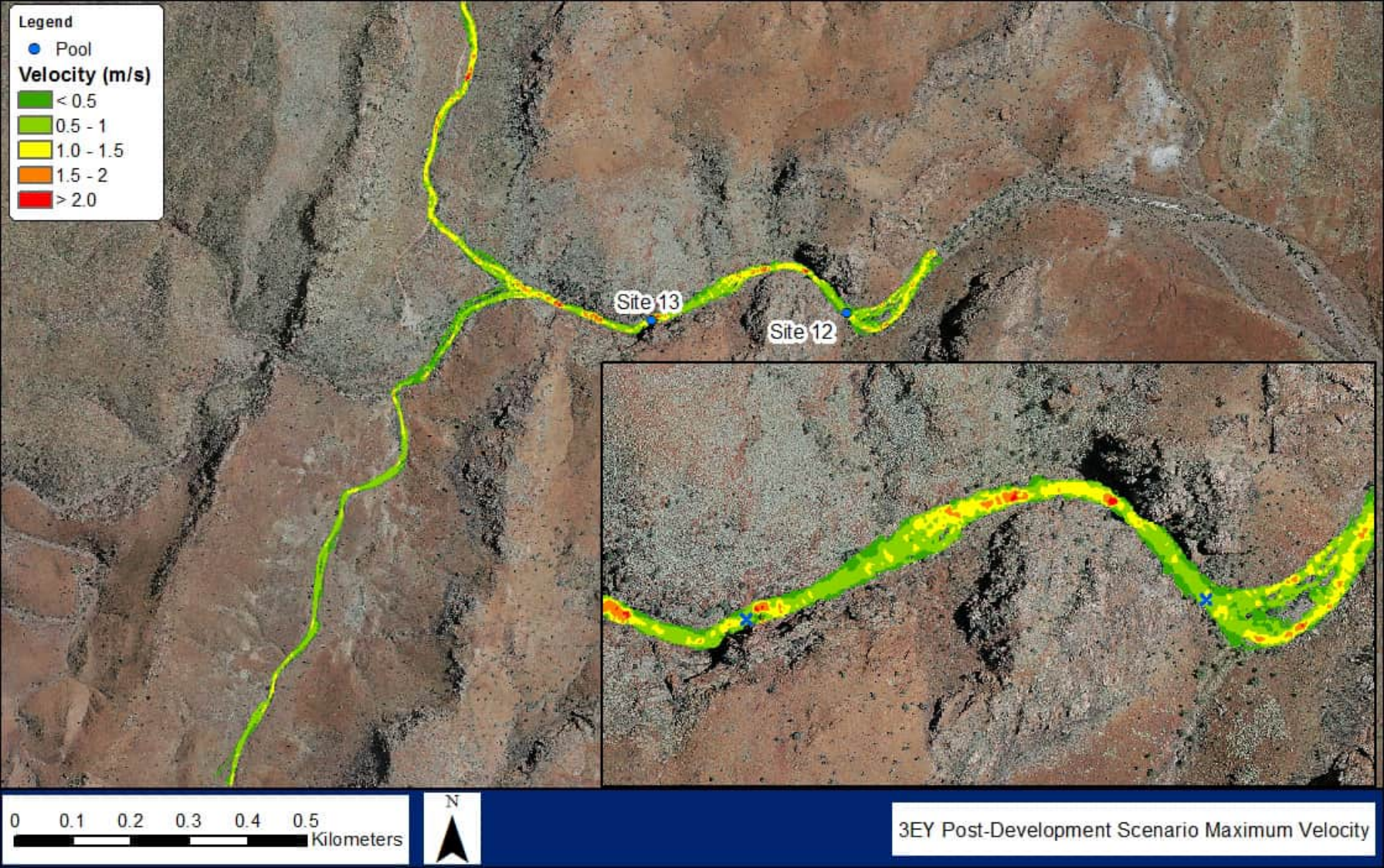
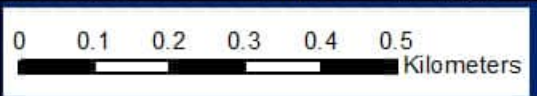
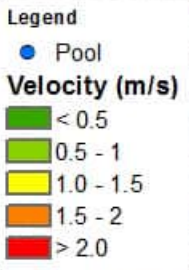


2EY Post-Development Scenario Maximum Velocity





4EY Post-Development Scenario Maximum Velocity

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# Attachment 3: Visual Inspection Field Datasheet

### Site 12 Pool Visual Inspection Field Data Sheet

Date:    /    /

Name:

Undertake the following visual inspection during routine water quality monitoring at Site 12 Pool Water Quality Monitoring Site. This will form part of the site investigation assessment in the event of Primary Trigger Levels being exceeded. See below for visual guide for conducting inspection, and example of site photo. Coordinates for all monitoring locations are provided on the site photo using the coordinate system is GDA 1995 MGA Zone 50. The access to the specified location for the individual monitoring sites are subject to the safe access particularly during the wet season.

Record YES or NO below as an indication of observed status of the ecological health.

Habitat health parameter	YES	NO
Fish presence	<input type="checkbox"/>	<input type="checkbox"/>
Macrophyte presence	<input type="checkbox"/>	<input type="checkbox"/>
Recent sedimentation presence	<input type="checkbox"/>	<input type="checkbox"/>

*(Provide additional details below)*

*(Include photos with GPS coordinates for future reference)*

.....  
.....

Observations of change	<input type="checkbox"/>	<input type="checkbox"/>
------------------------	--------------------------	--------------------------

*(i.e. recent fire, nearly dry, flooding, cattle impact or dead animals)*

*(Provide additional details below)*

.....  
.....

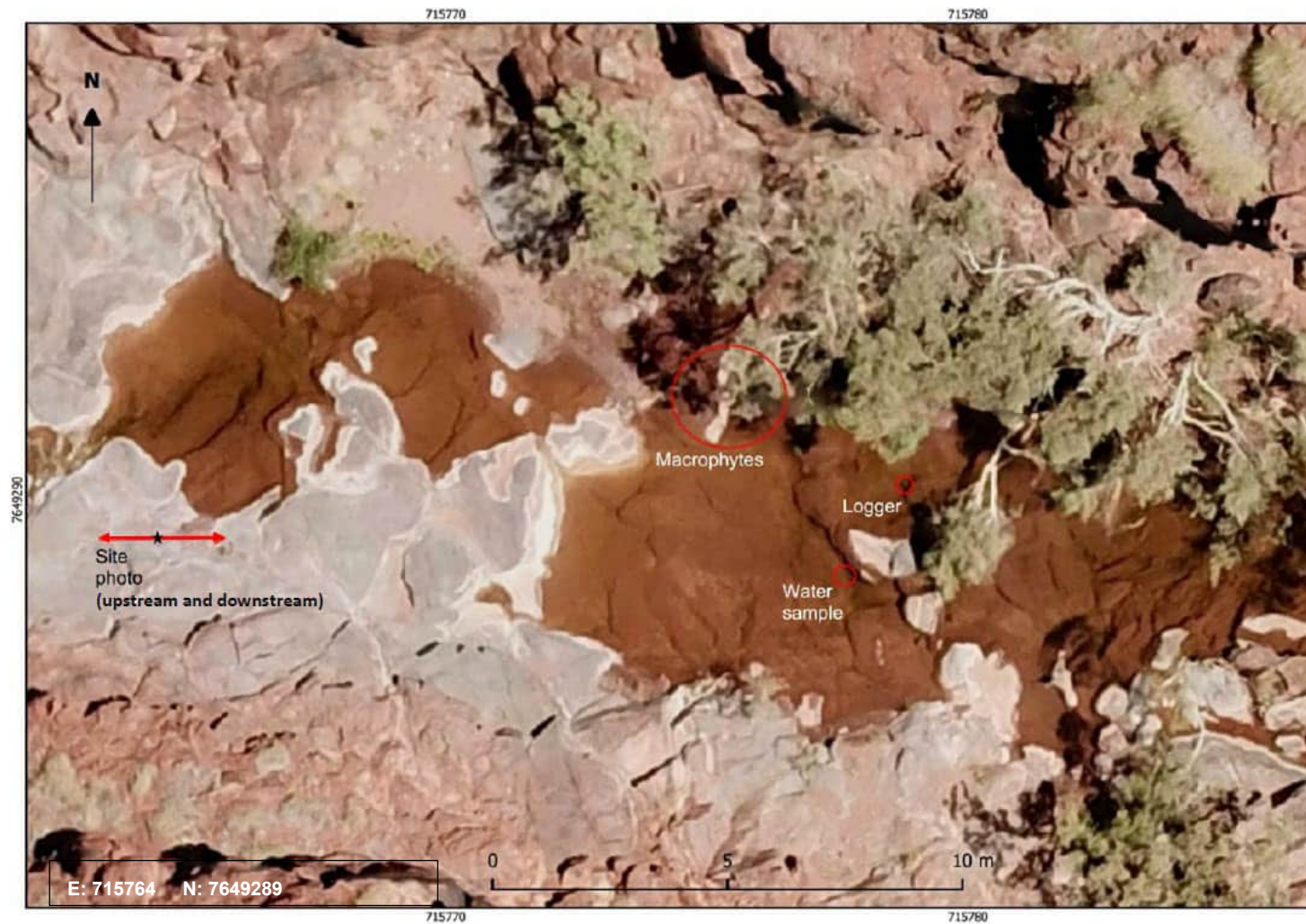
Site photo taken	<input type="checkbox"/>	<input type="checkbox"/>
------------------	--------------------------	--------------------------

*(Details of type of camera type (i.e. digital vs 35mm etc)*

.....  
.....

Any additional comments

.....  
.....  
.....



Guide for conducting visual inspection at Site 12 Pool

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## Attachment 4: Surface Water Monitoring Procedures

## **SURFACE WATER MONITORING PROCEDURES**

---

Surface water sampling should be conducted in accordance with:

- AS/NZS 5667.1:1998 Water Quality- Sampling - Guidance on the design of sampling programs, sampling techniques and preservation and handling of samples
- Department of Water (2009) Field Sampling Guidelines: A guideline for field sampling for surface water quality monitoring programs
- The methods outlined below.

### **Water Quality**

---

#### **Equipment Preparation**

---

This section outlines standard procedures (appropriate equipment, sample bottles, safety gear and a sampling procedure) to ensure that field staff are suitably prepared and able to collect high-quality monitoring data.

Any equipment that comes into contact with water samples (e.g. pH probes, scoops) must be appropriately cleaned and decontaminated prior to each use and between samples to minimise possible cross contamination. Sampling equipment (aside from bottles supplied by the laboratory) should be washed using detergent and tap water, and then rinsed thoroughly with deionised (DI) water before setting out. Sampling equipment should be rinsed with DI water again in between collection of each sample.

Field meters (e.g. pH and conductivity meters) must be calibrated according to the manufacturer's instructions at the start of each day of monitoring. Calibration should be performed using standards of a known concentration appropriate to the anticipated range of values in the water to be sampled. Calibration standards should be stored appropriately (e.g. keep refrigerated and do not exceed 'use by' dates) to ensure their accuracy. The required volume of standard should always be decanted into a suitable receptacle for calibration purposes and then discarded.

After all equipment is cleaned and calibrated, a field kit with the following items should be prepared to take out on the sampling round.

- Field data sheets
- Completed sample labels
- Chain of custody forms
- Container for field measurements

- Sample bottles for dispatch to a NATA accredited laboratory
- If necessary, equipment for collection of samples from a safe distance (e.g. sample pole)
- Filtration equipment and syringe (for metals analysis)
- Field parameter meters or test kits (pH and turbidity meter)
- Container with sufficient DI water
- Powder-less nitrile gloves
- Esky and ice packs for preserving samples
- Personal Protective Equipment (PPE), first aid, and communication equipment
- Other equipment may be needed and should be added to the field kit as required.

## Sample Bottle Preparation

---

When collecting water quality samples using the grab sample method the following instructions should be followed:

- The most important factor when sampling is personnel safety. If the monitoring program cannot be carried out in a reasonably safe manner, then alternative options should be considered. Always sample in pairs and have adequate safety equipment available
- Use non-powdered latex gloves when handling the sample bottles and try not to contaminate the sample by touching it with dirty hands or smoking during the sampling event
- Use an extendable water sampler with a plastic scoop on the end to collect the sample. Rinse the plastic scoop three times and collect the sample following the third rinse. Before adding the water sample to the bottle, check if the bottle has preservative (acid) within it, if it does, do not rinse this bottle
- Before filling, rinse the sample bottle out three times with the water being collected, unless the bottle contains a preservative. Fill the sample container to the top so no oxygen can enter the bottle
- Ensure sample blanks and replicates are collected
- All samples should be refrigerated or placed on ice in an esky immediately after being collected
- Water quality Suite A samples should be submitted for analyses at an NATA accredited laboratory within 4 days of collection (to take the holding time for surfactants into account); water quality Suite B and C stages should be submitted within 7 days

- Complete the necessary freight form and ensure it is attached to the esky
- Sample details should be recorded on a Chain of Custody (CoC) form and sample bottles should have corresponding labels. The laboratory copy of the CoC should be provided with the samples when they are couriered to the laboratory
- Attach both the CoC and the freight form to the esky and then take it to the courier who will transport it to the laboratory
- Results and confirmation from the laboratory receiving the samples will be e-mailed to the addresses that are put on the CoC
- Ensure the sample analysis invoice is submitted for processing.

## Field Measurements

---

Parameters to be monitored as 'field measurements' should be sampled and recorded on the Field Sampling Sheet. Sensors should be kept in gentle motion through the water column (or be immersed in gently flowing water) while a reading is being taken. Allow up to several minutes for the meter to stabilise.

Where possible, measurements are to be made directly from the water body. Where a risk assessment deems that it is unsafe to take samples directly from the water source a sampling device (i.e. a sampling pole) must be used, and the field measurements taken from a container. Care must be taken to ensure that any containers coming into contact with the sample have been properly decontaminated and rinsed with sample water prior to taking any readings.

Electrical Conductivity (EC) data are logged automatically at 6-hourly intervals at each location, and do not require to be manually measured. The EC data will be downloaded from the data logger during one of the sampling events (approximately quarterly) for analysis.

## Sample Collection

---

Where possible, water samples are to be collected directly from the water body. Where a risk assessment deems that it is unsafe to take samples directly from the water source, a sampling device (i.e. a sampling pole) must be used, and the sample bottles filled from the sampling container. Care must be taken to ensure that any containers coming into contact with the sample have been properly decontaminated and rinsed with sample water prior to collection of samples. A clean pair of nitrile gloves should be worn at each sample site to minimise potential contamination problems.

Most sample bottles are required to be filled completely, so that there is no airspace in the bottle. This should be done very carefully, particularly if there is acid preservative in the bottle, and the bottle should be filled to overflowing prior to replacing the cap.

Note: Sample bottles that have been supplied from an external laboratory may contain preservatives and therefore should not be rinsed or submerged in the water body.

## Field Filtration

---

Some samples (all samples being sent for metals analysis) require field-filtration. The analytical laboratory can typically provide the filtration equipment, which often consists of a syringe and a set of disk filters.

The standard procedure for syringe filtration is as follows:

- Draw an aliquot of the sample into the syringe from the water body or sample collection container taking care to maintain an air gap between the base of the plunger and the sample to minimise contact and potential contamination
- Dispense aliquot to waste to rinse syringe. Repeat
- Draw an aliquot of the sample into the syringe taking care to maintain an air gap between the base of the plunger and the sample to minimise contact and potential contamination
- Affix appropriate filter unit to syringe (between 0.4 and 0.5  $\mu\text{m}$ ) and dispense into laboratory sample container
- Re-seal laboratory sample container.

## Storage and Transport

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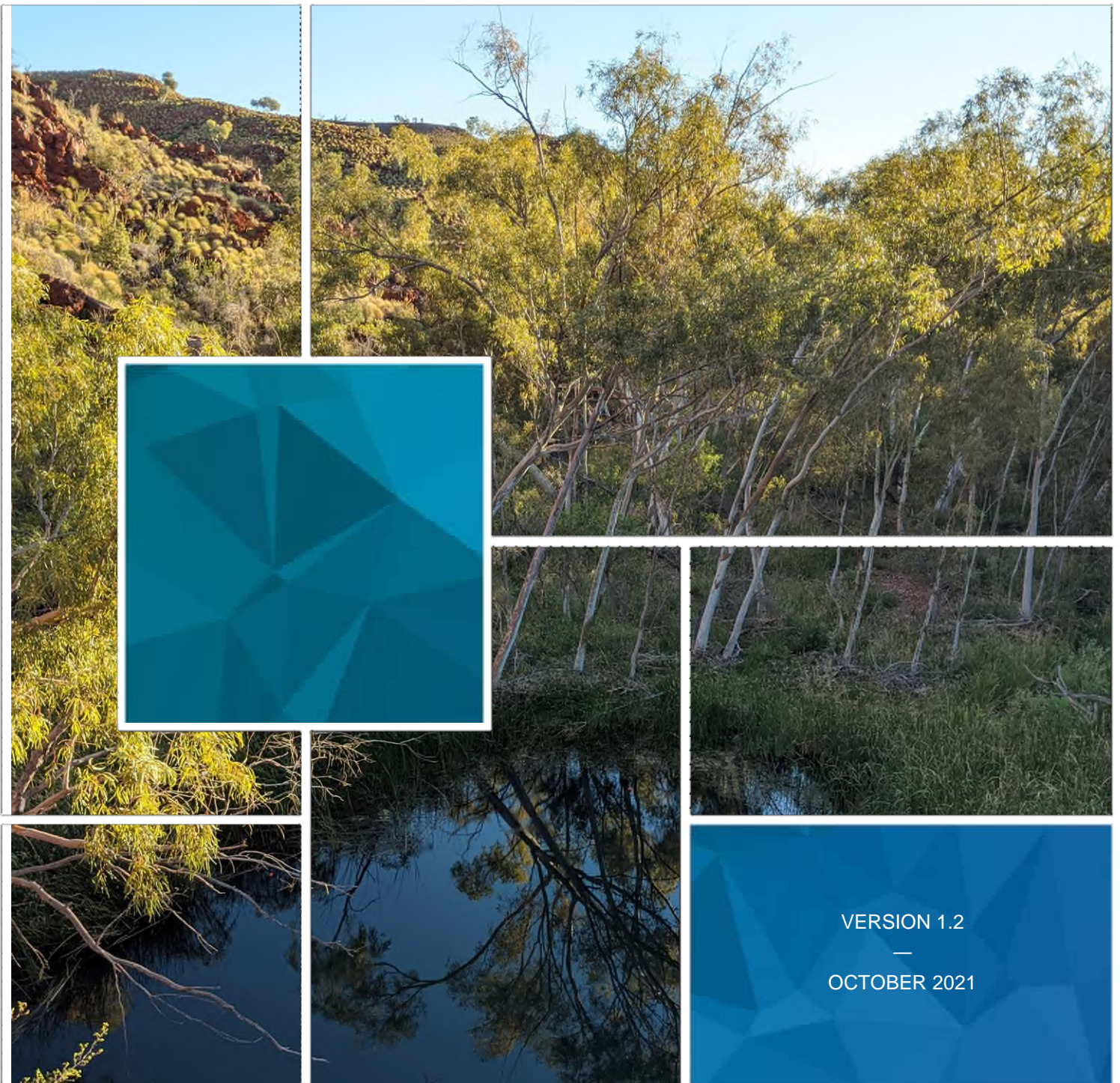
Samples should be stored according to the preservation procedures summarised from AS/NZS 5667.1:1998. Generally, samples are stored on ice (or ice-bricks) in an esky for transport to the laboratory. Depending on holding times and how long it will take for samples to be delivered to the laboratory, it may be necessary to freeze some of the samples. The appropriate method and period of storage is dependent on the analyte of interest and must be adhered to so that representative results from analysis are obtained. While sample preservation will limit degradation, dispatch to the laboratory should occur as soon as practicable, ideally on the same day they were collected.

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**Attachment 5: Surface Water Monitoring and Aquatic Ecology Survey Baseline Report (Hydrobiology 2021)**

# IRON BRIDGE: SURFACE WATER MONITORING & AQUATIC ECOLOGY BASELINE REPORT LATE WET 2019 TO LATE WET 2021

FMG IRON BRIDGE (AUST) PTY LTD



VERSION 1.2  
—  
OCTOBER 2021

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## GLOSSARY OF ACRONYMS

Acronym	Definition
ANZG	Australian and New Zealand Guidelines for fresh and marine water quality
BRUV	Baited Remote Underwater Video- a sampling method for fish
DO	Dissolved oxygen
DOC	Dissolved organic carbon
DSIAR	Diatom Species Index for Australian Rivers
EC	Electrical Conductivity
EPT	Ephemeroptera, Plecoptera, Trichoptera: three macroinvertebrate orders that comprise a biotic index
FMGIB	FMG Iron Bridge (Aust) Pty Ltd
N	Nitrogen
NTU	Nephelometric Turbidity Units
P	Phosphorous
QA/QC	Quality Assurance/Quality Control
SO4	Sulphate
SPC	Specific Conductivity (conductivity normalized to 25°C)
TDS	Total Dissolved Solids
TIC	Total Inorganic Carbon
TOC	Total Organic Carbon
TSS	Total Suspended Solids

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# 1. INTRODUCTION

This report presents the findings of the baseline aquatic ecology monitoring program of surface water pools at the Iron Bridge Project between December 2019 and June 2021.

## 1.1 BACKGROUND

Hydrobiology WA Pty Ltd (Hydrobiology) conducted an aquatic ecology baseline monitoring program of surface water pools to support the baseline development and approvals of the Iron Bridge Magnetite Project (the Project) in the Pilbara region of Western Australia on behalf of FMG Iron Bridge (Aust) Pty Ltd (FMGIB). The managing entity for the Project is IB Operations Pty Ltd (Iron Bridge), a joint venture company between FMGIB and Formosa Steel IB Pty Ltd.

## 1.2 OBJECTIVES

The objectives of the aquatic ecology survey are the following:

- Establish baseline aquatic ecology conditions at selected surface water pools, which will support future assessments of impacts potentially resulting from the Project.
- Implementation of the Iron Bridge Surface Water Management Plan (FMG, 2020).
- Inform the Site 12 Pool Water Quality and Hydrological Regime Investigation (Hydrobiology, 2020) and provide technical input to the Site 12 Pool Water Quality and Quantity Management Plan (FMG, 2020).

# 2. METHODOLOGY

## 2.1 SITE LOCATIONS

The Project is located 110 km south of Port Hedland in the Pilbara region and incorporates the North Star and Glacier Valley Magnetite ore bodies. The aquatic ecology survey was conducted at six surface water pools at Iron Bridge within the Turner and Strelley/Shaw River catchments (Figure 2-1) and is situated within the Chichester IBRA bioregion and the Grassland climate class. Hydrological data was additionally collected from surface water creeks at Iron Bridge. A map of the survey sites for aquatic ecology is provided in Figure 2-2, including catchment areas for each site. Study site catchment areas and coordinates are provided in Table 2-1.

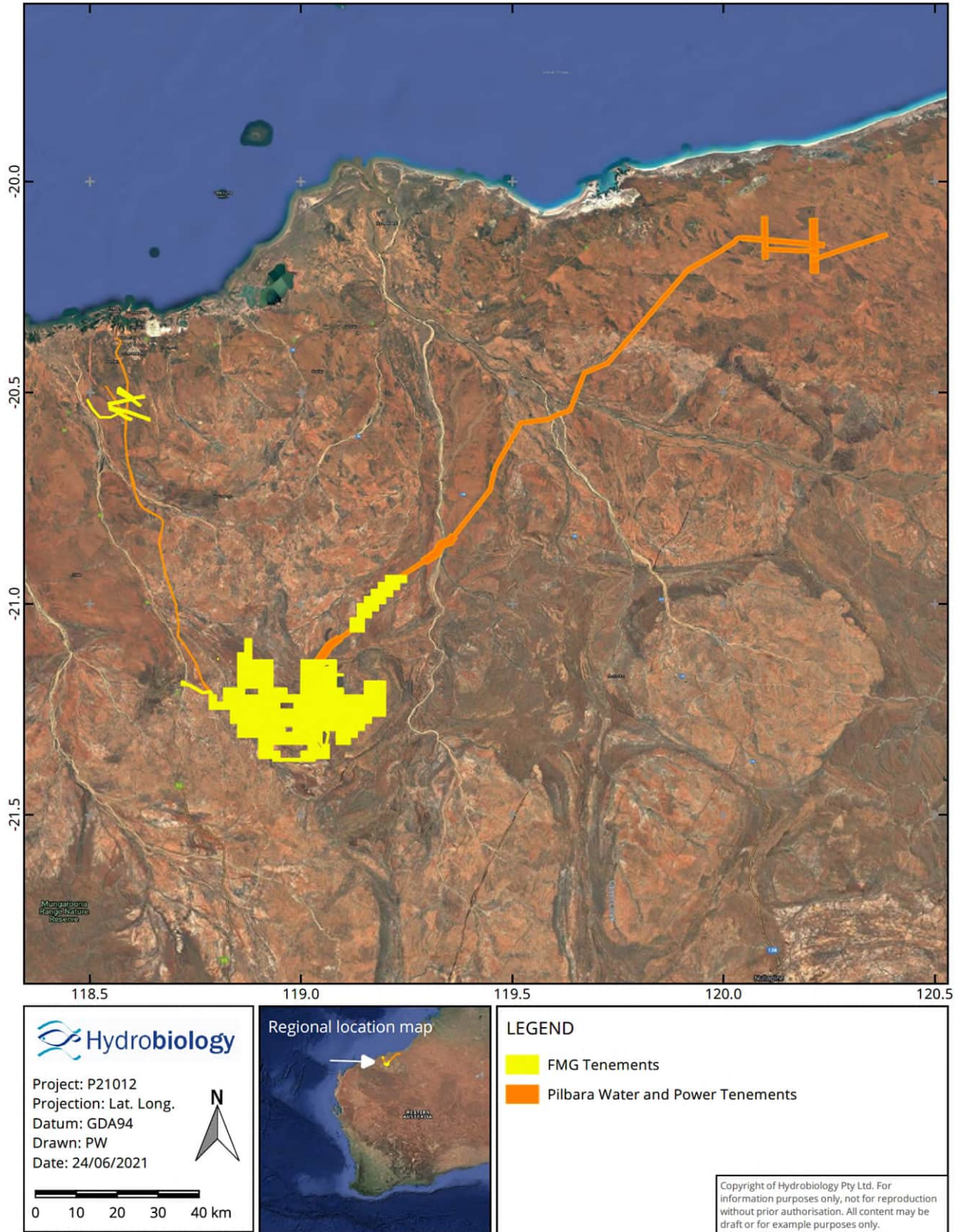


Figure 2-1 Regional study location area map showing project tenements

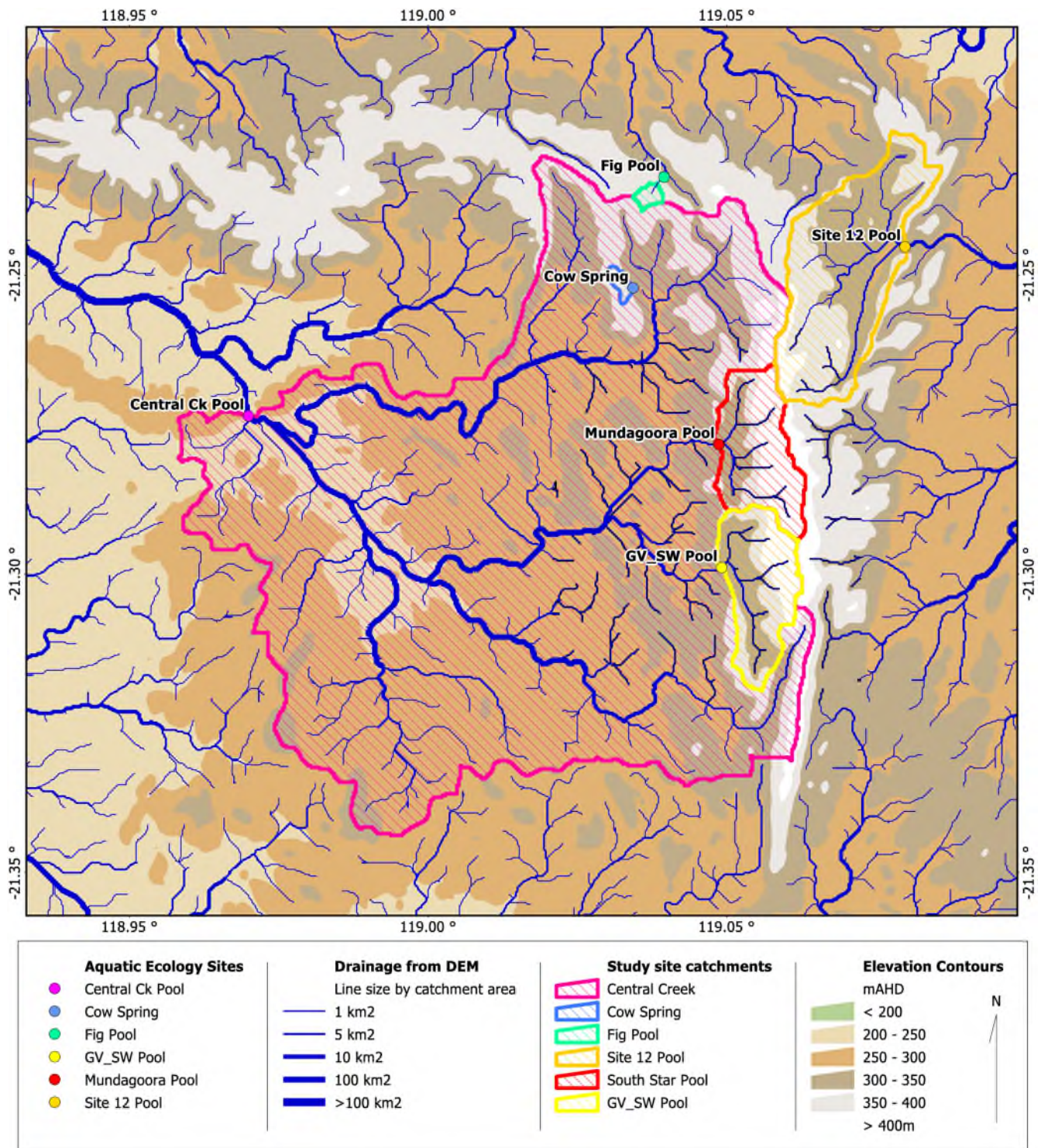


Figure 2-2 Study site catchments and drainage lines

Table 2-1. Summary of study sites included in the aquatic ecology and surface water monitoring survey for the late wet and late dry season for 2020, and the late wet season 2021, including catchment areas and coordinates (GDA94, UTM 50K)

Site Name	Catchment area (km <sup>2</sup> )	Northing	Easting
<b>Fig Pool</b>	0.16	711668	7650632
<b>Mundagoora Pool<sup>1</sup></b>	3.3	712558	7645667
<b>Site 12 Pool</b>	7.6	716248	7649263
<b>Cow Spring</b>	0.15	711103	7648587
<b>Central Creek Pool</b>	85.1	704385	7646299
<b>GV Pool<sup>2</sup></b>	3.3	712580	7643386

<sup>1</sup> Mundagoora Pool was previously named South Star Pool

<sup>2</sup> GV Pool was first sampled in the late wet season 2021.

## 2.2 MONITORING TIMING

Surface water level logger installations, water sampling and initial inspections of several sites were completed in December 2019 (Late Dry 2019). Aquatic ecology sampling for five pools (Fig Pool, Mundagoora Pool, Site 12 Pool, Cow Spring and Central Creek) was first initiated in May 2020 (Late Wet 2020). Subsequent surveys were completed at these sites in December 2020 (Late Dry 2020) and May-June 2021 (Late Wet 2021). An additional site, SW\_GV Pool, was added in December 2020 (Late Dry 2020) with a site inspection and the installation of a water level and conductivity logger. This site (GV\_SW Pool) was first surveyed for aquatic ecology in May-June 2021 (Late Wet 2021).

The late wet season baseline aquatic ecology surveys are conducted between May and June. Collecting baseline data during this period captures conditions when the aquatic food web is established, and early life stages of some aquatic organisms are present, which enables effective characterisation of the ecosystem health. The timing of baseline data collection aims to align with the water quality sampling periods for the assessment period, being the wet and drying season.

The late wet season baseline conditions are expected to show greater species diversity and abundance relative to dry season conditions when stressors (such as high temperature and salinity) are typically greater and result in declining ecosystem health. Capturing the seasonal variability is expected to allow for a more accurate assessment of baseline conditions and variability, which will inform surface water management.

Table 2-2 provides the key dates and seasons for the aquatic ecology and surface monitoring survey.

Table 2-2 Summary of the key sampling dates and seasons for the aquatic ecology and surface monitoring survey

Season	Year	Dates	Sites
<b>Late Dry</b>	2019	17 Dec-19 December	Installation of loggers, water sampling and site inspections. No Aquatic Ecology sampling.
<b>Late Wet</b>	2020	29 May – 2 June	Fig Pool, Mundagoora Pool, Site 12 Pool, Cow Spring, Central Creek
<b>Late Dry</b>	2020	8-13 December	Fig Pool, Mundagoora Pool, Site 12 Pool, Cow Spring, Central Creek
<b>Late Wet</b>	2021	21-28 May	Fig Pool, Mundagoora, Site 12 Pool, Cow Spring, Central Creek, GV Pool

## 2.3 WATER QUALITY AND HYDROLOGICAL MONITORING

### 2.3.1 IN-SITU SAMPLING

Water level, temperature and conductivity loggers were installed in each pool to continuously monitor the effects of rainfall, the rate of drying, and evapo-concentration effects. In situ Aquatroll CTD data loggers were installed in Site 12 Pool, Fig Pool and Mundagoora Pool from December 2019 and currently remain in situ. Further In situ Aquatroll CTD data loggers were installed in Cow Spring Pool and Central Creek Pool in May 2020 and currently remain in situ. An additional logger was installed in GV\_SW Pool in December 2020 and remains active. All loggers were downloaded during each survey, including most recently in June 2021.

In addition to the permanently deployed loggers, a calibrated YSI DSS Pro water quality sonde was used to collect in situ measurements from all sites where sufficient water was present during field surveys. Measurements were collected following the 'Field sampling guidelines: A guideline for field sampling for surface water quality monitoring programs' procedure for physical parameter sampling (Department of Water, 2009 pg. 13). In-situ measurements were collected before all other activities to ensure that no disturbance to water quality was caused by sampler activity. The following field parameters were collected; temperature (°C), pH, oxidation reduction potential (mV), dissolved oxygen, specific conductivity (µs/cm), salinity (ppt) and turbidity (NTU).

### 2.3.2 SURFACE WATER QUALITY

Water samples were collected following the 'Field sampling guidelines: A guideline for field sampling for surface water quality monitoring programs' (Department of Water, 2009) procedure for direct sampling. Water samples were collected by submerging the sample containers in the water at the waters' edge with the sampler on the bank to minimise disturbance. Powder-free nitrile gloves and laboratory prepared bottles were used to avoid potential sources of contamination. Unpreserved sample containers were rinsed three times with sample water before retaining a representative sample, and preserved bottles were filled from a pre-rinsed syringe. Samples for dissolved metals analysis were syringe filtered within 1 minute of collection through 0.45 µm membrane filters using 50 mL polyethylene disposable syringes.

Upon collection, samples were immediately placed on ice in a dedicated esky and then transferred to a fridge at the earliest convenience. For delivery to ALS Australia, samples were packed in clean coolers with ice bricks. All bottles and filtering equipment were prepared by NATA-accredited ALS, Perth. Samples were

sent to a NATA accredited laboratory for analysis for parameters which allowed for a broad characterisation of the examined environments. The parameters are identified in Appendix A.

Water quality samples were also delivered to the Stable Isotope Laboratory, West Australian Biogeochemistry Centre, University of Western Australia for isotope analysis. Samples were analysed for  $\delta^{2}\text{H}$  and  $\delta^{18}\text{O}$ , using an Isotopic Liquid Water and Continuous Water Vapour Analyser Picarro 2130i and followed the procedure of Skrzypek and Ford (2014).

### 2.3.3 SEDIMENT QUALITY

Sediment samples were collected following the 'Handbook for Sediment Quality Assessment' procedures for the collection of surface sediment (Simpson *et al.*, 2005). Surface sediment was collected from the top 5 cm of sediment and homogenised in a bowl before transferring to sterile jars. Powder-free nitrile gloves and laboratory prepared jars were used to avoid potential sources of contamination. Samples were stored on ice in a dedicated esky and transferred to a fridge at the earliest convenience. For delivery to ALS Australia, samples were packed in clean coolers with ice bricks. Samples were sent to a NATA accredited laboratory to analyse parameters, including total metals, major ions, total organic carbon, total nitrogen and total phosphorous. The specific parameters are identified in Appendix B.

## 2.4 AQUATIC ECOLOGY MONITORING

### 2.4.1 MONITORING PARAMETERS

Aquatic ecology monitoring parameters were selected following the ANZG process (ANZG, 2018) for selecting relevant ecological indicators of water quality through establishing environmental values and identifying conceptual impact mechanisms. These indicators are algal (diatom/phytoplankton) communities, macrophyte communities, macroinvertebrate communities and fish communities. The selection of these four communities provides multiple lines of evidence and spans multiple trophic levels and phyla, which is recommended by ANZG (2019) in order to capture the variable impact of ecosystems stressors and detect, for example, impacts of bioaccumulation and biomagnification. Algae, macroinvertebrates, fish and macrophytes typically underpin the food web in pools, providing habitat and/or food sources for a diversity of native species including terrestrial or semi-aquatic organisms that may utilise the pool such as reptiles (e.g. Pilbara olive python), avian fauna and amphibians (Halse *et al.* 2001).

### 2.4.2 FISH AND DECAPOD CRUSTACEANS

#### 2.4.2.1 SAMPLING

Fish and decapod communities were sampled to collect data on higher-order organisms with relatively long life spans, which is useful for assessing bioaccumulation and biomagnification effects, interannual survivability and reproduction. Evidence of reproduction was sought (*i.e.* presence of juveniles) to detect sub-lethal effects impacting reproduction or vulnerable size classes.

Fish and decapod crustaceans were sampled using fyke nets and traps. Two trap types, box traps and bait traps, were used to collect a more representative sample of size classes present at a site (Osawa *et al.* 2015). Fyke nets were 4 m long, 1 m diameter, 4 m wings, with a 4 mm mesh size and 150 cm diameter entry hole. Bait traps were 0.4 m long, 0.25 m wide and 0.25 m high, with a 5 mm mesh size and 30 mm diameter entry holes. Box traps were 0.6 m long, 0.45 m wide and 0.2 m high, with a 10 mm mesh size. Traps were baited with a 50/50 ratio of cat food biscuits and whiting based burley. At each pool, one fyke net, two bait traps, and two box traps were set for overnight an average of 12 hours (maximum 19 hours). Traps were set along the length of the pools, predominantly in bank habitats with high structural complexity (e.g. macrophytes, woody debris, root masses), where abundance was likely to be highest.

After two rounds of sampling (Late Wet 2020 and Late Dry 2020) it was decided that the box traps were not providing useful data as they rarely caught fish and those that were caught were not representative of the counts in the fyke nets, or fish abundance observable within the pools. The use of traps was discontinued for future surveys, and fyke nets are used as the primary measure of fish abundance and diversity for this program.

Following capture, the first 30 individuals of each species were randomly selected for subsampling to reduce handling stress on the entire catch. Subsampled individuals were counted, measured (total length and standard length) and weighed. The remaining individuals were counted and allocated to one of four length classes based on standard length (SL) (*i.e.* <30 mm, 30 – 60 mm, 60 – 90 mm and >90 mm). All fish were kept in aerated tubs immediately after capture, prior to being measured and were immediately released near the collection point after processing.

As a secondary measure of fish abundance and species presence at each site, Hydrobiology utilised baited remote underwater video traps (BRUVS). Baited underwater GoPro 5 cameras were deployed in suitable habitats at each site, and the video was set to record for 10 minutes.

#### 2.4.2.2 ANALYSIS

Fish abundance at each site was compared for each season. Catch per unit effort (CPUE) was used as a measure of abundance and was defined as the species total catch divided by the soak time in hours. Fish were grouped into standard length classes, and length frequency (%) figures were constructed for each species at each site across the three seasons. Juvenile presence was defined as the presence of smaller size classes that are below the size at sexual maturity described in the relevant literature (based on wild populations).

Where standard length was recorded for subsampled fish, length distribution box and whisker plots were constructed for each species at each site across the three seasons. Independent t-tests and analysis of variance (ANOVA) were used to assess any significant differences in the mean standard length for each species at all sites across the three seasons.

Fish abundance on BRUV footage was recorded using a common metric MaxN, the maximum number of fish per species on a single video frame.

### 2.4.3 MACROINVERTEBRATES

#### 2.4.3.1 SAMPLING

Macroinvertebrates are a commonly used bioindicator for assessing a variety of environmental issues. ANZG (2019) recommends macroinvertebrate monitoring to assess changes in biodiversity and changes in ecosystem processes of water bodies due to contaminant inputs. The taxonomic groups sensitive or tolerant to declines in water quality are well known and the presence and abundance of these taxa are used to score the water condition of surface water pools.

Macroinvertebrate sampling followed the procedures of 'Western Australia AUSRIVAS sampling and processing manual' (van Looij, 2009). Samples were collected using a 250 µm mesh pond net, 35 cm by 25 cm opening, a 30 cm depth (tail) and a 150 cm handle. The net was rinsed and checked for holes between each site. Two samples were collected from each pool. Due to the pool's small size, two replicates from the same habitat (*i.e.* macrophyte, pool) was not possible for all pools without risking re-sweeping the extent of the previous sweep. Therefore, samples were obtained from different habitats for most pools. Sites were sampled by sweeping the net starting at the downstream end of the 10 m sampling area and moving upstream while collecting the sample, aiming to sample all the different sub-components of the habitat and at different depths. The contents of the net were then rinsed into labelled sterile containers using 70%

ethanol for preservation. Samples were transported to Stream Macroinvertebrate Identification for identification and enumeration.

Specimens in each sample were laboratory picked following the AusRivAS methods. Samples were identified to family level, where possible. A 10% error margin is allowed for the identifications and enumerations of macroinvertebrates (as required for AusRivAS macroinvertebrate identification accreditation). Any taxa that could not be identified (usually due to their immature stage or deterioration/damage) were recorded at a higher taxonomic level (i.e. Order). Taxa were recorded as present if the head was present in the sample (provided it appeared to be alive at the time of collection). This is common with Ephemeroptera, Zygoptera and Oligochaeta, which are often damaged at the time of collection and only part of the specimen is retained in the sample. Empty (dead) Gastropoda shells are not recorded as being present. Specimens were preserved in a solution of 70% methylated spirits, 5% Glycerol and 25% water and retained for QA/QC purposes at Hydrobiology Perth.

#### 2.4.3.2 ANALYSIS

Several indices were derived from the macroinvertebrate data and are described below as per Negus *et al.* (2013) and Chessman (2003). Each of these indices was qualitatively assessed for changes in values among sampling occasions.

**Total abundance** - The number of individual macroinvertebrates collected in a sample, which can provide insights into the biological productivity, population health or carrying capacity of an ecosystem.

**SIGNAL 2 Index** - The SIGNAL index (Stream Invertebrate Grade Number - Average Level) was developed for the bioassessment of water quality in rivers in Australia. It is calculated by grading each macroinvertebrate family based upon the level of its sensitivity to various pollutants. The grades applied range from 1 (tolerant) to 10 (sensitive; Chessman, 2003) and a weight is applied to each taxa depending on its abundance. The SIGNAL 2 score for a sample is calculated by averaging the weighted sensitivity grades of the macroinvertebrate families collected. The version applied here is SIGNAL version 2.iv, SIGNAL 2 Scores suit both family and order-class-phylum identification (Chessman, 2003).

**EPT taxa richness** - The number of aquatic macroinvertebrate families collected from three orders of aquatic insects: Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). Macroinvertebrates belonging to these three orders are considered sensitive to changes in their environment and therefore EPT is often used to assess water body conditions. Sensitivity would generally be indicated by a decrease in EPT in the presence of changed environmental conditions; however, increases can occur depending on the nature of the impacts that are present.

**Taxa richness** - The number of aquatic macroinvertebrate taxa collected in a sample. This index is used as a common measure in many monitoring programs. The use of taxa richness is based on the premise that with changes in the condition of a site, the taxa richness will increase or decrease from the baseline condition. Increases or decreases will depend on the nature of the threats that are influencing the ecosystem.

Additionally, the taxonomic composition of the community was also assessed to see how abundances of individual taxa vary among sampling events. Note that the taxonomic classification level of taxa (e.g. genus, family, order) varies as the taxa are identified to the lowest practical level, with some groups harder to identify to lower levels than others (e.g. Ostracoda).

## 2.4.4 DIATOMS AND PHYTOPLANKTON

### 2.4.4.1 SAMPLING

Diatoms (single-celled algae with siliceous cell walls) are effective indicators for ecological change in freshwater systems (Gale, 2015). Diatoms are an important component of the riverine algae community and

are commonly used for assessing water quality based on the tolerance of species present to pollution (Oeding and Taffs, 2017). Artificial substrates called periphytometers were used to collect living diatoms over a specified time. Two periphytometers each containing 10 microscope slides were deployed at each of the pools. The substrates were left immersed for an average of four weeks to enable diatom communities to establish, reflecting the ambient water quality. On retrieval, the 10 slides from each artificial substrate were scraped into a small, labelled sample container and preserved with 70% ethanol. They were then submitted to the laboratory for taxonomic identification to species level and enumeration. Dr John Tibby of the University of Adelaide was engaged as the sub-consultant for the taxonomic identification and enumeration.

Water samples were taken from the survey sites and submitted to Dalcon Environmental to analyse a full count phytoplankton profile for each pool. Following the Dalcon Environmental recommended sampling protocol, 1.25 L of water was collected from each site from the mid-water column. Phytoplankton samples were preserved with Lugol's Iodine and chilled on ice for the duration of transport.

#### 2.4.4.2 ANALYSIS

The most widely used biotic indices in Australia, DSIAR score (Diatom Species Index for Australian Rivers score), was derived to quantify diatom ecology at the pools. The DSIAR score estimates water quality by the relative abundance of diatom species sensitive to water quality stressors, where a higher DSIAR score represents higher water quality (Chessman *et al.*, 2007). Total count per sample for each species of planktonic phytoplankton and diatoms is also presented.

#### 2.4.5 MACROPHYTES

Macrophytes (aquatic plants) are sensitive indicators of ecosystem health and can be used to assess when physico-chemical thresholds are reached (e.g. turbidity blocking photosynthesis of submerged macrophytes or impacts of sedimentation) (Barko *et al.*, 1982) and the abundance and spatial distribution of heavy metals in aquatic environments (Cardwell *et al.*, 2002). They play a fundamental role in aquatic systems by, for example, reducing erosion of stream banks, increasing dissolved oxygen levels, providing a food source and mediating food web dynamics by providing habitat structural complexity (Warfe and Barmuta, 2006).

Macrophyte sampling followed the AusRivAS guidance (van Looij, 2009). Macrophyte surface area coverage of emergent, submerged and floating macrophytes (Figure 2-3) was visually estimated across the pool habitat and defined as isolated, scattered, in beds or choking the stream as per the 'Field Sampling and Habitat Assessment Sheet 2006 v.14'. Macrophytes included those which were out of the water but in the active channel. Specimens were photographed and samples collected and preserved in 70% ethanol for subsequent confirmation of taxonomic identification and retained. Macrophytes were identified to the species level where possible.

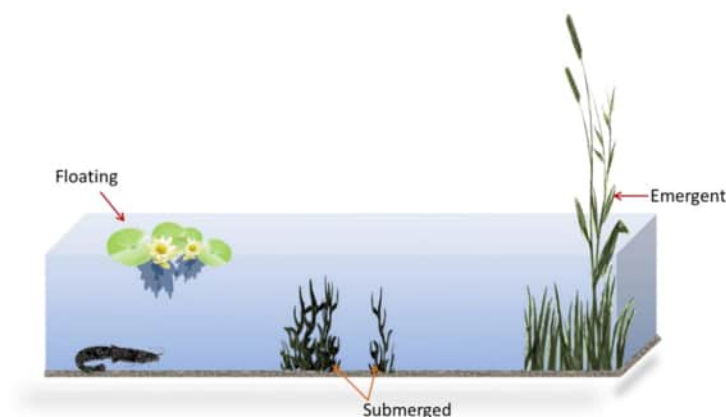


Figure 2-3 Schematic of floating, submerged and emergent macrophytes (DES, 2018).

# 3. RESULTS

This section presents the findings of the hydrology and aquatic ecology surveys conducted between December 2019 (Late Wet 2019) to June 2021 (Late Wet 2021). The results are presented as distinct chapters for each site to reflect that the surface water pools should not be directly assessed relative to other pools but rather to the temporal patterns of the individual pool. For example, each pool has different hydrology, size and habitats, and the methods used are not spatially uniform (i.e. macroinvertebrate sampling of different habitat types between pools).

## 3.1 SITE 12 POOL (IB\_SW\_POOL12\_01)

Site 12 Pool is part of a series of shallow pools that lie to the east of the Project on a small tributary to the upper Six Mile Creek. It is connected to both surface water and groundwater sources over the hydrologic cycle, typically sustained by groundwater until the local groundwater level drops below the pool base level over the late dry season. The pool is frequently perennial, though has been known to dry out following small wet seasons. During the late wet season sampling it is a fresh-brackish, predominantly bedrock habitat that supports fish, macroinvertebrates, algal communities, macrophytes and riparian vegetation (Figure 3-1).

### 3.1.1 WATER QUALITY AND HYDROLOGY

Water quality sampling included physico-chemical parameters, metals analysis and major ions to characterise the surface water system. Stable isotope analysis at Site 12 Pool and bore NS-0664 was also conducted to inform the connectivity of surface water and groundwater. A logger recorded conductivity, temperature and water level on a 3-hourly basis at Site 12 Pool between December 2019 and May 2020.

Site 12 Pool is a shallow bedrock supported natural habitat with a 7.6 km<sup>2</sup> catchment area (Figure 3-3) with typically low rainfall and infrequent high rainfall events largely driven by storm and cyclonic activity. The water quality experiences high seasonal variability due to the climatic conditions of the region, with the greatest variability recorded following rainfall events.

The water quality was predominantly clear (mean turbidity = 2.5 NTU), slightly alkaline (mean pH = 8.5) and a magnesium-bicarbonate (Ca/Mg-HCO<sub>3</sub>) dominated water type with low sulphates (SO<sub>4</sub>) (Figure 3-4; Appendix A). However, it is expected that during surface water flow events the turbidity temporarily increases. Similarly, during rainfall events, the typically slightly brackish pool (1,100-1,300 µS/cm) would become temporarily extremely fresh (<100 µS/cm).



Figure 3-1 Photographs of Site 12 Pool during the late wet season (June 2020; top) and late dry season (Dec 2019; bottom).

Figure 3-5 and Figure 3-6 display a high-resolution water level, salinity (conductivity) and temperature logger record from Site 12 Pool for December 2019 to June 2021 (two wet seasons). The rapid change in

conductivity after rainfall events is evident with one minor inflow at the start of the 2019-20 wet season that partially flushed and filled the pool as well as four major inflows that displayed flooding peaks and complete pool flushing. A similar pattern of four flushing events was also observed in the 2020-21 wet season (Figure 3-6). This preliminary baseline data indicates that the pool is sustained by groundwater (until the local groundwater level drops below the pool level) and is periodically flushed with fresh surface water flows after rainfall events. The ratio of Site 12 Pool volume against inflow volume is presented in *Site 12 Pool Water Quantity Assessment and Management* (FMG, 2020). It takes approximately 2 – 3 weeks for the groundwater to displace the surface water flows once a flushing event has occurred. Comparison of the nearby groundwater levels at the Site 12 Groundwater monitoring bore (NS-0664) with the rainfall and flow in the Site 12 Pool is provided in Figure 3-7. This data suggests that the groundwater level recedes at around 3 cm per week over the dry season, reaching the a level below which groundwater no longer maintains the Site 12 Pool towards the end of the dry season.

Site 12 Pool is a larger habitat area relative to other North Star pools, comprising a series of isolated pools spanning approximately a 650 m reach and 1266 m<sup>2</sup>, and likely has greater downstream connectivity relative to other pools in the Iron Bridge area. Most pools are shallow, with the deepest being approximately 2.5 m. The total volume of the pools is estimated to be 2,532 m<sup>3</sup> based on an average depth of 2 m. This is a small volume relative to the inflow volume; for example, the 1EY post-development estimated inflow is substantially higher (54,198 m<sup>3</sup>) (FMG, 2020). Recorded water levels were a maximum of ~0.6 m above the pool overflow levels during high-flow events, which typically lasted less than 24 hours before flows receded. The rapid falling stage after large flow events indicates there is little retention capacity in the system beyond the pool spill point.

Analysis of the stable isotopes  $\delta^{18}\text{O}$  and  $\delta^2\text{H}$  in Site 12 Pool and bore NS-0664 indicated that the isotope ratios for the surface water within Site 12 Pool and the upstream monitoring bore (NS-0664) were consistently different, with the groundwater being substantially more depleted, particularly for the late dry season (Dec 2019) sampling event. It is likely that some degree of evaporation along the groundwater inflow to the pool, and within the pool system itself, is creating an enriched signature relative to the deeper groundwater (NS-0664) which is more representative of large rainfall event recharge. The December 2019 isotope enrichment in the Site 12 Pool is evidence that at this stage “fresh” or deep groundwater recharge was at a minimum and evaporative isotopic enrichment was a dominant process. The most depleted isotopic ratio of the dataset was observed at the Site 12 groundwater monitoring bore (NS-0664) following the large 2020/21 wet season. This may indicate that the source of the groundwater at the site was relatively recent rainfall during this period. There are preliminary indications that the groundwater at the Site 12 Pool monitoring bore is more similar to a rainwater isotopic composition after the wet season, moving towards the evaporation line in the late dry.

Although the pool is sustained by groundwater for the majority of the dry season, it has been recorded as completely dry in recent years (2015, 2016 and 2020 dry seasons) following low rainfall and groundwater recharge wet seasons (BOM 2020). The more recent observations noted it did not completely dry out in 2019 (Plate 1). The pool naturally drying out or experiencing substantially lower water levels would be expected to impact significantly on the ecological health of Site 12 Pool due to evapo-concentration increasing environmental stressors (e.g. salinity) and lower water levels reducing available habitat. It is noted that visual observations in the late dry 2019 indicated there were no fish in the pool. However, after a drying event in mid November 2020 (late dry), the pool retained all three fish species within several weeks of re-wetting in December 2020. This indicated that the pool ecological response to drying is variable depending on antecedent conditions. It is unknown if the larger pools downstream of the monitoring location dry out at the same frequency as the monitoring location. These are not accessed regularly due to heritage restrictions.

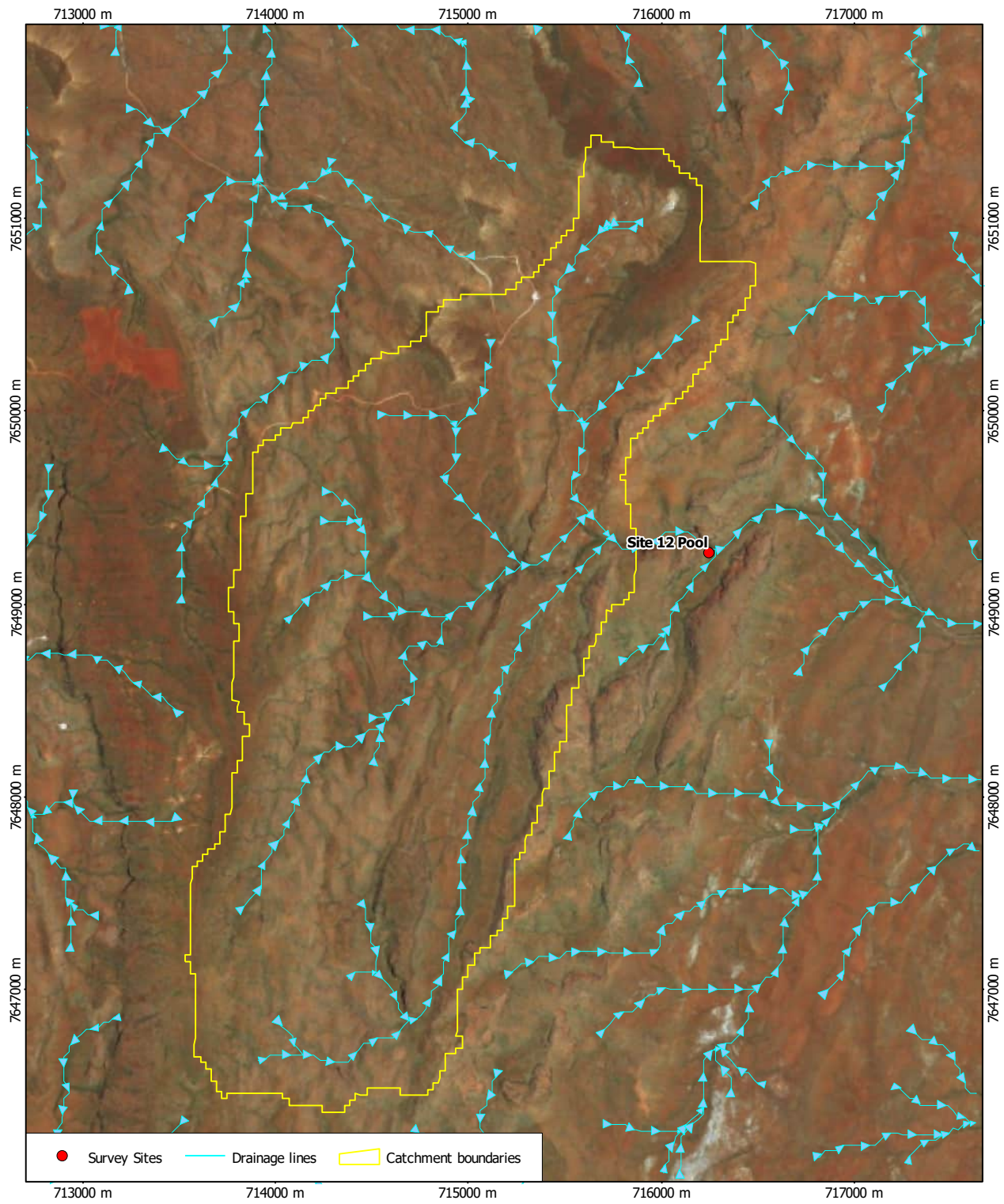


Figure 3-3 Site 12 Pool catchment area

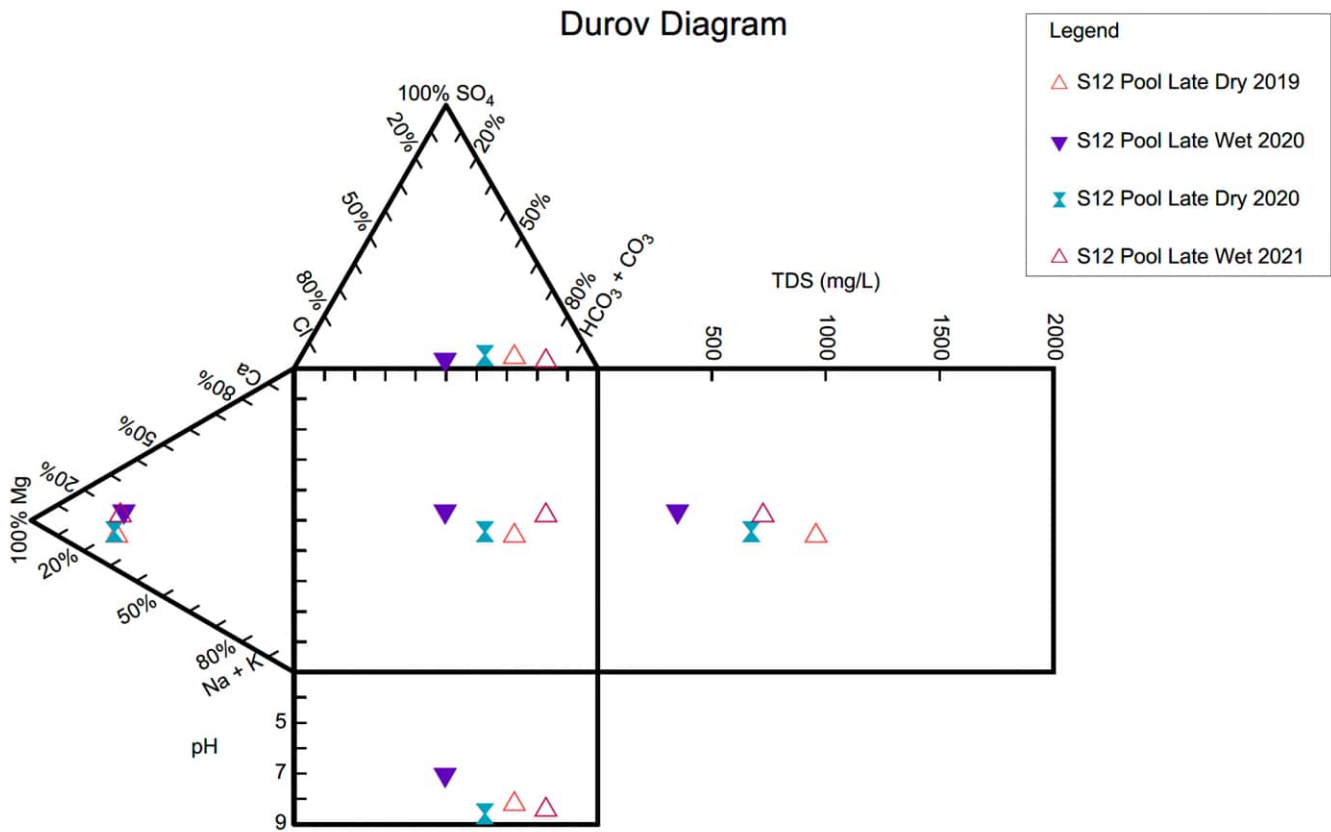


Figure 3-4 Durov diagram illustrates Site 12 Pool is a magnesium-bicarbonate (Ca/Mg-HCO<sub>3</sub>) dominated water type. It is fresh-brackish, alkaline (481 mg/kg CaCO<sub>3</sub>) with low sodium, chloride and sulphate (SO<sub>4</sub>).

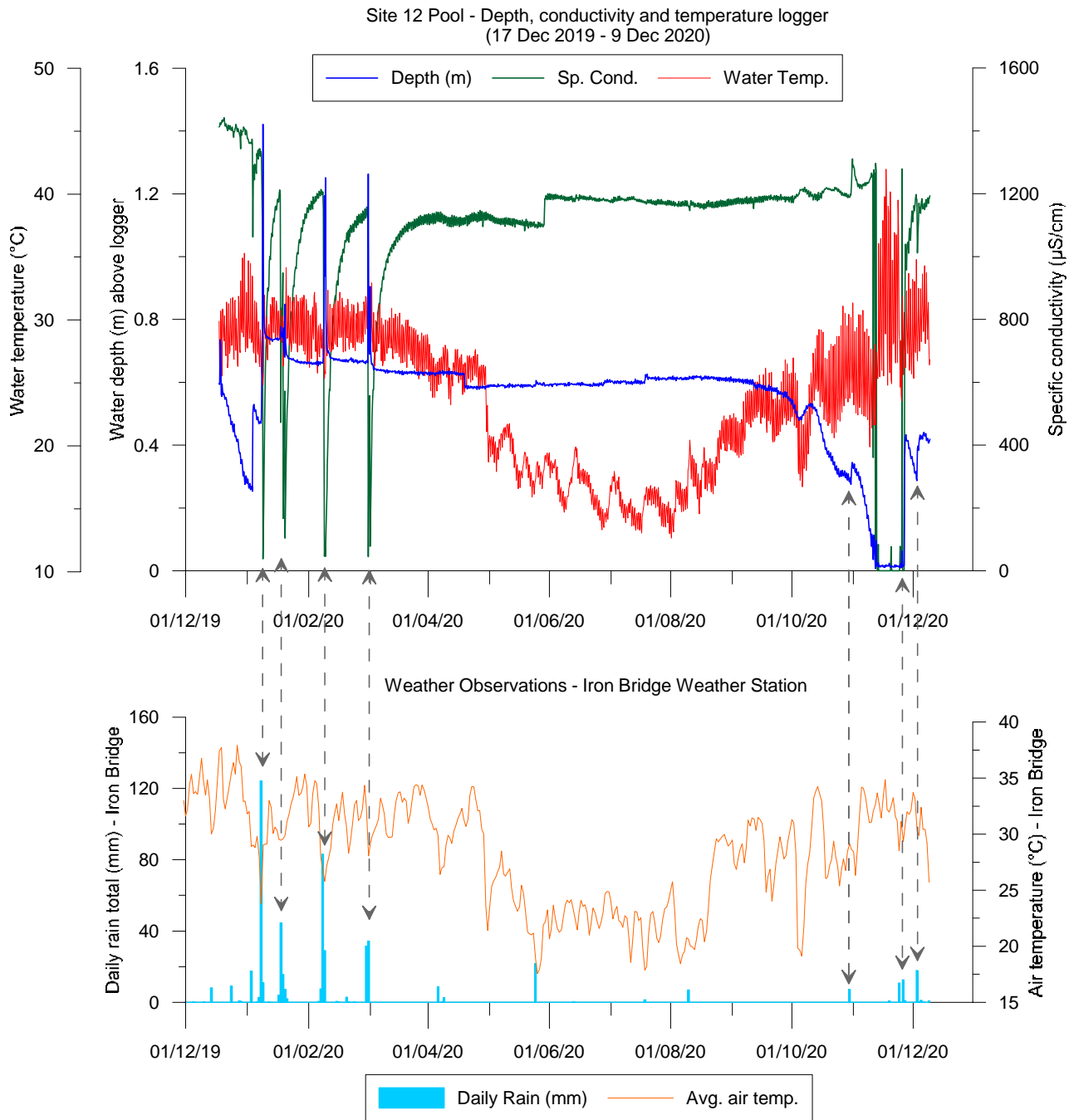


Figure 3-5 Depth, conductivity, and temperature logger data (above) relationship to daily rainfall (below).

Site 12 Pool - Depth, conductivity and temperature logger  
(9 Dec 2020 - 16 June 2021)

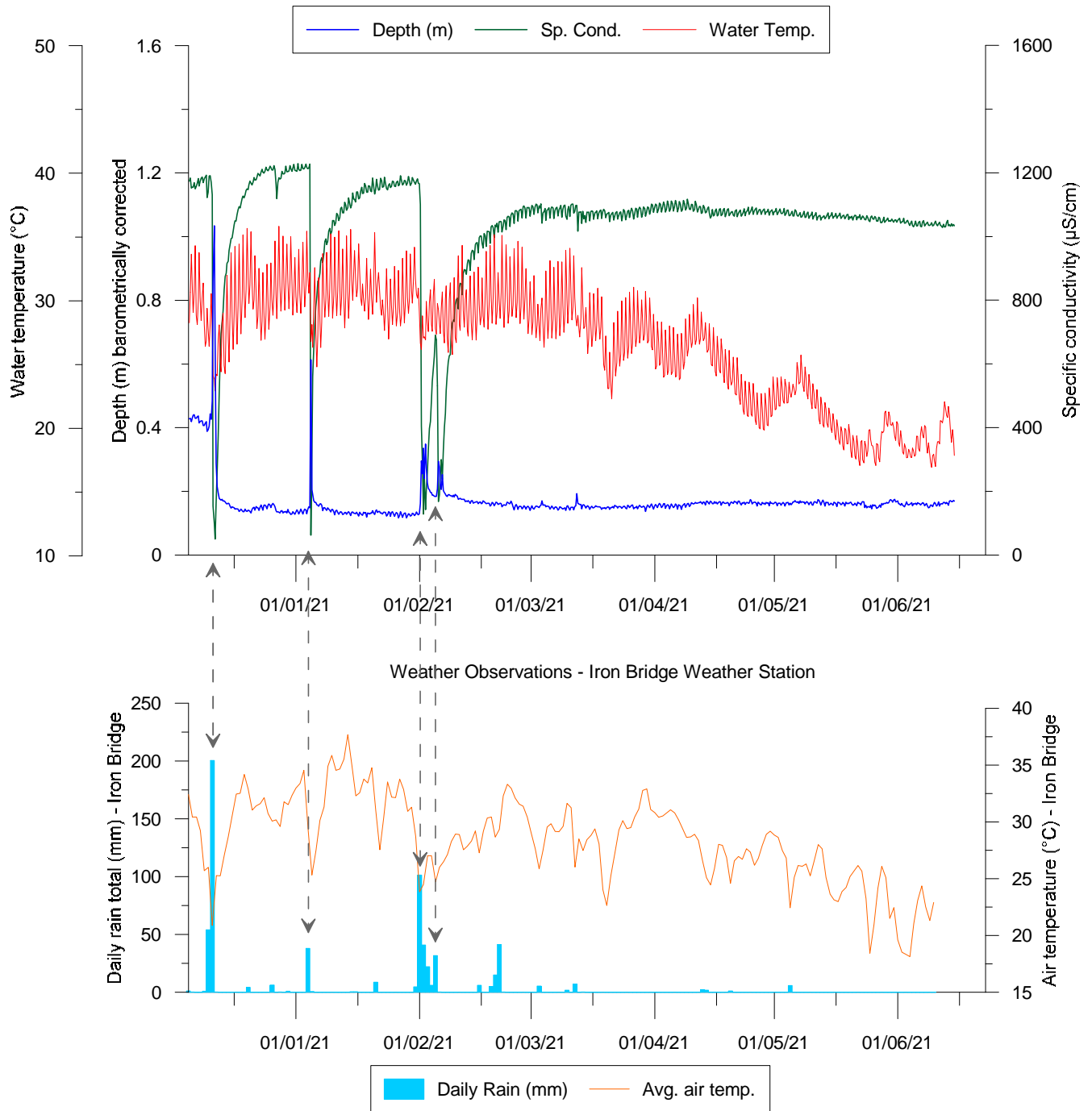


Figure 3-6 Site 12 Pool depth, conductivity, and temperature logger data (above) relationship to daily rainfall (below) – Wet-mid Dry season 2021

Site 12 Pool - Depth, conductivity and temperature logger  
 Site 12 Groundwater Logger - Water level  
 Iron Bridge Daily Rainfall  
 (17 Dec 2019 - 16 June 2021)

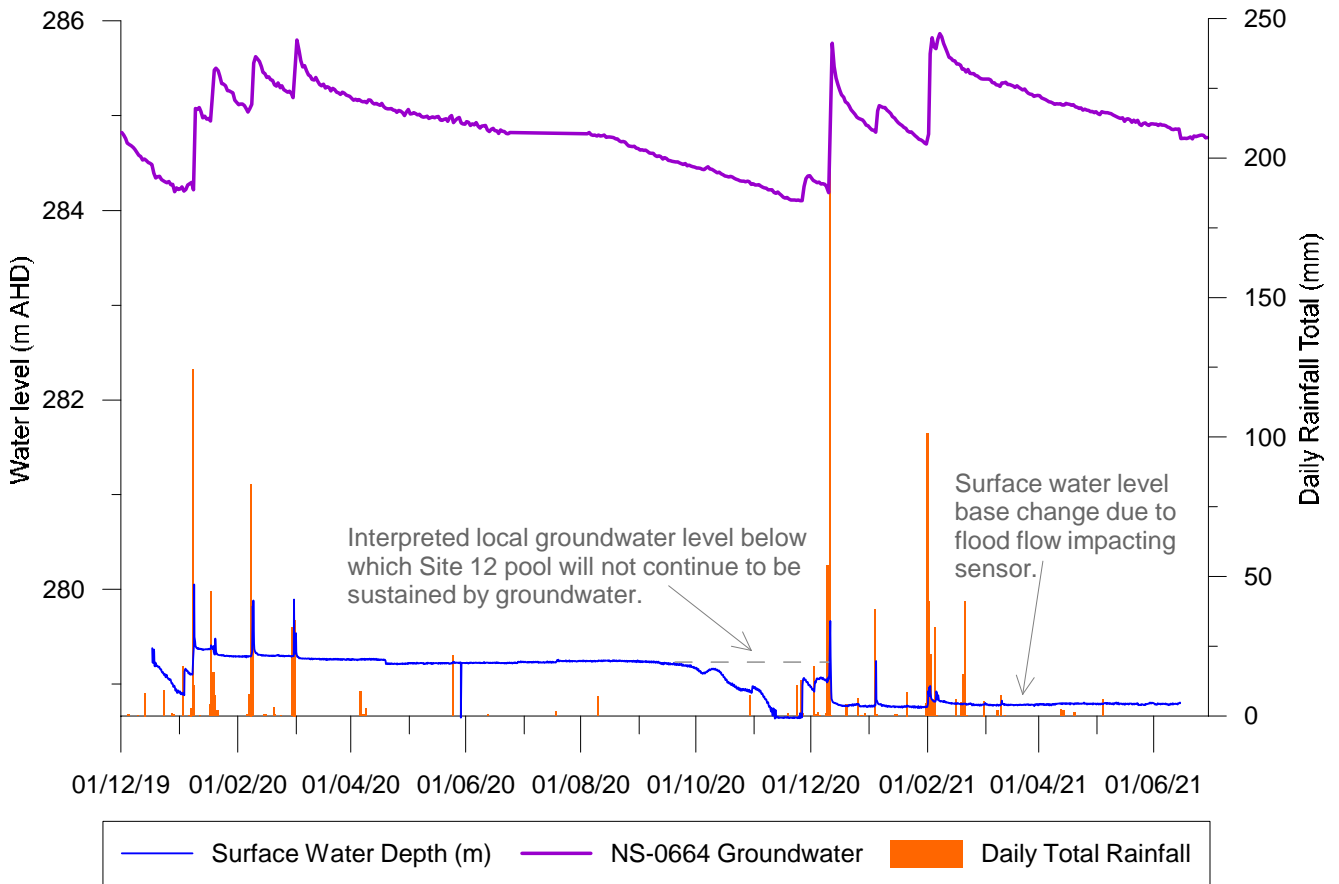


Figure 3-7 Comparison of surface water levels in Site 12 Pool and groundwater levels within the upgradient monitoring bore (NS-0664).



Plate 1 Site 12 Pool hydrological characteristics including; a) high flows over a steeper gradient of bedrock habitat b) confined creek line supporting riparian vegetation and c) sustained groundwater flow

### 3.1.2 SEDIMENT QUALITY

Table 3-1 provides the surface sediment quality at Site 12 Pool across the three seasons sampled. Metal and metalloid concentrations were assessed against the ANZG (2018) DGVs. Chromium and nickel concentrations exceeded the DGV (80 and 21 mg/kg respectively) and the GV-high (370 and 52 mg/kg, respectively). Chromium and nickel both naturally occur at high concentrations across the Project area and were similarly above DGVs at most other surveyed surface water pools in the Project area.

Table 3-1. Summary of sediment quality analytical results for Site 12 Pool. Concentration for each analyte and analyte group described for late wet season 2020 (June 2020), late dry season (December 2020) and late wet season (May 2021). Bolded values denote results above the limit of reporting (LOR).

Analyte grouping/Analyte	Unit	Late Wet 2020	Late Dry 2020	Late Wet 2021
Total Soluble Salts	mg/kg	<b>408</b>	-	<b>402</b>
Moisture Content (Dried @ 105-110°C)	%	<b>28.6</b>	<b>20.9</b>	<b>25</b>
Total Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>71</b>	<b>329</b>	<b>26</b>
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>67</b>	<b>265</b>	<b>26</b>
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>4</b>	<b>65</b>	<b>253</b>
Acidity	mg/kg	<b>4</b>	<5	<5
Sulfate as SO <sub>4</sub> <sup>2-</sup> (soluble sulfate by ICPAES)	mg/kg	<b>20</b>	<10	<10
Chloride (by Discrete Analyser)	mg/kg	<b>30</b>	<b>30</b>	<b>20</b>
Calcium	mg/kg	<b>50</b>	<b>40</b>	<b>30</b>
Magnesium	mg/kg	<b>60</b>	<b>90</b>	<b>60</b>
Sodium	mg/kg	<b>40</b>	<b>40</b>	<b>6</b>
Potassium	mg/kg	<10	<10	<10
Mercury (FIMS)	mg/kg	<0.1	-	<0.1
Nitrite + Nitrate as N (Sol.)	mg/kg	<0.1	<0.1	<0.1
Total Kjeldahl Nitrogen as N	mg/kg	<b>520</b>	<b>200</b>	<b>80</b>
Total Nitrogen as N	mg/kg	<b>520</b>	<b>200</b>	<b>80</b>
Total Phosphorus as P	mg/kg	<b>73</b>	<b>61</b>	<b>56</b>
Reactive Phosphorus as P	mg/kg	<0.1	<0.1	<0.1
Total Organic Carbon	%	<b>0.18</b>	<b>0.29</b>	<b>0.2</b>
<b>Total Metals by ICP-AES</b>				
Arsenic	mg/kg	<5	-	<b>6</b>
Barium	mg/kg	<b>50</b>	-	<b>70</b>
Beryllium	mg/kg	<1	-	<1

Analyte grouping/Analyte	Unit	Late Wet 2020	Late Dry 2020	Late Wet 2021
Boron	mg/kg	<50	-	<50
Cadmium	mg/kg	<1	-	<1
Chromium	mg/kg	<b>384</b>	-	<b>492</b>
Cobalt	mg/kg	<b>23</b>	-	<b>36</b>
Copper	mg/kg	<b>23</b>	-	<b>37</b>
Iron	mg/kg	<b>32,800</b>	<b>41,200</b>	<b>49,400</b>
Lead	mg/kg	<5	-	<5
Manganese	mg/kg	<b>561</b>	-	<b>894</b>
Nickel	mg/kg	<b>179</b>	-	<b>246</b>
Selenium	mg/kg	<5	-	<5
Vanadium	mg/kg	<b>48</b>	-	<b>65</b>
Zinc	mg/kg	<b>26</b>	-	<b>44</b>

### 3.1.3 FISH

Fish, decapods and non-fish vertebrates were sampled with a combination of nets/traps and underwater video (BRUVs). Table 3-2 and Figure 3-9 to Figure 3-14 present the fish species, abundance, and size distribution.

Three native omnivorous fish species were observed in Site 12 Pool across the three seasons: *Melanotaenia australis* (western rainbowfish), *Leiopotherapon unicolor* (spangled perch) and *Neosilurus hyrtlilii* (Hyrtl's catfish).

*Melanotaenia australis* was the dominant species in all three seasons (Table 3-2). Figure 3-9 demonstrates the frequency of each length class for *M. australis* for the three seasons. Predominately, the *M. australis* observed were adults (~50 mm) and estimated to be over 3 months old. In the Late Dry 2020 and Late Wet 2021, smaller fish (<30 mm) were observed, indicating the presence of juveniles at the site (Figure 3-9).

The larger size distribution of *L. unicolor* and *N. hyrtlilii*, ranging from juveniles to adults over a year old, more clearly indicates interannual survival of these species and demonstrating evidence of successful wet season or post-wet season reproduction. However, these species may aestivate (*L. unicolor*) or persist in downstream environments rather than at Site 12 Pool throughout the drier months and migrate upstream to the pool during wet season connective flows. For example, fish were abundant and clearly visible without sampling during the Late Wet 2020 survey, though were not observed during the previous years' late dry season site inspection (December 2019). Similarly, Site 12 Pool was the only pool of five pools surveyed at North Star where *N. hyrtlilii* has been recorded (Figure 3-18), which may be due to the connectivity to downstream creeks and rivers. This species exhibits spawning migration into tributaries and the tendency to inhabit riverine habitats more frequently than off-channel lentic habitats (Pusey, B., Kennard, M., & Arthington, 2004).

Further surveys will clarify the role of environmental stress and connectivity in determining fish presence. For example, whether extended dry season conditions result in decreased fish, or low wet seasons restrict connectivity and therefore fish movement.

Burrowing toadlets (*Uperoleia sp.*), a genus that typically inhabits rocky creeks, were observed in the tadpole phase during December 2019 though were not observed during wet season sampling. This finding may be due to the breeding season occurring earlier and only the semi-aquatic adult stage being present at the time of sampling, which was not targeted by sampling methods.

While baited marron/box traps were used to target decapod crustaceans, none were collected or observed.

Table 3-2. Summary of fish species observed at Site 12 Pool with number of fish for each size class sampled in the Late Wet 2020, Late Dry 2020 and Late Wet 2021. CPUE (catch per unit effort) calculated for each species and sampling date

Species	Size class (mm)	Late Wet (2020)		Late Dry (2020)		Late Wet (2021)	
		Fish Count	CPUE <sup>1</sup>	Fish Count	CPUE <sup>1</sup>	Fish Count	CPUE <sup>1</sup>
<b><i>Melanotaenia australis</i></b>		<b>196</b>	<b>12.6</b>	<b>111</b>	<b>7.1</b>	<b>25</b>	<b>1.61</b>
	0 – 30	0		7		6	
	30 – 60	84		18		16	
	60 – 90	112		86		3	
<b><i>Neosilurus hyrtlii</i></b>		<b>37</b>	<b>2.4</b>	<b>50</b>	<b>3.2</b>	<b>10</b>	<b>0.6</b>
	60 – 90	16		4		4	
	>90	21		46		6	
<b><i>Leiopotherapon unicolor</i></b>		<b>24</b>	<b>1.5</b>	<b>52</b>	<b>3.3</b>	<b>20</b>	
	0 - 30	0		0		2	
	30 – 60	7		5		12	
	60 – 90	10		32		5	
	> 90	7		15		1	
<b>Total</b>		<b>257</b>	<b>16.6</b>	<b>213</b>	<b>13.7</b>	<b>55</b>	<b>3.5</b>

<sup>1</sup> CPUE is catch per unit effort, a measure of relative abundance. Effort is fyke net set for 15.5 hours.

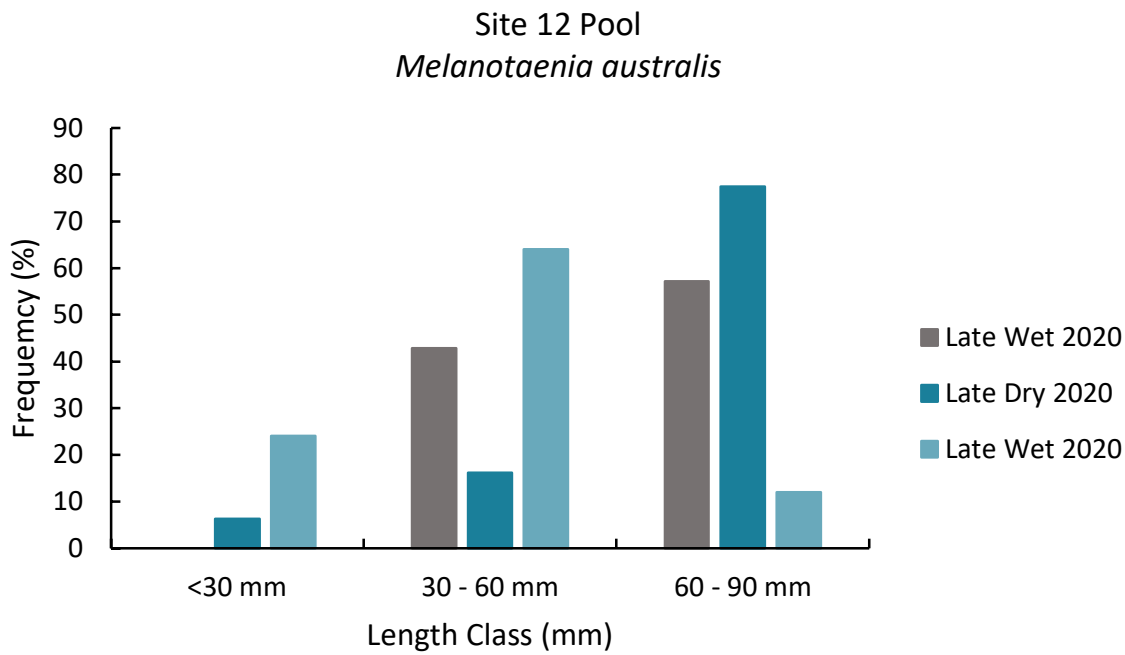


Figure 3-9. Frequency (%) of occurrence for each length class (SL, mm) of *Melanotaenia australis* sampled in Site 12 Pool in the Late Wet 2020, Late Dry 2020 and Late Wet 2021.

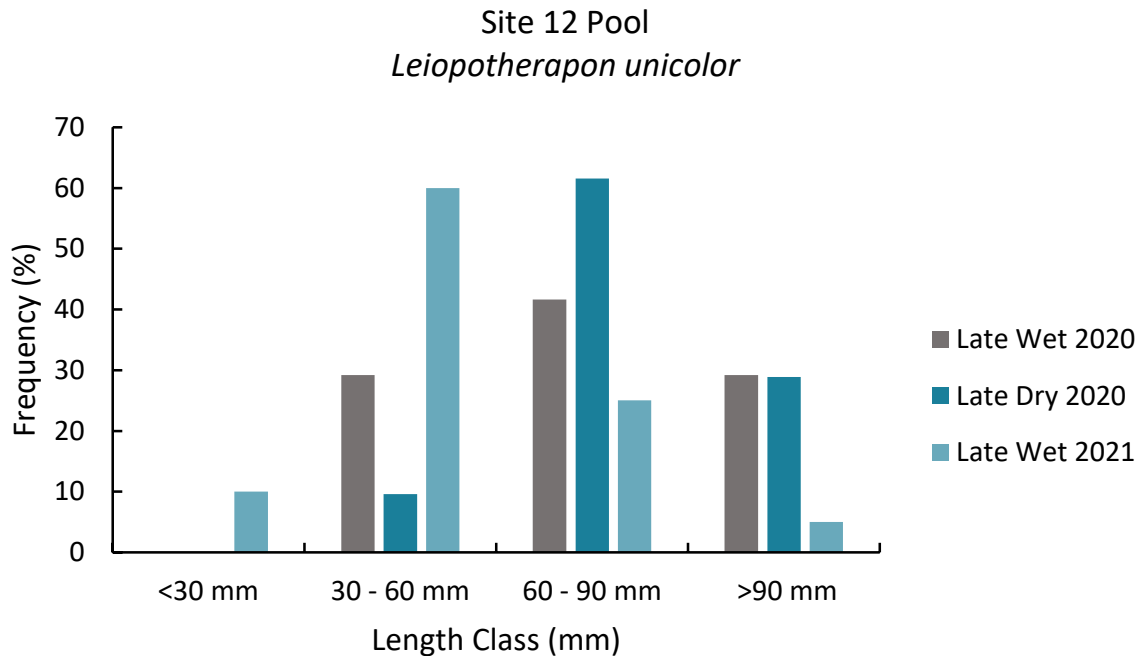


Figure 3-10. Frequency (%) of occurrence for each standard length class (SL, mm) of *Leiopotherapon unicolor* sampled in Site 12 Pool in the Late Wet 2020, Late Dry 2020 and Late Wet 2021.

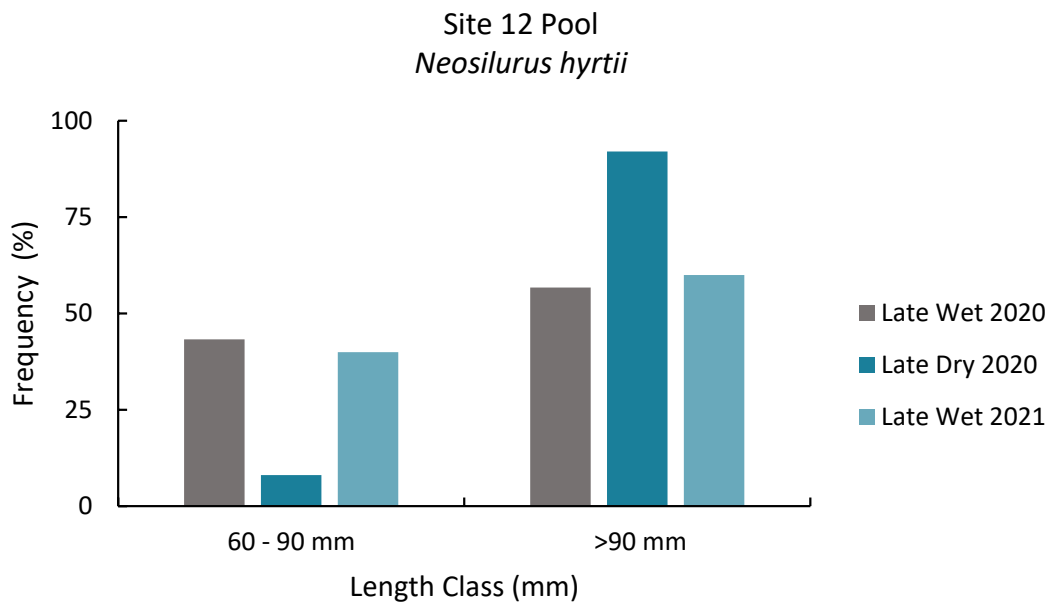


Figure 3-11. Frequency (%) of occurrence for each length class (SL, mm) of *Neosilurus hyrtii* sampled in Site 12 Pool in the Late Wet 2020, Late Dry 2020 and Late Wet 2021.

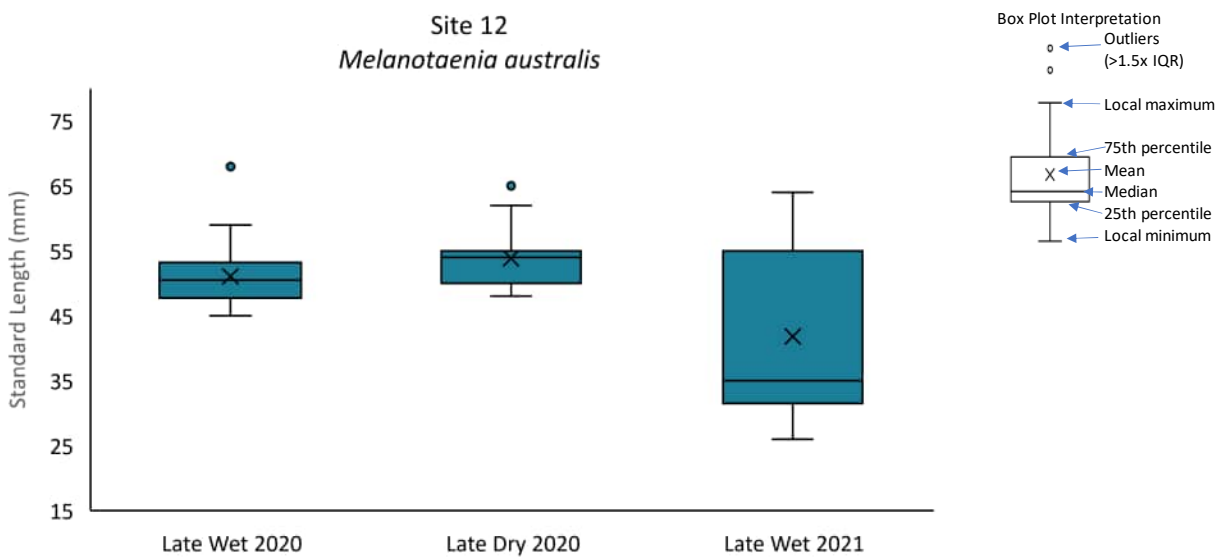


Figure 3-12. Distribution of standard length (SL, mm) of *Melanotaenia australis* sampled in Site 12 Pool in the Late Wet 2020, Late Dry 2020 and Late Wet 2021.

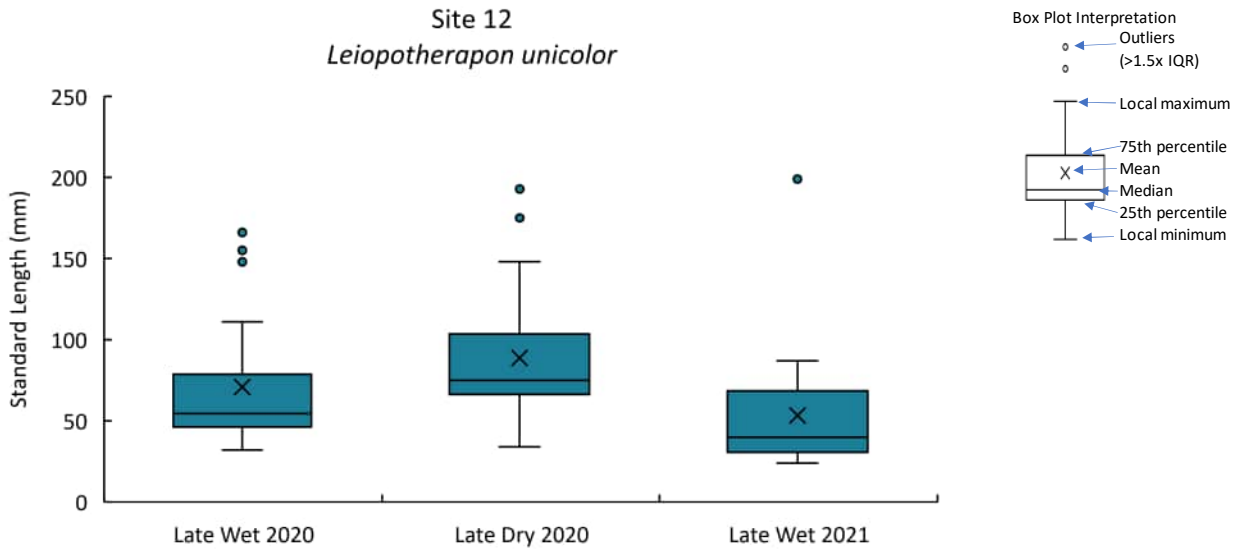


Figure 3-13 Distribution of standard length (SL, mm) of *Leiopotherapon unicolor* sampled in Site 12 Pool in the late wet 2020 (June 2020), late dry (December 2020) and late wet 2021 (May 2021).

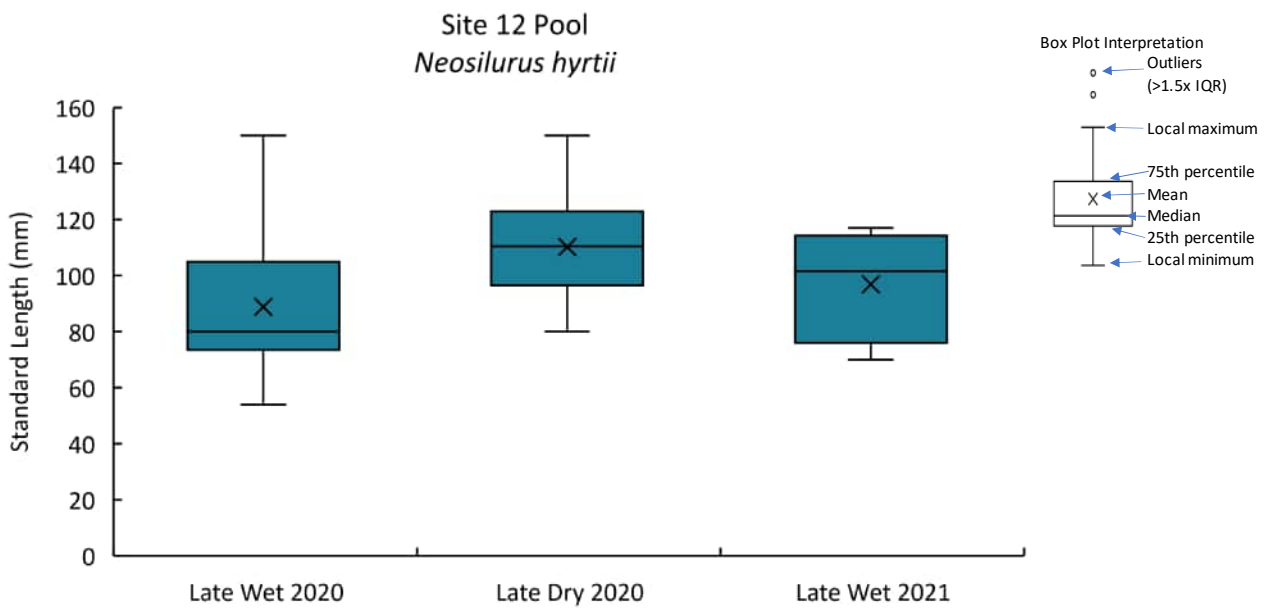
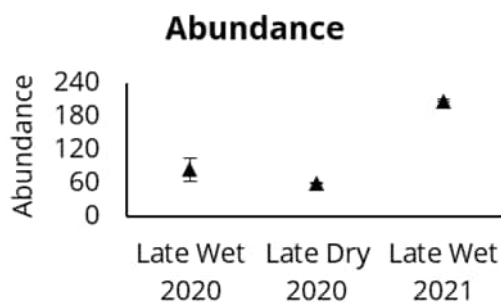


Figure 3-14 Distribution of standard length (SL, mm) of *Neosilurus hyrtlil* sampled in Site 12 Pool in the late wet 2020 (June 2020), late dry (December 2020) and late wet 2021 (May 2021).

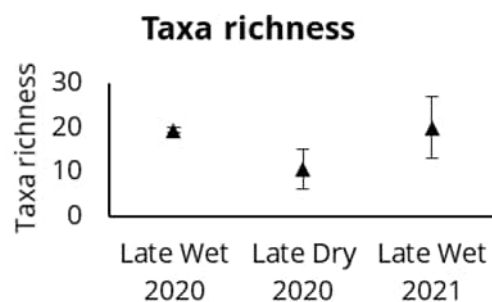
### 3.1.4 AQUATIC MACROINVERTEBRATES

Figure 3-15 presents the total abundance, taxa richness, EPT richness and SIGNAL2 scores for Site 12 Pool in the late wet seasons of 2020 and 2021, and the late dry season of 2020. The key findings were as follows:

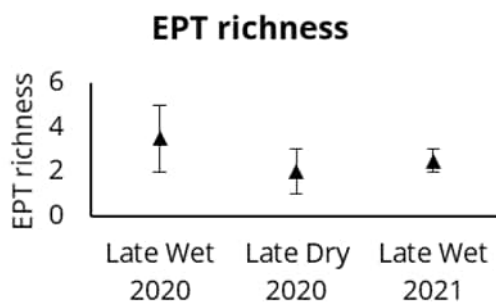
- Average macroinvertebrate abundance was two times greater in the latest wet season during 2021 (209 individuals) than those recorded in the wet (84 inds.) and dry (61 inds.) season of 2020 (Figure 3-15a).
- Taxa richness was similar in both late wet seasons with 20 taxa present, while a lesser 10 taxa were recorded during the late dry season of 2020 (Figure 3-15b).
- The number of taxa belonging to the sensitive Ephemeroptera, Plecoptera and Trichoptera orders was slightly higher in the Late Wet season of 2020 (EPT richness = 3.5), with similar measures in the Late Dry season and Late Wet season of 2020 and 2021, respectively (EPT richness = 2-2.5; Figure 3-15c).
- SIGNAL2 scores ranged from 2.8 to 3.6 among sampling events (Figure 3-15d), indicating the community is consistently dominated by tolerant macroinvertebrate families.



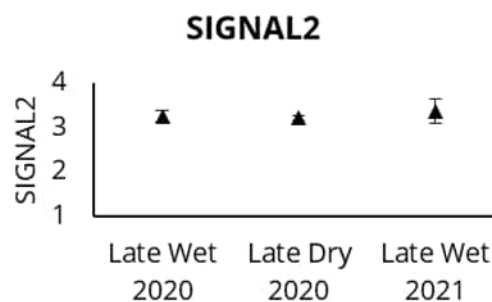
a) Total abundance at Site 12 Pool



b) Taxa richness at Site 12 Pool



c) EPT richness at Site 12 Pool



d) SIGNAL2 scores at Site 12 Pool

Figure 3-15 Macroinvertebrate indices for Site 12 Pool – Late Wet 2020, Late Dry 2020 and Late Wet 2021

The abundance of taxa for the three seasonal surveys is provided in Figure 3-16 and shows taxa ranging from the the most abundant (left) to the least abundant (right) along the x-axis. Briefly, the non-biting midge of Tanypodinae, oligochaete worms, and biting midge larvae of Ceratopognidae were much more abundant in the most recent 2021 wet season than the previous seasons. In contrast, the non-biting midge Chironominae was similarly abundant in all sampling events. Mites and ticks belonging to the Acarina were similarly abundant during both wet seasons, with a decline in the dry season of 2020. Some macroinvertebrates, such as chironomids and oligochaetes, can increase in abundance following freshwater flow events such as flooding in wetlands (e.g. McNerney et al. 2017), which may explain increased abundances of such taxa in the latest wet season when greater rainfall levels were recorded.

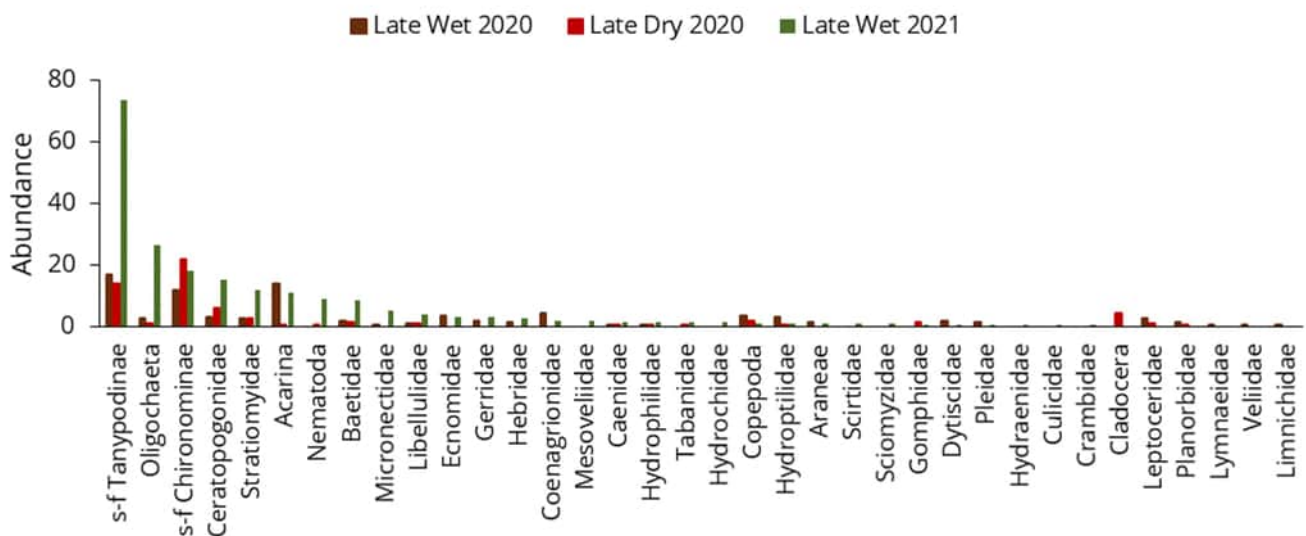


Figure 3-16 Average abundances of all macroinvertebrate taxa at Site 12 Pool in the Late Wet season of 2021 and the Late Wet and Late Dry season of 2020, with taxa arranged from most abundant (left) to least abundant (right) along the x-axis.

## 3.1.5 DIATOMS AND PHYTOPLANKTON

### 3.1.5.1 DIATOMS

The Late Wet 2020 and Late Wet 2021 results are presented. The Late Dry 2020 diatom samples were not analysed as there was a major flood event during the four-week sampler deployment time and, therefore, the samples were not considered representative or useful. Two replicates of diatom samples were collected from Site 12 Pool during each survey and species, abundance and biotic indices were recorded. Overall, a total of 26 diatom species were recorded (Table 3-3) across the two replicates and two seasonal sampling rounds. The most abundant species in all replicates and surveys was *Mastogloia smithii*, followed by *Achnantheidium minutissimum*. The Late Wet 2021 round indicated a higher diversity and abundance than the previous wet season with a doubling of the species richness and abundance. Figure 3-17 illustrates the mean abundance (diatom count per replicate) of diatom species recorded at Site 12 Pool.

The tolerance to environmental stress for Site 12 Pool is reflected in the moderate sensitivity DSIAR scores (52 to 55 across the replicates and seasonal surveys). In Site 12 Pool, there was a large number of teratological ("deformed") forms.

Table 3-3. Summary of diatom total count per species, average abundance and DSIAR score for Site 12 Pool collected in Late Wet 2020

Taxon name	Late Wet 2020		Late Wet 2021	
	Rep 1	Rep 2	Rep 1	Rep 2
<i>Achnantheidium exiguum</i>	2			
<i>Achnantheidium minutissimum</i>	4	24	44	24
<i>Amphora spp.</i>		6		
<i>Brachysira vitrea</i>	4	8		4
<i>Caloneis silicula</i>		4		
<i>Cymbella spp</i>				2
<i>Diploneis parma</i>				4
<i>Epithemia gibba</i>				8
<i>Eunotia arcus</i>				12
<i>Eunotia bilunaris</i>	8	10	18	
<i>Eunotia incisa</i>		2		
<i>Eunotia tenera</i>			4	
<i>Fragilaria acus</i>			22	
<i>Fragilaria capucina var gracilis</i>			2	
<i>Mastogloia elliptica</i>			12	
<i>Mastogloia smithii</i>	42	112	232	116
<i>Navicula gregaria</i>			2	
<i>Navicula lanceolata</i>			2	
<i>Nitzschia filiformis</i>			2	
<i>Nitzschia frustulum</i>			4	
<i>Nitzschia pumilla</i>			2	
<i>Pinnularia spp.</i>			2	
<i>Planothidium frequentissimum</i>			4	
<i>Surirella elegans</i>			2	
<i>Tryblionella calida</i>			2	
<i>Ulnaria ulna</i>			18	34
<b>Total Count</b>	<b>60</b>	<b>166</b>	<b>374</b>	<b>204</b>
<b>Species Richness</b>	<b>5</b>	<b>7</b>	<b>17</b>	<b>8</b>
<b>DSIAR Score</b>	<b>55</b>	<b>54</b>	<b>52</b>	<b>53</b>

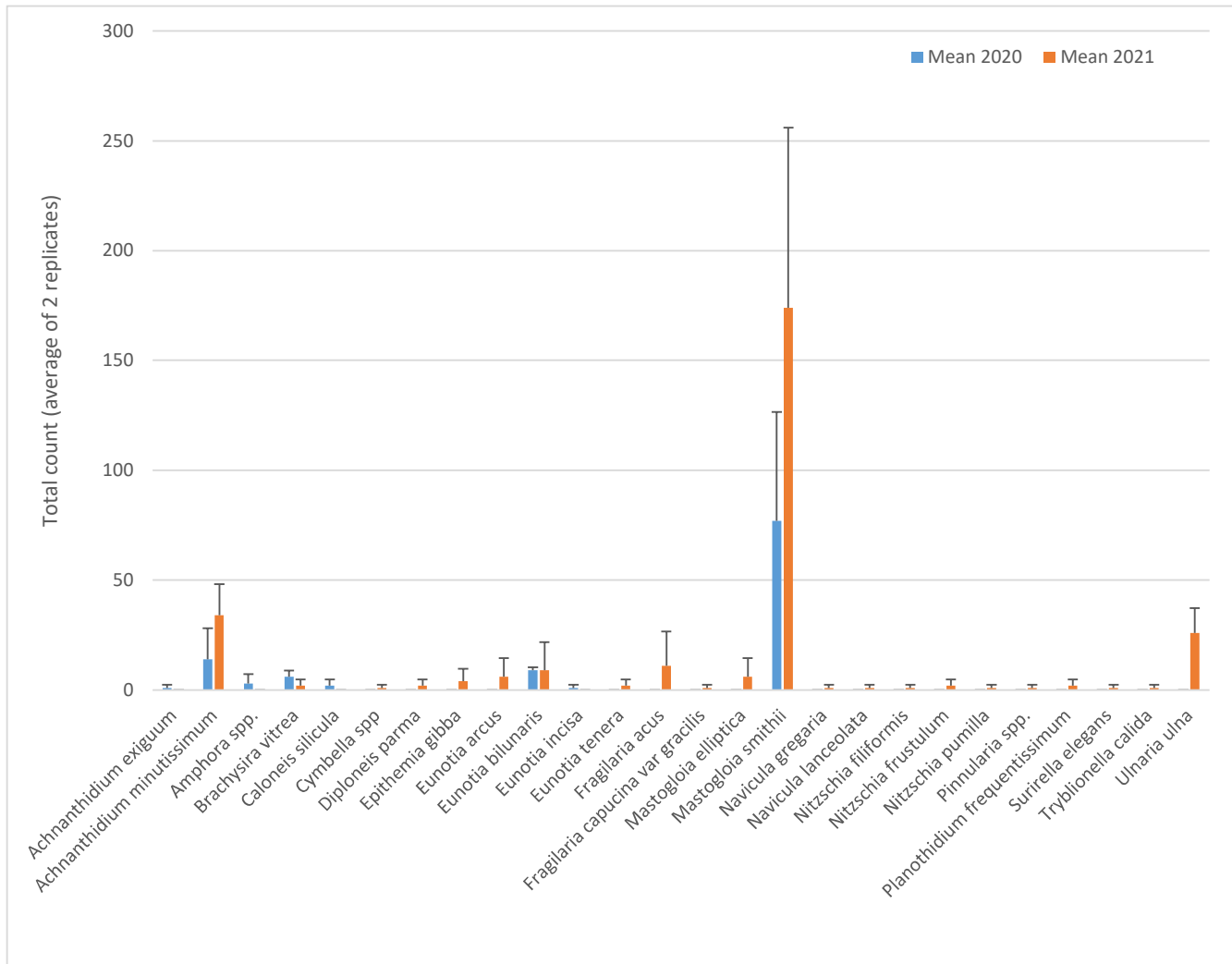


Figure 3-17. Average species abundance (diatom count per replicate) for diatoms sampled at Site 12 Pool in the Late Wet 2020 and Late Wet 2021. Standard deviation denoted by error bars.

### 3.1.5.2 PHYTOPLANKTON

As noted above, in the Late Dry 2020 sampling, the Diatom samplers (periphytometers) did not record meaningful data, as such, water samples were taken from the site to analyse a full phytoplankton profile for the site. This was repeated in the Late Dry 2021 survey for completeness and comparison of results.

Five classes of phytoplankton were identified at Site 12 Pool in Late Dry 2020, the most abundant being Dinophyceae (Dinoflagellates) at 72.8%, with two genera being observed *Gonyaulax sp.* and *Peridinium sp.* The second most abundant phytoplankton class was Cryptophyceae at 17%, with the genus *Cryptomonas sp.* having the highest contribution in this class. *Cryptomonas spp.* are always found in freshwater and function like diatoms. Cyanobacteria (blue-green algae) contributed 5.67% of the overall phytoplankton abundance. Chlorophyceae (green algae) and Bacillariophyceae (diatoms) had the lowest abundance at Site 12 Pool (Table 3-4).

Minimal algal cells were identified in the samples taken in Late Wet 2021 at Site 12 Pool; the only genus observed was *Navicula spp.* (Diatoms) (Table 3-4). This potentially indicates that late dry conditions are favourable for phytoplankton growth at this site, with moving water during the wet season not allowing the development of water column algal populations.

Table 3-4 Summary of phytoplankton analytical results for Site 12 Pool sampled in Late Dry 2020 and Late Wet 2021, abundance (cells L<sup>-1</sup>) and percentage contribution (%), limit of reporting 10 cell L<sup>-1</sup>.

Taxon	Late Dry 2020		Late Wet 2021	
	Abundance	%	Abundance	%
<b>Bacillariophyceae</b>	<b>5200</b>	<b>2.27</b>	<b>20</b>	<b>100</b>
<i>Amphora spp.</i>	400	0.28	0	0
<i>Navicula spp.</i>	1200	0.85	20	100
<i>Nitzschia spp.</i>	1200	0.85	0	0
<i>Synedra spp.</i>	400	0.28	0	0
<b>Chlorophyceae</b>	<b>3200</b>	<b>2.27</b>	<b>0</b>	<b>0</b>
<i>Closterium spp.</i>	1200	0.85	0	0
<i>Cosmarium spp.</i>	2000	1.42	0	0
<b>Cryptophyceae</b>	<b>24000</b>	<b>17</b>	<b>0</b>	<b>0</b>
<i>Chroomonas spp.</i>	2400	1.7	0	0
<i>Cryptomonas spp.</i>	21600	15.3	0	0
<b>Cyanobacteria</b>	<b>8000</b>	<b>5.67</b>	<b>0</b>	<b>0</b>
<i>Chroococcus spp.</i>	1600	1.13	0	0
<i>Planktolyngbya spp.</i>	6400	4.53	0	0
<b>Dinophyceae</b>	<b>102800</b>	<b>72.8</b>	<b>0</b>	<b>0</b>
<i>Gonyaulax spp.</i>	42800	30.31	0	0
<i>Peridinium spp.</i>	60000	42.49	0	0

### 3.1.6 MACROPHYTES

A diverse range of native flora was observed within Site 12 Pool. These comprised aquatic species and groundwater-dependent species. These species are likely not surface water inflow dependent, as the pool refills with groundwater within 2 – 3 weeks following flushing events.

During all surveys (Late Wet 2020, Late Dry 2020 and Late Wet 2021), a total of seven macrophyte species were observed belonging to five families (Table 3-5). Macrophytes observed at Site 12 Pool included Bulrush reeds (*Typha sp.*), sedges (*Cyperus sp.*), two charophytes (*Nitella sp.* and *Chara sp.*), as well as two submerged macrophytes (*Vallisneria sp.* and *Myriophyllum sp.*) (Figure 3-18). Table 3-5 summarises the macrophyte species observed at Site 12 Pool. No substantial changes in macrophyte composition were observed at the Site 12 Pool over the three surveys (Late Wet 2020, Late Dry 2020 and Late Wet 2021). A slight decrease in the abundance of both submerged and emergent macrophytes in the Late Wet 2021 compared to the Late Wet 2020 was noted, though no changes were substantial enough to alter the categorical abundance classification.

The types and species of macrophytes present in a system are indicators of water quality and ecological health. The abundance and diversity of macrophytes at Site 12 Pool plays a key role in nutrient dynamics,

indicates that water quality parameters (e.g., turbidity, salinity) have not reached levels that interfere with macrophyte growth and development and provides habitat structure and refuges to organisms. For example, the macrophyte habitat and its' structural complexity likely provide refuge to the *M. australis* (western rainbowfish) from predation by adult *L. unicolor* (spangled perch).

Table 3-5. Summary of macrophyte species abundance, with family name and common name observed at Site 12 Pool during sampling in the Late Wet 2020, Late Dry 2020 and Late Wet 2021.

Common name	Species name	Late Wet 2020 Abundance <sup>1</sup>	Late Dry 2020 Abundance <sup>1</sup>	Late Wet 2021 Abundance <sup>1</sup>
Ribbon weed	<i>Vallisneria sp.</i>	Isolated	Isolated	Isolated
Charophytes	<i>Nitella sp., Chara sp.</i>	Isolated	Isolated	Isolated
Clubrush	<i>Schoenoplectus sp.</i>	Isolated	Isolated	Isolated
Sedges	Cyperaceae	Isolated	Isolated	Isolated
Bulrush	<i>Typha sp.</i>	Isolated	Isolated	Isolated

<sup>1</sup> Abundance based on *Western Australia AUSRIVAS field sampling and habitat assessment sheet* (DoW, 2009).

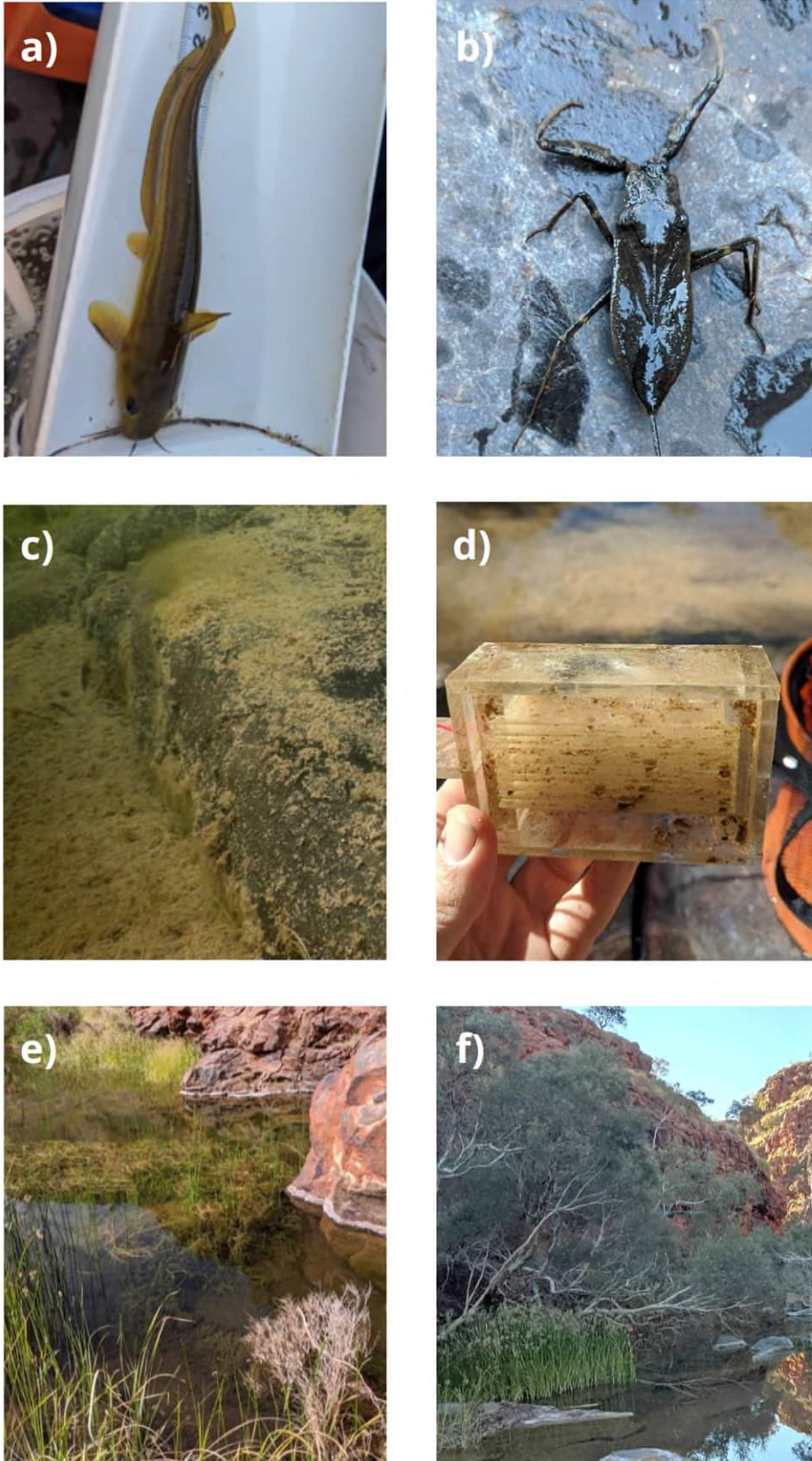


Figure 3-18 Site 12 Pool aquatic ecology. a) *Neosilurus hyrtlui* found at Site 12 Pool and no other surveyed pools; b) Belostomatidae, a giant water bug that typically hunts amongst macrophytes; c) bedrock covered in benthic algae; d) periphytometer used to sample diatoms shows benthic algae growth; e) and f) submerged and emergent macrophytes

## 3.2 FIG POOL (IB\_SW\_POOL\_Fig)

Fig Pool is an isolated small pool that lies at the base of a rockface (Figure 3-19) with a small catchment area of 0.16 km<sup>2</sup> (Figure 3-20). It is characterised by stable water levels maintained by fresh groundwater. A relatively low abundance and diversity of aquatic flora and fauna inhabit the pool, likely due to it being naturally acidic. For example, fish and macrophytes are absent in the pool. It is a bedrock dominated habitat with the primary structural complexity provided by the roots of *Melaleuca leucadendra* (paperbark tree) roots.



Figure 3-19 Fig Pool is a small, acidic pool that lies below a rockface and is surrounded by *Melaleuca leucadendra* (paper bark tree) of which the roots are a dominant feature.

### 3.2.1 WATER QUALITY AND HYDROLOGY

Water quality sampling results, including physio-chemical parameters, metals analysis, major ions, and stable isotope analysis to characterise the surface water system and its connectivity to groundwater are presented in Appendix A. Figure 3-21 and Figure 3-22 display a high-resolution water level, salinity (conductivity) and temperature logger record from Fig Pool for the wet seasons of 2019/2020 and 2020/2021 respectively.

Fig Pool is a small (~20 m<sup>3</sup>), shallow pool with water quality that varies minimally between seasons. The pool is largely sustained by groundwater and was periodically flushed with fresh surface water flows after rainfall events. It takes approximately 1 week for the groundwater to displace the surface water flows once a flushing event has occurred. Conductivity was typically fresh (~200 µS/cm) except during a surface water flow event when it would become extremely fresh (<20 µS/cm). Water levels were a maximum of ~0.06 m

above the pool overflow levels during high-flow events, which typically lasted less than 24 hours before flows receded. The minimal change in water level indicates the pool remained approximately at its spill point level throughout the logging period. Due to the small catchment area (0.16 km<sup>2</sup>) and the gradient of Fig Pool's upstream and downstream environment, it is likely the pool has very limited connectivity to surface drainage.

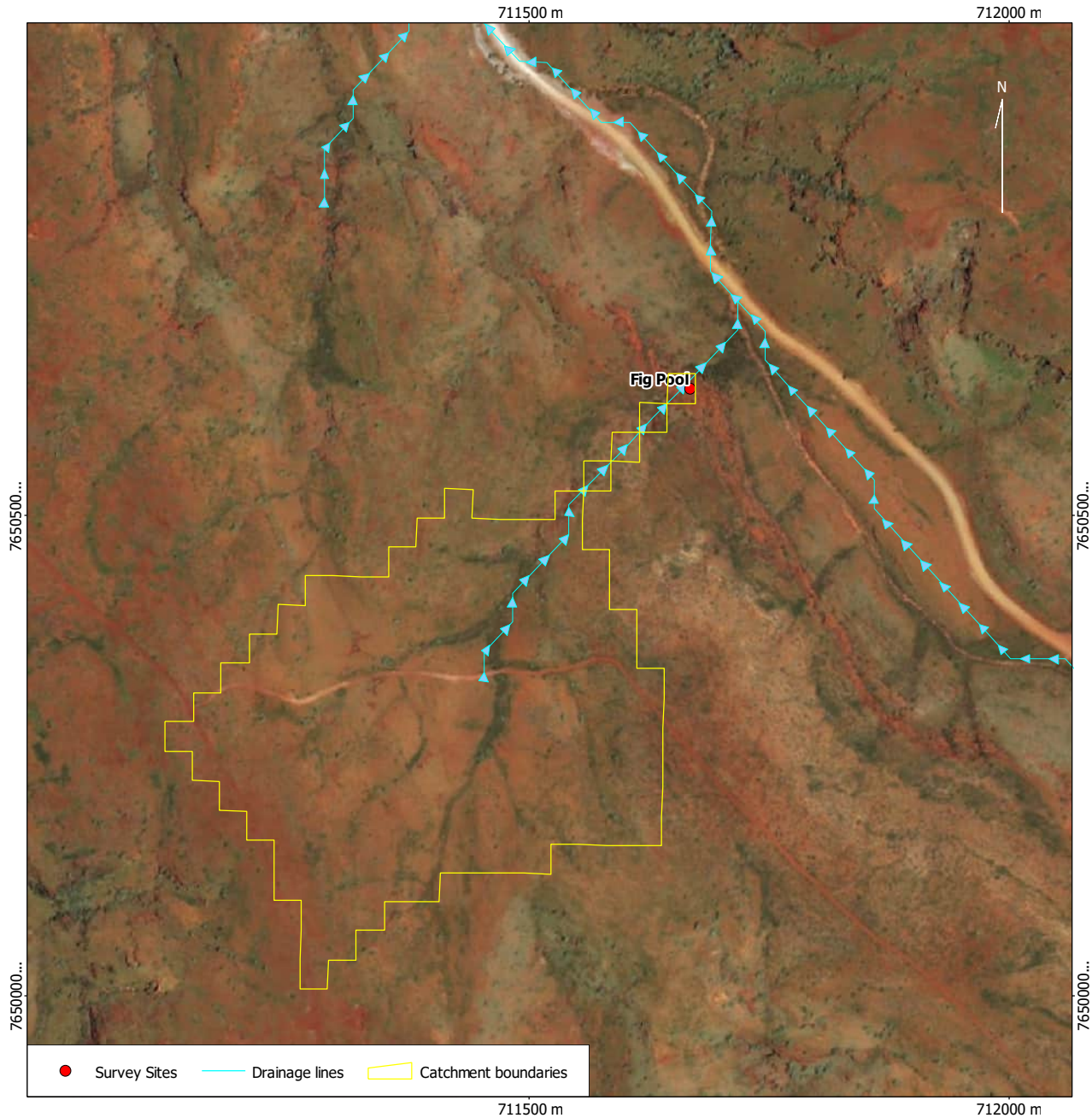


Figure 3-20 Fig Pool catchment area (0.16 km<sup>2</sup>)

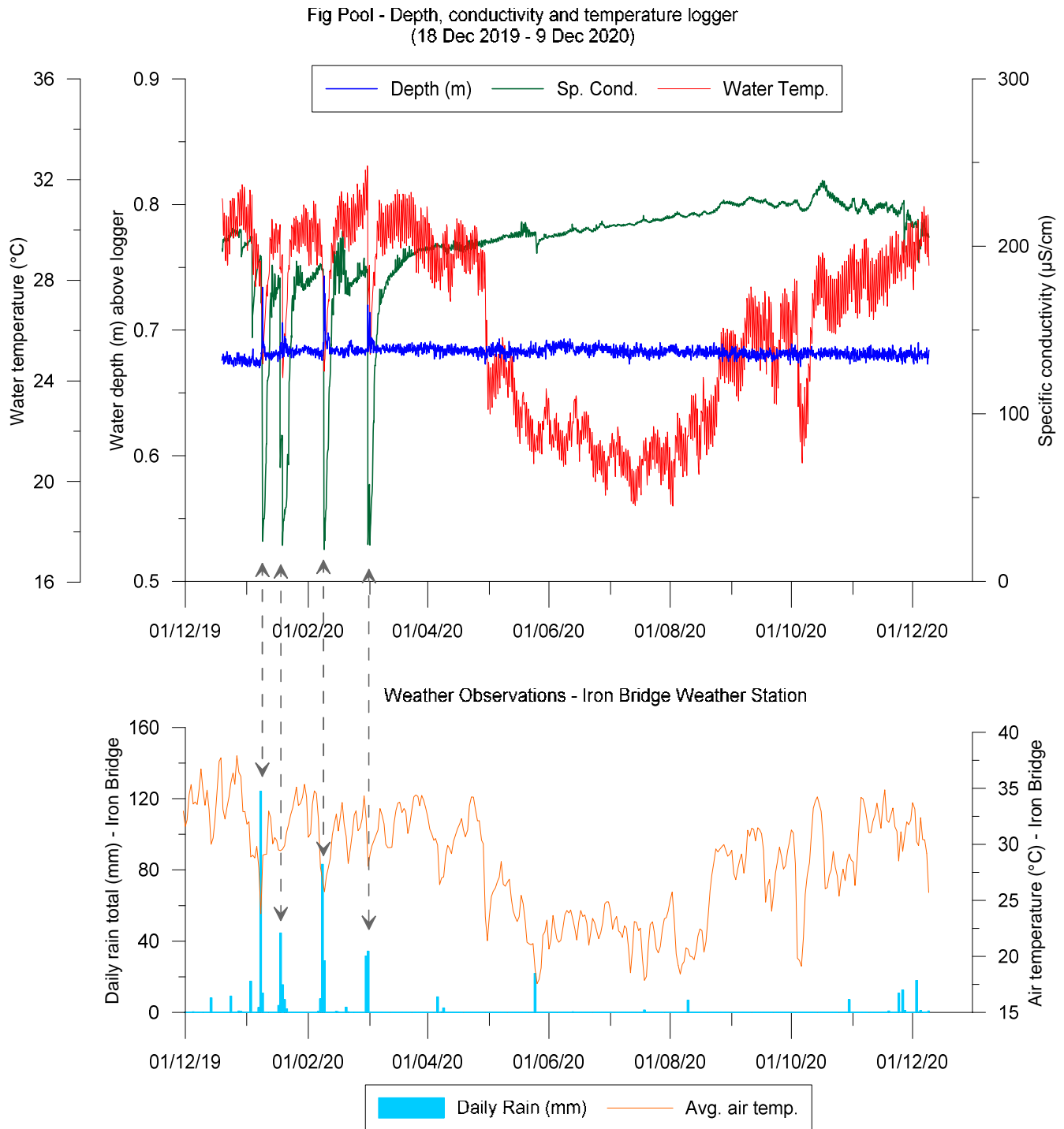


Figure 3-21 Fig Pool depth, conductivity, and temperature logger data (above) relationship to daily rainfall (below) – Wet-Dry season 2020.

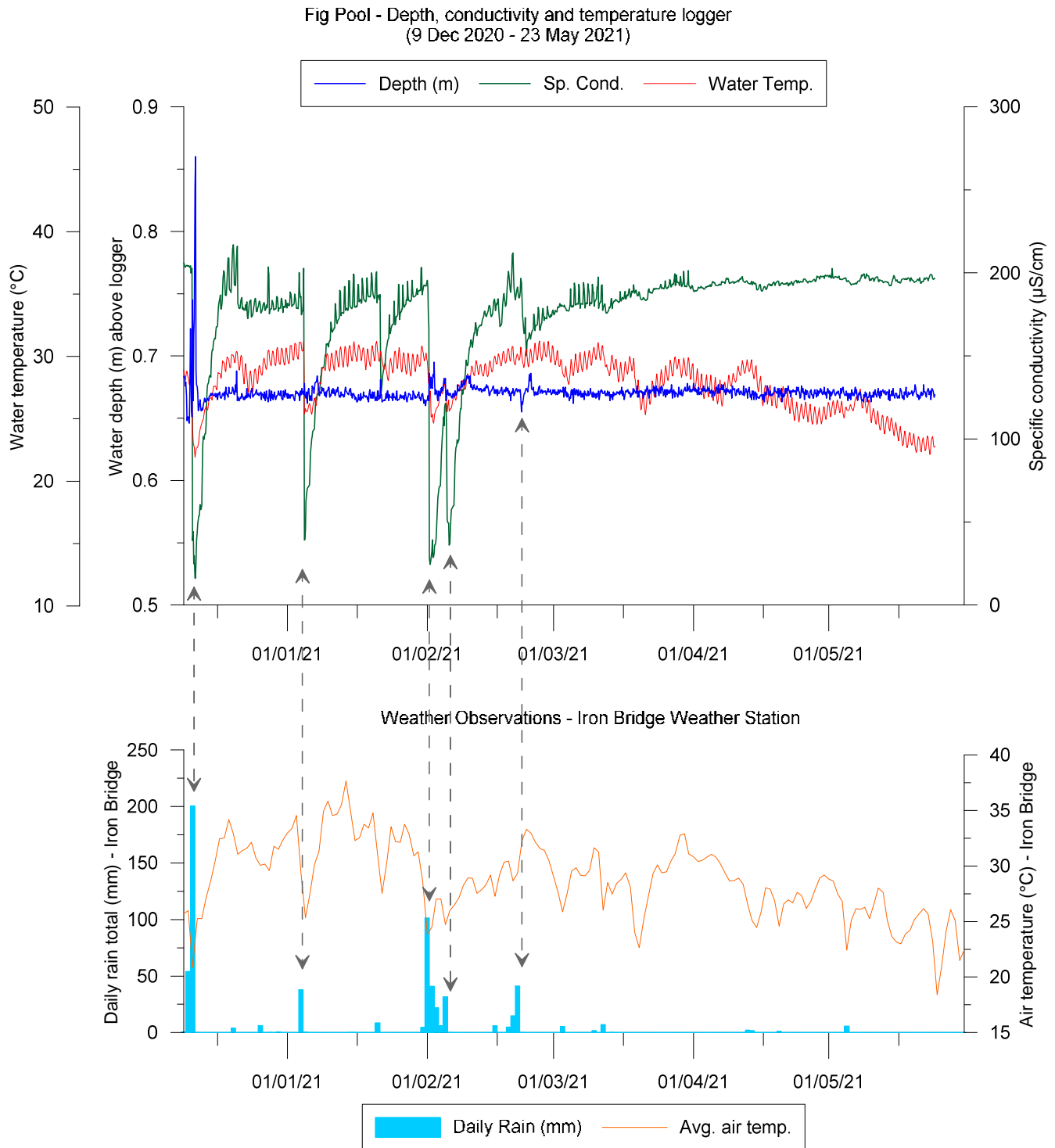


Figure 3-22 Fig Pool depth, conductivity, and temperature logger data (above) relationship to daily rainfall (below) - Wet-mid Dry season 2021.

### 3.2.1.1 WATER CHEMISTRY

The major ion balance at Fig Pool was remarkably stable over the four sampling events (Late Dry 2019, Late Wet 2020, Late Dry 2020 and Late Wet 2021). The water quality was clear (turbidity = <1 NTU NTU), acidic (pH = 3.4) and a sodium sulphate dominated water type (Figure 3-23). Although the pH at this site is low, the acidity levels are only moderate to low (16 mg/L as CaCO<sub>3</sub>). Observations at the site would indicate that the low pH based on spot samples (no pH logger is installed) is potentially due to the lack of buffering capacity in the low conductivity water and is likely to be controlled by the Fe(II)/Fe(III) redox couple at a pH of ~3.5. This is potentially mediated by biological processes in the root mats which surround the pool (e.g. root zone Fe(II) oxidation).

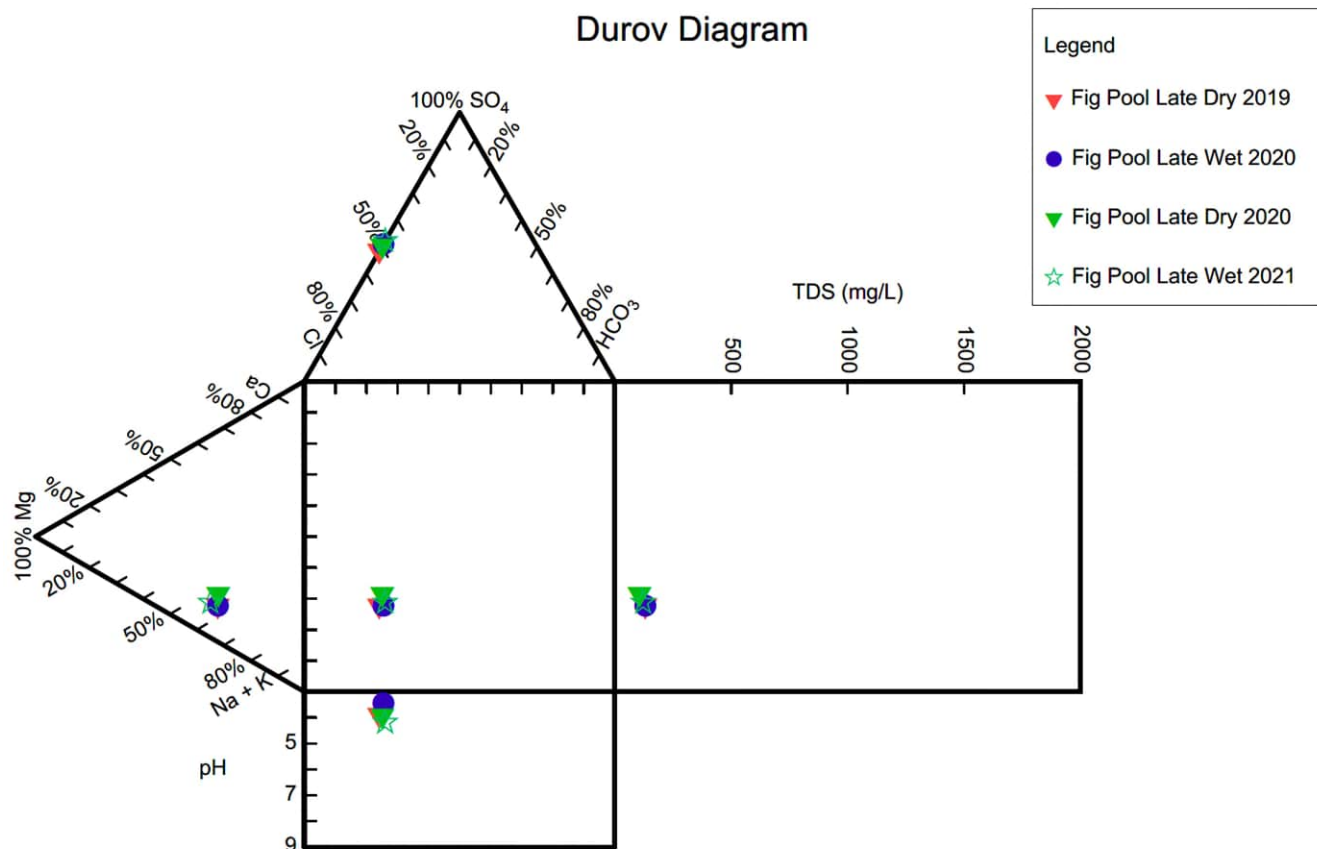


Figure 3-23 Durov diagram illustrates Fig Pool is a sodium-sulphate dominated water type. It is fresh, highly acidic pool with low total dissolved solids (TDS).

### 3.2.2 SEDIMENT QUALITY

Table 3-6 provides the surface sediment quality at Fig Pool during the Late Wet 2020, Late Dry 2020 and Late Wet 2021 surveys. Metal and metalloid concentrations were assessed against the ANZG (2018) DGVs. Chromium concentrations exceeded the DGV (80 mg/kg) though not the GV-high (370 mg/kg). Chromium naturally occurs at high concentrations across the Project area and were similarly above DGVs at most other surveyed surface water pools in the Project area.

Table 3-6. Summary of sediment analysis at Fig Pool sampled in late wet season 2020 (June 2020), late dry season 2020 (December 2020) and late wet season 2021 (May 2021).

Analyte grouping/Analyte	Unit	Late Wet 2020	Late Dry 2020	Late Wet 2021
Total Soluble Salts	mg/kg	<b>248</b>	-	<b>384</b>
Moisture Content (Dried @ 105-110°C)	%	-	<b>38.3</b>	<b>37</b>
Total Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>2</b>	<5	<5
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>2</b>	<5	<5
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<1	<5	<5
Acidity	mg/kg	<b>14</b>	<b>166</b>	<b>1000</b>
Sulfate as SO <sub>4</sub> <sup>2-</sup> (soluble sulfate by ICPAES)	mg/kg	<b>120</b>	<b>160</b>	<b>150</b>
Chloride (by Discrete Analyser)	mg/kg	<10	<b>40</b>	<b>60</b>
Calcium	mg/kg	<b>30</b>	<10	<10
Magnesium	mg/kg	<10	10	10
Sodium	mg/kg	<b>10</b>	<b>40</b>	<b>12</b>
Potassium	mg/kg	<b>10</b>	<b>30</b>	<b>10</b>
Mercury (FIMS)	mg/kg	<0.1	-	<b>0.2</b>
Nitrite + Nitrate as N (Sol.)	mg/kg	<0.1	<0.1	<b>0.2</b>
Total Kjeldahl Nitrogen as N	mg/kg	<b>1110</b>	<b>1670</b>	<b>3030</b>
Total Nitrogen as N	mg/kg	<b>1110</b>	<b>1670</b>	<b>3030</b>
Total Phosphorus as P	mg/kg	<b>60</b>	<b>223</b>	<b>310</b>
Reactive Phosphorus as P	mg/kg	<0.1	<0.1	<0.1
Total Organic Carbon	%	<b>0.30</b>	<b>3.60</b>	<b>3.08</b>
<b>Total Metals by ICP-AES</b>				
Arsenic	mg/kg	<5	-	<b>12</b>
Barium	mg/kg	<b>10</b>	-	<b>40</b>
Beryllium	mg/kg	<1	-	<1
Boron	mg/kg	<50	-	<50
Cadmium	mg/kg	<1	-	<1
Chromium	mg/kg	<b>143</b>	-	<b>127</b>
Cobalt	mg/kg	<2	-	<b>2</b>
Copper	mg/kg	<b>8</b>	-	<b>24</b>
Iron	mg/kg	<b>58500</b>	<b>90200</b>	<b>64600</b>
Lead	mg/kg	<5	-	<5

Analyte grouping/Analyte	Unit	Late Wet 2020	Late Dry 2020	Late Wet 2021
Manganese	mg/kg	94	-	39
Nickel	mg/kg	6	-	12
Selenium	mg/kg	<5	-	<5
Vanadium	mg/kg	27	-	53
Zinc	mg/kg	5	-	8

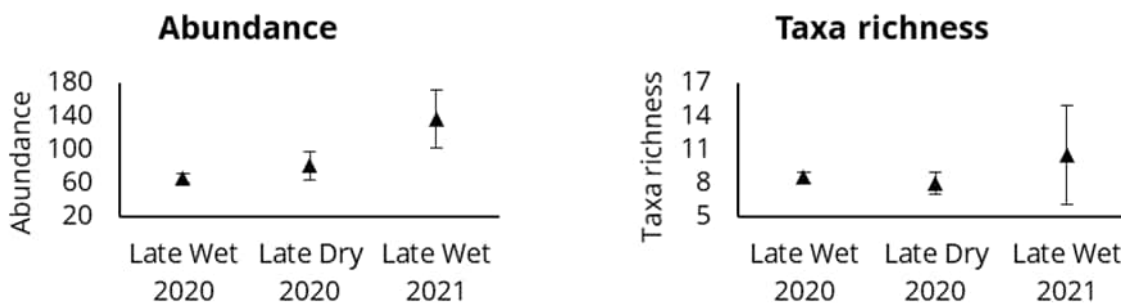
### 3.2.3 FISH

Fish, decapods, and non-fish vertebrates were sampled with a combination of nets/traps and BRUVs over three surveys (Late Wet 2020, Late Dry 2020 and Late Wet 2021). No fish were collected by fyke nets, traps or BRUVs and no fish have been observed to inhabit the pool across the three seasons. Similarly, no other vertebrates (e.g. tadpoles, frogs or snakes) have been observed at the pool. It is noted that organisms that are generally highly visible (e.g. fish) would have been readily observable if they inhabited the pool due to the small size of the pool, shallowness, and water clarity. The low pH of this pool (pH 3-4), as well as restricted connectivity, is likely to be controlling the absence of fish at this location.

### 3.2.4 AQUATIC MACROINVERTEBRATES

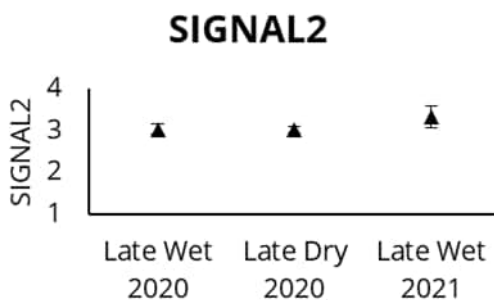
Figure 3-24 presents the total abundance, taxa richness, EPT richness and SIGNAL2 scores for Fig Pool in the late wet seasons of 2020 and 2021, and the late dry season of 2020. The key findings were as follows:

- Total abundance and taxonomic richness increased from 2020 to 2021 (Figure 3-24a,b), with abundances and number of taxa increasing to 138 and 11, respectively, in the Late Wet season of 2021. In contrast, 66 to 81 invertebrates of around 8 different taxa were present in 2020.
- There was only one individual of the Leptoceridae sampled from the Trichoptera order in Late Wet 2021, with no families belonging to the pollution sensitive Plecoptera or Ephemeroptera sampled at any time (EPT richness  $\leq 1$ ; not plotted).
- The SIGNAL2 score was 3.02 for 2020, with a slight increase to 3.33 in the late wet season of 2020. These scores considered with an EPT richness of 1, indicates that a mostly tolerant macroinvertebrate community resides in Fig Pool.



a) Total abundance at Fig Pool

b) Taxonomic richness at Fig Pool



c) SIGNAL2 scores at Fig Pool

Figure 3-24 Macroinvertebrate indices for Fig Pool – Late Wet 2020, Late Dry 2020 and Late Wet 2021.

The abundance of taxa for the three seasonal surveys is provided in Figure 3-25 and shows taxa ranging from the the most abundant (left) to the least abundant (right) along the x-axis. The non-biting midge of the Chironominae, dragonflies of the Libellulidae and water striders of the Veliidae were much more abundant in the latest Late Wet season of 2021 in comparison to previous seasons, while damselflies of the family Coenagrionidae were more abundant in the Late Wet season of 2020. Some macroinvertebrates, such as chironomids and oligochaetes, can increase in abundance following freshwater flow events such as flooding in wetlands (e.g. McInerney et al. 2017), which may explain increased abundances of such taxa in the latest wet season when greater rainfall levels were recorded.

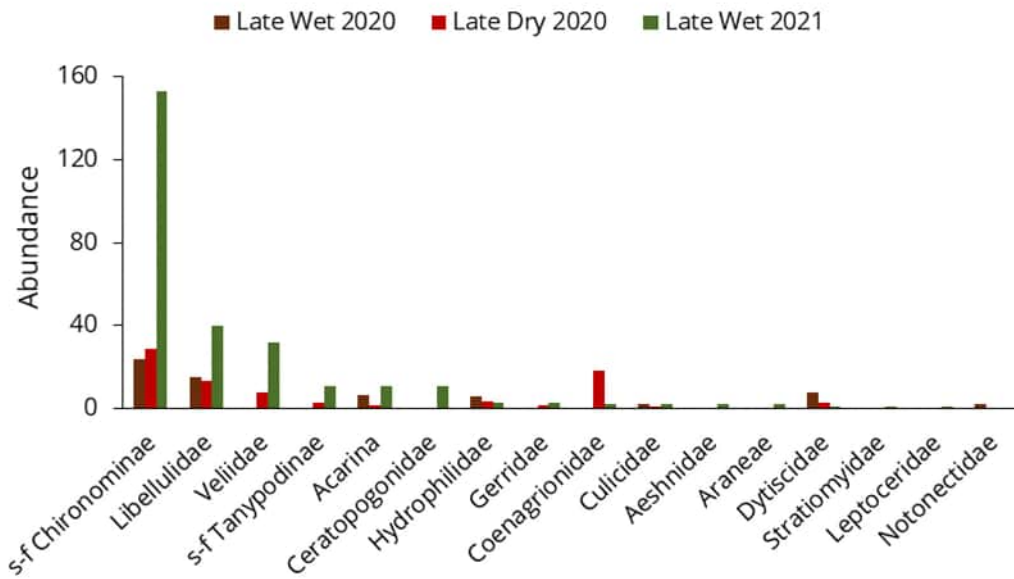


Figure 3-25 Average abundances of all macroinvertebrate taxa at Fig Pool in the Late Wet season of 2021 and the Late Wet and Late Dry season of 2020, with taxa arranged from most abundant (left) to least abundant (right) along the x-axis.

### 3.2.5 DIATOMS AND PHYTOPLANKTON

No diatom species were detected at Fig Pool across the two seasonal surveys to date (Late Wet 2020 and Late Wet 2021) by quantitative artificial substrate sampling. This indicates that the water conditions did not enable reproduction of diatoms during the sampling timeframe because none colonised the new artificial substrates. A DSIAR score could not be calculated. The Late Dry 2020 diatom samples were not analysed as there was a major flood event during the four-week sampler deployment time and therefore the samples were not considered representative or useful.

In the Late Dry 2020, an analysis of the phytoplankton abundance was conducted at Fig Pool. Overall, phytoplankton abundance at Fig Pool was low. Three classes of phytoplankton were observed with the most abundant being Chlorophyceae (Green Algae, 88%), with diatoms (Bacillariophyceae) at 8% and least abundant was Euglenophyceae (4%) (Table 3-7). Water samples from Fig Pool collected in May 2021 (late wet season) did not yield any algal cells, this finding was not unusual due to the previous low abundance of phytoplankton and similar results in the late wet season of the previous year.

Table 3-7 Summary of phytoplankton analytical results for Fig Pool sampled in late dry season (2020), abundance (cells L<sup>-1</sup>) and percentage contribution (%), limit of reporting 10 cell L<sup>-1</sup>. Samples taken from Fig Pool in late wet season 2021 did not yield any phytoplankton results.

Taxon	Late Dry 2020		Late Wet 2021	
	Abundance	%	Abundance	%
<b>Bacillariophyceae</b>	<b>200</b>	<b>8</b>	-	-
<i>Microtabella spp</i>	100	4	-	-
<i>Navicula spp.</i>	100	4	-	-
<b>Chlorophyceae</b>	<b>2200</b>	<b>88</b>	-	-
<i>Cosmarium spp. (O)</i>	2200	88	-	-
<b>Euglenophyceae</b>	<b>100</b>	<b>4</b>	-	-
<i>Trachelomonas spp.</i>	100	4	-	-

### 3.2.6 MACROPHYTES

Across the three seasons that Fig Pool was surveyed, no macrophytes species were observed. The natural acidity (pH = 3.4) at Fig Pool is likely to be the cause for the absence of macrophytes (Section 3.2.1 Water Quality and Hydrology). A considerable proportion of Fig Pool is bordered by *Melaleuca spp.* with extensive root mats, which likely provided habitat structural complexity typically provided by macrophytes (Figure 3-26). The fauna visible in Fig Pool, such as Dytiscidae (dive beetles), Hydrophilidae (water scavenger beetles) and Chironominae (midges) were noted to be inhabiting the root mats.



Figure 3-26 Fig Pool ecology. a) and b) root mats of *Melaleuca* spp extend into Fig Pool; c) and d) microscope slide used as artificial colonising habitat for diatoms appears stained by iron deposits and no algal growth; d) periphytometers to sample diatoms placed on root mats and leaf litter; e) and f) macroinvertebrate sampling found low abundance and diversity with predominantly tolerant taxa collected.

### 3.3 MUNDAGOORA POOL (GV\_SW\_POOL\_Mundagoora\_SS)

Mundagoora Pool has a catchment area of approximately 3.3 km<sup>2</sup>, draining two similarly sized basins (to the northeast and southeast; Figure 3-28). Discharge from the pool flows to Cockatoo Creek and the Turner River (see Figure 2-2). The likely permanent nature of the pool provides habitat to an abundance of fish, macroinvertebrates, and extensive beds of macrophytes and established riparian vegetation (Figure 3-27). Some key features of this pool are:

- The inflow is over a steep rock face (waterfall).
- The outflow is over a sill with little variation in pool height over wet/dry season (controlled by the sill level).
- It is a clear water pool dominated by submerged vegetation/algae and abundant fish (common species, not endangered).
- Downstream of the pool is dominated by dense emergent vegetation (reeds and sedges), which extends down a shallow braided channel downstream for several hundred metres from the pool.
- The pool contains a hard bottom (rock) at the inflow point, likely to be scoured out (removal of deposited sediments) during high-flow events.



Figure 3-27 Mundagoora Pool is a permanent pool with extensive macrophyte beds and riparian vegetation.

#### 3.3.1 WATER QUALITY AND HYDROLOGY

Figure 3-29 and Figure 3-30 display a high-resolution water level, salinity (conductivity) and temperature logger record from Mundagoora Pool for the wet seasons of 2019/2020 and 2020/2021 respectively.

Mundagoora pool is a relatively deep permanent pool located at the base of an intermittent waterfall, which appears to only flow during high rainfall events. The pool water level is controlled by a sill at the downstream edge. Water levels remain relatively consistent within the pool with the exception of short duration peaks during high rainfall events (Figure 3-29 and Figure 3-30). Mundagoora Pool appears to be largely sustained by groundwater; however, it was periodically flushed with fresh surface water flows after rainfall events. It takes approximately 3 weeks for the groundwater to displace the surface water flows once a flushing event has occurred. Conductivity was typically very slightly brackish ( $\sim 850 \mu\text{S}/\text{cm}$ ) except during a surface water flow event when it would become extremely fresh ( $< 50 \mu\text{S}/\text{cm}$ ). Water levels were a maximum of  $\sim 0.6 \text{ m}$  above the pool overflow levels during high-flow events, typically lasting less than 24 hours before flows receded. Water temperature within the pool was responsive to atmospheric temperature changes (Figure 3-29 and Figure 3-30).

Mundagoora Pool is a clear water pool with low turbidity ( $0.71 \text{ NTU}$ ), low salinity ( $870 \mu\text{S}/\text{cm}$ ) and moderate oxygenation ( $5.61 \text{ mg}/\text{L}$ ). No metals were recorded above ANZG (2018) and were predominantly below detection limits. Nutrients were low, with Total Nitrogen at  $0.5 \text{ mg}/\text{L}$  and Total Phosphorus at  $0.01 \text{ mg}/\text{L}$ . Dissolved organic carbon (DOC) was moderate at  $4 \text{ mg}/\text{L}$ . See Appendix A for complete water quality data.

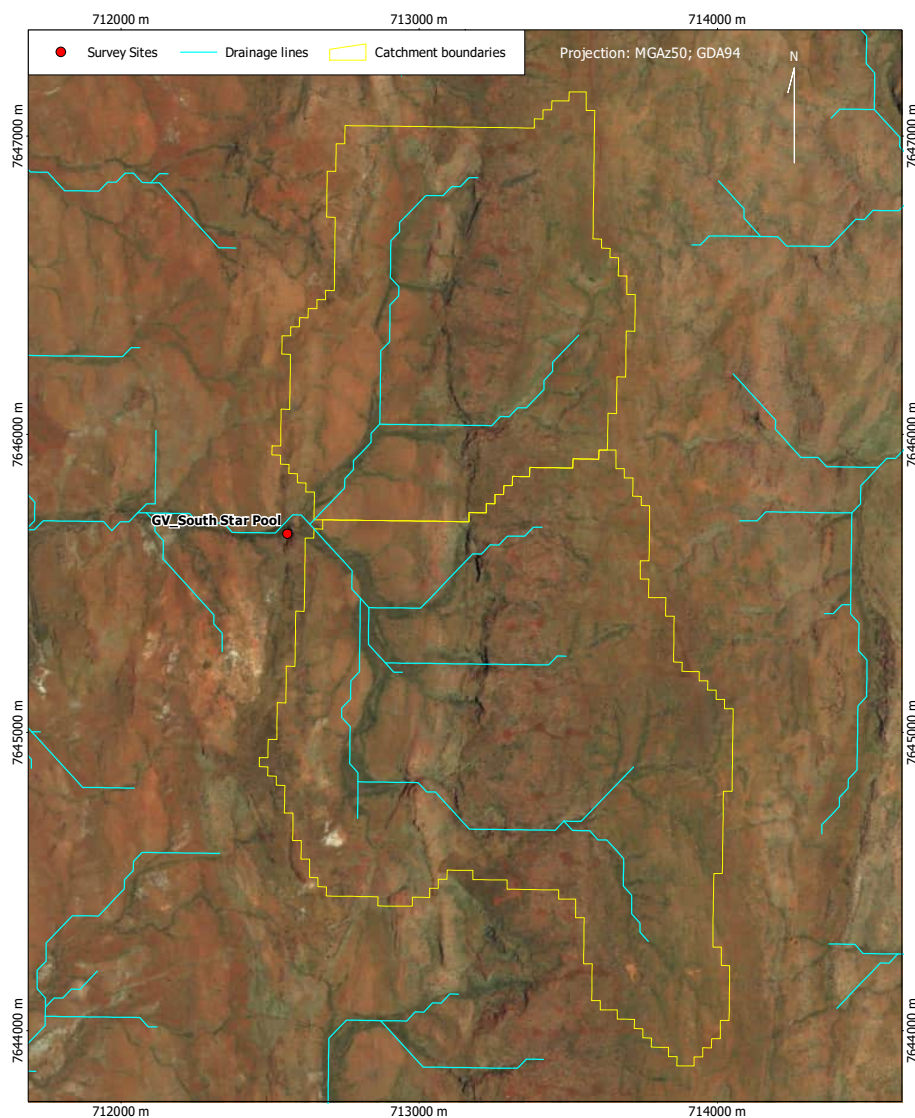


Figure 3-28 Mundagoora Pool catchment ( $3.3 \text{ km}^2$ )

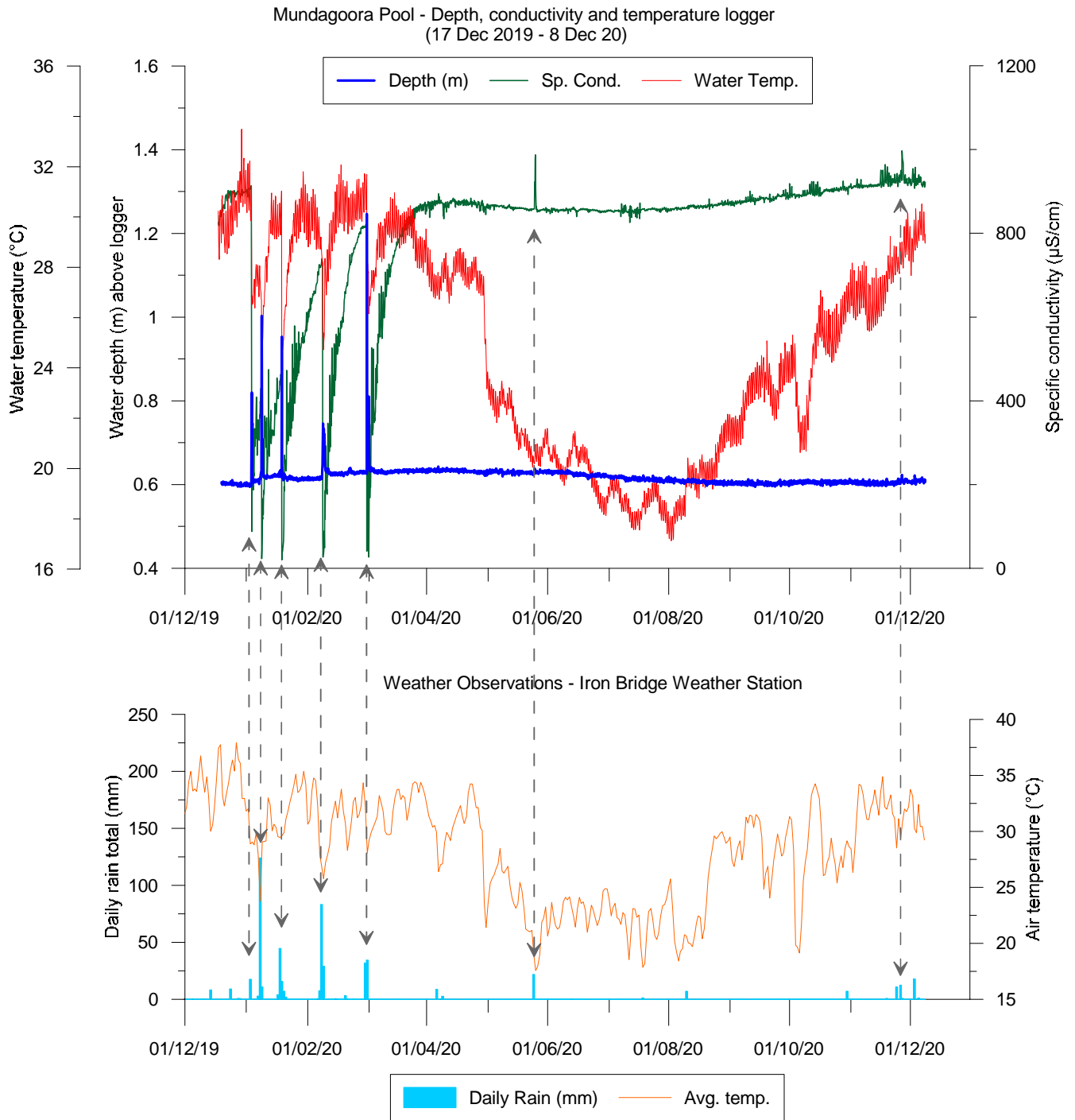


Figure 3-29 Water level, temperature and conductivity (salinity) at Mundagoora Pool – Wet-Dry Season 2020

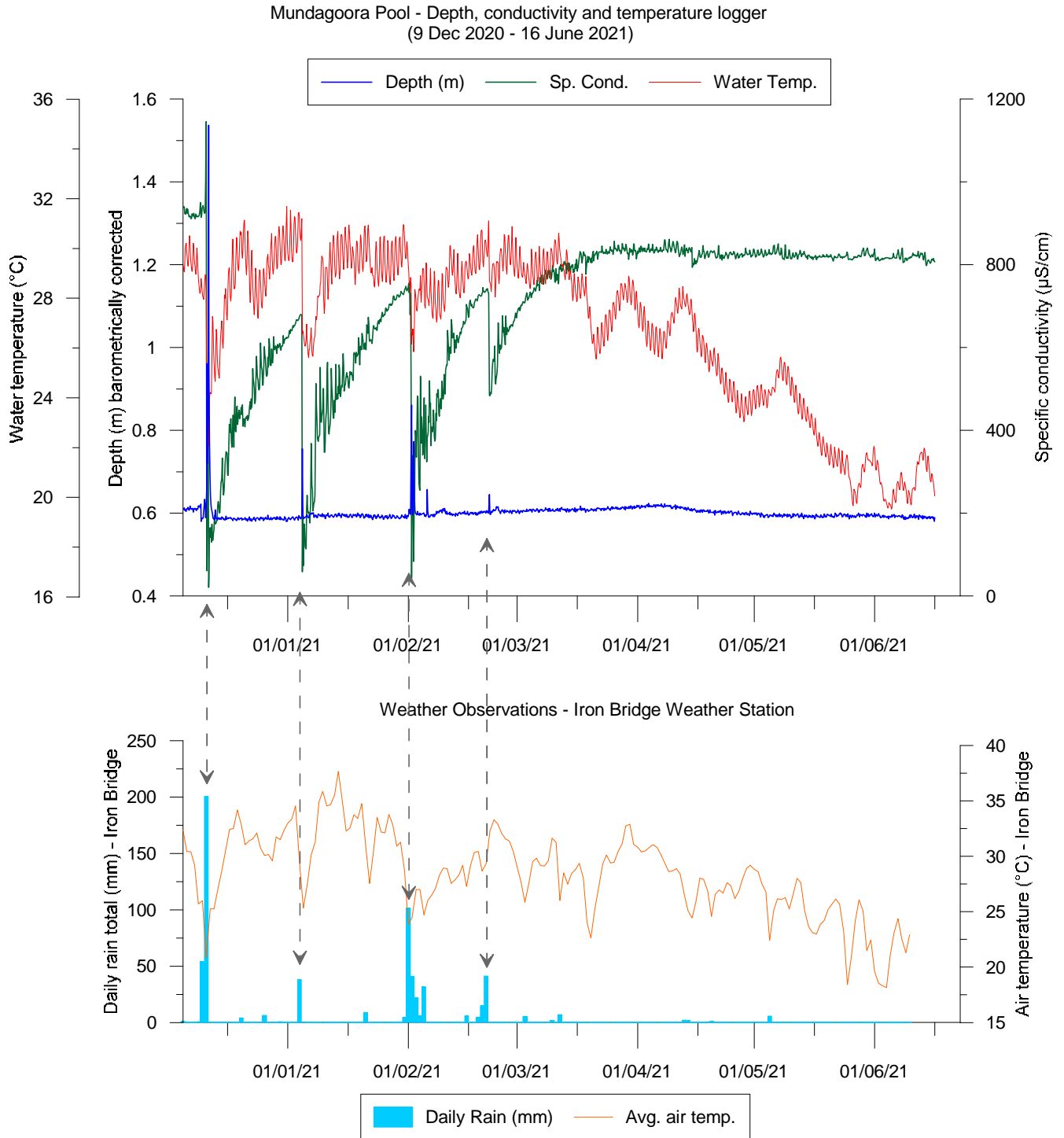


Figure 3-30 Water level, temperature and conductivity (salinity) at Mundagoora Pool – Wet – mid Dry Season 2021

Figure 3-31 provides a Durov plot displaying the major ion balance of Mundagoora Pool over four sampling events. It can be seen that the water quality is relatively stable over the four seasonal sampling events with a slightly alkaline pH. Cations are evenly distributed between Calcium, Magnesium and Sodium+Potassium with anions dominated by carbonates.

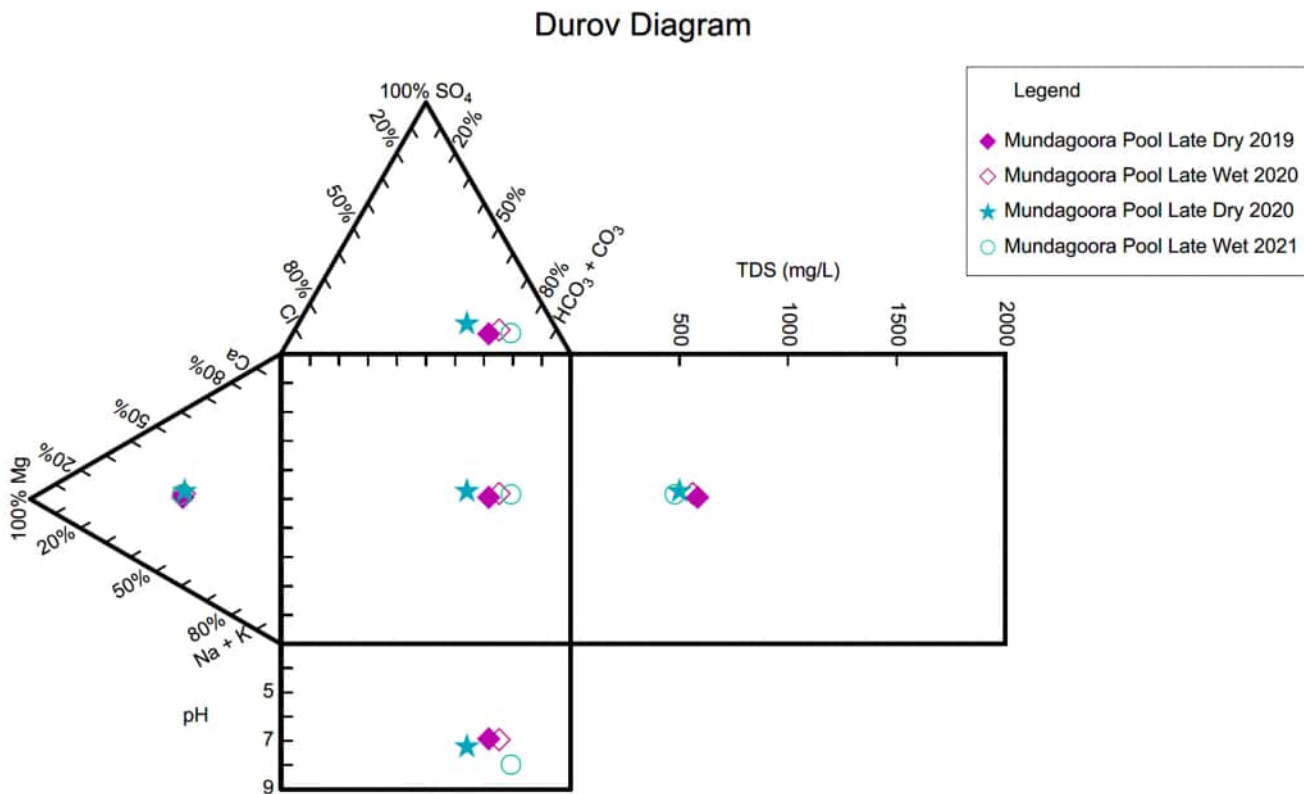


Figure 3-31 Durov diagram illustrates the Mundagoora Pool major ion distribution.

### 3.3.2 BATHYMETRY

Mundagoora Pool was surveyed in May 2020 using a down beam and side-scan sonar system attached to a remote-control boat. The maximum depth of the pool is approximately 3.5 m with the average depth 1.9 m (Figure 3-32). The volume of the pool has been calculated at 448 m<sup>3</sup>. The deepest section (3-3.5 m) is in the basin below the waterfall/rock face to the east with a shallower sill to the west at ~1 m deep (Figure 3-32 to Figure 3-36). The pool is 25 m in length (north-south) and 15 m at its widest point (east-west). The base of the pool is dominated by hard rock with gravel/sediments to the west at the pool overflow point.

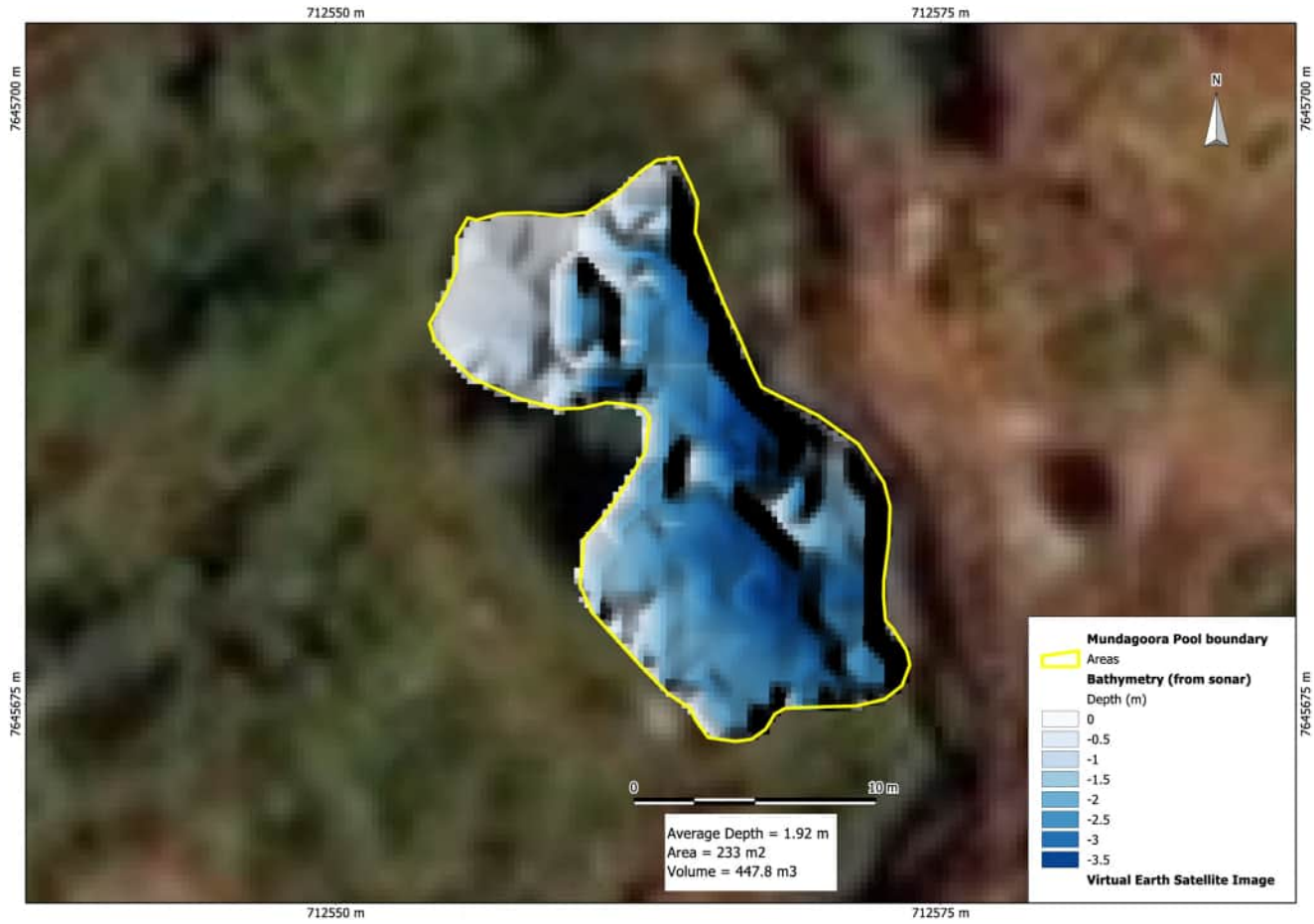


Figure 3-32 Bathymetry of Mundagoora Pool



Figure 3-33 Cross-section of deep southern portion of Mundagoora Pool (East-West)

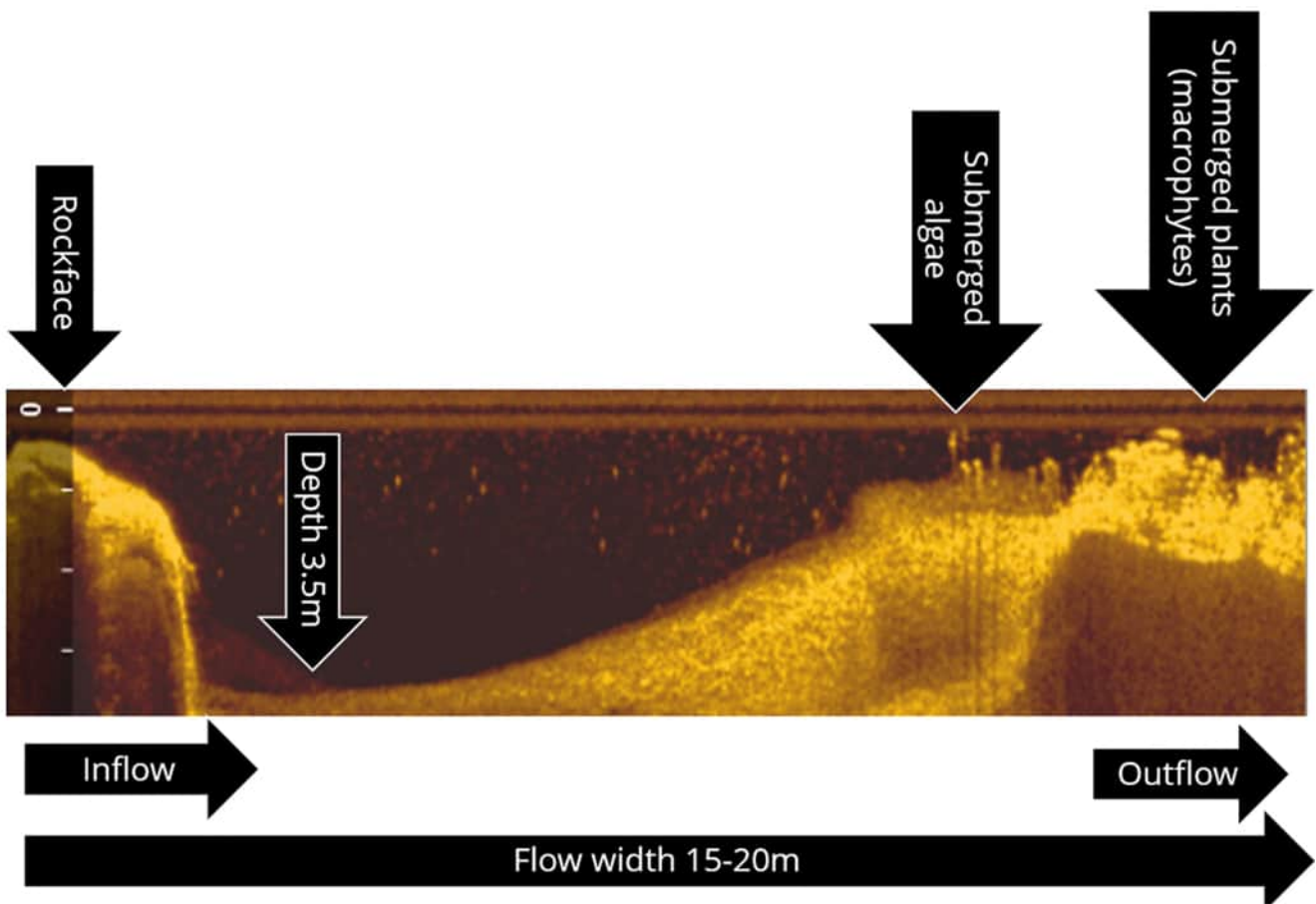


Figure 3-34 Sonar cross-section of Mundagoora Pool showing habitat features

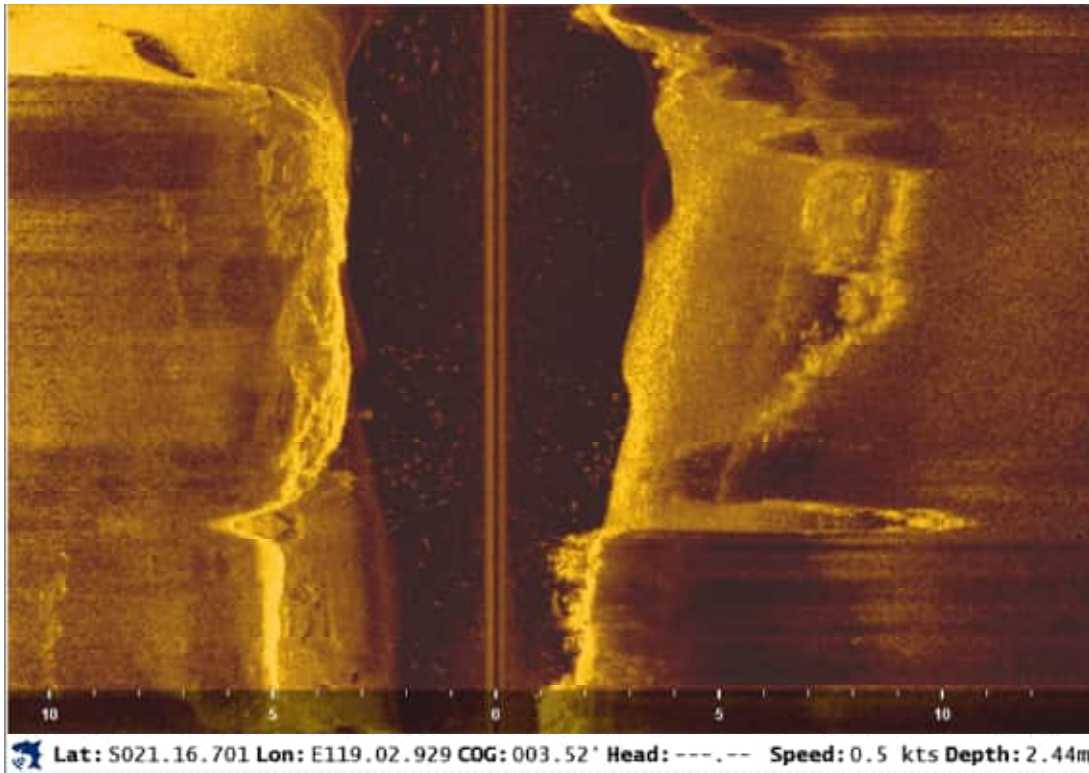


Figure 3-35 Side-scan sonar bathymetry: - cross-section north-south

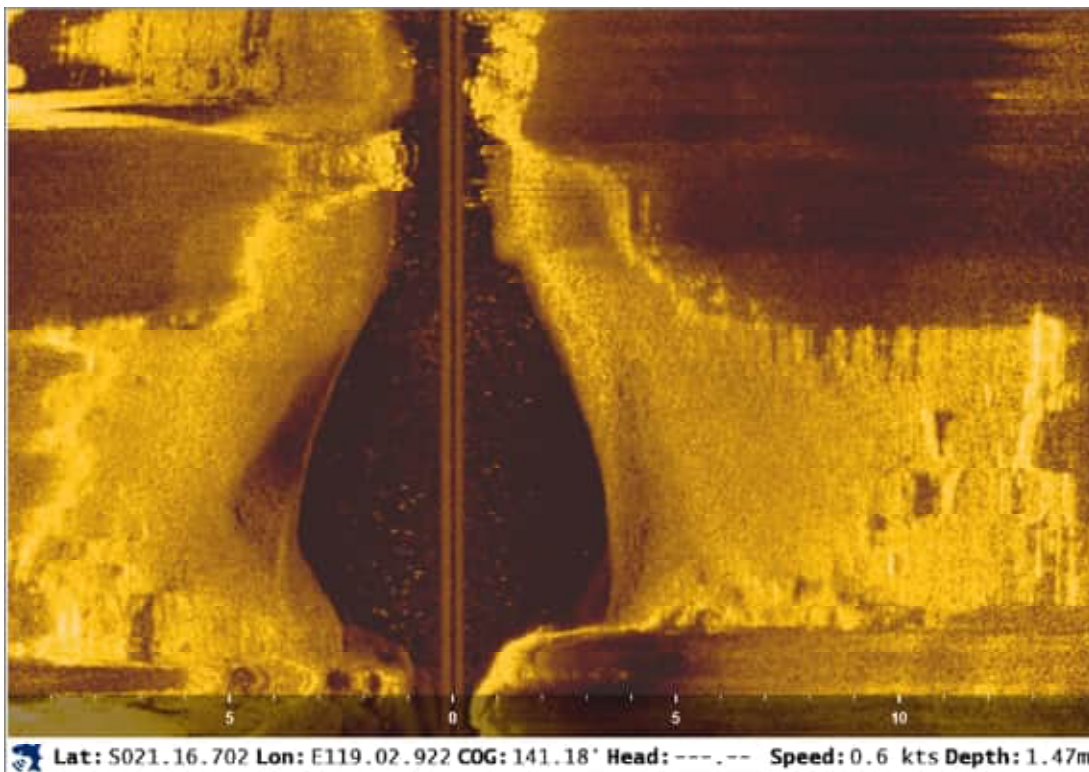


Figure 3-36 Side-scan sonar bathymetry: cross-section east-west

### 3.3.3 SEDIMENT QUALITY

Table 3-8 provides the surface sediment quality at Mundagoora Pool during the three seasonal surveys. Metal and metalloid concentrations were assessed against the ANZG (2018) DGVs. Chromium concentration (169 mg/kg) exceeded the DGV but not the GV-high. Nickel concentration (79 mg/kg) exceeded both the DGV and GV-high. These metals both naturally occur in high concentrations across the Project area. Alkalinity exceeded acidity in the sediments of Mundagoora Pool, indicating that there is unlikely to be an acid sulphate soil issue.

Table 3-8. Summary of sediment quality analyses for the late wet season (2020), late dry season (2020) and late wet season (2021). Bolded values denote results above the limit of reporting.

Analyte grouping/Analyte	Unit	Late Wet 2020	Late Dry 2020	Late Wet 2021
Total Soluble Salts	mg/kg	<b>693</b>	-	<b>280</b>
Moisture Content (Dried @ 105-110°C)	%	<b>59.7</b>	<b>49.3</b>	<b>24.8</b>
Total Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>77</b>	<b>104</b>	<5
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>77</b>	<b>104</b>	<b>239</b>
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<1	<5	<b>239</b>
Acidity	mg/kg	<b>12</b>	<b>53</b>	<b>62</b>
Sulfate as SO <sub>4</sub> <sup>2-</sup> (soluble sulfate by ICPAES)	mg/kg	<b>80</b>	<b>70</b>	<10
Chloride (by Discrete Analyser)	mg/kg	<b>100</b>	<b>40</b>	<b>20</b>
Calcium	mg/kg	<b>220</b>	<b>30</b>	<b>30</b>
Magnesium	mg/kg	<b>110</b>	<b>20</b>	<b>20</b>
Sodium	mg/kg	<b>170</b>	<b>100</b>	<b>30</b>
Potassium	mg/kg	<b>20</b>	<10	<10
Mercury (FIMS)	mg/kg	<b>0.6</b>	-	<0.1
Nitrite + Nitrate as N (Sol.)	mg/kg	<0.1	<0.1	<0.1
Total Kjeldahl Nitrogen as N	mg/kg	<b>3950</b>	<b>1970</b>	<b>430</b>
Total Nitrogen as N	mg/kg	<b>3950</b>	<b>1970</b>	<b>430</b>
Total Phosphorus as P	mg/kg	<b>242</b>	<b>179</b>	<b>190</b>
Reactive Phosphorus as P	mg/kg	<0.1	<0.1	<0.1
Total Organic Carbon	%	<b>3.15</b>	<b>4.88</b>	<b>0.13</b>
Arsenic	mg/kg	<b>9</b>	-	<b>9</b>
Barium	mg/kg	<b>40</b>	-	<b>60</b>
Beryllium	mg/kg	<b>1</b>	-	<1
Boron	mg/kg	<50	-	<b>50</b>
Cadmium	mg/kg	<1	-	<1
Chromium	mg/kg	<b>169</b>	-	<b>368</b>
Cobalt	mg/kg	<b>22</b>	-	<b>33</b>

Analyte grouping/Analyte	Unit	Late Wet 2020	Late Dry 2020	Late Wet 2021
Copper	mg/kg	52	-	67
Iron	mg/kg	76600	57000	114000
Lead	mg/kg	<5	-	6
Manganese	mg/kg	481	-	674
Nickel	mg/kg	79	-	134
Selenium	mg/kg	5	-	<5
Vanadium	mg/kg	166	-	161
Zinc	mg/kg	39	-	30

### 3.3.4 FISH

Table 3-9 presents the fish species, catch and size distribution collected during the Late Wet 2020, Late Dry 2020 and Late Wet 2021 surveys. Two fish species were present and were sampled by nets/traps and BRUVs; *M. australis* and *L. unicolor*. *M. australis* was substantially more abundant in all three seasons (Table 3-9). The highest number of *M. australis* was collected in the Late Dry 2020, with 451 fish caught, the late wet for both years had similar numbers of fish caught (213).

The majority of *M. australis* ranged between approximately 20 mm to 90 mm in total length, with very few individuals being observed > 90 mm in the late dry season (2020). Figure 3-37 displays the size distribution of measured *M. australis* individuals for each survey. Figure 3-38 displays the frequency of each size class, with the 30 – 60 mm size class being most frequent in all three seasons. In all three surveys, individuals <30 mm were observed at Mundagoora Pool, indicating a regular spawning and recruitment at the site (Pusey, B., Kennard, M., & Arthington, 2004).

Only one individual of *L. unicolor* was caught in the Fyke net in the Late Wet 2020 and three in the Late Dry 2020. No *L. unicolor* individuals were caught in the Late Wet 2020 though these were visually observed to be present in low numbers. As such, size distribution for *L. unicolor* has been pooled for the two seasons in Figure 3-39, all *L. unicolor* individuals caught within the Fyke nets were > 90 mm. The size range of *L. unicolor* observed demonstrated likely interannual survival and reproduction, with some estimated at several years old (Figure 3-43). The low abundance of *L. unicolor* was likely due to the net being placed in habitat less frequented by this species (edge/macrophytes). BRUVs directed towards open water captured a greater abundance of adult *L. unicolor*. BRUV footage in the Late Wet 2021 did not observe *L. unicolor*, potentially indicating lower abundance for this survey.

Table 3-9. Fish species, size class (SL, mm), overall count and CPUE for Mundagoora Pool

Species	Size class (mm)	Late Wet (2020)	CPUE <sup>1</sup>	Late Dry (2020)	CPUE <sup>1</sup>	Late Wet (2021)	CPUE <sup>1</sup>
<b><i>Melanotaenia australis</i></b>		<b>212</b>	<b>12.8</b>	<b>451</b>	<b>27.3</b>	<b>213</b>	<b>12.9</b>
	0 – 30	63		61		10	
	30 – 60	95		269		2020	
	60 – 90	54		100		1	
	> 90	0		21			
<b><i>Leiopotherapon unicolor</i></b>		<b>1</b>	<b>0.06</b>	<b>3</b>	<b>0.18</b>	<b>0</b>	<b>-</b>
	30 - 60	0		0		0	
	60 - 90	0		0		0	
	> 90	1		3		0	
<b>Total</b>		<b>213</b>	<b>12.9</b>	<b>454</b>	<b>27.5</b>	<b>213</b>	<b>12.9</b>

<sup>1</sup> CPUE is catch per unit effort, a measure of relative abundance. Effort is fyke net set for 16.5 hours.

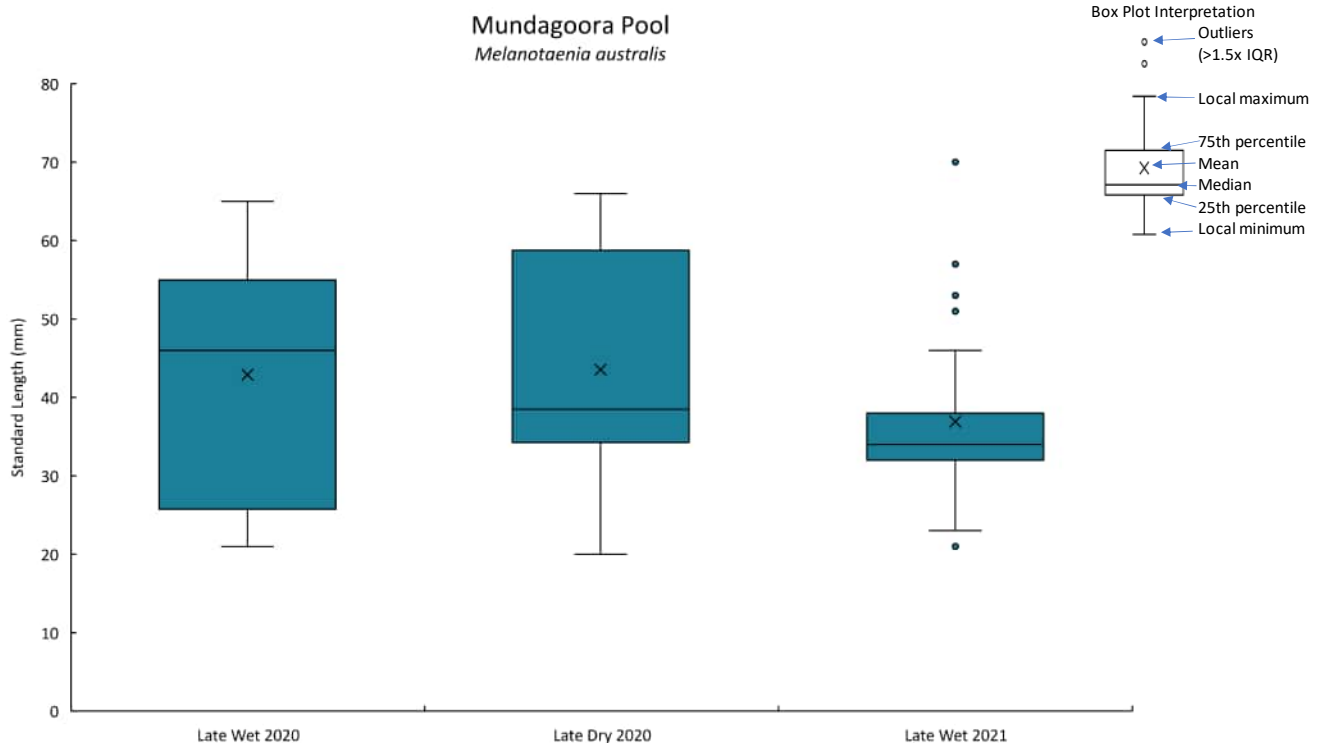


Figure 3-37. Distribution of standard length (SL, mm) for *Melatoenia australis* in Mundagoora Pool sampled with Fyke nets for the Late Wet 2020, Late Dry 2020 and Late Wet 2021 surveys.

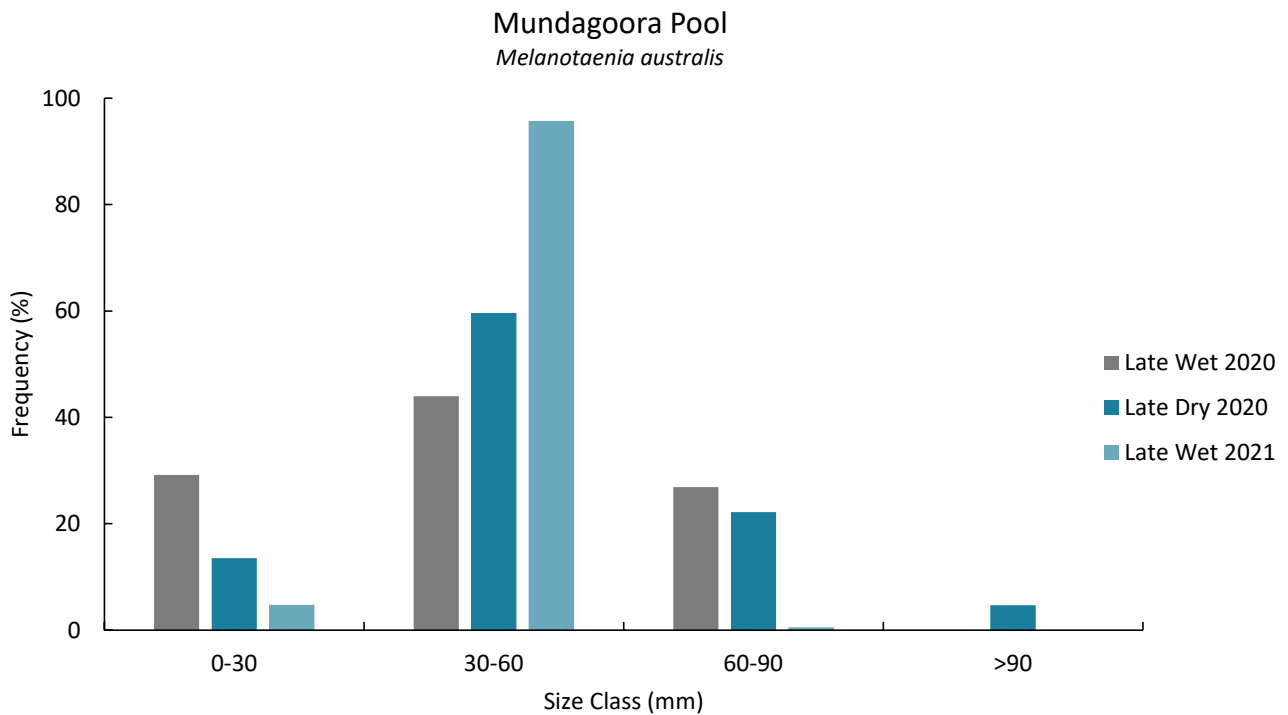


Figure 3-38. Frequency (%) of each size class (mm) for *M. australis* in Mundagoora Pool sampled with Fyke nets for the Late Wet 2020, Late Dry 2020 and Late Wet 2021 surveys.

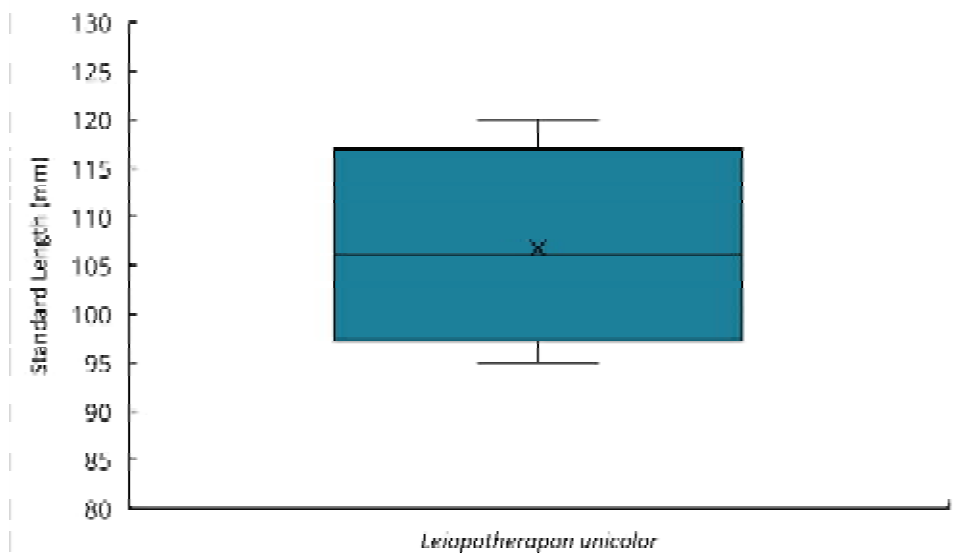
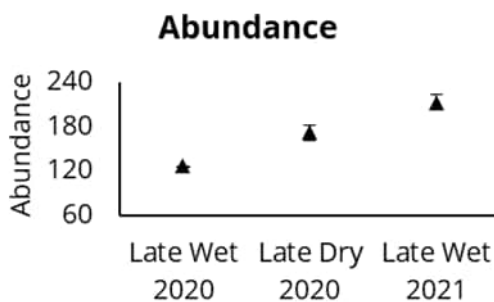


Figure 3-39. Distribution of standard length (SL, mm) for *Leipothorapon unicolor* sampled from Mundagoora Pool in the Late Wet 2020 and Late Dry 2020 seasons.

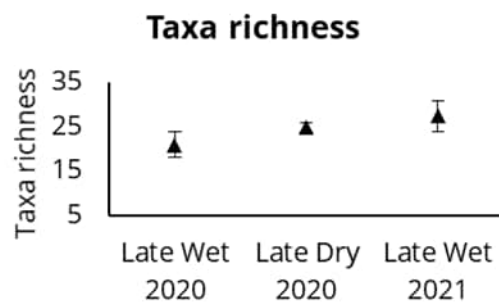
### 3.3.5 AQUATIC MACROINVERTEBRATES

Figure 3-40 presents the total abundance, taxa richness, EPT richness and SIGNAL2 scores for Mundagoora Pool in the late wet seasons of 2020 and 2021 and the late dry season of 2020. The key findings were as follows:

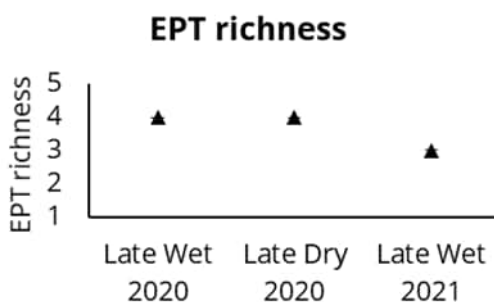
- Total abundance of aquatic macroinvertebrates gradually increased throughout the seasons, with an average of 214 individuals sampled in the recent Late Dry 2021 season (Figure 3-40a).
- Taxonomic richness remained relatively constant in comparison, with a slightly higher number of taxa recorded in the most recent season (Figure 3-40b)
- An average of four taxa belonging to the Plecoptera, Ephemeroptera and Trichoptera were found in both seasons in 2020 (EPT richness = 4) while it reduced to 3 in Late Wet 2021 (EPT richness = 3; Figure 3-40c).
- SIGNAL 2 scores were also consistent between seasons with a range of 2.8 to 3.2 (Figure 3-40d), indicating a community primarily dominated by tolerant taxa.



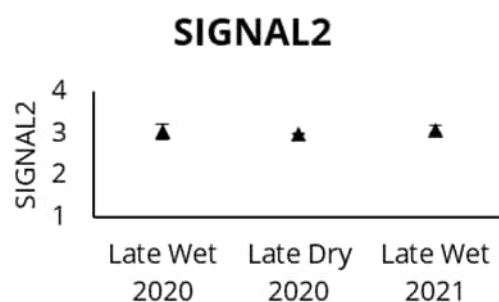
a) Total abundance at Mundagoora Pool



b) Taxonomic richness at Mundagoora Pool



c) PET richness at Mundagoora Pool



d) SIGNAL2 scores at Mundagoora Pool

Figure 3-40 Macroinvertebrate indices for Mundagoora Pool – Late Wet 2020, Late Dry 2020 and Late Wet 2021.

The taxonomic composition of the macroinvertebrate community is provided in Figure 3-41, ranging from most abundant (left) to least abundant (right) along the x-axis. There were higher numbers of the non-biting midge Tanypodinae, the biting midge Ceratopogonidae, backswimmers of the Pleidae, and oligochaete worms found during the recent Late Wet 2021 survey in comparison to others. In contrast, higher abundances of the caddisfly Leptoceridae were found during the Late Dry season of 2020. Relatively similar abundances of non-biting midge of the Chironominae and Coenagrionidae damselflies were found in each sampling event. Some macroinvertebrates, such as chironomids and oligochaetes, can increase in abundance following freshwater flow events such as flooding in wetlands (e.g. McInerney et al. 2017), which may explain increased abundances of such taxa in the latest wet season when greater rainfall levels were recorded.

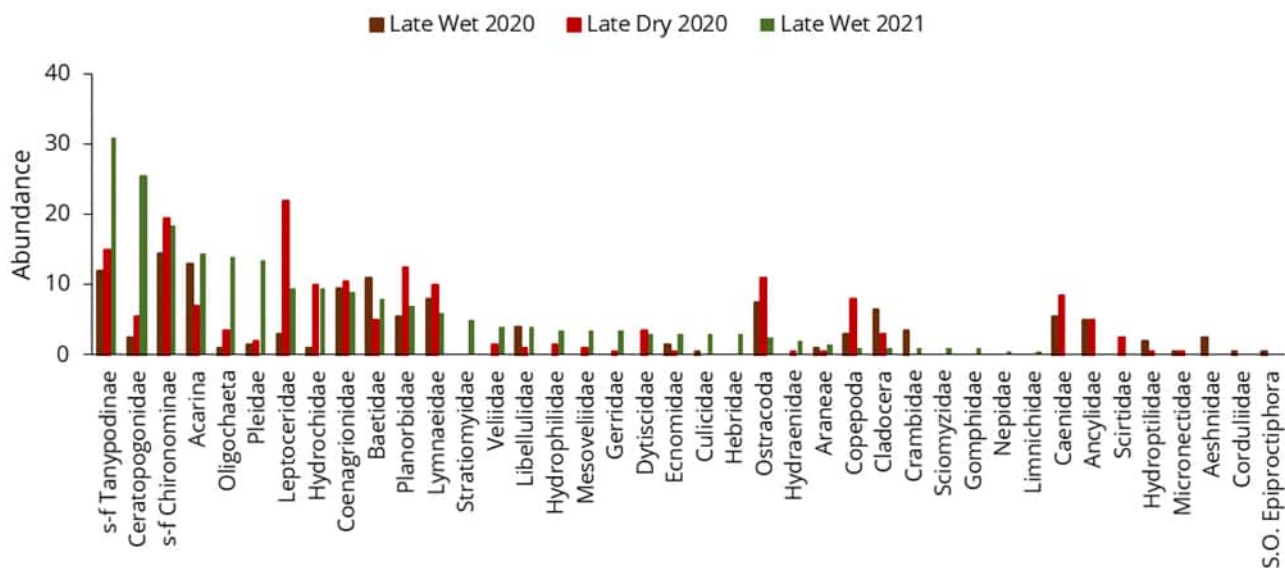


Figure 3-41 Average abundances of all macroinvertebrate taxa at Mundagoora Pool in the Late Wet season of 2021 and the Late Wet and Late Dry season of 2020, with taxa arranged from most abundant (left) to least abundant (right) along the x-axis.

### 3.3.6 DIATOMS AND PHYTOPLANKTON

#### 3.3.6.1 DIATOMS

Table 3-10 presents the Late Wet 2020 diatom species present, abundance and biotic indices as collected on Diatom plates. No data is available from the Late Dry 2020 due to flood conditions during the 4 week deployment period. The Late Wet 2021 data was not yet available at the time of reporting. Figure 3-42 shows the average count by diatom species present. A total of 17 diatom species were recorded and showed a high taxonomic diversity ranging across multiple families. The most dominant species were *Achnantheidium minutissimum* (average count=197) and *Brachysira vitrea* (average count=106) (Figure 3-42). The moderate sensitivity DSIAR scores (average DSIAR = 62.7) is associated with low levels of environmental stress and diatoms valves were relatively abundant compared to other North Star Pools.

Table 3-10. Diatom species list with count (total count per species), average abundance and DSIAR score for Mundagoora Pool surveyed in the Late Wet season 2020 and 2021.

Taxon	Late Wet 2020			Late Wet 2021		
	Replicate 1	Replicate 2	Average	Replicate 1	Replicate 2	Average
<i>Achnanthyidium minutissimum</i>	302	92	197	14	62	38
<i>Brachysira vitrea</i>	48	164	106	0	124	62
<i>Eunotia bilunaris</i>	14	70	42	0	102	51
<i>Navicula cryptocephala</i>	6	0	3	16	68	42
<i>Navicula radiosa</i>	12	24	18	0	24	12
<i>Encyonopsis microcephala</i>	0	0	0	0	24	12
<i>Brachysira styriaca</i>	0	0	0	0	16	8
<i>Cymbella affinis</i>	6	8	7	0	0	0
<i>Navicula menisculus</i>	0	0	0	6	8	7
<i>Navicula menisculoides</i>	8	4	6	0	0	0
<i>Navicula viridula</i>	0	0	0	12	0	6
<i>Ulnaria ulna</i>	0	12	6	0	0	0
<i>Cymbella spp</i>	4	4	4	0	0	0
<i>Eunotia naeglyi</i>	0	0	0	0	8	4
<i>Navicula cryptotenella</i>	0	2	1	0	8	4
<i>Navicula lanceolata</i>	4	4	4	0	2	1
<i>Nitzschia palea</i>	0	0	0	8	0	4
<i>Eunotia incisa</i>	0	0	0	0	6	3
<i>Eunotia mucophila</i>	0	0	0	0	6	3
<i>Encyonema minutum</i>	4	0	2	0	0	0
<i>Fragilaria tenera</i>	0	0	0	0	4	2
<i>Gomphonema affine</i>	0	0	0	0	4	2
<i>Navicula erifuga</i>	0	0	0	0	4	2
<i>Navicula gregaria</i>	4	0	2	0	2	1

Taxon	Late Wet 2020			Late Wet 2021		
<i>Navicula leptostriata</i>	0	0	0	0	4	2
<i>Navicula recens</i>	4	0	2	0	0	0
<i>Nitzschia fonticola</i>	0	0	0	4	0	2
<i>Nitzschia inconspicua</i>	0	0	0	4	0	2
<i>Caloneis silicula</i>	0	2	1	0	0	0
<i>Craticula halophila</i>	2	0	1	0	0	0
<i>Diploneis parma</i>	2	0	1	0	0	0
<i>Epithemia gibba</i>	0	0	0	0	2	1
<i>Eunotia pectinalis</i>	0	0	0	0	2	1
<i>Gomphonema gracile</i>	0	0	0	0	2	1
<i>Karayevia clevei</i>	0	0	0	0	2	1
<i>Navicula spp</i>	0	0	0	2	0	1
<i>Navicula veneta</i>	0	0	0	2	0	1
<b>Total Abundance</b>	<b>420</b>	<b>386</b>	<b>403</b>	<b>68</b>	<b>484</b>	<b>276</b>
<b>DSIAR Score</b>	<b>59.1</b>	<b>66.3</b>	<b>62.7</b>		<b>63</b>	

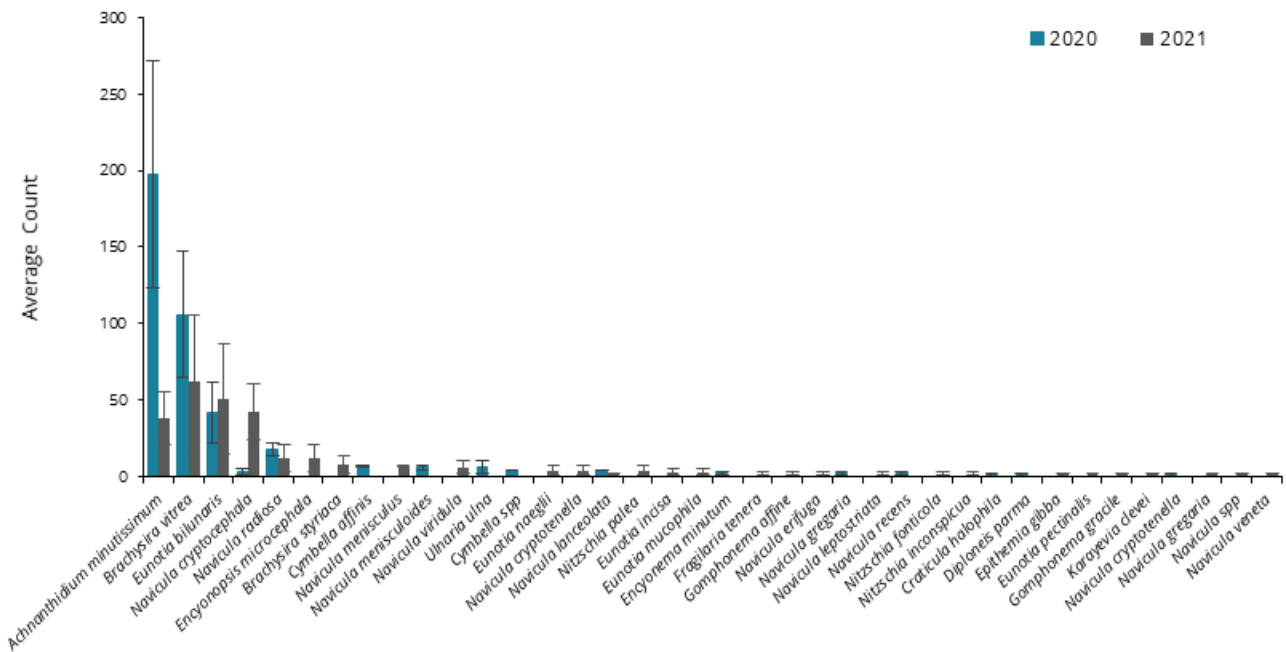


Figure 3-42. Mean abundance of diatom species recorded at Mundagoora Pool in the late wet season 2020, with error bars denoting  $0.5\pm\sigma$ .

### 3.3.6.2 PHYTOPLANKTON

In the Late Dry 2020 and the Late Wet 2021, water samples were taken from Mundagoora Pool for phytoplankton taxonomy and abundance. Table 3-11 summarises the abundance of the phytoplankton taxon identified at Mundagoora Pool. Overall, 6 classes of phytoplankton with ~19 species were identified across both seasons indicating a high phytoplankton diversity. The most abundant Class were diatoms (Bacillariophyceae) for both seasons.

Table 3-11 Summary of phytoplankton analytical results for Mundagoora Pool sampled in late dry season (2020) and late wet season (2021), abundance (cells L<sup>-1</sup>) and percentage contribution (%), limit of reporting 10 cell L<sup>-1</sup>.

Taxon	Late Dry (2020)		Late Wet (2021)	
	Abundance	%	Abundance	%
<b>Bacillariophyceae</b>	<b>80300</b>	<b>76.11</b>	<b>70</b>	<b>63.64</b>
<i>Achnantheidium sp.</i>	35200	33.36	10	9.09
<i>Amphora spp.</i>	0	0	10	9.09
<i>Cocconeis spp.</i>	700	0.66	0	0
<i>Cymbella spp.</i>	300	0.28	0	0
<i>Lyrella spp</i>	100	0.09	0	0
<i>Navicula spp.</i>	19600	18.58	0	0
<i>Navicula spp.</i>	19600	18.58	40	36.36
<i>Nitzschia spp.</i>	100	0.09	0	0
<i>Pinnularia spp.</i>	200	0.19	0	0
<i>Synedra spp. (O)</i>	4500	4.27	10	9.09
<b>Chlorophyceae</b>	<b>900</b>	<b>0.85</b>	<b>40</b>	<b>36.36</b>
<i>Mougeotia sp.</i>	0	0	40	36.36
<b>Cryptophyceae</b>	<b>8800</b>	<b>8.34</b>	<b>0</b>	<b>0</b>
<i>Chroomonas spp.</i>	800	0.76	0	0
<i>Cryptomonas spp. (O)</i>	8000	7.58	0	0
<b>Cyanobacteria</b>	<b>8200</b>	<b>7.77</b>	<b>0</b>	<b>0</b>
<i>Pseudoanabaena spp. (O) (PT)</i>	8200	7.77	0	0
<b>Dinophyceae</b>	<b>7200</b>	<b>6.82</b>	<b>0</b>	<b>0</b>
<i>Gomphonema spp.</i>	500	0.47	0	0
<i>Gonyaulax spp.</i>	800	0.76	0	0
<i>Gymnodinium spp.</i>	1400	1.33	0	0
<i>Peridinium spp. (O)</i>	4500	4.27	0	0
<b>Euglenophyceae</b>	<b>100</b>	<b>0.09</b>	<b>0</b>	<b>0</b>
<i>Euglena spp. (O)</i>	100	0.09	0	0

### 3.3.7 MACROPHYTES

Table 3-12 presents the macrophyte species and qualitative abundance during the three season surveys at Mundagoora Pool. The key findings were as follows:

- A total of 5 macrophyte species were recorded and show a range of emergent (bulrush and sedges) and submerged (charophyte and ribbon weed) types.
- Emergent macrophytes were the dominant edge habitat, occurring in wide dense beds along the pools edge except for along the upstream eastern rockface. Submerged macrophytes occurred in scattered abundance on the bed.
- There were no significant changes noted for macrophyte presence, abundance or health over the three survey periods. There was a decrease in the abundance of emergent macrophytes in the Late Wet 2021 compared to the Late Wet 2020, though no changes were substantial enough to alter the categorical abundance classification.

Table 3-12 Macrophytes present at Mundagoora Pool

Common name	Species name	Late Wet 2020 Abundance <sup>1</sup>	Late Dry 2020 Abundance <sup>1</sup>	Late Wet 2021 Abundance <sup>1</sup>
Ribbon weed	<i>Vallisneria sp.</i>	Abundant	Abundant	Abundant
Charophytes	<i>Nitella sp., Chara sp.</i>	Isolated	Isolated	Isolated
Clubrush	<i>Schoenoplectus sp.</i>	Abundant	Abundant	Abundant
Sedges	Cyperaceae	Isolated	Isolated	Isolated
Bulrush	<i>Typha sp.</i>	Abundant	Abundant	Abundant

<sup>1</sup> Abundance based on *Western Australia AUSRIVAS field sampling sheet* (DoW, 2009).

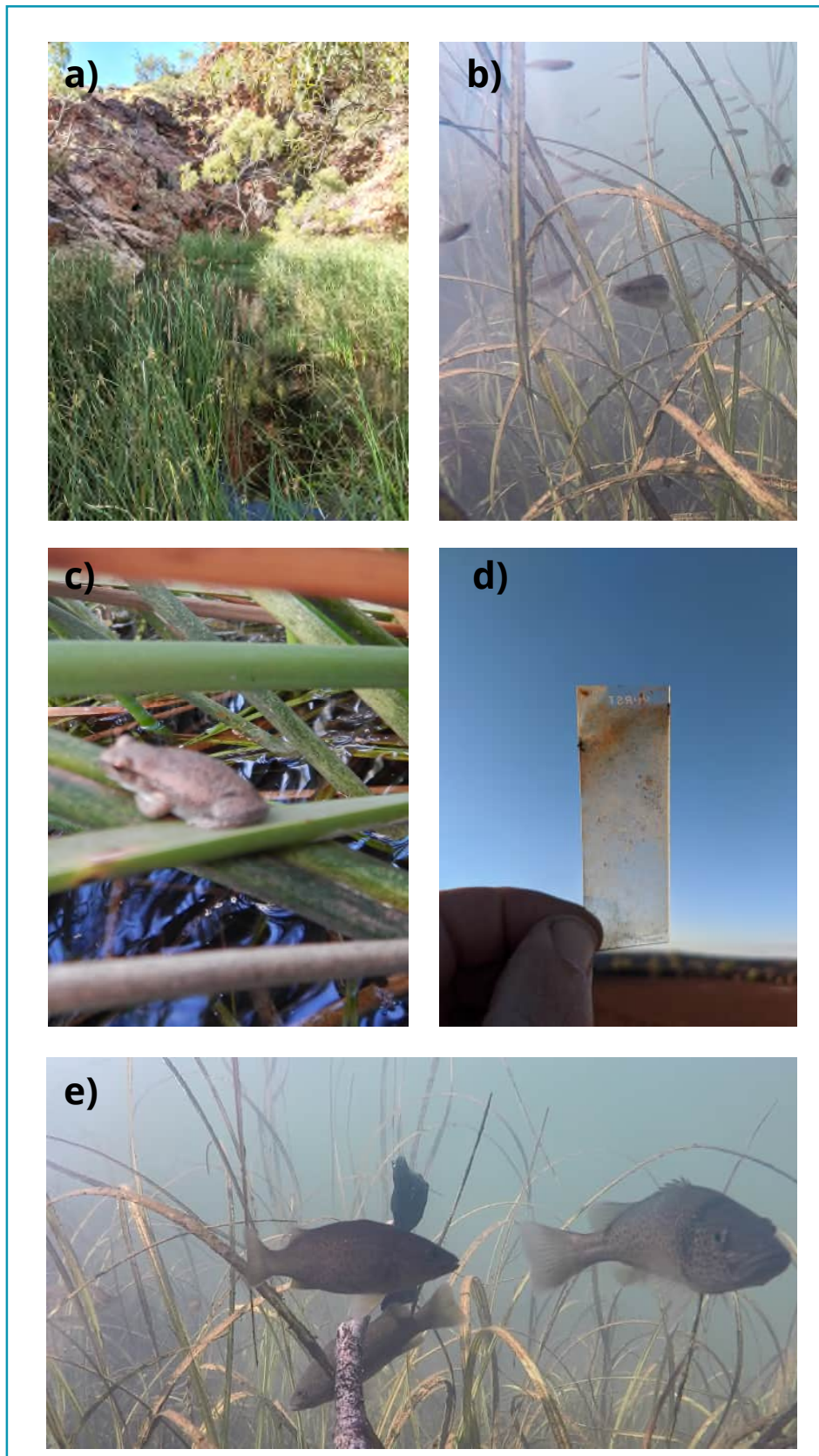


Figure 3-43 Mundagoora Pool aquatic ecology. a) emergent macrophytes forms beds at the edge of the pools; b) submerged macrophytes create important habitat for an abundance of *M. australis* and *L. unicolor*; c) frog (*Littoria rubella*) utilising the macrophyte habitat; d) abundant diatom growth on slide; e) adult *L. unicolor* observed in abundance using underwater video.

### 3.4 CENTRAL CREEK POOL (IB\_SW\_POOL\_Central Ck)

Central Creek Pool is a shallow pool that lies on deep alluvial sediments on Cockatoo Creek, which experiences high flows in the wet season. The pool is predominantly sustained by surface/hyporheic water and consequently undergoes high rates of evapo-concentration and has minimal established macrophyte habitat. The water quality is relatively turbid in comparison to other North Star pools and there is evidence of cattle visitation.

In the Late Dry 2020, samples were not obtained from Central Creek as the site was dry.



Figure 3-44 Central Creek is a shallow pool on Cockatoo Creek that experiences substantial evapo-concentration and is likely a temporary pool.

#### 3.4.1 WATER QUALITY AND HYDROLOGY

Central Creek Pool has a catchment area of 85.1 km<sup>2</sup>, draining to Cockatoo Creek and the Turner River (Figure 3-45). The surface water level logger was installed in Central Creek Pool during the Late Wet 2020 sampling round and as such there is no direct hydrology data available for the previous wet season. However, there was a logger installed on the same creek system approximately 550 m downstream in a similar pool (MAR Cockatoo Creek; Figure 3-47) and it is considered that this represents a reasonable analogue for the hydrology of Central Creek Pool. The logger data for May 2020 to June 2021 at Central Creek Pool is provided in Figure 3-47. Central Creek Pool shows a typical Pilbara creek flooding profile driven by alluvial (hyporheic) flows. There is an initial peak water level during high-rainfall events with a longer “tail” to the peak as water levels recede, driven by discharge from upper catchment alluvial storage and groundwater. Once recharged after the first flush event, the pool water levels are maintained over the

wet season, receding slowly as the alluvials dry out over the early dry season. It can be seen from Figure 3-47 that Central Creek Pool was dry by July 2020 and filled again with a major rainfall event on the 10<sup>th</sup> December 2020. The rate of recedance between flood events appears to lower as the wet season progresses, potentially in response to increase groundwater inflows to the hyporheic system of the creek.

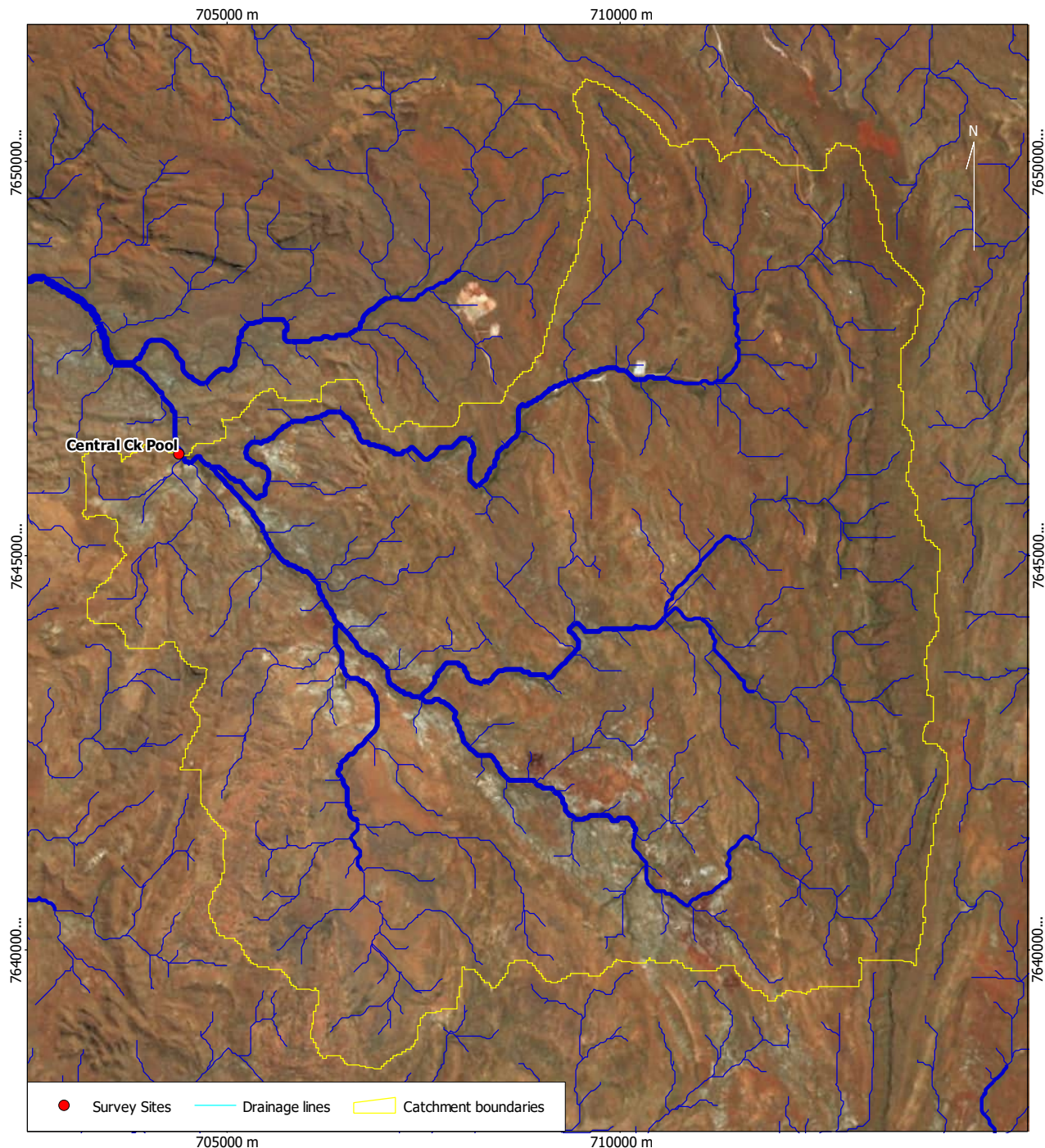
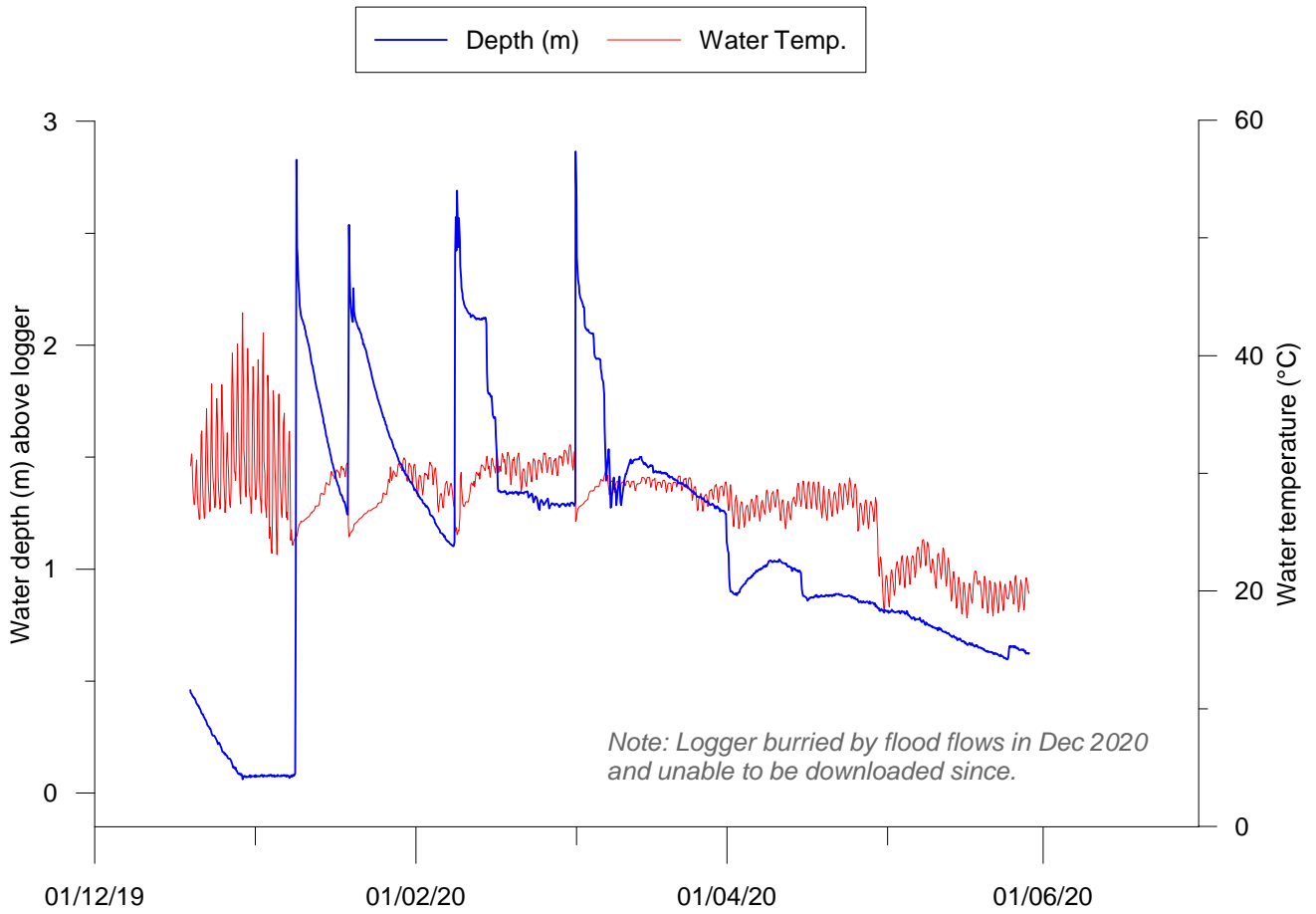


Figure 3-45 Central Creek Pool catchment area (85.1 km<sup>2</sup>)

MAR Cockatoo Creek - Depth and temperature logger  
(19 Dec 2019 - 29 May 2020)



Weather observations - Iron Bridge Weather Station

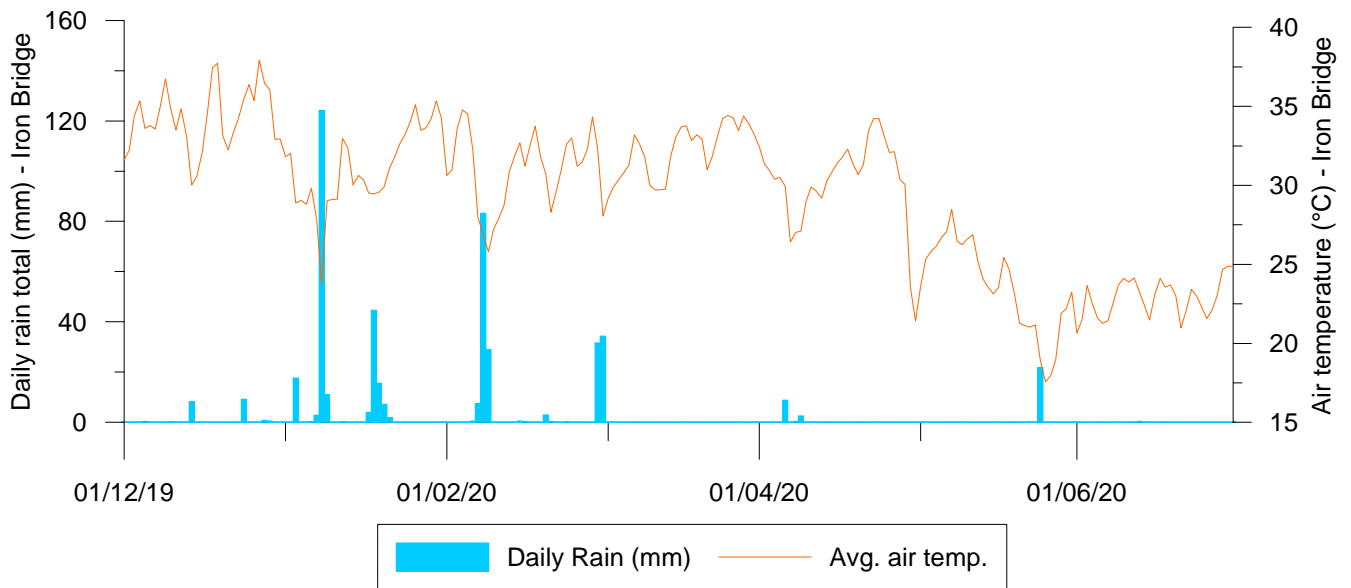


Figure 3-46 MAR Cockatoo Creek - water level logger data - Dec 2019 to June 2020

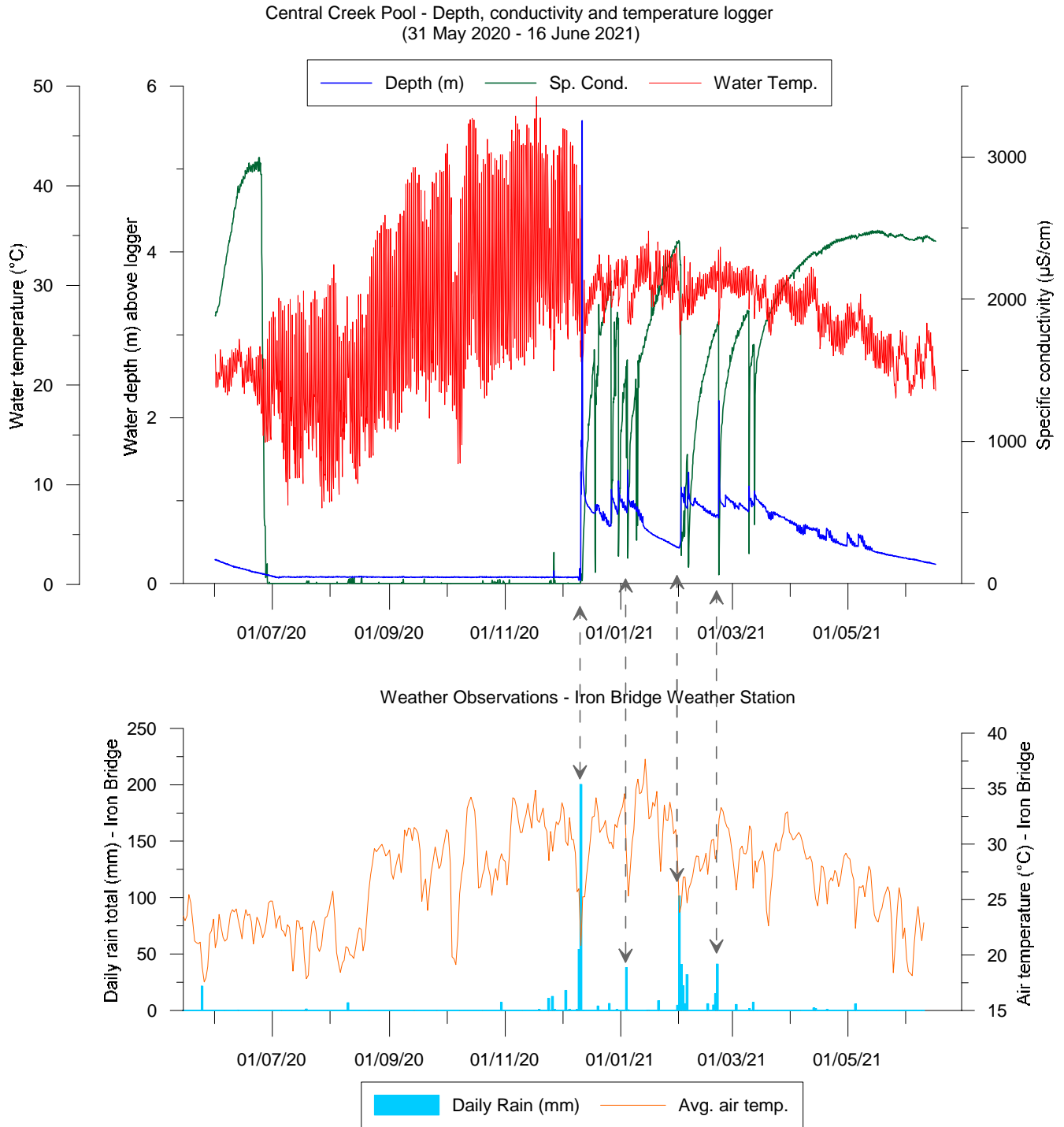


Figure 3-47 Central Creek Pool water level and temperature logger data – Late Wet 2020 – mid Dry 2021

Central Creek Pool displayed brackish salinity (2227  $\mu\text{S}/\text{cm}$  conductivity) during the Late Wet 2020, likely representing evapo-concentration effects since the last major flushing event occurred in March 2020. Water quality was representative of typical Pilbara streams with near-neutral pH (7.69), low-moderate turbidity (2.54 NTU) and moderate oxygenation (92% saturation). Alkalinity was moderate-high at 406 mg/L (as  $\text{CaCO}_3$ ) with major ions dominated by sodium chloride (Figure 3-48). Note that Figure 3-48 also shows the MAR Cockatoo Creek results for the Late Dry 2020 as these were opportunistically obtained following the large (200 mm) rainfall event on the 10<sup>th</sup> December 2020 (see Figure 3-47). The MAR Cockatoo Creek site is 550 m downstream of Central Creek Pool on the same reach.

Dissolved arsenic levels were potentially at, or exceeding, the ANZG (2018) 99 or 95% Ecosystem Protection Levels (EPLs) at 13  $\mu\text{g}/\text{L}$  however, the results represent non-specified arsenic while the guidelines are for individual inorganic species of arsenic (III and V). No other metals or metalloids were above guideline levels.

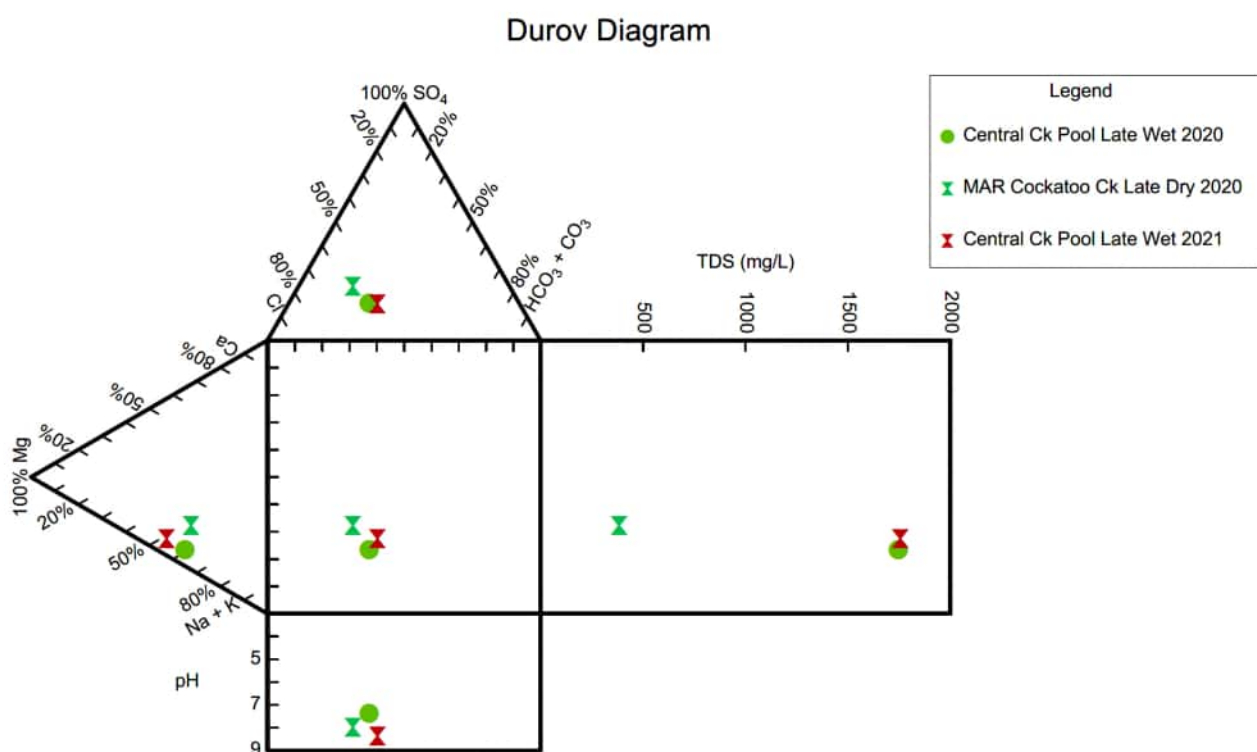


Figure 3-48 Durov diagram showing the Central Creek Pool major ion distribution.

### 3.4.2 SEDIMENT QUALITY

Table 3-13 provides the surface sediment quality at Central Creek Pool during the Late Wet 2020 and Late Wet 2021. Metal and metalloid concentrations were assessed against the ANZG (2018) DGVs. Chromium concentration (219-247 mg/kg) exceeded the DGV but not the GV-high. Nickel concentration (112-113 mg/kg) exceed both the DGV and GV-high. However, both chromium and nickel naturally occur in high concentrations across the Project area.

Table 3-13. Summary of sediment quality analyses for Central Creek for the late wet seasons (2020 and 2021), no analysis recorded for late dry season (2020) due to the site being dry. Bolded values denote results above the limit of reporting.

Analyte grouping/Analyte	Unit	Late Wet (2020)	Late Wet (2021)
Total Soluble Salts	mg/kg	<b>1,180</b>	<b>559</b>
Moisture Content (Dried @ 105-110°C)	%	<b>29.8</b>	<b>19.1</b>
Total Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>120</b>	<5
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>120</b>	<b>198</b>
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<1	<b>198</b>
Acidity	mg/kg	<b>4</b>	<5
Sulfate as SO <sub>4</sub> <sup>2-</sup> (soluble sulfate by ICPAES)	mg/kg	<b>200</b>	<b>40</b>
Chloride (by Discrete Analyser)	mg/kg	<b>170</b>	<b>90</b>
Calcium	mg/kg	<b>40</b>	<10
Magnesium	mg/kg	<b>70</b>	<b>40</b>
Sodium	mg/kg	<b>220</b>	<b>10</b>
Potassium	mg/kg	<b>20</b>	<10
Mercury (FIMS)	mg/kg	<0.1	<0.1
Nitrite + Nitrate as N (Sol.)	mg/kg	<0.1	<0.1
Total Kjeldahl Nitrogen as N	mg/kg	<b>1,090</b>	<b>80</b>
Total Nitrogen as N	mg/kg	<b>1,090</b>	<b>80</b>
Total Phosphorus as P	mg/kg	<b>100</b>	<b>43</b>
Reactive Phosphorus as P	mg/kg	<0.1	<0.1
Total Organic Carbon	%	<b>1.80</b>	<b>0.18</b>
<b>Total Metals by ICP-AES</b>			
Arsenic	mg/kg	<b>9</b>	<b>10</b>
Barium	mg/kg	<b>40</b>	<b>30</b>
Beryllium	mg/kg	<1	<1
Boron	mg/kg	<50	<50
Cadmium	mg/kg	<1	<1
Chromium	mg/kg	<b>219</b>	<b>247</b>
Cobalt	mg/kg	<b>16</b>	<b>18</b>
Copper	mg/kg	<b>22</b>	<b>17</b>
Iron	mg/kg	<b>26,600</b>	<b>30,600</b>
Lead	mg/kg	<5	<5
Manganese	mg/kg	<b>476</b>	<b>492</b>

Analyte grouping/Analyte	Unit	Late Wet (2020)	Late Wet (2021)
Nickel	mg/kg	<b>112</b>	<b>113</b>
Selenium	mg/kg	<5	<5
Vanadium	mg/kg	<b>39</b>	<b>36</b>
Zinc	mg/kg	<b>35</b>	<b>20</b>

### 3.4.3 FISH

Fish were present at Central Creek Pool during both wet season surveys and were not present in the dry season due to the pool being dry. Two fish species were present during both wet season surveys: *M. australis* and *L. unicolor*. Both species were observed roughly equal abundance in 2020 and considerably higher numbers of *M. australis* (n = 266) were observed in 2021.

Table 3-14 presents the fish species, catch and size distribution. The two fish species present, *M. australis* and *L. unicolor*, occurred at similarly high abundances for the size of the pool. The high abundance is likely a function of the high catchability due to evaporation reducing the pool habitat and thereby increasing fish density, rather than the pool providing a preferred habitat. The high interest in bait during the BRUVs survey may indicate low food resources in the pool.

For both seasons, the size distribution of *M. australis* was similar, with the SL size ranging from Figure 3-49 displays the size-frequency for *M. australis*, notably most fish were recorded in the 30 – 60 mm size class. Only one *M. australis* individual in the <30 mm size category was observed for both seasons, indicating minimal juvenile abundance in this site. However, due to Central Creek being dry over the late dry season and similar abundances of fish in both wet seasons, breeding and recruitment likely occur in nearby water bodies that seasonally open to Central Creek.

The size range for *L. unicolor* was generally larger in the Late Wet 2020 (subsamped range SL: 32 - 174 mm) than in the Late Wet 2021 (subsamped range SL: 39 - 110 mm), with a higher frequency of juveniles present in the Late Wet 2021 (Figure 3-50). The large proportion of *L. unicolor* individuals observed in the 30 – 60 mm size class indicates a notable juvenile presence in Central Creek in both years (Figure 3-50). *Leiopotherapon unicolor* displays rapid growth in the juvenile stage, attaining a length of ~25 mm TL in under 60 days (Llewellyn, 1973). Although very young juveniles (<30 mm) were not observed during each survey, most *L. unicolor* caught were between 30 – 60 mm, indicating spawning around 2 to 3 months before the survey. Most *L. unicolor* present at Central Creek are not sexually mature, as length at maturity is typically above 60 mm TL (Llewellyn, 1973).

Table 3-14. Fish species, size class (SL, mm), total catch number and CPUE for Central Creek surveyed in late wet seasons in 2020 and 2021.

Species	Size class (mm)	Late Wet 2020 Fish Count	Late Wet 2020 CPUE <sup>1</sup>	Late Wet 2021 Fish Count	Late Wet 2021 CPUE <sup>1</sup>
<b><i>Melanotaenia australis</i></b>		<b>188</b>	<b>9.8</b>	<b>266</b>	<b>14</b>
	0 – 30	1		1	
	30 – 60	128		237	
	60 – 90	590		28	
	> 90	0		0	
<b><i>Leiopotherapon unicolor</i></b>		<b>214</b>	<b>11.2</b>	<b>111</b>	<b>5.8</b>
	30 - 60	110		79	
	60 - 90	55		19	
	> 90	49		13	
<b>Total</b>		<b>402</b>	<b>21.1</b>	<b>377</b>	<b>19.8</b>

1 CPUE is catch per unit effort, a measure of relative abundance. Effort is fyke net set for 19 hours.

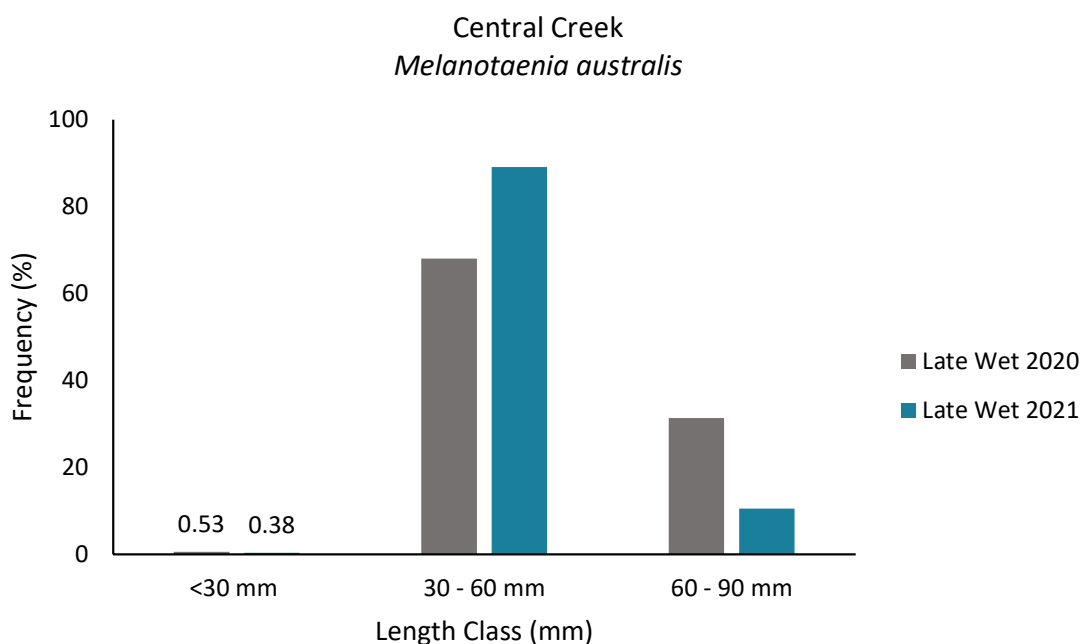


Figure 3-49. Frequency (%) of occurrence of each length class (SL, mm) *M. australis* sampled from Central Creek in the Late Wet 2020 and Late Wet 2021.

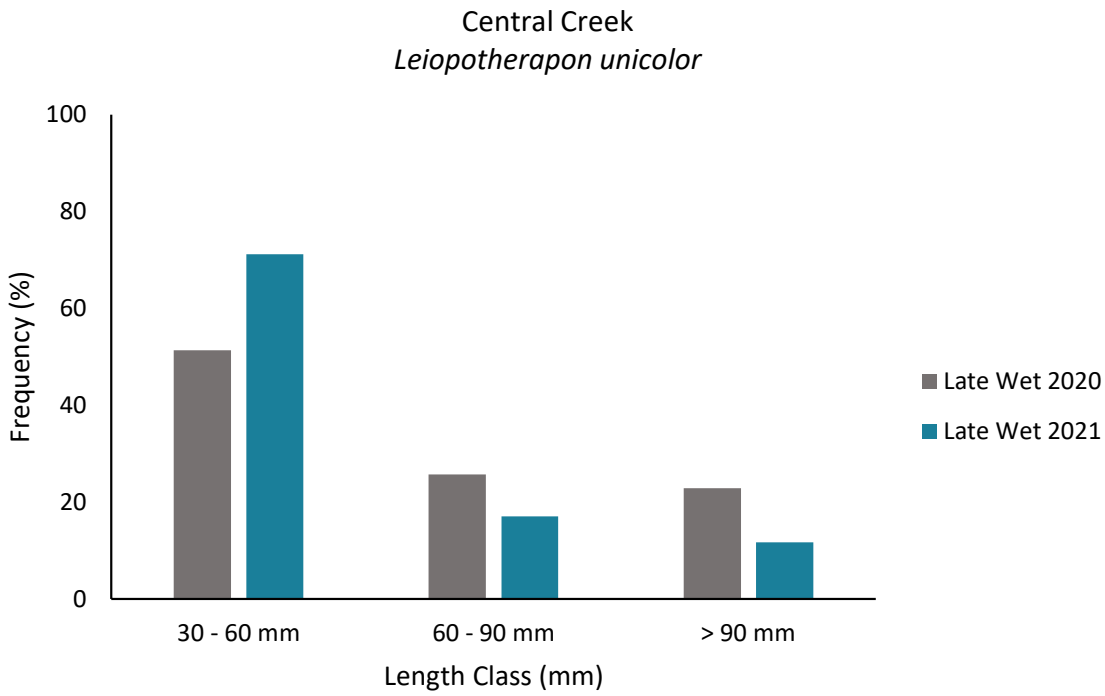


Figure 3-50 Frequency (%) of occurrence of each length class (SL, mm) for *L. unicolor* sampled from Central Creek in the Late Wet 2020 and Late Wet 2021

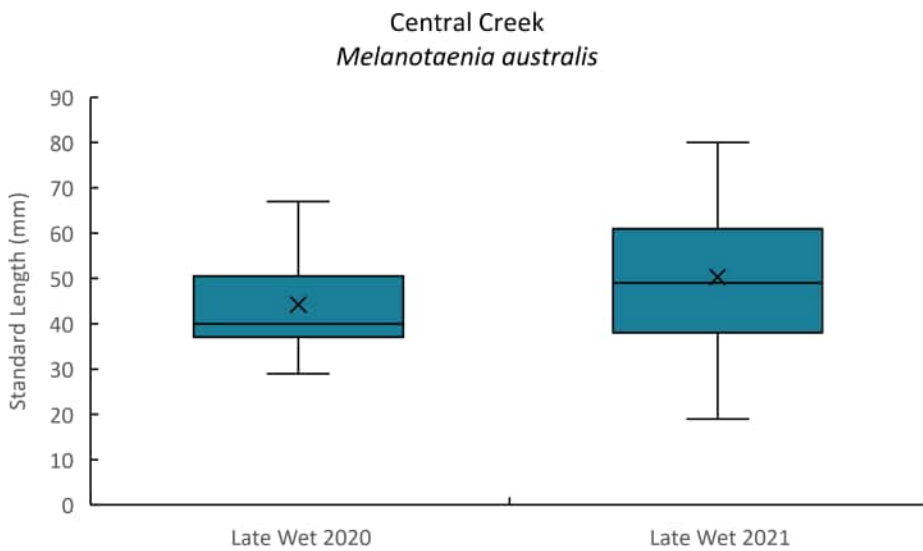


Figure 3-51 Distribution of standard length (SL, mm) of *Melanotaenia australis* sampled from Central Creek in the late wet season in 2020 (June) and 2021 (May)

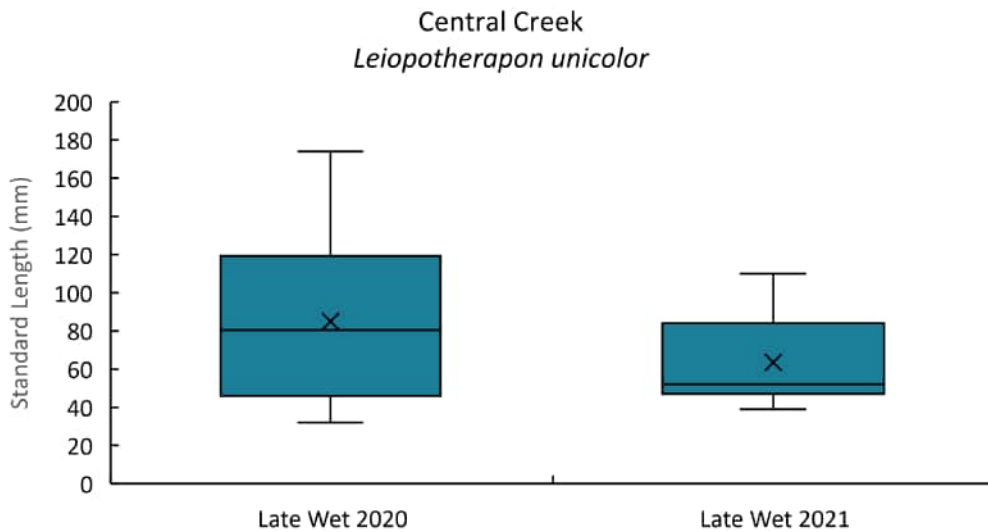


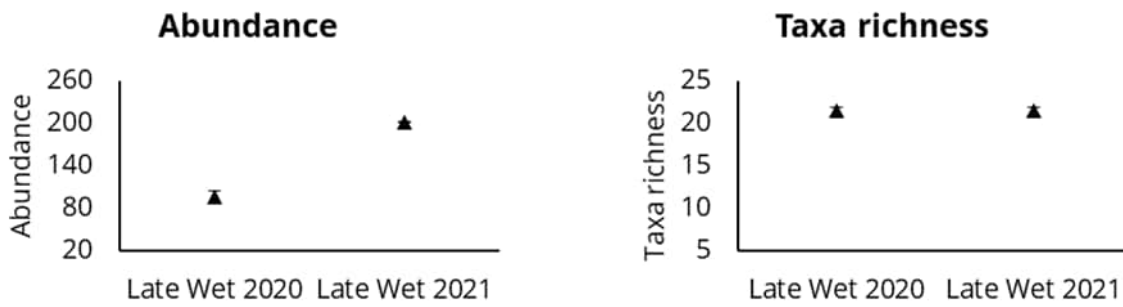
Figure 3-52 Distribution of standard length (SL, mm) of *Leiopotherapon unicolor* sampled from Central Creek in the late wet season in 2020 (June) and 2021 (May)

### 3.4.4 AQUATIC MACROINVERTEBRATES

Figure 3-53 presents the total abundance, taxa richness, EPT richness and SIGNAL2 scores for the Late Wet seasons of 2020 and 2021. No data is available for the Late Dry 2020 season due to the pool being dry. The key findings from both wet seasons were as follows:

- Average abundance of macroinvertebrates doubled from 96 in the Late Wet season of 2020 to 202 in the corresponding season in 2021 (Figure 3-53a).
- Similarly, PET richness also increased from 3 to 4.5 between seasons of 2020 and 2021 (Figure 3-53c), with a total of five families recorded from the Plecoptera and Trichoptera orders.
- In contrast, taxa richness (21.5) and SIGNAL2 (3.08-3.38) scores were consistent between the Late Wet seasons (Figure 3-53b, d), indicating that Central Creek Pool can maintain a relatively stable macroinvertebrate community in the wet seasons despite its ephemeral presence.
- A low SIGNAL2 score (SIGNAL2 grade = 3) indicates predominantly tolerant taxa were collected and the system experiences associated environmental stress (Chessman, 2003).

Many macroinvertebrate taxa were much more abundant in the Late Dry 2021 season than the previous Late Dry season, such as mayflies of the Baetidae and Caenidae, waterboatman of the Micronectidae, and the non-biting midge belonging to s-f Tanypodinae. In comparison, the backswimmer Pleidae, the diving beetle Dytiscidae and damselflies of the Coenagrionidae were more abundant in the Late Wet season of 2020. The increased abundances of macroinvertebrates in Late Wet 2021 after a period of desiccation suggest that the community is well adapted to this drying pattern. For example, chironomids are recognised to burrow deeper into the sediments when pools dry out and can also enter a period of aestivation (i.e. dormancy during dry periods; Jones 1997, Frouz et al. 2003). The relative abundance of taxa is also a function of pond permanence, with chironomids seen in high abundances when ponds have been recently established (Brooks 2000). As the mayflies Baetidae and Caenidae belong to the sensitive order Ephemeroptera, their presence in the Late Wet season of 2021 may suggest that the environmental quality of Central Creek Pool was apparently better during this period (Menetrey et al. 2007).



a) Total abundance at Central Creek Pool

b) Taxonomic richness at Central Creek Pool



c) EPT richness at Central Creek Pool

d) SIGNAL2 scores at Central Creek Pool

Figure 3-53 Macroinvertebrate indices for Central Creek Pool – Late Wet 2020 and Late Wet 2021.

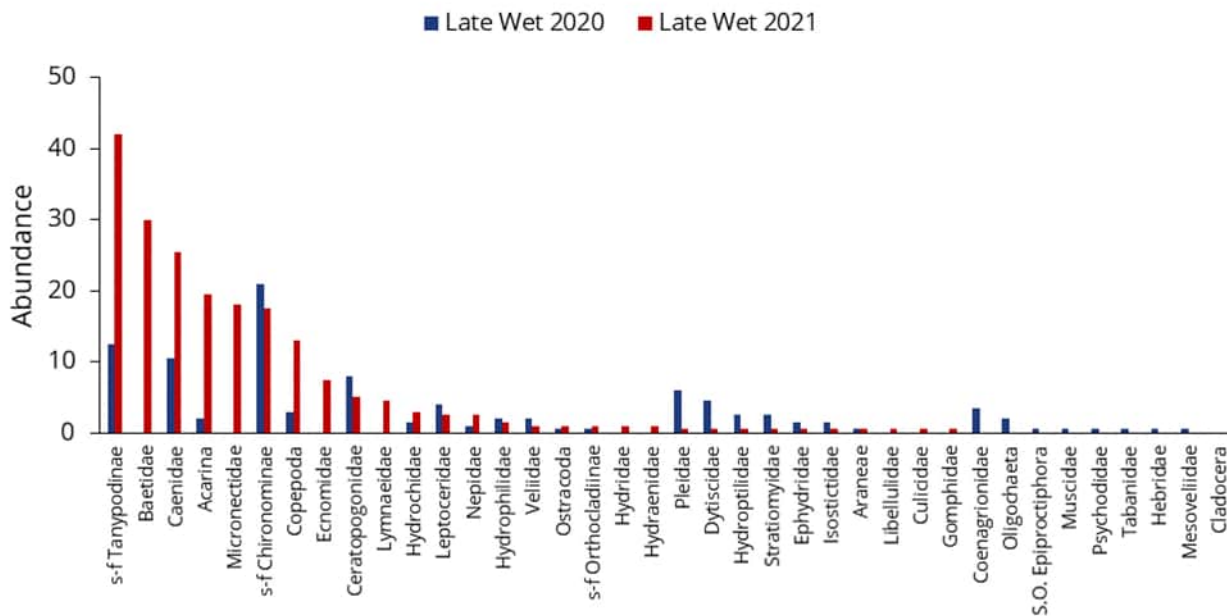


Figure 3-54 Average abundances of all macroinvertebrate taxa at Central Creek Pool in the Late Wet season of 2021 and the Late Wet and Late Dry season of 2020, with taxa arranged from most abundant (left) to least abundant (right) along the x-axis.

### 3.4.5 PHYTOPLANKTON & DIATOMS

#### 3.4.5.1 DIATOMS

Table 3-15 presents the Late Wet 2020 and Late Wet 2021 diatom species present, abundance, and biotic indices at Central Creek Pool. Figure 3-55 shows the average count by diatom species present. No diatom data was collected in the Late Dry 2020 due to the pool being dry.

High taxonomic diversity of diatoms was observed for both seasons at Central Creek. A total of 41 species were observed at Central Creek ranging across a large number of families, with the Late Wet 2021 season recording slightly higher taxonomic diversity with 33 species compared with Late Wet 2020 which recorded 27 diatom species. The majority of diatoms species observed in Central Creek were recorded in both seasons with only 14 species (~34% of total species) only observed in one season.

High average abundance was observed both seasons, with Late Wet 2021 recording a higher average abundance of 433. *Achnantheidium exiguum* (average count = 258) was the most abundant species in Late Wet 2020. The second most abundant diatom species in 2020, *Nitzschia palea*, occurred at a substantially lower abundance (average count = 28). The Late Wet 2021 season was dominated by *Pleurosigma elongatum* (average count = 116), followed by *Navicula menisculus* (average count = 85).

The tolerance to environmental stress is reflected in the low DSIAR scores for both 2020 and 2021 (42.0 and 36.5, respectively), which indicates the pool is dominated by species tolerant to degraded water quality. While the DSIAR score is low, no teratological forms were detected and the diversity of species is relatively high for North Star pools. The low presence or abundance of species associated with higher water quality likely reflects the environmental stress resulting from nutrient pollution from cattle visitation and declining water quality due to high evapo-concentration.

Table 3-15 Summary of Diatom species abundance (total count per species), average abundance and DSIAR score for Central Creek in the Late Wet 2020 and 2021.

Taxon name	Late Wet 2020			Late Wet 2021		
	Replicate 1	Replicate 2	Average	Replicate 1	Replicate 2	Average
<i>Achnantheidium exiguum</i>	246	270	258	88	0	44
<i>Pleurosigma elongatum</i>	28	0	14	118	114	116
<i>Navicula menisculus</i>	0	4	2	74	96	85
<i>Nitzschia palea</i>	40	16	28	44	38	41
<i>Diploneis parma</i>	6	2	4	46	16	31
<i>Achnantheidium minutissimum</i>	22	12	17	0	46	23
<i>Nitzschia frustulum</i>	10	8	9	14	12	13
<i>Achnanthes subexigua</i>	0	0	0	6	14	10
<i>Epithemia gibba</i>	0	0	0	0	18	9
<i>Navicula veneta</i>	12	6	9	0	0	0
<i>Nitzschia paleaceae</i>	0	0	0	10	8	9

Taxon name	Late Wet 2020			Late Wet 2021		
<i>Nitzschia lacuum</i>	8	4	6	8	4	6
<i>Nitzschia linearis</i>	0	0	0	4	4	4
<i>Nitzschia inconspicua</i>	0	6	3	0	0	0
<i>Brachysira vitrea</i>	0	0	0	0	4	2
<i>Eunotia bilunaris</i>	4	0	2	0	0	0
<i>Eunotia minor</i>	0	0	0	0	4	2
<i>Gomphonema minutum</i>	0	0	0	0	4	2
<i>Hantzschia amphioxys</i>	0	4	2	2	0	1
<i>Nitzschia filiformis</i>	0	0	0	4	0	2
<i>Nitzschia fonticola</i>	0	0	0	0	4	2
<i>Nitzschia graciliformis</i>	4	0	2	2	0	1
<i>Nitzschia microcephala</i>	0	4	2	0	0	0
<i>Pinnularia spp.</i>	0	4	2	0	0	0
<i>Ulnaria ulna</i>	4	0	2	0	0	0
<i>Amphora libyca</i>	0	0	0	0	2	1
<i>Brachysira brebissonii</i>	0	2	1	0	0	0
<i>Cymbella affinis</i>	0	0	0	0	2	1
<i>Cymbella spp</i>	0	2	1	0	0	0
<i>Diploneis smithii</i>	0	0	0	0	2	1
<i>Eolimna minima</i>	2	0	1	0	0	0
<i>Eunotia exigua</i>	0	0	0	0	2	1
<i>Fragilaria spp.</i>	2	0	1	0	0	0
<i>Haslea duerrenbergiana</i>	0	0	0	2	0	1
<i>Mastogloia smithii</i>	0	2	1	2	0	1
<i>Navicula lanceolata</i>	2	0	1	0	0	0
<i>Navicula phyllepta</i>	0	2	1	0	0	0

Taxon name	Late Wet 2020			Late Wet 2021		
<i>Navicula radiosa</i>	2	0	1	0	0	0
<i>Nitzschia gracilis</i>	2	0	1	0	0	0
<i>Nitzschia suchlandii</i>	0	2	1	0	0	0
<i>Pinnularia legumen</i>	0	2	1	0	0	0
<b>Total Abundance</b>	394	352	373	424	442	433
<b>DSIAR Score</b>	41.3	42.6	42	34	39	36.5

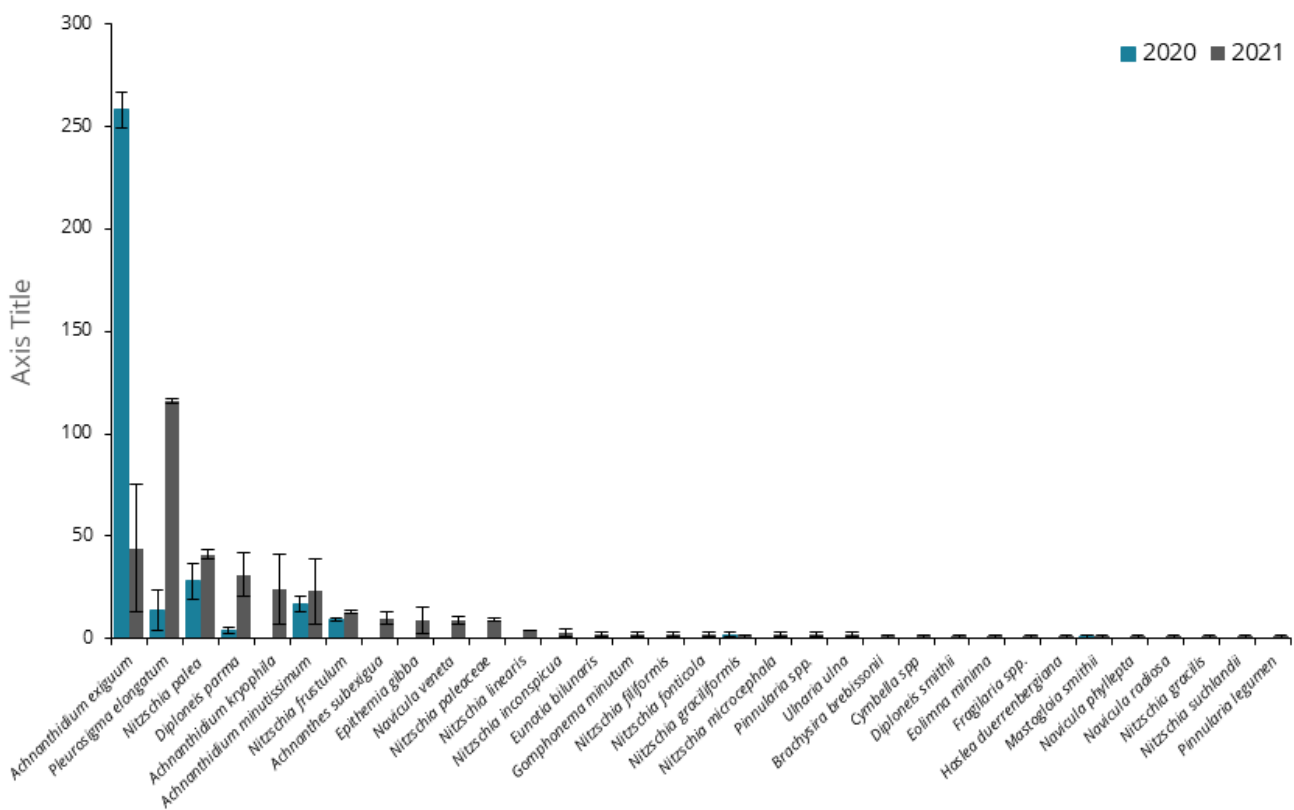


Figure 3-55 Average species abundance (diatom count per replicate) for diatoms sampled at Cental Creek in the Late Wet 2020 and 2021, with taxa arranged from most abundant (left) to least abundant (right) along the x-axis. Standard error (SE±0.5) denoted by error bars.

### 3.4.5.2 PHYTOPLANKTON

In the Late Wet 2021, a full phytoplankton profile for Central Creek was analysed. Overall, there were relatively low numbers of phytoplankton recorded for Central Creek, indicating relatively low

phytoplankton diversity. Two phytoplankton classes were identified; Diatoms (Bacillariophyceae) and Cryptophyceae. Diatoms were observed in considerably higher abundance than Cryptophyceae, and the recorded species in Late Wet 2021 are similar to those observed in Late Wet 2020. Therefore, while the relative phytoplankton biodiversity is low, the diversity within the Diatoms remains high across both wet seasons (Table 3-16).

Table 3-16 Summary of phytoplankton analytical results for Central Creek Pool sampled in late wet season (2021), abundance (cells L<sup>-1</sup>) and percentage contribution (%), limit of reporting 10 cell L<sup>-1</sup>. Central Creek Pool did not have phytoplankton samples taken in the late dry season (2020).

Taxon	Late Wet (2021)	
	Abundance	%
<b>Bacillariophyceae</b>	<b>460</b>	<b>93.88</b>
<i>Entomoneis sp.</i>	10	2.04
<b><i>Fragilaria sp. (O)</i></b>	10	2.04
<i>Microtabella spp.</i>	10	2.04
<i>Navicula spp.</i>	10	2.04
<i>Navicula spp.</i>	50	10.2
<i>Nitzschia spp.</i>	130	26.53
<b><i>Pleurosigma sp. (O)</i></b>	220	44.9
<i>Synedra spp. (O)</i>	10	2.04
<b>Cryptophyceae</b>	<b>30</b>	<b>6.12</b>
<i>Cryptomonas spp. (O)</i>	30	6.12

### 3.4.6 MACROPHYTES

There were very few and sparse macrophytes present at Central Creek Pool. These were represented by a small clump of emergent Clubrush reeds (*Schoenoplectus sp.*) and a few individual sedge (Cyperacea) plants on the southern side of the pool behind a protective in-stream boulder. Less than 1% of the pool area represented macrophyte habitat.

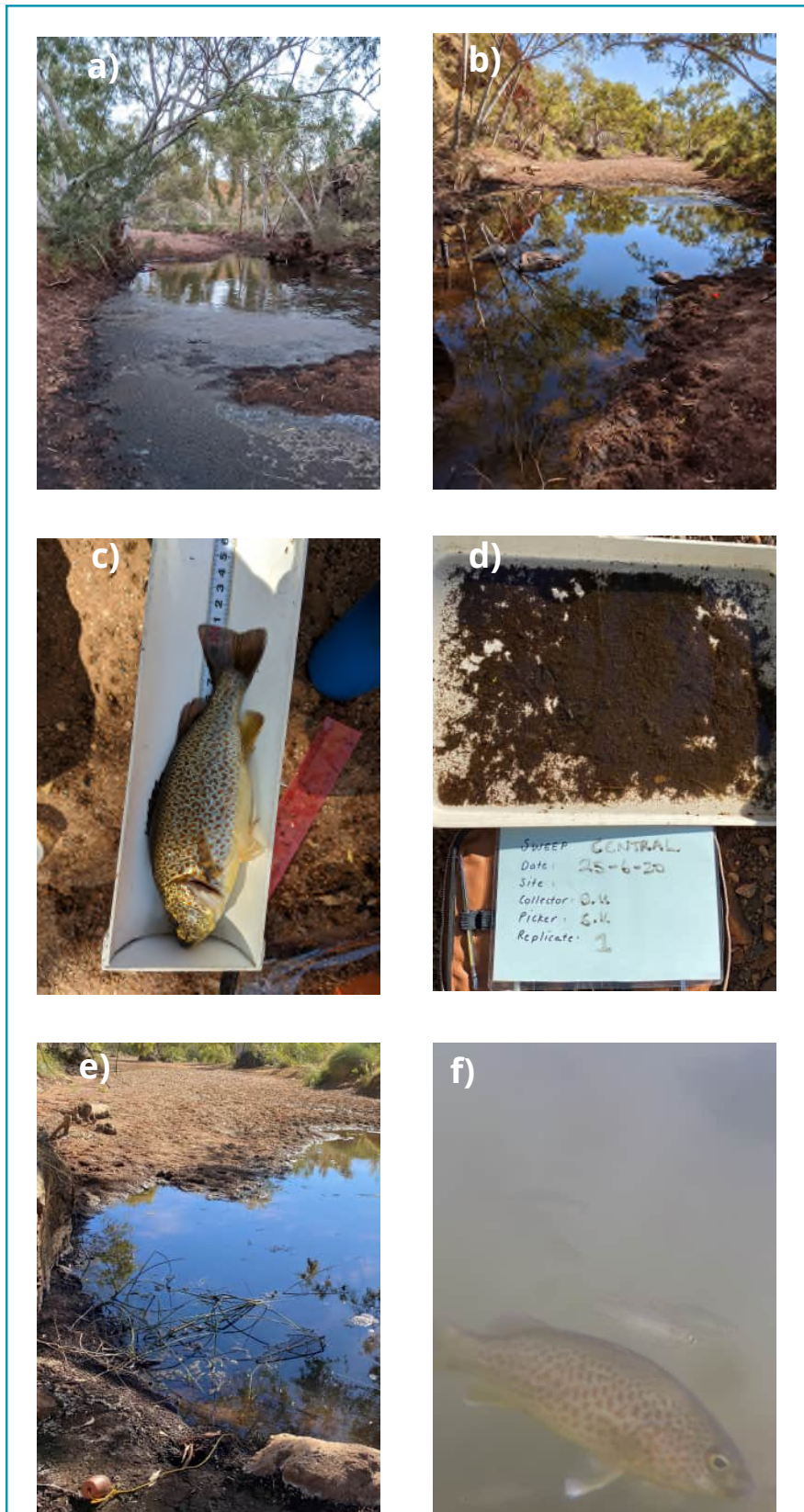


Figure 3-56 Central Creek Pool ecology. a) and b) the shallow pool over alluvial deposits lies on a wide creek bed; c) adult *L. unicolor* as well as juveniles were abundant; d) macroinvertebrates collected that utilise the sediment habitat; e) sparse macrophytes remain and will likely be absent by the late dry season; f) turbid waters may reduce visibility and provide a refuge from large fish predation and terrestrial predation.

### 3.5 COW SPRING POOL (IB\_SW\_POOL\_Cow Spring)

Cow Spring Pool is a small pool (~8 m by 4 m, average of 1 m depth) confined by bedrock habitat dominated by macrophytes and benthic algal cover. The pool is likely to be sustained by groundwater and has established macrophyte habitat and an abundance of *M. australis*, despite relatively acidic water quality.



Figure 3-57 Cow Spring Pool

#### 3.5.1 WATER QUALITY AND HYDROLOGY

Cow Spring has a small surface water catchment area of 0.15 km<sup>2</sup> (Figure 3-58), draining a single ridgeline to the west. The pool is shaded by the adjacent rockface and forms a micro-climate area with dense melaleuca woodland covering the pool and the downstream drainage line for approximately 50m. Figure 3-59 displays a high-resolution water level, salinity (conductivity) and temperature logger record from Mundagoora Pool for the late dry season 2020 to late wet season 2021.

Cow Spring Pool is very clear (<1 NTU turbidity), low pH (5.72), fresh (456  $\mu$ S/cm conductivity) and slightly acidic (10 mg/L as CaCO<sub>3</sub>). It has a mixed balance major ion distribution that is not dominated by any

particular ions (Figure 3-60). No metals or metalloids exceeded the ANZG (2018) default water quality guidelines.

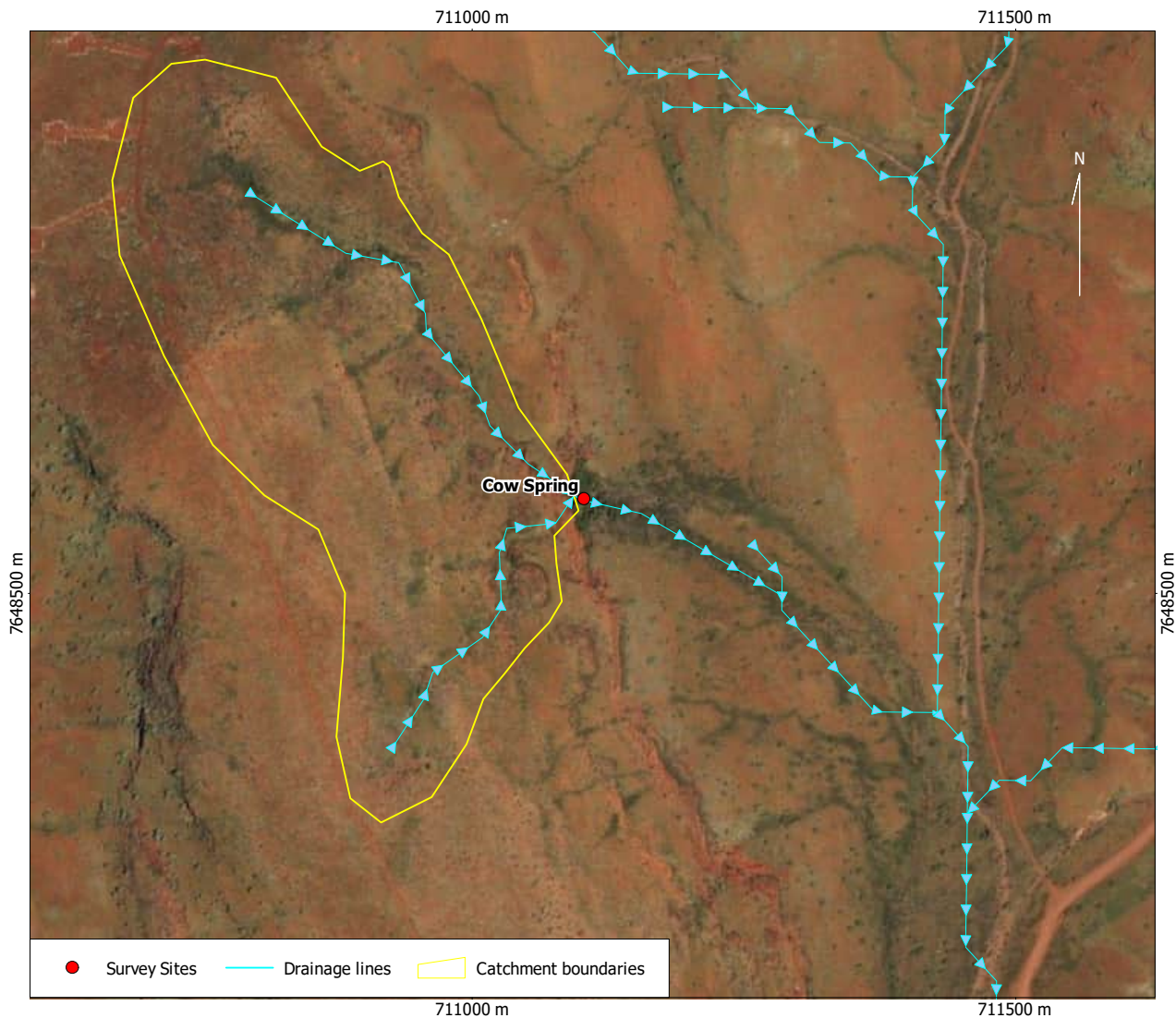


Figure 3-58 Cow Spring catchment area (0.15 km<sup>2</sup>)

The water level of Cow Spring Pool is relatively constant over the wet-dry season, with very short peaks of 10 to 20 cm above the mean level during high rainfall events (Figure 3-59). Due to the shaded positioning of the pool, the water temperature tends to be more stable than other pools in the region, ranging between 20-30°C over the annual cycle. Similarly, the water quality in the pool is relatively constant over the seasonal cycles with a mixed cation and SO<sub>4</sub><sup>-</sup> anion dominance (Figure 3-48). The pool is typically slightly acidic though it approached neutral pH in the Late Wet 2021 sampling.

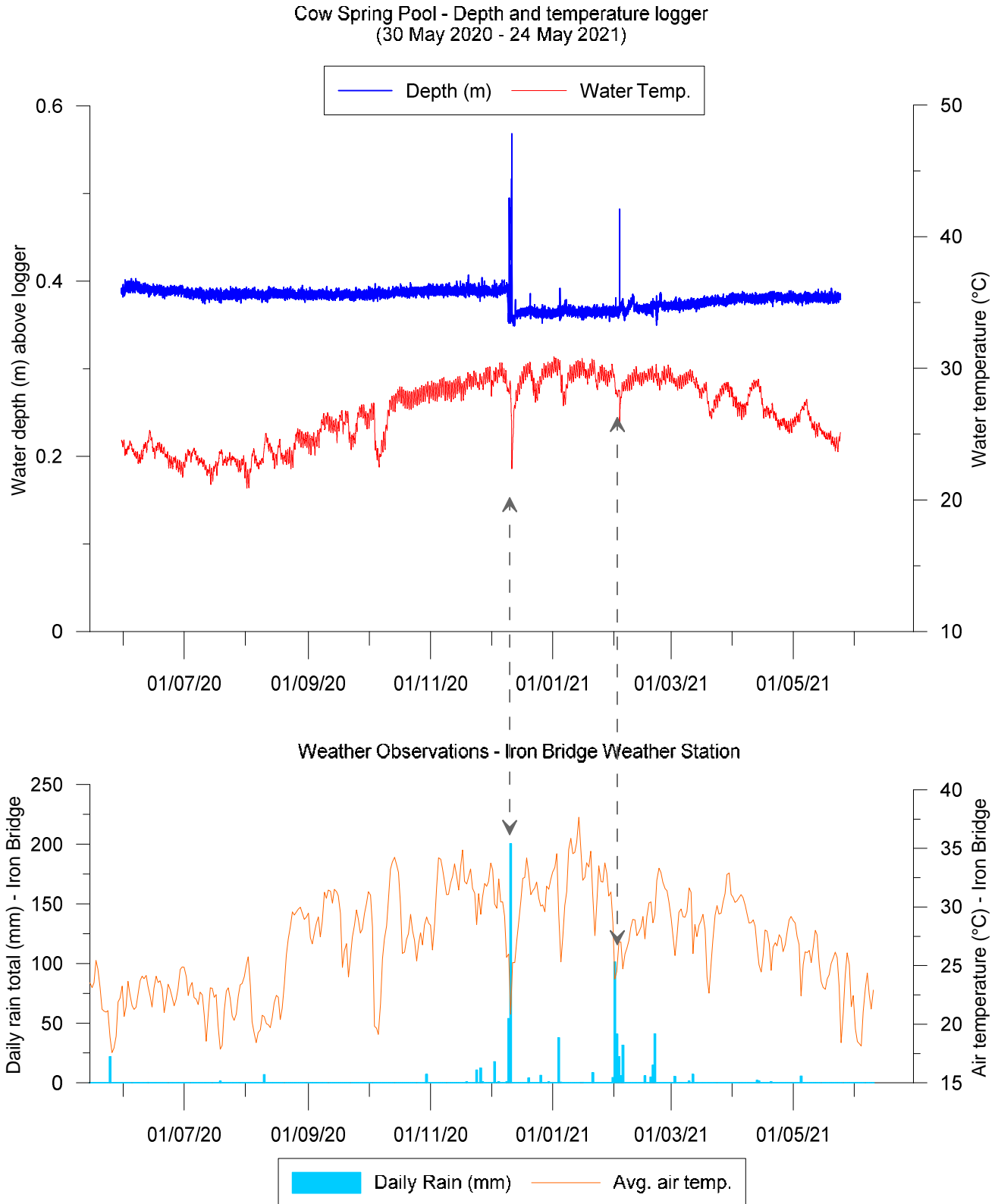


Figure 3-59 Cow Spring Pool depth and temperature logger data (above) relationship to daily rainfall (below) – Wet-Dry season 2021.

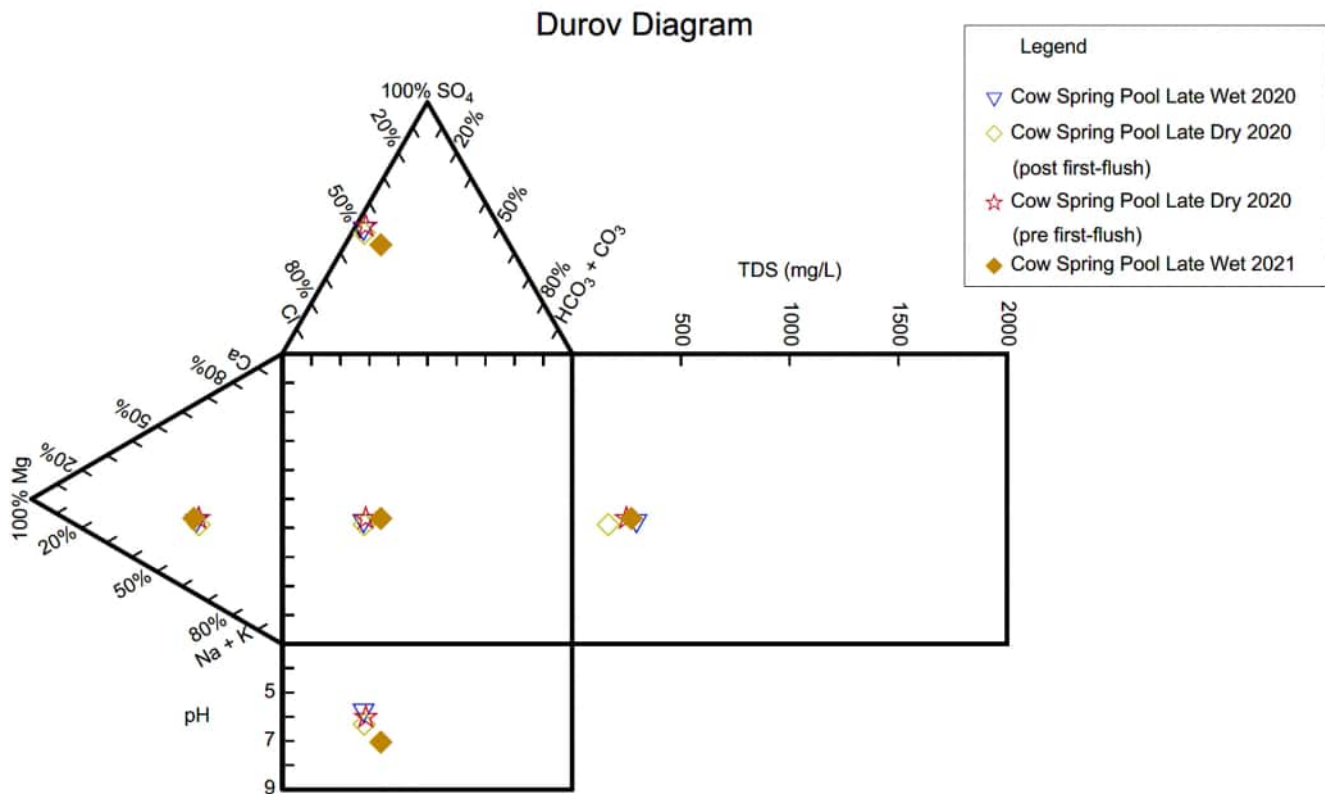


Figure 3-60 Durov diagram showing the Cow Spring Pool major ion distribution.

### 3.5.2 SEDIMENT QUALITY

Table 3-17 provides the surface sediment quality at Cow Spring Pool during the late wet season (sample collection 30<sup>th</sup> May 2020). Metal and metalloid concentrations were assessed against the ANZG (2018) DGVs. Chromium concentration (165 mg/kg) exceeded the DGV but not the GV-high. Chromium naturally occurs in high concentrations across the Project area.

Table 3-17. Summary of the sediment analysis for Cow Spring Pool in late wet season 2020. Bold values denote results recorded above the limit of reporting (LOR).

Analyte grouping/Analyte	Unit	Concentration
Total Soluble Salts	mg/kg	<b>114</b>
Moisture Content (Dried @ 105-110°C)	%	<b>23.9</b>
Total Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>4</b>
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>4</b>
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<1
Acidity	mg/kg	<1
Sulfate as SO <sub>4</sub> <sup>2-</sup> (soluble sulfate by ICPAES)	mg/kg	<b>40</b>
Chloride (by Discrete Analyser)	mg/kg	<b>20</b>
Calcium	mg/kg	<10

Analyte grouping/Analyte	Unit	Concentration
Magnesium	mg/kg	<10
Sodium	mg/kg	<b>20</b>
Potassium	mg/kg	<10
Mercury (FIMS)	mg/kg	<b>4.4</b>
Nitrite + Nitrate as N (Sol.)	mg/kg	<b>0.1</b>
Total Kjeldahl Nitrogen as N	mg/kg	<b>750</b>
Total Nitrogen as N	mg/kg	<b>750</b>
Total Phosphorus as P	mg/kg	<b>320</b>
Reactive Phosphorus as P	mg/kg	<0.1
Total Organic Carbon	%	<b>0.22</b>
<b>Total Metals by ICP-AES</b>		
Arsenic	mg/kg	<b>9</b>
Barium	mg/kg	<10
Beryllium	mg/kg	<1
Boron	mg/kg	<50
Cadmium	mg/kg	<1
Chromium	mg/kg	<b>165</b>
Cobalt	mg/kg	<b>4</b>
Copper	mg/kg	<b>7</b>
Iron	mg/kg	<b>124,000</b>
Lead	mg/kg	<b>9</b>
Manganese	mg/kg	<b>151</b>
Nickel	mg/kg	<b>18</b>
Selenium	mg/kg	<b>6</b>
Vanadium	mg/kg	<b>62</b>
Zinc	mg/kg	<b>16</b>

### 3.5.3 FISH

Only one species of fish, *M. australis* was observed at Cow Spring Pool throughout the three seasons. Table 3-18 presents the abundance, size distribution and CPUE for *M. australis* for all seasons surveyed.

*Leiopotherapon unicolor* was not detected at the pool through any methods, which may be due to various factors such as survival, aestivation, or reproduction may be limited by the naturally high acidity. Similarly, no decapod crustaceans were collected or observed.

Most *M. australis* sampled from Cow Spring Pool in the Late Wet 2020 were in the size class 30 – 60 mm, followed by the length classes <30 mm and 60 – 90mm at similar frequencies. Two individuals were recorded with a SL in >90 mm length class. The Late Dry 2020 was dominated by fish in the 60 – 90 mm

length class, with notably less in the smaller length classes (Figure 3-62). The Late Dry 2020 also had low frequency of larger fish (<90 mm). *M. australis* sampled in the Late Wet 2021 were dominated by fish in the 30 – 60 mm length class (74.1%). A similar frequency of very small fish (<30 mm) were present between seasons, indicating there is consistent juvenile recruitment occurring (Figure 3-61). As *M. australis* is considered to reach sexual maturity at 50 mm SL (Evans et al. 2010), Cow Spring Pool appears to be dominated with juvenile *M. australis*; only 6 individuals were larger than 50 mm. Individuals in the 30 – 60 mm length class likely hatched at the start of the wet season 2020/2021, with the <30 mm juveniles likely to have hatched post large wet season rains and indicate reproduction occurring within the pool, rather than migrating during periods of connecting flow (Pusey, B., Kennard, M., & Arthington, 2004).

*Uperoleia* sp. tadpoles were also observed at Cow Spring Pool. Their presence or catchability in Cow Spring Pool may be in part due to the absence of the predators *L. unicolor*.

Table 3-18. Summary of fish count for the standard length class (mm) and the CPUE for *M. australis* in the Late Wet 2020, Late Dry 2020 and Late Wet 2021 surveys.

Season	Size class (mm)	Catch	CPUE <sup>1</sup>
<b>Late Wet (2020)</b>		<b>67</b>	<b>3.8</b>
	0 – 30	13	
	30 – 60	37	
	60 – 90	15	
	> 90	2	
<b>Late Dry (2020)</b>		<b>102</b>	<b>5.8</b>
	0 – 30	12	
	30 – 60	20	
	60 – 90	67	
	> 90	3	
<b>Late Wet (2021)</b>		<b>31</b>	<b>1.77</b>
	0 – 30	5	
	30 – 60	23	
	60 – 90	3	
	>90	-	

<sup>1</sup> CPUE is catch per unit effort, a measure of relative abundance. Effort is fyke net set for 17.75 hours.

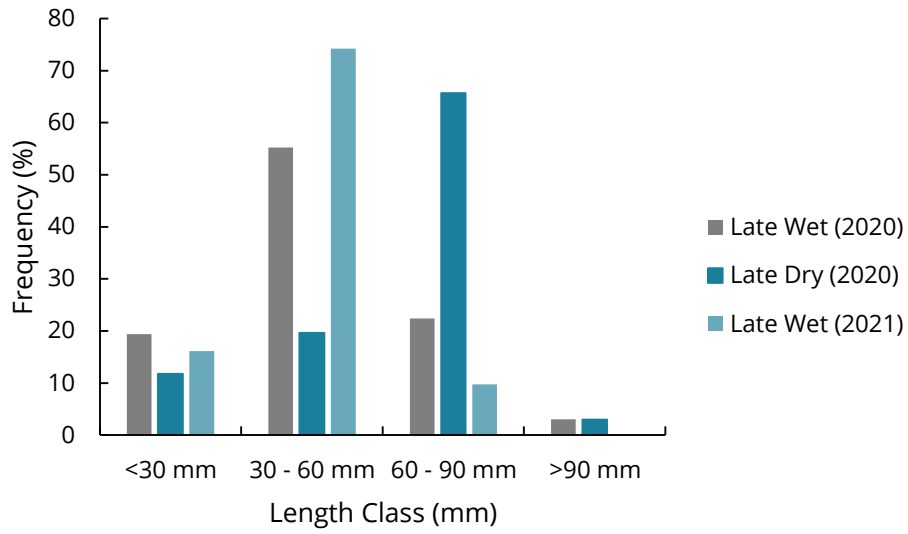


Figure 3-61. Frequency (%) of occurrence for each length class (SL, mm) for *Melanotaenia australis* sampled from Cow Spring Pool in late wet (June) and late dry (December) 2020.

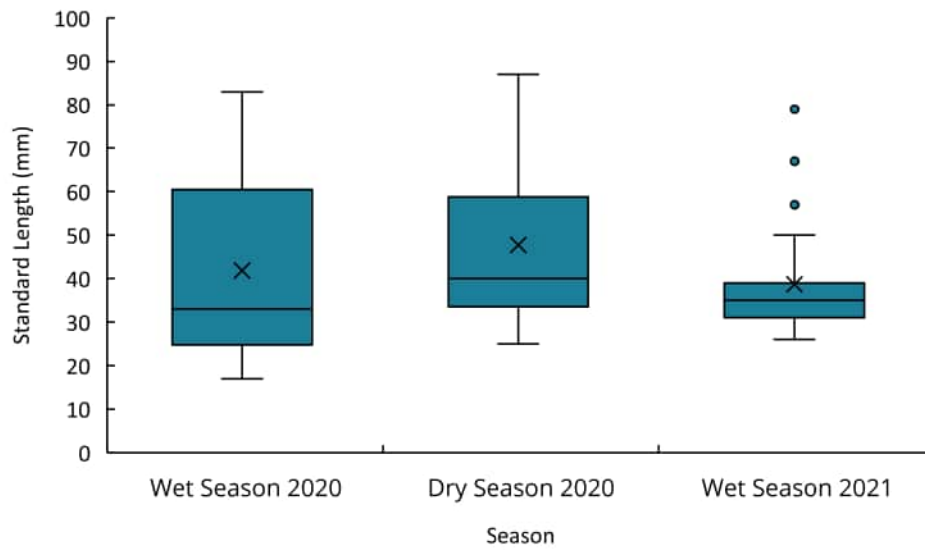
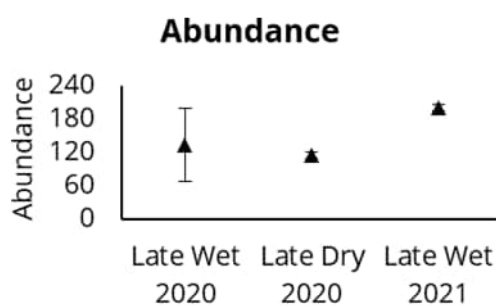


Figure 3-62. Size distribution of the standard length (SL, mm) for *Melanotaemia australis* sampled from Cow Spring Pool.

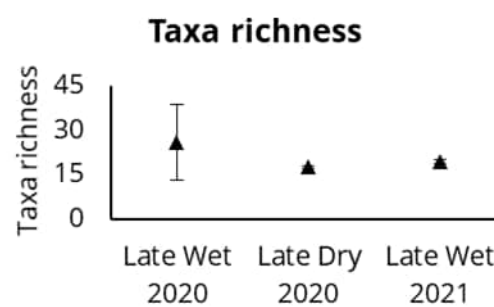
### 3.5.4 AQUATIC MACROINVERTEBRATES

Figure 3-63 presents the summary of the four macroinvertebrate indices for Cow Spring Pool in the late wet season of 2020 and 2021, and the late dry season of 2021. The key findings were as follows:

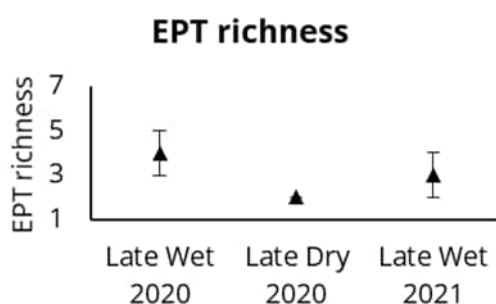
- Abundances of macroinvertebrates varied widely from 67 to 200 in Late Wet 2020, with consistent average abundances of 116 and 202 in the Late Dry 2020 and Late Wet 2021 seasons, respectively (Figure 3-63 a).
- Similarly, taxa richness ranged from 13 to 39 in Late Wet 2020 and from 17 to 20 in both other seasons, indicating more stable communities in Late Dry 2020 and the Late Dry 2021 seasons (Figure 3-63 b).
- EPT richness declined from the Late Wet to Dry season in 2020, before inclining slightly in the Late Wet season of 2021 (Figure 3-63 c). Five families belonging to the Ephemeroptera and Trichoptera orders have been recorded. Seasonal declines in EPT richness are likely due to the less favourable natural conditions experienced in the dry season.
- SIGNAL2 scores are relatively stable between seasons (Figure 3-63 d), with the range of scores (3.1-3.6) indicating the macroinvertebrate community is moderately tolerant.



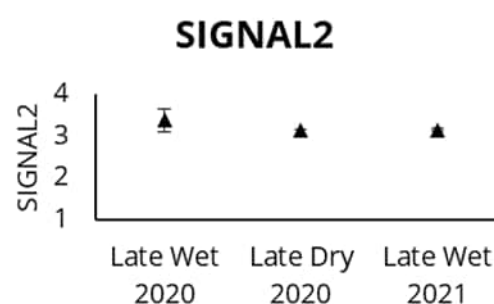
a) Total abundance at Cow Spring Pool



b) Taxonomic richness at Cow Spring Pool



c) EPT richness at Cow Spring Pool



d) SIGNAL2 scores at Cow Spring Pool

Figure 3-63 Macroinvertebrate indices for Cow Spring Pool – Late Wet 2020, Late Dry 2020 and Late Wet 2021.

The abundance of taxa for the three seasonal surveys is provided in Figure 3-64 and shows taxa ranging from the the most abundant (left) to the least abundant (right) along the x-axis. The non-biting midge of the Tanypodinae and Chironominae were more abundant in the most recent Late Wet survey of 2021,

with their increase potentially due to the greater rainfall levels in Late Wet 2021 as freshwater flow events such as flooding in wetlands can increase their abundances (McInerney et al. 2017). Similar abundances of the Acarina mites and ticks, Libellulidae dragonfly and biting midge of the Ceratopogonidae were found throughout all seasons. For damselflies of the Coenagrionidae, abundances increased during 2020 and then reduced substantially in the latest season of Late Wet 2021.

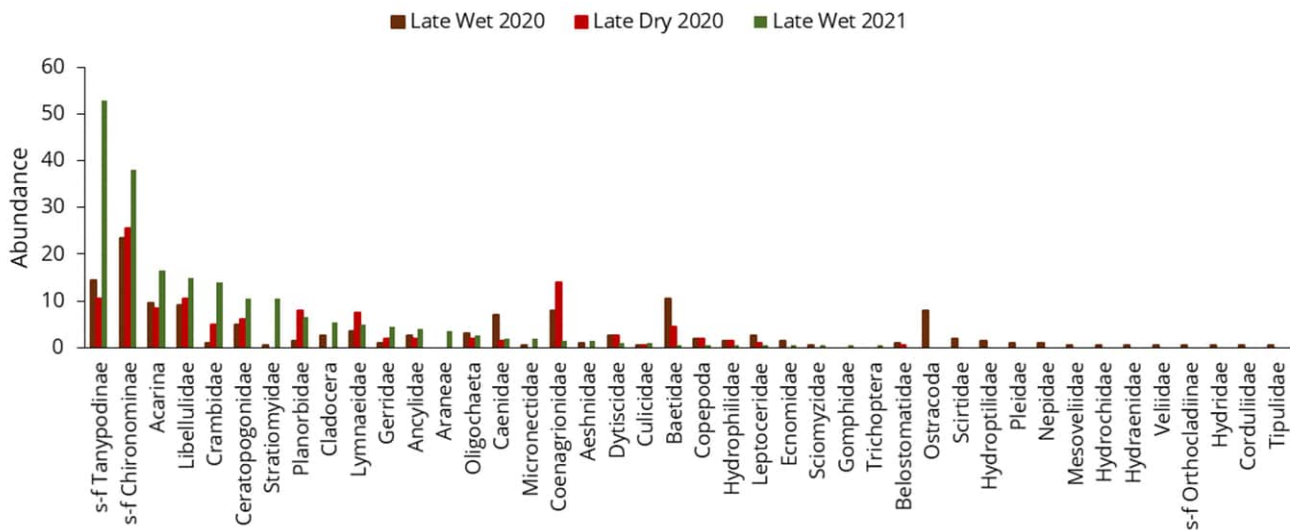


Figure 3-64 Average abundances of all macroinvertebrate taxa at Cow Spring Pool in the Late Wet season of 2021 and the Late Wet and Late Dry season of 2020, with taxa arranged from most abundant (left) to least abundant (right) along the x-axis.

### 3.5.5 DIATOMS AND PHYTOPLANKTON

#### 3.5.5.1 DIATOMS

**Error! Reference source not found.** summarises the species present, the overall abundance, and biotic indices of diatoms surveyed in the Late Wet 2020. Only one replicate of diatoms collected in Late Wet 2021 was analysed, therefore only total count has been recorded for this season. No diatom data was available for the Late Dry 2020 due to flood flows during the deployment period. **Error! Reference source not found.** presents the average abundance of diatom species recorded at Cow Spring Pool for Late Wet 2020. The key findings are as follows:

Overall, 21 species were recorded at Cow Spring Pool across both seasons, with Late Wet 2021 recording a higher number of species (19) than 2020 (7). Of the 21 species only 5 were present in both seasons. Total abundance of diatoms was higher in Late Wet 2021 but the notable difference in diatom count can be attributed to one species *Brachysira styriaca* with a total abundance of 218 recorded in 2021. The most abundant species for Cow Spring Pool recorded in Late Wet 2020 was *Achnantheidium minutissimum* and *Eunotia bilunaris*, species were also present at all other pools except Fig Pool (Figure 3-65).

Late Wet 2020 showed low diatom diversity for this site. The first replicate for this site detected no diatoms and the other samples noted very sparse abundance. The high acidity and low light conditions at Cow Spring Pool may have contributed to the relatively low diatom growth compared to other North Star pools. The low abundance of diatoms indicates they are able to survive, though the capacity for growth is limited under the conditions that were present during the sampling period. The DSIAR score (64.2) reflects the species sensitivity to environmental stress, where a higher score indicates 'better' water quality as species sensitive to environmental stress are present. This indicates the species richness is more likely limited by

factors needed to grow (i.e. sunlight) rather than stressors known to cause mortality of sensitive species (e.g. high salinity). While samples collected in 2021 recorded a higher number of species than 2020, Cow Spring Pool still shows lower taxonomic diversity than other North Star Pools. A higher taxonomic diversity in 2021 of diatoms has been observed for all North Star Pools, with exception of Fig Pool which recorded no diatoms either season.

Table 3-19. Diatom abundance (total count per species), average abundance and DSIAR score Cow Spring Pool surveyed in Late Wet 2020, only total abundance was recorded for Late Wet 2021

Taxon	Late Wet 2020			Late Wet 2021
	Replicate 1	Replicate 2	Average	Total Count
<i>Achnantheidium minutissimum</i>	0	8	4	14
<i>Brachysira styriaca</i>	0	0	0	12
<i>Brachysira vitrea</i>	0	0	0	218
<i>Cymbella affinis</i>	0	2	1	8
<i>Cymbella spp</i>	0	4	2	4
<i>Eunotia bilunaris</i>	0	8	4	62
<i>Eunotia exigua</i>	0	0	0	4
<i>Eunotia faba</i>	0	2	1	0
<i>Eunotia incisa</i>	0	0	0	6
<i>Eunotia paludosa</i>	0	0	0	4
<i>Eunotia spp.</i>	0	0	0	6
<i>Fragilaria acus</i>	0	0	0	16
<i>Fragilariforma virescens</i>	0	0	0	2
<i>Frustulia rhomboides</i>	0	0	0	2
<i>Gomphonema affine</i>	0	0	0	6
<i>Gomphonema minutum</i>	0	0	0	4
<i>Hantzschia amphioxys</i>	0	2	1	0
<i>Luticola mutica</i>	0	2	1	4
<i>Mastogloia smithii</i>	0	0	0	2
<i>Pinnularia spp.</i>	0	0	0	4
<i>Ulnaria ulna</i>	0	0	0	22
<b>Total Abundance</b>	0	28	14	400
<b>DSIAR Score</b>		64.2	64.2	68

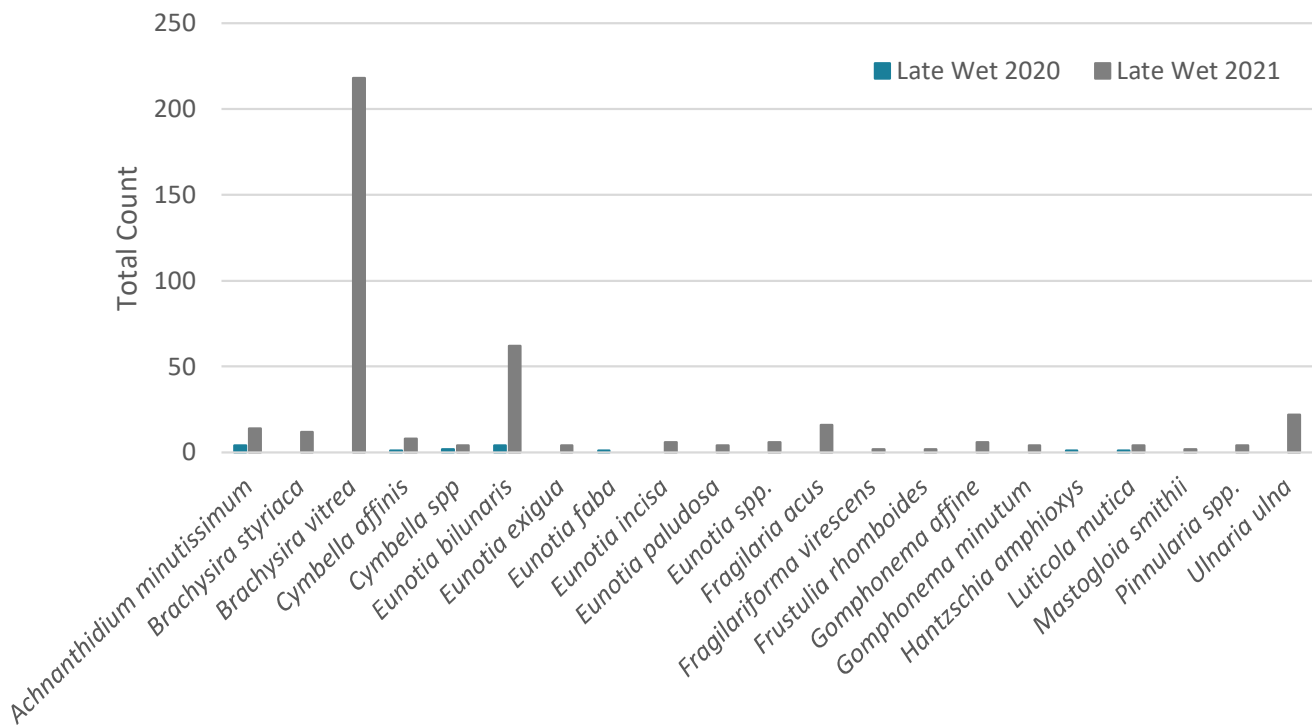


Figure 3-65. Mean abundance for diatom species recorded in late wet season 2020, with error bars denoting  $\pm 0.5\sigma$ .

### 3.5.5.2 PHYTOPLANKTON

In the Late Dry 2020 and Late Wet 2021, water samples were taken from Cow Spring Pool to analyse a complete planktonic phytoplankton profile for the site. In the Late Dry 2020, five phytoplankton classes with 15 species were identified, indicating Cow Spring Pool has a relative moderate phytoplankton diversity. Cryptophyceae occurred at the highest abundance, followed by Dinophyceae (Dinoflagellates). Diatoms (Bacillariophyceae) were the third most abundant, and samples collected in the late dry season identified similar diatom species as the previous season.

In the late wet season 2021, there were considerably fewer phytoplankton cells recorded. Overall, the only class that yielded a result above the LOR was the diatoms (Bacillariophyceae) at a very low abundance. The low abundance of phytoplankton is not unusual for Cow Spring Pool based on diatom results in the previous wet season and could also be attributed to heavy rain during the wet season (Table 3-20).

Table 3-20 Summary of phytoplankton analytical results for Cow Spring Pool sampled in late wet season (2021), abundance (cells  $L^{-1}$ ) and percentage contribution (%), limit of reporting 10 cell  $L^{-1}$ .

Taxon	Late Dry (2020)		Late Wet (2021)	
	Abundance	%	Abundance	%
<b>Bacillariophyceae</b>	<b>7000</b>	<b>19.02</b>	<b>20</b>	<b>100</b>
<i>Achnantheidium minutissima</i>	1400	3.8	0	0
<i>Amphora spp.</i>	200	0.54	0	0
<i>Cymbella spp.</i>	400	1.09	0	0
<i>Navicula spp.</i>	2800	7.61	10	50

Taxon	Late Dry (2020)		Late Wet (2021)	
<i>Nitzschia spp.</i>	400	1.09	0	0
<i>Synedra spp. (O)</i>	1800	4.89	10	50
<b>Chlorophyceae</b>	<b>1400</b>	<b>3.8</b>	<b>0</b>	<b>0</b>
<i>Cosmarium spp. (O)</i>	1200	3.26	0	0
<i>Staurastrum spp. (O)</i>	200	0.54	0	0
<b>Cryptophyceae</b>	<b>15000</b>	<b>40.76</b>	<b>0</b>	<b>0</b>
<i>Chroomonas spp.</i>	3000	8.15	0	0
<i>Cryptomonas spp. (O)</i>	11800	32.07	0	0
<i>Plagioselmis spp.</i>	200	0.54	0	0
<b>Dinophyceae</b>	<b>13200</b>	<b>35.87</b>	<b>0</b>	<b>0</b>
<i>Gonyaulax spp.</i>	12200	33.15	0	0
<i>Gymnodinium spp.</i>	600	1.63	0	0
<i>Peridinium spp. (O)</i>	400	1.09	0	0
<b>Euglenophyceae</b>	<b>200</b>	<b>0.54</b>	<b>0</b>	<b>0</b>
<i>Trachelomonas spp.</i>	200	0.54	0	0

### 3.5.6 MACROPHYTES

Table 3-21 presents the macrophyte species and qualitative abundance during the Late Wet 2020, Late Dry 2020 and Late Wet 2021 surveys. A diverse range of macrophyte flora was observed within Cow Spring Pool. These comprised aquatic species and groundwater-dependent species. A total of seven macrophyte species were recorded in each season. These included reeds (Clubrush, *Typha* spp.), sedges (Cyperaceae) as well as submerged macrophytes (ribbon weed, charophytes, Hydrocharitaceae) (Figure 3-66, Figure 3-67 and Figure 3-18). The abundance and diversity of species of macrophytes present in this system indicate relatively high water quality and ecological health conditions. The macrophytes, both emergent and submerged, are providing important habitat structure, refuge and food sources to organisms such as the *M. australis* (western rainbowfish). There was a decrease in the abundance of emergent macrophytes in the Late Wet 2021 compared to the Late Wet 2020. However, no changes were substantial enough to alter the categorical abundance classification.

Table 3-21. Description of macrophytes species and abundance observed at Cow Spring Pool in the late wet season (2020)

Common name	Species name	Late Wet 2020 Abundance <sup>1</sup>	Late Dry 2020 Abundance <sup>1</sup>	Late Wet 2021 Abundance <sup>1</sup>
Ribbon weed	<i>Vallisneria sp.</i>	Abundant	Abundant	Abundant
Charophytes	<i>Nitella sp.</i> , <i>Chara sp.</i>	Abundant	Abundant	Abundant
Clubrush	<i>Schoenoplectus sp.</i>	Abundant	Abundant	Abundant
Sedges	Cyperaceae	Isolated	Isolated	Isolated
Bulrush	<i>Typha sp.</i>	Isolated	Isolated	Isolated
Unidentified 1	Hydrocharitaceae	Isolated	Isolated	Isolated
Unidentified 2	Hydrocharitaceae	Isolated	Isolated	Isolated

<sup>1</sup> Abundance based on *Western Australia AUSRIVAS field sampling sheet* (DoW, 2009).



Figure 3-66 Two macrophytes pending taxonomic identification in Cow Spring Pool

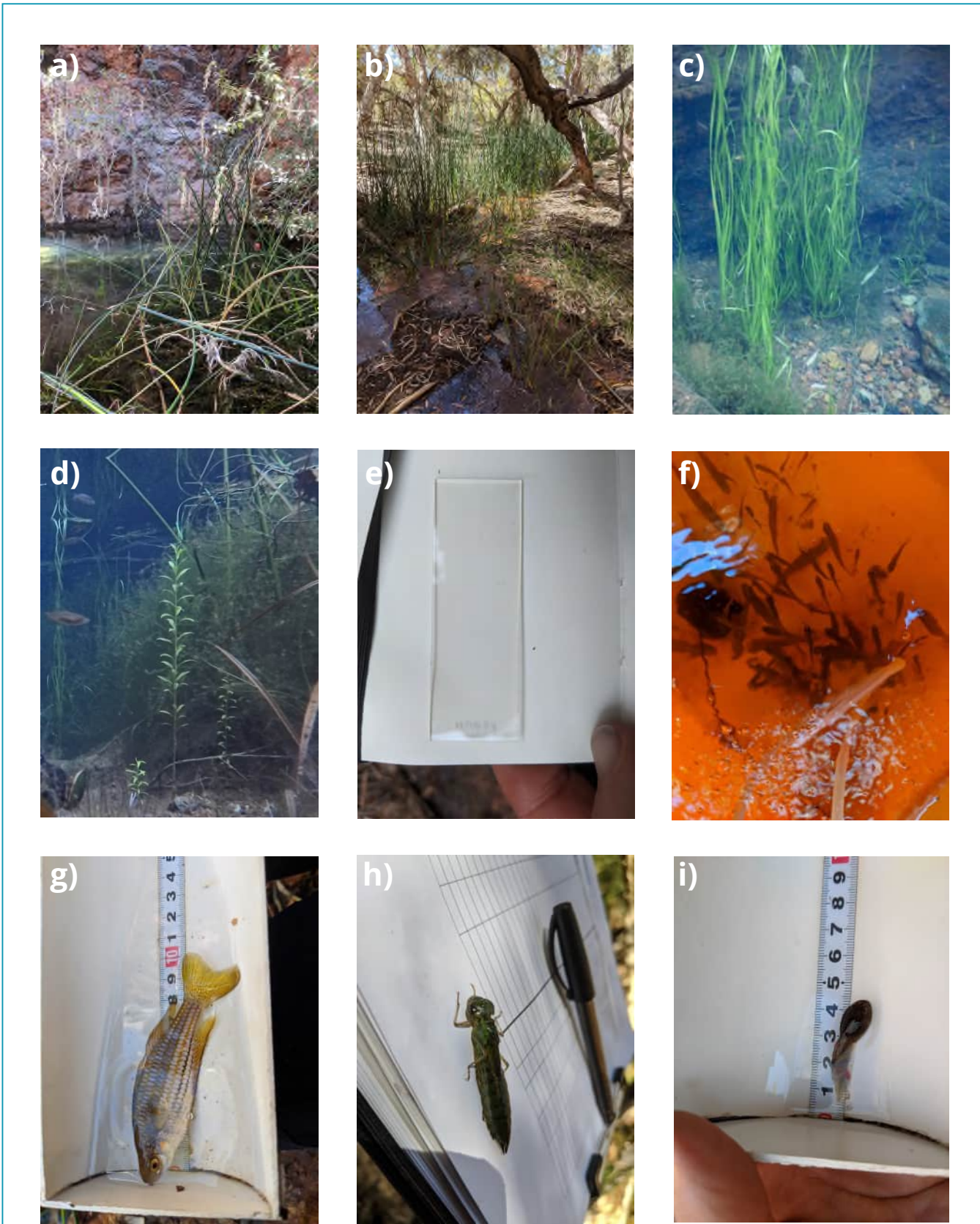


Figure 3-67 Cow Spring Pool aquatic ecology. a) to d) show a diversity of emergent and submerged macrophytes; e) a slide with minimal diatom colonisation; f) and g) *M. australis* present over a wide range of ages; h) Aeshnidae; an example of macroinvertebrates inhabiting macrophytes; i) tadpoles of *Uperoleia* spp.

### 3.6 GV POOL (GV\_SW\_POOL\_SW)

The South-West Glacier Valley Pool (GV SW Pool) is a series of small pools located in a cut across an adjacent ridgeline. The pool supports fish during the wet season (spangled perch - *Leiopotherapon unicolor*), likely to have migrated from downstream permanent pools as wet season flows provided habitat connectivity. The macrophyte (submerged vegetation community) was limited at GV Pool but some individual plants were observed within the various semi-connected pools along the drainage reach. Overall, the ecology observed at GV Pool was similar to other regional pools studied for the Iron Bridge aquatic ecology monitoring program.



Figure 3-68 GV Pool; The South-West Glacier Valley Pool during the Late Wet Season 2021.

#### 3.6.1 WATER QUALITY AND HYDROLOGY

The GV Pool monitoring site is a string of shallow ephemeral pools perched on bedrock, fed by a 3.3 km<sup>2</sup> catchment (Figure 3-69) draining the western face of the Glacier Valley ridgeline. This catchment is similar in nature to the Mundagoora Pool catchment directly to the north, draining the same ridge system. GV Pool differs in hydrology to the Mundagoora Pool, however, with surface water flows appearing to dominate inputs. The pool system was dry during observations in December 2020 and displayed remnant perched and semi-connected shallow (<0.5m depth) pools during the wet season (May 2021).

The water quality of GV Pool was similar to other ephemeral pools in the region during the Late Wet 2021 sampling with a slightly alkaline pH of 7.88 and moderately brackish salinity (EC = 1444 µS/cm). The pool was well oxygenated (Dissolved Oxygen = 7.99 mg/L) and clear (Turbidity = <1). The major ion distribution is presented as a Durov Plot in Figure 3-71, showing sodium bicarbonate (Na-HCO<sub>3</sub>) dominated water type that is saturated with respect to calcite precipitation.

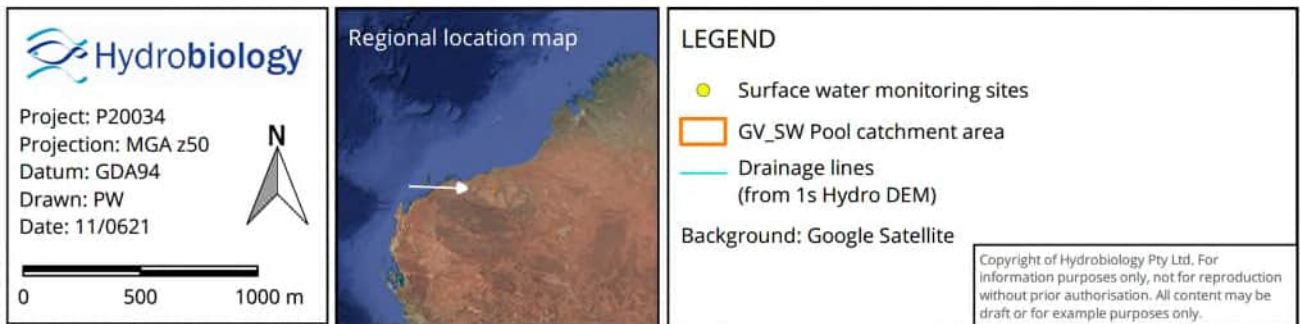
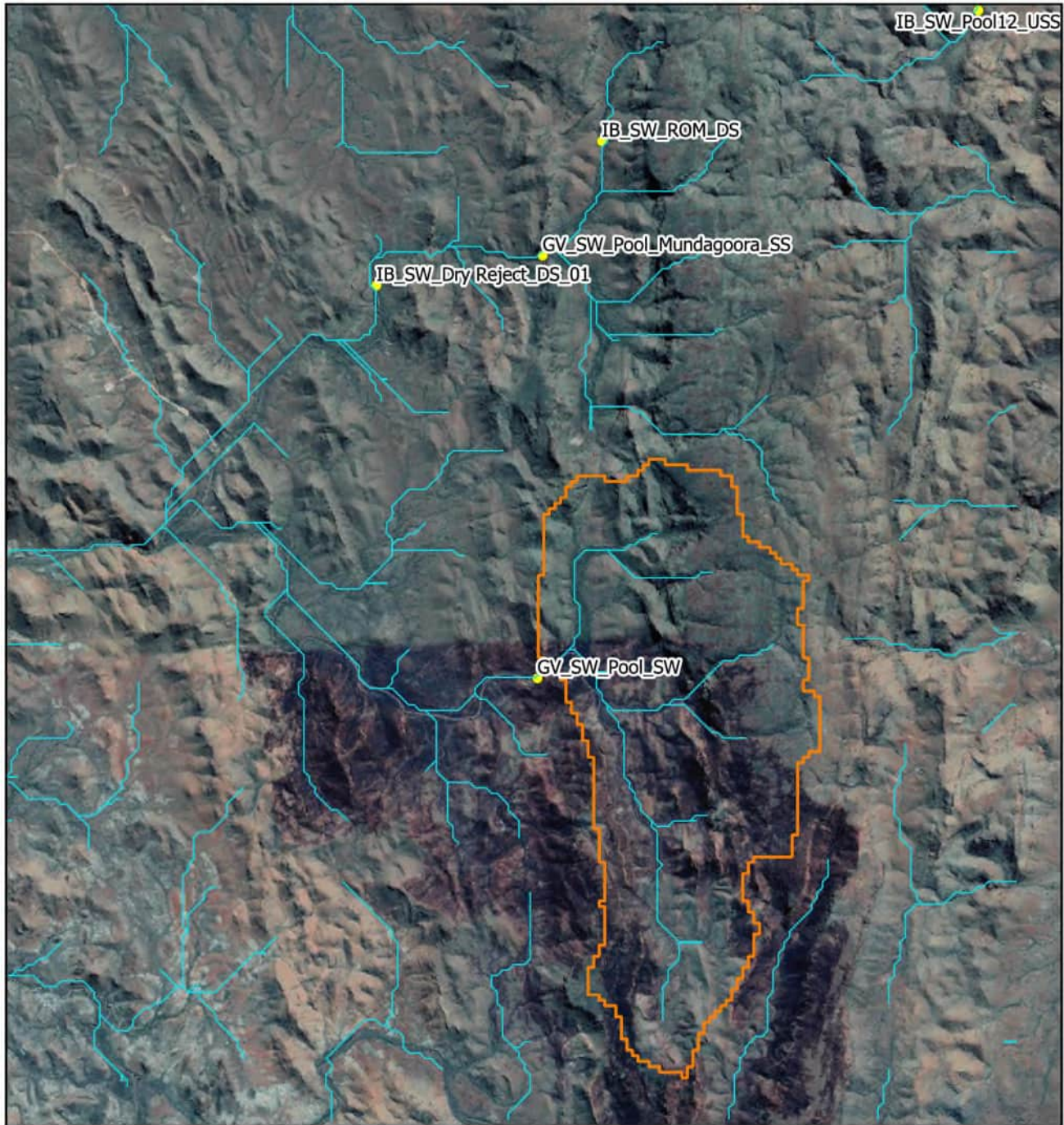


Figure 3-69 GV SW Pool catchment area (3.3 km<sup>2</sup>)

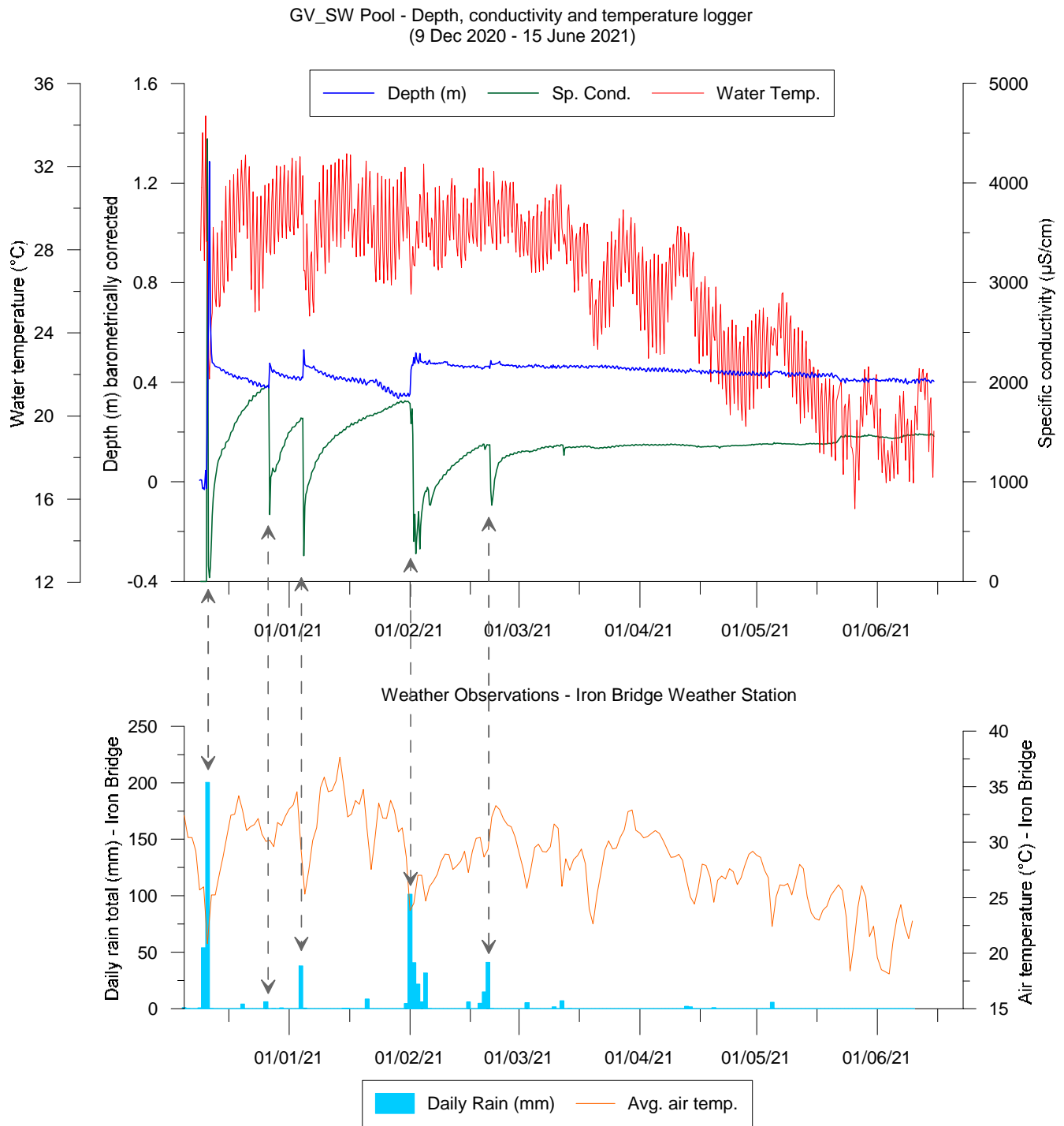


Figure 3-70 GV SW Pool depth, conductivity, and temperature logger data (above) relationship to daily rainfall (below) - Wet-Dry season 2021.

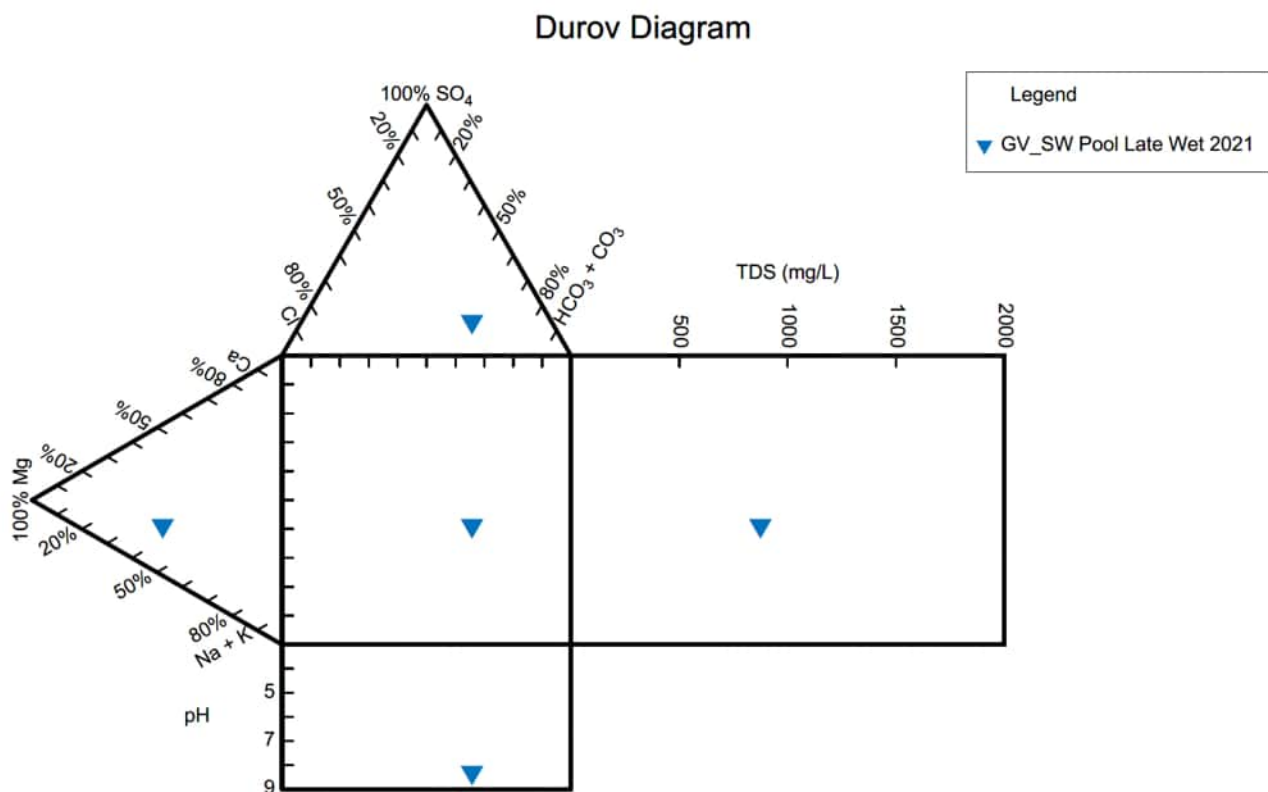


Figure 3-71 Durov diagram showing the South-West Glacier Valley Pool (GV SW Pool) major ion distribution.

### 3.6.2 SEDIMENT QUALITY

The sediment quality for the Late Wet 2021 sampling at GV Pool is provided in Table 3-22. As with the other sites surveyed, the Chromium concentrations exceeded the DGV of 80 mg/kg and were just below the GV-High of 370 mg/kg (ANZG 2018). Similarly, the Nickel concentrations were above both the DGV (21 mg/kg) and the GV-High (52 mg/kg). This pattern was consistent with other pools in the region.

Table 3-22 Summary of sediment quality analysis for GV Pool in the late wet season 2021. Bolded values denote results recorded above the limit of reporting (LOR).

Analyte grouping/Analyte	Unit	Late Wet 2021
Total Soluble Salts	mg/kg	<b>200</b>
Moisture Content (Dried @ 105-110°C)	%	<b>24.8</b>
Total Alkalinity as CaCO <sub>3</sub>	mg/kg	<5
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>239</b>
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>239</b>
Acidity	mg/kg	<b>62</b>
Sulfate as SO <sub>4</sub> <sup>2-</sup> (soluble sulfate by ICPAES)	mg/kg	<b>&lt;10</b>
Chloride (by Discrete Analyser)	mg/kg	<b>20</b>

Analyte grouping/Analyte	Unit	Late Wet 2021
Calcium	mg/kg	<b>30</b>
Magnesium	mg/kg	<b>20</b>
Sodium	mg/kg	<b>30</b>
Potassium	mg/kg	<10
Mercury (FIMS)	mg/kg	<0.1
Nitrite + Nitrate as N (Sol.)	mg/kg	<0.1
Total Kjeldahl Nitrogen as N	mg/kg	<b>430</b>
Total Nitrogen as N	mg/kg	<b>430</b>
Total Phosphorus as P	mg/kg	<b>190</b>
Reactive Phosphorus as P	mg/kg	<0.1
Total Organic Carbon	%	<b>0.13</b>
<i>Total Metals by ICP-AES</i>		
Arsenic	mg/kg	<b>9</b>
Barium	mg/kg	<b>60</b>
Beryllium	mg/kg	<1
Boron	mg/kg	<b>50</b>
Cadmium	mg/kg	<1
Chromium	mg/kg	<b>368</b>
Cobalt	mg/kg	<b>33</b>
Copper	mg/kg	<b>67</b>
Iron	mg/kg	<b>114000</b>
Lead	mg/kg	<b>6</b>
Manganese	mg/kg	<b>674</b>
Nickel	mg/kg	<b>134</b>
Selenium	mg/kg	<b>&lt;5</b>
Vanadium	mg/kg	<b>161</b>
Zinc	mg/kg	<b>30</b>

### 3.6.3 FISH

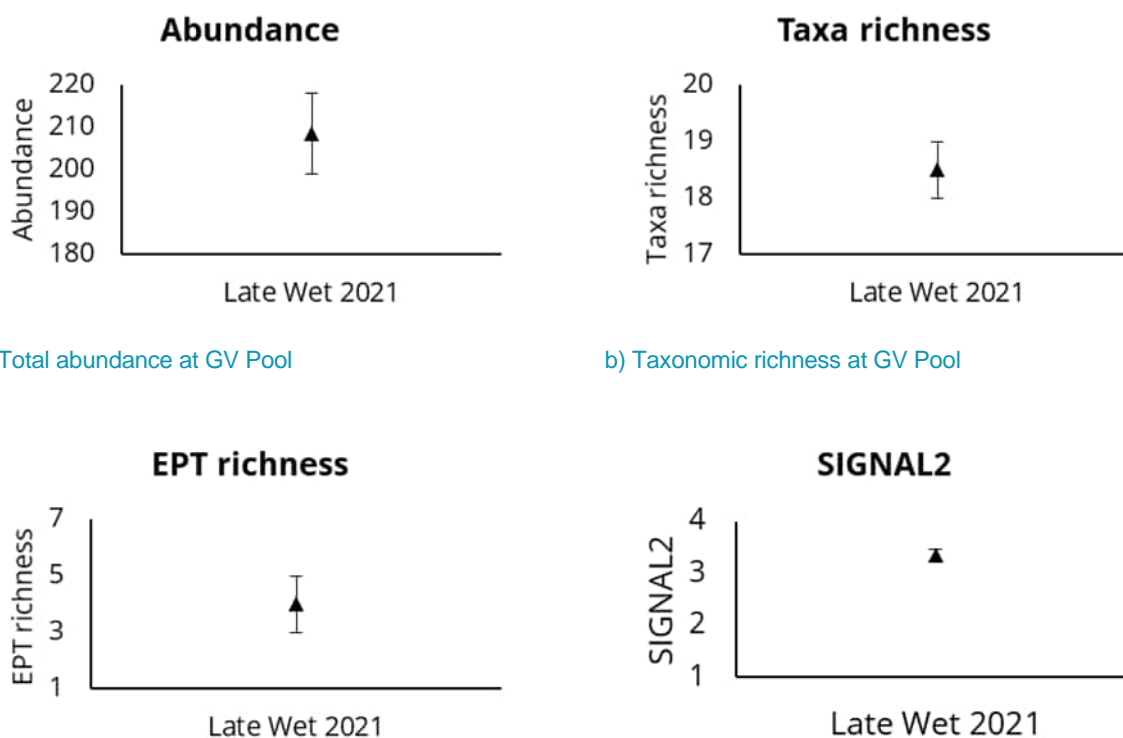
GV Pool was first surveyed in the Late Wet Season 2021. As GV Pool was shallow, a fyke net was not able to be used to survey the fish abundance at this site; therefore, species composition and fish counts were conducted using BRUVs.

*L. unicolor* (spangled perch) was the only fish species observed on the BRUV footage for GV Pool (MaxN = 13).

### 3.6.4 AQUATIC MACROINVERTEBRATES

Figure 3-72 presents the summary of total abundance, taxa richness, EPT richness and SIGNAL2 for the first season sampled (Late Wet 2021) in GV Pool. The key findings were as follows:

- Total abundance and taxa richness varied, with 199 to 218 individuals and 18 to 19 taxa recorded, respectively.
- Average EPT richness was 4 at the GV Pool, with a total of five families belonging to the Ephemeroptera and Trichoptera orders recorded.
- The average SIGNAL2 score was 3.4, which indicates that the macroinvertebrate community at GV Pool is moderately tolerant.



a) Total abundance at GV Pool

b) Taxonomic richness at GV Pool

c) EPT richness at GV Pool

d) SIGNAL2 scores at GV Pool

Figure 3-72 Macroinvertebrate indices for GV Pool in the Late Wet 2021 season.

Figure 3-73 shows the abundance of each macroinvertebrate taxa in GV Pool in the Late Wet season of 2021 and shows taxa ranging from the the most abundant (left) to the least abundant (right) along the x-

axis. Cnidarians were highly abundant macroinvertebrates at GV Pool, with members of Hydrozoa, Oceaniidae, Hydrodidae and Olindiidae were the top four most abundant taxa. Members of the sponge phylum Porifera were the next most abundant, followed by Bryozoa and the turbellarian flatworms of the Platyhelminthes.

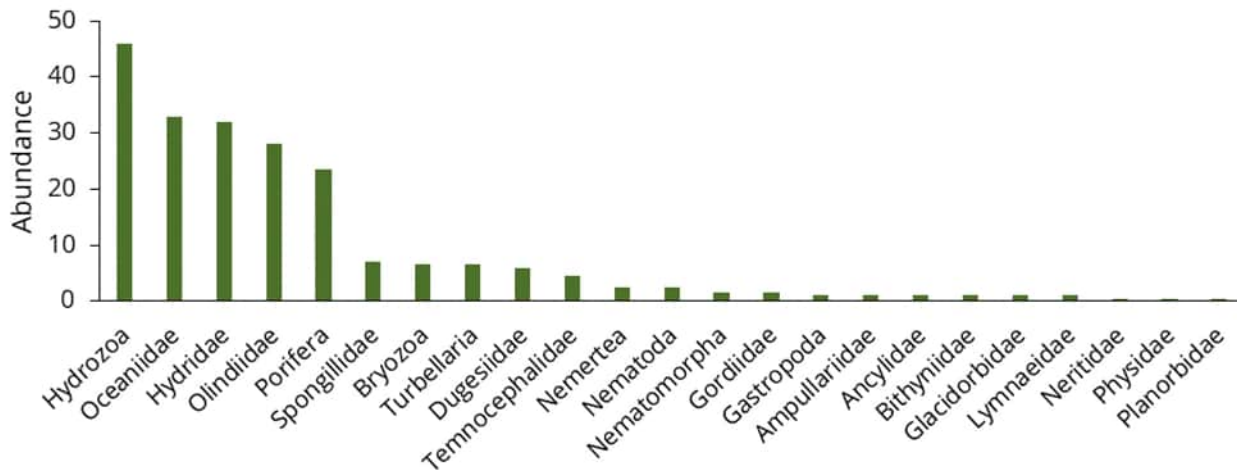


Figure 3-73 Average abundances of all macroinvertebrate taxa at GV Pool in the Late Wet season of 2021, with taxa arranged from most abundant (left) to least abundant (right) along the x-axis.

## 3.6.5 DIATOMS AND PHYTOPLANKTON

### 3.6.5.1 DIATOMS

Table 3-23 provides the diatom abundance (total count per species), average abundance and DSIAR score GV Pool surveyed in the Late Wet 2021. Figure 3-74 illustrates the mean abundance (diatom count per replicate) of diatom species recorded at GV Pool. GV Pool was not sampled before the Late Wet 2021 season, the key findings were as follows:

- GV Pool was observed as having a high taxonomic diversity with 34 diatoms species being recorded in Late Wet 2021.
- Overall average abundance was high (average count = 400) with both replicates recording similar total abundances.
- The tolerance to environmental stress for GV Pool is reflected in the moderate sensitivity DSIAR score (49.3 and 51.2 for replicate 1 and 2, respectively). There is likely to be some natural environmental (habitat) stress from the ephemeral nature of the shallow string of pools along the study reach. The catchment during the baseline phase is largely unimpacted by other activities such as grazing.

Table 3-23. Diatom abundance (total count per species), average abundance and DSIAR score GV Pool surveyed in the Late Wet 2021

Taxon name	GV Pool 1	GV Pool 2	Average
<i>Diploneis parma</i>	52	104	78
<i>Nitzschia paleacea</i>	0	96	48
<i>Nitzschia frustulum</i>	64	30	47
<i>Nitzschia fonticola</i>	22	46	34
<i>Navicula viridula</i>	16	42	29
<i>Gomphonema affine</i>	42	8	25
<i>Nitzschia filiformis</i>	46	4	25
<i>Nitzschia palea</i>	34	14	24
<i>Nitzschia microcephala</i>	14	8	11
<i>Achnantheidium minutissimum</i>	20	0	10
<i>Navicula erifuga</i>	0	16	8
<i>Achnantheidium exiguum</i>	14	0	7
<i>Nitzschia gracilis</i>	14	0	7
<i>Navicula menisculus</i>	4	8	6
<i>Navicula viridula var. linearis</i>	0	8	4
<i>Nitzschia lacuum</i>	8	0	4
<i>Diploneis smithii</i>	0	6	3
<i>Nitzschia inconspicua</i>	0	6	3
<i>Nitzschia linearis</i>	4	2	3
<i>Ulnaria ulna</i>	6	0	3
<i>Achnanthes subexigua</i>	4	0	2
<i>Gomphonema minutum</i>	0	4	2
<i>Karayevia clevei</i>	0	4	2
<i>Navicula cryptocephala</i>	0	4	2
<i>Navicula lanceolata</i>	0	4	2
<i>Navicula tenelloides</i>	4	0	2
<i>Navicula veneta</i>	4	0	2
<i>Fragilaria vaucheriae</i>	0	2	1
<i>Gomphonema gracile</i>	0	2	1
<i>Navicula radiosafallax</i>	0	2	1
<i>Navicula rhynchocephala</i>	2	0	1
<i>Nitzschia clausii</i>	2	0	1
<i>Nitzschia desertorum</i>	0	2	1
<i>Nitzschia palea var debilis</i>	2	0	1
<b>Total Abundance</b>	<b>378</b>	<b>422</b>	<b>400</b>
<b>DSIAR Score</b>	<b>49.3</b>	<b>51.2</b>	<b>50.3</b>

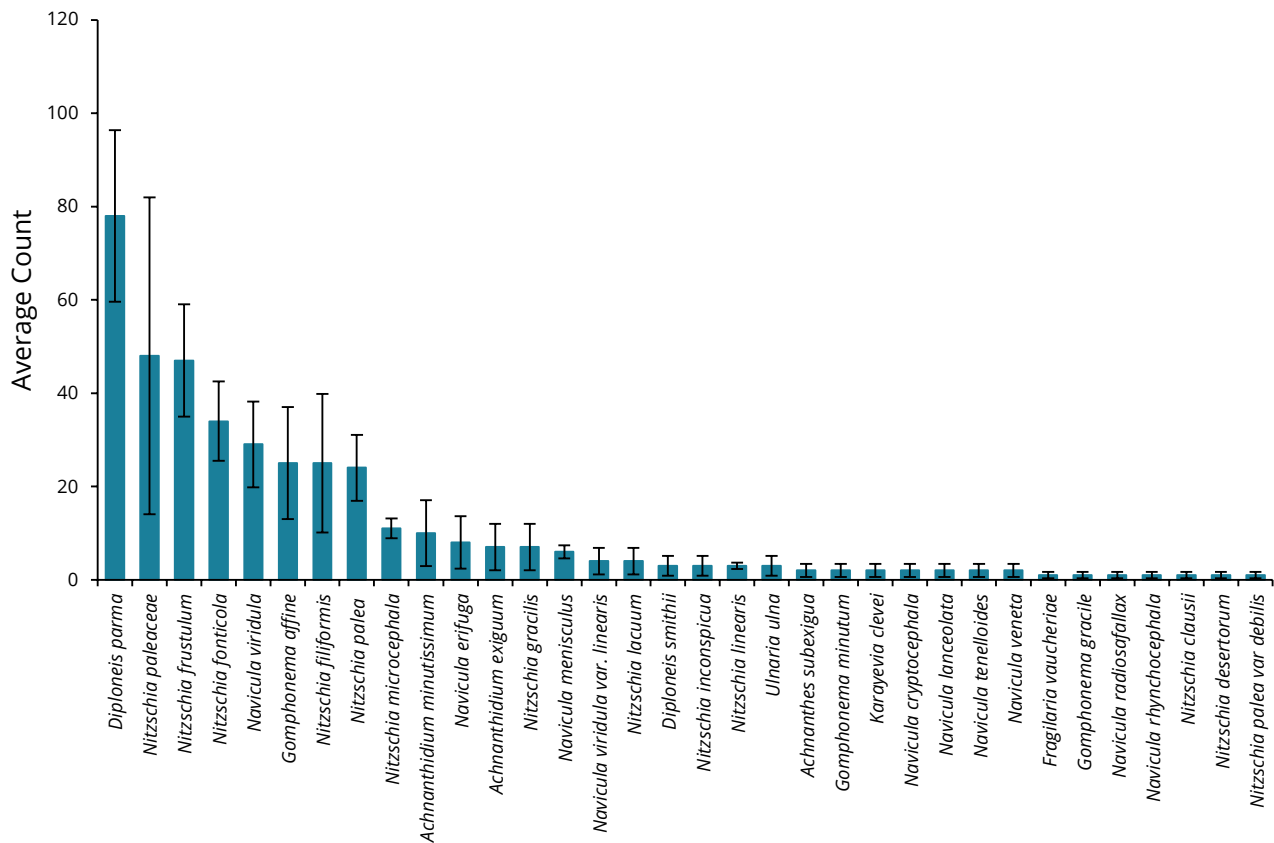


Figure 3-74. Average species abundance (diatom count per replicate) for diatoms sampled at GV Pool in the Late Wet 2021, with taxa arranged from most abundant (left) to least abundant (right) along the x-axis. Standard error (SE±0.5) denoted by error

### 3.6.5.1 PHYTOPLANKTON

Two classes of phytoplankton were identified in the late wet season (2021). GV Pool was dominated by diatoms (~98.9%, Bacillariophyceae), indicating a low phytoplankton diversity. Approximately six diatom genera were observed in the water sample, indicating a moderate level of diatom diversity.

Table 3-24 Summary of phytoplankton species and abundance for GV Pool sampled in the late wet season 2021.

Taxon	Late Wet (2021)	
	Abundance	%
<b>Bacillariophyceae</b>	860	98.85
<i>Amphora spp.</i>	40	4.6
<i>Placoneis sp.</i>	530	60.92
<i>Navicula spp.</i>	100	11.49
<i>Nitzschia spp.</i>	110	12.64
<i>Rhopalodia gibba</i>	60	6.9

Taxon	Late Wet (2021)	
<i>Synedra spp. (O)</i>	20	2.3
<b>Cryptophyceae</b>	10	1.15
<i>Cryptomonas spp. (O)</i>	10	1.15

### 3.6.6 MACROPHYTES

The macrophyte (submerged vegetation community) observed during the Late Wet 2021 survey (the initial baseline survey for this site) was limited at GV Pool, though some individual plants (sedges) were observed within the various semi-connected pools along the drainage reach (Figure 3-68). These were undergoing taxonomic identification at the time of reporting.

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# APPENDIX A. WATER QUALITY DATA

Table 25 Water quality data – late wet season 2019/2020. Bold font denotes values above the limit of reporting (LOR).

Analyte grouping/Analyte	Unit	LOR	Site 12 Pool	Central Ck Pool	Cow Spring Pool	Site 12 Pool GW	South Star Pool	Fig Pool GW	Fig Pool	Central Creek GW	TSF-1	TSF-2
		Sample Date	29/05/2020	31/05/2020	01/06/2020	29/05/2020	31/05/2020	01/06/2020	30/05/2020	01/06/2020	01/06/2020	01/06/2020
		ALS Sample Number	EP2005660001	EP2005660002	EP2005660003	EP2005660004	EP2005660005	EP2005660006	EP2005660007	EP2005660008	EP2005660009	EP2005660010
<b>Suspended Solids (SS)</b>	mg/L	5	<5	<5	<5	----	<5	----	<5	----	<b>9480</b>	<b>3220</b>
<b>Hydroxide Alkalinity as CaCO3</b>	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
<b>Carbonate Alkalinity as CaCO3</b>	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
<b>Bicarbonate Alkalinity as CaCO3</b>	mg/L	1	<b>478</b>	<b>406</b>	<b>34</b>	<b>204</b>	<b>399</b>	<b>142</b>	<1	<b>422</b>	<b>79</b>	<b>80</b>
<b>Total Alkalinity as CaCO3</b>	mg/L	1	<b>478</b>	<b>406</b>	<b>34</b>	<b>204</b>	<b>399</b>	<b>142</b>	<1	<b>422</b>	<b>79</b>	<b>80</b>
<b>Acidity as CaCO3</b>	mg/L	1	<1	<b>6</b>	<b>10</b>	<b>12</b>	<b>11</b>	<b>21</b>	<b>16</b>	<b>18</b>	<b>3</b>	<b>3</b>
<b>Sulfate as SO4 - Turbidimetric</b>	mg/L	1	<b>22</b>	<b>158</b>	<b>80</b>	<b>9</b>	<b>34</b>	<b>111</b>	<b>34</b>	<b>92</b>	<b>30</b>	<b>32</b>
<b>Chloride</b>	mg/L	1	<b>235</b>	<b>405</b>	<b>56</b>	<b>14</b>	<b>52</b>	<b>104</b>	<b>24</b>	<b>208</b>	<b>39</b>	<b>50</b>
<b>Calcium</b>	mg/L	1	<b>63</b>	<b>28</b>	<b>22</b>	<b>45</b>	<b>63</b>	<b>49</b>	<b>3</b>	<b>48</b>	<b>32</b>	<b>20</b>
<b>Magnesium</b>	mg/L	1	<b>120</b>	<b>100</b>	<b>18</b>	<b>30</b>	<b>45</b>	<b>41</b>	<b>5</b>	<b>99</b>	<b>15</b>	<b>17</b>
<b>Sodium</b>	mg/L	1	<b>52</b>	<b>317</b>	<b>39</b>	<b>18</b>	<b>64</b>	<b>58</b>	<b>16</b>	<b>142</b>	<b>20</b>	<b>32</b>

Analyte grouping/Analyte	Unit	LOR	Site 12 Pool	Central Ck Pool	Cow Spring Pool	Site 12 Pool GW	South Star Pool	Fig Pool GW	Fig Pool	Central Creek GW	TSF-1	TSF-2
<b>Potassium</b>	mg/L	1	<1	<b>9</b>	<b>2</b>	<b>2</b>	<1	<b>3</b>	<b>1</b>	<b>3</b>	<b>4</b>	<b>3</b>
<b>Arsenic</b>	mg/L	0.001	<b>0.001</b>	<b>0.013</b>	<0.001	<0.001	<0.001	<b>0.002</b>	<0.001	<b>0.012</b>	----	----
<b>Beryllium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	----	----
<b>Barium</b>	mg/L	0.001	<b>0.026</b>	<b>0.057</b>	<b>0.003</b>	<b>0.135</b>	<b>0.016</b>	<b>0.040</b>	<b>0.023</b>	<b>0.024</b>	----	----
<b>Cadmium</b>	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<b>0.0001</b>	----	----
<b>Chromium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.001</b>	----	----
<b>Cobalt</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.004</b>	<b>0.002</b>	<b>0.001</b>	----	----
<b>Copper</b>	mg/L	0.001	<0.001	<0.001	<0.001	<b>0.001</b>	<0.001	<0.001	<0.001	<b>0.016</b>	----	----
<b>Lead</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	----	----
<b>Manganese</b>	mg/L	0.001	<b>0.017</b>	<b>0.179</b>	<b>0.001</b>	<b>0.009</b>	<b>0.051</b>	<b>0.623</b>	<b>0.349</b>	<b>0.001</b>	----	----
<b>Nickel</b>	mg/L	0.001	<0.001	<b>0.002</b>	<b>0.005</b>	<b>0.002</b>	<0.001	<b>0.026</b>	<b>0.010</b>	<b>0.004</b>	----	----
<b>Selenium</b>	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	----	----
<b>Vanadium</b>	mg/L	0.01	<0.01	<b>0.02</b>	<0.01	<b>0.02</b>	<b>0.01</b>	<0.01	<0.01	<b>0.04</b>	----	----
<b>Zinc</b>	mg/L	0.005	<0.005	<0.005	<0.005	<b>0.017</b>	<0.005	<b>0.021</b>	<0.005	<b>0.034</b>	----	----

Analyte grouping/Analyte	Unit	LOR	Site 12 Pool	Central Ck Pool	Cow Spring Pool	Site 12 Pool GW	South Star Pool	Fig Pool GW	Fig Pool	Central Creek GW	TSF-1	TSF-2
<b>Boron</b>	mg/L	0.05	<b>0.20</b>	<b>0.66</b>	<b>0.14</b>	<b>0.11</b>	<b>0.23</b>	<b>0.16</b>	<b>0.06</b>	<b>0.35</b>	----	----
<b>Iron</b>	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<b>2.98</b>	<b>0.59</b>	<0.05	----	----
<b>Aluminium</b>	mg/L	0.01	<0.01	<b>0.05</b>	<0.01	<0.01	<b>0.01</b>	<0.01	<b>0.16</b>	<b>0.01</b>	<b>68.7</b>	<b>4.13</b>
<b>Antimony</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Arsenic</b>	mg/L	0.001	<0.001	<b>0.012</b>	<0.001	<0.001	<0.001	<b>0.003</b>	<0.001	<b>0.011</b>	<b>0.011</b>	<b>0.003</b>
<b>Beryllium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.004</b>	<0.001
<b>Barium</b>	mg/L	0.001	<b>0.026</b>	<b>0.056</b>	<b>0.003</b>	<b>0.096</b>	<b>0.018</b>	<b>0.019</b>	<b>0.022</b>	<b>0.024</b>	<b>0.523</b>	<b>0.065</b>
<b>Bismuth</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Cadmium</b>	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<b>0.0004</b>	<0.0001
<b>Cerium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.154</b>	<b>0.010</b>
<b>Caesium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.015</b>	<0.001
<b>Chromium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.001</b>	<b>0.774</b>	<b>0.070</b>
<b>Cobalt</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.004</b>	<b>0.001</b>	<b>0.002</b>	<b>0.202</b>	<b>0.011</b>
<b>Copper</b>	mg/L	0.001	<0.001	<0.001	<b>0.001</b>	<b>0.002</b>	<0.001	<0.001	<0.001	<b>0.019</b>	<b>0.212</b>	<b>0.017</b>

Analyte grouping/Analyte	Unit	LOR	Site 12 Pool	Central Ck Pool	Cow Spring Pool	Site 12 Pool GW	South Star Pool	Fig Pool GW	Fig Pool	Central Creek GW	TSF-1	TSF-2
<b>Dysprosium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.005</b>	<0.001
<b>Erbium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.002</b>	<0.001
<b>Europium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.002</b>	<0.001
<b>Gadolinium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.008</b>	<0.001
<b>Gallium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.006</b>	<b>0.003</b>
<b>Hafnium</b>	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
<b>Holmium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Indium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Lanthanum</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.040</b>	<b>0.008</b>
<b>Lead</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.056</b>	<b>0.003</b>
<b>Lithium</b>	mg/L	0.001	<b>0.005</b>	<b>0.020</b>	<b>0.005</b>	<b>0.003</b>	<b>0.005</b>	<b>0.031</b>	<b>0.002</b>	<b>0.005</b>	<b>0.097</b>	<b>0.007</b>
<b>Lutetium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Manganese</b>	mg/L	0.001	<b>0.014</b>	<b>0.198</b>	<0.001	<b>0.012</b>	<b>0.192</b>	<b>0.562</b>	<b>0.305</b>	<b>0.006</b>	<b>4.66</b>	<b>0.277</b>
<b>Molybdenum</b>	mg/L	0.001	<0.001	<b>0.003</b>	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.001</b>	<0.001	<0.001

Analyte grouping/Analyte	Unit	LOR	Site 12 Pool	Central Ck Pool	Cow Spring Pool	Site 12 Pool GW	South Star Pool	Fig Pool GW	Fig Pool	Central Creek GW	TSF-1	TSF-2
<b>Neodymium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.048</b>	<b>0.008</b>
<b>Nickel</b>	mg/L	0.001	<0.001	<b>0.001</b>	<b>0.005</b>	<b>0.002</b>	<0.001	<b>0.023</b>	<b>0.007</b>	<b>0.004</b>	<b>1.13</b>	<b>0.053</b>
<b>Praseodymium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.012</b>	<b>0.002</b>
<b>Rubidium</b>	mg/L	0.001	<0.001	<b>0.006</b>	<b>0.002</b>	<0.001	<0.001	<b>0.007</b>	<b>0.002</b>	<b>0.002</b>	<b>0.071</b>	<b>0.006</b>
<b>Samarium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.009</b>	<0.001
<b>Selenium</b>	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
<b>Silver</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Strontium</b>	mg/L	0.001	<b>0.191</b>	<b>0.271</b>	<b>0.087</b>	<b>0.081</b>	<b>0.182</b>	<b>0.099</b>	<b>0.038</b>	<b>0.232</b>	<b>0.245</b>	<b>0.109</b>
<b>Tellurium</b>	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
<b>Terbium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Thallium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Thorium</b>	mg/L	0.001	<b>0.001</b>	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.023</b>	<0.001
<b>Thulium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Tin</b>	mg/L	0.001	<b>0.001</b>	<b>0.001</b>	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Analyte grouping/Analyte	Unit	LOR	Site 12 Pool	Central Ck Pool	Cow Spring Pool	Site 12 Pool GW	South Star Pool	Fig Pool GW	Fig Pool	Central Creek GW	TSF-1	TSF-2
<b>Titanium</b>	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<b>0.23</b>	<b>0.06</b>
<b>Uranium</b>	mg/L	0.001	<0.001	<b>0.008</b>	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.003</b>	<b>0.004</b>	<0.001
<b>Vanadium</b>	mg/L	0.01	<0.01	<b>0.02</b>	<0.01	<b>0.03</b>	<b>0.02</b>	<0.01	<0.01	<b>0.04</b>	<b>0.09</b>	<b>0.02</b>
<b>Ytterbium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.002</b>	<0.001
<b>Yttrium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.023</b>	<b>0.004</b>
<b>Zinc</b>	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<b>0.012</b>	<0.005	<b>0.036</b>	<b>0.511</b>	<b>0.037</b>
<b>Zirconium</b>	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
<b>Boron</b>	mg/L	0.05	<b>0.17</b>	<b>0.69</b>	<b>0.11</b>	<b>0.11</b>	<b>0.22</b>	<b>0.17</b>	<b>0.06</b>	<b>0.34</b>	<b>0.15</b>	<b>0.08</b>
<b>Iron</b>	mg/L	0.05	<0.05	<b>0.11</b>	<0.05	<0.05	<b>0.19</b>	<b>2.85</b>	<b>0.49</b>	<0.05	<b>112</b>	<b>11.5</b>
<b>Mercury</b>	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<b>0.0002</b>	----	----
<b>Nitrite + Nitrate as N</b>	mg/L	0.01	<b>0.05</b>	<b>0.04</b>	<b>1.32</b>	<b>5.45</b>	<b>0.26</b>	<0.01	<b>0.02</b>	<b>0.70</b>	<b>7.48</b>	<b>0.24</b>
<b>Total Kjeldahl Nitrogen as N</b>	mg/L	0.1	<0.1	<b>0.2</b>	<b>0.1</b>	<b>1.0</b>	<b>0.2</b>	<b>0.1</b>	<0.1	<b>0.2</b>	<b>7.6</b>	<b>2.8</b>
<b>Total Nitrogen as N</b>	mg/L	0.1	<0.1	<b>0.2</b>	<b>1.4</b>	<b>6.4</b>	<b>0.5</b>	<b>0.1</b>	<0.1	<b>0.9</b>	<b>15.1</b>	<b>3.0</b>
<b>Total Phosphorus as P</b>	mg/L	0.01	<b>0.01</b>	<b>0.02</b>	<0.01	<b>0.05</b>	<b>0.01</b>	<b>0.06</b>	<b>0.01</b>	<b>0.02</b>	<b>1.43</b>	<b>0.46</b>

Analyte grouping/Analyte	Unit	LOR	Site 12 Pool	Central Ck Pool	Cow Spring Pool	Site 12 Pool GW	South Star Pool	Fig Pool GW	Fig Pool	Central Creek GW	TSF-1	TSF-2
Reactive Phosphorus as P	mg/L	0.01	<0.01	<b>0.01</b>	<0.01	<b>0.01</b>	<0.01	<0.01	<0.01	<0.01	<b>0.06</b>	<0.01
Total Anions	meq/L	0.01	<b>16.6</b>	<b>22.8</b>	<b>3.92</b>	<b>5.05</b>	<b>10.1</b>	<b>8.08</b>	<b>1.38</b>	<b>16.2</b>	<b>3.30</b>	<b>3.68</b>
Total Cations	meq/L	0.01	<b>15.3</b>	<b>23.6</b>	<b>4.33</b>	<b>5.55</b>	<b>9.63</b>	<b>8.42</b>	<b>1.28</b>	<b>16.8</b>	<b>3.80</b>	<b>3.86</b>
Ionic Balance	%	0.01	<b>4.25</b>	<b>1.76</b>	<b>4.87</b>	<b>4.69</b>	<b>2.61</b>	<b>2.04</b>	<b>3.83</b>	<b>1.76</b>	<b>7.04</b>	<b>2.53</b>
Dissolved Organic Carbon	mg/L	1	----	<b>4</b>	<1	----	<b>4</b>	----	<1	----	----	----
Total Organic Carbon	mg/L	1	----	<b>4</b>	<b>1</b>	----	<b>2</b>	----	<1	----	----	----

Table. Water quality data – late wet season 2021, Bold font denotes values above the limit of reporting (LOR)

Analyte grouping/Analyte	Unit	LOR	OPF 2	DRY RWW	MAR UPST	FIG	OPF 1	S12 GW	COW 2	CC	S12 POOL	COW	SS POOL
		<b>Sample Date:</b>	13/12/2020	13/12/2020	13/12/2020	10/12/2020	13/12/2020	09/12/2020	11/12/2020	13/12/2020	09/12/2020	10/12/2020	08/12/2020
		<b>ALS Sample Number:</b>	EP2013964001	EP2013964002	EP2013964003	EP2013964004	EP2013964005	EP2013964006	EP2013964007	EP2013964008	EP2013964009	EP2013964010	EP2013964011
Suspended Solids (SS)	mg/L	5	<b>32</b>	<b>1000</b>	<b>305</b>	<5	<b>50</b>	----	<b>18</b>	<5	<5	<5	<5
Hydroxide Alkalinity as CaCO <sub>3</sub>	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<b>101</b>	<1	<1
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/L	1	<b>84</b>	<b>25</b>	<b>16</b>	<1	<b>75</b>	<b>389</b>	<b>16</b>	<b>112</b>	<b>489</b>	<b>37</b>	<b>366</b>

Analyte grouping/Analyte	Unit	LOR	OPF 2	DRY RWW	MAR UPST	FIG	OPF 1	S12 GW	COW 2	CC	S12 POOL	COW	SS POOL
<b>Total Alkalinity as CaCO3</b>	mg/L	1	<b>84</b>	<b>25</b>	<b>16</b>	<1	<b>75</b>	<b>389</b>	<b>16</b>	<b>112</b>	<b>590</b>	<b>37</b>	<b>366</b>
<b>Sulfate as SO4 - Turbidimetric</b>	mg/L	1	<b>41</b>	<b>2</b>	<b>3</b>	<b>33</b>	<b>41</b>	<b>39</b>	<b>41</b>	<b>61</b>	<b>20</b>	<b>84</b>	<b>32</b>
<b>Chloride</b>	mg/L	1	<b>51</b>	<b>3</b>	<b>3</b>	<b>24</b>	<b>48</b>	<b>77</b>	<b>30</b>	<b>112</b>	<b>101</b>	<b>56</b>	<b>59</b>
<b><i>Dissolved Major Cations</i></b>													
<b>Calcium</b>	mg/L	1	<b>28</b>	<b>5</b>	<b>5</b>	<b>4</b>	<b>30</b>	<b>54</b>	<b>11</b>	<b>23</b>	<b>37</b>	<b>24</b>	<b>72</b>
<b>Magnesium</b>	mg/L	1	<b>23</b>	<b>2</b>	<b>2</b>	<b>5</b>	<b>18</b>	<b>72</b>	<b>9</b>	<b>28</b>	<b>126</b>	<b>18</b>	<b>50</b>
<b>Sodium</b>	mg/L	1	<b>35</b>	<b>3</b>	<b>2</b>	<b>15</b>	<b>33</b>	<b>74</b>	<b>20</b>	<b>82</b>	<b>68</b>	<b>40</b>	<b>69</b>
<b>Potassium</b>	mg/L	1	<b>3</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>3</b>	<b>1</b>	<b>3</b>	<b>5</b>	<1	<b>2</b>	<b>1</b>
<b><i>EG020F: Dissolved Metals by ICP-MS</i></b>													
<b>Arsenic</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	----	<b>0.004</b>	<b>0.001</b>	<0.001	<0.001
<b>Beryllium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	----	<0.001	<0.001	<0.001	<0.001
<b>Barium</b>	mg/L	0.001	<b>0.061</b>	<b>0.125</b>	<b>0.060</b>	<b>0.052</b>	<b>0.074</b>	<b>0.119</b>	----	<b>0.051</b>	<b>0.053</b>	<b>0.058</b>	<b>0.042</b>
<b>Cadmium</b>	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	----	<0.0001	<0.0001	<0.0001	<0.0001
<b>Chromium</b>	mg/L	0.001	<b>0.002</b>	<0.001	<0.001	<0.001	<b>0.002</b>	<0.001	----	<b>0.002</b>	<0.001	<0.001	<0.001
<b>Cobalt</b>	mg/L	0.001	<0.001	<0.001	<0.001	<b>0.002</b>	<0.001	<0.001	----	<0.001	<0.001	<0.001	<0.001

Analyte grouping/Analyte	Unit	LOR	OPF 2	DRY RWW	MAR UPST	FIG	OPF 1	S12 GW	COW 2	CC	S12 POOL	COW	SS POOL
<b>Copper</b>	mg/L	0.001	<b>0.001</b>	<0.001	<0.001	<0.001	<0.001	<0.001	----	<b>0.001</b>	<0.001	<0.001	<0.001
<b>Lead</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	----	<0.001	<0.001	<0.001	<0.001
<b>Manganese</b>	mg/L	0.001	<b>0.001</b>	<b>0.002</b>	<b>0.008</b>	<b>0.341</b>	<b>0.003</b>	<b>0.017</b>	----	<b>0.016</b>	<b>0.010</b>	<b>0.002</b>	<b>0.088</b>
<b>Nickel</b>	mg/L	0.001	<0.001	<0.001	<b>0.001</b>	<b>0.009</b>	<0.001	<b>0.002</b>	----	<b>0.001</b>	<0.001	<b>0.005</b>	<0.001
<b>Selenium</b>	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	----	<0.01	<0.01	<0.01	<0.01
<b>Vanadium</b>	mg/L	0.01	<b>0.01</b>	<0.01	<0.01	<0.01	<0.01	<b>0.04</b>	----	<b>0.01</b>	<0.01	<0.01	<b>0.01</b>
<b>Zinc</b>	mg/L	0.005	<b>0.008</b>	<b>0.020</b>	<b>0.023</b>	<b>0.016</b>	<b>0.014</b>	<b>0.008</b>	----	<b>0.009</b>	<b>0.007</b>	<b>0.038</b>	<b>0.006</b>
<b>Boron</b>	mg/L	0.05	<b>0.10</b>	<0.05	<0.05	<b>0.09</b>	<b>0.09</b>	<b>0.74</b>	----	<b>0.20</b>	<b>0.32</b>	<b>0.17</b>	<b>0.28</b>
<b>Total Metals by ICP-MS</b>													
<b>Arsenic</b>	mg/L	0.001	<0.001	<b>0.004</b>	<b>0.001</b>	<0.001	<0.001	<0.001	<0.001	<b>0.004</b>	<b>0.002</b>	<0.001	<0.001
<b>Beryllium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Barium</b>	mg/L	0.001	<b>0.015</b>	<b>0.121</b>	<b>0.040</b>	<b>0.023</b>	<b>0.021</b>	<b>0.104</b>	<b>0.005</b>	<b>0.023</b>	<b>0.014</b>	<b>0.004</b>	<b>0.016</b>
<b>Cadmium</b>	mg/L	0.0001	<0.0001	<b>0.0001</b>	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
<b>Chromium</b>	mg/L	0.001	<b>0.020</b>	<b>0.300</b>	<b>0.283</b>	<0.001	<b>0.018</b>	<b>0.001</b>	<b>0.001</b>	<b>0.003</b>	<0.001	<b>0.001</b>	<0.001
<b>Cobalt</b>	mg/L	0.001	<b>0.002</b>	<b>0.045</b>	<b>0.022</b>	<b>0.001</b>	<b>0.002</b>	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Analyte grouping/Analyte	Unit	LOR	OPF 2	DRY RWW	MAR UPST	FIG	OPF 1	S12 GW	COW 2	CC	S12 POOL	COW	SS POOL
<b>Copper</b>	mg/L	0.001	<b>0.003</b>	<b>0.069</b>	<b>0.031</b>	<0.001	<b>0.004</b>	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Lead</b>	mg/L	0.001	<0.001	<b>0.007</b>	<b>0.002</b>	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Manganese</b>	mg/L	0.001	<b>0.037</b>	<b>1.14</b>	<b>0.607</b>	<b>0.319</b>	<b>0.033</b>	<b>0.023</b>	<b>0.024</b>	<b>0.011</b>	<b>0.021</b>	<b>0.002</b>	<b>0.097</b>
<b>Nickel</b>	mg/L	0.001	<b>0.009</b>	<b>0.186</b>	<b>0.142</b>	<b>0.008</b>	<b>0.008</b>	<b>0.002</b>	<b>0.005</b>	<b>0.002</b>	<0.001	<b>0.005</b>	<0.001
<b>Selenium</b>	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
<b>Vanadium</b>	mg/L	0.01	<b>0.02</b>	<b>0.06</b>	<b>0.04</b>	<0.01	<b>0.01</b>	<b>0.04</b>	<0.01	<b>0.01</b>	<0.01	<0.01	<0.01
<b>Zinc</b>	mg/L	0.005	<0.005	<b>0.141</b>	<b>0.173</b>	<0.005	<b>0.009</b>	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
<b>Boron</b>	mg/L	0.05	<b>0.09</b>	<0.05	<0.05	<b>0.07</b>	<b>0.08</b>	<b>0.68</b>	<b>0.10</b>	<b>0.18</b>	<b>0.30</b>	<b>0.14</b>	<b>0.26</b>
<b><i>Dissolved Mercury by FIMS</i></b>													
<b>Mercury</b>	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	----	<0.0001	<0.0001	<0.0001	<0.0001
<b><i>Total Recoverable Mercury by FIMS</i></b>													
<b>Mercury</b>	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<b>0.0002</b>	<0.0001	<0.0001	<b>0.0004</b>	<0.0001
<b><i>Nitrite plus Nitrate as N (NOx) by Discrete Analyser</i></b>													
<b>Nitrite + Nitrate as N</b>	mg/L	0.01	<b>7.01</b>	<b>0.08</b>	<b>0.12</b>	<0.01	<b>6.88</b>	<b>0.42</b>	----	<b>3.08</b>	<0.01	<b>1.11</b>	<0.01
<b><i>Total Kjeldahl Nitrogen By Discrete Analyser</i></b>													
<b>Total Kjeldahl Nitrogen as N</b>	mg/L	0.1	<b>1.8</b>	<b>2.6</b>	<b>1.6</b>	<0.1	<b>1.6</b>	<0.1	----	<b>0.6</b>	<b>0.2</b>	<b>0.1</b>	<0.1

Analyte grouping/Analyte	Unit	LOR	OPF 2	DRY RWW	MAR UPST	FIG	OPF 1	S12 GW	COW 2	CC	S12 POOL	COW	SS POOL
<b>EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser</b>													
Total Nitrogen as N	mg/L	0.1	8.8	2.7	1.7	<0.1	8.5	0.4	----	3.7	0.2	1.2	<0.1
<b>EK067G: Total Phosphorus as P by Discrete Analyser</b>													
Total Phosphorus as P	mg/L	0.01	<0.02	0.41	0.17	<0.01	<0.02	<0.01	----	0.01	<0.01	<0.01	<0.01
<b>Reactive Phosphorus as P by discrete analyser</b>													
Reactive Phosphorus as P	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	----	<0.01	<0.01	<0.01	<0.01
<b>onic Balance</b>													
Total Anions	meq/L	0.01	4.47	0.62	0.48	1.36	4.20	10.8	2.02	6.67	15.0	4.07	9.64
Total Cations	meq/L	0.01	4.89	0.57	0.53	1.29	4.49	11.9	2.24	7.15	15.2	4.47	10.7
Ionic Balance	%	0.01	4.45	4.65	5.09	2.82	3.35	4.90	5.09	3.47	0.40	4.71	5.36
<b>Dissolved Organic Carbon (DOC)</b>													
Dissolved Organic Carbon	mg/L	1	----	----	----	4	----	----	----	----	10	2	11
<b>EP005: Total Organic Carbon (TOC)</b>													
Total Organic Carbon	mg/L	1	----	----	----	2	----	----	----	----	16	1	----

Table. Water quality data – late wet season 2021, Bold font denotes values above the limit of reporting (LOR)

Analyte grouping/analyte	Unit		GV_SW_Pool_Mundag oora_SS	GV_SW_Pool I_SW	IB_SW_Pool_Cent ral Ck	IB_SW_Pool_Cow Spring	IB_SW_Pool I_Fig	IB_SW_Pool12 _01
		Sample date:	21/05/2021	21/05/2021	22/05/2021	25/05/2021	24/05/2021	
		LOR						23/05/2021
<b>EA005P: pH by PC Titrator</b>								
pH Value	pH Unit	0.01	<b>7.98</b>	<b>8.31</b>	<b>8.38</b>	<b>7.05</b>	<b>4.19</b>	<b>8.42</b>
<b>EA010P: Conductivity by PC Titrator</b>								
Electrical Conductivity @ 25°C	µS/cm	1	<b>738</b>	<b>1350</b>	<b>2710</b>	<b>421</b>	<b>189</b>	<b>1120</b>
<b>EA016: Calculated TDS (from Electrical Conductivity)</b>								
Total Dissolved Solids (Calc.)	mg/L	1	<b>480</b>	<b>878</b>	<b>1760</b>	<b>274</b>	<b>123</b>	<b>728</b>
<b>EA025: Total Suspended Solids dried at 104 ± 2°C</b>								
Suspended Solids (SS)	mg/L	5	<5	<5	<b>5</b>	<5	<5	<5
<b>EA045: Turbidity</b>								
Turbidity	NTU	0.1	<b>0.3</b>	<b>0.2</b>	<b>0.4</b>	<b>0.1</b>	<b>3.6</b>	<b>0.2</b>
<b>EA065: Total Hardness as CaCO3</b>								
Total Hardness as CaCO3	mg/L	1	<b>327</b>	<b>508</b>	<b>735</b>	<b>128</b>	<b>28</b>	<b>623</b>

Analyte grouping/analyte	Unit	LOR	GV_SW_Pool_Mundag ooora_SS	GV_SW_Poo l_SW	IB_SW_Pool_Cent ral Ck	IB_SW_Pool_Cow Spring	IB_SW_Poo l_Fig	IB_SW_Pool12 _01	
			Sample date:	21/05/2021	21/05/2021	22/05/2021	25/05/2021	24/05/2021	
									23/05/2021
<b>ED037P: Alkalinity by PC Titrator</b>									
Hydroxide Alkalinity as CaCO <sub>3</sub>	mg/L	1	<1	<1	<1	<1	<1	<1	
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/L	1	<1	<b>6</b>	<b>19</b>	<1	<1	<b>31</b>	
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/L	1	<b>344</b>	<b>512</b>	<b>558</b>	<b>35</b>	<1	<b>561</b>	
Total Alkalinity as CaCO <sub>3</sub>	mg/L	1	<b>344</b>	<b>518</b>	<b>576</b>	<b>35</b>	<1	<b>592</b>	
<b>ED038A: Acidity</b>									
Acidity as CaCO <sub>3</sub>	mg/L	1	<b>6</b>	<1	<1	<b>6</b>	<b>10</b>	<1	
<b>ED041G: Sulfate (Turbidimetric) as SO<sub>4</sub><sup>2-</sup> by DA</b>									
Sulfate as SO <sub>4</sub> - Turbidimetric	mg/L	1	<b>29</b>	<b>94</b>	<b>209</b>	<b>81</b>	<b>34</b>	<b>14</b>	
<b>ED045G: Chloride by Discrete Analyser</b>									
Chloride	mg/L	1	<b>43</b>	<b>138</b>	<b>522</b>	<b>61</b>	<b>23</b>	<b>63</b>	
<b>ED093F-DW: Dissolved Major Cations - Drinking Water</b>									
Calcium	mg/L	0.1	<b>58.6</b>	<b>54.1</b>	<b>37.0</b>	<b>21.6</b>	<b>2.8</b>	<b>54.8</b>	

Analyte grouping/analyte	Unit	LOR	GV_SW_Pool_Mundag ooora_SS	GV_SW_Poo l_SW	IB_SW_Pool_Cent ral Ck	IB_SW_Pool_Cow Spring	IB_SW_Poo l_Fig	IB_SW_Pool12 _01	
			Sample date:	21/05/2021	21/05/2021	22/05/2021	25/05/2021	24/05/2021	
									23/05/2021
<b>Magnesium</b>	mg/L	0.1	<b>43.8</b>	<b>90.7</b>	<b>156</b>	<b>18.0</b>	<b>5.2</b>	<b>118</b>	
<b>Potassium</b>	mg/L	0.1	<b>0.7</b>	<b>1.3</b>	<b>12.9</b>	<b>2.3</b>	<b>1.4</b>	<b>0.7</b>	
<b>Sodium</b>	mg/L	0.1	<b>60.0</b>	<b>126</b>	<b>348</b>	<b>36.6</b>	<b>14.4</b>	<b>52.1</b>	
<i>EG035F: Dissolved Mercury by FIMS</i>									
<b>Mercury</b>	mg/L	0.00004	<b>0.00007</b>	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	
<i>EG035T: Total Mercury by FIMS</i>									
<b>Mercury</b>	mg/L	0.00004	<0.00004	<0.00004	<0.00004	<b>0.00023</b>	<0.00004	<0.00004	
<i>EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS</i>									
<b>Aluminium</b>	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<b>0.198</b>	<0.005	
<b>Iron</b>	mg/L	0.002	<b>0.007</b>	<0.002	<b>0.005</b>	<b>0.005</b>	<b>0.414</b>	<b>0.014</b>	
<b>Selenium</b>	mg/L	0.0002	<0.0002	<0.0002	<b>0.0002</b>	<b>0.0002</b>	<0.0002	<0.0002	
<b>Arsenic</b>	mg/L	0.0002	<b>0.0004</b>	<b>0.0015</b>	<b>0.0139</b>	<0.0002	<0.0002	<b>0.0010</b>	
<b>Barium</b>	mg/L	0.0005	<b>0.0164</b>	<b>0.0330</b>	<b>0.0555</b>	<b>0.0530</b>	<b>0.0222</b>	<b>0.0243</b>	
<b>Beryllium</b>	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
<b>Boron</b>	mg/L	0.005	<b>0.160</b>	<b>0.283</b>	<b>0.680</b>	<b>0.125</b>	<b>0.058</b>	<b>0.159</b>	
<b>Cadmium</b>	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	

Analyte grouping/analyte	Unit	LOR	GV_SW_Pool_Mundag oora_SS	GV_SW_Poo l_SW	IB_SW_Pool_Cent ral Ck	IB_SW_Pool_Cow Spring	IB_SW_Poo l_Fig	IB_SW_Pool12 _01	
			Sample date:	21/05/2021	21/05/2021	22/05/2021	25/05/2021	24/05/2021	
									23/05/2021
<b>Chromium</b>	mg/L	0.0002	<0.0002	<0.0002	<0.0002	<b>0.0006</b>	<0.0002	<0.0002	
<b>Cobalt</b>	mg/L	0.0001	<0.0001	<0.0001	<b>0.0002</b>	<0.0001	<b>0.0016</b>	<0.0001	
<b>Copper</b>	mg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	
<b>Lead</b>	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
<b>Manganese</b>	mg/L	0.0005	<b>0.0566</b>	<b>0.0055</b>	<b>0.0138</b>	<b>0.0010</b>	<b>0.359</b>	<b>0.0128</b>	
<b>Nickel</b>	mg/L	0.0005	<b>0.0009</b>	<b>0.0005</b>	<b>0.0013</b>	<b>0.0055</b>	<b>0.0098</b>	<0.0005	
<b>Vanadium</b>	mg/L	0.0002	<b>0.0136</b>	<b>0.0074</b>	<b>0.0312</b>	<0.0002	<0.0002	<b>0.0008</b>	
<b>Zinc</b>	mg/L	0.001	<0.001	<b>0.004</b>	<0.001	<b>0.034</b>	<b>0.002</b>	<0.001	
<i>EG094T: Total metals in Fresh water by ORC-ICPMS</i>									
<b>Aluminium</b>	mg/L	0.005	<b>0.008</b>	<b>0.011</b>	<b>0.017</b>	<0.005	<b>0.227</b>	<b>0.007</b>	
<b>Iron</b>	mg/L	0.002	<b>0.125</b>	<b>0.016</b>	<b>0.067</b>	<b>0.017</b>	<b>1.46</b>	<b>0.027</b>	
<b>Selenium</b>	mg/L	0.0002	<0.0002	<0.0002	<b>0.0002</b>	<0.0002	<0.0002	<0.0002	
<b>Arsenic</b>	mg/L	0.0002	<b>0.0004</b>	<b>0.0012</b>	<b>0.0122</b>	<0.0002	<b>0.0004</b>	<b>0.0008</b>	
<b>Barium</b>	mg/L	0.0005	<b>0.0147</b>	<b>0.0218</b>	<b>0.0521</b>	<b>0.0033</b>	<b>0.0214</b>	<b>0.0228</b>	
<b>Beryllium</b>	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
<b>Boron</b>	mg/L	0.005	<b>0.141</b>	<b>0.251</b>	<b>0.600</b>	<b>0.119</b>	<b>0.053</b>	<b>0.138</b>	
<b>Cadmium</b>	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	
<b>Chromium</b>	mg/L	0.0002	<0.0002	<b>0.0003</b>	<b>0.0004</b>	<b>0.0006</b>	<0.0002	<b>0.0003</b>	
<b>Cobalt</b>	mg/L	0.0001	<0.0001	<0.0001	<b>0.0002</b>	<0.0001	<b>0.0016</b>	<0.0001	

Analyte grouping/analyte	Unit	LOR	GV_SW_Pool_Mundag oora_SS	GV_SW_Poo l_SW	IB_SW_Pool_Cent ral Ck	IB_SW_Pool_Cow Spring	IB_SW_Poo l_Fig	IB_SW_Pool12 _01	
			Sample date:	21/05/2021	21/05/2021	22/05/2021	25/05/2021	24/05/2021	
									23/05/2021
<b>Copper</b>	mg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	
<b>Lead</b>	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
<b>Manganese</b>	mg/L	0.0005	<b>0.0793</b>	<b>0.0229</b>	<b>0.0372</b>	<b>0.0008</b>	<b>0.331</b>	<b>0.0129</b>	
<b>Nickel</b>	mg/L	0.0005	<b>0.0006</b>	<b>0.0006</b>	<b>0.0012</b>	<b>0.0049</b>	<b>0.0095</b>	<0.0005	
<b>Vanadium</b>	mg/L	0.0002	<b>0.0132</b>	<b>0.0068</b>	<b>0.0284</b>	<0.0002	<0.0002	<b>0.0008</b>	
<b>Zinc</b>	mg/L	0.001	<0.001	<0.001	<0.001	<b>0.002</b>	<b>0.002</b>	<0.001	
<i>EK055G-NH4: Ammonium as N by DA</i>									
<b>Ammonium as N</b>	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
<i>EK055G: Ammonia as N by Discrete Analyser</i>									
<b>Ammonia as N</b>	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
<i>EK057G: Nitrite as N by Discrete Analyser</i>									
<b>Nitrite as N</b>	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
<i>EK058G: Nitrate as N by Discrete Analyser</i>									
<b>Nitrate as N</b>	mg/L	0.01	<b>0.09</b>	<0.01	<0.01	<b>1.26</b>	<0.01	<0.01	

Analyte grouping/analyte	Unit	LOR	GV_SW_Pool_Mundag oora_SS	GV_SW_Poo l_SW	IB_SW_Pool_Cent ral Ck	IB_SW_Pool_Cow Spring	IB_SW_Poo l_Fig	IB_SW_Pool12 _01	
			Sample date:	21/05/2021	21/05/2021	22/05/2021	25/05/2021	24/05/2021	
									23/05/2021
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>									
Nitrite + Nitrate as N	mg/L	0.01	<b>0.09</b>	<0.01	<0.01	<b>1.26</b>	<0.01	<0.01	
<b>EK061G: Total Kjeldahl Nitrogen By Discrete Analyser</b>									
Total Kjeldahl Nitrogen as N	mg/L	0.1	<b>0.3</b>	<b>0.2</b>	<b>0.1</b>	<b>0.2</b>	<b>0.1</b>	<b>0.1</b>	
<b>EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser</b>									
Total Nitrogen as N	mg/L	0.1	<b>0.4</b>	<b>0.2</b>	<b>0.1</b>	<b>1.5</b>	<b>0.1</b>	<b>0.1</b>	
<b>EK067G: Total Phosphorus as P by Discrete Analyser</b>									
Total Phosphorus as P	mg/L	0.01	<b>0.01</b>	<0.01	<b>0.03</b>	<0.01	<b>0.02</b>	<0.01	
<b>EK071G: Reactive Phosphorus as P by discrete analyser</b>									
Reactive Phosphorus as P	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Reactive Phosphate	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	

Analyte grouping/analyte	Unit	LOR	GV_SW_Pool_Mundag oora_SS	GV_SW_Poo l_SW	IB_SW_Pool_Cent ral Ck	IB_SW_Pool_Cow Spring	IB_SW_Poo l_Fig	IB_SW_Pool12 _01	
			Sample date:	21/05/2021	21/05/2021	22/05/2021	25/05/2021	24/05/2021	
									23/05/2021
<b>EP002: Dissolved Organic Carbon (DOC)</b>									
Dissolved Organic Carbon	mg/L	1	2	3	2	<1	<1	2	
<b>EP005: Total Organic Carbon (TOC)</b>									
Total Organic Carbon	mg/L	1	6	4	3	<1	<1	2	
<b>EP025: Oxygen - Dissolved (DO)</b>									
Dissolved Oxygen	mg/L	0.1	9.1	10.0	10.3	9.9	9.2	10.3	
<b>ED009: Anions</b>									
Fluoride	mg/L	0.010	0.180	0.392	0.345	0.069	0.019	0.166	

# APPENDIX B. SEDIMENT QUALITY DATA

Table 26 Sediment quality data – late wet season 2019/2020. Bold font denotes values above the limit of reporting (LOR).

Analyte grouping/Analyte	Unit	LOR	South Star Pool	Cow Spring Pool	Fig Pool	Site 12 Pool	Central Ck Pool
		<i>Sample Date</i>	30/05/2020	30/05/2020	30/05/2020	29/05/2020	31/05/2020
		<i>ALS Sample Number</i>	EP2005660011	EP2005660012	EP2005660013	EP2005660014	EP2005660015
Total Soluble Salts	mg/kg	5	<b>693</b>	<b>114</b>	<b>248</b>	<b>408</b>	<b>1180</b>
Moisture Content (Dried @ 105-110°C)	%	1.0	<b>59.7</b>	<b>23.9</b>	----	<b>28.6</b>	<b>29.8</b>
Total Alkalinity as CaCO <sub>3</sub>	mg/kg	1	<b>77</b>	<b>4</b>	<b>2</b>	<b>71</b>	<b>120</b>
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	1	<b>77</b>	<b>4</b>	<b>2</b>	<b>67</b>	<b>120</b>
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	1	<1	<1	<1	<b>4</b>	<1
Acidity	mg/kg	1	<b>12</b>	<1	<b>14</b>	<b>4</b>	<b>4</b>
Sulfate as SO <sub>4</sub> <sup>2-</sup> (soluble sulfate by ICPAES)	mg/kg	10	<b>80</b>	<b>40</b>	<b>120</b>	<b>20</b>	<b>200</b>
Chloride (by Discrete Analyser)	mg/kg	10	<b>100</b>	<b>20</b>	<10	<b>30</b>	<b>170</b>
Calcium	mg/kg	10	<b>220</b>	<10	<b>30</b>	<b>50</b>	<b>40</b>
Magnesium	mg/kg	10	<b>110</b>	<10	<10	<b>60</b>	<b>70</b>
Sodium	mg/kg	10	<b>170</b>	<b>20</b>	<b>10</b>	<b>40</b>	<b>220</b>
Potassium	mg/kg	10	<b>20</b>	<10	<b>10</b>	<10	<b>20</b>
Mercury (FIMS)	mg/kg	0.1	<b>0.6</b>	<b>4.4</b>	<0.1	<0.1	<0.1
Nitrite + Nitrate as N (Sol.)	mg/kg	0.1	<0.1	<b>0.1</b>	<0.1	<0.1	<0.1
Total Kjeldahl Nitrogen as N	mg/kg	20	<b>3950</b>	<b>750</b>	<b>1110</b>	<b>520</b>	<b>1090</b>
Total Nitrogen as N	mg/kg	20	<b>3950</b>	<b>750</b>	<b>1110</b>	<b>520</b>	<b>1090</b>
Total Phosphorus as P	mg/kg	2	<b>242</b>	<b>320</b>	<b>60</b>	<b>73</b>	<b>100</b>

Analyte grouping/Analyte	Unit	LOR	South Star Pool	Cow Spring Pool	Fig Pool	Site 12 Pool	Central Ck Pool
Reactive Phosphorus as P	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Organic Carbon	%	0.02	<b>3.15</b>	<b>0.22</b>	<b>0.30</b>	<b>0.18</b>	<b>1.80</b>
<i>Total Metals by ICP-AES</i>							
Arsenic	mg/kg	5	<b>9</b>	<b>9</b>	<5	<5	<b>9</b>
Barium	mg/kg	10	<b>40</b>	<10	<b>10</b>	<b>50</b>	<b>40</b>
Beryllium	mg/kg	1	<b>1</b>	<1	<1	<1	<1
Boron	mg/kg	50	<50	<50	<50	<50	<50
Cadmium	mg/kg	1	<1	<1	<1	<1	<1
Chromium	mg/kg	2	<b>169</b>	<b>165</b>	<b>143</b>	<b>384</b>	<b>219</b>
Cobalt	mg/kg	2	<b>22</b>	<b>4</b>	<2	<b>23</b>	<b>16</b>
Copper	mg/kg	5	<b>52</b>	<b>7</b>	<b>8</b>	<b>23</b>	<b>22</b>
Iron	mg/kg	50	<b>76600</b>	<b>124000</b>	<b>58500</b>	<b>32800</b>	<b>26600</b>
Lead	mg/kg	5	<5	<b>9</b>	<5	<5	<5
Manganese	mg/kg	5	<b>481</b>	<b>151</b>	<b>94</b>	<b>561</b>	<b>476</b>
Nickel	mg/kg	2	<b>79</b>	<b>18</b>	<b>6</b>	<b>179</b>	<b>112</b>
Selenium	mg/kg	5	<b>5</b>	<b>6</b>	<5	<5	<5
Vanadium	mg/kg	5	<b>166</b>	<b>62</b>	<b>27</b>	<b>48</b>	<b>39</b>
Zinc	mg/kg	5	<b>39</b>	<b>16</b>	<b>5</b>	<b>26</b>	<b>35</b>

Analyte grouping/Analyte	Unit	LOR	Mundagoora Pool	Fig Pool	Site 12 Pool
		<i>Sample Date</i>	08/12/2020	10/12/2020	09/12/2020
		<i>ALS Sample Number</i>	EP2013964-012	EP2013964-013	EP2013964-014
Total Soluble Salts	mg/kg	5	-		
Moisture Content (Dried @ 105-110°C)	%	1.0	<b>49.3</b>	<b>38.3</b>	<b>20.9</b>
Total Alkalinity as CaCO <sub>3</sub>	mg/kg	1	<b>104</b>	<b>&lt;5</b>	<b>329</b>
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	1	<b>104</b>	<b>&lt;5</b>	<b>265</b>
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	1	<b>&lt;5</b>	<b>&lt;5</b>	<b>65</b>
Acidity	mg/kg	1	<b>53</b>	<b>166</b>	<b>&lt;5</b>
Sulfate as SO <sub>4</sub> <sup>2-</sup> (soluble sulfate by ICPAES)	mg/kg	10	<b>70</b>	<b>160</b>	<b>&lt;10</b>
Chloride (by Discrete Analyser)	mg/kg	10	<b>40</b>	<b>40</b>	<b>30</b>
Calcium	mg/kg	10	<b>30</b>	<b>&lt;10</b>	<b>40</b>
Magnesium	mg/kg	10	<b>20</b>	10	<b>90</b>
Sodium	mg/kg	10	<b>100</b>	<b>40</b>	<b>40</b>
Potassium	mg/kg	10	<b>&lt;10</b>	<b>30</b>	<b>&lt;10</b>
Mercury (FIMS)	mg/kg	0.1	-		
Nitrite + Nitrate as N (Sol.)	mg/kg	0.1	<b>&lt;0.1</b>	<b>&lt;0.1</b>	<b>&lt;0.1</b>
Total Kjeldahl Nitrogen as N	mg/kg	20	<b>1970</b>	<b>1670</b>	<b>200</b>
Total Nitrogen as N	mg/kg	20	<b>1970</b>	<b>1670</b>	<b>200</b>
Total Phosphorus as P	mg/kg	2	<b>179</b>	<b>223</b>	<b>61</b>
Reactive Phosphorus as P	mg/kg	0.1	<b>&lt;0.1</b>	<b>&lt;0.1</b>	<b>&lt;0.1</b>

Total Organic Carbon	%	0.02	<b>4.88</b>	<b>3.60</b>	<b>0.29</b>
<i>Total Metals by ICP-AES</i>					
Arsenic	mg/kg	5	-		
Barium	mg/kg	10	-		
Beryllium	mg/kg	1	-		
Boron	mg/kg	50	-		
Cadmium	mg/kg	1	-		
Chromium	mg/kg	2	-		
Cobalt	mg/kg	2	-		
Copper	mg/kg	5	-		
Iron	mg/kg	50	<b>57000</b>	<b>90200</b>	<b>41200</b>
Lead	mg/kg	5	-		
Manganese	mg/kg	5	-		
Nickel	mg/kg	2	-		
Selenium	mg/kg	5	-		
Vanadium	mg/kg	5	-		
Zinc	mg/kg	5	-		

Table. Sediment quality data – late dry season (2020). Bold font denotes values above the limit of reporting (LOR)

Table. Sediment quality data – late wet season (2021). Bold font denotes values above the limit of reporting (LOR)

Analyte grouping/Analyte	Unit	LOR	Mundagoora Pool	Fig Pool	Site 12 Pool	Central Ck Pool
		<i>Sample Date</i>	21/05/2021	30/05/2020	23/05/2021	28/05/2021
		<i>ALS Sample Number</i>	EP2106077-001	EP2106077-005	EP2106077-006	EP2106077-003
Total Soluble Salts	mg/kg	5	<b>200</b>	<b>384</b>	<b>402</b>	<b>559</b>
Moisture Content (Dried @ 105-110°C)	%	1.0	<b>24.8</b>	<b>37</b>	<b>25</b>	<b>19.1</b>
Total Alkalinity as CaCO <sub>3</sub>	mg/kg	1	<5	<5	<b>26</b>	<5
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	1	<b>239</b>	<5	<b>26</b>	<b>198</b>
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	1	<b>239</b>	<5	<b>253</b>	<b>198</b>
Acidity	mg/kg	1	<b>62</b>	<b>1000</b>	<5	<5
Sulfate as SO <sub>4</sub> <sup>2-</sup> (soluble sulfate by ICPAES)	mg/kg	10	<10	<b>150</b>	<10	<b>40</b>
Chloride (by Discrete Analyser)	mg/kg	10	<b>20</b>	<b>60</b>	<b>20</b>	<b>90</b>
Calcium	mg/kg	10	<b>30</b>	<10	<b>30</b>	<10
Magnesium	mg/kg	10	<b>20</b>	10	<b>60</b>	<b>40</b>
Sodium	mg/kg	10	<b>30</b>	<b>12</b>	<b>6</b>	<b>10</b>
Potassium	mg/kg	10	<10	<b>10</b>	<10	<10
Mercury (FIMS)	mg/kg	0.1	<0.1	<b>0.2</b>	<0.1	<0.1
Nitrite + Nitrate as N (Sol.)	mg/kg	0.1	<0.1	<b>0.2</b>	<0.1	<0.1
Total Kjeldahl Nitrogen as N	mg/kg	20	<b>430</b>	<b>3030</b>	<b>80</b>	<b>80</b>
Total Nitrogen as N	mg/kg	20	<b>430</b>	<b>3030</b>	<b>80</b>	<b>80</b>
Total Phosphorus as P	mg/kg	2	<b>190</b>	<b>310</b>	<b>56</b>	<b>43</b>

Analyte grouping/Analyte	Unit	LOR	Mundagoora Pool	Fig Pool	Site 12 Pool	Central Ck Pool
Reactive Phosphorus as P	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Total Organic Carbon	%	0.02		<b>3.08</b>	<b>0.2</b>	<b>0.18</b>
<i>Total Metals by ICP-AES</i>						
Arsenic	mg/kg	5	<b>9</b>	<b>12</b>	<b>6</b>	<b>10</b>
Barium	mg/kg	10	<b>60</b>	<b>40</b>	<b>70</b>	<b>30</b>
Beryllium	mg/kg	1	<1	<1	<1	<1
Boron	mg/kg	50	<b>50</b>	<50	<50	<50
Cadmium	mg/kg	1	<1	<1	<1	<1
Chromium	mg/kg	2	<b>68</b>	<b>127</b>	<b>492</b>	<b>247</b>
Cobalt	mg/kg	2	<b>33</b>	<b>2</b>	<b>36</b>	<b>18</b>
Copper	mg/kg	5	<b>67</b>	<b>24</b>	<b>37</b>	<b>17</b>
Iron	mg/kg	50	<b>114000</b>	<b>64600</b>	<b>49400</b>	<b>30600</b>
Lead	mg/kg	5	6	<5	<5	<5
Manganese	mg/kg	5	<b>674</b>	<b>39</b>	<b>894</b>	<b>492</b>
Nickel	mg/kg	2	<b>134</b>	<b>12</b>	<b>246</b>	<b>113</b>
Selenium	mg/kg	5	<5	<5	<5	<5
Vanadium	mg/kg	5	<b>161</b>	<b>53</b>	<b>65</b>	<b>36</b>
Zinc	mg/kg	5	<b>30</b>	<b>8</b>	<b>44</b>	<b>20</b>

# APPENDIX C. FISH DATA

Table 27 Fish catch summary table – Late Wet 2020

Species	Central Creek Pool	Cow Spring Pool	Site 12 Pool	South Star Pool	Fig Pool
<b><i>Neosilurus hyrtlii</i></b>	0	0	37	0	0
50 - 90 mm	0	0	18	0	0
90 - 130 mm	0	0	16	0	0
130 - 170 mm	0	0	3	0	0
<b><i>Melanotaenia australis</i></b>	171	67	196	212	0
< 30 mm	1	13	0	63	0
30 - 60 mm	113	37	84	95	0
60 - 90 mm	57	15	112	54	0
> 90 mm	0	2	0	0	0
<b><i>Leiopotherapon unicolor</i></b>	207	0	24	1	0
30 - 60 mm	109	0	7	0	0
60 - 90 mm	53	0	10	0	0
> 90 mm	45	0	7	1	0
<b>Total catch</b>	378	67	257	213	0
<b>Soak duration</b>	19	17.7	15.5	16.5	16
<b>CPUE</b>	19.9	3.8	16.6	12.9	0

<sup>1</sup> CPUE is catch per unit effort, a measure of relative abundance. Effort is net and trap soak duration hours.

## Fish standard length and total length - Late Wet 2020

Site Name	Gear Type	Rep- licate	Date	Time In	Time Out	Habitat Type	Species	Standard Length (mm)	Total length (mm)
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	32	37
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	36	45
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	38	47
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	37	49
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	41	49
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Leiopotherapon unicolor</i>	42	50
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	46	56
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	46	58
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	49	58
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	55	67
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	60	74
Central Ck Pool	Box	1	26/06/2020	16:00	10:30	Muddy	<i>Leiopotherapon unicolor</i>	66	81
Central Ck Pool	Box	2	26/06/2020	16:00	10:45	Muddy	<i>Leiopotherapon unicolor</i>	69	85
Central Ck Pool	Box	2	26/06/2020	16:00	10:45	Muddy	<i>Leiopotherapon unicolor</i>	75	94
Central Ck Pool	Box	2	26/06/2020	16:00	10:45	Muddy	<i>Leiopotherapon unicolor</i>	80	97
Central Ck Pool	Box	2	26/06/2020	16:00	10:45	Muddy	<i>Leiopotherapon unicolor</i>	81	100
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	87	109
Central Ck Pool	Box	1	26/06/2020	16:00	10:30	Muddy	<i>Leiopotherapon unicolor</i>	94	115
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	100	125
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	107	130
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	115	139
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	119	141
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	119	142
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	120	144

Site Name	Gear Type	Rep- licate	Date	Time In	Time Out	Habitat Type	Species	Standard Length (mm)	Total length (mm)
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	120	145
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	127	154
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	134	160
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	134	161
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	147	173
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	174	205
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	29	38
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	33	41
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	33	42
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	33	42
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	39	43
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	37	46
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	37	46
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	38	47
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	37	48
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	38	48
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	37	49
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	38	50
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	38	50
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	39	50
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	41	50
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	40	51
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	41	51
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	40	52
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	47	60
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	47	61

Site Name	Gear Type	Rep-licate	Date	Time In	Time Out	Habitat Type	Species	Standard Length (mm)	Total length (mm)
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	49	61
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	49	62
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	50	64
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	52	65
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	53	65
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	53	66
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	59	75
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	65	80
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	67	84
Central Ck Pool	Box	2	26/06/2020	16:00	10:45	Muddy	<i>Melanotaenia australis</i>	67	85
<hr/>									
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	17	22
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	18	23
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	20	25
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	23	27
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	23	30
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	24	30
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	24	31
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	25	32
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	29	37
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	30	39
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	32	40
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	30	41
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	30	41
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	31	41
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	33	42
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	33	43

Site Name	Gear Type	Rep-licate	Date	Time In	Time Out	Habitat Type	Species	Standard Length (mm)	Total length (mm)
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	35	43
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	38	46
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	40	50
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	49	62
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	53	67
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	57	72
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	60	74
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	62	80
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	67	85
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	68	85
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	70	86
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	71	87
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	80	100
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	83	104
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Uperoleia sp.</i>	NA	24
Cow Spring Pool	Bait	1	29/06/2020	16:00	9:30	Marco/Edge	<i>Uperoleia sp.</i>	NA	29
Cow Spring Pool	Bait	2	29/06/2020	16:00	9:30	Reeds	<i>Uperoleia sp.</i>	NA	35
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Uperoleia sp.</i>	NA	36
Cow Spring Pool	Bait	1	29/06/2020	16:00	9:30	Marco/Edge	<i>Uperoleia sp.</i>	NA	40
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	32	41
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	38	50
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	43	54
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	44	55
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	45	57
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	46	57
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	47	59

Site Name	Gear Type	Rep- licate	Date	Time In	Time Out	Habitat Type	Species	Standard Length (mm)	Total length (mm)
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	49	61
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	49	62
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	52	63
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	54	63
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	54	67
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	55	71
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	58	73
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	59	74
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	64	79
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	70	87
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	78	92
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	79	95
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	104	122
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	111	134
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	148	162
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	155	182
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	166	199
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	45	56
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	46	57
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	46	58
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	46	58
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	47	59
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	47	59
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	47	60
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	48	60
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	48	60

Site Name	Gear Type	Rep-licate	Date	Time In	Time Out	Habitat Type	Species	Standard Length (mm)	Total length (mm)
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	48	61
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	48	61
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	49	61
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	50	61
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	49	62
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	49	62
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	51	64
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	51	64
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	52	64
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	53	64
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	52	66
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	53	66
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	53	66
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	54	66
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	53	67
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	54	67
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	54	67
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	54	69
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	59	75
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	68	76
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	58	77
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	55	63
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	54	69
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	67	75
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	70	76
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	65	77

Site Name	Gear Type	Rep-licate	Date	Time In	Time Out	Habitat Type	Species	Standard Length (mm)	Total length (mm)
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	70	80
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	72	80
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	72	81
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	73	82
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	74	84
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	75	84
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	76	85
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	75	86
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	76	86
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	79	87
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	79	88
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	80	90
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	80	91
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	82	91
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	80	92
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	84	94
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	92	104
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	95	105
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	95	106
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	97	110
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	101	111
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	102	113
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	105	117
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	105	120
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	110	120
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	107	122

Site Name	Gear Type	Rep- licate	Date	Time In	Time Out	Habitat Type	Species	Standard Length (mm)	Total length (mm)
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlilii</i>	110	123
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlilii</i>	110	125
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlilii</i>	115	126
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlilii</i>	125	144
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlilii</i>	129	144
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlilii</i>	150	162
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	104	126
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	21	26
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	21	26
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	23	26
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	23	27
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	23	30
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	24	31
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	25	31
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	26	32
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	26	33
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	26	33
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	41	53
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	43	53
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	46	55
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	45	57
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	46	57
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	46	57
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	46	58
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	48	61
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	50	62

Site Name	Gear Type	Rep- licate	Date	Time In	Time Out	Habitat Type	Species	Standard Length (mm)	Total length (mm)
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	50	63
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	54	66
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	53	67
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	55	69
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	55	70
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	57	70
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	59	74
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	63	80
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	64	80
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	63	81
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	65	82

Table. Fish standard length (SL) and total length (TL) for Iron Bridge pools in the late dry season 2020

Site Name	Gear Type	Replicate	Date	Time Out	Habitat Type	Species	S L	TL	Size
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	25	33	X Small (<30mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	28	37	X Small (<30mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	30	39	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	30	38	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	30	39	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	31	40	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	32	41	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	34	42	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	36	46	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	37	47	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	38	50	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	39	51	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	39	50	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	40	51	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	40	50	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	42	53	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	43	56	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	45	57	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	47	61	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	48	60	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	50	63	Small (30-60mm)

Site Name	Gear Type	Replicate	Date	Time Out	Habitat Type	Species	S L	TL	Size
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	55	72	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	70	85	Large (60-90mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	72	92	Large (60-90mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	75	94	Large (60-90mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	81	112	Large (60-90mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	83	112	Large (60-90mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	86	110	Large (60-90mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	87	111	Large (60-90mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	20	25	X Small (<30mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	25	32	X Small (<30mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	26	33	X Small (<30mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	28	32	X Small (<30mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	32	40	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	33	43	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	33	41	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	34	43	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	35	45	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	35	43	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	35	42	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	36	44	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	36	47	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	37	74	Small (30-60mm)

Site Name	Gear Type	Replicate	Date	Time Out	Habitat Type	Species	S L	TL	Size
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	37	46	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	38	50	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	39	51	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	40	51	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	43	55	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	50	61	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	57	70	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	58	71	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	60	74	Large (60-90mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	62	76	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	34	41	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	48	60	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	49	63	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	49	61	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	50	62	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	50	61	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	50	63	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	53	66	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	53	67	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	53	65	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	55	70	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	55	69	Small (30-60mm)

Site Name	Gear Type	Replicate	Date	Time Out	Habitat Type	Species	SL	TL	Size
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	55	69	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	55	70	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	58	71	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	62	76	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	62	75	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	67	81	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	71	84	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	72	85	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	75	90	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	75	92	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	80	98	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Neosilurus hyrtlii	80	89	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	81	96	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Neosilurus hyrtlii	81	90	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Neosilurus hyrtlii	83	93	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Neosilurus hyrtlii	87	96	Large (60-90mm)

Table. Fish standard length (SL) and total length (TL) for Iron Bridge pools in the late wet season 2021

Site Name	Gear Type	Replicate	Date	Habitat Type	Species	SL	TL	Size
Cent Creek	Fyke	1	23/05/2021	Pool	Rainbow	30	39	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Rainbow	38	50	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Rainbow	49	62	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Rainbow	49	65	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Rainbow	50	62	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Rainbow	79	96	Large (60-90mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Rainbow	80	100	Large (60-90mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	39	47	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	42	54	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	42	53	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	43	53	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	47	57	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	47	58	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	47	57	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	49	60	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	50	62	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	50	62	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	55	104	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	55	66	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	80	97	Large (60-90mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	23	31	X Small (<30mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	30	36	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	31	43	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	32	41	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	32	40	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	32	41	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	32	40	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	32	39	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	33	43	Small (30-60mm)

Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	3	41	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	3	42	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	4	45	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	4	40	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	4	42	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	4	43	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	4	42	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	4	43	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	5	46	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	6	46	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	7	47	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	8	47	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	8	50	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	8	47	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	5	67	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	7	73	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	7	90	Large (60-90mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	2	31	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	4	33	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	5	33	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	2	34	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	6	34	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	7	35	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	2	36	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	8	36	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	8	34	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	9	38	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	9	38	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	9	38	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	3	38	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	3	39	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	0	38	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	3	40	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	0	40	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	3	42	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	3	42	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	4	44	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	4	44	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	3	43	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	4	43	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	4	42	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	4	42	Small (30-60mm)

Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	34	43	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	34	44	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	34	45	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	34	43	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	35	46	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	36	47	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	40	53	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	40	50	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	40	53	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	42	55	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	42	53	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	43	55	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	45	58	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	47	72	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	60	75	Large (60-90mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	62	77	Large (60-90mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	70	85	Large (60-90mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Catfish	70	80	Large (60-90mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	75	92	Large (60-90mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	81	100	Large (60-90mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	87	106	Large (60-90mm)

# APPENDIX D. MACROINVERTEBRATE DATA

			Site	Fig Pool	Fig Pool	Central Creek Pool	Central Creek Pool	South Star Pool	South Star Pool	Site 12	Site 12	Cow Spring Pool	Cow Spring Pool
			Habitat	Edge	Edge	Pool	Edge	Macrophyte	Macrophyte	Macrophyte	Edge	Macrophyte	Edge
			Replicate	1	2	1	2	1	2	1	2	1	2
			Date Sampled	24/06/2020	24/06/2020	25/06/2020	25/06/2020	26/06/2020	26/06/2020	28/06/2020	28/06/2020	29/06/2020	29/06/2020
			Sampled By	SK	SK	SK	SK	SK	SK	SK	SK	SK	SK
			Pick and ID By	SMJ	SMJ	SMJ	SMJ	SMJ	SMJ	SMJ	SMJ	SMJ	SMJ
			ID Date	27/07/2020	28/07/2020	28/07/2020	28/07/2020	29/07/2020	30/07/2020	30/07/2020	30/07/2020	30/07/2020	31/07/2020
SIGNAL2 Score	AusRivAS taxa code	Order	Family										
1		Hydrozoa	Hydrozoa										
3	IB029999	Hydrozoa	Oceaniidae										
2	IB019999	Hydrozoa	Hydridae									1	
		Hydrozoa	Olindiidae										
1	KG999999	Gastropoda	Gastropoda										
	-	Gastropoda	Ampullariidae										
4	KG069999	Gastropoda	Ancylidae					10				5	
3	KG039999	Gastropoda	Bithyniidae										
5	KG099999	Gastropoda	Glacidorbidae										
1	KG059999	Gastropoda	Lymnaeidae					12	4		1	7	
	KG109999	Gastropoda	Neritidae										
1	KG089999	Gastropoda	Physidae										
2	KG079999	Gastropoda	Planorbidae					3	8	3		3	
4	KG029999	Gastropoda	Tateidae										
4	KG049999	Gastropoda	Thiaridae										
4	KG019999	Gastropoda	Viviparidae										
2	QO219999	Oligochaeta	Oligochaeta				4	1	1	4	1	6	
	LP999999	Polychaeta	Polychaeta										
	-	Araneae	Araneae				1	1	1	2	1		
6	MM999999	Acarina	Acarina	10	3	2	2	5	21	14	14	11	8
		GROUP	Microcrustacea										
	OG999999	Cladocera	Cladocera					2	11			4	1
1	OF999999	Conchostraca	Conchostraca										

	OJ999999	Copepoda	Copepoda			1	5	6		3	4	2	2
	OH999999	Ostracoda	Ostracoda				1	15				16	
	<b>5 QCZZ9999</b>	<b>Coleoptera</b>	<b>Coleoptera</b>										
	3 QCAM9999	Coleoptera	Brentidae										
	3 QC059999	Coleoptera	Carabidae										
	2 QCAH9999	Coleoptera	Chrysomelidae										
	2 QCAN9999	Coleoptera	Curculionidae										
	2 QC099999	Coleoptera	Dytiscidae	9	6	2	7		2	2	3	2	
	7 QC349999	Coleoptera	Elmidae										
	2 QC119999	Coleoptera	Georissidae										
	4 QC109999	Coleoptera	Gyrinidae										
	2 QC069999	Coleoptera	Haliplidae										
	1 QC369999	Coleoptera	Heteroceridae										
	3 QC139999	Coleoptera	Hydraenidae									1	
	4 QCAO9999	Coleoptera	Hydrochidae			1	2	2				1	
	2 QC119999	Coleoptera	Hydrophilidae	10	2	2	2			1	3		
	1 QC079999	Coleoptera	Hygrobiiidae										
	4 QC359999	Coleoptera	Limnichidae							1			
	4 QC089999	Coleoptera	Noteridae										
	6 QC379999	Coleoptera	Psephenidae										
	10 QC399999	Coleoptera	Ptilodactylidae										
	6 QC209999	Coleoptera	Scirtidae									4	
	2 QC119999	Coleoptera	Spercheidae										
	7 QC039999	Coleoptera	Sphaeriidae										
	3 QC189999	Coleoptera	Staphylinidae										
	<b>3 QDZZ9999</b>	<b>Diptera</b>	<b>Diptera</b>										
	8 QD229999	Diptera	Athericidae										
	10 QD049999	Diptera	Blephariceridae										
	4 QD099999	Diptera	Ceratopogonidae			7	9	3	2	4	2	10	
	2 QD059999	Diptera	Chaoboridae										
	3 QDAZ9999	Diptera	Chironomidae										
	8 QDAA9999	Diptera	s-f Aphroteniinae										
	3 QDAJ9999	Diptera	s-f Chironominae	23	25	16	26	9	20	21	3	25	22
	6 QDAB9999	Diptera	s-f Diamesinae										
	4 QDAF9999	Diptera	s-f Orthoclaadiinae			1						1	

6	QDAD9999	Diptera	s-f Podonominae										
4	QDAE9999	Diptera	s-f Tanypodinae			14	11	15	9	19	15	25	4
-		Diptera	Corethrellidae										
1	QD079999	Diptera	Culicidae	1	4				1			1	
7	QD069999	Diptera	Dixidae										
3	QD369999	Diptera	Dolichopodidae										
5	QD359999	Diptera	Empididae										
2	QD789999	Diptera	Ephydriidae			1	2						
1	QD899999	Diptera	Muscidae						1				
3	QD129999	Diptera	Psychodidae						1				
6	-	Diptera	Sciaridae										
2	QD459999	Diptera	Sciomyzidae									1	
5	QD109999	Diptera	Simuliidae										
2	QD249999	Diptera	Stratiomyidae			4	1			2	3	1	
2	QD439999	Diptera	Syrphidae										
3	QD239999	Diptera	Tabanidae						1				
6	QD039999	Diptera	Tanyderidae										
7	QD119999	Diptera	Thaumaleidae										
5	QD019999	Diptera	Tipulidae										1
9	QE999999	<b>Ephemeroptera</b>	<b>Ephemeroptera</b>										
7	QE049999	Ephemeroptera	Ameletopsidae										
5	QE029999	Ephemeroptera	Baetidae					9	13	2	2	9	12
4	QE089999	Ephemeroptera	Caenidae			7	14	10	1	1		12	2
8	QE059999	Ephemeroptera	Coloburiscidae										
8	QE069999	Ephemeroptera	Leptophlebiidae										
10	-	Ephemeroptera	Nesameletidae										
8	QE039999	Ephemeroptera	Oniscigastriidae										
4	QE099999	Ephemeroptera	Prosopistomatidae										
9	QE079999	Ephemeroptera	Teloganodidae										
2	QHZZ9999	<b>Hemiptera</b>	<b>Hemiptera</b>										
-		Hemiptera	Aphelocheiridae										
1	QH629999	Hemiptera	Belostomatidae									2	
2	QH659999	Hemiptera	Corixidae										
-		Hemiptera	Dipsocoridae										
5	QH649999	Hemiptera	Gelastocoridae										

4	QH579999	Hemiptera	Gerridae							2	2	2	
3	QH539999	Hemiptera	Hebridae		1						3		
3	QH549999	Hemiptera	Hydrometridae										
	QH589999	Hemiptera	Leptopodidae										
2	QH529999	Hemiptera	Mesoveliidae		1							1	
2	QH659999	Hemiptera	Micronectidae					1			1	1	
2	QH669999	Hemiptera	Naucoridae										
3	QH619999	Hemiptera	Nepidae		1	1						2	
1	QH679999	Hemiptera	Notonectidae	2	3								
2	QH639999	Hemiptera	Ochteridae										
2	QH689999	Hemiptera	Pleidae		8	4	3			1	2	1	1
1	QH609999	Hemiptera	Saldidae										
3	QH569999	Hemiptera	Veliidae	1	4					1		1	
3	<b>QO999999</b>	<b>Odonata</b>	<b>Odonata</b>										
3	<b>QO999997</b>	<b>Odonata</b>	<b>S.O. Zygoptera</b>										
5	QO079999	Odonata	Argiolestidae										
	QO109999	Odonata	Calopterygidae										
	QO189999	Odonata	Chorismagrionidae										
2	QO029999	Odonata	Coenagrionidae		1	7	9	10		7	2	14	2
6	QO099999	Odonata	Diphlebiidae										
	QO019999	Odonata	Hemiphlebiidae										
9	QO069999	Odonata	Hypolestidae										
3	QO039999	Odonata	Isostictidae			3							
1	QO069999	Odonata	Lestidae										
4	QO049999	Odonata	Platycnemididae										
7	QO089999	Odonata	Synlestidae										
3	<b>QO999998</b>	<b>Odonata</b>	<b>S.O. Epiproctiphora</b>				1	1					
4	QO129999	Odonata	Aeshnidae		1				5			1	1
	QO199999	Odonata	Archipetaliidae										
10	QO279999	Odonata	Austrocorduliidae										
	QO209999	Odonata	Austropetaliidae										
9	QO219999	Odonata	Brachytronidae										
	QO289999	Odonata	Cordulephyidae										
5	QO169999	Odonata	Corduliidae					1				1	
5	QO139999	Odonata	Gomphidae										

	QO249999	Odonata	Gomphomacromiidae									
5	QO309999	Odonata	Hemicorduliidae									
4	QO179999	Odonata	Libellulidae	15	15		1	7	2		9	9
3	QO229999	Odonata	Lindeniidae									
8	QO269999	Odonata	Macromiidae									
	QO299999	Odonata	Oxygastridae									
	QO159999	Odonata	Petaluridae									
	QO259999	Odonata	Pseudocorduliidae									
2	QO239999	Odonata	Synthemistidae									
9	QO219999	Odonata	Telephlebiidae									
8	<b>QT999999</b>	<b>Trichoptera</b>	<b>Trichoptera</b>									
8	QT169999	Trichoptera	Antipodoeciidae									
7	QT239999	Trichoptera	Atriplectididae									
7	QT249999	Trichoptera	Calamoceratidae									
9	QT189999	Trichoptera	Calocidae									
7	QT159999	Trichoptera	Conoesucidae									
9	QT269999	Trichoptera	Dipseudopsidae									
4	QT089999	Trichoptera	Ecnomidae				3		7		2	1
9	QT029999	Trichoptera	Glossosomatidae									
10	QT199999	Trichoptera	Helicophidae									
8	QT179999	Trichoptera	Helicopsychidae									
10		Trichoptera	Helocubucidae									
8	QT019999	Trichoptera	Hydrobiosidae									
6	QT069999	Trichoptera	Hydropsychidae									
4	QT039999	Trichoptera	Hydroptilidae			2	3		4	3	3	3
3	QT209999	Trichoptera	Kokiriidae									
6	QT259999	Trichoptera	Leptoceridae			2	6	4	2	5		5
8	QT109999	Trichoptera	Limnephilidae									
7	QT229999	Trichoptera	Odontoceridae									
8	QT129999	Trichoptera	Oeconesidae									
8	QT049999	Trichoptera	Philopotamidae									
8	QT219999	Trichoptera	Philorheithridae									
	QT119999	Trichoptera	Plectrotarsidae									
7	QT079999	Trichoptera	Polycentropodidae									
	QT099999	Trichoptera	Psychomyiidae									

	QT059999	Trichoptera	Stenopsychidae									
<b>8</b>	QT139999	Trichoptera	Tasimiidae									
<b>3</b>	<b>QL019999</b>	<b>Lepidoptera</b>	<b>Crambidae</b>					<b>1</b>	<b>6</b>			<b>2</b>

Table 28 Macroinvertebrate taxa present at Iron Bridge pools in the late dry season (2020)

			Site		Cow spring		Fig pool		Site 12 Pool		Mundagoora Pool	
			Date sampled		11/12/2020		10/12/2020		9/12/2020		8/12/2020	
			Replicate		1	2	1	2	1	2	1	2
Order	Family	Signal2 score										
<b>Nematoda</b>	<b>Nematoda</b>	3								<b>1</b>		
<b>Gastropoda</b>	<b>Gastropoda</b>	1										
	Ancylidae	4	2	2							7	3
	Lymnaeidae	1	6	9							8	12
	Planorbidae	2	7	9					1		10	15
<b>Oligochaeta</b>	<b>Oligochaeta</b>	2	<b>2</b>	<b>2</b>					<b>2</b>	<b>4</b>	<b>3</b>	
<b>Araneae</b>	<b>Araneae</b>											<b>1</b>
<b>Acarina</b>	<b>Acarina</b>	6	<b>7</b>	<b>10</b>	<b>3</b>				<b>1</b>	<b>8</b>	<b>6</b>	
<b>Group</b>	<b>Microcrustacea</b>											
<b>Cladocera</b>	Cladocera								9		5	1
<b>Copepoda</b>	Copepoda		2	2						4	9	7
<b>Ostracoda</b>	Ostracoda										11	11
<b>Coleoptera</b>	<b>Coleoptera</b>	5										

	Site	Cow spring		Fig pool		Site 12 Pool		Mundagoora Pool	
	Dytiscidae	2	3	2	5	1		3	4
	Hydraenidae	3						1	
	Hydrochidae	4						18	2
	Hydrophilidae	2	2	1		7	1	1	2
	Scirtidae	6							5
<b>Diptera</b>	<b>Diptera</b>	3							
	Ceratopogonidae	4	4	8			7	5	4
	S-f chironominae	3	24	27	28	29	28	16	19
	S-f tanypodinae	4	10	11		6	12	16	7
	Culicidae	1		1	1	1			
	Stratiomyidae	2					5		
	Tabanidae	3					1		
<b>Ephemeroptera</b>	<b>Ephemeroptera</b>	9							
	Baetidae	5	9				3	5	5
	Caenidae	4		3			1	6	11
<b>Hemiptera</b>	<b>Hemiptera</b>	2							
	Belostomatidae	1	1						
	Gerridae	4		4		3			1
	Mesoveliidae	2						1	1
	Micronectidae	2							1
	Pleidae	2						3	1

	Site		Cow spring		Fig pool		Site 12 Pool		Mundagoora Pool	
	Veliidae	3			2	13			1	2
<b>Odonata</b>	<b>Odonata</b>	3								
	Coenagrionidae	2	12	16	13	23			6	15
	Gomphidae	5					3			
	Libellulidae	4	11	10	12	15		2	2	
<b>Trichoptera</b>	<b>Trichoptera</b>	8								
	Ecnomidae	4							1	
	Hydroptilidae	4					1			1
	Leptoceridae	6	1	1				2	22	22
<b>Lepidoptera</b>	<b>Crambidae</b>	3	7	3						

Table: Macroinvertebrate data for the Late Wet Season 2021

	Site	Fig Pool	Fig Pool	Central Creek Pool	Central Creek Pool	South Star Pool	South Star Pool	Site 12	Site 12	Cow Spring Pool	Cow Spring Pool
	<b>Replicate</b>	1	2	1	2	1	2	1	2	1	2
	<b>Date Sampled</b>	24/06/2020	24/06/2020	25/06/2020	25/06/2020	26/06/2020	26/06/2020	28/06/2020	28/06/2020	29/06/2020	29/06/2020
<b>Order</b>	<b>Family</b>										
<b>Hydrozoa</b>	Hydridae									1	
<b>Gastropoda</b>	Ancylidae					10				5	

	Site	Fig Pool	Fig Pool	Central Creek Pool	Central Creek Pool	South Star Pool	South Star Pool	Site 12	Site 12	Cow Spring Pool	Cow Spring Pool
<b>Gastropoda</b>	Lymnaeidae					12	4		1	7	
<b>Gastropoda</b>	Planorbidae					3	8	3		3	
<b>Oligochaeta</b>	<b>Oligochaeta</b>				4	1	1	4	1	6	
<b>Araneae</b>	<b>Araneae</b>				1	1	1	2	1		
<b>Acarina</b>	<b>Acarina</b>	10	3	2	2	5	21	14	14	11	8
<b>Cladocera</b>	Cladocera					2	11			4	1
<b>Copepoda</b>	Copepoda			1	5	6		3	4	2	2
<b>Ostracoda</b>	Ostracoda				1	15				16	
<b>Coleoptera</b>	Dytiscidae	9	6	2	7			2	2	3	2
<b>Coleoptera</b>	Hydraenidae									1	
<b>Coleoptera</b>	Hydrochidae			1	2	2				1	
<b>Coleoptera</b>	Hydrophilidae	10	2	2	2				1	3	
<b>Coleoptera</b>	Limnichidae								1		
<b>Coleoptera</b>	Scirtidae									4	
<b>Diptera</b>	Ceratopogonidae			7	9	3	2	4	2	10	
<b>Diptera</b>	s-f Chironominae	23	25	16	26	9	20	21	3	25	22

	Site	Fig Pool	Fig Pool	Central Creek Pool	Central Creek Pool	South Star Pool	South Star Pool	Site 12	Site 12	Cow Spring Pool	Cow Spring Pool
<b>Diptera</b>	s-f Orthocladiinae			1						1	
<b>Diptera</b>	s-f Tanypodinae			14	11	15	9	19	15	25	4
<b>Diptera</b>	Culicidae	1	4				1			1	
<b>Diptera</b>	Ephydriidae			1	2						
<b>Diptera</b>	Muscidae				1						
<b>Diptera</b>	Psychodidae				1						
<b>Diptera</b>	Sciomyzidae									1	
<b>Diptera</b>	Stratiomyidae			4	1			2	3	1	
<b>Diptera</b>	Tabanidae				1						
<b>Diptera</b>	Tipulidae									1	
<b>Ephemeroptera</b>	Baetidae					9	13	2	2	9	12
<b>Ephemeroptera</b>	Caenidae			7	14	10	1	1		12	2
<b>Hemiptera</b>	Belostomatidae									2	
<b>Hemiptera</b>	Gerridae							2	2	2	
<b>Hemiptera</b>	Hebridae			1					3		
<b>Hemiptera</b>	Mesoveliidae			1						1	

	Site	Fig Pool	Fig Pool	Central Creek Pool	Central Creek Pool	South Star Pool	South Star Pool	Site 12	Site 12	Cow Spring Pool	Cow Spring Pool
<b>Hemiptera</b>	Micronectidae					1			1	1	
<b>Hemiptera</b>	Nepidae			1	1					2	
<b>Hemiptera</b>	Notonectidae	2	3								
<b>Hemiptera</b>	Pleidae			8	4	3		1	2	1	1
<b>Hemiptera</b>	Veliidae	1		4				1		1	
<b>Odonata</b>	<b>Odonata</b>										
<b>Odonata</b>	Coenagrionidae		1	7		9	10	7	2	14	2
<b>Odonata</b>	Isostictidae			3							
<b>Odonata</b>	<b>S.O. Epiroctiphora</b>				1	1					
<b>Odonata</b>	Aeshnidae		1				5			1	1
<b>Odonata</b>	Corduliidae					1				1	
<b>Odonata</b>	Libellulidae	15	15			1	7	2		9	9
<b>Trichoptera</b>	Ecnomidae					3		7		2	1
<b>Trichoptera</b>	Hydroptilidae			2	3		4	3	3	3	
<b>Trichoptera</b>	Leptoceridae			2	6	4	2	5		5	
<b>Lepidoptera</b>	<b>Crambidae</b>					1	6			2	

	Site	Fig Pool	Fig Pool	Central Creek Pool	Central Creek Pool	South Star Pool	South Star Pool	Site 12	Site 12	Cow Spring Pool	Cow Spring Pool
	<b>Abundance</b>	71	60	87	105	127	126	105	63	200	67
	<b>Taxonomic Richness</b>	8	9	21	22	24	18	20	19	39	13
	<b>PET Richness</b>	0	0	3	3	4	4	5	2	5	3
	Terrestrial insect	1					7	5	5		1

	Site	Fig Pool	Fig Pool	Central Creek Pool	Central Creek Pool	South Star Pool	South Star Pool	Site 12	Site 12	Cow Spring Pool	Cow Spring Pool
	<b>SMI Comments</b>		3 Chironominae and 2 Culicidae are pupa	1 Hydroptilidae is a very early instar.	1 Hydroptilidae is a very early instar. Oligochaeta very small and unidentified Epiproctaphora too small to identify to family level. 1 Chironominae is a pupa.	1 Ceratopogonidae is a pupa. Label disintegrated when the sample was rinsed so I am unsure what habitat type sample was collected from. Unidentified Epiproctaphora too small to identify to family level.	1 Hydroptilidae, 1 Ceratopogonidae and 3 Chironominae are pupa. 1 Leptoceridae and Ecnomidae very small.	Partially live-picked sample. 1 Tanypodinae and 1 Ceratopogonidae are pupa. Many very small Chironomids.	1 Chironominae and 1 Ceratopogonidae are pupa. Limnichidae is an adult, which are generally considered semi-aquatic / terrestrial.	Photo of specimen is an Aeshnidae (can just see bifid apex of epiproct) and this record has been included in this data. 1 Ceratopogonidae is a pupa.	Some very small Acarina.

# APPENDIX E. DIATOM DATA

## Diatom species and count data for the five surveyed pools – Late Wet 2020.

Taxon name		Fig Pool	Fig Pool	Central Ck Pool	Central Ck Pool	South Star Pool	South Star Pool	Site 12 Pool	Site 12 Pool	Cow Spring Pool	Cow Spring Pool
	Replicate Number	1	2	1	2	1	2	1	2	1	2
	Collection date	24/06/2020	24/06/2020	25/06/2020	25/06/2020	26/06/2020	26/06/2020	27/06/2020	27/06/2020	28/06/2020	28/06/2020
	Sample description	no valves	no valves					very sparse	very sparse. teratological forms	no valves	very sparse
<b>Total Count</b>		<b>0</b>	<b>0</b>	<b>394</b>	<b>352</b>	<b>420</b>	<b>386</b>	<b>60</b>	<b>166</b>	<b>0</b>	<b>28</b>
<b>DSIAR Score</b>		<b>NA</b>	<b>NA</b>	<b>41.3</b>	<b>42.6</b>	<b>59.1</b>	<b>66.3</b>	<b>54.7</b>	<b>53.95</b>	<b>NA</b>	<b>64.25</b>
<i>Achnanthes brevipes</i>		0	0	22	12	302	92	4	24	0	8
<i>Achnanthes impexa</i>		0	0	0	0	48	164	4	8	0	0
<i>Achnanthes subexigua</i>		0	0	4	0	14	70	8	10	0	8
<i>Achnantheidium exiguum</i>		0	0	2	0	12	24	0	0	0	0
<i>Achnantheidium kryophila</i>		0	0	0	0	8	4	0	0	0	0
<i>Achnantheidium lineare</i>		0	0	0	0	6	8	0	0	0	2
<i>Achnantheidium minutissimum</i>		0	0	0	0	6	0	0	0	0	0
<i>Achnantheidium minutissimum var affine</i>		0	0	0	2	4	4	0	0	0	4
<i>Achnantheidium spp.</i>		0	0	2	0	4	4	0	0	0	0
<i>Actinocyclus normanii</i>		0	0	0	0	4	0	0	0	0	0
<i>Adlafia aff bryophila</i>		0	0	0	0	4	0	0	0	0	0
<i>Adlafia minuscula v. muralis</i>		0	0	0	0	4	0	0	0	0	0

Taxon name	Fig Pool	Fig Pool	Central Ck Pool	Central Ck Pool	South Star Pool	South Star Pool	Site 12 Pool	Site 12 Pool	Cow Spring Pool	Cow Spring Pool
<i>Amphicampa mirabilis</i>	0	0	6	2	2	0	0	0	0	0
<i>Amphipleura pellucida</i>	0	0	0	0	2	0	0	0	0	0
<i>Amphora delicatissima</i>	0	0	0	4	0	0	0	0	0	2
<i>Amphora libyca</i>	0	0	0	0	0	0	0	0	0	2
<i>Amphora ovalis</i>	0	0	0	0	0	0	0	0	0	2
<i>Amphora pediculus</i>	0	0	0	2	0	0	42	112	0	0
<i>Amphora spp.</i>	0	0	0	0	0	0	0	6	0	0
<i>Aneumastus tuscula</i>	0	0	0	0	0	2	0	4	0	0
<i>Anomoneis spaerophora</i>	0	0	0	0	0	0	0	2	0	0
<i>Asterionella ralfsii var americana</i>	0	0	246	270	0	0	2	0	0	0
<i>Aulacoseira ambigua</i>	0	0	4	0	0	12	0	0	0	0
<i>Aulacoseira crenulata</i>	0	0	0	0	0	2	0	0	0	0
<i>Aulacoseira granulata</i>	0	0	40	16	0	0	0	0	0	0
<i>Bacillaria paxillifer</i>	0	0	10	8	0	0	0	0	0	0
<i>Brachysira brebissonii</i>	0	0	12	6	0	0	0	0	0	0
<i>Brachysira styriaca</i>	0	0	0	6	0	0	0	0	0	0
<i>Brachysira vitrea</i>	0	0	8	4	0	0	0	0	0	0
<i>Caloneis aerophila</i>	0	0	0	4	0	0	0	0	0	0
<i>Caloneis silicula</i>	0	0	0	4	0	0	0	0	0	0
<i>Chamaepinnularia bremensis</i>	0	0	0	4	0	0	0	0	0	0
<i>Chamaepinnularia muscicola</i>	0	0	0	2	0	0	0	0	0	0

Taxon name	Fig Pool	Fig Pool	Central Ck Pool	Central Ck Pool	South Star Pool	South Star Pool	Site 12 Pool	Site 12 Pool	Cow Spring Pool	Cow Spring Pool
<i>Cocconeis pediculus</i>	0	0	0	2	0	0	0	0	0	0
<i>Cocconeis placentula</i>	0	0	0	2	0	0	0	0	0	0
<i>Cocconeis placentula</i> var. <i>euglypta</i>	0	0	0	2	0	0	0	0	0	0
<i>Cocconeis placentula</i> var. <i>lineata</i>	0	0	28	0	0	0	0	0	0	0
<i>Cocconeis pseudothumensis</i>	0	0	4	0	0	0	0	0	0	0
<i>Craticula accomoda</i>	0	0	2	0	0	0	0	0	0	0
<i>Craticula cuspidata</i>	0	0	2	0	0	0	0	0	0	0
<i>Craticula halophila</i>	0	0	2	0	0	0	0	0	0	0

## Diatom species and count data - late wet 2021

Sample name:	Fig Pool	Fig Pool	Central Ck Pool	Central Ck Pool	South Star Pool	South Star Pool	Site 12 Pool	Site 12 Pool	Cow Spring Pool	Cow Spring Pool
<b>Further sample details:</b>	1 of 2	2 of 2	1 of 2	2 of 2	1 of 2	2 of 2	1 of 2	2 of 2	1 of 2	2 of 2
<b>Date</b>	24/06/2020	24/06/2020	25/06/2020	25/06/2020	26/06/2020	26/06/2020	27/06/2020	27/06/2020	28/06/2020	28/06/2020
<b>Taxon name/Notes:</b>	no valves	no valves					very sparse	very sparse and teratological forms	no valves	very sparse
<b>Achnanthyidium exiguum</b>	0	0	246	270	0	0	2	0	0	0
<b>Achnanthyidium minutissimum</b>	0	0	22	12	302	92	4	24	0	8

Sample name:	Fig Pool	Fig Pool	Central Ck Pool	Central Ck Pool	South Star Pool	South Star Pool	Site 12 Pool	Site 12 Pool	Cow Spring Pool	Cow Spring Pool
<b>Amphora spp.</b>	0	0	0	0	0	0	0	6	0	0
<b>Brachysira brebissonii</b>	0	0	0	2	0	0	0	0	0	0
<b>Brachysira vitrea</b>	0	0	0	0	48	164	4	8	0	0
<b>Caloneis silicula</b>	0	0	0	0	0	2	0	4	0	0
<b>Craticula halophila</b>	0	0	0	0	2	0	0	0	0	0
<b>Cymbella affinis</b>	0	0	0	0	6	8	0	0	0	2
<b>Cymbella spp</b>	0	0	0	2	4	4	0	0	0	4
<b>Diploneis parma</b>	0	0	6	2	2	0	0	0	0	0
<b>Encyonema minutum</b>	0	0	0	0	4	0	0	0	0	0
<b>Eolimna minima</b>	0	0	2	0	0	0	0	0	0	0
<b>Eunotia bilunaris</b>	0	0	4	0	14	70	8	10	0	8
<b>Eunotia faba</b>	0	0	0	0	0	0	0	0	0	2
<b>Eunotia incisa</b>	0	0	0	0	0	0	0	2	0	0
<b>Fragilaria spp.</b>	0	0	2	0	0	0	0	0	0	0
<b>Hantzschia amphioxys</b>	0	0	0	4	0	0	0	0	0	2
<b>Luticola mutica</b>	0	0	0	0	0	0	0	0	0	2

Sample name:	Fig Pool	Fig Pool	Central Ck Pool	Central Ck Pool	South Star Pool	South Star Pool	Site 12 Pool	Site 12 Pool	Cow Spring Pool	Cow Spring Pool
<b>Mastogloia smithii</b>	0	0	0	2	0	0	42	112	0	0
<b>Navicula cryptocephala</b>	0	0	0	0	6	0	0	0	0	0
<b>Navicula cryptotenella</b>	0	0	0	0	0	2	0	0	0	0
<b>Navicula gregaria</b>	0	0	0	0	4	0	0	0	0	0
<b>Navicula lanceolata</b>	0	0	2	0	4	4	0	0	0	0
<b>Navicula menisculoides</b>	0	0	0	0	8	4	0	0	0	0
<b>Navicula menisculus</b>	0	0	0	4	0	0	0	0	0	0
<b>Navicula phyllepta</b>	0	0	0	2	0	0	0	0	0	0
<b>Navicula radiosa</b>	0	0	2	0	12	24	0	0	0	0
<b>Navicula recens</b>	0	0	0	0	4	0	0	0	0	0
<b>Navicula veneta</b>	0	0	12	6	0	0	0	0	0	0
<b>Nitzschia frustulum</b>	0	0	10	8	0	0	0	0	0	0
<b>Nitzschia graciliformis</b>	0	0	4	0	0	0	0	0	0	0
<b>Nitzschia gracilis</b>	0	0	2	0	0	0	0	0	0	0
<b>Nitzschia inconspicua</b>	0	0	0	6	0	0	0	0	0	0
<b>Nitzschia lacuum</b>	0	0	8	4	0	0	0	0	0	0

Sample name:	Fig Pool	Fig Pool	Central Ck Pool	Central Ck Pool	South Star Pool	South Star Pool	Site 12 Pool	Site 12 Pool	Cow Spring Pool	Cow Spring Pool
<b>Nitzschia microcephala</b>	0	0	0	4	0	0	0	0	0	0
<b>Nitzschia palea</b>	0	0	40	16	0	0	0	0	0	0
<b>Nitzschia suchlandii</b>	0	0	0	2	0	0	0	0	0	0
<b>Pinnularia legumen</b>	0	0	0	2	0	0	0	0	0	0
<b>Pinnularia spp.</b>	0	0	0	4	0	0	0	0	0	0
<b>Pleurosigma elongatum</b>	0	0	28	0	0	0	0	0	0	0
<b>Ulnaria ulna</b>	0	0	4	0	0	12	0	0	0	0
<b>Total</b>	0	0	394	352	420	386	60	166	0	28

# APPENDIX F. PHYTOPLANKTON DATA

Table. Phytoplankton profile for the Iron Bridge Pools sampled in the late dry season (2020)

Taxon	F16 HB		SS Pool		S12 Pool		Cow Spring	
	DE01565.1		DE01565.2		DE01565.3		DE01565.4	
	10/12/2020		8/12/2020		09/12/2020		11/12/2020	
	Abund.	%	Abund.	%	Abund.	%	Abund.	%
Bacillariophyceae	200	8.00	80300	76.11	3200	2.27	7000	19.02
<i>Achnanthidium minutissima</i>			35200	33.36			1400	3.80
<i>Amphora spp.</i>					400	0.28	200	0.54
<i>Cocconeis spp.</i>			700	0.66				
<i>Cymbella spp.</i>			300	0.28			400	1.09
<i>Lyrella spp.</i>			100	0.09				
<i>Microtabella spp.</i>	100	4.00						

Taxon	F16 HB		SS Pool		S12 Pool		Cow Spring	
	DE01565.1		DE01565.2		DE01565.3		DE01565.4	
	10/12/2020		8/12/2020		09/12/2020		11/12/2020	
	Abund.	%	Abund.	%	Abund.	%	Abund.	%
<i>Navicula spp.</i>	100	4.00	19600	18.58				
<i>Navicula spp.</i>			19600	18.58	1200	0.85	2800	7.61
<i>Nitzschia spp.</i>			100	0.09	1200	0.85	400	1.09
<i>Pinnularia spp.</i>			200	0.19				
<i>Synedra spp. (O)</i>			4500	4.27	400	0.28	1800	4.89
Chlorophyceae	<b>2200</b>	<b>88.00</b>	<b>900</b>	<b>0.85</b>	<b>3200</b>	<b>2.27</b>	<b>1400</b>	3.80
<i>Closterium spp. (O)</i>					1200	0.85		
<i>Cosmarium spp. (O)</i>	2200	88.00	700	0.66	2000	1.42	1200	3.26
<i>Oocystis spp.</i>			200	0.19				
<i>Staurastrum spp. (O)</i>							200	0.54
Cryptophyceae			<b>8800</b>	<b>8.34</b>	<b>24000</b>	<b>17.00</b>	<b>15000</b>	40.76
<i>Chroomonas spp.</i>			800	0.76	2400	1.70	3000	8.15
<i>Cryptomonas spp. (O)</i>			8000	7.58	21600	15.30	11800	32.07
<i>Plagioselmis spp.</i>							200	0.54
Cyanobacteria			<b>8200</b>	<b>7.77</b>	<b>8000</b>	<b>5.67</b>		
<i>Chroococcus spp.</i>					1600	1.13		
<i>Planktolyngbya spp.</i>					6400	4.53		
<i>Pseudoanabaena spp. (O) (PT)</i>			8200	7.77				
Dinophyceae			<b>7200</b>	<b>6.82</b>	<b>102800</b>	<b>72.80</b>	<b>13200</b>	35.87
<i>Gomphonema spp.</i>			500	0.47				


Taxon	F16 HB		SS Pool		S12 Pool		Cow Spring	
	DE01565.1		DE01565.2		DE01565.3		DE01565.4	
	10/12/2020		8/12/2020		09/12/2020		11/12/2020	
	Abund.	%	Abund.	%	Abund.	%	Abund.	%
<i>Gonyaulax spp.</i>			800	0.76	42800	30.31	12200	33.15
<i>Gymnodinium spp.</i>			1400	1.33			600	1.63
<i>Peridinium spp. (O)</i>			4500	4.27	60000	42.49	400	1.09
Euglenophyceae	100	4.00	100	0.09			200	0.54
<i>Euglena spp. (O)</i>			100	0.09				
<i>Trachelomonas spp.</i>	100	4.00					200	0.54
<i>TOTAL (All Taxa)</i>	2500	100	105500	100	141200	100	36800	100

Table. Phytoplankton profile for Iron Bridge pools sampled in the late wet season (2021)

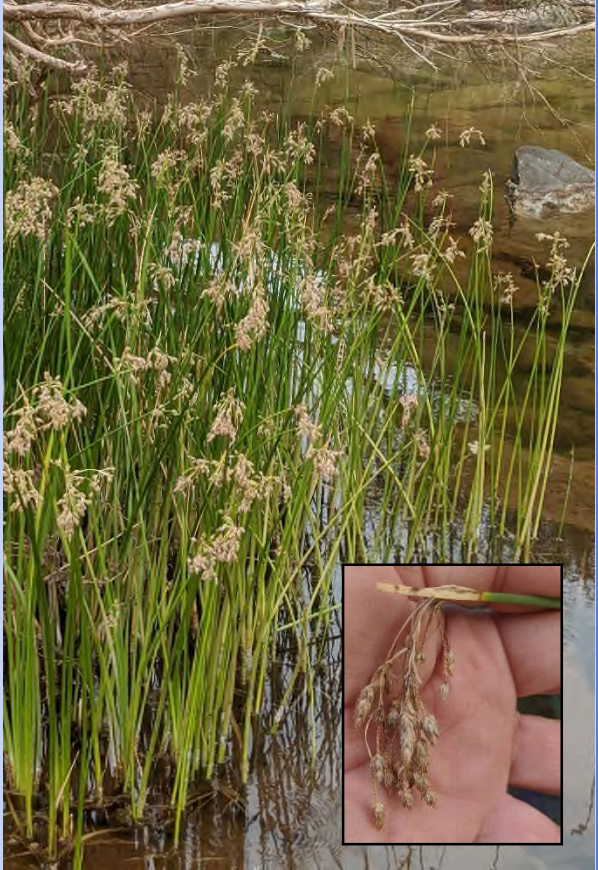

Taxon	Fig Pool		Central Creek		Site 12		Cow Spring		Gv Pool		Mundagoora Pool	
	DE01792.1		DE01792.2		DE01792.4		DE01792.5		DE01792.6		DE01792.3	
	24/05/2021		24/05/2021		24/05/2021		24/05/2021		24/05/2021		24/05/2021	
	Abund.	%	Abund.	%	Abund.	%	Abund.	%	Abund.	%	Abund.	%
Bacillariophyceae			460	93.88	20	100.00	20	100.00	860	98.85	70	63.64
<i>Achnanthisidium sp.</i>										10	9.09	
<i>Amphora sp.</i>								40	4.60	10	9.09	
<i>Entomoneis</i>			10	2.04								
<i>Fragilaria sp. (O)</i>			10	2.04								
<i>Placoneis sp.</i>								530	60.92			



Taxon	Fig Pool		Central Creek		Site 12		Cow Spring		Gv Pool		Mundagoora Pool	
	DE01792.1		DE01792.2		DE01792.4		DE01792.5		DE01792.6		DE01792.3	
	24/05/2021		24/05/2021		24/05/2021		24/05/2021		24/05/2021		24/05/2021	
	Abund.	%	Abund.	%	Abund.	%	Abund.	%	Abund.	%	Abund.	%
<i>Navicula capitata</i>			10	2.04								
<i>Navicula pupula capitata</i>			10	2.04								
<i>Navicula</i> sp.			50	10.20	20	100.00	10	50.00	100	11.49	40	<b>36.36</b>
<i>Nitzschia</i> sp.			130	26.53					110	12.64		
<i>Pleurosigma</i> sp. (O)			220	44.90								
<i>Rhopalodia gibba</i>			10	2.04					60	6.90		
<i>Stauroneis</i> sp.			10	2.04								
<i>Synedra</i> sp. (O)							10	50.00	20	2.30	10	<b>9.09</b>
Chlorophyceae											<b>40</b>	36.36
<i>Mougeotia</i> sp.											40	<b>36.36</b>
Cryptophyceae			<b>30</b>	<b>6.12</b>					<b>10</b>	<b>1.15</b>		
<i>Cryptomonas</i> sp. (O)			30	6.12					10	1.15		
TOTAL (All Taxa)			490	100	20	100	20	100	870	100	110	100


# APPENDIX G. MACROPHYTE TABLE

Name	Description	Image	Site 12	Cow	South	Central
<p><b>Ribbon weed</b> <i>(Vallisneria sp.)</i></p>	<p>Bright green soft ribbon fronds which float and spread across the water surface. Fronds about 0.5 cm wide.</p>		Y	Y	Y	

Name	Description	Image	Site 12	Cow	South	Central
<p><b>Charophytes</b> (<i>Nitella sp.</i>, <i>Chara sp.</i>)</p>			Y			

Name	Description	Image	Site 12	Cow	South	Central
<p><b>Clubrush</b> (<i>Schoenoplectus</i> sp.)</p>			Y	Y	Y	Y
<p><b>Sedges</b> (<i>Cyperus</i> sp.)</p>			Y	Y	Y	Y

Name	Description	Image	Site 12	Cow	South	Central
<p><b>Bulrush</b> (<i>Typha sp.</i>)</p>	<p>Tall emergent ribbon like fronds with sharp margins.</p>		<p>Y</p>	<p>Y</p>	<p>Y</p>	
<p><b>Unidentified species 1</b></p>				<p>Y</p>		

Name	Description	Image	Site 12	Cow	South	Central
Unidentified species 2				Y		

# APPENDIX H. ISOTOPE DATA ANALYSIS MEMO

# MEMORANDUM



TO: Sylvie Ogier-Halim (FMG- Strategic Planning - Hydrogeology Projects)

CC:

SENDER: Phil Whittle

DATE: 9 Sept 2021

PROJECT: Iron Bridge – Assessment of pool water sources from isotope analysis

## ASSESSMENT OF IRON BRIDGE POOL WATER SOURCES FROM ISOTOPE ANALYSIS

This memorandum provides a summary of the water quality isotopic data captured for Iron Bridge river pools and groundwater from December 2019 to June 2021. The isotope data was collected to assess the sustaining water sources for a range of permanent to semi-permanent river pools across the Iron Bridge project site.

Three groundwater monitoring bores and six permanent or semi-permanent river pools were sampled for the stable isotopes  $\delta^{18}\text{O}$  and  $\delta^2\text{H}$ , as well as a range of field and major ion parameters (Figure 1; Table 1). As common practice in hydrogeology, the isotopic ratios are compared to the Vienna Standard Mean Ocean Water (VSMOW) reference. The VSMOW represents enriched isotopic conditions in aged "seawater". Rainfall is typically depleted in  $\delta^{18}\text{O}$  and  $\delta^2\text{H}$ , therefore the enrichment or depletion of these isotopes in various water sources can provide a signature relative to recent rainfall, evaporative processes (which concentrate or enrich these isotopes) or groundwater sources (which are more stable relative to the age of the water source). Considering the lack of regional isotopic data in the Iron Bridge project area, the dataset of Dogramaci et al (2012) from the Hamersley Range region has been used for context (Figure 2). Overall, the isotope data showed a large range in values across both groundwater and surface waters at Iron Bridge (Figure 2). The relationship between the two isotopes ( $\delta^{18}\text{O}$  and  $\delta^2\text{H}$ ) was however relatively consistent across the site and sampling dates, as well as being consistent with regional literature (Dogramaci et al., 2012, Hedley 2009, Hedley et al, 2009, Dogramaci and Skrzypek 2015). There is a general pattern of depletion (increasingly negative) isotopic ratios in the region following large singular rainfall events (such as cyclones or associated large low systems; Dogramaci et al., 2012). There was an evident depletion of both isotopes between the dry to wet season 2019/20 and following the wet season of 2020/21. The tropical low (02U) of 11-12 December 2020 produced a large (200 mm) rainfall event across the Iron Bridge site. This may be a factor in the depleted June 2021 isotope ratios (Figure 3).

## SITE 12 POOL

The large range in isotope ratio values for the Site 12 pool groundwater (bore NS-0064; labelled as Site 12 GW in Figure 2) is consistent with the records from water level loggers and other water quality parameters from this bore, showing variability in response to rainfall events (Figure 4). It is notable that the isotope ratios for the surface water within Site 12 Pool and the upstream monitoring bore (NS-0664) were



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consistently different, with the groundwater being substantially more depleted, particularly for the late dry season (Dec 2019) sampling event. However, the water level data indicate that the bore (NS-0664) levels and the pool levels are both similarly responsive to large rainfall events (Figure 4). This suggests that the surface water within Site 12 Pool is maintained by groundwater, though not directly that which is represented by bore NS-0664. It is likely that some degree of evaporation along the groundwater inflow to the pool, and within the pool system itself, is creating an enriched signature relative to the deeper groundwater (NS-0664) which is more representative of large rainfall event recharge.

The December 2019 isotope enrichment in the Site 12 Pool is evidence that at this stage “fresh” or deep groundwater recharge was at a minimum and evaporative isotopic enrichment was a dominant process. This is consistent with the water level data (Figure 4) which shows that as the groundwater levels reach a critical point, evaporative losses from the pool are in excess of groundwater inflows and rapid drying occurs.

The most depleted isotopic ratio of the dataset was observed at the Site 12 groundwater monitoring bore (NS-0664) following the large 2020/21 wet season. This may indicate that the source of the groundwater at the site was relatively recent rainfall during this period. There are preliminary indications that the groundwater at the Site 12 Pool monitoring bore is more similar to a rainwater isotopic composition after the wet season, moving towards the evaporation line in the late dry. Further sampling would be required to confirm this.

## **MUNDAGOORA POOL**

While there are currently no groundwater monitoring bores within the vicinity of Mundagoora Pool, the water quality and water level logger data indicate that this is a groundwater dependent system. It is a permanent water feature and maintains a constant water level through to the end of the dry season. The pattern of isotopic enrichment within the pool is consistent with evaporative processes active over groundwater replenishment. The highest enrichment occurred in the late dry season, with the lowest following the large wet season of 2020/21. The evident isotopic ratios for Mundagoora Pool were along the Local Evaporation Line (LEL) for the region (Dogramaci et al 2012), providing further evidence that evaporative processes are a feature of the water balance for the pool and that groundwater recharge is relatively slow over the dry season, though high enough to replace evaporative losses (as the pool level remains constant). Older groundwater (with more isotopic enrichment) may also contribute a larger fraction of the inflows as the dry season progresses.

The isotope data from Mundagoora Pool indicates that there is little direct rainfall influence on the pool, with the trend-line being closest to the Hamersley groundwater line (Dogramaci et al 2012).

## **FIG AND COW SPRING POOLS**

Fig Pool was the least variable of the sampled sites with only minor variability and evaporative effects evident across the seasonal sampling (Figure 2). The local groundwater monitoring bore (NS-Obs29) was depleted relative to the pool, though to a lesser extent. The lack of direct catchment, and the permanent status of Fig Pool indicate that it is groundwater dependant. The low pH however indicates that there are geochemical processes within the pool that occur at a higher rate than groundwater replenishment (such as root mat iron oxidation (redox) processes). The evidence of evaporative enrichment of isotopes also indicates that groundwater inflow is relatively slow to this site.

Cow Spring Pool does not have an associated monitoring bore, however the late wet season (May 2020) sampling showed similar isotopic depletion at Cow Spring Pool and the Fig Pool monitoring bore (NS-

Obs29; Figure 2). The small catchment and permanent status of Cow Spring Pool indicate that it is likely to be groundwater dependant, which is supported by the limited available isotopic data.

### **CENTRAL CREEK POOL**

The groundwater adjacent to Central Creek Pool (monitoring bore NS-Obs17) was only sampled in May 2020 (late wet season), when it was representative of relatively isotopically enriched waters. This is possibly due to its location low within the catchment providing a more evaporative signature as groundwater moves down through the local elevation. The surface water pool showed a ratio closer to the Hamersley rainfall line (Figure 2) though with some enrichment evident. The late wet 2021 pool isotopic signature was closer to the groundwater signature indicating that under wetter conditions both may be associated with a superficial or alluvial aquifer.

### **SOUTH-WEST GV POOL**

There are no groundwater monitoring bores currently associated with the South-West GV Pool (GV\_SW\_Pool\_SW). Only a single late wet 2021 surface water sample is available for this site, which indicated that it had a similar isotopic signature to other pools in the area including Site 12 Pool, Mundagoora Pool and Central Creek Pool. It is likely that this pool is representative of local relatively recent inflows from superficial groundwater systems in the upper catchment. The ephemeral nature of the pool also suggests that it is not fed by regional groundwater over the dry season. There is anecdotal evidence from discussions with Traditional Owners that a spring is present at this site, though this was not evident (flowing) at the time of a late dry season (2020) site inspection.

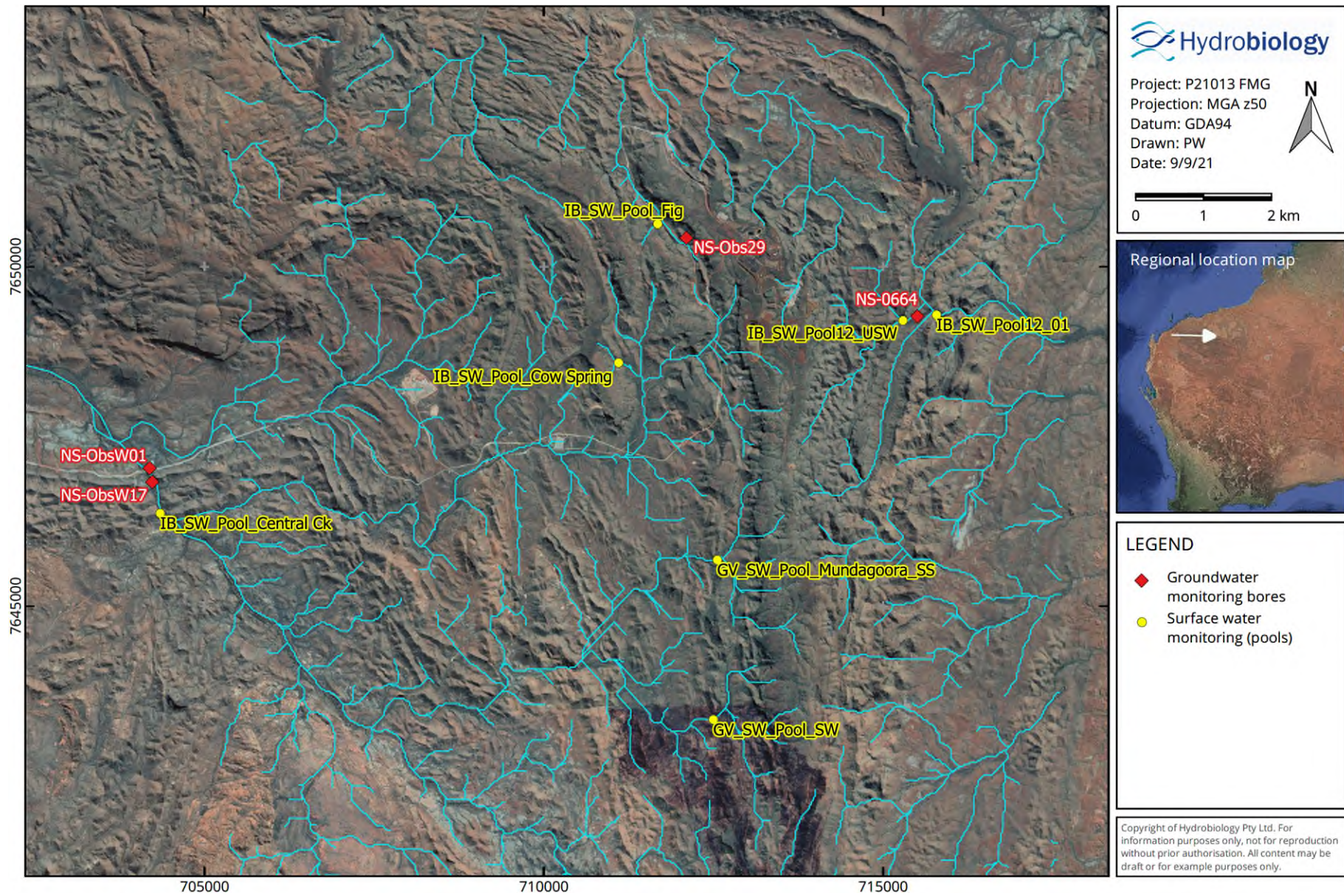


Figure 1 Map of site locations for isotope analysis – Iron Bridge Project Area

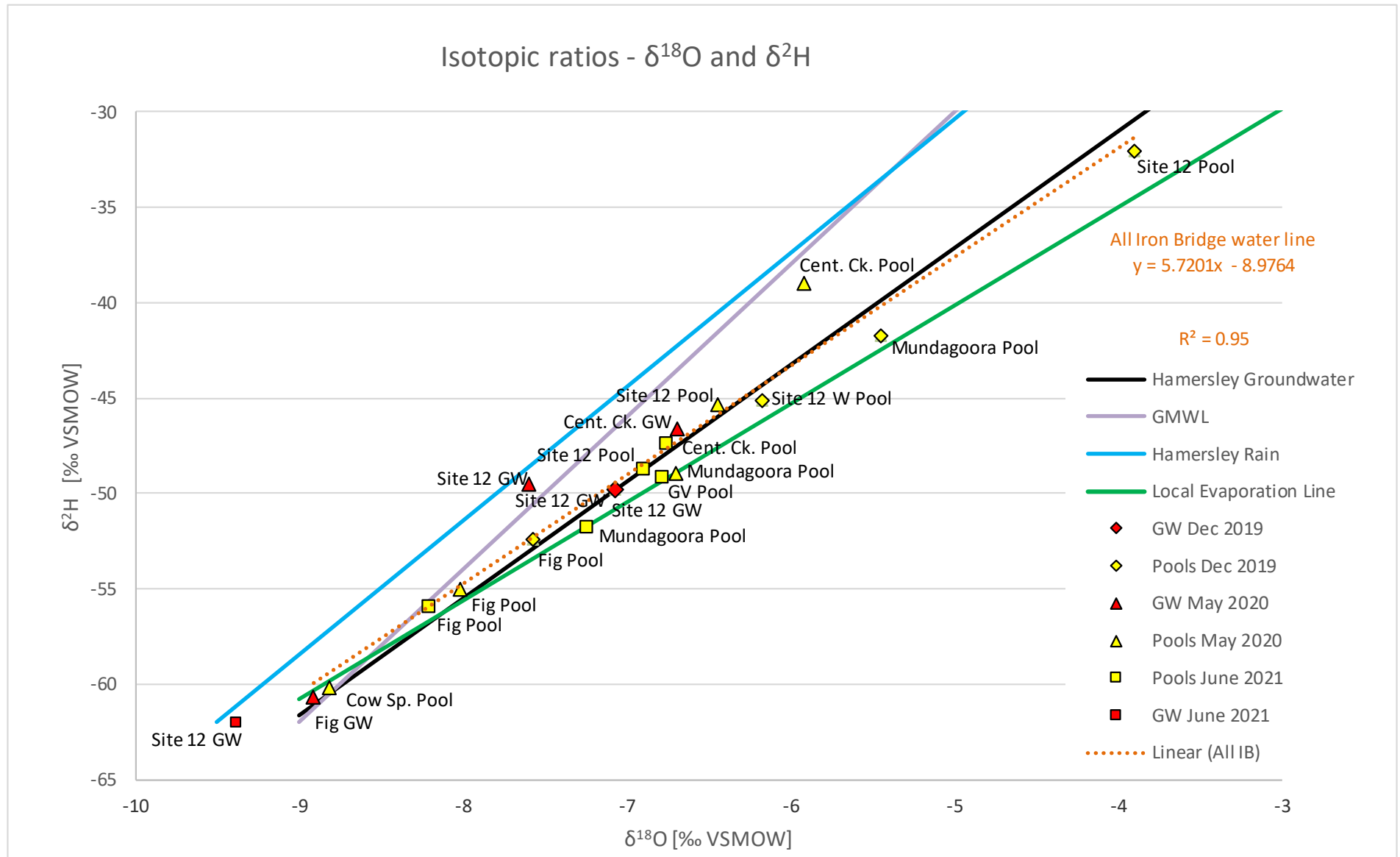


Figure 2 Isotope ratios for surface and groundwater samples collected from December 2019 to June 2021

Table 1 Stable isotope data (December 2019 to June 2021)

Site Name	Site description	Date	Type	d <sup>18</sup> O [‰ VSMOW]	d <sup>2</sup> H [‰ VSMOW]
<b>GV_SW_Pool_SW</b>	Small ephemeral river pool in Glacier Valley project area to south of Mundagoora pool catchment	16/06/2021	Pool	-6.78	-49.2
<b>GV_Pool_Mundagoora_SS</b>	Permanent pool in Glacier Valley project area	17/12/2019	Pool	-5.44	-41.8
<b>GV_Pool_Mundagoora_SS</b>		30/05/2020	Pool	-6.7	-49
<b>GV_Pool_Mundagoora_SS</b>		16/06/2021	Pool	-7.24	-51.8
<b>IB_SW_Pool_Central Ck</b>	Small ephemeral pool in Iron Bridge project area.	31/05/2020	Pool	-5.92	-39
<b>IB_SW_Pool_Central Ck</b>		16/06/2021	Pool	-6.75	-47.4
<b>IB_SW_Pool_Cow Spring</b>	Small permanent pool at base of rockface in Iron Bridge project area.	1/06/2020	Pool	-8.81	-60.2
<b>IB_SW_Pool_Fig</b>	Small permanent pool at base of rockface in Iron Bridge project area. Naturally low pH.	18/12/2019	Pool	-7.57	-52.5
<b>IB_SW_Pool_Fig</b>		30/05/2020	Pool	-8.01	-55.1
<b>IB_SW_Pool_Fig</b>		17/06/2021	Pool	-8.2	-56
<b>IB_SW_Pool12_01</b>	Semi-permanent river pool over bedrock in Iron Bridge project area.	17/12/2019	Pool	-3.9	-32.1
<b>IB_SW_Pool12_01</b>		29/05/2020	Pool	-6.44	-45.4
<b>IB_SW_Pool12_01</b>		15/06/2021	Pool	-6.89	-48.8
<b>IB_SW_Pool12_USW</b>	Small pool in crevice at ridgeline crossing of Site 12 creek. Upstream of Site 12 Pool.	19/12/2019	Pool	-6.17	-45.1
<b>NS-0064</b>	Monitoring bore upstream of Site 12 Pool.	17/12/2019	Groundwater	-7.07	-49.8
<b>NS-0064</b>		29/05/2020	Groundwater	-7.59	-49.6
<b>NS-0064</b>		15/06/2021	Groundwater	-9.38	-62.1
<b>NS-Obs17</b>	Monitoring bore downstream of Central Ck pool	1/06/2020	Groundwater	-6.68	-46.6
<b>NS-Obs29</b>	Monitoring Bore near Fig Pool	1/06/2020	Groundwater	-8.91	-60.7

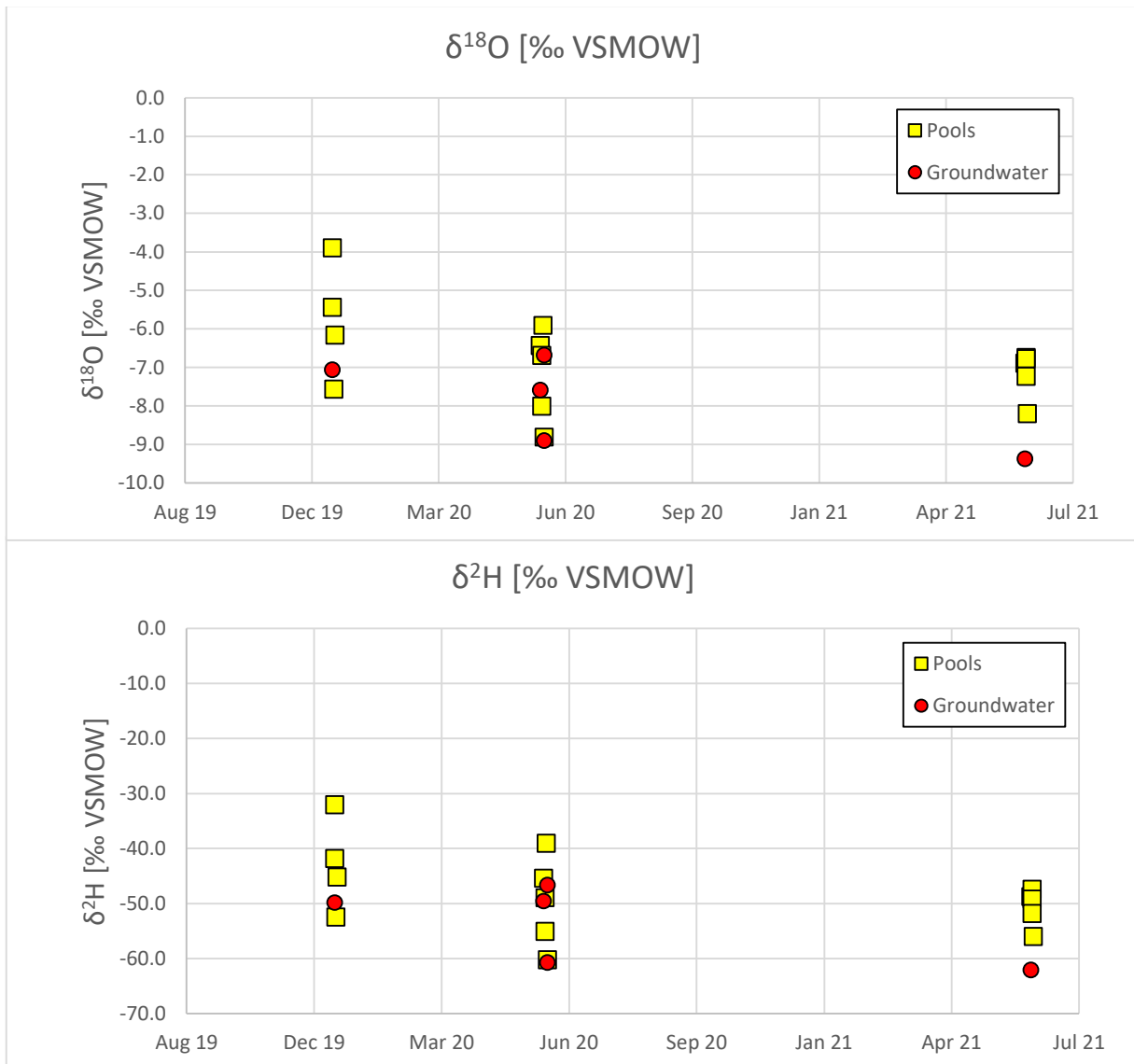


Figure 3 Isotopic ratios by sample date and water type – Dec 2019 to June 2021

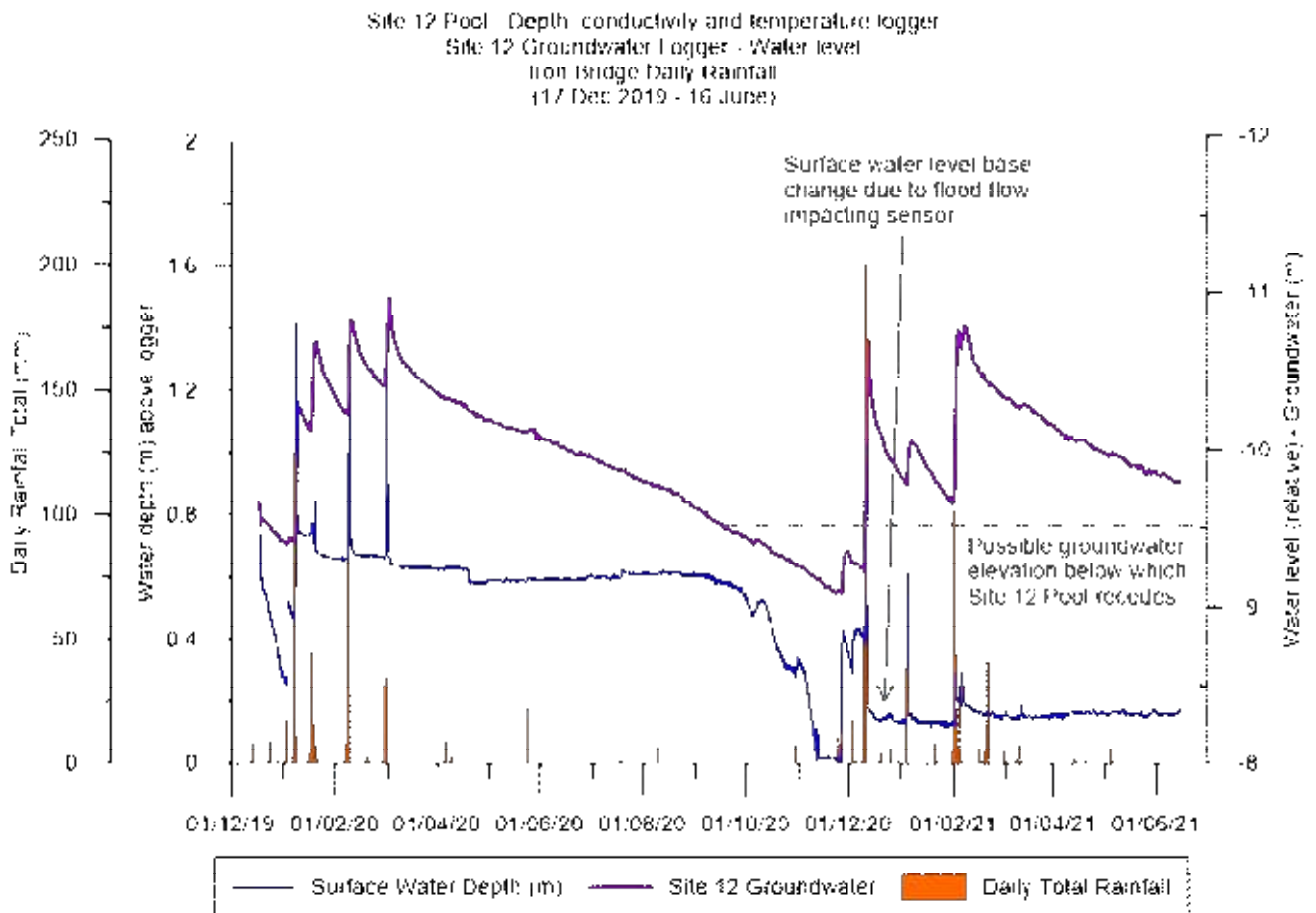


Figure 4 Comparison of surface water levels in Site 12 Pool (IB\_SW\_Pool12\_01) and groundwater levels within the adjacent monitoring bore (NS-0664).

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**Attachment 6: Site 12 Pool Water Quality and  
Hydrological Regime Investigation  
(Hydrobiology, 2021)**

# SITE 12 POOL WATER QUALITY & HYDROLOGICAL REGIME INVESTIGATION

BRISBANE | PERTH | SINGAPORE | PAPUA NEW GUINEA

FMG IRON BRIDGE (AUST) PTY LTD



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## GLOSSARY OF ACRONYMS

Acronym	Definition
ANZG	Australian and New Zealand Guidelines for fresh and marine water quality
CEO	Chief Executive Officer
DITR	Department of Industry, Tourism and Resources
DO	Dissolved oxygen
DOC	Dissolved organic carbon
DSIAR	Diatom Species Index for Australian Rivers
EC	Electrical Conductivity (conductivity normalised to 25°C)
eDNA	Environmental Deoxyribonucleic Acid
EPBC	Environmental Protection and Biodiversity Conservation
EPT	Ephemeroptera, Plecoptera, Tricoptera
FMGIB	FMG Iron Bridge (Aust) Pty Ltd
MS	Ministerial Statement
N	Nitrogen
NTU	Nephelometric Turbidity Units
P	Phosphorous
QA/QC	Quality Assurance/Quality Control
SO4	Sulphate
TDS	Total Dissolved Solids
TIC	Total Inorganic Carbon
TOC	Total Organic Carbon
TSS	Total Suspended Solids
WQMMP	Water Quality Monitoring and Management Plan
WRD	Waste Rock Dump

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# 1. INTRODUCTION

This document provides technical support to inform the Site 12 Pool monitoring and management approach at Iron Bridge mine

## 1.1 BACKGROUND

Site 12 Pool lies on a small tributary downstream of a proposed Waste Rock Dump (WRD) planned for construction by the proponent, FMG Iron Bridge (Aust) Pty Ltd (FMGIB), as part of the North Star Magnetite Project (the Project) in the Pilbara region of Western Australia (Figure 1-1). The managing entity for the Project is IB Operations Pty Ltd (Iron Bridge), a joint venture company between FMGIB and Formosa Steel IB Pty Ltd.

The Project was approved by Ministerial Statement (MS) 993, where Condition 12 of MS 993 specifies that a Water Quality and Quantity Monitoring Plan (WQQMP) is developed to demonstrate that the implementation of the Project within the Site 12 Pool catchment does not have a detrimental impact on the water quality or hydrological regime of Site 12 Pool. To assist FMGIB to meet MS 993 Condition 12, the current technical report was prepared to support the WQQMP. This report details the monitoring and evaluation process, trigger levels, threshold criteria and contingency actions to demonstrate compliance with the water quality and hydrological regime objectives under Condition 12-2 of MS 993.

The Project is located 145 km by road south of Port Hedland in the Pilbara region and incorporates the North Star Magnetite ore bodies. Site 12 Pool is part of a series of pools that lie to the east of the Project on a small tributary to the upper Six Mile Creek within the Strelley River Water Catchment (Figure 1-2) and is situated within the Chichester IBRA bioregion and the Grassland climate class (Koppen; Figure 2-6). It is connected to both surface water and groundwater sources over the hydrologic cycle. It is an ephemeral system, known to dry out following small wet seasons. The Site 12 Pool area provides a habitat to the EPBC Act (1999) listed Pilbara olive python (*Liasis olivaceus barroni*)

(vulnerable). The protection of the Pilbara olive python habitat was a factor for the inclusion of condition 12. The importance of managing the Project within the catchment of Site 12 Pool not to have a detrimental impact on the water quality is encompassed in this report.

This report followed the ANZG (2018a) guidance for developing water quality guidelines, the *Managing Acid and Metalliferous Drainage* (DITR 2007) guidelines, the EPA (2018) factor for *Inland Waters*, and applies the *Temporary Waters Guidance* (ANZG 2018b). The *Temporary Waters Guidance* (ANZG 2018b) considers the formulation of site-specific guideline values using a multiple lines of evidence approach to be most appropriate for the protection of aquatic ecosystems, above applying generic principles and default guidelines (ANZG 2018a; ANZG 2018b). Therefore, we have formed a management and monitoring approach by measuring indicators and developing guideline values from multiple lines of evidence across the Pressure-Stressor-Ecosystem Receptor (PSER) causal pathway. These were selected to be protective of the ecological functioning of the system and protect key temporal stages of the hydrological cycle.

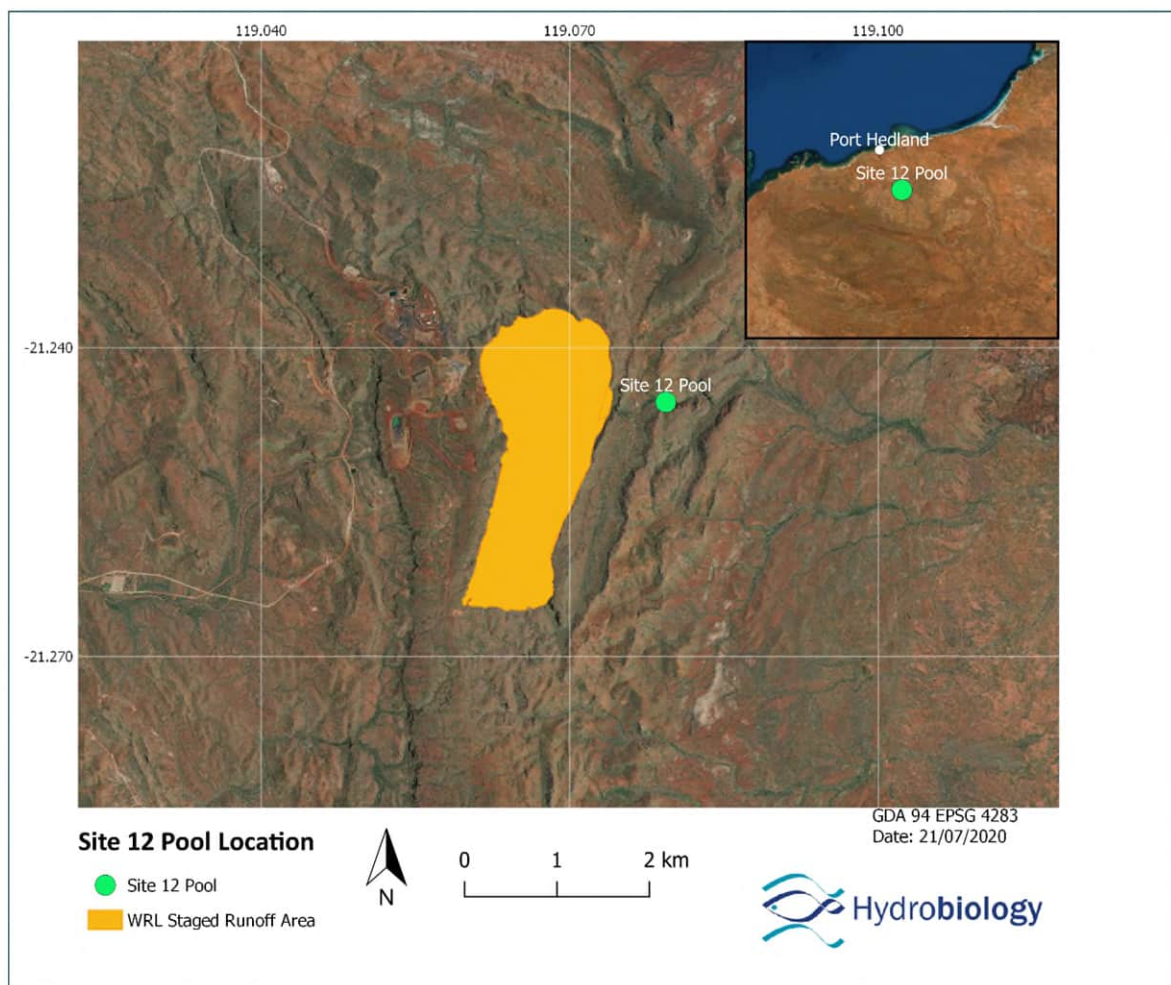


Figure 1-1 Overview map of Site 12 Pool location.

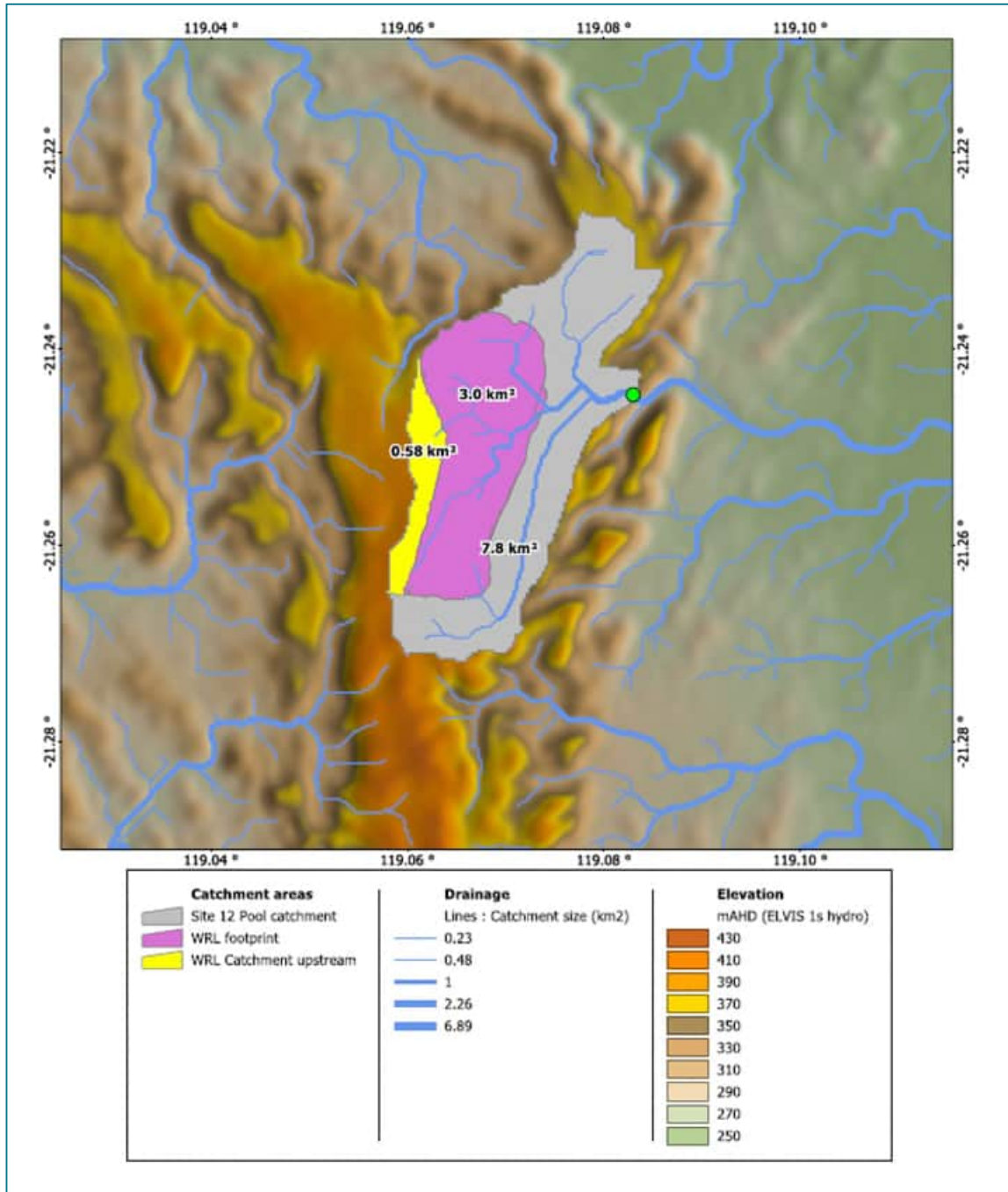


Figure 1-2 Site 12 Pool catchment and the footprint of the WRD within the catchment.

## 1.2 OBJECTIVES

The objective of this Water Quality and Hydrological Regime Investigation is to provide technical input to the Site 12 Pool WQQMP to inform the Site 12 Pool monitoring and management approach including:

- Monitoring locations, frequency and parameters
- Specified Early Response Trigger Levels and guidance for conducting an Early Response Trigger Investigation to determine the cause of exceedance
- Specified ecological monitoring parameters, levels and corresponding Threshold Criteria
- Framework for the development of contingency actions to be implemented for mitigating changes to water quality and quantity in the event that any Early Response Trigger Levels or Threshold Criteria are exceeded.
- Assessment framework to determine if the implementation of the Project within the catchment of Site 12 Pool has had a detrimental impact on Site 12 Pool.

# 2. RATIONALE AND APPROACH

This section outlines the monitoring and management approach as guided by ANZG (2018a), ANZG (2018b) and DITR (2007). This methodology section details the following:

- Environmental outcomes and outline of measures to ensure environmental outcomes are achieved.
- Detrimental impact definition and assessment, and environmental value definition.
- Survey and study findings of water quality, hydrological regime and aquatic ecology.
- Identification of conceptual impacts and impact mechanisms.
- Selection of relevant indicators from the PSER causal pathway using a multiple lines of evidence approach and rationale for indicator selection.
- Derivation of seasonally relevant Early Response Trigger Levels for water quality indicators.
- Derivation of Threshold Criteria based on ecological indicators.
- Key assumptions and uncertainties

## 2.1 ENVIRONMENTAL OUTCOMES

There shall be no detrimental impact on the water quality or hydrological regime of Site 12 Pool from implementation of the Project within the catchment of Site 12 Pool located in the Mine Development Envelope.

The environmental outcome is achieved through:

- Implementation of the Site 12 Pool WQQMP, which is informed by this Site 12 Pool Water Quality and Hydrological Regime Investigation.
- The monitoring approach incorporating the use of Early Response indicators to detect early changes to water quality and quantity parameters, and ecological parameters that link changes in water quality and quantity to changes to flora and fauna.
- The contingency actions were developed to be responsive to detected exceedances and allow for case-specific response to exceedances caused by the Project.
- Implementation of preventative management measures to ensure no detrimental impact to water quality and water quantity of Site 12 Pool, including a large toe bund / plug as part of the WRD development for the WRD sediment control.
- The monitoring of groundwater quality and level, as well as surface water quality and quantity upstream of Site 12 Pool to allow for early detection of changes.

## 2.2 DETRIMENTAL IMPACT ASSESSMENT

### 2.2.1 ENVIRONMENTAL VALUE

The Site 12 Pool environmental value is the value as an aquatic ecosystem, encompassing both the surface water and surface water dependant systems.

The management approach and derived guidelines, therefore, aim to monitor and mitigate detrimental impacts to the Site 12 Pool environmental value as an aquatic ecosystem. The ecological parameters selected to be monitored and assessed are those which can be reliably measured, and their presence and health indicate the ability of Site 12 Pool to sustain the aquatic ecosystem flora and fauna. These parameters include algal, macrophyte, fish and macroinvertebrate communities. Indicator selection is outlined in Section 2.6.2. The assessment of these parameters aligns with the EPA (2018) Environmental Factor Guideline for Inland Waters, where the environmental value related to inland waters includes the ability to sustain vegetation, aquatic fauna and birdlife and the ecological processes that support them.

#### Environmental Value

Environmental value is defined under the *Environmental Protection Act 1986* as a beneficial use or an ecosystem health condition. For example, water resources may be used for humans, food production or aquatic ecosystems. The Water Quality Guidelines (ANZG 2018a) aims to provide guidance to assess whether the water quality of the water resource is sufficient to allow it to be used for its environmental value. Where water quality guidelines are not met, this indicates the waters may not be suitable for the environmental values and management actions are triggered to assess the issue more thoroughly or implement contingency measures to mitigate the issue.

(ANZG 2018a)

## 2.2.2 DETRIMENTAL IMPACT

To comply with the approval requirements (MS 993 Condition 12) and the EPA (2018) Inland Waters objective, Iron Bridge shall ensure that the Project within the catchment of Site 12 Pool does not have a detrimental impact on Site 12 Pool.

'Detrimental impact' at Site 12 Pool is defined as **'the loss of environmental value'**, where the environmental value is the Site 12 Pool aquatic ecosystem (Section 2.2.1). The aquatic ecosystem is measured by a set of four ecological criteria that are assigned either low, moderate or high risk of indicating loss to the environmental value. When the designated number of moderate and/or high-risk criteria are met, the Threshold Criteria is determined to be exceeded. Detrimental impact or 'the loss of environmental value' is determined as where the Threshold Criteria is exceeded (Section 3.4.1).

A detrimental impact resulting from the Project is demonstrated through a multiple lines of evidence approach, where indicators have been selected from the Pressure-Stressor-Ecosystem Receptor (PSER) causal pathway (Figure 2-10). Due to the highly variable hydrological and ecological system at Site 12 Pool, determining a detrimental impact resulting from the Project rather than natural variability involves linking the Pressure to Stressor to Ecosystem Receptor. Therefore, Threshold Criteria is assessed after all the following have occurred:

- I. An exceedance of Early Response Trigger Levels (*Stressor identified*);
- II. Early Response Trigger Investigation determines the exceedance is due to the Project, not a natural cause (*Pressure identified*); and
- III. Ecological parameters meeting Moderate or High-Risk categories for indicating declining environmental value are validated by expert ecological assessment as not occurring due to natural causes (*Ecosystem receptor identified*)
- IV. The required number of Moderate-Risk or High-Risk ecological parameters exceeded meets the Threshold Criteria (Table 1 & Table 2).

Table 1 Threshold Criteria

Criteria	Assessment Parameters
Threshold Criteria	≥2 High Risk Criteria
	≥2 Moderate Risk and ≥1 High Risk Criteria
	≥3 Moderate Risk Criteria

Table 2 Threshold Criteria Assessment Table.

Environmental parameters	LOW RISK <sup>1</sup>	MODERATE RISK <sup>1</sup>	HIGH RISK <sup>1</sup>
Macroinvertebrate communities <sup>2</sup>	Presence of EPT taxa > 0.5B	EPT index < 0.5B OR SIGNAL2 score < the lower of 2 or B-1	No EPT taxa present
Fish communities	<i>Melanotaenia australis</i> present including small size classes (<60 mm)	<i>Melanotaenia australis</i> present and no small size classes present	No fish species present
Diatom communities <sup>3</sup>	DSIAR score > 0.5B	0.5B > DSIAR score > 0.2B	DSIAR score less than 0.2B
Macrophyte communities	Emergent (reed-like and tussock/rush-like species) present in ≥ isolated abundance	Emergent macrophytes present, with evidence of deteriorating health > B maximum	Emergent and submerged macrophytes absent

<sup>1</sup> B=Baseline seasonally relevant mean (i.e. wet or dry season ecological baseline values).

<sup>2</sup> The EPT Richness Index estimates water quality by the relative abundance of three major orders of stream insects that have low tolerance to water pollution: Ephemeroptera (mayflies), Plecoptera (stoneflies), and Tricoptera (caddisflies). SIGNAL (Stream Invertebrate Grade Number – Average Level) is a scoring system for macroinvertebrate samples from Australian rivers that indicates water quality based on tolerance or sensitivity of macroinvertebrate families present to water quality.

<sup>3</sup> DSIAR score (Diatom Species Index for Australian Rivers score) estimates water quality by the relative abundance of diatom species sensitive to water quality stressors.

## 2.3 SURVEY AND STUDY FINDINGS

The Water Quality Guidelines (ANZG 2018a) recommend the use of conceptual models to help understand the key processes involved and facilitate management decisions for complex natural systems. This section characterises the water quality, hydrological and ecological features of Site 12 Pool. This understanding was used to conceptually identify mechanisms that potentially impact environmental value (Section 2.4). The conceptual model was then used as a basis to select informative lines of evidence and indicators and develop the monitoring approach.

### 2.3.1 KEY CHARACTERISTICS OF POOLS AT IRON BRIDGE

The key characteristics, water quality and aquatic ecology of surface water pools at Iron Bridge are presented in detail in *Surface Water Monitoring and Aquatic Ecology Survey Baseline Report* (Hydrobiology 2021). To provide context to the features and values of Site 12 Pool, key features of Iron Bridge pools are summarised as follows:

- Surface water pools surveyed in the Iron Bridge area have high spatial and temporal variability. They are generally fresh-brackish and clear (<10 NTU) with pH ranging from acidic (pH: 3.3) to alkaline (pH: 9.3). Pools typically comprise isolated submerged macrophytes and emergent macrophytes. Benthic cover ranges from algae dominated bedrock, bare sediment to thick cover of macrophytes.
- Pools at Iron Bridge, like those of temporary pools in the Pilbara region, undergo large seasonal variability in water quality and water level (Figure 2-1). In the dry season, rivers and creeks are reduced to a series of these isolated pools which are largely sustained by groundwater levels. Where pools are not maintained by groundwater levels (e.g. Central Creek Pool), evaporation has a greater influence and concentrations of parameters that are normally diluted by flows (e.g. salinity) increase, and pH and dissolved oxygen generally decline.
- In the wet season, large flood events are required to recharge aquifers and fill pools. The first small rainfall events early in the wet season primarily infiltrate the surrounding soil and have little impact on surface water levels and quality. However, the first flush from larger rainfall events is typically high in sediment and dissolved oxygen and can have a substantial impact on the water quality. These flush events can transport relatively higher concentrations of metals and metalloids into the pools, and result in rapid decreases in salinity. In pools with substantial groundwater inputs, the salinity increases over time following the rainfall event as the groundwater replaces the pool volume.
- The wetting-drying cycle influences the ecological processes and the composition and distribution of aquatic biota. The ecology is adapted to highly variable hydrology and water quality of pools at Iron Bridge. Fish species recorded include common and widespread species, *Melanotaenia australis* (western rainbowfish) and *Leiopotherapon unicolor* (spangled perch), which were present in pools ranging from acidic to alkaline pH, though were absent from a small naturally acidic pool (Fig Pool). A wide diversity of macroinvertebrates and macrophyte species were present in all pools surveyed, with the exception of Fig Pool. The natural acidity of Fig Pool is discussed in *Surface Water Monitoring and Aquatic Ecology Survey Baseline Report* (Hydrobiology 2020).
- The aquatic ecology surveys which have informed the key characteristics of Iron Bridge pools were conducted in the late wet season 2020, late dry season 2020 and late wet season 2021. However, high seasonal variability in biodiversity and abundance within and between pools is expected. Typically, in temporary Pilbara pools, the early stages of inundation in the wet season are characterised by largely adult or resting stages being present and food webs are poorly established. In the recessional period (after the wet season), the aquatic ecosystem is established and includes life-history stages that are more sensitive to exposure to toxicants and declining

water quality. In the late drying phase, the concentration of potential stressors (e.g. salinity) occurs and, again, only adults and/or resting stages may be present. Differences in the age/size classes of fish within these pools from wet to dry season sampling events have been recorded, consistent with this cycle (Hydrobiology 2021).

## Ecology of Temporary Pilbara Pools

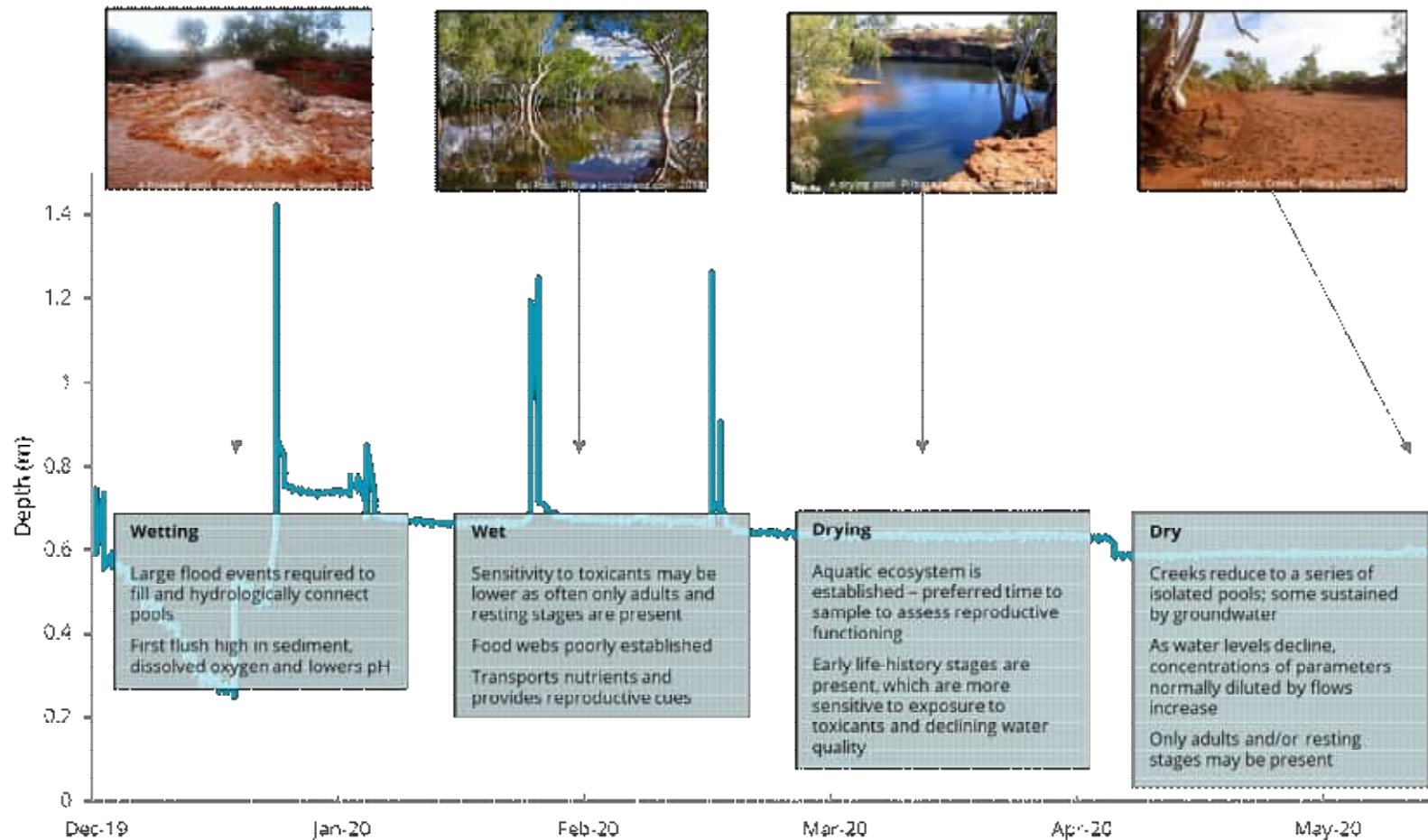


Figure 2-1 Site 12 Pool depth (m) varies over the wetting-drying cycle (Dec 2019 – May 2020). Note the graph is a representation of key stages and does not include the full hydrological cycle, and the above photographs depict a range of sites from the Pilbara, not Site 12 Pool.

## 2.3.2 KEY CHARACTERISTICS OF SITE 12 POOL

### 2.3.2.1 WATER QUALITY AND THE HYDROLOGICAL REGIME

The key characteristics of the Site 12 Pool water quality and the hydrological regime are provided in further detail in *Surface Water Monitoring and Aquatic Ecology Survey Baseline Report* (Hydrobiology 2021). The key features are:

- A bedrock supported natural habitat that lies in a small catchment (Figure 1-2) with typically low rainfall and infrequent high rainfall events largely driven by storm and cyclonic activity.
- The water quality experiences high seasonal variability due to the climatic conditions of the region and the temporary nature of the waterbody. The greatest variability recorded occurs following rainfall events (Figure 2-2 and Figure 2-3).
- Conductivity was typically slightly brackish (1,100-1,300  $\mu\text{S}/\text{cm}$ ) except during surface water flow events when it would become extremely fresh (<100  $\mu\text{S}/\text{cm}$ ) (Figure 2-2 and Figure 2-3).
- Groundwater levels in the upgradient monitoring bore (NS-0664) respond similarly to the fluctuations in the Site 12 Pool levels in response to large rainfall/recharge events (Figure 2-4).
- Predominantly clear (mean turbidity = 2.5 NTU), slightly alkaline (mean pH = 8.5) and a magnesium-bicarbonate ( $\text{Ca}/\text{Mg}-\text{HCO}_3$ ) dominated water type with low sulphates ( $\text{SO}_4$ ) (Figure 2-5).
- Preliminary baseline data indicates that the pool is sustained by groundwater, until the local groundwater level drops below the pool level. The pool is also periodically flushed with fresh surface water flows after rainfall events. The ratio of Site 12 Pool volume against inflow volume is presented in *Site 12 Pool Water Quantity Investigation* (FMG, 2020b). It takes approximately 2-3 weeks for groundwater to replace the pool water once a flushing event has occurred.
- A larger habitat area relative to other Iron Bridge pools, with a series of isolated pools spanning approximately a 650 m reach and 1266  $\text{m}^2$ , and likely has greater downstream connectivity relative to other pools in the Iron Bridge area.
- Most pools are shallow, with the deepest being approximately 2.5 m. The total volume of the pools is estimated to be 2,532  $\text{m}^3$  based on an average depth of 2 m. This is a small volume relative to the inflow volume; for example, the 1EY post-development estimated inflow is substantially higher (54,198  $\text{m}^3$ ) (FMG, 2020b).
- The proposed WRD would reduce the existing Site 12 Pool catchment by 40%, which is predicted to reduce the peak flow into the Site 12 Pool system by approximately 50%. Despite the significant reduction in flow, the impact on the scouring ability and total inflow volume to the pools remain largely unchanged. This is due to the relatively small pool volume compared to the inflow volume of the reduced catchment resulting in even small and frequent rainfall events causing the pool to fill and overflow, maintaining catchment connectivity.
- Recorded water levels were a maximum of ~0.6 m above the pool overflow levels during high-flow events, which typically lasted less than 24 hours before flows receded.
- The pool is frequently temporal, running dry for three to ten months of the year (based on a five-year monitoring period). The most recent observations noted it did not completely dry out in 2019 dry season, due to a relatively high rainfall previous wet season. There was a short dry period in the of several weeks at the end of the 2020 dry season before a rainfall event in November 2020 recharged inflows and groundwater levels (Figure 2-4).

Figure 2-2 displays a high-resolution water level, salinity (conductivity) and temperature logger record from Site 12 Pool for the wet season of 2019/20. The rapid change in conductivity after rainfall events

is evident, with one minor inflow at the start of the wet season that partially flushed and filled the pool as well as four major inflows that displayed flooding peaks and complete pool flushing. The falling stage is rapid after large flow events indicating there is little retention capacity in the system beyond the pool spill point.

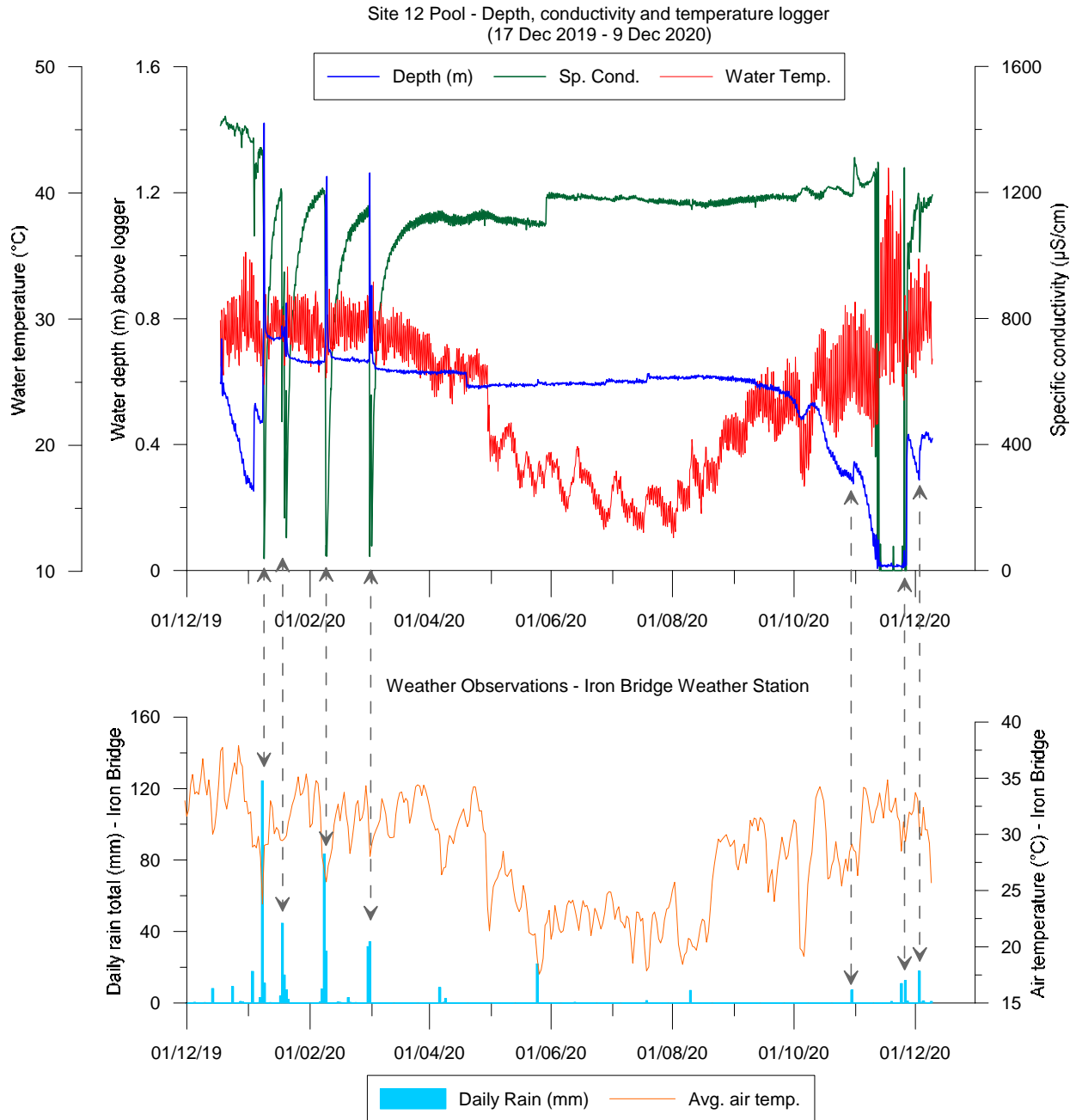


Figure 2-2 Depth, conductivity, and temperature logger data (above) relationship to daily rainfall (below) – Dec 2019 to Dec 2020.

Site 12 Pool - Depth, conductivity and temperature logger  
(9 Dec 2020 - 16 June 2021)

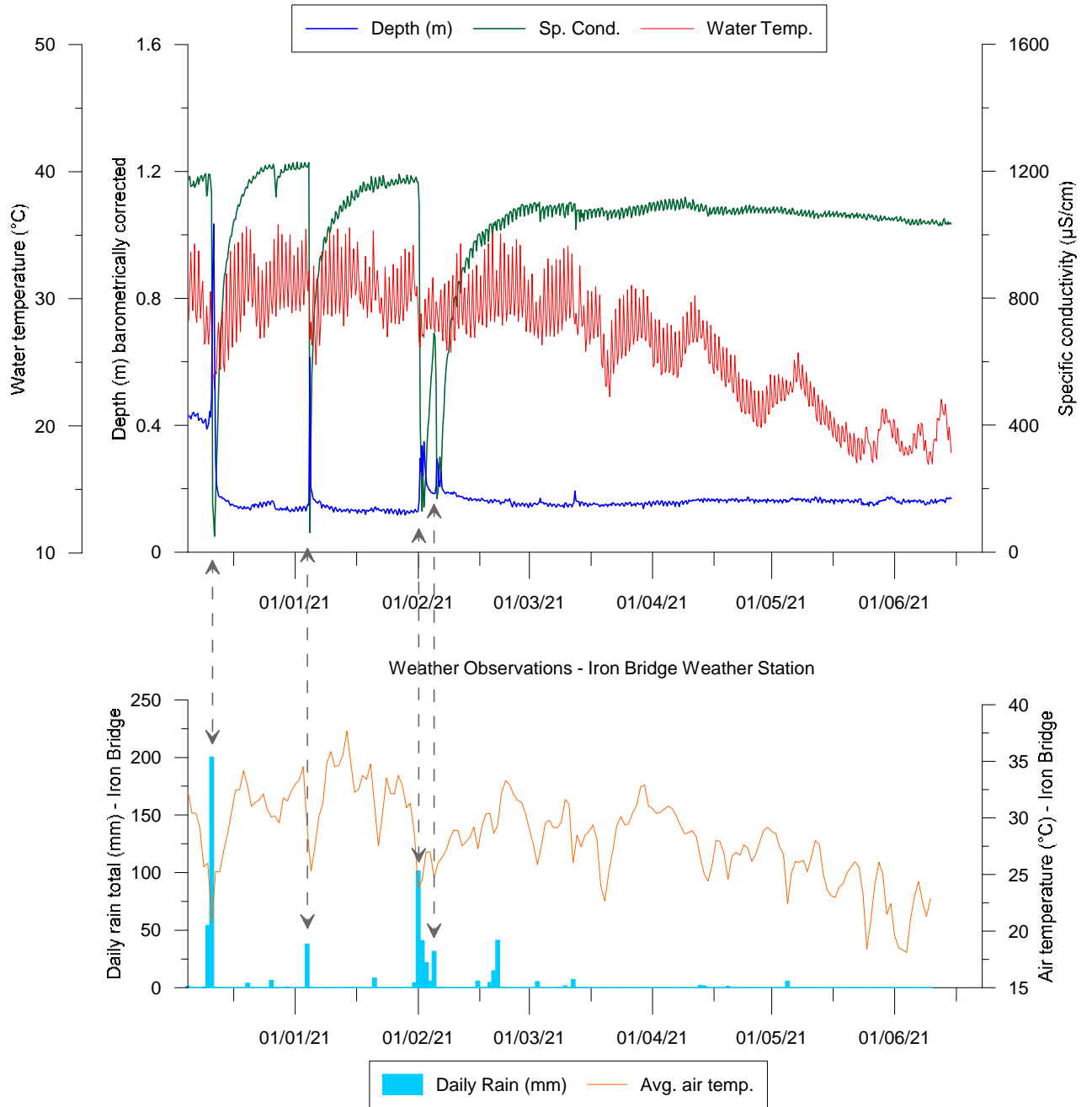


Figure 2-3 Depth, conductivity, and temperature logger data (above) relationship to daily rainfall (below) – Dec 2020 to June 2021.

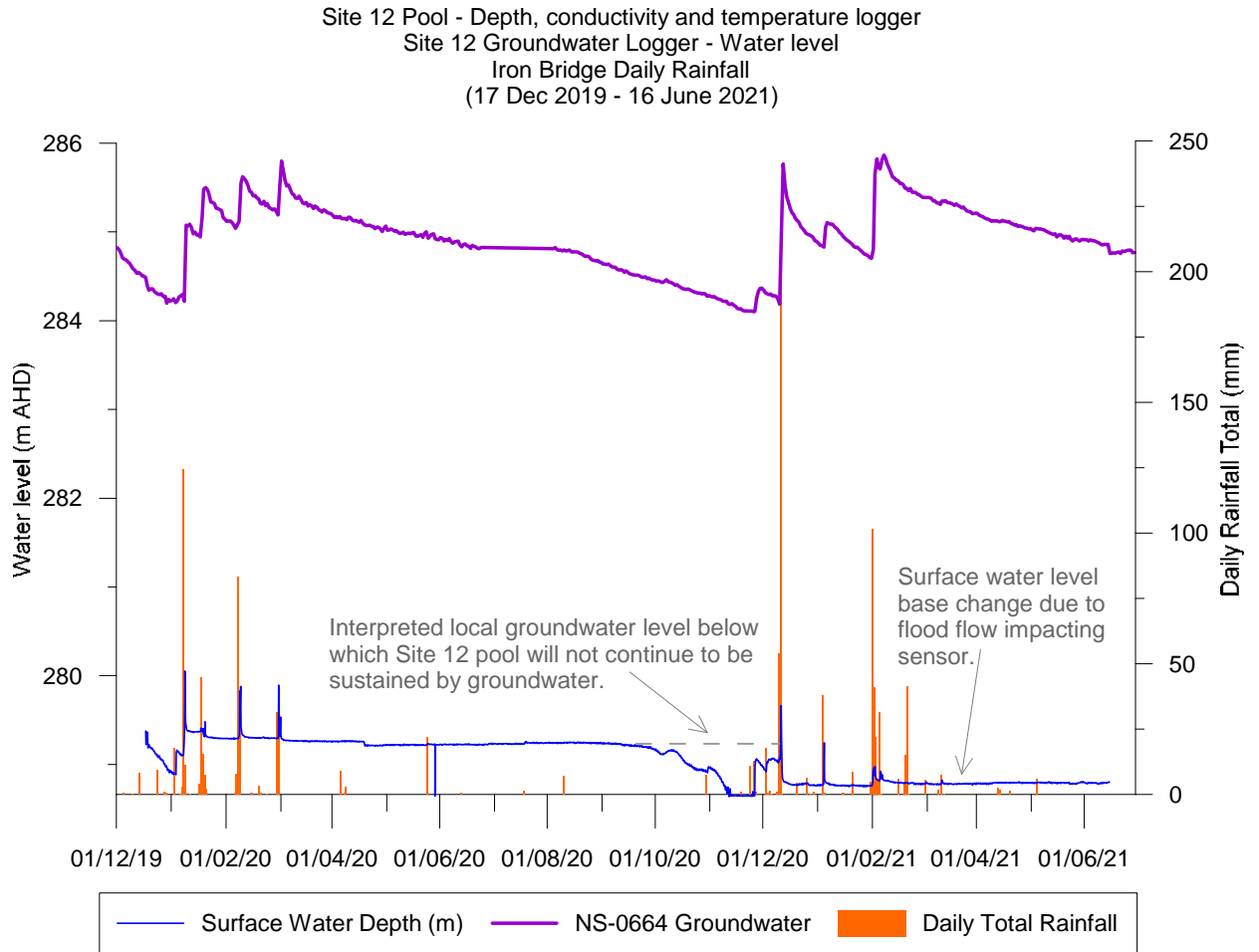


Figure 2-4 Comparison of surface water levels in Site 12 Pool and groundwater levels within the upgradient monitoring bore (NS-0664).

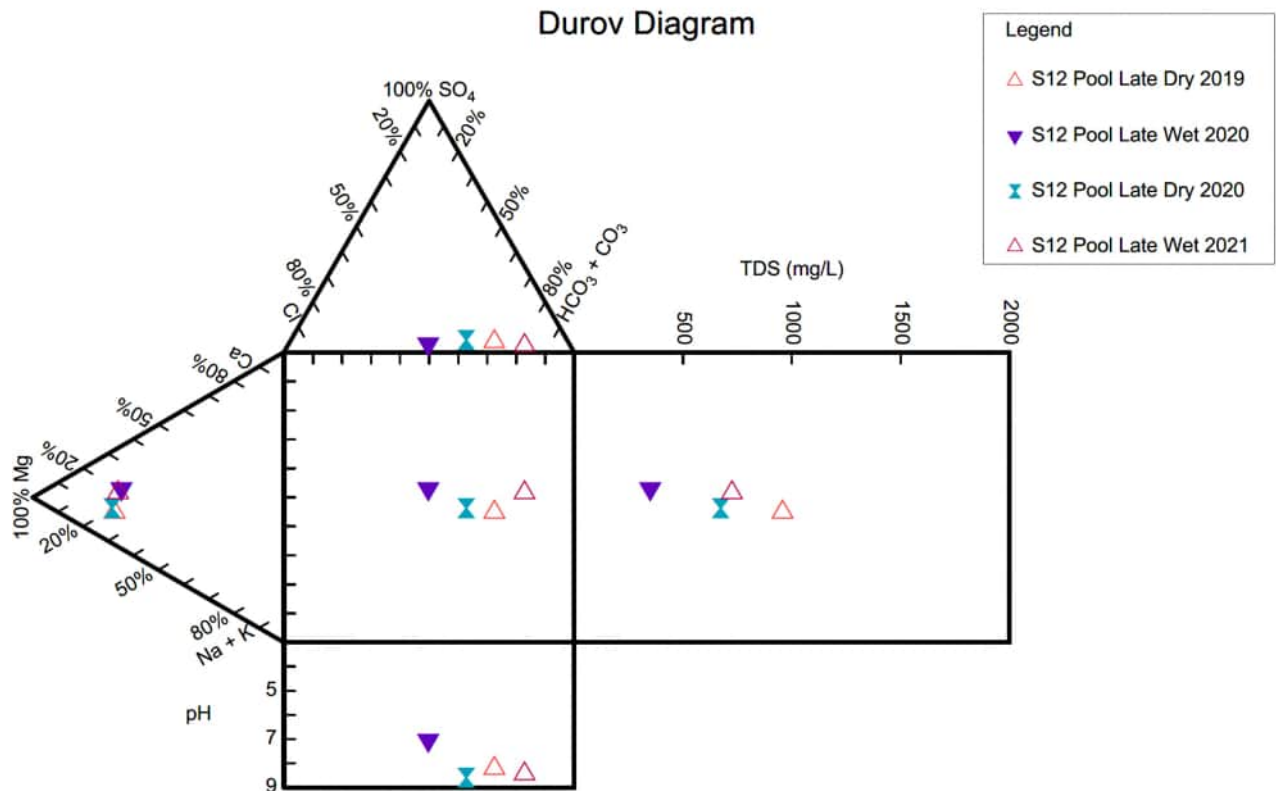


Figure 2-5 Durov diagram illustrates Site 12 Pool is a magnesium-bicarbonate (Ca/Mg-HCO<sub>3</sub>) dominated water type. It is fresh-brackish, alkaline (481 mg/kg CaCO<sub>3</sub>) with low sodium, chloride and sulphate (SO<sub>4</sub>).

### 2.3.2.2 AQUATIC ECOLOGY

Site 12 Pool is situated within the Chichester IBRA bioregion and the Grassland climate class (Koppen; Figure 2-6). The ecology of Site 12 Pool is adapted to wetting and drying cycles over an annual basis, with key reproductive processes occurring during favourable wet season conditions. Although the pool can be sustained by the local groundwater level throughout the dry season, it has been recorded as completely dry in recent years (2015, 2016 and 2020 dry seasons) following low rainfall wet seasons (BOM 2020). The pool naturally drying out or experiencing substantially lower water levels would be expected to impact significantly on the ecological health of Site 12 Pool due to evapo-concentration increasing environmental stressors (e.g. salinity) and lower water levels reducing available habitat. It is notable that during the short period for which the Site 12 Pool was dry in November 2020 (2-3 weeks), the ecological monitoring survey shortly after a small rainfall event which filled the pool (December 2021) showed that fish and other ecological indicators has returned to the site (Hydrobiology 2021). It is likely that the deeper pools below the monitoring site acted as refugia in this case (i.e. they did not dry out) and the fish were able to migrate upstream and rapidly recolonise the pool once connectivity had been returned.

Two wet season and one dry season aquatic ecology survey have been conducted (late wet 2020, late dry 2020 and late wet 2021) and one site visit (2019 late dry season) which inform the reported aquatic ecology characterisation (Hydrobiology 2021).

- The habitat assessment recorded algal (periphyton) dominated bedrock with minimal sediment at the Site 12 Pool water quality sampling site (Figure 2-7; Figure 2-8).

- The aquatic ecology surveys recorded three fish species at Site 12 Pool: *Melanotaenia australis* (western rainbowfish), *Leiopotherapon unicolor* (spangled perch), and *Neosilurus hyrtlii* (Hyrtl's catfish). Site 12 Pool is the only pool of five pools surveyed at Iron Bridge where *N. hyrtlii* has been recorded, which may be due to the connectivity to downstream creeks and rivers. This species exhibits spawning migration into tributaries and the tendency to inhabit riverine habitats more frequently than off-channel lentic habitats (Pusey et al. 2004). Juveniles of each fish species were present, demonstrating evidence of successful wet season or post-wet season reproduction. Fish were variably abundant during all three surveys, although were not observed during the previous years' late dry season site visit (December 2019). The baseline dataset indicates that there is a naturally variable fish presence/population at this site. A planned late dry 2021 survey will provide further evidence of seasonal variability, however the 2020/2021 wet season was established by a large >200 mm rainfall event and the pool is not expected to dry this year.
- Aquatic amphibian larvae (tadpoles) were present during the late dry season though were not observed in the late wet season sampling. eDNA sampling recorded the presence of *Uperoleia* spp. which are burrowing toadlets inhabiting rocky creeks. It is likely tadpoles were observed in the late dry and not the late wet due to the timing of the breeding season.
- Non-native vertebrate species (e.g. cattle, wild boar) were not observed at the pool during the ecology survey and were not detected by eDNA water sampling. However, cattle (*Bos Taurus*), wild boar (*Sus scrofa*) and dingo/dog (*Canis* spp.) were detected at other Iron Bridge pools and may have the potential to access the Site 12 Pool.
- A large number of teratological ('deformed') diatoms (a group of microalgae) were present at Site 12 Pool, which normally occurs as a result of environmental stress. Moisture stress, UV and salinity are possible causes, although heavy metals are most strongly associated with teratological forms (Falasco et al., 2009). Diatoms were present in very sparse abundance and had an average DSIAR score of 54.3.
- Macroinvertebrate taxonomic richness (mean=20) and EPT<sup>1</sup> scores (mean=2.6) showed a variety of taxonomic groups inhabit the pools, including species sensitive to water pollution.
- A diverse range of native flora were observed within Site 12 Pool. These comprised aquatic species and groundwater-dependent species. These species are likely not surface water (direct run-off) dependent as the pool refills with groundwater within 2-3 weeks following rainfall events. Aquatic species were present during both late dry and late wet seasons including reeds (*Typha* spp.), sedges (*Juncus* spp.) as well as submerged macrophytes (*Vallisneria* spp., *Myriophyllum* spp.). The types and species of macrophytes present in a system are indicators of water quality and ecological health. The abundance and diversity of macrophytes at Site 12 Pool provides habitat structure and refuges to organisms, plays a key role in nutrient dynamics, and indicates that water quality parameters (e.g. turbidity, salinity) have not reached levels that interfere with macrophyte growth and development. Furthermore, the persistence of a diverse range of groundwater-dependent species (including *Melaleuca* spp.) is tightly linked to the surface water quality, recruitment of other flora species, provision of food sources for native wildlife, stability and erosion control of the creek system and the provision of habitat/shelter to wildlife.

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<sup>1</sup> The EPT Richness Index estimates water quality by the relative abundance of three major orders of stream insects that have low tolerance to water pollution: Ephemeroptera (mayflies), Plecoptera (stoneflies), and Tricoptera (caddisflies).

- The Pilbara olive python (*Liasis olivaceus barroni*) has been recorded at multiple sites in the vicinity of Site 12 Pool by previous fauna surveys conducted by *ecologia* (2011a, 2011b, 2012). The species has not been sighted by Hydrobiology or recorded within the pool, either through observations or eDNA sampling. However, due to its low DNA shedding, the python and other reptiles are not commonly detected by eDNA water samples. The Pilbara olive python is a semi-aquatic species listed as vulnerable (EPBC Act 1999). Site 12 Pool may attract or provide habitat to the prey of the Pilbara olive python.
- No threatened aquatic species have currently been recorded at Site 12 Pool.

Comprehensive findings of the aquatic ecology survey are addressed in the *Surface Water Monitoring and Aquatic Ecology Survey Baseline Report* (Hydrobiology 2021).

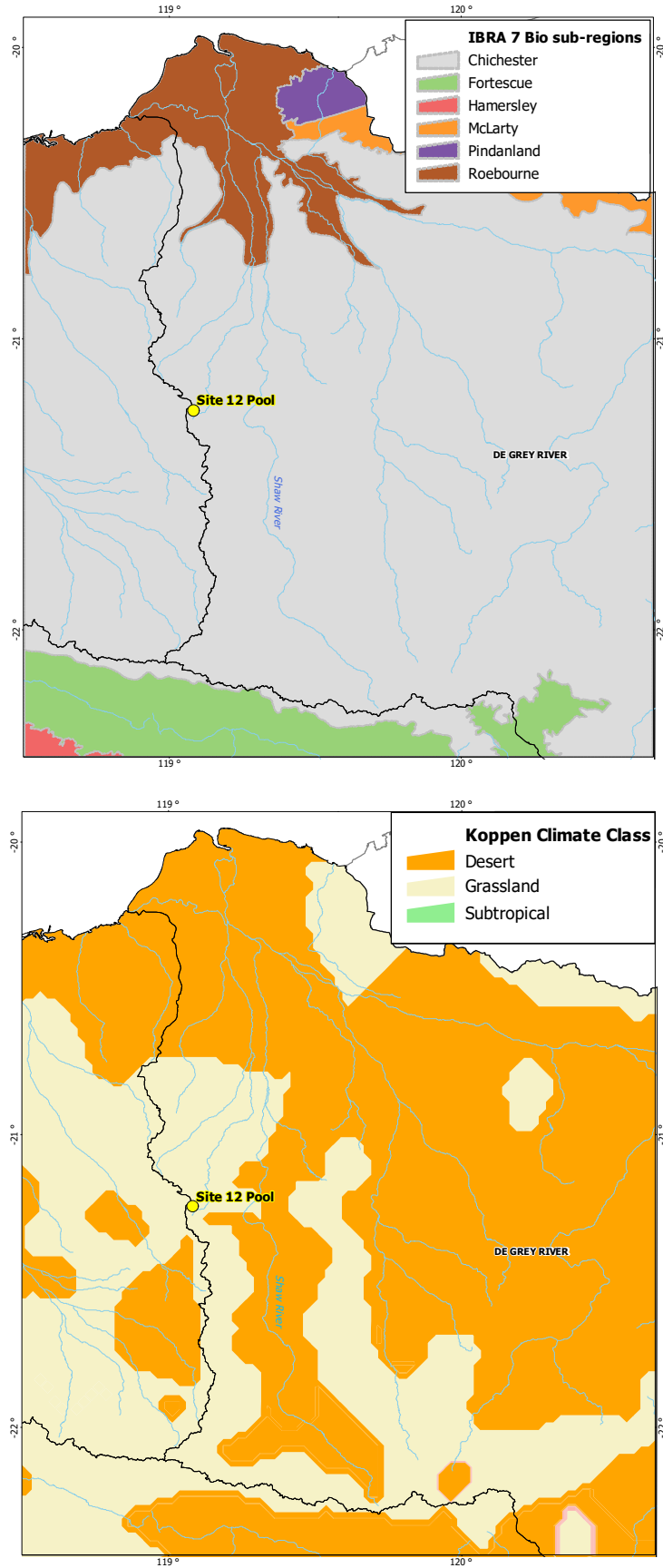


Figure 2-6 Site 12 pool situated within the Chichester IBRA bioregion and the Grassland climate class (Koppen)



Figure 2-7 Site 12 Pool survey site drone image with sampling features noted.



Figure 2-8 Site 12 Pool – general site photograph looking downstream.

## 2.4 CONCEPTUAL IMPACT MECHANISMS

As part of the Project, approximately 40% of the Site 12 Pool catchment is expected to comprise a WRD with a footprint of 3 km<sup>2</sup>, which has the potential to impact the Site 12 Pool downstream hydrology and water quality. Impacts to water quality and quantity, and consequently the ecology, may occur due to:

- Modification of the upper catchment results in decreased flow rates and deteriorating water quality.
- Storage of waste material resulting in water quality impact at the WRD contacted flow stream.
- Storage of waste material affects the Site 12 Pool catchment's run-off characteristics leading to decreased infiltration rates and volumes of run-off into Site 12 Pool.

These impacts may have direct or indirect effects and interconnect with the natural variability and factors integral to water quality in temporary pools (Figure 2-9). Table 3 outlines the conceptual impact mechanisms to aid in the identification of monitoring indicators and approaches in the development of the Site 12 Pool monitoring approach.

Table 3 Conceptual impact mechanism and associated monitoring parameters.

Conceptual Impact Mechanism	Description	Monitoring Parameters
<b>Ecotoxic response</b>	Ecotoxic response from one or more organisms in the food-web to the potential toxicants (including bioaccumulation) or changes to water quality resulting from WRD leachate or reduced flows causing a concentration of parameters (e.g. salinity) normally diluted by larger flows.	Macroinvertebrates Diatoms Fish Macrophytes Water quality Water quantity
<b>Food availability (indirect ecotoxic effects)</b>	Food availability impact to one or more organisms in the food-web due to an ecotoxic response to the water quality. Subsequent starvation or lowered reproduction of impacted species. For example, a reduced tadpole population directly resulting from toxins or low water quality reduces the food source (adult frogs) for Pilbara olive pythons and northern quolls.	Macroinvertebrates Diatoms Fish Macrophytes Water quality
<b>Vegetation health decline</b>	Decline in vegetation health at surface water pools due to changes in water quality, dust deposition and introduction or spread of invasive weed species.	Habitat Assessment Macrophytes Water quality Water quantity
<b>Habitat alteration</b>	Changes in the available aquatic habitat and/or suitable surrounding habitat due to impacts on vegetation, increased sediment load and turbidity, erosion due to altered hydrological regime or water chemistry.	Macrophytes Habitat Assessment Water quality Water quantity
<b>Hydrological regime alteration</b>	Aquatic ecology of Site 12 Pool is adapted to conditions of the pool including the variability of the hydrological regime and the corresponding water quality. For example, reproductive cues to may be linked to the water quality that corresponds to the natural patterns of the wetting-drying cycle.	Macroinvertebrates Diatoms Fish Macrophytes Water quality Water quantity

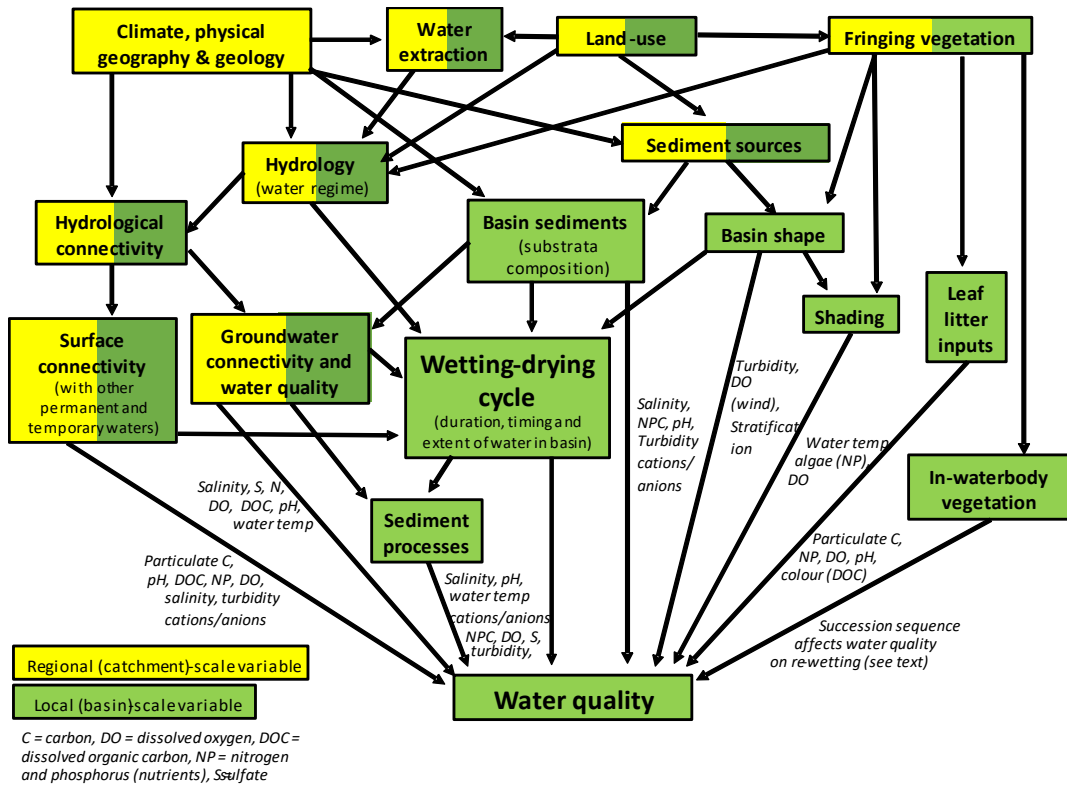


Figure 2-9 Conceptual diagram illustrating the interconnectedness and influence of various factors on water quality of temporary pools (ANZG 2018b).

## 2.5 MULTIPLE LINES OF EVIDENCE APPROACH

The monitoring approach applies a multiple lines of evidence approach (ANZG 2018a) to assess whether management goals are achieved, or if a detrimental impact has occurred. This approach gives greater certainty to assessment conclusions, and subsequent management decisions aimed to meet the water quality objective, compared to basing the evaluation on a single line of evidence.

Key indicators were selected across the following major groupings:

1. Pressure (Drivers): External activities or status that affect water quality
2. Stressor (Direct Effects): Physico-chemical quality elements and non-water quality stressors
3. Ecosystem receptor (Indirect Effects): Biological elements

Figure 2-10 presents an overview of the lines of evidence used in the monitoring approach and the assessment of management goals. Ecosystem receptors are an important line of evidence as these are what classify the health status of the system and ultimately determines whether a loss of environmental values has occurred. Stressor lines of evidence (physical, chemical, and non-water quality) provide cause-effect linkages to validate ecological status, are quantitative measures obtained more frequently in an ongoing sampling program and serve as early indicators to ecological impacts. Additionally, the selection of indicators across the surface water, sediment and biota systems of Site 12 Pool aims to provide a strong basis for meeting the EPA's (2018) objective of maintaining the quality of these so that the environmental values are protected.

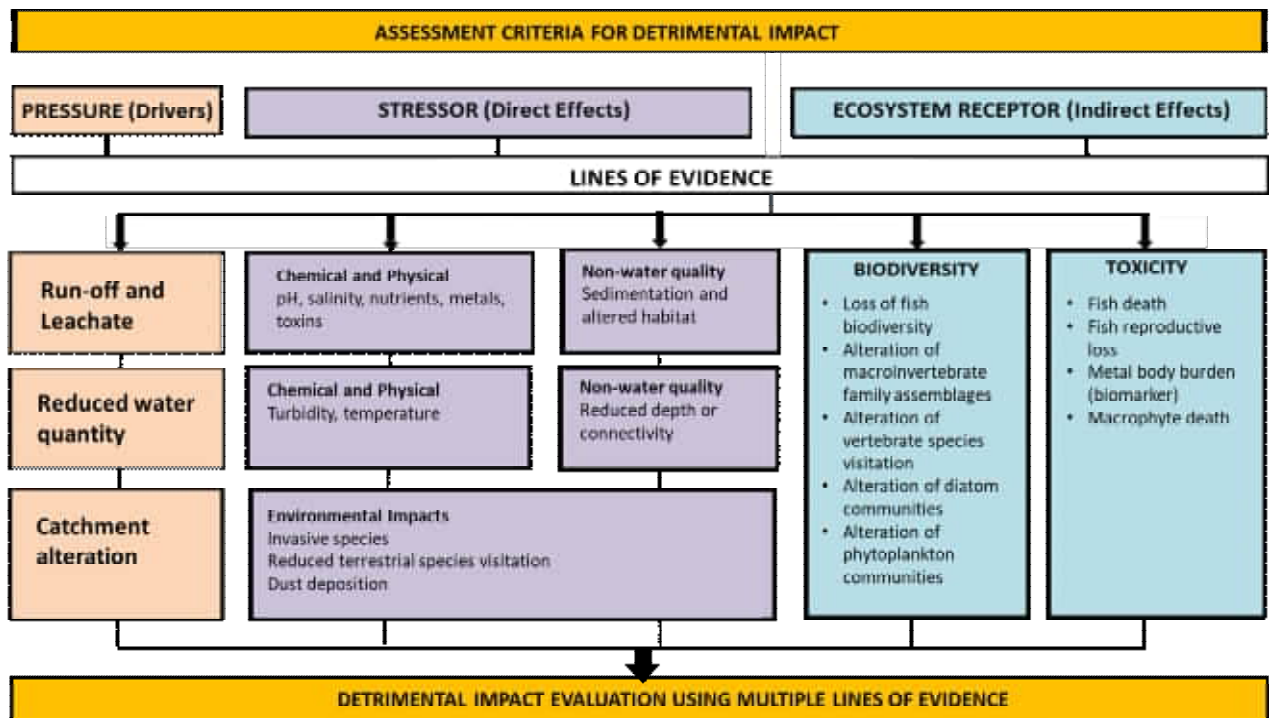


Figure 2-10 The multiple lines of evidence approach to monitoring water quality at Site 12 Pool

## 2.6 RATIONALE FOR INDICATORS

Site-specific indicators are listed in Table 6 (water quality) and Table 8 (ecological), which outlines the application of these indicators in the monitoring program. Site-specific indicators of water quality were selected for Site 12 Pool for the relevant stressors and anticipated ecosystem receptors identified for the system in Section 2.4 (Conceptual Model).

### 2.6.1 WATER QUALITY INDICATORS

The selected water quality indicators were developed into a monitoring program to utilise the stressors on the Site 12 Pool system (e.g. salinity, pH) as early detection for potential detrimental impacts to the ecosystem receptors (e.g. macrophytes).

Water quality indicators were selected from those recommended by *Managing Acid and Metalliferous Drainage* (DITR 2007), as per MS 993 Condition 12 – 3 (iv) and from the PSER causal pathway as recommended by ANZG (2018) to be informative of water quality changes that potentially impact environmental values. The selected indicators are conductivity, pH, turbidity, sulphate, total acidity, total alkalinity and dissolved iron.

Seasonal trigger levels for key water quality parameters were calculated from the baseline to accommodate the high temporal variability anticipated in temporary water systems (ANZG 2018b).

### 2.6.2 ECOLOGICAL INDICATORS

Threshold Criteria (Table 9) are derived from monitoring ecosystem receptor indicators, identified as resulting from changes to water quality in the conceptual impact mechanisms and as indicators of the loss of environmental values. These indicators are diatom communities, macrophyte communities, macroinvertebrate communities and fish communities.

Criteria are qualitatively assessed (Table 10) in order to accommodate the high natural seasonal variability anticipated in temporary waters, which impacts abundance and limits the applicability of quantitative assessment.

The rationale for the selected indicators is as follows:

- Algae (diatoms), macroinvertebrates, fish and macrophytes underpin the food web in temporary pools, providing habitat and/or food sources for a diversity of native species include terrestrial or semi-aquatic organisms that may utilise the pool such as the reptiles (e.g. Pilbara olive python), avian fauna and amphibians (Halse et al. 2001).
- The selection of these four communities spans multiple trophic levels and phyla, which is recommended in order to capture the variable impact of ecosystems stressors and detect, for example, impacts of bioaccumulation and biomagnification.
- Diatom communities – single-celled algae are effective indicators of ecological change in freshwater systems (Gale 2015). Quantitative sampling using periphytometers placed in situ for a defined period measures the capacity for growth, reproduction, and colonisation under current conditions.
- Macroinvertebrate communities – highly studied worldwide as indicators of water quality using a variety of bioindices and predictive models (e.g. EPT, SIGNAL, AUSRIVAS). As for diatoms, the taxonomic groups sensitive or tolerant to declines in water quality is well known, and the presence and abundance of these taxa are used to score the water condition of the pool.
- Macrophyte communities – effective indicators of ecological change, including indicators of when physical parameter thresholds are reached (e.g. turbidity blocking photosynthesis of

submerged macrophytes or impacts of sedimentation). Useful indicators of heavy metal bioaccumulation in a water body due to immobility. Provide an important habitat and refuge for fauna, especially in shallow water bodies such as Site 12 Pool.

- Fish communities – higher order organisms with relatively long-life spans. Useful for visually assessing health including bioaccumulation effects, interannual survivability and reproduction. Evidence of reproduction is sought (i.e. presence of juveniles) to detect sub-lethal effects impacting reproduction or vulnerable size classes.

## 2.7 TRIGGER LEVEL DERIVATION

The triggers selected for monitoring encompass multiple lines of evidence across the PSER pathway as per the Water Quality Guidelines (ANZG 2018a) and correspond to the strategies recommended by the guideline *Managing Acid and Metalliferous Drainage* (DITR 2007) to demonstrate the retainment of environmental values. The *Managing Acid and Metalliferous Drainage* guidance (DITR 2007) states that mining activities should not lead to water quality degradation such that the most conservative of environmental values defined for a water body is compromised. This does not mean that there must be no measurable impacts, but rather that impacts be minimised so that water quality is not degraded to the point where any existing environmental value is lost. Strategies the *Managing Acid and Metalliferous Drainage* (ANZG 2018a) guidance recommended to demonstrate the retainment of environmental values includes:

- Ensuring that relevant trigger values are not exceeded in receiving water bodies
- Ensuring that discharge does not result in a statistically significant change in key water quality parameters (no change occurs that is outside the seasonally relevant background concentration plus (or minus) two standard deviations).
- Demonstrating that the discharge will not have ecological impacts on the basis of site-specific ecotoxicological studies.

The Site 12 Pool WQMMP presents a three-step trigger assessment approach to align with the relevant guidelines:

1. **Early Response Trigger Levels** were developed for the receiving water body which ensures changes to key water quality parameters (as per MS 993 Condition 12) do not occur outside the seasonally relevant background concentration without triggering further investigation. To derive seasonally relevant site-specific trigger values, the median seasonal background concentration plus (and minus for pH) two standard deviations was applied as per the *Managing Acid and Metalliferous Drainage* guidance (DITR 2007). These were determined to be the most protective compared to values, where available, provided by the Water Quality Guidelines (ANZG 2018a).

The Early Response trigger levels presented, while seasonal, are not yet refined to encompass the entire high site-specific variability in water quality associated with the hydrological cycle (such as first flush events and drying events). Therefore, they are intended to trigger further investigation and not to assess compliance.

2. **Early Response Trigger Investigation** triggered by exceedance of the Early Response Trigger Levels is supported by the Temporary Waters Guidance (ANZG 2018b) and involves assessing the water quality against the highly variable hydrological regime (Section 3.3.1). This may result in subsequent refinement of the trigger levels based on site-specific conditions. The outcome of the Early Response Trigger Investigation determines whether the Threshold Criteria is assessed.

3. **Threshold Criteria** is established from the exceedance of Early Response Trigger Levels, no natural hydrological cause identified by Early Response Trigger Investigation, and exceedance of Threshold Criteria. Criteria were developed under guidance from the Temporary Waters Guidance (ANZG 2018b) and to align with *Managing Acid and Metalliferous Drainage* (DITR 2007). These criteria demonstrate whether the Project has had an ecological impact on the basis of biological parameters reflecting toxicity. The Threshold Criteria are derived from the ecosystem receptor lines of evidence and assess the aquatic ecology. A 'traffic light system' of low, moderate and high-risk criteria is applied, where exceedance of a set number of validated moderate or high-risk criteria is defined as an exceedance and is reportable for purposes of further investigation and compliance monitoring.

The trigger levels contained in this report are interim values and will be reviewed at the completion of the baseline data collection phase.

## 2.8 KEY ASSUMPTIONS AND UNCERTAINTIES

### 2.8.1 ASSUMPTIONS

- Early Response Indicators selected adequately detect declining water quality that encompasses the range of potential impact mechanisms.
- Ecological parameters selected adequately detect declining aquatic ecosystem functionality and thereby detect loss of environmental value.
- Seasonal and annual variability in water quality and quantity that results in non-Project caused exceedances of Early Response Trigger Levels and Threshold Criteria are identified by the Early Response Trigger Investigation and validation step of Threshold Criteria.

### 2.8.2 UNCERTAINTIES

- Groundwater contribution is unquantified, however the groundwater contribution is linked to the natural local groundwater levels. When the local groundwater level is above the pool elevation, groundwater will sustain the pool. When the local groundwater level drops below the pool elevation (during the dry season), no groundwater will contribute to the pool water.
- The baseline surveys provide a representative degree of variability (within and between seasons and years) in the natural system.

# 3. SITE 12 POOL MONITORING PLAN

## 3.1 MONITORING LOCATIONS

The locations of sites for monitoring Early Response indicators and ecology are outlined in Table 4 and shown in Figure 3-1. Further sites are identified for the purposes of calibrating water quality logger data (Site 12 Pool Barometer) or conducting site investigations triggered by Early Response trigger level exceedance. The main Site 12 Pool sampling sites are located at the upper pools for the purposes of capturing effects impacting both upper pools and the downstream lower pools.

The monitoring sites shown in Table 4 are the existing surface water and groundwater monitoring location for Site 12 pool.

Table 4 Existing Monitoring locations at the Site 12 Pool area. Coordinates reference system: GDA 94/MGA Zone 50.

Monitoring site	Description	Easting	Northing
<b>Site 12 Pool water quality sampling site (grab sample and field parameters)</b>	Over bedrock on southern edge of stream.	715784	7649287
<b>Site 12 Pool data logger</b>	Within creek/pool, at the cross-section of gorge confinement	715784	7649287
<b>Site 12 Pool barometer logger</b>	Barometer logger to calibrate water level logger in a tree east of Bore NS 0064	715536	7649255
<b>Site 12 Pool North Upstream rising stage sampler and data logger</b>	Reference site – Creek upstream of Site 12 Pool with rising stage sampler and data logger	715575	7649414
<b>Site 12 Pool West Upstream North Upstream data logger</b>	Reference site – Creek upstream of Site 12 Pool upstream creek with data logger	715286	7649215
<b>Site 12 Pool West Upstream North Upstream rising stage sampler</b>	Reference site – Creek upstream of Site 12 Pool upstream creek with rising stage sampler	715352	7649178
<b>Site 12 Pool South Upstream rising stage sampler and data logger</b>	Reference site – Creek upstream of Site 12 Pool upstream creek with rising stage sampler and data logger	714848	7647015
<b>Site 12 Pool groundwater bores</b>	Existing bore: Bore NS 0064; west of Site 12 pool.	715498	7649266
<b>Site 12 Pool ecological sampling site</b>	Diatom periphytometers – within 2 m of data logger Fyke net – downstream 3 m from data logger Sediment – northern edge of data logger cross section Macrophytes – 50 m reach Habitat Assessment – upper pools to downstream pools prior to downstream junction Macroinvertebrates – southern and northern edge of channel at gorge entrance	715779	7649295

Table 5 Site 12 Pool monitoring record sheet locations

Name	Easting (MGAz51; GDA94)	Northing (MGAz51; GDA94)	Long. (WGS84)	Lat. (WGS84)
<b>S12P Photo Point</b>	715764	7649289	119.0792	-21.2453
<b>S12P Macrophytes</b>	715777	7649292	119.0793	-21.2452
<b>S12P Logger</b>	715779	7649290	119.0793	-21.2453
<b>S12P Water Sample</b>	715778	7649288	119.0793	-21.2453

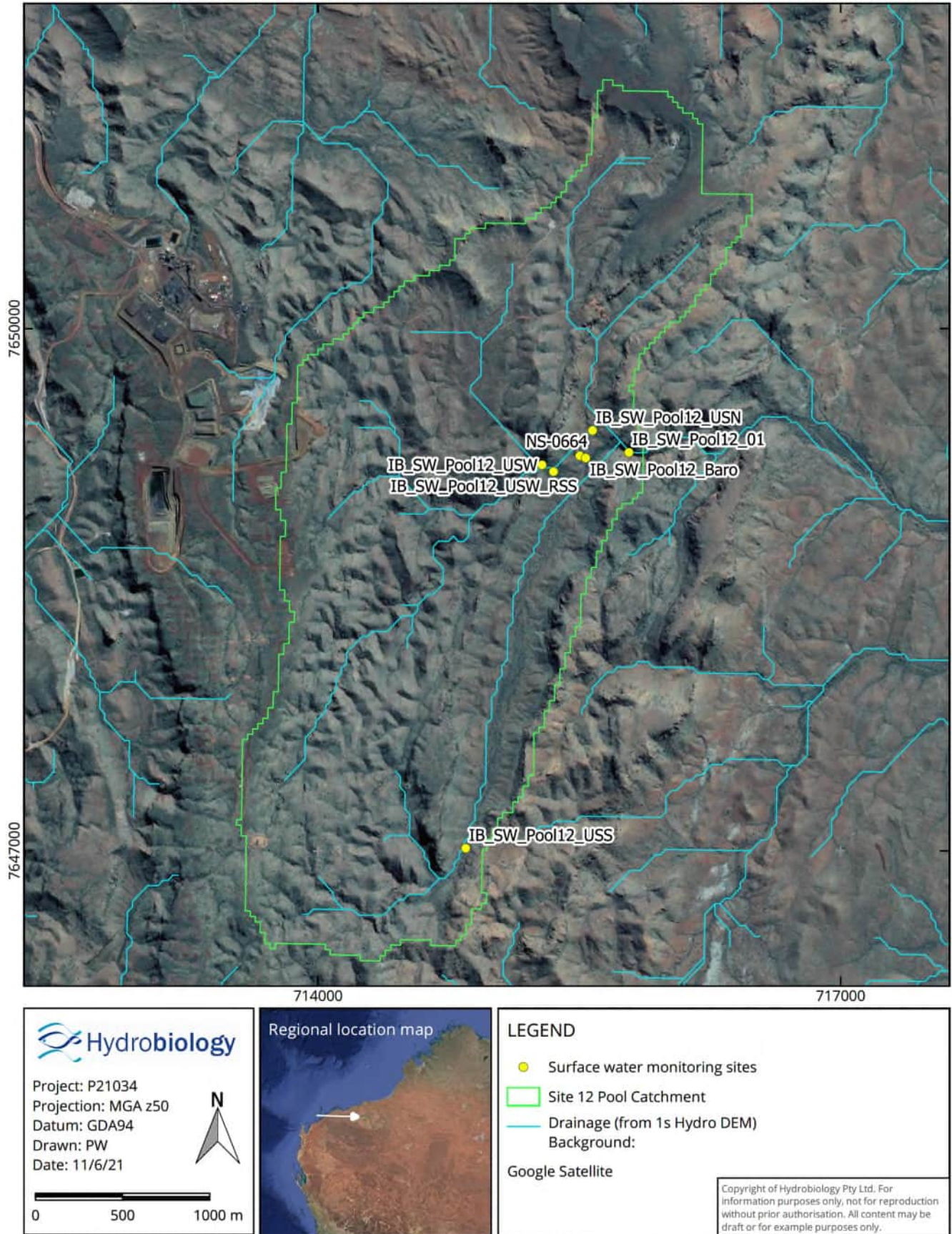


Figure 3-1 Site 12 Pool monitoring locations

### 3.2 MONITORING TIMING AND FREQUENCY

- Water quality monitoring at Site 12 Pool is undertaken biannually (Table 6), or as specified in Section 4 where trigger values are exceeded and may alter the sampling schedule.
- Water quality is sampled in the wet season and drying season. Sampling will align with these seasons based on the hydrological regime rather than the month (e.g. Figure 3).
- The wet season follows the wetting season and is approximately defined for the purposes of Site 12 Pool water quality monitoring as 1) the period following at least two large rainfall events/periods (greater than 20 mm over a 7 day period); and 2) prior to the drying season (see below). Sampling should occur more than 7 days following a substantial rainfall event. Figure 3-3 shows this period as occurring approximately between late January and May.
- The drying season follows the wet season and is approximately defined for the purposes of Site 12 Pool water quality monitoring as the period more than two months and less than four months following a substantial rainfall events/periods (greater than 20 mm over a 7 day period). The drying period typically occurs between June and November.
- Ecological monitoring (Table 7) is undertaken as required in Section 4 where a water quality trigger exceedance prompts further enquiry.

### 3.3 WATER QUALITY AND HYDROLOGICAL MONITORING

Table 6 shows the water quality monitoring parameters and frequency for Site 12 Pool.

Table 6 Water Quality Monitoring Parameters and Frequency.

Method	Monitoring parameters	Frequency <sup>1</sup>	Location <sup>5</sup>
<b>Water loggers</b>	Pool water level & Upstream channel water level	Automatic logging 3 hour for pool and 15 minutes for watercourse. <sup>6</sup>	IB_SW_Pool12_01 IB_SW_Pool12_Baro IB_SW_Pool12_USN IB_SW_Pool12_USW <sup>2</sup> IB_SW_Pool12_USS
	Groundwater level	Automatic logging min. 12h	NS-0664
<b>Field measurements</b>	Dissolved Oxygen (DO), pH, Electrical Conductivity (EC), Turbidity, Temperature	Monthly from Nov to Apr, Quarterly from May to Oct, and/or event based <sup>1</sup>	IB_SW_Pool12_01 IB_SW_Pool12_USN IB_SW_Pool12_USW_RS S <sup>2</sup> IB_SW_Pool12_USS
			NS-0664

Method	Monitoring parameters	Frequency <sup>1</sup>	Location <sup>5</sup>
<b>Grab water samples for laboratory analysis</b>	TSS, TDS, TOC, DOC Nutrients (Total Nitrogen, Total Phosphorus, Nitrate+Nitrite (NO <sub>x</sub> as N), Total Kjeldahl Nitrogen (TKN as N), Ammonia/Ammonium) <sup>9</sup>	Monthly from Nov to Apr, Quarterly from May to Oct, and/or event based <sup>1</sup>	IB_SW_Pool12_01 IB_SW_Pool12_USN IB_SW_Pool12_USW_RS S <sup>2</sup> IB_SW_Pool12_USS
	Ions (Total Alkalinity, Cl, F, Sulphate, Bicarbonate/Carbonate, , Ca, Mg, Na, K, Total Acidity SO <sub>4</sub> , Hardness) Total and dissolved metals (Al, As, Cd, Cr, Cu, Fe, Pb, Ni, Zn, Hg, B, Ba, Be, Co, Mn, Se, V) <sup>4,7</sup> AMD suit (Ag, Bi, Ce, Cs, La, Mo, Rb, Sb, Sc, Sn, Sr, Th, Ti, Tl, U, W) <sup>8</sup>	Bi-annual monitoring <sup>3</sup>	NS-0664

1 'event based' is defined as rainfall that has resulted in visual streamflow across a floodway or down a designated river/pool/creek/stream. Monitoring following rainfall events will only be undertaken once it is considered safe to access monitoring sites.

2 It is expected very limited water quality at west upstream of site 12 pool, once the WRD access road is extended to block the stream flow from WRD.

3 Biannual ecology survey including water quality and sediment quality for laboratory analysis are conducted during pool late wet period (indicative Feb to Apr) and pool drying periods (indicative Sep to Nov), only when water is present.

4 Limit of Detection (LOD) on metals requested as meeting ANZG (2018) 99% EPL where applicable.

5 Site 12 pool is the primary monitoring location as the reporting location in accordance with MS993 Condition 12, the other monitoring sites are non-reporting locations to provide supplementary information to support multiple lines of evidence

6 Biannual data download from data logger or when required

7 For sites in the waterways (IB\_SW\_Pool12\_USN, IB\_SW\_Pool12\_USW\_RSS, IB\_SW\_Pool12\_USS) while all dissolved metal parameters are required, total metal parameters only Cu, Hg, Zn are to be measured.

8 AMD suits water quality analysis are applicable to the impacted waterways only (IB\_SW\_Pool12\_USW\_RSS, IB\_SW\_Pool12\_USS)

9 TP, TN and NO<sub>x</sub> have a 28 day holding time, phosphate, nitrate and nitrite individually have a 2 day holding time. The remoteness of the site location prevents reliable laboratory delivery and analysis within less than 5 days (the laboratory recommendation is for samples to arrive at the lab with half the holding time remaining to allow for lab scheduling and processing).

Early Response Trigger Levels are presented in Table 7 as quantitative seasonal water quality trigger values which provide the first line of assessment at Site 12 Pool. These Trigger Levels are assessed on a biannual basis as per the water quality monitoring schedule.

In applying two standard deviations to the median seasonally relevant baseline value, exceedances exist within the baseline dataset. This is due to two standard deviations capturing 95% of data rather than 100% of data and, therefore, the most extreme events within the baseline fall outside the 95% statistical distribution.

Note that although the median of the dry season baseline data is higher or similar for some parameters (e.g. conductivity, turbidity), the high variability (and standard deviation) around wet season hydrological events results in a relatively higher wet season trigger value.

The values presented, while seasonal, are not yet refined to encompass the entire high site-specific variability in water quality associated with the hydrological cycle (such as first flush events and drying

events). Therefore, the exceedance of an Early Response Trigger Level is intended to trigger further investigation (Section 3.3.1) and not to assess compliance.

The trigger values contained in this report are interim values and will be reviewed at the completion of the baseline data collection phase.

Table 7 Early Response Trigger Levels

Parameter	Uni	Trigger Level (median seasonal baseline $\pm$ 2 SD)	
		Wet season <sup>1</sup>	Dry season <sup>1</sup>
pH	-	<6.5 >9.0 <sup>3</sup>	<6.5 >9.03 <sup>3</sup>
Electrical conductivity (SPC)	$\mu$ s/cm	>1854	>1517
Turbidity	NTU	>37	>1.6
Total alkalinity (as CaCO <sub>3</sub> )	mg/L	<82.2 >825.8	<364.1 >741.9
Total acidity (as CaCO <sub>3</sub> )	mg/L	>6.8	>5.5
Sulphate (SO <sub>4</sub> )	mg/L	>112.4	>65.0
Dissolved iron (Fe)	mg/L	>0.05 <sup>2</sup>	>0.05 <sup>2</sup>
Nitrate+Nitrite (NO <sub>x</sub> as N) <sup>4</sup>	mg/L	>0.6	>0.6

<sup>1</sup>Seasons vary interannually and are determined by the site-specific hydrological cycle. For guidance only; the dry season is typically from May – October and the wet season is typically from November - April.

<sup>2</sup>Dissolved Iron (Ferrous Iron mg/L) baseline concentrations consistently below LOD (0.05 mg/L), this LOD was applied as the trigger level as a reliable standard deviation could not be obtained.

<sup>3</sup> ANZG 2018 default pH guidelines.

<sup>4</sup> TP, TN and NO<sub>x</sub> have a 28 day holding time, phosphate, nitrate and nitrite individually have a 2 day holding time. The remoteness of the site location prevents reliable laboratory delivery and analysis within less than 5 days (the laboratory recommendation is for samples to arrive at the lab with half the holding time remaining to allow for lab scheduling and processing).

### 3.3.1 EARLY RESPONSE TRIGGER LEVELS INVESTIGATION

An Early Response Trigger Level Investigation is required when an Early Response Trigger Level exceedance is recorded. The aim is to validate and identify the cause of the exceedance.

This section provides guidance for assessment steps undertaken in response to an Early Response Trigger Level exceedance and can be adapted on a case by case basis. Note this Investigation forms a component of the Contingency Actions.

1. Re-examine water quality results by checking the QA/QC sample result is consistent and ensuring correct calibration of sampling equipment.

2. Resample and reassess to confirm the exceedance. This will also help to establish if the parameter in exceedance is increasing or decreasing in the timeframe since previous sampling.
3. Check Project related operations that have the potential to impact the water quality.
4. Acquire and use current Iron Bridge rain gauge data to ensure that the water quality parameter results are being assessed against the correct seasons Early Response Trigger Level (i.e. wet or drying season). Note that seasons vary interannually and the water quality parameters should be compared to the most representative seasons Early Response Trigger Levels based on rainfall events rather than sampling date. For example, if the wet season has not started prior to sampling in November, the November sample should be evaluated against the drying season Early Response Trigger Levels. For guidance only, the dry season is typically from May – October and the wet season is typically from November – April.
5. Assess the *Visual Inspection* results recorded during sampling for indications of causes to changes in water quality and preliminary evidence of ecological impacts (see Appendix A for field datasheet template). For example, check if the *Visual Inspection* notes nearly dry water levels, flood conditions, evidence of increased sedimentation or records of fish death.
6. Acquire and record logger data from the Site 12 Pool water level and water quality data logger and the Site 12 Pool Barometer (for locations see Section 3.1). Correct the water level for barometric pressure using the barometric data. Assess the water quality relative to the hydrological cycle by plotting the depth, temperature and specific conductivity over time and;
  - a. Inspect the conductivity, depth and temperature data against the Iron Bridge rain gauge data and the sampled water quality parameters. Evaluate whether there is evidence of a natural hydrological cause that could have resulted in the exceedance. See Box 3.3.1 below for guidance '*Hydrological Regime Impacts on Water Quality*'.
  - b. Assess for evidence that groundwater connectivity is being maintained. Baseline data shows the conductivity decline during a rainfall event and subsequently increase to near pre-rainfall conductivity levels over a 2-3 week period assuming no further significant rainfall (Figure 3-3). The lack of this pattern may be a preliminary indication that reduced groundwater inputs to Site 12 Pool are the cause of the Water Quality trigger exceedance. This may be further assessed by reviewing groundwater quality for changes in conductivity (similar surface water and groundwater levels may reduce the ability to discern connectivity through conductivity patterns) and check for declining groundwater water levels.
7. Investigate spatial trends upstream of Site 12 Pool and across the surface water pools at Iron Bridge. For locations, see *Surface Water Monitoring and Aquatic Ecology Survey Baseline Report* (Hydrobiology 2020). This may include;
  - a. Assess water level data from loggers located at Site 12 North Upstream, Site 12 West and Site 12 Downstream.
  - b. Check Site 12 Pool water quality relative to water quality from recent and baseline concentrations at Site 12 North Upstream, Site 12 West and Site 12 Downstream. This may include water quality from first flush sampling collected using rising stage samplers.
  - c. Review water quality and levels across other monitored Iron Bridge pools (e.g. Cow Spring Pool, Central Creek Pool, South Star Pool, Fig Pool) for evidence of a spatial trend across the region.

### 3.3.2 HYDROLOGICAL REGIME IMPACTS ON WATER QUALITY

The following key features are intended to assist the Primary Trigger Level assessment of the impact the hydrological regime has potentially had on the water quality at Site 12 Pool.

- Extended periods of no to low rainfall would be expected to cause evaporation and lower groundwater levels, resulting in decreased surface water levels, increased conductivity, increased sulphate, and lower pH.
- Recent rainfall events may result in a decrease in conductivity, increased turbidity, increased sulphate and increased dissolved iron. Note that the conductivity may have rebounded to pre-rainfall levels prior to other parameters stabilising.
- Rainfall, and consequently run-off, has a varying impact on the water quality depending on when it occurs relative to the wet season and large rainfall events. Minor rainfall in the early or late wet season infiltrates into the drier soil and has a relatively low impact to the water quality compared to similarly sized rainfall that occurs during the mid-wet season once the soil is more saturated. For example, a 21 mm rainfall event in May 2020 had negligible impact on the EC, whereas a 31 mm rainfall event in March 2020 decreased EC by over 60%.
- Figure 3-2 illustrates the relationship between the displacement of higher conductivity water in Site 12 Pool with fresher rainwater, which results in a rapid decrease in conductivity (EC). Conductivity change (%) can be used to guide the expected difference in other parameters. For example, where rainfall has occurred but has caused a small (<1%) change in EC, it has likely infiltrated into soil and significant changes to other water quality parameters (e.g. SO<sub>4</sub>, turbidity) are not expected to naturally occur. Likewise, where a significant change to EC occurs during or following rainfall, significant changes to other parameters (e.g. turbidity) are expected as a result of substantial surface run-off and may be due to the natural seasonal variability.

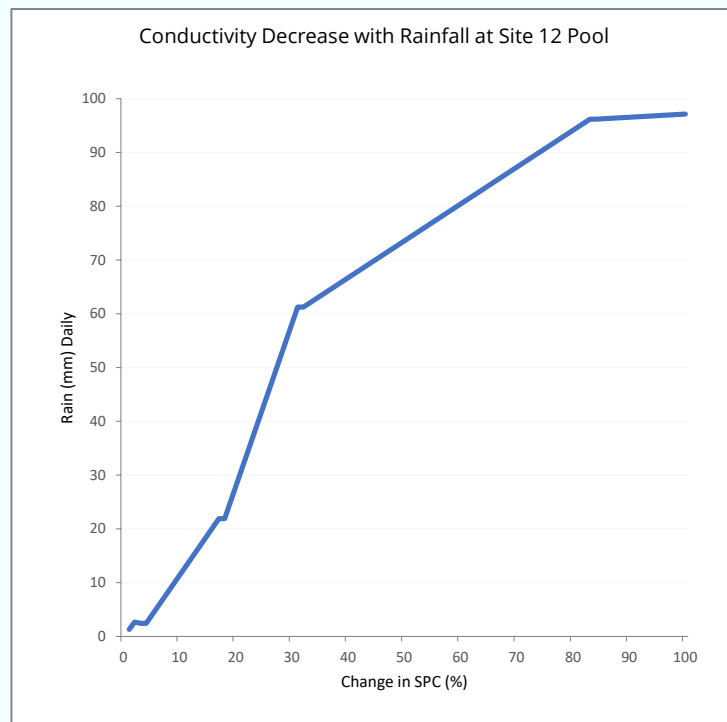


Figure 3-2 Conductivity (EC) decreases with increasing rainfall (mm) at Site 12 Pool. To be used as a guide only. Based on North Star rain gauge data (2019-2020) and Site 12 Pool water quality logger data (2019-2020) during the mid-wet season (Jan-Mar).

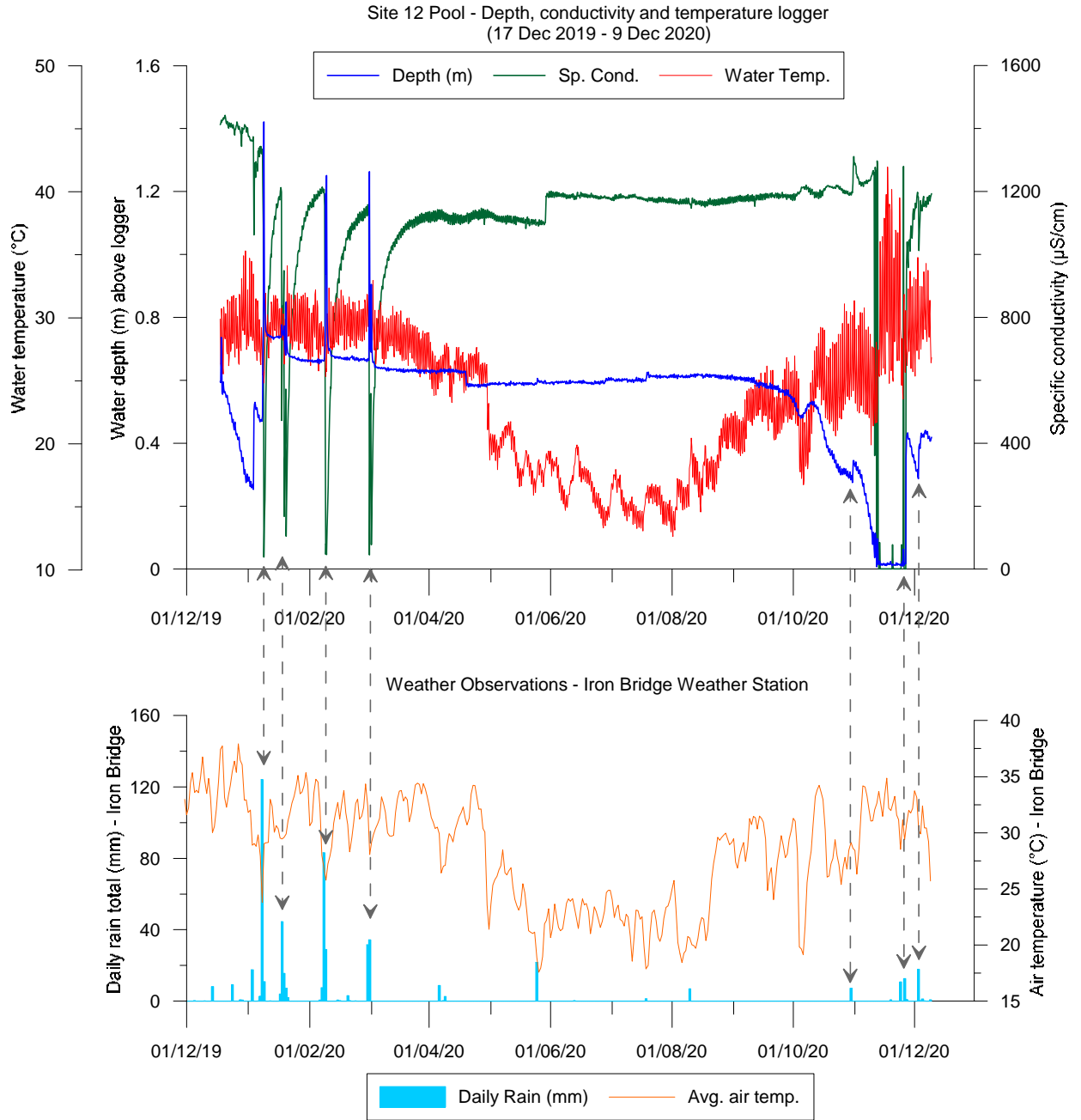


Figure 3-3 Depth, conductivity, and temperature logger data (above) relationship to daily rainfall (below). Rainfall events fill Site 12 Pool with relatively fresh water that decreases conductivity (green). Following rainfall events, conductivity increases with the infiltration and displacement of rainwater with the relatively high conductivity groundwater water.

## 3.4 ECOLOGICAL MONITORING

The indicators sampled for ecological monitoring include the ecosystem receptor lines of evidence (biodiversity) identified from the PSER causal pathway (Section 2.6).

Ecological monitoring is undertaken as required in Section 4 where a water quality trigger exceedance (Table 7) prompts further enquiry.

Table 8 Ecological monitoring plan

Indicator	Parameter(s)	Collection method <sup>1</sup>
Diatom community	DSIAR scores and diversity	Diatom plates (periphytometers)
Aquatic macroinvertebrate community	EPT abundance index	Sweep nets
Fish community	Presence/absence Size structure	Fyke nets
Sediment quality	Total Alkalinity, Total Acidity SO <sub>4</sub> , TSS, Nutrients (nitrite, nitrate, phosphate), Ions (Cl, F, Ca, Mg, Na, K), total metals (As, Cd, Cr, Cu, Fe, Pb, Ni, Zn, Hg, B, Ba, Be, Co, Mn, Se, V), TOC	Sediment sampling
Habitat assessment	Wider habitat health	Visual inspection of habitat quality/health record on habitat sheet
Macrophyte diversity	Presence/absence	Habitat sheet

<sup>1</sup>Collection methods described in *Surface Water Monitoring and Aquatic Ecology Survey Baseline Report* (Hydrobiology 2020).

### 3.4.1 THRESHOLD CRITERIA

Threshold Criteria are defined in Table 9 (Table 10 displays the matrix) and these refer to Table 11 for ecological criteria.

Threshold Criteria are assessed subsequent to the following occurring:

- 1) Exceedance of Early Response Trigger Levels; and
- 2) Early Response Trigger Levels Investigation determines no natural hydrological cause for exceedance.

Meeting the above criteria 1) and criteria 2) prompts Ecological Monitoring (Table 8) and subsequently Threshold Criteria assessment (Table 11).

By assessing Threshold Criteria using multiple ecological indicators after water quality and hydrological assessments have been conducted, this approach uses the multiple lines of evidence approach to determine whether a Threshold exceedance has occurred.

Where a parameter is deemed a 'High Risk' or 'Moderate Risk' of indicating a potential ecological impact, this is assessed in the context of the Early Response Trigger Level Investigation findings, baseline variability and transferability of baseline climatic conditions to current sampling conditions, and based on professional knowledge by experts in ecology of the applicability of environmental parameters to water quality assessments. As such, a sampling event may produce a result that is High or Moderate Risk, and subsequent analysis by ecological expertise may determine the result is not valid (e.g. due to erroneous data or technical failure) or not comparable to the baseline (e.g. a natural

cause not identified by the Early Response Trigger Investigation caused the impact such as detection of introduced species impact).

Table 9 Threshold Criteria.

Criteria	Assessment Parameters
Threshold Criteria	≥2 High Risk Criteria
	≥2 Moderate Risk and ≥1 High Risk Criteria
	≥3 Moderate Risk Criteria

Table 10 Threshold Criteria matrix. Y= threshold criteria exceeded, N=threshold criteria not exceeded.

**Threshold Criteria Decision Matrix**

		HIGH RISK CRITERIA (number of high-risk ecological parameters met)				
		0	1	2	3	4
MODERATE RISK CRITERIA (number of moderate risk ecological parameters met)	0	N	N	Y	Y	Y
	1	N	N	Y	Y	Y
	2	N	Y	Y	Y	Y
	3	Y	Y	Y	Y	Y
	4	Y	Y	Y	Y	Y
	4	Y	Y	Y	Y	Y

Table 11 Threshold Criteria Assessment Table.

Environmental parameters	LOW RISK <sup>1</sup>	MODERATE RISK <sup>1</sup>	HIGH RISK <sup>1</sup>
Macroinvertebrate communities <sup>2</sup>	Presence of EPT taxa > 0.5B	EPT index < 0.5B OR SIGNAL2 score < the lower of 2 or B-1	No EPT taxa present
Fish communities	<i>Melanotaenia australis</i> present including small size classes (<60 mm)	<i>Melanotaenia australis</i> present and no small size classes present	No fish species present
Diatom communities <sup>3</sup>	DSIAR score > 0.5B	0.5B > DSIAR score > 0.2B	DSIAR score less than 0.2B
Macrophyte communities	Emergent (reed like and tussock/rush like species) present in ≥ isolated abundance	Emergent macrophytes present, with evidence of deteriorating health > B maximum	Emergent and submerged macrophytes absent

<sup>1</sup> B=Baseline seasonally relevant mean (i.e. wet or dry season ecological baseline values).

<sup>2</sup> The EPT Richness Index estimates water quality by the relative abundance of three major orders of stream insects that have low tolerance to water pollution: Ephemeroptera (mayflies), Plecoptera (stoneflies), and Tricoptera (caddisflies). SIGNAL (Stream Invertebrate Grade Number – Average Level) is a scoring system for macro-invertebrate samples from Australian rivers that indicates water quality based on tolerance or sensitivity of macroinvertebrate families present to water quality.

<sup>3</sup> DSIAR score (Diatom Species Index for Australian Rivers score) estimates water quality by the relative abundance of diatom species sensitive to water quality stressors.

# 4. CONTINGENCY MANAGEMENT PLAN

## 4.1 CONTINGENCY ACTIONS

Further assessment is required if Early Response Trigger Levels are exceeded at Site 12 Pool. This section outlines the assessment process, contingency actions and the adaptive management process. See Figure 4-1 for the Contingency Actions Flow Diagram. Refer to the *Surface Water Management Plan: North Star* (FMG 2020a) for further details on the corrective actions and adaptive management process.

1. Has an Early Response Trigger Level exceedance been recorded (Table 7)?
  - a. NO – Resume standard monitoring frequency.
  - b. YES – Proceed to Step 2.
2. Validate and investigate the cause for the exceedance as outlined in Early Response Trigger Level Investigation (Section 3.3.1) and proceed to Step 3.
3. Has a natural cause been identified by the Early Response Trigger Level Investigation as the cause of the Early Response Trigger Level exceedance?
  - a. YES – Resume standard monitoring frequency.
  - b. NO – Proceed to Step 4.
4. Has a Threshold Criteria exceedance been recorded?

- a. NO – Conduct a follow-up visual inspection and re-sampling within two weeks. Record for the purposes of reassessing the trigger levels as part of an active management review.
  - b. YES – Report trigger exceedance as per Reporting Requirement (see *Surface Water Management Plan: North Star* (FMG 2020a)) and proceed to Step 5.
5. Develop a case-specific *Site 12 Pool Recovery Plan* and implement the contingency management measures as determined by the plan (see Section 4.2 for guidance). A period of time or event (such as substantial rainfall) will likely be required to occur before an assessment of the effectiveness of the *Site 12 Pool Recovery Plan* can be made. Therefore, proceeding the agreed and case-specific time after implementation of the *Site 12 Pool Recovery Plan*, proceed to Step 6.
  6. Reassess from Step 1 following the implementation of the *Site 12 Pool Recovery Plan*. Depending on the contingency actions implemented, the monitoring parameters or frequency may require review. Where reassessment of Early Response trigger parameters (and any other parameters, if warranted) finds they are below trigger levels, standard monitoring (or the revised monitoring plan) is resumed. Where the reassessment records an exceedance of Threshold Criteria, proceed to step 7.
  7. If monitoring indicates that implemented management measures are not mitigating impacts to Site 12 Pool, consider the following:
    - a. Review management measures with an adaptive management response. For example;
      - Re-evaluate trigger levels and threshold criteria.
      - Measure other indicators to assess if Site 12 Pool environmental values have been detrimentally impacted by the guideline value exceedance event.
      - Workshop potential management measures with site (FMG) stakeholders (e.g. mining, environment, water departments) and potentially bring in expert/regulator advice. Implement appropriate measures.
    - b. Carry on monthly monitoring frequency until Water Quality monitoring results do not exceed the Early Response Trigger Levels (see Table 6) for two consecutive sampling events, or as determined by the case-specific *Site 12 Pool Recovery Plan*.
    - c. Conduct sampling and analysis of biomarker lines of evidence to provide further evidence to establish cause and effect e.g. fish tissue analysis for heavy metal toxicity.

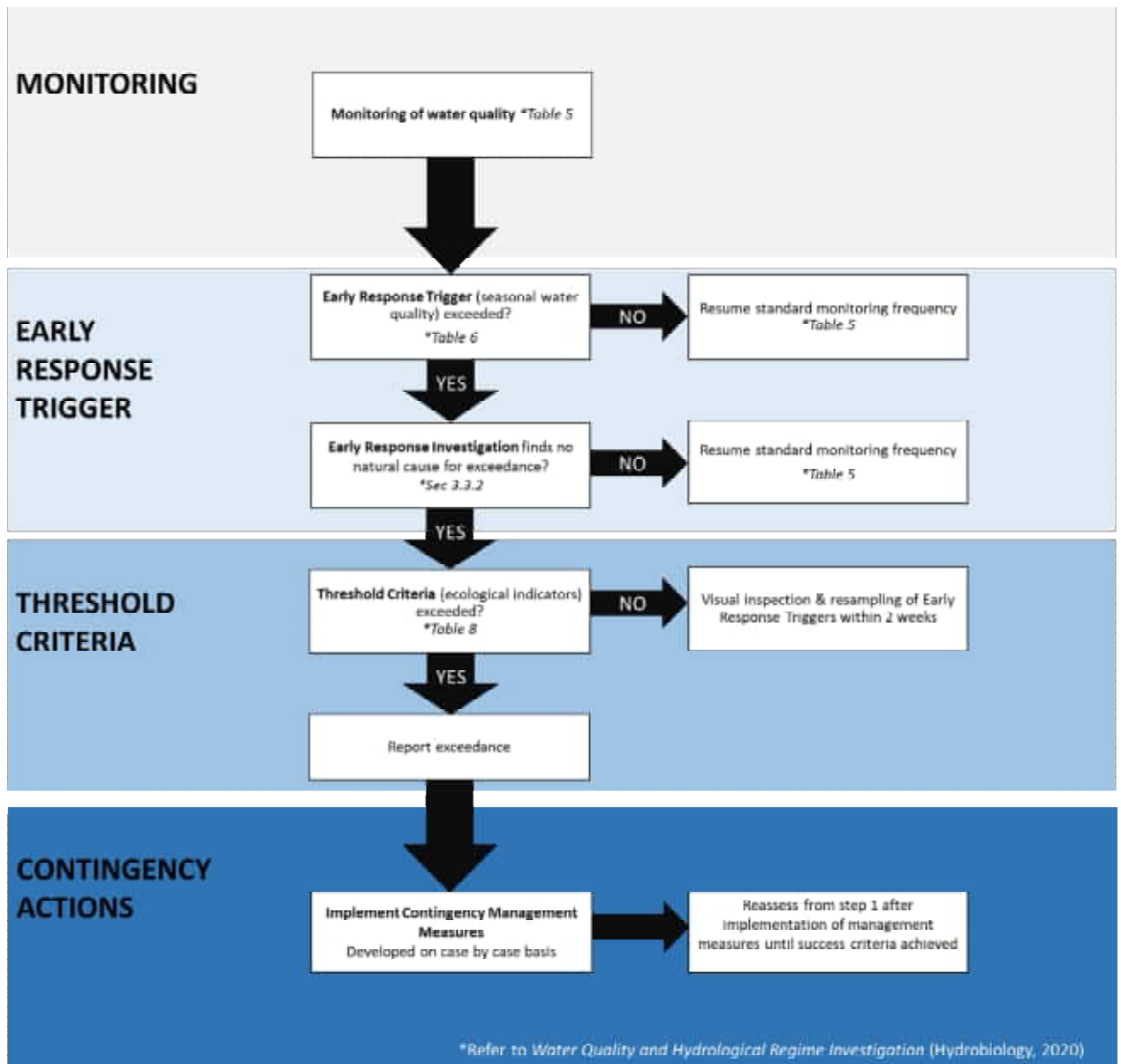


Figure 4-1 Contingency action diagram

## 4.2 CONTINGENCY MANAGEMENT MEASURES

This section conceptually outlines potential management measures for mitigating the immediate water quality and/or ecological impact to avoid a detrimental impact to water quality or hydrological regime of Site 12 Pool. The contingency actions are developed to be responsive to detected exceedances and allow for case-specific response to exceedances caused by the Project. The contingency actions are captured by the *Site 12 Pool Recovery Plan* as part of a multi-disciplinary approach.

Monitoring, preventative and review measures proposed to manage the potential environmental impacts associated with surface water at Site 12 Pool include:

- Implementation of the Site 12 Pool WQQMP, which is informed by this report.

- The monitoring approach incorporating the use of Early Response Indicators to detect early changes to water quality and quantity parameters, and ecological parameters that link changes in water quality and quantity to changes to flora and fauna.
- Monitor groundwater quality and level, as well as surface water quality and quantity upstream of Site 12 Pool to allow for early detection of changes.
- Where investigations deem the exceedance to be a result of the Project, the monitoring frequency will be increased to monthly until the Water Quality monitoring results are below the Early Response Trigger Levels (or a non-project cause is identified by the Early Response Trigger Investigation).
- Review Early Response Trigger Level, risk assignment of Ecological Parameters and Threshold Criteria. Evaluate whether the baseline remains representative, whether they are overprotective, under protective or otherwise not adequately reflective of the high natural variability.
- Implementation of the following preventative management measures to ensure no detrimental impact to water quality and water quantity:
  - Construct bunds at each bench to prevent mining impacted water from being released to the catchment.
  - Install toe bund downstream of WRD tip face to minimise the sediment discharge from WRD catchment to site 12 pool.

# 5. REFERENCES

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# APPENDIX A. VISUAL INSPECTION FIELD DATASHEET

## Site 12 Pool Visual Inspection Field Data Sheet

Date:    /    /

Name:

Undertake the following visual inspection during routine water quality monitoring at Site 12 Pool Water Quality Monitoring Site. This will form part of the site investigation assessment in the event of Primary Trigger Levels being exceeded. See below for visual guide for conducting inspection, and example of site photo.

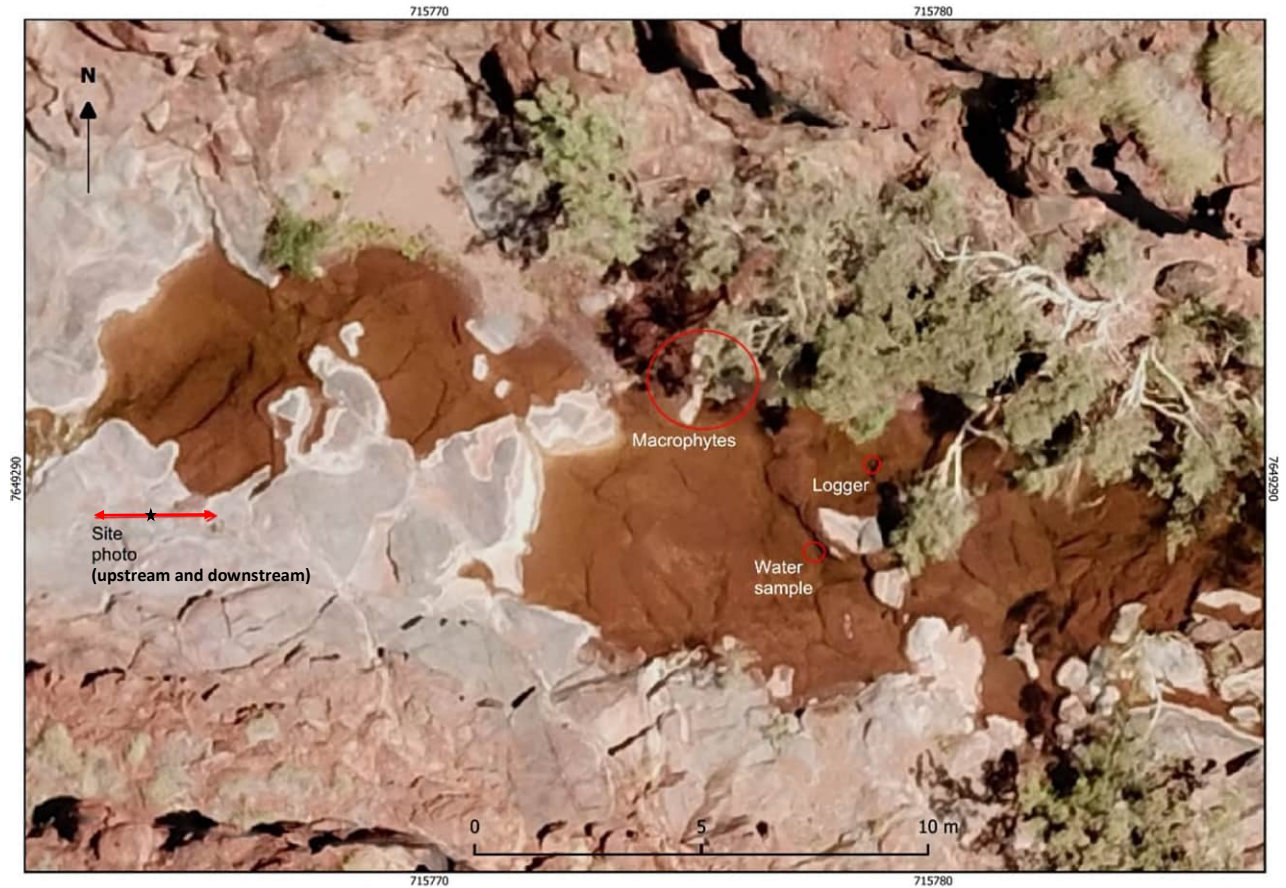
Record YES or NO below as an indication of observed status of the ecological health.

<b>Habitat health parameter</b>	<b>YES</b>	<b>NO</b>
Fish presence	<input type="checkbox"/>	<input type="checkbox"/>
Macrophyte presence	<input type="checkbox"/>	<input type="checkbox"/>
Recent sedimentation presence	<input type="checkbox"/>	<input type="checkbox"/>
Observations of change (i.e. nearly dry, flooding, dead animals/plants)	<input type="checkbox"/>	<input type="checkbox"/>
Site photos taken	<input type="checkbox"/>	<input type="checkbox"/>

Comments

.....

.....



Guide for conducting visual inspection at Site 12 Pool

Monitoring record sheet location coordinates

Name	Easting (MGAz51; GDA94)	Northing (MGAz51; GDA94)	Long. (WGS84)	Lat. (WGS84)
S12P Photo Point	715764	7649289	119.0792	-21.2453
S12P Macrophytes	715777	7649292	119.0793	-21.2452
S12P Logger	715779	7649290	119.0793	-21.2453
S12P Water Sample	715778	7649288	119.0793	-21.2453



Above: Site photo downstream field of view (taken July 2020) – note macrophytes on left bank of pool



Above: Site photo upstream field of view (taken May 2020)

# APPENDIX B. WATER QUALITY SEASONAL DATA

Table 12 Dry season water quality

Sample Date	(Acidity as CaCO <sub>3</sub> ) Acidity as CaCO <sub>3</sub> (mg/L)	(EC @ 25 Deg C) EC @ 25 Deg C (uS/cm)	(Ferrous Iron) Ferrous Iron (mg/L)	(pH) pH (pH units)	(SO <sub>4</sub> - Turbidimetric) SO <sub>4</sub> - Turbidimetric (mg/L)	(Alkalinity) Tot Alkalinity as CaCO <sub>3</sub> (mg/L)	(Turbidity) Turbidity (NTU)	Nitrate + Nitrite (NO <sub>x</sub> as N; mg/L)
9/12/2020	<1	1090	-	8.60	28	590	1.85	<0.05
17/12/2019	<1	1479	-	8.21	20	685	<0.1	<0.05
28/06/2019 13:35:00	10	1,150	0.025	8.24	77	629	0.3	0.01
23/05/2017 15:00:00	0.5	1,160	0.025	8.48	48	508	0.3	0.12
15/06/2017 09:00:00	0.5	1,150	0.025	8.38	44	568	0.3	<0.01
13/07/2017 15:00:00	0.5	1,220	0.025	8.61	40	595	0.2	<0.01
10/08/2017 15:00:00	0.5	1,230	0.025	8.61	41	482	0.2	<0.01
20/09/2017 15:00:00	0.5	1,300	0.025	8.73	42	535	0.7	<0.01
01/07/2018 08:00:00	0.5	1,370	0.025	8.6	44	543	0.4	
26/08/2018 08:25:00	0.5	1,380	0.025	8.8	53	536	0.5	<0.01
29/09/2018 08:35:00	0.5	1,720	0.025	8.98	71	739	1.7	0.01
025/07/2019 07:40:00	0.5	1,130	0.025	8.64	27	653	0.2	<0.01
29/08/2019 07:40:00	0.5	1,160	0.025	8.63	26	665	0.3	<0.01
22/09/2019 08:34:00	0.5	1,180	0.025	8.68	28	642	0.3	<0.01
28/10/2019 11:23:00	0.5	1,270	0.025	8.9	28	688	0.5	
21/06/2020 15:34:00	0.5	1,160	0.025	8.62	18	619	0.3	
28/06/2020 09:00:00	0.5		0.025		21	646		
13/07/2014 0:00		1290		8.28	41	502		<0.01
04/08/2015 09:00:00		1,100		8.25	22	633		<0.01
23/09/2015 02:00:00		1,350		8.81	47	682		<0.01

Table 13 Wet season water quality

Sample Date	(Acidity as CaCO <sub>3</sub> ) Acidity as CaCO <sub>3</sub> (mg/L)	(EC @ 25 Deg C) EC @ 25 Deg C (uS/cm)	(Ferrous Iron) Ferrous Iron (mg/L)	(pH) pH (pH units)	(SO <sub>4</sub> - Turbidimetric) SO <sub>4</sub> - Turbidimetric (mg/L)	(Alkalinity) Tot Alkalinity as CaCO <sub>3</sub> (mg/L)	(Turbidity) Turbidity (NTU)	Nitrate + Nitrite (NO <sub>x</sub> as N; mg/L)
23/05/2021	<1	1,120	0.014	8.42	14	592	0.2	<0.01
31/5/2020	<1	1,227	<0.05	8.26	22	478	0.16	0.05
24/11/2019 08:18:00	0.5	1,460	0.025	9.09	34	803	0.7	
16/03/2016 13:00:00	0.5	1,790	0.025	8.9	119	516	1.4	
15/11/2017 12:06:00	0.5	1,800	0.025	8.8	90	600	1.9	<0.01
20/10/2017 15:00:00	0.5	1,440	0.025	8.79	48	756	1.3	<0.01
19/04/2020 08:36:00	0.5	1,080	0.025	8.65	14	559	0.4	
15/03/2017 15:00:00	0.5	1,280	0.025	8.64	105	411	0.3	<0.01
28/01/2020 08:18:00	0.5	992	0.025	8.64	21	544	0.3	
11/05/2020 12:54:00	0.5	1,130	0.025	8.61	16	572	0.4	
31/03/2020 07:50:00	0.5	1,080	0.025	8.58	16	540	0.4	
28/04/2017 15:00:00	0.5	1,120	0.025	8.55	51	514	0.3	<0.01
18/02/2020 08:30:00	0.5	917	0.025	8.52	18	533	0.5	
04/03/2018 09:15:00	0.5	1,180	0.025	8.44	44	471	0.6	<0.01
11/02/2018 15:00:00	0.5	1,010	0.025	8.39	51	416	1	<0.01
03/04/2018 09:00:00	0.5	1,210	0.025	8.35	44	406	0.5	<0.01
06/05/2018 08:20:00	0.5	1,180	0.025	8.3	41	429	1.4	<0.01
29/05/2020 00:00:00	0.5	1,227	0.025	8.26	21	478	0.16	
17/12/2019 11:17:00	0.5	1479		8.21	28	685	0	
08/03/2015 00:00:00		750	0.01	8.1	58	210		<0.5
29/01/2016 13:00:00		334		8.04	32	82		0.32
10/02/2017 15:00:00	7	661	0.025	7.76	124	123	37.7	0.37



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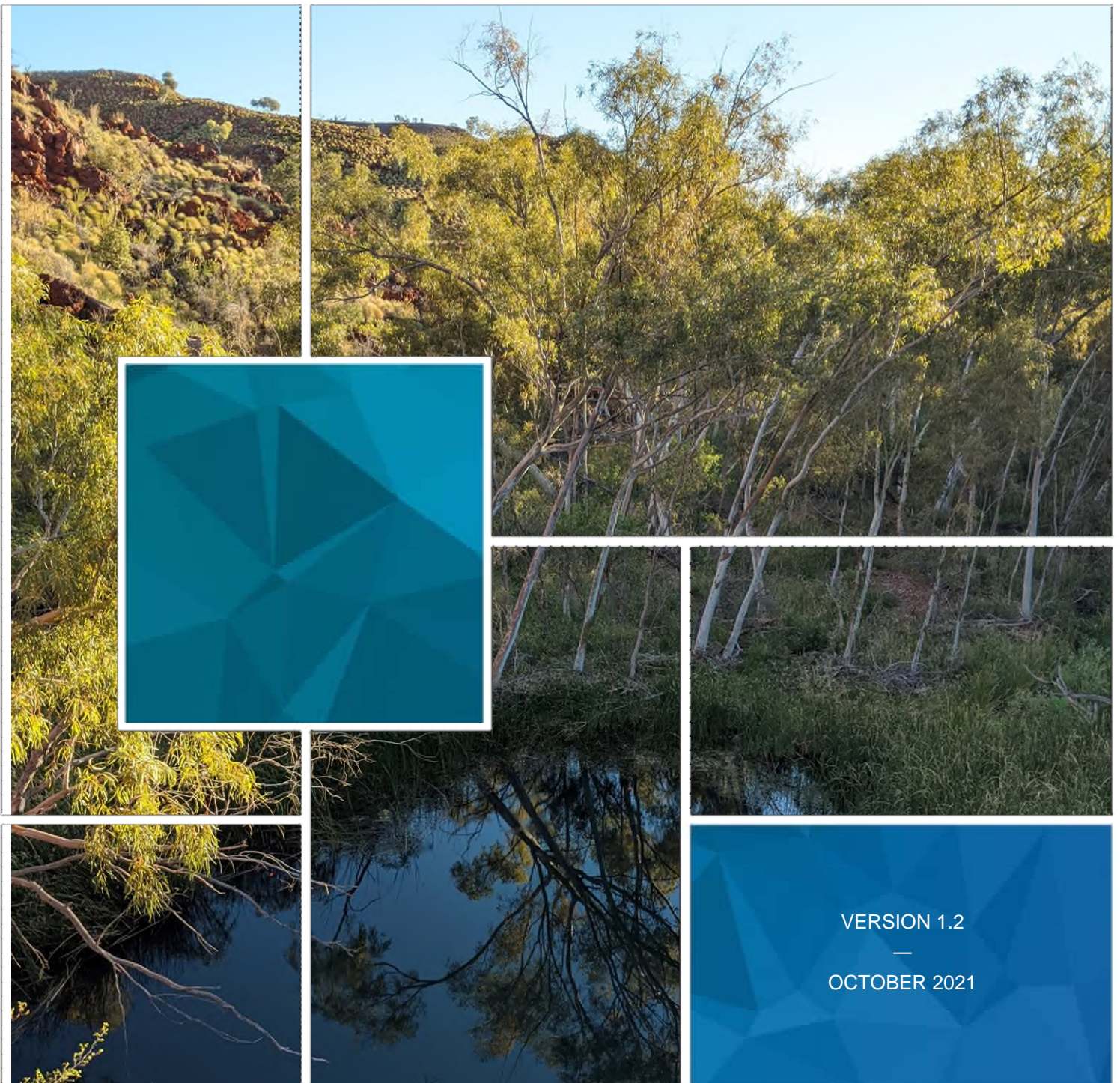
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Appendix 30:

Surface Water Monitoring and Aquatic Ecology  
Survey Baseline Report

# IRON BRIDGE: SURFACE WATER MONITORING & AQUATIC ECOLOGY BASELINE REPORT LATE WET 2019 TO LATE WET 2021

FMG IRON BRIDGE (AUST) PTY LTD



VERSION 1.2  
—  
OCTOBER 2021

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## GLOSSARY OF ACRONYMS

Acronym	Definition
ANZG	Australian and New Zealand Guidelines for fresh and marine water quality
BRUV	Baited Remote Underwater Video- a sampling method for fish
DO	Dissolved oxygen
DOC	Dissolved organic carbon
DSIAR	Diatom Species Index for Australian Rivers
EC	Electrical Conductivity
EPT	Ephemeroptera, Plecoptera, Trichoptera: three macroinvertebrate orders that comprise a biotic index
FMGIB	FMG Iron Bridge (Aust) Pty Ltd
N	Nitrogen
NTU	Nephelometric Turbidity Units
P	Phosphorous
QA/QC	Quality Assurance/Quality Control
SO4	Sulphate
SPC	Specific Conductivity (conductivity normalized to 25°C)
TDS	Total Dissolved Solids
TIC	Total Inorganic Carbon
TOC	Total Organic Carbon
TSS	Total Suspended Solids

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# 1. INTRODUCTION

This report presents the findings of the baseline aquatic ecology monitoring program of surface water pools at the Iron Bridge Project between December 2019 and June 2021.

## 1.1 BACKGROUND

Hydrobiology WA Pty Ltd (Hydrobiology) conducted an aquatic ecology baseline monitoring program of surface water pools to support the baseline development and approvals of the Iron Bridge Magnetite Project (the Project) in the Pilbara region of Western Australia on behalf of FMG Iron Bridge (Aust) Pty Ltd (FMGIB). The managing entity for the Project is IB Operations Pty Ltd (Iron Bridge), a joint venture company between FMGIB and Formosa Steel IB Pty Ltd.

## 1.2 OBJECTIVES

The objectives of the aquatic ecology survey are the following:

- Establish baseline aquatic ecology conditions at selected surface water pools, which will support future assessments of impacts potentially resulting from the Project.
- Implementation of the Iron Bridge Surface Water Management Plan (FMG, 2020).
- Inform the Site 12 Pool Water Quality and Hydrological Regime Investigation (Hydrobiology, 2020) and provide technical input to the Site 12 Pool Water Quality and Quantity Management Plan (FMG, 2020).

# 2. METHODOLOGY

## 2.1 SITE LOCATIONS

The Project is located 110 km south of Port Hedland in the Pilbara region and incorporates the North Star and Glacier Valley Magnetite ore bodies. The aquatic ecology survey was conducted at six surface water pools at Iron Bridge within the Turner and Strelley/Shaw River catchments (Figure 2-1) and is situated within the Chichester IBRA bioregion and the Grassland climate class. Hydrological data was additionally collected from surface water creeks at Iron Bridge. A map of the survey sites for aquatic ecology is provided in Figure 2-2, including catchment areas for each site. Study site catchment areas and coordinates are provided in Table 2-1.

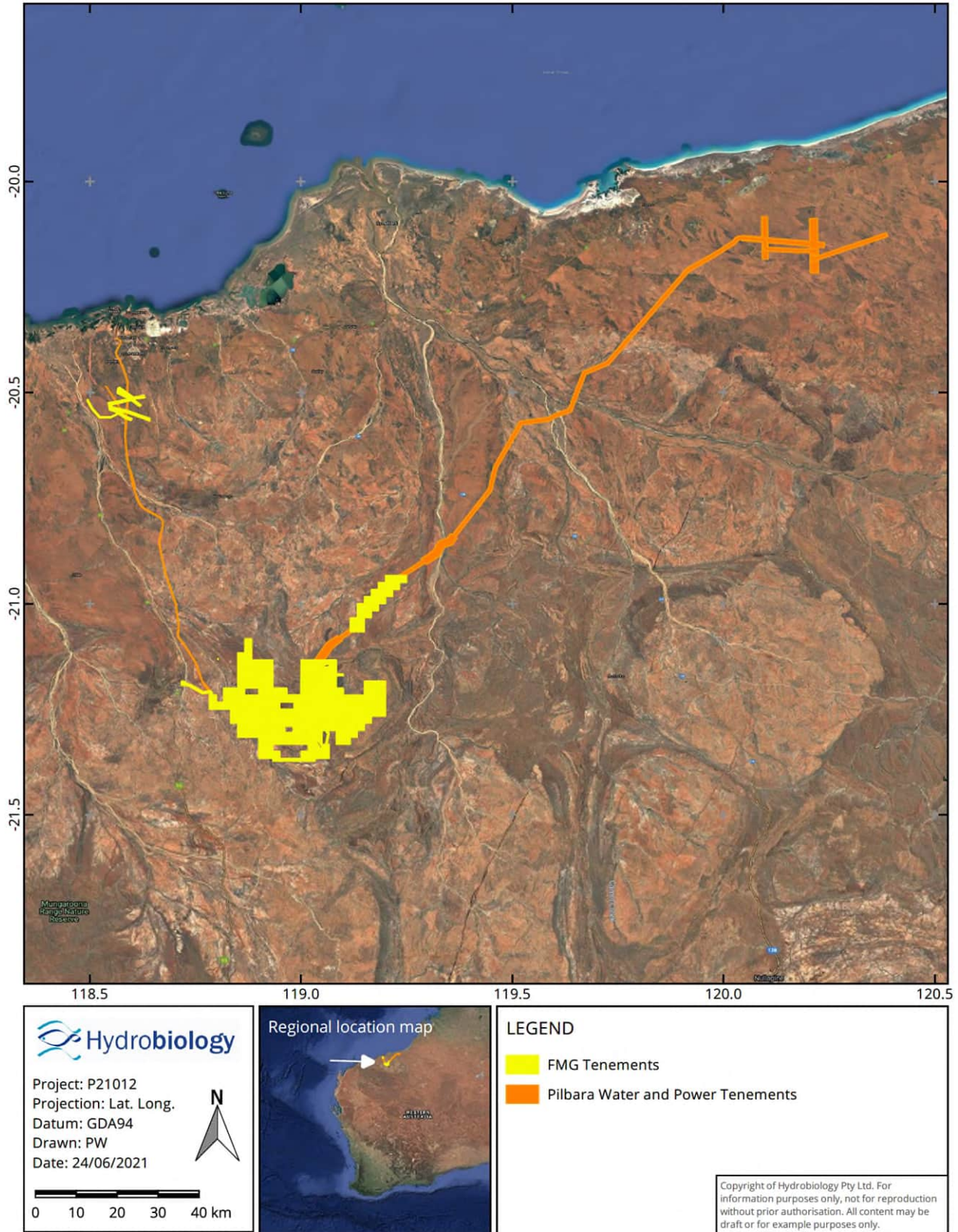


Figure 2-1 Regional study location area map showing project tenements

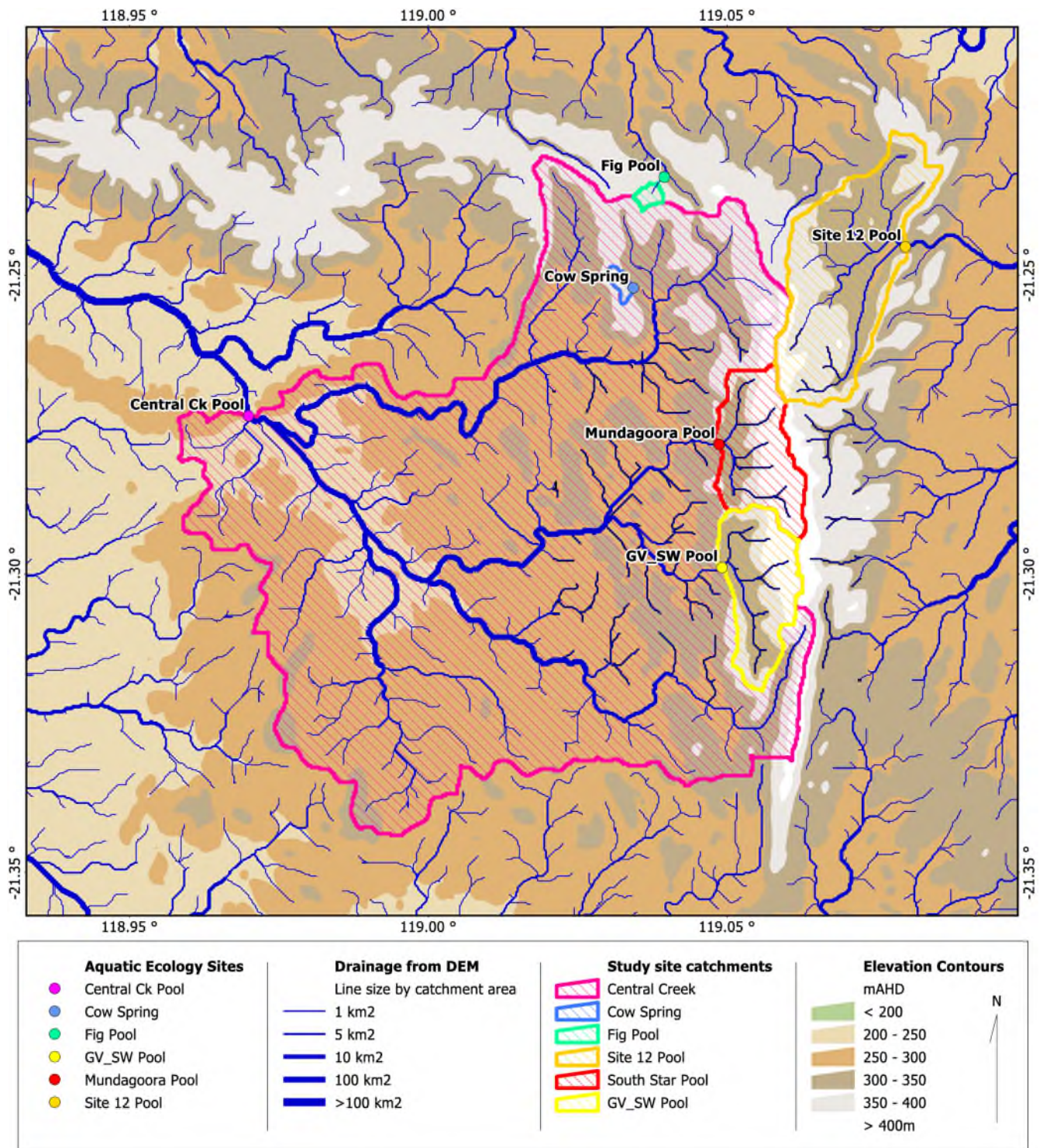


Figure 2-2 Study site catchments and drainage lines

Table 2-1. Summary of study sites included in the aquatic ecology and surface water monitoring survey for the late wet and late dry season for 2020, and the late wet season 2021, including catchment areas and coordinates (GDA94, UTM 50K)

Site Name	Catchment area (km <sup>2</sup> )	Northing	Easting
<b>Fig Pool</b>	0.16	711668	7650632
<b>Mundagoora Pool<sup>1</sup></b>	3.3	712558	7645667
<b>Site 12 Pool</b>	7.6	716248	7649263
<b>Cow Spring</b>	0.15	711103	7648587
<b>Central Creek Pool</b>	85.1	704385	7646299
<b>GV Pool<sup>2</sup></b>	3.3	712580	7643386

<sup>1</sup> Mundagoora Pool was previously named South Star Pool

<sup>2</sup> GV Pool was first sampled in the late wet season 2021.

## 2.2 MONITORING TIMING

Surface water level logger installations, water sampling and initial inspections of several sites were completed in December 2019 (Late Dry 2019). Aquatic ecology sampling for five pools (Fig Pool, Mundagoora Pool, Site 12 Pool, Cow Spring and Central Creek) was first initiated in May 2020 (Late Wet 2020). Subsequent surveys were completed at these sites in December 2020 (Late Dry 2020) and May-June 2021 (Late Wet 2021). An additional site, SW\_GV Pool, was added in December 2020 (Late Dry 2020) with a site inspection and the installation of a water level and conductivity logger. This site (GV\_SW Pool) was first surveyed for aquatic ecology in May-June 2021 (Late Wet 2021).

The late wet season baseline aquatic ecology surveys are conducted between May and June. Collecting baseline data during this period captures conditions when the aquatic food web is established, and early life stages of some aquatic organisms are present, which enables effective characterisation of the ecosystem health. The timing of baseline data collection aims to align with the water quality sampling periods for the assessment period, being the wet and drying season.

The late wet season baseline conditions are expected to show greater species diversity and abundance relative to dry season conditions when stressors (such as high temperature and salinity) are typically greater and result in declining ecosystem health. Capturing the seasonal variability is expected to allow for a more accurate assessment of baseline conditions and variability, which will inform surface water management.

Table 2-2 provides the key dates and seasons for the aquatic ecology and surface monitoring survey.

Table 2-2 Summary of the key sampling dates and seasons for the aquatic ecology and surface monitoring survey

Season	Year	Dates	Sites
<b>Late Dry</b>	2019	17 Dec-19 December	Installation of loggers, water sampling and site inspections. No Aquatic Ecology sampling.
<b>Late Wet</b>	2020	29 May – 2 June	Fig Pool, Mundagoora Pool, Site 12 Pool, Cow Spring, Central Creek
<b>Late Dry</b>	2020	8-13 December	Fig Pool, Mundagoora Pool, Site 12 Pool, Cow Spring, Central Creek
<b>Late Wet</b>	2021	21-28 May	Fig Pool, Mundagoora, Site 12 Pool, Cow Spring, Central Creek, GV Pool

## 2.3 WATER QUALITY AND HYDROLOGICAL MONITORING

### 2.3.1 IN-SITU SAMPLING

Water level, temperature and conductivity loggers were installed in each pool to continuously monitor the effects of rainfall, the rate of drying, and evapo-concentration effects. In situ Aquatroll CTD data loggers were installed in Site 12 Pool, Fig Pool and Mundagoora Pool from December 2019 and currently remain in situ. Further In situ Aquatroll CTD data loggers were installed in Cow Spring Pool and Central Creek Pool in May 2020 and currently remain in situ. An additional logger was installed in GV\_SW Pool in December 2020 and remains active. All loggers were downloaded during each survey, including most recently in June 2021.

In addition to the permanently deployed loggers, a calibrated YSI DSS Pro water quality sonde was used to collect in situ measurements from all sites where sufficient water was present during field surveys. Measurements were collected following the 'Field sampling guidelines: A guideline for field sampling for surface water quality monitoring programs' procedure for physical parameter sampling (Department of Water, 2009 pg. 13). In-situ measurements were collected before all other activities to ensure that no disturbance to water quality was caused by sampler activity. The following field parameters were collected; temperature (°C), pH, oxidation reduction potential (mV), dissolved oxygen, specific conductivity (µs/cm), salinity (ppt) and turbidity (NTU).

### 2.3.2 SURFACE WATER QUALITY

Water samples were collected following the 'Field sampling guidelines: A guideline for field sampling for surface water quality monitoring programs' (Department of Water, 2009) procedure for direct sampling. Water samples were collected by submerging the sample containers in the water at the waters' edge with the sampler on the bank to minimise disturbance. Powder-free nitrile gloves and laboratory prepared bottles were used to avoid potential sources of contamination. Unpreserved sample containers were rinsed three times with sample water before retaining a representative sample, and preserved bottles were filled from a pre-rinsed syringe. Samples for dissolved metals analysis were syringe filtered within 1 minute of collection through 0.45 µm membrane filters using 50 mL polyethylene disposable syringes.

Upon collection, samples were immediately placed on ice in a dedicated esky and then transferred to a fridge at the earliest convenience. For delivery to ALS Australia, samples were packed in clean coolers with ice bricks. All bottles and filtering equipment were prepared by NATA-accredited ALS, Perth. Samples were

sent to a NATA accredited laboratory for analysis for parameters which allowed for a broad characterisation of the examined environments. The parameters are identified in Appendix A.

Water quality samples were also delivered to the Stable Isotope Laboratory, West Australian Biogeochemistry Centre, University of Western Australia for isotope analysis. Samples were analysed for  $\delta^{2}\text{H}$  and  $\delta^{18}\text{O}$ , using an Isotopic Liquid Water and Continuous Water Vapour Analyser Picarro 2130i and followed the procedure of Skrzypek and Ford (2014).

### 2.3.3 SEDIMENT QUALITY

Sediment samples were collected following the 'Handbook for Sediment Quality Assessment' procedures for the collection of surface sediment (Simpson *et al.*, 2005). Surface sediment was collected from the top 5 cm of sediment and homogenised in a bowl before transferring to sterile jars. Powder-free nitrile gloves and laboratory prepared jars were used to avoid potential sources of contamination. Samples were stored on ice in a dedicated esky and transferred to a fridge at the earliest convenience. For delivery to ALS Australia, samples were packed in clean coolers with ice bricks. Samples were sent to a NATA accredited laboratory to analyse parameters, including total metals, major ions, total organic carbon, total nitrogen and total phosphorous. The specific parameters are identified in Appendix B.

## 2.4 AQUATIC ECOLOGY MONITORING

### 2.4.1 MONITORING PARAMETERS

Aquatic ecology monitoring parameters were selected following the ANZG process (ANZG, 2018) for selecting relevant ecological indicators of water quality through establishing environmental values and identifying conceptual impact mechanisms. These indicators are algal (diatom/phytoplankton) communities, macrophyte communities, macroinvertebrate communities and fish communities. The selection of these four communities provides multiple lines of evidence and spans multiple trophic levels and phyla, which is recommended by ANZG (2019) in order to capture the variable impact of ecosystems stressors and detect, for example, impacts of bioaccumulation and biomagnification. Algae, macroinvertebrates, fish and macrophytes typically underpin the food web in pools, providing habitat and/or food sources for a diversity of native species including terrestrial or semi-aquatic organisms that may utilise the pool such as reptiles (e.g. Pilbara olive python), avian fauna and amphibians (Halse *et al.* 2001).

### 2.4.2 FISH AND DECAPOD CRUSTACEANS

#### 2.4.2.1 SAMPLING

Fish and decapod communities were sampled to collect data on higher-order organisms with relatively long life spans, which is useful for assessing bioaccumulation and biomagnification effects, interannual survivability and reproduction. Evidence of reproduction was sought (*i.e.* presence of juveniles) to detect sub-lethal effects impacting reproduction or vulnerable size classes.

Fish and decapod crustaceans were sampled using fyke nets and traps. Two trap types, box traps and bait traps, were used to collect a more representative sample of size classes present at a site (Osawa *et al.* 2015). Fyke nets were 4 m long, 1 m diameter, 4 m wings, with a 4 mm mesh size and 150 cm diameter entry hole. Bait traps were 0.4 m long, 0.25 m wide and 0.25 m high, with a 5 mm mesh size and 30 mm diameter entry holes. Box traps were 0.6 m long, 0.45 m wide and 0.2 m high, with a 10 mm mesh size. Traps were baited with a 50/50 ratio of cat food biscuits and whiting based burley. At each pool, one fyke net, two bait traps, and two box traps were set for overnight an average of 12 hours (maximum 19 hours). Traps were set along the length of the pools, predominantly in bank habitats with high structural complexity (e.g. macrophytes, woody debris, root masses), where abundance was likely to be highest.

After two rounds of sampling (Late Wet 2020 and Late Dry 2020) it was decided that the box traps were not providing useful data as they rarely caught fish and those that were caught were not representative of the counts in the fyke nets, or fish abundance observable within the pools. The use of traps was discontinued for future surveys, and fyke nets are used as the primary measure of fish abundance and diversity for this program.

Following capture, the first 30 individuals of each species were randomly selected for subsampling to reduce handling stress on the entire catch. Subsampled individuals were counted, measured (total length and standard length) and weighed. The remaining individuals were counted and allocated to one of four length classes based on standard length (SL) (*i.e.* <30 mm, 30 – 60 mm, 60 – 90 mm and >90 mm). All fish were kept in aerated tubs immediately after capture, prior to being measured and were immediately released near the collection point after processing.

As a secondary measure of fish abundance and species presence at each site, Hydrobiology utilised baited remote underwater video traps (BRUVS). Baited underwater GoPro 5 cameras were deployed in suitable habitats at each site, and the video was set to record for 10 minutes.

#### 2.4.2.2 ANALYSIS

Fish abundance at each site was compared for each season. Catch per unit effort (CPUE) was used as a measure of abundance and was defined as the species total catch divided by the soak time in hours. Fish were grouped into standard length classes, and length frequency (%) figures were constructed for each species at each site across the three seasons. Juvenile presence was defined as the presence of smaller size classes that are below the size at sexual maturity described in the relevant literature (based on wild populations).

Where standard length was recorded for subsampled fish, length distribution box and whisker plots were constructed for each species at each site across the three seasons. Independent t-tests and analysis of variance (ANOVA) were used to assess any significant differences in the mean standard length for each species at all sites across the three seasons.

Fish abundance on BRUV footage was recorded using a common metric MaxN, the maximum number of fish per species on a single video frame.

### 2.4.3 MACROINVERTEBRATES

#### 2.4.3.1 SAMPLING

Macroinvertebrates are a commonly used bioindicator for assessing a variety of environmental issues. ANZG (2019) recommends macroinvertebrate monitoring to assess changes in biodiversity and changes in ecosystem processes of water bodies due to contaminant inputs. The taxonomic groups sensitive or tolerant to declines in water quality are well known and the presence and abundance of these taxa are used to score the water condition of surface water pools.

Macroinvertebrate sampling followed the procedures of 'Western Australia AUSRIVAS sampling and processing manual' (van Looij, 2009). Samples were collected using a 250 µm mesh pond net, 35 cm by 25 cm opening, a 30 cm depth (tail) and a 150 cm handle. The net was rinsed and checked for holes between each site. Two samples were collected from each pool. Due to the pool's small size, two replicates from the same habitat (*i.e.* macrophyte, pool) was not possible for all pools without risking re-sweeping the extent of the previous sweep. Therefore, samples were obtained from different habitats for most pools. Sites were sampled by sweeping the net starting at the downstream end of the 10 m sampling area and moving upstream while collecting the sample, aiming to sample all the different sub-components of the habitat and at different depths. The contents of the net were then rinsed into labelled sterile containers using 70%

ethanol for preservation. Samples were transported to Stream Macroinvertebrate Identification for identification and enumeration.

Specimens in each sample were laboratory picked following the AusRivAS methods. Samples were identified to family level, where possible. A 10% error margin is allowed for the identifications and enumerations of macroinvertebrates (as required for AusRivAS macroinvertebrate identification accreditation). Any taxa that could not be identified (usually due to their immature stage or deterioration/damage) were recorded at a higher taxonomic level (i.e. Order). Taxa were recorded as present if the head was present in the sample (provided it appeared to be alive at the time of collection). This is common with Ephemeroptera, Zygoptera and Oligochaeta, which are often damaged at the time of collection and only part of the specimen is retained in the sample. Empty (dead) Gastropoda shells are not recorded as being present. Specimens were preserved in a solution of 70% methylated spirits, 5% Glycerol and 25% water and retained for QA/QC purposes at Hydrobiology Perth.

#### 2.4.3.2 ANALYSIS

Several indices were derived from the macroinvertebrate data and are described below as per Negus *et al.* (2013) and Chessman (2003). Each of these indices was qualitatively assessed for changes in values among sampling occasions.

**Total abundance** - The number of individual macroinvertebrates collected in a sample, which can provide insights into the biological productivity, population health or carrying capacity of an ecosystem.

**SIGNAL 2 Index** - The SIGNAL index (Stream Invertebrate Grade Number - Average Level) was developed for the bioassessment of water quality in rivers in Australia. It is calculated by grading each macroinvertebrate family based upon the level of its sensitivity to various pollutants. The grades applied range from 1 (tolerant) to 10 (sensitive; Chessman, 2003) and a weight is applied to each taxa depending on its abundance. The SIGNAL 2 score for a sample is calculated by averaging the weighted sensitivity grades of the macroinvertebrate families collected. The version applied here is SIGNAL version 2.iv, SIGNAL 2 Scores suit both family and order-class-phylum identification (Chessman, 2003).

**EPT taxa richness** - The number of aquatic macroinvertebrate families collected from three orders of aquatic insects: Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). Macroinvertebrates belonging to these three orders are considered sensitive to changes in their environment and therefore EPT is often used to assess water body conditions. Sensitivity would generally be indicated by a decrease in EPT in the presence of changed environmental conditions; however, increases can occur depending on the nature of the impacts that are present.

**Taxa richness** - The number of aquatic macroinvertebrate taxa collected in a sample. This index is used as a common measure in many monitoring programs. The use of taxa richness is based on the premise that with changes in the condition of a site, the taxa richness will increase or decrease from the baseline condition. Increases or decreases will depend on the nature of the threats that are influencing the ecosystem.

Additionally, the taxonomic composition of the community was also assessed to see how abundances of individual taxa vary among sampling events. Note that the taxonomic classification level of taxa (e.g. genus, family, order) varies as the taxa are identified to the lowest practical level, with some groups harder to identify to lower levels than others (e.g. Ostracoda).

### 2.4.4 DIATOMS AND PHYTOPLANKTON

#### 2.4.4.1 SAMPLING

Diatoms (single-celled algae with siliceous cell walls) are effective indicators for ecological change in freshwater systems (Gale, 2015). Diatoms are an important component of the riverine algae community and

are commonly used for assessing water quality based on the tolerance of species present to pollution (Oeding and Taffs, 2017). Artificial substrates called periphytometers were used to collect living diatoms over a specified time. Two periphytometers each containing 10 microscope slides were deployed at each of the pools. The substrates were left immersed for an average of four weeks to enable diatom communities to establish, reflecting the ambient water quality. On retrieval, the 10 slides from each artificial substrate were scraped into a small, labelled sample container and preserved with 70% ethanol. They were then submitted to the laboratory for taxonomic identification to species level and enumeration. Dr John Tibby of the University of Adelaide was engaged as the sub-consultant for the taxonomic identification and enumeration.

Water samples were taken from the survey sites and submitted to Dalcon Environmental to analyse a full count phytoplankton profile for each pool. Following the Dalcon Environmental recommended sampling protocol, 1.25 L of water was collected from each site from the mid-water column. Phytoplankton samples were preserved with Lugol's Iodine and chilled on ice for the duration of transport.

#### 2.4.4.2 ANALYSIS

The most widely used biotic indices in Australia, DSIAR score (Diatom Species Index for Australian Rivers score), was derived to quantify diatom ecology at the pools. The DSIAR score estimates water quality by the relative abundance of diatom species sensitive to water quality stressors, where a higher DSIAR score represents higher water quality (Chessman *et al.*, 2007). Total count per sample for each species of planktonic phytoplankton and diatoms is also presented.

#### 2.4.5 MACROPHYTES

Macrophytes (aquatic plants) are sensitive indicators of ecosystem health and can be used to assess when physico-chemical thresholds are reached (e.g. turbidity blocking photosynthesis of submerged macrophytes or impacts of sedimentation) (Barko *et al.*, 1982) and the abundance and spatial distribution of heavy metals in aquatic environments (Cardwell *et al.*, 2002). They play a fundamental role in aquatic systems by, for example, reducing erosion of stream banks, increasing dissolved oxygen levels, providing a food source and mediating food web dynamics by providing habitat structural complexity (Warfe and Barmuta, 2006).

Macrophyte sampling followed the AusRivAS guidance (van Looij, 2009). Macrophyte surface area coverage of emergent, submerged and floating macrophytes (Figure 2-3) was visually estimated across the pool habitat and defined as isolated, scattered, in beds or choking the stream as per the 'Field Sampling and Habitat Assessment Sheet 2006 v.14'. Macrophytes included those which were out of the water but in the active channel. Specimens were photographed and samples collected and preserved in 70% ethanol for subsequent confirmation of taxonomic identification and retained. Macrophytes were identified to the species level where possible.

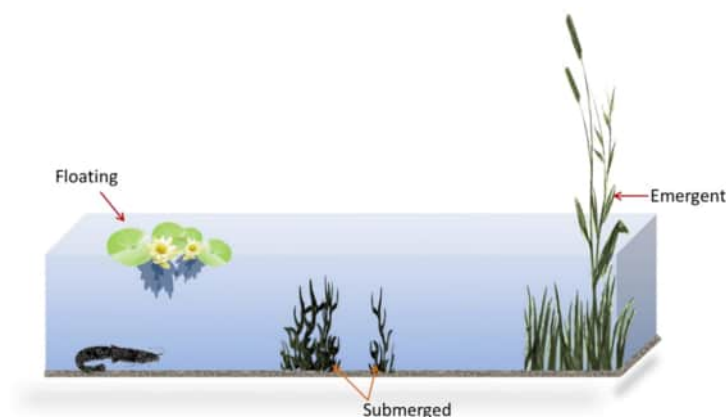


Figure 2-3 Schematic of floating, submerged and emergent macrophytes (DES, 2018).

# 3. RESULTS

This section presents the findings of the hydrology and aquatic ecology surveys conducted between December 2019 (Late Wet 2019) to June 2021 (Late Wet 2021). The results are presented as distinct chapters for each site to reflect that the surface water pools should not be directly assessed relative to other pools but rather to the temporal patterns of the individual pool. For example, each pool has different hydrology, size and habitats, and the methods used are not spatially uniform (i.e. macroinvertebrate sampling of different habitat types between pools).

## 3.1 SITE 12 POOL (IB\_SW\_POOL12\_01)

Site 12 Pool is part of a series of shallow pools that lie to the east of the Project on a small tributary to the upper Six Mile Creek. It is connected to both surface water and groundwater sources over the hydrologic cycle, typically sustained by groundwater until the local groundwater level drops below the pool base level over the late dry season. The pool is frequently perennial, though has been known to dry out following small wet seasons. During the late wet season sampling it is a fresh-brackish, predominantly bedrock habitat that supports fish, macroinvertebrates, algal communities, macrophytes and riparian vegetation (Figure 3-1).

### 3.1.1 WATER QUALITY AND HYDROLOGY

Water quality sampling included physico-chemical parameters, metals analysis and major ions to characterise the surface water system. Stable isotope analysis at Site 12 Pool and bore NS-0664 was also conducted to inform the connectivity of surface water and groundwater. A logger recorded conductivity, temperature and water level on a 3-hourly basis at Site 12 Pool between December 2019 and May 2020.

Site 12 Pool is a shallow bedrock supported natural habitat with a 7.6 km<sup>2</sup> catchment area (Figure 3-3) with typically low rainfall and infrequent high rainfall events largely driven by storm and cyclonic activity. The water quality experiences high seasonal variability due to the climatic conditions of the region, with the greatest variability recorded following rainfall events.

The water quality was predominantly clear (mean turbidity = 2.5 NTU), slightly alkaline (mean pH = 8.5) and a magnesium-bicarbonate (Ca/Mg-HCO<sub>3</sub>) dominated water type with low sulphates (SO<sub>4</sub>) (Figure 3-4; Appendix A). However, it is expected that during surface water flow events the turbidity temporarily increases. Similarly, during rainfall events, the typically slightly brackish pool (1,100-1,300 µS/cm) would become temporarily extremely fresh (<100 µS/cm).



Figure 3-1 Photographs of Site 12 Pool during the late wet season (June 2020; top) and late dry season (Dec 2019; bottom).

Figure 3-5 and Figure 3-6 display a high-resolution water level, salinity (conductivity) and temperature logger record from Site 12 Pool for December 2019 to June 2021 (two wet seasons). The rapid change in

conductivity after rainfall events is evident with one minor inflow at the start of the 2019-20 wet season that partially flushed and filled the pool as well as four major inflows that displayed flooding peaks and complete pool flushing. A similar pattern of four flushing events was also observed in the 2020-21 wet season (Figure 3-6). This preliminary baseline data indicates that the pool is sustained by groundwater (until the local groundwater level drops below the pool level) and is periodically flushed with fresh surface water flows after rainfall events. The ratio of Site 12 Pool volume against inflow volume is presented in *Site 12 Pool Water Quantity Assessment and Management* (FMG, 2020). It takes approximately 2 – 3 weeks for the groundwater to displace the surface water flows once a flushing event has occurred. Comparison of the nearby groundwater levels at the Site 12 Groundwater monitoring bore (NS-0664) with the rainfall and flow in the Site 12 Pool is provided in Figure 3-7. This data suggests that the groundwater level recedes at around 3 cm per week over the dry season, reaching the a level below which groundwater no longer maintains the Site 12 Pool towards the end of the dry season.

Site 12 Pool is a larger habitat area relative to other North Star pools, comprising a series of isolated pools spanning approximately a 650 m reach and 1266 m<sup>2</sup>, and likely has greater downstream connectivity relative to other pools in the Iron Bridge area. Most pools are shallow, with the deepest being approximately 2.5 m. The total volume of the pools is estimated to be 2,532 m<sup>3</sup> based on an average depth of 2 m. This is a small volume relative to the inflow volume; for example, the 1EY post-development estimated inflow is substantially higher (54,198 m<sup>3</sup>) (FMG, 2020). Recorded water levels were a maximum of ~0.6 m above the pool overflow levels during high-flow events, which typically lasted less than 24 hours before flows receded. The rapid falling stage after large flow events indicates there is little retention capacity in the system beyond the pool spill point.

Analysis of the stable isotopes  $\delta^{18}\text{O}$  and  $\delta^2\text{H}$  in Site 12 Pool and bore NS-0664 indicated that the isotope ratios for the surface water within Site 12 Pool and the upstream monitoring bore (NS-0664) were consistently different, with the groundwater being substantially more depleted, particularly for the late dry season (Dec 2019) sampling event. It is likely that some degree of evaporation along the groundwater inflow to the pool, and within the pool system itself, is creating an enriched signature relative to the deeper groundwater (NS-0664) which is more representative of large rainfall event recharge. The December 2019 isotope enrichment in the Site 12 Pool is evidence that at this stage “fresh” or deep groundwater recharge was at a minimum and evaporative isotopic enrichment was a dominant process. The most depleted isotopic ratio of the dataset was observed at the Site 12 groundwater monitoring bore (NS-0664) following the large 2020/21 wet season. This may indicate that the source of the groundwater at the site was relatively recent rainfall during this period. There are preliminary indications that the groundwater at the Site 12 Pool monitoring bore is more similar to a rainwater isotopic composition after the wet season, moving towards the evaporation line in the late dry.

Although the pool is sustained by groundwater for the majority of the dry season, it has been recorded as completely dry in recent years (2015, 2016 and 2020 dry seasons) following low rainfall and groundwater recharge wet seasons (BOM 2020). The more recent observations noted it did not completely dry out in 2019 (Plate 1). The pool naturally drying out or experiencing substantially lower water levels would be expected to impact significantly on the ecological health of Site 12 Pool due to evapo-concentration increasing environmental stressors (e.g. salinity) and lower water levels reducing available habitat. It is noted that visual observations in the late dry 2019 indicated there were no fish in the pool. However, after a drying event in mid November 2020 (late dry), the pool retained all three fish species within several weeks of re-wetting in December 2020. This indicated that the pool ecological response to drying is variable depending on antecedent conditions. It is unknown if the larger pools downstream of the monitoring location dry out at the same frequency as the monitoring location. These are not accessed regularly due to heritage restrictions.

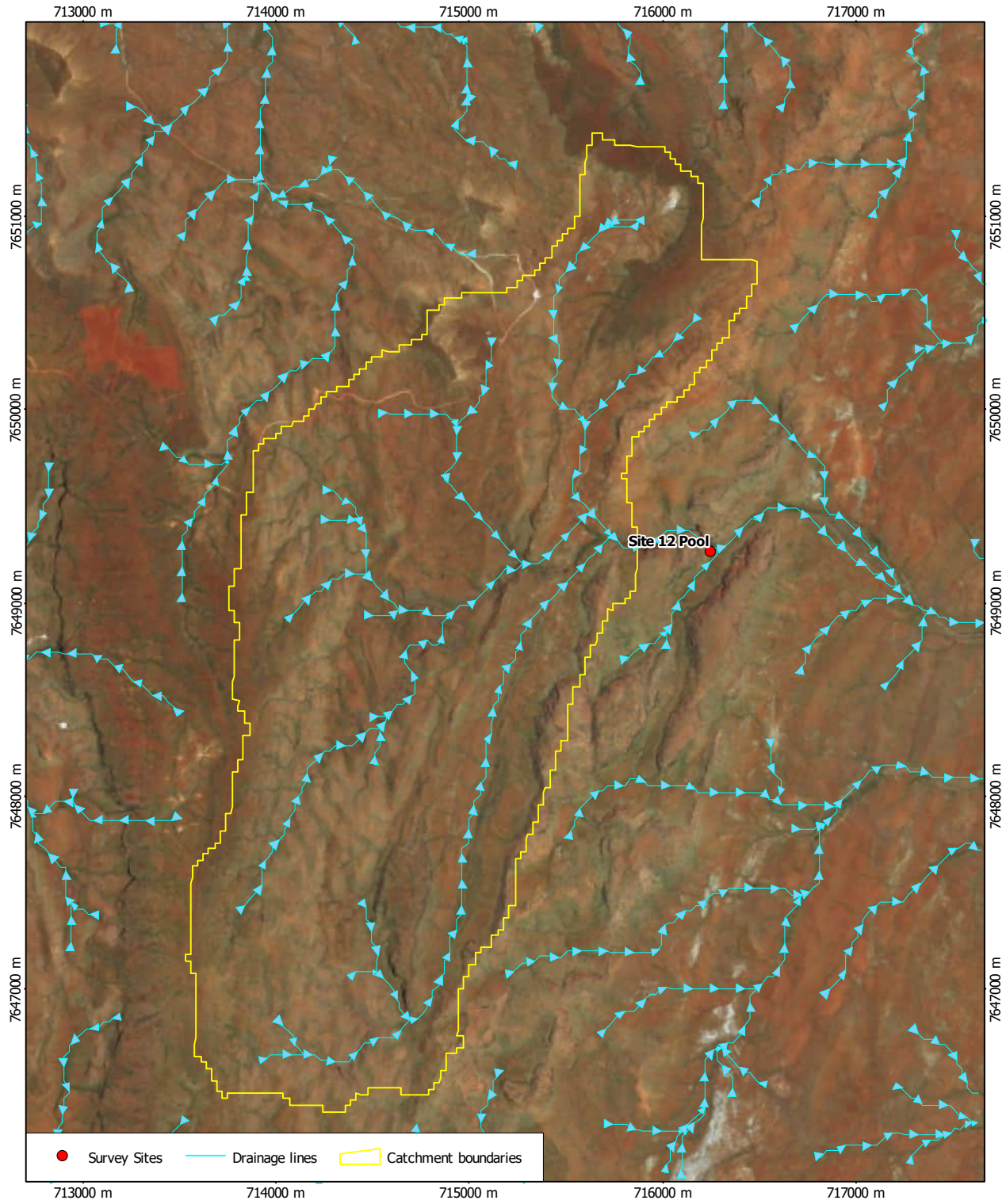


Figure 3-3 Site 12 Pool catchment area

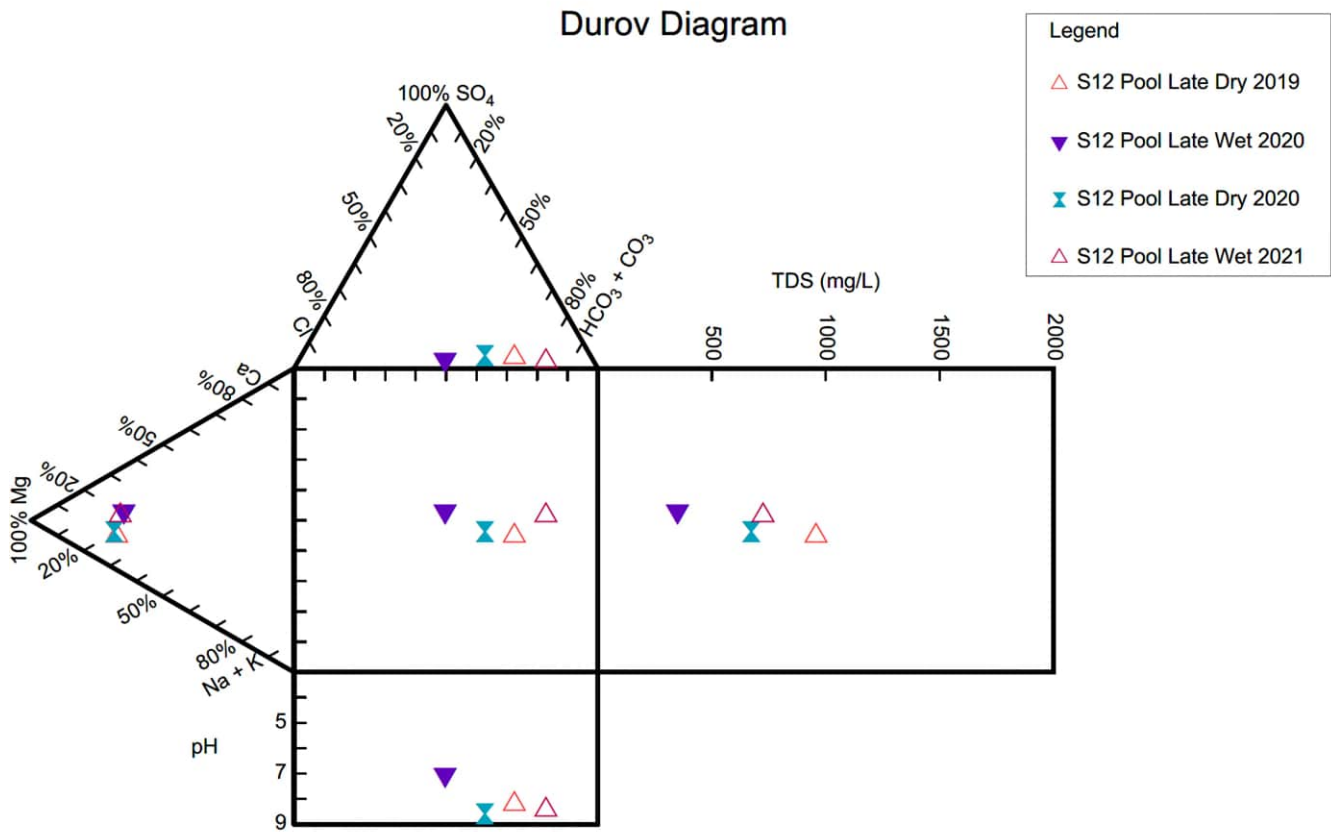


Figure 3-4 Durov diagram illustrates Site 12 Pool is a magnesium-bicarbonate (Ca/Mg-HCO<sub>3</sub>) dominated water type. It is fresh-brackish, alkaline (481 mg/kg CaCO<sub>3</sub>) with low sodium, chloride and sulphate (SO<sub>4</sub>).

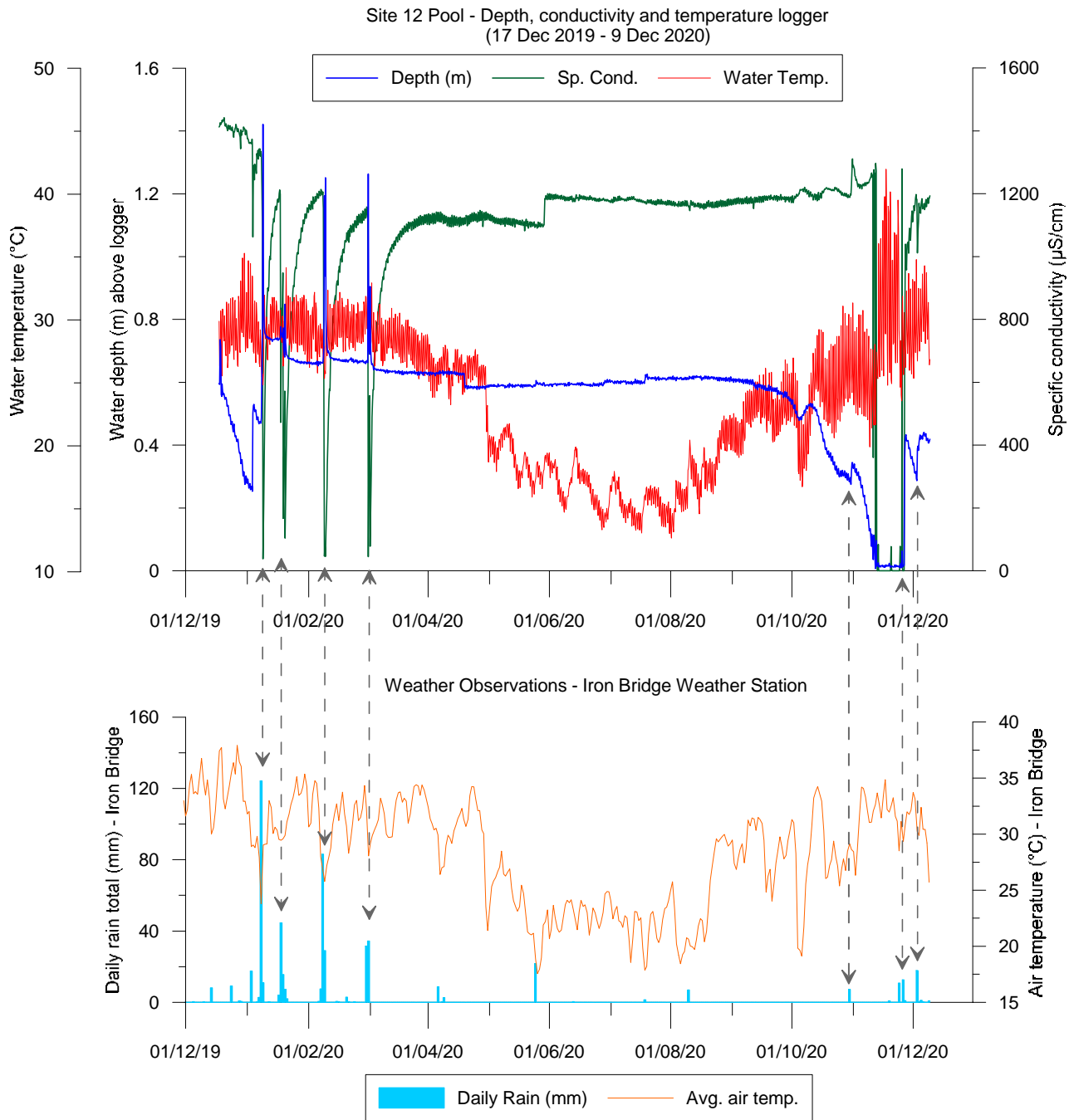


Figure 3-5 Depth, conductivity, and temperature logger data (above) relationship to daily rainfall (below).

Site 12 Pool - Depth, conductivity and temperature logger  
(9 Dec 2020 - 16 June 2021)

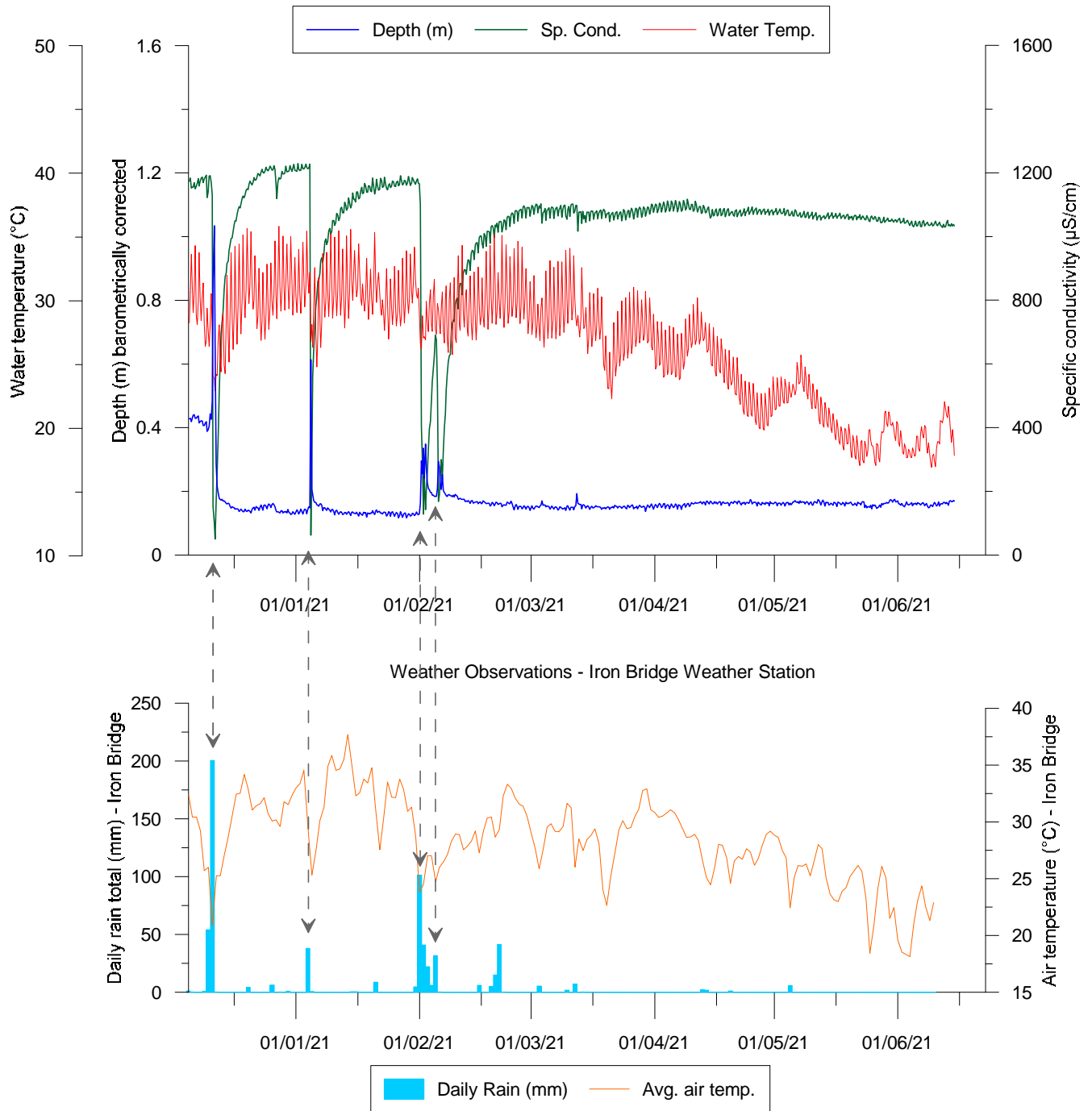


Figure 3-6 Site 12 Pool depth, conductivity, and temperature logger data (above) relationship to daily rainfall (below) – Wet-mid Dry season 2021

Site 12 Pool - Depth, conductivity and temperature logger  
 Site 12 Groundwater Logger - Water level  
 Iron Bridge Daily Rainfall  
 (17 Dec 2019 - 16 June 2021)

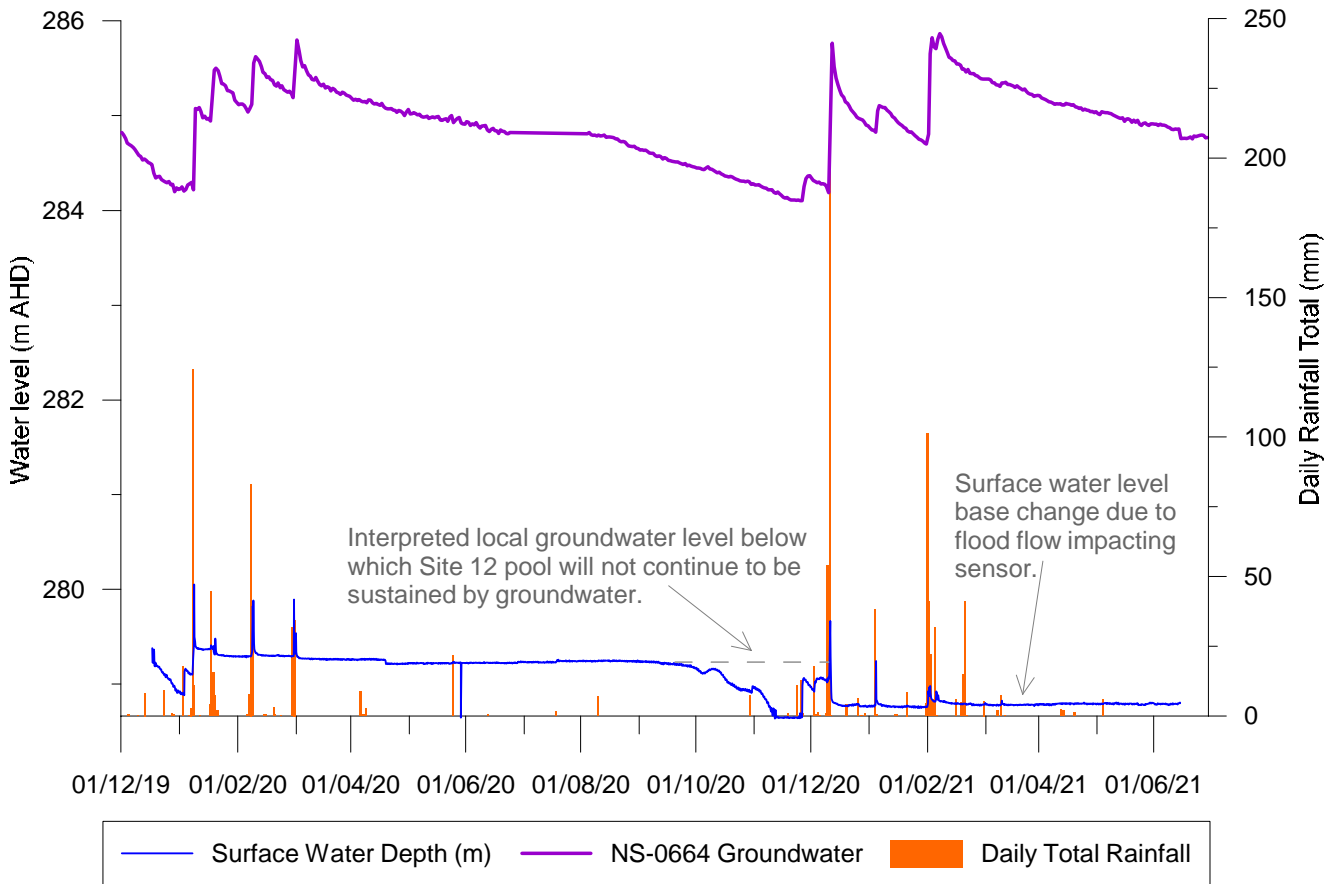


Figure 3-7 Comparison of surface water levels in Site 12 Pool and groundwater levels within the upgradient monitoring bore (NS-0664).



Plate 1 Site 12 Pool hydrological characteristics including; a) high flows over a steeper gradient of bedrock habitat b) confined creek line supporting riparian vegetation and c) sustained groundwater flow

### 3.1.2 SEDIMENT QUALITY

Table 3-1 provides the surface sediment quality at Site 12 Pool across the three seasons sampled. Metal and metalloid concentrations were assessed against the ANZG (2018) DGVs. Chromium and nickel concentrations exceeded the DGV (80 and 21 mg/kg respectively) and the GV-high (370 and 52 mg/kg, respectively). Chromium and nickel both naturally occur at high concentrations across the Project area and were similarly above DGVs at most other surveyed surface water pools in the Project area.

Table 3-1. Summary of sediment quality analytical results for Site 12 Pool. Concentration for each analyte and analyte group described for late wet season 2020 (June 2020), late dry season (December 2020) and late wet season (May 2021). Bolded values denote results above the limit of reporting (LOR).

Analyte grouping/Analyte	Unit	Late Wet 2020	Late Dry 2020	Late Wet 2021
Total Soluble Salts	mg/kg	<b>408</b>	-	<b>402</b>
Moisture Content (Dried @ 105-110°C)	%	<b>28.6</b>	<b>20.9</b>	<b>25</b>
Total Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>71</b>	<b>329</b>	<b>26</b>
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>67</b>	<b>265</b>	<b>26</b>
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>4</b>	<b>65</b>	<b>253</b>
Acidity	mg/kg	<b>4</b>	<5	<5
Sulfate as SO <sub>4</sub> <sup>2-</sup> (soluble sulfate by ICPAES)	mg/kg	<b>20</b>	<10	<10
Chloride (by Discrete Analyser)	mg/kg	<b>30</b>	<b>30</b>	<b>20</b>
Calcium	mg/kg	<b>50</b>	<b>40</b>	<b>30</b>
Magnesium	mg/kg	<b>60</b>	<b>90</b>	<b>60</b>
Sodium	mg/kg	<b>40</b>	<b>40</b>	<b>6</b>
Potassium	mg/kg	<10	<10	<10
Mercury (FIMS)	mg/kg	<0.1	-	<0.1
Nitrite + Nitrate as N (Sol.)	mg/kg	<0.1	<0.1	<0.1
Total Kjeldahl Nitrogen as N	mg/kg	<b>520</b>	<b>200</b>	<b>80</b>
Total Nitrogen as N	mg/kg	<b>520</b>	<b>200</b>	<b>80</b>
Total Phosphorus as P	mg/kg	<b>73</b>	<b>61</b>	<b>56</b>
Reactive Phosphorus as P	mg/kg	<0.1	<0.1	<0.1
Total Organic Carbon	%	<b>0.18</b>	<b>0.29</b>	<b>0.2</b>
<b>Total Metals by ICP-AES</b>				
Arsenic	mg/kg	<5	-	<b>6</b>
Barium	mg/kg	<b>50</b>	-	<b>70</b>
Beryllium	mg/kg	<1	-	<1

Analyte grouping/Analyte	Unit	Late Wet 2020	Late Dry 2020	Late Wet 2021
Boron	mg/kg	<50	-	<50
Cadmium	mg/kg	<1	-	<1
Chromium	mg/kg	<b>384</b>	-	<b>492</b>
Cobalt	mg/kg	<b>23</b>	-	<b>36</b>
Copper	mg/kg	<b>23</b>	-	<b>37</b>
Iron	mg/kg	<b>32,800</b>	<b>41,200</b>	<b>49,400</b>
Lead	mg/kg	<5	-	<5
Manganese	mg/kg	<b>561</b>	-	<b>894</b>
Nickel	mg/kg	<b>179</b>	-	<b>246</b>
Selenium	mg/kg	<5	-	<5
Vanadium	mg/kg	<b>48</b>	-	<b>65</b>
Zinc	mg/kg	<b>26</b>	-	<b>44</b>

### 3.1.3 FISH

Fish, decapods and non-fish vertebrates were sampled with a combination of nets/traps and underwater video (BRUVs). Table 3-2 and Figure 3-9 to Figure 3-14 present the fish species, abundance, and size distribution.

Three native omnivorous fish species were observed in Site 12 Pool across the three seasons: *Melanotaenia australis* (western rainbowfish), *Leiopotherapon unicolor* (spangled perch) and *Neosilurus hyrtlii* (Hyrtl's catfish).

*Melanotaenia australis* was the dominant species in all three seasons (Table 3-2). Figure 3-9 demonstrates the frequency of each length class for *M. australis* for the three seasons. Predominately, the *M. australis* observed were adults (~50 mm) and estimated to be over 3 months old. In the Late Dry 2020 and Late Wet 2021, smaller fish (<30 mm) were observed, indicating the presence of juveniles at the site (Figure 3-9).

The larger size distribution of *L. unicolor* and *N. hyrtlii*, ranging from juveniles to adults over a year old, more clearly indicates interannual survival of these species and demonstrating evidence of successful wet season or post-wet season reproduction. However, these species may aestivate (*L. unicolor*) or persist in downstream environments rather than at Site 12 Pool throughout the drier months and migrate upstream to the pool during wet season connective flows. For example, fish were abundant and clearly visible without sampling during the Late Wet 2020 survey, though were not observed during the previous years' late dry season site inspection (December 2019). Similarly, Site 12 Pool was the only pool of five pools surveyed at North Star where *N. hyrtlii* has been recorded (Figure 3-18), which may be due to the connectivity to downstream creeks and rivers. This species exhibits spawning migration into tributaries and the tendency to inhabit riverine habitats more frequently than off-channel lentic habitats (Pusey, B., Kennard, M., & Arthington, 2004).

Further surveys will clarify the role of environmental stress and connectivity in determining fish presence. For example, whether extended dry season conditions result in decreased fish, or low wet seasons restrict connectivity and therefore fish movement.

Burrowing toadlets (*Uperoleia sp.*), a genus that typically inhabits rocky creeks, were observed in the tadpole phase during December 2019 though were not observed during wet season sampling. This finding may be due to the breeding season occurring earlier and only the semi-aquatic adult stage being present at the time of sampling, which was not targeted by sampling methods.

While baited marron/box traps were used to target decapod crustaceans, none were collected or observed.

Table 3-2. Summary of fish species observed at Site 12 Pool with number of fish for each size class sampled in the Late Wet 2020, Late Dry 2020 and Late Wet 2021. CPUE (catch per unit effort) calculated for each species and sampling date

Species	Size class (mm)	Late Wet (2020)		Late Dry (2020)		Late Wet (2021)	
		Fish Count	CPUE <sup>1</sup>	Fish Count	CPUE <sup>1</sup>	Fish Count	CPUE <sup>1</sup>
<b><i>Melanotaenia australis</i></b>		<b>196</b>	<b>12.6</b>	<b>111</b>	<b>7.1</b>	<b>25</b>	<b>1.61</b>
	0 – 30	0		7		6	
	30 – 60	84		18		16	
	60 – 90	112		86		3	
<b><i>Neosilurus hyrtlii</i></b>		<b>37</b>	<b>2.4</b>	<b>50</b>	<b>3.2</b>	<b>10</b>	<b>0.6</b>
	60 – 90	16		4		4	
	>90	21		46		6	
<b><i>Leiopotherapon unicolor</i></b>		<b>24</b>	<b>1.5</b>	<b>52</b>	<b>3.3</b>	<b>20</b>	
	0 - 30	0		0		2	
	30 – 60	7		5		12	
	60 – 90	10		32		5	
	> 90	7		15		1	
<b>Total</b>		<b>257</b>	<b>16.6</b>	<b>213</b>	<b>13.7</b>	<b>55</b>	<b>3.5</b>

<sup>1</sup> CPUE is catch per unit effort, a measure of relative abundance. Effort is fyke net set for 15.5 hours.

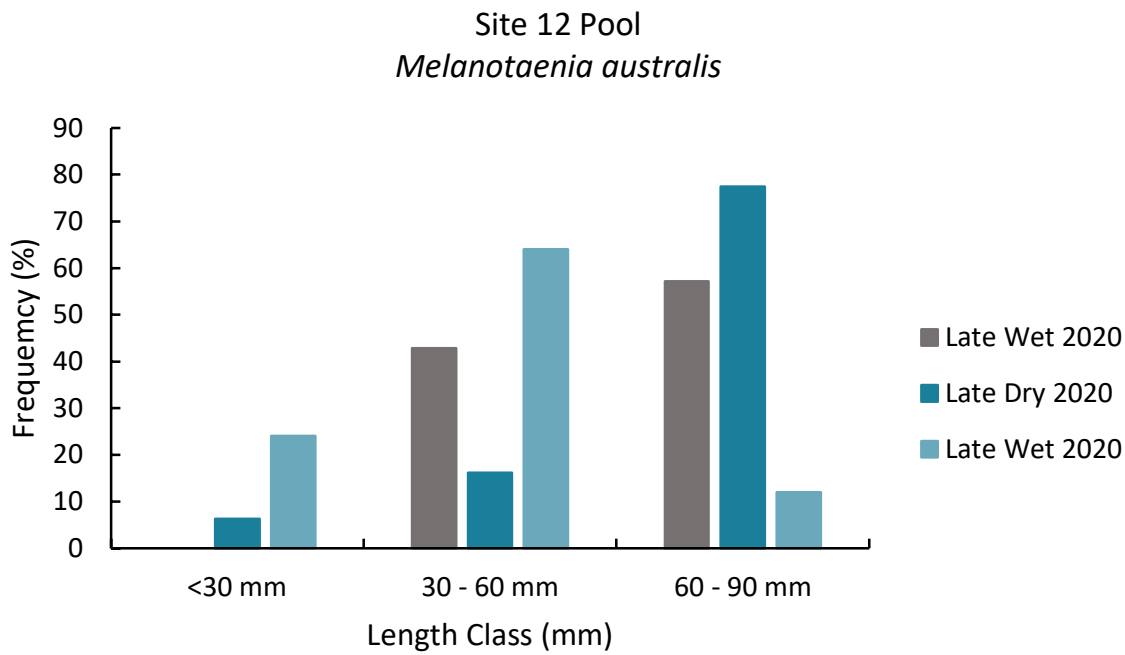


Figure 3-9. Frequency (%) of occurrence for each length class (SL, mm) of *Melanotaenia australis* sampled in Site 12 Pool in the Late Wet 2020, Late Dry 2020 and Late Wet 2021.

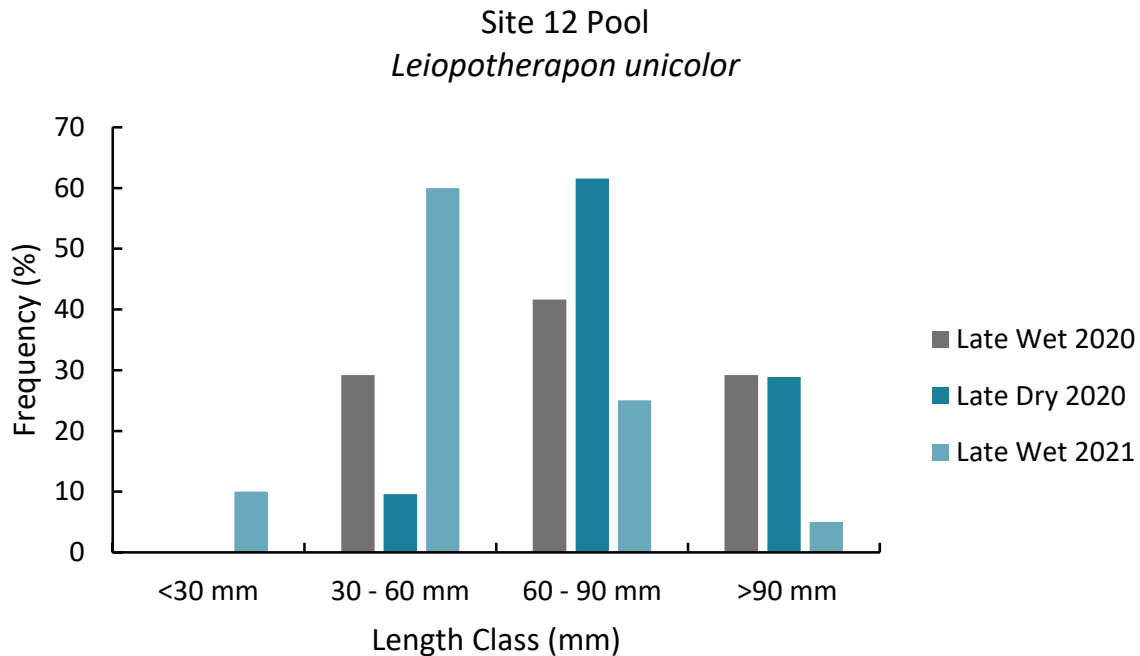


Figure 3-10. Frequency (%) of occurrence for each standard length class (SL, mm) of *Leiopotherapon unicolor* sampled in Site 12 Pool in the Late Wet 2020, Late Dry 2020 and Late Wet 2021.

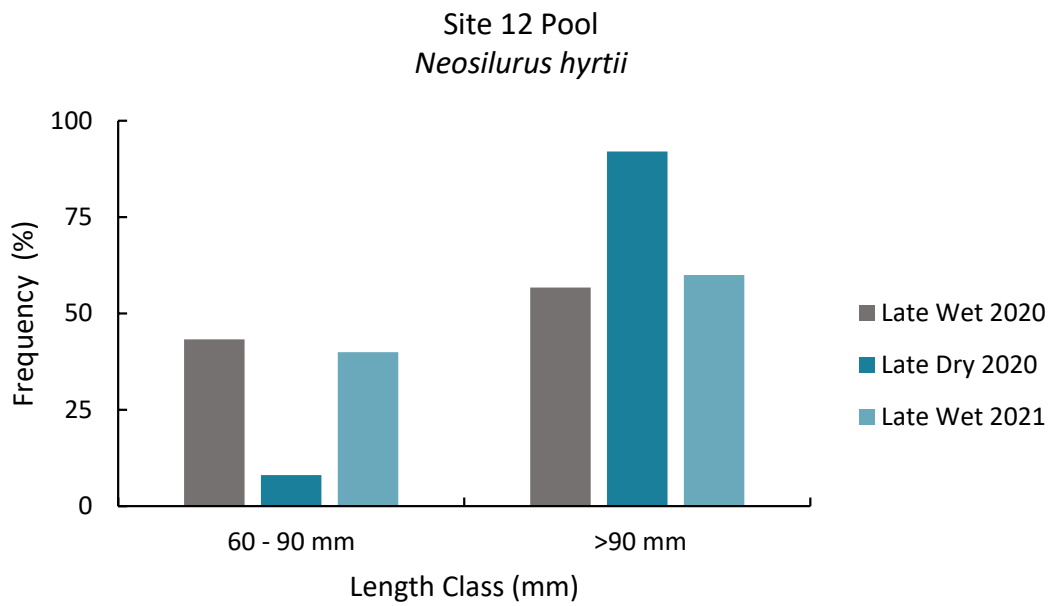


Figure 3-11. Frequency (%) of occurrence for each length class (SL, mm) of *Neosilurus hyrtii* sampled in Site 12 Pool in the Late Wet 2020, Late Dry 2020 and Late Wet 2021.

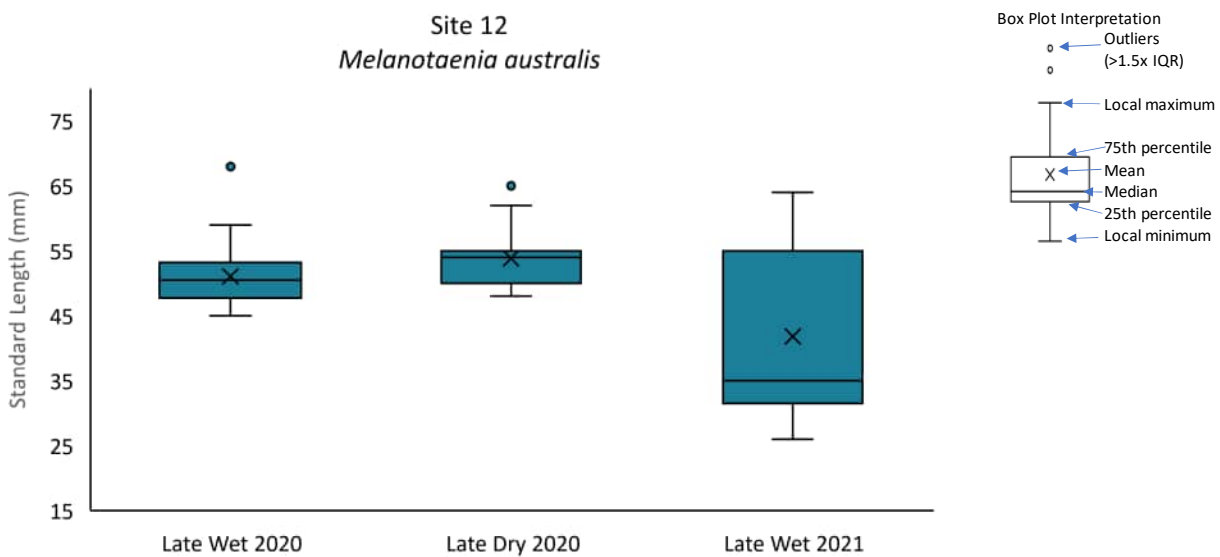


Figure 3-12. Distribution of standard length (SL, mm) of *Melanotaenia australis* sampled in Site 12 Pool in the Late Wet 2020, Late Dry 2020 and Late Wet 2021.

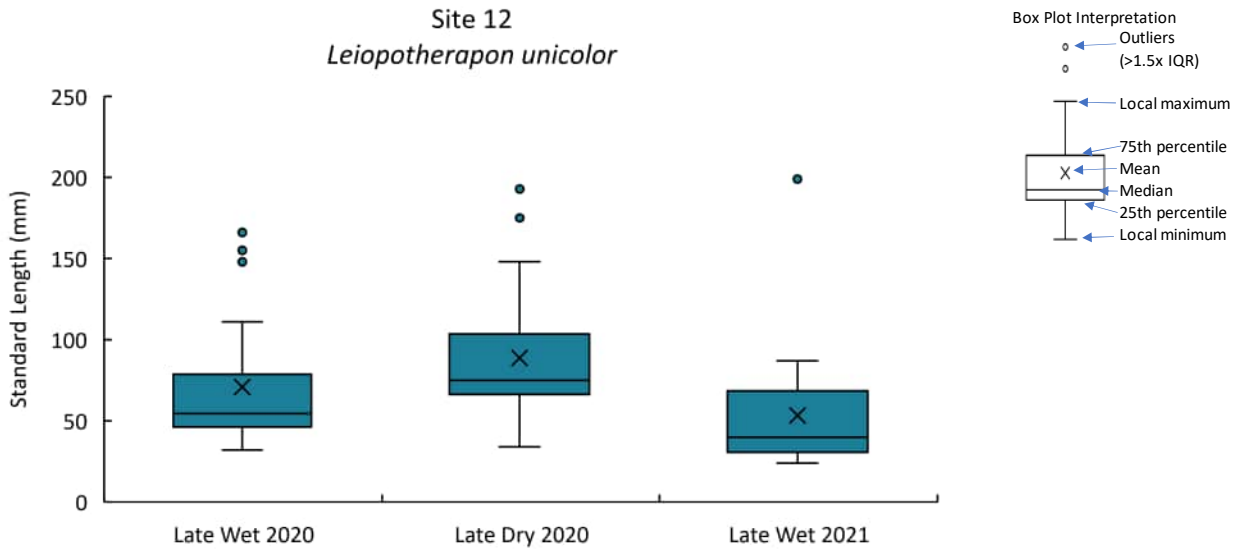


Figure 3-13 Distribution of standard length (SL, mm) of *Leiopotherapon unicolor* sampled in Site 12 Pool in the late wet 2020 (June 2020), late dry (December 2020) and late wet 2021 (May 2021).

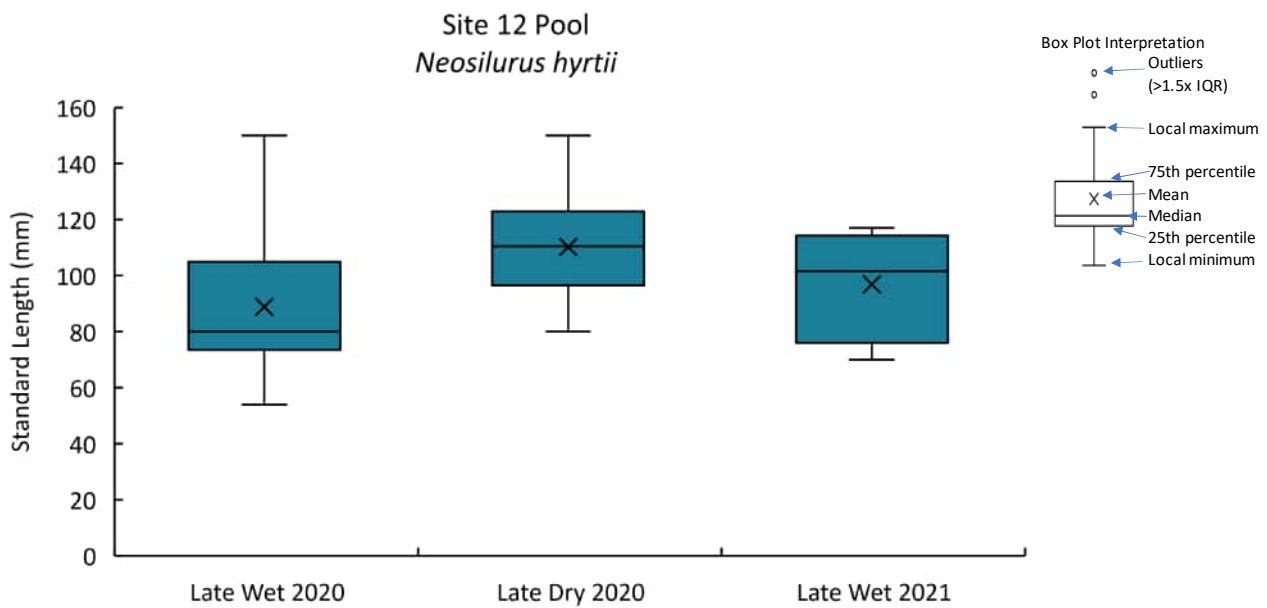
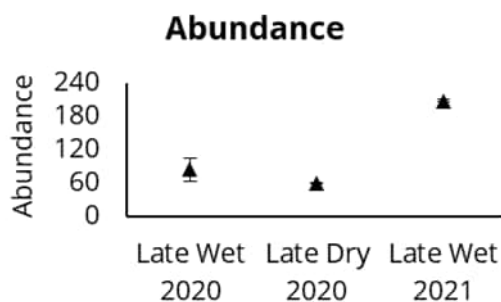


Figure 3-14 Distribution of standard length (SL, mm) of *Neosilurus hyrtlil* sampled in Site 12 Pool in the late wet 2020 (June 2020), late dry (December 2020) and late wet 2021 (May 2021).

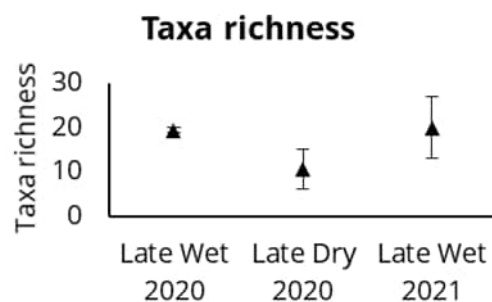
### 3.1.4 AQUATIC MACROINVERTEBRATES

Figure 3-15 presents the total abundance, taxa richness, EPT richness and SIGNAL2 scores for Site 12 Pool in the late wet seasons of 2020 and 2021, and the late dry season of 2020. The key findings were as follows:

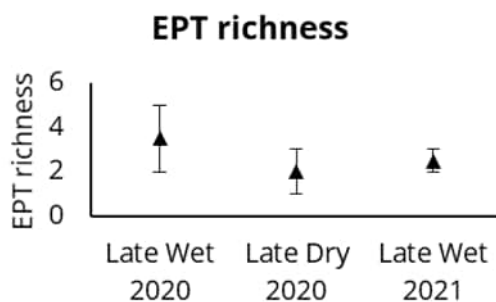
- Average macroinvertebrate abundance was two times greater in the latest wet season during 2021 (209 individuals) than those recorded in the wet (84 inds.) and dry (61 inds.) season of 2020 (Figure 3-15a).
- Taxa richness was similar in both late wet seasons with 20 taxa present, while a lesser 10 taxa were recorded during the late dry season of 2020 (Figure 3-15b).
- The number of taxa belonging to the sensitive Ephemeroptera, Plecoptera and Trichoptera orders was slightly higher in the Late Wet season of 2020 (EPT richness = 3.5), with similar measures in the Late Dry season and Late Wet season of 2020 and 2021, respectively (EPT richness = 2-2.5; Figure 3-15c).
- SIGNAL2 scores ranged from 2.8 to 3.6 among sampling events (Figure 3-15d), indicating the community is consistently dominated by tolerant macroinvertebrate families.



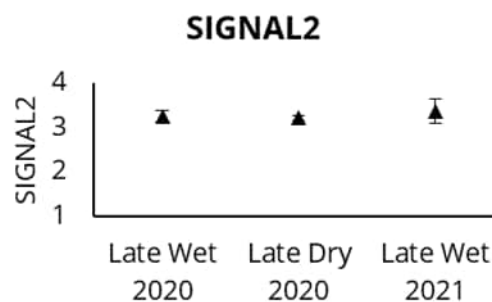
a) Total abundance at Site 12 Pool



b) Taxa richness at Site 12 Pool



c) EPT richness at Site 12 Pool



d) SIGNAL2 scores at Site 12 Pool

Figure 3-15 Macroinvertebrate indices for Site 12 Pool – Late Wet 2020, Late Dry 2020 and Late Wet 2021

The abundance of taxa for the three seasonal surveys is provided in Figure 3-16 and shows taxa ranging from the the most abundant (left) to the least abundant (right) along the x-axis. Briefly, the non-biting midge of Tanypodinae, oligochaete worms, and biting midge larvae of Ceratopogonidae were much more abundant in the most recent 2021 wet season than the previous seasons. In contrast, the non-biting midge Chironominae was similarly abundant in all sampling events. Mites and ticks belonging to the Acarina were similarly abundant during both wet seasons, with a decline in the dry season of 2020. Some macroinvertebrates, such as chironomids and oligochaetes, can increase in abundance following freshwater flow events such as flooding in wetlands (e.g. McNerney et al. 2017), which may explain increased abundances of such taxa in the latest wet season when greater rainfall levels were recorded.

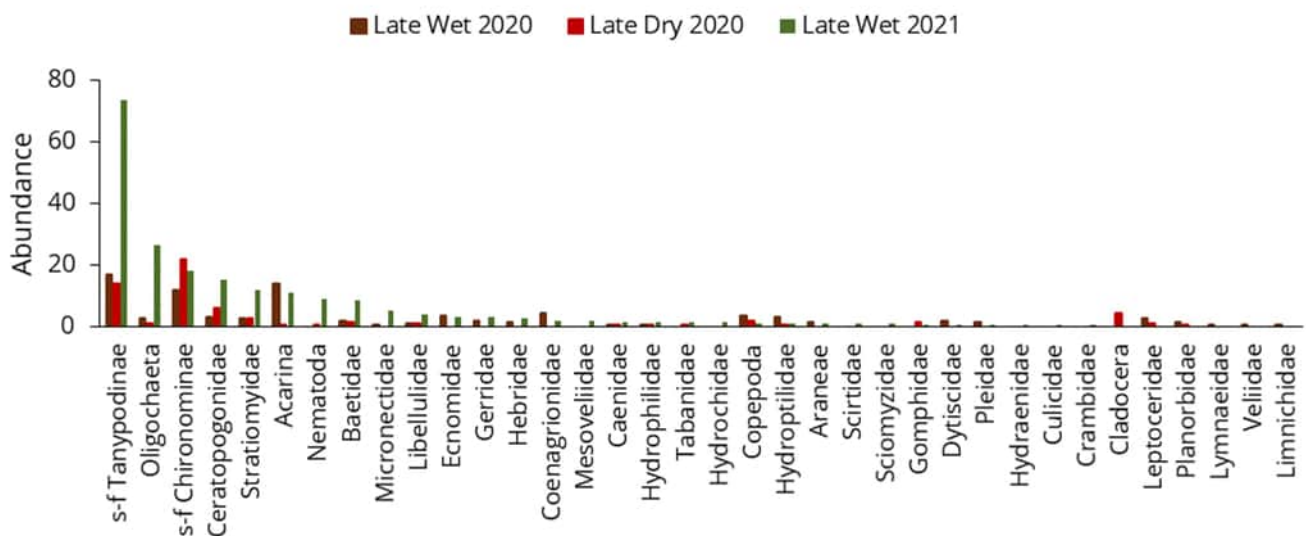


Figure 3-16 Average abundances of all macroinvertebrate taxa at Site 12 Pool in the Late Wet season of 2021 and the Late Wet and Late Dry season of 2020, with taxa arranged from most abundant (left) to least abundant (right) along the x-axis.

### 3.1.5 DIATOMS AND PHYTOPLANKTON

#### 3.1.5.1 DIATOMS

The Late Wet 2020 and Late Wet 2021 results are presented. The Late Dry 2020 diatom samples were not analysed as there was a major flood event during the four-week sampler deployment time and, therefore, the samples were not considered representative or useful. Two replicates of diatom samples were collected from Site 12 Pool during each survey and species, abundance and biotic indices were recorded. Overall, a total of 26 diatom species were recorded (Table 3-3) across the two replicates and two seasonal sampling rounds. The most abundant species in all replicates and surveys was *Mastogloia smithii*, followed by *Achnantheidium minutissimum*. The Late Wet 2021 round indicated a higher diversity and abundance than the previous wet season with a doubling of the species richness and abundance. Figure 3-17 illustrates the mean abundance (diatom count per replicate) of diatom species recorded at Site 12 Pool.

The tolerance to environmental stress for Site 12 Pool is reflected in the moderate sensitivity DSIAR scores (52 to 55 across the replicates and seasonal surveys). In Site 12 Pool, there was a large number of teratological ("deformed") forms.

Table 3-3. Summary of diatom total count per species, average abundance and DSIAR score for Site 12 Pool collected in Late Wet 2020

Taxon name	Late Wet 2020		Late Wet 2021	
	Rep 1	Rep 2	Rep 1	Rep 2
<i>Achnantheidium exiguum</i>	2			
<i>Achnantheidium minutissimum</i>	4	24	44	24
<i>Amphora spp.</i>		6		
<i>Brachysira vitrea</i>	4	8		4
<i>Caloneis silicula</i>		4		
<i>Cymbella spp</i>				2
<i>Diploneis parma</i>				4
<i>Epithemia gibba</i>				8
<i>Eunotia arcus</i>				12
<i>Eunotia bilunaris</i>	8	10	18	
<i>Eunotia incisa</i>		2		
<i>Eunotia tenera</i>			4	
<i>Fragilaria acus</i>			22	
<i>Fragilaria capucina var gracilis</i>			2	
<i>Mastogloia elliptica</i>			12	
<i>Mastogloia smithii</i>	42	112	232	116
<i>Navicula gregaria</i>			2	
<i>Navicula lanceolata</i>			2	
<i>Nitzschia filiformis</i>			2	
<i>Nitzschia frustulum</i>			4	
<i>Nitzschia pumilla</i>			2	
<i>Pinnularia spp.</i>			2	
<i>Planothidium frequentissimum</i>			4	
<i>Surirella elegans</i>			2	
<i>Tryblionella calida</i>			2	
<i>Ulnaria ulna</i>			18	34
<b>Total Count</b>	<b>60</b>	<b>166</b>	<b>374</b>	<b>204</b>
<b>Species Richness</b>	<b>5</b>	<b>7</b>	<b>17</b>	<b>8</b>
<b>DSIAR Score</b>	<b>55</b>	<b>54</b>	<b>52</b>	<b>53</b>

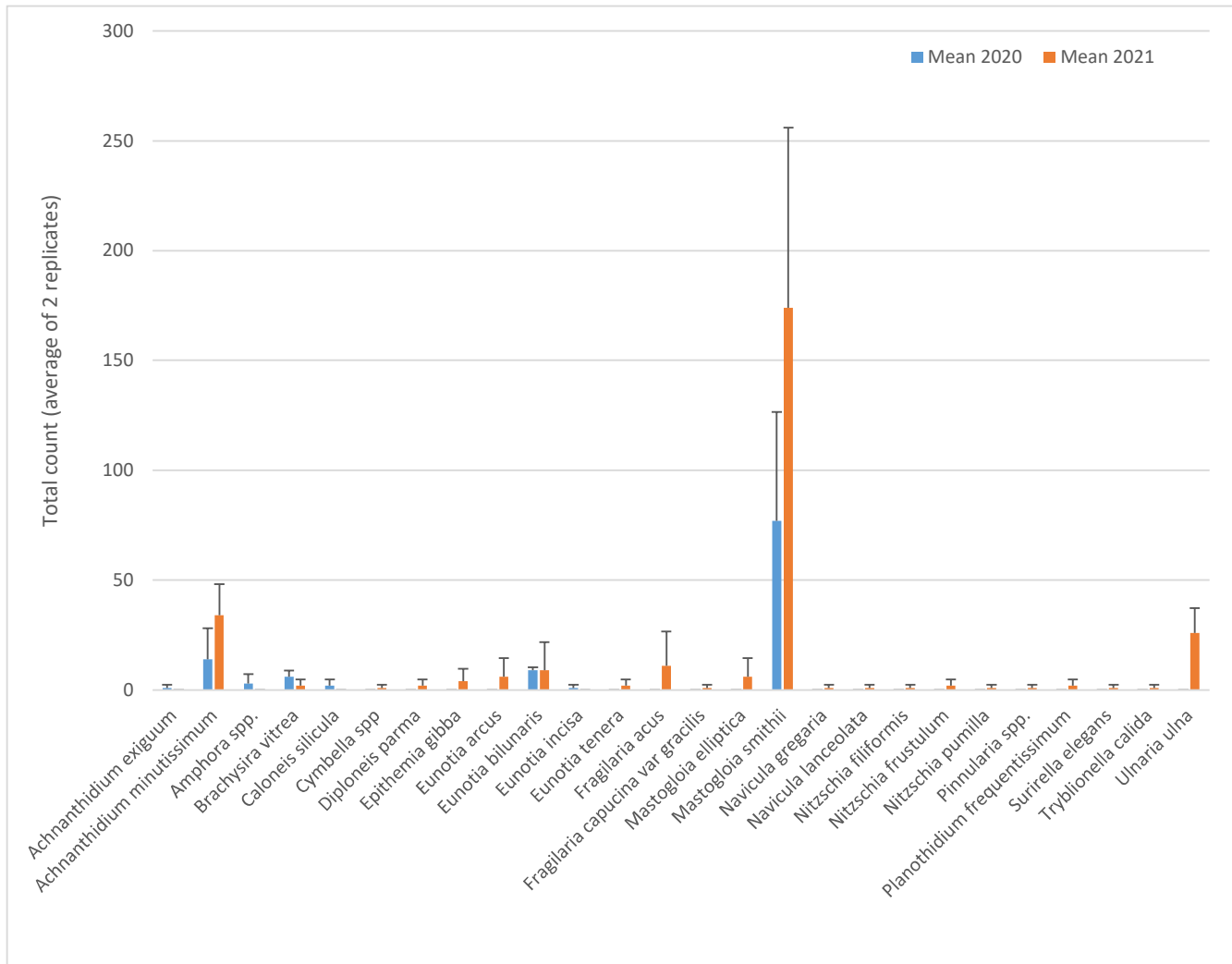


Figure 3-17. Average species abundance (diatom count per replicate) for diatoms sampled at Site 12 Pool in the Late Wet 2020 and Late Wet 2021. Standard deviation denoted by error bars.

### 3.1.5.2 PHYTOPLANKTON

As noted above, in the Late Dry 2020 sampling, the Diatom samplers (periphytometers) did not record meaningful data, as such, water samples were taken from the site to analyse a full phytoplankton profile for the site. This was repeated in the Late Dry 2021 survey for completeness and comparison of results.

Five classes of phytoplankton were identified at Site 12 Pool in Late Dry 2020, the most abundant being Dinophyceae (Dinoflagellates) at 72.8%, with two genera being observed *Gonyaulax sp.* and *Peridinium sp.* The second most abundant phytoplankton class was Cryptophyceae at 17%, with the genus *Cryptomonas sp.* having the highest contribution in this class. *Cryptomonas spp.* are always found in freshwater and function like diatoms. Cyanobacteria (blue-green algae) contributed 5.67% of the overall phytoplankton abundance. Chlorophyceae (green algae) and Bacillariophyceae (diatoms) had the lowest abundance at Site 12 Pool (Table 3-4).

Minimal algal cells were identified in the samples taken in Late Wet 2021 at Site 12 Pool; the only genus observed was *Navicula spp.* (Diatoms) (Table 3-4). This potentially indicates that late dry conditions are favourable for phytoplankton growth at this site, with moving water during the wet season not allowing the development of water column algal populations.

Table 3-4 Summary of phytoplankton analytical results for Site 12 Pool sampled in Late Dry 2020 and Late Wet 2021, abundance (cells L<sup>-1</sup>) and percentage contribution (%), limit of reporting 10 cell L<sup>-1</sup>.

Taxon	Late Dry 2020		Late Wet 2021	
	Abundance	%	Abundance	%
<b>Bacillariophyceae</b>	<b>5200</b>	<b>2.27</b>	<b>20</b>	<b>100</b>
<i>Amphora spp.</i>	400	0.28	0	0
<i>Navicula spp.</i>	1200	0.85	20	100
<i>Nitzschia spp.</i>	1200	0.85	0	0
<i>Synedra spp.</i>	400	0.28	0	0
<b>Chlorophyceae</b>	<b>3200</b>	<b>2.27</b>	<b>0</b>	<b>0</b>
<i>Closterium spp.</i>	1200	0.85	0	0
<i>Cosmarium spp.</i>	2000	1.42	0	0
<b>Cryptophyceae</b>	<b>24000</b>	<b>17</b>	<b>0</b>	<b>0</b>
<i>Chroomonas spp.</i>	2400	1.7	0	0
<i>Cryptomonas spp.</i>	21600	15.3	0	0
<b>Cyanobacteria</b>	<b>8000</b>	<b>5.67</b>	<b>0</b>	<b>0</b>
<i>Chroococcus spp.</i>	1600	1.13	0	0
<i>Planktolyngbya spp.</i>	6400	4.53	0	0
<b>Dinophyceae</b>	<b>102800</b>	<b>72.8</b>	<b>0</b>	<b>0</b>
<i>Gonyaulax spp.</i>	42800	30.31	0	0
<i>Peridinium spp.</i>	60000	42.49	0	0

### 3.1.6 MACROPHYTES

A diverse range of native flora was observed within Site 12 Pool. These comprised aquatic species and groundwater-dependent species. These species are likely not surface water inflow dependent, as the pool refills with groundwater within 2 – 3 weeks following flushing events.

During all surveys (Late Wet 2020, Late Dry 2020 and Late Wet 2021), a total of seven macrophyte species were observed belonging to five families (Table 3-5). Macrophytes observed at Site 12 Pool included Bulrush reeds (*Typha sp.*), sedges (*Cyperus sp.*), two charophytes (*Nitella sp.* and *Chara sp.*), as well as two submerged macrophytes (*Vallisneria sp.* and *Myriophyllum sp.*) (Figure 3-18). Table 3-5 summarises the macrophyte species observed at Site 12 Pool. No substantial changes in macrophyte composition were observed at the Site 12 Pool over the three surveys (Late Wet 2020, Late Dry 2020 and Late Wet 2021). A slight decrease in the abundance of both submerged and emergent macrophytes in the Late Wet 2021 compared to the Late Wet 2020 was noted, though no changes were substantial enough to alter the categorical abundance classification.

The types and species of macrophytes present in a system are indicators of water quality and ecological health. The abundance and diversity of macrophytes at Site 12 Pool plays a key role in nutrient dynamics,

indicates that water quality parameters (e.g., turbidity, salinity) have not reached levels that interfere with macrophyte growth and development and provides habitat structure and refuges to organisms. For example, the macrophyte habitat and its' structural complexity likely provide refuge to the *M. australis* (western rainbowfish) from predation by adult *L. unicolor* (spangled perch).

Table 3-5. Summary of macrophyte species abundance, with family name and common name observed at Site 12 Pool during sampling in the Late Wet 2020, Late Dry 2020 and Late Wet 2021.

Common name	Species name	Late Wet 2020 Abundance <sup>1</sup>	Late Dry 2020 Abundance <sup>1</sup>	Late Wet 2021 Abundance <sup>1</sup>
Ribbon weed	<i>Vallisneria sp.</i>	Isolated	Isolated	Isolated
Charophytes	<i>Nitella sp., Chara sp.</i>	Isolated	Isolated	Isolated
Clubrush	<i>Schoenoplectus sp.</i>	Isolated	Isolated	Isolated
Sedges	Cyperaceae	Isolated	Isolated	Isolated
Bulrush	<i>Typha sp.</i>	Isolated	Isolated	Isolated

<sup>1</sup> Abundance based on *Western Australia AUSRIVAS field sampling and habitat assessment sheet* (DoW, 2009).

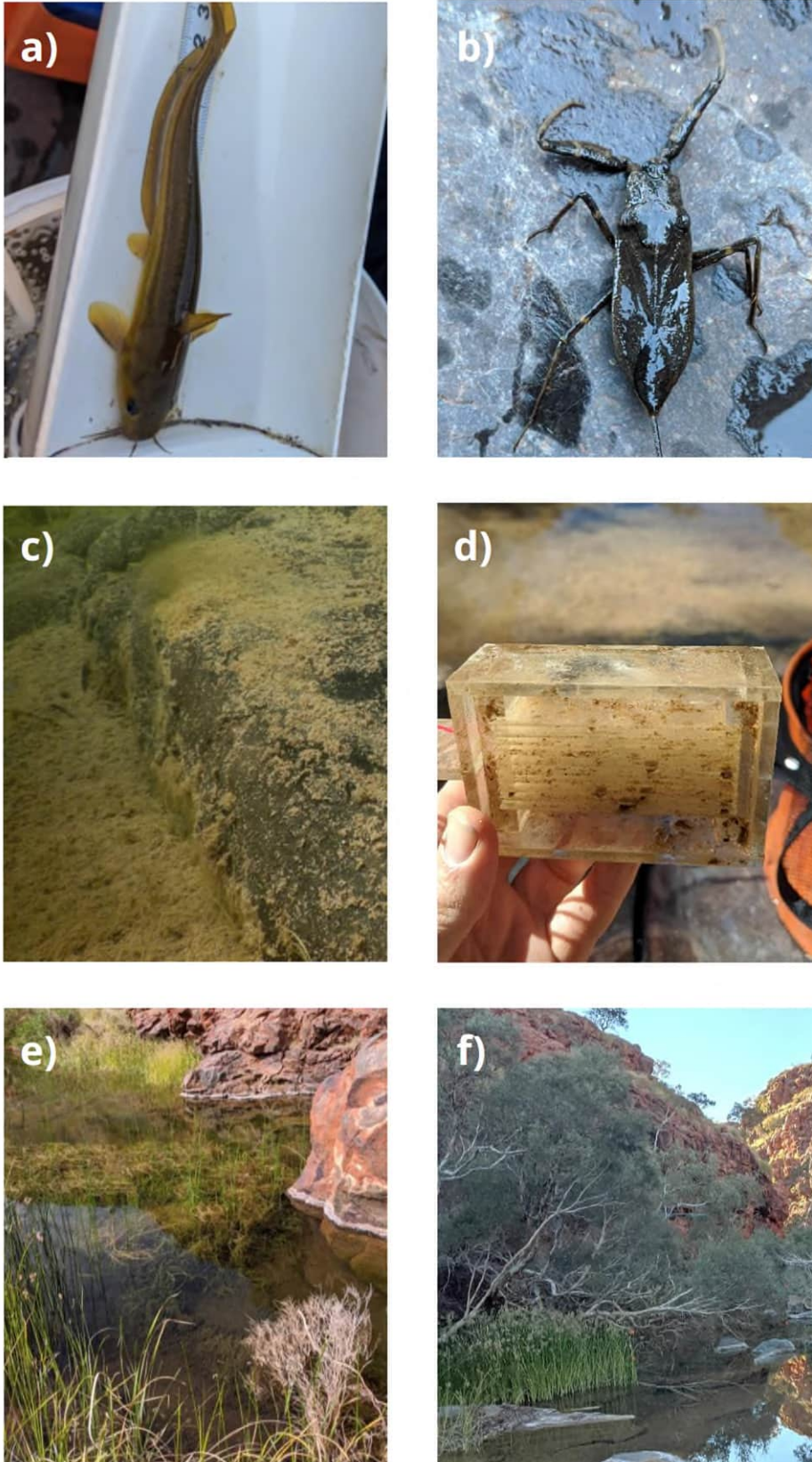


Figure 3-18 Site 12 Pool aquatic ecology. a) *Neosilurus hyrtlii* found at Site 12 Pool and no other surveyed pools; b) Belostomatidae, a giant water bug that typically hunts amongst macrophytes; c) bedrock covered in benthic algae; d) periphytometer used to sample diatoms shows benthic algae growth; e) and f) submerged and emergent macrophytes

## 3.2 FIG POOL (IB\_SW\_POOL\_Fig)

Fig Pool is an isolated small pool that lies at the base of a rockface (Figure 3-19) with a small catchment area of 0.16 km<sup>2</sup> (Figure 3-20). It is characterised by stable water levels maintained by fresh groundwater. A relatively low abundance and diversity of aquatic flora and fauna inhabit the pool, likely due to it being naturally acidic. For example, fish and macrophytes are absent in the pool. It is a bedrock dominated habitat with the primary structural complexity provided by the roots of *Melaleuca leucadendra* (paperbark tree) roots.



Figure 3-19 Fig Pool is a small, acidic pool that lies below a rockface and is surrounded by *Melaleuca leucadendra* (paper bark tree) of which the roots are a dominant feature.

### 3.2.1 WATER QUALITY AND HYDROLOGY

Water quality sampling results, including physio-chemical parameters, metals analysis, major ions, and stable isotope analysis to characterise the surface water system and its connectivity to groundwater are presented in Appendix A. Figure 3-21 and Figure 3-22 display a high-resolution water level, salinity (conductivity) and temperature logger record from Fig Pool for the wet seasons of 2019/2020 and 2020/2021 respectively.

Fig Pool is a small (~20 m<sup>3</sup>), shallow pool with water quality that varies minimally between seasons. The pool is largely sustained by groundwater and was periodically flushed with fresh surface water flows after rainfall events. It takes approximately 1 week for the groundwater to displace the surface water flows once a flushing event has occurred. Conductivity was typically fresh (~200 µS/cm) except during a surface water flow event when it would become extremely fresh (<20 µS/cm). Water levels were a maximum of ~0.06 m

above the pool overflow levels during high-flow events, which typically lasted less than 24 hours before flows receded. The minimal change in water level indicates the pool remained approximately at its spill point level throughout the logging period. Due to the small catchment area (0.16 km<sup>2</sup>) and the gradient of Fig Pool's upstream and downstream environment, it is likely the pool has very limited connectivity to surface drainage.

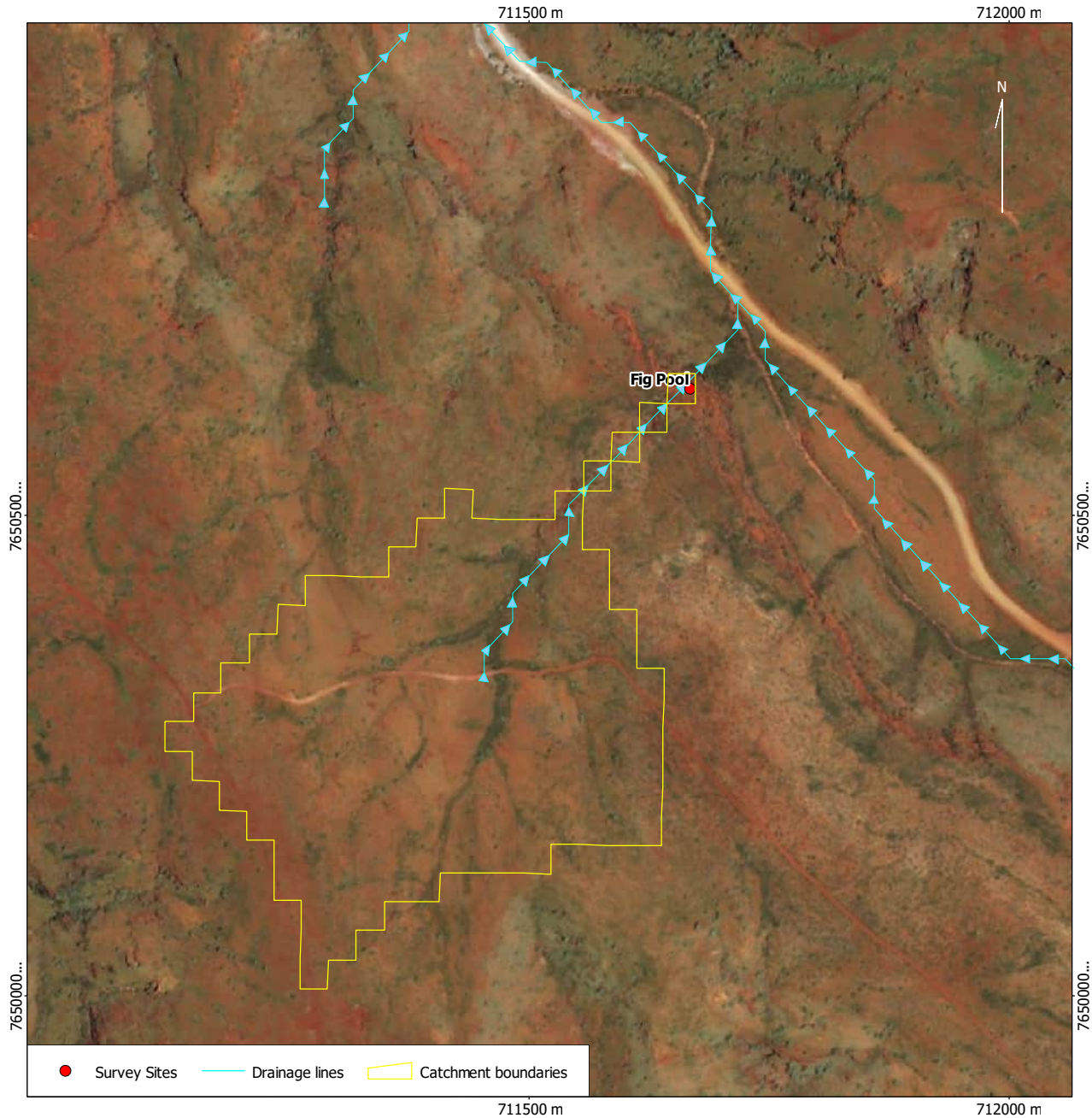


Figure 3-20 Fig Pool catchment area (0.16 km<sup>2</sup>)

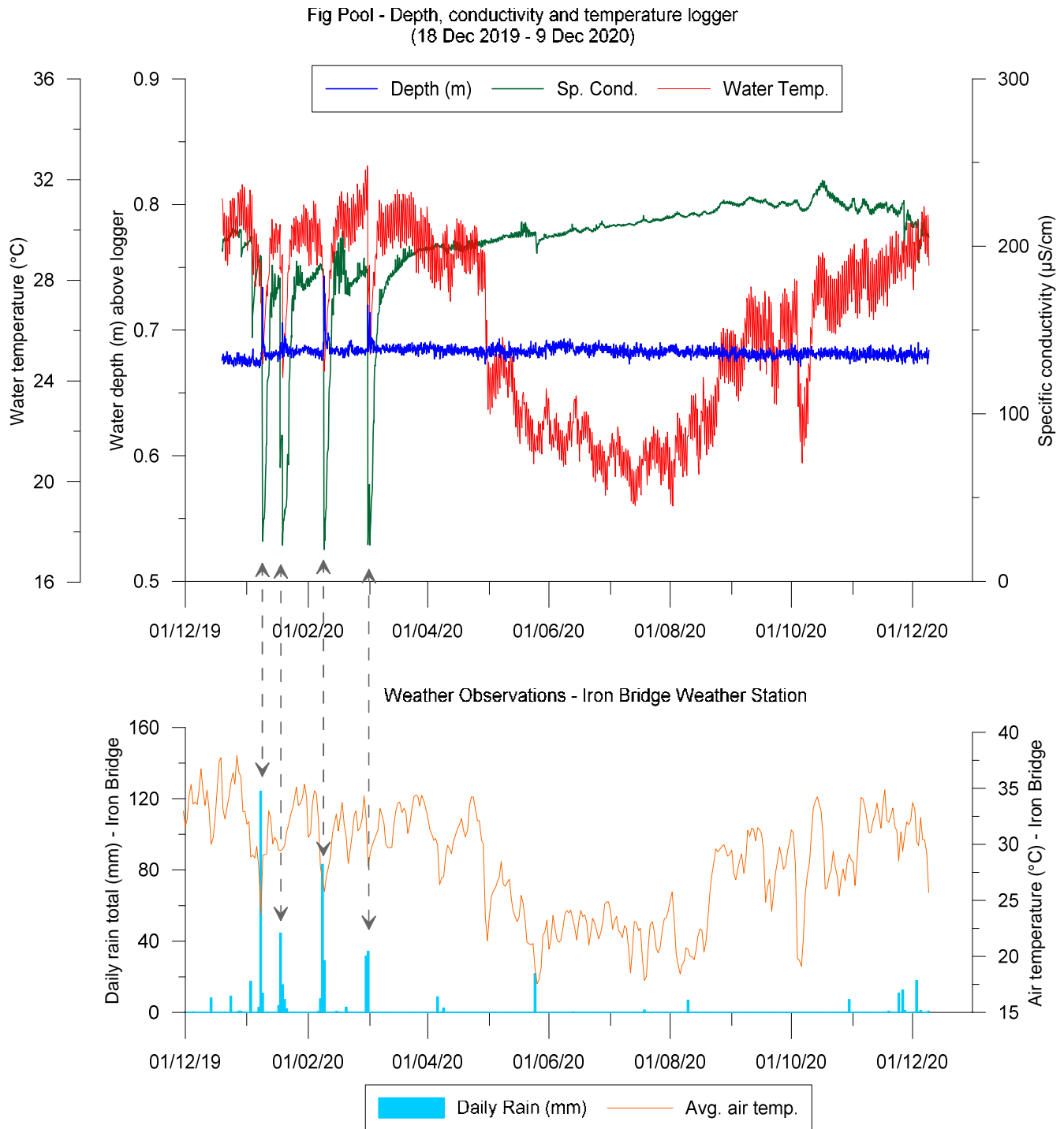


Figure 3-21 Fig Pool depth, conductivity, and temperature logger data (above) relationship to daily rainfall (below) – Wet-Dry season 2020.

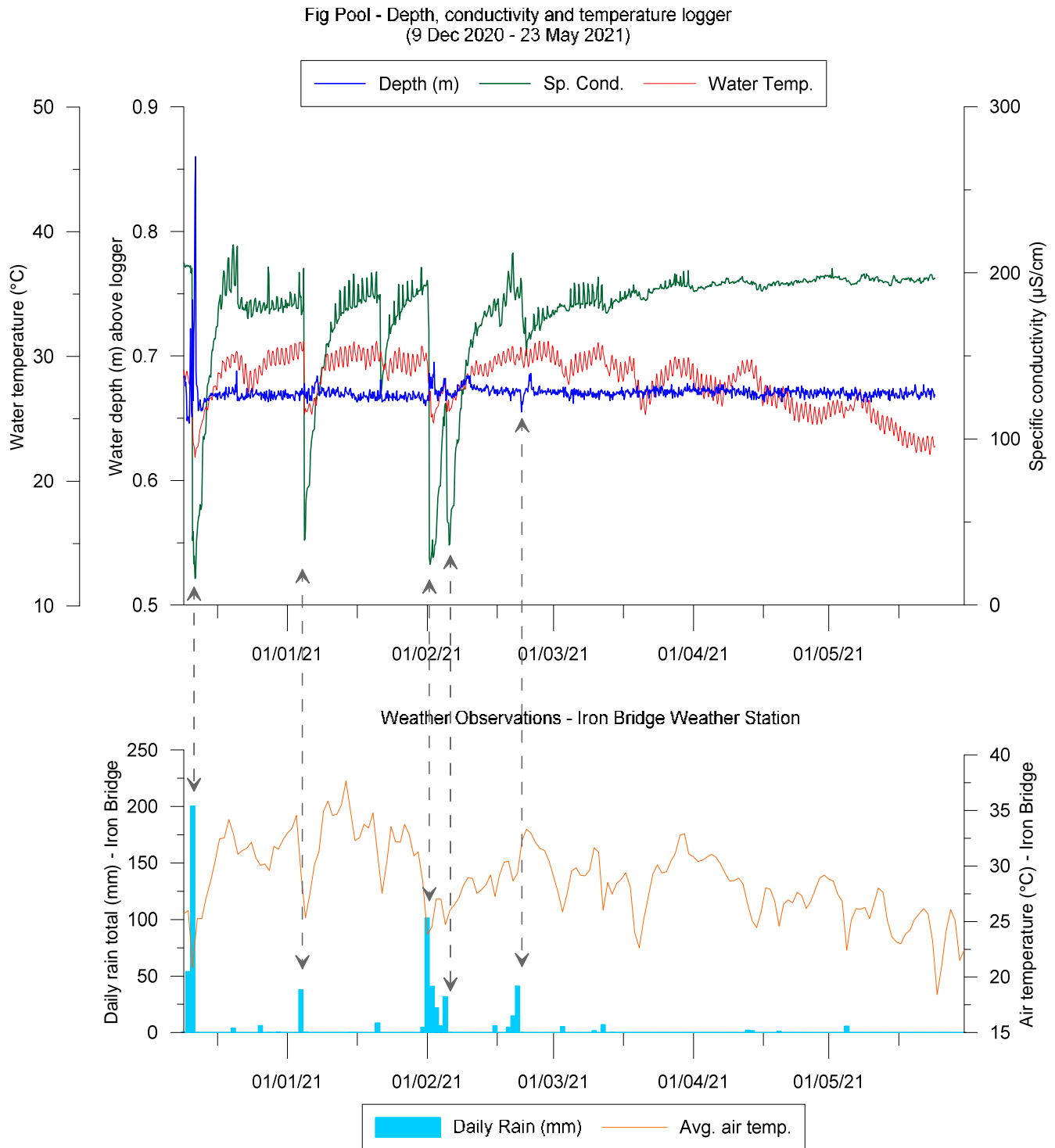


Figure 3-22 Fig Pool depth, conductivity, and temperature logger data (above) relationship to daily rainfall (below) – Wet-mid Dry season 2021.

### 3.2.1.1 WATER CHEMISTRY

The major ion balance at Fig Pool was remarkably stable over the four sampling events (Late Dry 2019, Late Wet 2020, Late Dry 2020 and Late Wet 2021). The water quality was clear (turbidity = <1 NTU NTU), acidic (pH = 3.4) and a sodium sulphate dominated water type (Figure 3-23). Although the pH at this site is low, the acidity levels are only moderate to low (16 mg/L as CaCO<sub>3</sub>). Observations at the site would indicate that the low pH based on spot samples (no pH logger is installed) is potentially due to the lack of buffering capacity in the low conductivity water and is likely to be controlled by the Fe(II)/Fe(III) redox couple at a pH of ~3.5. This is potentially mediated by biological processes in the root mats which surround the pool (e.g. root zone Fe(II) oxidation).

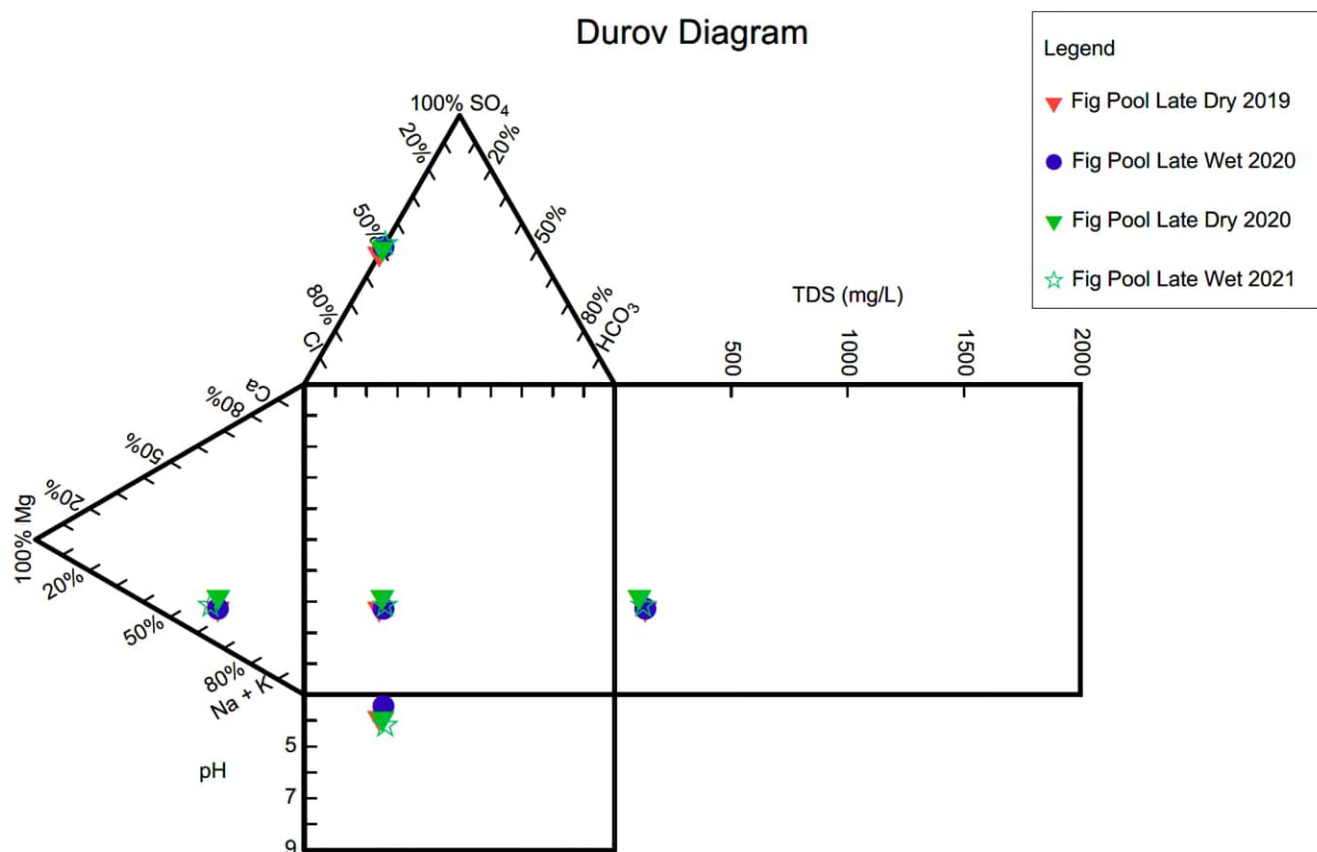


Figure 3-23 Durov diagram illustrates Fig Pool is a sodium-sulphate dominated water type. It is fresh, highly acidic pool with low total dissolved solids (TDS).

### 3.2.2 SEDIMENT QUALITY

Table 3-6 provides the surface sediment quality at Fig Pool during the Late Wet 2020, Late Dry 2020 and Late Wet 2021 surveys. Metal and metalloid concentrations were assessed against the ANZG (2018) DGVs. Chromium concentrations exceeded the DGV (80 mg/kg) though not the GV-high (370 mg/kg). Chromium naturally occurs at high concentrations across the Project area and were similarly above DGVs at most other surveyed surface water pools in the Project area.

Table 3-6. Summary of sediment analysis at Fig Pool sampled in late wet season 2020 (June 2020), late dry season 2020 (December 2020) and late wet season 2021 (May 2021).

Analyte grouping/Analyte	Unit	Late Wet 2020	Late Dry 2020	Late Wet 2021
Total Soluble Salts	mg/kg	<b>248</b>	-	<b>384</b>
Moisture Content (Dried @ 105-110°C)	%	-	<b>38.3</b>	<b>37</b>
Total Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>2</b>	<5	<5
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>2</b>	<5	<5
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<1	<5	<5
Acidity	mg/kg	<b>14</b>	<b>166</b>	<b>1000</b>
Sulfate as SO <sub>4</sub> <sup>2-</sup> (soluble sulfate by ICPAES)	mg/kg	<b>120</b>	<b>160</b>	<b>150</b>
Chloride (by Discrete Analyser)	mg/kg	<10	<b>40</b>	<b>60</b>
Calcium	mg/kg	<b>30</b>	<10	<10
Magnesium	mg/kg	<10	10	10
Sodium	mg/kg	<b>10</b>	<b>40</b>	<b>12</b>
Potassium	mg/kg	<b>10</b>	<b>30</b>	<b>10</b>
Mercury (FIMS)	mg/kg	<0.1	-	<b>0.2</b>
Nitrite + Nitrate as N (Sol.)	mg/kg	<0.1	<0.1	<b>0.2</b>
Total Kjeldahl Nitrogen as N	mg/kg	<b>1110</b>	<b>1670</b>	<b>3030</b>
Total Nitrogen as N	mg/kg	<b>1110</b>	<b>1670</b>	<b>3030</b>
Total Phosphorus as P	mg/kg	<b>60</b>	<b>223</b>	<b>310</b>
Reactive Phosphorus as P	mg/kg	<0.1	<0.1	<0.1
Total Organic Carbon	%	<b>0.30</b>	<b>3.60</b>	<b>3.08</b>
<b>Total Metals by ICP-AES</b>				
Arsenic	mg/kg	<5	-	<b>12</b>
Barium	mg/kg	<b>10</b>	-	<b>40</b>
Beryllium	mg/kg	<1	-	<1
Boron	mg/kg	<50	-	<50
Cadmium	mg/kg	<1	-	<1
Chromium	mg/kg	<b>143</b>	-	<b>127</b>
Cobalt	mg/kg	<2	-	<b>2</b>
Copper	mg/kg	<b>8</b>	-	<b>24</b>
Iron	mg/kg	<b>58500</b>	<b>90200</b>	<b>64600</b>
Lead	mg/kg	<5	-	<5

Analyte grouping/Analyte	Unit	Late Wet 2020	Late Dry 2020	Late Wet 2021
Manganese	mg/kg	94	-	39
Nickel	mg/kg	6	-	12
Selenium	mg/kg	<5	-	<5
Vanadium	mg/kg	27	-	53
Zinc	mg/kg	5	-	8

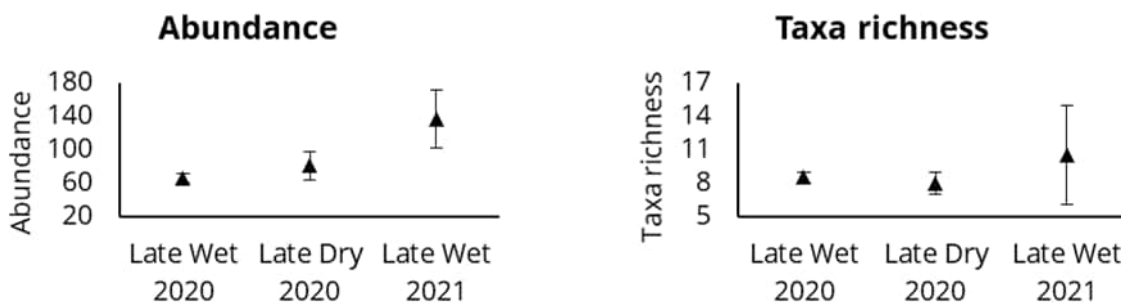
### 3.2.3 FISH

Fish, decapods, and non-fish vertebrates were sampled with a combination of nets/traps and BRUVs over three surveys (Late Wet 2020, Late Dry 2020 and Late Wet 2021). No fish were collected by fyke nets, traps or BRUVs and no fish have been observed to inhabit the pool across the three seasons. Similarly, no other vertebrates (e.g. tadpoles, frogs or snakes) have been observed at the pool. It is noted that organisms that are generally highly visible (e.g. fish) would have been readily observable if they inhabited the pool due to the small size of the pool, shallowness, and water clarity. The low pH of this pool (pH 3-4), as well as restricted connectivity, is likely to be controlling the absence of fish at this location.

### 3.2.4 AQUATIC MACROINVERTEBRATES

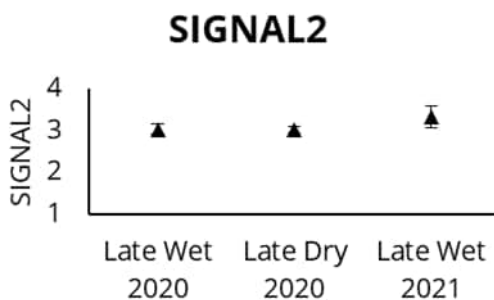
Figure 3-24 presents the total abundance, taxa richness, EPT richness and SIGNAL2 scores for Fig Pool in the late wet seasons of 2020 and 2021, and the late dry season of 2020. The key findings were as follows:

- Total abundance and taxonomic richness increased from 2020 to 2021 (Figure 3-24a,b), with abundances and number of taxa increasing to 138 and 11, respectively, in the Late Wet season of 2021. In contrast, 66 to 81 invertebrates of around 8 different taxa were present in 2020.
- There was only one individual of the Leptoceridae sampled from the Trichoptera order in Late Wet 2021, with no families belonging to the pollution sensitive Plecoptera or Ephemeroptera sampled at any time (EPT richness  $\leq 1$ ; not plotted).
- The SIGNAL2 score was 3.02 for 2020, with a slight increase to 3.33 in the late wet season of 2020. These scores considered with an EPT richness of 1, indicates that a mostly tolerant macroinvertebrate community resides in Fig Pool.



a) Total abundance at Fig Pool

b) Taxonomic richness at Fig Pool



c) SIGNAL2 scores at Fig Pool

Figure 3-24 Macroinvertebrate indices for Fig Pool – Late Wet 2020, Late Dry 2020 and Late Wet 2021.

The abundance of taxa for the three seasonal surveys is provided in Figure 3-25 and shows taxa ranging from the the most abundant (left) to the least abundant (right) along the x-axis. The non-biting midge of the Chironominae, dragonflies of the Libellulidae and water striders of the Veliidae were much more abundant in the latest Late Wet season of 2021 in comparison to previous seasons, while damselflies of the family Coenagrionidae were more abundant in the Late Wet season of 2020. Some macroinvertebrates, such as chironomids and oligochaetes, can increase in abundance following freshwater flow events such as flooding in wetlands (e.g. McInerney et al. 2017), which may explain increased abundances of such taxa in the latest wet season when greater rainfall levels were recorded.

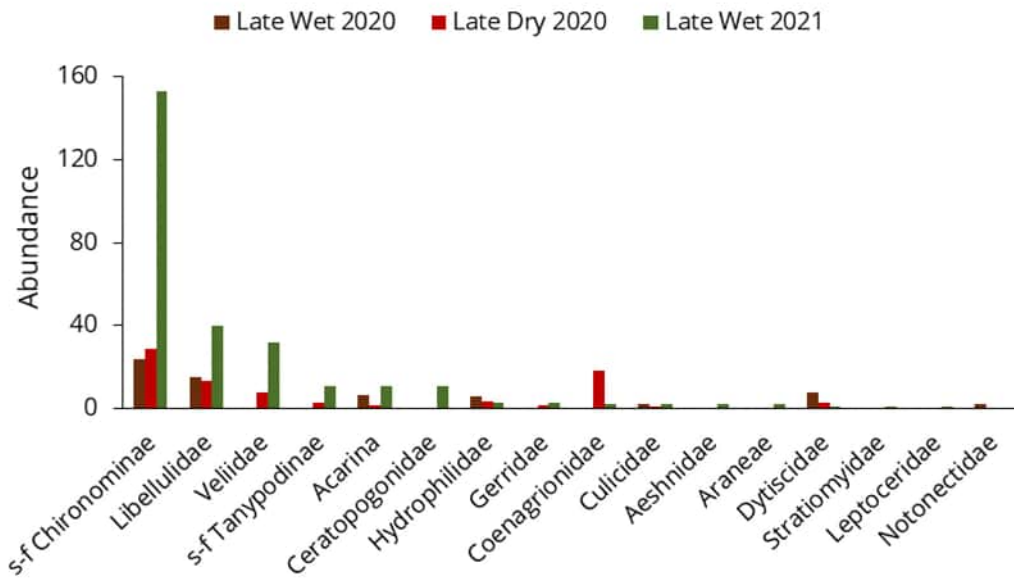


Figure 3-25 Average abundances of all macroinvertebrate taxa at Fig Pool in the Late Wet season of 2021 and the Late Wet and Late Dry season of 2020, with taxa arranged from most abundant (left) to least abundant (right) along the x-axis.

### 3.2.5 DIATOMS AND PHYTOPLANKTON

No diatom species were detected at Fig Pool across the two seasonal surveys to date (Late Wet 2020 and Late Wet 2021) by quantitative artificial substrate sampling. This indicates that the water conditions did not enable reproduction of diatoms during the sampling timeframe because none colonised the new artificial substrates. A DSIAR score could not be calculated. The Late Dry 2020 diatom samples were not analysed as there was a major flood event during the four-week sampler deployment time and therefore the samples were not considered representative or useful.

In the Late Dry 2020, an analysis of the phytoplankton abundance was conducted at Fig Pool. Overall, phytoplankton abundance at Fig Pool was low. Three classes of phytoplankton were observed with the most abundant being Chlorophyceae (Green Algae, 88%), with diatoms (Bacillariophyceae) at 8% and least abundant was Euglenophyceae (4%) (Table 3-7). Water samples from Fig Pool collected in May 2021 (late wet season) did not yield any algal cells, this finding was not unusual due to the previous low abundance of phytoplankton and similar results in the late wet season of the previous year.

Table 3-7 Summary of phytoplankton analytical results for Fig Pool sampled in late dry season (2020), abundance (cells L<sup>-1</sup>) and percentage contribution (%), limit of reporting 10 cell L<sup>-1</sup>. Samples taken from Fig Pool in late wet season 2021 did not yield any phytoplankton results.

Taxon	Late Dry 2020		Late Wet 2021	
	Abundance	%	Abundance	%
<b>Bacillariophyceae</b>	<b>200</b>	<b>8</b>	-	-
<i>Microtabella spp</i>	100	4	-	-
<i>Navicula spp.</i>	100	4	-	-
<b>Chlorophyceae</b>	<b>2200</b>	<b>88</b>	-	-
<i>Cosmarium spp. (O)</i>	2200	88	-	-
<b>Euglenophyceae</b>	<b>100</b>	<b>4</b>	-	-
<i>Trachelomonas spp.</i>	100	4	-	-

### 3.2.6 MACROPHYTES

Across the three seasons that Fig Pool was surveyed, no macrophytes species were observed. The natural acidity (pH = 3.4) at Fig Pool is likely to be the cause for the absence of macrophytes (Section 3.2.1 Water Quality and Hydrology). A considerable proportion of Fig Pool is bordered by *Melaleuca spp.* with extensive root mats, which likely provided habitat structural complexity typically provided by macrophytes (Figure 3-26). The fauna visible in Fig Pool, such as Dytiscidae (dive beetles), Hydrophilidae (water scavenger beetles) and Chironominae (midges) were noted to be inhabiting the root mats.



Figure 3-26 Fig Pool ecology. a) and b) root mats of *Melaleuca* spp extend into Fig Pool; c) and d) microscope slide used as artificial colonising habitat for diatoms appears stained by iron deposits and no algal growth; d) periphytometers to sample diatoms placed on root mats and leaf litter; e) and f) macroinvertebrate sampling found low abundance and diversity with predominantly tolerant taxa collected.

### 3.3 MUNDAGOORA POOL (GV\_SW\_POOL\_Mundagoora\_SS)

Mundagoora Pool has a catchment area of approximately 3.3 km<sup>2</sup>, draining two similarly sized basins (to the northeast and southeast; Figure 3-28). Discharge from the pool flows to Cockatoo Creek and the Turner River (see Figure 2-2). The likely permanent nature of the pool provides habitat to an abundance of fish, macroinvertebrates, and extensive beds of macrophytes and established riparian vegetation (Figure 3-27). Some key features of this pool are:

- The inflow is over a steep rock face (waterfall).
- The outflow is over a sill with little variation in pool height over wet/dry season (controlled by the sill level).
- It is a clear water pool dominated by submerged vegetation/algae and abundant fish (common species, not endangered).
- Downstream of the pool is dominated by dense emergent vegetation (reeds and sedges), which extends down a shallow braided channel downstream for several hundred metres from the pool.
- The pool contains a hard bottom (rock) at the inflow point, likely to be scoured out (removal of deposited sediments) during high-flow events.



Figure 3-27 Mundagoora Pool is a permanent pool with extensive macrophyte beds and riparian vegetation.

#### 3.3.1 WATER QUALITY AND HYDROLOGY

Figure 3-29 and Figure 3-30 display a high-resolution water level, salinity (conductivity) and temperature logger record from Mundagoora Pool for the wet seasons of 2019/2020 and 2020/2021 respectively.

Mundagoora pool is a relatively deep permanent pool located at the base of an intermittent waterfall, which appears to only flow during high rainfall events. The pool water level is controlled by a sill at the downstream edge. Water levels remain relatively consistent within the pool with the exception of short duration peaks during high rainfall events (Figure 3-29 and Figure 3-30). Mundagoora Pool appears to be largely sustained by groundwater; however, it was periodically flushed with fresh surface water flows after rainfall events. It takes approximately 3 weeks for the groundwater to displace the surface water flows once a flushing event has occurred. Conductivity was typically very slightly brackish ( $\sim 850 \mu\text{S}/\text{cm}$ ) except during a surface water flow event when it would become extremely fresh ( $< 50 \mu\text{S}/\text{cm}$ ). Water levels were a maximum of  $\sim 0.6 \text{ m}$  above the pool overflow levels during high-flow events, typically lasting less than 24 hours before flows receded. Water temperature within the pool was responsive to atmospheric temperature changes (Figure 3-29 and Figure 3-30).

Mundagoora Pool is a clear water pool with low turbidity ( $0.71 \text{ NTU}$ ), low salinity ( $870 \mu\text{S}/\text{cm}$ ) and moderate oxygenation ( $5.61 \text{ mg}/\text{L}$ ). No metals were recorded above ANZG (2018) and were predominantly below detection limits. Nutrients were low, with Total Nitrogen at  $0.5 \text{ mg}/\text{L}$  and Total Phosphorus at  $0.01 \text{ mg}/\text{L}$ . Dissolved organic carbon (DOC) was moderate at  $4 \text{ mg}/\text{L}$ . See Appendix A for complete water quality data.

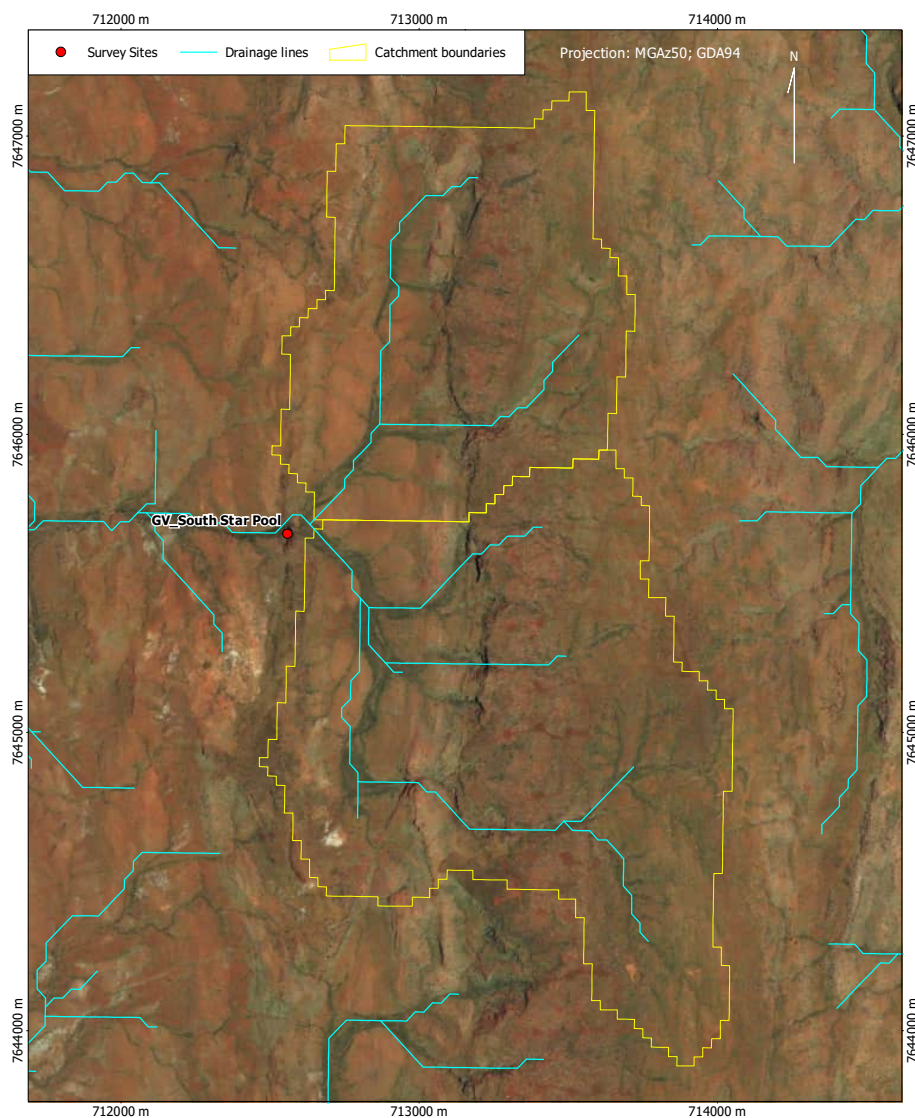


Figure 3-28 Mundagoora Pool catchment ( $3.3 \text{ km}^2$ )

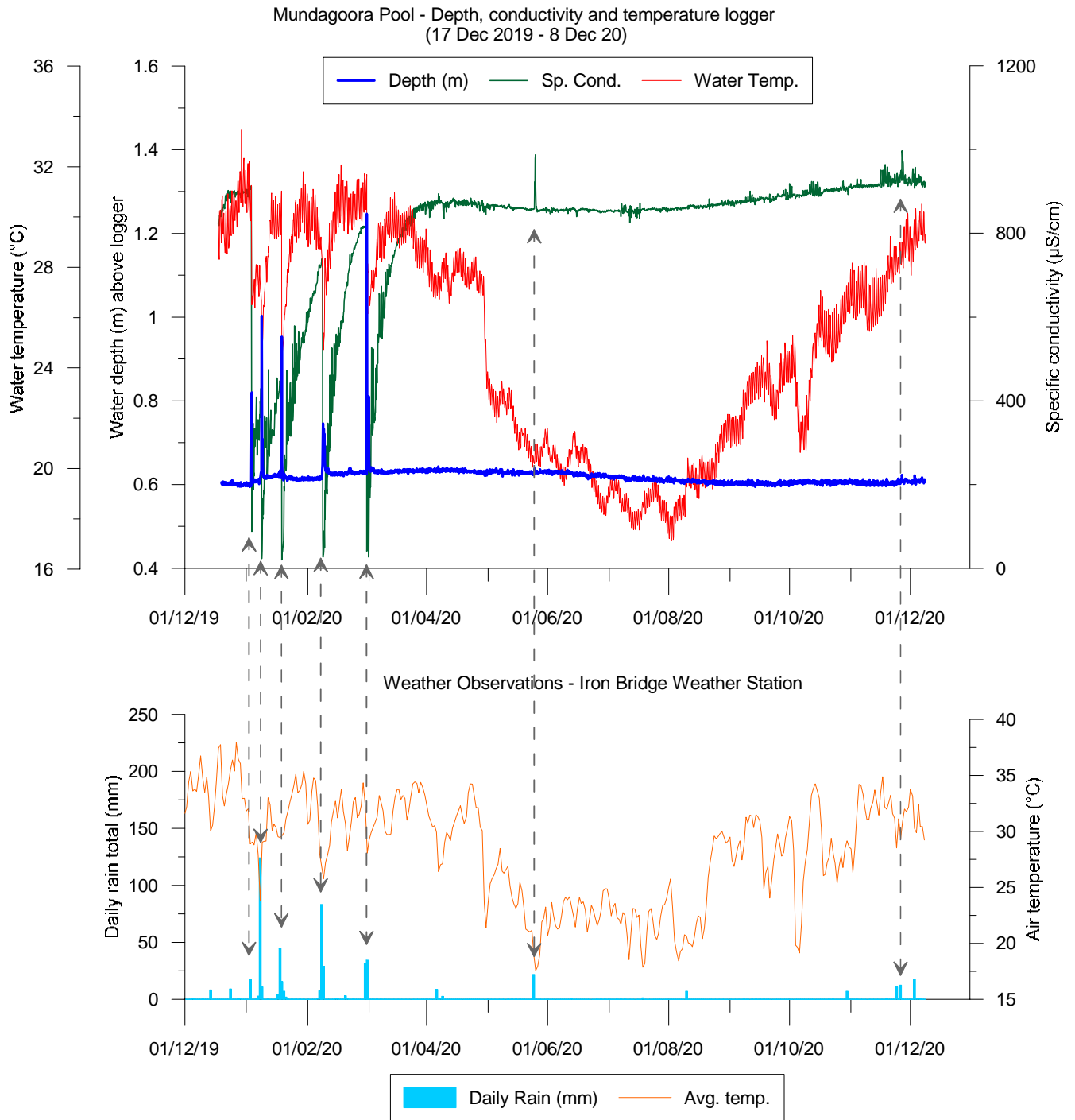


Figure 3-29 Water level, temperature and conductivity (salinity) at Mundagoora Pool – Wet-Dry Season 2020

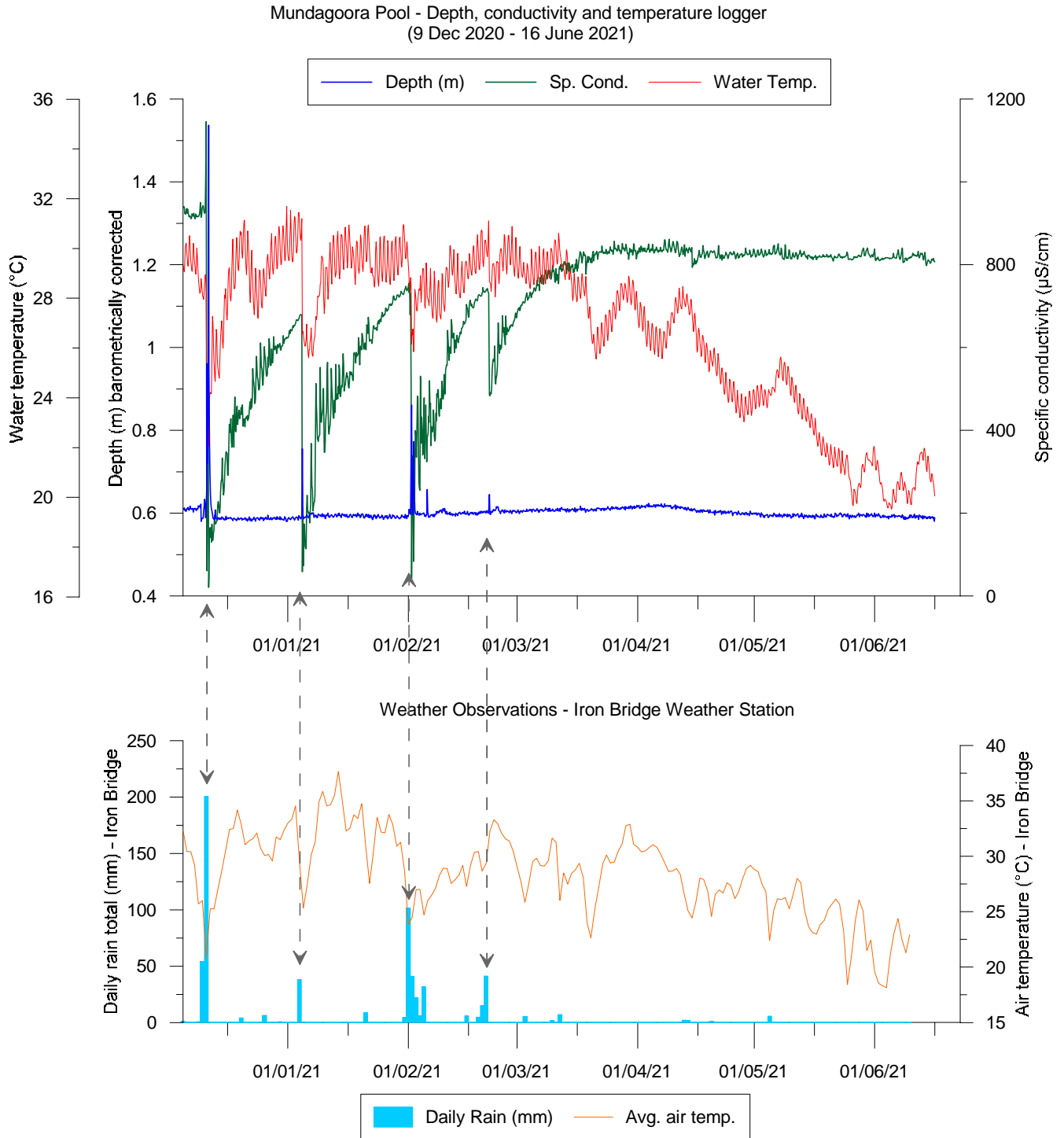


Figure 3-30 Water level, temperature and conductivity (salinity) at Mundagoora Pool – Wet – mid Dry Season 2021

Figure 3-31 provides a Durov plot displaying the major ion balance of Mundagoora Pool over four sampling events. It can be seen that the water quality is relatively stable over the four seasonal sampling events with a slightly alkaline pH. Cations are evenly distributed between Calcium, Magnesium and Sodium+Potassium with anions dominated by carbonates.

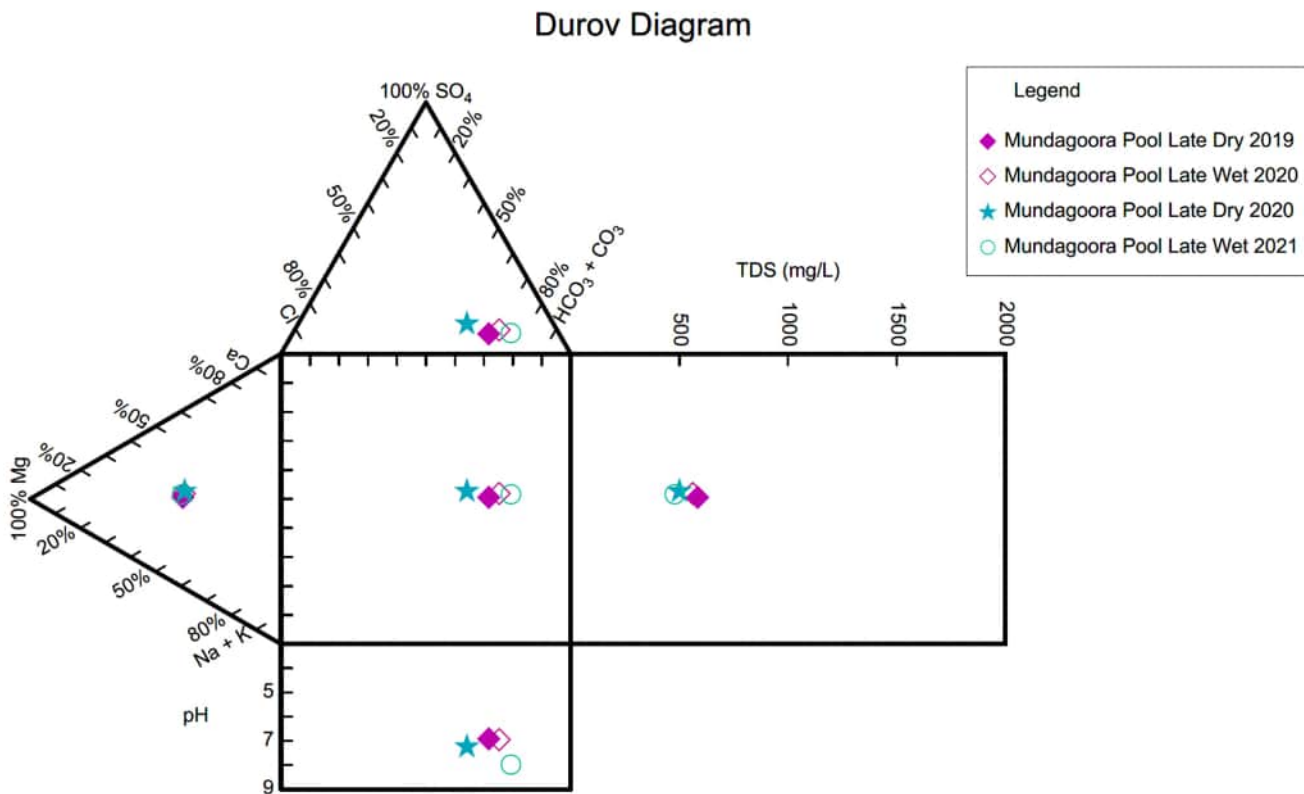


Figure 3-31 Durov diagram illustrates the Mundagoora Pool major ion distribution.

### 3.3.2 BATHYMETRY

Mundagoora Pool was surveyed in May 2020 using a down beam and side-scan sonar system attached to a remote-control boat. The maximum depth of the pool is approximately 3.5 m with the average depth 1.9 m (Figure 3-32). The volume of the pool has been calculated at 448 m<sup>3</sup>. The deepest section (3-3.5 m) is in the basin below the waterfall/rock face to the east with a shallower sill to the west at ~1 m deep (Figure 3-32 to Figure 3-36). The pool is 25 m in length (north-south) and 15 m at its widest point (east-west). The base of the pool is dominated by hard rock with gravel/sediments to the west at the pool overflow point.

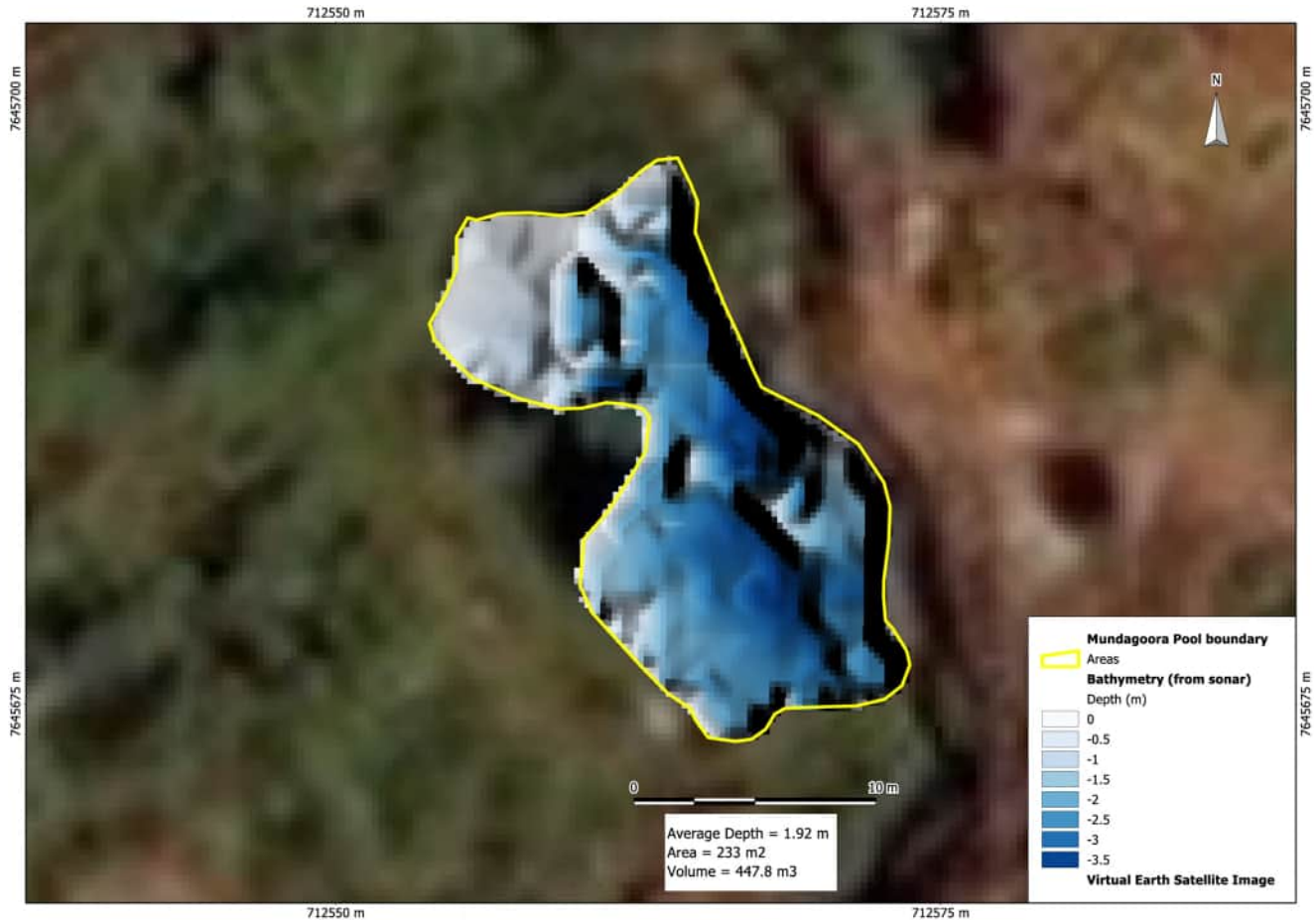


Figure 3-32 Bathymetry of Mundagoora Pool



Figure 3-33 Cross-section of deep southern portion of Mundagoora Pool (East-West)

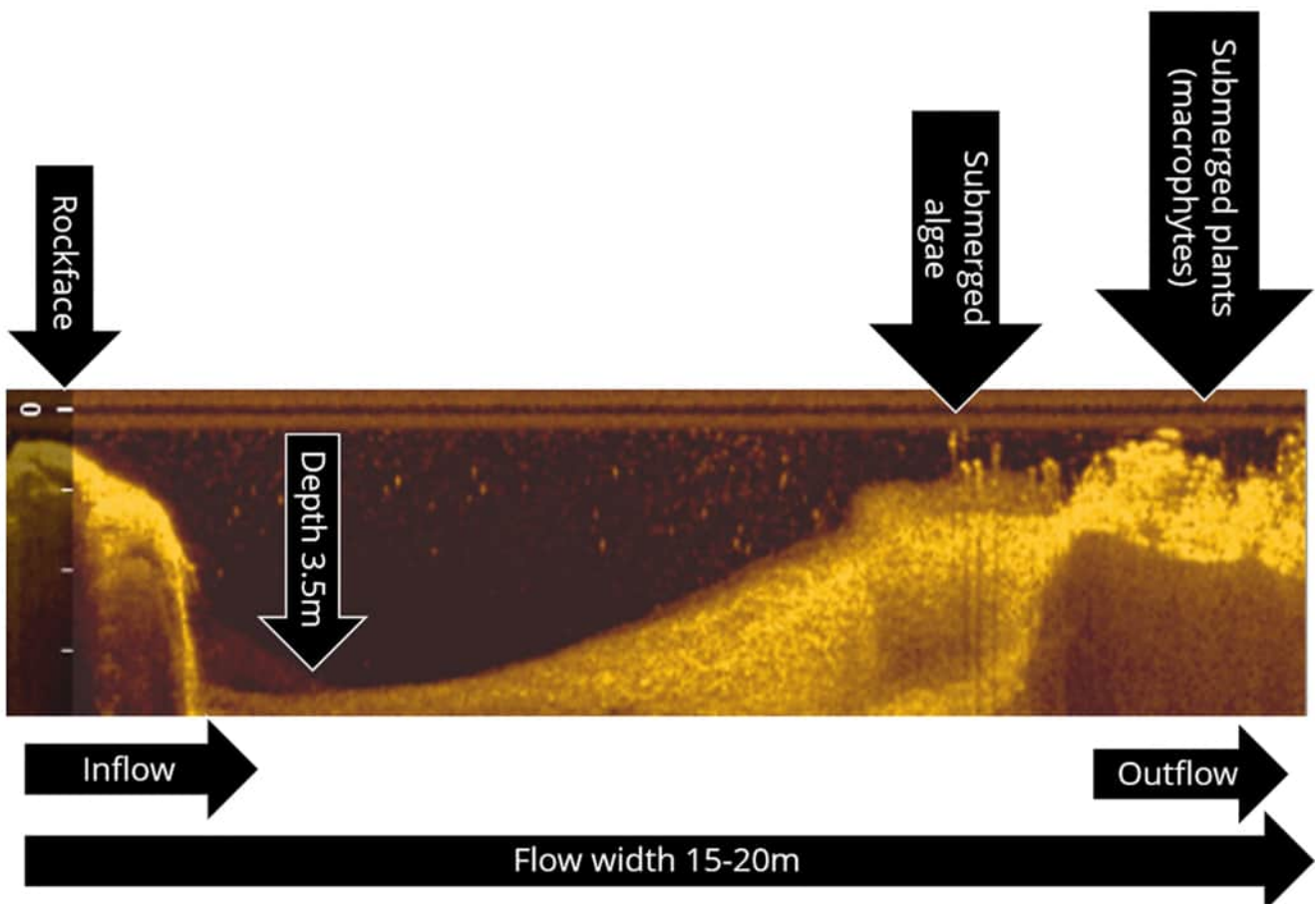


Figure 3-34 Sonar cross-section of Mundagoora Pool showing habitat features

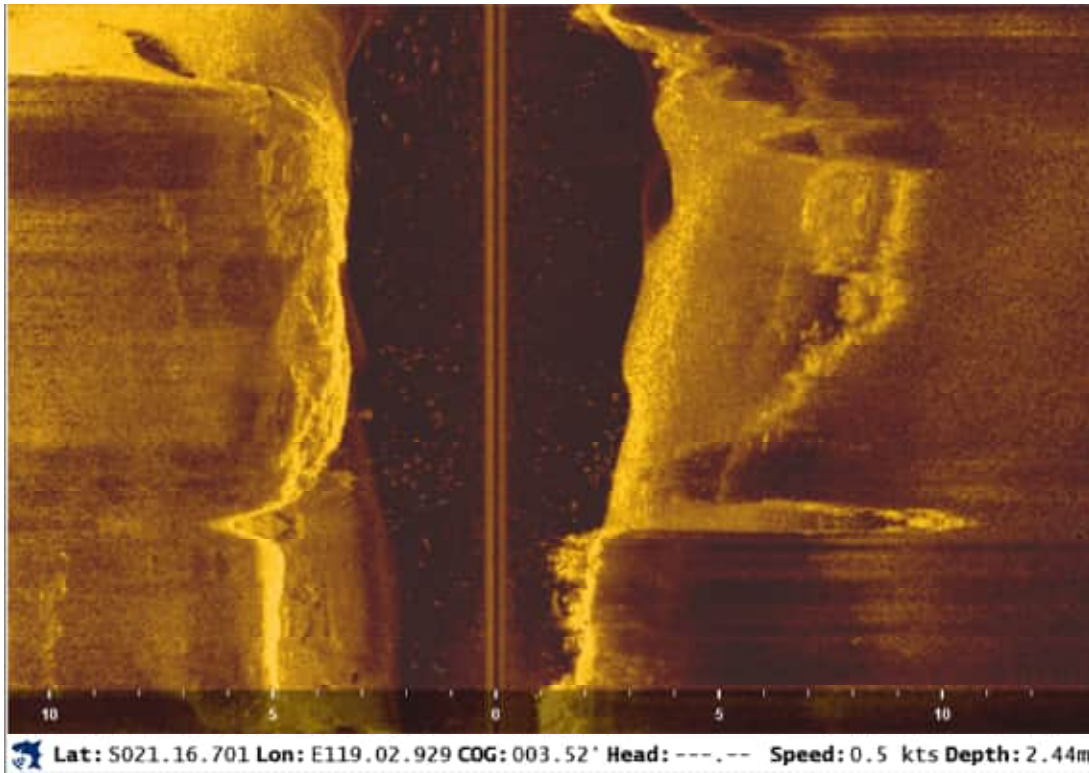


Figure 3-35 Side-scan sonar bathymetry: - cross-section north-south

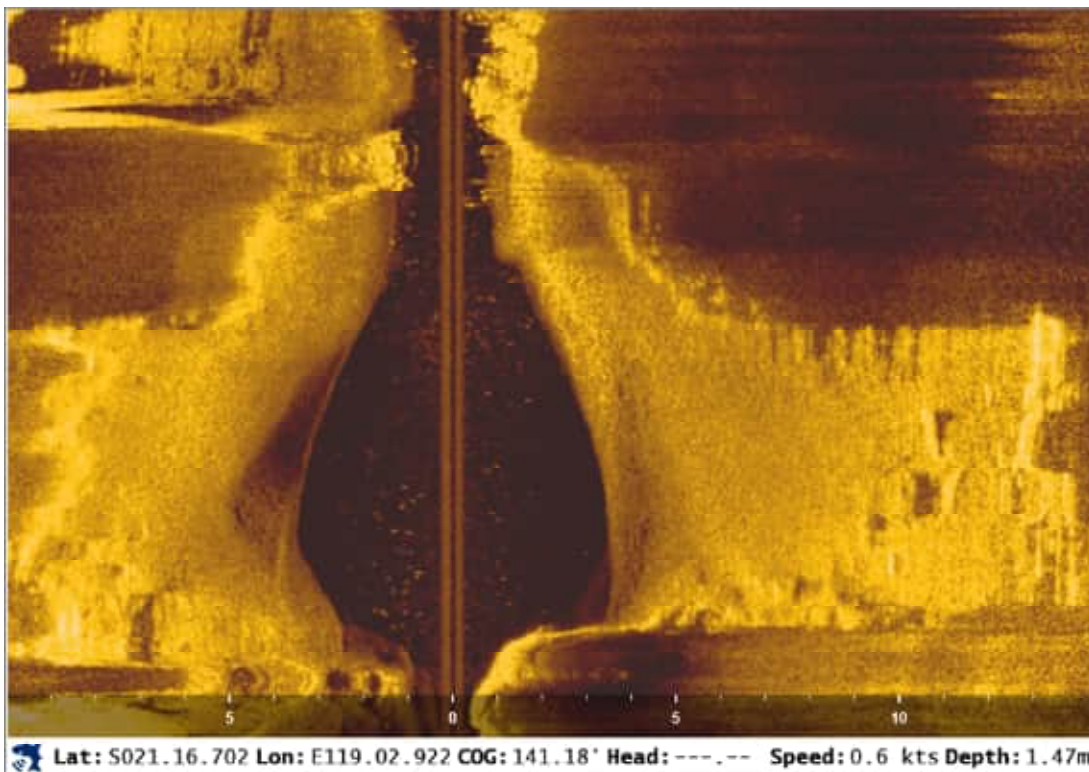


Figure 3-36 Side-scan sonar bathymetry: cross-section east-west

### 3.3.3 SEDIMENT QUALITY

Table 3-8 provides the surface sediment quality at Mundagoora Pool during the three seasonal surveys. Metal and metalloid concentrations were assessed against the ANZG (2018) DGVs. Chromium concentration (169 mg/kg) exceeded the DGV but not the GV-high. Nickel concentration (79 mg/kg) exceeded both the DGV and GV-high. These metals both naturally occur in high concentrations across the Project area. Alkalinity exceeded acidity in the sediments of Mundagoora Pool, indicating that there is unlikely to be an acid sulphate soil issue.

Table 3-8. Summary of sediment quality analyses for the late wet season (2020), late dry season (2020) and late wet season (2021). Bolded values denote results above the limit of reporting.

Analyte grouping/Analyte	Unit	Late Wet 2020	Late Dry 2020	Late Wet 2021
Total Soluble Salts	mg/kg	<b>693</b>	-	<b>280</b>
Moisture Content (Dried @ 105-110°C)	%	<b>59.7</b>	<b>49.3</b>	<b>24.8</b>
Total Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>77</b>	<b>104</b>	<5
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>77</b>	<b>104</b>	<b>239</b>
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<1	<5	<b>239</b>
Acidity	mg/kg	<b>12</b>	<b>53</b>	<b>62</b>
Sulfate as SO <sub>4</sub> <sup>2-</sup> (soluble sulfate by ICPAES)	mg/kg	<b>80</b>	<b>70</b>	<10
Chloride (by Discrete Analyser)	mg/kg	<b>100</b>	<b>40</b>	<b>20</b>
Calcium	mg/kg	<b>220</b>	<b>30</b>	<b>30</b>
Magnesium	mg/kg	<b>110</b>	<b>20</b>	<b>20</b>
Sodium	mg/kg	<b>170</b>	<b>100</b>	<b>30</b>
Potassium	mg/kg	<b>20</b>	<10	<10
Mercury (FIMS)	mg/kg	<b>0.6</b>	-	<0.1
Nitrite + Nitrate as N (Sol.)	mg/kg	<0.1	<0.1	<0.1
Total Kjeldahl Nitrogen as N	mg/kg	<b>3950</b>	<b>1970</b>	<b>430</b>
Total Nitrogen as N	mg/kg	<b>3950</b>	<b>1970</b>	<b>430</b>
Total Phosphorus as P	mg/kg	<b>242</b>	<b>179</b>	<b>190</b>
Reactive Phosphorus as P	mg/kg	<0.1	<0.1	<0.1
Total Organic Carbon	%	<b>3.15</b>	<b>4.88</b>	<b>0.13</b>
Arsenic	mg/kg	<b>9</b>	-	<b>9</b>
Barium	mg/kg	<b>40</b>	-	<b>60</b>
Beryllium	mg/kg	<b>1</b>	-	<1
Boron	mg/kg	<50	-	<b>50</b>
Cadmium	mg/kg	<1	-	<1
Chromium	mg/kg	<b>169</b>	-	<b>368</b>
Cobalt	mg/kg	<b>22</b>	-	<b>33</b>

Analyte grouping/Analyte	Unit	Late Wet 2020	Late Dry 2020	Late Wet 2021
Copper	mg/kg	52	-	67
Iron	mg/kg	76600	57000	114000
Lead	mg/kg	<5	-	6
Manganese	mg/kg	481	-	674
Nickel	mg/kg	79	-	134
Selenium	mg/kg	5	-	<5
Vanadium	mg/kg	166	-	161
Zinc	mg/kg	39	-	30

### 3.3.4 FISH

Table 3-9 presents the fish species, catch and size distribution collected during the Late Wet 2020, Late Dry 2020 and Late Wet 2021 surveys. Two fish species were present and were sampled by nets/traps and BRUVs; *M. australis* and *L. unicolor*. *M. australis* was substantially more abundant in all three seasons (Table 3-9). The highest number of *M. australis* was collected in the Late Dry 2020, with 451 fish caught, the late wet for both years had similar numbers of fish caught (213).

The majority of *M. australis* ranged between approximately 20 mm to 90 mm in total length, with very few individuals being observed > 90 mm in the late dry season (2020). Figure 3-37 displays the size distribution of measured *M. australis* individuals for each survey. Figure 3-38 displays the frequency of each size class, with the 30 – 60 mm size class being most frequent in all three seasons. In all three surveys, individuals <30 mm were observed at Mundagoora Pool, indicating a regular spawning and recruitment at the site (Pusey, B., Kennard, M., & Arthington, 2004).

Only one individual of *L. unicolor* was caught in the Fyke net in the Late Wet 2020 and three in the Late Dry 2020. No *L. unicolor* individuals were caught in the Late Wet 2020 though these were visually observed to be present in low numbers. As such, size distribution for *L. unicolor* has been pooled for the two seasons in Figure 3-39, all *L. unicolor* individuals caught within the Fyke nets were > 90 mm. The size range of *L. unicolor* observed demonstrated likely interannual survival and reproduction, with some estimated at several years old (Figure 3-43). The low abundance of *L. unicolor* was likely due to the net being placed in habitat less frequented by this species (edge/macrophytes). BRUVs directed towards open water captured a greater abundance of adult *L. unicolor*. BRUV footage in the Late Wet 2021 did not observe *L. unicolor*, potentially indicating lower abundance for this survey.

Table 3-9. Fish species, size class (SL, mm), overall count and CPUE for Mundagoora Pool

Species	Size class (mm)	Late Wet (2020)	CPUE <sup>1</sup>	Late Dry (2020)	CPUE <sup>1</sup>	Late Wet (2021)	CPUE <sup>1</sup>
<b><i>Melanotaenia australis</i></b>		<b>212</b>	<b>12.8</b>	<b>451</b>	<b>27.3</b>	<b>213</b>	<b>12.9</b>
	0 – 30	63		61		10	
	30 – 60	95		269		2020	
	60 – 90	54		100		1	
	> 90	0		21			
<b><i>Leiopotherapon unicolor</i></b>		<b>1</b>	<b>0.06</b>	<b>3</b>	<b>0.18</b>	<b>0</b>	<b>-</b>
	30 - 60	0		0		0	
	60 - 90	0		0		0	
	> 90	1		3		0	
<b>Total</b>		<b>213</b>	<b>12.9</b>	<b>454</b>	<b>27.5</b>	<b>213</b>	<b>12.9</b>

<sup>1</sup> CPUE is catch per unit effort, a measure of relative abundance. Effort is fyke net set for 16.5 hours.

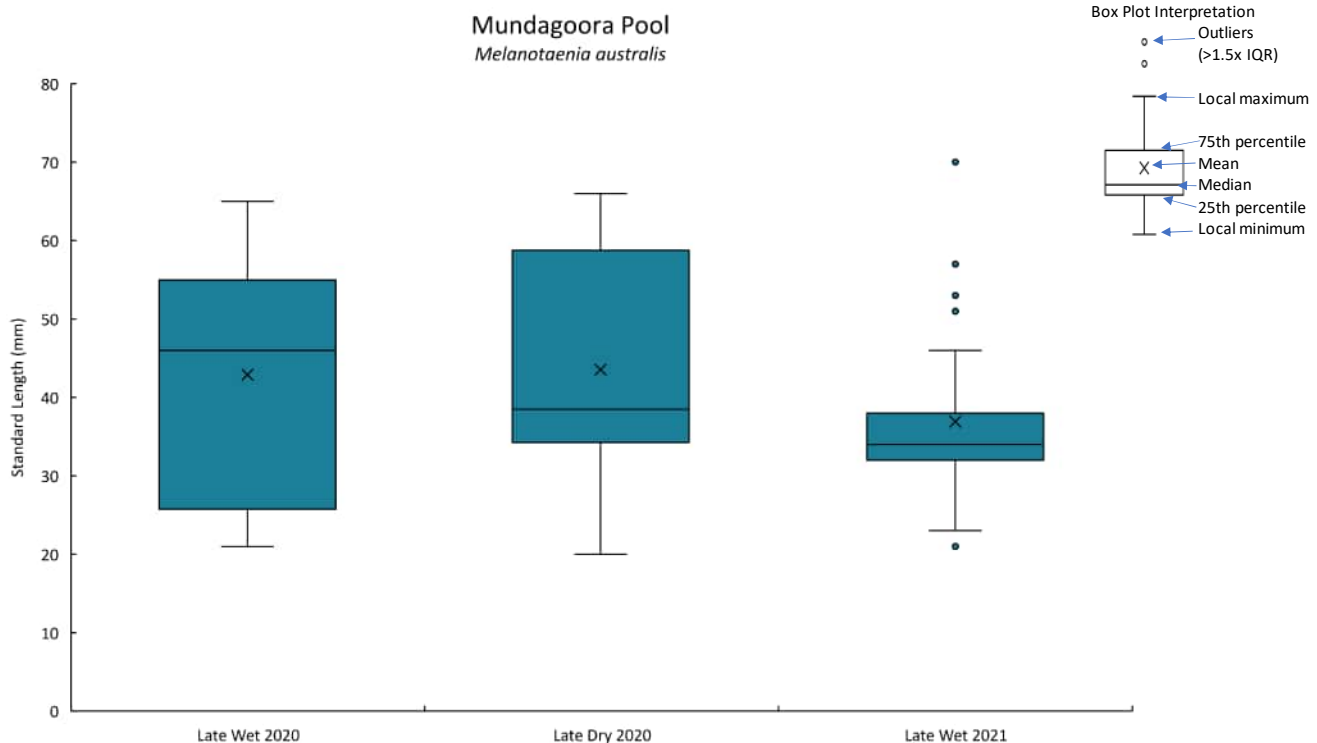


Figure 3-37. Distribution of standard length (SL, mm) for *Melatoenia australis* in Mundagoora Pool sampled with Fyke nets for the Late Wet 2020, Late Dry 2020 and Late Wet 2021 surveys.

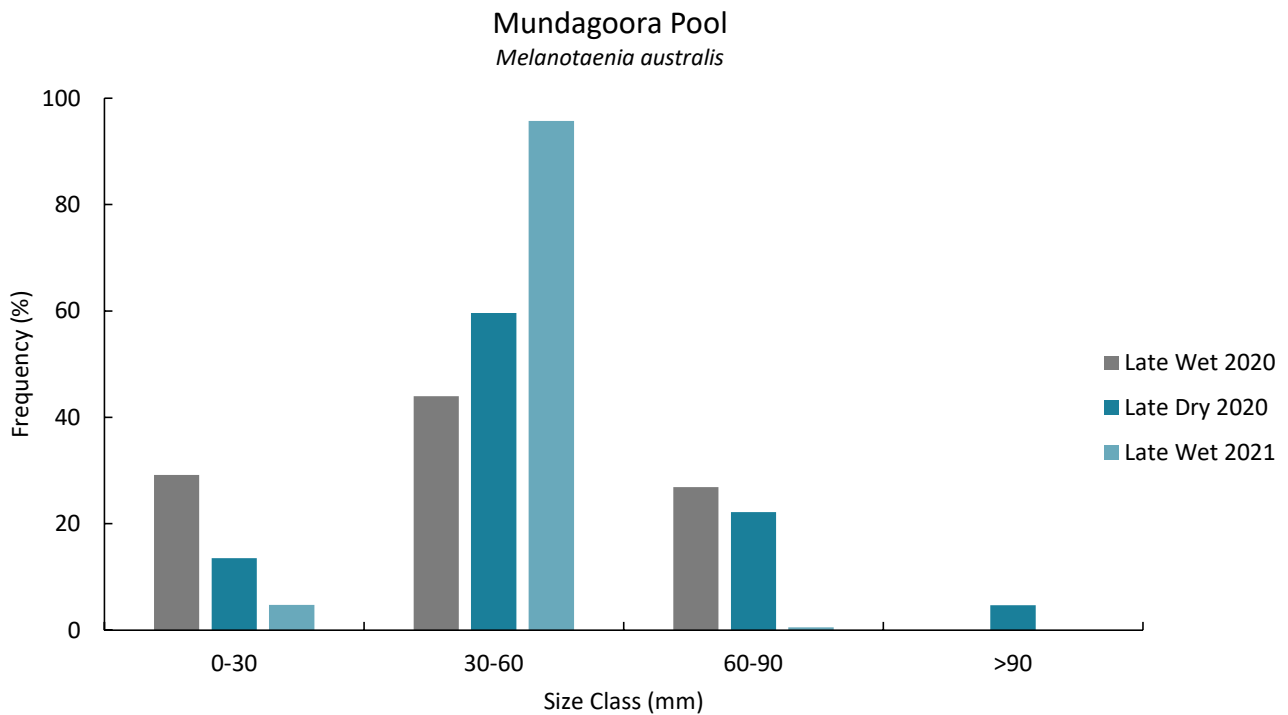


Figure 3-38. Frequency (%) of each size class (mm) for *M. australis* in Mundagoora Pool sampled with Fyke nets for the Late Wet 2020, Late Dry 2020 and Late Wet 2021 surveys.

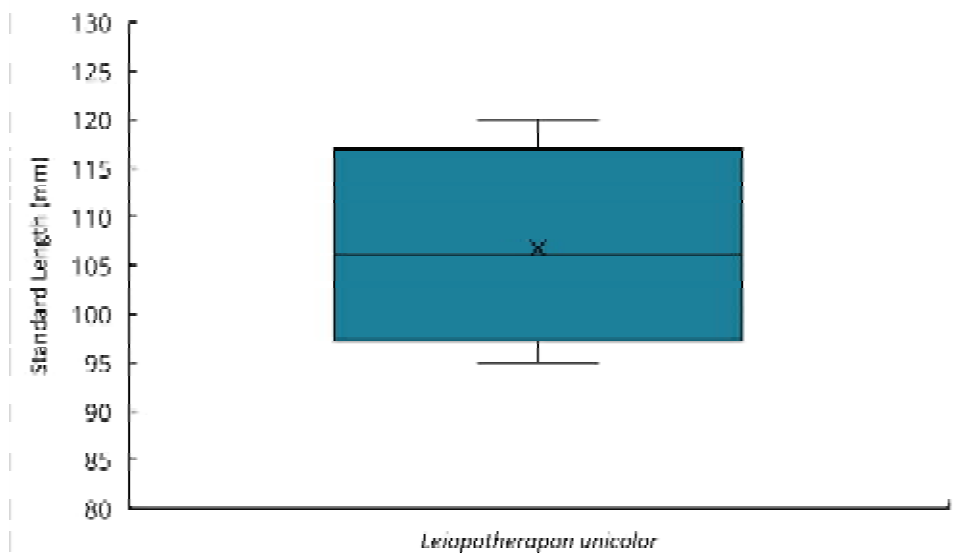
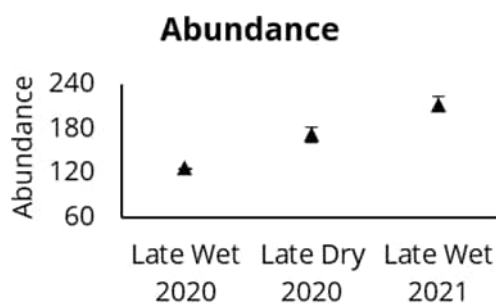


Figure 3-39. Distribution of standard length (SL, mm) for *Leipothorapon unicolor* sampled from Mundagoora Pool in the Late Wet 2020 and Late Dry 2020 seasons.

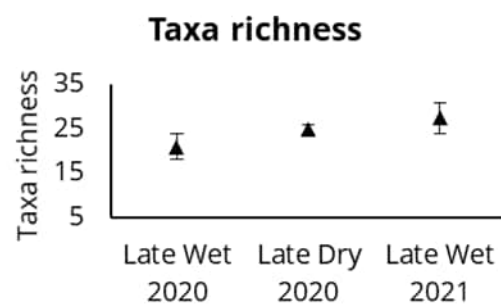
### 3.3.5 AQUATIC MACROINVERTEBRATES

Figure 3-40 presents the total abundance, taxa richness, EPT richness and SIGNAL2 scores for Mundagoora Pool in the late wet seasons of 2020 and 2021 and the late dry season of 2020. The key findings were as follows:

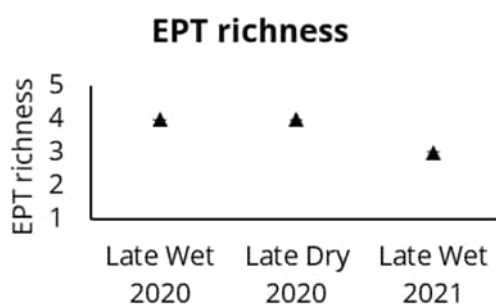
- Total abundance of aquatic macroinvertebrates gradually increased throughout the seasons, with an average of 214 individuals sampled in the recent Late Dry 2021 season (Figure 3-40a).
- Taxonomic richness remained relatively constant in comparison, with a slightly higher number of taxa recorded in the most recent season (Figure 3-40b)
- An average of four taxa belonging to the Plecoptera, Ephemeroptera and Trichoptera were found in both seasons in 2020 (EPT richness = 4) while it reduced to 3 in Late Wet 2021 (EPT richness = 3; Figure 3-40c).
- SIGNAL 2 scores were also consistent between seasons with a range of 2.8 to 3.2 (Figure 3-40d), indicating a community primarily dominated by tolerant taxa.



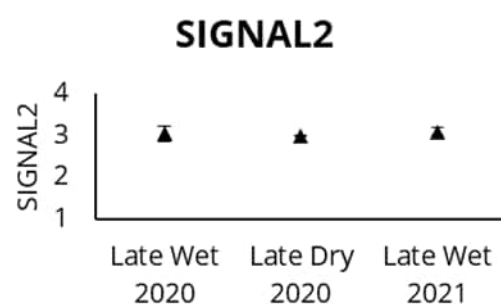
a) Total abundance at Mundagoora Pool



b) Taxonomic richness at Mundagoora Pool



c) PET richness at Mundagoora Pool



d) SIGNAL2 scores at Mundagoora Pool

Figure 3-40 Macroinvertebrate indices for Mundagoora Pool – Late Wet 2020, Late Dry 2020 and Late Wet 2021.

The taxonomic composition of the macroinvertebrate community is provided in Figure 3-41, ranging from most abundant (left) to least abundant (right) along the x-axis. There were higher numbers of the non-biting midge Tanypodinae, the biting midge Ceratopogonidae, backswimmers of the Pleidae, and oligochaete worms found during the recent Late Wet 2021 survey in comparison to others. In contrast, higher abundances of the caddisfly Leptoceridae were found during the Late Dry season of 2020. Relatively similar abundances of non-biting midge of the Chironominae and Coenagrionidae damselflies were found in each sampling event. Some macroinvertebrates, such as chironomids and oligochaetes, can increase in abundance following freshwater flow events such as flooding in wetlands (e.g. McInerney et al. 2017), which may explain increased abundances of such taxa in the latest wet season when greater rainfall levels were recorded.

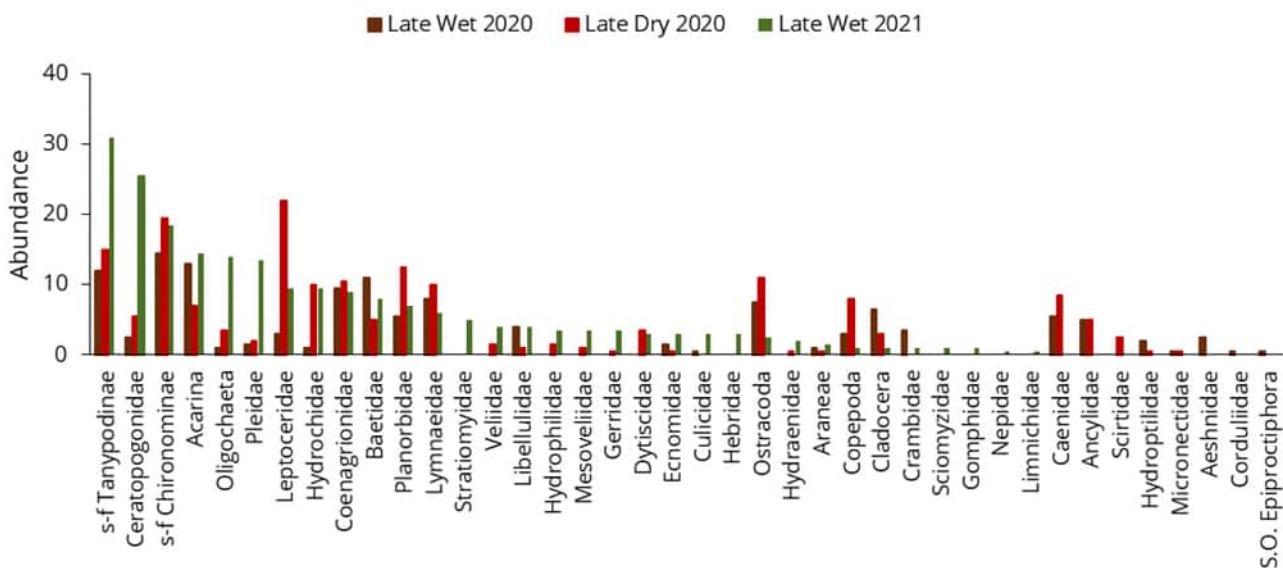


Figure 3-41 Average abundances of all macroinvertebrate taxa at Mundagoora Pool in the Late Wet season of 2021 and the Late Wet and Late Dry season of 2020, with taxa arranged from most abundant (left) to least abundant (right) along the x-axis.

### 3.3.6 DIATOMS AND PHYTOPLANKTON

#### 3.3.6.1 DIATOMS

Table 3-10 presents the Late Wet 2020 diatom species present, abundance and biotic indices as collected on Diatom plates. No data is available from the Late Dry 2020 due to flood conditions during the 4 week deployment period. The Late Wet 2021 data was not yet available at the time of reporting. Figure 3-42 shows the average count by diatom species present. A total of 17 diatom species were recorded and showed a high taxonomic diversity ranging across multiple families. The most dominant species were *Achnantheidium minutissimum* (average count=197) and *Brachysira vitrea* (average count=106) (Figure 3-42). The moderate sensitivity DSIAR scores (average DSIAR = 62.7) is associated with low levels of environmental stress and diatoms valves were relatively abundant compared to other North Star Pools.

Table 3-10. Diatom species list with count (total count per species), average abundance and DSIAR score for Mundagoora Pool surveyed in the Late Wet season 2020 and 2021.

Taxon	Late Wet 2020			Late Wet 2021		
	Replicate 1	Replicate 2	Average	Replicate 1	Replicate 2	Average
<i>Achnanthidium minutissimum</i>	302	92	197	14	62	38
<i>Brachysira vitrea</i>	48	164	106	0	124	62
<i>Eunotia bilunaris</i>	14	70	42	0	102	51
<i>Navicula cryptocephala</i>	6	0	3	16	68	42
<i>Navicula radiosa</i>	12	24	18	0	24	12
<i>Encyonopsis microcephala</i>	0	0	0	0	24	12
<i>Brachysira styriaca</i>	0	0	0	0	16	8
<i>Cymbella affinis</i>	6	8	7	0	0	0
<i>Navicula menisculus</i>	0	0	0	6	8	7
<i>Navicula menisculoides</i>	8	4	6	0	0	0
<i>Navicula viridula</i>	0	0	0	12	0	6
<i>Ulnaria ulna</i>	0	12	6	0	0	0
<i>Cymbella spp</i>	4	4	4	0	0	0
<i>Eunotia naeglii</i>	0	0	0	0	8	4
<i>Navicula cryptotenella</i>	0	2	1	0	8	4
<i>Navicula lanceolata</i>	4	4	4	0	2	1
<i>Nitzschia palea</i>	0	0	0	8	0	4
<i>Eunotia incisa</i>	0	0	0	0	6	3
<i>Eunotia mucophila</i>	0	0	0	0	6	3
<i>Encyonema minutum</i>	4	0	2	0	0	0
<i>Fragilaria tenera</i>	0	0	0	0	4	2
<i>Gomphonema affine</i>	0	0	0	0	4	2
<i>Navicula erifuga</i>	0	0	0	0	4	2
<i>Navicula gregaria</i>	4	0	2	0	2	1

Taxon	Late Wet 2020			Late Wet 2021		
<i>Navicula leptostriata</i>	0	0	0	0	4	2
<i>Navicula recens</i>	4	0	2	0	0	0
<i>Nitzschia fonticola</i>	0	0	0	4	0	2
<i>Nitzschia inconspicua</i>	0	0	0	4	0	2
<i>Caloneis silicula</i>	0	2	1	0	0	0
<i>Craticula halophila</i>	2	0	1	0	0	0
<i>Diploneis parma</i>	2	0	1	0	0	0
<i>Epithemia gibba</i>	0	0	0	0	2	1
<i>Eunotia pectinalis</i>	0	0	0	0	2	1
<i>Gomphonema gracile</i>	0	0	0	0	2	1
<i>Karayevia clevei</i>	0	0	0	0	2	1
<i>Navicula spp</i>	0	0	0	2	0	1
<i>Navicula veneta</i>	0	0	0	2	0	1
<b>Total Abundance</b>	<b>420</b>	<b>386</b>	<b>403</b>	<b>68</b>	<b>484</b>	<b>276</b>
<b>DSIAR Score</b>	<b>59.1</b>	<b>66.3</b>	<b>62.7</b>		<b>63</b>	

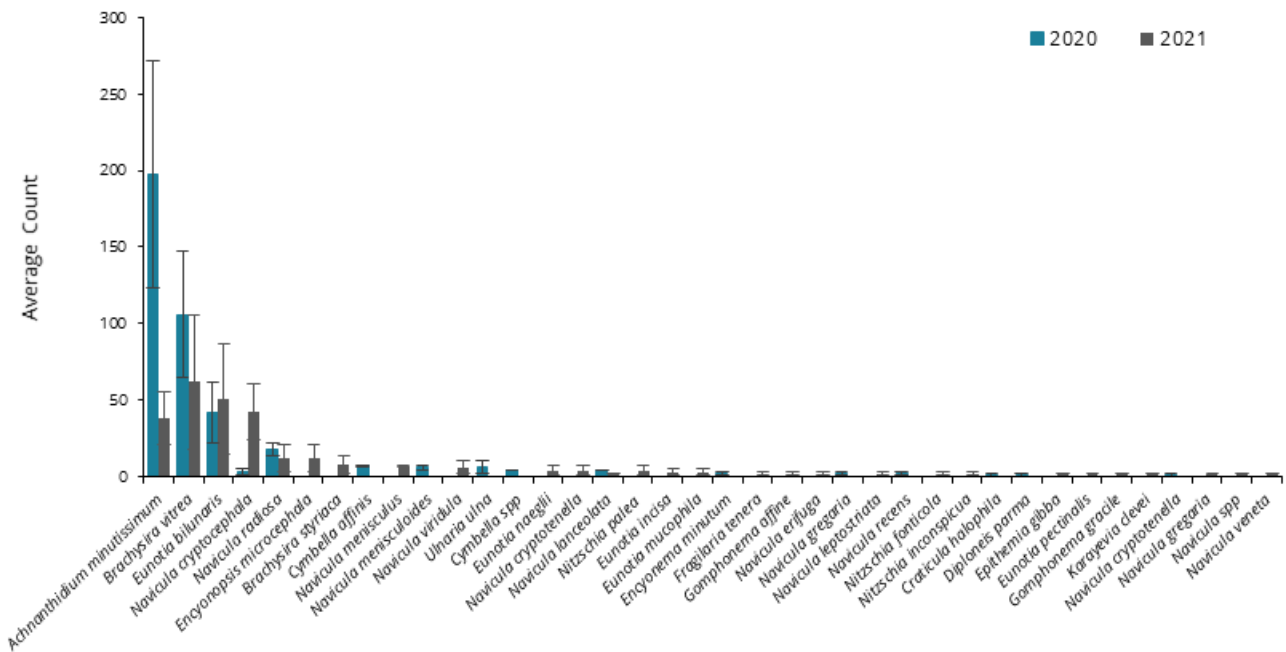


Figure 3-42. Mean abundance of diatom species recorded at Mundagoora Pool in the late wet season 2020, with error bars denoting 0.5±σ.

### 3.3.6.2 PHYTOPLANKTON

In the Late Dry 2020 and the Late Wet 2021, water samples were taken from Mundagoora Pool for phytoplankton taxonomy and abundance. Table 3-11 summarises the abundance of the phytoplankton taxon identified at Mundagoora Pool. Overall, 6 classes of phytoplankton with ~19 species were identified across both seasons indicating a high phytoplankton diversity. The most abundant Class were diatoms (Bacillariophyceae) for both seasons.

Table 3-11 Summary of phytoplankton analytical results for Mundagoora Pool sampled in late dry season (2020) and late wet season (2021), abundance (cells L<sup>-1</sup>) and percentage contribution (%), limit of reporting 10 cell L<sup>-1</sup>.

Taxon	Late Dry (2020)		Late Wet (2021)	
	Abundance	%	Abundance	%
<b>Bacillariophyceae</b>	<b>80300</b>	<b>76.11</b>	<b>70</b>	<b>63.64</b>
<i>Achnantheidium sp.</i>	35200	33.36	10	9.09
<i>Amphora spp.</i>	0	0	10	9.09
<i>Cocconeis spp.</i>	700	0.66	0	0
<i>Cymbella spp.</i>	300	0.28	0	0
<i>Lyrella spp</i>	100	0.09	0	0
<i>Navicula spp.</i>	19600	18.58	0	0
<i>Navicula spp.</i>	19600	18.58	40	36.36
<i>Nitzschia spp.</i>	100	0.09	0	0
<i>Pinnularia spp.</i>	200	0.19	0	0
<i>Synedra spp. (O)</i>	4500	4.27	10	9.09
<b>Chlorophyceae</b>	<b>900</b>	<b>0.85</b>	<b>40</b>	<b>36.36</b>
<i>Mougeotia sp.</i>	0	0	40	36.36
<b>Cryptophyceae</b>	<b>8800</b>	<b>8.34</b>	<b>0</b>	<b>0</b>
<i>Chroomonas spp.</i>	800	0.76	0	0
<i>Cryptomonas spp. (O)</i>	8000	7.58	0	0
<b>Cyanobacteria</b>	<b>8200</b>	<b>7.77</b>	<b>0</b>	<b>0</b>
<i>Pseudoanabaena spp. (O) (PT)</i>	8200	7.77	0	0
<b>Dinophyceae</b>	<b>7200</b>	<b>6.82</b>	<b>0</b>	<b>0</b>
<i>Gomphonema spp.</i>	500	0.47	0	0
<i>Gonyaulax spp.</i>	800	0.76	0	0
<i>Gymnodinium spp.</i>	1400	1.33	0	0
<i>Peridinium spp. (O)</i>	4500	4.27	0	0
<b>Euglenophyceae</b>	<b>100</b>	<b>0.09</b>	<b>0</b>	<b>0</b>
<i>Euglena spp. (O)</i>	100	0.09	0	0

### 3.3.7 MACROPHYTES

Table 3-12 presents the macrophyte species and qualitative abundance during the three season surveys at Mundagoora Pool. The key findings were as follows:

- A total of 5 macrophyte species were recorded and show a range of emergent (bulrush and sedges) and submerged (charophyte and ribbon weed) types.
- Emergent macrophytes were the dominant edge habitat, occurring in wide dense beds along the pools edge except for along the upstream eastern rockface. Submerged macrophytes occurred in scattered abundance on the bed.
- There were no significant changes noted for macrophyte presence, abundance or health over the three survey periods. There was a decrease in the abundance of emergent macrophytes in the Late Wet 2021 compared to the Late Wet 2020, though no changes were substantial enough to alter the categorical abundance classification.

Table 3-12 Macrophytes present at Mundagoora Pool

Common name	Species name	Late Wet 2020 Abundance <sup>1</sup>	Late Dry 2020 Abundance <sup>1</sup>	Late Wet 2021 Abundance <sup>1</sup>
Ribbon weed	<i>Vallisneria sp.</i>	Abundant	Abundant	Abundant
Charophytes	<i>Nitella sp., Chara sp.</i>	Isolated	Isolated	Isolated
Clubrush	<i>Schoenoplectus sp.</i>	Abundant	Abundant	Abundant
Sedges	Cyperaceae	Isolated	Isolated	Isolated
Bulrush	<i>Typha sp.</i>	Abundant	Abundant	Abundant

<sup>1</sup> Abundance based on *Western Australia AUSRIVAS field sampling sheet* (DoW, 2009).

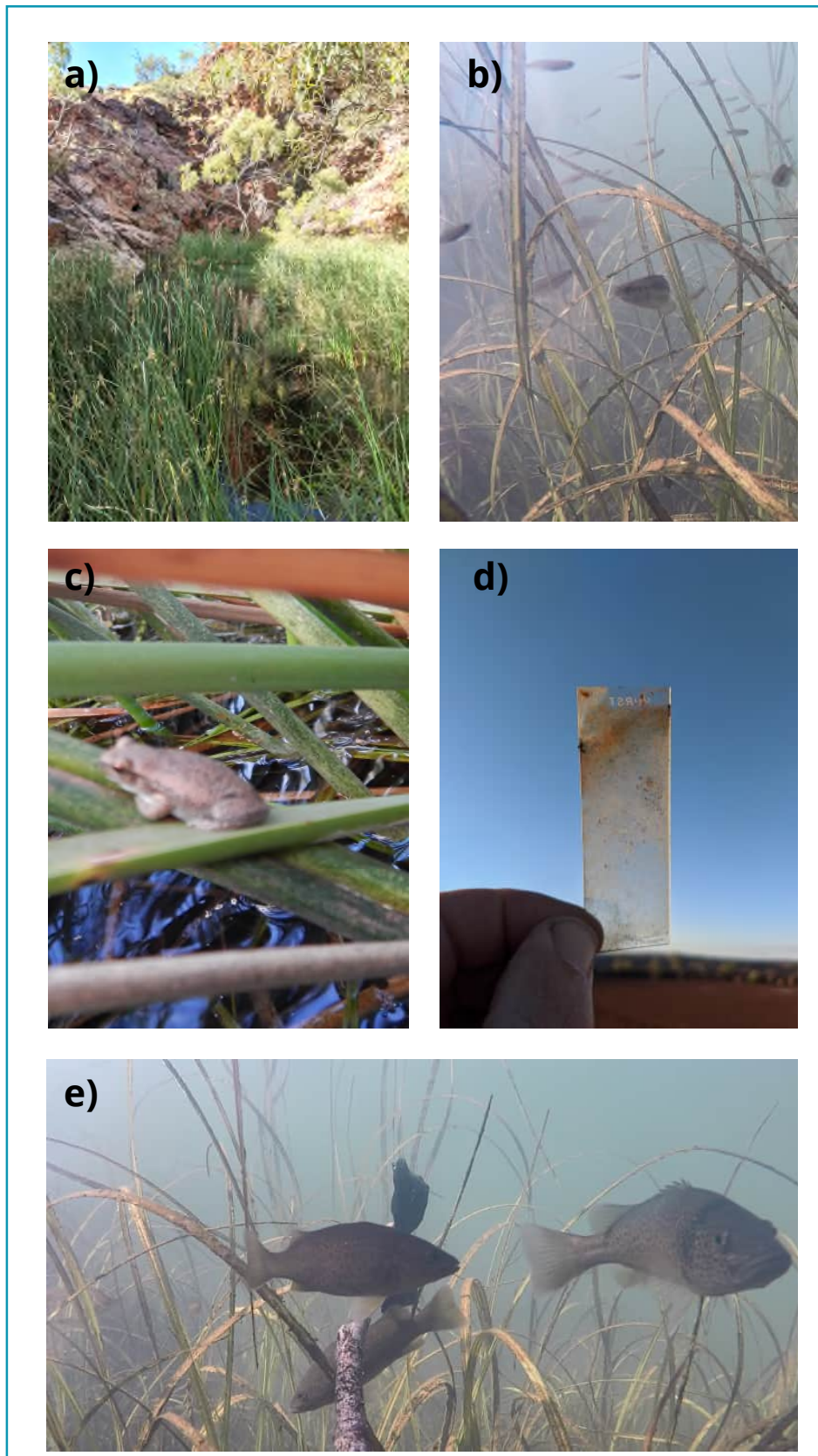


Figure 3-43 Mundagoora Pool aquatic ecology. a) emergent macrophytes forms beds at the edge of the pools; b) submerged macrophytes create important habitat for an abundance of *M. australis* and *L. unicolor*; c) frog (*Littoria rubella*) utilising the macrophyte habitat; d) abundant diatom growth on slide; e) adult *L. unicolor* observed in abundance using underwater video.

### 3.4 CENTRAL CREEK POOL (IB\_SW\_POOL\_Central Ck)

Central Creek Pool is a shallow pool that lies on deep alluvial sediments on Cockatoo Creek, which experiences high flows in the wet season. The pool is predominantly sustained by surface/hyporheic water and consequently undergoes high rates of evapo-concentration and has minimal established macrophyte habitat. The water quality is relatively turbid in comparison to other North Star pools and there is evidence of cattle visitation.

In the Late Dry 2020, samples were not obtained from Central Creek as the site was dry.



Figure 3-44 Central Creek is a shallow pool on Cockatoo Creek that experiences substantial evapo-concentration and is likely a temporary pool.

#### 3.4.1 WATER QUALITY AND HYDROLOGY

Central Creek Pool has a catchment area of 85.1 km<sup>2</sup>, draining to Cockatoo Creek and the Turner River (Figure 3-45). The surface water level logger was installed in Central Creek Pool during the Late Wet 2020 sampling round and as such there is no direct hydrology data available for the previous wet season. However, there was a logger installed on the same creek system approximately 550 m downstream in a similar pool (MAR Cockatoo Creek; Figure 3-47) and it is considered that this represents a reasonable analogue for the hydrology of Central Creek Pool. The logger data for May 2020 to June 2021 at Central Creek Pool is provided in Figure 3-47. Central Creek Pool shows a typical Pilbara creek flooding profile driven by alluvial (hyporheic) flows. There is an initial peak water level during high-rainfall events with a longer “tail” to the peak as water levels recede, driven by discharge from upper catchment alluvial storage and groundwater. Once recharged after the first flush event, the pool water levels are maintained over the

wet season, receding slowly as the alluvials dry out over the early dry season. It can be seen from Figure 3-47 that Central Creek Pool was dry by July 2020 and filled again with a major rainfall event on the 10<sup>th</sup> December 2020. The rate of recedance between flood events appears to lower as the wet season progresses, potentially in response to increase groundwater inflows to the hyporheic system of the creek.

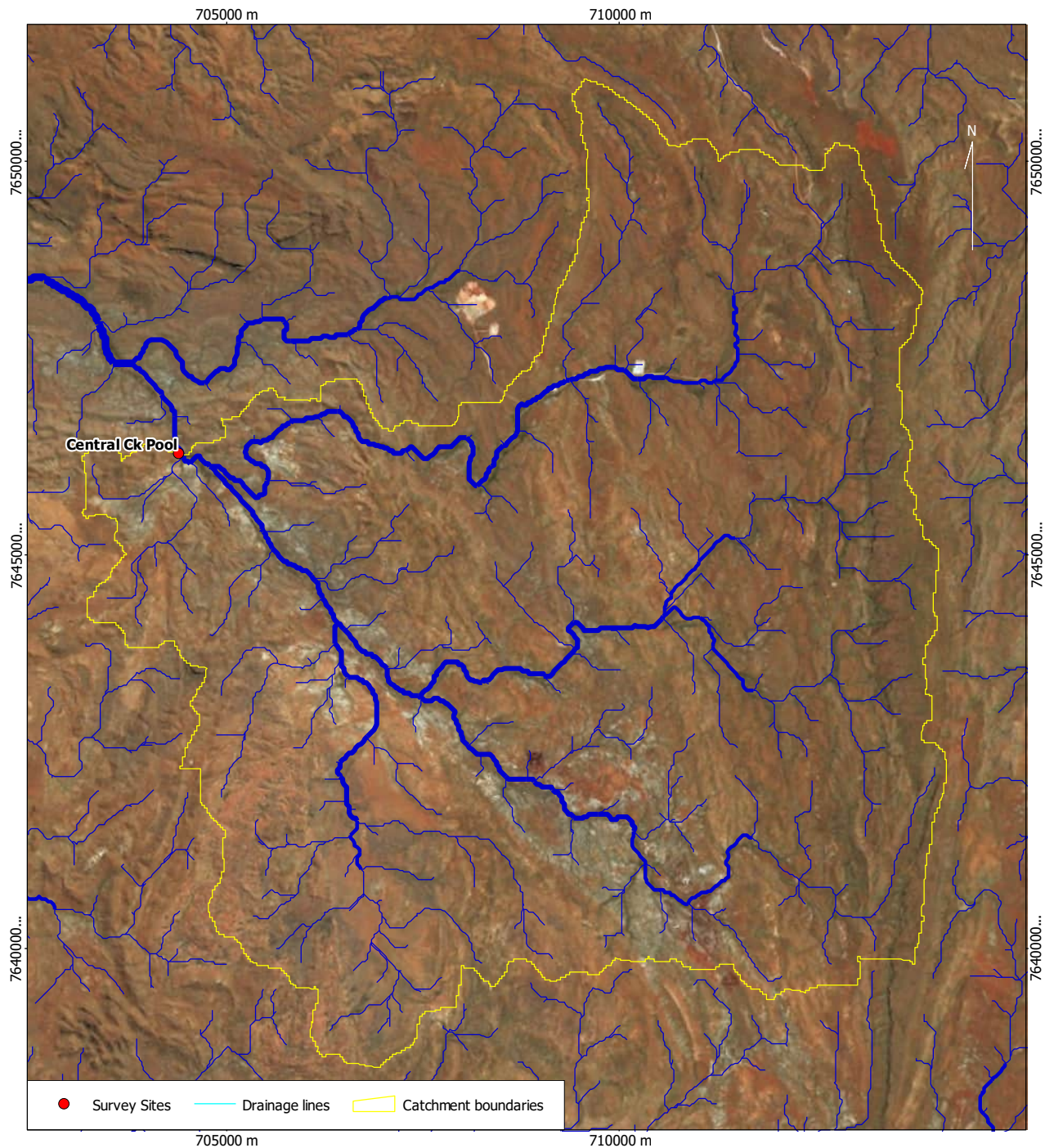
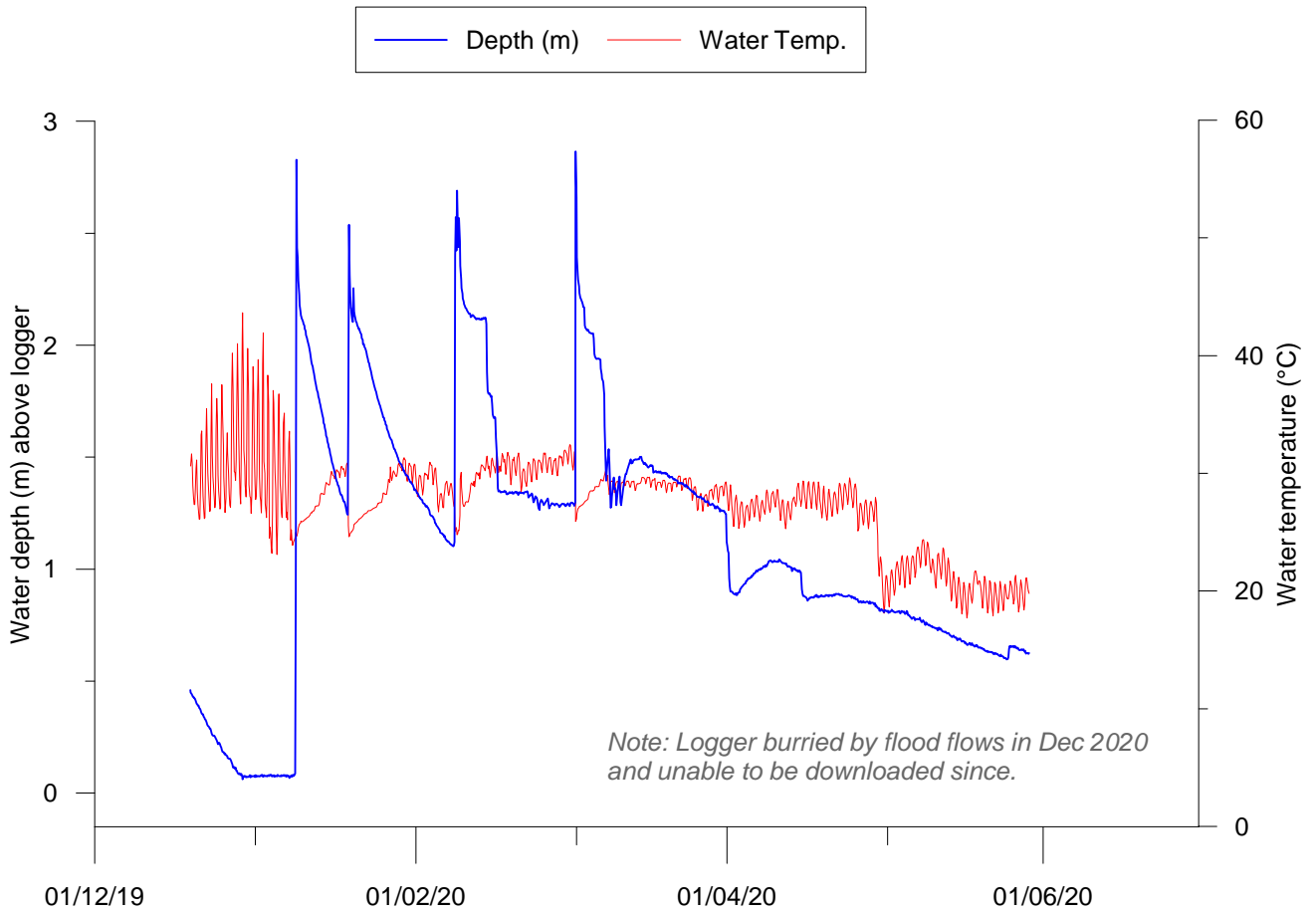


Figure 3-45 Central Creek Pool catchment area (85.1 km<sup>2</sup>)

MAR Cockatoo Creek - Depth and temperature logger  
(19 Dec 2019 - 29 May 2020)



Weather observations - Iron Bridge Weather Station

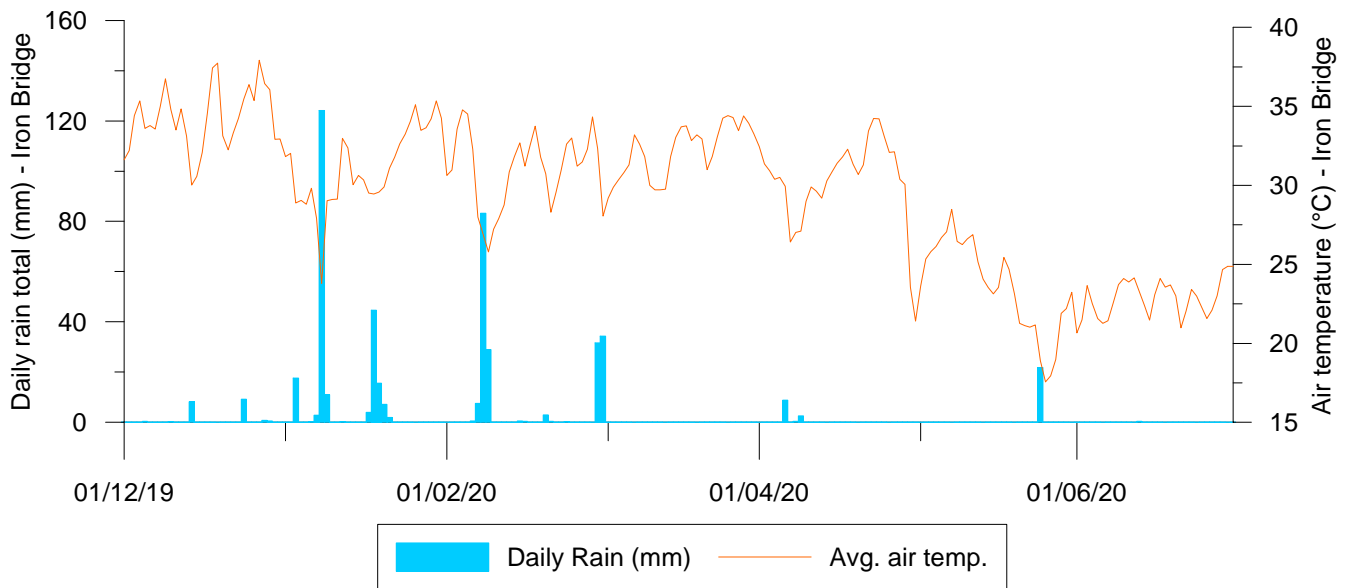


Figure 3-46 MAR Cockatoo Creek - water level logger data - Dec 2019 to June 2020

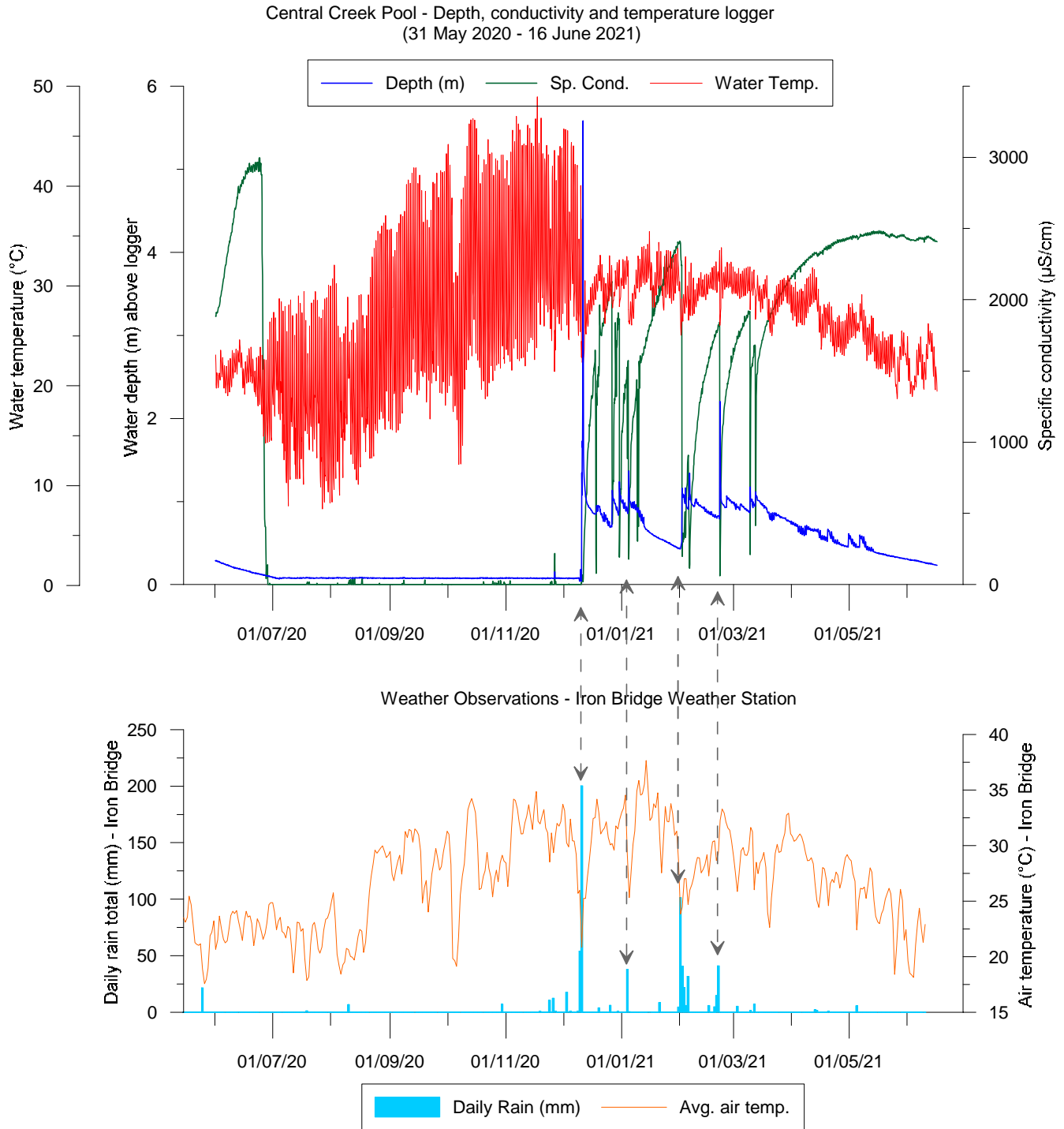


Figure 3-47 Central Creek Pool water level and temperature logger data – Late Wet 2020 – mid Dry 2021

Central Creek Pool displayed brackish salinity (2227  $\mu\text{S}/\text{cm}$  conductivity) during the Late Wet 2020, likely representing evapo-concentration effects since the last major flushing event occurred in March 2020. Water quality was representative of typical Pilbara streams with near-neutral pH (7.69), low-moderate turbidity (2.54 NTU) and moderate oxygenation (92% saturation). Alkalinity was moderate-high at 406 mg/L (as  $\text{CaCO}_3$ ) with major ions dominated by sodium chloride (Figure 3-48). Note that Figure 3-48 also shows the MAR Cockatoo Creek results for the Late Dry 2020 as these were opportunistically obtained following the large (200 mm) rainfall event on the 10<sup>th</sup> December 2020 (see Figure 3-47). The MAR Cockatoo Creek site is 550 m downstream of Central Creek Pool on the same reach.

Dissolved arsenic levels were potentially at, or exceeding, the ANZG (2018) 99 or 95% Ecosystem Protection Levels (EPLs) at 13  $\mu\text{g}/\text{L}$  however, the results represent non-specified arsenic while the guidelines are for individual inorganic species of arsenic (III and V). No other metals or metalloids were above guideline levels.

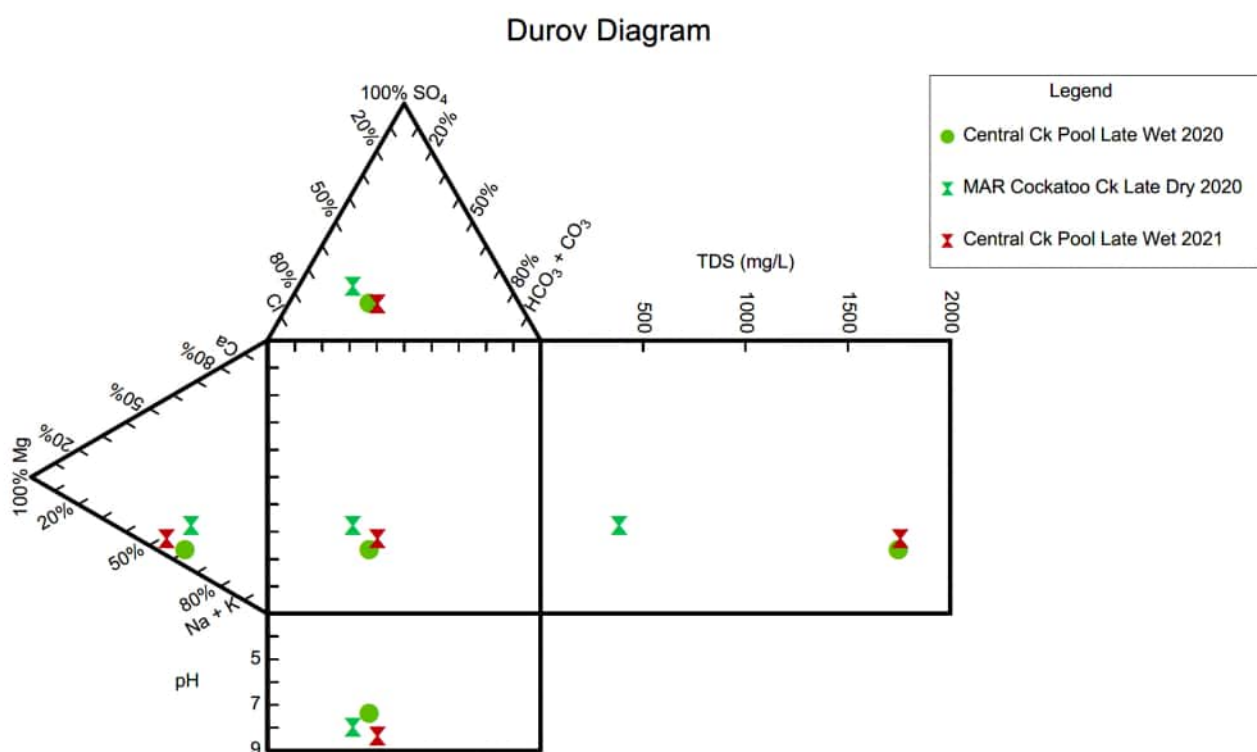


Figure 3-48 Durov diagram showing the Central Creek Pool major ion distribution.

### 3.4.2 SEDIMENT QUALITY

Table 3-13 provides the surface sediment quality at Central Creek Pool during the Late Wet 2020 and Late Wet 2021. Metal and metalloid concentrations were assessed against the ANZG (2018) DGVs. Chromium concentration (219-247 mg/kg) exceeded the DGV but not the GV-high. Nickel concentration (112-113 mg/kg) exceed both the DGV and GV-high. However, both chromium and nickel naturally occur in high concentrations across the Project area.

Table 3-13. Summary of sediment quality analyses for Central Creek for the late wet seasons (2020 and 2021), no analysis recorded for late dry season (2020) due to the site being dry. Bolded values denote results above the limit of reporting.

Analyte grouping/Analyte	Unit	Late Wet (2020)	Late Wet (2021)
Total Soluble Salts	mg/kg	<b>1,180</b>	<b>559</b>
Moisture Content (Dried @ 105-110°C)	%	<b>29.8</b>	<b>19.1</b>
Total Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>120</b>	<5
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>120</b>	<b>198</b>
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<1	<b>198</b>
Acidity	mg/kg	<b>4</b>	<5
Sulfate as SO <sub>4</sub> <sup>2-</sup> (soluble sulfate by ICPAES)	mg/kg	<b>200</b>	<b>40</b>
Chloride (by Discrete Analyser)	mg/kg	<b>170</b>	<b>90</b>
Calcium	mg/kg	<b>40</b>	<10
Magnesium	mg/kg	<b>70</b>	<b>40</b>
Sodium	mg/kg	<b>220</b>	<b>10</b>
Potassium	mg/kg	<b>20</b>	<10
Mercury (FIMS)	mg/kg	<0.1	<0.1
Nitrite + Nitrate as N (Sol.)	mg/kg	<0.1	<0.1
Total Kjeldahl Nitrogen as N	mg/kg	<b>1,090</b>	<b>80</b>
Total Nitrogen as N	mg/kg	<b>1,090</b>	<b>80</b>
Total Phosphorus as P	mg/kg	<b>100</b>	<b>43</b>
Reactive Phosphorus as P	mg/kg	<0.1	<0.1
Total Organic Carbon	%	<b>1.80</b>	<b>0.18</b>
<b>Total Metals by ICP-AES</b>			
Arsenic	mg/kg	<b>9</b>	<b>10</b>
Barium	mg/kg	<b>40</b>	<b>30</b>
Beryllium	mg/kg	<1	<1
Boron	mg/kg	<50	<50
Cadmium	mg/kg	<1	<1
Chromium	mg/kg	<b>219</b>	<b>247</b>
Cobalt	mg/kg	<b>16</b>	<b>18</b>
Copper	mg/kg	<b>22</b>	<b>17</b>
Iron	mg/kg	<b>26,600</b>	<b>30,600</b>
Lead	mg/kg	<5	<5
Manganese	mg/kg	<b>476</b>	<b>492</b>

Analyte grouping/Analyte	Unit	Late Wet (2020)	Late Wet (2021)
Nickel	mg/kg	<b>112</b>	<b>113</b>
Selenium	mg/kg	<5	<5
Vanadium	mg/kg	<b>39</b>	<b>36</b>
Zinc	mg/kg	<b>35</b>	<b>20</b>

### 3.4.3 FISH

Fish were present at Central Creek Pool during both wet season surveys and were not present in the dry season due to the pool being dry. Two fish species were present during both wet season surveys: *M. australis* and *L. unicolor*. Both species were observed roughly equal abundance in 2020 and considerably higher numbers of *M. australis* (n = 266) were observed in 2021.

Table 3-14 presents the fish species, catch and size distribution. The two fish species present, *M. australis* and *L. unicolor*, occurred at similarly high abundances for the size of the pool. The high abundance is likely a function of the high catchability due to evaporation reducing the pool habitat and thereby increasing fish density, rather than the pool providing a preferred habitat. The high interest in bait during the BRUVs survey may indicate low food resources in the pool.

For both seasons, the size distribution of *M. australis* was similar, with the SL size ranging from Figure 3-49 displays the size-frequency for *M. australis*, notably most fish were recorded in the 30 – 60 mm size class. Only one *M. australis* individual in the <30 mm size category was observed for both seasons, indicating minimal juvenile abundance in this site. However, due to Central Creek being dry over the late dry season and similar abundances of fish in both wet seasons, breeding and recruitment likely occur in nearby water bodies that seasonally open to Central Creek.

The size range for *L. unicolor* was generally larger in the Late Wet 2020 (subsamped range SL: 32 - 174 mm) than in the Late Wet 2021 (subsamped range SL: 39 - 110 mm), with a higher frequency of juveniles present in the Late Wet 2021 (Figure 3-50). The large proportion of *L. unicolor* individuals observed in the 30 – 60 mm size class indicates a notable juvenile presence in Central Creek in both years (Figure 3-50). *Leiopotherapon unicolor* displays rapid growth in the juvenile stage, attaining a length of ~25 mm TL in under 60 days (Llewellyn, 1973). Although very young juveniles (<30 mm) were not observed during each survey, most *L. unicolor* caught were between 30 – 60 mm, indicating spawning around 2 to 3 months before the survey. Most *L. unicolor* present at Central Creek are not sexually mature, as length at maturity is typically above 60 mm TL (Llewellyn, 1973).

Table 3-14. Fish species, size class (SL, mm), total catch number and CPUE for Central Creek surveyed in late wet seasons in 2020 and 2021.

Species	Size class (mm)	Late Wet 2020 Fish Count	Late Wet 2020 CPUE <sup>1</sup>	Late Wet 2021 Fish Count	Late Wet 2021 CPUE <sup>1</sup>
<b><i>Melanotaenia australis</i></b>		<b>188</b>	<b>9.8</b>	<b>266</b>	<b>14</b>
	0 – 30	1		1	
	30 – 60	128		237	
	60 – 90	590		28	
	> 90	0		0	
<b><i>Leiopotherapon unicolor</i></b>		<b>214</b>	<b>11.2</b>	<b>111</b>	<b>5.8</b>
	30 - 60	110		79	
	60 - 90	55		19	
	> 90	49		13	
<b>Total</b>		<b>402</b>	<b>21.1</b>	<b>377</b>	<b>19.8</b>

1 CPUE is catch per unit effort, a measure of relative abundance. Effort is fyke net set for 19 hours.

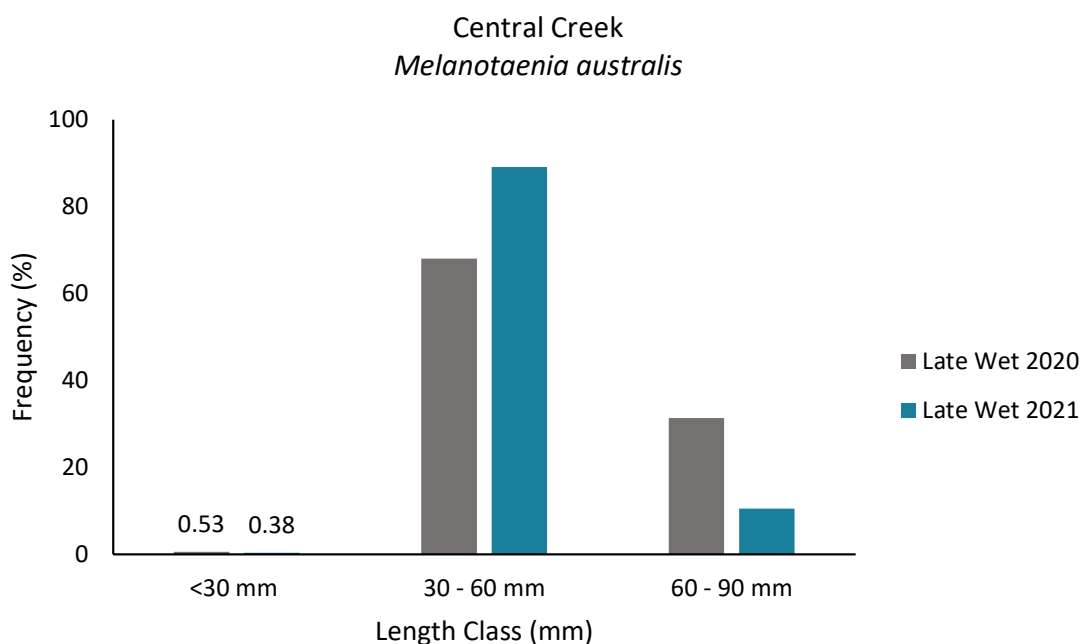


Figure 3-49. Frequency (%) of occurrence of each length class (SL, mm) *M. australis* sampled from Central Creek in the Late Wet 2020 and Late Wet 2021.

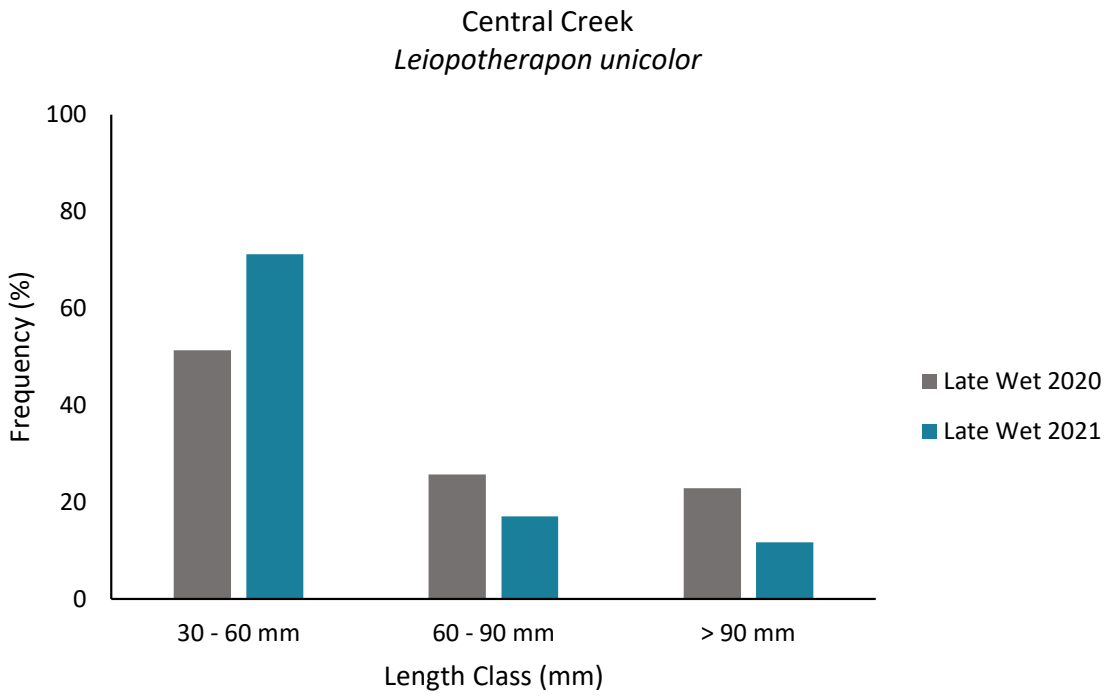


Figure 3-50 Frequency (%) of occurrence of each length class (SL, mm) for *L. unicolor* sampled from Central Creek in the Late Wet 2020 and Late Wet 2021

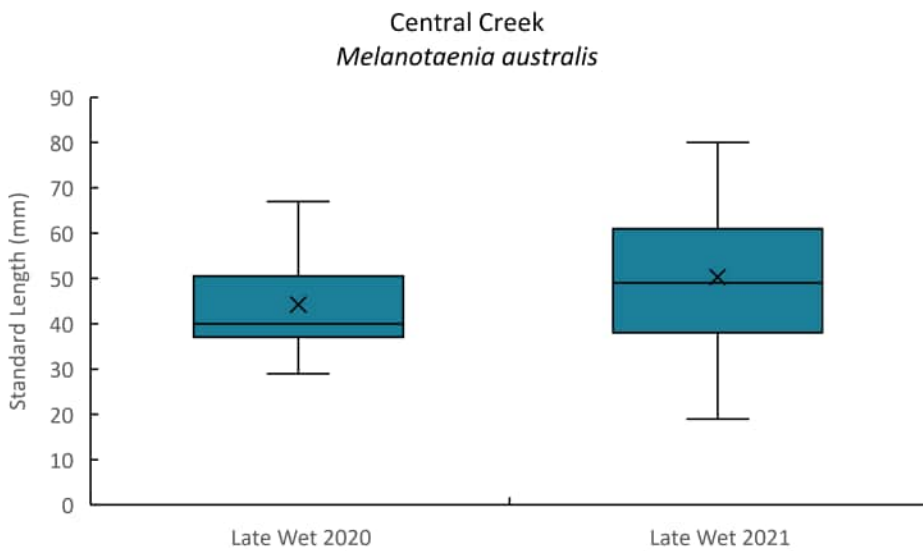


Figure 3-51 Distribution of standard length (SL, mm) of *Melanotaenia australis* sampled from Central Creek in the late wet season in 2020 (June) and 2021 (May)

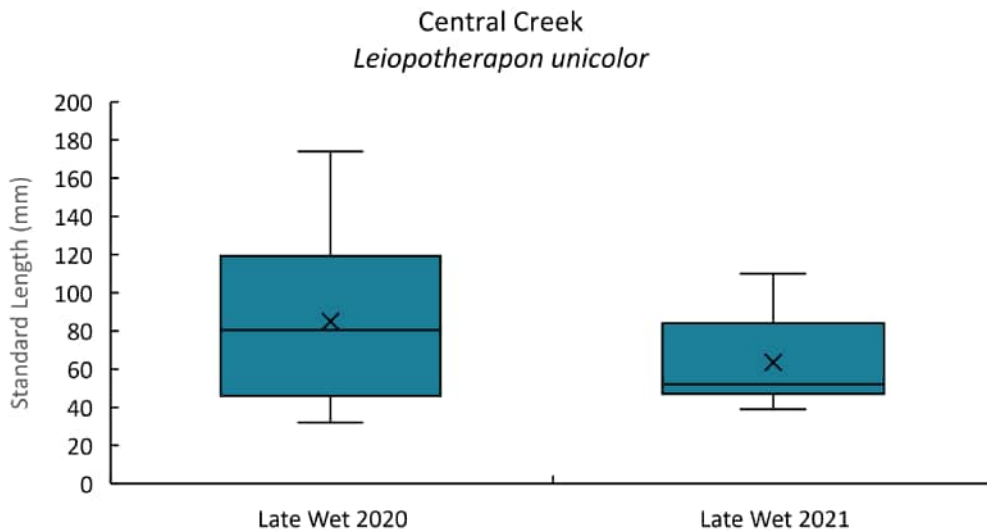


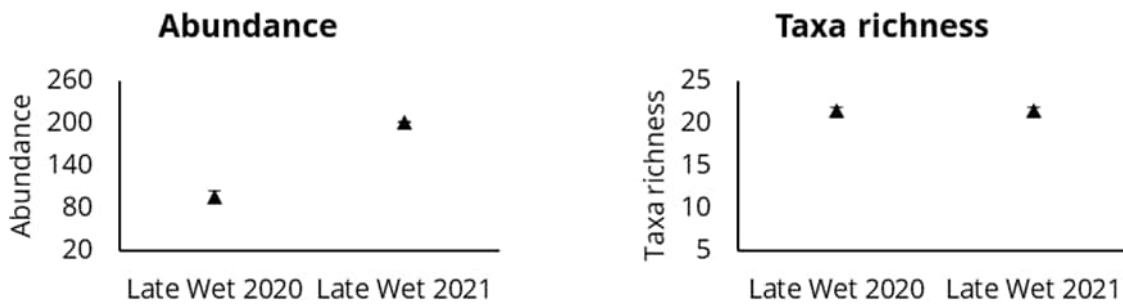
Figure 3-52 Distribution of standard length (SL, mm) of *Leiopotherapon unicolor* sampled from Central Creek in the late wet season in 2020 (June) and 2021 (May)

### 3.4.4 AQUATIC MACROINVERTEBRATES

Figure 3-53 presents the total abundance, taxa richness, EPT richness and SIGNAL2 scores for the Late Wet seasons of 2020 and 2021. No data is available for the Late Dry 2020 season due to the pool being dry. The key findings from both wet seasons were as follows:

- Average abundance of macroinvertebrates doubled from 96 in the Late Wet season of 2020 to 202 in the corresponding season in 2021 (Figure 3-53a).
- Similarly, PET richness also increased from 3 to 4.5 between seasons of 2020 and 2021 (Figure 3-53c), with a total of five families recorded from the Plecoptera and Trichoptera orders.
- In contrast, taxa richness (21.5) and SIGNAL2 (3.08-3.38) scores were consistent between the Late Wet seasons (Figure 3-53b, d), indicating that Central Creek Pool can maintain a relatively stable macroinvertebrate community in the wet seasons despite its ephemeral presence.
- A low SIGNAL2 score (SIGNAL2 grade = 3) indicates predominantly tolerant taxa were collected and the system experiences associated environmental stress (Chessman, 2003).

Many macroinvertebrate taxa were much more abundant in the Late Dry 2021 season than the previous Late Dry season, such as mayflies of the Baetidae and Caenidae, waterboatman of the Micronectidae, and the non-biting midge belonging to s-f Tanypodinae. In comparison, the backswimmer Pleidae, the diving beetle Dytiscidae and damselflies of the Coenagrionidae were more abundant in the Late Wet season of 2020. The increased abundances of macroinvertebrates in Late Wet 2021 after a period of desiccation suggest that the community is well adapted to this drying pattern. For example, chironomids are recognised to burrow deeper into the sediments when pools dry out and can also enter a period of aestivation (i.e. dormancy during dry periods; Jones 1997, Frouz et al. 2003). The relative abundance of taxa is also a function of pond permanence, with chironomids seen in high abundances when ponds have been recently established (Brooks 2000). As the mayflies Baetidae and Caenidae belong to the sensitive order Ephemeroptera, their presence in the Late Wet season of 2021 may suggest that the environmental quality of Central Creek Pool was apparently better during this period (Menetrey et al. 2007).



a) Total abundance at Central Creek Pool

b) Taxonomic richness at Central Creek Pool



c) EPT richness at Central Creek Pool

d) SIGNAL2 scores at Central Creek Pool

Figure 3-53 Macroinvertebrate indices for Central Creek Pool – Late Wet 2020 and Late Wet 2021.

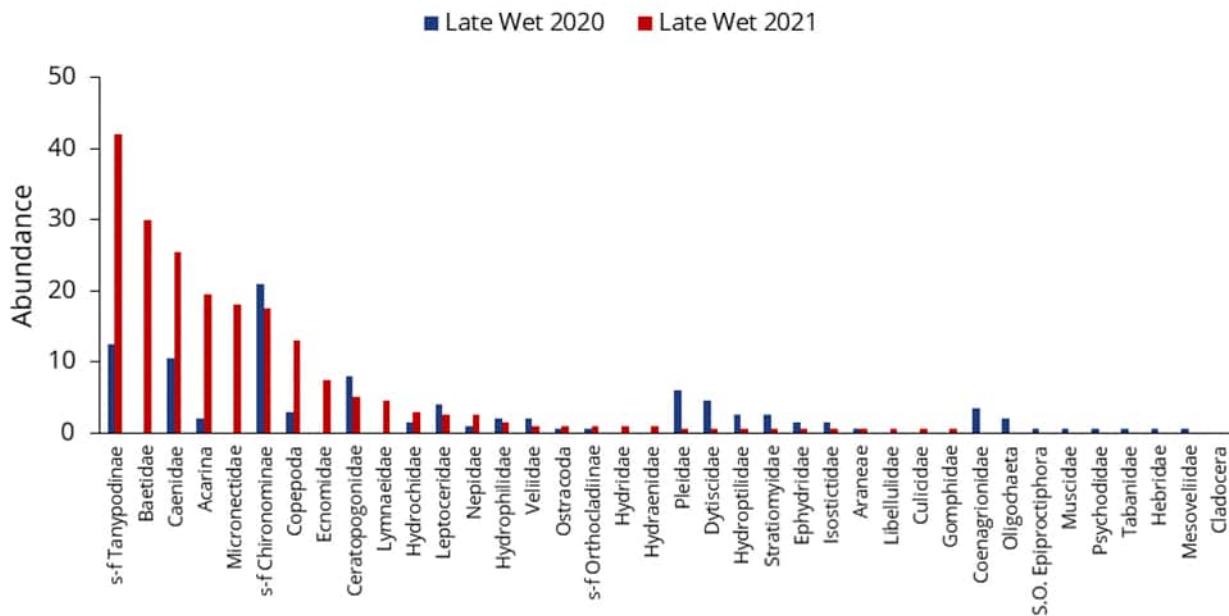


Figure 3-54 Average abundances of all macroinvertebrate taxa at Central Creek Pool in the Late Wet season of 2021 and the Late Wet and Late Dry season of 2020, with taxa arranged from most abundant (left) to least abundant (right) along the x-axis.

### 3.4.5 PHYTOPLANKTON & DIATOMS

#### 3.4.5.1 DIATOMS

Table 3-15 presents the Late Wet 2020 and Late Wet 2021 diatom species present, abundance, and biotic indices at Central Creek Pool. Figure 3-55 shows the average count by diatom species present. No diatom data was collected in the Late Dry 2020 due to the pool being dry.

High taxonomic diversity of diatoms was observed for both seasons at Central Creek. A total of 41 species were observed at Central Creek ranging across a large number of families, with the Late Wet 2021 season recording slightly higher taxonomic diversity with 33 species compared with Late Wet 2020 which recorded 27 diatom species. The majority of diatoms species observed in Central Creek were recorded in both seasons with only 14 species (~34% of total species) only observed in one season.

High average abundance was observed both seasons, with Late Wet 2021 recording a higher average abundance of 433. *Achnantheidium exiguum* (average count = 258) was the most abundant species in Late Wet 2020. The second most abundant diatom species in 2020, *Nitzschia palea*, occurred at a substantially lower abundance (average count = 28). The Late Wet 2021 season was dominated by *Pleurosigma elongatum* (average count = 116), followed by *Navicula menisculus* (average count = 85).

The tolerance to environmental stress is reflected in the low DSIAR scores for both 2020 and 2021 (42.0 and 36.5, respectively), which indicates the pool is dominated by species tolerant to degraded water quality. While the DSIAR score is low, no teratological forms were detected and the diversity of species is relatively high for North Star pools. The low presence or abundance of species associated with higher water quality likely reflects the environmental stress resulting from nutrient pollution from cattle visitation and declining water quality due to high evapo-concentration.

Table 3-15 Summary of Diatom species abundance (total count per species), average abundance and DSIAR score for Central Creek in the Late Wet 2020 and 2021.

Taxon name	Late Wet 2020			Late Wet 2021		
	Replicate 1	Replicate 2	Average	Replicate 1	Replicate 2	Average
<i>Achnantheidium exiguum</i>	246	270	258	88	0	44
<i>Pleurosigma elongatum</i>	28	0	14	118	114	116
<i>Navicula menisculus</i>	0	4	2	74	96	85
<i>Nitzschia palea</i>	40	16	28	44	38	41
<i>Diploneis parma</i>	6	2	4	46	16	31
<i>Achnantheidium minutissimum</i>	22	12	17	0	46	23
<i>Nitzschia frustulum</i>	10	8	9	14	12	13
<i>Achnanthes subexigua</i>	0	0	0	6	14	10
<i>Epithemia gibba</i>	0	0	0	0	18	9
<i>Navicula veneta</i>	12	6	9	0	0	0
<i>Nitzschia paleaceae</i>	0	0	0	10	8	9

Taxon name	Late Wet 2020			Late Wet 2021		
<i>Nitzschia lacuum</i>	8	4	6	8	4	6
<i>Nitzschia linearis</i>	0	0	0	4	4	4
<i>Nitzschia inconspicua</i>	0	6	3	0	0	0
<i>Brachysira vitrea</i>	0	0	0	0	4	2
<i>Eunotia bilunaris</i>	4	0	2	0	0	0
<i>Eunotia minor</i>	0	0	0	0	4	2
<i>Gomphonema minutum</i>	0	0	0	0	4	2
<i>Hantzschia amphioxys</i>	0	4	2	2	0	1
<i>Nitzschia filiformis</i>	0	0	0	4	0	2
<i>Nitzschia fonticola</i>	0	0	0	0	4	2
<i>Nitzschia graciliformis</i>	4	0	2	2	0	1
<i>Nitzschia microcephala</i>	0	4	2	0	0	0
<i>Pinnularia spp.</i>	0	4	2	0	0	0
<i>Ulnaria ulna</i>	4	0	2	0	0	0
<i>Amphora libyca</i>	0	0	0	0	2	1
<i>Brachysira brebissonii</i>	0	2	1	0	0	0
<i>Cymbella affinis</i>	0	0	0	0	2	1
<i>Cymbella spp</i>	0	2	1	0	0	0
<i>Diploneis smithii</i>	0	0	0	0	2	1
<i>Eolimna minima</i>	2	0	1	0	0	0
<i>Eunotia exigua</i>	0	0	0	0	2	1
<i>Fragilaria spp.</i>	2	0	1	0	0	0
<i>Haslea duerrenbergiana</i>	0	0	0	2	0	1
<i>Mastogloia smithii</i>	0	2	1	2	0	1
<i>Navicula lanceolata</i>	2	0	1	0	0	0
<i>Navicula phyllepta</i>	0	2	1	0	0	0

Taxon name	Late Wet 2020			Late Wet 2021		
<i>Navicula radiosa</i>	2	0	1	0	0	0
<i>Nitzschia gracilis</i>	2	0	1	0	0	0
<i>Nitzschia suchlandii</i>	0	2	1	0	0	0
<i>Pinnularia legumen</i>	0	2	1	0	0	0
<b>Total Abundance</b>	394	352	373	424	442	433
<b>DSIAR Score</b>	41.3	42.6	42	34	39	36.5

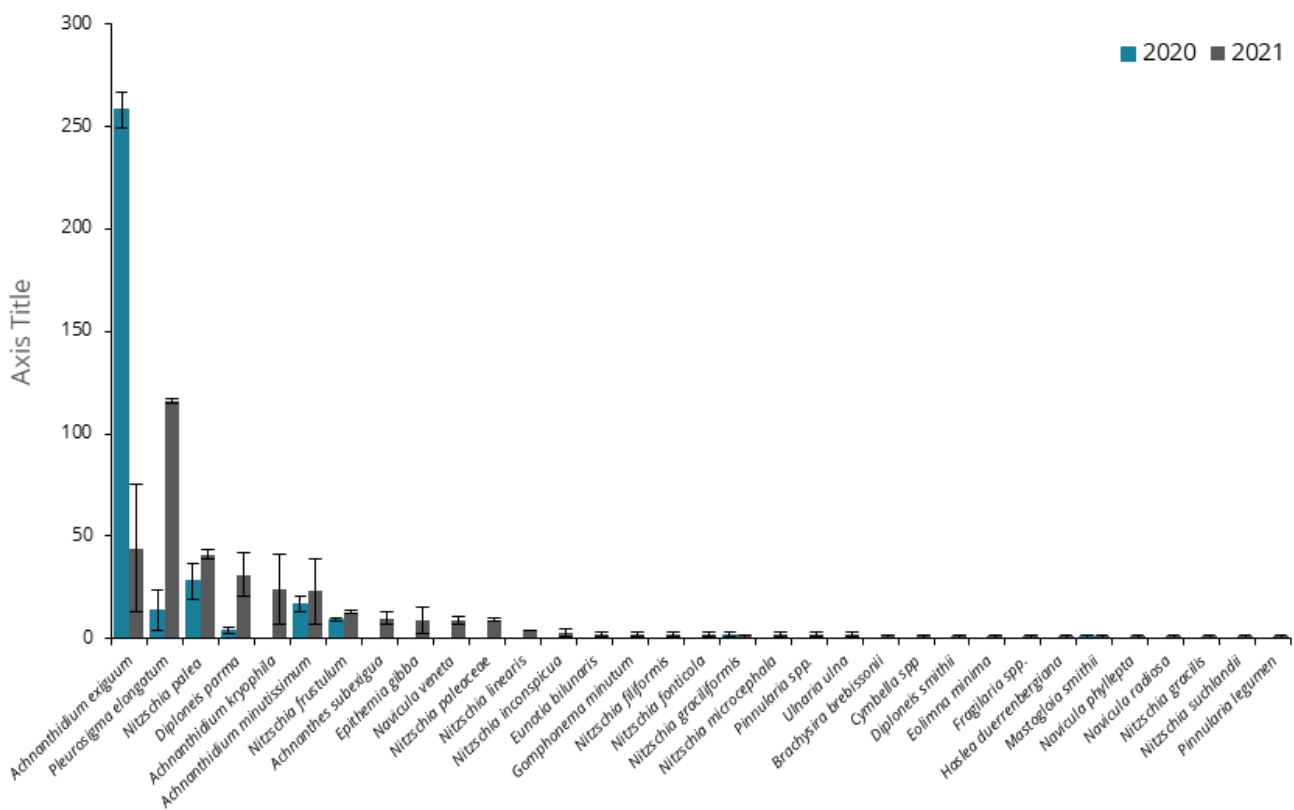


Figure 3-55 Average species abundance (diatom count per replicate) for diatoms sampled at Cental Creek in the Late Wet 2020 and 2021, with taxa arranged from most abundant (left) to least abundant (right) along the x-axis. Standard error (SE±0.5) denoted by error bars.

### 3.4.5.2 PHYTOPLANKTON

In the Late Wet 2021, a full phytoplankton profile for Central Creek was analysed. Overall, there were relatively low numbers of phytoplankton recorded for Central Creek, indicating relatively low

phytoplankton diversity. Two phytoplankton classes were identified; Diatoms (Bacillariophyceae) and Cryptophyceae. Diatoms were observed in considerably higher abundance than Cryptophyceae, and the recorded species in Late Wet 2021 are similar to those observed in Late Wet 2020. Therefore, while the relative phytoplankton biodiversity is low, the diversity within the Diatoms remains high across both wet seasons (Table 3-16).

Table 3-16 Summary of phytoplankton analytical results for Central Creek Pool sampled in late wet season (2021), abundance (cells L<sup>-1</sup>) and percentage contribution (%), limit of reporting 10 cell L<sup>-1</sup>. Central Creek Pool did not have phytoplankton samples taken in the late dry season (2020).

Taxon	Late Wet (2021)	
	Abundance	%
<b>Bacillariophyceae</b>	<b>460</b>	<b>93.88</b>
<i>Entomoneis sp.</i>	10	2.04
<b><i>Fragilaria sp. (O)</i></b>	10	2.04
<i>Microtabella spp.</i>	10	2.04
<i>Navicula spp.</i>	10	2.04
<i>Navicula spp.</i>	50	10.2
<i>Nitzschia spp.</i>	130	26.53
<b><i>Pleurosigma sp. (O)</i></b>	220	44.9
<i>Synedra spp. (O)</i>	10	2.04
<b>Cryptophyceae</b>	<b>30</b>	<b>6.12</b>
<i>Cryptomonas spp. (O)</i>	30	6.12

### 3.4.6 MACROPHYTES

There were very few and sparse macrophytes present at Central Creek Pool. These were represented by a small clump of emergent Clubrush reeds (*Schoenoplectus sp.*) and a few individual sedge (Cyperacea) plants on the southern side of the pool behind a protective in-stream boulder. Less than 1% of the pool area represented macrophyte habitat.

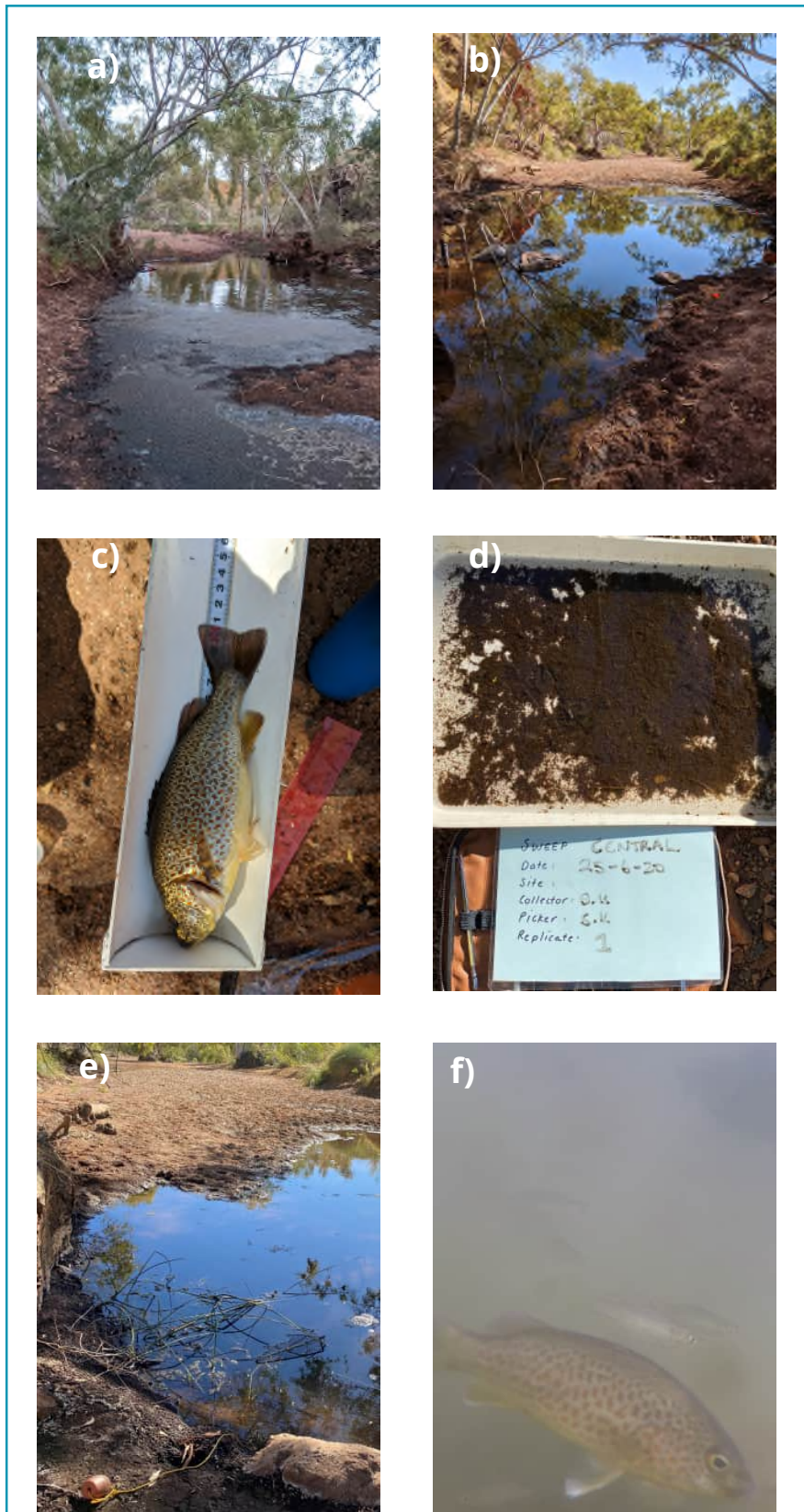


Figure 3-56 Central Creek Pool ecology. a) and b) the shallow pool over alluvial deposits lies on a wide creek bed; c) adult *L. unicolor* as well as juveniles were abundant; d) macroinvertebrates collected that utilise the sediment habitat; e) sparse macrophytes remain and will likely be absent by the late dry season; f) turbid waters may reduce visibility and provide a refuge from large fish predation and terrestrial predation.

### 3.5 COW SPRING POOL (IB\_SW\_POOL\_Cow Spring)

Cow Spring Pool is a small pool (~8 m by 4 m, average of 1 m depth) confined by bedrock habitat dominated by macrophytes and benthic algal cover. The pool is likely to be sustained by groundwater and has established macrophyte habitat and an abundance of *M. australis*, despite relatively acidic water quality.



Figure 3-57 Cow Spring Pool

#### 3.5.1 WATER QUALITY AND HYDROLOGY

Cow Spring has a small surface water catchment area of 0.15 km<sup>2</sup> (Figure 3-58), draining a single ridgeline to the west. The pool is shaded by the adjacent rockface and forms a micro-climate area with dense melaleuca woodland covering the pool and the downstream drainage line for approximately 50m. Figure 3-59 displays a high-resolution water level, salinity (conductivity) and temperature logger record from Mundagoora Pool for the late dry season 2020 to late wet season 2021.

Cow Spring Pool is very clear (<1 NTU turbidity), low pH (5.72), fresh (456 µS/cm conductivity) and slightly acidic (10 mg/L as CaCO<sub>3</sub>). It has a mixed balance major ion distribution that is not dominated by any

particular ions (Figure 3-60). No metals or metalloids exceeded the ANZG (2018) default water quality guidelines.

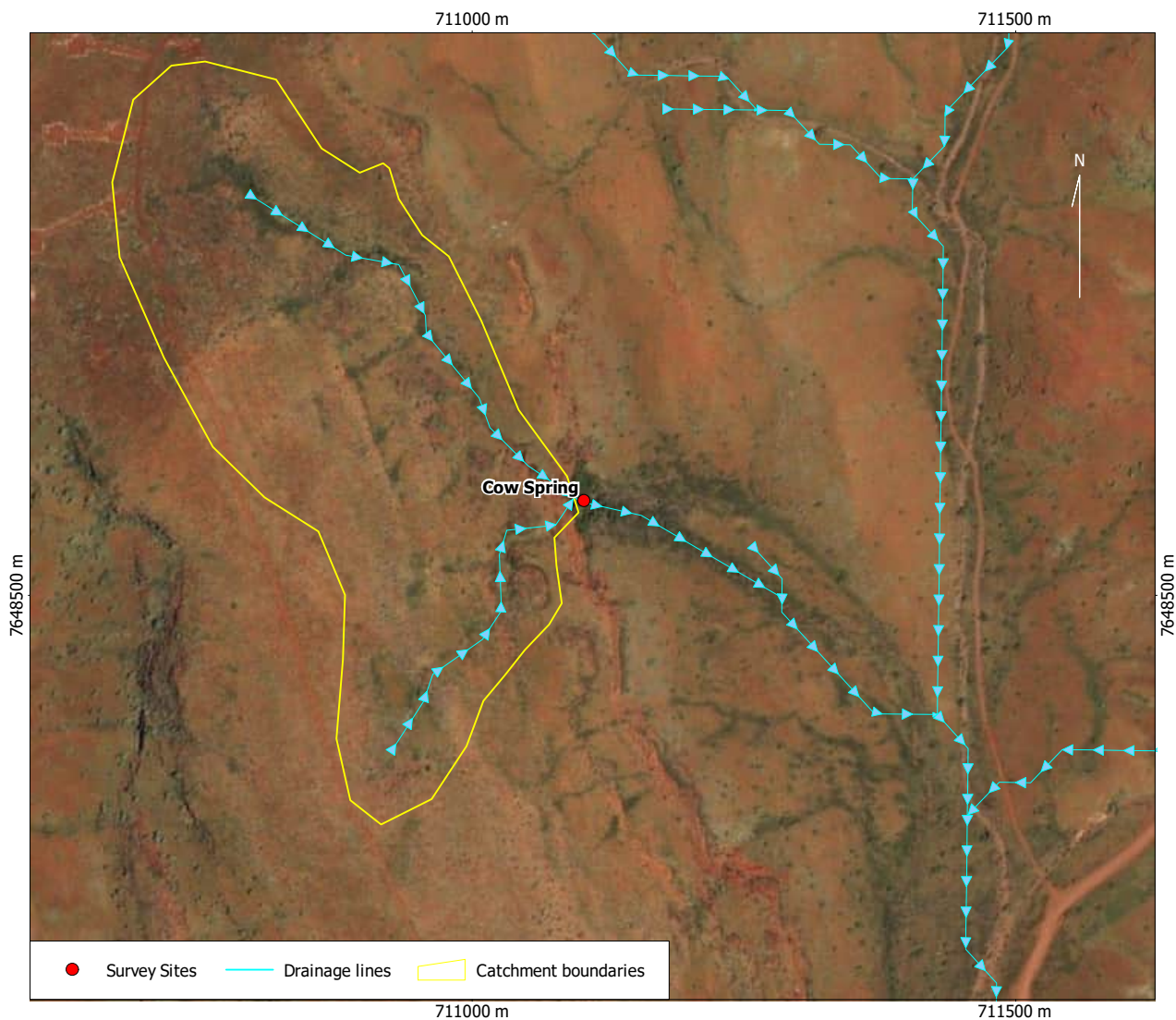


Figure 3-58 Cow Spring catchment area (0.15 km<sup>2</sup>)

The water level of Cow Spring Pool is relatively constant over the wet-dry season, with very short peaks of 10 to 20 cm above the mean level during high rainfall events (Figure 3-59). Due to the shaded positioning of the pool, the water temperature tends to be more stable than other pools in the region, ranging between 20-30°C over the annual cycle. Similarly, the water quality in the pool is relatively constant over the seasonal cycles with a mixed cation and SO<sub>4</sub><sup>-</sup> anion dominance (Figure 3-48). The pool is typically slightly acidic though it approached neutral pH in the Late Wet 2021 sampling.

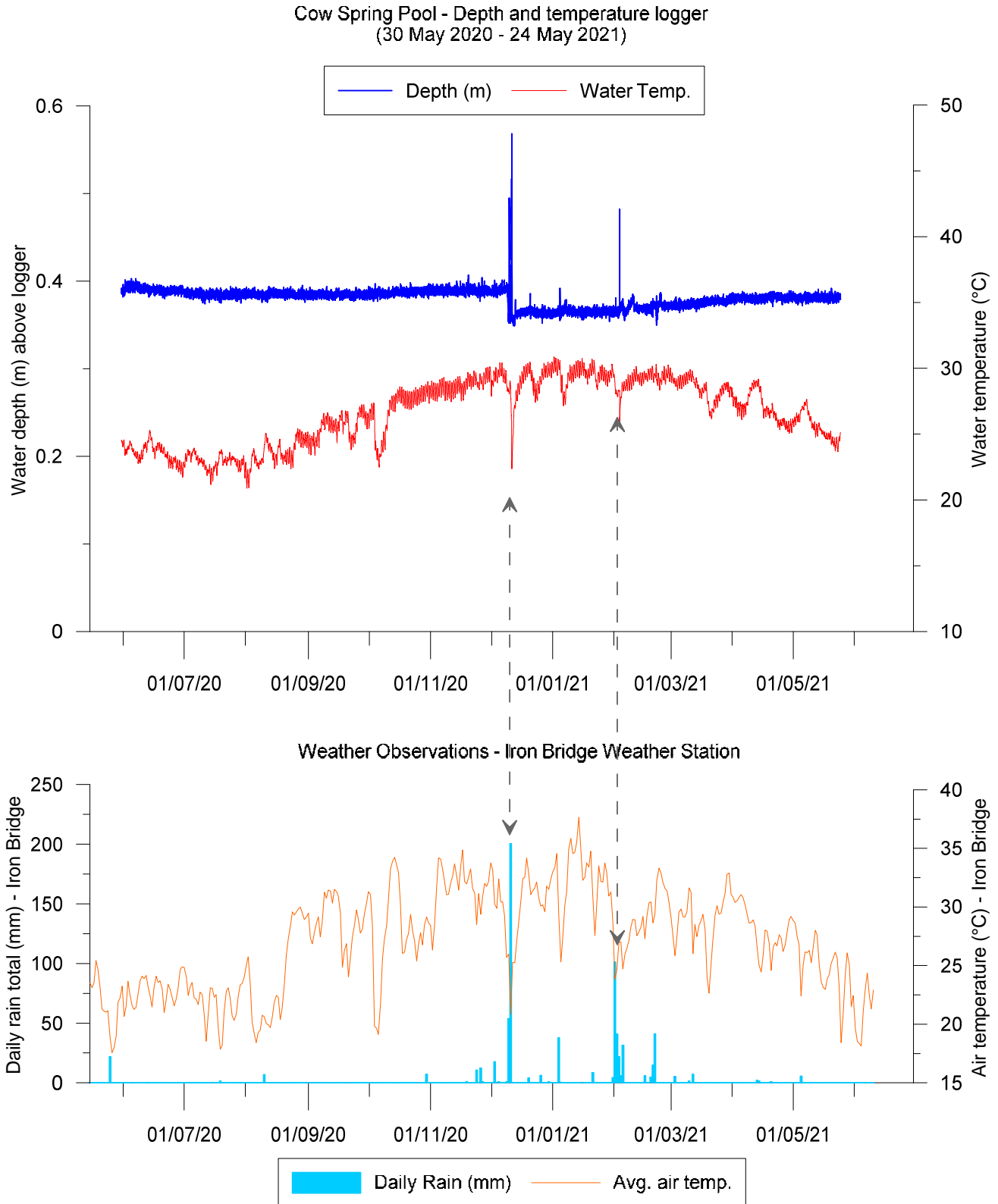


Figure 3-59 Cow Spring Pool depth and temperature logger data (above) relationship to daily rainfall (below) – Wet-Dry season 2021.

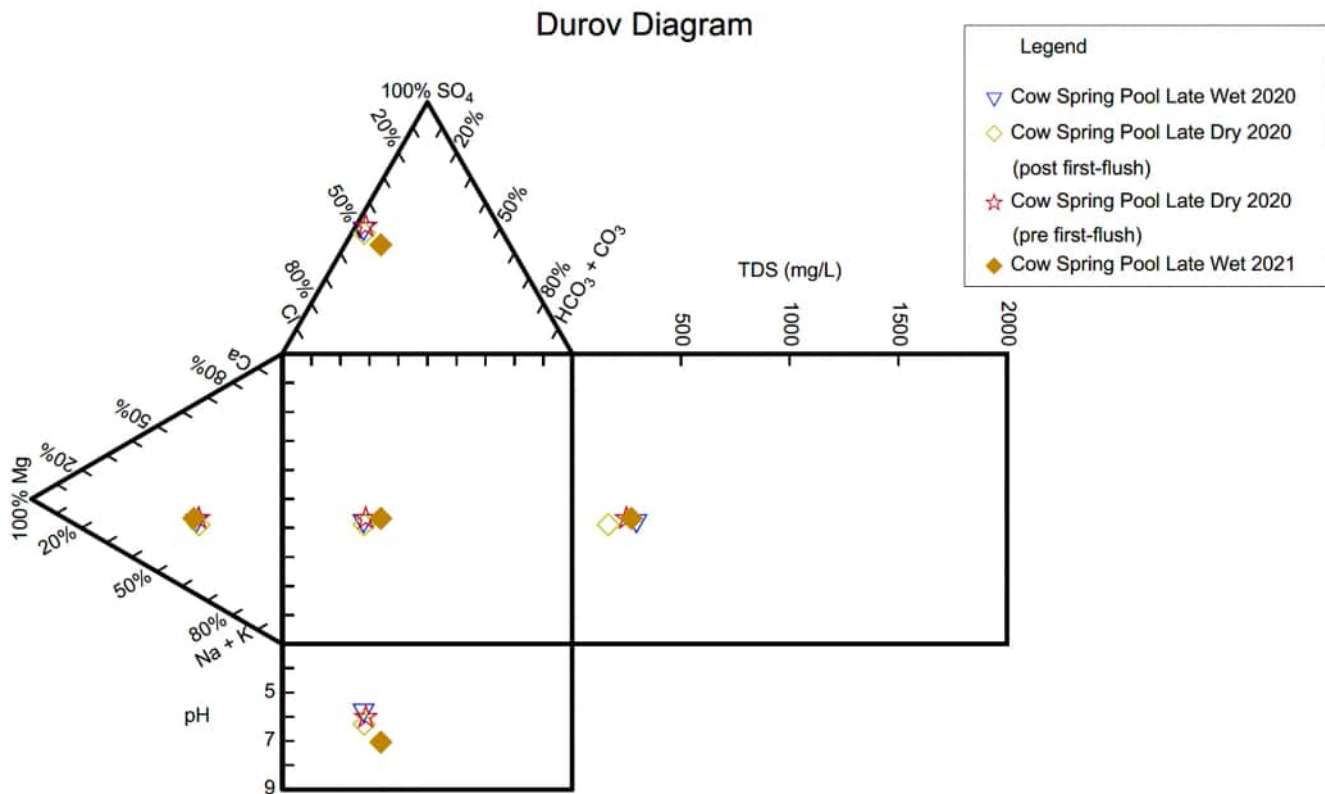


Figure 3-60 Durov diagram showing the Cow Spring Pool major ion distribution.

### 3.5.2 SEDIMENT QUALITY

Table 3-17 provides the surface sediment quality at Cow Spring Pool during the late wet season (sample collection 30<sup>th</sup> May 2020). Metal and metalloid concentrations were assessed against the ANZG (2018) DGVs. Chromium concentration (165 mg/kg) exceeded the DGV but not the GV-high. Chromium naturally occurs in high concentrations across the Project area.

Table 3-17. Summary of the sediment analysis for Cow Spring Pool in late wet season 2020. Bold values denote results recorded above the limit of reporting (LOR).

Analyte grouping/Analyte	Unit	Concentration
Total Soluble Salts	mg/kg	<b>114</b>
Moisture Content (Dried @ 105-110°C)	%	<b>23.9</b>
Total Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>4</b>
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>4</b>
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<1
Acidity	mg/kg	<1
Sulfate as SO <sub>4</sub> <sup>2-</sup> (soluble sulfate by ICPAES)	mg/kg	<b>40</b>
Chloride (by Discrete Analyser)	mg/kg	<b>20</b>
Calcium	mg/kg	<10

Analyte grouping/Analyte	Unit	Concentration
Magnesium	mg/kg	<10
Sodium	mg/kg	<b>20</b>
Potassium	mg/kg	<10
Mercury (FIMS)	mg/kg	<b>4.4</b>
Nitrite + Nitrate as N (Sol.)	mg/kg	<b>0.1</b>
Total Kjeldahl Nitrogen as N	mg/kg	<b>750</b>
Total Nitrogen as N	mg/kg	<b>750</b>
Total Phosphorus as P	mg/kg	<b>320</b>
Reactive Phosphorus as P	mg/kg	<0.1
Total Organic Carbon	%	<b>0.22</b>
<b>Total Metals by ICP-AES</b>		
Arsenic	mg/kg	<b>9</b>
Barium	mg/kg	<10
Beryllium	mg/kg	<1
Boron	mg/kg	<50
Cadmium	mg/kg	<1
Chromium	mg/kg	<b>165</b>
Cobalt	mg/kg	<b>4</b>
Copper	mg/kg	<b>7</b>
Iron	mg/kg	<b>124,000</b>
Lead	mg/kg	<b>9</b>
Manganese	mg/kg	<b>151</b>
Nickel	mg/kg	<b>18</b>
Selenium	mg/kg	<b>6</b>
Vanadium	mg/kg	<b>62</b>
Zinc	mg/kg	<b>16</b>

### 3.5.3 FISH

Only one species of fish, *M. australis* was observed at Cow Spring Pool throughout the three seasons. Table 3-18 presents the abundance, size distribution and CPUE for *M. australis* for all seasons surveyed.

*Leiopotherapon unicolor* was not detected at the pool through any methods, which may be due to various factors such as survival, aestivation, or reproduction may be limited by the naturally high acidity. Similarly, no decapod crustaceans were collected or observed.

Most *M. australis* sampled from Cow Spring Pool in the Late Wet 2020 were in the size class 30 – 60 mm, followed by the length classes <30 mm and 60 – 90mm at similar frequencies. Two individuals were recorded with a SL in >90 mm length class. The Late Dry 2020 was dominated by fish in the 60 – 90 mm

length class, with notably less in the smaller length classes (Figure 3-62). The Late Dry 2020 also had low frequency of larger fish (<90 mm). *M. australis* sampled in the Late Wet 2021 were dominated by fish in the 30 – 60 mm length class (74.1%). A similar frequency of very small fish (<30 mm) were present between seasons, indicating there is consistent juvenile recruitment occurring (Figure 3-61). As *M. australis* is considered to reach sexual maturity at 50 mm SL (Evans et al. 2010), Cow Spring Pool appears to be dominated with juvenile *M. australis*; only 6 individuals were larger than 50 mm. Individuals in the 30 – 60 mm length class likely hatched at the start of the wet season 2020/2021, with the <30 mm juveniles likely to have hatched post large wet season rains and indicate reproduction occurring within the pool, rather than migrating during periods of connecting flow (Pusey, B., Kennard, M., & Arthington, 2004).

*Uperoleia* sp. tadpoles were also observed at Cow Spring Pool. Their presence or catchability in Cow Spring Pool may be in part due to the absence of the predators *L. unicolor*.

Table 3-18. Summary of fish count for the standard length class (mm) and the CPUE for *M. australis* in the Late Wet 2020, Late Dry 2020 and Late Wet 2021 surveys.

Season	Size class (mm)	Catch	CPUE <sup>1</sup>
<b>Late Wet (2020)</b>		<b>67</b>	<b>3.8</b>
	0 – 30	13	
	30 – 60	37	
	60 – 90	15	
	> 90	2	
<b>Late Dry (2020)</b>		<b>102</b>	<b>5.8</b>
	0 – 30	12	
	30 – 60	20	
	60 – 90	67	
	> 90	3	
<b>Late Wet (2021)</b>		<b>31</b>	<b>1.77</b>
	0 – 30	5	
	30 – 60	23	
	60 – 90	3	
	>90	-	

<sup>1</sup> CPUE is catch per unit effort, a measure of relative abundance. Effort is fyke net set for 17.75 hours.

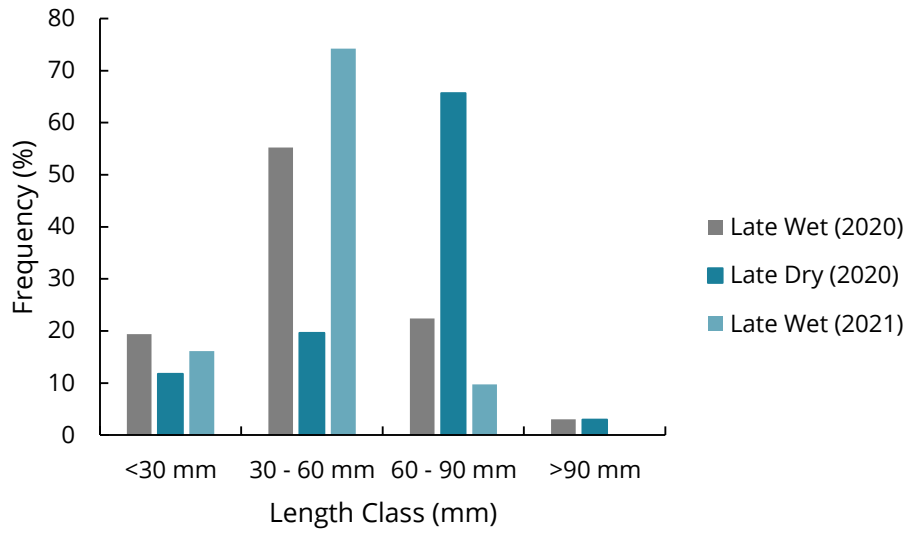


Figure 3-61. Frequency (%) of occurrence for each length class (SL, mm) for *Melanotaenia australis* sampled from Cow Spring Pool in late wet (June) and late dry (December) 2020.

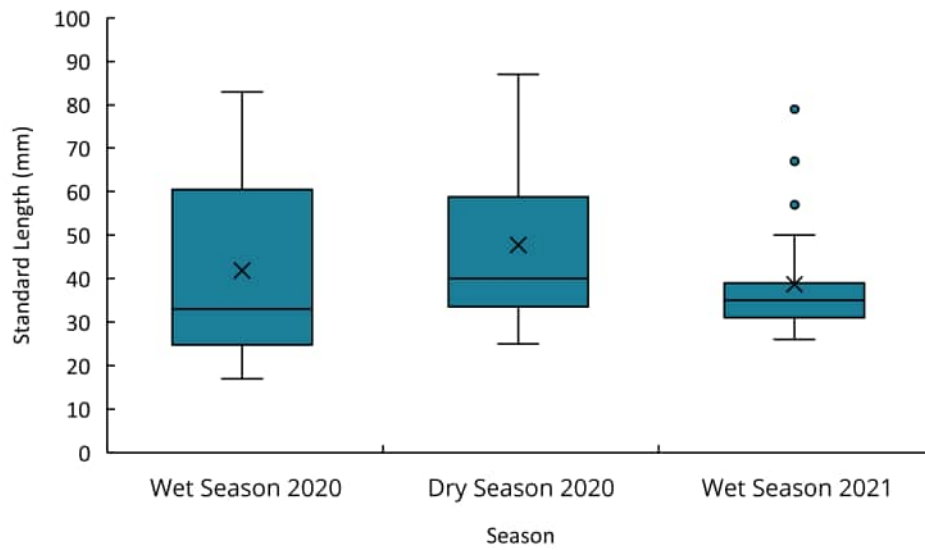
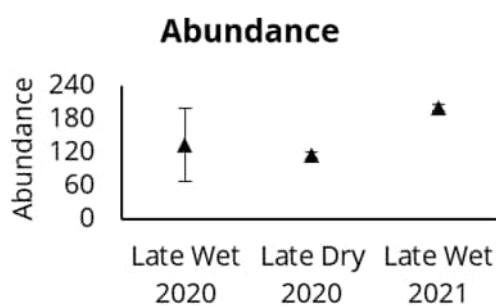


Figure 3-62. Size distribution of the standard length (SL, mm) for *Melanotaemia australis* sampled from Cow Spring Pool.

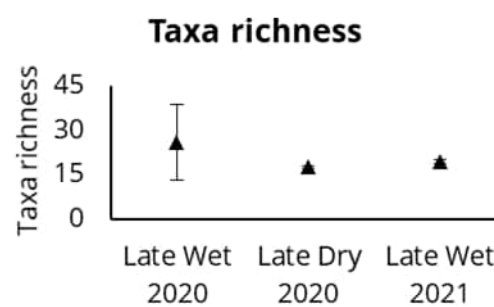
### 3.5.4 AQUATIC MACROINVERTEBRATES

Figure 3-63 presents the summary of the four macroinvertebrate indices for Cow Spring Pool in the late wet season of 2020 and 2021, and the late dry season of 2021. The key findings were as follows:

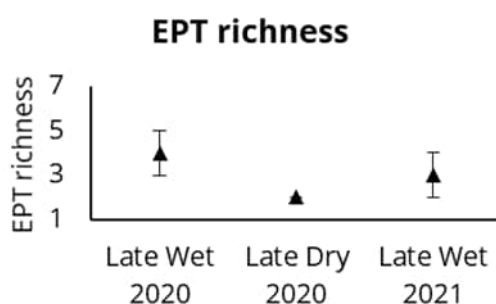
- Abundances of macroinvertebrates varied widely from 67 to 200 in Late Wet 2020, with consistent average abundances of 116 and 202 in the Late Dry 2020 and Late Wet 2021 seasons, respectively (Figure 3-63 a).
- Similarly, taxa richness ranged from 13 to 39 in Late Wet 2020 and from 17 to 20 in both other seasons, indicating more stable communities in Late Dry 2020 and the Late Dry 2021 seasons (Figure 3-63 b).
- EPT richness declined from the Late Wet to Dry season in 2020, before inclining slightly in the Late Wet season of 2021 (Figure 3-63 c). Five families belonging to the Ephemeroptera and Trichoptera orders have been recorded. Seasonal declines in EPT richness are likely due to the less favourable natural conditions experienced in the dry season.
- SIGNAL2 scores are relatively stable between seasons (Figure 3-63 d), with the range of scores (3.1-3.6) indicating the macroinvertebrate community is moderately tolerant.



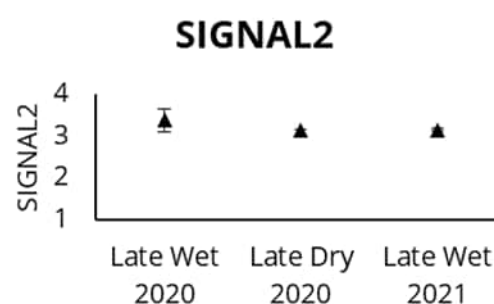
a) Total abundance at Cow Spring Pool



b) Taxonomic richness at Cow Spring Pool



c) EPT richness at Cow Spring Pool



d) SIGNAL2 scores at Cow Spring Pool

Figure 3-63 Macroinvertebrate indices for Cow Spring Pool – Late Wet 2020, Late Dry 2020 and Late Wet 2021.

The abundance of taxa for the three seasonal surveys is provided in Figure 3-64 and shows taxa ranging from the the most abundant (left) to the least abundant (right) along the x-axis. The non-biting midge of the Tanypodinae and Chironominae were more abundant in the most recent Late Wet survey of 2021,

with their increase potentially due to the greater rainfall levels in Late Wet 2021 as freshwater flow events such as flooding in wetlands can increase their abundances (McInerney et al. 2017). Similar abundances of the Acarina mites and ticks, Libellulidae dragonfly and biting midge of the Ceratopogonidae were found throughout all seasons. For damselflies of the Coenagrionidae, abundances increased during 2020 and then reduced substantially in the latest season of Late Wet 2021.

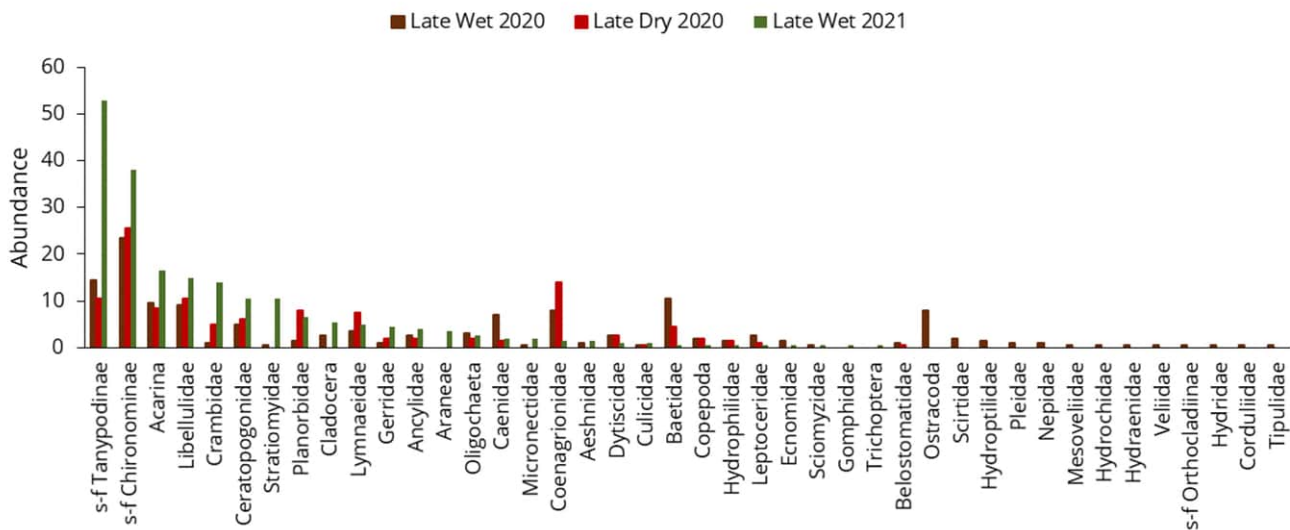


Figure 3-64 Average abundances of all macroinvertebrate taxa at Cow Spring Pool in the Late Wet season of 2021 and the Late Wet and Late Dry season of 2020, with taxa arranged from most abundant (left) to least abundant (right) along the x-axis.

### 3.5.5 DIATOMS AND PHYTOPLANKTON

#### 3.5.5.1 DIATOMS

**Error! Reference source not found.** summarises the species present, the overall abundance, and biotic indices of diatoms surveyed in the Late Wet 2020. Only one replicate of diatoms collected in Late Wet 2021 was analysed, therefore only total count has been recorded for this season. No diatom data was available for the Late Dry 2020 due to flood flows during the deployment period. **Error! Reference source not found.** presents the average abundance of diatom species recorded at Cow Spring Pool for Late Wet 2020. The key findings are as follows:

Overall, 21 species were recorded at Cow Spring Pool across both seasons, with Late Wet 2021 recording a higher number of species (19) than 2020 (7). Of the 21 species only 5 were present in both seasons. Total abundance of diatoms was higher in Late Wet 2021 but the notable difference in diatom count can be attributed to one species *Brachysira styriaca* with a total abundance of 218 recorded in 2021. The most abundant species for Cow Spring Pool recorded in Late Wet 2020 was *Achnanthes minutissimum* and *Eunotia bilunaris*, species were also present at all other pools except Fig Pool (Figure 3-65).

Late Wet 2020 showed low diatom diversity for this site. The first replicate for this site detected no diatoms and the other samples noted very sparse abundance. The high acidity and low light conditions at Cow Spring Pool may have contributed to the relatively low diatom growth compared to other North Star pools. The low abundance of diatoms indicates they are able to survive, though the capacity for growth is limited under the conditions that were present during the sampling period. The DSIAR score (64.2) reflects the species sensitivity to environmental stress, where a higher score indicates 'better' water quality as species sensitive to environmental stress are present. This indicates the species richness is more likely limited by

factors needed to grow (i.e. sunlight) rather than stressors known to cause mortality of sensitive species (e.g. high salinity). While samples collected in 2021 recorded a higher number of species than 2020, Cow Spring Pool still shows lower taxonomic diversity than other North Star Pools. A higher taxonomic diversity in 2021 of diatoms has been observed for all North Star Pools, with exception of Fig Pool which recorded no diatoms either season.

Table 3-19. Diatom abundance (total count per species), average abundance and DSIAR score Cow Spring Pool surveyed in Late Wet 2020, only total abundance was recorded for Late Wet 2021

Taxon	Late Wet 2020			Late Wet 2021
	Replicate 1	Replicate 2	Average	Total Count
<i>Achnanthis minutissimum</i>	0	8	4	14
<i>Brachysira styriaca</i>	0	0	0	12
<i>Brachysira vitrea</i>	0	0	0	218
<i>Cymbella affinis</i>	0	2	1	8
<i>Cymbella spp</i>	0	4	2	4
<i>Eunotia bilunaris</i>	0	8	4	62
<i>Eunotia exigua</i>	0	0	0	4
<i>Eunotia faba</i>	0	2	1	0
<i>Eunotia incisa</i>	0	0	0	6
<i>Eunotia paludosa</i>	0	0	0	4
<i>Eunotia spp.</i>	0	0	0	6
<i>Fragilaria acus</i>	0	0	0	16
<i>Fragilariforma virescens</i>	0	0	0	2
<i>Frustulia rhomboides</i>	0	0	0	2
<i>Gomphonema affine</i>	0	0	0	6
<i>Gomphonema minutum</i>	0	0	0	4
<i>Hantzschia amphioxys</i>	0	2	1	0
<i>Luticola mutica</i>	0	2	1	4
<i>Mastogloia smithii</i>	0	0	0	2
<i>Pinnularia spp.</i>	0	0	0	4
<i>Ulnaria ulna</i>	0	0	0	22
<b>Total Abundance</b>	0	28	14	400
<b>DSIAR Score</b>		64.2	64.2	68

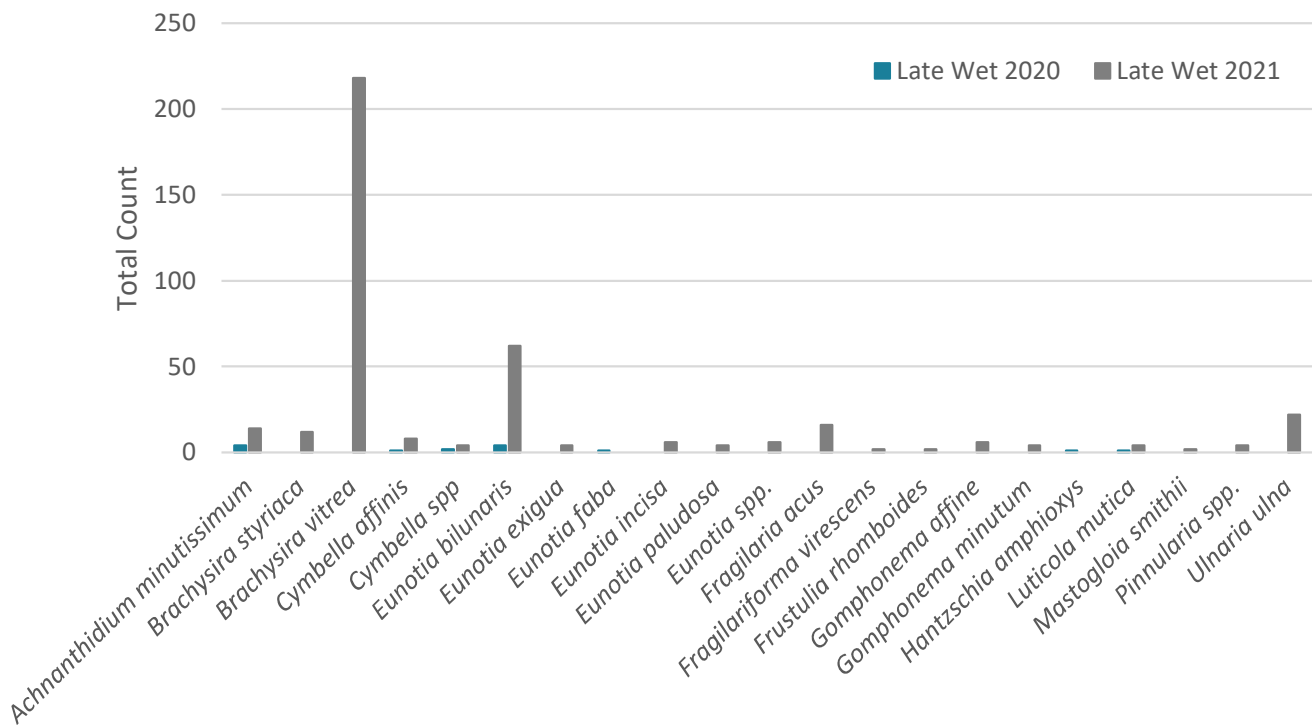


Figure 3-65. Mean abundance for diatom species recorded in late wet season 2020, with error bars denoting  $\pm 0.5\sigma$ .

### 3.5.5.2 PHYTOPLANKTON

In the Late Dry 2020 and Late Wet 2021, water samples were taken from Cow Spring Pool to analyse a complete planktonic phytoplankton profile for the site. In the Late Dry 2020, five phytoplankton classes with 15 species were identified, indicating Cow Spring Pool has a relative moderate phytoplankton diversity. Cryptophyceae occurred at the highest abundance, followed by Dinophyceae (Dinoflagellates). Diatoms (Bacillariophyceae) were the third most abundant, and samples collected in the late dry season identified similar diatom species as the previous season.

In the late wet season 2021, there were considerably fewer phytoplankton cells recorded. Overall, the only class that yielded a result above the LOR was the diatoms (Bacillariophyceae) at a very low abundance. The low abundance of phytoplankton is not unusual for Cow Spring Pool based on diatom results in the previous wet season and could also be attributed to heavy rain during the wet season (Table 3-20).

Table 3-20 Summary of phytoplankton analytical results for Cow Spring Pool sampled in late wet season (2021), abundance (cells  $L^{-1}$ ) and percentage contribution (%), limit of reporting 10 cell  $L^{-1}$ .

Taxon	Late Dry (2020)		Late Wet (2021)	
	Abundance	%	Abundance	%
<b>Bacillariophyceae</b>	<b>7000</b>	<b>19.02</b>	<b>20</b>	<b>100</b>
<i>Achnanthis minutissima</i>	1400	3.8	0	0
<i>Amphora spp.</i>	200	0.54	0	0
<i>Cymbella spp.</i>	400	1.09	0	0
<i>Navicula spp.</i>	2800	7.61	10	50

Taxon	Late Dry (2020)		Late Wet (2021)	
<i>Nitzschia spp.</i>	400	1.09	0	0
<i>Synedra spp. (O)</i>	1800	4.89	10	50
<b>Chlorophyceae</b>	<b>1400</b>	<b>3.8</b>	<b>0</b>	<b>0</b>
<i>Cosmarium spp. (O)</i>	1200	3.26	0	0
<i>Staurastrum spp. (O)</i>	200	0.54	0	0
<b>Cryptophyceae</b>	<b>15000</b>	<b>40.76</b>	<b>0</b>	<b>0</b>
<i>Chroomonas spp.</i>	3000	8.15	0	0
<i>Cryptomonas spp. (O)</i>	11800	32.07	0	0
<i>Plagioselmis spp.</i>	200	0.54	0	0
<b>Dinophyceae</b>	<b>13200</b>	<b>35.87</b>	<b>0</b>	<b>0</b>
<i>Gonyaulax spp.</i>	12200	33.15	0	0
<i>Gymnodinium spp.</i>	600	1.63	0	0
<i>Peridinium spp. (O)</i>	400	1.09	0	0
<b>Euglenophyceae</b>	<b>200</b>	<b>0.54</b>	<b>0</b>	<b>0</b>
<i>Trachelomonas spp.</i>	200	0.54	0	0

### 3.5.6 MACROPHYTES

Table 3-21 presents the macrophyte species and qualitative abundance during the Late Wet 2020, Late Dry 2020 and Late Wet 2021 surveys. A diverse range of macrophyte flora was observed within Cow Spring Pool. These comprised aquatic species and groundwater-dependent species. A total of seven macrophyte species were recorded in each season. These included reeds (Clubrush, *Typha* spp.), sedges (Cyperaceae) as well as submerged macrophytes (ribbon weed, charophytes, Hydrocharitaceae) (Figure 3-66, Figure 3-67 and Figure 3-18). The abundance and diversity of species of macrophytes present in this system indicate relatively high water quality and ecological health conditions. The macrophytes, both emergent and submerged, are providing important habitat structure, refuge and food sources to organisms such as the *M. australis* (western rainbowfish). There was a decrease in the abundance of emergent macrophytes in the Late Wet 2021 compared to the Late Wet 2020. However, no changes were substantial enough to alter the categorical abundance classification.

Table 3-21. Description of macrophytes species and abundance observed at Cow Spring Pool in the late wet season (2020)

Common name	Species name	Late Wet 2020 Abundance <sup>1</sup>	Late Dry 2020 Abundance <sup>1</sup>	Late Wet 2021 Abundance <sup>1</sup>
Ribbon weed	<i>Vallisneria sp.</i>	Abundant	Abundant	Abundant
Charophytes	<i>Nitella sp., Chara sp.</i>	Abundant	Abundant	Abundant
Clubrush	<i>Schoenoplectus sp.</i>	Abundant	Abundant	Abundant
Sedges	Cyperaceae	Isolated	Isolated	Isolated
Bulrush	<i>Typha sp.</i>	Isolated	Isolated	Isolated
Unidentified 1	Hydrocharitaceae	Isolated	Isolated	Isolated
Unidentified 2	Hydrocharitaceae	Isolated	Isolated	Isolated

<sup>1</sup> Abundance based on *Western Australia AUSRIVAS field sampling sheet* (DoW, 2009).



Figure 3-66 Two macrophytes pending taxonomic identification in Cow Spring Pool

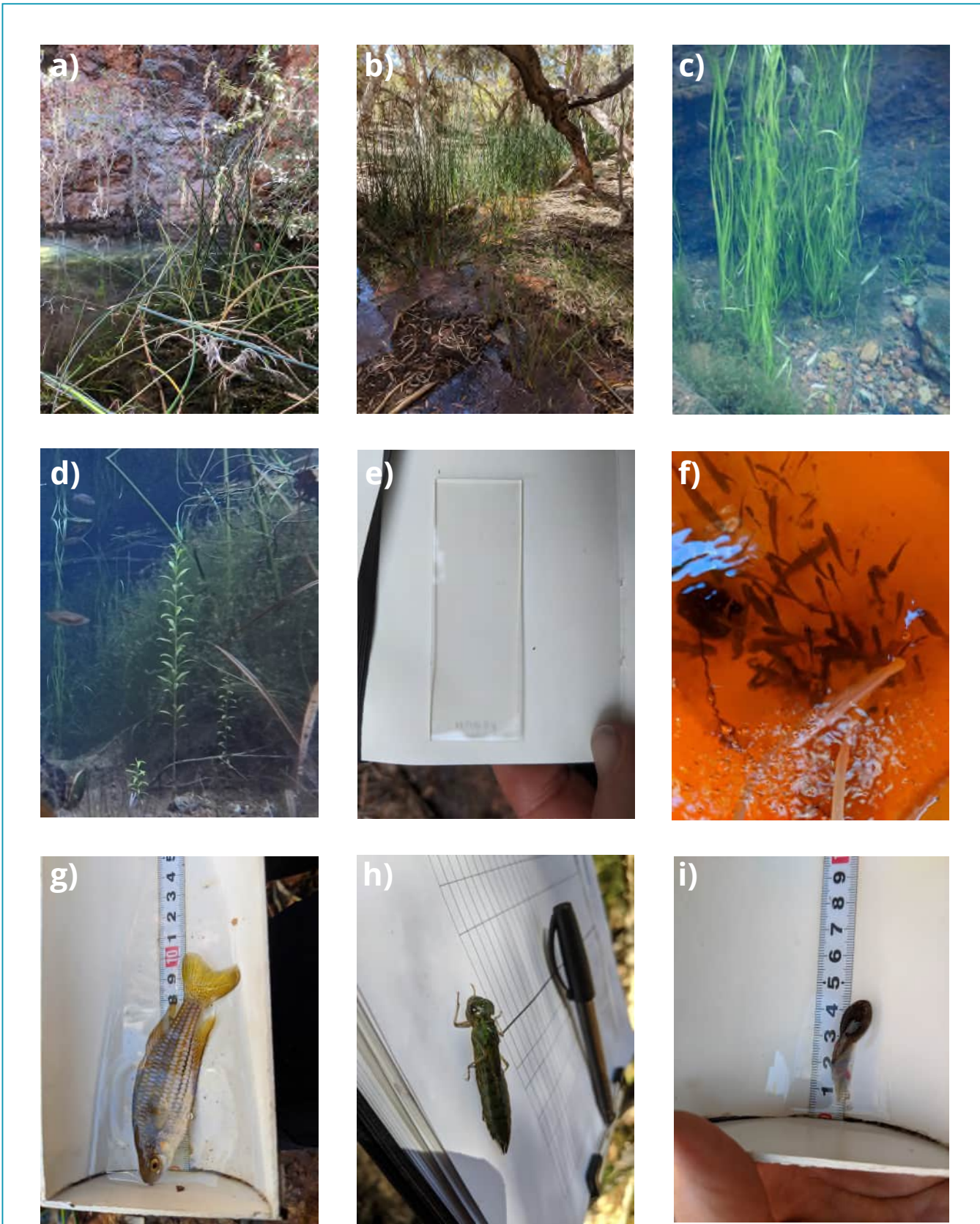


Figure 3-67 Cow Spring Pool aquatic ecology. a) to d) show a diversity of emergent and submerged macrophytes; e) a slide with minimal diatom colonisation; f) and g) *M. australis* present over a wide range of ages; h) Aeshnidae; an example of macroinvertebrates inhabiting macrophytes; i) tadpoles of *Uperoleia* spp.

### 3.6 GV POOL (GV\_SW\_POOL\_SW)

The South-West Glacier Valley Pool (GV SW Pool) is a series of small pools located in a cut across an adjacent ridgeline. The pool supports fish during the wet season (spangled perch - *Leiopotherapon unicolor*), likely to have migrated from downstream permanent pools as wet season flows provided habitat connectivity. The macrophyte (submerged vegetation community) was limited at GV Pool but some individual plants were observed within the various semi-connected pools along the drainage reach. Overall, the ecology observed at GV Pool was similar to other regional pools studied for the Iron Bridge aquatic ecology monitoring program.



Figure 3-68 GV Pool; The South-West Glacier Valley Pool during the Late Wet Season 2021.

#### 3.6.1 WATER QUALITY AND HYDROLOGY

The GV Pool monitoring site is a string of shallow ephemeral pools perched on bedrock, fed by a 3.3 km<sup>2</sup> catchment (Figure 3-69) draining the western face of the Glacier Valley ridgeline. This catchment is similar in nature to the Mundagoora Pool catchment directly to the north, draining the same ridge system. GV Pool differs in hydrology to the Mundagoora Pool, however, with surface water flows appearing to dominate inputs. The pool system was dry during observations in December 2020 and displayed remnant perched and semi-connected shallow (<0.5m depth) pools during the wet season (May 2021).

The water quality of GV Pool was similar to other ephemeral pools in the region during the Late Wet 2021 sampling with a slightly alkaline pH of 7.88 and moderately brackish salinity (EC = 1444 µS/cm). The pool was well oxygenated (Dissolved Oxygen = 7.99 mg/L) and clear (Turbidity = <1). The major ion distribution is presented as a Durov Plot in Figure 3-71, showing sodium bicarbonate (Na-HCO<sub>3</sub>) dominated water type that is saturated with respect to calcite precipitation.

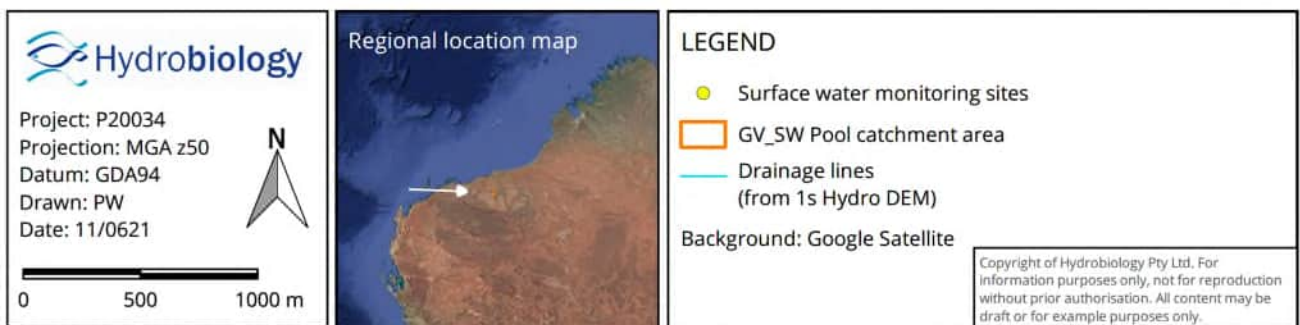
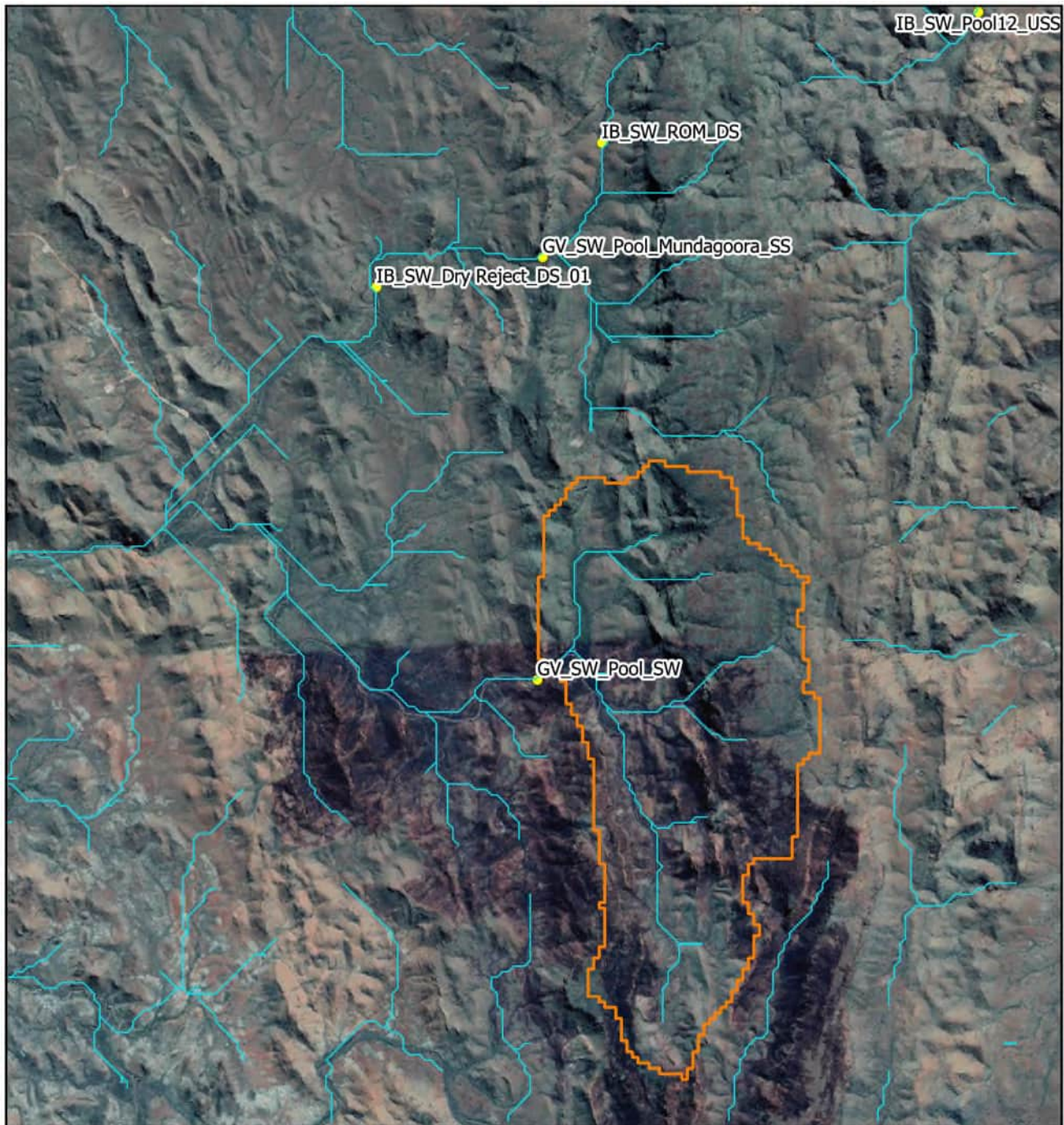


Figure 3-69 GV SW Pool catchment area (3.3 km<sup>2</sup>)

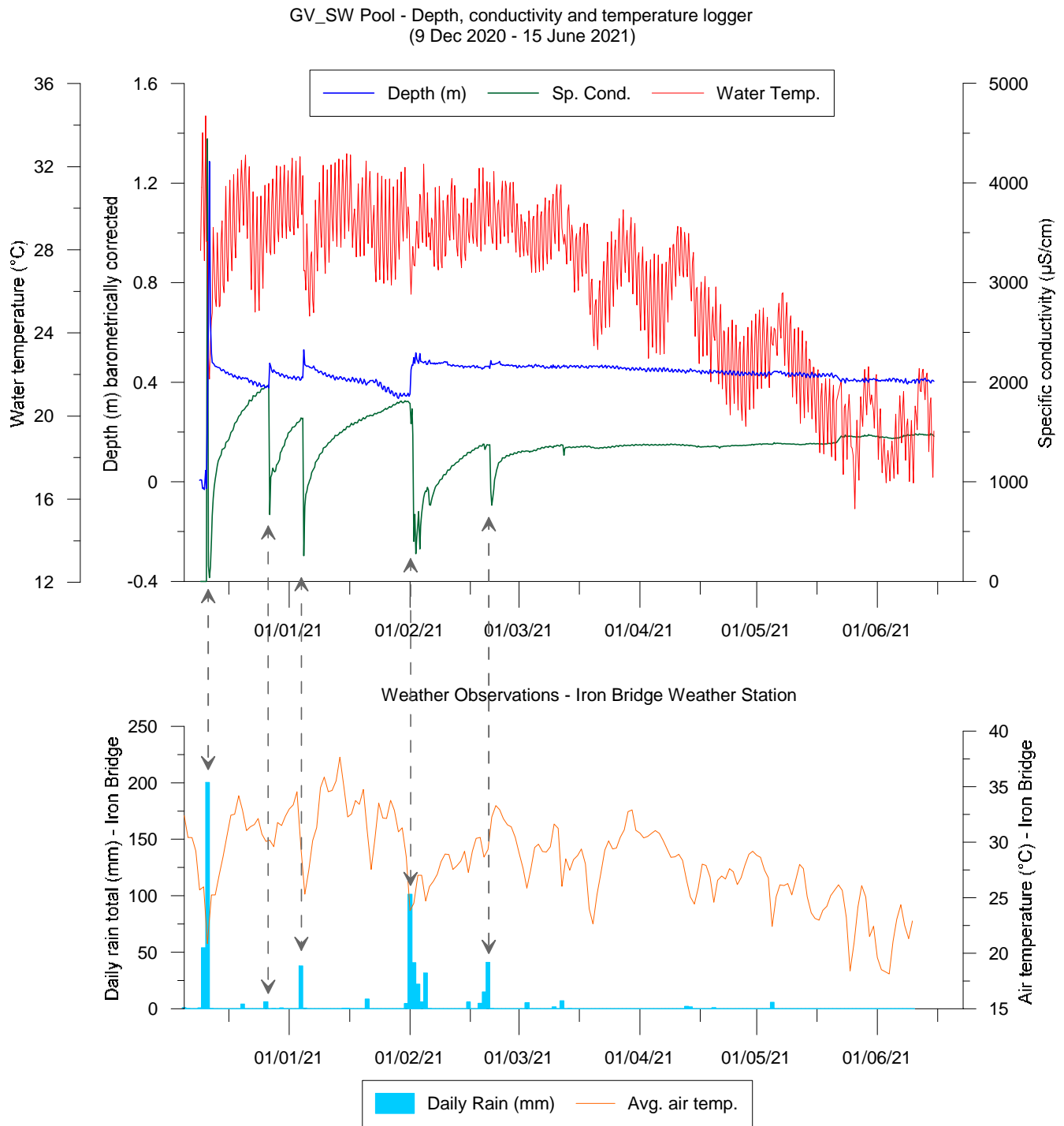


Figure 3-70 GV SW Pool depth, conductivity, and temperature logger data (above) relationship to daily rainfall (below) - Wet-Dry season 2021.

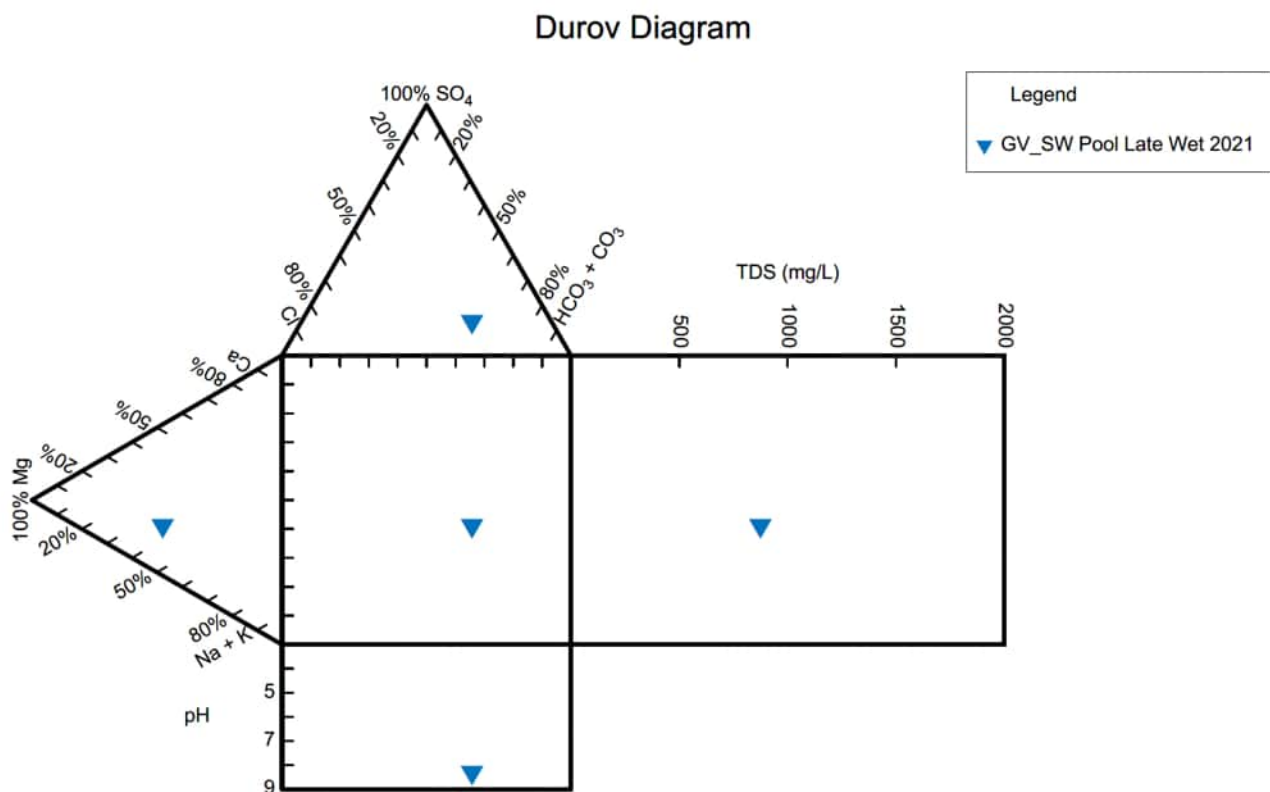


Figure 3-71 Durov diagram showing the South-West Glacier Valley Pool (GV SW Pool) major ion distribution.

### 3.6.2 SEDIMENT QUALITY

The sediment quality for the Late Wet 2021 sampling at GV Pool is provided in Table 3-22. As with the other sites surveyed, the Chromium concentrations exceeded the DGV of 80 mg/kg and were just below the GV-High of 370 mg/kg (ANZG 2018). Similarly, the Nickel concentrations were above both the DGV (21 mg/kg) and the GV-High (52 mg/kg). This pattern was consistent with other pools in the region.

Table 3-22 Summary of sediment quality analysis for GV Pool in the late wet season 2021. Bolded values denote results recorded above the limit of reporting (LOR).

Analyte grouping/Analyte	Unit	Late Wet 2021
Total Soluble Salts	mg/kg	<b>200</b>
Moisture Content (Dried @ 105-110°C)	%	<b>24.8</b>
Total Alkalinity as CaCO <sub>3</sub>	mg/kg	<5
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>239</b>
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	<b>239</b>
Acidity	mg/kg	<b>62</b>
Sulfate as SO <sub>4</sub> <sup>2-</sup> (soluble sulfate by ICPAES)	mg/kg	<b>&lt;10</b>
Chloride (by Discrete Analyser)	mg/kg	<b>20</b>

Analyte grouping/Analyte	Unit	Late Wet 2021
Calcium	mg/kg	<b>30</b>
Magnesium	mg/kg	<b>20</b>
Sodium	mg/kg	<b>30</b>
Potassium	mg/kg	<10
Mercury (FIMS)	mg/kg	<0.1
Nitrite + Nitrate as N (Sol.)	mg/kg	<0.1
Total Kjeldahl Nitrogen as N	mg/kg	<b>430</b>
Total Nitrogen as N	mg/kg	<b>430</b>
Total Phosphorus as P	mg/kg	<b>190</b>
Reactive Phosphorus as P	mg/kg	<0.1
Total Organic Carbon	%	<b>0.13</b>
<i>Total Metals by ICP-AES</i>		
Arsenic	mg/kg	<b>9</b>
Barium	mg/kg	<b>60</b>
Beryllium	mg/kg	<1
Boron	mg/kg	<b>50</b>
Cadmium	mg/kg	<1
Chromium	mg/kg	<b>368</b>
Cobalt	mg/kg	<b>33</b>
Copper	mg/kg	<b>67</b>
Iron	mg/kg	<b>114000</b>
Lead	mg/kg	<b>6</b>
Manganese	mg/kg	<b>674</b>
Nickel	mg/kg	<b>134</b>
Selenium	mg/kg	<b>&lt;5</b>
Vanadium	mg/kg	<b>161</b>
Zinc	mg/kg	<b>30</b>

### 3.6.3 FISH

GV Pool was first surveyed in the Late Wet Season 2021. As GV Pool was shallow, a fyke net was not able to be used to survey the fish abundance at this site; therefore, species composition and fish counts were conducted using BRUVs.

*L. unicolor* (spangled perch) was the only fish species observed on the BRUV footage for GV Pool (MaxN = 13).

### 3.6.4 AQUATIC MACROINVERTEBRATES

Figure 3-72 presents the summary of total abundance, taxa richness, EPT richness and SIGNAL2 for the first season sampled (Late Wet 2021) in GV Pool. The key findings were as follows:

- Total abundance and taxa richness varied, with 199 to 218 individuals and 18 to 19 taxa recorded, respectively.
- Average EPT richness was 4 at the GV Pool, with a total of five families belonging to the Ephemeroptera and Trichoptera orders recorded.
- The average SIGNAL2 score was 3.4, which indicates that the macroinvertebrate community at GV Pool is moderately tolerant.

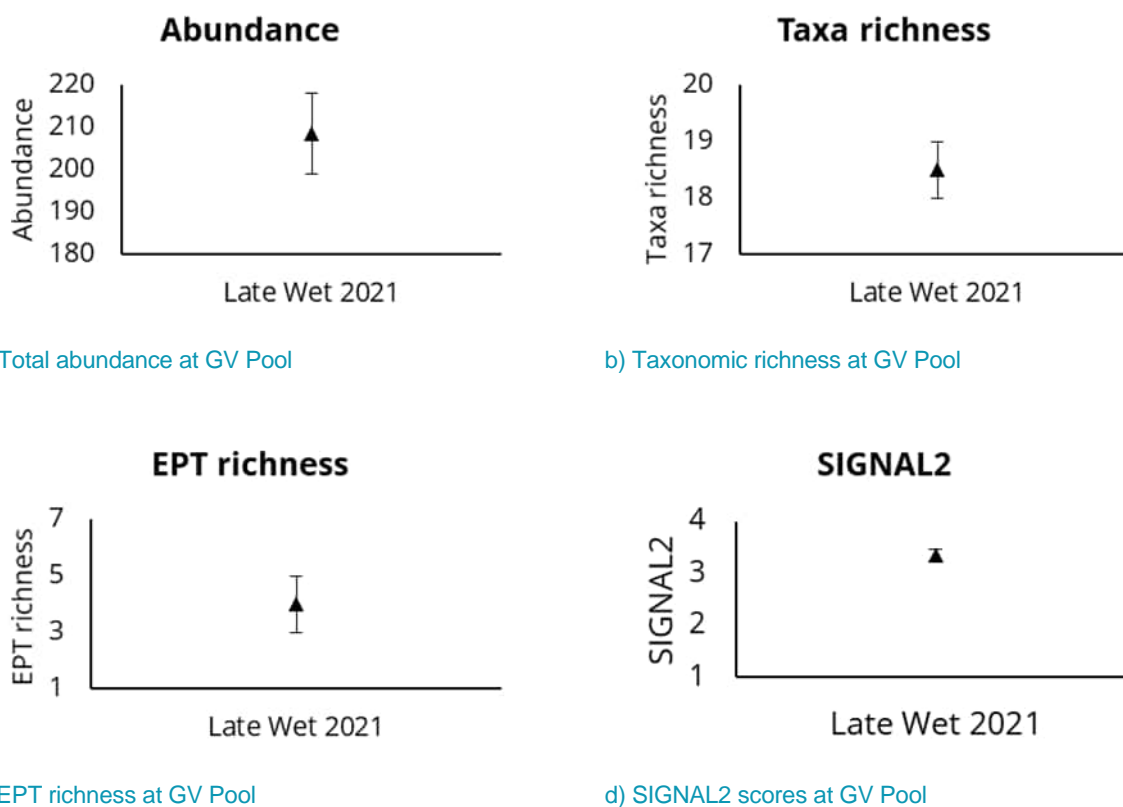


Figure 3-72 Macroinvertebrate indices for GV Pool in the Late Wet 2021 season.

Figure 3-73 shows the abundance of each macroinvertebrate taxa in GV Pool in the Late Wet season of 2021 and shows taxa ranging from the the most abundant (left) to the least abundant (right) along the x-

axis. Cnidarians were highly abundant macroinvertebrates at GV Pool, with members of Hydrozoa, Oceaniidae, Hydrodidae and Olindiidae were the top four most abundant taxa. Members of the sponge phylum Porifera were the next most abundant, followed by Bryozoa and the turbellarian flatworms of the Platyhelminthes.

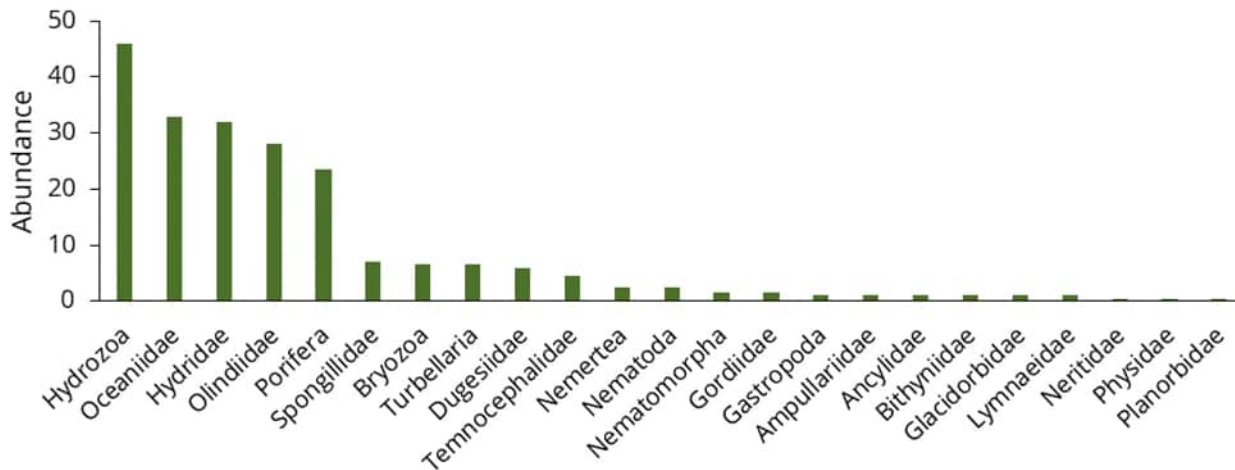


Figure 3-73 Average abundances of all macroinvertebrate taxa at GV Pool in the Late Wet season of 2021, with taxa arranged from most abundant (left) to least abundant (right) along the x-axis.

### 3.6.5 DIATOMS AND PHYTOPLANKTON

#### 3.6.5.1 DIATOMS

Table 3-23 provides the diatom abundance (total count per species), average abundance and DSIAR score GV Pool surveyed in the Late Wet 2021. Figure 3-74 illustrates the mean abundance (diatom count per replicate) of diatom species recorded at GV Pool. GV Pool was not sampled before the Late Wet 2021 season, the key findings were as follows:

- GV Pool was observed as having a high taxonomic diversity with 34 diatoms species being recorded in Late Wet 2021.
- Overall average abundance was high (average count = 400) with both replicates recording similar total abundances.
- The tolerance to environmental stress for GV Pool is reflected in the moderate sensitivity DSIAR score (49.3 and 51.2 for replicate 1 and 2, respectively). There is likely to be some natural environmental (habitat) stress from the ephemeral nature of the shallow string of pools along the study reach. The catchment during the baseline phase is largely unimpacted by other activities such as grazing.

Table 3-23. Diatom abundance (total count per species), average abundance and DSIAR score GV Pool surveyed in the Late Wet 2021

Taxon name	GV Pool 1	GV Pool 2	Average
<i>Diploneis parma</i>	52	104	78
<i>Nitzschia paleacea</i>	0	96	48
<i>Nitzschia frustulum</i>	64	30	47
<i>Nitzschia fonticola</i>	22	46	34
<i>Navicula viridula</i>	16	42	29
<i>Gomphonema affine</i>	42	8	25
<i>Nitzschia filiformis</i>	46	4	25
<i>Nitzschia palea</i>	34	14	24
<i>Nitzschia microcephala</i>	14	8	11
<i>Achnantheidium minutissimum</i>	20	0	10
<i>Navicula erifuga</i>	0	16	8
<i>Achnantheidium exiguum</i>	14	0	7
<i>Nitzschia gracilis</i>	14	0	7
<i>Navicula menisculus</i>	4	8	6
<i>Navicula viridula var. linearis</i>	0	8	4
<i>Nitzschia lacuum</i>	8	0	4
<i>Diploneis smithii</i>	0	6	3
<i>Nitzschia inconspicua</i>	0	6	3
<i>Nitzschia linearis</i>	4	2	3
<i>Ulnaria ulna</i>	6	0	3
<i>Achnanthes subexigua</i>	4	0	2
<i>Gomphonema minutum</i>	0	4	2
<i>Karayevia clevei</i>	0	4	2
<i>Navicula cryptocephala</i>	0	4	2
<i>Navicula lanceolata</i>	0	4	2
<i>Navicula tenelloides</i>	4	0	2
<i>Navicula veneta</i>	4	0	2
<i>Fragilaria vaucheriae</i>	0	2	1
<i>Gomphonema gracile</i>	0	2	1
<i>Navicula radiosafallax</i>	0	2	1
<i>Navicula rhynchocephala</i>	2	0	1
<i>Nitzschia clausii</i>	2	0	1
<i>Nitzschia desertorum</i>	0	2	1
<i>Nitzschia palea var debilis</i>	2	0	1
<b>Total Abundance</b>	<b>378</b>	<b>422</b>	<b>400</b>
<b>DSIAR Score</b>	<b>49.3</b>	<b>51.2</b>	<b>50.3</b>

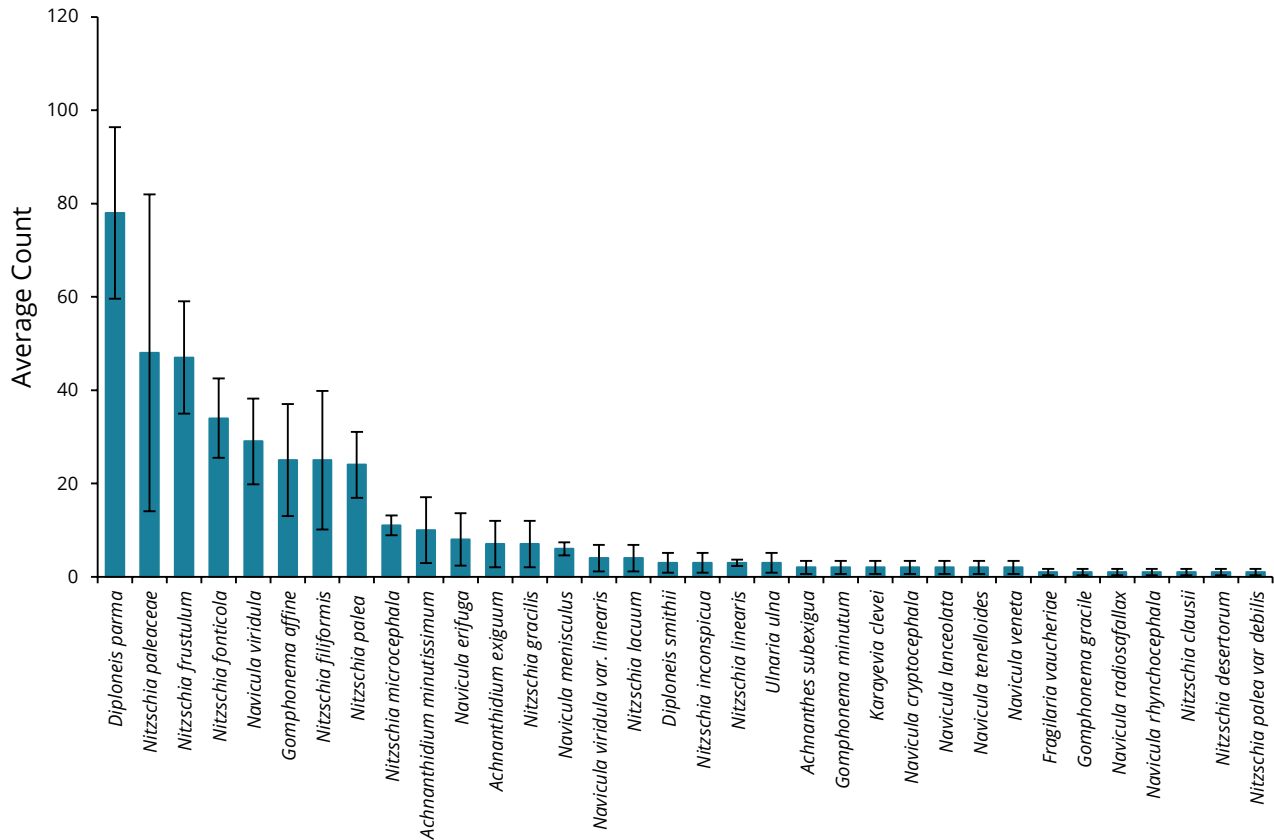


Figure 3-74. Average species abundance (diatom count per replicate) for diatoms sampled at GV Pool in the Late Wet 2021, with taxa arranged from most abundant (left) to least abundant (right) along the x-axis. Standard error (SE±0.5) denoted by error

### 3.6.5.1 PHYTOPLANKTON

Two classes of phytoplankton were identified in the late wet season (2021). GV Pool was dominated by diatoms (~98.9%, Bacillariophyceae), indicating a low phytoplankton diversity. Approximately six diatom genera were observed in the water sample, indicating a moderate level of diatom diversity.

Table 3-24 Summary of phytoplankton species and abundance for GV Pool sampled in the late wet season 2021.

Taxon	Late Wet (2021)	
	Abundance	%
<b>Bacillariophyceae</b>	860	98.85
<i>Amphora spp.</i>	40	4.6
<i>Placoneis sp.</i>	530	60.92
<i>Navicula spp.</i>	100	11.49
<i>Nitzschia spp.</i>	110	12.64
<i>Rhopalodia gibba</i>	60	6.9

Taxon	Late Wet (2021)	
<i>Synedra spp. (O)</i>	20	2.3
<b>Cryptophyceae</b>	10	1.15
<i>Cryptomonas spp. (O)</i>	10	1.15

### 3.6.6 MACROPHYTES

The macrophyte (submerged vegetation community) observed during the Late Wet 2021 survey (the initial baseline survey for this site) was limited at GV Pool, though some individual plants (sedges) were observed within the various semi-connected pools along the drainage reach (Figure 3-68). These were undergoing taxonomic identification at the time of reporting.

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# APPENDIX A. WATER QUALITY DATA

Table 25 Water quality data – late wet season 2019/2020. Bold font denotes values above the limit of reporting (LOR).

Analyte grouping/Analyte	Unit	LOR	Site 12 Pool	Central Ck Pool	Cow Spring Pool	Site 12 Pool GW	South Star Pool	Fig Pool GW	Fig Pool	Central Creek GW	TSF-1	TSF-2
		Sample Date	29/05/2020	31/05/2020	01/06/2020	29/05/2020	31/05/2020	01/06/2020	30/05/2020	01/06/2020	01/06/2020	01/06/2020
		ALS Sample Number	EP2005660001	EP2005660002	EP2005660003	EP2005660004	EP2005660005	EP2005660006	EP2005660007	EP2005660008	EP2005660009	EP2005660010
<b>Suspended Solids (SS)</b>	mg/L	5	<5	<5	<5	----	<5	----	<5	----	<b>9480</b>	<b>3220</b>
<b>Hydroxide Alkalinity as CaCO<sub>3</sub></b>	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
<b>Carbonate Alkalinity as CaCO<sub>3</sub></b>	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
<b>Bicarbonate Alkalinity as CaCO<sub>3</sub></b>	mg/L	1	<b>478</b>	<b>406</b>	<b>34</b>	<b>204</b>	<b>399</b>	<b>142</b>	<1	<b>422</b>	<b>79</b>	<b>80</b>
<b>Total Alkalinity as CaCO<sub>3</sub></b>	mg/L	1	<b>478</b>	<b>406</b>	<b>34</b>	<b>204</b>	<b>399</b>	<b>142</b>	<1	<b>422</b>	<b>79</b>	<b>80</b>
<b>Acidity as CaCO<sub>3</sub></b>	mg/L	1	<1	<b>6</b>	<b>10</b>	<b>12</b>	<b>11</b>	<b>21</b>	<b>16</b>	<b>18</b>	<b>3</b>	<b>3</b>
<b>Sulfate as SO<sub>4</sub> - Turbidimetric</b>	mg/L	1	<b>22</b>	<b>158</b>	<b>80</b>	<b>9</b>	<b>34</b>	<b>111</b>	<b>34</b>	<b>92</b>	<b>30</b>	<b>32</b>
<b>Chloride</b>	mg/L	1	<b>235</b>	<b>405</b>	<b>56</b>	<b>14</b>	<b>52</b>	<b>104</b>	<b>24</b>	<b>208</b>	<b>39</b>	<b>50</b>
<b>Calcium</b>	mg/L	1	<b>63</b>	<b>28</b>	<b>22</b>	<b>45</b>	<b>63</b>	<b>49</b>	<b>3</b>	<b>48</b>	<b>32</b>	<b>20</b>
<b>Magnesium</b>	mg/L	1	<b>120</b>	<b>100</b>	<b>18</b>	<b>30</b>	<b>45</b>	<b>41</b>	<b>5</b>	<b>99</b>	<b>15</b>	<b>17</b>
<b>Sodium</b>	mg/L	1	<b>52</b>	<b>317</b>	<b>39</b>	<b>18</b>	<b>64</b>	<b>58</b>	<b>16</b>	<b>142</b>	<b>20</b>	<b>32</b>

Analyte grouping/Analyte	Unit	LOR	Site 12 Pool	Central Ck Pool	Cow Spring Pool	Site 12 Pool GW	South Star Pool	Fig Pool GW	Fig Pool	Central Creek GW	TSF-1	TSF-2
<b>Potassium</b>	mg/L	1	<1	<b>9</b>	<b>2</b>	<b>2</b>	<1	<b>3</b>	<b>1</b>	<b>3</b>	<b>4</b>	<b>3</b>
<b>Arsenic</b>	mg/L	0.001	<b>0.001</b>	<b>0.013</b>	<0.001	<0.001	<0.001	<b>0.002</b>	<0.001	<b>0.012</b>	----	----
<b>Beryllium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	----	----
<b>Barium</b>	mg/L	0.001	<b>0.026</b>	<b>0.057</b>	<b>0.003</b>	<b>0.135</b>	<b>0.016</b>	<b>0.040</b>	<b>0.023</b>	<b>0.024</b>	----	----
<b>Cadmium</b>	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<b>0.0001</b>	----	----
<b>Chromium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.001</b>	----	----
<b>Cobalt</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.004</b>	<b>0.002</b>	<b>0.001</b>	----	----
<b>Copper</b>	mg/L	0.001	<0.001	<0.001	<0.001	<b>0.001</b>	<0.001	<0.001	<0.001	<b>0.016</b>	----	----
<b>Lead</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	----	----
<b>Manganese</b>	mg/L	0.001	<b>0.017</b>	<b>0.179</b>	<b>0.001</b>	<b>0.009</b>	<b>0.051</b>	<b>0.623</b>	<b>0.349</b>	<b>0.001</b>	----	----
<b>Nickel</b>	mg/L	0.001	<0.001	<b>0.002</b>	<b>0.005</b>	<b>0.002</b>	<0.001	<b>0.026</b>	<b>0.010</b>	<b>0.004</b>	----	----
<b>Selenium</b>	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	----	----
<b>Vanadium</b>	mg/L	0.01	<0.01	<b>0.02</b>	<0.01	<b>0.02</b>	<b>0.01</b>	<0.01	<0.01	<b>0.04</b>	----	----
<b>Zinc</b>	mg/L	0.005	<0.005	<0.005	<0.005	<b>0.017</b>	<0.005	<b>0.021</b>	<0.005	<b>0.034</b>	----	----

Analyte grouping/Analyte	Unit	LOR	Site 12 Pool	Central Ck Pool	Cow Spring Pool	Site 12 Pool GW	South Star Pool	Fig Pool GW	Fig Pool	Central Creek GW	TSF-1	TSF-2
<b>Boron</b>	mg/L	0.05	<b>0.20</b>	<b>0.66</b>	<b>0.14</b>	<b>0.11</b>	<b>0.23</b>	<b>0.16</b>	<b>0.06</b>	<b>0.35</b>	----	----
<b>Iron</b>	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<b>2.98</b>	<b>0.59</b>	<0.05	----	----
<b>Aluminium</b>	mg/L	0.01	<0.01	<b>0.05</b>	<0.01	<0.01	<b>0.01</b>	<0.01	<b>0.16</b>	<b>0.01</b>	<b>68.7</b>	<b>4.13</b>
<b>Antimony</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Arsenic</b>	mg/L	0.001	<0.001	<b>0.012</b>	<0.001	<0.001	<0.001	<b>0.003</b>	<0.001	<b>0.011</b>	<b>0.011</b>	<b>0.003</b>
<b>Beryllium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.004</b>	<0.001
<b>Barium</b>	mg/L	0.001	<b>0.026</b>	<b>0.056</b>	<b>0.003</b>	<b>0.096</b>	<b>0.018</b>	<b>0.019</b>	<b>0.022</b>	<b>0.024</b>	<b>0.523</b>	<b>0.065</b>
<b>Bismuth</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Cadmium</b>	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<b>0.0004</b>	<0.0001
<b>Cerium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.154</b>	<b>0.010</b>
<b>Caesium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.015</b>	<0.001
<b>Chromium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.001</b>	<b>0.774</b>	<b>0.070</b>
<b>Cobalt</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.004</b>	<b>0.001</b>	<b>0.002</b>	<b>0.202</b>	<b>0.011</b>
<b>Copper</b>	mg/L	0.001	<0.001	<0.001	<b>0.001</b>	<b>0.002</b>	<0.001	<0.001	<0.001	<b>0.019</b>	<b>0.212</b>	<b>0.017</b>

Analyte grouping/Analyte	Unit	LOR	Site 12 Pool	Central Ck Pool	Cow Spring Pool	Site 12 Pool GW	South Star Pool	Fig Pool GW	Fig Pool	Central Creek GW	TSF-1	TSF-2
<b>Dysprosium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.005</b>	<0.001
<b>Erbium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.002</b>	<0.001
<b>Europium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.002</b>	<0.001
<b>Gadolinium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.008</b>	<0.001
<b>Gallium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.006</b>	<b>0.003</b>
<b>Hafnium</b>	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
<b>Holmium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Indium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Lanthanum</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.040</b>	<b>0.008</b>
<b>Lead</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.056</b>	<b>0.003</b>
<b>Lithium</b>	mg/L	0.001	<b>0.005</b>	<b>0.020</b>	<b>0.005</b>	<b>0.003</b>	<b>0.005</b>	<b>0.031</b>	<b>0.002</b>	<b>0.005</b>	<b>0.097</b>	<b>0.007</b>
<b>Lutetium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Manganese</b>	mg/L	0.001	<b>0.014</b>	<b>0.198</b>	<0.001	<b>0.012</b>	<b>0.192</b>	<b>0.562</b>	<b>0.305</b>	<b>0.006</b>	<b>4.66</b>	<b>0.277</b>
<b>Molybdenum</b>	mg/L	0.001	<0.001	<b>0.003</b>	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.001</b>	<0.001	<0.001

Analyte grouping/Analyte	Unit	LOR	Site 12 Pool	Central Ck Pool	Cow Spring Pool	Site 12 Pool GW	South Star Pool	Fig Pool GW	Fig Pool	Central Creek GW	TSF-1	TSF-2
<b>Neodymium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.048</b>	<b>0.008</b>
<b>Nickel</b>	mg/L	0.001	<0.001	<b>0.001</b>	<b>0.005</b>	<b>0.002</b>	<0.001	<b>0.023</b>	<b>0.007</b>	<b>0.004</b>	<b>1.13</b>	<b>0.053</b>
<b>Praseodymium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.012</b>	<b>0.002</b>
<b>Rubidium</b>	mg/L	0.001	<0.001	<b>0.006</b>	<b>0.002</b>	<0.001	<0.001	<b>0.007</b>	<b>0.002</b>	<b>0.002</b>	<b>0.071</b>	<b>0.006</b>
<b>Samarium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.009</b>	<0.001
<b>Selenium</b>	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
<b>Silver</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Strontium</b>	mg/L	0.001	<b>0.191</b>	<b>0.271</b>	<b>0.087</b>	<b>0.081</b>	<b>0.182</b>	<b>0.099</b>	<b>0.038</b>	<b>0.232</b>	<b>0.245</b>	<b>0.109</b>
<b>Tellurium</b>	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
<b>Terbium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Thallium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Thorium</b>	mg/L	0.001	<b>0.001</b>	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.023</b>	<0.001
<b>Thulium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Tin</b>	mg/L	0.001	<b>0.001</b>	<b>0.001</b>	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Analyte grouping/Analyte	Unit	LOR	Site 12 Pool	Central Ck Pool	Cow Spring Pool	Site 12 Pool GW	South Star Pool	Fig Pool GW	Fig Pool	Central Creek GW	TSF-1	TSF-2
<b>Titanium</b>	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<b>0.23</b>	<b>0.06</b>
<b>Uranium</b>	mg/L	0.001	<0.001	<b>0.008</b>	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.003</b>	<b>0.004</b>	<0.001
<b>Vanadium</b>	mg/L	0.01	<0.01	<b>0.02</b>	<0.01	<b>0.03</b>	<b>0.02</b>	<0.01	<0.01	<b>0.04</b>	<b>0.09</b>	<b>0.02</b>
<b>Ytterbium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.002</b>	<0.001
<b>Yttrium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<b>0.023</b>	<b>0.004</b>
<b>Zinc</b>	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<b>0.012</b>	<0.005	<b>0.036</b>	<b>0.511</b>	<b>0.037</b>
<b>Zirconium</b>	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
<b>Boron</b>	mg/L	0.05	<b>0.17</b>	<b>0.69</b>	<b>0.11</b>	<b>0.11</b>	<b>0.22</b>	<b>0.17</b>	<b>0.06</b>	<b>0.34</b>	<b>0.15</b>	<b>0.08</b>
<b>Iron</b>	mg/L	0.05	<0.05	<b>0.11</b>	<0.05	<0.05	<b>0.19</b>	<b>2.85</b>	<b>0.49</b>	<0.05	<b>112</b>	<b>11.5</b>
<b>Mercury</b>	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<b>0.0002</b>	----	----
<b>Nitrite + Nitrate as N</b>	mg/L	0.01	<b>0.05</b>	<b>0.04</b>	<b>1.32</b>	<b>5.45</b>	<b>0.26</b>	<0.01	<b>0.02</b>	<b>0.70</b>	<b>7.48</b>	<b>0.24</b>
<b>Total Kjeldahl Nitrogen as N</b>	mg/L	0.1	<0.1	<b>0.2</b>	<b>0.1</b>	<b>1.0</b>	<b>0.2</b>	<b>0.1</b>	<0.1	<b>0.2</b>	<b>7.6</b>	<b>2.8</b>
<b>Total Nitrogen as N</b>	mg/L	0.1	<0.1	<b>0.2</b>	<b>1.4</b>	<b>6.4</b>	<b>0.5</b>	<b>0.1</b>	<0.1	<b>0.9</b>	<b>15.1</b>	<b>3.0</b>
<b>Total Phosphorus as P</b>	mg/L	0.01	<b>0.01</b>	<b>0.02</b>	<0.01	<b>0.05</b>	<b>0.01</b>	<b>0.06</b>	<b>0.01</b>	<b>0.02</b>	<b>1.43</b>	<b>0.46</b>

Analyte grouping/Analyte	Unit	LOR	Site 12 Pool	Central Ck Pool	Cow Spring Pool	Site 12 Pool GW	South Star Pool	Fig Pool GW	Fig Pool	Central Creek GW	TSF-1	TSF-2
Reactive Phosphorus as P	mg/L	0.01	<0.01	<b>0.01</b>	<0.01	<b>0.01</b>	<0.01	<0.01	<0.01	<0.01	<b>0.06</b>	<0.01
Total Anions	meq/L	0.01	<b>16.6</b>	<b>22.8</b>	<b>3.92</b>	<b>5.05</b>	<b>10.1</b>	<b>8.08</b>	<b>1.38</b>	<b>16.2</b>	<b>3.30</b>	<b>3.68</b>
Total Cations	meq/L	0.01	<b>15.3</b>	<b>23.6</b>	<b>4.33</b>	<b>5.55</b>	<b>9.63</b>	<b>8.42</b>	<b>1.28</b>	<b>16.8</b>	<b>3.80</b>	<b>3.86</b>
Ionic Balance	%	0.01	<b>4.25</b>	<b>1.76</b>	<b>4.87</b>	<b>4.69</b>	<b>2.61</b>	<b>2.04</b>	<b>3.83</b>	<b>1.76</b>	<b>7.04</b>	<b>2.53</b>
Dissolved Organic Carbon	mg/L	1	----	<b>4</b>	<1	----	<b>4</b>	----	<1	----	----	----
Total Organic Carbon	mg/L	1	----	<b>4</b>	<b>1</b>	----	<b>2</b>	----	<1	----	----	----

Table. Water quality data – late wet season 2021, Bold font denotes values above the limit of reporting (LOR)

Analyte grouping/Analyte	Unit	LOR	OPF 2	DRY RWW	MAR UPST	FIG	OPF 1	S12 GW	COW 2	CC	S12 POOL	COW	SS POOL
		<b>Sample Date:</b>	13/12/2020	13/12/2020	13/12/2020	10/12/2020	13/12/2020	09/12/2020	11/12/2020	13/12/2020	09/12/2020	10/12/2020	08/12/2020
		<b>ALS Sample Number:</b>	EP2013964001	EP2013964002	EP2013964003	EP2013964004	EP2013964005	EP2013964006	EP2013964007	EP2013964008	EP2013964009	EP2013964010	EP2013964011
Suspended Solids (SS)	mg/L	5	<b>32</b>	<b>1000</b>	<b>305</b>	<5	<b>50</b>	----	<b>18</b>	<5	<5	<5	<5
Hydroxide Alkalinity as CaCO <sub>3</sub>	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<b>101</b>	<1	<1
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/L	1	<b>84</b>	<b>25</b>	<b>16</b>	<1	<b>75</b>	<b>389</b>	<b>16</b>	<b>112</b>	<b>489</b>	<b>37</b>	<b>366</b>

Analyte grouping/Analyte	Unit	LOR	OPF 2	DRY RWW	MAR UPST	FIG	OPF 1	S12 GW	COW 2	CC	S12 POOL	COW	SS POOL
<b>Total Alkalinity as CaCO3</b>	mg/L	1	<b>84</b>	<b>25</b>	<b>16</b>	<1	<b>75</b>	<b>389</b>	<b>16</b>	<b>112</b>	<b>590</b>	<b>37</b>	<b>366</b>
<b>Sulfate as SO4 - Turbidimetric</b>	mg/L	1	<b>41</b>	<b>2</b>	<b>3</b>	<b>33</b>	<b>41</b>	<b>39</b>	<b>41</b>	<b>61</b>	<b>20</b>	<b>84</b>	<b>32</b>
<b>Chloride</b>	mg/L	1	<b>51</b>	<b>3</b>	<b>3</b>	<b>24</b>	<b>48</b>	<b>77</b>	<b>30</b>	<b>112</b>	<b>101</b>	<b>56</b>	<b>59</b>
<b><i>Dissolved Major Cations</i></b>													
<b>Calcium</b>	mg/L	1	<b>28</b>	<b>5</b>	<b>5</b>	<b>4</b>	<b>30</b>	<b>54</b>	<b>11</b>	<b>23</b>	<b>37</b>	<b>24</b>	<b>72</b>
<b>Magnesium</b>	mg/L	1	<b>23</b>	<b>2</b>	<b>2</b>	<b>5</b>	<b>18</b>	<b>72</b>	<b>9</b>	<b>28</b>	<b>126</b>	<b>18</b>	<b>50</b>
<b>Sodium</b>	mg/L	1	<b>35</b>	<b>3</b>	<b>2</b>	<b>15</b>	<b>33</b>	<b>74</b>	<b>20</b>	<b>82</b>	<b>68</b>	<b>40</b>	<b>69</b>
<b>Potassium</b>	mg/L	1	<b>3</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>3</b>	<b>1</b>	<b>3</b>	<b>5</b>	<1	<b>2</b>	<b>1</b>
<b><i>EG020F: Dissolved Metals by ICP-MS</i></b>													
<b>Arsenic</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	----	<b>0.004</b>	<b>0.001</b>	<0.001	<0.001
<b>Beryllium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	----	<0.001	<0.001	<0.001	<0.001
<b>Barium</b>	mg/L	0.001	<b>0.061</b>	<b>0.125</b>	<b>0.060</b>	<b>0.052</b>	<b>0.074</b>	<b>0.119</b>	----	<b>0.051</b>	<b>0.053</b>	<b>0.058</b>	<b>0.042</b>
<b>Cadmium</b>	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	----	<0.0001	<0.0001	<0.0001	<0.0001
<b>Chromium</b>	mg/L	0.001	<b>0.002</b>	<0.001	<0.001	<0.001	<b>0.002</b>	<0.001	----	<b>0.002</b>	<0.001	<0.001	<0.001
<b>Cobalt</b>	mg/L	0.001	<0.001	<0.001	<0.001	<b>0.002</b>	<0.001	<0.001	----	<0.001	<0.001	<0.001	<0.001

Analyte grouping/Analyte	Unit	LOR	OPF 2	DRY RWW	MAR UPST	FIG	OPF 1	S12 GW	COW 2	CC	S12 POOL	COW	SS POOL
<b>Copper</b>	mg/L	0.001	<b>0.001</b>	<0.001	<0.001	<0.001	<0.001	<0.001	----	<b>0.001</b>	<0.001	<0.001	<0.001
<b>Lead</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	----	<0.001	<0.001	<0.001	<0.001
<b>Manganese</b>	mg/L	0.001	<b>0.001</b>	<b>0.002</b>	<b>0.008</b>	<b>0.341</b>	<b>0.003</b>	<b>0.017</b>	----	<b>0.016</b>	<b>0.010</b>	<b>0.002</b>	<b>0.088</b>
<b>Nickel</b>	mg/L	0.001	<0.001	<0.001	<b>0.001</b>	<b>0.009</b>	<0.001	<b>0.002</b>	----	<b>0.001</b>	<0.001	<b>0.005</b>	<0.001
<b>Selenium</b>	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	----	<0.01	<0.01	<0.01	<0.01
<b>Vanadium</b>	mg/L	0.01	<b>0.01</b>	<0.01	<0.01	<0.01	<0.01	<b>0.04</b>	----	<b>0.01</b>	<0.01	<0.01	<b>0.01</b>
<b>Zinc</b>	mg/L	0.005	<b>0.008</b>	<b>0.020</b>	<b>0.023</b>	<b>0.016</b>	<b>0.014</b>	<b>0.008</b>	----	<b>0.009</b>	<b>0.007</b>	<b>0.038</b>	<b>0.006</b>
<b>Boron</b>	mg/L	0.05	<b>0.10</b>	<0.05	<0.05	<b>0.09</b>	<b>0.09</b>	<b>0.74</b>	----	<b>0.20</b>	<b>0.32</b>	<b>0.17</b>	<b>0.28</b>
<b>Total Metals by ICP-MS</b>													
<b>Arsenic</b>	mg/L	0.001	<0.001	<b>0.004</b>	<b>0.001</b>	<0.001	<0.001	<0.001	<0.001	<b>0.004</b>	<b>0.002</b>	<0.001	<0.001
<b>Beryllium</b>	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Barium</b>	mg/L	0.001	<b>0.015</b>	<b>0.121</b>	<b>0.040</b>	<b>0.023</b>	<b>0.021</b>	<b>0.104</b>	<b>0.005</b>	<b>0.023</b>	<b>0.014</b>	<b>0.004</b>	<b>0.016</b>
<b>Cadmium</b>	mg/L	0.0001	<0.0001	<b>0.0001</b>	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
<b>Chromium</b>	mg/L	0.001	<b>0.020</b>	<b>0.300</b>	<b>0.283</b>	<0.001	<b>0.018</b>	<b>0.001</b>	<b>0.001</b>	<b>0.003</b>	<0.001	<b>0.001</b>	<0.001
<b>Cobalt</b>	mg/L	0.001	<b>0.002</b>	<b>0.045</b>	<b>0.022</b>	<b>0.001</b>	<b>0.002</b>	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Analyte grouping/Analyte	Unit	LOR	OPF 2	DRY RWW	MAR UPST	FIG	OPF 1	S12 GW	COW 2	CC	S12 POOL	COW	SS POOL
<b>Copper</b>	mg/L	0.001	<b>0.003</b>	<b>0.069</b>	<b>0.031</b>	<0.001	<b>0.004</b>	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Lead</b>	mg/L	0.001	<0.001	<b>0.007</b>	<b>0.002</b>	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<b>Manganese</b>	mg/L	0.001	<b>0.037</b>	<b>1.14</b>	<b>0.607</b>	<b>0.319</b>	<b>0.033</b>	<b>0.023</b>	<b>0.024</b>	<b>0.011</b>	<b>0.021</b>	<b>0.002</b>	<b>0.097</b>
<b>Nickel</b>	mg/L	0.001	<b>0.009</b>	<b>0.186</b>	<b>0.142</b>	<b>0.008</b>	<b>0.008</b>	<b>0.002</b>	<b>0.005</b>	<b>0.002</b>	<0.001	<b>0.005</b>	<0.001
<b>Selenium</b>	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
<b>Vanadium</b>	mg/L	0.01	<b>0.02</b>	<b>0.06</b>	<b>0.04</b>	<0.01	<b>0.01</b>	<b>0.04</b>	<0.01	<b>0.01</b>	<0.01	<0.01	<0.01
<b>Zinc</b>	mg/L	0.005	<0.005	<b>0.141</b>	<b>0.173</b>	<0.005	<b>0.009</b>	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
<b>Boron</b>	mg/L	0.05	<b>0.09</b>	<0.05	<0.05	<b>0.07</b>	<b>0.08</b>	<b>0.68</b>	<b>0.10</b>	<b>0.18</b>	<b>0.30</b>	<b>0.14</b>	<b>0.26</b>
<b><i>Dissolved Mercury by FIMS</i></b>													
<b>Mercury</b>	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	----	<0.0001	<0.0001	<0.0001	<0.0001
<b><i>Total Recoverable Mercury by FIMS</i></b>													
<b>Mercury</b>	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<b>0.0002</b>	<0.0001	<0.0001	<b>0.0004</b>	<0.0001
<b><i>Nitrite plus Nitrate as N (NOx) by Discrete Analyser</i></b>													
<b>Nitrite + Nitrate as N</b>	mg/L	0.01	<b>7.01</b>	<b>0.08</b>	<b>0.12</b>	<0.01	<b>6.88</b>	<b>0.42</b>	----	<b>3.08</b>	<0.01	<b>1.11</b>	<0.01
<b><i>Total Kjeldahl Nitrogen By Discrete Analyser</i></b>													
<b>Total Kjeldahl Nitrogen as N</b>	mg/L	0.1	<b>1.8</b>	<b>2.6</b>	<b>1.6</b>	<0.1	<b>1.6</b>	<0.1	----	<b>0.6</b>	<b>0.2</b>	<b>0.1</b>	<0.1

Analyte grouping/Analyte	Unit	LOR	OPF 2	DRY RWW	MAR UPST	FIG	OPF 1	S12 GW	COW 2	CC	S12 POOL	COW	SS POOL
<b>EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser</b>													
Total Nitrogen as N	mg/L	0.1	8.8	2.7	1.7	<0.1	8.5	0.4	----	3.7	0.2	1.2	<0.1
<b>EK067G: Total Phosphorus as P by Discrete Analyser</b>													
Total Phosphorus as P	mg/L	0.01	<0.02	0.41	0.17	<0.01	<0.02	<0.01	----	0.01	<0.01	<0.01	<0.01
<b>Reactive Phosphorus as P by discrete analyser</b>													
Reactive Phosphorus as P	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	----	<0.01	<0.01	<0.01	<0.01
<b>onic Balance</b>													
Total Anions	meq/L	0.01	4.47	0.62	0.48	1.36	4.20	10.8	2.02	6.67	15.0	4.07	9.64
Total Cations	meq/L	0.01	4.89	0.57	0.53	1.29	4.49	11.9	2.24	7.15	15.2	4.47	10.7
Ionic Balance	%	0.01	4.45	4.65	5.09	2.82	3.35	4.90	5.09	3.47	0.40	4.71	5.36
<b>Dissolved Organic Carbon (DOC)</b>													
Dissolved Organic Carbon	mg/L	1	----	----	----	4	----	----	----	----	10	2	11
<b>EP005: Total Organic Carbon (TOC)</b>													
Total Organic Carbon	mg/L	1	----	----	----	2	----	----	----	----	16	1	----

Table. Water quality data – late wet season 2021, Bold font denotes values above the limit of reporting (LOR)

Analyte grouping/analyte	Unit		GV_SW_Pool_Mundag oora_SS	GV_SW_Pool I_SW	IB_SW_Pool_Cent ral Ck	IB_SW_Pool_Cow Spring	IB_SW_Pool I_Fig	IB_SW_Pool12 _01
		Sample date:	21/05/2021	21/05/2021	22/05/2021	25/05/2021	24/05/2021	
		LOR						23/05/2021
<b>EA005P: pH by PC Titrator</b>								
pH Value	pH Unit	0.01	<b>7.98</b>	<b>8.31</b>	<b>8.38</b>	<b>7.05</b>	<b>4.19</b>	<b>8.42</b>
<b>EA010P: Conductivity by PC Titrator</b>								
Electrical Conductivity @ 25°C	µS/cm	1	<b>738</b>	<b>1350</b>	<b>2710</b>	<b>421</b>	<b>189</b>	<b>1120</b>
<b>EA016: Calculated TDS (from Electrical Conductivity)</b>								
Total Dissolved Solids (Calc.)	mg/L	1	<b>480</b>	<b>878</b>	<b>1760</b>	<b>274</b>	<b>123</b>	<b>728</b>
<b>EA025: Total Suspended Solids dried at 104 ± 2°C</b>								
Suspended Solids (SS)	mg/L	5	<5	<5	<b>5</b>	<5	<5	<5
<b>EA045: Turbidity</b>								
Turbidity	NTU	0.1	<b>0.3</b>	<b>0.2</b>	<b>0.4</b>	<b>0.1</b>	<b>3.6</b>	<b>0.2</b>
<b>EA065: Total Hardness as CaCO3</b>								
Total Hardness as CaCO3	mg/L	1	<b>327</b>	<b>508</b>	<b>735</b>	<b>128</b>	<b>28</b>	<b>623</b>

Analyte grouping/analyte	Unit	LOR	GV_SW_Pool_Mundag ooora_SS	GV_SW_Poo l_SW	IB_SW_Pool_Cent ral Ck	IB_SW_Pool_Cow Spring	IB_SW_Poo l_Fig	IB_SW_Pool12 _01	
			Sample date:	21/05/2021	21/05/2021	22/05/2021	25/05/2021	24/05/2021	
									23/05/2021
<b>ED037P: Alkalinity by PC Titrator</b>									
Hydroxide Alkalinity as CaCO <sub>3</sub>	mg/L	1	<1	<1	<1	<1	<1	<1	
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/L	1	<1	<b>6</b>	<b>19</b>	<1	<1	<b>31</b>	
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/L	1	<b>344</b>	<b>512</b>	<b>558</b>	<b>35</b>	<1	<b>561</b>	
Total Alkalinity as CaCO <sub>3</sub>	mg/L	1	<b>344</b>	<b>518</b>	<b>576</b>	<b>35</b>	<1	<b>592</b>	
<b>ED038A: Acidity</b>									
Acidity as CaCO <sub>3</sub>	mg/L	1	<b>6</b>	<1	<1	<b>6</b>	<b>10</b>	<1	
<b>ED041G: Sulfate (Turbidimetric) as SO<sub>4</sub><sup>2-</sup> by DA</b>									
Sulfate as SO <sub>4</sub> - Turbidimetric	mg/L	1	<b>29</b>	<b>94</b>	<b>209</b>	<b>81</b>	<b>34</b>	<b>14</b>	
<b>ED045G: Chloride by Discrete Analyser</b>									
Chloride	mg/L	1	<b>43</b>	<b>138</b>	<b>522</b>	<b>61</b>	<b>23</b>	<b>63</b>	
<b>ED093F-DW: Dissolved Major Cations - Drinking Water</b>									
Calcium	mg/L	0.1	<b>58.6</b>	<b>54.1</b>	<b>37.0</b>	<b>21.6</b>	<b>2.8</b>	<b>54.8</b>	

Analyte grouping/analyte	Unit	LOR	GV_SW_Pool_Mundag ooora_SS	GV_SW_Poo l_SW	IB_SW_Pool_Cent ral Ck	IB_SW_Pool_Cow Spring	IB_SW_Poo l_Fig	IB_SW_Pool12 _01	
			Sample date:	21/05/2021	21/05/2021	22/05/2021	25/05/2021	24/05/2021	
									23/05/2021
<b>Magnesium</b>	mg/L	0.1	<b>43.8</b>	<b>90.7</b>	<b>156</b>	<b>18.0</b>	<b>5.2</b>	<b>118</b>	
<b>Potassium</b>	mg/L	0.1	<b>0.7</b>	<b>1.3</b>	<b>12.9</b>	<b>2.3</b>	<b>1.4</b>	<b>0.7</b>	
<b>Sodium</b>	mg/L	0.1	<b>60.0</b>	<b>126</b>	<b>348</b>	<b>36.6</b>	<b>14.4</b>	<b>52.1</b>	
<i>EG035F: Dissolved Mercury by FIMS</i>									
<b>Mercury</b>	mg/L	0.00004	<b>0.00007</b>	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	
<i>EG035T: Total Mercury by FIMS</i>									
<b>Mercury</b>	mg/L	0.00004	<0.00004	<0.00004	<0.00004	<b>0.00023</b>	<0.00004	<0.00004	
<i>EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS</i>									
<b>Aluminium</b>	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<b>0.198</b>	<0.005	
<b>Iron</b>	mg/L	0.002	<b>0.007</b>	<0.002	<b>0.005</b>	<b>0.005</b>	<b>0.414</b>	<b>0.014</b>	
<b>Selenium</b>	mg/L	0.0002	<0.0002	<0.0002	<b>0.0002</b>	<b>0.0002</b>	<0.0002	<0.0002	
<b>Arsenic</b>	mg/L	0.0002	<b>0.0004</b>	<b>0.0015</b>	<b>0.0139</b>	<0.0002	<0.0002	<b>0.0010</b>	
<b>Barium</b>	mg/L	0.0005	<b>0.0164</b>	<b>0.0330</b>	<b>0.0555</b>	<b>0.0530</b>	<b>0.0222</b>	<b>0.0243</b>	
<b>Beryllium</b>	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
<b>Boron</b>	mg/L	0.005	<b>0.160</b>	<b>0.283</b>	<b>0.680</b>	<b>0.125</b>	<b>0.058</b>	<b>0.159</b>	
<b>Cadmium</b>	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	

Analyte grouping/analyte	Unit	LOR	GV_SW_Pool_Mundag oora_SS	GV_SW_Poo l_SW	IB_SW_Pool_Cent ral Ck	IB_SW_Pool_Cow Spring	IB_SW_Poo l_Fig	IB_SW_Pool12 _01	
			Sample date:	21/05/2021	21/05/2021	22/05/2021	25/05/2021	24/05/2021	
									23/05/2021
<b>Chromium</b>	mg/L	0.0002	<0.0002	<0.0002	<0.0002	<b>0.0006</b>	<0.0002	<0.0002	
<b>Cobalt</b>	mg/L	0.0001	<0.0001	<0.0001	<b>0.0002</b>	<0.0001	<b>0.0016</b>	<0.0001	
<b>Copper</b>	mg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	
<b>Lead</b>	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
<b>Manganese</b>	mg/L	0.0005	<b>0.0566</b>	<b>0.0055</b>	<b>0.0138</b>	<b>0.0010</b>	<b>0.359</b>	<b>0.0128</b>	
<b>Nickel</b>	mg/L	0.0005	<b>0.0009</b>	<b>0.0005</b>	<b>0.0013</b>	<b>0.0055</b>	<b>0.0098</b>	<0.0005	
<b>Vanadium</b>	mg/L	0.0002	<b>0.0136</b>	<b>0.0074</b>	<b>0.0312</b>	<0.0002	<0.0002	<b>0.0008</b>	
<b>Zinc</b>	mg/L	0.001	<0.001	<b>0.004</b>	<0.001	<b>0.034</b>	<b>0.002</b>	<0.001	
<i>EG094T: Total metals in Fresh water by ORC-ICPMS</i>									
<b>Aluminium</b>	mg/L	0.005	<b>0.008</b>	<b>0.011</b>	<b>0.017</b>	<0.005	<b>0.227</b>	<b>0.007</b>	
<b>Iron</b>	mg/L	0.002	<b>0.125</b>	<b>0.016</b>	<b>0.067</b>	<b>0.017</b>	<b>1.46</b>	<b>0.027</b>	
<b>Selenium</b>	mg/L	0.0002	<0.0002	<0.0002	<b>0.0002</b>	<0.0002	<0.0002	<0.0002	
<b>Arsenic</b>	mg/L	0.0002	<b>0.0004</b>	<b>0.0012</b>	<b>0.0122</b>	<0.0002	<b>0.0004</b>	<b>0.0008</b>	
<b>Barium</b>	mg/L	0.0005	<b>0.0147</b>	<b>0.0218</b>	<b>0.0521</b>	<b>0.0033</b>	<b>0.0214</b>	<b>0.0228</b>	
<b>Beryllium</b>	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
<b>Boron</b>	mg/L	0.005	<b>0.141</b>	<b>0.251</b>	<b>0.600</b>	<b>0.119</b>	<b>0.053</b>	<b>0.138</b>	
<b>Cadmium</b>	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	
<b>Chromium</b>	mg/L	0.0002	<0.0002	<b>0.0003</b>	<b>0.0004</b>	<b>0.0006</b>	<0.0002	<b>0.0003</b>	
<b>Cobalt</b>	mg/L	0.0001	<0.0001	<0.0001	<b>0.0002</b>	<0.0001	<b>0.0016</b>	<0.0001	

Analyte grouping/analyte	Unit	LOR	GV_SW_Pool_Mundag oora_SS	GV_SW_Poo l_SW	IB_SW_Pool_Cent ral Ck	IB_SW_Pool_Cow Spring	IB_SW_Poo l_Fig	IB_SW_Pool12 _01	
			Sample date:	21/05/2021	21/05/2021	22/05/2021	25/05/2021	24/05/2021	
									23/05/2021
<b>Copper</b>	mg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	
<b>Lead</b>	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
<b>Manganese</b>	mg/L	0.0005	<b>0.0793</b>	<b>0.0229</b>	<b>0.0372</b>	<b>0.0008</b>	<b>0.331</b>	<b>0.0129</b>	
<b>Nickel</b>	mg/L	0.0005	<b>0.0006</b>	<b>0.0006</b>	<b>0.0012</b>	<b>0.0049</b>	<b>0.0095</b>	<0.0005	
<b>Vanadium</b>	mg/L	0.0002	<b>0.0132</b>	<b>0.0068</b>	<b>0.0284</b>	<0.0002	<0.0002	<b>0.0008</b>	
<b>Zinc</b>	mg/L	0.001	<0.001	<0.001	<0.001	<b>0.002</b>	<b>0.002</b>	<0.001	
<i>EK055G-NH4: Ammonium as N by DA</i>									
<b>Ammonium as N</b>	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
<i>EK055G: Ammonia as N by Discrete Analyser</i>									
<b>Ammonia as N</b>	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
<i>EK057G: Nitrite as N by Discrete Analyser</i>									
<b>Nitrite as N</b>	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
<i>EK058G: Nitrate as N by Discrete Analyser</i>									
<b>Nitrate as N</b>	mg/L	0.01	<b>0.09</b>	<0.01	<0.01	<b>1.26</b>	<0.01	<0.01	

Analyte grouping/analyte	Unit	LOR	GV_SW_Pool_Mundag oora_SS	GV_SW_Poo l_SW	IB_SW_Pool_Cent ral Ck	IB_SW_Pool_Cow Spring	IB_SW_Poo l_Fig	IB_SW_Pool12 _01	
			Sample date:	21/05/2021	21/05/2021	22/05/2021	25/05/2021	24/05/2021	
									23/05/2021
<b>EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser</b>									
Nitrite + Nitrate as N	mg/L	0.01	<b>0.09</b>	<0.01	<0.01	<b>1.26</b>	<0.01	<0.01	
<b>EK061G: Total Kjeldahl Nitrogen By Discrete Analyser</b>									
Total Kjeldahl Nitrogen as N	mg/L	0.1	<b>0.3</b>	<b>0.2</b>	<b>0.1</b>	<b>0.2</b>	<b>0.1</b>	<b>0.1</b>	
<b>EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser</b>									
Total Nitrogen as N	mg/L	0.1	<b>0.4</b>	<b>0.2</b>	<b>0.1</b>	<b>1.5</b>	<b>0.1</b>	<b>0.1</b>	
<b>EK067G: Total Phosphorus as P by Discrete Analyser</b>									
Total Phosphorus as P	mg/L	0.01	<b>0.01</b>	<0.01	<b>0.03</b>	<0.01	<b>0.02</b>	<0.01	
<b>EK071G: Reactive Phosphorus as P by discrete analyser</b>									
Reactive Phosphorus as P	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Reactive Phosphate	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	

Analyte grouping/analyte	Unit	LOR	GV_SW_Pool_Mundag oora_SS	GV_SW_Poo l_SW	IB_SW_Pool_Cent ral Ck	IB_SW_Pool_Cow Spring	IB_SW_Poo l_Fig	IB_SW_Pool12 _01	
			Sample date:	21/05/2021	21/05/2021	22/05/2021	25/05/2021	24/05/2021	
									23/05/2021
<b>EP002: Dissolved Organic Carbon (DOC)</b>									
Dissolved Organic Carbon	mg/L	1	2	3	2	<1	<1	2	
<b>EP005: Total Organic Carbon (TOC)</b>									
Total Organic Carbon	mg/L	1	6	4	3	<1	<1	2	
<b>EP025: Oxygen - Dissolved (DO)</b>									
Dissolved Oxygen	mg/L	0.1	9.1	10.0	10.3	9.9	9.2	10.3	
<b>ED009: Anions</b>									
Fluoride	mg/L	0.010	0.180	0.392	0.345	0.069	0.019	0.166	

# APPENDIX B. SEDIMENT QUALITY DATA

Table 26 Sediment quality data – late wet season 2019/2020. Bold font denotes values above the limit of reporting (LOR).

Analyte grouping/Analyte	Unit	LOR	South Star Pool	Cow Spring Pool	Fig Pool	Site 12 Pool	Central Ck Pool
		<i>Sample Date</i>	30/05/2020	30/05/2020	30/05/2020	29/05/2020	31/05/2020
		<i>ALS Sample Number</i>	EP2005660011	EP2005660012	EP2005660013	EP2005660014	EP2005660015
Total Soluble Salts	mg/kg	5	<b>693</b>	<b>114</b>	<b>248</b>	<b>408</b>	<b>1180</b>
Moisture Content (Dried @ 105-110°C)	%	1.0	<b>59.7</b>	<b>23.9</b>	----	<b>28.6</b>	<b>29.8</b>
Total Alkalinity as CaCO <sub>3</sub>	mg/kg	1	<b>77</b>	<b>4</b>	<b>2</b>	<b>71</b>	<b>120</b>
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	1	<b>77</b>	<b>4</b>	<b>2</b>	<b>67</b>	<b>120</b>
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	1	<1	<1	<1	<b>4</b>	<1
Acidity	mg/kg	1	<b>12</b>	<1	<b>14</b>	<b>4</b>	<b>4</b>
Sulfate as SO <sub>4</sub> <sup>2-</sup> (soluble sulfate by ICPAES)	mg/kg	10	<b>80</b>	<b>40</b>	<b>120</b>	<b>20</b>	<b>200</b>
Chloride (by Discrete Analyser)	mg/kg	10	<b>100</b>	<b>20</b>	<10	<b>30</b>	<b>170</b>
Calcium	mg/kg	10	<b>220</b>	<10	<b>30</b>	<b>50</b>	<b>40</b>
Magnesium	mg/kg	10	<b>110</b>	<10	<10	<b>60</b>	<b>70</b>
Sodium	mg/kg	10	<b>170</b>	<b>20</b>	<b>10</b>	<b>40</b>	<b>220</b>
Potassium	mg/kg	10	<b>20</b>	<10	<b>10</b>	<10	<b>20</b>
Mercury (FIMS)	mg/kg	0.1	<b>0.6</b>	<b>4.4</b>	<0.1	<0.1	<0.1
Nitrite + Nitrate as N (Sol.)	mg/kg	0.1	<0.1	<b>0.1</b>	<0.1	<0.1	<0.1
Total Kjeldahl Nitrogen as N	mg/kg	20	<b>3950</b>	<b>750</b>	<b>1110</b>	<b>520</b>	<b>1090</b>
Total Nitrogen as N	mg/kg	20	<b>3950</b>	<b>750</b>	<b>1110</b>	<b>520</b>	<b>1090</b>
Total Phosphorus as P	mg/kg	2	<b>242</b>	<b>320</b>	<b>60</b>	<b>73</b>	<b>100</b>

Analyte grouping/Analyte	Unit	LOR	South Star Pool	Cow Spring Pool	Fig Pool	Site 12 Pool	Central Ck Pool
Reactive Phosphorus as P	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Organic Carbon	%	0.02	<b>3.15</b>	<b>0.22</b>	<b>0.30</b>	<b>0.18</b>	<b>1.80</b>
<i>Total Metals by ICP-AES</i>							
Arsenic	mg/kg	5	<b>9</b>	<b>9</b>	<5	<5	<b>9</b>
Barium	mg/kg	10	<b>40</b>	<10	<b>10</b>	<b>50</b>	<b>40</b>
Beryllium	mg/kg	1	<b>1</b>	<1	<1	<1	<1
Boron	mg/kg	50	<50	<50	<50	<50	<50
Cadmium	mg/kg	1	<1	<1	<1	<1	<1
Chromium	mg/kg	2	<b>169</b>	<b>165</b>	<b>143</b>	<b>384</b>	<b>219</b>
Cobalt	mg/kg	2	<b>22</b>	<b>4</b>	<2	<b>23</b>	<b>16</b>
Copper	mg/kg	5	<b>52</b>	<b>7</b>	<b>8</b>	<b>23</b>	<b>22</b>
Iron	mg/kg	50	<b>76600</b>	<b>124000</b>	<b>58500</b>	<b>32800</b>	<b>26600</b>
Lead	mg/kg	5	<5	<b>9</b>	<5	<5	<5
Manganese	mg/kg	5	<b>481</b>	<b>151</b>	<b>94</b>	<b>561</b>	<b>476</b>
Nickel	mg/kg	2	<b>79</b>	<b>18</b>	<b>6</b>	<b>179</b>	<b>112</b>
Selenium	mg/kg	5	<b>5</b>	<b>6</b>	<5	<5	<5
Vanadium	mg/kg	5	<b>166</b>	<b>62</b>	<b>27</b>	<b>48</b>	<b>39</b>
Zinc	mg/kg	5	<b>39</b>	<b>16</b>	<b>5</b>	<b>26</b>	<b>35</b>

Analyte grouping/Analyte	Unit	LOR	Mundagoora Pool	Fig Pool	Site 12 Pool
		<i>Sample Date</i>	08/12/2020	10/12/2020	09/12/2020
		<i>ALS Sample Number</i>	EP2013964-012	EP2013964-013	EP2013964-014
Total Soluble Salts	mg/kg	5	-		
Moisture Content (Dried @ 105-110°C)	%	1.0	<b>49.3</b>	<b>38.3</b>	<b>20.9</b>
Total Alkalinity as CaCO <sub>3</sub>	mg/kg	1	<b>104</b>	<b>&lt;5</b>	<b>329</b>
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	1	<b>104</b>	<b>&lt;5</b>	<b>265</b>
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	1	<b>&lt;5</b>	<b>&lt;5</b>	<b>65</b>
Acidity	mg/kg	1	<b>53</b>	<b>166</b>	<b>&lt;5</b>
Sulfate as SO <sub>4</sub> <sup>2-</sup> (soluble sulfate by ICPAES)	mg/kg	10	<b>70</b>	<b>160</b>	<b>&lt;10</b>
Chloride (by Discrete Analyser)	mg/kg	10	<b>40</b>	<b>40</b>	<b>30</b>
Calcium	mg/kg	10	<b>30</b>	<b>&lt;10</b>	<b>40</b>
Magnesium	mg/kg	10	<b>20</b>	10	<b>90</b>
Sodium	mg/kg	10	<b>100</b>	<b>40</b>	<b>40</b>
Potassium	mg/kg	10	<b>&lt;10</b>	<b>30</b>	<b>&lt;10</b>
Mercury (FIMS)	mg/kg	0.1	-		
Nitrite + Nitrate as N (Sol.)	mg/kg	0.1	<b>&lt;0.1</b>	<b>&lt;0.1</b>	<b>&lt;0.1</b>
Total Kjeldahl Nitrogen as N	mg/kg	20	<b>1970</b>	<b>1670</b>	<b>200</b>
Total Nitrogen as N	mg/kg	20	<b>1970</b>	<b>1670</b>	<b>200</b>
Total Phosphorus as P	mg/kg	2	<b>179</b>	<b>223</b>	<b>61</b>
Reactive Phosphorus as P	mg/kg	0.1	<b>&lt;0.1</b>	<b>&lt;0.1</b>	<b>&lt;0.1</b>

Total Organic Carbon	%	0.02	<b>4.88</b>	<b>3.60</b>	<b>0.29</b>
<i>Total Metals by ICP-AES</i>					
Arsenic	mg/kg	5	-		
Barium	mg/kg	10	-		
Beryllium	mg/kg	1	-		
Boron	mg/kg	50	-		
Cadmium	mg/kg	1	-		
Chromium	mg/kg	2	-		
Cobalt	mg/kg	2	-		
Copper	mg/kg	5	-		
Iron	mg/kg	50	<b>57000</b>	<b>90200</b>	<b>41200</b>
Lead	mg/kg	5	-		
Manganese	mg/kg	5	-		
Nickel	mg/kg	2	-		
Selenium	mg/kg	5	-		
Vanadium	mg/kg	5	-		
Zinc	mg/kg	5	-		

Table. Sediment quality data – late dry season (2020). Bold font denotes values above the limit of reporting (LOR)

Table. Sediment quality data – late wet season (2021). Bold font denotes values above the limit of reporting (LOR)

Analyte grouping/Analyte	Unit	LOR	Mundagoora Pool	Fig Pool	Site 12 Pool	Central Ck Pool
		<i>Sample Date</i>	21/05/2021	30/05/2020	23/05/2021	28/05/2021
		<i>ALS Sample Number</i>	EP2106077-001	EP2106077-005	EP2106077-006	EP2106077-003
Total Soluble Salts	mg/kg	5	<b>200</b>	<b>384</b>	<b>402</b>	<b>559</b>
Moisture Content (Dried @ 105-110°C)	%	1.0	<b>24.8</b>	<b>37</b>	<b>25</b>	<b>19.1</b>
Total Alkalinity as CaCO <sub>3</sub>	mg/kg	1	<5	<5	<b>26</b>	<5
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	1	<b>239</b>	<5	<b>26</b>	<b>198</b>
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/kg	1	<b>239</b>	<5	<b>253</b>	<b>198</b>
Acidity	mg/kg	1	<b>62</b>	<b>1000</b>	<5	<5
Sulfate as SO <sub>4</sub> <sup>2-</sup> (soluble sulfate by ICPAES)	mg/kg	10	<10	<b>150</b>	<10	<b>40</b>
Chloride (by Discrete Analyser)	mg/kg	10	<b>20</b>	<b>60</b>	<b>20</b>	<b>90</b>
Calcium	mg/kg	10	<b>30</b>	<10	<b>30</b>	<10
Magnesium	mg/kg	10	<b>20</b>	10	<b>60</b>	<b>40</b>
Sodium	mg/kg	10	<b>30</b>	<b>12</b>	<b>6</b>	<b>10</b>
Potassium	mg/kg	10	<10	<b>10</b>	<10	<10
Mercury (FIMS)	mg/kg	0.1	<0.1	<b>0.2</b>	<0.1	<0.1
Nitrite + Nitrate as N (Sol.)	mg/kg	0.1	<0.1	<b>0.2</b>	<0.1	<0.1
Total Kjeldahl Nitrogen as N	mg/kg	20	<b>430</b>	<b>3030</b>	<b>80</b>	<b>80</b>
Total Nitrogen as N	mg/kg	20	<b>430</b>	<b>3030</b>	<b>80</b>	<b>80</b>
Total Phosphorus as P	mg/kg	2	<b>190</b>	<b>310</b>	<b>56</b>	<b>43</b>

Analyte grouping/Analyte	Unit	LOR	Mundagoora Pool	Fig Pool	Site 12 Pool	Central Ck Pool
Reactive Phosphorus as P	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1
Total Organic Carbon	%	0.02		<b>3.08</b>	<b>0.2</b>	<b>0.18</b>
<i>Total Metals by ICP-AES</i>						
Arsenic	mg/kg	5	<b>9</b>	<b>12</b>	<b>6</b>	<b>10</b>
Barium	mg/kg	10	<b>60</b>	<b>40</b>	<b>70</b>	<b>30</b>
Beryllium	mg/kg	1	<1	<1	<1	<1
Boron	mg/kg	50	<b>50</b>	<50	<50	<50
Cadmium	mg/kg	1	<1	<1	<1	<1
Chromium	mg/kg	2	<b>68</b>	<b>127</b>	<b>492</b>	<b>247</b>
Cobalt	mg/kg	2	<b>33</b>	<b>2</b>	<b>36</b>	<b>18</b>
Copper	mg/kg	5	<b>67</b>	<b>24</b>	<b>37</b>	<b>17</b>
Iron	mg/kg	50	<b>114000</b>	<b>64600</b>	<b>49400</b>	<b>30600</b>
Lead	mg/kg	5	6	<5	<5	<5
Manganese	mg/kg	5	<b>674</b>	<b>39</b>	<b>894</b>	<b>492</b>
Nickel	mg/kg	2	<b>134</b>	<b>12</b>	<b>246</b>	<b>113</b>
Selenium	mg/kg	5	<5	<5	<5	<5
Vanadium	mg/kg	5	<b>161</b>	<b>53</b>	<b>65</b>	<b>36</b>
Zinc	mg/kg	5	<b>30</b>	<b>8</b>	<b>44</b>	<b>20</b>

# APPENDIX C. FISH DATA

Table 27 Fish catch summary table – Late Wet 2020

Species	Central Creek Pool	Cow Spring Pool	Site 12 Pool	South Star Pool	Fig Pool
<b><i>Neosilurus hyrtlii</i></b>	0	0	37	0	0
50 - 90 mm	0	0	18	0	0
90 - 130 mm	0	0	16	0	0
130 - 170 mm	0	0	3	0	0
<b><i>Melanotaenia australis</i></b>	171	67	196	212	0
< 30 mm	1	13	0	63	0
30 - 60 mm	113	37	84	95	0
60 - 90 mm	57	15	112	54	0
> 90 mm	0	2	0	0	0
<b><i>Leiopotherapon unicolor</i></b>	207	0	24	1	0
30 - 60 mm	109	0	7	0	0
60 - 90 mm	53	0	10	0	0
> 90 mm	45	0	7	1	0
<b>Total catch</b>	378	67	257	213	0
<b>Soak duration</b>	19	17.7	15.5	16.5	16
<b>CPUE</b>	19.9	3.8	16.6	12.9	0

<sup>1</sup> CPUE is catch per unit effort, a measure of relative abundance. Effort is net and trap soak duration hours.

## Fish standard length and total length - Late Wet 2020

Site Name	Gear Type	Rep- licate	Date	Time In	Time Out	Habitat Type	Species	Standard Length (mm)	Total length (mm)
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	32	37
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	36	45
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	38	47
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	37	49
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	41	49
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Leiopotherapon unicolor</i>	42	50
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	46	56
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	46	58
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	49	58
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	55	67
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	60	74
Central Ck Pool	Box	1	26/06/2020	16:00	10:30	Muddy	<i>Leiopotherapon unicolor</i>	66	81
Central Ck Pool	Box	2	26/06/2020	16:00	10:45	Muddy	<i>Leiopotherapon unicolor</i>	69	85
Central Ck Pool	Box	2	26/06/2020	16:00	10:45	Muddy	<i>Leiopotherapon unicolor</i>	75	94
Central Ck Pool	Box	2	26/06/2020	16:00	10:45	Muddy	<i>Leiopotherapon unicolor</i>	80	97
Central Ck Pool	Box	2	26/06/2020	16:00	10:45	Muddy	<i>Leiopotherapon unicolor</i>	81	100
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	87	109
Central Ck Pool	Box	1	26/06/2020	16:00	10:30	Muddy	<i>Leiopotherapon unicolor</i>	94	115
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	100	125
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	107	130
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	115	139
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	119	141
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	119	142
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	120	144

Site Name	Gear Type	Rep-licate	Date	Time In	Time Out	Habitat Type	Species	Standard Length (mm)	Total length (mm)
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	120	145
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	127	154
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	134	160
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	134	161
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	147	173
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Leiopotherapon unicolor</i>	174	205
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	29	38
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	33	41
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	33	42
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	33	42
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	39	43
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	37	46
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	37	46
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	38	47
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	37	48
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	38	48
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	37	49
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	38	50
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	38	50
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	39	50
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	41	50
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	40	51
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	41	51
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	40	52
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	47	60
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	47	61

Site Name	Gear Type	Rep-licate	Date	Time In	Time Out	Habitat Type	Species	Standard Length (mm)	Total length (mm)
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	49	61
Central Ck Pool	Bait	2	26/06/2020	16:00	9:45	Muddy	<i>Melanotaenia australis</i>	49	62
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	50	64
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	52	65
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	53	65
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	53	66
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	59	75
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	65	80
Central Ck Pool	Fyke	1	26/06/2020	16:00	11:00	Pool	<i>Melanotaenia australis</i>	67	84
Central Ck Pool	Box	2	26/06/2020	16:00	10:45	Muddy	<i>Melanotaenia australis</i>	67	85
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	17	22
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	18	23
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	20	25
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	23	27
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	23	30
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	24	30
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	24	31
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	25	32
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	29	37
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	30	39
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	32	40
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	30	41
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	30	41
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	31	41
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	33	42
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	33	43

Site Name	Gear Type	Rep-licate	Date	Time In	Time Out	Habitat Type	Species	Standard Length (mm)	Total length (mm)
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	35	43
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	38	46
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	40	50
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	49	62
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	53	67
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	57	72
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	60	74
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	62	80
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	67	85
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	68	85
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	70	86
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	71	87
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	80	100
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Melanotaenia australis</i>	83	104
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Uperoleia sp.</i>	NA	24
Cow Spring Pool	Bait	1	29/06/2020	16:00	9:30	Marco/Edge	<i>Uperoleia sp.</i>	NA	29
Cow Spring Pool	Bait	2	29/06/2020	16:00	9:30	Reeds	<i>Uperoleia sp.</i>	NA	35
Cow Spring Pool	Fyke	1	29/06/2020	16:00	9:45	Pool	<i>Uperoleia sp.</i>	NA	36
Cow Spring Pool	Bait	1	29/06/2020	16:00	9:30	Marco/Edge	<i>Uperoleia sp.</i>	NA	40
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	32	41
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	38	50
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	43	54
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	44	55
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	45	57
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	46	57
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	47	59

Site Name	Gear Type	Rep-licate	Date	Time In	Time Out	Habitat Type	Species	Standard Length (mm)	Total length (mm)
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	49	61
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	49	62
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	52	63
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	54	63
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	54	67
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	55	71
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	58	73
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	59	74
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	64	79
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	70	87
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	78	92
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	79	95
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	104	122
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	111	134
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	148	162
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	155	182
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	166	199
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	45	56
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	46	57
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	46	58
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	46	58
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	47	59
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	47	59
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	47	60
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	48	60
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	48	60

Site Name	Gear Type	Rep-licate	Date	Time In	Time Out	Habitat Type	Species	Standard Length (mm)	Total length (mm)
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	48	61
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	48	61
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	49	61
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	50	61
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	49	62
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	49	62
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	51	64
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	51	64
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	52	64
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	53	64
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	52	66
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	53	66
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	53	66
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	54	66
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	53	67
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	54	67
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	54	67
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	54	69
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	59	75
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	68	76
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Melanotaenia australis</i>	58	77
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	55	63
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	54	69
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	67	75
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	70	76
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	65	77

Site Name	Gear Type	Rep-licate	Date	Time In	Time Out	Habitat Type	Species	Standard Length (mm)	Total length (mm)
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	70	80
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	72	80
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	72	81
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	73	82
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	74	84
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	75	84
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	76	85
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	75	86
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	76	86
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	79	87
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	79	88
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	80	90
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	80	91
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	82	91
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	80	92
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	84	94
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	92	104
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	95	105
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	95	106
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	97	110
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	101	111
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	102	113
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	105	117
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	105	120
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	110	120
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlii</i>	107	122

Site Name	Gear Type	Rep- licate	Date	Time In	Time Out	Habitat Type	Species	Standard Length (mm)	Total length (mm)
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlilii</i>	110	123
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlilii</i>	110	125
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlilii</i>	115	126
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlilii</i>	125	144
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlilii</i>	129	144
Site 12 Pool	Fyke	1	28/06/2020	17:00	8:30	Pool	<i>Neosilurus hyrtlilii</i>	150	162
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Leiopotherapon unicolor</i>	104	126
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	21	26
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	21	26
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	23	26
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	23	27
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	23	30
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	24	31
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	25	31
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	26	32
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	26	33
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	26	33
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	41	53
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	43	53
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	46	55
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	45	57
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	46	57
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	46	57
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	46	58
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	48	61
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	50	62

Site Name	Gear Type	Rep- licate	Date	Time In	Time Out	Habitat Type	Species	Standard Length (mm)	Total length (mm)
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	50	63
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	54	66
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	53	67
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	55	69
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	55	70
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	57	70
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	59	74
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	63	80
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	64	80
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	63	81
South Star	Fyke	1	27/06/2020	16:00	8:30	Pool	<i>Melanotaenia australis</i>	65	82

Table. Fish standard length (SL) and total length (TL) for Iron Bridge pools in the late dry season 2020

Site Name	Gear Type	Replicate	Date	Time Out	Habitat Type	Species	S L	TL	Size
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	25	33	X Small (<30mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	28	37	X Small (<30mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	30	39	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	30	38	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	30	39	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	31	40	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	32	41	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	34	42	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	36	46	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	37	47	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	38	50	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	39	51	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	39	50	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	40	51	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	40	50	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	42	53	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	43	56	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	45	57	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	47	61	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	48	60	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	50	63	Small (30-60mm)

Site Name	Gear Type	Replicate	Date	Time Out	Habitat Type	Species	S L	TL	Size
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	55	72	Small (30-60mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	70	85	Large (60-90mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	72	92	Large (60-90mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	75	94	Large (60-90mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	81	112	Large (60-90mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	83	112	Large (60-90mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	86	110	Large (60-90mm)
Cow Spring Pool	Fyke	1	11/12/2020	9:37	Pool	Melanotaenia australis	87	111	Large (60-90mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	20	25	X Small (<30mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	25	32	X Small (<30mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	26	33	X Small (<30mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	28	32	X Small (<30mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	32	40	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	33	43	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	33	41	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	34	43	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	35	45	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	35	43	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	35	42	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	36	44	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	36	47	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	37	74	Small (30-60mm)

Site Name	Gear Type	Replicate	Date	Time Out	Habitat Type	Species	S L	TL	Size
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	37	46	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	38	50	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	39	51	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	40	51	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	43	55	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	50	61	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	57	70	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	58	71	Small (30-60mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	60	74	Large (60-90mm)
Mundagoora Pool	Fyke	1	9/12/2020	9:24	Pool	Melanotaenia australis	62	76	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	34	41	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	48	60	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	49	63	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	49	61	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	50	62	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	50	61	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	50	63	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	53	66	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	53	67	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	53	65	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	55	70	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	55	69	Small (30-60mm)

Site Name	Gear Type	Replicate	Date	Time Out	Habitat Type	Species	SL	TL	Size
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	55	69	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	55	70	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	58	71	Small (30-60mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Melanotaenia australis	62	76	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	62	75	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	67	81	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	71	84	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	72	85	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	75	90	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	75	92	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	80	98	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Neosilurus hyrtlii	80	89	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Leiopotherapon unicolor	81	96	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Neosilurus hyrtlii	81	90	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Neosilurus hyrtlii	83	93	Large (60-90mm)
Site 12 Pool	Fyke	1	10/12/2020	10:00	Pool	Neosilurus hyrtlii	87	96	Large (60-90mm)

Table. Fish standard length (SL) and total length (TL) for Iron Bridge pools in the late wet season 2021

Site Name	Gear Type	Replicate	Date	Habitat Type	Species	SL	TL	Size
Cent Creek	Fyke	1	23/05/2021	Pool	Rainbow	30	39	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Rainbow	38	50	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Rainbow	49	62	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Rainbow	49	65	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Rainbow	50	62	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Rainbow	79	96	Large (60-90mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Rainbow	80	100	Large (60-90mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	39	47	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	42	54	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	42	53	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	43	53	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	47	57	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	47	58	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	47	57	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	49	60	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	50	62	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	50	62	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	55	104	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	55	66	Small (30-60mm)
Cent Creek	Fyke	1	23/05/2021	Pool	Spangled	80	97	Large (60-90mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	23	31	X Small (<30mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	30	36	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	31	43	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	32	41	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	32	40	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	32	41	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	32	40	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	32	39	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	33	43	Small (30-60mm)

Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	3	41	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	3	42	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	4	45	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	4	40	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	4	42	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	4	43	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	4	42	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	4	43	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	5	46	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	6	46	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	7	47	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	8	47	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	8	50	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	8	47	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	3	67	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	7	73	Small (30-60mm)
Mundagoora Pool	Fyke	1	22/05/2021	Pool	Rainbow	7	90	Large (60-90mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	2	31	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	4	33	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	5	34	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	6	35	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	7	35	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	8	36	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	8	34	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	9	38	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	9	38	X Small (<30mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	2	38	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	3	38	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	3	39	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	0	40	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	3	42	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	3	42	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	4	44	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	4	44	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	3	43	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	4	43	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	4	42	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	4	42	Small (30-60mm)

Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	34	43	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	34	44	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	34	45	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	34	43	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	35	46	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	36	47	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	40	53	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	40	50	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	40	53	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	42	55	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	42	53	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	43	55	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	45	58	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	57	72	Small (30-60mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	60	75	Large (60-90mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Rainbow	62	77	Large (60-90mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	70	85	Large (60-90mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Catfish	70	80	Large (60-90mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	75	92	Large (60-90mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	81	100	Large (60-90mm)
Site 12 Pool	Fyke	1	24/05/2021	Pool	Spangled	87	106	Large (60-90mm)

# APPENDIX D. MACROINVERTEBRATE DATA

			Site	Fig Pool	Fig Pool	Central Creek Pool	Central Creek Pool	South Star Pool	South Star Pool	Site 12	Site 12	Cow Spring Pool	Cow Spring Pool
			Habitat	Edge	Edge	Pool	Edge	Macrophyte	Macrophyte	Macrophyte	Edge	Macrophyte	Edge
			Replicate	1	2	1	2	1	2	1	2	1	2
			Date Sampled	24/06/2020	24/06/2020	25/06/2020	25/06/2020	26/06/2020	26/06/2020	28/06/2020	28/06/2020	29/06/2020	29/06/2020
			Sampled By	SK	SK	SK	SK	SK	SK	SK	SK	SK	SK
			Pick and ID By	SMJ	SMJ	SMJ	SMJ	SMJ	SMJ	SMJ	SMJ	SMJ	SMJ
			ID Date	27/07/2020	28/07/2020	28/07/2020	28/07/2020	29/07/2020	30/07/2020	30/07/2020	30/07/2020	30/07/2020	31/07/2020
SIGNAL2 Score	AusRivAS taxa code	Order	Family										
1		Hydrozoa	Hydrozoa										
3	IB029999	Hydrozoa	Oceaniidae										
2	IB019999	Hydrozoa	Hydridae									1	
		Hydrozoa	Olindiidae										
1	KG999999	Gastropoda	Gastropoda										
	-	Gastropoda	Ampullariidae										
4	KG069999	Gastropoda	Ancylidae					10				5	
3	KG039999	Gastropoda	Bithyniidae										
5	KG099999	Gastropoda	Glacidorbidae										
1	KG059999	Gastropoda	Lymnaeidae					12	4		1	7	
	KG109999	Gastropoda	Neritidae										
1	KG089999	Gastropoda	Physidae										
2	KG079999	Gastropoda	Planorbidae					3	8	3		3	
4	KG029999	Gastropoda	Tateidae										
4	KG049999	Gastropoda	Thiaridae										
4	KG019999	Gastropoda	Viviparidae										
2	QO219999	Oligochaeta	Oligochaeta				4	1	1	4	1	6	
	LP999999	Polychaeta	Polychaeta										
	-	Araneae	Araneae				1	1	1	2	1		
6	MM999999	Acarina	Acarina	10	3	2	2	5	21	14	14	11	8
		GROUP	Microcrustacea										
	OG999999	Cladocera	Cladocera					2	11			4	1
1	OF999999	Conchostraca	Conchostraca										

	OJ999999	Copepoda	Copepoda			1	5	6		3	4	2	2
	OH999999	Ostracoda	Ostracoda				1	15				16	
	<b>5 QCZZ9999</b>	<b>Coleoptera</b>	<b>Coleoptera</b>										
	3 QCAM9999	Coleoptera	Brentidae										
	3 QC059999	Coleoptera	Carabidae										
	2 QCAH9999	Coleoptera	Chrysomelidae										
	2 QCAN9999	Coleoptera	Curculionidae										
	2 QC099999	Coleoptera	Dytiscidae	9	6	2	7		2	2	3	2	
	7 QC349999	Coleoptera	Elmidae										
	2 QC119999	Coleoptera	Georissidae										
	4 QC109999	Coleoptera	Gyrinidae										
	2 QC069999	Coleoptera	Haliplidae										
	1 QC369999	Coleoptera	Heteroceridae										
	3 QC139999	Coleoptera	Hydraenidae									1	
	4 QCAO9999	Coleoptera	Hydrochidae			1	2	2				1	
	2 QC119999	Coleoptera	Hydrophilidae	10	2	2	2			1	3		
	1 QC079999	Coleoptera	Hygrobiidae										
	4 QC359999	Coleoptera	Limnichidae							1			
	4 QC089999	Coleoptera	Noteridae										
	6 QC379999	Coleoptera	Psephenidae										
	10 QC399999	Coleoptera	Ptilodactylidae										
	6 QC209999	Coleoptera	Scirtidae									4	
	2 QC119999	Coleoptera	Spercheidae										
	7 QC039999	Coleoptera	Sphaeriidae										
	3 QC189999	Coleoptera	Staphylinidae										
	<b>3 QDZZ9999</b>	<b>Diptera</b>	<b>Diptera</b>										
	8 QD229999	Diptera	Athericidae										
	10 QD049999	Diptera	Blephariceridae										
	4 QD099999	Diptera	Ceratopogonidae			7	9	3	2	4	2	10	
	2 QD059999	Diptera	Chaoboridae										
	3 QDAZ9999	Diptera	Chironomidae										
	8 QDAA9999	Diptera	s-f Aphroteniinae										
	3 QDAJ9999	Diptera	s-f Chironominae	23	25	16	26	9	20	21	3	25	22
	6 QDAB9999	Diptera	s-f Diamesinae										
	4 QDAF9999	Diptera	s-f Orthoclaadiinae			1						1	

6	QDAD9999	Diptera	s-f Podonominae										
4	QDAE9999	Diptera	s-f Tanypodinae			14	11	15	9	19	15	25	4
-		Diptera	Corethrellidae										
1	QD079999	Diptera	Culicidae	1	4				1			1	
7	QD069999	Diptera	Dixidae										
3	QD369999	Diptera	Dolichopodidae										
5	QD359999	Diptera	Empididae										
2	QD789999	Diptera	Ephydriidae			1	2						
1	QD899999	Diptera	Muscidae						1				
3	QD129999	Diptera	Psychodidae						1				
6	-	Diptera	Sciaridae										
2	QD459999	Diptera	Sciomyzidae									1	
5	QD109999	Diptera	Simuliidae										
2	QD249999	Diptera	Stratiomyidae			4	1			2	3	1	
2	QD439999	Diptera	Syrphidae										
3	QD239999	Diptera	Tabanidae						1				
6	QD039999	Diptera	Tanyderidae										
7	QD119999	Diptera	Thaumaleidae										
5	QD019999	Diptera	Tipulidae										1
9	QE999999	<b>Ephemeroptera</b>	<b>Ephemeroptera</b>										
7	QE049999	Ephemeroptera	Ameletopsidae										
5	QE029999	Ephemeroptera	Baetidae					9	13	2	2	9	12
4	QE089999	Ephemeroptera	Caenidae			7	14	10	1	1		12	2
8	QE059999	Ephemeroptera	Coloburiscidae										
8	QE069999	Ephemeroptera	Leptophlebiidae										
10	-	Ephemeroptera	Nesameletidae										
8	QE039999	Ephemeroptera	Oniscigastriidae										
4	QE099999	Ephemeroptera	Prosopistomatidae										
9	QE079999	Ephemeroptera	Teloganodidae										
2	QHZZ9999	<b>Hemiptera</b>	<b>Hemiptera</b>										
-		Hemiptera	Aphelocheiridae										
1	QH629999	Hemiptera	Belostomatidae									2	
2	QH659999	Hemiptera	Corixidae										
-		Hemiptera	Dipsocoridae										
5	QH649999	Hemiptera	Gelastocoridae										

4	QH579999	Hemiptera	Gerridae							2	2	2	
3	QH539999	Hemiptera	Hebridae		1						3		
3	QH549999	Hemiptera	Hydrometridae										
	QH589999	Hemiptera	Leptopodidae										
2	QH529999	Hemiptera	Mesoveliidae		1							1	
2	QH659999	Hemiptera	Micronectidae					1			1	1	
2	QH669999	Hemiptera	Naucoridae										
3	QH619999	Hemiptera	Nepidae		1	1						2	
1	QH679999	Hemiptera	Notonectidae	2	3								
2	QH639999	Hemiptera	Ochteridae										
2	QH689999	Hemiptera	Pleidae		8	4	3			1	2	1	1
1	QH609999	Hemiptera	Saldidae										
3	QH569999	Hemiptera	Veliidae	1	4					1		1	
3	QO999999	<b>Odonata</b>	<b>Odonata</b>										
3	QO999997	<b>Odonata</b>	<b>S.O. Zygoptera</b>										
5	QO079999	Odonata	Argiolestidae										
	QO109999	Odonata	Calopterygidae										
	QO189999	Odonata	Chorismagrionidae										
2	QO029999	Odonata	Coenagrionidae		1	7	9	10		7	2	14	2
6	QO099999	Odonata	Diphlebiidae										
	QO019999	Odonata	Hemiphlebiidae										
9	QO069999	Odonata	Hypolestidae										
3	QO039999	Odonata	Isostictidae			3							
1	QO069999	Odonata	Lestidae										
4	QO049999	Odonata	Platycnemididae										
7	QO089999	Odonata	Synlestidae										
3	QO999998	<b>Odonata</b>	<b>S.O. Epiproctiphora</b>				1	1					
4	QO129999	Odonata	Aeshnidae		1					5		1	1
	QO199999	Odonata	Archipetaliidae										
10	QO279999	Odonata	Austrocorduliidae										
	QO209999	Odonata	Austropetaliidae										
9	QO219999	Odonata	Brachytronidae										
	QO289999	Odonata	Cordulephyidae										
5	QO169999	Odonata	Corduliidae					1				1	
5	QO139999	Odonata	Gomphidae										

	QO249999	Odonata	Gomphomacromiidae									
5	QO309999	Odonata	Hemicorduliidae									
4	QO179999	Odonata	Libellulidae	15	15		1	7	2		9	9
3	QO229999	Odonata	Lindeniidae									
8	QO269999	Odonata	Macromiidae									
	QO299999	Odonata	Oxygastridae									
	QO159999	Odonata	Petaluridae									
	QO259999	Odonata	Pseudocorduliidae									
2	QO239999	Odonata	Synthemistidae									
9	QO219999	Odonata	Telephlebiidae									
8	<b>QT999999</b>	<b>Trichoptera</b>	<b>Trichoptera</b>									
8	QT169999	Trichoptera	Antipodoeciidae									
7	QT239999	Trichoptera	Atriplectididae									
7	QT249999	Trichoptera	Calamoceratidae									
9	QT189999	Trichoptera	Calocidae									
7	QT159999	Trichoptera	Conoesucidae									
9	QT269999	Trichoptera	Dipseudopsidae									
4	QT089999	Trichoptera	Ecnomidae				3		7		2	1
9	QT029999	Trichoptera	Glossosomatidae									
10	QT199999	Trichoptera	Helicophidae									
8	QT179999	Trichoptera	Helicopsychidae									
10		Trichoptera	Helocubucidae									
8	QT019999	Trichoptera	Hydrobiosidae									
6	QT069999	Trichoptera	Hydropsychidae									
4	QT039999	Trichoptera	Hydroptilidae			2	3		4	3	3	3
3	QT209999	Trichoptera	Kokiriidae									
6	QT259999	Trichoptera	Leptoceridae			2	6	4	2	5		5
8	QT109999	Trichoptera	Limnephilidae									
7	QT229999	Trichoptera	Odontoceridae									
8	QT129999	Trichoptera	Oeconesidae									
8	QT049999	Trichoptera	Philopotamidae									
8	QT219999	Trichoptera	Philorheithridae									
	QT119999	Trichoptera	Plectrotarsidae									
7	QT079999	Trichoptera	Polycentropodidae									
	QT099999	Trichoptera	Psychomyiidae									

	QT059999	Trichoptera	Stenopsychidae									
<b>8</b>	QT139999	Trichoptera	Tasimiidae									
<b>3</b>	<b>QL019999</b>	<b>Lepidoptera</b>	<b>Crambidae</b>					<b>1</b>	<b>6</b>			<b>2</b>

Table 28 Macroinvertebrate taxa present at Iron Bridge pools in the late dry season (2020)

			Site		Cow spring		Fig pool		Site 12 Pool		Mundagoora Pool	
			Date sampled		11/12/2020		10/12/2020		9/12/2020		8/12/2020	
			Replicate		1	2	1	2	1	2	1	2
Order	Family	Signal2 score										
<b>Nematoda</b>	<b>Nematoda</b>	3								<b>1</b>		
<b>Gastropoda</b>	<b>Gastropoda</b>	1										
	Ancylidae	4	2	2							7	3
	Lymnaeidae	1	6	9							8	12
	Planorbidae	2	7	9					1		10	15
<b>Oligochaeta</b>	<b>Oligochaeta</b>	2	<b>2</b>	<b>2</b>					<b>2</b>	<b>4</b>	<b>3</b>	
<b>Araneae</b>	<b>Araneae</b>											<b>1</b>
<b>Acarina</b>	<b>Acarina</b>	6	<b>7</b>	<b>10</b>	<b>3</b>				<b>1</b>	<b>8</b>	<b>6</b>	
<b>Group</b>	<b>Microcrustacea</b>											
<b>Cladocera</b>	Cladocera								9		5	1
<b>Copepoda</b>	Copepoda		2	2						4	9	7
<b>Ostracoda</b>	Ostracoda										11	11
<b>Coleoptera</b>	<b>Coleoptera</b>	5										

	Site	Cow spring		Fig pool		Site 12 Pool		Mundagoora Pool	
	Dytiscidae	2	3	2	5	1		3	4
	Hydraenidae	3						1	
	Hydrochidae	4						18	2
	Hydrophilidae	2	2	1		7	1	1	2
	Scirtidae	6							5
<b>Diptera</b>	<b>Diptera</b>	3							
	Ceratopogonidae	4	4	8			7	5	4
	S-f chironominae	3	24	27	28	29	28	16	19
	S-f tanypodinae	4	10	11		6	12	16	7
	Culicidae	1		1	1	1			
	Stratiomyidae	2					5		
	Tabanidae	3					1		
<b>Ephemeroptera</b>	<b>Ephemeroptera</b>	9							
	Baetidae	5	9				3	5	5
	Caenidae	4		3			1	6	11
<b>Hemiptera</b>	<b>Hemiptera</b>	2							
	Belostomatidae	1	1						
	Gerridae	4		4		3			1
	Mesoveliidae	2						1	1
	Micronectidae	2							1
	Pleidae	2						3	1

	Site		Cow spring		Fig pool		Site 12 Pool		Mundagoora Pool	
	Veliidae	3			2	13			1	2
<b>Odonata</b>	<b>Odonata</b>	3								
	Coenagrionidae	2	12	16	13	23			6	15
	Gomphidae	5					3			
	Libellulidae	4	11	10	12	15		2	2	
<b>Trichoptera</b>	<b>Trichoptera</b>	8								
	Ecnomidae	4							1	
	Hydroptilidae	4					1			1
	Leptoceridae	6	1	1				2	22	22
<b>Lepidoptera</b>	<b>Crambidae</b>	3	7	3						

Table: Macroinvertebrate data for the Late Wet Season 2021

	Site	Fig Pool	Fig Pool	Central Creek Pool	Central Creek Pool	South Star Pool	South Star Pool	Site 12	Site 12	Cow Spring Pool	Cow Spring Pool
	<b>Replicate</b>	1	2	1	2	1	2	1	2	1	2
	<b>Date Sampled</b>	24/06/2020	24/06/2020	25/06/2020	25/06/2020	26/06/2020	26/06/2020	28/06/2020	28/06/2020	29/06/2020	29/06/2020
<b>Order</b>	<b>Family</b>										
<b>Hydrozoa</b>	Hydridae									1	
<b>Gastropoda</b>	Ancylidae					10				5	

	Site	Fig Pool	Fig Pool	Central Creek Pool	Central Creek Pool	South Star Pool	South Star Pool	Site 12	Site 12	Cow Spring Pool	Cow Spring Pool
<b>Gastropoda</b>	Lymnaeidae					12	4		1	7	
<b>Gastropoda</b>	Planorbidae					3	8	3		3	
<b>Oligochaeta</b>	<b>Oligochaeta</b>				4	1	1	4	1	6	
<b>Araneae</b>	<b>Araneae</b>				1	1	1	2	1		
<b>Acarina</b>	<b>Acarina</b>	10	3	2	2	5	21	14	14	11	8
<b>Cladocera</b>	Cladocera					2	11			4	1
<b>Copepoda</b>	Copepoda			1	5	6		3	4	2	2
<b>Ostracoda</b>	Ostracoda				1	15				16	
<b>Coleoptera</b>	Dytiscidae	9	6	2	7			2	2	3	2
<b>Coleoptera</b>	Hydraenidae									1	
<b>Coleoptera</b>	Hydrochidae			1	2	2				1	
<b>Coleoptera</b>	Hydrophilidae	10	2	2	2				1	3	
<b>Coleoptera</b>	Limnichidae								1		
<b>Coleoptera</b>	Scirtidae									4	
<b>Diptera</b>	Ceratopogonidae			7	9	3	2	4	2	10	
<b>Diptera</b>	s-f Chironominae	23	25	16	26	9	20	21	3	25	22

	Site	Fig Pool	Fig Pool	Central Creek Pool	Central Creek Pool	South Star Pool	South Star Pool	Site 12	Site 12	Cow Spring Pool	Cow Spring Pool
<b>Diptera</b>	s-f Orthocladiinae			1						1	
<b>Diptera</b>	s-f Tanypodinae			14	11	15	9	19	15	25	4
<b>Diptera</b>	Culicidae	1	4				1			1	
<b>Diptera</b>	Ephydriidae			1	2						
<b>Diptera</b>	Muscidae				1						
<b>Diptera</b>	Psychodidae				1						
<b>Diptera</b>	Sciomyzidae									1	
<b>Diptera</b>	Stratiomyidae			4	1			2	3	1	
<b>Diptera</b>	Tabanidae				1						
<b>Diptera</b>	Tipulidae									1	
<b>Ephemeroptera</b>	Baetidae					9	13	2	2	9	12
<b>Ephemeroptera</b>	Caenidae			7	14	10	1	1		12	2
<b>Hemiptera</b>	Belostomatidae									2	
<b>Hemiptera</b>	Gerridae							2	2	2	
<b>Hemiptera</b>	Hebridae			1					3		
<b>Hemiptera</b>	Mesoveliidae			1						1	

	Site	Fig Pool	Fig Pool	Central Creek Pool	Central Creek Pool	South Star Pool	South Star Pool	Site 12	Site 12	Cow Spring Pool	Cow Spring Pool
Hemiptera	Micronectidae					1			1	1	
Hemiptera	Nepidae			1	1					2	
Hemiptera	Notonectidae	2	3								
Hemiptera	Pleidae			8	4	3		1	2	1	1
Hemiptera	Veliidae	1		4				1		1	
Odonata	<b>Odonata</b>										
Odonata	Coenagrionidae		1	7		9	10	7	2	14	2
Odonata	Isostictidae			3							
<b>Odonata</b>	<b>S.O. Epiroctiphora</b>				<b>1</b>	<b>1</b>					
Odonata	Aeshnidae		1				5			1	1
Odonata	Corduliidae					1				1	
Odonata	Libellulidae	15	15			1	7	2		9	9
Trichoptera	Ecnomidae					3		7		2	1
Trichoptera	Hydroptilidae			2	3		4	3	3	3	
Trichoptera	Leptoceridae			2	6	4	2	5		5	
Lepidoptera	<b>Crambidae</b>					<b>1</b>	<b>6</b>			<b>2</b>	

	Site	Fig Pool	Fig Pool	Central Creek Pool	Central Creek Pool	South Star Pool	South Star Pool	Site 12	Site 12	Cow Spring Pool	Cow Spring Pool
	<b>Abundance</b>	71	60	87	105	127	126	105	63	200	67
	<b>Taxonomic Richness</b>	8	9	21	22	24	18	20	19	39	13
	<b>PET Richness</b>	0	0	3	3	4	4	5	2	5	3
	Terrestrial insect	1					7	5	5		1

	Site	Fig Pool	Fig Pool	Central Creek Pool	Central Creek Pool	South Star Pool	South Star Pool	Site 12	Site 12	Cow Spring Pool	Cow Spring Pool
	<b>SMI Comments</b>		3 Chironominae and 2 Culicidae are pupa	1 Hydroptilidae is a very early instar.	1 Hydroptilidae is a very early instar. Oligochaeta very small and unidentified Epiproctaphora too small to identify to family level. 1 Chironominae is a pupa.	1 Ceratopogonidae is a pupa. Label disintegrated when the sample was rinsed so I am unsure what habitat type sample was collected from. Unidentified Epiproctaphora too small to identify to family level.	1 Hydroptilidae, 1 Ceratopogonidae and 3 Chironominae are pupa. 1 Leptoceridae and Ecnomidae very small.	Partially live-picked sample. 1 Tanypodinae and 1 Ceratopogonidae are pupa. Many very small Chironomids.	1 Chironominae and 1 Ceratopogonidae are pupa. Limnichidae is an adult, which are generally considered semi-aquatic / terrestrial.	Photo of specimen is an Aeshnidae (can just see bifid apex of epiproct) and this record has been included in this data. 1 Ceratopogonidae is a pupa.	Some very small Acarina.

# APPENDIX E. DIATOM DATA

## Diatom species and count data for the five surveyed pools – Late Wet 2020.

Taxon name	Fig Pool	Fig Pool	Central Ck Pool	Central Ck Pool	South Star Pool	South Star Pool	Site 12 Pool	Site 12 Pool	Cow Spring Pool	Cow Spring Pool
Replicate Number	1	2	1	2	1	2	1	2	1	2
Collection date	24/06/2020	24/06/2020	25/06/2020	25/06/2020	26/06/2020	26/06/2020	27/06/2020	27/06/2020	28/06/2020	28/06/2020
Sample description	no valves	no valves					very sparse	very sparse. teratological forms	no valves	very sparse
<b>Total Count</b>	<b>0</b>	<b>0</b>	<b>394</b>	<b>352</b>	<b>420</b>	<b>386</b>	<b>60</b>	<b>166</b>	<b>0</b>	<b>28</b>
<b>DSIAR Score</b>	<b>NA</b>	<b>NA</b>	<b>41.3</b>	<b>42.6</b>	<b>59.1</b>	<b>66.3</b>	<b>54.7</b>	<b>53.95</b>	<b>NA</b>	<b>64.25</b>
<i>Achnanthes brevipes</i>	0	0	22	12	302	92	4	24	0	8
<i>Achnanthes impexa</i>	0	0	0	0	48	164	4	8	0	0
<i>Achnanthes subexigua</i>	0	0	4	0	14	70	8	10	0	8
<i>Achnantheidium exiguum</i>	0	0	2	0	12	24	0	0	0	0
<i>Achnantheidium kryophila</i>	0	0	0	0	8	4	0	0	0	0
<i>Achnantheidium lineare</i>	0	0	0	0	6	8	0	0	0	2
<i>Achnantheidium minutissimum</i>	0	0	0	0	6	0	0	0	0	0
<i>Achnantheidium minutissimum var affine</i>	0	0	0	2	4	4	0	0	0	4
<i>Achnantheidium spp.</i>	0	0	2	0	4	4	0	0	0	0
<i>Actinocyclus normanii</i>	0	0	0	0	4	0	0	0	0	0
<i>Adlafia aff bryophila</i>	0	0	0	0	4	0	0	0	0	0
<i>Adlafia minuscula v. muralis</i>	0	0	0	0	4	0	0	0	0	0

Taxon name	Fig Pool	Fig Pool	Central Ck Pool	Central Ck Pool	South Star Pool	South Star Pool	Site 12 Pool	Site 12 Pool	Cow Spring Pool	Cow Spring Pool
<i>Amphicampa mirabilis</i>	0	0	6	2	2	0	0	0	0	0
<i>Amphipleura pellucida</i>	0	0	0	0	2	0	0	0	0	0
<i>Amphora delicatissima</i>	0	0	0	4	0	0	0	0	0	2
<i>Amphora libyca</i>	0	0	0	0	0	0	0	0	0	2
<i>Amphora ovalis</i>	0	0	0	0	0	0	0	0	0	2
<i>Amphora pediculus</i>	0	0	0	2	0	0	42	112	0	0
<i>Amphora spp.</i>	0	0	0	0	0	0	0	6	0	0
<i>Aneumastus tuscula</i>	0	0	0	0	0	2	0	4	0	0
<i>Anomoneis spaerophora</i>	0	0	0	0	0	0	0	2	0	0
<i>Asterionella ralfsii var americana</i>	0	0	246	270	0	0	2	0	0	0
<i>Aulacoseira ambigua</i>	0	0	4	0	0	12	0	0	0	0
<i>Aulacoseira crenulata</i>	0	0	0	0	0	2	0	0	0	0
<i>Aulacoseira granulata</i>	0	0	40	16	0	0	0	0	0	0
<i>Bacillaria paxillifer</i>	0	0	10	8	0	0	0	0	0	0
<i>Brachysira brebissonii</i>	0	0	12	6	0	0	0	0	0	0
<i>Brachysira styriaca</i>	0	0	0	6	0	0	0	0	0	0
<i>Brachysira vitrea</i>	0	0	8	4	0	0	0	0	0	0
<i>Caloneis aerophila</i>	0	0	0	4	0	0	0	0	0	0
<i>Caloneis silicula</i>	0	0	0	4	0	0	0	0	0	0
<i>Chamaepinnularia bremensis</i>	0	0	0	4	0	0	0	0	0	0
<i>Chamaepinnularia muscicola</i>	0	0	0	2	0	0	0	0	0	0

Taxon name	Fig Pool	Fig Pool	Central Ck Pool	Central Ck Pool	South Star Pool	South Star Pool	Site 12 Pool	Site 12 Pool	Cow Spring Pool	Cow Spring Pool
<i>Cocconeis pediculus</i>	0	0	0	2	0	0	0	0	0	0
<i>Cocconeis placentula</i>	0	0	0	2	0	0	0	0	0	0
<i>Cocconeis placentula</i> var. <i>euglypta</i>	0	0	0	2	0	0	0	0	0	0
<i>Cocconeis placentula</i> var. <i>lineata</i>	0	0	28	0	0	0	0	0	0	0
<i>Cocconeis pseudothumensis</i>	0	0	4	0	0	0	0	0	0	0
<i>Craticula accomoda</i>	0	0	2	0	0	0	0	0	0	0
<i>Craticula cuspidata</i>	0	0	2	0	0	0	0	0	0	0
<i>Craticula halophila</i>	0	0	2	0	0	0	0	0	0	0

## Diatom species and count data - late wet 2021

Sample name:	Fig Pool	Fig Pool	Central Ck Pool	Central Ck Pool	South Star Pool	South Star Pool	Site 12 Pool	Site 12 Pool	Cow Spring Pool	Cow Spring Pool
<b>Further sample details:</b>	1 of 2	2 of 2	1 of 2	2 of 2	1 of 2	2 of 2	1 of 2	2 of 2	1 of 2	2 of 2
<b>Date</b>	24/06/2020	24/06/2020	25/06/2020	25/06/2020	26/06/2020	26/06/2020	27/06/2020	27/06/2020	28/06/2020	28/06/2020
<b>Taxon name/Notes:</b>	no valves	no valves					very sparse	very sparse and teratological forms	no valves	very sparse
<b>Achnanthisdium exiguum</b>	0	0	246	270	0	0	2	0	0	0
<b>Achnanthisdium minutissimum</b>	0	0	22	12	302	92	4	24	0	8

Sample name:	Fig Pool	Fig Pool	Central Ck Pool	Central Ck Pool	South Star Pool	South Star Pool	Site 12 Pool	Site 12 Pool	Cow Spring Pool	Cow Spring Pool
<b>Amphora spp.</b>	0	0	0	0	0	0	0	6	0	0
<b>Brachysira brebissonii</b>	0	0	0	2	0	0	0	0	0	0
<b>Brachysira vitrea</b>	0	0	0	0	48	164	4	8	0	0
<b>Caloneis silicula</b>	0	0	0	0	0	2	0	4	0	0
<b>Craticula halophila</b>	0	0	0	0	2	0	0	0	0	0
<b>Cymbella affinis</b>	0	0	0	0	6	8	0	0	0	2
<b>Cymbella spp</b>	0	0	0	2	4	4	0	0	0	4
<b>Diploneis parma</b>	0	0	6	2	2	0	0	0	0	0
<b>Encyonema minutum</b>	0	0	0	0	4	0	0	0	0	0
<b>Eolimna minima</b>	0	0	2	0	0	0	0	0	0	0
<b>Eunotia bilunaris</b>	0	0	4	0	14	70	8	10	0	8
<b>Eunotia faba</b>	0	0	0	0	0	0	0	0	0	2
<b>Eunotia incisa</b>	0	0	0	0	0	0	0	2	0	0
<b>Fragilaria spp.</b>	0	0	2	0	0	0	0	0	0	0
<b>Hantzschia amphioxys</b>	0	0	0	4	0	0	0	0	0	2
<b>Luticola mutica</b>	0	0	0	0	0	0	0	0	0	2

Sample name:	Fig Pool	Fig Pool	Central Ck Pool	Central Ck Pool	South Star Pool	South Star Pool	Site 12 Pool	Site 12 Pool	Cow Spring Pool	Cow Spring Pool
<b>Mastogloia smithii</b>	0	0	0	2	0	0	42	112	0	0
<b>Navicula cryptocephala</b>	0	0	0	0	6	0	0	0	0	0
<b>Navicula cryptotenella</b>	0	0	0	0	0	2	0	0	0	0
<b>Navicula gregaria</b>	0	0	0	0	4	0	0	0	0	0
<b>Navicula lanceolata</b>	0	0	2	0	4	4	0	0	0	0
<b>Navicula menisculoides</b>	0	0	0	0	8	4	0	0	0	0
<b>Navicula menisculus</b>	0	0	0	4	0	0	0	0	0	0
<b>Navicula phyllepta</b>	0	0	0	2	0	0	0	0	0	0
<b>Navicula radiosa</b>	0	0	2	0	12	24	0	0	0	0
<b>Navicula recens</b>	0	0	0	0	4	0	0	0	0	0
<b>Navicula veneta</b>	0	0	12	6	0	0	0	0	0	0
<b>Nitzschia frustulum</b>	0	0	10	8	0	0	0	0	0	0
<b>Nitzschia graciliformis</b>	0	0	4	0	0	0	0	0	0	0
<b>Nitzschia gracilis</b>	0	0	2	0	0	0	0	0	0	0
<b>Nitzschia inconspicua</b>	0	0	0	6	0	0	0	0	0	0
<b>Nitzschia lacuum</b>	0	0	8	4	0	0	0	0	0	0

Sample name:	Fig Pool	Fig Pool	Central Ck Pool	Central Ck Pool	South Star Pool	South Star Pool	Site 12 Pool	Site 12 Pool	Cow Spring Pool	Cow Spring Pool
<b>Nitzschia microcephala</b>	0	0	0	4	0	0	0	0	0	0
<b>Nitzschia palea</b>	0	0	40	16	0	0	0	0	0	0
<b>Nitzschia suchlandii</b>	0	0	0	2	0	0	0	0	0	0
<b>Pinnularia legumen</b>	0	0	0	2	0	0	0	0	0	0
<b>Pinnularia spp.</b>	0	0	0	4	0	0	0	0	0	0
<b>Pleurosigma elongatum</b>	0	0	28	0	0	0	0	0	0	0
<b>Ulnaria ulna</b>	0	0	4	0	0	12	0	0	0	0
<b>Total</b>	0	0	394	352	420	386	60	166	0	28

# APPENDIX F. PHYTOPLANKTON DATA

Table. Phytoplankton profile for the Iron Bridge Pools sampled in the late dry season (2020)

Taxon	F16 HB		SS Pool		S12 Pool		Cow Spring	
	DE01565.1		DE01565.2		DE01565.3		DE01565.4	
	10/12/2020		8/12/2020		09/12/2020		11/12/2020	
	Abund.	%	Abund.	%	Abund.	%	Abund.	%
Bacillariophyceae	200	8.00	80300	76.11	3200	2.27	7000	19.02
<i>Achnanthidium minutissima</i>			35200	33.36			1400	3.80
<i>Amphora spp.</i>					400	0.28	200	0.54
<i>Cocconeis spp.</i>			700	0.66				
<i>Cymbella spp.</i>			300	0.28			400	1.09
<i>Lyrella spp.</i>			100	0.09				
<i>Microtabella spp.</i>	100	4.00						

Taxon	F16 HB		SS Pool		S12 Pool		Cow Spring	
	DE01565.1		DE01565.2		DE01565.3		DE01565.4	
	10/12/2020		8/12/2020		09/12/2020		11/12/2020	
	Abund.	%	Abund.	%	Abund.	%	Abund.	%
<i>Navicula spp.</i>	100	4.00	19600	18.58				
<i>Navicula spp.</i>			19600	18.58	1200	0.85	2800	7.61
<i>Nitzschia spp.</i>			100	0.09	1200	0.85	400	1.09
<i>Pinnularia spp.</i>			200	0.19				
<i>Synedra spp. (O)</i>			4500	4.27	400	0.28	1800	4.89
Chlorophyceae	<b>2200</b>	<b>88.00</b>	<b>900</b>	<b>0.85</b>	<b>3200</b>	<b>2.27</b>	<b>1400</b>	3.80
<i>Closterium spp. (O)</i>					1200	0.85		
<i>Cosmarium spp. (O)</i>	2200	88.00	700	0.66	2000	1.42	1200	3.26
<i>Oocystis spp.</i>			200	0.19				
<i>Staurastrum spp. (O)</i>							200	0.54
Cryptophyceae			<b>8800</b>	<b>8.34</b>	<b>24000</b>	<b>17.00</b>	<b>15000</b>	40.76
<i>Chroomonas spp.</i>			800	0.76	2400	1.70	3000	8.15
<i>Cryptomonas spp. (O)</i>			8000	7.58	21600	15.30	11800	32.07
<i>Plagioselmis spp.</i>							200	0.54
Cyanobacteria			<b>8200</b>	<b>7.77</b>	<b>8000</b>	<b>5.67</b>		
<i>Chroococcus spp.</i>					1600	1.13		
<i>Planktolyngbya spp.</i>					6400	4.53		
<i>Pseudoanabaena spp. (O) (PT)</i>			8200	7.77				
Dinophyceae			<b>7200</b>	<b>6.82</b>	<b>102800</b>	<b>72.80</b>	<b>13200</b>	35.87
<i>Gomphonema spp.</i>			500	0.47				


Taxon	F16 HB		SS Pool		S12 Pool		Cow Spring	
	DE01565.1		DE01565.2		DE01565.3		DE01565.4	
	10/12/2020		8/12/2020		09/12/2020		11/12/2020	
	Abund.	%	Abund.	%	Abund.	%	Abund.	%
<i>Gonyaulax spp.</i>			800	0.76	42800	30.31	12200	33.15
<i>Gymnodinium spp.</i>			1400	1.33			600	1.63
<i>Peridinium spp. (O)</i>			4500	4.27	60000	42.49	400	1.09
Euglenophyceae	100	4.00	100	0.09			200	0.54
<i>Euglena spp. (O)</i>			100	0.09				
<i>Trachelomonas spp.</i>	100	4.00					200	0.54
<i>TOTAL (All Taxa)</i>	2500	100	105500	100	141200	100	36800	100

Table. Phytoplankton profile for Iron Bridge pools sampled in the late wet season (2021)

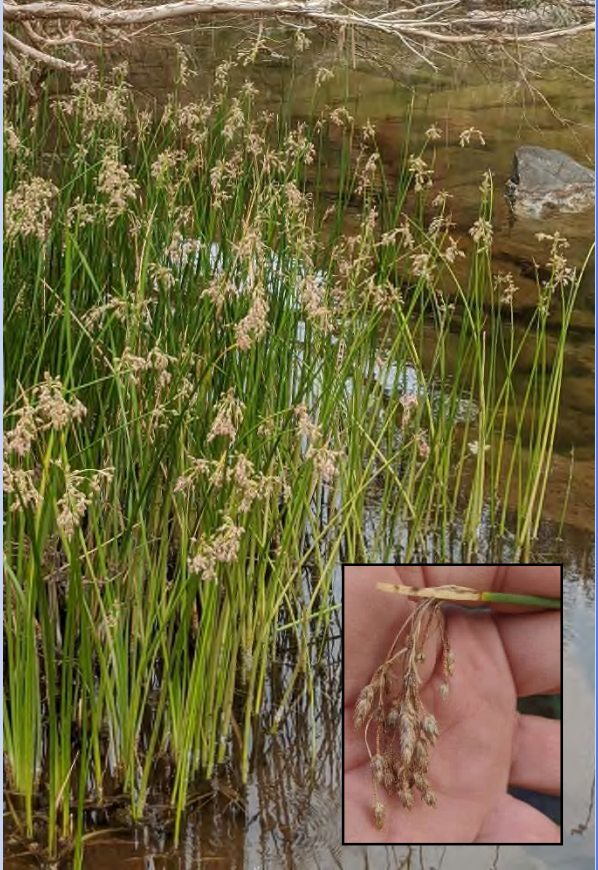

Taxon	Fig Pool		Central Creek		Site 12		Cow Spring		Gv Pool		Mundagoora Pool	
	DE01792.1		DE01792.2		DE01792.4		DE01792.5		DE01792.6		DE01792.3	
	24/05/2021		24/05/2021		24/05/2021		24/05/2021		24/05/2021		24/05/2021	
	Abund.	%	Abund.	%	Abund.	%	Abund.	%	Abund.	%	Abund.	%
Bacillariophyceae			460	93.88	20	100.00	20	100.00	860	98.85	70	63.64
<i>Achnanthisidium sp.</i>										10	9.09	
<i>Amphora sp.</i>								40	4.60	10	9.09	
<i>Entomoneis</i>			10	2.04								
<i>Fragilaria sp. (O)</i>			10	2.04								
<i>Placoneis sp.</i>								530	60.92			



Taxon	Fig Pool		Central Creek		Site 12		Cow Spring		Gv Pool		Mundagoora Pool	
	DE01792.1		DE01792.2		DE01792.4		DE01792.5		DE01792.6		DE01792.3	
	24/05/2021		24/05/2021		24/05/2021		24/05/2021		24/05/2021		24/05/2021	
	Abund.	%	Abund.	%	Abund.	%	Abund.	%	Abund.	%	Abund.	%
<i>Navicula capitata</i>			10	2.04								
<i>Navicula pupula capitata</i>			10	2.04								
<i>Navicula</i> sp.			50	10.20	20	100.00	10	50.00	100	11.49	40	<b>36.36</b>
<i>Nitzschia</i> sp.			130	26.53					110	12.64		
<i>Pleurosigma</i> sp. (O)			220	44.90								
<i>Rhopalodia gibba</i>			10	2.04					60	6.90		
<i>Stauroneis</i> sp.			10	2.04								
<i>Synedra</i> sp. (O)							10	50.00	20	2.30	10	<b>9.09</b>
Chlorophyceae											<b>40</b>	36.36
<i>Mougeotia</i> sp.											40	<b>36.36</b>
Cryptophyceae			<b>30</b>	<b>6.12</b>					<b>10</b>	<b>1.15</b>		
<i>Cryptomonas</i> sp. (O)			30	6.12					10	1.15		
TOTAL (All Taxa)			490	100	20	100	20	100	870	100	110	100

# APPENDIX G. MACROPHYTE TABLE

Name	Description	Image	Site 12	Cow	South	Central
<p><b>Ribbon weed</b> <i>(Vallisneria sp.)</i></p>	<p>Bright green soft ribbon fronds which float and spread across the water surface. Fronds about 0.5 cm wide.</p>		Y	Y	Y	

Name	Description	Image	Site 12	Cow	South	Central
<p><b>Charophytes</b> (<i>Nitella sp.</i>, <i>Chara sp.</i>)</p>			Y			

Name	Description	Image	Site 12	Cow	South	Central
<p><b>Clubrush</b> (<i>Schoenoplectus</i> sp.)</p>			Y	Y	Y	Y
<p><b>Sedges</b> (<i>Cyperus</i> sp.)</p>			Y	Y	Y	Y

Name	Description	Image	Site 12	Cow	South	Central
<p><b>Bulrush</b> (<i>Typha sp.</i>)</p>	<p>Tall emergent ribbon like fronds with sharp margins.</p>		<p>Y</p>	<p>Y</p>	<p>Y</p>	
<p><b>Unidentified species 1</b></p>				<p>Y</p>		

Name	Description	Image	Site 12	Cow	South	Central
Unidentified species 2				Y		

# APPENDIX H. ISOTOPE DATA ANALYSIS MEMO

# MEMORANDUM



TO: Sylvie Ogier-Halim (FMG- Strategic Planning - Hydrogeology Projects)

CC:

SENDER: Phil Whittle

DATE: 9 Sept 2021

PROJECT: Iron Bridge – Assessment of pool water sources from isotope analysis

## ASSESSMENT OF IRON BRIDGE POOL WATER SOURCES FROM ISOTOPE ANALYSIS

This memorandum provides a summary of the water quality isotopic data captured for Iron Bridge river pools and groundwater from December 2019 to June 2021. The isotope data was collected to assess the sustaining water sources for a range of permanent to semi-permanent river pools across the Iron Bridge project site.

Three groundwater monitoring bores and six permanent or semi-permanent river pools were sampled for the stable isotopes  $\delta^{18}\text{O}$  and  $\delta^2\text{H}$ , as well as a range of field and major ion parameters (Figure 1; Table 1). As common practice in hydrogeology, the isotopic ratios are compared to the Vienna Standard Mean Ocean Water (VSMOW) reference. The VSMOW represents enriched isotopic conditions in aged "seawater". Rainfall is typically depleted in  $\delta^{18}\text{O}$  and  $\delta^2\text{H}$ , therefore the enrichment or depletion of these isotopes in various water sources can provide a signature relative to recent rainfall, evaporative processes (which concentrate or enrich these isotopes) or groundwater sources (which are more stable relative to the age of the water source). Considering the lack of regional isotopic data in the Iron Bridge project area, the dataset of Dogramaci et al (2012) from the Hamersley Range region has been used for context (Figure 2). Overall, the isotope data showed a large range in values across both groundwater and surface waters at Iron Bridge (Figure 2). The relationship between the two isotopes ( $\delta^{18}\text{O}$  and  $\delta^2\text{H}$ ) was however relatively consistent across the site and sampling dates, as well as being consistent with regional literature (Dogramaci et al., 2012, Hedley 2009, Hedley et al, 2009, Dogramaci and Skrzypek 2015). There is a general pattern of depletion (increasingly negative) isotopic ratios in the region following large singular rainfall events (such as cyclones or associated large low systems; Dogramaci et al., 2012). There was an evident depletion of both isotopes between the dry to wet season 2019/20 and following the wet season of 2020/21. The tropical low (02U) of 11-12 December 2020 produced a large (200 mm) rainfall event across the Iron Bridge site. This may be a factor in the depleted June 2021 isotope ratios (Figure 3).

## SITE 12 POOL

The large range in isotope ratio values for the Site 12 pool groundwater (bore NS-0064; labelled as Site 12 GW in Figure 2) is consistent with the records from water level loggers and other water quality parameters from this bore, showing variability in response to rainfall events (Figure 4). It is notable that the isotope ratios for the surface water within Site 12 Pool and the upstream monitoring bore (NS-0664) were



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consistently different, with the groundwater being substantially more depleted, particularly for the late dry season (Dec 2019) sampling event. However, the water level data indicate that the bore (NS-0664) levels and the pool levels are both similarly responsive to large rainfall events (Figure 4). This suggests that the surface water within Site 12 Pool is maintained by groundwater, though not directly that which is represented by bore NS-0664. It is likely that some degree of evaporation along the groundwater inflow to the pool, and within the pool system itself, is creating an enriched signature relative to the deeper groundwater (NS-0664) which is more representative of large rainfall event recharge.

The December 2019 isotope enrichment in the Site 12 Pool is evidence that at this stage “fresh” or deep groundwater recharge was at a minimum and evaporative isotopic enrichment was a dominant process. This is consistent with the water level data (Figure 4) which shows that as the groundwater levels reach a critical point, evaporative losses from the pool are in excess of groundwater inflows and rapid drying occurs.

The most depleted isotopic ratio of the dataset was observed at the Site 12 groundwater monitoring bore (NS-0664) following the large 2020/21 wet season. This may indicate that the source of the groundwater at the site was relatively recent rainfall during this period. There are preliminary indications that the groundwater at the Site 12 Pool monitoring bore is more similar to a rainwater isotopic composition after the wet season, moving towards the evaporation line in the late dry. Further sampling would be required to confirm this.

## **MUNDAGOORA POOL**

While there are currently no groundwater monitoring bores within the vicinity of Mundagoora Pool, the water quality and water level logger data indicate that this is a groundwater dependent system. It is a permanent water feature and maintains a constant water level through to the end of the dry season. The pattern of isotopic enrichment within the pool is consistent with evaporative processes active over groundwater replenishment. The highest enrichment occurred in the late dry season, with the lowest following the large wet season of 2020/21. The evident isotopic ratios for Mundagoora Pool were along the Local Evaporation Line (LEL) for the region (Dogramaci et al 2012), providing further evidence that evaporative processes are a feature of the water balance for the pool and that groundwater recharge is relatively slow over the dry season, though high enough to replace evaporative losses (as the pool level remains constant). Older groundwater (with more isotopic enrichment) may also contribute a larger fraction of the inflows as the dry season progresses.

The isotope data from Mundagoora Pool indicates that there is little direct rainfall influence on the pool, with the trend-line being closest to the Hamersley groundwater line (Dogramaci et al 2012).

## **FIG AND COW SPRING POOLS**

Fig Pool was the least variable of the sampled sites with only minor variability and evaporative effects evident across the seasonal sampling (Figure 2). The local groundwater monitoring bore (NS-Obs29) was depleted relative to the pool, though to a lesser extent. The lack of direct catchment, and the permanent status of Fig Pool indicate that it is groundwater dependant. The low pH however indicates that there are geochemical processes within the pool that occur at a higher rate than groundwater replenishment (such as root mat iron oxidation (redox) processes). The evidence of evaporative enrichment of isotopes also indicates that groundwater inflow is relatively slow to this site.

Cow Spring Pool does not have an associated monitoring bore, however the late wet season (May 2020) sampling showed similar isotopic depletion at Cow Spring Pool and the Fig Pool monitoring bore (NS-

Obs29; Figure 2). The small catchment and permanent status of Cow Spring Pool indicate that it is likely to be groundwater dependant, which is supported by the limited available isotopic data.

### **CENTRAL CREEK POOL**

The groundwater adjacent to Central Creek Pool (monitoring bore NS-Obs17) was only sampled in May 2020 (late wet season), when it was representative of relatively isotopically enriched waters. This is possibly due to its location low within the catchment providing a more evaporative signature as groundwater moves down through the local elevation. The surface water pool showed a ratio closer to the Hamersley rainfall line (Figure 2) though with some enrichment evident. The late wet 2021 pool isotopic signature was closer to the groundwater signature indicating that under wetter conditions both may be associated with a superficial or alluvial aquifer.

### **SOUTH-WEST GV POOL**

There are no groundwater monitoring bores currently associated with the South-West GV Pool (GV\_SW\_Pool\_SW). Only a single late wet 2021 surface water sample is available for this site, which indicated that it had a similar isotopic signature to other pools in the area including Site 12 Pool, Mundagoora Pool and Central Creek Pool. It is likely that this pool is representative of local relatively recent inflows from superficial groundwater systems in the upper catchment. The ephemeral nature of the pool also suggests that it is not fed by regional groundwater over the dry season. There is anecdotal evidence from discussions with Traditional Owners that a spring is present at this site, though this was not evident (flowing) at the time of a late dry season (2020) site inspection.

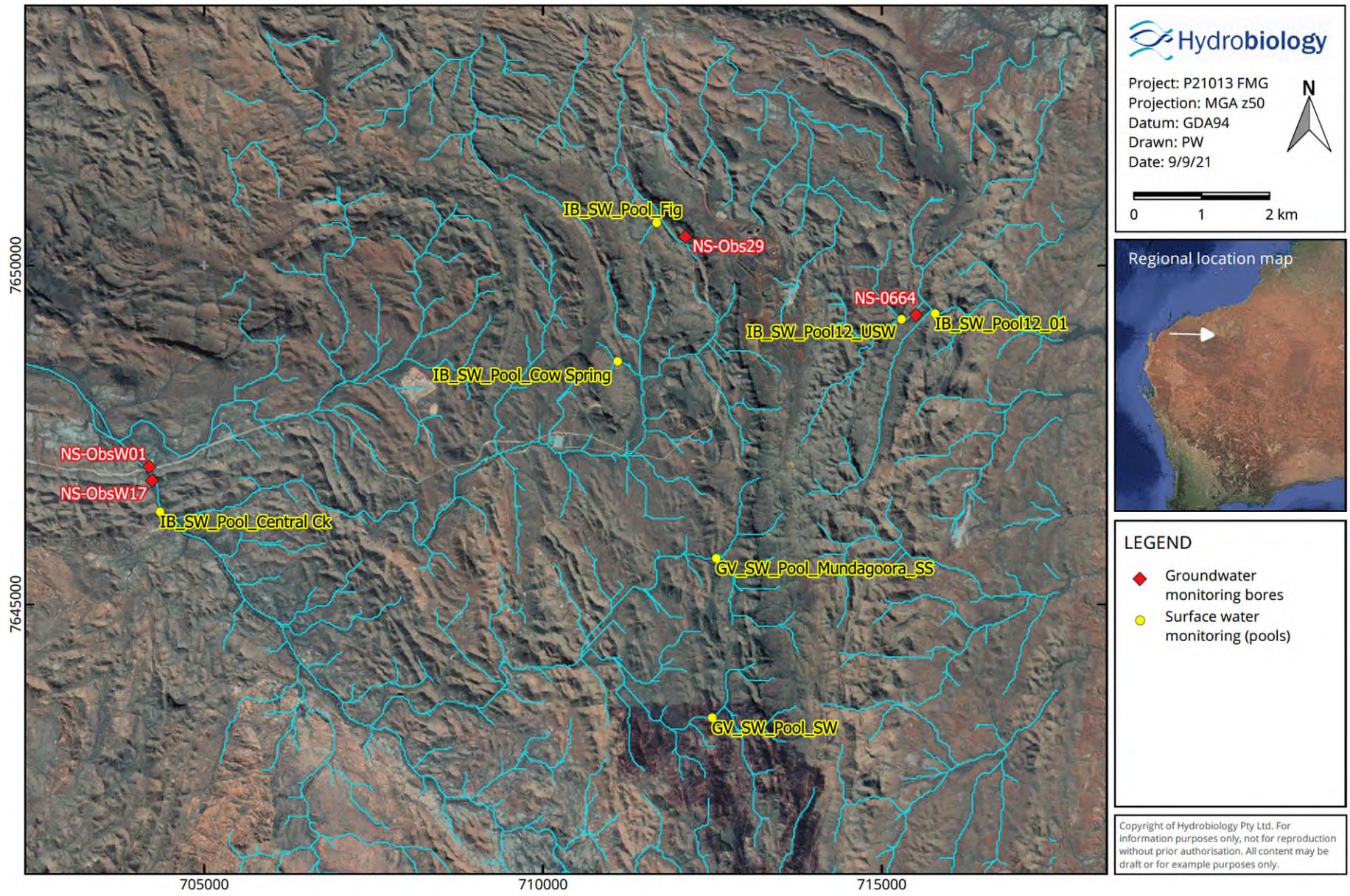


Figure 1 Map of site locations for isotope analysis – Iron Bridge Project Area



Table 1 Stable isotope data (December 2019 to June 2021)

Site Name	Site description	Date	Type	d <sup>18</sup> O [‰ VSMOW]	d <sup>2</sup> H [‰ VSMOW]
<b>GV_SW_Pool_SW</b>	Small ephemeral river pool in Glacier Valley project area to south of Mundagoora pool catchment	16/06/2021	Pool	-6.78	-49.2
<b>GV_Pool_Mundagoora_SS</b>	Permanent pool in Glacier Valley project area	17/12/2019	Pool	-5.44	-41.8
<b>GV_Pool_Mundagoora_SS</b>		30/05/2020	Pool	-6.7	-49
<b>GV_Pool_Mundagoora_SS</b>		16/06/2021	Pool	-7.24	-51.8
<b>IB_SW_Pool_Central Ck</b>	Small ephemeral pool in Iron Bridge project area.	31/05/2020	Pool	-5.92	-39
<b>IB_SW_Pool_Central Ck</b>		16/06/2021	Pool	-6.75	-47.4
<b>IB_SW_Pool_Cow Spring</b>	Small permanent pool at base of rockface in Iron Bridge project area.	1/06/2020	Pool	-8.81	-60.2
<b>IB_SW_Pool_Fig</b>	Small permanent pool at base of rockface in Iron Bridge project area. Naturally low pH.	18/12/2019	Pool	-7.57	-52.5
<b>IB_SW_Pool_Fig</b>		30/05/2020	Pool	-8.01	-55.1
<b>IB_SW_Pool_Fig</b>		17/06/2021	Pool	-8.2	-56
<b>IB_SW_Pool12_01</b>	Semi-permanent river pool over bedrock in Iron Bridge project area.	17/12/2019	Pool	-3.9	-32.1
<b>IB_SW_Pool12_01</b>		29/05/2020	Pool	-6.44	-45.4
<b>IB_SW_Pool12_01</b>		15/06/2021	Pool	-6.89	-48.8
<b>IB_SW_Pool12_USW</b>	Small pool in crevice at ridgeline crossing of Site 12 creek. Upstream of Site 12 Pool.	19/12/2019	Pool	-6.17	-45.1
<b>NS-0064</b>	Monitoring bore upstream of Site 12 Pool.	17/12/2019	Groundwater	-7.07	-49.8
<b>NS-0064</b>		29/05/2020	Groundwater	-7.59	-49.6
<b>NS-0064</b>		15/06/2021	Groundwater	-9.38	-62.1
<b>NS-Obs17</b>	Monitoring bore downstream of Central Ck pool	1/06/2020	Groundwater	-6.68	-46.6
<b>NS-Obs29</b>	Monitoring Bore near Fig Pool	1/06/2020	Groundwater	-8.91	-60.7

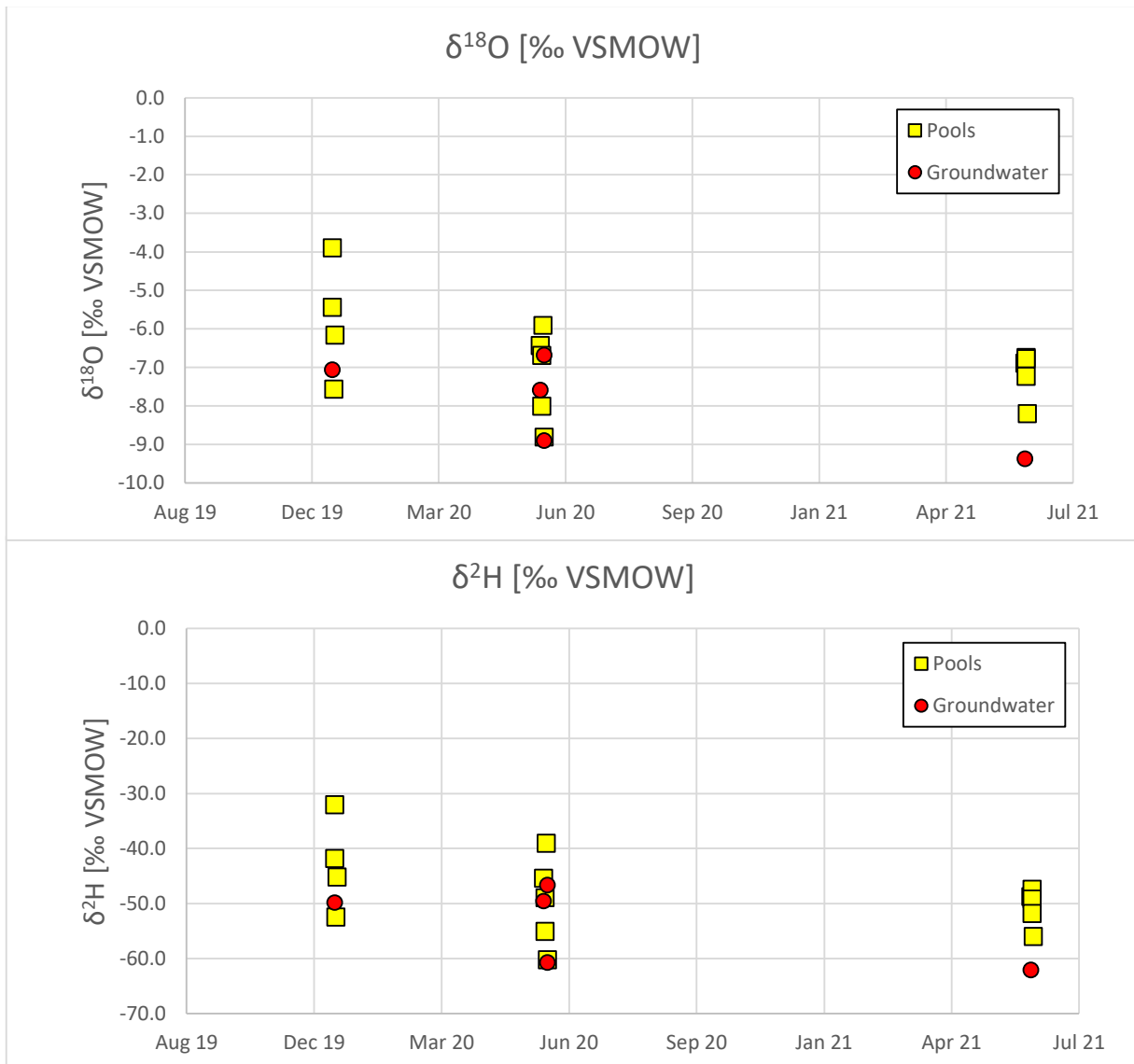


Figure 3 Isotopic ratios by sample date and water type – Dec 2019 to June 2021

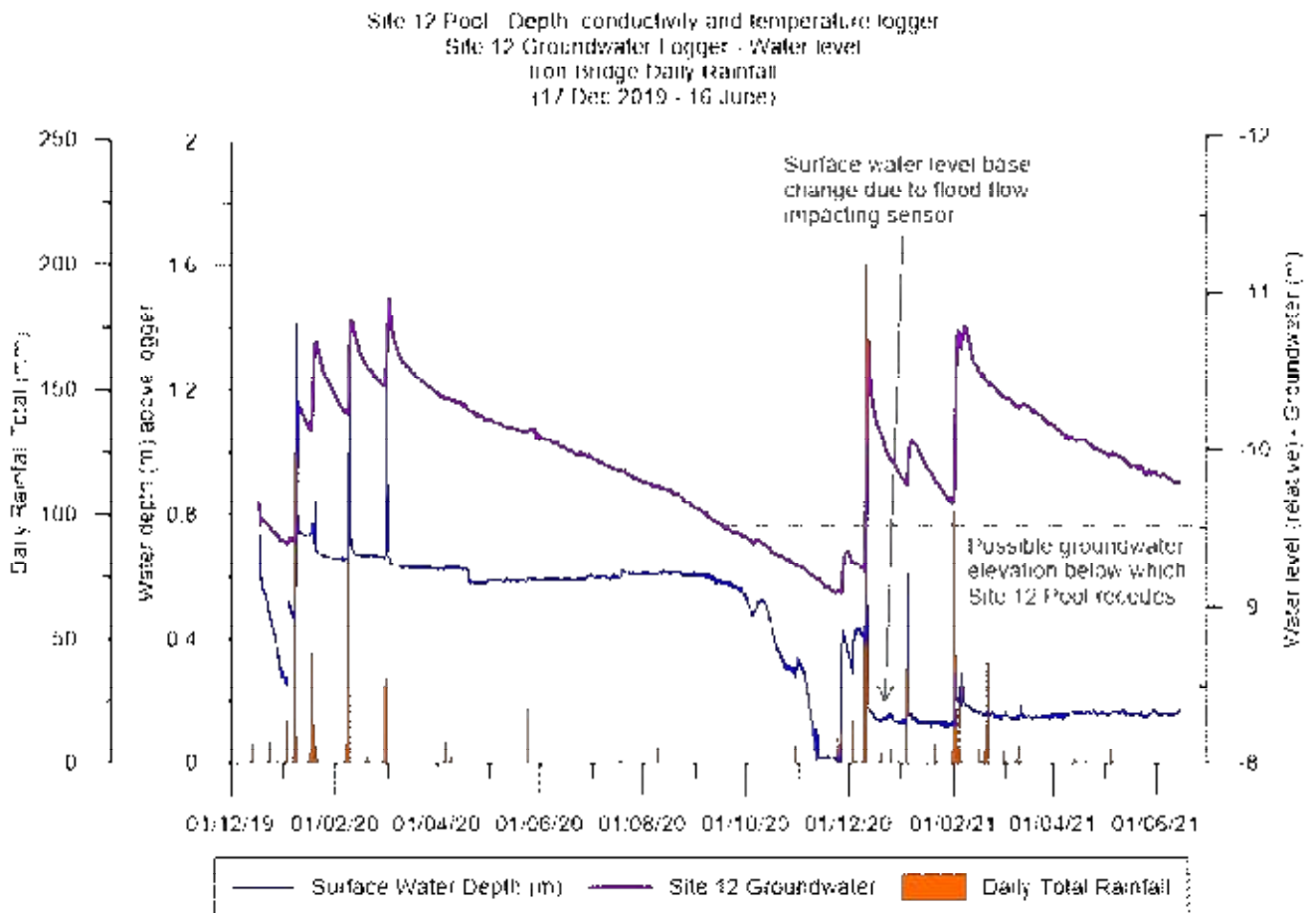


Figure 4 Comparison of surface water levels in Site 12 Pool (IB\_SW\_Pool12\_01) and groundwater levels within the adjacent monitoring bore (NS-0664).

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Appendix 31:

North Star Surface Water Monitoring Plan



# Plan

## Surface water management plan

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### Iron Bridge Project

20 April 2023

NS-00000-PL-EN-0001

Rev: 2

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## ACRONYMS

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The following acronyms, defined in Table 1, have been used throughout this Plan.

**Table 1: Acronyms**

Acronyms	
EP Act	<i>Environment Protection Act 1986</i>
EPA	Environment Protection Authority
FMGIB	FMG Iron Bridge Australia Pty Ltd
DMIRS	Department of Mines, Industry Regulation and Safety
DWER	Department of Water and Environment Regulation
IBO	IB Operations Pty Ltd
SWMP	Surface Water Management Plan
WQQMP	Site 12 Pool Water Quality and Quantity Monitoring Plan

# 1 INTRODUCTION

## 1.1 Proposal

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The North Star Magnetite Project (the Project) was approved under Part IV of the Environment Protection Act 1986 (EP Act) by Ministerial Statement 993 (MS) in January 2015. This Surface Water Management Plan (SWMP) informs the monitoring program across the whole Project area and supersedes Surface Water Management Plan (662MI-5700-PL-WM-0002 Rev1 - 2016).

The proponent for the North Star Magnetite Project is FMG Iron Bridge (Aust) Pty Ltd (FMGIB). The Project is a joint venture between FMGIB and Formosa Steel IB Pty Ltd (Formosa). The managing entity for the Project is IB Operations Pty Ltd (IBO), a joint venture company between FMGIB and Formosa.

### 1.1.1 North Star Magnetite Project

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The Project consists of the development of an open-cut iron ore mine. Waste from the mine will be sent to a dedicated waste rock dump or used to construct infrastructure. The ore will be crushed and further processed onsite to produce a magnetite concentrate, dry rejects and wet tailings.

The Project also comprises three pipelines:

- Canning Basin water supply pipeline – to carry water from a Canning Basin borefield to the Project area for use in operations including processing
- Slurry pipeline – to transfer concentrate slurry from the ore processing facility to a concentrate handling facility at Port Hedland for dewatering and export
- Return water pipeline – to return water from the concentrate handling facility to the ore processing facility for reuse.

FMGIB are seeking to extend the life of the North Star Operation through the development of nearby deposit to the south known as Glacier Valley which will sustain the North Star Operation total ore feed at 22 Mtpa (North Star Extension). North Star Extension (NSE) is proposed to include an additional pit, an extension of the waste rock dump (WRD) and ancillary infrastructure.

The location and extent of the Stage 2 North Star project is shown in Figure 1.

## 1.2 Key environmental values

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The key environmental values associated with surface waters at the Project are:

- Conservation significant fauna and their critical habitat
- Conservation significant vegetation and flora
- Surface water systems and pools with significant cultural and heritage values
- Water dependent systems (Refer to Section 1.3 for a complete definition).

### 1.3 Definitions

Surface water dependent systems occur where the composition of species and natural ecological processes are determined by the permanent or temporary presence of flowing or standing surface water.

Rainfall runoff refers to water flow over ground surfaces and in natural streams and drains as a direct result of rainfall excess (that is after rainfall losses through infiltration, evaporation and evapotranspiration) over a catchment.

### 1.4 Legislative and regulatory framework

IBO employees and contractors are obliged to comply with all relevant environmental Commonwealth and State Legislation. The legislation relevant to the management of inland waters in Western Australia is provided in Table 2.

**Table 2: Commonwealth and state legislation relating to inland waters**

Legislation	Application
Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act)	The EPBC Act is the central piece of environmental legislation which protects Matters of National Environmental Significance (MNES) including flora and fauna species and forms the framework for MNES protection at the Federal level.
Biodiversity Conservation Act 2016 (BC Act)	The BC Act provides protection and conservation for biodiversity and biodiversity components. The BC Act repeals parts of the Wildlife Conservation Act 1950.
Environmental Protection Act 1986 (EP Act)	The EP Act is the key legislative tool for environmental protection in Western Australia. It is administered by the Department of Water and Environmental Regulation (DWER) and the Minister for Environment.
Environmental Protection (Unauthorised Discharge) Regulations 2004	The Regulations administer the prevention of direct discharge of sediment or pollutants to surrounding surface waters.
Rights in Water and Irrigation Act 1914 (RIWI Act)	The RIWI Act relates to rights in water resources, to make provision for regulation, management, use and protection of water resources, to provide for irrigation schemes, and for related purposes.
Soil and Land Conservation Act 1945	Addresses the conservation of soil and land resources and the mitigation of the effects of erosion.

The following standards and guidelines are also of relevance to this Plan:

- AS/NZS 5667.1:1998 Water Quality-Sampling-Guidance
- Water Quality Protection Guidelines for Mining and Mineral Processing (Department of Water, 2000)
- Water Quality Protection Note 68 – Mechanical Equipment Wash Down (Department of Water, 2013)
- Western Australian Water in Mining Guideline (Department of Water, 2013)
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018)

- Guidance Document for Assessing and Managing Water Quality in Temporary Waters, ANZG (2018, Unpublished)
- Australian Rainfall and Runoff: A Guide to Flood Estimation (Commonwealth of Australia, 2019)

## 2 ROLES AND RESPONSIBILITIES

All FMGIB employees and contractors are required to comply with the monitoring and management procedures set out in this Plan. The commitments in this Plan are dependent on the stage of project development (i.e., exploration, construction, operations, decommissioning) and the project type (port, rail or mine), and should be implemented accordingly.

Table 3 outlines the project stage and relevant project personnel responsible for overseeing and implementing this Plan. Where responsibilities are delegated, this must be clearly recorded and communicated. Section 4 details specific management actions that have been attributed to the appropriate personnel.

**Table 3: Roles and responsibilities**

Project stage	Project personnel
Exploration	During the exploration stage, the Group Manager of Exploration will be accountable for ensuring the requirements of the Plan are met.
Construction	The Project Director (Iron Bridge) will be accountable for ensuring the requirements of this Plan are met as the Project moves into the construction stage. This includes activities undertaken by an external service provider or internal IBO or Fortescue personnel
Operation, decommissioning and closure	The General Manager (Iron Bridge) will be accountable for ensuring the requirements of this Plan are met during operations, decommissioning and closure phases This includes activities undertaken by an external service provider or internal IBO or Fortescue personnel.

When site specific Management and Monitoring Programs are developed to support this Plan, the RASCI framework will be used to delegate roles, responsibilities, and review approval levels. RASCI is used to denote:

- R-Responsible** Those who do the work to achieve the task.
- A-Accountable** Those who are ultimately accountable for the completion of the deliverable or task, and the one to whom the Responsible person is accountable
- S-Supportive** Resources allocated to the Responsible person and who will also assist in completing the task
- C-Consulted** Those whose opinions are sought, two-way communication
- I-Informed** Those who are kept informed, one-way communication.

### 3 MANAGING ENVIRONMENTAL RISK

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IBO actively reviews risk by undertaking an Annual Environmental Impact Risk review. Although the review considers all environmental risks, there is a focus on the inherent moderate to high-risk impacts. The review considers the effectiveness of management actions that are currently in place for these impacts. The review also considers any relevant incidents that have occurred, if the actions from incident investigations have translated into new management actions, and generally considers the need for any new management actions to lower potential risk.

The potential environmental impacts associated with surface water management at Iron Bridge include:

- Potential impacts to surface water flows and quality associated with the placement of infrastructure and landforms
- Potential impacts to surface water quality associated with leaching of acid and/or metalliferous drainage from temporary or permanent mine void water bodies, open mining void walls, tailings storage facilities and waste dumps during operations and following closure
- Potential changes to surface water quality as a result of excess water disposal options during emergencies
- Changes in erosion and sedimentation processes within the watercourses and pools due to altered hydrological regimes
- Impacts to surface water flows resulting from controlled surface discharge
- Permanent modifications to existing catchments and associated impacts to flow paths and inundation areas of surface water streamflow's
- Increases in sediment load in surface water runoff owing to poor management of disturbed areas
- Impacts to surface water quality associated with hydrocarbon and chemical spills.

Section 4 provides the management actions proposed to manage these potential environmental impacts associated with surface water at Iron Bridge.

#### 3.1 Site 12 Pool

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Site 12 Pool is a gorge hosting a chain of small pools over a linear distance of approximately 650 m. Most pools are shallow, with the deepest pool at a maximum depth of approximately 2.5 m. Collectively, these pools are referred to as 'Site 12 Pool'.

Site 12 Pool is a fresh-brackish (<1500 uS/cm), clear (low turbidity), alkaline pool, and water levels and quality are highly seasonal. Site 12 Pool is a magnesium-bicarbonate (Mg-HCO<sub>3</sub>) dominated water type with low sulphates (SO<sub>4</sub>) (Hydrobiology, 2020, 2021).

Since 2013, monitoring data indicates that the pools are initially filled by surface water runoff and maintain sustained by groundwater for some time thereafter, before drying out later in

the year. Following larger rainfall events, the local fractured rock aquifer can sustain pool water levels for the remainder of the wet season and into the dry season, until the local groundwater level drops below the pool elevation.

Site 12 Pool was identified as a significant water body and potential Pilbara Olive Python habitat. Located on the eastern boundary of the Disturbance Envelope, the Site 12 Pool was the subject of Condition 12 of Ministerial Statement 993, which required that IBO prepare a Water Quality and Quantity Monitoring Plan (WQQMP) prior to ground disturbing activities within the catchment of the pool. The *Site 12 WQQMP* (662MI-5700-PL-WM-0001) has been prepared separate to this SWMP and should be referred to for monitoring requirements specific to Site 12 Pool.

Potential impacts upon Site 12 Pool from the construction and operation of the Stage 2 waste rock dump (WRD) will be managed through the *Site 12 Pool WQQMP* (662MI-5700-PL-WM-0001).

## 4 ENVIRONMENTAL MANAGEMENT

A series of environmental management objectives have been developed to mitigate environmental impacts. Those relating to surface water management include:

1. Assess the potential detrimental impacts to surface water dependent flora and fauna, land hydrological processes (watercourses and pools) within high-risk areas
2. Establish management strategies to minimise the number of potential detrimental impacts to surface water dependent flora and fauna
3. Develop and implement a monitoring program to assess the effectiveness of the management strategies.

For each objective, management actions have been developed to ensure the impacts from the operations are managed, and that appropriate monitoring, reporting and corrective action functions are implemented to support the successful implementation of the management actions.

The management actions have been derived from the initial analysis of key environmental values described in Section 1.2. It is anticipated that these management actions will evolve over time in response to new data availability and information as the development of the mine progresses (Table 4).

**Table 4: Descriptions of key elements of the environmental management process**

Element	Definition / description
Objective	What is intended to be achieved
Management action	Assigned tasks to meet the objective
Performance indicators	Metrics for evaluating the outcomes achieved by Management Actions
Reporting / evidence	Evidence demonstrates that the Management Action has been applied and the outcome evaluated
Timing	Period during which the Management Action should be undertaken
Responsibility	Accountability for ensuring management action is completed. The responsible role is dependent on project timing.

The key management actions, performance indicators, evidence, timing and responsibilities for each objective are provided in Table 5.

**Table 5: Surface water management actions**

Reference	Management controls	Performance indicator	Reporting / evidence	Timing	Responsibility
<b>Objective 1</b>	<b>Assess potential direct and indirect detrimental impacts on surface water dependent flora and fauna, and hydrological processes within high-risk areas</b>				
1.1	Conduct and maintain a risk assessment process to identify areas where surface water dependent flora and fauna, and hydrological processes (watercourses and pools) may be impacted.	Hydrological assessment conducted and risk identified High risk areas identified	Management Controls	All stages	Manager Environmental Approvals/ Project Manager/ Group Manager, Environment Manager Water Planning
1.2	Where inherent high risk areas have been identified, management controls will be implemented to reduce the residual risk. This may also include further hydrological modelling to understand potential impacts and determine if future studies are required.	Assessments completed GIS and PIMS updated Future studies identified	Fieldwork notes / surveys GIS dataset PIMS record Monitoring planned	All stages	Project Manager/ Group Manager, Environment
1.3	The LUC Procedure will be followed to ensure surface water related flora and fauna, and hydrological processes (watercourses and pools) are identified prior to ground disturbance. Where works may potentially impact on these within identified high-risk areas, management measures will be applied to the LUC.	Management measures included in relevant LUCs	LUC approval	Construction / operations	Project Manager, Manager Environment Operations.
<b>Objective 2</b>	<b>Establish management strategies to minimise potential detrimental impacts</b>				
2.1	Personnel will be inducted to site with information relevant to their roles and the protection of environmental values, including surface water. Relevant personnel will be directed in the requirements for appropriate management of surface water, if and when required."	Staff with appropriate qualifications and experience assigned to relevant tasks FMG inductions completed Role dependent training completed	Qualifications and experience verified Induction materials and register of attendees Training materials /records	All stages	Project Manager/ Manager Environment, Operations
2.2	Minimise interaction with major drainage lines where practicable to reduce impacts on downstream hydrological processes that may be linked to flora, fauna and surface water dependent ecosystems. Where avoidance is not practicable, surface water management infrastructure is to be developed to minimise the impacts on surface water dependent flora and fauna. Where practicable, this may include construction of diversion structures to maintain surface water flow continuity downstream of development.	Major drainage lines avoided where practicable Surface water management infrastructure in line with FMG Drainage Specification No detrimental impact to hydrological regimes and health of the ecological systems/ SWDE	Design Surface water modelling	Design / Construction	Project Manager/ Manager Mine Planning and Water Planning
2.3	Design main access road crossings to allow for the flow continuity and so that they do not have a detrimental impact on hydrological processes on Turner River, Cockatoo Creek or Central Creek Pool.	Main access road designed with either floodway or up to at least a 20% AEP (1 in 5 year) event or higher to allow flow continuity. No detrimental impacts to hydrological processes at Turner River West, Turner River, Cockatoo Creek or Central Pool.	Surface water modelling Design Downstream monitoring	Design	Project Manager, Manager Mine Planning
2.4	Consider the 1% AEP (1 in 100 year) event in the design of the camp facilities and process infrastructure and 2% (1 in 50 year) event in the design of airport with an allowance for climate change over the serviceable life. Ensure that there are no significant detrimental impacts on the hydrological processes of the Turner River or Cockatoo Creek (including Central Creek Pool).	Camp and process infrastructure designed for a 1% AEP event. No detrimental impacts to hydrological processes at Turner River, Cockatoo Creek or Central Pool.	Surface water modelling Design Downstream monitoring	Design / operations	Project Manager, Manager Mine Planning
2.5	Install culverts and drainage infrastructure to prevent mine infrastructure from causing detrimental harm to hydrological processes for all catchments	Location of infrastructure and drainage aligns with the risk assessment outcomes in the Mining Proposal.	Surface water modelling Design Downstream monitoring	Design	Project Manager, Manager Mine Planning , Manager Mining
2.6	Drainage and diversion infrastructure location and detailed design to align with FMG Standard Engineering Specification for Drainage and Flood Protections (100-SP-CI-0004).	Location of infrastructure and drainage aligns with Standard	Design	All stages	Project Manager, Water Planning Manager, Manager for relevant assets.
2.7	Access to all identified pools will be restricted to authorised personnel only.	Management measures included in relevant LUCs	LUC Approval	All stages	Manager Mining, Iron Bridge General Manger

Reference	Management controls	Performance indicator	Reporting / evidence	Timing	Responsibility
			Signage will be installed to notify and restrict access around the pools		
2.8	Use erosion management strategies (e.g., sediment basin/ trap, bunding, vegetated batters, etc.) to control potential release of sediment from cleared areas, mining and waste landforms into major creeks and pools.	Water quality of monitored major creeks with the diluted streams downstream of hardstand area, mining and waste landforms remain similar to background / reference levels	Design Downstream monitoring	Design/ construction/ operation	Project Manager/ Manager Mining
2.9	Conduct progressive rehabilitation of disturbed areas no longer required for operations in accordance with the North Star Mine Closure Plan (NS-PL-EN-0001).	Areas no longer required for operational use are rehabilitated.	Compliance Assessment Report Annual Environmental Report	Construction/ operations/ closure	Manager Mine Planning Mine Closure
2.10	Chemical and hydrocarbon storage areas will be designed, constructed and operated in accordance with the requirements outlined in the Chemical and Hydrocarbon Management Plan (100-PL-EN-0011) and a Licence issued under Part V of the Environmental Protection Act 1986, where relevant	Compliance with Chemical and Hydrocarbon Management Plan	Design Inspection reports	Construction/ operations	Project Manager/ NPI Manager Manager Environment Operations
2.11	The TSF will be designed, constructed and monitored in accordance with the requirements of the Department of Mines, Industry Regulation and Safety (DMIRS) tailings Guidelines and the Australian National Committee on Large Dams (ANCOLD) Guidelines and relevant Part V approvals under EP Act.	The TSF is designed and operated to avoid detrimental impact on the hydrological processes of the Lost Boys Creek as stated in the PER (NS-AE-EN-0001)	Surface water modelling Design Compliance with TSF Operations Manual Downstream monitoring Annual Environmental Report	Design/ construction	Planning Manager Geotechnical / TSF Principal
2.12	Implementation of the Site 12 Pool WQQMP (662MI-5700-PL-WM-0001)	No significant detrimental impact on flora, fauna or hydrological processes and water quality at Site 12 Pool	Ongoing multiple lines of evidence monitoring regime for Site 12 pool	Design/ construction/ operations	Planning Manager Manager Environmental Operations
2.13	The landfill to be designed in accordance with the Siting, Design, Operation and Rehabilitation of Landfills (DoE, 2005) and any Licence issued under Part V of the Environmental Protection Act 1986.	Location and design of the landfill reduces impacts to ecological and heritage areas	Design Part V Compliance Report (Landfill)	Design/ construction	Planning Manager
2.14	As part of pit flood management, surface water runoff collected in the mine pits will be pumped to the TSF for use within the ore processing facilities. Should capacity issues prevent discharge to the TSF, the surface water collected in the pits will be discharged into the environment via dewatering infrastructure (sump/pumps), as described in a Pit Flood Response Plan. The Pit Flood Response Plan will be developed and updated annually as part of each wet season preparedness. Water will be tested prior to discharge to the environment to ensure that it meets the water quality requirements outlined in the Pit Flood Response Plan. This includes measurement of electrical conductivity (EC) and turbidity, as well as a visual inspection of hydrocarbons.	Compliance with the Pit Flood Response Plan TSF Operations Manual Monitoring demonstrates water quality within acceptable limits	Annual Environmental Monitoring Report	Operations	Manager Mining Manager Water Management/ Mine Services Manager Environment Operations
2.15	The Canning Basin, Slurry and Return Water pipelines will be buried along most of their routes to prevent any disruption to hydrological processes. The pipeline burial depth and alignment at major river crossings as per the scour elevation recommendation outlined in the geomorphological study to minimise pipeline scouring risk. Surface water management measures will be put in place during construction to minimise disruption to hydrological processes. The measures will be outlined in the Iron Bridge Construction Management Plan (662NS-0000-PL-EN-003).	No significant change in hydrological processes, or erosion at watercourse crossings	Post-construction inspection report Annual Environmental Monitoring Report	Construction / operations	Manager Mining
2.16	Sediment Control Management for identified impact pools as shown in Figure 2 • Hydrological assessment of pools and ongoing monitoring of pool water quality and quantity to understand the sediment transport risk for individual pools • Develop site specific sediment control measures for the pools based on the risk assessment of development activities and potential impact on the pools	No detrimental impact on flora, fauna or hydrological processes and water quality at individual pools	Ongoing multi-lines of evidence monitoring regime for all pools within North Star and North Star Extension Development Envelope Site specific control measures established	Design/ construction/ operations	Planning Manager Manager Environmental Operations

Reference	Management controls	Performance indicator	Reporting / evidence	Timing	Responsibility
<b>Objective 3</b>	<b>Establish management strategies to minimise potential detrimental impacts</b>				
3.1	Ensure baseline modelling and sampling are undertaken to document surface water quality and quantity within impact and reference / unimpacted sites. Compare data across impact and reference sites (and/or regional monitoring sites where available) to rationalise the natural variance vs development impact	Baseline modelling and/or surface water sampling undertaken for all sites. Data comparison undertaken.	Baseline monitoring reports Modelling reports	Design/ construction/ operation	Project Manager/ Manager Water Planning/ Manager Water Services/ Manager Mine Services/ Manager Environment Operations.
3.2	Implement the monitoring program Outlined in Section 5 of this document	Compliance with the Plan Monitoring program implemented	Monitoring reports Annual Compliance Reporting	Design/ construction/ operations/ decommissioning and closure	Manager Environment Operation
3.3	Implement contingency actions where monitoring indicates potential impacts to surface water dependent flora and fauna, or hydrological processes. Update this Plan where required to inform an adaptive management approach to surface water management across the Project.	Contingency actions established and implemented Monitoring program implemented	Monitoring reports AEMR Reporting records	Design/ construction/ operations/ decommissioning and closure	Manager Environment Operation

## 5 MONITORING GUIDELINES

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A monitoring program is required to measure the efficacy of actions identified in this Plan. The outcomes of the monitoring program will contribute to ongoing improvements in management actions to ensure an adaptive management approach is adopted.

### 5.1 Objectives

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The objectives of the Plan are to:

1. Establish a monitoring network that is adequate to capture spatial and temporal changes in surface water quality and quantity across the Project area
2. Outline protocols, procedures and frequency for monitoring and evaluating water quality and quantity at monitoring sites
3. Set monitoring methodology to mitigate against potential detrimental impacts to key environmental values
4. Describe contingency measures to be implemented for mitigating changes to surface water quality and quantity in an event that a performance indicator is exceeded
5. Establish review and reporting arrangements to feed into the adaptive management process.

### 5.2 Multiple lines of evidence monitoring

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Due to the complexity of the hydrological and environmental conditions at the site, the use of single parameters to indicate potential detrimental harm may not be representative.

The multiple lines of evidence monitoring approach adopted in this SWMP is consistent with the Site 12 Pool WQQMP, which is supported by ANZG (2018a). Australian and New Zealand Guidelines for Fresh and Marine Water Quality and ANZG (2018b) Guidance Document for Assessing and Managing Water Quality in Temporary Waters, Unpublished.

The primary monitoring parameters for analyses are:

1. Surface water elevation in watercourses and pools
2. Surface water quality in watercourses and pools.

Supplementary monitoring parameters will be collected and analysed in the event of the primary monitoring parameters have been identified as potential development impact. The supplementary monitoring parameters include:

- Groundwater levels and quality upstream of pools where required
- Reference and local region watercourses and pools
- Ecosystem health monitoring in watercourses and pools

### 5.3 Monitoring site locations

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Monitoring sites have been, and will continue to be, positioned throughout the mine development area in:

- Major waterways
- Significant permanent and semi-permanent pools
- Downstream of waste landforms, including WRD, dry rejects landform (DRL) and tailings storage facility (TSF)
- Downstream of OPF and Landfill

Surface water monitoring locations installed to date are presented in Figure 2 and are summarised in Table 6.

The monitoring locations include potential impact and reference / unimpacted sites. The location of potential impact sites facilitate the assessment of surface water management measures against the

Reference or unimpacted monitoring sites are located in undisturbed surface water sub-catchments to identify any natural seasonal changes to the regional surface water quantity or quality from current and planned future mining activities.

**Table 6: Monitoring site locations**

Area / aspect to be monitored	Monitoring sites	Parameter	Collection method	Frequency <sup>1,2</sup>
Major waterways – upstream of development areas (reference waterways)	IB_SW_TSF_3 IB_SW_Camp_US IB_SW_MAR_US (IB_SW_MAR_US_RSS) IB_SW_Pool12_USN	Surface water level and quality (Physicals, Nutrients, Ions, Metal suite)	Field Measurement using calibrated instruments Pressure transducers (water level) Rising stage samplers (water quality)	15 min automatic water level logging Quarterly and/or event based water sample and field measurement
Major waterways – downstream of development areas (Potential impact waterways)	IB_SW_TSF_01 IB_SW_TSF_02 IB_SW_CockatooCr_MAR3 IB_SW_DryReject_DS_01 IB_SW_DryReject_DS_02 IB_SW_OPF_DS_01 IB_SW_OPF_DS_02 IB_SW_ROM_DS IB_SW_Landfill_01 GV_SW_WRD_01 IB_SW_Pool12_USS IB_SW_Pool12_USW (IB_SW_Pool12_USW_RSS)	Surface water level and quality (Physicals, Nutrients, Ions, Metal suite, AMD suite <sup>5</sup> )	Field Measurement using calibrated instruments Pressure transducers (water level) Rising stage samplers (water quality)	15 min automatic water level logging Quarterly and/or event based water sample and field measurement
Unimpacted Pools	GV_SW_Pool_NJA19-002 GV_SW_Pool_NJA19-004	Surface water level	Pressure transducers (water level)	3hr automatic water level logging
Potentially impacted pools <sup>4</sup>	IB_SW_Pool_Fig IB_SW_Pool_CentralCk IB_SW_Pool12_01 IB_SW_POOL_CowSpring	Surface water level and quality (Physicals, Nutrients, Ions, Metal suite)	Field Measurement using calibrated instruments Pressure transducers (water level) Grab water samples	3hr automatic water level logging Monthly from November to April, Quarterly from May to October, and/or event based.

	GV_SW_Pool_Mundagoora_SS GV_SW_Pool_SW GV_SW_Pool_SWGV_DS GV_SW_Pool_NJA21-006_US GV_SW_Pool_NJA21-006_DS	Surface water level and quality (Physicals, Nutrients, Ions, Metal suite)	Field measurement using calibrated instruments Pressure transducers (water level) Grab water samples	3hr automatic water level logging  Biannually and/or event based
	Fig Pool Central Creek Pool Site12Pool Cow Spring pool Mundagoora Pool SWGV Pool (known as Glacier Valley Spring) NJA21-006Pool	Ecosystem health	Visual inspection Fauna traps Grab water samples	Biannually
Discharge point of washdown bays and oily water ponds/sumps (if available), otherwise suitable location downstream of any flow.	As per Part V requirements	Surface water quality	Field measurement using calibrated instruments. Grab water samples from pond/basin/oily water separator.	As per Part V requirements
Centroid, upper reaches of rainfall catchment. On high ground away from buildings, vegetation etc.	Nate Tower	Rainfall	Local weather stations including Nate Communication Tower and Met Station at the aerodome Tipping bucket rain gauge	Continuous
Drainage infrastructure	Culverts, bunds, levees, bridge guide banks	Structural integrity		
Drainage infrastructure	Floodways, diversion and stormwater drains	Structural integrity Accumulation of sediment and vegetation debris	Field assessment	Annually
Drainage infrastructure	Sediment traps and sedimentation basins	Surface water quality	Field assessment and/or level indicators	Biannually when water is present

Mine void water bodies	Directly from the waterbody, at surface level	Surface water quality	Field measurement using calibrated instruments Grab (field) samples	Prior to pit flood response discharge to Environment
RoM	ROM B sediment pond	Surface water quality	Field measurement using calibrated instruments Grab (field) samples from pond	Biannually when water is present
Major waterway crossings along raw water and slurry pipeline corridors	Length of pipeline corridor waterways crossings Photopoints TBC	Depth of scour	Visual inspection Georeferenced Photo Monitoring Erosion pins LiDAR	Annually inspection within six weeks of the end of the wet season (pending safe access) Annual LiDAR comparison

1. For the purpose of this plan, 'event based' is defined as rainfall that has resulted in visual streamflow across a floodway or down a designated river/creek/stream. It is noted the waterways and the pools are expected to be dry during dry season and wet season before the first flush. The samples can only be collected when there is water present in waterways and pool.
2. There is no vehicle access for all the monitoring sites at NSE including GV\_SW\_SW\_WRD\_01, GV\_SW\_Pool\_NJA19-002, GV\_SW\_Pool\_NJA19-004, GV\_SW\_Pool\_Mundagoora\_SS, GV\_SW\_Pool\_SW, GV\_SW\_Pool\_SWGV\_DS, GV\_SW\_Pool\_NJA21-006\_US and GV\_SW\_Pool\_NJA21-006\_DS.
3. IB\_SW\_Cockatoo Cr\_MAR refers to water level logger site only. The water quality sampling will be taken at Central Creek pool immediately upstream of IB\_SW\_Cockatoo Cr\_MAR.
4. Potentially impacted pools and waterways include current and planned future mine activities.
5. AMD suite is only required for the monitoring sites downstream of the waste rock dump, including GV\_SW\_WRD\_01, IB\_SW\_Pool 12\_USS and IB\_SW\_Pool 12\_USW\_RSS.

## 5.4 Monitoring parameters

An effective monitoring program may be modified over time, dependent on quality and quantity of data collected from each site, with innovations in monitoring techniques and methodologies incorporated into the program design. This would however be dependent on and be driven by the quality and quantity of data collected from each site, coupled with a periodic review of monitoring methods. Further, program design should be based on replicable sampling at potential impact and reference sites.

A set of preliminary monitoring parameters and methods have been selected to provide comprehensive coverage of potential changes in water flow and quality that can be expected under a range of different mining related impacts.

The precise timing and frequency of field measurements and sample collection will depend on the presence of water at the monitoring locations. It may not be possible to collect measurements or samples in every event, as the sampling locations may be dry for several months of the year or in some instances, inaccessible. Monitoring locations will be checked at the frequencies outlined in Table 6 and recorded as “dry” or “nil” if there is no water.

### 5.4.1 Water quantity

Pressure Transducers have been and will continue to be installed at all surface water level monitoring locations. The sensors will allow for collection of a time series of water levels.

Surface water levels will be recorded at a maximum of fifteen-minute intervals for waterways and 3 hrs interval for pools during events. The data will be downloaded once every six months and the sensor will be serviced annually. The data will be adjusted to account for variations in barometric pressure as recorded by the Site 12 Pool Barometer.

### 5.4.2 Water quality

Water quality parameters are outlined in Table 7 to Table 9 and are based on the requirements identified in:

- Water Quality Protection Guidelines No. 11 Mining and Mineral Processing – Mine Dewatering
- The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000)
- North Star Magnetite Project Conceptual Site Model, SRK Consulting 2020
- Site 12 pool WQQMP, 662MI-5700-PL-WM-0001.

**Table 7: Water quality parameters for waterways**

Parameter class	Monitoring parameter
Physical-chemical <sup>4</sup>	pH, Temperature, Dissolved Oxygen (DO), Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Turbidity, Total Organic Carbon (TOC) <sup>1</sup> , Dissolved Organic Carbon (DOC) <sup>1</sup>
Nutrients	Total Nitrogen, Total Phosphorus, Ammonia/Ammonium, Total Kjeldahl Nitrogen: TKN, Nitrate+Nitrite (NOx as N)
Ions – Major anions	Total Alkalinity, Chloride, Fluoride, Sulphate, Bicarbonate/Carbonate

Ions – Major cations	Calcium (Ca), Potassium (K), Magnesium (Mg), Sodium (Na), Total Acidity as CaCO <sub>3</sub> <sup>2</sup> , Hardness
Metals suite – Dissolved	Al, As, Cd, Cr, Cu, Fe, Pb, Ni, Zn, Hg, B, Ba, Be, Co, Mn, Se, V
Metals suite – Total	Cu, Hg, Zn
Metals suite – dissolved for AMD <sup>3</sup>	Ag, Bi, Ce, Cs, La, Mo, Rb, Sb, Sn, Sr, Th, Ti, Tl, U, W

1. TOC and DOC are to be collected for baseline only. Applicable only to the monitoring locations downstream of OPF with potential hydrocarbon risk; IB\_SW\_Cockatoo Cr\_MAR, IB\_SW\_OPF\_DS\_01, IB\_SW\_OPF\_DS\_02.

2. The parameter will be collected for the baseline monitoring prior to operation. The long-term monitoring requirement will be reviewed further, subject to the baseline monitoring evaluation.

3. AMD suit is only required for the monitoring sites downstream of the waste rock dump, including GV\_SW\_WRD\_01, IB\_SW\_Pool12\_USS and IB\_SW\_Pool12\_USW\_RSS.

4. Field measurement include pH, EC, DO, Turbidity and Temperature. The Temperature and DO are to be carried out only as field measurement. Others will be included in both field measurement and lab analysis.

**Table 8: Water quality parameters for pools**

Parameter class	Monitoring parameter
Physical-chemical	pH, Temperature, Dissolved Oxygen (DO), Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Turbidity, Total Organic Carbon (TOC), Dissolved Organic Carbon (DOC)
Nutrients	Total Nitrogen, Total Phosphorus, Ammonia/Ammonium, Total Kjeldahl Nitrogen (TKN), Nitrate+Nitrite (NO <sub>x</sub> as N)
Ions – Major anions	Total Alkalinity, Chloride, Fluoride, Sulphate, Bicarbonate/Carbonate,
Ions – Major cations	Calcium (Ca), Potassium (K), Magnesium (Mg), Sodium (Na), Total Acidity as CaCO <sub>3</sub> Hardness
Metals suite – Dissolved	Al, As, Cd, Cr, Cu, Fe, Pb, Ni, Zn, Hg, B, Ba, Be, Co, Mn, Se, V
Metals suite – Total	Cu, Hg, Zn

**Table 9: Water quality parameters for miscellaneous sources**

Parameter class	Monitoring parameter	Source signature
Physical-chemical	pH, Temperature, Dissolved Oxygen (DO), Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Surfactants <sup>1</sup> , Turbidity	Workshops/washdowns areas sedimentation basins
Nutrients	Total Nitrogen, Total Phosphorus, Ammonia/Ammonium	Wastewater treatment facilities Landfill
Metal Suite - AMD	Ag, Bi, Ce, Cs, La, Mo, Rb, Sb, Sn, Sr, Th, Ti, Tl, U, W	Pit Flood Response water discharge Acid and metalliferous drainage

1. Surfactants is to be monitored for workshop/washdown areas only.

## 5.5 Ecological health monitoring

Ecological health will be monitored biannually at Site 12 Pool, Fig pool, Central Creek Pool, Cow Spring Pool, Mundagoora Pool, Pool SWGV, NJA21-006 Pool, NJA19-002 pool and NJA19-004 pool.

The data will provide supplementary information to assist in the assessment of changes in conditions at the pools that exceed natural variability.

The parameters included in the ecological health assessment are summarised in Table 10.

**Table 10: Ecological health parameters**

Indicator	Parameter	Collection method
Diatom community	DSIAR scores and diversity	Diatom plates (periphytometers)
Aquatic macroinvertebrate community	EPT abundance index	Sweep nets
Fish community	Presence/absence Size structure	Fyke nets
Sediment quality	Total Alkalinity, Total Acidity, SO <sub>4</sub> , Nutrients (nitrite, nitrate, phosphate), Ions (Cl, F, Ca, Mg, Na, K), total metals (As, Cd, Cr, Cu, Fe, Pb, Ni, Zn, Hg, B, Ba, Be, Co, Mn, Se, V), TOC	Sediment sampling
Habitat assessment	Wider habitat health	Visual inspection of habitat Quality / health record on habitat sheet Visual inspection of habitat
Macrophyte diversity	Presence/absence	Habitat sheet

## 5.6 Monitoring methodology

Surface water monitoring methodology and techniques used to monitor identified parameters include:

Monitoring will be conducted in accordance with the monitoring procedures outlined in the Environment Procedure: Surface Water Quality Sampling (100-PR-EN-0028).

Surface Water Sampling should be conducted in accordance with the AS/NZS 5667.1:1998 Water Quality-Sampling-Guidance on the design of sampling programs, sampling techniques and preservation and handling of samples and the Department of Water Field Sampling Guidelines: A guideline for field sampling for surface water quality monitoring programs.

## 5.7 Review

The overarching monitoring program will be technically assessed and reviewed upon acceptance of this plan and then every three years thereafter. The main objective of the assessment and review will be to ensure that the methods, parameters and frequency used are considered and appropriate to the findings of the monitoring program.

Once site-specific guideline values are set, the monitoring program will be reviewed as part of annual reporting process. If no targets are exceeded after three years (as a minimum) where sufficient rainfall occurs, the frequency of monitoring will be reduced to a frequency supported by the review.

Monitoring sites may need to be modified over time in response to project impacts.

Contingency action and reporting requirements will be implemented where required.

## **5.8 Data-handling and statistical analysis**

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Data handling protocols will be established annually by the responsible consultant. The protocol will include the requirements as to data storage and protection, data extraction, quality control, analysis, interpretation, reporting and presentation.

The protocol will also directly reference and align with the requirements detailed in Document Control (Information Management) Standard (100-ST-DC-001) and Geographic Information Systems and Raw Data Guidelines (100-GU-EN-0009).

Statistical analysis of data will be undertaken where data permits. Where data capture allows, analysis will include using appropriate statistical analysis techniques. If parameter relationships appear to be present or exceedances or trends occur, causative assessment will be undertaken and corrective actions implemented.

The results of chemical and physical data should be analysed after every sample event, values of each parameter should be compared to the existing dataset.

Monitoring (water elevation) data will be used to identify any variation in the baseline modelling using actual flood event data recorded from rainfall and surface water monitoring sites within the project catchments. A minimum of two annual seasonal events will be required to revisit a review of the surface water model for the site, and only events that have whole of catchment runoff will be considered as significant for modelling review to take place. Where an exceedance has occurred, a complete verification of the flood model developed during baseline modelling will be required.

## **6 COMPLIANCE**

---

IBO ensures compliance with its legal obligations through first party quality assurance by site and corporate environment teams with a focus on effective environmental management via implementation of the Fortescue-wide Environmental Management System (EMS).

IBO has adopted a risk-based approach to monitor compliance with its legal obligations.

Site environment teams will monitor compliance with this Plan and the required site-specific management and monitoring programs.

Where non-conformance issues or opportunities for improvement are identified these will be documented and tracked via the Business Management System (BMS).

## **7 REPORTING**

### **7.1 Annual compliance assessment report**

---

IBO is required to prepare Annual Compliance Assessment Reports (CAR) to the CEO in accordance with Condition 4-6 of MS 993, documenting compliance with the conditions of MS 993.

The CARs are prepared in accordance with the OEPAs (2012) Post Assessment Guideline for *Preparing a Compliance Assessment Report, Post Assessment Guideline No. 3*.

In the event that management targets or threshold criteria were exceeded during the reporting period, the CAR will include a description of the effectiveness of the contingency actions that have been implemented to manage the impact and any adaptive management measures applied as a result of the exceedance.

### **7.2 Reporting of potential non-compliances**

---

In accordance with Condition 12-7 of MS 993, in the event that monitoring trigger levels are exceeded as a result of mining activities, IBO will provide a report to the OEPA CEO that describes the investigations and management actions to be undertaken. This report will be provided within 21 days of the identification of the exceedance.

## 8 ADAPTIVE MANAGEMENT

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IBO will implement adaptive management practices to learn from the implementation of mitigation measures, monitoring and evaluation against management targets, to more effectively meet the conditioned environmental objective. Adaptive management practices that will be assessed for the management and monitoring program as part of this approach may include:

- Evaluation of the monitoring program, data and comparison to baseline data and reference sites on an annual basis to verify whether responses to project activities are the same or similar to predictions
- Evaluation of assumptions and uncertainties of the management and monitoring program
- Re-evaluation of risks and revision of risk-based priorities as a result of monitoring outcomes
- Review of data and information gathered over the review period that has increased understanding of site environment in the context of the regional ecosystem
- Review of management actions as the project matures and new management measures and technologies become available that may be more effective for environmental management
- Assessment of changes which are outside the control of the project and the management measures identified (i.e. a new project within the area or region; regional change affecting management)
- Review of the Environmental Management Plan will be undertaken following the review of the associated monitoring program and the corresponding results.

## **9 REVIEW OF THE PLAN**

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Review of this Plan will be undertaken in response to:

- Revision to the conceptual water model(s) in response to testing and verification
- The site Geochemical Conceptual Site Model (662NS-0000-RP-EN-0045)
- Amendments to the environmental risk assessment in response to a new Mining Proposal submitted under the Mining Act 1978
- Monitoring program review, inclusive of baseline data capture and site-specific target development
- Adaptive management response.

## 10 REFERENCES

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This Plan and all internal supporting documents will be managed as per Fortescue Document Governance Standards. These may be read in conjunction with this report.

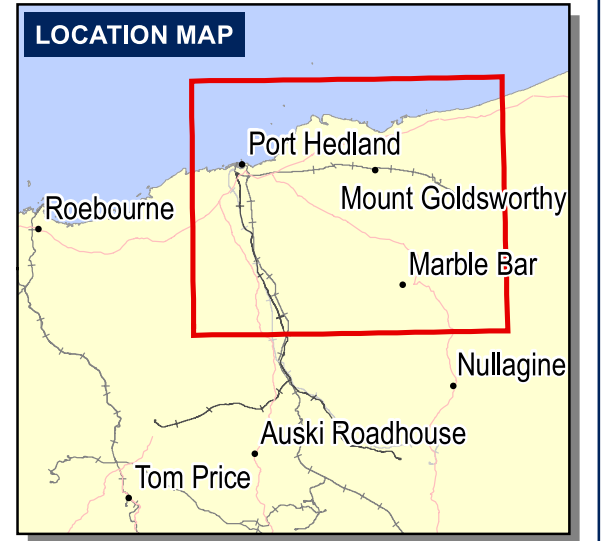
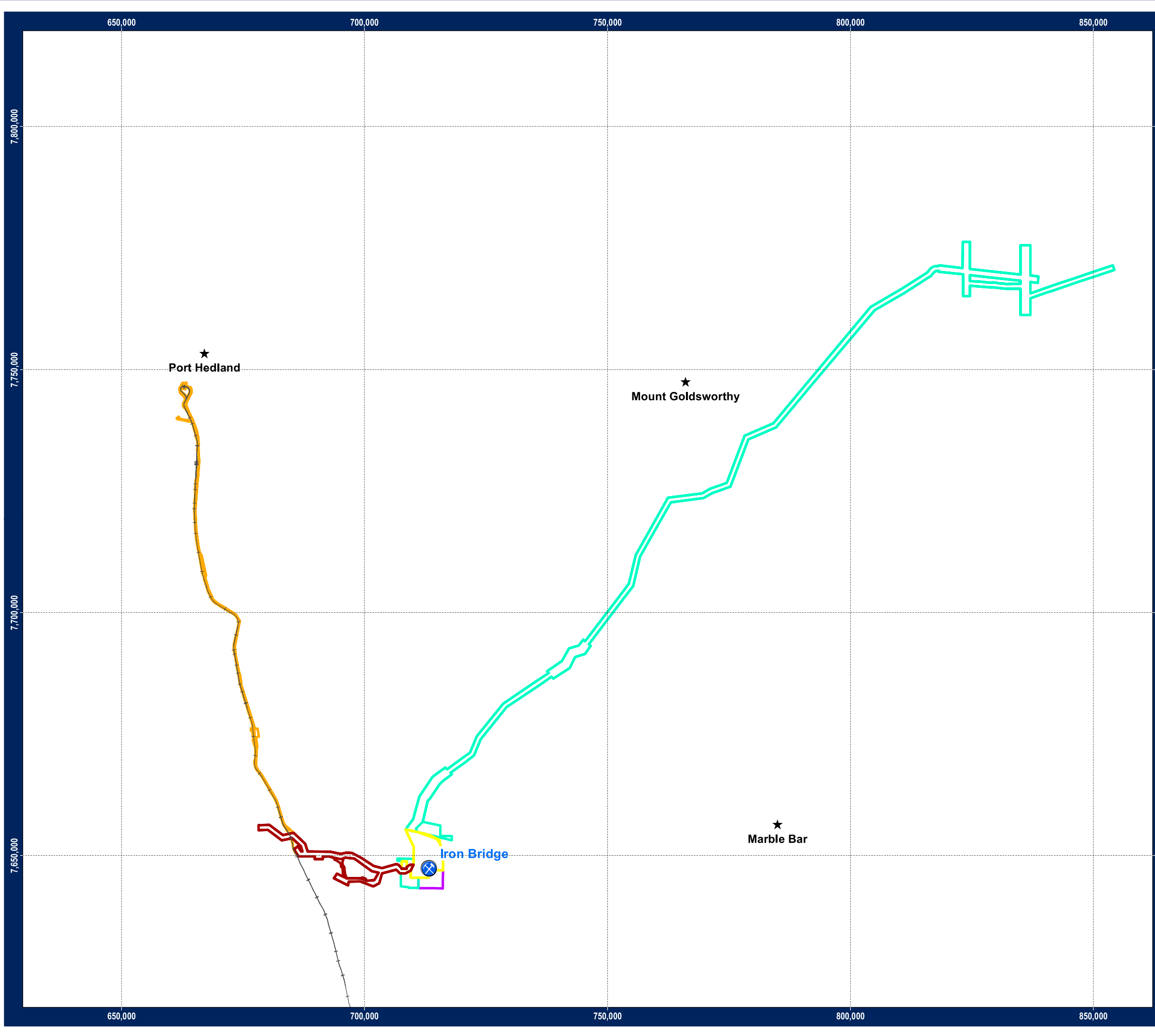
- [1] BoM. (2019). Bureau of Meteorology. Retrieved from Climate Summary Statistics for Port Hedland Airport (Site No. 004032):  
[http://www.bom.gov.au/climate/averages/tables/cw\\_004032.shtml](http://www.bom.gov.au/climate/averages/tables/cw_004032.shtml)
- [2] ecologia Environment. (2012a). Fortescue Metals Group Ltd North Star Vegetation and Flora Assessment. Perth: Unpublished report for Fortescue Metals Group Limited.
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- [6] Ecologia Environment. (2012). Fortescue Metals Group Ltd North Star Vegetation and Flora Assessment. Perth: unpublished report for Fortescue Metals Group Limited.
- [7] EPA. (2012). A review of subterranean fauna assessment in Western Australia. Environmental Protection Authority, Perth.
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- [12] Subterranean Ecology. (2012). North Star Project: Subterranean Fauna Survey. Perth: Prepared by Subterranean Ecology Pty Ltd

## DOCUMENT CONTROL

Surface water management plan		
Status	IFU - Issued for Use	20-Apr-23
Summary of Changes	Update of Figure 2	
Author	Jane Humphrey	_____ Signature
Checked or Squad Review# (if applicable)	Marlene Lootz	_____ Signature
Approved	Todd Edwards	_____ Signature
Next Review Date (if applicable)	20-Apr-28	

## FIGURE 1 PROJECT LOCATION

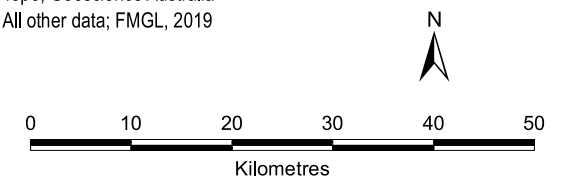
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**LEGEND**

- Infrastructure Development Envelope
- Mining Area Development
- North Star Extension Disturbance Envelope (proposed)
- Slurry Corridor Development Envelope
- Water Corridor Development Envelope
- FMG Managed Tenements
- Towns
- X FMG Mines
- FMG Rail

**Data Source(s):**  
 Topo; Geoscience Australia  
 All other data; FMGL, 2019



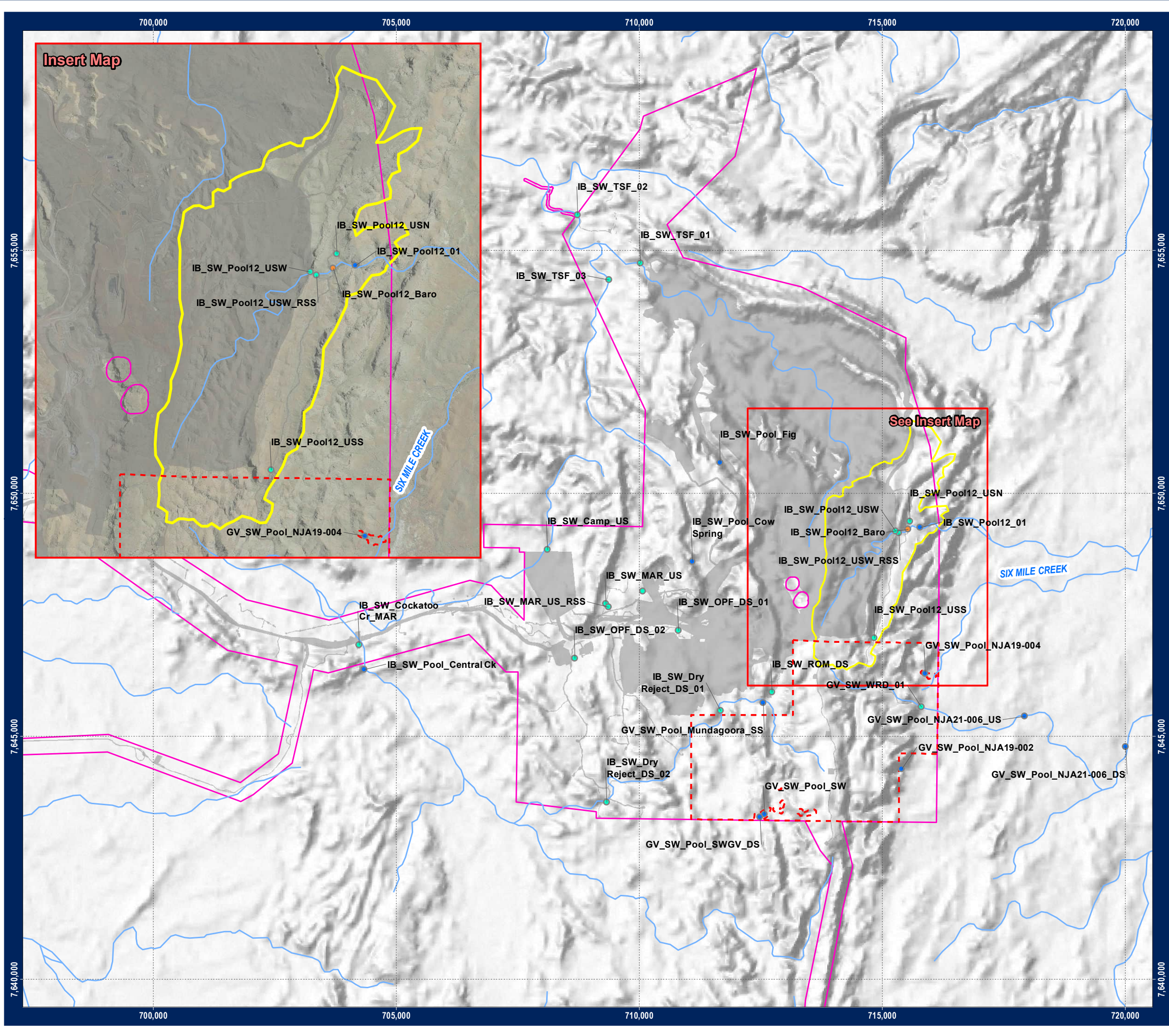
**Project Location**

Requested By: A. Harris	Date: 18/11/2020
Drawn By: B. Ralebala	Size: A3L
Revised By: sanli	Revision: 0
Approved By: P. Mastalir	Confidentiality: 0
Scale: 1:750,000	
Coordinate System: GDA 1994 MGA Zone 50	
Document Name: 662NS_0000_MP_EN_0057_r1	

FMG accepts no liability and gives no representation or warranty, express or implied, as to the information provided including its accuracy, completeness, merchantability or fitness for purpose.

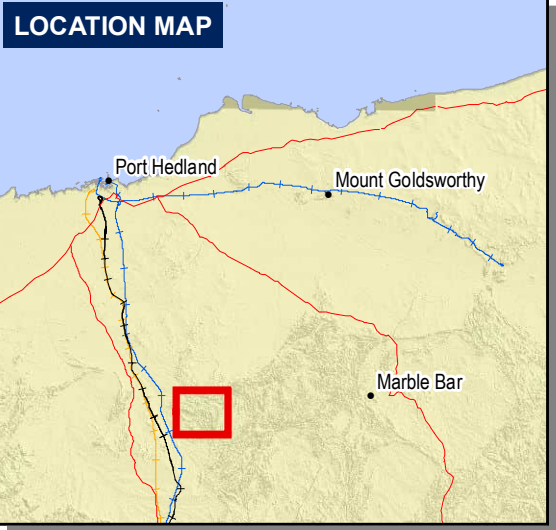
## **FIGURE 2 SURFACE WATER MONITORING LOCATIONS**

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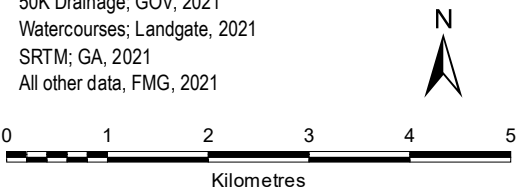
Insert Map

See Insert Map



- LEGEND**
- Disturbance Envelope
  - Indicative Disturbance Footprint
  - Watercourses
  - Site 12 Pool Catchment
  - Proposed Amendment
- Surface Water Monitoring Location**
- Barometer
  - Waterways
  - Pools

**Data Source(s):**  
 Hydrographic Catchments; Landgate, 2021  
 50K Drainage; GOV, 2021  
 Watercourses; Landgate, 2021  
 SRTM; GA, 2021  
 All other data, FMG, 2021



**Surface Water Monitoring Location**

Requested By: Y. Yu	Date: 21/03/2023
Drawn By: S.Li	Size: A3L
Revised By: rushall	Revision: 2
Approved By: P. Mastalir	Confidentiality: 0
Scale: 1:75,000	
Coordinate System: GDA 1994 MGA Zone 50	
Document Name: 662NS_0000_MP_EN_0158.004_r4	

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**Iron Bridge**

Appendix 32:

Closure Cost Estimation Process for Stakeholders



# Report

## Closure Cost Estimation Process for Stakeholders

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Closure Planning

**9 May 2022**

**100-RP-FI-0046 Rev 0**

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<b>Closure Cost Estimation Process for Stakeholders</b>			
<b>Document &amp; Revision Number</b>	100-RP-FI-0046	Rev 0	<b>9/05/2022</b>
<b>Status</b>	IFU - Issued for Use		
<b>Summary of Changes</b>	New reports		
<b>Author</b>	Kirsty Beckett		
<b>Checked or Squad Review# (if applicable)</b>	Fotios Gardounis		
<b>Approved</b>	Justin Dixon		
<b>Access to this document:</b>	Public Use (Access to all)	<b>Next Review Date (if applicable)</b>	9/05/2025

<b>Revision History (to be completed for each version retained by Document Control)</b>					
<b>Author</b>	<b>Checker</b>	<b>Approver</b>	<b>Rev No.</b>	<b>Status</b>	<b>Issued Date</b>
K. Beckett	F. Gardounis	J. Dixon	0	IFU	9/05/2022

## **EXECUTIVE SUMMARY**

---

The focus of closure planning at Fortescue Metals Group Ltd (Fortescue) is to return the land to a state that provides future use and value. We work with our stakeholders including local communities, Traditional Custodians and government agencies when considering post-closure land uses, to develop achievable closure outcomes.

Provisions to finance closure activities are reported for all our mine sites and infrastructure projects. The estimates are revised every six months to capture our mine progress and any other changes to our commitments that may have arisen. Our closure cost estimates are underpinned by detailed closure plans, developed to meet Western Australian regulatory requirements, that are provided to our stakeholders and approved by environmental regulators (where relevant). These provisions are further outlined in our Annual Reports, which are available on our website at [www.fmgl.com.au](http://www.fmgl.com.au)

This report details how closure cost estimates for rehabilitation activities are developed for provisioning. The report also describes how costs for other activities associated with closure, such as infrastructure and community commitments, are managed to inform the provision.

## DEFINITIONS

Word/Term	Definition
Allowance	A value in an estimate to cover the cost of known but not yet fully defined work.
Basis of estimate	A document that describes the scope basis, pricing basis, methods, qualifications, assumptions, inclusions, and exclusions.
Contingency	Contingency costs represent an allowance for uncertainties associated with the costs of material, labour, and closure methods. These have been determined based on past experience and industry practice.
Cost	The value of currency required to obtain a product or service, to expend labor and use equipment and tools, or to operate a business.
Direct costs	Costs that are directly attributable to achieving the closure objectives. E.g., the costs of materials, labor, equipment (including Mobilisation), etc., and all directly involved efforts or expenses for undertaking decommissioning, demolition or rehabilitation activities etc.
Indirect costs	Costs that are not directly accountable to closure activities. Includes overheads, administrative, project management, Mobilisation (of people), safety training etc.
Owner costs	Includes taxes, insurance, risk allowances, escalation and contingency.
Present Cost Obligation (PCO)	The portion of the total projected closure cost that relates to existing disturbance and infrastructure.
Provision	Financial balance sheet items representing the funds set aside by the company as assets to make good on closure obligations for existing disturbance, infrastructure etc. on closure of the site.
Total Projected Closure Cost (TPC)	Total costs that will be incurred at the point of closure of a site. Includes activities that are planned but have not yet been implemented.

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## **1. INTRODUCTION**

---

'Closure' is the action of closing out all legal obligations and other commitments in order to relinquish or transfer title, ownership, tenure, proprietorship etc., and any associated liability for the ongoing maintenance / management etc., of an asset.

The focus of closure planning at Fortescue Metals Group Ltd (Fortescue) is to return the land to a state that provides future use and value. We work with our stakeholders including local communities, Traditional Custodians and government agencies when considering post-closure land uses, to develop achievable closure outcomes.

Fortescue develops Closure Plans for all of our operations, consistent with leading best practice approaches to mine closure. Our Closure Plans include completion criteria that describe the physical conditions of the land or infrastructure that will be achieved or provided 'on closure', i.e. after the implementation of closure activities when the asset is relinquished or transferred. These criteria reflect the outcomes of agreements negotiated with the assets' key stakeholders.

Closure Plans also include a description of the process that will be used to achieve these outcomes. The process that will be followed to achieve completion criteria associated with land condition is commonly referred to as a 'rehabilitation strategy'. This report describes the generic process Fortescue employs to estimate the cost to implement a rehabilitation strategy. This report also describes how costs for other activities associated with closure, such as infrastructure removal / management and community commitments, are managed for Fortescue's bi-annual financial provision.

## 2. COST REPORTING AND REVISION PROCESSES

---

Closure costs are developed for a variety of purposes, using different assumptions depending on the way in which the values are used in different financial models. The closure costs most commonly discussed with stakeholders are the *provision* and the *total projected closure cost* ('TPC').

The TPC is Fortescue's best estimate of the expenditure required to meet all the costs associated with closure plans, including the legal obligations, commitments and closure outcomes. TPCs are developed during the Study phase, for use in financial models such as Net Present Value, to ensure that a new Project is profitable after closure costs are considered. There are a range of methods that are employed to develop TPCs, the value of which is periodically reviewed over the life of the asset. This report, however, will focus on the development of the present closure cost obligation (PCO) which is used in Fortescue's provisioning process and is published in our Annual Report.

The PCO is the portion of the total projected closure cost that relates to existing disturbance and infrastructure. Fortescue's PCO provides a central estimate with a target accuracy of  $\pm 30$  per cent.

To achieve this target accuracy, direct rehabilitation costs are developed using a first principles approach, based on rates and semi-detailed material take-offs derived from applying the closure strategies and engineering designs provided within the Closure Plans. The market rates and assumptions that are used to calculate the rehabilitation costs are reviewed annually and revised based on the rates or rate changes experienced by Fortescue's business units as part of daily mine operations. These rates, however, have not been provided in this report for confidentiality purposes. Examples of the assumption verification process have been included.

Decommissioning, dismantling/demolition and disposal costs are generally developed by third parties, e.g. experienced demolition companies, based on market rates at the date of issue. These costs are reviewed and revised every three years or when significant changes to the site infrastructure occur.

Other costs, such as those pertaining to community commitments, are similarly estimated by a third party and revised periodically.

The closure cost estimate used in Fortescue's provisioning process is updated every 6 months. Every 12 months, prior to the release of Fortescue's Annual Report, the value and process are subjected to an external, independent financial audit.

The closure cost estimation methodology employed by Fortescue is also periodically reviewed by an external party, to ensure our methodologies align with contemporary industry norms and that the resulting costs are within expected (i.e. benchmarked) ranges. The last cost methodology review was completed by engineering firm Jacobs in 2018.

### 3. COST ESTIMATION APPROACH

#### 3.1 Estimation philosophy

---

Fortescue's closure cost estimation approach is developed in three parts: direct costs, indirect costs and other owner costs.

- **Direct costs** are estimated in accordance with the closure strategy – how the activity is undertaken. These costs are developed using first principles, based on rates and semi-detailed material take-offs.
- **Indirect costs** are distributable costs. These costs include overheads, administrative support, project management, safety, monitoring, maintenance, accommodation etc. These costs are developed as a proportion of the direct cost.
- All other identifiable costs as classified as **Owner costs**. Owner costs include contingencies and allowances, such as undertaking studies, fulfilling community commitments during and after mine closure, etc. Contingency and allowances are developed as a proportion of the direct and indirect cost, while community and other costs are developed specifically to address individual commitments.

Direct closure costs are developed separately for rehabilitation, decommissioning and contamination clean-up activities.

*Decommissioning costs* comprises actions associated with decommissioning, demolishing, dismantling or otherwise removing fixed infrastructure, including removal of concrete where applicable, and disposal of the materials to a suitable landfill site, salvage yard, or recycle facility. These costs are developed when infrastructure is present.

*Contamination clean-up costs* are undertaken following or during the removal of infrastructure, if chemicals are identified to have contaminated the local environment or potentially contaminate the local environment in the future. These costs are developed when the potential for contamination is identified.

Where infrastructure is present the decommissioning and contamination clean-up activities are completed prior to the commencement of rehabilitation.

*Rehabilitation costs* comprise actions required to change the land (following decommissioning and clean-up, if present) to a condition suitable for the next land use. These activities may include landform shaping to create safe and stable landscapes and surface treatments to encourage vegetation to establish. These costs are developed wherever ground disturbance occurs.

### 3.2 Decommissioning and clean-up costs

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Demolition subject matter experts are engaged by Fortescue to develop decommissioning, dismantle / demolition and disposal strategies for our sites every three years. With each review the bill of quantities (or inventory) for the site is reviewed and updated based on the observed infrastructure layout. Strategies for removing the infrastructure are then revised or developed, for new infrastructure, based on contemporary practice and industry management standards, and in consideration of the availability of modern demolition / dismantling equipment and techniques.

On occasion, some infrastructure needs to be retained after the initial removal phase. Examples of when this could occur includes:

- The retention of groundwater supplementation systems, to ensure environmental flows are maintained until the ecosystem is self-sustaining.
- The retention of workshops, ablution and / or water supply systems for use during extended rehabilitation campaigns.
- The retention of water collection systems to manage potential water quality impacts associated with specific TSFs or WRLs, which are removed once the water quality is compatible with the downstream environment.

Where these obligations exist, additional closure costs are incurred to maintain the assets. These additional closure costs could include, but are not limited to:

- Diesel or other energy generation and consumption
- Asset repairs, maintenance and (where applicable) replacement cycles, as per established operational asset management protocols.
- Specialist personnel contractor costs for monitoring, maintenance etc., i.e. flights, accommodation, rental vehicles etc.

These assets continue to be managed in accordance with site's applicable operational health, safety and environment approvals (including Part V licenses where applicable), permits and protocols, and other operational controls relevant to the asset as defined within the Mining Proposal.

Contamination clean-up costs are developed for the closure cost estimate when an incident is identified and remediation works cannot be completed while the site is operational. These situations are rare, and none exist currently at Fortescue operations.

Clean-up for smaller spills that may occur or are identified during decommissioning activities are factored within the decommissioning contingency.

### 3.3 Rehabilitation costs

#### 3.3.1 Rehabilitation cost domains

Closure Plans list and group the activities that will be undertaken to achieve the required closure outcome. Similar action lists that are undertaken across various areas or features of the mine are called closure domains.

Rehabilitation cost domains represent closure domains that have similar or comparable activities that produce similar unit costs per hectare to implement, once any infrastructure has been removed. The rehabilitation cost domains that are commonly used by Fortescue are:

- Exploration – Ground disturbance for exploration and grade control;
- Rehabilitation – General ground disturbance associated with general mining support activities, includes:
  - Rehabilitation heavy disturbance (RHD);
  - Rehabilitation light disturbance (RLD); and
  - Rehabilitation water structures (RWS)
- Tailings Storage Facilities (TSF) – Ground disturbance associated with the disposal of the waste fines by-product of processing, also known as tailings;
- Waste Rock Landforms (WRL) – Landforms that are constructed from waste rock, overburden or quarried rock that are greater than 5 m high and remain in the landscape post-mining; and
- Pits – Mine voids that remain in the landscape post-mining.

**Table 1** lists the range of mine activities that are tracked by Fortescue’s compliance team and the cost domains that are associated with the activity.

**Table 1: Tracked disturbance activities and associated rehabilitation cost domain allocation**

Activity / Landclass	Cost domain	Activity / Landclass	Cost domain
Access Road	RLD	Pipeline Corridor	RLD
Airstrip	RHD	Plant Site	RHD
Borrow Pit	RHD	Powerline Corridor	RLD
Bund	RHD	Rail Corridor	RLD
Camp	RHD	ROM	WRL
Communication Tower	RHD	Settlement Pond (Fresh)	RWS
Conveyor	RHD	Settlement Pond (Saline)	RWS
Core Yard	RHD	Sewage Pond	RHD
Exploration (Tracks and Drill pads)	Exploration	Tailings Storage	TSF
Explosive Magazine	RHD	Topsoil Stockpile	RLD

Activity / Landclass	Cost domain	Activity / Landclass	Cost domain
Fuel Storage Facility	RHD	Topsoil Storage	RLD
Grade Control Drilling	Exploration	Transfer Pond (Fresh)	RWS
Haul Road	RHD	Transfer Pond (Saline)	RWS
Landfill	RHD	Turkeys Nest (Fresh)	RWS
Laydown	RLD	Turkeys Nest (Saline)	RWS
Low Impact Disturbance	RLD	Waste Dump	WRL
Mine Pit	Pit	Water Infrastructure	RLD
Mine Pit (Backfilling)	Pit	Water Infrastructure (Bores)	RLD
Open Unlined Drain	RHD	Water Storage Dam (Fresh)	RWS
OPF	RHD	Water Storage Dam (Saline)	RWS
Optic Fibre	RLD	Workshop	RHD
Ore Stockpile	RHD	Key: RLD Rehabilitation light disturbance, RHD Rehabilitation heavy disturbance, RWS Rehabilitation water storage	

The cost to implement the sequence of activities that define each cost domain is calculated based on a combination of:

- Equipment hours required to undertake an activity basis per hectare of disturbance type. Where more significant bulk earth movement is required, haulage distance and variable cycle times are also taken into account; and
- Fixed-rate costs per activity.

The activity sequences and assumptions that are used to develop the per hectare unit costs are presented in more detail in Appendix 1.

### 3.3.2 Rehabilitation cost estimation process

The following process is used to calculate the rehabilitation costs.

1. Elevation change data is reviewed to identify WRLs that have been constructed or expanded since the previous cost estimate. The landforms are checked against the Closure Plan and the current Mine Plan to confirm they will be present in the landscape as WRLs on closure.
2. The pit geometry is evaluated to calculate the volume of waste rock that needs to be returned (i.e. backfilled) to meet the closure design, based on the current pit depth.
3. The haul distance from Closure Plan assigned waste rock (WRL) source(s) are calculated, accounting for travel along road or around mine features.
4. The volume of waste rock stored on the WRL backfill source(s) are reduced, to account for waste rock backfilled into pits. In many cases, entire WRLs are rehandled and the closure cost domain for the former WRL disturbance is reclassified as RHD.

5. The remainder of the site disturbance is grouped into cost domains based on the land class / activity, as listed in Table 1.
6. Rehabilitation direct costs are calculated based on the unit cost per domain. Additional rehabilitation costs are included for other domain features, i.e. bores.
7. Indirect cost to implement the rehabilitation are factored as a percentage of the total direct rehabilitation costs. An example is provided in **Table 2**. These include:
  - Project management, i.e. setup, administration, field supervision, reporting etc.
  - Site inspection and rehabilitation monitoring, including:
    - Regular site inspection to identify maintenance requirements (e.g. stability, erosion, weeds, pests etc.);
    - Performance indicator monitoring in the early years following rehabilitation, to ensure rehabilitation is performing as anticipated and to trigger early intervention and corrective actions; and
    - Completion criteria monitoring, as per closure plans, required to be undertaken until regulators agree rehabilitation is performing to an acceptable standard.
  - Maintenance of rehabilitation, i.e. cost to repair erosion, undertake corrective actions and maintain site prior to relinquishment.
  - Pest and weed management

**Table 2: General monitoring and maintenance costs**

Activity	Description	Rate
Monitoring	Site inspection and rehabilitation monitoring	XX% direct rehabilitation costs
Maintenance of rehabilitation	Cost to repair erosion, undertake corrective actions and maintain site prior to relinquishment	A\$ XXX per hectare
Pest and weed management	Actions to manage weeds and feral animals	A\$ XXX per hectare

### 3.4 Owner costs

Fortescue’s owner costs are factored values or ‘uplifts’ that are applied to the closure costs to account for uncertainty, based on Fortescue’s acceptance of risk. These include third party allowances, contingency and other community costs.

A *third party allowance* is included in the cost estimate to cover the additional costs that would be incurred if the decommissioning and rehabilitation activities were undertaken by third parties instead of the standard Fortescue workforce. These factor-based allowances cover aspects such as contractor overheads and contractor profit margin.

*Contingency* costs represent an allowance for uncertainties associated with the costs of material, labour, and closure methods. The current rate of 15 per cent of the present cost obligation base estimate was determined based on past experience and industry practice estimate, supported by the external peer review undertaken by Jacobs in 2018.

Other allowances are provided to address specific obligations that arise through third party agreements. These costs do not relate to the decommissioning or rehabilitation of the site, but provide funding to meet the third party obligation during the closure phase, once mining has ceased.

### **3.5 Assumptions**

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The following assumptions have been built into the basis of the estimate.

#### **3.5.1 Fortescue's management structure on closure**

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At the point in time when an individual mine ceases production and closure activities commence, Fortescue is assumed to continue to operate as a mining company. As a result, the existing company support structures, roles and responsibilities remain in place throughout the closure process. Based on this premise, and in accordance with Fortescue's current practice, the following assumptions have been applied in this cost estimate:

- Pre-closure activities are/have been integrated into Fortescue operational roles include engineering design, project management and monitoring activities. It is assumed that all of the engineering design activities will have been completed by Fortescue staff and approved, where required, by regulators prior to closure. Therefore, provision for project management and monitoring is only required for each operation when closure commences.
- Prior to closure, Fortescue will redistribute staff, mobile infrastructure and other inventory to other operating sites when an individual operation winds down.
- Third-Party Activities, if undertaken, are performed under the supervision of existing Fortescue staff and support structures.
- No provision for social impairment is required as Fortescue continues to operate and honour its ongoing obligations, when required, after closure of an individual mine.

#### **3.5.2 Other cost estimate assumptions**

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Over the life of the mine, studies will be undertaken to validate or update these assumptions:

- No closure cost provision is required for contamination clean-up as no reported contaminated sites have been designated as requiring clean-up under the *Contaminated Sites Act 2003*.

- No closure cost provision is required for expenses incurred and accounted as part of operating costs, e.g. backfill undertaken as part of mining activities, drill holes plugged for fauna management within future mining pits, etc.
- No closure cost provision is required for features not expected to be present on/after closure. For example, third party owned and operated facilities, temporary stockpiles of ore or waste rock, etc.
- Costs for water truck use are included in the provision when significant dust generation is expected to occur, e.g. for bulk earth movements (pit backfill).
- Completed, permanent waste rock dumps will be constructed with 10m lifts with berms as per the mine plans and closure strategies. Consequently, the volume of material required to be moved on closure to stabilise the landform can be estimated using generic movement calculations.
- There is no cost difference applicable between different engineered erosion controls, i.e. specifically sized rock costs.
- Ground that is not suitable as an alternative growth has been identified in the Closure Plan, such that the rehabilitation strategy includes capping with an alternative growth media when required.
- Topsoil stockpiles are located adjacent to the rehabilitation areas. Where topsoil is not available, it is assumed that the existing ground provides a suitable alternative growth media and seeding of the area would be required at a cost comparable to the topsoil movement and application cost.

## APPENDIX 1: REHABILITATION DIRECT COST DEVELOPMENT

### 4. EXPLORATION COST DOMAIN

Exploration direct costs include:

- Restoration of vegetation associated with tracks and drill pads;
- Capping drill holes; and
- Sealing water (monitoring and production) bores.

The disturbance is generated by pushing vegetation and soil aside to facilitate light vehicle movement, the construction of drill pads to support the drill rigs and the creation of drill spoil piles, a by-product of the drilling activity. In the process of disturbing the land, many small, local vegetation and soil stockpiles are created adjacent to the disturbed land.

Rehabilitation costs are based on implementing the low-level disturbance closure domain strategy (Table 3), using a dozer and grader to:

- Reshape drill pads and fill in sumps;
- Integrate drill spoil (assumed to be benign) into the landscape; and
- Redistribute stockpiled soil and vegetation.

Additional costs incurred in this domain that are not based on the disturbance area are presented in Table 4.

**Table 3: Exploration cost domain equipment assumptions, applied per Ha of disturbance**

Activity	Earth moving process	Equipment
Dozer push windows and locally stockpiled topsoil/vegetation	Dozer push	D11
Grader rip surface materials	Grade	16M
Assumptions	Description	
Surface material	Surface material weight 2.2 t/lcm	
	Bulk cubic meters material moved = Area (in Hectares) × 500 <sup>#</sup> ÷ weight	
	<sup>#</sup> Factor used where the volume of stockpiled material is insubstantive and machinery movement costs dominate. Equates to assumption of 0.6 ha/hr at 300 t/hr.	
Housekeeping	Removal of sample bags and others scrap undertaken during earthmoving (no additional cost).	

**Table 4: Other Exploration costs**

Activity	Description	Cost	Cost source	
Cap drill hole	Clear and grub area surrounding drill hole, where not already cleared. Hand dig around drill collar to a depth of 0.5 m. Cut drill collars	A\$ X per drill hole	[#]	Consistent with rate used in FY2019 cost model.

Activity	Description	Cost	Cost source	
	to 0.4 m below ground level. Plug drill hole appropriately Re-establish ground surface and return grubbed material.			
Seal water bore	Pack small diameter bores, i.e. monitoring bore, to seal bore.	A\$ X per bore	[1]	Chris Oppenheim (2020) Guidance from recent hydrogeology activities, provided by Chris Oppenheim, Manager Drilling, May 2020.
Seal production bore	Pack large diameter water supply bores, i.e. injection or production bore, to seal bore.	A\$ X per bore	[1]	Chris Oppenheim (2020) Guidance from recent hydrogeology activities, provided by Chris Oppenheim, Manager Drilling, May 2020.

## 5. GENERAL REHABILITATION COST DOMAINS

General *rehabilitation* direct costs include:

- Minor landscaping;
- Rehabilitation of vegetation;
- Capping drill holes; and
- Sealing water (monitoring and production) bores.

General Rehabilitation is generated by clearing land for mine infrastructure and stockpiling the vegetation and topsoil for later rehabilitation use. The disturbance can be divided into three categories:

- **Light Disturbance.** Minor to no topographical change.  
Mine land use may include unlined drains, laydowns and general infrastructure corridors. Assumes that the ground is not substantially compacted after decommissioning activities are completed.
- **Heavy Disturbance.** Extensive re-shaping and construction of minor landforms during the mine life. Includes waste rock landforms constructed with an open face of 5 metres<sup>1</sup> or less above the adjacent topography.  
Mine land use may include workshops, haul roads, and laydowns constructed in steep topography. Assumes decommissioning activities are completed, the ground remains compacted.
  - Pits that are backfilled to merge with the adjacent landscape during operations are also rehabilitated in accordance with the Heavy disturbance closure and cost domain strategies.

<sup>1</sup> Landforms constructed of waste rock with open faces of more than 5 m are classified as Waste Rock Landforms, and require different rehabilitation management.

- **Water Structures.** Minor and temporary water storage areas, such as ponds, turkeys, nests and water storage dams.

The number of drill holes requiring rehabilitation is managed by the Exploration Geology team.

## 5.1 Rehabilitation light disturbance (RLD)

Light disturbance rehabilitation costs are based on implementing the light disturbance closure domain strategy (**Table 5**), using a dozer and grader to:

- Redistribute topsoil and vegetation stockpiled adjacent to the disturbed areas across the landscape and blend into the local topography; and
- Shallow rip the topsoil and vegetation in the ground to encourage infiltration.

**Table 5: Light disturbance cost domain equipment assumptions, applied per Ha of disturbance**

Activity	Earth moving process	Equipment
Dozer push stockpiles and blend with topography	Dozer push	D11
Grader rip surface materials across area	Grade	16M
Assumptions	Description	
Soil	Soil weight 1.9 t/lcm, surface material weight 2.2 t/lcm	
	Bulk cubic meters material moved = Area (in Hectares) × 0.1m ÷ weight	
Topsoil	Topsoil is located adjacent to light disturbance. Topsoil contains sufficient seedbank, such that no ancillary seed is required to achieve vegetation targets.	
Drainage	Drainage channels are maintained during operations, and no additional drainage channels are required to be cut during rehabilitation.	

## 5.2 Rehabilitation heavy disturbance (RHD)

Heavy disturbance rehabilitation costs are based on implementing the heavy disturbance closure domain strategy (**Table 6**):

- Reshape landscape to accommodate local drainage lines;
- Rip the area to remove traffic compaction and blend with the topography;
- Load and haul stockpiled topsoil, distribute to a depth of 10 cm;
- Shallow rip topsoil into the ground to encourage infiltration; and
- Review vegetation emergence, and apply ancillary seed mix to achieve vegetation targets.

**Table 6: Heavy disturbance cost domain equipment assumptions, applied per Ha of disturbance**

Activity	Earth moving process	Equipment
Dozer push blend with topography	Dozer push	D11
Grader rip surface across area to break compaction	Grader rip	16M
Load soil from soil stockpile	Load	993
Haul soil to area	Haul	789
Dozer push soil across area	Dozer push	D11
Grader rip surface materials to bend into ground	Grader rip	16M
Assumptions	Description	
Topsoil	Soil weight 1.9 t/lcm, surface material weight 2.2 t/lcm	
	10cm topsoil returned	
	Topsoil is located near to area.	
Seed	No equipment cost to apply seed is required.	
Floodplain closure domain	Floodplain closure domain is costed as per the Heavy disturbance cost domain.	

### 5.3 Rehabilitation water structures (RWS)

Water structures are a type of heavy disturbance that requires additional bulk earthworks to blend the dam structures into the landscape (Table 7).

**Table 7: Water structure cost domain equipment assumptions, applied per Ha of disturbance**

Activity	Earth moving process	Equipment
Dozer push dam walls and re-contour surface to appropriate topography	Dozer push	D11
Load soil from soil stockpile	Load	993
Haul soil to area	Haul	789
Dozer push soil across area	Dozer push	D11
Grader rip surface materials across area	Grader rip	16M
Assumptions	Description	
Dam	Material weight 2.2 t/lcm	
	Dam height 1 m average	
	Ground is not compacted and does not require primary ripping	
Topsoil	Soil weight 1.9 t/lcm, surface material weight 2.2 t/lcm	
	10cm topsoil returned	
	Topsoil is located near to area.	
Seed	No equipment cost to apply seed is required.	
Housekeeping	Disposal of liner to an appropriate facility (no additional cost)	

### 5.4 Other costs

Additional costs incurred in this domain that are not based on the disturbance area are presented in **Table 8**. The water bore inventories are managed by the Hydrogeology team.

**Table 8: Other Rehabilitation costs**

Activity	Description	Cost	Cost source
Cap drill hole	Clear and grub area surrounding drill hole, where not already cleared. Hand dig around drill collar to a depth of 0.5 m. Cut drill collars to 0.4 m below ground level. Plug drill hole appropriately Re-establish ground surface and return grubbed material.	A\$ X per drill hole	[#] Consistent with rate used in FY2019 cost model.
Seal water bore	Pack small diameter bores, i.e. monitoring bore, to seal bore.	A\$ X per bore	[1] Chris Oppenheim (2021) Guidance from recent hydrogeology activities, provided by Chris Oppenheim, Manager Drilling.
Seal production bore	Pack large diameter water supply bores, i.e. injection or production bore, to seal bore.	A\$ X per bore	[1] Chris Oppenheim (2021) Guidance from recent hydrogeology activities, provided by Chris Oppenheim, Manager Drilling.
Ancillary seed	Develop appropriate seed mix to address vegetation species gaps and apply.	A\$ X per Ha	[2] Kirsty Beckett and Sarah Robinson (2020) Update of seed cost per hectare

## 6. TAILINGS STORAGE FACILITY COST DOMAIN

*Tailings Storage Facility* direct costs include:

- Construction of an alternative growth medium cap, if required to meet an environmental obligation;
- Construction of drainage and other erosion controls (i.e. spillways, rock armour etc.);
- Stabilising embankments; and
- Rehabilitation or establishment of vegetation.

Each Tailings Storage Facility will require a location specific closure strategy to be developed, based on the position of the storage facility in the landscape, vegetation and water management requirements. Pending development of location specific designs, rehabilitation costs have been estimated based on (**Table 9**):

- Load, haul and placement of waste rock to cap the tailings;
- Redistribute stockpiled soil to a depth of 10 cm;
- Shallow rip topsoil into the ground to encourage infiltration; and
- Review vegetation emergence and apply ancillary seed mix to achieve vegetation targets.

Site specific engineering designs and associated inventories are required in the future to estimate the drainage and landform stability requirement costs.

**Table 9: Tailings Storage Facility cost domain equipment assumptions, applied per Ha of disturbance**

Activity	Earth moving process	Equipment
Load capping material from mineral waste landform	Load Mineral waste rock	R996B
Haul capping to waste fines cell(s)	Haul Mineral waste rock	793
Dozer push capping material across waste fines cell	10% Load Rock hours	D10
Grader rip surface materials ready for soil	10% Load Rock hours	24M
Dust suppression	10% Load Rock hours	793 water cart
Load soil from soil stockpile	Load Soil	993
Haul soil to domain	Haul Soil	789
Dozer push soil across area	Dozer push Soil	D11
Grader rip surface materials to blend into ground	Grader rip Surface material	16M
Assumptions	Description	
Topsoil	Soil weight 1.9 t/lcm	
	10cm topsoil returned	
	Topsoil is located near to area.	
Seed	No equipment cost to apply seed is required.	
Drainage	Drainage requirements will be refined in due course. Costs are provisioned through rehabilitation contingency.	
Landform stability	Engineered controls will be refined in due course. Costs are provisioned through rehabilitation contingency.	

## 7. WASTE ROCK LANDFORM COST DOMAIN

*Waste Rock Landform* direct costs include:

- Significant reshaping of waste dumps according to the long term landform performance of the waste rock type and the destination of sediment eroded from the landform;
- Placement of rock armour or rock mulch, if required for erosion control;
- Construction of drainage controls, if identified as part of location specific engineering designs; and
- Rehabilitation or establishment of vegetation.

Waste Rock Landform cost domain is applied to all landforms and features constructed of waste rock, where a tip face is 5 metres or more above the surrounding landscape at the time of closure. This can include waste dumps, ROM pads, raised haul roads and land bridges.

A reconciliation process is used during cost estimation to ensure that Waste Rock Landform features are correctly identified and that only the areas that will require reshaping to achieve landform stability are classified as Waste Rock Landforms. This process reviews the latest elevation data and disturbance classification against the Mine Closure Plan or similar closure strategy to capture and refine the disturbance categories. Waste Rock Landforms, or parts of the landform, are reclassified to the Heavy disturbance cost domain, if:

- The waste rock dump is scheduled to be moved later in the mine life or to be used on closure for pit backfill;
- The tip face is in pit and scheduled to extend across to an adjacent pit wall, thereby filling the void; or if
- Sections of the waste dump do not requiring reshaping, rock armour or other management unique to waste rock landforms, e.g. the flat top of very large waste dumps.

Permanent Waste Rock Landforms will require a location specific closure strategy to be developed, based on the position of the landform in the landscape, vegetation and water management requirements. Pending development of location specific designs, rehabilitation costs have been estimated based on (Table 10):

- Approximate volume of waste rock moved to reshape 10m tip faces to approximately 14 degrees with 15m berms;
- Redistribute stockpiled soil to a depth of 10 cm;
- Shallow rip topsoil into the ground to encourage infiltration;
- Application of rock armour to areas identified as ex-pit waste dumps only;
- Secondary rip of surface materials to blend rock, waste rock and soil, when rock armour is required; and
- Review vegetation emergence, and apply ancillary seed mix to achieve vegetation targets.

Site specific engineering designs and associated inventories are required in the future to estimate the full earthwork and drainage costs.

**Table 10: Waste Rock Landforms cost domain equipment assumptions, applied per Ha of disturbance**

Activity	Earth moving process	Equipment
Dozer push to reshape waste rock slopes	Dozer push waste rock	D11
Load soil from soil stockpile	Load	993
Haul soil to area	Haul	789
Dozer push soil across waste dump	Dozer push	D11
Grader rip soil to blend with waste rock	Grader rip	16M
Quarry rock	Excavate	-

Activity	Earth moving process	Equipment
Load rock from quarry	Load	R996B
Haul rock to WRL location	Haul	793
Dozer push rock across waste dump	Dozer push	D11
Additional rip to blend rock, soil, waste rock	Grader rip	16M
Assumptions	Description	
Topsoil	Soil weight 1.9 t/lcm, surface material weight 2.2 t/lcm	
	10cm topsoil returned	
	Topsoil is located near to area.	
Seed	No equipment cost to apply seed is required.	
Reshaping	It is assumed all waste rock landform faces are left constructed at 10m lift, 42m berm width – as per mine plan for waste dump construction.	
	Conversion factor of Hectares to m <sup>3</sup> is 0.6, based on 10m lift, 42m berm width as tipped landform geometry conversion to 14 degree, 15m berm rehabilitated design.	
	Additional costs to be estimated when waste dump closure designs are available.	
Drainage	Engineered controls will be refined in due course. Costs are provisioned through rehabilitation contingency.	
Sediment control bunds	Sediment control bunds will be refined in due course. Costs are provisioned through rehabilitation contingency.	

## 8. PIT COST DOMAINS

General *Pit* direct costs include:

- Backfill of select areas to nominated levels, e.g. to suppress the groundwater table or to facilitate creek flow through the area, if required;
- Construction of buttresses to provide long term landform stability to backfilled landforms or pit walls, if required;
- Minor landscaping, if required;
- Construction of an abandonment bund, where required; and
- Rehabilitation or establishment of vegetation, if required.

Each Pit will require a location specific closure strategy to be developed, based on the pit's position in the landscape, vegetation and water management requirements.

Pending development of location specific designs, rehabilitation costs have been estimated based on (Table 11):

- Load, haul and placement of waste rock to cover the water table when pits extend below the nominated water table depth and the area is not scheduled to be backfilled to the appropriate level during mining;

- Load, haul and placement of waste rock to reinstate the pre-mining topography when pits are located within the PMF corridor of the proposed creek alignment on closure and the area is not scheduled to be backfilled to the appropriate level during mining;
- Shallow rip along contour to remove earthwork compaction and encourage infiltration;
- Redistribute stockpiled soil to a depth of 10 cm, and shallow rip along contour to blend topsoil into the ground; and
- Review vegetation emergence, and apply ancillary seed mix to achieve vegetation targets.

Site specific engineering designs and associated inventories are required in the future to cost the abandonment bund. At Solomon’s Firetail and North Star deposit, no internal pit rehabilitation is required, and so no rehabilitation cost has been provisioned for those locations.

**Table 11: Pit cost domain equipment assumptions, applied per Ha of disturbance**

Activity	Earth moving process	Equipment
Load backfill material from mineral waste landform	Load waste rock	R996B
Haul backfill to waste fines cell(s)	Haul waste rock	793
Dozer push backfill	10% Load Rock hours	D10
Dust suppression	10% Load Rock hours	793 water cart
Load soil from soil stockpile	Load	993
Haul soil to domain	Haul	789
Dozer push soil across area	Dozer push	D11
Grader rip surface materials to blend	Grader rip	16M
Assumptions	Description	
Topsoil	Soil weight 1.9 t/lcm, surface material weight 2.2 t/lcm	
	10cm topsoil returned	
	Topsoil is located near to area.	
Seed	No equipment cost to apply seed is required.	
Abandonment bunds	Abandonment bunds will be refined in due course. Costs are provisioned through rehabilitation contingency.	

## Appendix 1A Equipment Performance

Table 12 and Table 13 define the equipment operation assumptions used to establish fleet hours for rehabilitation activities. Where the cycle times are variable, the total cycle time equation in Equation 1 was employed.

**Table 12: Equipment operation and efficiency rates**

Action	Equipment	Tonnes per hour
Grade	Cat 16M	500
Dozer push	D11	867.6
Dozer rip	D11	975.8
Load soil	Cat 993	1379
Load rock	RH170 exc	1755
Load rock (mine equipment)	R996B	3485
Haul soil	Cat 789	216.9
Haul rock (mine equipment)	Cat 793F	Variable

**Table 13: Cat 793F (Activity: Load rock) cycle times rates**

Action	Equipment	Capacity	Average speed (A)	Spot and load time (B)	Travel delay time (C)	Dump time (D)
Truck rock (mine equipment)	793F#	112.5 lcm 225 tonnes	30 km/hr 0.002 minutes/m	4.3 minutes	4 minutes	2 minutes

#Total cycle times are generally between 500 and 1500 t/hr

**Equation 1: Total Cycle Time = (Total Haul Distance (m) / A)+B+C+D)**