BoorYul-Bah-Bilya
Mandoon Bilya (Helena River)

Baseline Surface Water and Sediment Sampling 2024

April 2025

Bibbul Ngarma Aboriginal Association Incorporated

A collaboration with the Local Health Authorities Analytical Committee, Shire of Mundaring, City of Kalamunda, City of Swan and Evergreen Consultancy WA

Summary

This report details the findings of surface water and sediment sampling undertaken in the Mandoon Bilya (Helena River) catchment in September 2024. The objective of the sampling was to increase understanding of the river's ecological health and contribute towards a baseline for further investigation and to monitor future changes. This work forms part of the BoorYul-Bah-Bilya program 'Conservation Audit'.

The sampling was enabled by collaborative funding from three local governments (City of Kalamunda, Shire of Mundaring, City of Swan) that was facilitated by the Local Health Authorities Analytical Committee (LHAAC), a statutory WA State Government entity under the *Health (Miscellaneous Provisions) Act 1911*.

The sampling results are summarised below:

Salinity: The river's water is predominantly fresh. Salinity ranged between 80–4,620 ppm across the catchment, reflecting fresh conditions (<5,000 ppm). With the exception of Salty Pool, all sites had salinities of 80–590 ppm, with the lowest at Beraking Yarra being reflective of ambient background conditions in the river's headwaters. Salinity at Salty Pool was 4,620 ppm, which is close to the range for brackish water (5,000–25,000 ppm). Salty Pool is downstream of Wundabiniring Brook which is salinity-impacted due to historical vegetation clearing.

Conductivity: The river contains elevated dissolved particles. With the exception of Beraking Yarra (162 uS/cm), all sites were above the Australia and New Zealand Guideline (ANZG) trigger value for lowland rivers in south-west Australia (<300 uS/cm). The middle catchment had lower conductivities (416–648 uS/cm) compared to the lower catchment (1,095–1,176 uS/cm). Conductivity at Salty Pool was 8,274 uS/cm.

Dissolved Oxygen: The river has localised areas of low dissolved oxygen. The lowest levels were at Lower Pumpback Dam (27.6%) and in the upper catchment at Beraking Yarra and Salty Pool (36.4–46.9%). Low dissolved oxygen was also reported at all sites in the lower catchment (54.8–59.3%) and at the two large pools in the middle catchment (69.3–70.5%). Only three sites were below the ANZG trigger value of >80% for lowland rivers in south-west Australia: Pipe Bridge, Rocky Pool and Piesse Culvert (94.4–101.4%).

pH: Most sites reported neutral pH conditions between 6.52–7.43, however, slightly acidic conditions were reported outside of the ANZG range for lowland rivers in south-west Australia (6.5–8.0) at 3 sites: Craignish (6.24), Lower Pumpback Dam (6.49) and Cobblers Pool (6.44).

Major Ions: Naturally occurring major ions were detected at all sites. Four sites reported fluoride, chloride and/or sodium variably above the default guideline values (DGV), including freshwater ecosystems (2 sites), drinking water aesthetic and recreation (3 sites), agricultural irrigation (4 sites) and stock watering (1 site). Major ions were detected in all sediment samples although DGV do not exist to enable comparison.

Nutrients: The river contains elevated nutrients, predominantly in the form of nitrogen. Total oxidised nitrogen and nitrate were at least one order of magnitude higher in Piesse Brook, a major tributary of Mandoon Bilya, than at other sites. Concentrations were highest at Piesse Culvert (6.9 mg/L), adjacent to various orchards in Pickering Brook. Downstream at Rocky Pool, where Piesse Brook flows through Kalamunda National Park, they had reduced to 1.4 mg/L. Elevated nitrogen was also detected at Helena Swan (1.2 mg/L). Ammonia was an order of magnitude higher at Whiteman Rd and Helena Roe (0.12–0.13 mg/L) compared to other sites (0.02–0.05 mg/L). All sites except Lower Pumpback Dam reported nitrogen and/or phosphorus variably above the DGV for freshwater ecosystems (8 sites), recreation (5 sites) and agricultural irrigation (6 sites). Nutrients were present in all sediment samples although DGV do not exist.

Metals and Inorganics: The river contains elevated metals. These include naturally occurring metals like iron, manganese, aluminium and barium, as well as those that may be due to human activities such as boron, chromium, cobalt, copper, lead, titanium, uranium, vanadium, zinc and cyanide. For example, chromium, titanium and vanadium were only detected in water at Craignish, and uranium in water was only detected downstream of the former Bellevue Hazardous Waste Facility. Some heavy metals were detected in sediment only e.g. arsenic at Whiteman Rd, cadmium at Whiteman Rd and Piesse Culvert, and mercury at eight sites. Mercury at Whiteman Rd (0.23 mg/kg) was an order of magnitude higher than other sites

(0.03–0.07 mg/kg). All sites reported metals variably above the DGV for freshwater ecosystems (12 sites). Ten sites reported metals above the DGV for human health and primary industries although these exceedances were only related to naturally occurring metals (e.g. aluminium, iron and manganese). Exceedances of sediment DGV were reported at Whiteman Rd (mercury) and Piesse Culvert (copper).

Microbes: The river contains elevated microbes, faecal bacteria and amoeba. *Escherichia coli (E. coli)* and *Enterococci* were detected at all sites and *Thermophilic Amoeba* were detected at three sites in the middle and upper catchment (Pipe Bridge, Salty Pool and Beraking Yarra). *Thermophilic Naegleria* and *Naegleria fowleri* were not identified at any site. All sites reported microbes variably above the DGV for drinking water, non-potable use and recreation (12 sites), agricultural irrigation (12 sites) and stock watering (5 sites).

Herbicides and Pesticides: Pesticides were detected at two sites: Piesse Culvert and Whiteman Rd. Dieldrin was detected in water at Piesse Culvert (0.003 ug/L) below the DGV for drinking water (0.3 ug/L) and freshwater ecosystems (0.01 ug/L). Dichlorodiphenyldichloroethylene/DDE (0.05 mg/kg) and Dichlorodiphenyltrichloroethane/DDT (0.03 mg/kg) were detected in sediment at Piesse Culvert above the DGV for sediment quality (0.0022 mg/kg and 0.0016 mg/kg respectively). Bifenthrin was also detected in sediment at Whiteman Rd (0.7 mg/kg), although no DGV exists. Herbicides were not detected at any site, although it is noted that previous sampling in the catchment required passive techniques to detect herbicides at low concentrations[1].

Hydrocarbons: The river's sediment contains elevated hydrocarbons although it is unknown if they are naturally occurring or due to human activity. Total recoverable hydrocarbons (TRH) were detected in sediment at all sites except Helena Swan and Piesse Culvert, and naphthalene was detected at Whiteman Rd and Helena Roe. TRH in sediment was mostly semi-volatile compounds in the C10-C40 range, with the highest concentrations (880–1,310 mg/kg) in the middle and upper catchment at Pipe Bridge, Salty Pool, LookSee Pool and Cobblers Pool. Elevated C10-C40 in sediment were also reported at Whiteman Rd (335 mg/kg). Volatile TRH C6-C10 compounds were detected in sediment at two sites, Helena Roe and Whiteman Rd (25–33 mg/kg), in the lower catchment. Six sites reported hydrocarbons above the DGV for sediment quality including TRH C10-C40 (280 mg/kg) at 5 sites and naphthalene (0.16 mg/kg) at 2 sites. Hydrocarbons (TRH C6-C10) were detected in water at only one site, Cobblers Pool, at a concentration (0.03 mg/L) below the DGV for drinking water and stock watering (0.09 mg/L).

PFAS: The river contains elevated per- and polyfluoroalkyl substances. PFAS were detected in water at all sites except Helena Swan. Concentrations were highest at Helena Roe, where 11 PFAS compounds were detected, followed by Whiteman Road, where 10 PFAS compounds were detected. The most commonly detected PFAS was PFOS, which was reported at all sites except Helena Swan. Other detections included perfluorohexanesulfonic acid/PFHxS (0.002–0.024 ug/L) at 4 sites, perfluorooctanoic acid/PFOA (0.011–0.013 ug/L) at 2 sites and perfluorobutanoic acid/PFBA (0.009–0.017 ug/L) at 4 sites. All sites except Beraking Yarra and Helena Swan reported PFOS (0.0003–0.048 ug/L) above the DGV for freshwater ecosystems (0.00023 ug/L). One site, Helena Roe, reported PFHxS+PFOS (0.072 ug/L) above the DGV for drinking water, non-potable use and stock watering (0.07 ug/L). PFAS were not detected in sediment, although the laboratory reporting limit (5 ug/kg) may be insufficient to detect low concentrations.

Surfactants: The river contains elevated surfactants. All sites except Lower Pumpback Dam and Rocky Pool reported methylene blue active substances (MBAS) in water (0.2–1.4 mg/L) above the DGV for recreation (0.2 mg/L). DGV do not exist for drinking water, primary industries or freshwater ecosystems. MBAS were present in sediment at Whiteman Rd (32 mg/kg) and Piesse Culvert (3.6 mg/kg) although DGV do not exist.

Volatile and Semi-Volatile Organic Compounds: Volatile and semi-volatile organic compounds, including polychlorinated biphenyls (PCB), were not detected in any sample.

There are generally more exceedances of DGV in the lower catchment compared to the middle and upper catchment, indicating lower water quality downstream of the Lower Pumpback Dam.

Exceedances of the DGV are summarised in **Diagram 1**.

Group		Helena Swan	Whiteman Rd	Helena Roe	Craignish US	Lower Pumpback Dam	Rocky Pool	Pipe Bridge	Cobblers Pool	LookSee Pool	Piesse Culvert	Salty Pool	Beraking Yarra
Water Quality Parameters	Water	Red	Red	Red	Red	Red	Orange	Orange	Red	Orange	Orange	Red	Red
	Sediment	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Major Ions	Water	Brown	Red	Red	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Red	Yellow
	Sediment	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Nutrients	Water	Red	Red	Red	Red	Yellow	Orange	Brown	Red	Red	Red	Red	Brown
	Sediment	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Metals & Other Inorganics	Water	Red	Red	Red	Red	Red	Orange	Red	Red	Red	Orange	Red	Red
	Sediment	Yellow	Red	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Red	Yellow	Yellow
Herbicides & Pesticides	Water	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Green	Green
	Sediment	Green	Yellow	Green	Green	Green	Green	Green	Green	Green	Red	Green	Green
Hydrocarbons	Water	Green	Green	Green	Green	Green	Green	Green	Yellow	Green	Green	Green	Green
	Sediment	Green	Red	Red	Yellow	Yellow	Yellow	Red	Red	Red	Green	Red	Yellow
Microbes	Water	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
	Sediment	-	-	-	-	-	-	-	-	-	-	-	-
PFAS	Water	Green	Orange	Red	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Yellow
	Sediment	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Surfactants	Water	Red	Red	Red	Red	Green	Green	Red	Red	Red	Red	Red	Red
	Sediment	Green	Yellow	Green	Green	Green	Green	Green	Green	Green	Yellow	Green	Green
Volatile & Semi-Volatile Organics	Water	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	Sediment	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green

- Green: Not detected
- Yellow: Detected below guideline and/or no guideline exists
- Orange: Ecological guideline exceedances
- Brown: Primary industries guideline exceedances
- Red: Human health and/or primary industries and/or ecological guideline exceedances

Diagram 1 Exceedances of the Default Guideline Values in Water and Sediment

The results support previous studies which indicate that the river has elevated nutrients, metals, microbes, pesticides, hydrocarbons, PFAS and surfactants (MBAS):

- With the exception of elevated nitrogen at Piesse Culvert, nutrient concentrations were similar to those reported in the *Helena River Swan Canning Catchment Nutrient Report*[2] for 2008–2018.
- Concentrations of naturally occurring metals such as aluminium and iron were broadly similar to the 2014 *Helping the Helena* study[3] however there were differences e.g. arsenic was previously detected at low concentrations in water and lead was not previously detected in water.
- Dieldrin was previously reported in the river at similar concentrations, although previous studies reported detections of a far greater number of pesticides[1].
- Hydrocarbon concentrations in sediment were somewhat similar to the 2014 *Helping the Helena* study[3], although total PAH concentrations were several orders of magnitude higher in 2014[3].
- PFOS and PFHxS concentrations were similar to those reported in the 2022 DBCA Swan-Canning catchment study undertaken between 2016 and 2018[4].
- MBAS concentrations were similar to those reported in the 2014 *Helping the Helena* study[3].

DGV for sediment and some freshwater contaminants are limited. The absence of a DGV does not mean there is no potential risk, instead it means that a guideline is yet to be developed. As the BoorYul-Bah-Bilya program progresses, BNAA hope to develop catchment-specific guidelines for water and sediment quality that can be incorporated into an overarching plan with management targets to measure progress.

DGV exceedances do not automatically imply an impact to ecosystems or beneficial users. Instead, a DGV exceedance indicates that further investigation is required to determine if a risk exists. Determining impacts to ecosystems and beneficial users requires a detailed risk assessment, including consideration of exposure pathways to various receptors, ecotoxicology and catchment-specific conditions. Ideally, this should include potential exposure pathways that are specifically relevant to Noongar people, for example, direct contact with the river during water ceremonies.

Assessment of potential risks to freshwater ecosystems requires consideration of ecotoxicology and catchment-specific conditions. Ecotoxicology is the measure of the impact of substances in water, soils and sediment on organisms in an ecosystem, including natural tolerances to site-specific conditions such as naturally occurring elevated metals. Based on current data findings, potential risks to freshwater ecosystems may exist due to elevated PFAS (PFOS), nutrients (nitrogen and nitrate), various metals and naturally occurring major ions (fluoride). Poor water quality may also present a potential risk due to low dissolved oxygen, elevated conductivity and turbidity, and slightly acidic conditions. Particular mention is made of the potential risks due to elevated PFOS at all sites except Helena Swan and Beraking Yarra, and elevated nutrients in Piesse Brook.

Assessment of potential risks to drinking water requires consideration of the likelihood of the water being used for drinking (e.g. location in the catchment) as well as any treatment prior to consumption. Water from Mundaring Weir and the Lower Pumpback Dam is treated, including filtration and disinfection, prior to distribution in the Integrated Water Supply Scheme (IWSS). PFAS (PFHxS+PFOS) concentrations at Helena Roe were above the drinking water DGV, however this site is downstream of the two water supply dams, meaning that it is unlikely to be used for drinking. Poor quality drinking water aesthetics were reported at most sites, variably due to elevated hardness, turbidity, dissolved solids and naturally occurring metals (aluminium, iron and manganese) and major ions (chloride and sodium). Whilst these do not pose a health risk, these properties will likely make the water undesirable to drink. (e.g. taste, odour, appearance).

Assessment of potential risks to non-potable users of the river's water requires consideration of the likelihood of the water being used for different purposes, as well as the way people come into contact with the water e.g. growing produce, garden irrigation, filling swimming pools and other uses. Whilst review of the Department of Water and Environmental Regulation (DWER) Water Information Register does not identify any licensed surface water abstractions apart from Water Corporation, private abstractions are known to exist in the catchment.

Based on current data findings, potential risks to non-potable users may exist due to elevated PFAS and microbes, as well as naturally occurring metals (aluminium and iron) and major ions (chloride). Poor quality non-potable water was reported at most sites, variably due to elevated suspended solids, turbidity and/or slightly acidic conditions. Whilst less likely to cause an impact to human health, the water's properties may make it undesirable for non-potable use. Particular mention is made of the potential risks to any unlicensed non-potable water users in the vicinity of Helena Roe due to elevated PFAS (PFHxS+PFOS) concentrations. BNAA will report these findings to the Department of Health so they can consider notifying any users of water abstractions in the area and undertaking more PFAS sampling in the short term to verify these results.

Assessment of potential risks to recreational users of the river also requires consideration of the likelihood of the water being used for different recreation types, as well as the way people come into contact with the water. For example, swimming (primary contact) is popular at Rocky Pool in Kalamunda National Park, but is more unlikely at sites in the lower catchment.

Based on current data findings, potential risks to recreation users may exist due to elevated microbes, nutrients (ammonia) and surfactants, as well as naturally occurring metals (aluminium, iron and manganese) and major ions (chloride and sodium). Poor water quality may also present a potential risk due to elevated dissolved solids, hardness, and slightly acidic conditions. Particular mention is made of the potential risks to swimmers at Rocky Pool and other known swimming locations (e.g. Nyaania Pool) due to elevated *E. coli* and *Enterococci*. BNAA will report these findings to the Department of Biodiversity, Conservation and Attractions so they can consider notifying swimmers of potential risks e.g. signage.

Potential risks to human health may also exist due to possibly elevated PFAS in aquatic organisms. DGV are not protective of a pathway of PFAS accumulation in fish/shellfish, and subsequent human consumption (e.g. by recreational fishers or Noongar people sourcing traditional foods). In Western Australia, fishing is banned in drinking water supply catchments, including the majority of Mandoon catchment. However, anecdotal evidence indicates that some community members may consume crustaceans and fish from the river, indicating a potential risk. There are currently no DGV that are protective of these pathways, and further assessment is warranted wherever PFAS is present and fishing may occur.

Assessment of potential risks to primary industries requires consideration of the likelihood of the water being used for agriculture and/or stock water, as well as the way in which it is used (e.g. frequency, volume, location etc). For example, orchards and wineries along Piesse Brook may use the river to irrigate crops, whilst semi-rural properties that graze livestock in the lower catchment may use the river for stock watering. Based on current data findings, potential risks to primary industries may exist due to elevated PFAS, microbes and nutrients (nitrogen and phosphorous), as well as naturally occurring metals (iron and manganese) and major ions (chloride, magnesium and sodium). Poor water quality may also present a potential risk due to elevated dissolved solids, hardness, and slightly acidic conditions. Particular mention is made of the potential risks due to elevated PFAS (PFHxS+PFOS) in the vicinity of Helena Roe. DGV do not currently exist for PFAS in irrigation or stock water, including uptake into crops and subsequent human consumption. Drinking water guidelines are a useful surrogate for comparison, however, additional assessment may be warranted where PFAS is identified in water used for primary industries.

The findings in this report are based on a single seasonal sampling event. Further data is needed to understand spatio-temporal trends and associated potential risks to beneficial users and freshwater ecosystems.

Recommendations

BNAA recommends undertaking similar sampling in September 2025 to enable comparison of results and build a multi-year baseline. This should include analysis of dissolved metals and selected leachable analysis of sediment to assist assessment of potential risks, as well as silica gel clean-up on any detectable hydrocarbons to assess if they are petroleum based. BNAA also recommends consideration of:

- Additional sampling sites including:
    - Nyaania Creek Pool, a popular swimming location where BNAA is undertaking landcare works.
    - Downstream of Lower Pumpback Dam, to assess water quality decline in the lower catchment.
    - Along Piesse Brook, to assess nutrients entering the Lower Pumpback Dam drinking water source.
- Additional sampling event in low flow conditions e.g. first heavy rains after summer, circa. April-June.
- Salinity testing in the upper catchment including during low-high flows and targeting both surface and bottom waters to assess the presence of possible stratifications.
- Passive sampling to assess the presence of herbicides and pesticides at low concentrations.
- Analysis of microplastics.
- Developing catchment-specific DGV to better assess potential risks, including consideration of cultural/spiritual values of the river to Noongar people.
- Undertaking a detailed risk assessment and/or ecotoxicology testing to determine actual impacts, including consideration of exposure pathways that are specific to Noongar people.

With support from Lotterywest, environmental DNA (eDNA) sampling will be undertaken at all sites in 2025 to enable a more complete picture of river health to be considered, as part of a multiple lines of evidence based approach.

Document Information

Revision	Date	Status	Comment
0	13 December 2024	DRAFT	Draft for comment
1	25 April 2025	FINAL	Final document issued

Author: Francesca Flynn, Director

This document should be referred to as: Flynn, F (2025) Mandoon Bilya (Helena River) Baseline Surface Water and Sediment Sampling 2024, BoorYul-Bah-Bilya, Ref: BBB-MBHR-BWQS-002, April 2025. Bibbul Ngarma Aboriginal Association Incorporated and Evergreen Consultancy WA

Details

This document was prepared by Francesca Flynn of Bibbul Ngarma Aboriginal Association Incorporated (BNAA) and Evergreen Consultancy WA Pty Ltd (Evergreen) with input from the wider BNAA team including Senior Elders, Greg Ugle and May McGuire, and the BNAA Board, Walter McGuire, Meg McGuire, Ilona McGuire and Callum Haines. Input was also sought from:

- Cameron Chisholm, City of Kalamunda
- Neil Harries and Nathan Russell, City of Swan
- Shekofeh Elhani, Shire of Mundaring
- Ryan Janes and Ryan Quinn, Local Health Authorities Analytical Committee (LHAAC)
- Dr Kerry Trayler, Suzanne Thompson and Dr Steeg Hoeksema, Department of Biodiversity Conservation and Attractions (DBCA)
- Dr Tim Storer and Dominic Heald, Department of Water and Environmental Regulation (DWER)
- Jess Moloney-Christie, Eric Brahim and Michelle Pheonix, Water Corporation
- Natalie Hill, Eurofins ARL Pty Ltd
- Steve Morrison and Katie Richardson, Senversa Pty Ltd

Document Use

Information sharing and community education is an integral part of the BoorYul-Bah-Bilya program and is strongly encouraged for all non-sensitive data. Making information available to the community will allow BNAA to deliver the greatest possible value and help to unlock opportunities for future use, deliver more informed outcomes and reduce duplication of data collection.

Disclaimer

This report is based on available data and may not be entirely accurate or comprehensive. We make no warranties or representations regarding the completeness, reliability, or accuracy of the information. Use of this report is at your own risk, and we are not liable for any damages arising from its use.

Contents

Abbreviations

ADWG	Australian drinking water guideline(s)
ANZECC	Australia and New Zealand Environment and Conservation Council
ANZG	Australian and New Zealand guideline(s)
ATU	Aerobic treatment unit
BBB	BoorYul-Bah-Bilya
BNAA	Bibbul Ngarma Aboriginal Association Incorporated
BTEX	Benzene, toluene, ethylbenzene, xylene
CFU	Colony forming unit
COPC	Contaminant of potential concern
DBCA	Department of Biodiversity, Conservation and Attractions
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DFES	Department of Fire and Emergency Services
DGV	Default guideline value
DLGSC	Department of Local Government, Sport and Cultural Industries
DMIRS	Department of Energy, Mines, Industry Regulation and Safety
DOH	Department of Health
DOT	Department of Transport
DPIRD	Department of Primary Industries and Regional Development
DPLH	Department of Planning, Lands and Heritage
DWER	Department of Water and Environmental Regulation
E. coli	*Escherichia coli*
EMRC	Eastern Metropolitan Regional Council
EPA	Environmental Protection Agency
ERLP	Eastern Region Landcare Program
FPC	Forest Products Commission
ILUA	Indigenous Land Use Agreement
IWSS	Integrated Water Supply Scheme
HPC	Heterotrophic plate count
LHAAC	Local Health Authorities Analytical Committee
LOR	Limit of reporting
LPD	Lower Pumpback Dam
LTV	Long term trigger value
MAL	Microbial assessment level(s)
MBAS	Methylene blue active substance
NATA	National Association of Testing Authorities
NEMP	National environmental management plan
NHMRC	National Health and Medical Research Council

NPUG	Non-potable use guideline
NTU	Nephelometric turbidity units
ORP	Oxidation-reduction potential (redox)
PAH	Polyaromatic hydrocarbons
PCB	Total polychlorinated biphenyls
PCU	Platinum cobalt units
PFAS	Per- and polyfluoroalkyl substances
PFBA	Perfluorobutanoic acid
PFHxS	Perfluorohexanesulfonic acid
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctanesulfonic acid
ppm	Parts per million
RPZ	Reservoir protection zone
RSL	Regional screening level(s)
STV	Short term trigger value
SVOC	Semi-volatile organic compounds
TDS	Total dissolved solids
TOC	Total organic carbon
TPH	Total petroleum hydrocarbons
TRH	Total recoverable hydrocarbons
TSS	Total suspended solids
VOC	Volatile organic compounds
WA	Western Australia
WAPC	Western Australian Planning Commission
WHO	World Health Organisation
WIR	Water information reporting

Background

Western Australian rivers are in trouble. Of 208 major rivers, many are degraded and less than 1% are in pristine or near-pristine condition[5]. Despite the good work of many, river health continues to decline. In 2014, a WA Auditor General report found that community and parliament are insufficiently educated about river health decline and there is no overall plan for the actions and resources needed to restore river health[6]. To have a realistic chance of restoring river health, new approaches are urgently needed.

We believe that we have a unique opportunity to change the future for our rivers. BoorYul-Bah-Bilya (BBB) is a new initiative developed by Bibbul Ngarma Aboriginal Association Incorporated (BNAA) that aims to address declining river health through creation of a new type of integrated community catchment plan.

BoorYul-Bah-Bilya is the first program of its kind to consider environmental, social, cultural and economic factors in one integrated plan, and to combine traditional Indigenous and Western knowledge to enable a better balance between the many values of rivers. Its grassroots approach ensures local knowledge is embedded throughout and allows government, residents, businesses, schools and community groups to contribute equally towards the future vision.

Our plan will provide a costed roadmap to restore river health, protect cultural and social values, improve community health and wellbeing, and support sustainable economic growth and local jobs. It will identify actions that can be delivered by community and government working together to create a shared journey for everyone.

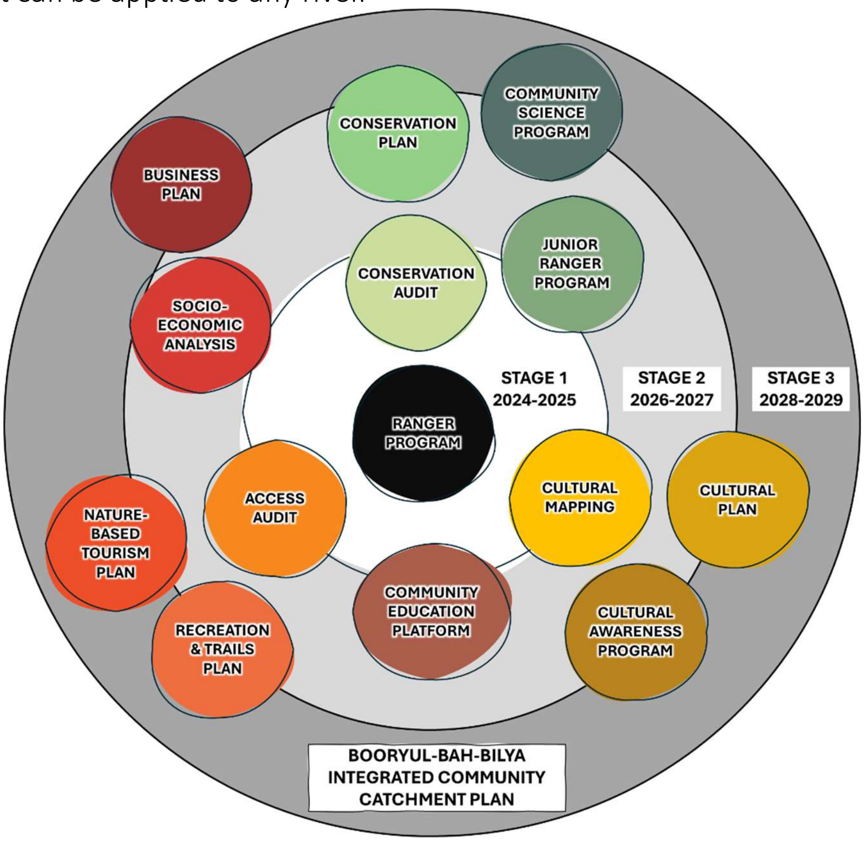
Our first plan focuses on the Mandoon Bilya (Helena River) catchment, but we hope to have far-reaching impacts by creating a model process that can be applied to any river.

Our plan coincides with the 2029 Perth Bicentenary, an important opportunity to consider the devastating impact of colonisation on rivers and the future challenges of a drying climate and growing population.

Through BoorYul-Bah-Bilya, we hope to create transformative change for all rivers and a legacy for all Australians.

A 3-staged program of activities is being delivered leading up to 2029. Each stage builds on the previous through data collation, information sharing and community engagement.

This report presents the results of surface water and sediment sampling undertaken in the Mandoon catchment in September 2024. It forms part of the BBB 'Conservation Audit' which aims to assess the river's ecological health.



The sampling was enabled by collaborative funding from three local governments (City of Kalamunda, Shire of Mundaring and City of Swan) that was facilitated by the Local Health Authorities Analytical Committee (LHAAC), a statutory WA State Government entity under the *Health (Miscellaneous Provisions) Act 1911*. LHAAC funds were used for laboratory analysis, whilst sampling and reporting was self-funded by BNAA and Evergreen Consultancy WA. Sampling equipment was loaned by the Department of Biodiversity, Conservation and Attractions (DBCA), who also assisted with site access.

Objectives

To undertake surface water and sediment sampling and analysis that will increase understanding of the river's ecological health and contribute towards a baseline for further investigation and to monitor future changes.

Mandoon Bilya (Helena River) Catchment

Mandoon Bilya (Helena River) flows from Ballardong and Gnaala Karla Booja near York and Beverley, through Mundaring and Kalamunda in the Perth Hills, down into Whadjuk Country through Midland, before joining the Derbarl Yerrigan (Swan River) in Guildford (refer **Figure 1**). The Mandoon catchment includes six local government areas: Swan, Mundaring, Kalamunda, York, Beverley and Northam, with small areas also located in Armadale and Wandering.

The catchment includes 900+ seasonal waterways that flow into the Derbarl Yerrigan as part of Mandoon Bilya including Darkin River, Beraking Brook, Pickering Brook, Piesse Brook, Nyaania Creek, Quenda Creek, Elder Creek, Bourkes Gully, Helena Brook, Wariin Brook and Kadina Brook (refer **Figure 2**). The waterways are predominantly fresh and ephemeral, flowing only in the wetter months, typically in the seasons of Makuru, Djilba and into Kambarang (approximately June to October).

The catchment has two dams, Mundaring Weir and the Lower Pumpback Dam, which supply public drinking water for areas of Perth and the Goldfields. The dams divide the catchment into three parts:

- Upper – upstream of Mundaring Weir
- Middle – between Mundaring Weir and Lower Pumpback Dam
- Lower – downstream of Lower Pumpback Dam

Water Corporation release water from the Lower Pumpback Dam in summer to maintain downstream habitat[7]. However, there are no releases from Mundaring Weir, meaning that the middle catchment is mostly devoid of water flow. Community members and scientists have called for measures to enable water flows from Mundaring Weir to the middle catchment[8]. Restoring some water flow is also an important long term aspiration of the BoorYul-Bah-Bilya program as identified by our Senior Elders.

Land use in the upper catchment is mostly state forest, drinking water catchment, forestry plantations and conservation estate managed by state government agencies, with a few private properties used for agriculture and sand mining. Land use in the middle catchment has many more private residences in suburbs like Glen Forrest, Darlington and Mahogany Creek, as well as properties associated with agriculture, viticulture and tourism. This includes Piesse Brook, a major tributary that flows from Pickering Brook townsite through the Bickley Valley tourism precinct and into the Lower Pumpback Dam. Most of the lower catchment has been developed for private residential, commercial and industrial use, with the river forming a thin green corridor through the suburbs of Guildford, Woodbridge, Midland, Hazelmere, Bellevue, Boya, Koongamia, Bushmead and Helena Valley.

Noongar people are recognised as the Traditional Owners of the catchment by the South West Native Title Settlement. The catchment is predominantly within Whadjuk country with the easternmost area within Ballardong and the southernmost in Gnaala Karla Booja (refer **Figure 1**). The river is highly significant to Noongar people. In Noongar culture, the river was formed by the Wagyl, the Great Creation Spirit. The river continues to sustain Noongar people with freshwater, food, medicine and provides an important route from Whadjuk to Ballardong Country.

When Europeans arrived in 1829, they immediately recognised the river's value. They renamed it "Helena River", likely after the sister of Ensign Robert Dale, a 19 year old who explored the river and hills east of Perth in 1829[9,10]. They quickly divided up the river for the Swan River Colony and forced Noongar people off the land. By 1832, Noongar leader Midgegooroo was captured on the banks of the Mandoon Bilya and executed days later by firing squad without trial, after acting-Governor Irwin declared him and son Yagan

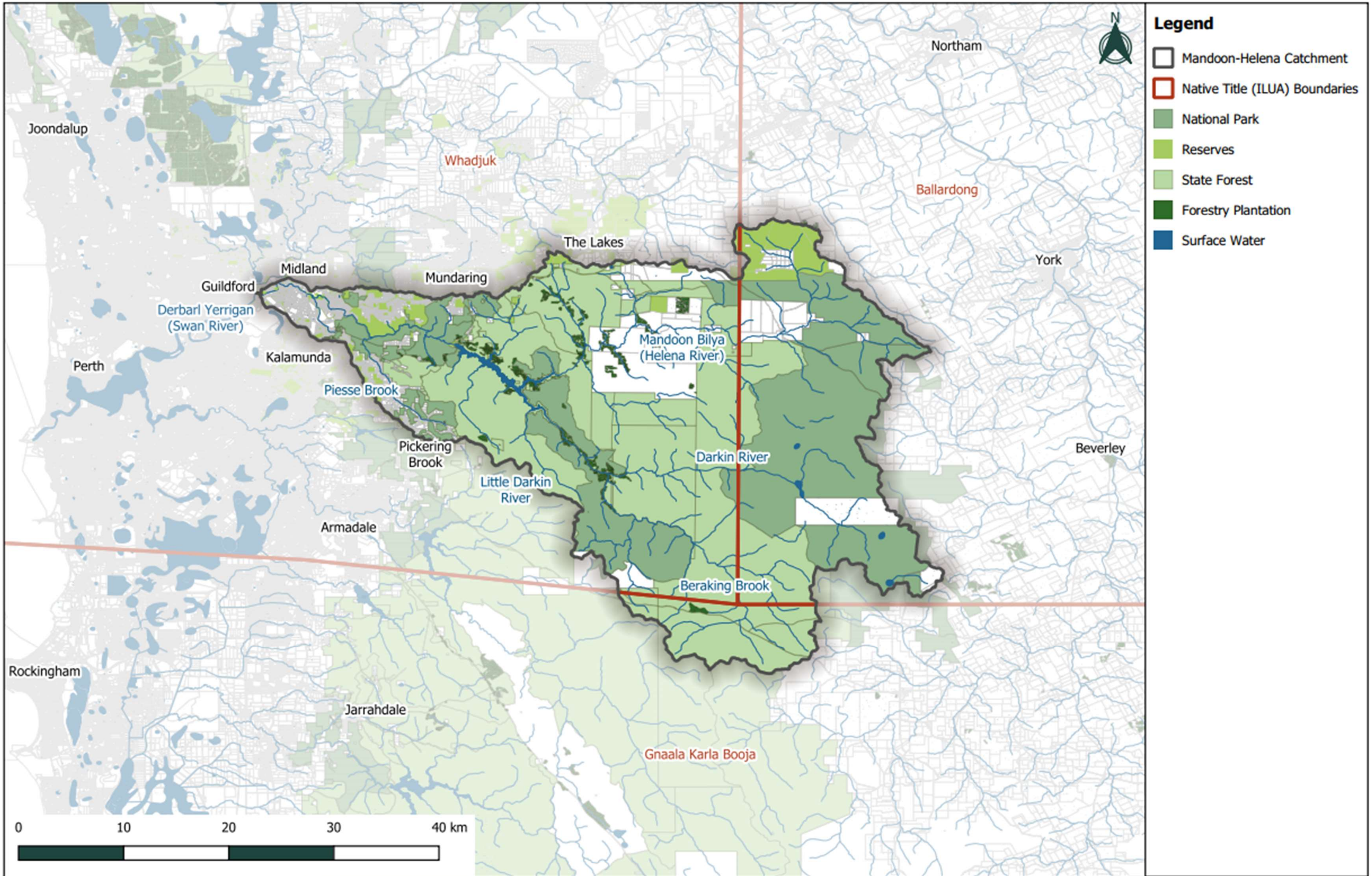


Figure 1 Mandoon Bilya (Helena River) Catchment Location

Bibbul Ngarma Aboriginal Association Incorporated
Prepared by: Francesca Flynn

BoorYul-Bah-Bilya (Mandoon Bilya - Helena River Catchment) Baseline Surface Water and Sediment Sampling 2024, Conservation Audit

Data Sources: Landgate, Department of Water and Environmental Regulation, Shire of Mundaring, City of Kalamunda, City of Swan

Ref: BBB-MBHR-BWQS-001
Date: 21 March 2025

BOORYUL BAH BILYA

outlaws for their role in Noongar resistance[11]. Yagan was captured weeks later, his head cut off, smoked, and sent to England for display, coincidentally transported by Robert Dale[12].

By 1903, Mundaring Weir had been built, flooding a deep valley in the upper catchment, and C Y O'Connor's "Golden Pipeline" now transported the river's water 526 km east to the desert[13]. Construction of Mundaring Weir fuelled the gold rush, giving rise to Kalgoorlie and the Goldfields, and permanently altering the course of what we now know as Western Australia[14–16]. The Lower Pumpback Dam was constructed in 1971 to collect runoff from the middle catchment and supplement Mundaring Weir via the pumpback pipeline[17].


Mandoon-Helena River in 1905 © State Library of Western Australia

The Mandoon catchment has very high ecological, cultural and social significance:

- Entire river is an Aboriginal heritage site with 40+ individual sites registered along its length.
- Lower floodplain in Hazelmere has the second oldest archaeological site in south-west WA, dating back at least 29,000 years[18].
- Important public drinking water source via Mundaring Weir and the Lower Pumpback Dam.
- Relatively unknown river that is often overlooked compared to other Perth rivers.
- Some of the last fresh waterways in the Perth region.
- Large and regionally significant natural space (approx. 1,655 km^2).

- Important biodiversity habitat with 3 biogeographic regions: Swan Coastal Plain, Jarrah Forest and Avon Wheatbelt.
- Only major river valley in Perth that is still relatively natural with large areas of native vegetation and few sealed roads in the upper catchment.
- Seven National Parks: Beelu, Greenmount, Gooseberry Hill, Helena, Kalamunda, Korung, Wandoo.
- Home to threatened and priority species including 10 plants and 15 animals (chuditch, numbat, quenda, Western ringtail possum, Dell's skink, Muir's corella, white egret, rainbow bee-eater, peregrine falcon, Carters freshwater mussel, three black cockatoo species[19], and a mainland quokka population that was discovered in 2024 as part of the BoorYul-Bah-Bilya program)[19,20].
- Home to three Black Cockatoo species (Forest Red Tailed, Carnaby's and Baudin's)[19].
- Home to 5 threatened and protected ecological communities including the priority 4 *Central Northern Darling Scarp Granite Shrubland* and critically endangered *Shrublands and Woodlands of the Eastern Side of the Swan Coastal Plain*[19].
- The catchment's granite outcrops and claypan wetlands, including Darkin, Little Darkin, Goonaping and Dobaderry, have particularly unique ecological and cultural values[21,22].
- Some of the oldest geology in the world: Archaean granite formed 2,600 million years ago[23].
- Contains the trailheads for the Bibbulmun Track, Munda Biddi Foundation and Kep Track.

Middle Mandoon Catchment near Glen Forrest

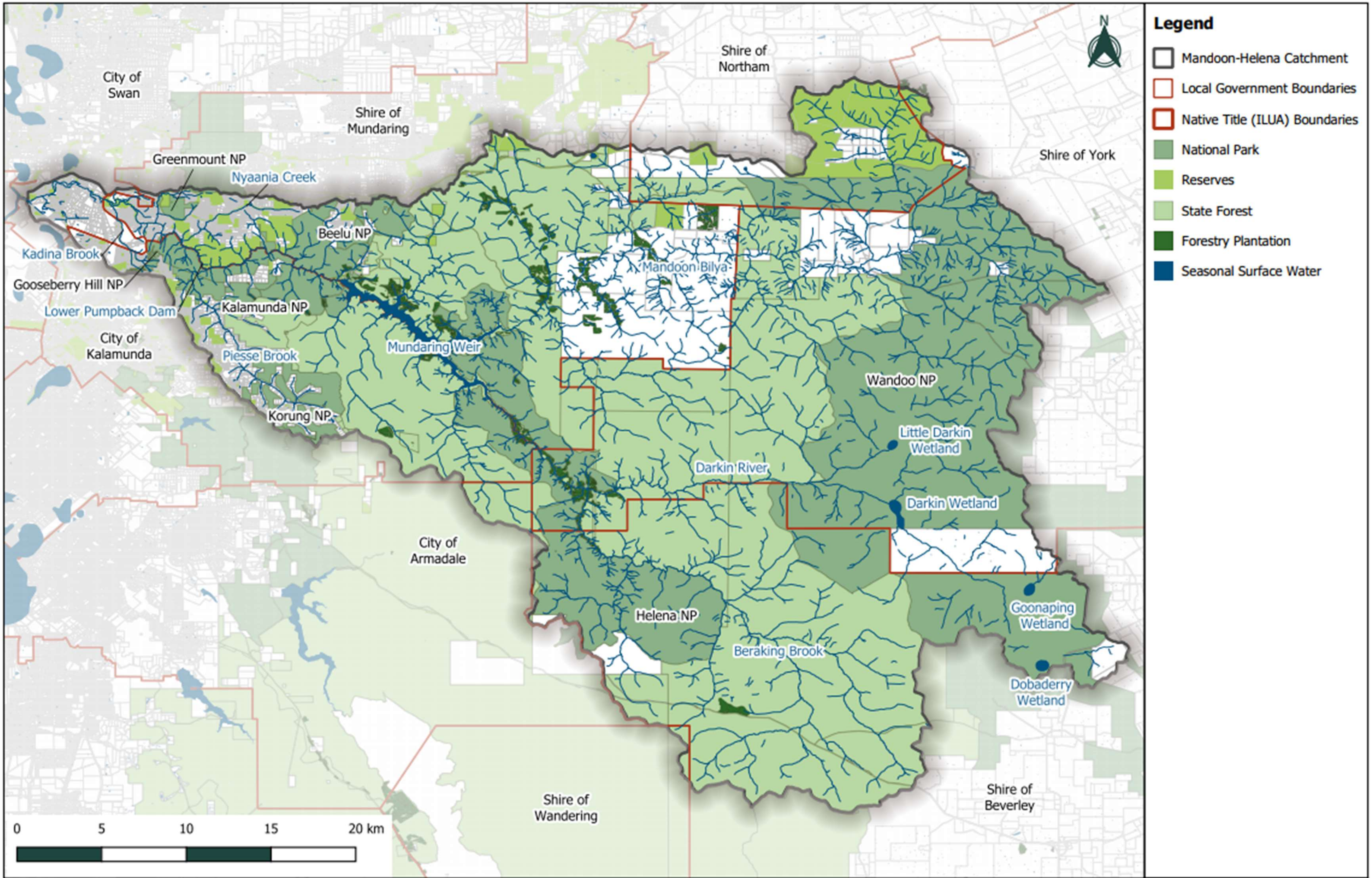


Figure 2 Mandoon Bilya (Helena River) Catchment Seasonal Waterways

BoorYul-Bah-Bilya (Mandoon Bilya - Helena River Catchment) Baseline Surface Water and Sediment Sampling 2024, Conservation Audit

Bibbul Ngarma Aboriginal Association Incorporated
Prepared by: Francesca Flynn

Data Sources: Landgate, Department of Water and Environmental Regulation, Shire of Mundaring, City of Kalamunda, City of Swan

Ref: BBB-MBHR-BWQS-002
Date: 21 March 2025

BOORYUL BAH BILYA

Mandoon Catchment Management

In Australia, state and territory governments are responsible for managing rivers and their catchments. Management of Mandoon catchment is highly fragmented, with responsibility shared by many state and local government agencies, each with different legislation. Work effort and priorities are focused on individual legislation, with widely varying resources and capacities across agencies. Outside of the drinking water catchment area, no one agency has overall responsibility, meaning there is no overarching plan for the entire catchment. The complexity of current governance structures that manage the river's values is demonstrated in the simplified diagram below (**Diagram 2**) and summarised in **Appendix 1**.

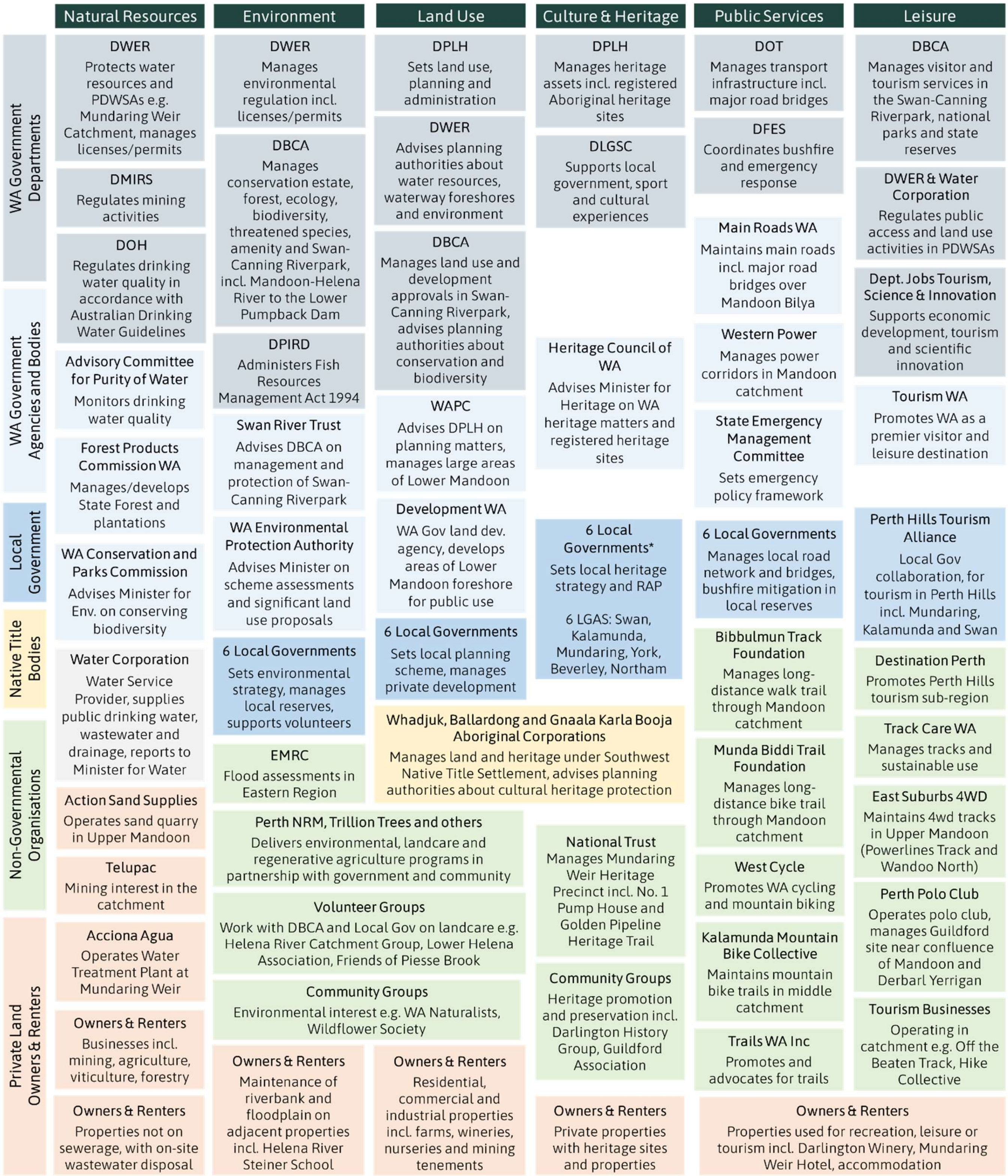


Diagram 2 Mandoon Catchment Simplified Governance

Mandoon Catchment Health

Based on our current understanding, the Mandoon Bilya is not in good health.

Due to a drying climate and up to 40% less rainfall since the 1970s[24], the catchment's streams no longer provide enough water flow to fill the dams[24]. Desalinated water and groundwater must be pumped into Mundaring Weir to maintain adequate drinking water supply[25].

Decades of water abstraction from the dams have taken their toll on the river's values. Impacts include low water flows, loss of habitat, disconnection of pools, siltation, barriers to fish movement, limited gene flow, poor water quality, low oxygen and restricted public access[19]. Many river pools are no longer permanent and the lower reaches are heavily sedimented[26]. Catchment-wide threats such as Phytophthora dieback, feral species, weeds, erosion, sedimentation, unauthorised vehicle access, unsealed tracks, mining, water extraction and increased bushfire risk contribute to the extraordinary pressure placed on the river[3,27].

Condition assessments in 2001 and 2018 revealed extensive weeds, degraded vegetation, eroded riverbanks and a mostly cleared lower floodplain[19,28]. Sampling has identified pollutants such as nutrients, hydrocarbons, metals, pesticides, herbicides, surfactants and per- and polyfluoroalkyl substances (PFAS) in the river's water and sediments[1,3,4,29–31].

Decline of riverbank vegetation has been recorded at the river's confluence with the Derbarl Yerrigan (Swan River) in Guildford since 2010[32]. Studies confirm that numbers of native fish, crayfish, mussels and invertebrates have declined, likely due to a combination of pressure from low water flows, drying of pools, vegetation clearance, habitat degradation, poor water quality and feral species[7,8,33,34]. It is thought that deformed freshwater mussels found in the river may demonstrate chronic effects of water pollution[35,36].

The river's water is predominantly fresh but is highly vulnerable to rising salinity caused by land clearing[17,37–41]. Shortly after the construction of Mundaring Weir, over 20,000 acres of surrounding trees were ringbarked and killed in an attempt to increase the amount of water flow into the dam[42,43]. The result was an increase in water salinity in Mundaring Weir, although it was not until the 1920s that there was widespread acceptance of the link between tree clearance and salinity[17]. The lessons learned were short lived when forest clearing resumed between the 1940s and 1970s, however, the government eventually adopted a strategy to purchase freehold land to reforest and protect from clearing[17].

Now, even though 97% of the weir's catchment is forested, the salinity of runoff is very sensitive to the remaining 3%[17]. Whilst the river remains predominantly fresh, salinity impacted runoff occurs in the catchment's north-east where private property and cleared land still exist (e.g. salinity-impacted Wundabiniring Brook)[17]. Future land clearing from proposed mining activities remains a major risk to salinity of Mundaring Weir and contamination of drinking water supplies. This risk is exacerbated by a drying climate, reduced rainfall and increased evaporation[17].

Perth has undergone a rapid expansion of population and infrastructure in recent years, with extensive clearing of native vegetation and floodplain development. The middle and upper reaches of Mandoon are largely protected from development by national parks and drinking water catchment. However, the lower floodplain and its few remaining wetlands are very vulnerable to a continuous pressure to develop land for Perth's growing population. The floodplain is gradually being rezoned and infilled for housing as the government pushes towards a target of 3.5 million people in Perth by 2050 (now 2.1 million)[44–53]. As a result, the floodplain has lost most of its "Guildford Complex", a rare and threatened vegetation type, and developments continue to be approved that will clear what little remains.

Since colonisation, the river has a history of neglect. The lower reaches have a legacy of industrial land use and historical contaminated sites including the Midland Railway Workshops, OPEX oil refinery, brickworks, a tannery and an abattoir[54–62]. Stockpiles of contaminated soil that were excavated from the former Railway Workshops site still remain on the river's floodplain in Midland[56,63,64]. The hazardous fire that occurred at the former Bellevue Hazardous Waste Facility in 2001 was one of Australia's largest hazardous materials fires[65–68]. Post-fire monitoring revealed that groundwater under the site was contaminated with hydrocarbons and halogenated solvents and was moving towards Mandoon Bilya[69–74]. Almost ten years later, WA's first permeable reactive barrier was installed in 2010 in an attempt to stop contaminated groundwater from reaching the river and the adjacent floodplain 'damplands'[75].

Threats to the river's health are exacerbated by complex land ownership, fragmented management and lack of investment in landcare. Catchment land use includes a mix of private property, conservation estate, drinking water catchment and state forest that stretches over six local governments and at least six state government agencies. Management is governed by a complicated web of overlapping policies and plans[26].

There is a general lack of awareness and understanding about the value of Mandoon Bilya compared to the Derbarl Yerrigan (Swan River) and Djarlgarro (Canning River), including a common misconception that Mandoon is not a "real" river because it has lost much of its water flow to the dams. The importance of the lower floodplain is not recognised, despite its high ecological and cultural values, and its wetlands are largely ignored. Many people do not know how valuable Mandoon is or how vulnerable it is to incremental threats. A Swan councillor recently suggested rerouting a heavy freight rail directly through the river valley, demonstrating a lack of knowledge about the river's values[76].

Limited access to the river's places exacerbates the problem by increasing community disconnection from its values and apathy towards its protection. In a way, the river is under threat from a lack of knowledge, appreciation of its values and commitment for its protection. A 2014 report by the WA Auditor General found that despite a range of plans and strategies, the Swan Canning river, is not adequately protected and water quality is continuing to decline[6]. It stated that despite long term monitoring, the information has not been well used to educate the community or parliament about river decline, and there is no overall plan for actions and resources needed to restore river health. The 2015 *Swan Canning River Protection Strategy* was designed to address this issue; however, it excludes the Avon River, a major tributary of the Swan River, and only covers the lower reaches of Mandoon Bilya up to the Lower Pumpback Dam[77].

Declining health is not unique to Mandoon Bilya. Among Western Australia's 208 major rivers, fewer than 1% are in "pristine or near pristine" condition[5]. River management is working as designed by government, and there are many people and organisations doing great work, yet river health continues to decline.

Globally, rivers are under similar threat from population growth, urban expansion and climate change. Common risks include pollution, acidification, vegetation decline, altered flow, erosion and sedimentation. Internationally, there have been recent calls by scientists to give rivers the same legal rights to exist as people to protect them for the generations of the future[78,79]. In Australia, Birrarung, or the Yarra River, was the first to be legally recognized as a living entity in 2017, although it was not granted legal personhood[80].


Lower Mandoon, Military Rd Bridge

Water and Sediment Quality Monitoring

Water and sediment quality is critical to understanding river health and community value, including:

- Planning and managing water use by the community.
- Mapping water resources and preparing for future changes.

The *Swan Canning Water Quality Monitoring Program* is a long term routine water monitoring program that assists the DBCA with managing the Swan Canning Estuary, including the Lower Mandoon Bilya up to the Lower Pumpback Dam. There is one Swan Canning water sampling site on the Mandoon: 'Whiteman Road–HELENR' at the same location as the DWER 'Whiteman Road–SWN10' site. The program reports on water quality and compliance with short and long term nutrient targets originally identified as part of the *Swan Canning Cleanup Program*[2,81–87] and ANZECC guidelines for aquatic ecosystems (now referred to as ANZG default guideline values)[88]. Analytes measured include nitrogen, phosphorus and various nutrient species, as well as dissolved organic carbon, suspended solids, dissolved oxygen, pH, temperature and specific conductivity. Data is shared with DWER and stored in the *Water Information Reporting* (WIR) platform (https://wir.water.wa.gov.au/Pages/Water-Information-Reporting.aspx).

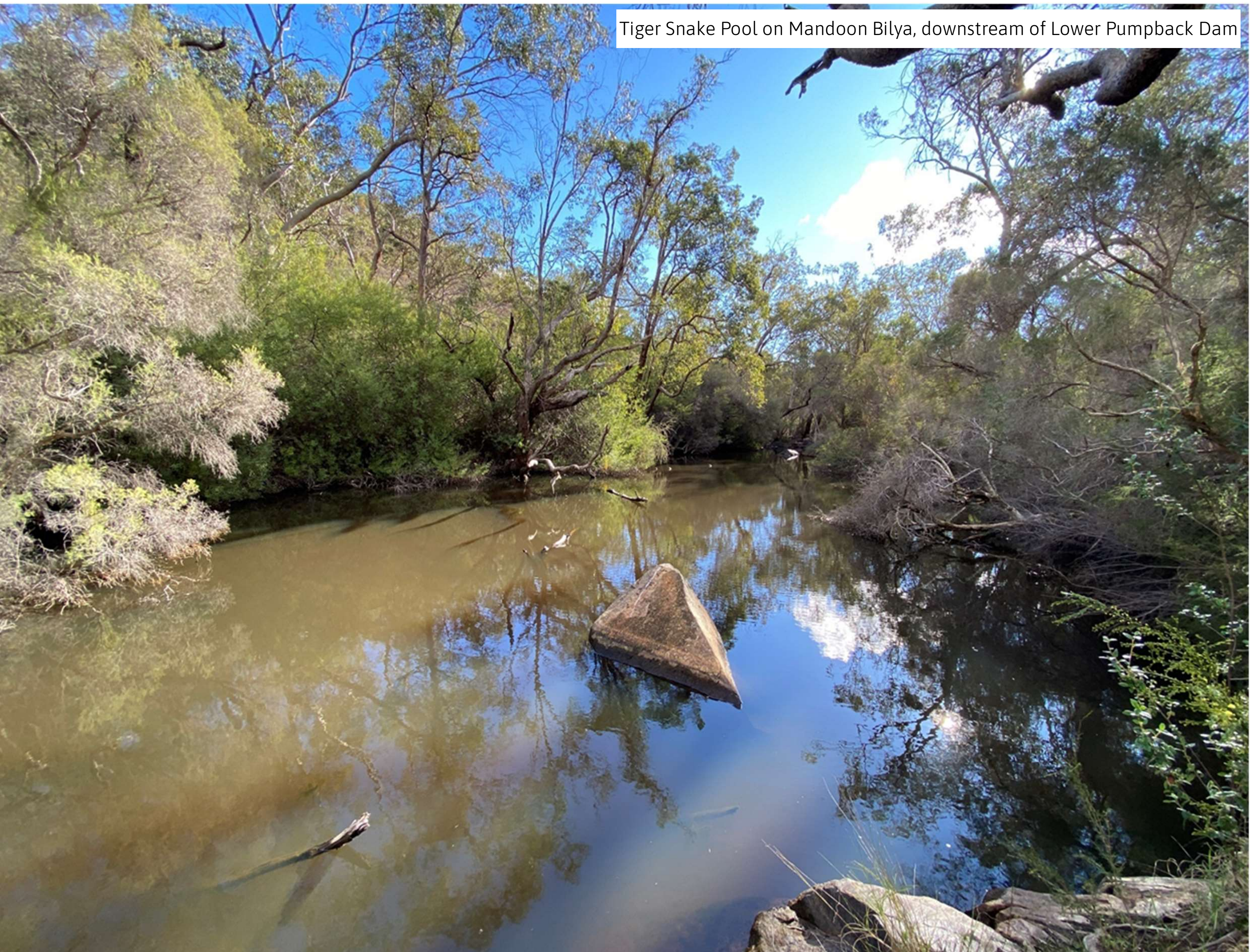
DWER coordinate the Healthy Rivers program which collects data and develops solutions to improve river health. There are two Healthy Rivers sites on the Mandoon: 'Mundaring Weir Downstream–HRDSMW' in the middle catchment and 'Whiteman Road–SWN10' in the lower, both of which were last assessed by DWER in November 2012. The assessments use standard methods from the *South West Index of River Condition*[89] including fish and crayfish presence, aquatic habitat, water quality (dissolved oxygen, temperature, conductivity, pH, colour, alkalinity, turbidity, nutrients), fringing vegetation, channel morphology, erosion, connectivity, land use and water flow. On online condition summary has not been prepared for either site, however, the Healthy Rivers website displays names of observed fish and crayfish species, and DWER have provided the field records to BNAA for inclusion in the BoorYul-Bah-Bilya program.

Most government monitoring is focused on nutrients and salinity, however some exceptions to this are listed below. These studies have identified pollutants like hydrocarbons, metals, microbes, pesticides, herbicides, surfactants and PFAS in the river's water and sediments.

- 2022 '*An Assessment of Per- and Poly-Fluoroalkyl Substances (PFAS) in the Surface Water and Biota of the Swan Canning Estuary and its Catchment*' – one site on the Lower Mandoon (SWN10, corresponding to Whiteman Rd site in this report)[4].
- 2022 '*An Assessment of Contaminants in the Sediments of the Swan Canning Estuary*' – a study of non-nutrient contaminants, one site on the Lower Mandoon Bilya ("Helena River 02")[31].
- 2014 '*Helping the Helena*' – a study of non-nutrient contaminants at 8 sites on Mandoon Bilya downstream of Mundaring Weir[3]. Recommendations for further investigation included between the Lower Pumpback Dam and Mundaring Weir, and lower catchment areas bordered by agriculture.
- 2009 '*Baseline Study of Contaminants in the Swan and Canning Catchment Drainage System*' – a study of non-nutrient contaminants, one site on the Lower Mandoon (HRJSB)[29].
- 2009 '*Baseline Study of Contaminants in the Sediments of the Swan and Canning Estuaries*' – a study of non-nutrient contaminants, one site in the Derbarl Yerrigan (Swan River) at the Mandoon confluence (Helena River)[30].
- 2009 '*Baseline Study of Organic Contaminants in the Swan and Canning Catchment Drainage System using Passive Sampling Devices*' – one site on the Lower Mandoon (Helena River)[1]. An initial field trial of passive sampling undertaken by Water Corporation in Piesse Brook (middle Mandoon catchment) revealed detectable concentrations of herbicides, despite them not being detected at the site previously using conventional grab sampling. The trial confirmed that passive sampling is practicable and effective at measuring low concentrations of organic contaminants in waterways.

Other assessments and studies that contribute to our understanding of the river's health include:

- 2020 'Fish Response to Flow in the Lower Helena River'[90]
- 2019 'Lower Helena River Ecological Condition Assessment'[91]
- 2018 'Helena River (Mandoon) Tributary Foreshore Assessment'[19]
- 2014 ' Evaluation of Environmental Water Releases on the Aquatic Fauna of the Helena River'[7]
- 2011 'Freshwater Mussel Response to Drying in the Lower Helena Pipehead Dam'[35]
- 2011 'Helena River Fish and Macroinvertebrate Surveys'[33]
- 2010 'Lower Helena River Trial Environmental Releases'[8]
- 2007 'Helena River Salinity Situation Statement'[17]
- 2006 'Helena River Freshwater Fish Habitat Survey'[34]
- 2001 'Foreshore Assessment in the Helena River Catchment'[28]
- 1999 'Stream Salinity Response to Clearing and Revegetation of the Helena Catchment'[41]
- 1991 'Lower Helena Catchment Water Quality Study'[92]
- 1990 'Bioaccumulation of Pesticides by Freshwater Mussels in Lower Helena River'[36]
- 1987 'Environment and Recreation Study of the Lower Helena Water Catchment'[93]


Tiger Snake Pool on Mandoon Bilya, downstream of Lower Pumpback Dam

Contaminants of Potential Concern

Industrial, agricultural, rural, recreational and residential activities can all contribute contaminants to the environment. Previous studies have identified that the river contains contaminants such as nutrients, hydrocarbons, metals, microbes, pesticides, herbicides, surfactants and PFAS[1,3,4,29–31]. The catchment is also very sensitive to rising salinity due to vegetation clearing[17].

Contaminants of potential concern (COPC) were identified based on a review of previous historical reports and current and historical land use in the catchment, including:

- Historical industry and contaminated sites in the lower catchment e.g. former Bellevue Hazardous Waste Facility, OPEX Oil Refinery, Bellevue Holding Yards and Midland Railway Workshops.
- Agricultural and rural land use along Piesse Brook in the middle catchment, including wineries, cideries and fruit growers in the tourism precincts of Bickley Valley and Pickering Brook.
- Land clearing for agriculture, mining and forestry in the upper catchment.

The laboratory analytical suite for the baseline sampling is presented in **Table 1**.

Group	Analysis	Rationale
Major Ions	Calcium, Chloride, Fluoride, Magnesium, Potassium, Sodium, Sulphate	General indicator of water quality
Nutrients	Nitrogen, Nitrate, Nitrite, Ammonium, Phosphates	Reported in previous sampling, COPC for agriculture, rural land use and wastewater
Metals & Other Inorganics (Total)	Aluminium, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Cobalt, Copper, Iron, Lead, Lithium, Manganese, Mercury, Molybdenum, Nickel, Selenium, Silver, Thallium, Thorium, Tin, Titanium, Uranium, Vanadium, Zinc, Zirconium	Elevated metals reported in previous sampling
	Chromium (Total, Chromium VI, Chromium III) (field filtered)	
	Cyanide (Total, field preserved)	COPC for lower catchment
Microbes*	Heterotrophic Plate Count (Total)	Measure of bacterial colonies
	Total Coliforms, *E. coli* and *Enterococci*	Reported in previous sampling
	Thermophilic Amoeba and *Thermophilic Naegleria*	Warm water pathogens
Herbicides & Pesticides	Acidic Herbicides & Pesticides (2.4-D, 2.4.5-T, 2.4.6-T, Clopyralid, Dicamba, Fluazifop, MCPA, Metsulfuron Methyl, Picloram, Triclopyr)	Reported in previous sampling, COPC for rural land use and public open space
	Base Neutrals (Amitraz, Atrazine, Azinphos Methyl, Chlorpyrifos, Diclofop Methyl, Dimethoate, Diuron, Endosulfan I, Endosulfan II, Endosulfan Sulfate, Fenamiphos, Fenitrothion, Fluometuron, Hexazinone, Metolachlor, Molinate, Myclobutanil, Prometryn, Propazine, Propiconazole, Simazine, Tebuconazole, Terbutryn, Trifluralin)	Reported in previous sampling, COPC for rural land use and public open space
	Organochloride & Organiphosphate Pesticides (alpha-BHC (HCH), Aldrin, beta-BHC (HCH), Bifenthrin, Bromophos Ethyl, Chlordane, Chlorothalonil, Chlorpyrifos, delta BHC (HCH), Diazinon, Dieldrin, Endosulfan I, Endosulfan II, Endosulfan Sulfate, Endrin, Ethion, Fenitrothion, Fipronil, Hexachlorobenzene (HCB), Heptachlor Epoxide, Heptachlor, Lindane, Malathion, Methoxychlor, o.p-DDT, Oxychlordane, Parathion Ethyl, Parathion Methyl, p.p-DDD, p.p-DDE, p.p-DDT, Trifluralin, Vinclozolin)	Reported in previous sampling, COPC for rural land use and public open space
Hydrocarbons	Total Recoverable Hydrocarbon (TRH) fractions including Benzene, Toluene, Ethylbenzene and Xylenes (BTEX) and naphthalene, and NEPM "F1" (TRH C6-C10 minus BTEX) and "F2" (TRH >C10-C16 minus naphthalene) fractions	Reported in previous sampling, COPC for various urban and rural land use

Group	Analysis	Rationale
	Polycyclic Aromatic Hydrocarbons (PAH) including Acenaphthene, Acenaphthylene, Anthracene, Benz(a)anthracene, Benzo(a)pyrene, Benzo(b&j)fluoranthene, Benzo(g.h.i)perylene, Benzo(k)fluoranthene, Chrysene, Dibenz(a.h)anthracene, Fluoranthene, Fluorene, Indeno(1.2.3-cd)pyrene, Naphthalene, Phenanthrene, Pyrene, Total PAH	Reported in previous sampling, by-product of incomplete combustion
PFAS	Per and Polyfluoroalkyl Substances Full Ultra Trace (99% Freshwater Guidelines)	Reported in previous sampling, persistent and widespread in urban and rural settings
Surfactants	Methylene Blue Active Substance (MBAS)	Reported in previous sampling, COPC for wastewater (detergents or foaming agents)
Volatiles	Volatile & Semi-Volatile Organic Compounds**	COPC for historical land use in lower catchment e.g. former Bellevue Waste Facility and Midland Railway Workshops
	Polychlorinated Biphenyls (Aroclor-1016, 1221, 1232,1242, 1248, 1254, 1260, Total PCB)	
Water Quality Parameters	Alkalinity	Acid-neutralising capacity
	Hardness*	Capacity to precipitate soap
	pH, Salinity*	Acidity/alkalinity and salinity
	Colour*, Turbidity*	Water clarity
	Total Suspended Solids*, Dissolved Solids*	Amount of sediment in water
	Biochemical Oxygen Demand*, Total Organic Carbon	Amount of organic material

Table 1 Water and Sediment Analysis Suite

Table 1 Notes:

* Water samples only, not applicable for sediment samples

** SVOC - Total PAH*, 2-Fluorobiphenyl (surr.), 2.4.6-Tribromophenol (surr.), 1-Chloronaphthalene, 1-Naphthylamine, 2.4.6-Trichlorophenol, 2.4-Dichlorophenol, 2.4-Dimethylphenol, 2.4-Dinitrophenol, 2.4-Dinitrotoluene, 2.6-Dichlorophenol, 2.6-Dinitrotoluene, 2-Methylphenol (o-Cresol), 2-Naphthylamine, 2-Picoline, 3&4-Methylphenol (m&p-Cresol), 3-Methylcholanthrene, 4-Aminobiphenyl, 4-Bromophenyl phenyl ether, 4-Chloro-3-methylphenol, 4-Chlorophenyl phenyl ether, 7.12-Dimethylbenz(a)anthracene, Benz(a)anthracene, Benzo(a)pyrene, Benzo(b&j)fluoranthene, Benzo(g.h.i)perylene, Benzo(k)fluoranthene, Bis(2-chloroethoxy)methane, Bis(2-chloroisopropyl)ether, Dibenz(a.h)anthracene, Dibenz(a.j)acridine, 3.3'-Dichlorobenzidine, Dimethylaminoazobenzene, Di-n-octylphthalate, Fluoranthene, Indeno(1.2.3-cd)pyrene, N Nitrosodibutylamine, N-Nitrosodipropylamine, N-Nitrosopiperidine, 2-Nitroaniline, Pronamide, Phenol-d6 (surr.), Diphenylamine, Aniline, Acenaphthene, Dibenzofuran, Pentachloronitrobenzene, Acetophenone, Di-n-butyl phthalate, Phenanthrene, Butyl benzyl phthalate, 2-Chloronaphthalene, Fluorene, Nitrobenzene-d5 (surr.), Trifluralin, Pyrene, Nitrobenzene, 2-Nitrophenol, Diethyl phthalate, Pentachlorophenol, Acenaphthylene, Phenol, Anthracene, Bis(2-ethylhexyl)phthalate, 2.3.4.6-Tetrachlorophenol, 2-Methylnaphthalene, Naphthalene, Chrysene, Dimethyl phthalate, 2-Chlorophenol, 1.2-Dichlorobenzene, 1.3-Dichlorobenzene, 1.4-Dichlorobenzene, 1.2.3-Trichlorobenzene, 1.2.3.4-Tetrachlorobenzene, 1.2.3.5-Tetrachlorobenzene, 1.2.4-Trichlorobenzene, 1.2.4.5-Tetrachlorobenzene, 1.3.5-Trichlorobenzene, Benzyl chloride, Hexachlorobenzene, Pentachlorobenzene, Hexachlorocyclopentadiene, Hexachloroethane, Hexachlorobutadiene, 4.4'-DDE, b-HCH, Endrin ketone, Heptachlor, Methoxychlor, Endrin, Endosulfan II, Endosulfan I, Endosulfan sulphate, 4.4'-DDD, a-HCH, Aldrin, 4.4'-DDT, Heptachlor epoxide, g-HCH (Lindane), d-HCH, Endrin aldehyde, Dieldrin, 2.4.5-Trichlorophenol, 4-Nitrophenol, 2-Methyl-4.6-dinitrophenol, Benzo(a)pyrene TEQ (medium bound), Benzo(a)pyrene TEQ (lower bound), Benzo(a)pyrene TEQ (upper bound), Aldrin and Dieldrin (Total), DDT+DDE+DDD (Total)

* VOC = Isopropyl benzene (Cumene), 1.3-Dichloropropane, Bromochloromethane, Total MAH*, Toluene-d8 (surr.), 1.1.1.2-Tetrachloroethane, 1.1.1-Trichloroethane, 1.1.2.2-Tetrachloroethane, 1.1.2-Trichloroethane, 1.1-Dichloroethane, 1.1-Dichloroethene, 1.2.3-Trichloropropane, 1.2-Dibromoethane, 1.2-Dichloroethane, 1.2-Dichloropropane, 2-Butanone (MEK), 2-Propanone (Acetone), 4-Methyl-2-pentanone (MIBK), cis-1.2-Dichloroethene, cis-1.3-Dichloropropene, trans-1.2-Dichloroethene, trans-1.3-Dichloropropene, Xylenes - Total*, 4-Bromofluorobenzene (surr.), Bromodichloromethane, Chloroethane, Allyl chloride, Chlorobenzene, Dichlorodifluoromethane, Toluene, Carbon Tetrachloride, Iodomethane, Chloromethane, Bromomethane, Styrene, Dibromomethane, Vinyl Chloride, Trichlorofluoromethane, Dibromochloromethane, Ethylbenzene, Bromoform, Carbon disulfide, Chloroform, Methylene Chloride, Tetrachloroethene, Benzene, Trichloroethene, 1.2-Dichlorobenzene, 1.3-Dichlorobenzene, 1.4-Dichlorobenzene, 4-Chlorotoluene, Bromobenzene, 1.2.4-Trimethylbenzene, 1.3.5-Trimethylbenzene, o-Xylene, m&p-Xylenes, Vic EPA IWRG 621 Other CHC (Total), Vic EPA IWRG 621 CHC (Total)

The limits of reporting (LOR) were the lowest available through a NATA accredited laboratory: Eurofins ARL in Welshpool, Perth. Eurofins ARL assisted with identification of the analytical suite and provided discounted rates for the BoorYul-Bah-Bilya program.

Guideline Values

Guideline values are a useful tool to help ensure that the physical and chemical properties of rivers do not present a risk to the environment or community.

Default Guideline Values

Default guideline values (DGV) can be used to assess if water or sediment quality represents a potential risk to a river's "community values". A DGV exceedance indicates that further investigation is required to determine if a risk or impact exists, although action is not mandatory.

Community values are defined under the *Australian and New Zealand Guidelines for Fresh & Marine Water Quality* (ANZG) as "*a particular value or use of the environment that is important for a healthy ecosystem or for public benefit, health, safety or welfare, and requires protection from the effects of stressors*"[94]. The ANZG recognise the following community values that may apply to a waterway:

- Aquatic ecosystems: the health or integrity of the waterway's ecosystem(s).
- Cultural and spiritual values: water is particularly important for Indigenous people.
- Drinking water: suitable for human consumption.
- Industrial water: suitable for industry use e.g. mining, manufacturing, cooling, electricity generation.
- Primary industries: suitable for irrigation, livestock drinking water, aquaculture and human consumption of aquatic food.
- Recreational water and aesthetics: recreation can be undertaken without risk of sickness or disease or loss of aesthetic appeal.

In Western Australia, DGV are used to protect "ecosystem health", specifically through protection of a certain percentage of species, and "beneficial use" of the river by the community. These terms are defined in the WA *Environmental Protection Act 1986*[95] as follows:

- Ecosystem health condition relevant to the maintenance of ecological structure ecological function or ecological process[95].
- Beneficial use of the environment which is conductive to public benefit, public amenity, public safety, public health or aesthetic enjoyment[95].

Under the ANZG, community engagement should be undertaken to identify community values relevant for a particular waterway. Community values for Mandoon Bilya are identified in the *Mandoon – Helena River Confluence* report produced as part of the 2023 Waterways Western Australia project[26] These include:

- Ecological health value: water that provides a healthy freshwater aquatic environment for ecological communities that live in or are dependent on freshwater and support biodiversity (e.g. plants, animals, microorganisms, physical/chemical environment and climatic regime).
- Cultural and spiritual values: water that accounts for the cultural and spiritual significance of rivers and water sources for Noongar people including minimum water flows.
- Drinking water value: water that is suitable for human consumption.
- Primary industries value: water that is suitable for watering crops and livestock, and that supports healthy aquatic fauna for potential consumption e.g. fish/crustaceans.
- Non-potable value: water that is suitable for household irrigation and other uses (some adjacent residences use water from the river, typically referred to as "riparian rights" depending on the legislation that the abstraction falls under).
- Recreational value: water that is suitable for swimming and kayaking and supports recreation through walking and cycling tails.
- Aesthetical value: water that provides visual and social amenity.

DGV used to assess water quality in the Mandoon Bilya catchment are described in **Table 2**. The DGV and notes on their application are presented in **Tables T1–T2**.

	Default Guideline Value
Aquatic Freshwater Ecosystem	Australian and New Zealand guidelines (ANZG) address the quality and environmental values of natural and semi-natural waters and provide different levels of species protection (LOSP) depending on the current or desired ecosystem condition (ANZG, 2018[94]). The 99% LOSP for high conservation /ecological value systems has been adopted for the BoorYul-Bah-Bilya program to reflect the river's high ecological value and a desire by the Senior Elders to restore the river to pristine health as far as reasonably practicable. The ANZG include physiochemical values specific to lowland rivers in South-West Australia. Regional ANZG for toxicants are being developed by the Australian government but have been significantly delayed due to prioritisation of some marine regions e.g. Great Barrier Reef. There are currently no regional toxicant ANZG for inland waters in the Southwest Coast drainage division where the Mandoon catchment is located. Guidelines for ecological assessment levels for selected chemical stressors relevant to south west region of WA derived during base flow condition (DWER, 2021)[96]. Australian and New Zealand national environmental management plan (NEMP) guidelines for PFAS (PFOS and PFOA) in slightly to moderately disturbed freshwater ecosystems at 99% LOSP for chemicals that bioaccumulate and biomagnify in wildlife, version 3.0 (HEPA, 2025)[97].
Drinking Water Health & Aesthetics	Australian drinking water guidelines (ADWG) for human health and aesthetic properties e.g. taste, odour, appearance (NHMRC, 2022 (2011))[98]. ADWG are part of the National Water Quality Management Strategy managed by the National Health and Medical Research Council (NHMRC). World Health Organisation values for petroleum products in drinking water are adopted in the absence of ADWG for petroleum hydrocarbons (WHO, 2008)[99]. Where no DGV is available, Regional Screening Levels (RSL) from the US Environmental Protection Agency are adopted for screening purposes (US EPA, 2024)[100].
Non-Potable Use	WA Department of Health non-potable use guidelines (NPUG) for human health and aesthetic properties, including irrigation of gardens/parks/reserves, cleaning, bathing, filling swimming pools, growing produce, flushing toilets and washing vehicles (DOH, 2014)[101]. NPUG are typically ten times the ADWG but there are exceptions for odorous chemicals and aesthetic properties. Microbial assessment levels (MAL) for water used in urban recreational areas, open spaces, parks and gardens with unrestricted access and application (DWER, 2021)[96]. PFAS ADWG are used for screening purposes for non-potable use where consumption of home-grown produce is a viable/plausible exposure pathway (DWER, 2021)[102]. DOH guidelines and ongoing monitoring requirements for high risk use of recycled water in WA e.g. residential/commercial irrigation with unrestricted access and application, laundry, toilet flushing, car washing, firefighting and enhancement of environmental flows (DOH, 2011)[102].
Recreation & Aesthetics	Non-potable use guidelines for human health and recreational use of surface water (DOH, 2014)[101]. Australian and New Zealand guidelines for recreational water quality (ANZECC, 2000)[88]. Microbial assessment levels (MAL) for water used in urban recreational areas, open spaces, parks and gardens with unrestricted access and application (DWER, 2021)[96]. Australian guideline values for PFAS in recreational water (NHMRC, 2019)[103]. These do not consider fish/shellfish caught and consumed from recreational waters. Guidelines aim to ensure safe recreational water use, including consideration of natural hazards (e.g. currents, aquatic organisms) and artificial hazards (e.g. pollution and pathogens).
Primary Industries – Agriculture, Farming & Aquaculture	Australian and New Zealand guidelines for primary industries – long and short term trigger values for agricultural irrigation and for livestock drinking water quality (ANZECC, 2000)[88]. Australian and New Zealand draft guidelines for livestock drinking water (ANZG, 2023b)[104]. Guidelines address water suitability for agricultural irrigation and livestock drinking water. Guidelines do not exist for PFAS in irrigation or stock water, including uptake into crops and subsequent human consumption. Drinking water guidelines are a useful surrogate for comparison, however additional assessment may be warranted where PFAS is identified. Primary industries also include aquaculture and human consumption of aquatic food. Guidelines for aquaculture protection include physico-chemical stressor guidelines and toxicant guidelines

	Default Guideline Value
	for protection of aquaculture species (Tables 4.4.2–4.4.3) in the ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality[88]. The ANZECC (2000) guidelines do not consider PFAS, including accumulation in fish/shellfish and subsequent human consumption. In WA, fishing is banned in drinking water supply catchments, including the majority of Mandoon catchment. As such, aquaculture guidelines were not adopted in this assessment. Anecdotal evidence indicates that some people may consume crustaceans and fish from the river. Further assessment is warranted wherever PFAS is present and fishing may occur.
Cultural & Spiritual	Australian guidelines are not currently available for cultural/spiritual values of rivers.

Table 2 Default Guideline Values for Water in the Mandoon-Helena Catchment

DGV used to assess sediment quality in the Mandoon Bilya catchment are presented in **Table 3**. The DGV and notes on their application are presented in **Table T3**.

	Default Guideline Value
Sediment Quality	Australian and New Zealand guidelines for sediment quality (ANZECC, 2000)[88]. Australian and New Zealand guidelines for toxicants in sediment (ANZG, 2018)[94]. Sediment guidelines are limited and do not include nutrients, surfactants and PFAS.

Table 3 Default Guideline Values for Sediment in the Mandoon-Helena Catchment

Swan Canning Water Quality Targets

Water quality targets are determined for the Swan Canning tributaries, including the lower Mandoon-Helena from the confluence of the Derbarl Yerrigan (Swan River) to the Lower Pumpback Dam[82,105]. These were established as part of the *Swan Canning Cleanup Program*[82] and are still used today to report on progress of the *Swan Canning River Protection Strategy*[77]. They are designed to provide a measure of progress nutrient management targets. The targets are presented in **Table T2**.

Compliance with the water quality targets is based on data from the main river discharge period in winter and spring in typical condition (median values). Data from three years is combined and used to calculate the number of samples that exceed the target and the 90% confidence interval of those exceedances. Compliance or non-compliance is based on whether the 90% confidence interval lies above (exceedance) or below (compliance) the target. Compliance also depends on the waterway condition in previous years. If the waterway was previously non-compliant, the 90% confidence interval must be below target for compliance. If previously compliant, the 90% confidence interval must be above target for non-compliance.

Wastewater Effluent Criteria

Some areas of the Mandoon catchment are not connected to government sewerage, meaning that treated wastewater must be disposed on-site. Leachate drains were previously common although new developments require on-site treatment using aerobic treatment units (ATU). Most development approvals stipulate water quality criteria for treated wastewater effluent[106]. The criteria are presented in **Table T2**.

Catchment-specific Guideline Values

DGV can be used to assess water and sediment quality in the absence of specific guidelines for local conditions. Through the BoorYul-Bah-Bilya program, BNAA hope to develop catchment-specific guidelines that can be incorporated into an overarching plan with management targets to measure progress.

Protecting the cultural and spiritual values of rivers is a high priority for many Aboriginal people, however ANZG do not currently exist for cultural/spiritual values. As the BoorYul-Bah-Bilya program progresses, BNAA hope to develop cultural and spiritual guidelines for the Mandoon catchment, including targets for minimum water flows downstream of dams as identified by our Senior Elders.

Sampling Locations

The number of sampling sites was determined by the LHAAC approved budget and the cost of laboratory analysis. The budget enabled water and sediment samples to be collected from 12 sites including one quality control duplicate sample. Of these, five sites were located in the lower catchment, five in the middle catchment and two in the upper catchment.

Sampling sites were selected based on proximity to current and historical land use, including:

- Historical industry and contaminated sites, including the former Bellevue Hazardous Waste Facility, OPEX Oil Refinery, Bellevue Holding Yards and Midland Railway Workshops.
- Agricultural and rural land use, including wineries, cideries and fruit growers in the tourism precincts of Bickley Valley and Pickering Brook.
- Popular swimming locations, including Rocky Pool on Piesse Brook.

Sites were also selected based on the location of previous sampling sites, including:

- Ongoing Swan Canning Water Quality Monitoring Program at Whiteman Road (WIR: 616086), noting that DBCA have confirmed that this site is likely to be moved further upstream in the near future (to immediately downstream of Roe Hwy)
- Helping the Helena – Baseline water quality pollutants study (ERMC, 2014)[3]
- DWER Healthy Rivers assessments in 2012 at Whiteman Road–SWN10 (61086) and Mundaring Weir Downstream-HRDSMW (WIR: 6163844)
- Helena River Fish and Macroinvertebrate Surveys 2010 and 2011 (ERMC, 2011)[33]
- Historical data in the Water Information Reporting (WIR) database (https://wir.water.wa.gov.au/)

Site selection was influenced by the presence of flowing water in Djilba/spring (approximately August – September). Sampling was undertaken to reflect base flow condition rather than heavy flows during storm events. Flows were checked regularly in the lead up to sampling using the WIR database, consultation with DBCA staff and field visits.

Site selection was also influenced by ease of safe access, considering:

- All sample sites are located on public land and not on private property.
- All sample sites are accessible using established tracks.

Sites were also selected based on their position in the catchment, with all sites located upstream of saline water that is tidally influenced near the confluence with the Derbarl Yerrigan (Swan River).

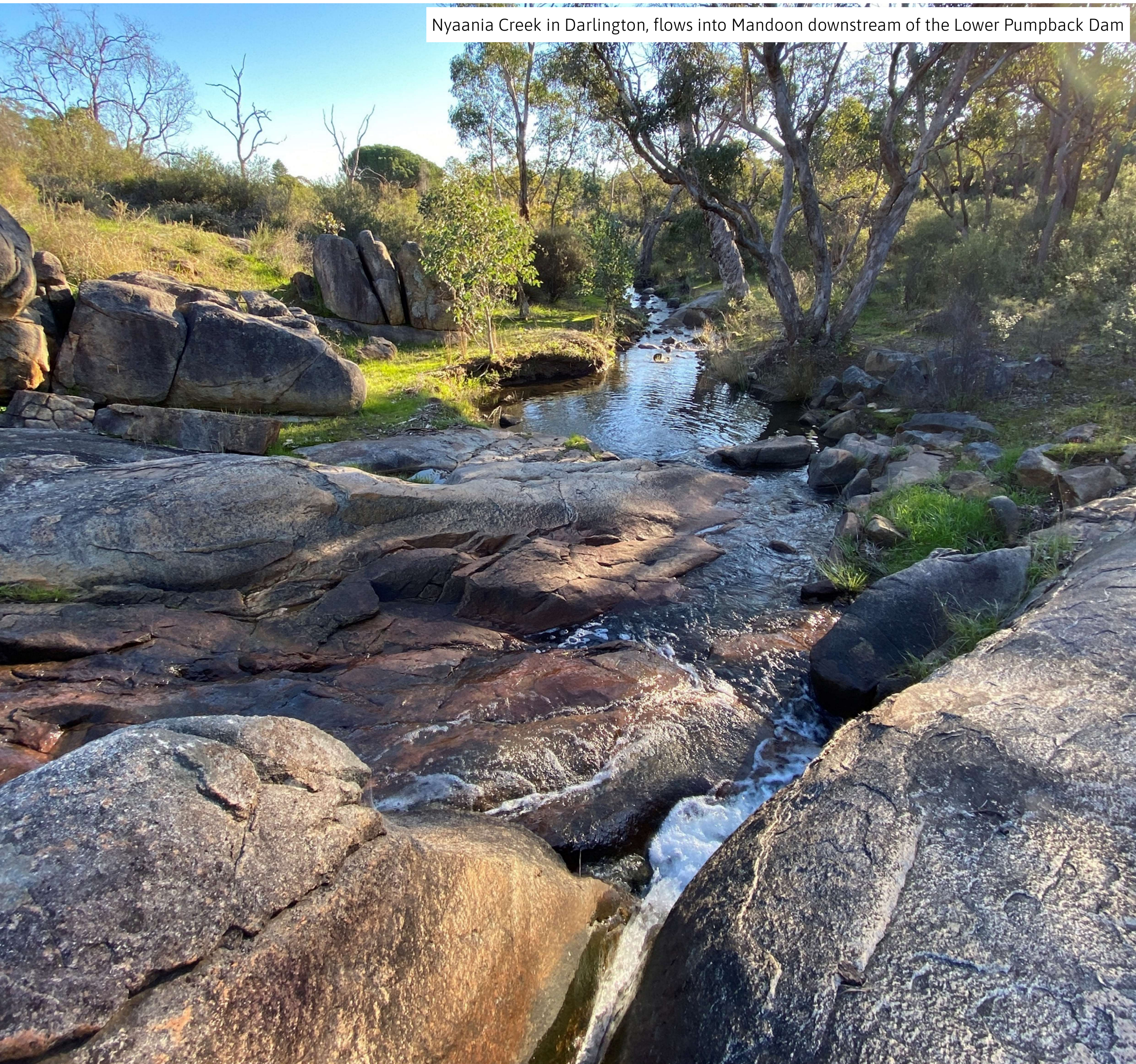
Safety was a primary concern for selection of sampling sites. Alternative sites were identified in case access to primary sites could not be safely achieved e.g. wet/soft ground or prescribed burns.

Water Corporation will not permit BNAA to collect water samples from Mundaring Weir or the Lower Pumpback Dam or from any watercourse within 200 m of the dams within the Reservoir Protection Zones (RPZ) until a risk assessment is undertaken to determine if the sampling will pose an unacceptable risk to drinking water quality. Ongoing discussions with Water Corporation indicate that they may also be willing to share their sampling data with BNAA for the BoorYul-Bah-Bilya program, although it is possible that the data may be covered by a confidentiality agreement, limiting its ability to be shared with the community. These discussions are ongoing and BNAA hope that Water Corporation will continue to work towards collaborative sampling and data sharing in the future.

Some amendments were made to the proposed sampling locations documented in the Sampling and Analysis Plan[107] as follows:

- Helena Swan – site was moved 76 m downstream due to access constraints (dense tall weeds).
- Helena Roe – site was moved 83 m downstream due to access constraints (construction fence).
- Skeleton Pool – site could not be accessed due to steep banks. An alternative location was identified 360 m upstream at a large permanent pool, named Cobblers Pool, at the confluence with Gunjin Gully (incorrectly referred to as Skeleton Pool in field notes and laboratory documentation).
- LookSee Pool – site was moved 56 m upstream due to access constraints (steep banks).
- Piesse Culvert – site was moved 140 m upstream due to access constraints (private property).
- Helena Pony – site could not be sampled due to a lack of water. An alternative location was identified 3.1 km downstream at the nearest accessible water, named Salty Pool (incorrectly referred to as Helena Pony in field notes and lab documentation). This location is downstream of salinity-impacted Wundabiniring Brook, and cannot be used to assess ambient background conditions.

Sampling sites are shown on **Figure 3** and **Figure 4**. Site details and rationale are shown in **Table 4**.


Nyaania Creek in Darlington, flows into Mandoon downstream of the Lower Pumpback Dam

No	Site Name	WIR Ref	Waterway	Section	Local Gov	Coords	Location	Rationale	Other Names
1	**Helena Swan**	N/A (6161091 is 76 m upstream)	Mandoon	Lower	Swan	-31.89708, 115.9858	Immediately upstream of Bushmead Rd bridge - moved 76 m downstream due to dense weeds	Downstream site not tidally influenced by Derbarl Yerrigan, downstream of Midland workshops, near BNAA 2023 eDNA site	Not previously sampled. WIR 6161091 = 13820; Helena River - Swan St
2	**Whiteman Rd**	616086	Mandoon	Lower	Swan	-31.89997, 116.0075	At site of former Whiteman Rd bridge - as proposed	DBCA Swan Canning & DWER Healthy Rivers site, long-established government monitoring site, downstream of Hazelmere industrial estate, near BNAA 2023 eDNA site	WIR 616086; SWN10; HELENR; HR01; 12863074; Whiteman Rd Bridge
3	**Helena Roe**	N/A (6167030 is 83 m upstream)	Mandoon	Lower	Swan-Mundaring	-31.90541, 116.0160	Immediately downstream of Military Rd bridge - moved 83 m downstream due to construction fence	At COS-SOM boundary, adjacent former Bellevue Hazardous Waste Facility, Helping the Helena sampling site, previously detected low pH and elevated metals	Not previously sampled. WIR 6167030 = HELENA2; 23046732; EMRC4; Site 4; Helena Valley Floodplain - Pool DS Roe Hwy Br
4	**Craignish US**	6167032	Mandoon	Lower	Mundaring-Kalamunda	-31.93554, 116.0687	Immediately upstream of Craignish gauging station (WIR 616018) – as proposed.	At Craignish gauging station, Helping the Helena sampling site, previously detected elevated hydrocarbons (PAH), near BNAA 2023 eDNA site	WIR 6167032; HELENA4; 23046734; EMRC10; Site 12; Pool US of Craignish; Craignish Weir; Pool 13
5	**Lower Pumpback Dam**	N/A	Mandoon - Lower Pumpback Dam	Lower	Mundaring-Kalamunda	-31.94179, 116.0761	As proposed – immediately downstream of Lower Pumpback Dam in river channel.	Immediately downstream of LPD wall, LPD is a public drinking water source, near BNAA 2023 eDNA site, outside of Reservoir Protection Zone (RPZ)	Not previously sampled. Historical samples have been collected in the dam = LH01T; LH01B; Q6161607
6	**Rocky Pool**	N/A	Piesse Brook	Middle	Kalamunda	-31.95366, 116.0716	As proposed – in Kalamunda National Park	Major tributary from Pickering Brook and Bickley Valley, flows into LPD, downstream of Kalamunda, popular swimming spot	Not previously sampled.

No	Site Name	WIR Ref	Waterway	Section	Local Gov	Coords	Location	Rationale	Other Names
7	**Pipe Bridge**	6161604	Mandoon	Middle	Mundaring-Kalamunda	-31.93834, 116.1217	Under the water pipe, in Shire of Mundaring reserve – as proposed	Upstream of LPD, historically identified as high public health significance, previously detected elevated metals and hydrocarbons between Mundaring Weir and LPD	WIR 6161604; 14110: Lower Helena River - Pipe Bridge 5.5Km
8	**Cobblers Pool***	N/A (6167034 is 360 m downstream)	Mandoon	Middle	Mundaring-Kalamunda	-31.94693, 116.1348	Large permanent pool at confluence with Gunjin Gully - moved 360 m upstream from Skeleton Pool (6167034) due to steep banks	Upstream of LPD, close to historical site that previously detected elevated metals and hydrocarbons (PAH), large permanent summer pool * Incorrectly referred to as Skeleton Pool in field and laboratory data	Not previously sampled. WIR 6167034 = HELENA 6; 23046736; EMRC14; Site 14; Helena River - Pool DS of Wpipe
9	**LookSee Pool**	N/A (6163844 is 56 m downstream)	Mandoon	Middle	Mundaring-Kalamunda	-31.94991, 116.1459	Large permanent pool - moved 56 m upstream due to steep banks, still within same pool	DWER Healthy Rivers site, downstream of Bourkes Gully (tributary from Mundaring town site), BNAA 2023 eDNA site, permanent summer pool	WIR 6163844; 23025644; EMRC23; Site 23; HRDSMW; DS Mundaring; 2014_LookSeePool; 2012_LookSeePool
10	**Piesse Culvert**	N/A (6161253 Is 140 m downstream)	Piesse Brook	Middle	Kalamunda	-32.03209 116.1370	Immediately upstream of Patterson Rd culvert - moved 140 m upstream due to private property	Furthest upstream location on Piesse Brook that is accessible via public land	Not previously sampled. WIR 6161253 = 13947; LH21; Piesse Gully
11	**Salty Pool***	N/A (6161278 is 1.4 km upstream on Wundabiniring Brook and 6160175 is 2 km downstream)	Mandoon	Upper	York	-31.93916 116.5150	Large pool - moved 3.1 km downstream from Helena Pony site due to lack of surface water	Mandoon headwaters, downstream of salinity-impacted Wundabiniring Brook tributary * Incorrectly referred to as Helena Pony in field and laboratory data	Not previously sampled. WIR 6161278 = 23015445; HR20; Helena River - Pony Rd; WIR 6160175 = 23015297; HR19; Helena River – West Talbot Rd
12	**Beraking Yarra**	6161259	Beraking Brook	Upper	Beverley	-32.18183, 116.4349	Immediately downstream of Yarra Rd culvert – as proposed	Beraking Brook headwaters, upstream of any private property and cleared land, ambient background location	WIR 6161259; HR10; MD105; Yarra Rd; Beraking Brook-Yarra Rd

Table 4 Baseline Water and Sediment Sampling Locations and Rationale

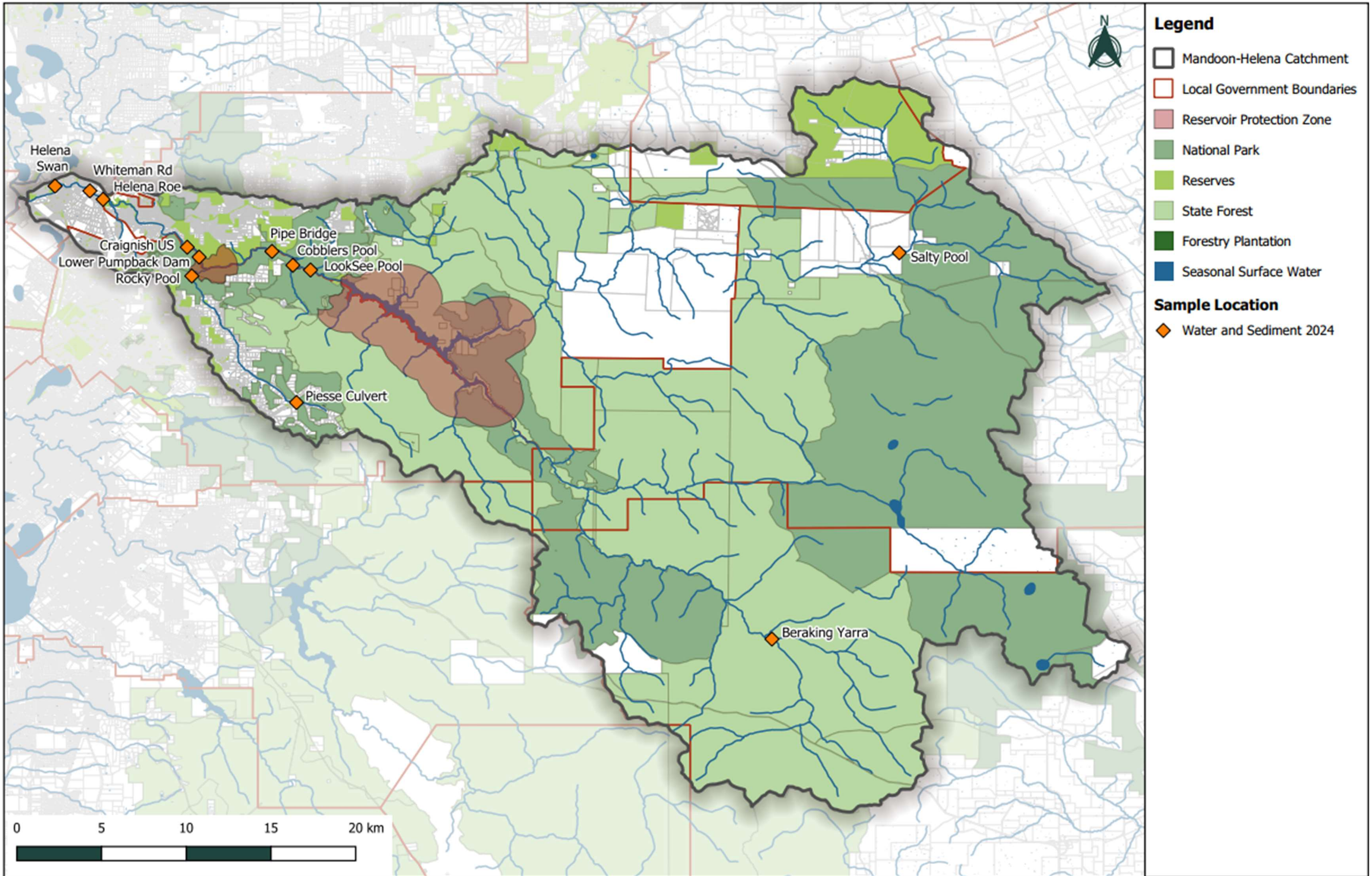


Figure 3 Surface Water and Sediment Sampling Locations

BoorYul-Bah-Bilya (Mandoon Bilya - Helena River Catchment) Baseline Surface Water and Sediment Sampling 2024, Conservation Audit

Bibbul Ngarma Aboriginal Association Incorporated
Prepared by: Francesca Flynn

Data Sources: Landgate, Department of Water and Environmental Regulation, Shire of Mundaring, City of Kalamunda, City of Swan

Ref: BBB-MBHR-BWQS-003
Date: 21 March 2025

BOORYUL BAH BILYA

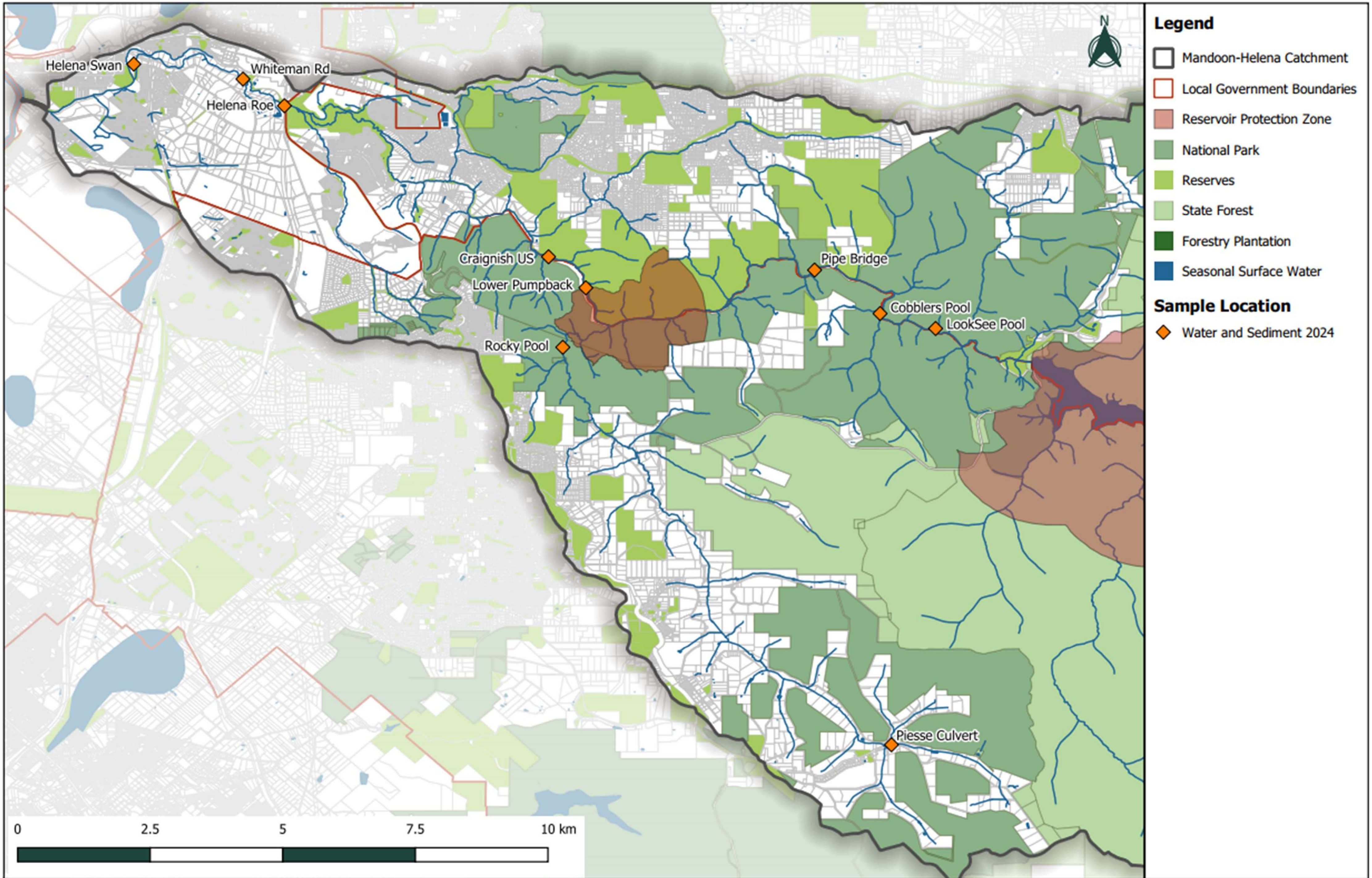


Figure 4 Surface Water and Sediment Sampling Locations Lower and Middle Catchment

BoorYul-Bah-Bilya (Mandoon Bilya - Helena River Catchment) Baseline Surface Water and Sediment Sampling 2024, Conservation Audit

Bibbul Ngarma Aboriginal Association Incorporated
Prepared by: Francesca Flynn

Data Sources: Landgate, Department of Water and Environmental Regulation, Shire of Mundaring, City of Kalamunda, City of Swan

Ref: BBB-MBHR-BWQS-004
Date: 21 March 2025

BOORYUL BAH BILYA

Sampling Methodology

Sampling was undertaken between 16–18 September 2024. Water and sediment sampling was conducted in accordance with the procedures for chemical and physiochemical parameters as presented in **Appendix 2**.

Water samples were collected first and then sediment samples. Following sample collection, physiochemical parameters were measured within 20 cm of the surface using a YSI Pro DSS multiprobe.

Cross contamination is a significant risk when sampling for PFAS. To avoid this, DWER's *Interim Guideline on Assessment and Management of PFAS*[108] was strictly adhered to, as presented in **Appendix 3**.

One duplicate quality control water sample was collected from a randomly chosen sampling location to check for replicability and errors in sampling and processing procedures. Due to budget constraints, the duplicate sample was analysed for TRH and BTEX only.

Consideration was given to the following documents when developing the methodology:

- DBCA (2022) Swan Canning Catchment Sampling and Analysis Plan, Rivers and Estuaries Science[109]
- DWER (2018) Swan Canning Water Quality Improvement Plan (Project: SG-C-SCWQIP), Sampling and Analysis Plan, TRIM File No: WT9835, Aquatic Science Branch[110]
- DWER (2018) Swan and Canning River Catchment Water Quality Monitoring Program (Project: SG-C-SWANCATCH), Sampling and Analysis Plan, TRIM File No: WT895, Water Science Branch[111]
- Government of Queensland (2018) Environmental Protection (Water) Policy 2009 – Monitoring and Sampling Manual, Collection and Preservation of Sediment
- DWER (2016) Interim Guideline on the Assessment and Management of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS): Contaminated Sites Guidelines[108]
- DOW (2009) Field Sampling Guidelines: A Guideline for Field Sampling for Surface Water Quality Monitoring Programs[112]
- DOW (2009) Surface Water Sampling Methods and Analysis – Technical Appendices: Standard Operating Procedures for Water Sampling – Methods and Analysis[113]
- DOW (2009) Water Quality Monitoring Program Design: A Guideline to the Development of Surface Water Quality Monitoring Programs[114]
- CSIRO (2005) Handbook for Sediment Quality and Assessment[115]

Sampling was undertaken in accordance with the Water Corporation Catchment Access Agreement for the BoorYul-Bah-Bilya program.

White Myrtle (*Hypocalymma angustifolium*) in the middle catchment

Results

Sampling results are summarised against default guideline values (DGV) in the following section and **Tables T1-T3**. A conservative approach has been adopted in that exceedances are reported when a concentration is the same as the DGV. Results are presented by sampling location in **Appendix 4**. Laboratory documentation is presented in **Appendix 5**.

Water Quality Parameters

Water quality parameters are indicators that assess the chemical, physical, and biological characteristics of water, helping determine its suitability for supporting aquatic ecosystems and beneficial uses. Field and laboratory measured parameters are described below and presented on **Figure 5**.

Salinity is a measure of the total concentration of dissolved salts. Generally, water is considered to be fresh when salinity is less than 5,000 parts per million (ppm). Salinity ranged between 80–4,620 ppm across the catchment, reflecting fresh conditions. With the exception of Salty Pool, all sites had salinities of 80–590 ppm, with the lowest at Beraking Yarra being reflective of ambient background conditions in the river's headwaters. Salinity at Salty Pool was 4,620 ppm, which is close to brackish (5,000–25,000 ppm). Salty Pool is downstream of Wundabiniring Brook, which is salinity-impacted due to historical vegetation clearing.

Salinity stratification refers to the layering of a water body based on salinity, with denser saltier water sinking below less dense fresher water. Given that the sampling targeted surface water and was undertaken in September when flow rates would likely have ensured well-mixed water, it is possible that more saline waters may have been missed at depth. It is recommended that consideration be given to additional salinity testing in the upper catchment, including during low and high flows and targeting both surface and bottom waters to assess the presence of possible stratifications.

Conductivity is a measure of water's capability to conduct electrical flow, which directly relates to the concentration of conductive ions from dissolved salts and inorganic materials. As such, conductivity is often used as a measure of salinity. Salinity is the total concentration of all dissolved salts in ionic form, whereas total dissolved solids (TDS) is the sum of all small ions, including dissolved solids that make up salinity as well as other particles such as dissolved organic matter. The river contains elevated dissolved particles. With the exception of Beraking Yarra (162 uS/cm), all sites were above the ANZG trigger value for conductivity in lowland rivers in south-west Australia (<300 uS/cm). Sites in the middle catchment were 416–648 uS/cm, compared to 1,095–1,176 uS/cm in the lower catchment. Conductivity at Salty Pool was 8,274 uS/cm.

Dissolved oxygen is a measure of how much oxygen is dissolved in the water and available to aquatic animals. If dissolved oxygen falls too low, aquatic animals can die, with native fish and crustaceans being some of the most vulnerable. Low water flows typically correspond with lower dissolved oxygen, as faster flowing water allows greater mixing (aeration) and more oxygen absorption from the air. Still water is also more likely to be warmer, which reduces its ability to retain dissolved oxygen. Sample temperatures were between 12.8–17.2 °C, with lower temperatures generally reported in the upper catchment.

The river has localised areas of low dissolved oxygen, ranging between 27.6–101.4%. The lowest levels were at Lower Pumpback Dam (27.6%) and in the upper catchment at Beraking Yarra and Salty Pool (36.4–46.9%). Low dissolved oxygen was also reported at all sites in the lower catchment (54.8–59.3%) and the two large pools in the middle catchment (69.3–70.5%). Only three sites were below the ANZG trigger value of >80% for lowland rivers in south-west Australia: Pipe Bridge (94.4%), Rocky Pool (96.9%) and Piesse Culvert (101.4%).

pH is a measure of hydrogen ion concentrations, which indicates how acidic or basic (alkaline) a substance is. The pH scale ranges from 0 to 14 with 7 being neutral. Most sites reported neutral pH conditions ranging between 6.52–7.43, however, slightly acidic conditions were reported below the ANZG range for lowland rivers in south-west Australia (6.5–8.0) at 3 sites: Craignish (6.24), Lower Pumpback Dam (6.49) and Cobblers Pool (6.44). pH recorded in the laboratory differed slightly from that in the field, possibly as the laboratory test must begin within 30 minutes of sampling, and also reflecting differences in the accuracy of field and laboratory instrumentation. Only the field measured pH values were used for screening.

Turbidity is a measure of water clarity by the amount of light that cannot pass through due to suspended and dissolved particles. High turbidity can affect light penetration and aquatic plant growth as well as cause sedimentation and degradation of habitat for aquatic animals. Turbidity varied between 0.3–28.8 NTU across the catchment. With the exception of Craignish (28.8 NTU), all sites were below the ANZG trigger value for lowland rivers in south-west Australia (<20 NTU). Sites in the lower catchment (12.2–17.8 NTU) had higher turbidity compared to sites in the middle and upper catchment (0.3–5.14 NTU).

Colour is a measure of the colour of the river's water using the platinum cobalt unit (PCU) scale, which ranges from 0–500 PCU. Colour in water is caused by dissolved and suspended materials including salt, soil, dust and organic material. Water colour is important not only for drinking water, but also aquatic environments and the presence of animals and plants. The highest colour reading was at Salty Pool (130 PCU) which corresponds to the highest concentration of dissolved solids. Other sites had colour between <5–31 PCU.

Total Organic Carbon refers to the total amount of carbon present in organic compounds within a substance. It provides a measure of the organic matter in water, soil, or other materials, including that from natural sources e.g. plant material as well as anthropogenic sources e.g. wastewater. Four water samples reported detectable TOC, with the highest at Salty Pool (21 mg/L) and the remainder in the middle catchment at Pipe Bridge, Cobblers Pool and LookSee Pool (5.1–6.8 mg/L). With the exception of Helena Swan (<0.1 mg/kg), all sediment samples reported TOC between 0.4–43 mg/kg.

Water Samples

Eleven samples exceeded the DGV for protection of freshwater ecosystems (ANZG trigger value for lowland rivers in south-west Australia):

- Conductivity (416–8,274 mg/L) above the DGV (<300 mg/L) at all sites except Beraking Yarra.
- Dissolved oxygen (27.6–70.5%) below the DGV (>80%) at all sites except Rocky Pool, Pipe Bridge and Piesse Culvert.
- pH (6.24–6.49) below the DGV (6.5-8.5) at Craignish, Lower Pumpback Dam and Cobblers Pool.
- Turbidity (28.8 NTU) above the DGV (<10-20 NTU) at Craignish.

Eight samples exceeded the DGV for protection of human health:

- Hardness as $CaCO_3$ (200–1,700 mg/L) above the DGV for drinking water aesthetic (200 mg/L) at Whiteman Rd and Salty Pool, and the DGV for recreation (500 mg/L) at Salty Pool.
- pH (6.24–6.49) below the DGV for drinking water, non-potable use and recreation (6.5-8.5) at Craignish US, Lower Pumpback Dam and Cobblers Pool.
- TDS (712–5,390 mg/L) above the DGV for drinking water aesthetic (600 mg/L) at 4 sites: Helena Swan, Whiteman Rd, Helena Roe and Salty Pool, and the DGV for recreation (1,000 mg/L) at Salty Pool.
- Total suspended solids (23 mg/L) above the DGV for non-potable use (10 mg/L) at Craignish.
- Turbidity (5.1–28.8 NTU) above the DGV for drinking water aesthetic and non-potable use (5 NTU) at 6 sites: Helena Swan, Whiteman Rd, Helena Roe, Craignish, Lower Pumpback Dam and Beraking Yarra.

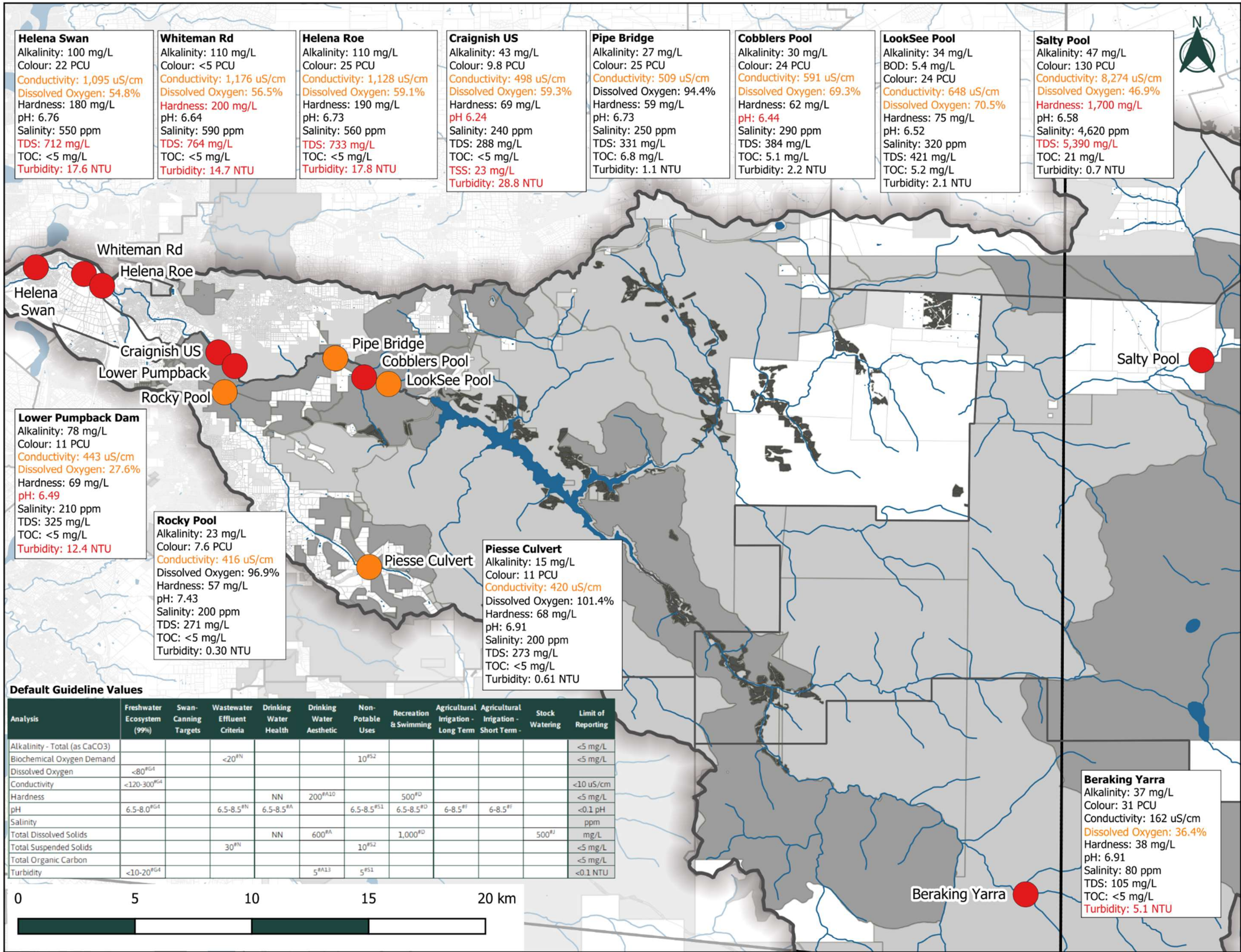
Four samples exceeded the DGV for protection of primary industries:

- TDS (712–5,390 mg/L) above the DGV for stock watering (500 mg/L) at 4 sites: Helena Swan, Whiteman Rd, Helena Roe and Salty Pool.

DGV do not exist for all water quality parameters.

Sediment Samples

Most water quality parameters are not applicable to sediment although samples were analysed for alkalinity, moisture content. pH and TOC (refer **Figure 6**).



Default Guideline Values

Analysis	Freshwater Ecosystem (99%)	Swan-Canning Targets	Wastewater Effluent Criteria	Drinking Water Health	Drinking Water Aesthetic	Non-Potable Uses	Recreation & Swimming	Agricultural Irrigation - Long Term	Agricultural Irrigation - Short Term -	Stock Watering	Limit of Reporting
Alkalinity - Total (as CaCO3)											<5 mg/L
Biochemical Oxygen Demand			<20 [#N]			10 [#S2]					<5 mg/L
Dissolved Oxygen	<80 [#G4]										
Conductivity	<120-300 [#G4]										<10 uS/cm
Hardness				NN	200 [#A10]		500 [#D]				<5 mg/L
pH	6.5-8.0 [#G4]		6.5-8.5 [#N]	6.5-8.5 [#A]		6.5-8.5 [#S1]	6.5-8.5 [#D]	6-8.5 [#F]	6-8.5 [#F]		<0.1 pH
Salinity											ppm
Total Dissolved Solids				NN	600 [#A]		1,000 [#D]			500 [#J]	mg/L
Total Suspended Solids			30 [#N]			10 [#S2]					<5 mg/L
Total Organic Carbon											<5 mg/L
Turbidity	<10-20 [#G4]				5 [#A13]	5 [#S1]					<0.1 NTU

Legend

- Mandoon-Helena Catchment
- Local Government Boundaries
- Native Title (ILUA) Boundaries
- Forestry Plantation
- National Park
- State Forest
- Reserves
- Seasonal Surface Water

Water Quality Parameters

- Ecological Guideline Exceeded
- Human Health and/or Primary Industries and/or Ecological Guidelines Exceeded

Detectable concentrations are presented for each sampling location.

Guideline Value Notes:
A: NHMRC (2022) Australian Drinking Water Guidelines
A10: NHMRC (2022) 60-200mg/L CaCO3 good quality; 200-500mg/L CaCO3 increasing scaling; >500mg/L CaCO3 severe scaling.
A13: NHMRC (2022) 5 NTU is noticeable in a glass; <0.2 NTU for effective filtration of Cryptosporidium and Giardia; <1 NTU for effective disinfection; insufficient data to set drinking water guideline.
D: ANZECC (2000) Guidelines for Recreational Water Quality and Aesthetics, Table 5.2.3.
F: ANZECC (2000) Guidelines for Primary Industries - Water Quality for Irrigation and General Water Use.
G4: ANZECC (2000) Default trigger values for lowland rivers in south-west Australia, Tables 3.3.6 and 3.3.7.
J: ANZG (2023b) Draft Livestock Drinking Water Guidelines.
N: Common wastewater effluent criteria for on-site disposal for development approvals in Mandoon-Helena Catchment.
NN: Not necessary, NHMRC 2011.
S1: DOH (2011) Guideline for ongoing monitoring for high level exposure risk (residential/urban unrestricted access), Table 8.
S2: DOH (2011) Guideline for commissioning validation and verification monitoring for high level exposure risk used for screening in the absence of an ongoing monitoring guideline, Table 7.

Figure 5 Water Sampling Results: Water Quality Parameters

BoorYul-Bah-Bilya (Mandoon Bilya - Helena River Catchment)
Baseline Surface Water and Sediment Sampling 2024, Conservation Audit

Bibbul Ngarma Aboriginal Association Incorporated
Prepared by: Francesca Flynn

Data Sources: Landgate, Department of Water and Environmental Regulation, Shire of Mundaring, City of Kalamunda, City of Swan

Ref: BBB-MBHR-BWQS-005
Date: 21 March 2025

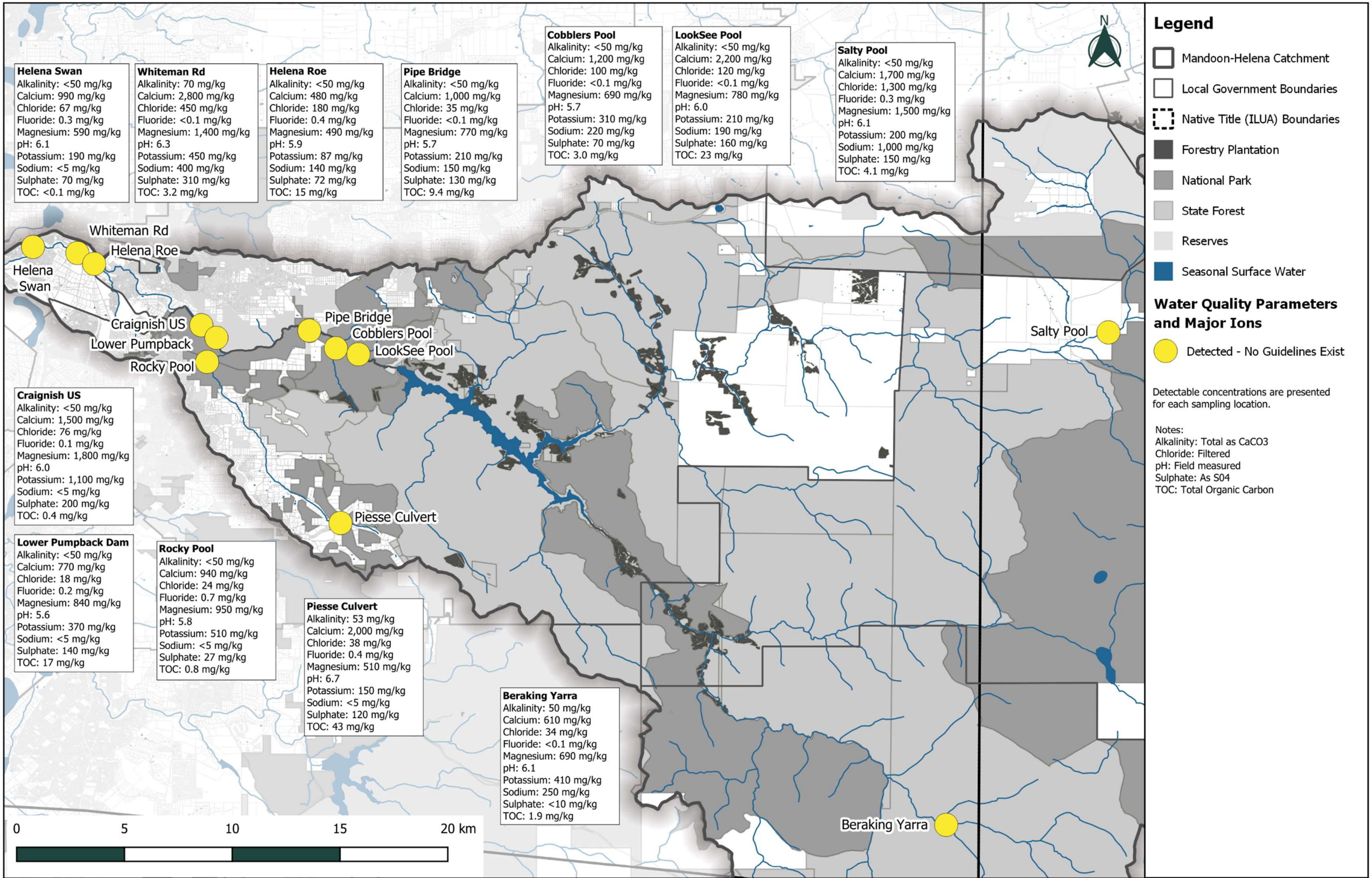


Figure 6 Sediment Sampling Results: Water Quality Parameters and Major Ions

BoorYul-Bah-Bilya (Mandoon Bilya - Helena River Catchment)
Baseline Surface Water and Sediment Sampling 2024, Conservation Audit

Bibbul Ngarma Aboriginal Association Incorporated
Prepared by: Francesca Flynn

Data Sources: Landgate, Department of Water and Environmental Regulation, Shire of Mundaring, City of Kalamunda, City of Swan

Ref: BBB-MBHR-BWQS-006
Date: 21 March 2025

BOORYUL BAH BILYA
BIBBUL NGARMA ABORIGINAL ASSOCIATION INC.

Major Ions

Major ions are the positively and negatively charged ions present in natural waters at levels in the parts per million (ppm) and higher range. These include calcium, chloride, fluoride, magnesium, potassium, sodium and sulphate. Major ions play a crucial role in maintaining ecosystem health by influencing water quality, supporting aquatic life, and providing an indication of environmental changes, including due to human activity.

Water Samples

Major ions were analysed in all water samples (refer **Figure 7**).

Two samples exceeded the DGV for protection of freshwater ecosystems:

- Fluoride (0.3–0.5 mg/L) above the DGV (0.29 mg/L) at Whiteman Rd and Salty Pool.

Three samples exceeded the DGV for protection of human health:

- Chloride (250–2,500 mg/L) above the DGV for drinking water aesthetic (250 mg/L) at Whiteman Rd, Helena Roe and Salty Pool, and the DGV for recreation (400 mg/L) at Salty Pool.
- Sodium (1,000 mg/L) above the DGV for drinking water aesthetic (180 mg/L) and recreation (300 mg/L) at Salty Pool.

Four samples exceeded the DGV for protection of primary industries:

- Chloride (230–2,500 mg/L) above the DGV for short and long term agricultural irrigation (175 mg/L) at 4 sites: Helena Swan, Whiteman Rd, Helena Roe and Salty Pool.
- Magnesium (340 mg/L) above the DGV for stock watering (125 mg/L) at Salty Pool.
- Sodium (140–1,000 mg/L) above the DGV for short and long term agricultural irrigation (115 mg/L) at 4 sites: Helena Swan, Whiteman Rd, Helena Roe and Salty Pool.

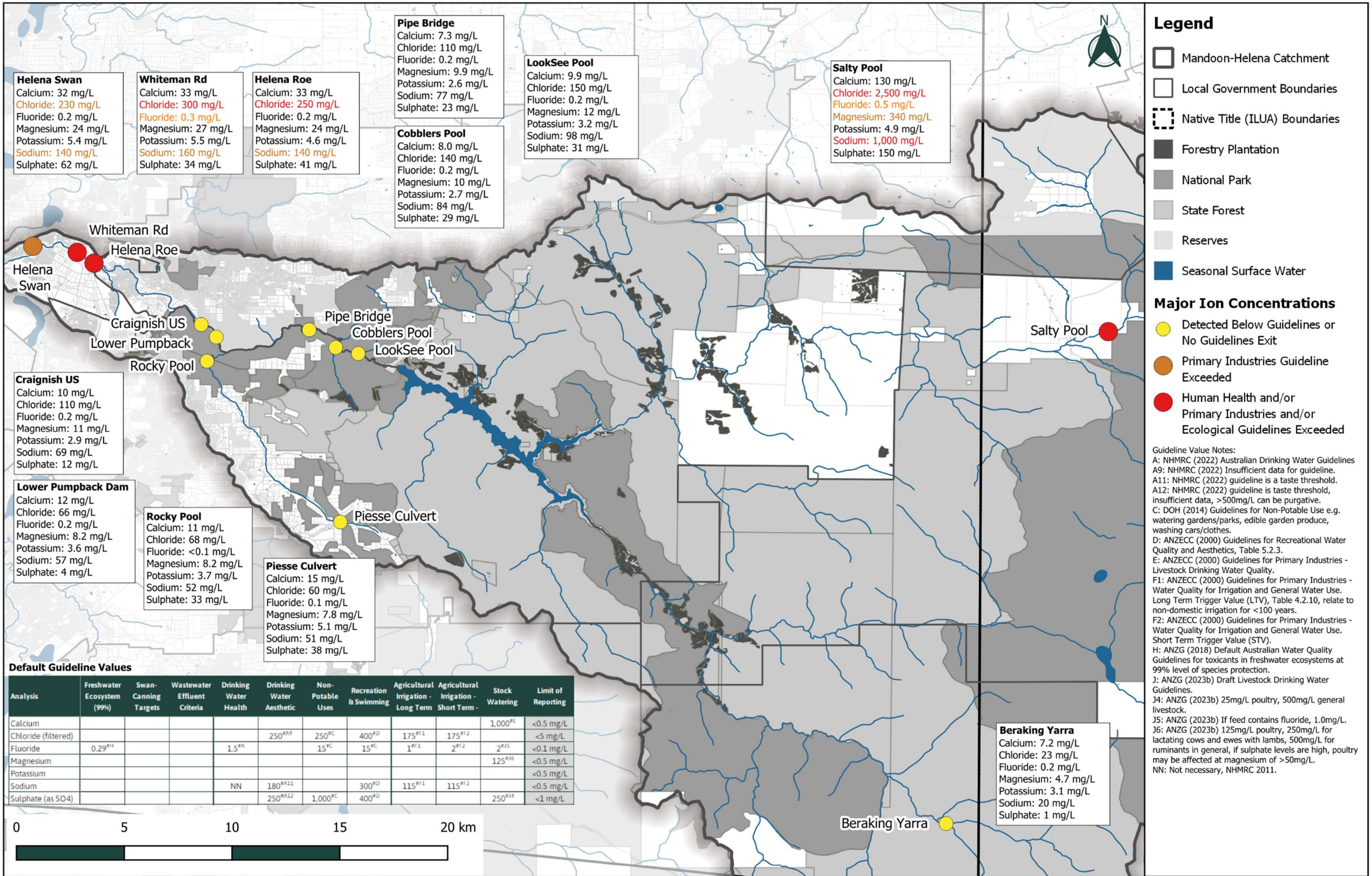
DGV do not exist for all major ions in water.

It is noted that these exceedances are all in relation to major ions that are naturally occurring in the catchment.

Sediment Samples

Major ions were analysed in all sediment samples (refer **Figure 6**).

DGV do not exist for major ions in sediment.



Default Guideline Values

Analysis	Freshwater Ecosystem (99%)	Swan-Canning Targets	Wastewater Effluent Criteria	Drinking Water Health	Drinking Water Aesthetic	Non-Potable Uses	Recreation & Swimming	Agricultural Irrigation - Long Term	Agricultural Irrigation - Short Term -	Stock Watering	Limit of Reporting
Calcium										1,000[#E]	<0.5 mg/L
Chloride (filtered)					250[#A9]	250[#C]	400[#D]	175[#F1]	175[#F2]		<5 mg/L
Fluoride	0.29[#H]			1.5[#A]		15[#C]	15[#C]	1[#F1]	2[#F2]	2[#J5]	<0.1 mg/L
Magnesium										125[#J6]	<0.5 mg/L
Potassium											<0.5 mg/L
Sodium				NN	180[#A11]		300[#D]	115[#F1]	115[#F2]		<0.5 mg/L
Sulphate (as SO4)					250[#A12]	1,000[#C]	400[#D]			250[#J4]	<1 mg/L

Guideline Value Notes:
A: NHMRC (2022) Australian Drinking Water Guidelines
A9: NHMRC (2022) Insufficient data for guideline.
A11: NHMRC (2022) guideline is a taste threshold.
A12: NHMRC (2022) guideline is taste threshold, insufficient data, >500mg/L can be purgative.
C: DOH (2014) Guidelines for Non-Potable Use e.g. watering gardens/parks, edible garden produce, washing cars/clothes.
D: ANZECC (2000) Guidelines for Recreational Water Quality and Aesthetics, Table 5.2.3.
E: ANZECC (2000) Guidelines for Primary Industries - Livestock Drinking Water Quality.
F1: ANZECC (2000) Guidelines for Primary Industries - Water Quality for Irrigation and General Water Use. Long Term Trigger Value (LTV), Table 4.2.10, relate to non-domestic irrigation for <100 years.
F2: ANZECC (2000) Guidelines for Primary Industries - Water Quality for Irrigation and General Water Use. Short Term Trigger Value (STV).
H: ANZG (2018) Default Australian Water Quality Guidelines for toxicants in freshwater ecosystems at 99% level of species protection.
J: ANZG (2023b) Draft Livestock Drinking Water Guidelines.
J4: ANZG (2023b) 25mg/L poultry, 500mg/L general livestock.
J5: ANZG (2023b) If feed contains fluoride, 1.0mg/L.
J6: ANZG (2023b) 125mg/L poultry, 250mg/L for lactating cows and ewes with lambs, 500mg/L for ruminants in general, if sulphate levels are high, poultry may be affected at magnesium of >50mg/L.
NN: Not necessary, NHMRC 2011.

Figure 7 Water Sampling Results: Major Ions

Bibbul Ngarma Aboriginal Association Incorporated
Prepared by: Francesca Flynn

BoorYul-Bah-Bilya (Mandoon Bilya - Helena River Catchment)
Baseline Surface Water and Sediment Sampling 2024, Conservation Audit

Data Sources: Landgate, Department of Water and Environmental Regulation, Shire of Mundaring, City of Kalamunda, City of Swan

Ref: BBB-MBHR-BWQS-007
Date: 21 March 2025

Nutrients

Nutrients in the form of nitrogen and phosphorus play a crucial role in river ecosystems. Phosphorous is a naturally occurring trace element found in rocks, soil and water. Nitrogen is the most abundant element in the Earth's atmosphere and its cycle is a natural process in all aquatic environments. Ammonia, nitrite, and nitrate are key components of the cycle: ammonia is the primary waste product of fish and other organisms, which is converted to nitrite and then nitrate by bacteria, enabling it to be used for plant growth. Elevated nutrients can cause eutrophication, where algal blooms deplete oxygen levels and harm aquatic life. Nutrient pollution in waterways is typically due to fertiliser use, agricultural/forestry runoff, and wastewater.

Water Samples

Nutrients in the form of nitrogen and phosphorus were detected in all water samples (refer **Figure 8**).

The river has elevated nutrients predominantly in the form of nitrogen. Nitrate and total oxidised nitrogen (NO_X-N) concentrations were at least one order of magnitude higher in Piesse Brook, a major tributary of Mandoon Bilya, than at any other location. Concentrations were highest at Piesse Culvert (6.9 mg/L), adjacent to various orchards in the townsite of Pickering Brook. Further downstream at Rocky Pool, where Piesse Brook flows through Kalamunda National Park, concentrations had reduced to 1.4 mg/L. Elevated nitrogen was also detected at Helena Swan (1.2 mg/L). Ammonia concentrations were an order of magnitude higher at Whiteman Rd and Helena Roe (0.12–0.13 mg/L) compared to other sites (0.02–0.05 mg/L).

Nitrogen and/or phosphorus exceedances of the DGV were reported at all sites except Lower Pumpback Dam. Eight samples exceeded the DGV for protection of freshwater ecosystems:

- Nitrate-N (0.02–6.9 mg/L) above the DGV (0.017 mg/L) at 8 sites: Helena Swan, Whiteman Rd, Helena Roe, Craignish, Rocky Pool, Cobblers Pool, LookSee Pool and Piesse Culvert.
- Total oxidised nitrogen (nitrate+nitrite as NOx-N) (0.18–6.9 mg/L) above the DGV (0.15 mg/L) at 4 sites: Helena Swan, Whiteman Rd, Rocky Pool and Piesse Culvert.
- Total nitrogen (1.2–6.9 mg/L) above the DGV (1.2 mg/L) at Helena Swan, Rocky Pool and Piesse Culvert. These concentrations also exceeded the long term Swan Canning water quality target (1.0 mg/L), although compliance is based on data from three years rather than single events.

Five samples exceeded the DGV for protection of human health:

- Ammonia as NH_3-N (0.02–0.13 mg/L) above the DGV for recreation (0.01 mg/L) at 5 sites: Helena Swan, Whiteman Rd, Helena Roe, Craignish and Salty Pool.

Six samples exceeded the DGV for protection of primary industries:

- Total nitrogen (6.9 mg/L) above the DGV for short term (2 mg/L) and long term agricultural irrigation (5 mg/L) at Piesse Culvert.
- Total phosphorous (0.06 mg/L) above the DGV for long term agricultural irrigation (0.05 mg/L) at 5 sites: Helena Swan, Pipe Bridge, Cobblers Pool, LookSee Pool and Beraking Yarra.

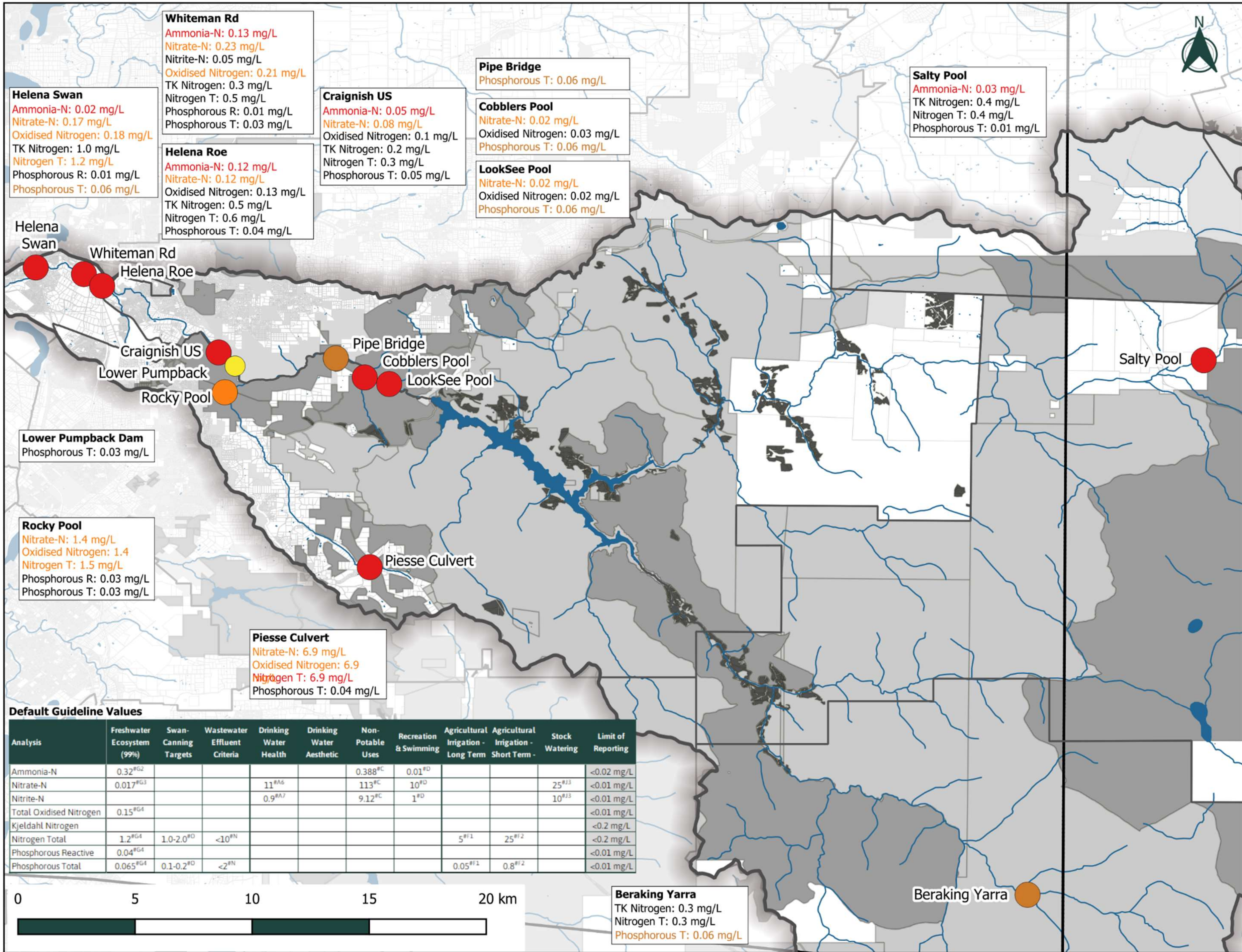
DGV do not exist for all detectable nutrient forms.

With the exception of significantly elevated nitrogen at Piesse Culvert (6.9 mg/L), nutrient concentrations were broadly similar to those reported in the '*Swan Canning Catchment Nutrient Report for the Helena River*'[2] for the period 2008–2018.

- Total nitrogen of 0.3–1.5 mg/L in 2024 compared to a median of 0.6–1.0 mg/L in 2008-2018.
- Total phosphorous of 0.01–0.06 mg/L in 2024 compared to a median of 0.01–0.02 mg/L in 2008-2018.

Sediment Samples

Nutrients were detected in all sediment samples (refer **Figure 9**). DGV do not exist for nutrients in sediment.



Legend

- Mandoon-Helena Catchment
- Local Government Boundaries
- Native Title (ILUA) Boundaries
- Forestry Plantation
- National Park
- State Forest
- Reserves
- Seasonal Surface Water

Nutrient Concentrations

- Not Detected
- Detected Below Guidelines or No Guidelines Exist
- Ecological Guideline Exceeded
- Primary Industries Guideline Exceeded
- Human Health and/or Primary Industries and/or Ecological Guidelines Exceeded

Detectable concentrations are presented for each sampling location.

Default Guideline Values

Analysis	Freshwater Ecosystem (99%)	Swan-Canning Targets	Wastewater Effluent Criteria	Drinking Water Health	Drinking Water Aesthetic	Non-Potable Uses	Recreation & Swimming	Agricultural Irrigation - Long Term	Agricultural Irrigation - Short Term -	Stock Watering	Limit of Reporting
Ammonia-N	0.32[#G2]					0.388[#C]	0.01[#D]				<0.02 mg/L
Nitrate-N	0.017[#G3]			11[#A6]		113[#C]	10[#D]			25[#J3]	<0.01 mg/L
Nitrite-N				0.9[#A7]		9.12[#C]	1[#D]			10[#J3]	<0.01 mg/L
Total Oxidised Nitrogen	0.15[#G4]										<0.01 mg/L
Kjeldahl Nitrogen											<0.2 mg/L
Nitrogen Total	1.2[#G4]	1.0-2.0[#O]	<10[#N]					5[#F1]	25[#F2]		<0.2 mg/L
Phosphorous Reactive	0.04[#G4]										<0.01 mg/L
Phosphorous Total	0.065[#G4]	0.1-0.2[#O]	<2[#N]					0.05[#F1]	0.8[#F2]		<0.01 mg/L

Guideline Value Notes:
A6: NHMRC (2022) Australian Drinking Water Guidelines, converted from guideline for nitrate (as nitrate), protects bottle-fed infants <3 months from methemoglobinemia; adults/children can safely drink up to 100mg/L.
A7: NHMRC (2022) Converted from guideline for nitrite (as nitrite), rapidly oxidised to nitrate (see above).
C: DOH (2014) Guidelines for Non-Potable Use e.g. watering gardens/parks, edible garden produce, washing cars/clothes.
D: ANZECC (2000) Guidelines for Recreational Water Quality and Aesthetics, Tables 5.2.3 and 5.2.4.
F1: ANZECC (2000) Primary Industries - Water Quality for Irrigation and General Water Use, Long Term Trigger Values, Table 4.2.10, for non-domestic irrigation of <100 years.
F2: ANZECC (2000) Short Term Trigger Values, Table 4.2.10.
G2: ANZECC (2000) Trigger Values for Freshwater Ecosystems for high ecological/conservation systems at 99% level of species protection, ammonia as total ammonia (NH3-N) at pH 8, drops to 2.18mg/L at pH 7, Vol 2 Table 8.3.7.
G3: ANZECC (2000), protects against toxicity, not eutrophication.
G4: ANZECC (2000) Default trigger values for lowland rivers and slightly disturbed ecosystems in south-west Australia, values reflect high site-specific and regional variability, refer Table 3.3.6 and 3.3.7
J3: ANZG (2023b) Nitrate: 25mg/L poultry, 100mg/L general livestock, 400mg/L cattle; nitrite: 10mg/L general livestock; tolerance lowest in poultry, medium in pigs, highest in cattle.
N: Common wastewater effluent criteria for on-site disposal for development approvals in Mandoon-Helena Catchment.
O: SRT (2001) Total nitrogen: 1mg/L long term, 2mg/L short term; total phosphorous: 0.1mg/L long term, 0.2mg/L short term, compliance based on 3 years data, adopted for screening.

Figure 8 Water Sampling Results: Nutrients

BoorYul-Bah-Bilya (Mandoon Bilya - Helena River Catchment)
Baseline Surface Water and Sediment Sampling 2024, Conservation Audit

Bibbul Ngarma Aboriginal Association Incorporated
Prepared by: Francesca Flynn

Data Sources: Landgate, Department of Water and Environmental Regulation, Shire of Mundaring, City of Kalamunda, City of Swan

Ref: BBB-MBHR-BWQS-008
Date: 21 March 2025

BOORYUL BAH BILYA
BIBBUL NGARMA ABORIGINAL ASSOCIATION INC.

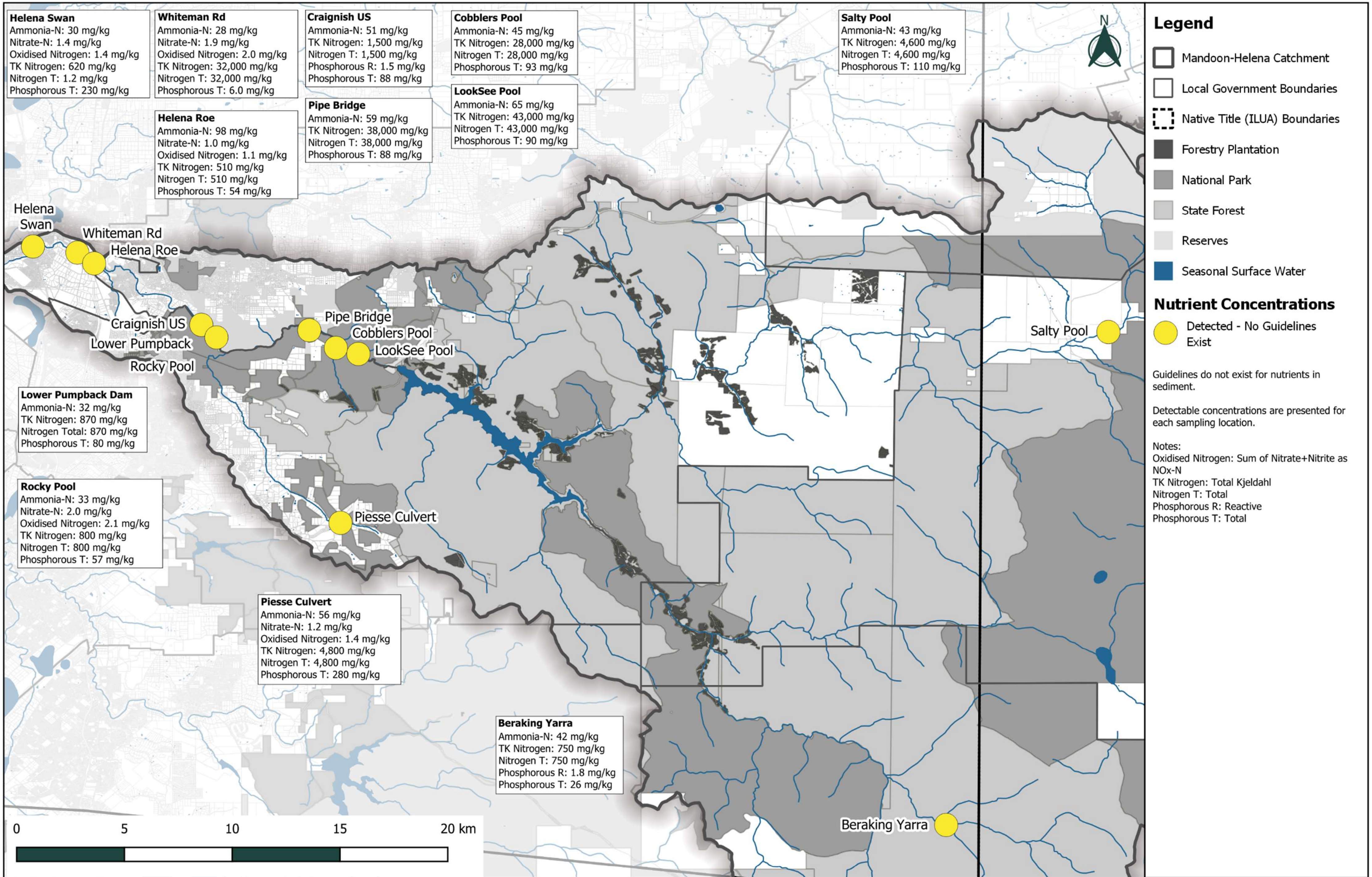


Figure 9 Sediment Sampling Results: Nutrients

Bibbul Ngarma Aboriginal Association Incorporated
Prepared by: Francesca Flynn

BoorYul-Bah-Bilya (Mandoon Bilya - Helena River Catchment)
Baseline Surface Water and Sediment Sampling 2024, Conservation Audit

Data Sources: Landgate, Department of Water and Environmental Regulation, Shire of Mundaring, City of Kalamunda, City of Swan

Ref: BBB-MBHR-BWQS-009
Date: 21 March 2025

BOORYUL BAH BILYA
BIBBUL NGARMA ABORIGINAL ASSOCIATION INC.

Metals and Other Inorganics

Metals are naturally present in rocks but can also enter the environment from a variety of anthropogenic (human) sources including road runoff, fossil fuel combustion, industrial activities and waste disposal.

Naturally occurring metals occur across the catchment including:

- Aluminium is the most abundant metal in the Earth's crust but has little known biological function.
- Iron and manganese play an important role in biogeochemical cycles that are vital for life including the water, carbon, nitrogen, phosphorus, and sulphur cycles.
- Barium is also a trace element that can accumulate in manganese oxides in soil.
- Boron, copper, nickel, selenium and zinc naturally occur in waterways through weathering of rocks and soils, and also through runoff from agricultural and urban areas. All are essential for plant growth, although high concentrations can be toxic to aquatic life and humans if present in drinking water.
- Lithium, titanium and vanadium can naturally occur in waterways through weathering of rocks and soils, and also through urban runoff, industrial activities and waste disposal.
- Uranium is a naturally occurring radioactive trace element found in rocks, soil, water and air. It can also enter the environment through industrial activities and waste disposal.

Metals that are more likely due to anthropogenic sources also occur in the catchment:

- Chromium is often associated with fossil fuel combustion and industrial activity such as chromium plating and brick making.
- Cobalt is often associated with industrial activity such as specialised alloys for strength and corrosion resistance in aircraft engines, turbines and heavy-duty cutting tools, and an additive in paint, glass and ceramics.
- Lead is most often associated with anthropogenic sources rather than natural sources from weathering of sulphide ores and galena. Lead typically enters waterways through precipitation, fall-out of lead dust, street runoff, industrial activities and wastewater discharges.
- Mercury in the environment is typically from human activity such as electrical power generation and industrial waste disposal. It is very toxic and can bioaccumulate in organic tissues, causing it to biomagnify higher up the food chain.

Cyanide is an common inorganic industrial chemical used in pesticides, nitrile and organic nitrile compounds, extraction of gold and silver from low grade ores, electroplating and metal production e.g. steel. Cyanide can also be found naturally in some plants, for example, the germination of kangaroo paw seeds is stimulated by cyanide released when the plants are burned[116].

Water Samples

The river's water contains elevated metals (refer **Figure 10**. These include naturally occurring metals like iron, manganese, aluminium and barium, as well as metals and inorganics that may be due to anthropogenic sources including boron, chromium, cobalt, copper, lead, titanium, uranium, vanadium, zinc and cyanide. For example, chromium, titanium and vanadium were only detected at Craignish, and uranium was only detected at sites downstream of the former Bellevue Hazardous Waste Facility.

All samples exceeded the DGV for protection of freshwater ecosystems:

- Aluminium (0.06–0.7 mg/L) above the DGV (0.027 mg/L) at all sites except Whiteman Rd, Lower Pumpback Dam and Salty Pool.
- Boron (0.09–0.13 mg/L) above the DGV (0.09 mg/L) at Whiteman Rd and Lower Pumpback Dam.
- Chromium (total) (0.002 mg/L) above the DGV (0.00001 mg/L) at Craignish, noting that the DGV for chromium VI has been conservatively applied to total chromium.

- Cobalt (0.001–0.002 mg/L) above the DGV (0.0014 mg/L) at Craignish and Beraking Yarra.
- Copper (0.001–0.003 mg/L) above the DGV (0.001 mg/L) at 4 sites: Helena Swan, Craignish, Piesse Culvert and Beraking Yarra.
- Cyanide (0.007 mg/L) above the DGV (0.004 mg/L) at Beraking Yarra.
- Iron (0.53–6.0 mg/L) above the DGV (0.3 mg/L) at all sites except Rocky Pool and Piesse Culvert.
- Lead (0.001 mg/L) above the DGV (0.001 mg/L) at Craignish and Beraking Yarra.
- Uranium (0.001–0.002 mg/L) above the DGV (0.0005 mg/L) at Helena Swan, Whiteman Rd and Helena Roe.
- Vanadium (0.007 mg/L) above the DGV (0.06 mg/L) at Craignish.
- Zinc (0.005–0.007 mg/L) above the DGV (0.0024 mg/L) at 6 sites: Helena Swan, Whiteman Rd, LookSee Pool, Piesse Culvert, Salty Pool and Beraking Yarra.

Ten samples exceeded the DGV for protection of human health, all in relation to naturally occurring metals:

- Aluminium (0.22–0.7 mg/L) above the DGV for drinking water aesthetics, non-potable use and recreation (0.2 mg/L) at Craignish, Cobblers Pool and LookSee Pool.
- Iron (0.53–6.0 mg/L) above the DGV for drinking water aesthetics, non-potable use and recreation (0.3 mg/L) at all sites except Rocky Pool and Piesse Culvert.
- Manganese (0.12–0.46 mg/L) above the DGV for drinking water aesthetics and recreation (0.1 mg/L) at 7 sites: Helena Swan, Whiteman Rd, Helena Roe, Craignish, Lower Pumpback Dam, Salty Pool and Beraking Yarra.

Ten samples exceeded the DGV for protection of primary industries, all in relation to naturally occurring metals:

- Iron (0.53–6.0 mg/L) above the DGV for long term agricultural irrigation (0.2 mg/L) at all sites except Rocky Pool and Piesse Culvert.
- Manganese (0.22–0.46 mg/L) above the DGV for long term agricultural irrigation (0.2 mg/L) at Lower Pumpback Dam, Salty Pool and Beraking Yarra.

Soils in the catchment are naturally high in some metals e.g. aluminium, iron and manganese. The current assessment undertook analysis for total metals in water, rather than dissolved metals. It is noted that the highest iron concentrations correspond with the highest turbidity levels, likely meaning the elevated iron concentrations are mostly indicative of the iron content of suspended sediment and not dissolved iron that is bioavailable to aquatic animals. For future sampling events, it is recommended that analysis of dissolved metals be undertaken rather than totals metals, including field filtration to remove suspended sediment, which will enable assessment of the bioavailability of detected metals.

DGV do not exist for all detectable metals in water.

Concentrations of naturally occurring metals such as aluminium and iron were broadly similar to those reported in the 2014 '*Helping the Helena*' study[3] however there were some general differences e.g. lead was not previously detected in water, and arsenic was previously detected at low concentrations (<0.001 mg/L). Some metals were not analysed in 2014 (e.g. barium, boron, cyanide, manganese vanadium and uranium).

Sediment Samples

The river's sediment contains elevated metals (refer **Figure 11**). These include naturally occurring metals like iron, manganese, aluminium and barium, as well as metals and inorganics that may be due to anthropogenic sources including chromium, cobalt, copper, lead, titanium, uranium, vanadium, zinc. Some heavy metals were reported in sediment only including arsenic at Whiteman Rd, cadmium at Whiteman Rd and Piesse Culvert, and mercury at several sites. Some metals and inorganics that were present in water were not detected in sediment at the same site, including boron and cyanide. Two samples exceeded the DGV for protection of sediment quality:

- Copper (86 mg/kg) above the DGV (65 mg/kg) at Piesse Culvert.
- Mercury (0.23 mg/kg) above the DGV (0.15 mg/kg) at Whiteman Rd.

Copper is a naturally occurring trace element although this elevated concentration may be due to an anthropogenic source e.g. copper-based pesticides which are common in agricultural land use.

Mercury concentrations at Whiteman Rd (0.23 mg/kg) were an order of magnitude higher compared to other sites (0.03–0.07 mg/kg).Elevated mercury at this location could be due to historical contamination from the former Bellevue Hazardous Waste Facility and Midland Railway Workshops which are upstream of the site.

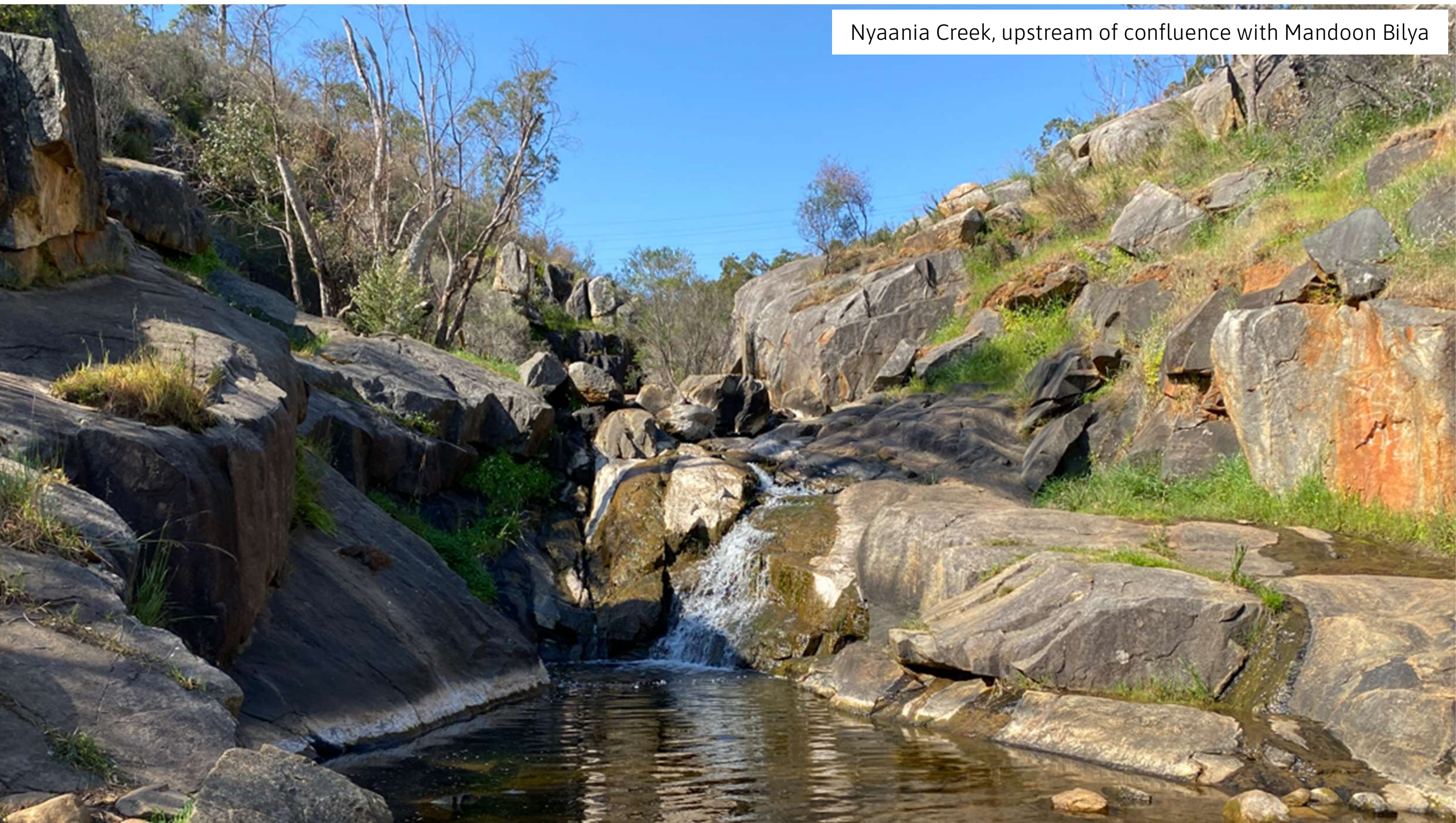
Zinc (190 mg/kg) was close to the DGV (200 mg/kg) at Pipe Bridge, where the water supply pipeline crosses the river. The pipeline often has a scour valve at river crossings to empty sections for maintenance. Water pipelines are typically galvanized, or coated with a layer of zinc, to prevent rusting. This coating can degrade over time, releasing zinc into the environment. It is possible that elevated zinc at this site is linked to the pipeline.

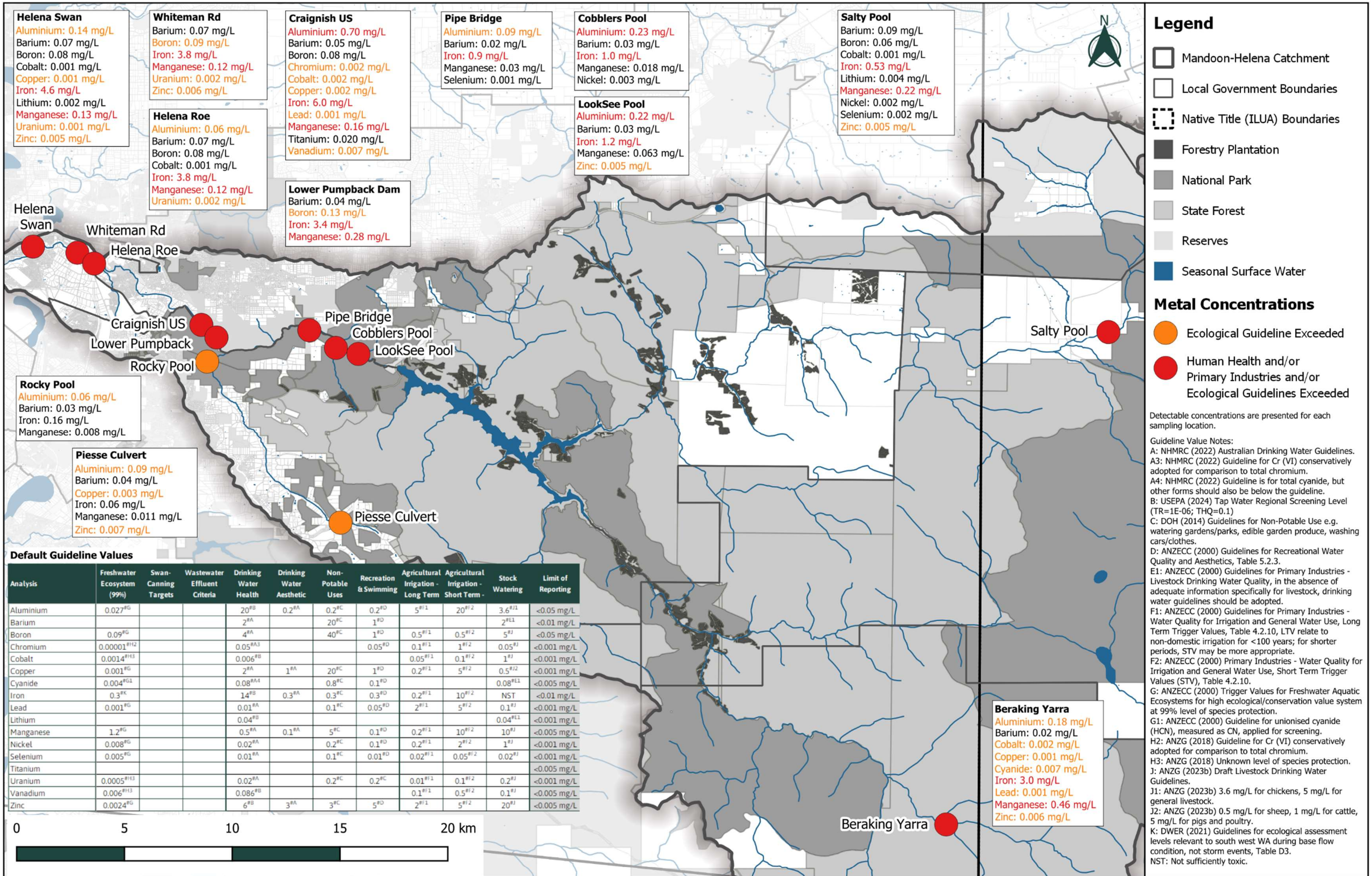
Lead (46 mg/kg) was close to the DGV (50 mg/kg) at Piesse Culvert.

DGV do not exist for all detectable metals in sediment.

It is noted that the use of sediment DGV is limited as detectable concentrations must first partition into porewater before impacts to the aquatic environment or beneficial users of water may be posed. For future sampling events, it is recommended that leachable analysis be undertaken on sediment as this provides a better metric for risk assessment compared to total sediment concentrations (mg/kg). Leachable analysis from sediment provides a porewater surrogate, and can be directly compared with DGV for water.

Concentrations of metals in sediment were similar to those reported in the 2014 '*Helping the Helena*' study[3] including naturally occurring metals like iron and aluminium, mercury at concentrations of up to 0.2 mg/kg and lead at concentrations of up to 40 mg/kg. However there were also some differences e.g. arsenic was detected in sediment at concentrations of up to 2.5 mg/kg at five locations in 2014. Some metals were not analysed in 2014 (e.g. barium, boron, cyanide, manganese vanadium and uranium).


Nyaania Creek, upstream of confluence with Mandoon Bilya



Default Guideline Values

Analysis	Freshwater Ecosystem (99%)	Swan-Canning Targets	Wastewater Effluent Criteria	Drinking Water Health	Drinking Water Aesthetic	Non-Potable Uses	Recreation & Swimming	Agricultural Irrigation - Long Term	Agricultural Irrigation - Short Term -	Stock Watering	Limit of Reporting
Aluminium	0.027[#G]			20[#B]	0.2[#A]	0.2[#C]	0.2[#D]	5[#F1]	20[#F2]	3.6[#J1]	<0.05 mg/L
Barium				2[#A]		20[#C]	1[#D]			2[#E1]	<0.01 mg/L
Boron	0.09[#G]			4[#A]		40[#C]	1[#D]	0.5[#F1]	0.5[#F2]	5[#J]	<0.05 mg/L
Chromium	0.00001[#H2]			0.05[#A3]			0.05[#D]	0.1[#F1]	1[#F2]	0.05[#J]	<0.001 mg/L
Cobalt	0.0014[#H3]			0.006[#B]				0.05[#F1]	0.1[#F2]	1[#J]	<0.001 mg/L
Copper	0.001[#G]			2[#A]	1[#A]	20[#C]	1[#D]	0.2[#F1]	5[#F2]	0.5[#J2]	<0.001 mg/L
Cyanide	0.004[#G1]			0.08[#A4]		0.8[#C]	0.1[#D]			0.08[#E1]	<0.005 mg/L
Iron	0.3[#K]			14[#B]	0.3[#A]	0.3[#C]	0.3[#D]	0.2[#F1]	10[#F2]	NST	<0.01 mg/L
Lead	0.001[#G]			0.01[#A]		0.1[#C]	0.05[#D]	2[#F1]	5[#F2]	0.1[#J]	<0.001 mg/L
Lithium				0.04[#B]						0.04[#E1]	<0.001 mg/L
Manganese	1.2[#G]			0.5[#A]	0.1[#A]	5[#C]	0.1[#D]	0.2[#F1]	10[#F2]	10[#J]	<0.005 mg/L
Nickel	0.008[#G]			0.02[#A]		0.2[#C]	0.1[#D]	0.2[#F1]	2[#F2]	1[#J]	<0.001 mg/L
Selenium	0.005[#G]			0.01[#A]		0.1[#C]	0.01[#D]	0.02[#F1]	0.05[#F2]	0.02[#J]	<0.001 mg/L
Titanium											<0.005 mg/L
Uranium	0.0005[#H3]			0.02[#A]		0.2[#C]	0.2[#C]	0.01[#F1]	0.1[#F2]	0.2[#J]	<0.001 mg/L
Vanadium	0.006[#H3]			0.086[#B]				0.1[#F1]	0.5[#F2]	0.1[#J]	<0.005 mg/L
Zinc	0.0024[#G]			6[#B]	3[#A]	3[#C]	5[#D]	2[#F1]	5[#F2]	20[#J]	<0.005 mg/L

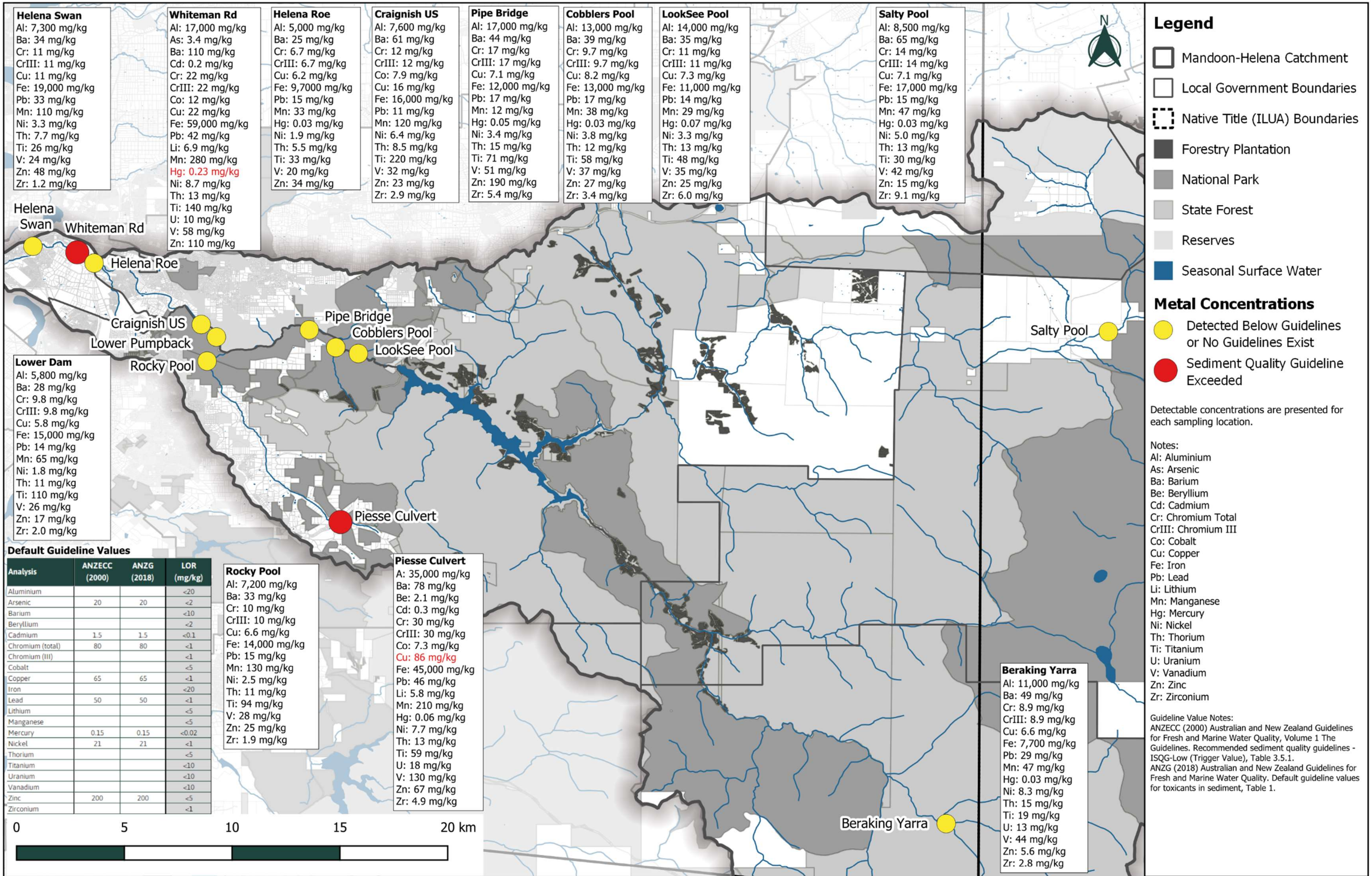
Figure 10 Water Sampling Results: Metals and Other Inorganics

Bibbul Ngarma Aboriginal Association Incorporated
Prepared by: Francesca Flynn

BoorYul-Bah-Bilya (Mandoon Bilya - Helena River Catchment) Baseline Surface Water and Sediment Sampling 2024, Conservation Audit

Data Sources: Landgate, Department of Water and Environmental Regulation, Shire of Mundaring, City of Kalamunda, City of Swan

Ref: BBB-MBHR-BWQS-010
Date: 21 March 2025



Default Guideline Values

Analysis	ANZECC (2000)	ANZG (2018)	LOR (mg/kg)
Aluminium			<20
Arsenic	20	20	<2
Barium			<10
Beryllium			<2
Cadmium	1.5	1.5	<0.1
Chromium (total)	80	80	<1
Chromium (III)			<1
Cobalt			<5
Copper	65	65	<1
Iron			<20
Lead	50	50	<1
Lithium			<5
Manganese			<5
Mercury	0.15	0.15	<0.02
Nickel	21	21	<1
Thorium			<5
Titanium			<10
Uranium			<10
Vanadium			<10
Zinc	200	200	<5
Zirconium			<1

Figure 11 Sediment Sampling Results: Metals and Other Inorganics

Bibbul Ngarma Aboriginal Association Incorporated
Prepared by: Francesca Flynn

**BoorYul-Bah-Bilya (Mandoon Bilya - Helena River Catchment)
Baseline Surface Water and Sediment Sampling 2024, Conservation Audit**

Data Sources: Landgate, Department of Water and Environmental Regulation, Shire of Mundaring, City of Kalamunda, City of Swan

Ref: BBB-MBHR-BWQS-011
Date: 21 March 2025

BOORYUL BAH BILYA
BIBBUL NGARMA ABORIGINAL ASSOCIATION INC.

Microbes

Rivers contain a diverse and essential community of microbes, including bacteria, algae, fungi, protozoa, and viruses. These microbes play crucial roles in river ecosystems, including nutrient cycling, decomposition of organic matter, and influencing water quality. Some microbes are beneficial, while others can be harmful and pose potential health risks.

E. coli and *Enterococci* are bacteria from the intestinal tract of warm-blooded animals including humans, livestock and wildlife. They are associated with faecal contamination and enter waterways from many sources including wastewater discharge, stormwater, urban/agricultural runoff and animal scat.

Thermophilic Amoeba are unicellular organisms that live in warm water. Their presence indicates that conditions are favourable for the growth of *Naegleria fowleri*, a type of amoeba that can cause a potentially fatal brain infection.

Water Samples

The river contains elevated microbes in the form of faecal bacteria and amoeba. *E. coli* and *Enterococci* were detected at all sites and *Thermophilic Amoeba* were detected at three sites: Pipe Bridge, Salty Pool and Beraking Yarra (refer **Figure 12**). *Thermophilic Naegleria* species and *Naegleria fowleri* were not detected at any site.

All samples exceeded the DGV for protection of human health, as follows:

- *E. coli* and *Enterococci* detections above the DGV for drinking water (detect versus non-detect) at all sites.
- *Thermophilic Amoeba* detections above the DGV for drinking water (detect versus non-detect) at Pipe Bridge, Salty Pool and Beraking Yarra.
- *E. coli* (12–240 CFU/100ml) above the DGV for non-potable use and recreation (1 CFU/100ml) at all sites.
- *Enterococci* (63–160 CFU/100ml) above the DGV for recreation (60 CFU/100ml) at 6 sites: Helena Swan, Helena Roe, Craignish, Lower Pumpback Dam, Piesse Culvert and Salty Pool. Whilst not an exceedance, *Enterococci* (59 CFU/100ml) at Rocky Pool is also noted given the site's popularity with swimmers.

All samples exceeded the DGV for protection of primary industries, as follows:

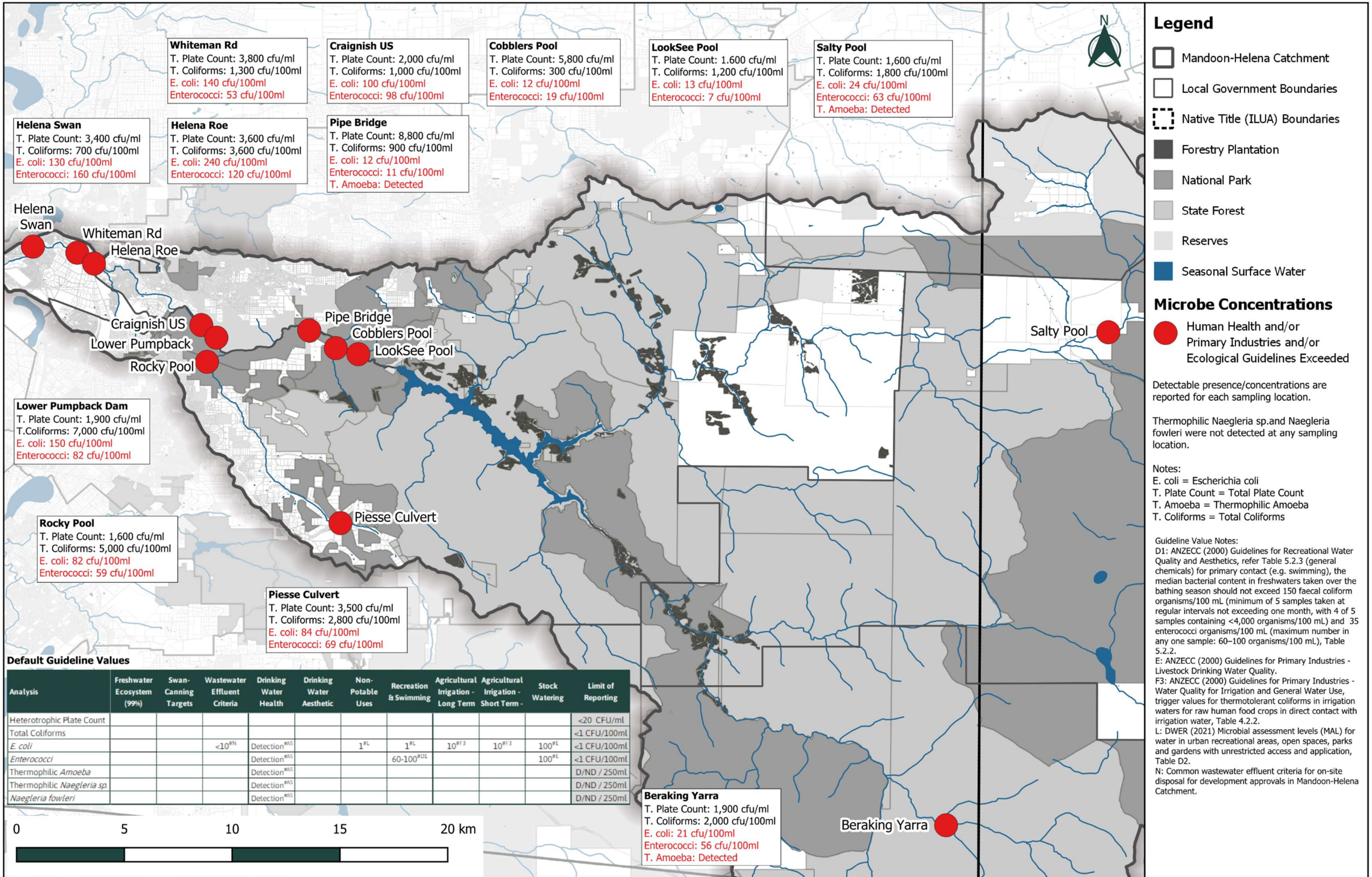
- *E. coli* (12–240 CFU/100ml) above the DGV for short and long term agricultural irrigation (10 CFU/100ml) at all sites, and the DGV for stock watering (100 CFU/100ml) at 5 sites: Helena Swan, Whiteman Rd, Helena Roe, Craignish and Lower Pumpback Dam.
- *Enterococci* (120–160 CFU/100ml) above the DGV for stock watering (100 CFU/100ml) at Helena Swan and Helena Roe.

DGV do not exist for microbes in freshwater ecosystems.

E. coli (12–240 CFU/100ml) exceeded the effluent criteria for on-site wastewater treatment systems (10 CFU/100ml) at all sites.

Sediment Samples

Microbial analysis was not undertaken on sediment samples.



Default Guideline Values

Analysis	Freshwater Ecosystem (99%)	Swan-Canning Targets	Wastewater Effluent Criteria	Drinking Water Health	Drinking Water Aesthetic	Non-Potable Uses	Recreation & Swimming	Agricultural Irrigation - Long Term	Agricultural Irrigation - Short Term -	Stock Watering	Limit of Reporting
Heterotrophic Plate Count											<20 CFU/ml
Total Coliforms											<1 CFU/100ml
E. coli			<10[#N]	Detection[#AS]		1[#L]	1[#L]	10[#F3]	10[#F3]	100[#E]	<1 CFU/100ml
Enterococci				Detection[#AS]			60-100[#D1]			100[#E]	<1 CFU/100ml
Thermophilic *Amoeba*				Detection[#AS]							D/ND / 250ml
Thermophilic *Naegleria sp.*				Detection[#AS]							D/ND / 250ml
Naegleria fowleri				Detection[#AS]							D/ND / 250ml

Figure 12 Water Sampling Results: Microbes

BoorYul-Bah-Bilya (Mandoon Bilya - Helena River Catchment) Baseline Surface Water and Sediment Sampling 2024, Conservation Audit

Bibbul Ngarma Aboriginal Association Incorporated
Prepared by: Francesca Flynn

Data Sources: Landgate, Department of Water and Environmental Regulation, Shire of Mundaring, City of Kalamunda, City of Swan

Ref: BBB-MBHR-BWQS-012
Date: 21 March 2025

Herbicides and Pesticides

Herbicides and pesticides can contaminate waterways through various pathways, including runoff from agricultural land, industrial wastewater discharge, and direct application for weed and pest control. These chemicals can be toxic to aquatic animals and cause harm to aquatic ecosystems as well as posing potential risks to human health. Many pesticides are persistent and can accumulate in the tissue of aquatic organisms, potentially leading to higher concentrations in larger predators and ultimately potential impact on humans from consumption. Long term exposure to low levels of pesticides in water may be associated with various health issues, including hormonal disruption and reproductive problems.

Water Samples

Pesticides were detected in water at one site: Piesse Culvert (refer **Figure 13**). Piesse Culvert is located in the townsite of Pickering Brook and immediately adjacent to various orchards where pesticide use is likely to occur.

Dieldrin was detected at Piesse Culvert at a concentration (0.003 ug/L) that is below the DGV for protection of drinking water (0.3 ug/L) and freshwater ecosystems (0.01 ug/L). Dieldrin is a synthetic chemical that was used as an insecticide for agriculture and termite control until it was banned in Australia in 1994. It is a chlorinated organochlorine compound that is highly persistent in the environment and can be carcinogenic.

Pesticides in the form of Bifenthrin, DDE and DDT were not detected in any water sample, despite their detection in sediment samples from two locations.

Dieldrin was previously reported in the river at concentrations of up to 0.005 ug/L during the 2007 passive sampling study [1]. Other pesticides previously reported in the river at low concentrations (0.0002–0.121 ug/L) include Chlordane trans, Chlorpyrifos, Diazinon, Heptachlor epoxide, Methidathion, Metolachlor, Oxadiazon, Phosphate Tri-n-Butyl, Piperonyl butoxide, Propiconazole, Terbutryn and Trifluralin[1].

Herbicides were not detected at any site although it is noted that some previous sampling in the Mandoon catchment required passive sampling techniques to detect herbicides at low concentrations[1]. Herbicides previously reported in the river at concentrations of between 0.0003–0.3 ug/L include Ametryn, Atrazine, Dimethyl tetrachloroterephthalate/DCPA, Desisopropyl atrazine, Diuron, Glyphosate, Hexazinone, Simazine, Tebuthiuron and 2,4-dichlorophenoxyacetic acid/2-4-D[1,3].

Sediment Samples

Pesticides were detected in sediment at two sites: Piesse Culvert and Whiteman Rd (refer **Figure 14**). Whiteman Rd is located in the lower catchment downstream of residential, commercial and industrial land use.

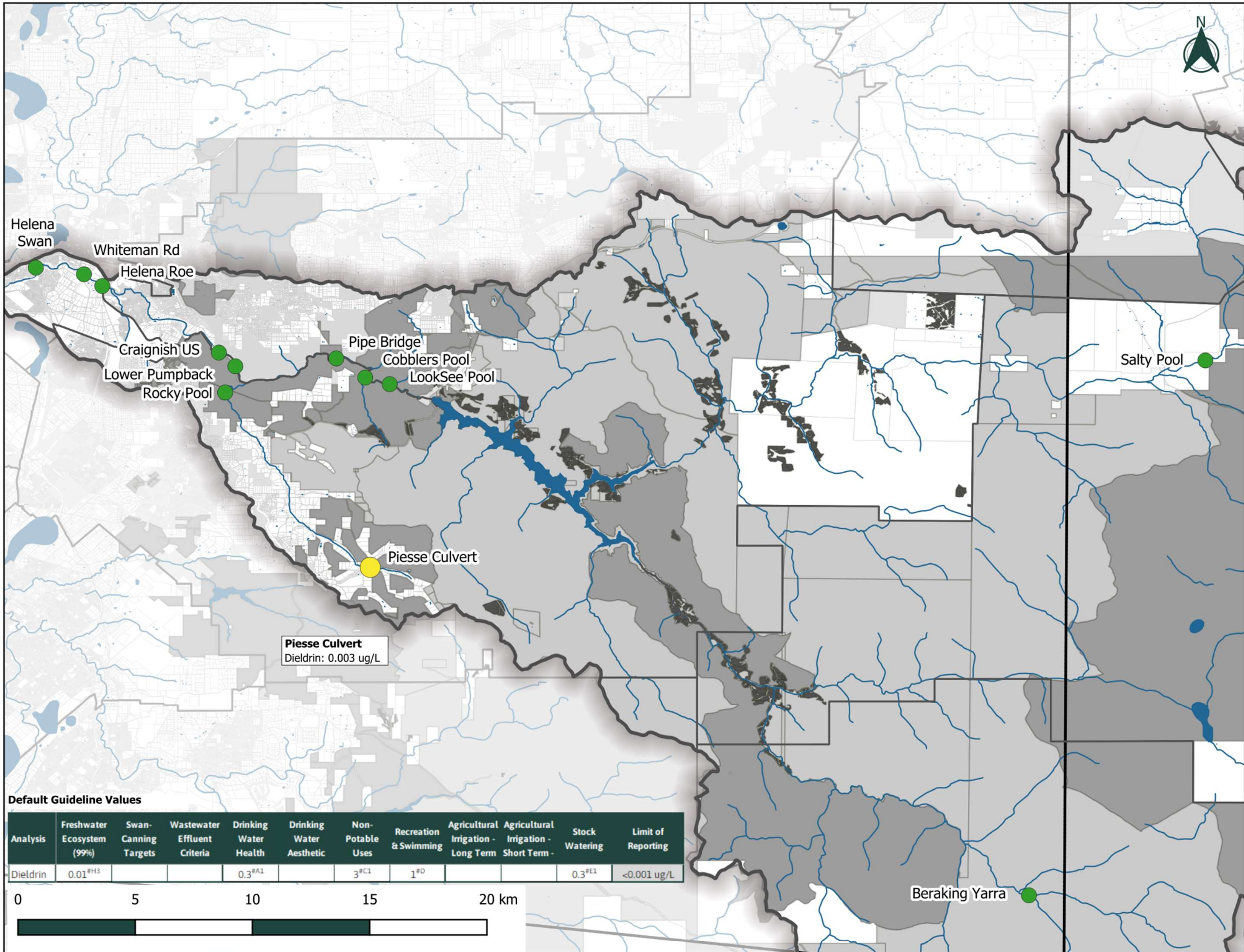
Dichlorodiphenyldichloroethylene/DDE (0.05 mg/kg) and Dichlorodiphenyltrichloroethane/DDT (0.03 mg/kg) were detected at Piesse Culvert at concentrations above the DGV for sediment quality (0.0022 mg/kg and 0.0016 mg/kg respectively). DDT is a toxic, synthetic chemical that was once widely used as a pesticide until it was banned in Australia in 1987. It is a toxic and highly persistent pollutant that can bioaccumulate in animals, humans and the environment. DDE is a breakdown product of DDT.

Bifenthrin also was detected in sediment at Whiteman Rd (0.7 mg/kg), although no DGV exists to enable comparison. Bifenthrin is a pesticide used in Australia to control insects like termites, borers, aphids, mites, spiders, ants, fleas and mosquitoes.

Dieldrin was not detected in sediment at Piesse Culvert, despite its detection in water at the site.

It is noted that sediments with high organic content will tend to bind organochlorine pesticides. Total organic carbon in the sediment at Piesse Culvert was 43 mg/kg, the highest reported compared to other sites (0.4–23 mg/kg).

Herbicides were not detected in any sediment sample.



Default Guideline Values

Analysis	Freshwater Ecosystem (99%)	Swan-Canning Targets	Wastewater Effluent Criteria	Drinking Water Health	Drinking Water Aesthetic	Non-Potable Uses	Recreation & Swimming	Agricultural Irrigation - Long Term	Agricultural Irrigation - Short Term -	Stock Watering	Limit of Reporting
Dieldrin	0.01[#H3]			0.3[#A1]		3[#C1]	1[#D]			0.3[#E1]	<0.001 ug/L

Legend

- Mandoon-Helena Catchment
- Local Government Boundaries
- Native Title (ILUA) Boundaries
- Forestry Plantation
- National Park
- State Forest
- Reserves
- Seasonal Surface Water

Pesticide Concentrations

- Not Detected
- Detected Below Guidelines or No Guidelines Exist

Detectable concentrations are presented for each sampling location.

Herbicides were not detected in any water sample although it is noted that previous sampling in the Mandoon catchment required passive sampling techniques to detect herbicides at low concentrations (Foulsham et al, 2009).

Guideline Value Notes:
A1: NHMRC (2022) Australian Drinking Water Guidelines, guideline is for aldrin + dieldrin.
C1: DOH (2014) Guidelines for Non-Potable Use (NPUG) e.g. watering gardens/parks, edible garden produce, and washing cars/clothes. Guideline is for aldrin + dieldrin.
D: ANZECC (2000) Guidelines for Recreational Water Quality and Aesthetics, refer Table 5.2.3 (general chemicals) and Table 5.2.4 (pesticides).
E1: ANZECC (2000) Guidelines for Primary Industries - Livestock Drinking Water Quality, in the absence of adequate information derived specifically for livestock under Australian and New Zealand conditions, it is recommended that the drinking water guidelines for human health be adopted.
H3: ANZG (2018) Default Australian Water Quality Guidelines (AWQG) for Toxicants in Freshwater Ecosystems at unknown level of species protection (LOSP).

Figure 13 Water Sampling Results: Herbicides and Pesticides

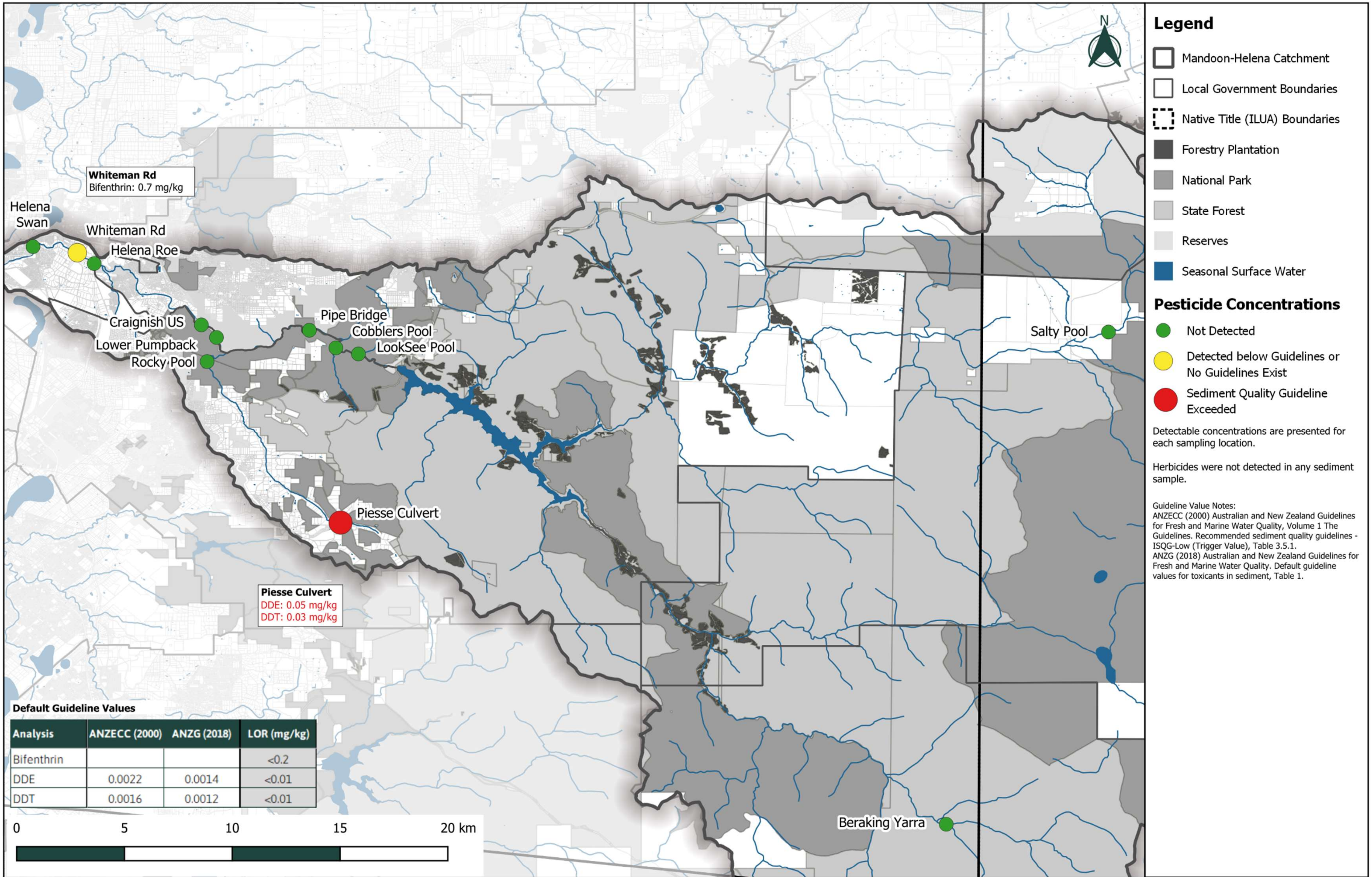
BoorYul-Bah-Bilya (Mandoon Bilya - Helena River Catchment) Baseline Surface Water and Sediment Sampling 2024, Conservation Audit

Bibbul Ngarma Aboriginal Association Incorporated
Prepared by: Francesca Flynn

Data Sources: Landgate, Department of Water and Environmental Regulation, Shire of Mundaring, City of Kalamunda, City of Swan

Ref: BBB-MBHR-BWQS-013
Date: 21 March 2025

BOORYUL BAH BILYA
BIBBUL NGARMA ABORIGINAL ASSOCIATION INC.



Default Guideline Values

Analysis	ANZECC (2000)	ANZG (2018)	LOR (mg/kg)
Bifenthrin			<0.2
DDE	0.0022	0.0014	<0.01
DDT	0.0016	0.0012	<0.01

Figure 14 Sediment Sampling Results: Herbicides and Pesticides

BoorYul-Bah-Bilya (Mandoon Bilya - Helena River Catchment) Baseline Surface Water and Sediment Sampling 2024, Conservation Audit

Bibbul Ngarma Aboriginal Association Incorporated
Prepared by: Francesca Flynn

Data Sources: Landgate, Department of Water and Environmental Regulation, Shire of Mundaring, City of Kalamunda, City of Swan

Ref: BBB-MBHR-BWQS-014
Date: 21 March 2025

Hydrocarbons

Total recoverable hydrocarbons (TRH) is a measure of all organic compounds made up of hydrogen and carbon atoms in various combinations. Hydrocarbons can be naturally occurring, for example, those formed during decomposition of organic matter and microbial activity. They can also enter the environment through human activity including petroleum hydrocarbons such as fossil fuel, and non-petroleum hydrocarbons such as fatty acids and cholesterols from sewage.

TRH results represent a mixture of compounds that are quantified against aliphatic hydrocarbon standards in different carbon (C) number ranges. Semi-volatile TRH cover carbon range >C10-C40. Volatile TRH cover carbon range C6-C10 and include BTEX (benzene, toluene, ethylbenzene and xylene) and naphthalene.

Polycyclic aromatic hydrocarbons (PAHs) are a class of organic compounds that are found in coal, oil, and gas, and are produced by incomplete burning of fuels and other organic material. They are known for their persistence in the environment and potential health effects. There are over 100 different types of PAH although studies typically prioritise 16 significant PAH. These include naphthalene, which is toxic to aquatic life and typically enters waterways after forest fires and from roads and urban/agricultural runoff.

Water Samples

Total recoverable hydrocarbons (TRH) were detected in water at one site: Cobblers Pool (refer **Figure 15**). TRH C6-C9 (0.02 mg/L) and TRH C6-C10 (0.03 mg/L) were detected at concentrations below the DGV for protection of drinking water and stock watering (0.09 mg/L). Cobblers Pool is a large permanent pool on Mandoon Bilya located at the confluence with Gunjin Gully (downstream of Mundaring Weir).

BTEX and PAH were not detected in any water sample.

These findings are somewhat similar to those reported in the 2014 '*Helping the Helena*' study[3] which did not detect petroleum hydrocarbons in water and only detected trace concentrations of naphthalene at two sites (<0.001 mg/L).

Sediment Samples

The river's sediment contains elevated hydrocarbons although it is unknown if they are naturally occurring or due to human activity. TRH were detected in sediment at all sites except Helena Swan and Piesse Culvert, and naphthalene was detected at two sites: Whiteman Rd and Helena Roe (refer **Figure 16**).

Detectable TRH were mostly semi-volatile compounds in the C10-C40 range, with the highest concentrations reported in the middle and upper catchment, including Pipe Bridge (1,310 mg/kg), Salty Pool (990 mg/kg), LookSee Pool (910 mg/kg) and Cobblers Pool (880 mg/kg). Elevated TRH C10-C40 concentrations in sediment were also reported at Whiteman Rd (335 mg/kg). Volatile TRH in the C6-C10 range were only detected in sediment at two sites: Helena Roe and Whiteman Rd (25 – 33 mg/kg), located in the lower catchment.

Six samples exceeded the DGV for sediment quality:

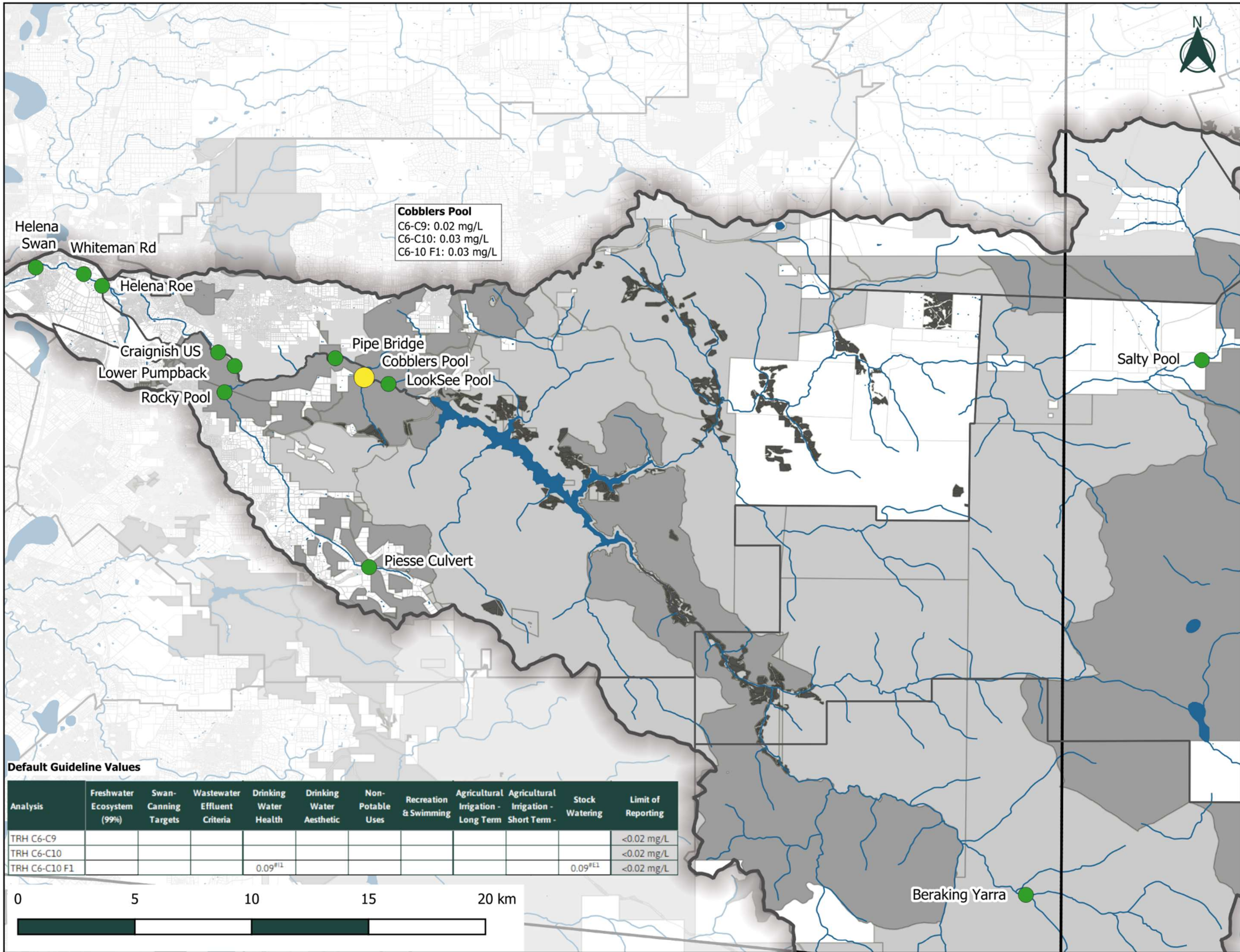
- TRH C10-C40 (335–1,310 mg/kg) above the DGV (280 mg/kg) at 5 sites: Whiteman Rd, Pipe Bridge, Cobblers Pool, LookSee Pool and Salty Pool.
- Naphthalene (0.7–0.8 mg/kg) above the DGV (0.16 mg/kg) at Whiteman Rd and Helena Roe.

DGV do not exist for other detectable hydrocarbon ranges.

BTEX and other PAH were not detected in any sediment sample.

TRH in sediment were similar to petroleum hydrocarbons concentrations reported in the 2014 '*Helping the Helena*' study[3]. However, total PAH (0.5-0.8 mg/kg) was significantly higher in 2014 (<34 mg/kg)[3].

Given that analysis was only undertaken for TRH, it is uncertain whether the detectable hydrocarbons are natural or derived from human activities. For future sampling events, it is recommended that silica gel clean-up analysis be undertaken on any detectable hydrocarbons to assess if they are petroleum based.



Default Guideline Values

Analysis	Freshwater Ecosystem (99%)	Swan-Canning Targets	Wastewater Effluent Criteria	Drinking Water Health	Drinking Water Aesthetic	Non-Potable Uses	Recreation & Swimming	Agricultural Irrigation - Long Term	Agricultural Irrigation - Short Term -	Stock Watering	Limit of Reporting
TRH C6-C9											<0.02 mg/L
TRH C6-C10											<0.02 mg/L
TRH C6-C10 F1				$0.09^{\#I1}$						$0.09^{\#E1}$	<0.02 mg/L

Legend

- Mandoon-Helena Catchment
- Local Government Boundaries
- Native Title (ILUA) Boundaries
- Forestry Plantation
- National Park
- State Forest
- Reserves
- Seasonal Surface Water

Hydrocarbon Concentrations

- Not Detected
- Detected below Guidelines or No Guidelines Exist

Detectable concentrations are presented for each sampling location.

Notes:
TRH C6-C10 F1: TRH C6-C10 less BTEX
TRH C10-C16 F2: TRH C0-C16 less napthalene

BTEX (benzene, toluene, ethylbenzene and xylene) and PAH (polycyclic arpomatic hydrocarbons) compunds were not detected at any sampling location.

Guideline Value Notes:
E1: ANZECC (2000) Guidelines for Primary Industries - Livestock Drinking Water Quality, in the absence of adequate information derived specifically for livestock under Australian and New Zealand conditions, it is recommended that the drinking water guidelines for human health be adopted.
G: ANZECC (2000) Trigger Values for Freshwater Aquatic Ecosystems for high ecological/conservation value system at 99% level of species protection (LOSP).
I1: WHO (2008) Petroleum Products in Drinking Water, lowest derived guideline for aliphatic and aromatic fractions in this range.
I2: WHO (2008) Lowest derived guideline for aliphatic and aromatic fractions in this range rounded to 100 ug/L.

Figure 15 Water Sampling Results: Hydrocarbons

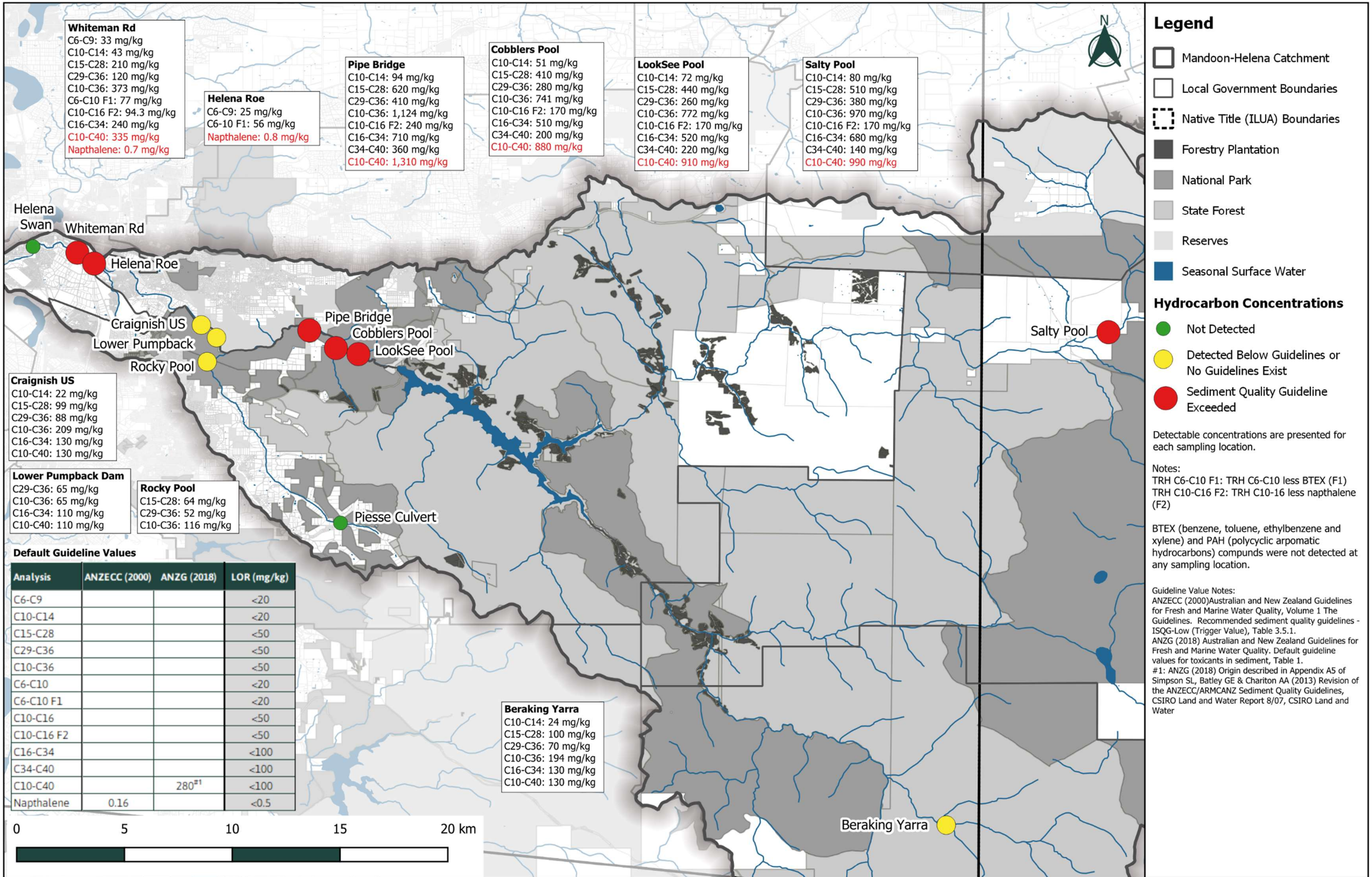
Bibbul Ngarma Aboriginal Association Incorporated
Prepared by: Francesca Flynn

BoorYul-Bah-Bilya (Mandoon Bilya - Helena River Catchment)
Baseline Surface Water and Sediment Sampling 2024, Conservation Audit

Data Sources: Landgate, Department of Water and Environmental Regulation, Shire of Mundaring, City of Kalamunda, City of Swan

Ref: BBB-MBHR-BWQS-015
Date: 21 March 2025

BOORYUL BAH BILYA
BIBBUL NGARMA ABORIGINAL ASSOCIATION INC.



Default Guideline Values

Analysis	ANZECC (2000)	ANZG (2018)	LOR (mg/kg)
C6-C9			<20
C10-C14			<20
C15-C28			<50
C29-C36			<50
C10-C36			<50
C6-C10			<20
C6-C10 F1			<20
C10-C16			<50
C10-C16 F2			<50
C16-C34			<100
C34-C40			<100
C10-C40		280#1	<100
Napthalene	0.16		<0.5

Figure 16 Sediment Sampling Results: Hydrocarbons

BoorYul-Bah-Bilya (Mandoon Bilya - Helena River Catchment) Baseline Surface Water and Sediment Sampling 2024, Conservation Audit

Bibbul Ngarma Aboriginal Association Incorporated
Prepared by: Francesca Flynn

Data Sources: Landgate, Department of Water and Environmental Regulation, Shire of Mundaring, City of Kalamunda, City of Swan

Ref: BBB-MBHR-BWQS-016
Date: 21 March 2025

Per- and Polyfluoroalkyl Substances

Per- and polyfluoroalkyl substances (PFAS), also known as 'forever chemicals', are considered to be toxic and highly persistent synthetic chemicals that can bioaccumulate in animals, humans and the environment. They have been used extensively to make products that are resistant to stains, grease, soil, and water including firefighting foams, protective coatings, hydraulic fuels and food/beverage containers.

PFAS production methods and subsequent transformation processes can create complex mixtures of many different intentionally produced and unintentionally generated compounds. The most widely studied are PFOS (perfluorooctanesulfonic acid), PFOA (perfluorooctanoic acid) and PFHxS (perfluorohexanesulfonic acid), and their precursors[97]. The Australian Government has banned the import, use and manufacture of some of the more prominent types of PFAS (including PFOS, PFOA and PFHxS) from 1 July 2025.

PFAS are not easily broken down and can persist for a long time. Their widespread use and persistence means that many types of PFAS may be present, mostly at low levels, in our environment. PFAS also bioaccumulate in living organisms, meaning that PFAS in the body can increase with repeated exposure over time.

Water Samples

PFAS compounds were detected in water at all sites except Helena Swan (refer **Figure 17**). The absence of PFAS at Helena Swan is surprising given that is the furthest downstream location to the Derbarl Yerrigan (Swan River) and considering the previous detections of PFAS throughout the Swan Canning catchment[4].

PFAS concentrations were highest at Helena Roe followed by Whiteman Road. Helena Roe reported detections of all 11 PFAS compounds that were analysed (0.001–0.048 ug/L), whilst Whiteman Rd reported 10 PFAS compounds (0.001–0.041 ug/L). Helena Roe is located immediately adjacent to the former Bellevue Hazardous Waste Facility site, where PFAS compounds were possibly stored and/or lost to the environment during the 2001 hazardous waste fire. Whiteman Road is located 1 km downstream from Helena Roe.

The most commonly detected PFAS compound was PFOS (0.0001–0.048 ug/L), which was reported at all sites except Helena Swan. It is noted that the laboratory limit of detection for PFOS is an order of magnitude lower than the other PFAS compounds, enabling detection at lower concentrations.

Other detections included:

- PFHxS (0.002–0.024 ug/L) at 4 sites: Whiteman Rd, Helena Roe, Lower Pumpback Dam and Rocky Pool.
- PFOA (0.011–0.013 ug/L) at 2 sites: Whiteman Rd and Helena Roe.
- Perfluorobutanoic acid (PFBA) (0.009–0.017 ug/L) at 4 sites: Whiteman Rd, Helena Roe, Salty Pool and Breaking Yarra.

Ten samples exceeded the DGV for protection of freshwater ecosystems:

- PFOS (0.0003–0.048 ug/L) above the DGV (0.00023 ug/L) at all sites except Beraking Yarra and Helena Swan.

One sample exceeded the DGV for protection of human health:

- PFHxS+PFOS (0.072 ug/L) above the DGV for drinking water and non-potable use (0.07 ug/L) at Helena Roe. It is noted that these DGV do not consider fish, crustaceans or other animals caught and consumed from recreational waters.

One sample exceeded the DGV for protection of primary industries:

- PFHxS+PFOS (0.072 ug/L) above the DGV for stock watering (0.07 ug/L) at Helena Roe.

DGV do not exist for all PFAS chemicals.

Potential risks to human health may also exist due to possibly elevated PFAS in aquatic organisms. DGV are not protective of a pathway of PFAS accumulation in fish/shellfish, and subsequent human consumption (e.g.

by recreational fishers or Noongar people sourcing traditional foods). In Western Australia, fishing is banned in drinking water supply catchments, including the majority of Mandoon catchment. However, anecdotal evidence indicates that some community members may consume crustaceans and fish from the river, indicating a potential risk. There are currently no DGV that are protective of these pathways, and further assessment is warranted wherever PFAS is present and fishing may occur.

Given the widespread prevalence of PFAS compounds and their detection in previous studies of the Swan Canning catchment, their presence in the river was expected. PFAS concentrations were similar to those reported in the 2022 DBCA study of the Swan-Canning catchment which took place between December 2016 and June 2018[4]:

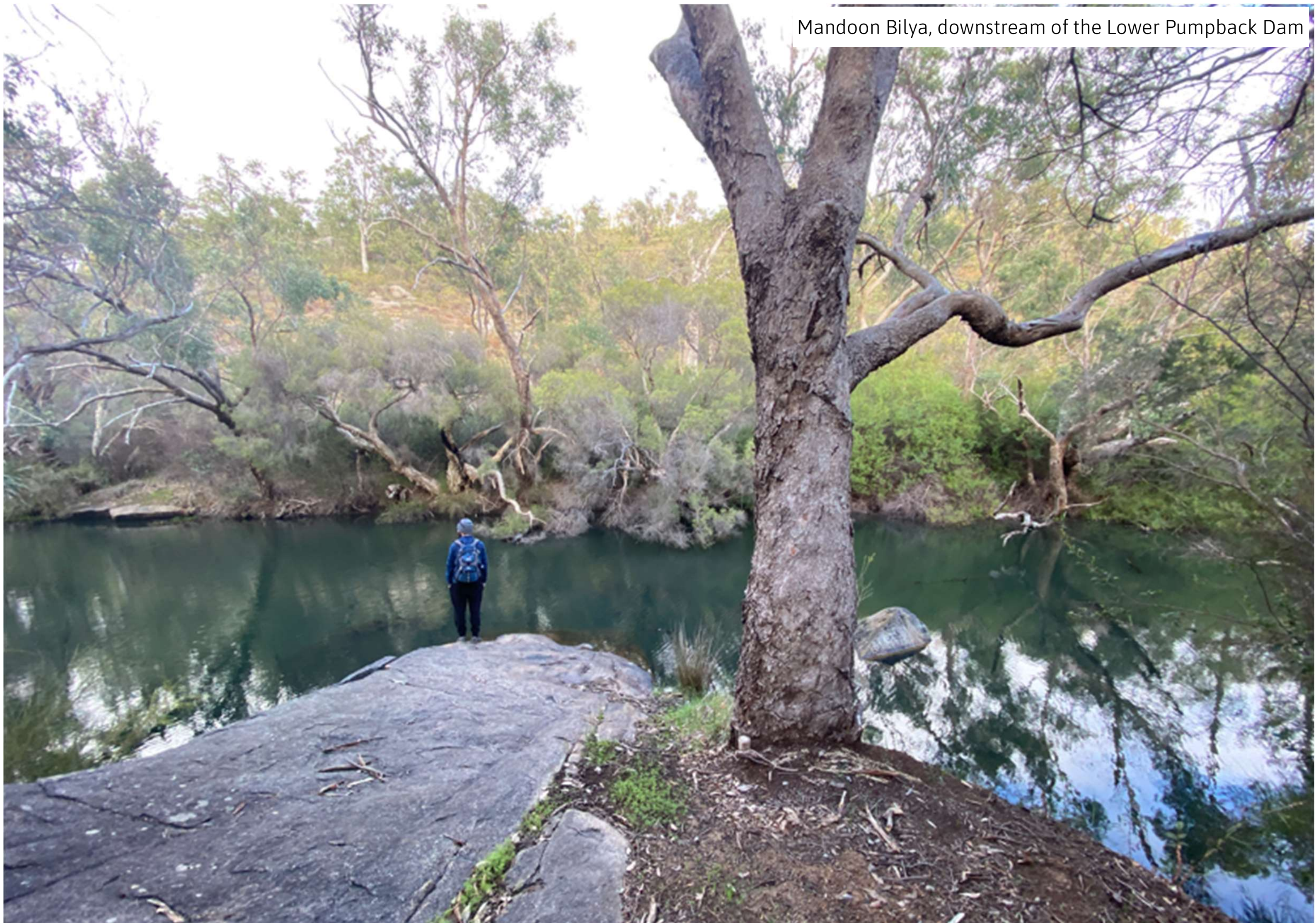
- PFOS concentrations of 0.0001–0.048 ug/L in 2024 compared to 0.0041–0.120 ug/L in 2016-2018.
- PFHxS concentrations of 0.002-0.024 ug/L in 2024 compared to 0.0022–0.0510 ug/L in 2016-2018.

BNAA will report these findings to the Department of Health and DWER so they can consider notifying any users of water abstractions in the area and undertaking more PFAS sampling in the short term to verify these results.

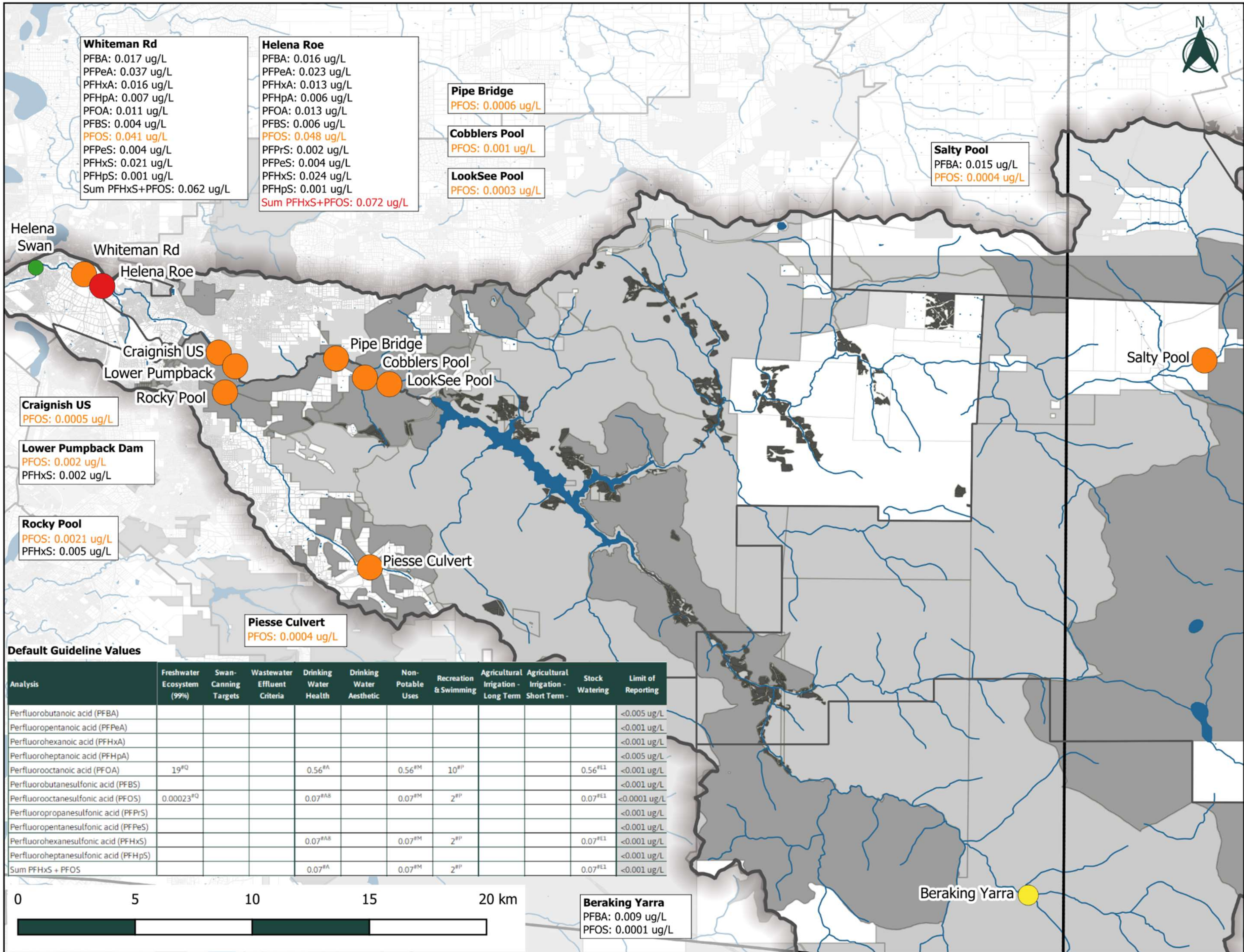
Sediment Samples

PFAS compounds were not detected in sediment, however it is noted that the detection limit in sediment (<5 ug/kg) is several orders of magnitude higher than that in water (<0.0001–0.005 ug/L) meaning that PFAS could be present at lower concentrations that cannot be detected by this laboratory method.

For future sampling events, it is recommended that leachable PFAS analysis be undertaken on sediment. This will not only enable PFAS detection at lower limits of reporting, but will also provide a better metric for risk assessment compared to total sediment concentrations (mg/kg).



Mandoon Bilya, downstream of the Lower Pumpback Dam



Default Guideline Values

Analysis	Freshwater Ecosystem (99%)	Swan-Canning Targets	Wastewater Effluent Criteria	Drinking Water Health	Drinking Water Aesthetic	Non-Potable Uses	Recreation & Swimming	Agricultural Irrigation - Long Term	Agricultural Irrigation - Short Term -	Stock Watering	Limit of Reporting
Perfluorobutanoic acid (PFBA)											<0.005 ug/L
Perfluoropentanoic acid (PFPeA)											<0.001 ug/L
Perfluorohexanoic acid (PFHxA)											<0.001 ug/L
Perfluoroheptanoic acid (PFHpA)											<0.005 ug/L
Perfluorooctanoic acid (PFOA)	19#Q			0.56#A		0.56#M	10#P			0.56#E1	<0.001 ug/L
Perfluorobutanesulfonic acid (PFBS)											<0.001 ug/L
Perfluorooctanesulfonic acid (PFOS)	0.00023#Q			0.07#A8		0.07#M	2#P			0.07#E1	<0.0001 ug/L
Perfluoropropanesulfonic acid (PFPrS)											<0.001 ug/L
Perfluoropentanesulfonic acid (PFPeS)											<0.001 ug/L
Perfluorohexanesulfonic acid (PFHxS)				0.07#A8		0.07#M	2#P			0.07#E1	<0.001 ug/L
Perfluoroheptanesulfonic acid (PFHpS)											<0.001 ug/L
Sum PFHxS + PFOS				0.07#A		0.07#M	2#P			0.07#E1	<0.001 ug/L

Legend

- Mandoon-Helena Catchment
- Local Government Boundaries
- Native Title (ILUA) Boundaries
- Forestry Plantation
- National Park
- State Forest
- Reserves
- Seasonal Surface Water

PFAS Concentrations

- Not Detected
- Detected Below Guidelines or No Guidelines Exist
- Ecological Guideline Exceeded
- Human Health and/or Primary Industries and/or Ecological Guidelines Exceeded

Detectable concentrations are presented for each sampling location.

Guideline Value Notes:
A: NHMRC (2022) Australian Drinking Water Guidelines
A8: NHMRC (2022) guideline for PFOS+PFHxS applied to PFOS and PFHxS for screening.
E1: ANZECC (2000) Guidelines for Primary Industries - Livestock Drinking Water Quality, in the absence of adequate information specifically for livestock in Australia and New Zealand, it is recommended that drinking water guidelines be adopted.
M: DWER (2021) For PFAS, the drinking water guideline values are appropriate Tier 1 screening levels for non-potable uses such as watering gardens where consumption of home-grown produce is a viable/plausible exposure pathway.
P: NHMRC (2019) Guideline for PFOS+PFHxS applied to PFOS and PFHxS for screening, does not consider fish caught/consumed from recreational waters.
Q: HEPA (2025) PFAS National Environmental Management Plan (NEMP), Version 3.0, interim guideline for 99% level of species protection (LOSP) used for high conservation value systems, generally adopted for chemicals that bioaccumulate and biomagnify in wildlife. Interim guidelines do not account for bioaccumulation and biomagnification of toxicants in air-breathing animals or in animals which prey on aquatic organisms. The 99% LOSP for PFOS is close to the ultra-trace level of detection.

Figure 17 Water Sampling Results:Per- and Polyfluoroalkyl Substances (PFAS)

Bibbul Ngarma Aboriginal Association Incorporated
Prepared by: Francesca Flynn

BoorYul-Bah-Bilya (Mandoon Bilya - Helena River Catchment)
Baseline Surface Water and Sediment Sampling 2024, Conservation Audit

Data Sources: Landgate, Department of Water and Environmental Regulation, Shire of Mundaring, City of Kalamunda, City of Swan

Ref: BBB-MBHR-BWQS-017
Date: 21 March 2025

BOORYUL BAH BILYA
BIBBUL NGARMA ABORIGINAL ASSOCIATION INC.

Methylene Blue Active Substances

Methylene blue active substances (MBAS) are often used as a screening tool to assess the presence of anionic surfactants like detergents or foaming agents in water. Analysis for MBAS does not identify specific types of anionic surfactants, but it can be used as a tool to assess overall levels in a substance. Anionic surfactants are typically found in household wastewater and industrial runoff, and are often used to increase the effectiveness of active ingredients in herbicides and pesticides. Surfactants have varying toxicity in aquatic environments, although their presence can increase the mobility and bioavailability of other contaminants[3].

Water Samples

MBAS were detected at all sites except Lower Pumpback Dam and Rocky Pool (refer **Figure 18**).

MBAS concentrations can be strongly influenced by the presence of salts, particularly chloride ions. The highest MBAS concentration corresponded with the highest chloride concentration, reported at Salty Pool.

Ten samples exceeded the DGV for protection of human health:

- MBAS (0.2–1.4 mg/L) above the DGV for recreation (0.2 mg/L) at all sites except Lower Pumpback Dam and Rocky Pool.

DGV do not exist for MBAS for protection of drinking water, primary industries and freshwater ecosystems.

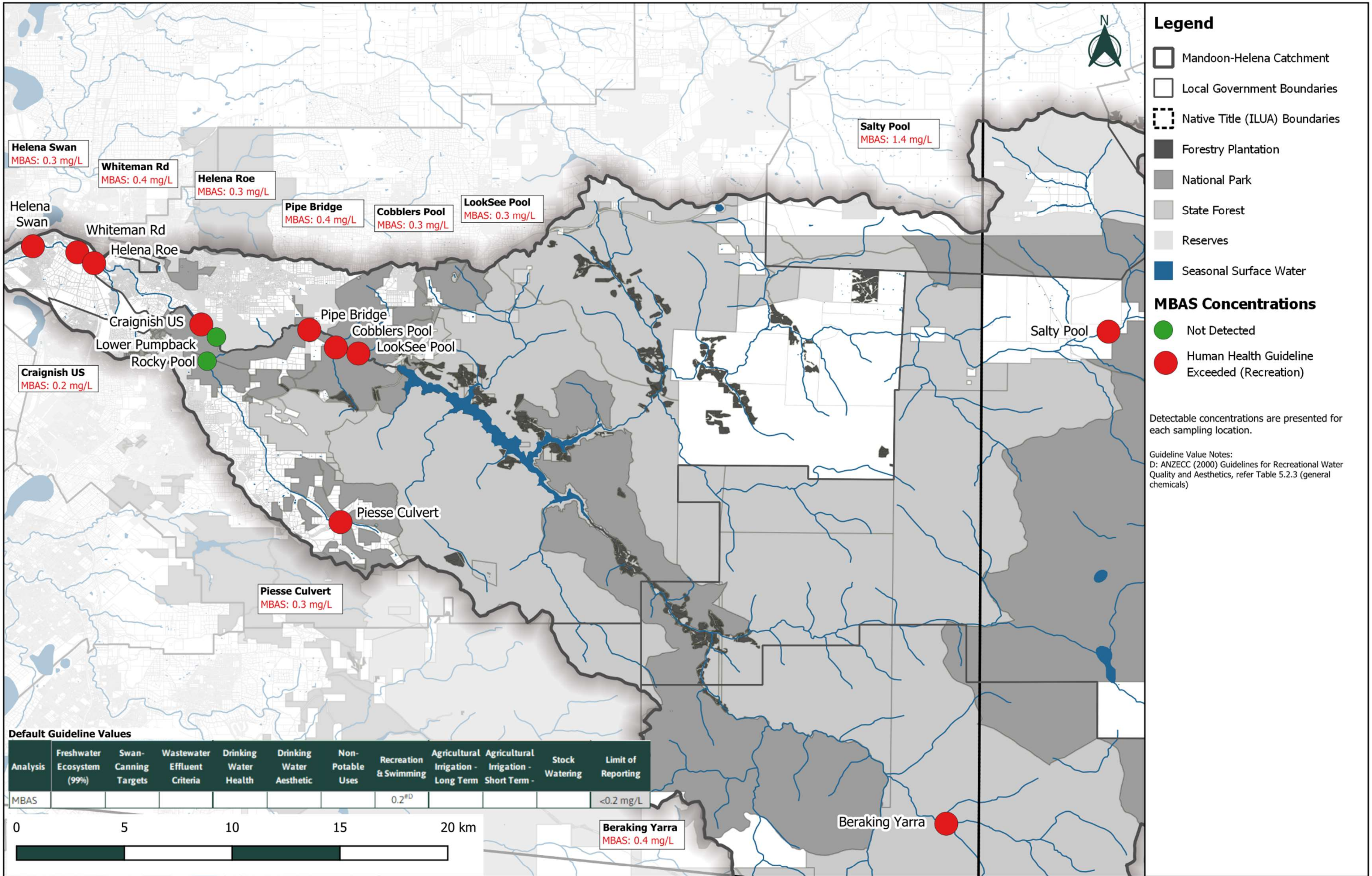
It is noted that soap bush (*Trymalium odoratissimum*) is prolific in the lower and middle catchment. When the leaves of soap bush are rubbed together with water, they produce a lather that is very similar to soap. It is unknown if the elevated MBAS concentrations are connected to the presence of soap bush.

MBAS concentrations were similar to those reported in the 2014 'Helping the Helena' study[3] (<0.85 mg/L).

Sediment Samples

MBAS were detected at Piesse Culvert (3.6 mg/kg) and Whiteman Rd (32 mg/kg) (refer **Figure 19**). DGV do not exist for MBAS in sediments.

Mandoon Bilya, downstream of Mundaring Weir



Default Guideline Values

Analysis	Freshwater Ecosystem (99%)	Swan-Canning Targets	Wastewater Effluent Criteria	Drinking Water Health	Drinking Water Aesthetic	Non-Potable Uses	Recreation & Swimming	Agricultural Irrigation - Long Term	Agricultural Irrigation - Short Term -	Stock Watering	Limit of Reporting
MBAS							0.2[#D]				<0.2 mg/L

Figure 18 Water Sampling Results: Methylene Blue Active Substances (MBAS) - Surfactants

BoorYul-Bah-Bilya (Mandoon Bilya - Helena River Catchment)
Baseline Surface Water and Sediment Sampling 2024, Conservation Audit

Bibbul Ngarma Aboriginal Association Incorporated
Prepared by: Francesca Flynn

Data Sources: Landgate, Department of Water and Environmental Regulation, Shire of Mundaring, City of Kalamunda, City of Swan

Ref: BBB-MBHR-BWQS-018
Date: 21 March 2025

BOORYUL BAH BILYA
BIBBUL NGARMA ABORIGINAL ASSOCIATION INC.

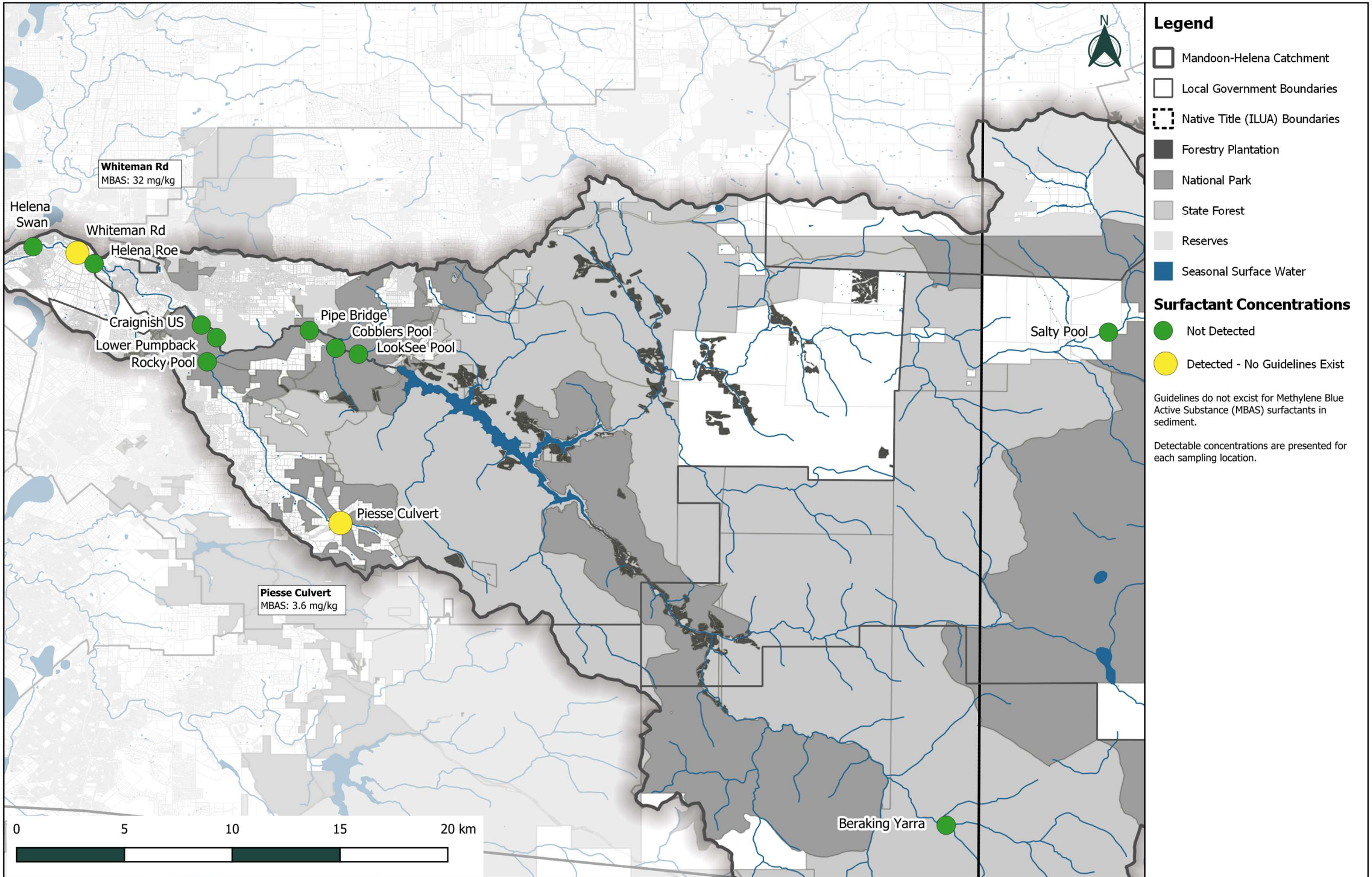


Figure 19 Sediment Sampling Results: Methylene Blue Active Substances (MBAS) - Surfactants

BoorYul-Bah-Bilya (Mandoon Bilya - Helena River Catchment) Baseline Surface Water and Sediment Sampling 2024, Conservation Audit

Bibbul Ngarma Aboriginal Association Incorporated
Prepared by: Francesca Flynn

Data Sources: Landgate, Department of Water and Environmental Regulation, Shire of Mundaring, City of Kalamunda, City of Swan

Ref: BBB-MBHR-BWQS-019
Date: 21 March 2025

BOORYUL BAH BILYA
BIBBUL NGARMA ABORIGINAL ASSOCIATION INC.

Volatile and Semi-Volatile Organic Compounds

Volatile and semi-volatile organic compounds, including polychlorinated biphenyls (PCB), were not detected in any water or sediment sample.

Quality Control

One duplicate water sample was collected from Piesse Culvert to check for replicability and errors in sampling and processing procedures. Due to budget constraints, the duplicate sample was analysed for TRH and BTEX only. Hydrocarbons were not detected in either the primary or duplicate sample meaning that relative percentage differences could not be calculated (refer **Table 5**). For future sampling events, it is recommended that duplicate analysis be undertaken on metals, rather than hydrocarbons, to ensure that relative percentage differences can be calculated.

Group	Analysis (mg/L)	Piesse Culvert (PC) Primary	Piesse Culvert (PC) Duplicate
Hydrocarbons	TRH C6-C9	<0.02	<0.02
	TRH C10-C14	<0.02	<0.02
	TRH C15-C28	<0.04	<0.04
	TRH C29-C36	<0.04	<0.04
	TRH C10-C36 (total)	<0.04	<0.04
	TRH C6-C10	<0.02	<0.02
	TRH C6-C10 (less BTEX) (F1)	<0.02	<0.02
	TRH >C10-C16	<0.02	<0.02
	TRH >C10-C16 (less naphthalene) (F2)	<0.02	<0.02
	TRH >C16-C34	<0.05	<0.05
	TRH >C34-C40	<0.05	<0.05
	TRH >C10-C40 (total)	<0.05	<0.05

Table 5 Primary and duplicate water sample analysis

The following quality control analysis was undertaken by the laboratory:

- Three laboratory duplicate samples
- Three laboratory method blank samples
- Three laboratory control samples reported as % recovery
- Three certified reference material samples reported as % recovery
- Three spiked samples reported as % recovery

All samples passed quality control acceptance limits.

The following sample integrity comments were provided by the laboratory:

- Attempt to chill samples was evident
- Samples were correctly preserved
- Appropriate sample containers were used
- Sample containers for volatile analysis were received with minimal headspace
- Samples were received within the required holding time

Discussion

Potential risks to the freshwater ecosystem may exist based on current DGV exceedances:

- Low dissolved oxygen at all sites except Rocky Pool, Pipe Bridge and Piesse Culvert.
- Elevated PFOS at all sites except Helena Swan and Beraking Yarra.
- Elevated nutrients (variably total nitrogen, oxidised nitrogen and/or nitrate) at 8 sites: Helena Swan, Whiteman Rd, Helena Roe, Craignish, Rocky Pool, Cobblers Pool, LookSee Pool and Piesse Culvert.
- Elevated metals and other inorganics (variably aluminium, boron, chromium, cobalt, copper, cyanide, iron, lead, uranium, vanadium and/or zinc), at all sites. Some of these metals are naturally elevated in the catchment, particularly aluminium and iron.
- Elevated conductivity at all sites except Beraking Yarra.
- Slightly acidic conditions at Craignish, Lower Pumpback Dam and Cobblers Pool.
- Elevated fluoride at Whiteman Rd and Salty Pool.
- Elevated turbidity at Craignish.

Potential risks to human health may exist based on current DGV exceedances:

- Elevated microbes in water used for drinking, non-potable use or recreation at all sites.
- Elevated PFHxS+PFOS in water used for drinking or non-potable use at Helena Roe. It is also noted that PFAS DGV do not consider consumption of fish or other animals caught in recreational waters.
- Slightly acidic conditions in water used for drinking, non-potable use or recreation at Craignish, Lower Pumpback Dam and Cobblers Pool.
- Poor quality drinking water aesthetics, variably due to elevated dissolved solids, hardness, turbidity, and/or naturally occurring metals (aluminium, iron and manganese) and major ions (chloride and sodium), at all sites except Rocky Pool and Piesse Culvert.
- Poor quality non-potable water, variably due to elevated suspended solids, turbidity and/or naturally occurring metals (aluminium and iron) and major ions (chloride), at all sites except Rocky Pool and Piesse Culvert.
- Poor quality recreational water, variably due to elevated surfactants, nutrients (ammonia), hardness, dissolved solids, and/or naturally occurring metals (aluminium, iron and manganese) and major ions (chloride and sodium), at all sites except Rocky Pool.

Potential risks to primary industries may exist based on current DGV exceedances:

- Elevated microbes in agricultural irrigation water at all sites, and stock water at 5 sites: Helena Swan, Whiteman Rd, Helena Roe, Craignish and Lower Pumpback Dam.
- PFHxS+PFOS in stock water at Helena Roe.
- Poor quality agricultural irrigation water due to elevated:
  - Iron at all sites except Rocky Pool and Piesse Culvert.
  - Nutrients (total nitrogen and/or phosphorous) at 6 sites: Helena Swan, Pipe Bridge, Cobblers Pool, LookSee Pool, Piesse Culvert and Beraking Yarra.
  - Chloride and sodium at 4 sites: Helena Swan, Whiteman Rd, Helena Roe and Salty Pool.
  - Manganese at Lower Pumpback Dam, Salty Pool and Beraking Yarra.
- Poor quality stock water due to elevated magnesium at Salty Pool, and dissolved solids at 4 sites: Helena Swan, Whiteman Rd, Helena Roe and Salty Pool.

In addition, potential risks may exist due to sediment quality, including elevated:

- Copper at Piesse Culvert and mercury at Whiteman Rd.

- DDE and DDT at Piesse Culvert.
- TRH C10-C40 at 5 sites: Whiteman Rd, Pipe Bridge, Cobblers Pool, LookSee Pool and Salty Pool.
- Naphthalene at Whiteman Rd and Helena Roe.

It is noted that the use of sediment DGV is limited as detectable concentrations must first partition into porewater before impacts to the aquatic environment or beneficial users of water may be posed. For future sampling events, it is recommended that leachable analysis be undertaken on sediment as this provides a better metric for risk assessment compared to total sediment concentrations (mg/kg).

DGV for sediment and some freshwater contaminants are limited. The absence of a DGV does not mean there is no potential risk, instead it means that a guideline is yet to be developed. As the BoorYul-Bah-Bilya program progresses, BNAA hope to develop catchment-specific guidelines for water and sediment quality that can be incorporated into an overarching plan with management targets to measure progress.

DGV exceedances do not automatically imply an impact to ecosystems or beneficial users. Instead, a DGV exceedance indicates that further investigation is required to determine if a risk exists. Determining impacts to ecosystems and beneficial users requires a detailed risk assessment, including consideration of exposure pathways to various receptors, ecotoxicology and catchment-specific conditions. Ideally, this should include potential exposure pathways that are specifically relevant to Noongar people, for example, direct contact with the river during water ceremonies.

Assessment of potential risks to freshwater ecosystems requires consideration of ecotoxicology and catchment-specific conditions. Ecotoxicology is the measure of the impact of substances in water, soils and sediment on organisms in an ecosystem. For example, many freshwater fish have a tolerance for salinity, so unless salinity is sufficiently high to cause sickness or mortality, an impact cannot be determined without ecotoxicity testing. Similarly, some metals are naturally elevated in the catchment, particularly aluminium and iron, meaning that aquatic organisms will be adapted to higher concentrations. As such, catchment-specific DGV would be more suitable to assess potential risks.

Based on current data findings, potential risks to freshwater ecosystems may exist due to elevated PFAS (PFOS), nutrients (nitrogen and nitrate), various metals and naturally occurring major ions (fluoride). Poor water quality may also present a potential risk due to low dissolved oxygen, elevated conductivity and turbidity, and slightly acidic conditions. Particular mention is made of the potential risks due to elevated PFOS at all sites except Helena Swan and Beraking Yarra, and elevated nutrients in Piesse Brook.

Assessment of potential risks to drinking water requires consideration of the likelihood of the water being used for drinking as well as any treatment prior to consumption, including via the Integrated Water Supply Scheme (IWSS). The IWSS is the water distribution network operated by Water Corporation that supplies Perth, the Goldfields and Agricultural Region, and parts of South West WA. A global infrastructure company, Acciona, operates the 165 ML/day water treatment plant at Mundaring Weir and supplies treated water to Water Corporation for distribution in the IWSS. Treatment includes filtration, disinfection and compliance with Australian drinking water guidelines, effectively removing the potential risk from microbes.

PFAS (PFHxS+PFOS) concentrations at Helena Roe were above the drinking water DGV, however this location is downstream of the two water supply dams, meaning that it is unlikely to be used for drinking.

Poor quality drinking water aesthetics were reported at most sites, variably due to elevated hardness, turbidity, dissolved solids and naturally occurring metals (aluminium, iron and manganese) and major ions (chloride and sodium). Whilst these do not pose a health risk, these properties will likely make the water undesirable to drink. (e.g. taste, odour, appearance). Slightly acidic conditions were also reported at Lower Pumpback Dam and Cobblers Pool, which flows into the dam.

Assessment of potential risks to non-potable users of the river's water also requires consideration of the likelihood of the water being used for different purposes, as well as the way people come into contact with the water. For example, several properties downstream of the Lower Pumpback Dam and along Piesse Brook abstract water from the river for growing produce, garden irrigation and other uses. Non-potable use DGV allow for filling swimming pools, although it is unknown if the river's water is used for this purpose. Review of DWER's Water Information Register (https://maps.water.wa.gov.au/#/webmap/register) does not identify any licensed surface water abstractions in those areas apart from Water Corporation, but private abstractions are known to exist following observation of pumps in the river channel and conversations with residents.

Based on current data findings, potential risks to non-potable users may exist due to elevated PFAS and microbes, as well as naturally occurring metals (aluminium and iron) and major ions (chloride).

Particular mention is made of the potential risks to any unlicensed non-potable water users in the vicinity of Helena Roe due to elevated PFAS (PFHxS+PFOS) concentrations. BNAA will report these findings to the Department of Health and DWER so they can consider notifying any users of water abstractions in the area and undertaking more PFAS sampling in the short term to verify these results.

Poor quality non-potable water was reported at most sites, variably due to elevated suspended solids, turbidity and/or slightly acidic conditions. Whilst less likely to cause an impact to human health, the water's properties may make it undesirable for non-potable use.

Assessment of potential risks to recreational users of the river also requires consideration of the likelihood of the water being used for different recreation types, as well as the way people come into contact with the water. For example, swimming (primary contact) is popular at Rocky Pool in Kalamunda National Park, but is more unlikely at other sites, particularly in the lower catchment at Helena Swan, Whiteman Rd, Helena Roe, Craignish and Lower Pumpback Dam. Kayaking (secondary contact) is possible at Helena Swan given its proximity to the Derbarl Yerrigan (Swan River), however kayaks cannot travel much further upstream than this due to obstructions and a lack of continuous flow.

Based on current data findings, potential risks to recreation users may exist due to elevated microbes, nutrients (ammonia) and surfactants, as well as naturally occurring metals (aluminium, iron and manganese) and major ions (chloride and sodium). Poor water quality may also present a potential risk due to elevated dissolved solids, hardness and slightly acidic conditions.

Particular mention is made of the potential risks to swimmers at Rocky Pool and other known swimming locations (e.g. Nyaania Pool) due to elevated *E. coli* and *Enterococci*. BNAA will report these findings to the DBCA so they can consider notifying swimmers in the area of the potential risk e.g. signage.

Potential risks to human health may also exist due to possibly elevated PFAS in aquatic organisms. DGV are not protective of a pathway of PFAS accumulation in fish/shellfish, and subsequent human consumption (e.g. by recreational fishers or Noongar people sourcing traditional foods). In Western Australia, fishing is banned in drinking water supply catchments, including the majority of Mandoon catchment. However, anecdotal evidence indicates that some community members may consume crustaceans and fish from the river, indicating a potential risk. There are currently no DGV that are protective of these pathways, and further assessment is warranted wherever PFAS is present and fishing may occur.

Assessment of potential risks to primary industries requires consideration of the likelihood of the water being used for agriculture and/or stock water, as well as the way in which it is used (e.g. frequency, volume, location etc). For example, Piesse Brook flows through orchards and wineries in Bickley Valley, Carmel and Pickering Brook and may be used to irrigate crops on some properties. Similarly, semi-rural properties downstream of the Lower Pumpback Dam that are used to graze livestock may use the river for stock watering.

Based on current data findings, potential risks to primary industries may exist due to elevated PFAS, microbes and nutrients (nitrogen and phosphorous), as well as naturally occurring metals (iron and manganese) and major ions (chloride, magnesium and sodium). Poor water quality may also present a potential risk due to elevated dissolved solids, hardness and slightly acidic conditions.

Particular mention is made of the potential risks due to elevated PFAS (PFHxS+PFOS) in the vicinity of Helena Roe. DGV do not currently exist for PFAS in irrigation or stock water, including uptake into crops and subsequent human consumption. Drinking water guidelines are a useful surrogate for comparison, however, additional assessment may be warranted where PFAS is identified in water used for primary industries.

Recommendations

BNAA recommends undertaking similar water and sediment quality sampling in September 2025 to enable comparison of results and build a multi-year baseline, including:

- Removal of analysis for volatile and semi-volatile organic compounds and polychlorinated biphenyls given they were not detected at any sampling location in 2024.
- Analysis of dissolved metals using field filtration to remove suspended sediment and assess bioavailability.
- Silica gel clean-up analysis on detectable hydrocarbons to assess if they are petroleum based.
- Leachable analysis of all sediment samples for PFAS to enable lower detection limits.
- Leachable analysis of any sediment samples that exceed DGV to assist assessment of potential risks.
- Duplicate analysis for metals to enable calculation of relative percentage differences.
- Invitation to Shire of York, Shire of Beverley, Water Corporation, DWER, DBCA and Eurofins-ARL to support future sampling in addition to the Shire of Mundaring, City of Kalamunda and City of Swan.
- Collection of water samples from Mundaring Weir and the Lower Pumpback Dam with Water Corporation permission, or inclusion of data collected by Water Corporation.

BNAA also recommends consideration of:

- Additional sampling locations:
  - Nyaania Creek Pool, a popular swimming location where BNAA is undertaking landcare works.
  - Between the Lower Pumpback Dam and Helena Swan, to assess the general decline in water quality in the lower catchment including potential point sources and entry points.
  - Between Piesse Culvert and the Lower Pumpback Dam, to assess nutrient concentrations entering the drinking water source.
- Additional sampling event in low flow conditions e.g. first heavy rains after summer, circa. April-June.
- Additional salinity testing in the upper catchment including during low-high flows and targeting both surface and bottom waters to assess the presence of possible stratifications.
- Passive sampling to assess the presence of herbicides and pesticides at low concentrations.
- Analysis of microplastics in water and sediment, noting that this is a specialist and costly analysis.
- Analysis of sucralose as an indicator of treated wastewater.
- Field analysis of free chlorine as an indicator of treated effluent, noting that chlorine is highly volatile and breaks down quickly soon after discharge into the environment.
- Analysis of particle size distribution in sediment to support future risk assessment.
- Developing catchment-specific DGV to better assess potential risks, including consideration of cultural/spiritual values of the river to Noongar people.
- Undertaking a detailed risk assessment and/or ecotoxicology testing to determine actual impacts, including consideration of exposure pathways that are specific to Noongar people.

With support from Lotterywest, environmental DNA (eDNA) sampling will be undertaken at all sampling locations in 2025 to assess the presence of plant and animal species through DNA that is shed into the environment. This will enable a more complete picture of river health to be considered as part of a multiple lines of evidence based approach.

Tables

Table T1	Field Parameters
Table T2	Water Results
Table T3	Sediment Results

BoorYul-Bah-Bilya (Mandoon Bilya-Helena River)
LHAAC Water and Sediment Sampling, September 2024
Table T1 Field Parameters

BOORYUL BAH BILYA
BIBBUL NGARMA ABORIGINAL ASSOCIATION INC.

Group	Parameter	Default Guideline Value for Freshwater Ecosystem	Helena Swan	Whiteman Rd	Helena Roe	Craignish US	Lower Pumpback Dam	Rocky Pool	Pipe Bridge	Cobblers Pool*	LookSee Pool	Piesse Culvert	Salty Pool*	Beraking Yarra
Location	Altitude (m AHD)		19.9	26.3	27.4	32.9	40.8	85.9	86.1	92.8	108.0	252.3	257.1	262.0
	Latitude		-31.89708	-31.89997	-31.90541	-31.93554	-31.94179	-31.95366	-31.93834	-31.94693	-31.94991	-32.03209	-31.93916	-32.18183
	Longitude		115.9858	116.0075	116.0160	116.0687	116.0761	116.0716	116.1217	116.1348	116.1459	116.1370	116.5150	116.4349
Weather	Date		16.09.24	18.09.24	16.09.24	16.09.24	16.09.24	16.09.24	17.09.24	17.09.24	17.09.24	16.09.24	17.09.24	17.09.24
	Time		16:15	10:20	15:15	14:15	13:15	10:35	14:15	15:00	15:30	8:30	10:15	11:45
	Air Temperature (°C)		20.7	20.1	22.0	21.3	21.5	19.5	-	-	22.4	14.1	-	23.9
	Humidity (%)		38	51	36	43	37	42	-	-	29	65	-	23
	Rain (mm)		0	0	0	0	0	0	0	0	0	0	0	0
	Wind (kmph)		11-13 E	9-11 SW	15-20 NE	15-24 NE	20-26 NE	26 NE	-	-	13-19 NE	30 NE	-	11-24 NW
Water Quality Parameters	Water Depth (m)		0.534	0.518	0.464	0.324	0.321	0.549	0.209	0.794	0.362	0.106	0.292	0.273
	Air Pressure (mmHg)		767.4	765.1	767	766.4	766.7	763.8	756.6	755	754.9	750.1	745	743.6
	Water Temperature (°C)		16.8	16.5	17.2	17.0	15.6	16.4	17.0	15.4	15.4	16.2	13.4	12.8
	Conductivity Field (uS/cm)	<120-300[#A]	1,095	1,176	1,128	498.3	442.6	415.8	509	591	648	420	8,274	161.7
	Conductivity Laboratory (uS/cm)	<120-300[#A]	1,200	1,300	1,200	520	460	440	540	630	700	450	8,600	170
	Dissolved Oxygen (%, optical)	>80[#A]	54.8	56.5	59.1	59.3	27.6	96.9	94.4	69.3	70.5	101.4	46.9	36.4
	Dissolved Oxygen (mg/L, optical)		5.30	5.50	5.67	5.71	2.76	9.47	9.10	6.93	7.04	9.95	4.75	3.85
	pH Field	6.5-8.0[#A]	6.76	6.64	6.73	6.24	6.49	7.43	6.73	6.44	6.52	6.91	6.58	6.91
	pH Laboratory	6.5-8.0[#A*]	7.1	6.8	6.6	6.3	6.6	6.0	6.1	6.3	6.0	5.9	6.3	6.2
	pH mV (pH as millivolt signal)		14.5	18.5	16.4	43.2	29.9	-23.1	14.9	31.1	26.4	12.7	23.0	4.2
	Salinity Field (ppm)		550	590	560	240	210	200	250	290	320	200	4,620	80
	Salinity Laboratory (mg/L)		530	560	540	240	210	200	240	280	310	200	3,900	76
	Redox (ORP) (mV)		131.3	158.9	106.4	89.1	83.1	145.2	132.4	171.1	152.0	182.7	218.2	187.9
	Total Dissolved Solids Field (mg/L)		712	764	733	288	325	271	331	384	421	273	5,390	105
	Total Dissolved Solids Laboratory (mg/L)		700	760	710	310	280	270	320	380	420	270	5,200	100
	Turbidity Field (NTU)	<10-20[#A]	17.59	14.70	17.80	28.77	12.24	0.30	1.11	2.24	2.08	0.61	0.69	5.14
	Turbidity Laboratory (NTU)	<10-20[#A]	18	10	19	36	17	2.2	3.7	4.3	3.7	2.1	2.6	6.9

Notes

123	Concentration is at or above the ecological guideline value
-	Weather unable to be recorded without phone signal

Default guideline values for freshwater ecosystems are presented for comparative purposes. A full screen of the field and laboratory data against default guideline values for protection of human health, primary industries and freshwater ecosystems is presented in Table T2.

Laboratory measured field parameters are presented for comparison

* Salty Pool is referred to as Helena Pony in field notes and laboratory documentation

* Cobblers Pool is referred to as Skeleton Pool in field notes and laboratory documentation

NTU = Nephelometric Turbidity Units

PCU = Platinum Cobalt Units (a measure of colour)

Redox = Reduction Oxidation Potential

Specific conductance is a conductivity measurement made at or corrected to 25° C. This is the standardized method of reporting conductivity as water temperature will affect conductivity readings.

TDS = Total Dissolved Solids (dried at 180°C + 2°C), TSS = Total Suspended Solids (dried at 103°C to 105°C)

Guideline Value Comments

ANZECC (2000)	Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 1 The Guidelines. Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand. October 2000. Available at: https://www.waterquality.gov.au/sites/default/files/documents/anzecc-armcanz-2000-guidelines-vol1.pdf
#A	ANZECC (2000) Default trigger values for base flow in lowland rivers and slightly disturbed ecosystems in south west Australia, reflecting high site and regional variability, refer Table 3.3.6 and 3.3.7
#A*	pH recorded in the laboratory differs from that recorded in the field, likely because the laboratory test must begin within 30 minutes of sampling, which was not possible. As such, only the field measured pH were used for screening purposes.

BoorYul-Bah-Bilya (Mandoon Bilya-Helena River)
LHAAC Water and Sediment Sampling, September 2024
Table T2 Water Results

		Default Guideline Value																					
		Freshwater Ecosystem			Human Health				Primary Industry														
Group	Analysis	Freshwater Ecosystem (99% protection)	Swan-Canning Targets	Wastewater Effluent Criteria	Drinking Water Health	Drinking Water Aesthetic	Non-Potable Uses	Recreation & Swimming	Agricultural Irrigation - Long Term	Agricultural Irrigation - Short Term -	Stock Watering	LOR (mg/L)	Helena Swan	Whiteman Rd	Helena Roe	Craignish US	Lower Pumpback Dam	Rocky Pool	Pipe Bridge	Cobblers Pool*	LookSee Pool	Piesse Culvert	Salty Pool*	Beraking Yarra
Major Ions	Calcium										1,000[#E]	<0.5	32	33	33	10	12	11	7.3	8.0	9.9	15	130	7.2
	Chloride (filtered)					250[#A9]	250[#C]	400[#D]	175[#F1]	175[#F2]		<5	230	300	250	110	66	68	110	140	150	60	2,500	23
	Fluoride	0.29[#H]			1.5[#A]		15[#C]	15[#C]	1[#F1]	2[#F2]	2[#J5]	<0.1	0.2	0.3	0.2	0.2	0.2	<0.1	0.2	0.2	0.2	0.1	0.5	0.2
	Magnesium										125[#J6]	<0.5	24	27	24	11	8.2	7.2	9.9	10	12	7.8	340	4.7
	Potassium											<0.5	5.4	5.5	4.6	2.9	3.6	3.7	2.6	2.7	3.2	5.1	4.9	3.1
	Sodium				NN	180[#A11]		300[#D]	115[#F1]	115[#F2]		<0.5	140	160	140	69	57	52	77	84	98	51	1,000	20
	Sulphate (as SO4)					250[#A12]	1,000[#C]	400[#D]			250[#J4]	<1	62	34	41	12	4	33	23	29	31	38	150	<1
Nutrients	Ammonia-N (NH3-N)	0.32[#G2]					0.388[#C]	0.01[#D]				<0.02	0.02	0.13	0.12	0.05	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02
	Nitrate-N	0.017[#G3]			11[#A6]		113[#C]	10[#D]			25[#J3]	<0.01	0.17	0.23	0.12	0.08	<0.01	1.4	<0.01	0.02	0.02	6.9	<0.01	<0.01
	Nitrite-N				0.9[#A7]		9.12[#C]	1[#D]			10[#J3]	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Total Oxidised Nitrogen (Nitrate + Nitrite as NOx-N)	0.15[#G4]										<0.01	0.18	0.21	0.13	0.1	<0.01	1.4	<0.01	0.03	0.02	6.9	<0.01	<0.01
	Total Kjeldahl Nitrogen											<0.2	1.0	0.3	0.5	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.4	0.3
	Nitrogen (organic)											<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
	Nitrogen (total)	1.2[#G4]	1.0-2.0[#O]	<10[#N]					5[#F1]	25[#F2]		<0.2	1.2	0.5	0.6	0.3	<0.2	1.5	<0.2	<0.2	<0.2	6.9	0.4	0.3
	Phosphorous (filterable reactive)	0.04[#G4]										<0.01	0.01	0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Phosphorous (total)	0.065[#G4]	0.1-0.2[#O]	<2[#N]					0.05[#F1]	0.8[#F2]		<0.01	0.06	0.03	0.04	0.05	0.03	0.03	0.06	0.06	0.06	0.04	0.01	0.06
Metals & Other Inorganics (Total)	Aluminium	0.027[#G]			20[#B]	0.2[#A]	0.2[#C]	0.2[#D]	5[#F1]	20[#F2]	3.6[#J1]	<0.05	0.14	<0.05	0.06	0.70	<0.05	0.06	0.09	0.23	0.22	0.09	<0.05	0.18
	Antimony	0.009[#H3]			0.003[#A]		0.03[#C]	0.03[#C]			0.003[#E1]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Arsenic	0.008[#H1]			0.01[#A]			0.05[#D]	0.1[#F1]	2[#F2]	0.025[#J]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Barium				2[#A]		20[#C]	1[#D]			2[#E1]	<0.01	0.07	0.07	0.07	0.05	0.04	0.03	0.02	0.03	0.03	0.04	0.09	0.02
	Beryllium				0.06[#A]		0.6[#C]	0.6[#C]	0.1[#F1]	0.5[#F2]	0.06[#J]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Boron	0.09[#G]			4[#A]		40[#C]	1[#D]	0.5[#F1]	0.5[#F2]	5[#J]	<0.05	0.08	0.09	0.08	0.08	0.13	<0.05	<0.05	<0.05	<0.05	<0.05	0.06	<0.05
	Cadmium	0.00006[#G]			0.002[#A]		0.02[#C]	0.005[#D]	0.01[#F1]	0.05[#F2]	0.01[#J]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Chromium (total)	0.00001[#H2]			0.05[#A3]			0.05[#D]	0.1[#F1]	1[#F2]	0.05[#J]	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Chromium (total filtered)	0.00001[#H2]			0.05[#A3]			0.05[#D]	0.1[#F1]	1[#F2]	0.05[#J]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Chromium (III) (filtered)	0.0033[#H3]			22[#B]						0.05[#J]	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Chromium (VI)	0.00001[#G]			0.05[#A]		0.5[#C]	0.5[#C]			0.05[#J]	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
	Cobalt	0.0014[#H3]			0.006[#B]				0.05[#F1]	0.1[#F2]	1[#J]	<0.001	0.001	<0.001	0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002
	Copper	0.001[#G]			2[#A]	1[#A]	20[#C]	1[#D]	0.2[#F1]	5[#F2]	0.5[#J2]	<0.001	0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	0.001
	Cyanide (total)	0.004[#G1]			0.08[#A4]		0.8[#C]	0.1[#D]			0.08[#E1]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.007
	Iron	0.3[#K]			14[#B]	0.3[#A]	0.3[#C]	0.3[#D]	0.2[#F1]	10[#F2]	NST	<0.01	4.6	3.8	3.8	6.0	3.4	0.16	0.90	1.0	1.2	0.06	0.53	3.0
	Lead	0.001[#G]			0.01[#A]		0.1[#C]	0.05[#D]	2[#F1]	5[#F2]	0.1[#J]	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
	Lithium				0.04[#B]						0.04[#E1]	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	<0.001
	Manganese	1.2[#G]			0.5[#A]	0.1[#A]	5[#C]	0.1[#D]	0.2[#F1]	10[#F2]	10[#J]	<0.005	0.13	0.12	0.12	0.16	0.28	0.008	0.03	0.018	0.063	0.011	0.22	0.46
	Mercury	0.00006[#G]			0.001[#A]		0.01[#C]	0.01[#C]	0.002[#F1]	0.002[#F2]	0.002[#J]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Molybdenum	0.034[#H3]			0.05[#A]		0.5[#C]	0.5[#C]	0.01[#F1]	0.05[#F2]	0.01[#J]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Nickel	0.008[#G]			0.02[#A]		0.2[#C]	0.1[#D]	0.2[#F1]	2[#F2]	1[#J]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	0.002	<0.001
	Selenium	0.005[#G]			0.01[#A]		0.1[#C]	0.01[#D]	0.02[#F1]	0.05[#F2]	0.02[#J]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.002	0.002
	Silver	0.00002[#G]			0.1[#A]		1[#C]	0.05[#D]			0.1[#E1]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Thallium	0.00003[#H3]			0.0002[#B]						0.0002[#E1]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	Thorium											<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Tin				12[#B]						12[#E1]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Titanium											<0.005	<0.005	<0.005	<0.005	0.020	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	Uranium	0.0005[#H3]			0.02[#A]		0.2[#C]	0.2[#C]	0.01[#F1]	0.1[#F2]	0.2[#J]	<0.001	0.001	0.002	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Vanadium	0.006[#H3]			0.086[#B]				0.1[#F1]	0.5[#F2]	0.1[#J]	<0.005	<0.005	<0.005	<0.005	0.007	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	Zinc	0.0024[#G]			6[#B]	3[#A]	3[#C]	5[#D]	2[#F1]	5[#F2]	20[#J]	<0.005	0.005	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	0.007	0.005	0.006
	Zirconium (total)				0.0016[#B]						0.0016[#E1]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Microbes	Heterotrophic Plate Count at 37°C (HPC) (total)											<20 CFU/ml	3,400	3,800	3,600	2,000	1,900	1,600	8,800	5,800	1,600	3,500	1,600	1,900
	Total Coliforms											<1 CFU/100ml	700	1,300	3,600	1,000	7,000	5,000	900	300	1,200	2,800	1,800	2,000
	E. coli[#V]			<10[#N]	Detection[#A5]		1[#L]	1[#L]	10[#F3]	10[#F3]	100[#E]	<1 CFU/100ml	130	140	240	100	150	82	12	12	13	84	24	21
	Enterococci				Detection[#A5]			60-100[#D1]			100[#E]	<1 CFU/100ml	160	53	120	98	82	59	11	19	7	69	63	56
	Thermophilic Amoeba				Detection[#A5]							D/ND / 250ml	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Detected	Not Detected	Not Detected	Not Detected	Detected	Detected
	Thermophilic Naegleria sp.				Detection[#A5]							D/ND / 250ml	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
	Naegleria fowleri				Detection[#A5]							D/ND / 250ml	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
Herbicides & Pesticides	Acidic Herbicides & Pesticides											Various ug/L	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
	Base Neutrals											Various ug/L	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
	Organochloride & Organophosphate Pesticides											Various ug/L	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	See below	<LOR	<LOR
	Bifenthrin				300[#B]		350[#C]	350[#C]			300[#E1]	<0.05 ug/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	DDE											<0.001 ug/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
	DDT	0.01[#G]			9[#A]		90[#C]	3[#D]			9[#E1]	<0.001 ug/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
	Dieldrin	0.01[#H3]			0.3[#A1]		3[#C1]	1[#D]			0.3[#E1]	<0.001 ug/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001
Hydrocarbons	TRH C6-C9											<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02	<0.02
	TRH C10-C14											<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	TRH C15-C28											<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
	TRH C29-C36											<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
	TRH C10-C36 (total)											<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
	TRH C6-C10											<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	<0.02
	TRH C6-C10 (less BTEX) (F1)				0.09[#I1]						0.09[#E1]	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	<0.02
	TRH >C10-C16											<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	TRH >C10-C16 (less naphthalene) (F2)				0.09[#I1]						0.09[#E1]	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	TRH >C16-C34				0.1[#I2]						0.1[#E1]	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	TRH >C34-C40				0.1[#I2]						0.1[#E1]	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	TRH >C10-C40 (total)											<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Total BTEX Compounds											Various mg/L	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
	Naphthalene	0.016[#G]			0.07[#A2]						0.07[#E1]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Total Polycyclic Aromatic Hydrocarbons (PAH)											Various ug/L	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
PFAS	Per- and Polyfluoroalkyl Substances Full Ultra Trace											Various ug/L	<LOR	See below	See below	See below	See below	See below	See below	See below	See below	See below	See below	See below
	Perfluorobutanoic acid (PFBA)[#T]											<0.005 ug/L	<0.005	0.017	0.016	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.015	0.009
	Perfluoropentanoic acid (PFPeA)[#T]											<0.001 ug/L	<0.001	0.037	0.023	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Perfluorohexanoic acid (PFHxA)[#T]											<0.001 ug/L	<0.001	0.016	0.013	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Perfluoroheptanoic acid (PFHpA)[#T]											<0.005 ug/L	<0.005	0.007	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	Perfluorooctanoic acid (PFOA)[#T]	19[#Q]			0.56[#A]		0.56[#M]	10[#P]			0.56[#E1]	<0.001 ug/L	<0.001	0.011	0.013	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Perfluorobutanesulfonic acid (PFBS)[#T]											<0.001 ug/L	<0.001	0.004	0.006	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Perfluorooctanesulfonic acid (PFOS)[#T]	0.00023[#Q]			0.07[#A8]		0.07[#M]	2[#P]			0.07[#E1]	<0.0001 ug/L	<0.0001	0.041	0.048	0.0005	0.002	0.0021	0.0006	0.001	0.0003	0.0004	0.0004	0.0001
	Perfluoropropanesulfonic acid (PFPrS)[#U]											<0.001 ug/L	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Perfluoropentanesulfonic acid (PFPeS)[#U]											<0.001 ug/L	<0.001	0.004	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Perfluorohexanesulfonic acid (PFHxS)[#T]				0.07[#A8]		0.07[#M]	2[#P]			0.07[#E1]	<0.001 ug/L	<0.001	0.021	0.024	<0.001	0.002	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Perfluoroheptanesulfonic acid (PFHpS)[#U]											<0.001 ug/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
	Sum PFHxS + PFOS				0.07[#A]		0.07[#M]	2[#P]			0.07[#E1]	<0.001 ug/L	<0.001	0.062	0.072	<0.001	0.004	0.0071	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
	Sum enHealth PFAS (PFHxS + PFOS + PFOA)											<0.001 ug/L	<0.001	0.073	0.085	<0.001	0.004	0.0071	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
	Sum PFASs (n=30)											<0.005 ug/L	<0.005	0.16	0.16	<0.005	<0.005	0.007	<0.005	<0.005	<0.005	<0.005	0.015	0.009
	Sum US EPA PFAS (PFOS + PFOA)											<0.001 ug/L	<0.001	0.052	0.061	<0.001	0.002	0.0021	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
	Sum WA DWER PFAS (n=10)											<0.005 ug/L	<0.005	0.154	0.149	<0.005	<0.005	0.0071	<0.005	<0.005	<0.005	<0.005	0.0154	0.0091
Surfactants	Methylene Blue Active Substance (MBAS)							0.2[#D]				<0.2	0.3	0.4	0.3	0.2	<0.2	<0.2	0.4	0.3	0.3	0.3	1.4	0.4
Volatiles	Volatile & Semi-Volatile Organic Compounds											Various mg/L	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
	Total Polychlorinated Biphenyls (PCB)	0.00001[#H4]						0.0001[#D]				<0.05 mg/L	<0.05	<LOR	<0.05	<0.05	<0.05	<0.05	<LOR	<LOR	<LOR	<0.05	<LOR	<LOR
Water Quality Parameters	Alkalinity - Bicarbonate (as CaCO3)											<5	100	110	110	43	78	23	27	30	34	15	47	37
	Alkalinity - Carbonate (as CaCO3)											<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Alkalinity - Hydroxide (as CaCO3)											<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Alkalinity - Total (as CaCO3)											<5	100	110	110	43	78	23	27	30	34	15	47	37
	Biochemical Oxygen Demand			<20[#N]			10[#S2]					<5	<5	<5	<5	<5	<5	<5	<5	<5	5.4	<5	<5	<5
	Colour											<5 PCU	22	<5	25	9.8	11	7.6	25	24	<5	11	130	31
	Conductivity (field measured at 25°C)	<120-300[#G4]										<10 uS/cm	1,095	1,176	1,128	498.3	442.6	415.8	509	591	648	420	8,274	161.7
	Conductivity (lab measured at 25°C)	<120-300[#G4]										<10 uS/cm	1,200	1,300	1,200	520	460	440	540	630	700	450	8,600	170
	Dissolved Oxygen (optical)	<80[#G4]										%	54.8	56.5	59.1	59.3	27.6	96.9	94.4	69.3	70.5	101.4	46.9	36.4
	Dissolved Oxygen (optical)											mg/L	5.30	5.50	5.67	5.71	2.76	9.47	9.10	6.93	7.04	9.95	4.75	3.85
	Hardness (equivalent CaCO3/L)				NN	200[#A10]		500[#D]				<5	180	200	190	69	69	57	59	62	75	68	1,700	38
	pH (field measured)	6.5-8.0[#G4]		6.5-8.5[#N]	6.5-8.5[#A]		6.5-8.5[#S1]	6.5-8.5[#D]	6-8.5[#F]	6-8.5[#F]		<0.1 pH	6.76	6.64	6.73	6.24	6.49	7.43	6.73	6.44	6.52	6.91	6.58	6.91
	pH (lab measured)*	6.5-8.0[#G4]		6.5-8.5[#N]	6.5-8.5[#A]		6.5-8.5[#S1]	6.5-8.5[#D]	6-8.5[#F]	6-8.5[#F]		<0.1 pH	7.1	6.8	6.6	6.3	6.6	6.0	6.1	6.3	6.0	5.9	6.3	6.2
	Salinity (field measured) (ppm)											-	550	590	560	240	210	200	250	290	320	200	4,620	80
	Salinity (lab measured) (mg/L)											<10	530	560	540	240	210	200	240	280	310	200	3,900	76
	Total Dissolved Solids (field measured)				NN	600[#A]		1,000[#D]			500[#J]	-	712	764	733	288	325	271	331	384	421	273	5,390	105
	Total Dissolved Solids (dried at 180°C + 2°C)				NN	600[#A]		1,000[#D]			500[#J]	<5	700	760	710	310	280	270	320	380	420	270	5,200	100
	Total Suspended Solids (dried at 103°C to 105°C)			30[#N]			10[#S2]					<5	<5	6	<5	23	6	<5	<5	<5	<5	6	5	5
	Total Organic Carbon											<5	<5	<5	<5	<5	<5	<5	6.8	5.1	5.2	<5	21	<5
	Turbidity (field measured)	<10-20[#G4]				5[#A13]	5[#S1]					<0.1 NTU	17.59	14.70	17.80	28.77	12.24	0.30	1.11	2.24	2.08	0.61	0.69	5.14
	Turbidity (lab measured)	<10-20[#G4]				5[#A13]	5[#S1]					<0.1 NTU	18	10	19	36	17	2.2	3.7	4.3	3.7	2.1	2.6	6.9

Notes

123	Concentration is at or above the primary industry guideline value
123	Concentration is at or above the ecological guideline value
123	Concentration is at or above the human health and/or industrial and/or ecological guideline value

All units in mg/L unless otherwise specified
All other contaminants analysed (incl. herbicides, pesticides and speciated BTEX, PAH, PCB, PFAS, SVOC and SVOC) were not reported above the LOR. Refer laboratory documentation for full analysis suite.
*pH recorded in the laboratory differs from that recorded in the field, likely because the laboratory test must begin within 30 minutes of sampling, which was not possible. As such, only the field measured pH were used for screening purposes.
*Salty Pool is incorrectly referred to as Helena Pony in field notes and laboratory documentation.
*Cobblers Pool is incorrectly referred to as Skeleton Pool in field notes and laboratory documentation.

BTEX = Benzene, Toluene, Ethylbenzene, Xylene
CFU = Colony Forming Unit
D/ND = Detect/Non-Detect
E. Coli = Escherichia coli
LOR = Limit of Reporting
NN = Not Necessary (NHMRC, 2011)
NPUG = Non-Potable Use Guideline
NST = Not Sufficiently Toxic (ANZG, 2023)
NTU = Nephelometric Turbidity Units
PCU = Platinum-Cobalt Units (a measure of colour)
TRH = Total Recoverable Hydrocarbons

Guideline Value Comments

ANZECC (2000)	Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 1 The Guidelines. Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand. October 2000. Available at: https://www.waterquality.gov.au/sites/default/files/documents/anzecc-armcanz-2000-guidelines-vol1.pdf
ANZG (2018)	Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian State and Territory Governments. Available at: https://www.waterquality.gov.au/anz-guidelines
ANZG (2023a)	Draft Toxicant Default Guideline Values for Aquatic Ecosystem Protection: Perfluorooctane Sulfonate (PFOS) in Freshwater. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian State and Territory Governments. May 2023. Available at: https://www.waterquality.gov.au/sites/default/files/documents/pfos-fresh-dgv-draft-technical-brief.pdf
ANZG (2023b)	Draft Livestock Drinking Water Guidelines. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian State and Territory Governments. November 2023. Available at: https://www.waterquality.gov.au/sites/default/files/documents/livestock-drinking-water-guidelines-draft.pdf
DOH (2011)	Guidelines for the Non-Potable Uses of Recycled Water in Western Australia. Government of Western Australia Department of Health. 2011. Available at: https://www.health.wa.gov.au/~/media/Files/Corporate/general-documents/water/Recycling/Guidelines-for-the-Non-potable-Uses-of-Recycled-Water-in-WA.pdf
DOH (2014)	Contaminated Sites Ground and Surface Water Chemical Screening Guidelines. Government of Western Australia Department of Health. December 2014. Available at: https://www.health.wa.gov.au/-/media/Files/Corporate/general-documents/Environmental-health/Ground-and-Surface-Chemical-Water-Screening-Guidelines.pdf
DWER (2021)	Assessment and Management of Contaminated Sites: Guidelines. Government of Western Australia Department of Water and Environmental Regulation. November 2021. Available at: https://www.wa.gov.au/system/files/2023-05/guideline-assessment-and-management-of-contaminated-sites.pdf
HEPA (2025)	PFAS National Environmental Management Plan (NEMP), Version 3.0. Heads of EPA Australia and New Zealand. 2025. Available at: https://www.dcceew.gov.au/sites/default/files/documents/pfas-nemp-3.pdf
NHMRC (2019)	Guidance on Per and Polyfluoroalkyl (PFAS) in Recreational Water. National Health and Medical Research Council & Natural Resource Management Ministerial Council, Commonwealth of Australia. 2019. Available at: https://www.nhmrc.gov.au/file/14374/download?token=tlh5Ztjn
NHMRC (2022)	Australian Drinking Water Guidelines 6, National Water Quality Management Strategy, Version 3.8. National Health and Medical Research Council & Natural Resource Management Ministerial Council, Commonwealth of Australia. September 2022. Available at: https://www.nhmrc.gov.au/sites/default/files/documents/attachments/publications/Australian_Drinking_Water_Guidelines_ADWG_V3-8_Sep2022.pdf
SRT (2001)	Swan River Trust & Water and Rivers Commission. Swan-Canning Cleanup Program: The Catchment of the Swan-Canning River System. 2001.
US EPA (2024)	Regional Screening Levels - Generic Tables. United States Environmental Protection Agency. December 2024. Available at: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
WHO (2008)	Petroleum Products in Drinking Water. World Health Organisation. 2008. Available at: https://cdn.who.int/media/docs/default-source/wash-documents/wash-chemicals/petroleumproducts-2add-june2008.pdf?sfvrsn=9f397b0c_4

#A	NHMRC (2022) Australian Drinking Water Guidelines (ADWG)
#A1	NHMRC (2022) Guideline is for aldrin + dieldrin
#A2	NHMRC (2022) Derived as per NHMRC (2011) based on tolerable daily intake (TDI) used for National Environment Protection Measures (NEPM) Health Screening Level (HSL) derivation
#A3	NHMRC (2022) Guideline for Cr (VI) conservatively adopted for comparison to total chromium
#A4	NHMRC (2022) Guideline is for total cyanide, but other forms (free, WAD, SAD) should also be below the guideline
#A5	NHMRC (2022) E. Coli and enterococci and thermotolerant coliforms should not be detected in a minimum 100mL sample of drinking water
#A6	NHMRC (2022) Converted from guideline for nitrate (as nitrate) - will protect bottle-fed infants under 3 months from methemoglobinemia; adults and children can safely drink up to 100 mg/L
#A7	NHMRC (2022) Converted from guideline for nitrite (as nitrite), rapidly oxidised to nitrate (see above)
#A8	NHMRC (2022) Guideline for PFOS+PFHxS also applied to PFOS and PFHxS for screening purposes
#A9	NHMRC (2022) Chloride is derived from natural mineral salts and effluent contamination. High concentrations more common in groundwater and certain catchments. Insufficient data to set a drinking water guideline value based on health considerations.
#A10	NHMRC (2022) Hard water is caused by calcium and magnesium salts and is difficult to lather; <60 mg/L CaCO3 – soft but possibly corrosive; 60-200 mg/L CaCO3 – good quality; 200-500 mg/L CaCO3 – increasing scaling problems; >500 mg/L CaCO3 – severe scaling
#A11	NHMRC (2022) Sodium is a natural component of water - guideline value is a taste threshold

#A12	NHMRC (2022) Sulphate is a natural component of water and may be added via treatment chemicals - guideline value is a taste threshold as insufficient data to set a drinking water guideline value based on health considerations, >500 mg/L can have purgative effects
#A13	NHMRC (2022) 5 NTU is just noticeable in a glass; <0.2 NTU is the target for effective filtration of Cryptosporidium and Giardia; <1 NTU is the target for effective disinfection - insufficient data to set a drinking water guideline value based on health considerations, values are representative of base river flow in lowland rivers
#B	USEPA (2024) Tap Water Regional Screening Level (TR=1E-06; THQ=0.1)
#C	DOH (2014) Guidelines for Non-Potable Use (NPUG) including watering gardens and edible garden produce, irrigating parks and reserves, and washing cars and clothes
#C1	DOH (2014) Guideline is for aldrin + dieldrin
#D	ANZECC (2000) Guidelines for Recreational Water Quality and Aesthetics, refer Table 5.2.3 (general chemicals) and Table 5.2.4 (pesticides)
#D1	ANZECC (2000) For primary contact (e.g. swimming), the median bacterial content in freshwaters taken over the bathing season should not exceed 150 faecal coliform organisms/100 mL (minimum of 5 samples taken at regular intervals not exceeding one month, with 4 of 5 samples containing <4,000 organisms/100 mL) and 35 enterococci organisms/100 mL (maximum number in any one sample: 60–100 organisms/100 mL), refer Table 5.2.2
#E	ANZECC (2000) Guidelines for Primary Industries - Livestock Drinking Water Quality
#E1	ANZECC (2000) Livestock Drinking Water Quality - in the absence of adequate information derived specifically for livestock under Australian and New Zealand conditions, it is recommended that the drinking water guidelines for human health be adopted
#F	ANZECC (2000) Guidelines for Primary Industries - Water Quality for Irrigation and General Water Use
#F1	ANZECC (2000) Primary Industries - Water Quality for Irrigation and General Water Use, Long Term Trigger Values (LTV), refer Table 4.2.10 - LTV are applicable to application of irrigation water for up to 100 years in a non-domestic setting; for shorter periods, STV may be more appropriate
#F2	ANZECC (2000) Primary Industries - Water Quality for Irrigation and General Water Use, Short Term Trigger Values (STV), refer Table 4.2.10
#F3	ANZECC (2000) Trigger values for thermotolerant coliforms in irrigation waters for raw human food crops in direct contact with irrigation water, refer Table 4.2.2
#G	ANZECC (2000) Trigger Values for Freshwater Aquatic Ecosystems for slightly to moderately disturbed systems at 99% level of species protection (LOSP)
#G1	ANZECC (2000) Guideline is for unionised cyanide (HCN), measured as CN, but has been applied to all forms for screening purposes
#G2	ANZECC (2000) Ammonia as total ammonia (NH3-N) at pH 8 - guideline drops to 2.18 mg/L at pH 7, refer Vol 2, Table 8.3.7
#G3	ANZECC (2000) Figures protect against toxicity and do not relate to eutrophication issues
#G4	ANZECC (2000) Default trigger values for lowland rivers and slightly disturbed ecosystems in south-west Australia, values reflect high site-specific and regional variability, refer Table 3.3.6 and 3.3.7
#H	ANZG (2018) Default Australian Water Quality Guidelines for Toxicants in Freshwater Ecosystems at 99% level of species protection (LOSP)
#H1	ANZG (2018) Guideline for As (VI) conservatively adopted for comparison to total arsenic
#H2	ANZG (2018) Guideline for Cr (VI) conservatively adopted for comparison to total chromium
#H3	ANZG (2018) Unknown level of species protection (LOSP)
#H3	ANZG (2018) Guideline for Arochlor 1254 adopted for comparison to total PCBs
#I1	WHO (2008) Lowest derived guideline for aliphatic and aromatic fractions in this range
#I2	WHO (2008) Lowest derived guideline for aliphatic and aromatic fractions in this range rounded to 100 ug/L
#J	ANZG (2023b) Draft Livestock Drinking Water Guidelines
#J1	ANZG (2023b) 3.6 mg/L for chickens, 5 mg/L for general livestock
#J2	ANZG (2023b) 0.5 mg/L for sheep, 1 mg/L for cattle, 5 mg/L for pigs and poultry
#J3	ANZG (2023b) Nitrate = 25 mg/L for poultry, 100 mg/L for livestock in general, 400 mg/L for cattle; nitrite = 10 mg/L for livestock in general - levels of nitrate tolerance are lowest in poultry, medium in pigs and highest in cattle
#J4	ANZG (2023b) 25 mg/L for poultry, 500 mg/L for livestock in general, pigs may tolerate higher levels
#J5	ANZG (2023b) If livestock feed also contains fluoride, the guideline value should be reduced to 1.0 mg/L
#J6	ANZG (2023b) 125 mg/L for poultry, 250 mg/L for lactating cows and ewes with lambs, 500 mg/L for ruminants in general - also, if sulphate levels are high, poultry performance may be affected at magnesium concentrations >50 mg/L
#K	DWER (2021) Guidelines for ecological assessment levels for selected chemical stressors relevant to south west region of Western Australia derived during base flow condition, not storm events, refer Table D3
#L	DWER (2021) Microbial assessment levels (MAL) for water in urban recreational areas, open spaces, parks and gardens with unrestricted access and application, refer Table D2
#M	DWER (2021) For PFAS, values equal to the drinking water guideline values are appropriate Tier 1 screening levels for non-potable uses such as watering gardens in situations where consumption of home-grown produce is a viable/plausible exposure pathway
#N	Common wastewater effluent criteria for on-site disposal for development approvals in the Mandoon-Helena Catchment (City of Kalamunda (2020) Notice of Determination on Application for Planning Approval, Lot 3 (415) Mundaring Weir Road, Piesse Brook)
#O	SRT (2001) Total nitrogen = 1.0 mg/L long term and 2.0 mg/L short term; total phosphorous = 0.1 mg/L long term and 0.2 mg/L short term, based on a 1997 Swan River Trust classification scheme for Swan-Canning catchment tributaries, compliance is based on data from three years, guidelines adopted for screening purposes
#P	NHMRC (2019) Guideline for PFOS+PFHxS also applied to PFOS and PFHxS for screening purposes
#Q	HEPA (2025) PFAS National Environmental Management Plan (NEMP), Version 3.0, interim guideline for 99% level of species protection used for high conservation value systems - this approach is generally adopted for chemicals that bioaccumulate and biomagnify in wildlife Interim guidelines do not account for effects which result from the bioaccumulation and biomagnification of toxicants in air-breathing animals or in animals which prey on aquatic organisms. The 99% species protection level for PFOS is close to the commercially available ultra-trace level of detection. Agencies may wish to apply an 'ultra-trace detect' threshold in such circumstances rather than a quantified measurement.
#S1	DOH (2011) Guideline for ongoing monitoring requirements for a high level of exposure risk (i.e. residential and urban use with unrestricted access and application) used for screening purposes, refer Table 8
#S2	DOH (2011) Guideline for commissioning validation and verification monitoring requirements for a high level of exposure risk (i.e. residential and urban use with unrestricted access and application) used for screening purposes in the absence of a guideline for ongoing monitoring guidelines, refer Table 7
#T	Isotope dilution is used for calibration of each native compound for which an exact labelled analogue is available (Isotope Dilution Quantitation) - the isotopically labelled analogues allow identification and recovery correction of the concentration of the associated native PFAS compounds
#U	Where the native PFAS compound does not have labelled analogue then the quantification is made using the Extracted Internal Standard Analyte with the closest retention time to the analyte and no recovery correction has been made (Internal Standard Quantitation)
#V	*E.coli* to be used as a faecal pathogen indicator but where salinity exceeds one per cent (10,000 ppm), *Enterococci* should be substituted for *E.coli*

BoorYul-Bah-Bilya (Mandoon Bilya-Helena River)
LHAAC Water and Sediment Sampling, September 2024
Table T3 Sediment Results

Group	Analysis	Default Guideline Value		LOR (mg/kg)	Helena Swan	Whiteman Rd	Helena Roe	Craignish US	Lower Pumpback Dam	Rocky Pool	Pipe Bridge	Cobblers Pool*	LookSee Pool	Piesse Culvert	Salty Pool*	Beraking Yarra
		ANZECC (2000)	ANZG (2018)													
Major Ions	Calcium			<5	990	2,800	480	1,500	770	940	1,000	1,200	2,200	2,000	1,700	610
	Chloride			<10	67	450	180	76	18	24	35	100	120	38	1,300	34
	Fluoride (1:5 aqueous extract)			<0.1	0.3	<0.1	0.4	0.1	0.2	0.7	<0.1	<0.1	<0.1	0.4	0.3	<0.1
	Magnesium			<5	590	1,400	490	1,800	840	950	770	690	780	510	1,500	690
	Potassium			<5	190	450	87	1,100	370	510	210	310	210	150	200	410
	Sodium			<5	<5	400	140	<5	<5	<5	150	220	190	<5	1,000	250
	Sulphate			<10	70	310	72	200	140	27	130	70	160	120	150	<10
Nutrients	Ammonia-N			<10	30	28	29	51	32	33	59	45	65	56	43	42
	Nitrate-N			<1	1.4	1.9	1.0	<1	<1	2.0	<1	<1	<1	1.2	<1	<1
	Nitrite-N			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Total Oxidised Nitrogen (Nitrate + Nitrite as NOx-N)			<1	1.4	2.0	1.1	<1	<1	2.1	<1	<1	<1	1.4	<1	<1
	Total Kjeldahl Nitrogen			<10	620	32,000	510	1,500	870	800	38,000	28,000	43,000	4,800	4,600	750
	Nitrogen (total)			<10	620	32,000	510	1,500	870	800	38,000	28,000	43,000	4,800	4,600	750
	Phosphorous (reactive)			<1	<1	<1	<1	1.5	<1	<1	<1	<1	<1	<1	<1	1.8
	Phosphorous (total)			<1	230	6.0	54	88	80	57	88	93	90	280	110	26
Metals & Other Inorganics (Total)	Aluminium			<20	7,300	17,000	5,000	7,600	5,800	7,200	17,000	13,000	14,000	35,000	8,500	11,000
	Antimony	2	2	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Arsenic	20	20	<2	<2	3.4	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Barium			<10	34	110	25	61	28	33	44	39	35	78	65	49
	Beryllium			<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	2.1	<2	<2
	Boron			<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	Cadmium	1.5	1.5	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	<0.1
	Chromium (total)	80	80	<1	11	22	6.7	12	9.8	10	17	9.7	11	30	14	8.9
	Chromium (III)			<1	11	22	6.7	12	9.8	10	17	9.7	11	30	14	8.9
	Chromium (VI)			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Cobalt			<5	<5	12	<5	7.9	<5	<5	<5	<5	<5	7.3	<5	<5
	Copper	65	65	<1	11	22	6.2	16	5.8	6.6	7.1	8.2	7.3	**86**	7.1	6.6
	Cyanide			<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Iron			<20	19,000	59,000	9,700	16,000	15,000	14,000	12,000	13,000	11,000	45,000	17,000	7,700
	Lead	50	50	<1	33	42	15	11	14	15	17	17	14	46	15	29
	Lithium			<5	<5	6.9	<5	<5	<5	<5	<5	<5	<5	5.8	<5	<5
	Manganese			<5	110	280	33	120	65	130	12	38	29	210	47	47
	Mercury	0.15	0.15	<0.02	<0.02	**0.23**	0.03	<0.02	<0.02	<0.02	0.05	0.03	0.07	0.06	0.03	0.03
	Molybdenum			<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
	Nickel	21	21	<1	3.3	8.7	1.9	6.4	1.8	2.5	3.4	3.8	3.3	7.7	5.0	8.3
	Selenium			<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Silver	1	1	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
	Thallium			<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	Thorium			<5	7.7	13	5.5	8.5	11	11	15	12	13	13	13	15
	Tin			<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
	Titanium			<10	26	140	33	220	110	94	71	58	48	59	30	19
	Uranium			<10	<10	10	<10	<10	<10	<10	<10	<10	<10	18	<10	13
	Vanadium			<10	24	58	20	32	26	28	51	37	35	130	42	44
	Zinc	200	200	<5	48	110	34	23	17	25	190	27	25	67	15	5.6
	Zirconium			<1	1.2	<1	<1	2.9	2.0	1.9	5.4	3.4	6.0	4.9	9.1	2.8
Herbicides & Pesticides	Acidic Herbicides & Pesticides			Various	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
	Base Neutrals			Various	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
	Organochloride & Organophosphate Pesticides			Various	<LOR	See below	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	See below	<LOR	<LOR
	Bifenthrin			<0.2	<0.2	0.7	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
	DDE	0.0022	0.0014	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.05**	<0.01	<0.01
	DDT	0.0016	0.0012	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.03**	<0.01	<0.01
	Dieldrin	0.00002	0.0028	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Hydrocarbons	TRH C6-C9			<20	<20	33	25	<20	<20	<20	<20	<20	<20	<20	<20	<20
	TRH C10-C14			<20	<20	43	<20	22	<20	<20	94	51	72	<20	80	24
	TRH C15-C28			<50	<50	210	<50	99	<50	64	620	410	440	<50	510	100
	TRH C29-C36			<50	<50	120	<50	88	65	52	410	280	260	<50	380	70
	TRH C10-C36 (total)			<50	<50	373	<50	209	65	116	1,124	741	772	<50	970	194
	Bifenthrin			<20	<20	77	56	<20	<20	<20	<20	<20	<20	<20	<20	<20
	TRH C6-C10 (less BTEX) (F1)			<20	<20	77	56	<20	<20	<20	<20	<20	<20	<20	<20	<20
	TRH >C10-C16			<50	<50	95	<50	<50	<50	<50	240	170	170	<50	170	<50
	TRH >C10-C16 (less naphthalene) (F2)			<50	<50	94.3	<50	<50	<50	<50	240	170	170	<50	170	<50
	TRH >C16-C34			<100	<100	240	<100	130	110	<100	710	510	520	<100	680	130
	TRH >C34-C40			<100	<100	<100	<100	<100	<100	<100	360	200	220	<100	140	<100
	TRH >C10-C40 (total)		280[#1]	<100	<100	**335**	<100	130	110	<100	**1,310**	**880**	**910**	<100	**990**	130
	Total BTEX			Various	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
	Napthalene[#2]	0.16		<0.5	<0.5	**0.7**	**0.8**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	Total Polycyclic Aromatic Hydrocarbons (PAH)	4	10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PFAS	PFAS Full Ultra Trace			5 ug/kg	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Surfactants	Methylene Blue Active Substance (MBAS)[#3]			<0.2	<5	32	<5	<1	<2	<5	<5	<5	<5	3.6	<5	<10
Volatiles	Volatile & Semi-Volatile Organic Compounds			Various	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
	Total Polychlorinated Biphenyls (PCB)[#4]	0.023	0.034	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Water Quality Parameters	Alkalinity (mg CaCO3/kg)			<50	<50	70	<50	<50	<50	<50	<50	<50	<50	53	<50	50
	Moisture Content			<1 %	24	47	26	37	29	30	55	40	58	42	39	41
	pH (lab measured)			<0.1	6.1	6.3	5.9	6.0	5.6	5.8	5.7	5.7	6.0	6.7	6.1	6.1
	Total Organic Carbon			<0.1	<0.1	3.2	15	0.4	17	0.8	9.4	3.0	23	43	4.1	1.9

Notes

123	Result is at or exceeds default guideline value

All units in mg/kg unless otherwise specified.
All other contaminants analysed (incl. herbicides, pesticides and speciated BTEX, PAH, PCB, PFAS, SVOC and SVOC) were not reported above the LOR. Refer laboratory documentation for full analysis suite.
Cobblers Pool is referred to as Skeleton Pool in field notes and laboratory documentation
Salty Pool is referred to as Helena Pony in field notes and laboratory documentation
BTEX = Benzene, Toluene, Ethylbenzene, Xylene
CFU = Colony Forming Unit
D/ND = Detect/Non-Detect
LOR = Limit of Reporting
NTU = Nephelometric Turbidity Units
PCU = Platinum-Cobalt Units (a measure of colour)
PFAS = Per- and Polyfluoroalkyl Substances
TRH = Total Recoverable Hydrocarbons

#2 Where both volatile (P&T GCMS) and semi volatile (GCMS) naphthalene is reported, results may not be identical. Any observed differences are likely due to procedural differences in each methodology. Results have passed all QAQC acceptance criteria and are technically valid.

#3 LORs were raised due to sample interference. Interference could be due to varying organic sulfonates, sulphates, carboxylates and phenols, and inorganic thiocyanates, cyanates, nitrates, and chlorides. MBAS was not detected above a LOR of 1-5 mg/kg for any sample.

#4 LOR was raised for one sample as a dilution was required due to the matrix. This is usually due to some types of sediments causing the PCB profile to be masked by the organic material in the sample, so the dilution is required to get a clear chromatogram.

Guideline Value Comments

ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 1 The Guidelines. Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand. October 2000. Recommended sediment quality guidelines - ISQG-Low (Trigger Value), Table 3.5.1. Available at: https://www.waterquality.gov.au/sites/default/files/documents/anzecc-armcanz-2000-guidelines-vol1.pdf

ANZG (2018) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Default guideline values for toxicants in sediment, Table 1. Available at https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/sediment-quality-toxicants

#1 ANZG (2018) Origin described in Appendix A5 of Simpson SL, Batley GE & Chariton AA (2013) Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines, CSIRO Land and Water Report 8/07, CSIRO Land and Water

References

1. Foulsham, G. *et al. A Baseline Study of Organic Contaminants in the Swan and Canning Catchment Drainage System Using Passive Sampling Devices*. (2009).
2. Department of Water and Environmental Regulation. *Helena River: Swan Canning Catchment Nutrient Report 2018*. (2019).
3. Eastern Metropolitan Regional Council. *Helping the Helena: Establishing a Baseline of Water Quality Pollutants for Linkages in Fish and Mussel Decline*. (2014).
4. Novak, P., Hoeksema, S. & Department of Biodiversity Conservation & Attractions. *An Assessment of Per- and Poly-Fluoroalkyl Substances (PFAS) in the Surface Water and Biota of the Swan Canning Estuary and Its Catchment*. (2022).
5. Water and Rivers Commission & Department of Environment. The Importance of Western Australia's Waterways. *Archived from website on 1 July 2004*. (2004).
6. Office of the Auditor General Western Australia. *Our Heritage and Our Future: Health of the Swan Canning River System, Report 16*. (2014).
7. Close, P., Ford, B., Maughan, J. & Ryan, T. *Evaluation of Environmental Water Releases on the Aquatic Fauna of the Helena River, Aquatic Fauna Surveys Summer 2013 and Autumn 2014*. (2014).
8. Storey, A. & Creagh, S. *Lower Helena River: Trial Environmental Releases, Report Prepared on Behalf of Department of Water*. (2010).
9. Quicke, E. *Mundaring Weir Among the Hills*. (1979).
10. Quicke, E. *The Helena Story*. (1985).
11. Green, N. *Broken Spears: Aborigines and Europeans in the Southwest of Australia*. (1984).
12. Bates, M. & Bates, C. R. *A Report on the Geophysical Investigation of the Site of a Grave in Everton Cemetery, Liverpool, Unpublished Technical Report*. (1997).
13. Lowe, G. The Golden Pipeline. *Australian Journal of Multi-Disciplinary Engineering* 2, 45–53 (2004).
14. Batini, F. Mundaring Weir and the Pipeline to Kalgoorlie. *Australian Rural and Regional News* (2022).
15. Hartley, R. A century of water supply to the Western Australian goldfields and wheat-belt from Mundaring Weir and the Kalgoorlie pipeline. *Early Days: Journal of the Royal Western Australian Historical Society* 11, 727–744 (2000).
16. Tauman, M. *The Chief, C Y O'Connor*. (University of Western Australia Press, Nedlands, 1978).
17. Smith, R. A., Bari, M. A., Dixon, R. N. M. & Rowlands, D. W. *Helena River Salinity Situation Statement, Water Resource Technical Series, Report No WRT 34*. (2007).
18. Schwede, M. L. Super Trench - Phase 2: A Report on Excavation Results. in *Archaeology at ANZAAS 1983* 53–62 (1983).
19. McGilvray, A. & Sylva, K. *Helena River (Mandoon) Tributary Foreshore Assessment*. (2018).
20. Bibbul Ngarma Aboriginal Association Inc. *Media Announcement: New Quokka Population Discovered in Perth Hills*. (2024).
21. Forster, P. *Review of Aboriginal Culture in Relation to Granite Outcrops, a Western Australian Focus*. (2020).
22. Commonwealth of Australia. *Draft National Recovery Plan for Clay Pans of the Swan Coastal Plain Ecological Community*. (2017).
23. Braimbridge, M. & Commander, P. *Water Notes for River Management: The Wheatbelt's Ancient Rivers*. (2005).
24. CSIRO & Bureau of Meteorology. *Climate Change in Australia Information for Australia's Natural Resource Management Regions: Technical Report*. (2015).
25. Water Corporation. Dam Levels. (2023).

26. Flynn, F. & Ugle, G. *Mandoon - The Helena River Confluence, Waterways Western Australia*. (2023).
27. Gager, P. & Conacher, A. Erosion of Access Tracks in Kalamunda National Park, Western Australia: Causes and management implications. *Australian Geographer* 32, 343–357 (2001).
28. Siemon, N. *Foreshore Assessment in the Helena River Catchment, Report No. 20*. (2001).
29. Nice, H., Foulsham, G., Morgan, B. & Evans, S. *A Baseline Study of Contaminants in the Swan and Canning Catchment Drainage System, Water Science Technical Series, Report No WST 3*. (2009).
30. Nice, H. E. *A Baseline Study of Contaminants in the Sediments of the Swan and Canning Estuaries, Water Science Technical Report Series No 6*. (2009).
31. Novak, P. & Hoeksema, S. *An Assessment of Contaminants in the Sediments of the Swan Canning Estuary*. (2022).
32. Trayler, K. *Understanding and Predicting Riparian Decline: Ecohydrology and Hydro-Climatological Change. Information Sheet 101/2020*. (2020).
33. Creagh, S. & Storey, A. *Helena River Fish and Macroinvertebrate Surveys 2010 and 2011, Prepared for the Eastern Metropolitan Regional Council*. (2011).
34. Wansbrough, C. & Stewart, S. *Helena River Freshwater Fish Habitat Survey*. (2006).
35. Klunzinger, M. W., Beatty, S. & Lymbery, A. J. *Freshwater Mussel Response to Drying in the Lower Helena Pipehead Dam, Mussel Translocation Strategy for Conservation Management, Report to Swan River Trust*. (2011).
36. Edward, D. H. & Aquatic Research Laboratory. *Stream Fauna Study: Bioaccumulation of Organochlorine Pesticides by the Freshwater Mussel, Westralunio Carteri Iredale, Piesse Gully, Lower Helena River Catchment, Report No 14*. (1990).
37. Forests Department of Western Australia, Batini, F. & Selkirk, A. *Salinity Sampling in the Helena Catchment, Western Australia, Research Paper No 45*. (1978).
38. Wood, W. Increase of Salinity in Soil and Streams following Destruction of Native Vegetation. *J R Soc West Aust* 10, 35–47 (1924).
39. Batini, F. E. & Selkirk, A. B. *Salinity Sampling in the Helena Catchment, Research Paper 45*. (1978).
40. Forests Department of Western Australia & Ward, D. *Tree Removal and Salinity in Helena Catchment, Western Australia, Research Paper No 29*. (1977).
41. Croton, J. T. & Dalton, J. A. *Stream Salinity Response to Clearing and Revegetation of the Helena Catchment, Prepared for Water & Rivers Commission*. (1999).
42. Menck, C. *Mundaring Weir Forestry Settlement 1923-2011. A History of Community Life and Work.* (Mundaring and Hills Historical Society, 2013).
43. Bush, F. *Heritage Assessment: Mundaring Weir Forestry Settlement*. (2009).
44. Shire of Mundaring. *Mundaring Foothills Growth Strategy*. (2017).
45. City of Swan. *Local Planning Scheme No 17 Amendment No. 85: Hazelmere Enterprise Area Structure Plan, Precinct 2A Helena River*. (2014).
46. Helena River Catchment Group & Hill, A. *Letter from A Hill to Shire of Mundaring CEO, Planning to Ensure Protection of Kadina Brook and the Helena River's Bellevue Wetlands from Proposed Developments on Lot 206 Helena Valley Road and Adjacent Lands in Local Subdivision and Infrastructure Plan No 298, 15 December 2010*. (2010).
47. Shire of Mundaring. *Ordinary Council Meeting Agenda, Item 10.2 Endorsement of Draft Helena Valley Urban Expansion Strategy for Advertising*. (2016).
48. RPS. *Helena Valley Land Use Study*. (2013).
49. Cardno. *Helena Valley Traffic and Land Use Study*. (2015).
50. TPG Town Planning, U. D. and H. *Lots 2, 3 and 6 Midland Road Helena Valley, Local Structure Plan: Part 1 Implementation*. (2016).

51. Department of Planning Lands and Heritage. *North-East Sub-Regional Planning Framework, Perth and Peel @ 3.5 Million*. (2018).
52. Department of Planning and Urban Development. *Foothills Structure Plan, Final*. (1992).
53. Department of Planning & City of Swan. *Hazelmere Enterprise Area Structure Plan*. (2011).
54. Metropolitan Redevelopment Authority. *Midland Heritage Interpretation Strategy*. (2017).
55. Midland Redevelopment Authority. *Heritage Strategy for the Midland Central Redevelopment Area*. (2004).
56. Crisalis International Pty Ltd. *Midland Railway Workshops Site, Helena East Precinct: Review of Reports Relating to Hydrogeology of the Site and Potential Impacts of Groundwater Contaminants on the Helena River. Report to ATA Environmental for Midland Redevelopment Authority*. (2005).
57. Environmental Protection Authority. *Remediation of Midland Railway Workshops Site - Inquiry under Section 46 of the Environmental Protection Act 1986 to Amend Ministerial Statements 583, 612, 640 and 742*. (2019).
58. Environmental Protection Authority. *Remediation of Midland Railway Workshop Site, Helena West, Midland by the Midland Redevelopment Authority, Report and Recommendations of the Environmental Protection Authority, Bulletin 1111*. (2003).
59. Midland Redevelopment Authority. *Remediation of the Midland Railway Workshops Site Area B, D and D for the Proposed Police Operations Support Facility, Public Environmental Review* . (2001).
60. Environmental Protection Authority. *Remediation of the Midland Railway Workshops – Areas B, C and D for the Proposed Police Operations Support Facility Midland, Report and Recommendations, Bulletin 1057, Prepared for the Midland Redevelopment Authority*. (2002).
61. Ellis, N. & Smyth, C. *Midland Railway Workshops: A History in Pictures 1904-2004*. (St George Books, Osbourne Park, 2004).
62. Environmental Protection Authority. *Remediation of the Midland Railway Workshops Site, Clayton Precinct Area E, Midland, Report and Recommendations, Bulletin 1030, Prepared for the Midland Redevelopment Authority*. (2001).
63. Environmental Protection Authority. *Helena East Remediation and Redevelopment: Report and Recommendations*. (2006).
64. Midland Redevelopment Authority. *Helena East Precinct Remediation and Redevelopment: Public Environmental Review, Volume 1 and Volume 2 (Appendices), Version 3, Report No: 2005/142*. (2006).
65. Western Australian Legislative Assembly, E. and I. S. C. *Bellevue Hazardous Waste Fire Inquiry Volume 1, Report No. 1*. (2001).
66. Western Australian Legislative Assembly, E. and I. S. C. *Bellevue Hazardous Waste Fire Inquiry Volume 2, Report No. 2*. (2002).
67. Golder Associates. *Former Waste Control Site, Bellevue WA: Stakeholder Update Meeting Briefing Document, Prepared for Department of Environment and Conservation*. (2009).
68. Mundle, K. World-First PRB Remediation System. *Waste Management and Environment* 24, 49 (2013).
69. Landcorp. *Bellevue Cleanup Update*. (2018).
70. Department of Environment and Conservation. *Bellevue Community Update, November 2009*. (2009).
71. Department of Environment and Conservation. *Bellevue Community Update, March 2009*. (2009).
72. Department of Environment Regulation. *Bellevue Site - Clean Up, Contaminated Sites Fact Sheet 17*. (2013).
73. Department of Environment Regulation. *Bellevue Site - Groundwater Monitoring, Contaminated Sites Fact Sheet 18*. (2013).

74. Department of Environment Regulation. *Bellevue Site - Background and Risk, Contaminated Sites Fact Sheet 16*. (2013).

75. Golder Associates. *Construction Environmental Management Plan for Installation of Sequenced Permeable Reactive Barriers, Bellevue WA, Prepared for Landcorp*. (2010).

76. City of Swan. *Minutes of Ordinary Meeting of Council, 1 June 2022, C13.15 Cr Zannino - Proposed Realignment of National Freight Route*. (2022).

77. Department of Parks and Wildlife and Swan River Trust. *Swan Canning River Protection Strategy*. (2015).

78. Clark, C. Should Nature Have Rights? Orthodoxy and Innovation. *Law & Social Inquiry* 48, 1471–1476 (2023).

79. Barkham, P. Should rivers have the same rights as people? *The Guardian* (2021).

80. O'Donnell, E. The River's Voice. *The Association of Commonwealth Universities*.

81. Swan River Trust, Waterways Commission & Atkins, R. *Action for the Future: The Swan and Canning Rivers Cleanup Program*. (1995).

82. Swan River Trust & Water and Rivers Commission. *Swan-Canning Cleanup Program. The Catchment of the Swan-Canning River System.* (2001).

83. Department of Water & Department of Parks and Wildlife. *Helena River: Swan Canning Catchment Nutrient Report 2015*. (2017).

84. Department of Water and Environmental Regulation & Department of Biodiversity Conservation and Attractions. *Helena River: Swan Canning Catchment Nutrient Report 2017*. (2019).

85. Department of Water and Environmental Regulation & Department of Biodiversity Conservation and Attractions. *Helena River: Swan Canning Catchment Nutrient Report 2016*. (2019).

86. Department of Water & Swan River Trust. *Helena River: Swan Canning Catchment Nutrient Report 2011*. (2011).

87. Department of Water & Department of Parks and Wildlife. *Helena River: Swan Canning Catchment Nutrient Report 2014*. (2016).

88. Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality: Volume 1 The Guidelines, National Water Quality Management Strategy Paper No. 4*. (2000).

89. Storer, T., White, G., O'Neill, K., Galvin, L. & van Looij, E. *South-West Index of River Condition - Method Summary for the Assessment of River Health for South-West Western Australian Rivers, River Science Technical Series Report 1, Healthy Rivers Program*. (2020).

90. Beatty, S. J., Ryan, T. J., Summers, V. & Morgan, D. L. *Fish Response to Flow in the Lower Helena River. A Report to the Department of Biodiversity Conservation and Attractions.* (2020).

91. Wetland Research Management. *Lower Helena River, Ecological Condition Assessment 2018-2019, Unpublished Report to the Water Corporation*. (2019).

92. Conti, L., Wilke, S. & Koska, L. *Lower Helena Catchment Water Quality Study, Report No: SSB 01/91*. (1991).

93. Students of Environmental Management. *Environment and Recreation Study of the Lower Helena Water Catchment, Prepared for the Water Authority of Western Australia*. (1987).

94. Australian and New Zealand Governments and Australian State and Territory Governments. Australian and New Zealand Guidelines for Fresh and Marine Water Quality (online). https://www.waterquality.gov.au/anz-guidelines (2018).

95. Government of Western Australia. *Environmental Protection Act 1986*. (1986).

96. Department of Water and Environmental Regulation. *Guideline: Assessment and Management of Contaminated Sites*. (2021).

97. HEPA. *PFAS National Environmental Management Plan, Version 3.0*. (2025).

98. National Health and Medical Research Council. *Australian Drinking Water Guidelines Paper 6, National Water Quality Management Strategy, Version 3.8 (2011, Updated 2022)*. (2022).

99. World Health Organisation. *Petroleum Products in Drinking Water*. (2008).

100. United States Environmental Protection Agency. Regional Screening Levels - Generic Tables. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables (2024).

101. Department of Health. *Contaminated Sites Ground and Surface Water Chemical Screening Guidelines*. (2014).

102. Department of Health. *Guidelines for the Non-Potable Uses of Recycled Water in Western Australia*. (2011).

103. National Health and Medical Research Council. *Guidance on Per and Polyfluoroalkyl Substances (PFAS) in Recreational Water*. (2019).

104. Australian and New Zealand Governments. *Draft Australian & New Zealand Guidelines for Fresh and Marine Water Quality: Livestock Drinking Water Guidelines*. (2023).

105. Oceanica Consulting Pty Ltd. *Evaluation of the Swan Canning Cleanup Program Action Plan, Final Evaluation Reports, Part A: Key Evaluation Findings, Report No. 394/6 and Part B: Supporting Information, Report No 394/7. Prepared for the Swan River Trust*. (2005).

106. City of Kalamunda. *Notice of Determination on Application for Planning Approval, Lot 3 (415) Mundaring Weir Road, Piesse Brook*. (2020).

107. Bibbul Ngarma Aboriginal Association & Evergreen Consultancy WA. *BoorYul-Bah-Bilya (Mandoon Bilya – Helena River) Baseline Water and Sediment Sampling: Sampling and Analysis Plan, Ref: BBB-MBHR-BWQS-001*. (2024).

108. Department of Environmental Regulation. *Interim Guideline on the Assessment and Management of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS): Contaminated Sites Guidelines*. (2016).

109. Department of Biodiversity Conservation and Attractions. *Swan Canning Catchment Sampling and Analysis Plan, Rivers and Estuaries Science*. (2022).

110. Department of Water and Environmental Regulation. *Swan Canning Water Quality Improvement Plan (Project: SG-C-SCWQIP), Sampling and Analysis Plan, TRIM File No: WT9835, Aquatic Science Branch*. (2018).

111. Department of Water and Environmental Regulation. *Swan and Canning River Catchment Water Quality Monitoring Program (Project: SG-C-SWANCATCH), Sampling and Analysis Plan, TRIM File No: WT895, Water Science Branch*. (2018).

112. Department of Water. *Field Sampling Guidelines: A Guideline for Field Sampling for Surface Water Quality Monitoring Programs*. (2009).

113. Department of Water. *Surface Water Sampling Methods and Analysis - Technical Appendices: Standard Operating Procedures for Water Sampling - Methods and Analysis*. (2009).

114. Department of Water. *Water Quality Monitoring Program Design: A Guideline to the Development of Surface Water Quality Monitoring Programs*. (2009).

115. CSIRO. *Handbook for Sediment Quality and Assessment*. (2005).

116. University of Western Australia. Kangaroo paw's poisonous past. *https://www.news.uwa.edu.au/archive/201106223672/research/kangaroo-paws-poisonous-past/* (2011).

117. Department of Planning. *Middle Helena Catchment Area: Land Use and Water Management Strategy*. (2010).

118. Department of Planning Lands and Heritage. *Draft State Planning Policy 2.9 Planning for Water*. (2021).

119. Department of Water. *Mundaring Weir Catchment Area, Drinking Water Source Protection Plan, Report No 69*. (2007).

120. Department of Water and Environmental Regulation. *Operational Policy 13: Recreation within Public Drinking Water Source Areas on Crown Land*. (2019).

121. Department of Water and Environment Regulation. *Water Quality Information Sheet 39, Aboriginal Customary Activities in Public Drinking Water Source Areas in the South West Native Title Settlement Area*. (2019).

122. Trility. *Mundaring Water Treatment Project: Achieving and Securing Future Water Needs*. (2020).

123. Department of Water. *Operational Policy 4.3, , Identifying and Establishing Waterways Foreshore Area*. (2012).

124. Department of Water and Environmental Regulation. *Waterwise Perth Action Plan 2: Kep Katitjin Gabi Kaadadjan - Growing Waterwise Communities in Boorloo (Perth) and Bindjareb (Peel) to Address Climate Change*. (2022).

125. Department of Biodiversity Conservation and Attractions. *Planning for Localities along the Swan Canning Development Control Area - Draft for Public Comment*. (2022).

126. Hassell Ltd. *Swan and Helena Rivers Management Framework Report*. (2007).

127. Latitude Creative Services, Heritage and Conservation Professionals & National Trust (WA). *Swan and Helena Rivers Management Framework: Heritage Audit and Statement of Significance, Prepared for the Eastern Metropolitan Regional Council*. https://www.emrc.org.au/Profiles/emrc/Assets/ClientData/Documents/Page_Content/Environmental_Services/Swan_Helena/Heritage-Audit-and-Statement-of-Significance-Report.pdf (2009).

128. Eastern Metropolitan Regional Council. *Eastern Catchment Management Plan 2012-2022*. (2012).

129. Eastern Metropolitan Regional Council. Story Map: Swan and Helena Rivers Floodplain Development Strategy. https://www.arcgis.com/apps/MapJournal/index.html?appid=c93ca8893b584e06976bbb35ce502c6a (2020).

130. Transplan Pty Ltd. *Swan and Helena Rivers Regional Recreational Path, Development Plan Prepared for Eastern Metropolitan Regional Council*. (2009).

131. Stephens, D. *Swan and Helena Rivers Flood Study: Hydrology. Prepared for Eastern Metropolitan Regional Council*. (2016).

132. Nathan, R. *Swan and Helena Rivers Flood Study, Review of HARC Draft Report for the Eastern Metropolitan Regional Council*. (2016).

133. Eastern Metropolitan Regional Council. *Understanding and Managing Flood Risk in Perth's Eastern Region, Final Project Report*. (2016).

134. Department of Biodiversity, C. and A. & Conservation and Parks Commission. *Forest Management Plan 2024-2033*. (2023).

135. Milne, P. Alcoa mining threatens Perth's drinking water. *WA Today* (2023).

136. Thompson, B. WA Premier warns Alcoa over threat to drinking water. *Australian Financial Review* (2023).

137. Environmental Protection Authority. *Bauxite Mining in the Darling Range, Western Australia*. (1978).

Appendix 1 Mandoon Catchment Management

Under the South West Native Title Settlement 2021, Noongar people are recognised as Traditional Owners of southwest WA through six Indigenous Land Use Agreements (ILUAs). The Whadjuk ILUA covers most of Mandoon catchment except the river's headwaters which fall under the Ballardong and Gnaala Karla Booja ILUAs. In 2022, the Whadjuk, Ballardong and Gnaala Karla Booja Aboriginal Corporations were appointed to represent the ILUAs. The settlement includes opportunities for co-management of conservation land with DBCA and creation of the Noongar Land Estate, with up to 320,000 hectares to be held by the Noongar Boodja Trust. Large areas of the Middle Mandoon are earmarked for potential transfer to the Estate

Planning authorities, such as the Western Australian Planning Commission (WAPC), Department of Planning, Lands and Heritage (DPLH), local governments and redevelopment authorities (e.g. DevelopmentWA), administer the *Planning and Development Act 2005*. Authorities seek advice on water resources and waterways from relevant government departments e.g. DWER and DBCA. Planning in the Mandoon Catchment is administered by six local planning schemes (Mundaring, Swan, Kalamunda, York, Beverley and Northam) and decisions are impacted by different knowledge levels and motivations of local government councillors.

In 2010, DPLH released the *Middle Helena Land Use and Water Management Strategy*[117] to combine land use planning, management and water protection in the middle catchment (upper and lower excluded). The *Draft State Planning Policy 2.9 Planning for Water*[118] and its guidelines apply to land planning decisions that may impact the river. DPLH also manage the river's heritage values including the Helena River Aboriginal Heritage Site under the Aboriginal Heritage Act 1972.

The WAPC acquires and manages land on the Lower Mandoon foreshore for parks and recreation under the *Metropolitan Region Scheme 1963*, including large areas in Midland, Hazelmere, Guildford and Woodbridge. DevelopmentWA is responsible for developing areas of the foreshore for public use under the *Metropolitan Redevelopment Act 2011*, including the former Midland Railway Workshops.

Water resources in WA are protected and managed under six separate management acts. Through one of these acts, the *Water Agencies (Powers) Act 1984*, the Department of Water and Environmental Regulation (DWER) leads water resources management by coordinating cross-government efforts. A Water Reform Bill was proposed in 2006 to consolidate and update the six separate pieces of legislation that govern WA's water resources but this was abandoned in December 2023.

DWER manage parts of the Mandoon catchment for public drinking water supply through the *Mundaring Weir Catchment Area Drinking Water Source Protection Plan*[119] and *Operational Policy 13, Recreation in Public Drinking Water Source Areas (PDWSA)*[120]. PDWSA are managed under the *Country Areas Water Supply Act 1947* and *Metropolitan Water Supply, Sewerage and Drainage Act 1909*. Noongar Traditional Owners have controlled access to heritage sites in PDWSA for cultural activites[121].

Management is shared with Water Corporation, a water service provider of public drinking water, wastewater and drainage which operates the river's dams and drinking water infrastructure under license conditions. This includes water releases from the Lower Pumpback Dam to maintain stream habitat. A global infrastructure company, Acciona, operates the 165 ML/day water treatment plant at the Weir and supplies treated water to Water Corporation[122].

DWER have a role in approving water management strategies that accompany planning proposals adjacent foreshore areas where development may impact waterways, consistent with *Operational Policy 4.3, Identifying and Establishing Waterways Foreshore Areas*[123]. DWER also manages water and environmental regulation (e.g. vegetation clearing, industry licences, permits and approvals), urban water management and building waterwise communities[124].

DWER coordinate the *Healthy Rivers* program which collects data and develops collaborative solutions to improve river health. There are two *Healthy Rivers* sites on the Mandoon: 'Mundaring Weir Downstream - HRDSMW' in the middle catchment and 'Whiteman Road – SWN10' in the lower, both of which were last assessed by DWER in November 2012. The 2012 assessments used standard methods from the South West

Index of River Condition[89] including fish, crayfish and macroinvertebrate presence, aquatic habitat, water quality (dissolved oxygen, temperature, conductivity, pH, colour, alkalinity, turbidity and nutrients), fringing vegetation, channel morphology, erosion, connectivity, local land use and water flow. There is very little public information on the assessment results and consultation with DWER's River Science team indicates that they have not prepared Condition Summaries for the sites.

The Department of Health (DOH) regulates the quality of drinking water in WA in accordance with guidance set out in the Australian Drinking Water Guidelines[98]. These guidelines are published by the National Health and Medical Research Council, Australia's peak public health policy organisation, and are designed to provide an authoritative reference on what defines safe, good quality water, how it can be achieved and how it can be assured. Scheme suppliers, such as Water Corporation, must manage and monitor their systems and report the results to the DOH in accordance with agreed protocols. The Advisory Committee for the Purity of Water is a non-statutory inter-departmental committee that operates under the DOH. The Committee has been monitoring the quality of drinking water in WA since 1925, and also recommends improvements in monitoring and management protocols to the Ministers responsible for Health and Water Resources.

The Department of Biodiversity, Conservation and Attractions (DBCA) manages state forest and conservation estate along the river under the *Conservation and Land Management Act 1984 (CALM Act)*. There are no individual management plans for the river's six national parks (Beelu, Gooseberry Hill, Greenmount, Helena, Kalamunda, Wandoo).

DBCA also manage the Lower Mandoon downstream of the Pumpback Dam under the *Swan and Canning Rivers Management Act 2006* and *Swan Canning River Protection Strategy 2015*[77]. Under the Act, the Riverbed (River Reserve) is vested in DBCA and the Riverpark (crown land along the river) is jointly managed by DBCA and the foreshore manager who include local government, other state government agencies and private land owners. The CALM Act established the *Swan Canning Development Control Area (DCA)* for which DBCA is the primary planning authority. In 2022, DBCA released a draft Planning Policy for the DCA, including the Lower Helena 'Mandoon' area[125]. The Swan River Trust is an advisory body under the Act.

The Swan Canning Water Quality Monitoring Program is a long term routine monitoring program that assists the DBCA with managing the Swan Canning Estuary which includes the Lower Mandoon locality up to the Lower Pumpback Dam. The program provides regular reporting on water quality and catchment compliance against short and long term nutrient management targets from the *Swan-Canning Cleanup Program*[81,82] and/or the ANZECC guidelines for aquatic ecosystems[88]. Key analytes measured include nitrogen, phosphorus, dissolved organic carbon, suspended solids, dissolved oxygen, pH, temperature and specific conductivity. There is one sampling site on the Mandoon: 'Whiteman Road – HELENR' located in the same location as the DWER 'Whiteman Road – SWN10' site. Data is shared with DWER for input into the Water Information Reporting platform : (https://wir.water.wa.gov.au/Pages/Water-Information-Reporting.aspx).

DBCA is also responsible for biodiversity and threatened flora, fauna and ecological communities in accordance with the *Biodiversity Conservation Act 2016* and support community on-ground action and strategic initiatives in the catchment via the Eastern Region Landcare Program (ERLP), the Swan Alcoa Landcare Program (SALP) and Community Rivercare grants. The ERLP coordinates landcare by state and local government and community groups in Perth's Eastern Region. This includes the catchments of Mandoon-Helena River, Jane Brook, Susannah Brook, Blackadder-Woodbridge Creek and Wooroloo Brook. ERLP was hosted by the Eastern Metropolitan Regional Council (EMRC) until 2021 and Perth NRM until 2023. DBCA are currently exploring future ERLP delivery models with the community. Under EMRC, ERLP delivered the *Swan and Helena River Management Framework 2007*[126], the *Swan and Helena Rivers Heritage Audit & Statement of Significance* 2009[127], the *Eastern Catchment Management Plan 2012-2022*[128], the *Swan and Helena Rivers Floodplain Development Strategy 2020*[129] and various flood, ecology and recreation plans[130–133].

The Forest Products Commission (FPC) manages and develops WA's forest industry including plantation and native forest on state government land. In the Mandoon catchment, this includes Greenmount and Mundaring State Forests. The FPC work under the *Forest Products Act 2000* and the *WA Forest Management Plan 2024-2033*[134] which was produced by DBCA. The plan aims for a significant reduction in native forest logging although it excludes clearing for mining.

The Department of Mines, Industry Regulation and Safety (DMIRS) regulates mining including environmental compliance and management. Sand mining occurs in the Upper Mandoon although the catchment has largely avoided, thus far, the extensive clearing associated with bauxite strip mining which has impacted the wider southwest forests[135,136]. Parts of the Mandoon catchment are within Alcoa and other mining lease areas[137].

The Department of Primary Industries and Regional Development (DPIRD) administer the *Fish Resources Management Act 1994* under which it is illegal to capture freshwater fish and crayfish without a licence. A south-west freshwater angling licence is required in waters south of Greenough and above the tidal influence including all lakes, dams, rivers and streams. A separate licence and rules apply to marron. Fishing is banned in drinking water supply catchments. DPIRD undertake surveillance, monitoring and, where possible, eradication of aquatic pests. They manage Freshwater Fish Distribution in WA, an interactive online website, and FishWatch, a 24 hour hotline for reporting aquatic pests, illegal fishing and fish kills. DPIRD are the state coordinator for fish kills, including response to ocean fish kills, although DWER manage kills in estuaries, rivers and inland water bodies and DBCA manage kills specifically in the Swan Canning system, which includes the Lower Mandoon locality up to the Lower Pumpback Dam.

Appendix 2 Sampling Procedures

Sampling will be undertaken in the following order:

1. Sampling for chemical analysis.
2. Measurement of physiochemical parameters.
3. Any other measurements and samples (i.e. stream width, macroinvertebrate presence etc).

Sampling will be undertaken in accordance with the following procedures.

General Sampling Procedures

Complete the sample documentation and field record sheets during the sampling. Chain of custody forms are required to keep track of samples from the field to the laboratory.

Wear a new pair of powder-free, disposable nitrile gloves at all times at each site whilst sampling. Once sampling has been completed at each site, the gloves must be disposed of in the designated bin bag to avoid cross contamination between different sites and contamination from suncream etc. Latex and PVC gloves are not suitable for sampling.

Always use laboratory supplied sample bottles.

Don't remove the lid from the sample bottle until just before the sample is to be taken and replace the lid immediately afterwards. Never put the lid on the ground as this increases contamination risk.

Do not touch the inside of sample collection vessels (e.g., grab pole sampler), sample bottles or lids with bare hands or other sampling equipment.

Certain parameters require direct collection into the sample bottle (with no transfer allowed) including PAHS, TRH, PFAS and various pesticides and herbicides.

Sample bottles should not be pre-rinsed when sampling for metals, TOC, BTEX, PFAS and VOCs. This includes any sample bottles containing acid preservatives.

Fill sample bottles slowly and down the side edge to the specified level. Slow filling is essential to prevent splash back of corrosive and toxic chemicals and loss of preservatives.

In some cases, the sample bottle must be filled to the top, as the existence of an air space may affect the sample, including samples collected for the analysis of TRH, BTEX and VOCs. Samples that need to be filled completely, to exclude all air space, must never be frozen.

All other sample bottles should be filled to just below the shoulder of the bottle (~80% of capacity) to leave an airspace which will allow for freezing.

Store and transport the samples as specified. Most samples require storage at 1-4 °C and to be kept cool using ice bricks or ice (refrigeration), however, samples for amoeba should not be chilled and should be kept at ambient temperature.

Samples must be received by the laboratory within the maximum holding time for the parameter to be analysed, allowing enough time within the holding time for the laboratory to process the sample.

Samples that require filtration should be filtered as soon as possible after sample collection. Take care never to handle the filter paper. Filter papers should never be reused.

If in any doubt about any aspect of sample collection, treatment, storage or analysis for particular parameters, then consult the analytical laboratory for up-to-date advice/techniques.

Water Sampling for Chemical Analysis

Water samples will be collected by direct sampling or grab pole sampling as follows:

1. Ensure that labelling on the bottle to be filled is correct and that the sample number matches the number on the paperwork (field record sheets and chain of custody form).

2. Take the sample from the bank, or wade into the water in waders or wellington boots, minimising disturbance as much as possible.

3. When filling the bottle (both for rinsing and for the final sample) take the sample upstream and to the side of you. Collect samples from just below the surface, avoiding any surface scum and debris.

4. Uncap the bottle to be filled, immerse the bottle in the water (depth of ~15 cm) lying it flat with its mouth towards the flow of the water, then slowly move the bottle forwards into the flowing water.

5. If the bottles contain preservatives, they must not be rinsed and should be filled by decanting from another rinsed bottle. Be careful when filling to prevent splash back.

6. If rinsing is required, allow approximately 20 mL of water to enter the bottle. Cap, shake well and pour the rinsate out downstream. Repeat twice so the bottle is rinsed three times (if required).

7. Fill the bottle, again upstream and to the side of yourself at a depth of ~15 cm, moving it slowly forwards through the water to the required level.

8. Cap tightly and store the sample bottle as required for transport to the laboratory.

Filtering Water Samples

Some water samples should be filtered in the field using either a portable filter station or a disposable filter and syringe supplied by the laboratory. A filter and syringe was used for this sampling event, as follows:

1. Preferably filter the samples on a level surface (e.g. back of a ute tray). Avoid duty conditions and rain: in both cases use the lid to cover the top funnel while filtering.

2. Always wear nitrile gloves for all filtering.

3. Homogenise your sample gently before filtering.

4. Fill the syringe with sample water.

5. Carefully pick up the filter, making sure not to touch the centre and that nothing is stuck to it, and screw the syringe onto the filter.

6. Slowly close the syringe to push the water through the filter and fill the sample bottle.

7. Cap tightly and store the sample bottle in an esky on ice-bricks.

Sediment Sampling for Chemical Analysis

Sediment samples will be collected by direct sampling or sediment tube sampling as follows:

1. Ensure that labelling on the container to be filled is correct and that the sample number matches the number on the paperwork (field record sheets and chain of custody form).

2. Take the sample from the bank, or wade into the water in waders or wellington boots, minimising disturbance as much as possible.

3. Take the sediment sample from upstream and to the side of you. Collect samples from the surface sediment, avoiding any vegetation, rocks, gravel and debris.

4. Uncap the container to be filled.

5. Push the container on an angle into the sediment of the riverbed to a depth of ~5 cm and slowly move forwards into the direction of the current to fill with sediment.

6. Whilst the container is still under the water, replace the lid and close tightly.

7. Store the sample container as required for transport to the laboratory.

Measurement of Physiochemical Parameters

Measurement

Physiochemical parameters will be measured using the following process:

1. Remove the protective, water filled cap.

2. Turn on the YSI Pro DSS handheld unit.

3. Lower the clean and calibrated Pro DSS into the water near or at the same site where water samples were taken. Take care to minimise sediment disturbance if you have to enter the water.

4. Ensure that all probes are fully submerged in the water. In shallow water, the probe may need to be held on an angle. Ideally the probes should be ~10cm under the water surface, but this may not be possible in shallow waters, and not within ~10cm of sediments. If the water is very shallow, place the probes in the middle of the water column and kept them in a gentle motion while taking care not to stir up the sediments.

5. Allow sufficient time for the probe to stabilise (minimum of two minutes).

6. Press enter to log the measurements and then record the readings on the field record sheet. Results should be stored electronically on the instrument as well as the field record sheet as a back-up in case the electronic file is corrupted. Include the date and time of sampling in the record.

7. When back at the car, store the sonde back in its protective water filled casing.

Take care when handling and transporting the water quality parameter meter as they are delicate and can easily be damaged.

Calibration of the water quality parameter is critical to ensure the accuracy and precision of the probes and the physiochemical data you collect. It allows you to verify the data and ensure it can be used with confidence. Daily calibration is required each day before you go out into the field and as soon as you return from sampling. You should keep a written record of these calibrations.

Calibration Process

The YSI Pro DSS unit will be calibrated using the following process:

Conductivity:

1. Rinse calibration cup and probes with a small amount of 1413uS/cm solution three times.

2. Fill calibration cup with 1413uS/cm conductivity so that the solution is above the vent holes of sensor, then place probes into calibration cup and allow readings to stabilise.

3. Once stable, press 'Cal', then select Conductivity → Sp Conductance → SPC mS/cm.

4. Using the arrow keys select 'Calibration Value' and enter 1.413 using the arrow keys, then Enter.

5. Select 'Accept Calibration' – this will correct your reading to 1.413mS/cm.

6. Empty standard solution into container labelled 'Post Check 1.413mS/cm solution.

pH (2 point):

1. Rinse calibration cup and probes with a small amount of pH 7 solution three times.

2. Fill calibration cup with pH 7 solution so that the probes are fully immersed, then place probes into calibration cup and allow readings to stabilise.

3. Once stable, press 'Cal', then select pH.

4. Select ‘Accept Calibration’ – pH is automatically adjusted due inbuilt temperature compensation.

5. At the bottom of the screen will ready ‘Ready for point 2’.

6. Empty pH 7 solution into container labelled ‘Post Check pH 7’.

7. Rinse calibration cup and probes with a small amount of pH 10 solution three times.

8. Fill calibration cup with pH 10 solution so that the probes are fully immersed, then place probes into calibration cup and allow readings to stabilise.

9. Select ‘Accept Calibration’.

10. At the bottom of the screen, will ready ‘Ready for point 3’.

11. Repeat above steps for third calibration point (pH 10 solution). If undertaking a two-step process, press ‘Cal’ to finish.

12. Rinse calibration cup and probes with tap water.

Dissolved oxygen:

1. Gently remove any moisture from the DO cap and temperature probes with a cotton bud.

2. Place 1 cm of tap water in the bottom of the calibration cup (ensure probe is not immersed).

3. Screw the lid partially on to allow the DO probe to be vented to the atmosphere (1-2 threads).

4. Allow a few minutes for the readings to stabilise.

5. Press ‘Cal’, then select DO → DO %.

6. When stable select ‘Accept Calibration’ – this will correct your readings to 100.0%

After calibration, wash the calibration cup with tap water and fill with 3 cm of water for storage. Ensure cables are clean and near for the next use and enter the details into the Field Record Sheets.

Appendix 3 Procedures for PFAS Sampling

Cross contamination is a significant risk in the sampling for PFAS in surface waters and sediment. To avoid this, the protocols developed by DWER in the *Interim Guideline on the Assessment and Management of PFAS*[108] will be strictly adhered to during all PFAS sampling and laboratory processing.

- Sun cream must not be worn. Physical barriers will be used instead i.e. long sleeved shirt, face and neck sleeve, wide brimmed hat, long pants and nitrile gloves
- All clothing must be more than six washes old.
- Hand creams, moisturisers and make up must not be worn.
- Plastic or foil packaged food or drink with a non-stick internal barrier is not allowed.

Sampling

1. Before sampling commences, samplers will be assigned roles: one person will be the sample collector and the other will be assigned the "clean-hands" role.

2. At the start of each sampling day, both samplers will wash their hands and forearms with soap, then PFAS free deionised water, then dry their hands with a clean paper towel and put on clean nitrile gloves.

3. At each site and before sample collection, the clean hands sampler will put on new nitrile gloves and then provide the sample collector with clean nitrile gloves and a sample bottle (HDPE with no PFTE liner provided by the laboratory).

4. When samples are collected on foot, the sampler will enter the water downstream of the intended sampling location and walk slowly into the flow.

5. Once at the desired location, the sampler will submerge the sample bottle into the water, cap first. When fully submerged the bottle will be faced into the direction flow and the cap removed to allow the bottle to fill.

6. Before the bottle is removed from the water, the cap will be screwed on tightly.

7. The sampler will return the sample to the clean hands sampler, who will dry the bottle with a clean paper towel.

8. The sample collector will then remove their gloves, wash their hands with deionised water, dry them with a clean paper towel and put on a new pair of gloves.

9. The sample bottle will be double bagged (in food grade snap-lock HDPE bag) and stored in a clean esky on double bagged ice.

10. The nitrile gloves will then be worn whilst travelling to the next site.

Appendix 4 Field Observations and Results by Location

Name	**Helena Swan**
Watercourse	Mandoon Bilya – Helena River
Location	-31.89708, 115.9858, immediately upstream of Bushmead Rd bridge
WIR Ref	6161091 is located 76 m upstream
LGA	City of Swan
Rationale	Downstream site not tidally influenced by Derbarl Yerrigan, downstream of former Bellevue Hazardous Waste Facility and Midland workshops, near BNAA 2023 eDNA site on Riverbank Bld.
Elevation	19.9 m AHD
Field Parameters	Conductivity 1,095 uS/cm; dissolved oxygen 55%; salinity 550 ppm; pH 6.76, redox 131 mV; TDS 712 mg/L; turbidity 17.6 NTU

Field Observations

- Flowing water, brown and orange colour, no sheen or floating debris.
- Many weeds on banks e.g. fumitory, grassy weeds, arum lily, bamboo, possible aquatic weeds.
- Some native vegetation e.g. river gums, melaleuca sp.
- No visible fish, frogs, tadpoles and no frog noises. Bubbles observed from the river bed when taking sample.
- Many mosquitoes, no other visible insects, lots of footprints (birds, dog/fox/cat?).
- Difficult access, steep slope from Bushmead Rd, tall grassy weeds and trip hazards. Much litter on banks.

Water Results

- Metals, nutrients, surfactants and microbes detected above the limit of reporting (LOR).
- Pesticides, herbicides, hydrocarbons, volatile organics and PFAS compounds not detected.

Water – Human Health DGV Exceedances

- Ammonia at 0.02 mg/L above a recreation DGV of 0.01 mg/L.
- Dissolved solids at 700–712 mg/L (lab-field) above a drinking water aesthetic DGV of 600 mg/L.
- *E. coli* at 130 CFU/100ml above a drinking water DGV of 'detection' and non-potable/recreation DGV of 1 CFU/100ml.
- *Enterococci* at 160 CFU/100ml above a drinking water DGV of 'detection' and recreation DGV of 60-100 CFU/100ml.
- Iron at 4.6 mg/L above a drinking water aesthetic, non-potable and recreation DGV of 0.3 mg/L.
- Manganese at 0.13 mg/L above a drinking water aesthetic and recreation DGV of 0.1 mg/L.
- MBAS at 0.3 mg/L above a recreation DGV of 0.2 mg/L
- Turbidity at 17.6–18 NTU (field–lab) above a drinking water aesthetic and non-potable DGV of 5 mg/L.

Water – Primary Industries DGV Exceedances

- Chloride at 230 mg/L above an agricultural irrigation LTV and STV of 175 mg/L.
- Dissolved solids at 700–712 mg/L (lab-field) above a stock watering DGV of 500 mg/L.
- *E. coli* at 130 CFU/100ml above an agricultural irrigation LTV and STV of 10 mg/L and a stock watering DGV of 100 CFU/100ml.
- *Enterococci* at 160 CFU/100ml above a stock watering DGV of 100 CFU/100ml.
- Iron at 4.6 mg/L above an agricultural irrigation LTV of 0.2 mg/L.
- Sodium at 140 mg/L above an agricultural irrigation LTV and STV of 115 mg/L.
- Total phosphorous at 0.06 mg/L above an agricultural irrigation LTV of 0.005 mg/L.

Water – Freshwater Ecosystem DGV Exceedances

- Aluminium at 0.14 mg/L above a freshwater DGV of 0.027 mg/L.
- Conductivity at 1,095–1,200 uS/cm (field–lab) above a freshwater DGV of <120-300 uS/cm.
- Copper at 0.001 mg/L at a freshwater DGV of 0.001 mg/L.
- Dissolved oxygen at 54.8% above a freshwater DGV of >80%.
- *E. coli* at 130 CFU/100ml above wastewater effluent criteria of 10 CFU/100ml.
- Iron at 4.6 mg/L above a freshwater DGV of 0.3 mg/L.
- Nitrate at 0.17 mg/L above a freshwater DGV of 0.017 mg/L.
- Total oxidised nitrogen (nitrate+nitrite as NOx-N) at 0.18 mg/L above a freshwater DGV of 0.15 mg/L.
- Total nitrogen at 1.2 mg/L at a freshwater DGV of 1.2 mg/L and above the Swan Canning target of 1 mg/L.
- Total phosphorous at 0.06 mg/L above a freshwater DGV of 0.065 mg/L.
- Uranium at 0.001 mg/L above a freshwater DGV of 0.0005 mg/L.
- Zinc at 0.005 mg/L above a freshwater DGV of 0.0024 mg/L.

Sediment Results

- Metals and nutrients detected above the LOR.
- Pesticides, herbicides, hydrocarbons, surfactants, volatiles and PFAS compounds not detected.

Sediment – Sediment Quality DGV Exceedances

- No exceedances of the DGV, although limited DGV exist to enable screening.

Helena Swan Standing under Bushmead Rd bridge looking upstream at sample site

Helena Swan Immediately downstream of Bushmead Rd bridge looking downstream to Riverbank Reserve

Name	**Whiteman Rd**
Watercourse	Mandoon Bilya – Helena River
Location	-31.9000, 116.0075, at site of former Whiteman Rd bridge
WIR Ref	616086
LGA	City of Swan
Rationale	DBCA & DWER sampling site, downstream of Hazelmere industrial estate
Elevation	26.3 m AHD
Field Parameters	Conductivity 1,176 uS/cm; dissolved oxygen 56%; salinity 590 ppm; pH 6.64, redox 159 mV; TDS 764 mg/L; turbidity 14.7 NTU

Field Observations

- Flowing water, brown and yellow colour, no sheen or floating debris.
- Many weeds on banks e.g. grassy weeds, arum lily, blackberry, fig, wavy gladioli, oxalis, castor oil, eastern states wattles, possible aquatic weeds. Some native vegetation e.g. large river gums, bulrushes.
- No visible fish, frogs, tadpoles and no frog noises. Bubbles observed from river bed when taking sampling.
- Loud insects, possibly crickets/cicada. Many dragonflies, butterflies, galahs, 28 parrots, wardongs (ravens), a blue wren, unidentified birds and 4 guinea fowl.
- Much litter, fly-tipped commercial waste, drums, tyres, concrete, barbed wire fence, green waste.
- Moderately easy to access from Whiteman Rd, some rough ground and trip hazards.

Water Results

- Metals, nutrients, surfactants, microbes and PFAS compounds detected.
- Pesticides, herbicides, hydrocarbons and volatile organics not detected above the LOR.

Water – Human Health DGV Exceedances

- Ammonia at 0.13 mg/L above a recreation DGV of 0.01 mg/L.
- Chloride at 300 mg/L above a drinking water aesthetic and non-potable DGV of 250 mg/L.
- Dissolved solids at 760–764 mg/L (lab-field) above a drinking water aesthetic DGV of 600 mg/L.
- *E. coli* at 140 CFU/100ml above a drinking water DGV of 'detection' and non-potable/recreation DGV of 1 CFU/100ml.
- *Enterococci* at 53 CFU/100ml above a drinking water DGV of 'detection'.
- Iron at 3.8 mg/L above a drinking water aesthetic, non-potable and recreation DGV of 0.3 mg/L.
- Manganese at 0.12 mg/L above a drinking water aesthetic and recreation DGV of 0.1 mg/L.
- MBAS at 0.4 mg/L above a recreation DGV of 0.2 mg/L.
- Turbidity at 10–14.7 NTU (lab-field) above a drinking water aesthetic and non-potable DGV of 5 mg/L.

Water – Primary Industries DGV Exceedances

- Chloride at 300 mg/L above an agricultural irrigation LTV and STV of 175 mg/L.
- Dissolved solids at 760–764 mg/L (lab-field) above a stock watering DGV of 500 mg/L.
- *E. coli* at 140 CFU/100ml above an agricultural DGV of 10 CFU/100ml and a stock watering DGV of 100 CFU/100ml.
- Iron at 3.8 mg/L above an agricultural irrigation LTV of 0.2 mg/L.
- Sodium at 160 mg/L above an agricultural irrigation LTV and STV of 115 mg/L.

Water – Freshwater Ecosystem DGV Exceedances

- Boron at 0.09 mg/L at a freshwater DGV of 0.09 mg/L.
- Conductivity at 1,176–1,300 uS/cm (field-lab) above a freshwater DGV of <120-300 uS/cm.
- Dissolved oxygen at 56.5% above a freshwater DGV of >80%.
- *E. coli* at 140 CFU/100ml above wastewater effluent criteria of 10 CFU/100ml
- Fluoride at 0.3 mg/L above a freshwater DGV of 0.29 mg/L.
- Iron at 3.8 mg/L above a freshwater DGV of 0.3 mg/L.
- Nitrate at 0.23 mg/L above a freshwater DGV of 0.017 mg/L.
- Total oxidised nitrogen (nitrate+nitrite as NOx-N) at 0.21 mg/L above a freshwater DGV of 0.15 mg/L.
- PFOS at 0.041 ug/L above a freshwater DGV of 0.00023 ug/L.
- Uranium at 0.002 mg/L above a freshwater DGV of 0.0005 mg/L.
- Zinc at 0.006 mg/L above a freshwater DGV of 0.0024 mg/L.

Sediment Results

- Pesticides, hydrocarbons, metals, nutrients and surfactants detected.
- Herbicides, volatiles and PFAS compounds not detected above the LOR.

Sediment – Sediment Quality DGV Exceedances

- TRH C10-C40 at 335 mg/kg above a DGV of 280 mg/kg.
- Mercury at 0.23 mg/kg above a DGV of 0.15 mg/kg.
- Naphthalene at 0.7 above a DGV of 0.16 mg/kg.

Whiteman Rd Standing at location of former Whiteman Rd bridge, looking upstream

Whiteman Rd Standing at location of former Whiteman Road bridge, looking downstream

Name	**Helena Roe**
Watercourse	Mandoon Bilya – Helena River
Location	-31.90541, 116.0160, immediately upstream of Military Rd bridge (moved 83 m downstream of proposed site due to access constraints – construction fence)
WIR Ref	6167030 is located 83 m upstream
LGA	City of Swan – Shire of Mundaring boundary
Rationale	At COS-SOM boundary, adjacent former Bellevue Hazardous Waste Facility, Helping the Helena sampling site, previously detected low pH and elevated metals.
Elevation	27.4 m AHD
Field Parameters	Conductivity 1,128 uS/cm; dissolved oxygen 59%; salinity 560 ppm; pH 6.73, redox 106 mV; TDS 733 mg/L; turbidity 17.8 NTU

Field Observations

- Flowing water, brown and orange colour, no sheen or floating debris, eroded banks.
- Many weeds on banks e.g. grassy weeds, bamboo, oxalis, castor oil, possible aquatic weeds.
- Some native vegetation e.g. large river gums.
- Many mosquitoes, no other visible insects. Wardongs (ravens).
- No visible fish, frogs, tadpoles and no frog noises. Bubbles observed from river bed when taking sample.
- Very neglected and degraded, much litter, plastic, traffic cones, construction fencing on floor.
- Difficult access, requires climbing down bank, through tall weeds and over trip hazards.
- Bridge works in process (shoring up), river fenced off with construction fencing.

Water Results

- Metals, nutrients, surfactants, microbes and PFAS compounds detected.
- Pesticides, herbicides, hydrocarbons and volatile organics not detected above the LOR.

Water – Human Health DGV Exceedances

- Ammonia at 0.12 mg/L above a recreation DGV of 0.01 mg/L.
- Chloride at 250 mg/L at a drinking water aesthetic and non-potable DGV of 250 mg/L.
- Dissolved solids at 710–733 mg/L (lab-field) above a drinking water aesthetic DGV of 600 mg/L.
- *E. coli* at 240 CFU/100ml above a drinking water DGV of 'detection' and non-potable/recreation DGV of 1 CFU/100ml.
- *Enterococci* at 120 CFU/100ml above a drinking water DGV of 'detection' and recreation DGV of 60-100 CFU/100ml.
- Iron at 3.8 mg/L above a drinking water aesthetic, non-potable and recreation DGV of 0.3 mg/L.
- Manganese at 0.12 mg/L above a drinking water aesthetic and recreation DGV of 0.1 mg/L.
- MBAS at 0.3 mg/L above a recreation DGV of 0.2 mg/L.
- PFHxS+PFOS at 0.072 ug/L above a drinking water and non-potable DGV of 0.07 ug/L.
- Turbidity at 17.8–19 NTU (field-lab) above a drinking water aesthetic and non-potable DGV of 5 mg/L.

Water – Primary Industries DGV Exceedances

- Chloride at 250 mg/L above an agricultural irrigation LTV and STV of 175 mg/L.
- Dissolved solids at 710–733 mg/L (lab-field) above a stock watering DGV of 500 mg/L.
- *E. coli* at 240 CFU/100ml above an agricultural DGV of 10 CFU/100ml and a stock watering DGV of 100 CFU/100ml.
- *Enterococci* at 120 CFU/100ml above a stock watering DGV of 100 CFU/100ml.
- Iron at 3.8 mg/L above an agricultural irrigation LTV of 0.2 mg/L.
- PFHxS+PFOS at 0.072 ug/L above a stock watering DGV of 0.07 ug/L.
- Sodium at 140 mg/L above an agricultural irrigation LTV and STV of 115 mg/L.

Water – Freshwater Ecosystem DGV Exceedances

- Aluminium at 0.06 mg/L above a freshwater DGV of 0.027 mg/L.
- Conductivity at 1,200–1,128 uS/cm (field-lab) above a freshwater DGV of <120-300 uS/cm.
- Dissolved oxygen at 59.1% above a freshwater DGV of >80%.
- *E. coli* at 240 CFU/100ml above wastewater effluent criteria of 10 CFU/100ml.
- Iron at 3.8 mg/L above a freshwater DGV of 0.3 mg/L.
- Nitrate at 0.12 mg/L above a freshwater DGV of 0.017 mg/L.
- PFOS at 0.048 ug/L above a freshwater DGV of 0.00023 ug/L.
- Uranium at 0.002 mg/L above a freshwater DGV of 0.0005 mg/L.

Sediment Results

- Hydrocarbons, metals and nutrients detected.
- Pesticides, herbicides, volatiles, surfactants and PFAS compounds not detected above the LOR.

Sediment – Sediment Quality DGV Exceedances

- Naphthalene at 0.8 mg/kg above a DGV of 0.16 mg/kg.

Helena Roe Standing immediately downstream of Military Road bridge, looking downstream

Helena Roe Standing under Military Rd bridge, looking upstream

Name	**Craignish US**
Watercourse	Mandoon Bilya – Helena River
Location	-31.93554, 116.0687, immediately upstream of Craignish gauging station (WIR 616018), in Beelu National Park (south bank) and Shre of Mundaring Reserve (north bank)
WIR Ref	6167032
LGA	Shire of Mundaring – City of Kalamunda boundary
Rationale	Immediately upstream of Craignish gauging station (616018), Helping the Helena site, previously detected elevated hydrocarbons (PAH), near BNAA 2023 eDNA site.
Elevation	32.9 m AHD
Field Parameters	Conductivity 498.3 uS/cm; dissolved oxygen 59%; salinity 240 ppm; pH 6.24, redox 89.1 mV; TDS 288 mg/L; turbidity 28.8 NTU

Field Observations

- Flowing water, brown and orange colour, no sheen or floating debris.
- Water depth at 1 m at gauging station, light flow over the weir, water difficult to filter.
- Many weeds e.g. cape tulip, bridal creeper, weedy grasses, oxalis, buckthorn, olive, eastern states wattles, fumitory, possible aquatic weeds, algae. Native vegetation in surrounding forest e.g. river gums, melaleuca sp, jarrah and marri trees.
- Lots of tiny silver fish, no visible frogs or tadpoles, many loud frog noises (motorbike frog and unidentified).
- Lots of dragonflies (big brown, small red and medium blue), kulbardi (magpie), 28 parrot, galahs, ducks, unknown bird song, honey bees, Carters freshwater mussels on bank.
- Two groups of walkers sitting by the river, dog/fox (?) footprints on bank.
- Damage to southern bank from Water Corporation dredging works.
- Easy to access from walk trails along northern and southern banks.

Water Results

- Metals, nutrients, surfactants, microbes and PFAS compounds detected.
- Pesticides, herbicides, hydrocarbons and volatile organics not detected above the LOR.

Water – Human Health DGV Exceedances

- Aluminium at 0.7 mg/L above a drinking water aesthetic, non-potable and recreation DGV of 0.2 mg/L.
- Ammonia at 0.05 mg/L above a recreation DGV of 0.01 mg/L.
- *E. coli* at 100 CFU/100ml above a drinking water DGV of 'detection' and non-potable/recreation DGV of 1 CFU/100ml.
- *Enterococci* at 98 CFU/100ml above a drinking water DGV of 'detection' and recreation DGV of 60-100 CFU/100ml.
- Iron at 6.0 mg/L above a drinking water aesthetic, non-potable and recreation DGV of 0.3 mg/L.
- Manganese at 0.16 mg/L above a drinking water aesthetic and recreation DGV of 0.1 mg/L.
- MBAS at 0.2 mg/L above a recreation DGV of 0.2 mg/L.
- pH (field) at 6.2 below a drinking water, non-potable and recreation DGV of >6.5.
- Turbidity at 28.8–36 NTU (field-lab) above a drinking water aesthetic and non-potable DGV of 5 mg/L.

Water – Primary Industries DGV Exceedances

- *E. coli* at 100 CFU/100ml above an agricultural irrigation DGV of 10 CFU/100ml and stock watering DGV of 100 CFU/100ml.
- Iron at 6.0 mg/L above an agricultural irrigation LTV of 0.2 mg/L.

Water – Freshwater Ecosystem DGV Exceedances

- Aluminium at 0.7 mg/L above a freshwater DGV of 0.027 mg/L.
- Chromium (total) at 0.002 mg/L above a freshwater DGV of 0.00001 mg/L.
- Cobalt at 0.002 mg/L above a freshwater DGV of 0.0014 mg/L.
- Conductivity at 498–520 uS/cm (field-lab) above a freshwater DGV of <120-300 uS/cm.
- Copper at 0.002 mg/L above a freshwater DGV of 0.001 mg/L.
- Dissolved oxygen at 59.3% above a freshwater DGV of >80%.
- *E. coli* at 100 CFU/100ml above wastewater effluent criteria of 10 CFU/100ml.
- Iron at 6.0 mg/L above a freshwater DGV of 0.3 mg/L.
- Lead at 0.001 mg/L at a freshwater DGV of 0.001 mg/L.
- Nitrate at 0.08 mg/L above a freshwater DGV of 0.017 mg/L.
- PFOS at 0.0005 ug/L above a freshwater DGV of 0.00023 ug/L.
- pH (field) at 6.2 below a freshwater DGV and wastewater effluent criteria of >6.5.
- Turbidity at 28.8–36 NTU (field-lab) above a freshwater DGV of <10-20 NTU.
- Vanadium at 0.007 mg/L above a freshwater DGV of 0.006 mg/L.

Sediment Results

- Hydrocarbons, metals and nutrients detected.
- Pesticides, herbicides, volatiles, surfactants and PFAS compounds not detected above the LOR.

Sediment – Sediment Quality DGV Exceedances

- No exceedances of the DGV, although limited DGV exist to enable screening.

Craignish US Standing at Craignish Gauging Station, looking upstream

Craignish US Standing at Craignish Gauging Station, looking downstream at Craignish Weir

Name	**Lower Pumpback Dam**
Watercourse	Mandoon Bilya – Helena River
Location	-31.94179, 116.0761, immediately downstream of Lower Pumpback Dam in river channel, in Beelu National Park (south bank) and Shre of Mundaring Reserve (north bank)
WIR Ref	-
LGA	Shire of Mundaring – City of Kalamunda boundary
Rationale	Immediately downstream of LPD, LPD is a public drinking water source, near BNAA 2023 eDNA site, outside of Reservoir Protection Zone (RPZ).
Elevation	40.8 m AHD
Field Parameters	Conductivity 442.6 uS/cm; dissolved oxygen 28%; salinity 210 ppm; pH 6.49, redox 83.1 mV; TDS 325 mg/L; turbidity 12.2 NTU

Field Observations

- Very light-no flow, brown and orange colour, organic rainbow sheen, strong iron-like smell, some floating organic matter, orange algae in water, lots of debris and fallen branches in the channel.
- Large black/blue pipe in river channel, appears to be for release of water from LPD but unsure if pipe takes from dam or blue metal lined pool at base of dam wall, blue metal pool had shallow water in it.
- Black/blue pipe not flowing at time of sampling, sample taken from first river pool downstream of pipe outlet, no apparent surface water connection from blue metal pool and sample site at time of sampling.
- Many weeds on banks e.g. fumitory, grassy weeds, oxalis, cotton bush, watsonia, veldt daisy, bamboo, blackberry, possible aquatic weeds. Very overgrown and neglected.
- Native vegetation in surrounding forest e.g. river gums, large mature paper barks, melaleuca sp, trymalium (karri hazel), bracken ferns, jarrah and marri trees.
- Tiny silver fish, no visible frogs or tadpoles, no frog noises.
- Many dragonflies, march flies, honey bees, mosquitoes, wardongs (ravens), 28 parrot, other unidentified birds, small Carters freshwater mussels.
- Some litter on banks e.g. plastic, tyres.
- Difficult access, requires climbing down steep slope, through tall weeds and over trip hazards. Razor wire on Water Corporation facility fence.

Water Results

- Metals, nutrients, microbes and PFAS compounds detected.
- Pesticides, herbicides, hydrocarbons, surfactants and volatile organics not detected above the LOR.

Water – Human Health DGV Exceedances

- *E. coli* at 150 CFU/100ml above a drinking water DGV of ‘detection’ and non-potable/recreation DGV of 1 CFU/100ml
- *Enterococci* at 82 CFU/100ml above a drinking water DGV of ‘detection’ and recreation DGV of 60-100 CFU/100ml.
- Iron at 3.4 mg/L above a drinking water aesthetic, non-potable and recreation DGV of 0.3 mg/L.
- Manganese at 0.28 mg/L above a drinking water aesthetic and recreation DGV of 0.1 mg/L.
- Turbidity at 12.2–17 NTU (field-lab) above a drinking water aesthetic and non-potable DGV of 5 mg/L.

Water – Primary Industries DGV Exceedances

- *E. coli* at 150 CFU/100ml above an agricultural LTV and STV of 10 CFU/100ml and stock watering DGV of 100 CFU/100ml.
- Iron at 3.4 mg/L above an agricultural irrigation LTV of 0.2 mg/L.
- Manganese at 0.28 mg/L above an agricultural irrigation LTV of 0.2 mg/L.

Water – Freshwater Ecosystem DGV Exceedances

- Boron at 0.13 mg/L above a freshwater DGV of 0.09 mg/L.
- Conductivity at 443–460 uS/cm (field-lab) above a freshwater DGV of <120-300 uS/cm.
- Dissolved oxygen at 27.6% above a freshwater DGV of >80%.
- *E. coli* at 150 CFU/100ml above wastewater effluent criteria of 10 CFU/100ml.
- Iron at 3.4 mg/L above a freshwater DGV of 0.3 mg/L.
- PFOS at 0.002 ug/L above a freshwater DGV of 0.00023 ug/L.
- pH (field) at 6.49 below a freshwater DGV and wastewater effluent criteria of >6.5.

Sediment Results

- Hydrocarbons, metals and nutrients detected.
- Pesticides, herbicides, volatiles, surfactants and PFAS compounds not detected above the LOR.

Sediment – Sediment Quality DGV Exceedances

- No exceedances of the DGV, although limited DGV exist to enable screening.

Lower Pumpback Dam Sample site in river channel downstream of LPD, looking downstream

Lower Pumpback Dam Upstream of sample site, pool at base of LPD, pipe for apparent water releases

Name	**Rocky Pool**
Watercourse	Piesse Brook (Mandoon-Helena tributary)
Location	-31.95366, 116.0716, in Kalamunda National Park
WIR Ref	-
LGA	City of Kalamunda
Rationale	Major tributary from Pickering Brook and Bickley Valley, flows into Lower Pumpback Dam, downstream of Kalamunda, large pool, popular swimming spot.
Elevation	85.9 m AHD
Field Parameters	Conductivity 415.8 uS/cm; dissolved oxygen 97%; salinity 200 ppm; pH 7.43, redox 145 mV; TDS 271 mg/L; turbidity 0.3 NTU

Field Observations

- Strong flowing water, almost fully clear and colourless, no sheen or floating debris.
- Some weeds on banks and granite rocks e.g. fumitory, grassy weeds, gazania sp, capeweed.
- Good native vegetation in surrounding forest e.g. river gums, melaleuca, marri and jarrah trees, trymalium and diverse understory species.
- No visible fish, frogs or tadpoles. No frog noises.
- Many dragonflies, honey bees, orange/white/black butterflies, white butterflies, kulbardi (magpie), 28 parrots and unidentified bird song. Waalitj (eagle) spotted soaring above and blue wren on access track.
- Very little litter.
- Very easy to access from walking trail on east bank of brook, approx. 1.7 km from car park. 4WD vehicle required on access track due to wash out.
- Many people using the area recreationally – 7 groups of walkers and 3 groups swimming in the pool.
- Several groups walking dogs including one off-leash and swimming in the pool.

Water Results

- Metals, nutrients, microbes and PFAS compounds detected.
- Pesticides, herbicides, hydrocarbons, surfactants and volatile organics not detected above the LOR.

Water – Human Health DGV Exceedances

- *E. coli* at 82 CFU/100ml above a drinking water DGV of 'detection' and non-potable/recreation DGV of 1 CFU/100ml.
- *Enterococci* at 59 CFU/100ml was close to a recreation DGV of 60 CFU/100ml – noted but not an exceedance.

Water – Primary Industries DGV Exceedances

- *E. coli* at 82 CFU/100ml above an agricultural irrigation LTV and STV of CFU/100ml.

Water – Freshwater Ecosystem DGV Exceedances

- Aluminium at 0.06 mg/L above a freshwater DGV of 0.027 mg/L.
- Conductivity at 416–440 uS/cm (field-lab) above a freshwater DGV of <120-300 uS/cm.
- *E. coli* at 82 CFU/100ml above wastewater effluent criteria of 10 CFU/100ml.
- Nitrate at 1.4 mg/L above a freshwater DGV of 0.017 mg/L.
- Total oxidised nitrogen (nitrate+nitrite as NOx-N) at 1.4 mg/L above a freshwater DGV of 0.15 mg/L.
- PFOS at 0.0021 ug/L above a freshwater DGV of 0.00023 ug/L.
- Total nitrogen at 1.5 mg/L above a freshwater DGV of 1.2 mg/L. This concentration also exceeded the long term Swan Canning water quality target of 1 mg/L, although compliance is based on data from three years.

Sediment Results

- Hydrocarbons, metals and nutrients detected.
- Pesticides, herbicides, volatiles, surfactants and PFAS compounds not detected above the LOR.

Sediment – Sediment Quality DGV Exceedances

- No exceedances of the DGV, although limited DGV exist to enable screening.

Rocky Pool Sample taken at the downstream point of the largest pool, looking downstream

Rocky Pool Several groups of swimmers were observed using the large pool, looking upstream

Name	**Pipe Bridge**
Watercourse	Mandoon Bilya – Helena River
Location	-31.93834, 116.1217, under the water pipe, in Shire of Mundaring reserve
WIR Ref	6161604
LGA	Shire of Mundaring – City of Kalamunda boundary
Rationale	Upstream of Lower Pumpback Dam, historically identified as high public health significance, previously detected elevated metals and hydrocarbons between Mundaring Weir and LPD.
Elevation	86.1 m AHD
Field Parameters	Conductivity 509 uS/cm; dissolved oxygen 94%; salinity 250 ppm; pH 6.73, redox 132 mV; TDS 331 mg/L; turbidity 1.1 NTU

Field Observations

- Flowing water, almost clear and colourless, no sheen or floating debris.
- Some weeds on banks e.g. fumitory, grassy weeds, watsonia, possible aquatic weeds.
- Native vegetation in surrounding forest e.g. river gums, mature paperbarks, melaleuca, marri and jarrah trees, trymalium, acacia saligna, white myrtle, and diverse understory species.
- No visible fish, frogs or tadpoles. Frog noises. Bubbles observed from river bed when taking sample.
- Many dragonflies, mosquitoes, unknown bird calls.
- Very easy to access from walking trail on south bank of river.
- Vehicle access difficult on management track between Mundaring Weir and LPD, washed out and eroded. 4WD essential.
- Cyclist using trail, asked if access was allowed for recreation.

Water Results

- Metals, nutrients, microbes, surfactants and PFAS compounds detected.
- Pesticides, herbicides, hydrocarbons and volatile organics not detected above the LOR.

Water – Human Health DGV Exceedances

- *E. coli* at 12 CFU/100ml above a drinking water DGV of 'detection' and non-potable/recreation DGV of 1 CFU/100ml.
- *Enterococci* at 11 CFU/100ml above a drinking water DGV of 'detection'.
- Iron at 0.9 mg/L above a drinking water aesthetic, non-potable and recreation DGV of 0.3 mg/L.
- MBAS at 0.4 mg/L above a recreation DGV of 0.2 mg/L.
- Thermophilic *Amoeba* presence above a drinking water DGV of 'detection'.

Water – Primary Industries DGV Exceedances

- *E. coli* at 12 CFU/100ml above an agricultural irrigation LTV and STV of 10 CFU/100ml.
- Iron at 0.9 mg/L above an agricultural irrigation LTV of 0.2 mg/L.
- Total phosphorous at 0.06 mg/L above an agricultural irrigation LTV of 0.005 mg/L.

Water – Freshwater Ecosystem DGV Exceedances

- Aluminium at 0.09 mg/L above a freshwater DGV of 0.027 mg/L.
- Conductivity at 509–540 uS/cm (field-lab) above a freshwater DGV of <120-300 uS/cm.
- *E. coli* at 12 CFU/100ml above wastewater effluent criteria of 10 CFU/100ml.
- Iron at 0.9 mg/L above a freshwater DGV of 0.3 mg/L.
- PFOS at 0.0006 ug/L above a freshwater DGV of 0.00023 ug/L.
- Total phosphorous at 0.06 mg/L above a freshwater DGV of 0.065 mg/L.

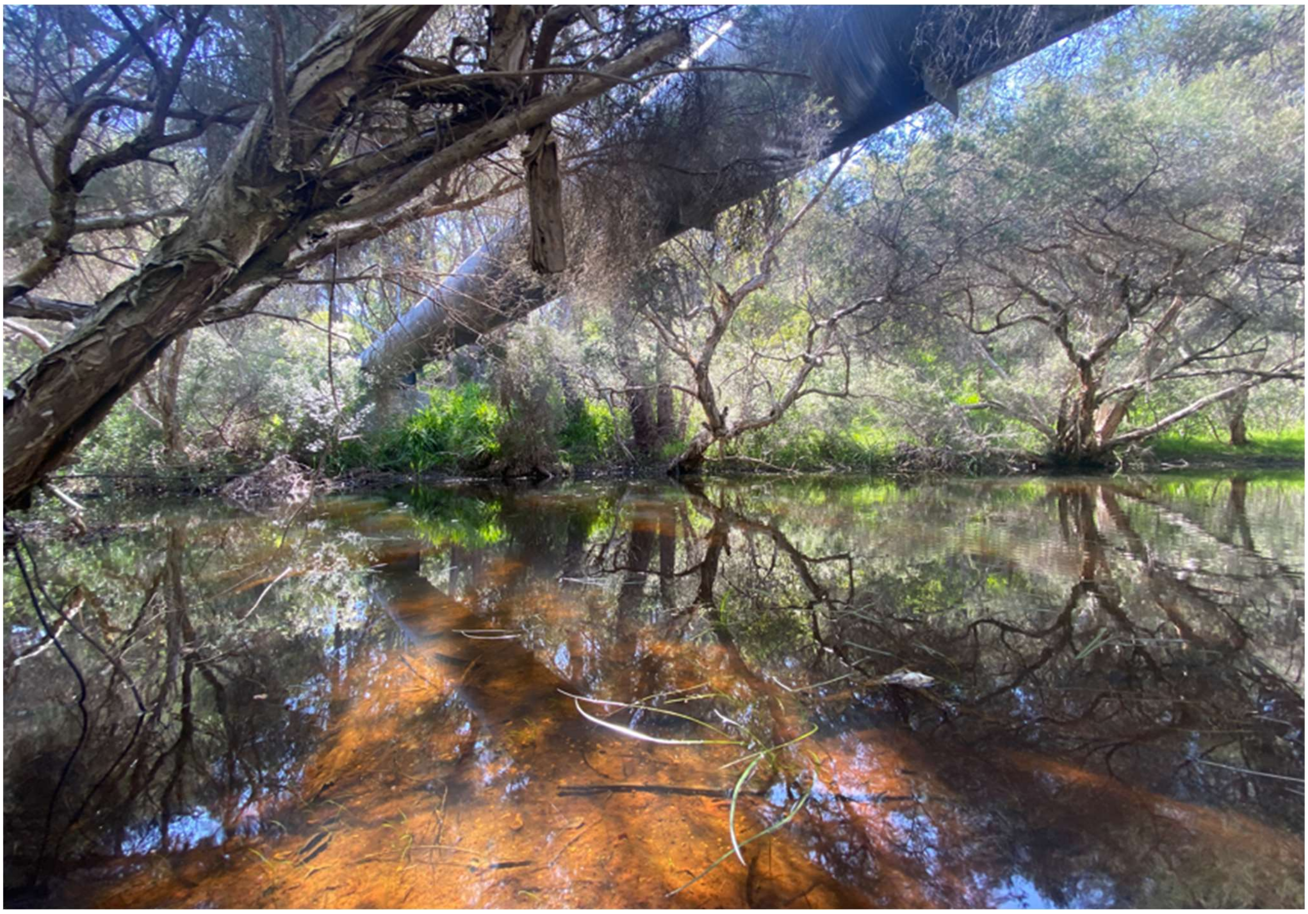
Sediment Results

- Hydrocarbons, metals and nutrients detected.
- Pesticides, herbicides, volatiles, surfactants and PFAS compounds not detected above the LOR.

Sediment – Sediment Quality DGV Exceedances

- TRH C10-C40 at 1,310 mg/kg above a DGV of 280 mg/kg.
- Zinc at 190 mg/kg was close to a DGV of 200 mg/kg – noted but not an exceedance.

Pipe Bridge Sample taken under the pipe, looking downstream



Pipe Bridge Sample taken under the pipe, looking upstream

Name	Cobblers Pool
Watercourse	Mandoon Bilya – Helena River
Location	-31.94693, 116.1348, large permanent pool at confluence with Gunjin Gully, in Beelu National Park (moved 360 m upstream from proposed site (Skeleton Pool) due to access constraints - steep banks, incorrectly referred to as Skeleton Pool in field notes and laboratory documentation)
WIR Ref	6167034 is located 360 m downstream
LGA	Shire of Mundaring – City of Kalamunda boundary
Rationale	Upstream of LPD, close to historical sampling site that previously detected elevated metals and hydrocarbons (PAH), large permanent summer pool.
Elevation	92.8 m AHD
Field Parameters	Conductivity 591 uS/cm; dissolved oxygen 69.3%; salinity 290 ppm; pH 6.44, redox 171 mV; TDS 384 mg/L; turbidity 2.2 NTU

Field Observations

- Flowing water, almost clear and colourless, no sheen or floating debris, pool appears greenish from surface.
- Weeds on banks e.g. fumitory, grassy weeds, watsonia, arum lily, wavy gladioli, possible aquatic weeds.
- Native vegetation in surrounding forest e.g. river gums, mature paperbarks, melaleuca, marri and jarrah trees, trymalium, acacia saligna, white myrtle, and diverse understory species.
- Small fish. No visible frogs or tadpoles. Frog noises from adjacent Gunjin Gully (not in pool).
- Bubbles observed from pool bed when taking sample.
- Many dragonflies, butterflies, mosquitoes, unknown bird calls.
- Very easy to access from walking trail from Paulls Valley.
- Vehicle access difficult on management track between Mundaring Weir and Lower Pumpback Dam – very washed out and eroded. 4WD essential.

Water Results

- Metals, hydrocarbons, nutrients, microbes, surfactants and PFAS compounds detected.
- Pesticides, herbicides and volatile organics not detected above the LOR.

Water – Human Health DGV Exceedances

- Aluminium at 0.23 mg/L above a drinking water aesthetic, non-potable and recreation DGV of 0.2 mg/L.
- *E. coli* at 12 CFU/100ml above a drinking water DGV of 'detection' and non-potable/ recreation DGV of 1 CFU/100ml.
- *Enterococci* at 19 CFU/100ml above a drinking water DGV of 'detection'.
- Iron at 1.0 mg/L above a drinking water aesthetic, non-potable and recreation DGV of 0.3 mg/L.
- MBAS at 0.3 mg/L above a recreation DGV of 0.2 mg/L.
- pH at 6.44 below a drinking water, non-potable and recreation DGV of >6.5.

Water – Primary Industries DGV Exceedances

- *E. coli* at 12 CFU/100ml above an agricultural irrigation LTV and STV of 10 CFU/100ml.
- Iron at 1.0 mg/L above an agricultural irrigation LTV of 0.2 mg/L.
- Total phosphorous at 0.06 mg/L above an agricultural irrigation LTV of 0.005 mg/L.

Water – Freshwater Ecosystem DGV Exceedances

- Aluminium at 0.23 mg/L above a freshwater DGV of 0.027 mg/L.
- Conductivity at 591-630 uS/cm (field-lab) above a freshwater DGV of <120-300 uS/cm.
- Dissolved oxygen at 69.3% above a freshwater DGV of >80%.
- *E. coli* at 12 CFU/100ml above wastewater effluent criteria of 10 CFU/100ml.
- Iron at 1.0 mg/L above a freshwater DGV of 0.3 mg/L.
- Nitrate at 0.02 mg/L above a freshwater DGV of 0.017 mg/L.
- PFOS at 0.001 ug/L above a freshwater DGV of 0.00023 ug/L.
- pH at 6.44 below a freshwater DGV and wastewater effluent criteria of >6.5.
- Total phosphorous at 0.06 mg/L above a freshwater DGV of 0.065 mg/L.

Sediment Results

- Hydrocarbons, metals and nutrients detected.
- Pesticides, herbicides, volatiles, surfactants and PFAS compounds not detected above the LOR.

Sediment – Sediment Quality DGV Exceedances

- TRH C10-C40 at 880 mg/kg above a DGV of 280 mg/kg.

Cobblers Pool Sample taken at northern extent of pool, looking upstream towards Gunjin Gully confluence

Cobblers Pool Banks overgrown with weeds including arum lily, looking downstream

Name	LookSee Pool
Watercourse	Mandoon Bilya – Helena River
Location	-31.9499, 116.1459, large permanent pool, in Beelu National Park (moved 56 m upstream from proposed site due to access constraints - steep banks, still within same pool)
WIR Ref	6163844 is located 56 m downstream
LGA	Shire of Mundaring – City of Kalamunda boundary
Rationale	DWER Healthy Rivers site, downstream of Bourkes Gully (tributary from Mundaring), BNAA 2023 eDNA site, large permanent summer pool.
Elevation	108.0 m AHD
Field Parameters	Conductivity 648 uS/cm; dissolved oxygen 70.5%; salinity 320 ppm; pH 6.52, redox 152 mV; TDS 421 mg/L; turbidity 2.1 NTU

Field Observations

- Flowing water, light brown colour, slight organic rainbow sheen, plant material/bark floating on surface.
- Weeds on banks e.g. fumitory, grassy weeds, watsonia, arum lily, possible aquatic weeds.
- Native vegetation in surrounding forest e.g. river gums, mature paperbarks, melaleuca, marri and jarrah trees, trymalium, acacia saligna, white myrtle, diverse understory species, wagyl whiskers (reeds).
- No visible fish, frogs or tadpoles. No frog noises.
- Lots of insect noises (crickets/cicada?). Mosquitoes, unknown bird calls.
- Difficult access from management track, very heavily vegetated, steep banks.
- Vehicle access difficult on management track between Mundaring Weir and Lower Pumpback Dam – very washed out and eroded. 4WD essential.

Water Results

- Metals, nutrients, microbes, surfactants and PFAS compounds detected.
- Pesticides, herbicides, hydrocarbons and volatile organics not detected above the LOR.

Water – Human Health DGV Exceedances

- Aluminium at 0.22 mg/L above a drinking water aesthetic, non-potable and recreation DGV of 0.2 mg/L.
- *E. coli* at 13 CFU/100ml above a drinking water DGV of ‘detection’ and non-potable/recreation DGV of 1 CFU/100ml.
- *Enterococci* at 7 CFU/100ml above a drinking water DGV of ‘detection’.
- Iron at 1.2 mg/L above a drinking water aesthetic, non-potable and recreation DGV of 0.3 mg/L.
- MBAS at 0.3 mg/L above a recreation DGV of 0.2 mg/L.

Water – Primary Industries DGV Exceedances

- *E. coli* at 13 CFU/100ml above an agricultural irrigation LTV and STV of 10 CFU/100ml.
- Iron at 1.2 mg/L above an agricultural irrigation LTV of 0.2 mg/L.
- Total phosphorous at 0.06 mg/L above an agricultural irrigation LTV of 0.005 mg/L.

Water – Freshwater Ecosystem DGV Exceedances

- Aluminium at 0.22 mg/L above a freshwater DGV of 0.027 mg/L.
- Conductivity at 648–700 uS/cm (field-lab) above a freshwater DGV of <120-300 uS/cm.
- Dissolved oxygen at 70.5% above a freshwater DGV of >80%.
- *E. coli* at 13 CFU/100ml above wastewater effluent criteria of 10 CFU/100ml.
- Iron at 1.2 mg/L above a freshwater DGV of 0.3 mg/L.
- Nitrate at 0.02 mg/L above a freshwater DGV of 0.017 mg/L.
- PFOS at 0.0003 ug/L above a freshwater DGV of 0.00023 ug/L.
- Total phosphorous at 0.06 mg/L above a freshwater DGV of 0.065 mg/L.
- Zinc at 0.005 mg/L above a freshwater DGV of 0.0024 mg/L.

Sediment Results

- Hydrocarbons, metals and nutrients detected.
- Pesticides, herbicides, volatiles, surfactants and PFAS compounds not detected above the LOR.

Sediment – Sediment Quality DGV Exceedances

- TRH C10-C40 at 910 mg/kg above a DGV of 280 mg/kg.

LookSee Pool Sample taken on edge of the pool, looking downstream

LookSee Pool Sample taken on edge of the pool, looking upstream

Name	Piesse Culvert
Watercourse	Piesse Brook (Mandoon-Helena tributary)
Location	-32.03209, 116.1370, immediately upstream of Patterson Rd culvert (moved 140 m upstream from proposed site due to access constraints - private property)
WIR Ref	6161253 is 140 m downstream
LGA	City of Kalamunda
Rationale	Furthest upstream location on Piesse Brook that is accessible via public land.
Elevation	252.3 m AHD
Field Parameters	Conductivity 420 uS/cm; dissolved oxygen 101.4%; salinity 200 ppm; pH 6.91, redox 183 mV; TDS 273 mg/L; turbidity 0.6 NTU

Field Observations

- Flowing water, almost clear and colourless, no sheen, some algae and floating aquatic plants on surface.
- Weeds on banks e.g. fumitory, grassy weeds, vinca, brassicas, wild oats, possible aquatic weeds.
- Prickly pear cactus infestation growing upstream on private property.
- No native understory or trees.
- Eroded banks, broken pipe in watercourse, possible drainage from private property?
- No visible fish, frogs or tadpoles. Loud frog noises.
- Ducks, freshwater snails. Small flock of Carnaby's black cockatoos drinking from brook on arrival.
- Easy to access from Patterson Road. Traffic hazard.
- Local resident interested in sampling.

Water Results

- Pesticides, metals, nutrients, microbes, surfactants and PFAS compounds detected.
- Herbicides, hydrocarbons and volatile organics not detected above the LOR.

Water – Human Health DGV Exceedances

- *E. coli* at 84 CFU/100ml above a drinking water DGV of 'detection' and non-potable/recreation DGV of 1 CFU/100ml.
- *Enterococci* at 69 CFU/100ml above a drinking water DGV of 'detection' and recreation DGV of 60-100 CFU/100ml.
- MBAS at 0.3 mg/L above a recreation DGV of 0.2 mg/L.

Water – Primary Industries DGV Exceedances

- *E. coli* at 84 CFU/100ml above an agricultural irrigation LTV and STV of 10 CFU/100ml.

Water – Freshwater Ecosystem DGV Exceedances

- Aluminium at 0.09 mg/L above a freshwater DGV of 0.027 mg/L.
- Conductivity at 420–450 uS/cm (field-lab) above a freshwater DGV of <120-300 uS/cm.
- Copper at 0.003 mg/L above a freshwater DGV of 0.001 mg/L.
- *E. coli* at 84 CFU/100ml above wastewater effluent criteria of 10 CFU/100ml.
- Nitrate at 6.9 mg/L above a freshwater DGV of 0.017 mg/L.
- Total oxidised nitrogen (nitrate+nitrite as NOx-N) at 6.9 mg/L above a freshwater DGV of 0.15 mg/L.
- PFOS at 0.0004 ug/L above a freshwater DGV of 0.00023 ug/L.
- Total nitrogen at 6.9 mg/L above a freshwater DGV of 1.2 mg/L. This concentration also exceeded the long term Swan Canning water quality target of 1 mg/L, although compliance is based on data from three years.
- Zinc at 0.007 mg/L above a freshwater DGV of 0.0024 mg/L.

Sediment Results

- Pesticides, metals, nutrients and surfactants detected.
- Herbicides, hydrocarbons, volatiles and PFAS compounds not detected above the LOR.

Sediment – Sediment Quality DGV Exceedances

- Copper at 86 mg/kg above a DGV of 65 mg/kg.
- DDT at 0.03 mg/kg above a DGV of 0.0012–0.0016 mg/kg.
- DDE at 0.05 mg/kg above a DGV of 0.0014–0.0022 mg/kg.
- Lead at 46 mg/kg was close to a DGV of 50 mg/kg – noted but not an exceedance.

Piesse Culvert Sample taken upstream of Patterson Rd culvert, looking upstream across private property

Piesse Culvert Looking downstream from Patterson Rd across private property

Name	**Salty Pool**
Watercourse	Mandoon Bilya – Helena River
Location	-31.93916, 116.5150, large pool downstream of Helena National Park (moved 3.1 km downstream from proposed site (Helena Pony) due to lack of water, referred to as Helena Pony in field notes and lab docs)
WIR Ref	6161278 is 1.4 km upstream on Wundabiniring Brook and 6160175 is 2 km downstream on Mandoon at Talbot Rd culvert
LGA	Shire of York
Rationale	Mandoon headwaters, downstream of salinity-impacted Wundabiniring Brook tributary.
Elevation	257.1 m AHD
Field Parameters	Conductivity 8,274 uS/cm; dissolved oxygen 47%; salinity 4,620 ppm; pH 6.58, redox 218 mV; TDS 5,390 mg/L; turbidity 0.7 NTU

Field Observations

- Flowing water, almost clear and colourless, very slight organic sheen, some floating debris/plant material.
- Weeds on banks e.g. fumitory, grassy weeds, lavender, cape tulip, cape weed, possible aquatic weeds.
- Native vegetation in surrounding forest e.g. river gums, paperbarks, wandoo, balga, diverse understory.
- No visible fish, frogs or tadpoles. No frog noises.
- Many dragonflies, march flies, mosquitoes, swimming aquatic insects. Flock of unknown small white/black birds. Lots of unidentified song birds. Kangaroo poo.
- Easy access from Pony Road track. 4WD essential for unsealed track.
- Motorbike tracks across river channel.

Water Results

- Metals, nutrients, microbes, surfactants and PFAS compounds detected.
- Pesticides, herbicides, hydrocarbons and volatile organics not detected above the LOR.

Water – Human Health DGV Exceedances

- Ammonia at 0.03 mg/L above a recreation DGV of 0.01 mg/L.
- Chloride at 2,500 mg/L above a drinking water aesthetic and non-potable DGV of 250 mg/L and recreation DGV of 400 mg/L.
- Dissolved solids at 5,200–5,390 mg/L (lab-field) above a drinking water aesthetic DGV of 600 mg/L and recreation DGV of 1,000 mg/L.
- *E. coli* at 24 CFU/100ml above a drinking water DGV of 'detection' and non-potable/recreation DGV of 1 CFU/100ml.
- *Enterococci* at 63 CFU/100ml above a drinking water DGV of 'detection' and recreation DGV of 60-100 CFU/100ml.
- Hardness at 1,700 mg/L above a drinking water aesthetic of 200 mg/L and a recreation DGV of 500 mg/L.
- Iron at 0.53 mg/L above a drinking water aesthetic, non-potable and recreation DGV of 0.3 mg/L.
- Manganese at 0.22 mg/L above a drinking water aesthetic and recreation DGV of 0.1 mg/L.
- MBAS at 1.4 mg/L above a recreation DGV of 0.2 mg/L.
- Sodium at 1,000 mg/L above a recreation DGV of 180 mg/L.
- Thermophilic *Amoeba* presence above a drinking water DGV of 'detection'.

Water – Primary Industries DGV Exceedances

- Chloride at 2,500 mg/L above an agricultural irrigation LTV and STV of 175 mg/L.
- Dissolved solids at 5,200–5,390 mg/L (lab-field) above a stock watering DGV of 500 mg/L.
- *E. coli* at 24 CFU/100ml above an agricultural irrigation LTV and STV of 10 CFU/100ml.
- Iron at 0.53 mg/L above an agricultural irrigation LTV of 0.2 mg/L.
- Magnesium at 340 mg/L above a stock watering DGV of 125 mg/L.
- Manganese at 0.22 mg/L above an agricultural irrigation LTV of 0.2 mg/L.
- Sodium at 1,000 mg/L above an agricultural irrigation LTV and STV of 115 mg/L.

Water – Freshwater Ecosystem DGV Exceedances

- Conductivity at 8,274–8,600 uS/cm (field-lab) above a freshwater DGV of <120-300 uS/cm.
- Dissolved oxygen at 46.9% above a freshwater DGV of >80%.
- *E. coli* at 24 CFU/100ml above wastewater effluent criteria of 10 CFU/100ml.
- Fluoride at 0.5 mg/L above a freshwater DGV of 0.29 mg/L.
- Iron at 0.53 mg/L above a freshwater DGV of 0.3 mg/L.
- PFOS at 0.0004 ug/L above a freshwater DGV of 0.00023 ug/L.
- Zinc at 0.005 mg/L above a freshwater DGV of 0.0024 mg/L.

Sediment Results

- Hydrocarbons, metals and nutrients detected.
- Pesticides, herbicides, surfactants, volatiles and PFAS compounds not detected above the LOR.

Sediment – Sediment Quality DGV Exceedances

- TRH C10-C40 at 990 mg/kg above a DGV of 280 mg/kg.

Salty Pool Sample taken at downstream edge of pool, looking upstream

Salty Pool Looking downstream of pool at river channel

Name	**Beraking Yarra**
Watercourse	Beraking Brook
Location	-32.18183, 116.4349, immediately downstream of Yarra Rd culvert
WIR Ref	6161259
LGA	Shire of Beverley
Rationale	Beraking Brook headwaters, upstream of any private property and cleared land, ambient background location.
Elevation	262.0 m AHD
Field Parameters	Conductivity 161.7 uS/cm; dissolved oxygen 36%; salinity 80 ppm; pH 6.91, redox 188 mV; TDS 105 mg/L; turbidity 5.1 NTU

Field Observations

- Flowing water, slight brown and yellow colour, no sheen, some floating debris/plant material on surface.
- Very few weeds on banks e.g. grassy weeds, possible aquatic weeds.
- Native vegetation in surrounding forest e.g. river gums, mature paperbarks, melaleuca, marri, jarrah, balga, trymalium, much acacia saligna, white myrtle, hakea, diverse understory, wagyl whiskers (reeds).
- No visible fish, frogs or tadpoles. No frog noises.
- Dragonflies. Unidentified song birds. Bubbles observed from the river bed when taking sample.
- Small bird nesting or feeding in balga skirt.
- Sediment erosion from unsealed Yarra Rd into brook.
- Easy access from Yarra Road.

Water Results

- Metals, nutrients, microbes, surfactants and PFAS compounds detected.
- Pesticides, herbicides, hydrocarbons and volatile organics not detected above the LOR.

Water – Human Health DGV Exceedances

- *E. coli* at 21 CFU/100ml above a drinking water DGV of 'detection' and non-potable/recreation DGV of 1 CFU/100ml.
- *Enterococci* at 56 CFU/100ml above a drinking water DGV of 'detection'.
- Iron at 3.0 mg/L above a drinking water aesthetic, non-potable and recreation DGV of 0.3 mg/L.
- Manganese at 0.46 mg/L above a drinking water aesthetic and recreation DGV of 0.1 mg/L.
- MBAS at 0.4 mg/L above a recreation DGV of 0.2 mg/L.
- Thermophilic *Amoeba* presence above a drinking water DGV of 'detection'.
- Turbidity at 5.1–6.9 NTU (field-lab) above a drinking water aesthetic and non-potable DGV of 5 mg/L.

Water – Primary Industries DGV Exceedances

- *E. coli* at 21 CFU/100ml above an agricultural irrigation LTV and STV of 10 CFU/100ml.
- Iron at 3.0 mg/L above an agricultural irrigation LTV of 0.2 mg/L.
- Manganese at 0.46 mg/L above an agricultural irrigation LTV of 0.2 mg/L.
- Total phosphorous at 0.06 mg/L above an agricultural irrigation LTV of 0.005 mg/L.

Water – Freshwater Ecosystem DGV Exceedances

- Aluminium at 0.18 mg/L above a freshwater DGV of 0.027 mg/L.
- Cobalt at 0.002 mg/L above a freshwater DGV of 0.0014 mg/L.
- Copper at 0.001 mg/L at a freshwater DGV of 0.001 mg/L.
- Cyanide at 0.007 mg/L at a freshwater DGV of 0.004 mg/L.
- Dissolved oxygen at 36.4% above a freshwater DGV of >80%.
- *E. coli* at 21 CFU/100ml above wastewater effluent criteria of 10 CFU/100ml.
- Iron at 3.0 mg/L above a freshwater DGV of 0.3 mg/L.
- Lead at 0.001 mg/L at a freshwater DGV of 0.001 mg/L.
- Total phosphorous at 0.06 mg/L above a freshwater DGV of 0.065 mg/L.
- Zinc at 0.006 mg/L above a freshwater DGV of 0.0024 mg/L.

Sediment Results

- Hydrocarbons, metals and nutrients detected.
- Pesticides, herbicides, surfactants, volatiles and PFAS compounds not detected above the LOR.

Sediment – Sediment Quality DGV Exceedances

- No exceedances of the DGV, although limited DGV exist to enable screening.

Beraking Yarra Sample taken downstream of Yarra Road culvert, looking upstream

Beraking Yarra Sample taken downstream of Yarra Road culvert, looking downstream

Appendix 5 Laboratory Documentation

Available upon request from manager@bibbul.org

BOORYUL
BAH BILYA

BIBBUL NGARMA ABORIGINAL ASSOCIATION INC.

manager@bibbul.org

www.bibbul.org