Water and sediment quality in the Bull Creek catchment and City of Melville lakes 2018

Prepared by the South East Regional Centre for Urban Landcare for the City of Melville

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This assessment of surface water and sediment quality within the Melville Bull Creek catchment was undertaken in 2018 as part of an annual monitoring partnership program between the City of Melville, SERCUL and Department of Water and Environmental Regulation. Initiated in 2007, the purpose of this monitoring program is to determine the water and sediment quality in the City of Melville (western) side of the Bull Creek catchment to guide management responses within the catchment.

This assessment is based on four surface water sampling events and one sediment sampling event conducted in 2018. This report also compares the 2018 data with data from the previous 11 years of monitoring (2007 - 2017).

Water and sediment results recorded in samples collected in 2018 were generally similar to results recorded in previous years. The following key water and sediment quality issues have been identified in the catchment over the eleven years of monitoring:

- Bull Creek main drain:
  - Total nitrogen concentrations exceeding the ANZECC trigger value for lowland rivers have consistently been recorded in some Bull Creek main drain sites, including the site closest to the drain outfall (PSDTBCMD);
    - A significant proportion of this nitrogen enters the drain in the form of ammonia nitrogen between the convergence of the two main upstream branches of the drain and Brockman Park;
  - Total phosphorus concentrations exceeding the ANZECC trigger value for lowland rivers have often been recorded at John Creaney Park lake;
  - Oxygen saturations have consistently been below the ANZECC acceptable range for lowland rivers;
  - Sediment samples collected from John Creaney Park lake have recorded lead concentrations exceeding the ANZECC low trigger value in five out of the last six years;
  - Concentrations of iron and aluminium (total and soluble) exceeding ANZECC trigger values are consistently recorded at all Bull Creek main drain sites;
  - Concentrations of total zinc exceeding ANZECC trigger values have been regularly recorded at John Creaney Park inlet and downstream Elizabeth Manion Park (since monitoring at these sites began in 2014);
  - Concentrations of total copper exceeding ANZECC trigger values have often been recorded at downstream Elizabeth Manion Park (since monitoring at this site began in 2014);
- Brentwood drain:
  - Water quality is generally better at Brentwood drain sites than Bull Creek main drain sites, with total nitrogen, total phosphorus and most metals generally below relevant ANZECC trigger values, although total oxidised nitrogen regularly exceeds the guideline value;
  - A pattern of generally declining concentrations of nitrogen as ammonia/ammonium, total and soluble iron and total aluminium has been noted at the most downstream Brentwood drain site (at Bateman Park) over the twelve years of monitoring;
  - Oxygen saturations have consistently been below the ANZECC acceptable range for lowland rivers at all Brentwood main drain sites;
  - Concentrations of iron and aluminium exceeding ANZECC trigger values are often recorded at all Brentwood drain sites;

- Melville lakes:
    - Total nitrogen (and ammonia) and total phosphorus (and filterable reactive phosphorus) concentrations exceeding the respective ANZECC trigger values for lowland rivers have been recorded on almost all sampling occasions at Booragoon Lake outlet and Blue Gum Lake outlet;
    - Particularly low pH values (significantly less than the acceptable range for wetlands) have often been recorded at Booragoon Lake outlet and Blue Gum Lake outlet (and to a lesser degree Piney Lakes outlet) throughout the twelve year monitoring period, although pH values at these sites were only slightly below the acceptable range in 2017 and 2018;
    - Dissolved oxygen saturations and pH values are lower, and total nitrogen (and dissolved organic nitrogen) and total aluminium concentrations are higher at Quenda Lake outlet from 2014 to 2018 when compared to 2007 to 2013;
    - In Booragoon Lake sediment samples, lead concentrations exceeding the ANZECC trigger value have often been recorded, and arsenic, copper, mercury and nickel exceeding ANZECC trigger values have been recorded on at least one sampling occasions within the last five years;
    - Regular exceedances of the ANZECC trigger value for soluble zinc have been recorded at Frederick Baldwin Lake, partially as a result of the soft water at this site;
    - Concentrations of total and soluble iron and aluminium exceeding ANZECC trigger values are consistently recorded at most Melville Lakes sites, and total and soluble iron concentrations recorded at Booragoon Lake outlet and Blue Gum Lake outlet are particularly high;
    - Oxygen saturations have usually been below the ANZECC acceptable range for wetlands at all Melville Lakes sites.

Based on the above findings, it is considered that Bull Creek main drain, Booragoon Lake and Blue Gum Lake have the poorest water quality in the catchment and therefore management responses should be focussed on improvement of these sites.

It is recommended that the monitoring program be continued in 2019 to detect any changes in water quality and to evaluate the impacts of changes to the catchment (such as the Brentwood Living Stream project and the ongoing works in the Bull Creek Reserves and the lakes). Further recommendations are focussed on suggested structural and non-structural controls to improve water quality and continued implementation of existing City of Melville management plans and restoration projects.

1. Introduction

1.1 City of Melville

The City of Melville is located 8km from the central business district of Perth and has an area of 52.72 km^2 with 18.1 km of foreshore. The City encompasses 18 suburbs connected by over 1,300 km of local, arterial and major roads. The City is the third largest local government in the metropolitan region (Melville Talks 2018) and in 2017 had an estimated population of 102,131 with an average of 19.26 persons per hectare (.id 2017). The City residents enjoy 210 parks and reserves comprising 600 hectares of public open space and 300ha of bushland. In the City, there are approximately 67 drainage sumps and over 300 km of stormwater drainage pipes (City of Melville 2010).

1.2 Melville Bull Creek catchment

The Bull Creek Catchment, as described in the Swan River Trust's Local Water Quality Improvement Plan – Bull Creek Catchment (2012), contains the sub-catchments of Bull Creek itself and six other adjacent drainage catchments that have outfalls to the Canning River. The entire Bull Creek Catchment covers an area of approximately 43.5 km^2. It includes areas within the cities of Melville and Canning in Perth's southern and south-eastern suburbs Willagee, Kardinya, Winthrop, Murdoch, Leeming, Bull Creek, Rossmoyne, Willetton, Riverton, Shelley and Parkwood. Most of the Bull Creek Catchment has been cleared for urban residential development, with some recreational areas and a light industrial area in Willetton. To accommodate this development, the drainage network within the Bull Creek Catchment is highly modified and is largely piped, however some natural wetlands remain. There is over 10 km of foreshore within the Bull Creek catchment, some of which is in relatively natural condition (Swan River Trust 2012). This water quality assessment concerns the western part of the Bull Creek catchment within the City of Melville, which includes Bull Creek main drain and Brentwood drain as well as the chain of lakes to the west of Bull Creek (Booragoon Lake, Blue Gum Lake, Piney Lakes, Quenda Wetland, Frederick Baldwin Lake and Marmion Reserve), hereafter referred to as the "Melville Bull Creek catchment".

Bull Creek main drain winds its way through a series of parks and urban land in the lower catchment, receiving stormwater from local drains, before discharging directly into Bull Creek and the Canning River (SRT 2012). Bull Creek main drain has strong flow all throughout the year, even in summer, suggesting it is also receives a significant amount of groundwater (Foulsham et al 2009).

The Brentwood drain also flows permanently due to groundwater interception and receives additional water when flood control pumps at Frederick Baldwin Lake and Kingston Place in Kardinya are in operation. Frederick Baldwin Lake and Kingston Place receive stormwater and groundwater from the suburbs of Kardinya and Murdoch (City of Melville 2004). The Brentwood main drain also receives water from local drains and converges with the Mandala Crescent Branch Drain (also known as the RAAF drain) at the Brentwood Living Stream site before passing through Bateman Park and discharging into the Canning River. The Brentwood Living Stream project, driven by a partnership of several agencies (including Department of Biodiversity, Conservation and Attractions (DBCA) Rivers and Estuaries Division, City of Melville, SERCUL, Water Corporation and Main Roads) was launched in 2012 to mitigate some of the water quality issues identified in Brentwood drain at Bateman Park. The project involved the reconstruction of the water course where the Brentwood and Mandala Crescent drains converge (upstream of Bateman Park) using urban water sensitive nutrient/non-nutrient stripping designs.

Booragoon Lake, Blue Gum Lake outlet and Piney Lakes Reserve represent the northern extent of the Beeliar Wetland chain, a system consisting of inter-dunal depressions between the Spearwood and Bassendean dune systems which include a series of lakes running parallel with the coast (Natural Area Consulting 2012a 2012b and 2016). The chain of wetlands holds significance for the local aboriginal people as they were important camping and ceremonial areas; as well as providing an abundant source of food, offering fish, water fowl, shell fish, vegetable roots and bulbs (City of Melville n.d.). These wetlands are a surface expression of the underlying Jandakot Groundwater Mound aquifer (Natural Area Consulting 2012a).

Booragoon Lake Reserve is located approximately 10.5 km south of Perth CBD in the suburb of Booragoon, bounded by Leach Highway, Aldridge Road and Lang Street, and occupies an area of approximately 13.5 ha. The reserve is comprised of wetland areas, upland remnant vegetation and parkland cleared spaces (Natural Area

Consulting 2012). In the 1970s and 80s the Council drew water from a subterranean bore in the Alfred Cove area and pumped it into Blue Gum and Booragoon Lakes during summer to maintain the water level (City of Melville 2004a). However this practice no longer occurs and the Lake now has a water regime typical of Swan Coastal Plain wetlands, with water levels fluctuating in response to rainfall and groundwater level. Stormwater also enters the Lake from the surrounding urban catchment via five drains (including one drain collecting water from Leach Highway) and one drainage basin (Natural Area Consulting 2012a).

Blue Gum Lake Reserve is a wetland reserve located approximately 9.5 km south of Perth Central Business District in the suburb of Mount Pleasant, and occupies an area of approximately 11.09 ha. The Reserve is bounded by Canning Avenue, Moolyeen Road and Rountree Road and is comprised of wetland areas, upland remnant vegetation and parkland cleared spaces. The Reserve is comprised of four main areas: two wetland basins with an artificial island located between them, two areas of upland Banksia woodland community, a transitional zone characterised by *Melaleuca* and *Eucalyptus rudis* woodlands, and parkland cleared areas with an over storey of predominantly non-native eucalyptus. In addition to being a surface expression of the groundwater, Blue Gum Lake also receives water from stormwater inflow from seven drains collecting water from the surrounding urban catchment, two of which have defective basins at their outlet (Natural Area Consulting 2012b). Historically Blue Gum Lake would respond to fluctuations of the water table relating to seasonality and climatic variations, however following development in its surrounding area the lake has experienced significant changes to its water natural cycle (Natural Area Consulting 2012b).

Piney Lakes Reserve is a bushland and wetland remnant area surrounded by urban development in the suburb of Winthrop. The Reserve is bounded by Leach Highway to the north and Murdoch Drive to the east and encompasses approximately 67 ha (50 ha of bushland and wetland environments and about 17 ha of developed parklands to the south and west) (Natural Area Consulting 2016a). Piney Lakes includes two conservation category groundwater dependent wetlands: an eastern and a western wetland (DBCA 2017). The western wetland is sampled for the purposes of this assessment. The western wetland used to contain water permanently but in recent years has often been found to be dry (Natural Area Consulting 2016a).

Quenda Wetland is a unique small reserve of a high conservation value located at the corner of Murdoch Drive and South Street in the suburb of Murdoch. The wetland was originally seasonal, drying out in the summer months; however it has been artificially deepened to accommodate stormwater flows from surrounding development (Natural Area Consulting 2016b). A number of stormwater drains enter the lake, including a large drain collecting water from Murdoch St John of God Hospital carparks and roads to the south east of the lake (Natural Area Consulting 2016b).

Marmion Reserve is located in the suburb of Myaree. In 2012 the lake was found to be infested with a pest eel-tailed catfish species (*Tandanus tandanus*) and the aquatic weed *Salvinia molesta* (City of Melville 2016). In an effort to control these species the lake was drained in 2014 and the species successfully eradicated (Clayton 2015). Revegetation and removal of old vegetation has been occurring immediately surrounding the lake since this time (City of Melville 2016).

1.3 Background of the monitoring program

The City of Melville began sampling its lakes and the Bull Creek drainage biannually in 1996. In 2007 a partnership between the City, SERCUL and the Department of Water (now Department of Water and Environmental Regulation or DWER) was established in order to standardise all water quality monitoring data collection, management and storage methods. Since this time, the sites and parameters monitored have been modified in response to changes in budget and requirements (see **Appendix B**). The City has utilised data collected from this monitoring program to develop management plans for surface water assets within the city.

In 2006 the Australian Government's Coastal Catchments Initiative identified the Swan Canning river system as a coastal 'hot spot' and funding was provided to the Swan River Trust (now DBCA Rivers and Estuaries Division) to coordinate a Water Quality Improvement Plan for the region. The Swan River Trust developed the Local Water Quality Improvement Plan (WQIP) for the Bull Creek Catchment which was released on November 2012. The Bull Creek Catchment WQIP aims to reduce nutrient loads entering the Canning River through nutrient intervention and changed management practices. By using a treatment train approach, a combined set of management actions are applied along the nutrient pathways to meet water quality targets in the catchment (SRT 2012). The water quality monitoring partnership program between the City, SERCUL and DWER forms part of the "Prevention" approach.

1.4 Purpose of the sampling

The purpose of this sampling program is to:

- Assess current water and sediment quality in the Melville Bull Creek Catchment;
- Identify patterns in water and sediment quality over time in the Catchment;
- Identify any pollutant hotspots in the Catchment; and
- Make recommendations for improvement of water and sediment quality in the Catchment.

This water quality monitoring program also contributes valid data to the DWER Water Information (WIN) database, which is utilised in the management of the State's water resources.

2. Methodology

For more information regarding the methodology of this monitoring program see the Sampling and Analysis Plan (SAP) prepared by SERCUL (2018).

2.1 Site locations

14 sites from the Melville Bull Creek catchment were sampled to represent the water quality in different portions of Bull Creek catchment and the Melville lakes, whilst taking into account accessibility and historical sampling sites.

Table 2-1 provides a detailed description and GPS coordinates of each of the sample sites. A map showing the location of the sites is provided in **Figure 2.1-1**.

Table 2-1: List and description of sampling sites

Site No.	WIR site ref.	Drain section/component	Sampling point Location	Easting	Northing
PSDTBCMD (MELDR-01)	6162178	Bull Creek Park Main Drain	Culvert under Leach Hwy	392965.3	6453785.6
MELDR-02	6162370	Brockman Park	Where piped drain opens	393466.5	6453208.5
MELDR-05	6162373	John Creaney Park outlet	Compensation Basin Outlet	392359	6452734.7
MELDR-06	6161691	Bateman Park	Downstream of the confluence of the 2 drains	392269.8	6453880.2
MELDR-07	6162375	Booragoon Lake	In the lake at the end of walkway	390734.68	6454164.09
MELDR-08	6162376	Piney Lakes	At the lake outlet	390151.59	6453473.10
MELDR-09	6140831	Quenda Lake	At the lake outlet	390749.20	6451597.51
MELDR-10	6162377	Frederick Baldwin	At the lake outlet	387989.87	6452295.91
MELDR-11	6162378	Marmion Reserve	At the lake outlet	387774.89	6454629.75
MELDR-12	6162379	Blue Gum Lake	At the lake outlet	391282.81	6454886.75
MELDR-13	6165324	Brentwood drain	Pulo Rd & Leach highway, 10m walking from Pulo Rd. Site moved at beginning of 2015-16 sampling due to construction works reshaping the drain.	392126.59	6453865.28
MELDR-14	6165325	RAAF drain	10 m down from pipe under Leach highway	392195	6453841
MELDR-15	6165331	John Creaney Park inlet	Approx. 5m upstream of the main inlet into John Creaney Park, access via Water Corp drain man hole (lid lifting and bucket and rope required)	392256.48	6452699.35
MELDR-16	6165332	Closed pipe Downstream Elizabeth Manion Park	On Nicholls Cres close to Hurley Way, in front of pathway, access via Water Corp man hole (lid lifting and bucket and rope required)	393327.76	6452478.47

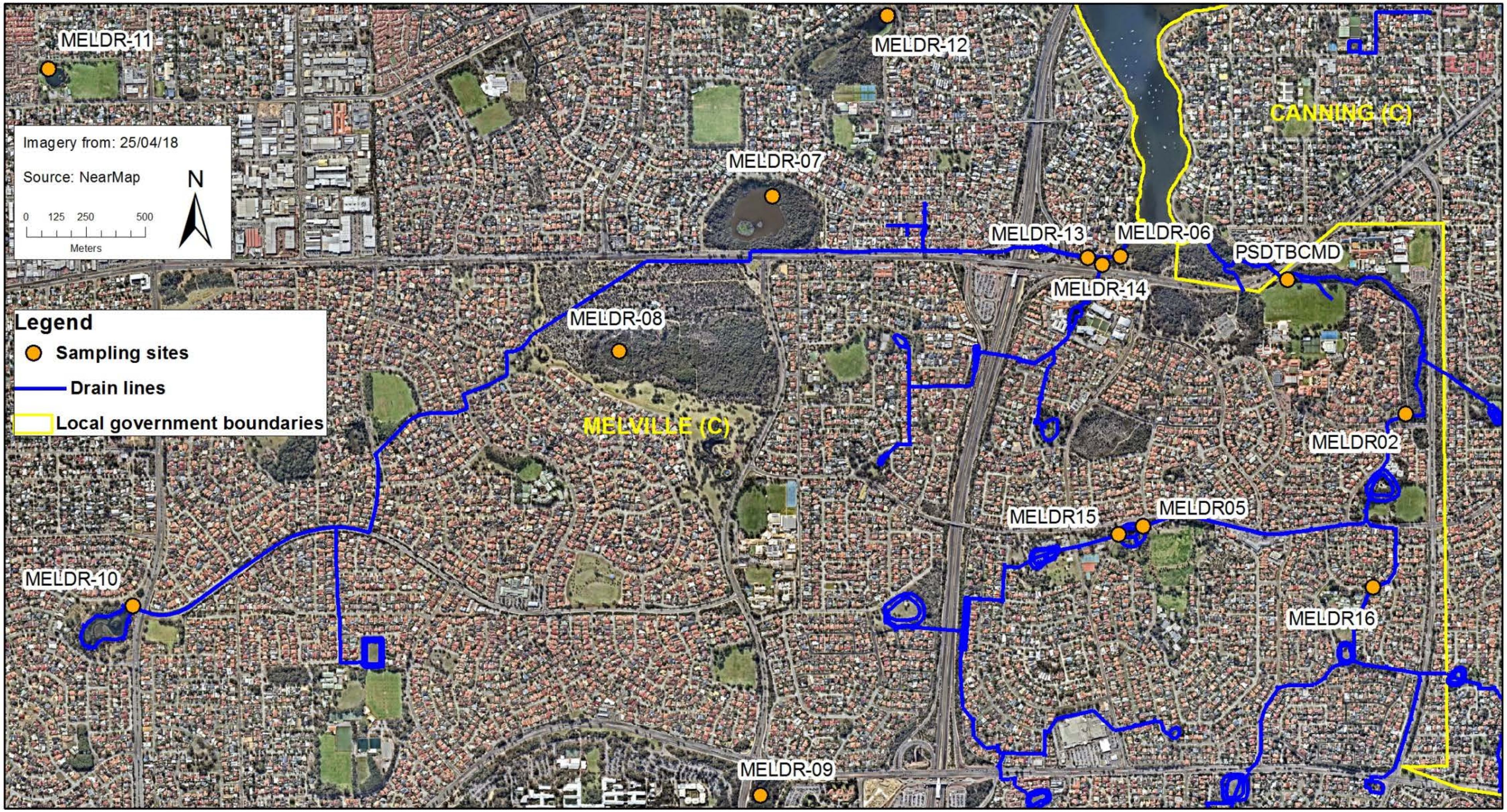

Figure 2.1-1: Melville Bull Creek Catchment and Melville Lakes sampling sites in 2018

2.2 Sampling schedule and procedures

Sampling was conducted from the 14 Melville sites on the following dates: 10th July, 7th August, 13th September, and 9th October 2018. All sites were sampled on all sampling occasions except for site 16 (Downstream Elizabeth Manion Park) which was unable to be sampled in July as the manhole lid covering this drainage site could not be opened at this time. Temperature and rainfall data for the duration of the sampling is detailed in **Appendix A.**

Field observation forms were filled out for all samples and all of them were transported under “chain of custody” to the laboratory and analysed in accordance with the laboratory methods. All water and sediment samples collected were analysed by Chemcentre, a laboratory accredited by the National Association of Testing Authorities (NATA). Sediment samples were also submitted to CSIRO for particle size analysis.

2.3 Parameters measured

Water at each of the 14 sites was measured in situ for physical properties (dissolved oxygen, pH, electrical conductivity and temperature). It should be noted that electrical conductivity has been measured as specific conductance: that is, values have been corrected to 25°C to allow for comparisons to be made between samples taken at different temperatures (i.e. between different sites and different months). Samples were collected from each site and analysed for a range of contaminants likely to be present in urban and industrial catchments.

Water samples at all Melville Bull Creek sites were analysed for:

- Nutrients - total phosphorus (TP), total nitrogen (TN), total oxidised nitrogen (NO_x-N), total organic nitrogen (TON), dissolved organic nitrogen (DON), filterable reactive phosphorus (FRP) and nitrogen as ammonia/ammonium (NH_3-N/NH^{4+}-N) at all sites on all four sampling occasions;
- Total metals - aluminium (Al), chromium (Cr), copper (Cu), iron (Fe), lead (Pb) and zinc (Zn) tested at all sites on the first sampling occasion for surveillance;
- Total mercury (Hg) tested at 3 sites (13, 14 and 6) on all four sampling occasions;
- Soluble metals - aluminium (Al), chromium (Cr), copper (Cu), iron (Fe), lead (Pb) and zinc (Zn) tested at all sites on all four sampling occasions;
- Soluble metals - mercury (Hg) at 3 sites (13, 14 and 6) on all four sampling occasions; and
- Total suspended solids and total water hardness at all sites on all four sampling occasions.

Sediment samples at the west side of the catchment were collected from 11 sites (sites PSDTBCMD, 2, 5, 6, 7, 8, 9, 11, 12, 13 and 14) for the analysis of:

- Total metals/metalloids (Al, As, Cr, Cu, Fe, Hg, Ni, Pb, Se and Zn), and
- Moisture
- Particle size analysis

It is noted that sediment could not be sampled at site 10 (Frederick Baldwin Lake) in 2018 as a thick layer of impacted roots and leaf litter precluded sampling; this was also the case in 2017. Sediment samples were not collected from sites 15 and 16 (John Creaney Park inlet and Downstream Elizabeth Manion Park) as both sites are closed pipes.

2.4 Analysis methodology

All water and sediment samples collected were analysed by Chemcentre, which is a National Association of Testing Authorities (NATA) accredited laboratory.

Laboratory results were reported as per the limits of reporting (being the minimum detection level) for each parameter listed in **Table 2-2.**

Table 2-2: Analysis method and maximum limits of reporting (LOR) for water and sediment samples

Measured parameter	LOR
WATER	
Total phosphorus	0.005 mg/L
Total nitrogen	0.025 mg/L
Total organic nitrogen	0.025 mg/L
Filterable reactive phosphorus	0.005 mg/L
Total oxidised nitrogen	0.01 mg/L
Nitrogen as ammonia	0.01 mg/L
Dissolved organic nitrogen	0.025 mg/L
Total Suspended Solids	1 mg/L
Total water hardness	1 mg/L
Aluminium – total and soluble	0.005 mg/L
Chromium - total and soluble	0.0001 mg/L
Copper - total and soluble	0.0001 mg/L
Iron – total and soluble	0.005 mg/L
Lead - total and soluble	0.0001 mg/L
Mercury – total and soluble	0.0001 mg/L
Zinc - total	0.005 mg/L
Zinc - soluble	0.005 or 0.001 mg/L
SEDIMENT	
Aluminium – total	1 mg/Kg
Arsenic – total	0.1 mg/Kg
Chromium - total	0.05 mg/Kg
Copper - total	0.5 mg/Kg
Iron - total	1 mg/Kg
Lead - total	0.5 mg/Kg
Mercury	0.02 mg/kg
Nickel - total	0.1 mg/Kg
Selenium	0.05 mg/kg
Zinc - total	0.25 mg/Kg

Sediment samples were also analysed by CSIRO laboratory for the particle size distribution. Particles were grouped into the following size classes according to the Wentworth scale (Wentworth 1922) using wet sieving followed by laser diffraction (Mudroch et al. 1997):

Class	Size
Clay	<4 µm
Silt	4-62 µm
Fine sand	62-250 µm
Medium sand	250-500 µm
Coarse sand	500-2,000 µm
Gravel	>2,000 µm

3. Guidelines

To provide a frame of reference for water and sediment quality data collected from the Melville Bull Creek catchment, laboratory results have been compared to trigger levels from the ANZECC and ARMCANZ (2000) *Australian and New Zealand Guideline for Fresh and Marine Water Quality* (hereafter referred to as the "ANZECC guidelines"). Exceedance of a trigger value from the ANZECC guidelines indicates that there is the potential for an impact to occur and should therefore trigger a management response. The rationale for the trigger values used in the ANZECC guidelines is provided in chapter 8 of the guidelines. **Table A-1, Table A-2 and Table A-3, Appendix A** show the ANZECC trigger values used to compare the results of the analysed parameters.

The ANZECC guidelines specify trigger values that should not be exceeded for physical and chemical stressors of different ecosystem types. The results of some sites (15, 5, 16, 2, ROSSTAFE, PSDTBMCD, 13, 14 and 6) were compared to the 'lowland rivers' trigger values and others (7, 8, 9, 10, 11 and 12) to 'wetlands' ecosystem trigger values. These are considered to be most applicable for drain and lake sites respectively. ANZECC and ARMCANZ do not provide a trigger value for total suspended solids, however DWER (DoW n.d.) use an interim assessment value of 6 mg/L, which has been used for comparison purposes in this assessment. To better graph the site results in accordance with their referenced trigger values they have been ordered with the 'lowland rivers' sites to the left and the 'wetlands' sites to the right. The 'lowland rivers' sites have been separated into the two main drainage lines (Bull Creek Main Drain and Brentwood Main Drain) and arranged from the top of the catchment to the bottom (entrance to the Canning River) creating a more visual display of the individual segments allowing for better interpretation of flow and spatial patterns and understanding the aquatic conditions upstream and downstream.

The ANZECC guidelines also specify "high reliability" trigger values for toxicants (including metals and ammonia) in fresh waters where sufficient "No Observed Effect Concentration" (NOEC) data is available and is published in chapter 3 of the guidelines. Several trigger values have been derived for each toxicant depending on the proportion of species for which protection is sought: 99%, 95%, 90% or 80%. Urban and industrial catchments tend to be highly modified and are often artificial ecosystems, where the risk of toxicant contamination is high and current environmental value is low. On that basis, the ANZECC trigger values for 80% protection of freshwater biota would be applicable to the waterbodies/tributaries within the City of Melville. However, the Bull Creek and Brentwood drains discharge into the Canning River where environmental values are high and for this reason, toxicant concentrations were compared to the trigger values for 95% protection levels (where available), applicable to high conservation value and slightly to moderately disturbed ecosystems. For the metals cobalt and molybdenum, "high reliability" values are not available and therefore ANZECC and ARMCANZ recommend the use of "low reliability" trigger values calculated by different means. For chromium (III), the "high reliability" trigger value is considered too high and therefore the use of an interim value for freshwater protection is recommended. For iron, the ANZECC guidelines suggest the use of an interim value based upon the current Canadian guideline level (CCREM 1991). The ANZECC trigger values for protection of biota for chromium (III), copper, lead and zinc are hardness dependent, and as such specific trigger values for each sample have been calculated (see relevant tables in **Appendix D** for the details and calculations).

The system being monitored is largely a piped system that ultimately discharges into the Canning River. Much of the monitoring captures data from water running directly off roads and residential areas with no treatment prior to entering the lakes and drains. From a human-use perspective, Bull Creek is not a source of drinking water but may be accessed by the public at several points, on public and privately owned land. Therefore it is reasonable to compare the toxicant results to the National Health and Medical Research Council's (NHMRC) *Guidelines for Managing Risks in Recreational Water* (2008) (hereafter referred to as the "NHMRC recreational guidelines"). Trigger values for pH and dissolved oxygen are specified in these guidelines. For toxicant parameters (i.e. metals and ammonia), these guidelines recommend that recreational trigger values be calculated by multiplying the relevant trigger values in the NHMRC (2016) *Australian Drinking Water Guidelines* 6: 2011 (ADWG) by ten. An exceedance of the referenced trigger level does not indicate that 'standards' are not being met, but is an indication that further consideration should be given to the situation.

The revision to the ANZECC guidelines for sediment (Simpson et al 2013) provides both low and high trigger values for metals in sediment. Where concentrations are between the low and high values background concentrations should be investigated. If the results exceed the high guidelines or are above the background concentrations a further assessment for the bioavailability of the metal is required.

4. Field observations

The following relevant observations were recorded at Melville Bull Creek catchment sites on at least one sampling occasion in the 2018 sampling period:

- Higher water levels in all lakes compared to the previous several years of monitoring;
- Iron staining, iron floc or iron reducing bacteria noted at sites 15, 5, 16, 2 and 13;
- Turbid or cloudy water at sites 6, 13 and 11;
- Anoxic smell at site 6;
- Tannin staining at sites 15, PSDTBCMD, 7, 8, 9 and 12;
- Duckweed at site 12;
- Green scum on the surface at sites 12 and 11; and
- Green water (indicative of phytoplankton) at sites 2, 14, 6 and 10.

5. Physicochemical Properties

Refer to **Tables D-1 to D-6** in **Appendix D** for all physicochemical parameter data (pH, dissolved oxygen, electrical conductivity, total suspended solids and temperature) collected in the 2018 water quality sampling of the Melville Bull Creek catchment. **Table E-1, Appendix E** outlines the factors that influence changes in these physicochemical parameters and the impacts that changes to these parameters can have to aquatic ecosystems.

5.1 pH

pH is a measure of the acidity or alkalinity of a water body and is measured on a logarithmic scale. As such, for example, a pH of 5 is ten times more acidic than a pH of 6. A pH value of less than 6.5 is considered acidic, between 6.5 and 8.0 is considered neutral and higher than 8.0 is considered high by DWER (DoW n.d.).

When compared against the appropriate ANZECC lowland rivers (6.5 – 8) or wetlands (7 – 8.5) acceptable range, 21 out of the 59 samples collected from at eight out of the 15 Melville Bull Creek catchment sites (15, 5, 2, 7, 8, 9, 10 and 12) recorded pH values below the acceptable range (**Figure 5.1-1** and **Table D-1, Appendix D**). Nine samples recorded pH values below the NHMRC recreational guidelines acceptable range (6.5 – 8.5). No site recorded a sample exceeding either acceptable range. The highest pH of 8.28 was recorded in August at site 11 (Marmion Reserve) and the lowest of 5.92 in August at site 8 (Piney Lakes outlet).

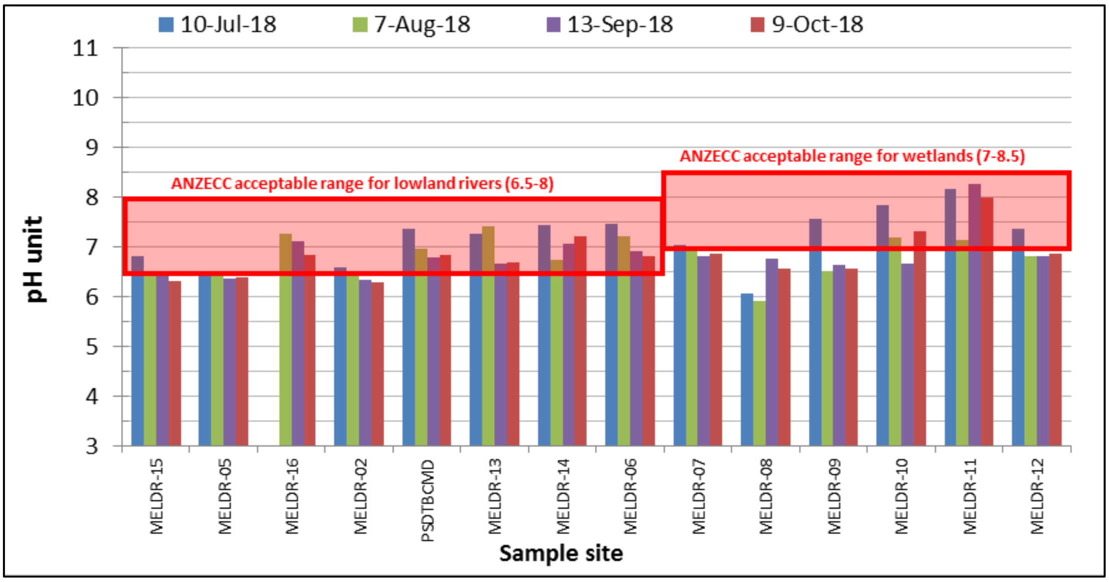

Figure 5.1-1: pH values recorded in Melville Bull Creek catchment sites in 2018

The pH values recorded in 2018 are similar to those recorded in the preceding 11 years of monitoring (**Table 5-1**). However, while particularly low pH values (<5) have often been recorded at Booragoon Lake (site 7) and Blue Gum Lake (site 12) in previous years (generally in the winter sampling months), pH values recorded at these sites in 2017 and 2018 were only slightly below the acceptable range for wetlands. Furthermore, pH values recorded at site 11 in 2018 did not exceed the ANZECC acceptable range as they have often done in the preceding three years.

Throughout the 12 year monitoring period, Brockman Park, Booragoon Lake outlet, Piney Lakes outlet, Quenda Lake outlet and Blue Gum Lake outlet (sites 2, 7, 8, 9 and 12) have recorded pH below the acceptable range for lowland rivers or wetlands on at least 60% of sampling occasions. John Creaney Park sites (15 and 5) and Frederick Baldwin Lake (10) have also often recorded results below the relevant acceptable range.

On the Bull Creek main drain, pH values are generally more acidic at John Creaney Park (site 5) than at downstream Elizabeth Manion Park (site 16), suggesting that the low pH values recorded at Brockman Park may be attributed to contributions from the western branch feeding into the Bull Creek main drain. However, pH levels are generally within acceptable limits further downstream at the Bull Creek main drain site closest to the river (PSDTBCMD).

5.2 Dissolved oxygen

44 out of 55 samples collected from Melville Bull Creek catchment sites recorded dissolved oxygen (DO) saturations below the ANZECC acceptable ranges (lowland rivers: 80-120%, wetlands: 90-120%) and the NHMRC recreational guidelines lower limit (80%) (**Figure 5.2-1** and **Table D-2, Appendix D**). Only site 14 (RAAF drain) recorded a saturation within the acceptable range (the highest recorded saturation) on all occasions when it was sampled. Two samples from site 11 (Marmion Reserve) recorded DO saturations greater than the acceptable range of 135.5% and 131.4% in October and September respectively. Site 5 (John Creaney Park) recorded the lowest saturation in the catchment of 3.7% in July.

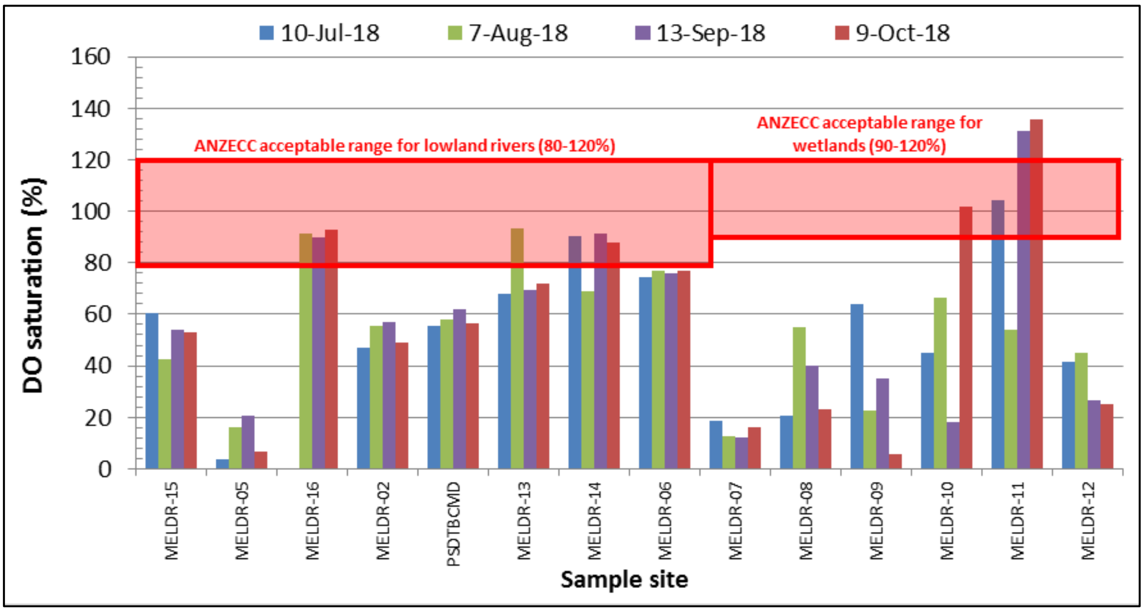

Figure 5.2-1: Dissolved oxygen (DO %) saturations recorded at Melville Bull Creek catchment sites in 2018

When considering the DO concentrations in mg/L, from a total of 55 samples, 17 recorded very low concentrations (<4 mg/L), 16 recorded low concentrations (4.0 to 6.0 mg/L), 11 recorded moderately oxygenated concentrations (6.0 to 8.0 mg/L), 8 samples recorded well oxygenated concentrations (8.0 to 10.0 mg/L) and three samples recorded hyperoxic concentrations (>10 mg/L) according to DWER standards (DoW n.d.) (**Figure 5.2-2** and **Table D-3, Appendix D)**.

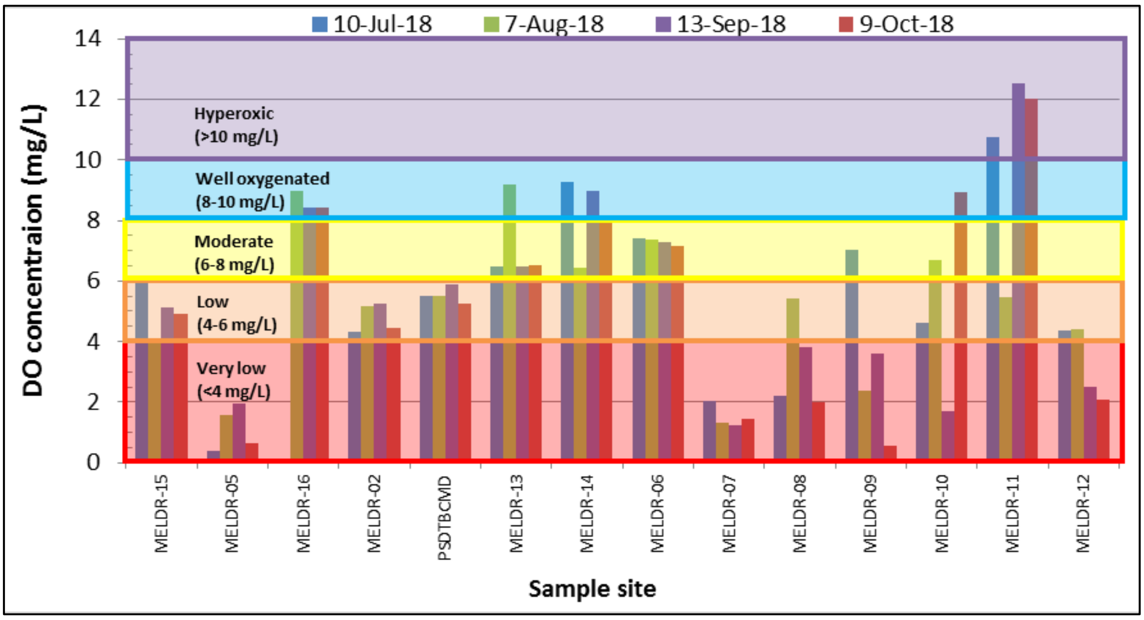

Figure 5.2-2: Dissolved oxygen concentrations (mg/L) recorded in Melville Bull Creek catchment sites in 2018

Dissolved oxygen saturations and concentrations recorded in 2018 were similar to those recorded in the preceding 11 years of monitoring (**Table 5-1**). However, it should be noted that DO saturations recorded at site 12 (Blue Gum Lake) since 2013 and at site 9 (Quenda Lake outlet) since 2014 are lower than in the preceding years of sampling. It should also be noted that Quenda Lake has recorded generally higher nitrogen concentrations and lower oxygen saturations since 2013 and Blue Gum Lake has recorded generally higher nitrogen and phosphorus concentrations and lower oxygen saturations since 2012 than in previous years (see **Section 6.1**), suggesting a possible link between eutrophication and low dissolved oxygen saturations at these sites.

Over the twelve year monitoring period, most sites have generally recorded very low to moderate median DO concentrations, and DO saturations generally below the acceptable range for lowland rivers and wetlands. Only sites 16 and 14 (downstream Elizabeth Manion Park and RAAF drain) record acceptable saturations on more than 50% of sampling occasions.

DO saturations have generally been slightly lower at site 13 (Brentwood drain) than at site 14 (RAAF drain), with saturations at downstream site 6 (Bateman Park) similar to those at site 13. DO saturations are generally significantly lower at the outlet of John Creaney Park (site 5) than the inlet (site 15) and also lower than at the other branch of the Bull Creek main drain at site 16 (downstream Elizabeth Manion Park). DO saturations at site 2 (Brockman Park) are between those at sites 5 and 16, with DO usually slightly higher at the most downstream Bull Creek main drain site (PSDTBCMD).

5.3 Electrical conductivity

Electrical conductivity (EC) is the ability of water or soil to conduct an electric current. It is commonly used as a measure of salinity or total dissolved salts as solutions with high salt concentrations conduct electricity better than pure water. EC is increased when the total concentration of inorganic ions (particularly sodium, chlorides, carbonates, magnesium, calcium, potassium and sulfates) is increased.

EC values recorded in Melville Bull Creek catchment sites were varied, with two samples from sites 10 (Frederick Baldwin) recording concentrations below the acceptable range for wetlands (0.3-1.5mS/cm) and all 31 samples from the drain sites (15, 5, 16, 2, PSDTBCMD, 13, 14 and 6) and two samples from sites 7 and 8 (Booragoon Lake and Piney Lakes outlet) recording values above ANZECC acceptable ranges for lowland rivers (0.12-0.3 mS/cm) or wetlands (0.3-1.5 mS/cm) respectively (**Figure 5.3-1** and **Table D-4, Appendix D)**. The lowest EC reading (0.1951 mS/cm) was recorded at site 10 in July and the highest of 1.583 mS/cm recorded at site 8 in August.

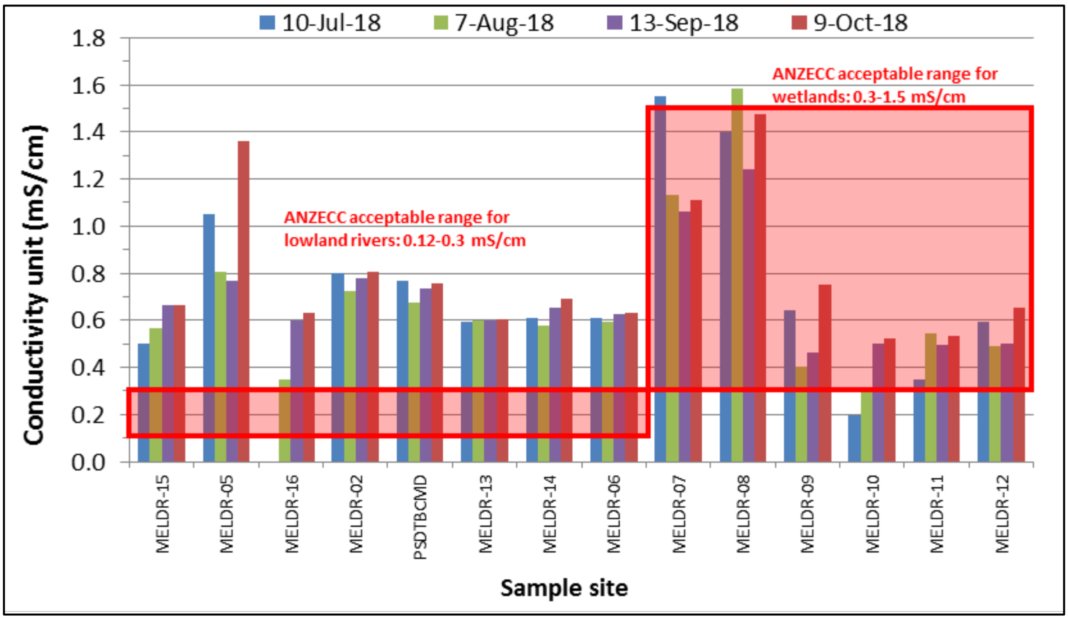

Figure 5.3-1: Electrical conductivity (mS/cm) recorded in Melville Bull Creek catchment sites in 2018

EC values recorded at most sites in 2018 are generally similar to those recorded in the preceding 11 years of sampling, however it is noted that somewhat lower EC values were recorded at site 7 (Booragoon Lake) in 2018 than in previous years, and higher values were recorded at site 11 (Marmion Reserve) than in previous years (**Table 5-1**). Over the twelve year monitoring period, all drain sites (15, 5, 16, 2, PSDTBCMD, 13, 14 and 6) as well site 7 have generally recorded EC higher than the applicable acceptable range and site 11 has generally, and site 10 (Frederick Baldwin) has often, recorded EC levels lower than the acceptable range. Although electrical conductivity levels recorded in the Melville Bull Creek catchment are often above ANZECC acceptable ranges, they do not appear to be changing substantially over time and therefore any biota living in these lakes and drainage lines is likely to be adapted to these levels.

5.4 Total suspended solids

Total Suspended Solids (TSS) in a waterbody is a measure of the concentration of suspended materials in the water that can be removed by filtration. TSS can include a wide variety of material, most often comprising soil particles and organic material (e.g. algae, microorganisms, decaying plant and animal matter).

Total suspended solids concentrations were generally low across the catchment, with 14 out of 55 samples collected from Melville Bull Creek catchment sites recording concentrations equal to or above the DWER interim guideline (6 mg/L) at sites 15, 5, 16, 13, 6, 7, 8,10 and 12 (John Creaney Park inlet, John Creaney Park, Downstream Elizabeth Manion Park, Brentwood Drain, Bateman Park, Booragoon lake outlet, Piney Lakes outlet, Frederick Baldwin and Blue Gum Lake outlet respectively) (**Figure 5.4-1, Table D-5, Appendix D**). The highest concentration of 54 mg/L was recorded at site 8 in October. Site 13 recording exceeding TSS concentrations on all four sampling occasions. Six samples recorded concentrations below the limit of reporting of 1.0 mg/L.

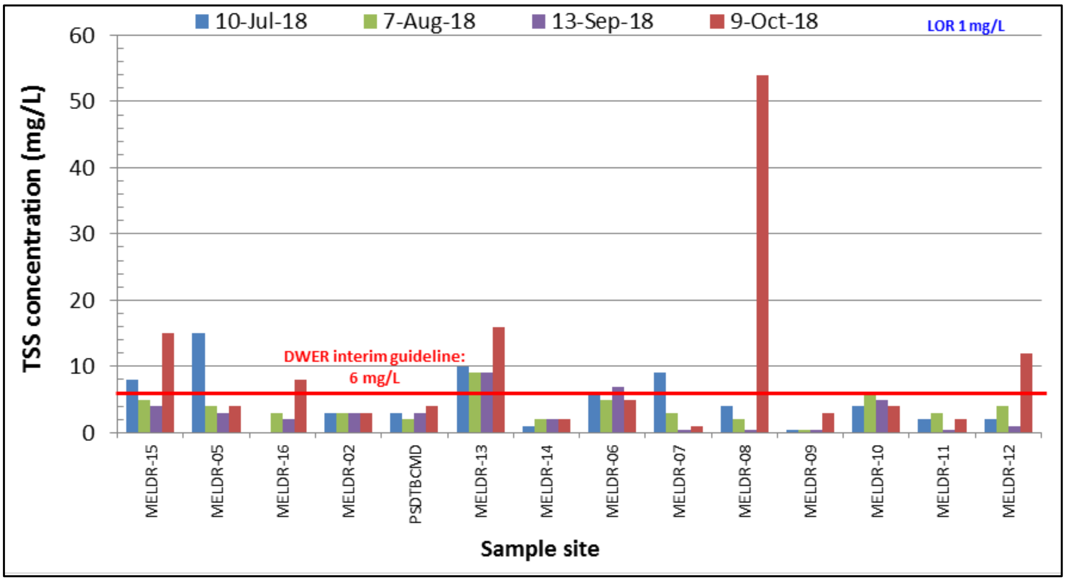

Figure 5.4-1: Total suspended solids (mg/L) recorded in Melville Bull Creek catchment sites in 2018[1]

TSS concentrations recorded in 2018 are similar to those recorded in the preceding 11 years (**Table 5-1**). Sites 15, 16, 13, 6 and 7 (John Creaney Park inlet, downstream Elizabeth Manion Park, Brentwood Drain, Bateman Park and Booragoon Lake outlet) have recorded concentrations above the interim guideline more than 60% of the time and Blue Gum Lake (site 12) has recorded exceedances on approximately 50% of sampling occasions over the twelve year monitoring period.

When comparing results between sites 13 and 14 (Brentwood Drain and RAAF Drain respectively), total suspended solids concentrations are usually lower at site 14 than at site 13, with TSS at site 6 often somewhere in between the two sites, suggesting the clearer water at site 14 may be diluting the more turbid water at site 13. On the Bull Creek main drain, TSS results are usually lower at site 5 than site 15, perhaps indicating that some particulate material settles to the bottom of the John Creaney Park lake after flowing through the drainage pipes.

[1] A value equal to half the limit of reporting was substituted for occasions where concentrations were recorded as 'below the laboratory limit of reporting', which is a standard technique to allow these 'unknown' values to be represented graphically and to differentiate them from those samples that recorded concentrations equal to the limit of reporting.

5.5 Temperature

It should be noted that water temperature will often increase throughout the day, and hence sampling time can partially influence recorded water temperature. During the 2018 monitoring period, sampling was conducted at varying times between 8 am and 2:30 pm.

Temperatures in the surface waters of the Melville Bull Creek catchments ranged from 11.2°C in July at Quenda Lake outlet (site 9) to 24.9°C in October at Blue Gum Lake outlet (site 12) (**Figure 5.5-1** and **Table D-6, Appendix D**). Temperatures at all sites were considered to lie within a normal seasonal range and are comparable to those recorded in the previous 11 years of monitoring (**Table 5-1**).

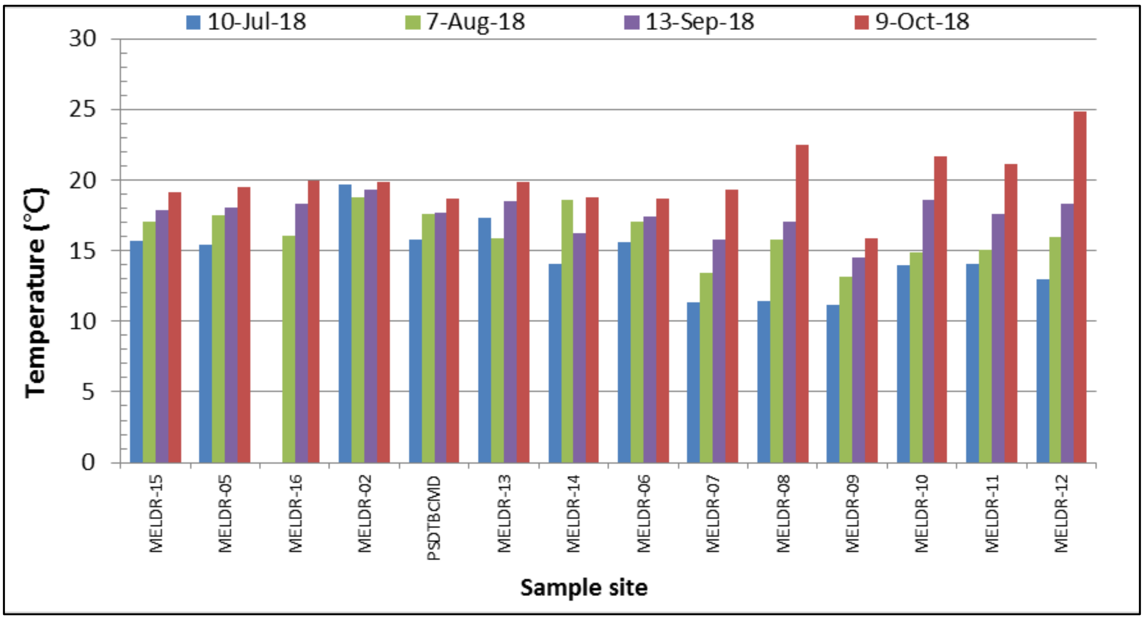

Figure 5.5-1: Water temperatures (°C) recorded in Melville Bull Creek catchment sites in 2018

Table 5-1: Physicochemical parameter (pH, dissolved oxygen (DO) saturation (%), DO concentration (mg/L), conductivity (mS/cm) and temperature (°C)) results recorded in Melville Bull Creek catchment sites from 2007 to 2018

	Site	Jul-07	Oct-07	Jan-08	Apr-08	Sep-08	Nov-08	Jan-09	Mar-09	Sep-09	Nov-09	Jan-10	Mar-10	Aug-10	Sep-10	Oct-10	Nov-10	Jul-11	Aug-11	Sep-11	Oct-11	Jul-12	Aug-12	Sep-12	Oct-12	Aug-13	Sep-13	Oct-13	Nov-13	Aug-14	Sep-14	Oct-14	Nov-14	Aug-15	Sep-15	Oct-15	Nov-15	Jul-16	Aug-16	Sep-16	Oct-16	Jul-17	Aug-17	Sep-17	Oct-17	Jul-18	Aug-18	Sep-18	Oct-18	Median
pH (pH units)	MELDR-15																														6.16	6.11	6.21	6.41	6.24	6.76	6.68	6.61	6.56	6.46	6.54	6.85	6.58	6.4	6.49	6.83	6.51	6.5	6.32	6.5
	MELDR-05	6.74	6.65			6.45	7.18	7.35		6.65	6.85			6.93	6.91	7.1	7.31	7.22	6.33	6.29	6.45	6.23	6.62	6.52	6.67	6.51	6.57	6.96	7.1	6.13	6.25	6.17	6.43	6.33	6.15	6.55	6.55	6.24	6.33	6.4	6.22	6.53	6.46	6.32	6.39	6.52	6.45	6.36	6.4	6.51
	MELDR-16																														6.29	6.24	6.56	6.44	7.1	6.48	6.9	6.61	6.61	6.74		7.15	6.83	6.93	7.02		7.27	7.11	6.85	6.83
ANZECC acceptable range for lowland rivers: 6.5 - 8 wetlands: 7 - 8.5	MELDR-02	6.07	6.21	6.44	6.23	6.14	6.94	6.34	6.39	6.29	6.54	6.36		6.24	6.34	6.28	6.37	6.31	6.45	6.18	6.28	6.22	6.18	6.33	6.38	6.27	6.32	6.54	6.71	6.1	6.21	6.17	6.22	6.11	6.04	6.16	6.16	6.26	6.22	6.16	6.23	6.24	6.24	6.21	6.25	6.59	6.45	6.35	6.3	6.26
	PSDTBCMD	6.89	6.88	6.47	7.3	6.82	7.46	7.47	7.2	7.07	7.24	7.23		6.92	7.29	7.51	7.49	6.73	7.36	6.58	7.27	6.81	6.74	7.25	7.07	6.62	7.27	6.6	6.8	6.61	6.73	6.67	6.76	6.66	6.51	6.68	6.66	6.77	6.73	6.77	6.8	6.68	6.84	6.78	6.74	7.38	6.97	6.79	6.84	6.81
	MELDR-13																											6.67	6.72	6.59	6.69	6.66	6.74	6.5	6.31	6.57	6.41	6.77	6.67	6.81	6.69	6.61	6.75	6.64	6.71	7.27	7.41	6.67	6.69	6.68
	MELDR-14																											6.29	6.33	6.99	7.14	7.11	7.12	7.01	6.8	6.89	6.86	7.04	7.03	7.06	7.09	7.11	7.24	7.15	7.18	7.45	6.75	7.07	7.21	7.065
	MELDR-06	6.17	6.51	7.6	6.35	6.35	7.27	6.58	6.68	6.74	6.52	6.67		6.98	6.94	7.26	6.87	7.15	7.01	6.46	7.07	6.88	6.89	7.08	7.12	6.71	7.06	6.12	6.25	6.82	6.8	6.78	6.87	6.83	6.74	6.74	6.56	7.25	7.13	7.48	6.91	6.79	7.18	6.82	6.98	7.47	7.23	6.91	6.83	6.87
	MELDR-07	3.26	4.69			5.71	7.17	7.19		3.94	6.77			6.23	6.55	6.88	5.6		5.45	6.29	6.78			3.91	3.94		3.74	6.38	6.68	4.5	6.26	6.76	6.83	3.34	3.24	6.19	6.58	4.35	3.55	3.83	6.55		6.79	6.85	6.67	7.05	6.93	6.81	6.87	6.335
	MELDR-08	4.3	5.03			5.67	7.33			5.87										4.19	4.73		4.99	5.62	5.68	5.02	5.37	7.25	7.26	5.23	5.34	5.43	5.4	5.45	5.31	6.55	6.49	5.48	5.54	5.57	6.33	5.61	5.9	6.18	6.06	6.08	5.92	6.78	6.56	5.615
	MELDR-09	7.08	7.37			7.11	7.69	7.52	7.51	7.04	7.14	6.96		7.5	7.53	7.26		5.14	6.91	6.07	6.83	7.08	6.74	7.21	7.03	6.92	6.6	8.04	9.29	6.02	6.31	6.26	6.85	6.41	6.27	6.92	6.8	6.37	6.38	5.66	6.73	6.39	6.37	6.72	6.76	7.56	6.51	6.64	6.57	6.84
	MELDR-10	7.21	8.4			9.3	8.16	7.1	7.07	9.01	9.39	6.88		7.55	7.51	7.32	7.55	6.96	7.95	6.99	7.62	7.31	7.4	8.42	7.1	7.14	7.31	5.62	5.72	6.98	7.37	7.61	6.73	6.77	6.94	6.63	8.31	6.8	7.01	6.9	6.56	6.95	7.19	7.37	6.96	7.84	7.2	6.68	7.31	7.2
Min 3.24	MELDR-11	7.56	8.31			8.38	8.17	9.08	8.16	8.67	9.3	9.7	9.21	7.34	7.52	7.87	9.08	7.22	7.8	7.51	7.59	7.64	7.65	8.24	8.42	7.43	7.64	6.26	6.82	7.32	7.09	7.81	8.3	8.08	7.9	9.92	9.99	7.4	7.46	7.96	10.02	9.12	9.82	9.51	9.21	8.18	7.15	8.28	7.99	8.035
Max 10.02	MELDR-12	4.31	7.5			7.05	7.92	8.49		6.74	9.3	7.96		7.17	7.61	9.44	8.57	3.41	3.5	6.47	7.08	3.99	4.03	5.16	6.97	4.12	6.6	6.79	7.04	6.39	6.58	6.9	7	6.48	6.43	6.95	6.97	3.74	4.57	5.91	6.98	6.8	6.6	6.79	6.92	7.36	6.82	6.81	6.86	6.815
	MELDR-15																														41.1	39.3	47.7	56.9	53	48.4	56	45.8	44.1	43.7	42.9	49.7	44	39.7	37.9	60.6	42.6	54.2	53	45.8
Dissolved Oxygen (DO) saturation (%)	MELDR-05	13.1	21.9			29.9	8.8	2.7		42.8	65.4			74.3	26.2	14.6	12.7	60.2	11.4	76.3	7.7	9.4	60.9	2.3	21.1	27.8	22.5	88.9	71.7	31.6	8.1	12.6	18.2	13.1	0.3	0.6	1.6	10.1	12	45.4	12.9	37.9	19.3	7.8	7.7	3.7	16.2	20.5	6.8	14.6
	MELDR-16																														79.4	97.9	82	65.1	71.1	63.7	70.2	68.1	80.8	87.1		71	61.7	65.2	79.5		91.2	89.8	92.6	79.4
	MELDR-02	51.8	53.7	46.7	44.5	53.1	50.1	46.9	44.9	53.4	49.7	41.5		54.8	47.2	40.2	41.1	46.1	48.2	49.7	44.1	45.6	47.1	43.2	41.1	45.1	45.9	70.5	72.9	52.3	40.8	46	37	41.7	37.5	32.4	35.1	42	45.8	50.9	43.5	44.1	47.7	43.1	32	47.1	55.7	56.9	48.8	46
	PSDTBCMD	65.5	70.7	83.7	66.1	66.6	61.2	68.3	62.7	61.8	67.2	69.5		65.3	57.9	55	51.6	62.2	59.1	54.3	57.7	48.3	56.8	51.7	48.6	57.2	55.1	75.7	73.2	63.7	53.6	53.6	52.5	56.4	53.7	45.9	51.5	50	56.9	64.4	55.1	52.2	42.6	50.1	47.1	55.7	57.8	62.1	56.4	56.9
ANZECC acceptable range for lowland rivers: 80-120% for wetlands: 90-120%	MELDR-13																											51.2	47.8	78.1	65.4	69.3	71.8	55.1	63.1	65.5	47.6	58.7	64.2	57.3	68.5	60.1	63.5	61.1	61.5	67.7	93.2	69.4	71.8	63.85
	MELDR-14																											8.7	13.3	88.4	77.7	82	80	91.6	75.7	50.7	69.5	78.5	85	87.5	82.4	69.9	75	81.1	75	90.2	68.8	91.3	88	79.25
	MELDR-06	76.4	84.3	63.2	76.5	76.4	82.9	86.5	80.7	76.4	84.7	84.8		75.7	74.9	72.3	79.8	74.5	75.7	80.2	80.5	56.9	76.8	74.8	83.1	59	73.4	41.3	40	72.4	71.9	73.1	75.8	77	54.2	66.2	49.4	57.3	54.9	57.9	58.8	61.5	63.9	66.9	56	74.4	76.7	75.9	76.7	74.8
	MELDR-07	123.2	20.7			49.5	47.2	36.6		115.2	19			61.2	12.1	91.4	78.6		115.6	32.9	22.9			51.9	52.5		71.7	36.8	37.8	42.5	0.6	136.6	19.9	79.6	61.4	1.7	2.2	37.5	56.4	52.9	8.9		23.9	30.3	1.2	18.8	12.8	12.3	15.9	37.15
	MELDR-08	122.8	37.5			65.9	43.4			66.1										54.1	49.8		41.5	39	88.7	20.1	27.1	72.9	63.9	32.7	40.1	25.5	38.9	54.8	46.1	55.5	73.4	37.8	38.3	37.4	62.2	33.4	29.8	38.3	26.8	20.4	55.2	39.8	23.3	39.95
	MELDR-09	62.4	92.1			93.4	82.5	91	75.6	84.9	100.7	74.1		101.2	89.9	80.4		76.2	97.3	70	78.3	72.5	85	81.3	77.8	77.8	55	86.7	97.6	35	3	0.8	29.6	33.4	32.4	60.2	36.8	36.2	40	22.3	31.7	19.8	33.4	33.4	21.8	64.1	22.7	35.3	5.8	67.05
	MELDR-10	59.2	113			143.8	81.9	125.6	41.8	116.5	156.1	37.5		82.8	67.5	23.7	45.8	57.3	63	57.3	82.4	55.2	71.2	84.6	27.9	52.1	72.6	32.9	30.2	54.2	61.3	70.2	59.6	32.2	52	3.7	69	28.1	47.9	73.2	2.5	45.3	62.6	70.5	34.4	44.8	66.3	18	101.8	59.2
Min 0.30	MELDR-11	84.8	122.8			110.5	80	123.8		102	206.5	188.3	186.4	48.5	54.8	103.7	134.1	61	65	67.2	55	65.8	68	82	110.7	39.6	68.5	33.9	37.3	61.6	15	64.6	67.6	76.2	80.5	121	96.1	65.4	68.1	75.1	132.3	75.1	83.1	63.6	88.4	105	54.2	131.4	135.5	76.2
Max 206.5	MELDR-12	121.9	79.7			48.8	88.8	123.4	83.5	41.2	134.2	88.4		90	95.6	160.4	125.5	107	78.6	17.7	47.7	107.3	118.4	95.2	81.1	8.8	17.9	26.3	15.3	21.1		30.3	21.7	31.2	41.7	48.8	35.3	90	33	14.2	36.1	63.9	32.5	12.3	31.4	41.4	44.8	26.5	25.1	46.25
Dissolved Oxygen (DO) concentration	MELDR-15																														3.92	3.61	4.27	5.56	5.1	4.42	5.06	4.58	4.34	4.38	3.99	4.86	4.29	3.73	3.56	6	4.1	5.13	4.9	4.38
	MELDR-05	1.4	2.03			2.9	0.8	0.24		4.11	5.42			7.35	2.6	1.33	1.16	6.15	1.11	7.28	0.69	1.01	6.23	0.22	1.96	2.7	2.1	8.26	6.33	3.01	0.77	1.15	1.64	1.33	0.03	0.05	0.14	1.07	1.22	4.61	1.23	3.74	1.78	0.74	0.71	0.37	1.55	1.93	0.62	1.4
	MELDR-16																														7.52	9.06	7.39	6.05	6.58	5.78	6.36	6.39	7.67	8.57		6.75	5.83	6.01	7.44		8.97	8.44	8.41	7.39
	MELDR-02	4.77	4.91	4.12	3.92	4.87	4.52	4.16	3.95	4.93	4.46	3.65		5.13	4.31	3.64	3.69	4.18	4.39	4.5	3.96	4.1	4.32	3.92	3.7	4.17	4.19	6.39	6.42	4.91	3.73	4.16	3.3	3.81	3.43	2.9	3.14	3.84	4.22	4.78	3.95	4.08	4.39	3.93	2.92	4.3	5.17	5.24	4.44	4.17
very low <4	PSDTBCMD	6.59	6.66	7.32	6.14	6.44	5.79	6.33	5.84	5.96	6.04	6.37		6.32	5.7	5.23	4.88	6.06	5.68	5.12	5.31	4.85	5.59	5.02	4.6	5.45	5.11	6.89	6.49	6.04	5.1	4.96	4.89	5.54	5.32	4.22	4.76	5.01	5.58	6.4	5.28	4.97	4.07	4.76	4.5	5.5	5.51	5.9	5.25	5.51
low 4-6	MELDR-13																											4.74	4.38	7.5	6.1	6.28	6.41	5.27	5.98	5.75	4.15	5.65	6.1	5.49	6.29	5.63	5.93	5.69	5.68	6.49	9.2	6.49	6.53	5.955
moderately oxygenated	MELDR-14																											0.79	1.18	8.5	7.45	7.52	7.28	9.33	7.62	4.57	6.21	8.18	8.71	8.83	7.78	6.94	7.39	7.65	7.22	9.26	6.43	8.96	8.18	7.57
well oxygenated 8-10	MELDR-06	7.37	7.8	5.83	6.71	7.25	7.5	7.45	7.03	7.29	7.22	7.24		7.25	7.27	6.66	7.32	7.01	7.1	7.43	7.21	4.87	7.63	7.12	7.65	5.56	6.75	3.74	3.56	6.93	6.77	6.66	6.81	7.51	5.3	5.91	4.43	5.77	5.45	5.77	5.51	5.93	6.11	6.33	5.3	7.4	7.38	7.27	7.15	7.01
hyperoxic >10	MELDR-07	12.03	1.84			4.67	3.65	2.78		11.16	1.53			5.72	1.17	7.83	6.36		11.24	3.02	2.02			5.08	4.84		6.58	3.36	3.29	4.13	0.05	11.53	1.64	8.25	6.06	0.15	0.19	4.15	5.89	5.29	0.77		2.22	2.61	0.12	2.05	1.33	1.22	1.46	3.325
	MELDR-08	11.6	3.32			6.71	3.53			6.49										5.17	4.5		4.53	3.88	7.79	1.96	2.48	6.46	5.15	3.24	3.79	2.28	3.57	5.87	4.8	4.7	6.37	4.39	4.05	3.81	5.75	3.39	2.93	3.7	2.36	2.22	5.44	3.83	2.01	3.965
	MELDR-09	6.78	8.34			9.41	7.18	7.38	6.83	8.27	8.3	6.21		10.3	9	7.4		8.04	9.85	6.75	7.04	8.31	9.21	7.98	7.12	7.88	5.17	7.77	7.99	3.45	0.29	0.07	2.66	3.52	3.35	5.14	3.2	3.98	4.23	2.27	3.04	2.04	3.43	3.33	2.16	7.03	2.38	3.59	0.57	6.765
	MELDR-10	5.9	9.85			13.46	6.9	10.16	3.76	11.03	12.36	3.1		7.84	6.55	2.17	4.28	5.78	6.13	5.21	7.25	5.94	7.26	7.77	2.61	4.97	6.71	2.93	2.54	5.19	5.53	6.1	5.24	3.21	4.95	0.33	5.67	2.94	4.88	7.32	0.23	4.5	6.05	6.28	3.23	4.62	6.7	1.68	8.94	5.67
Min 0.03	MELDR-11	8.66	10.9			10.59	6.85	9.89	7.24	9.8	16.35	14.53	13.81	4.66	5.18	8.99	11.39	6.16	6.38	6.19	5.01	7.03	6.96	7.57	9.82	3.76	6.35	3.1	2.98	5.91	1.41	5.68	5.78	7.58	7.7	9.76	7.75	6.81	6.94	7.43	11.51	7.46	8.03	5.9	8.14	10.7	5.45	12.52	12.04	7.445
Max 16.35	MELDR-12	11.8	6.9			4.51	7.08	9.5		3.93	10.65	6.66		8.12	8.81	13.57	9.79	10.3	7.34	1.61	4.05	11.2	11.86	8.38	6.82	0.86	1.57	2.17	1.2	1.96		2.39	1.76	3.03	3.71	3.68	2.65	9.14	3.25	1.35	2.84	6.08	2.92	1.07	2.75	4.36	4.42	2.49	2.08	4.05
	MELDR-15																														0.61	0.617	0.712	0.505	0.557	0.808	0.792	0.68	0.477	0.344	0.621	0.234	0.481	0.626	0.649	0.5	0.566	0.663	0.665	0.617
Electrical Conductivity (EC) (mS/cm)	MELDR-05	0.096	0.798			1.038	0.796	1.23		0.761	0.877			0.289	0.9	1.036	0.738	0.04	1.061	0.839	1.182	0.768	0.124	1.211	1.026	0.437	0.608	0.679	0.729	0.49	0.879	0.803	1.316	0.822	0.916	1.475	1.05	0.47	0.651	0.371	0.81	0.403	1.858	1.006	1.196	1.05	0.804	0.768	1.363	0.81
	MELDR-16																														0.517	0.641	0.741	0.617	0.76	0.725	0.845	0.39	0.432	0.219		0.143	0.484	0.604	0.424		0.351	0.6	0.629	0.6
	MELDR-02	0.79	0.769	0.814	0.809	0.814	0.788	0.822	0.806	0.742	0.806	0.848		0.568	0.79	0.805	0.809	0.76	0.754	0.832	0.773	0.832	0.689	0.842	0.82	0.701	0.767	0.608	0.655	0.504	0.836	0.831	0.878	0.836	0.854	0.864	0.86	0.8	0.794	0.656	0.828	0.666	0.785	0.814	0.801	0.8	0.726	0.779	0.804	0.802
	PSDTBCMD	0.746	0.709	0.736	0.776	0.706	0.725	0.754	0.665	0.693	0.737	0.763		0.415	0.72	0.738	0.726	0.69	0.712	0.758	0.694	0.78	0.598	0.761	0.744	0.48	0.741	0.606	0.655	0.551	0.782	0.766	0.802	0.769	0.773	0.77	0.779	0.75	0.734	0.519	0.779	0.575	0.726	0.764	0.744	0.77	0.674	0.733	0.757	0.737
ANZECC acceptable range for lowland rivers: 0.12 - 0.3 mS/cm for wetlands: 0.3 - 1.5 mS/cm	MELDR-13																											0.753	0.79	0.19	0.623	0.619	0.635	0.597	0.429	0.627	0.695	0.46	0.511	0.587	0.619	0.555	0.587	0.606	0.6	0.59	0.598	0.601	0.606	0.601
	MELDR-14																											0.828	0.86	0.49	0.459	0.634	0.736	0.502	0.539	0.701	0.607	0.48	0.445	0.545	0.665	0.51	0.605	0.695	0.685	0.61	0.577	0.652	0.692	0.607
	MELDR-06	0.769	0.711	0.734	0.989	0.724	0.705	0.769	0.713	0.603	0.644	0.661		0.415	0.604	0.624	0.632	0.62	0.614	0.638	0.597	33.2	0.45	0.675	0.658	0.597	0.644	1.18	0.856	0.256	0.53	0.533	0.572	0.517	0.611	0.641	0.635	0.59	0.561	0.56	0.646	0.439	0.602	0.631	0.624	0.61	0.596	0.627	0.63	0.627
	MELDR-07	3.83	1.92			1.890	1.920	2.820		1.93	2.41			2.65	2.51	3.4	4.76		2.62	2.65	2.32			3.57	3.94		2.17	1.166	1.333	2.038	1.874	1.75	1.811	3.06	2.989	3.134	2.767	2.45	2.336	1.919	1.671		1.619	1.662	1.454	1.55	1.132	1.063	1.108	2.104
	MELDR-08	0.951	0.79			0.666	0.685			0.781										1.278	0.984		1.038	1.164	1.026	1.504	1.358	0.282	0.458	0.984	1.012	0.967	0.863	1.105	1.089	0.815	0.972	1.14	1.329	1.198	0.833	1.13	1.162	0.996	0.921	1.4	1.583	1.239	1.477	1.019
	MELDR-09	0.926	0.821			0.841	1.010	1.280	1.472	0.814	1.09	1.415		0.717	0.748	0.889		0.92	0.827	0.853	0.919	0.814	0.806	0.828	0.855	0.782	0.739	0.289	0.267	0.877	0.788	0.672	0.935	0.706	0.727	0.852	0.749	0.86	0.909	0.825	0.997	0.758	0.492	0.676	0.641	0.64	0.401	0.464	0.75	0.818
	MELDR-10	0.212	0.24			0.342	0.328	0.590	0.558	0.351	0.418	0.7		0.181	0.23	0.452	0.547	0.09	0.114	0.19	0.212	0.168	0.113	0.156	0.316	0.138	0.092	0.982	0.98	0.158	0.213	0.318	0.499	0.132	0.164	0.494	0.256	0.09	0.15	0.173	0.425	0.132	0.16	0.326	0.305	0.2	0.295	0.503	0.524	0.24
Min 0.04	MELDR-11	0.318	0.517			0.432	0.421	0.502	0.736	0.258	0.417	0.705	0.988	0.297	0.35	0.483	0.409	0.2	0.234	0.289	0.204	0.34	0.346	0.317	0.391	0.297	0.211	1.746	1.981	0.187	0.235	0.248	0.242	0.24	0.287	0.281	0.234	0.17	0.21	0.286	0.295	0.214	0.129	0.195	0.213	0.35	0.546	0.494	0.533	0.297
Max 33.2	MELDR-12	1.014	0.706			0.687	0.888	1.006		0.667	0.936	1.411		0.714	0.809	1.003	1.196	0.83	0.732	0.652	0.832	1.385	1.177	0.812	1.021	0.574	0.542	0.609	0.887	0.531	0.652	0.643	0.974	0.921	1.09	1.399	1.27	0.75	0.874	0.721	0.88	0.721	0.571	0.737	0.749	0.59	0.488	0.502	0.655	0.779
	MELDR-15																														13	4	3	12	13	10	8	1	8	2	1	10	12	13	8	8	5	4	15	8
	MELDR-05	11	2			6	10	12		7	4			8	7	12	6	8	10	11	<1	9	2	4	3	7	5	5	5	6	4	3	11	3	4	4	5	8	2	2	2	4	5	7	2	15	4	3	4	5
Total Suspended Solids (TSS) (mg/L)	MELDR-16																														18	10	9	8	13	20	14	13	2	1	1	<1	12	58	2		3	2	8	9
	MELDR-02	1	3	2	3	4	1	2	1	2	2	2	54	1	2	1	3	2	1	3	1	3	1	1	<1	3	2	3	1	3	3	2	1	2	1	1	1	0.5	1	1	1	2	3	4	3	3	3	3	3	2
	PSDTBCMD	4	3	29	4	7	1	5	12	6	2	2	7	8	3	4	2	2	<1	2	4	4	3	5	5	12	4	6	5	15	5	4	3	2	2	2	1	1	3	3	5	4	3	4	2	3	2	3	4	4
	MELDR-13																											21	12	17	13	17	8	7	6	5	5	10	11	10	1	8	10	11	8	10	9	9	16	10
DWER interim guideline value: 6 mg/L	MELDR-14																											<1	3	2	2	1	<1	<1	<1	1	1	0.5	1	2	4	1	<1	2	<1	1	2	2	2	2
	MELDR-06	51	56	4	44	35	27	24	14	13	8	11	8	14	9	13	10	12	13	15	9	14	13	8	6	17	10	16	7	18	11	11	2	17	5	4	4	5	6	7	5	3	3	6	5	6	5	7	5	9.5
	MELDR-07	17	59			42	5	58		37	11			32	11	11	184		19	5	3			10	2		8	29	2	7	7	17	2	<1	1	8	7	15	4	7	1		7	6	2	9	3	<1	1	7.5
	MELDR-08	7	27			23	5			2										<1	<1		1	1	3	3	<1	<1	1	<1	1	4	<1	<1	<1	2	3	<1	1	<1	1	2	3	9	7	4	2	<1	54	3
	MELDR-09	3	1			9	<1	2	3	1	5	<1		2	<1	1	1	3	3	<1	<1	1	1	<1	<1	1	<1	2	1	<1	1	1	<1	1	2	1	1	<1	<1	<1	5	1	2	4	<1	<1	<1	<1	3	1.5
	MELDR-10	1	1			3	1	6	11	1	1	8		1	1	4	3	1	<1	<1	1	1	2	5	3	2	1	<1	<1	2	<1	<1	<1	2	1	2	1	<1	2	2	2	2	1	5	<1	4	6	5	4	2
Min <1	MELDR-11	7	3			5	2	3	12	2	2	14	15	1	3	3	50	2	<1	2	1	1	3	1	2	3	2	1	3	1	3	2	1	2	3	4	2	<1	1	1	4	3	<1	4	1	2	3	<1	2	2
Max 184	MELDR-12	27	2			4	1	6		2	<1	9		1	<1	<1	3	<1	1	21	4	15	57	63	24	6	15	22	20	11	8	24	23	3	5	17	3	62	10	16	4	8	16	6	2	2	4	1	12	8
	MELDR-15																														17.5	19.4	20.7	16.4	17.1	19.7	20.2	15.2	16	15.2	18.7	16.4	16.6	18.2	18.2	15.7	17.1	17.9	19.1	17.5
Temperature (°C)	MELDR-05	12.95	19.18			16.65	20.07	22.61		17.18	24.8			15.81	15.77	19.23	19.1	14.3	16.57	17.52	20.32	12.08	14.35	17.81	18.7	16.6	18.61	18.8	21.5	18.4	17.4	19.6	20.2	14.3	15	21.2	20.9	12.4	14.8	14.6	17.6	15.9	19.1	18.1	18.7	15.4	17.5	18.1	19.5	17.81
	MELDR-16																														17.9	19	20.4	18.8	19	20	20.1	18.4	17.8	16.1		17.7	18	19.2	18.5		16.1	18.3	20	18.5
	MELDR-02	19.96	19.76	21.27	21.57	19.53	20.56	21.27	21.64	19.4	20.65	21.59		18.46	19.65	20.13	20.47	20.1	19.92	20.01	20.44	20.39	19.34	19.94	20.44	19.1	19.82	20.1	21.5	18.4	19.6	20.2	20.7	19.5	19.6	20.6	20.8	19.6	19.3	18.3	19.9	19.1	19.3	19.8	19.7	19.7	18.8	19.3	19.9	19.9
	PSDTBCMD	15.69	18.29	21.81	19	17.04	18.3	19.07	18.82	17.25	20.6	19.6		16.88	16.05	17.62	17.96	16.5	17.22	18.13	19.28	15.03	16.04	16.77	17.8	17.6	18.79	19.9	21.2	17.9	17.6	19.1	18.6	16.1	15.7	19.3	19	15.2	16.2	15.6	17.3	17.7	17.4	17.6	17.4	15.8	17.6	17.7	18.7	17.62
	MELDR-13																											19	19.5	17.3	18.6	20	20.9	17.4	17.9	21.7	22	17.1	17.7	17.3	19.5	18.4	18.6	18.7	19.1	17.3	15.9	18.5	19.9	18.6
Highest concentration of the year	MELDR-14																											19.9	21.3	17.2	17.3	19.5	19.8	14.5	15.1	20.4	20.8	13.4	14.2	14.9	18	15.6	16	18.1	17.1	14.1	18.6	16.2	18.8	17.25
	MELDR-06	17.63	19.15	19.07	21.73	17.87	20.38	22.87	22.2	17.7	23.34	23.29		17.39	16.73	19.22	19.49	18.1	18.37	18.96	20.57	16.57	15.59	17.67	19.3	18.1	19.3	20	21	17.4	18.2	19.8	20.6	16.5	16.4	20.8	20.6	15	15.7	15.5	18.4	17.1	17.4	17.9	18	15.6	17.1	17.4	18.7	18.2
Lowest concentration of the year	MELDR-07	16.54	21.04			18.03	28.58	29.34		16.83	25.94			18.15	16.48	22.42	25.12		16.26	19.34	20.99			15.9	18.63		19.14	19.6	22.1	16.4	19	23.6	24.7	13.3	15.5	21.6	22.5	10.5	13.1	15.1	21.9		18.7	22.5	17	11.3	13.4	15.8	19.3	18.85
	MELDR-08	18.62	21.42			14.66	26.12			16.36										17.29	20.13		11.31	15.42	21.63	16.5	19.35	21.3	26.3	15.6	17.9	20.8	19.4	12.1	13.5	23.6	22.3	8.7	12.7	14.4	19.1	14.5	16	16.9	21.5	11.4	15.8	17.1	22.5	17.2
	MELDR-09	12.14	20.25			15	22.29	25.98	20.21	16.8	25.07	24.03		14.49	15.25	19.59		12.8	14.7	16.9	20.37	9.25	11.66	16.04	19.54	14.7	18.25	20.7	25.5	16	16.6	18.2	20.5	12.8	13.7	23.2	22.1	11	12.7	14.5	17.2	14	14.2	15.5	15.6	11.2	13.2	14.5	15.9	15.95
	MELDR-10	16.14	22.26			18.65	24.15	26.07	20.84	18.2	27.42	24.98		18	16.78	19.6	18.54	15	16.61	19.97	21.65	12.02	14.36	19.52	18.65	17.6	19.22	20.9	24	17.4	20.4	22.3	21.7	15.5	17.7	21.1	25.3	13.3	14.6	15.4	19.6	15.7	17	21	18.4	14	14.9	18.6	21.7	18.65
Min 8.7	MELDR-11	15.07	21.32			17.46	23.35	27.06	22.39	17.5	27.41	28.81	31.03	17.39	18.06	22.35	23.45	15	16.21	19.34	19.9	12.41	14.29	19.11	21.22	17.8	19.03	19.5	26.4	17.3	18.6	21.7	23.1	15.6	17.4	26.3	26.3	13.5	14.5	15.8	22.2	15.7	17	19	19.3	14.1	15.1	17.6	21.1	19.02
Max 31.03	MELDR-12	17.47	22.59			19.28	27.03	28.96		17.86	27.13	29.99		20.24	19.23	23.47	27.91	17.3	18.57	19.71	23.34	13.17	15.11	21.55	23.94	16.5	22.15	24.9	27.8	19.1	18	27.4	25.7	16.7	21	30	30.3	14.6	16	18	27.6	17.7	20.5	22.3	21.9	13	16	18.3	24.9	20.75

SITES RECORDING VALUES ALWAYS/GENERALLY ABOVE TV/OUTSIDE ACCEPTABLE RANGE
SITES RECORDING 40-60% VALUES ABOVE TV/OUTSIDE ACCEPTABLE RANGE
SITES RECORDING VALUES ALWAYS/GENERALLY BELOW TV/WITHIN ACCEPTABLE RANGE

Concentration ABOVE trigger value/acceptable range
Concentration BELOW trigger value/within acceptable range
Record BELOW acceptable range
Concentration < LOR
NO sample taken

6. Nutrients

The nutrient forms analysed during the 2018 monitoring program include total nitrogen, ammonia/ammonium nitrogen, nitrate and nitrite (oxidised nitrogen), total and dissolved organic nitrogen, total phosphorus and filterable reactive phosphorus.

Nutrient concentrations recorded in Melville Bull Creek catchment sites are displayed in **Tables D-7 to D-13** in **0. Table E-1, Appendix E** outlines the sources of nitrogen and phosphorus nutrients and the impacts that changes in these nutrients can have to aquatic ecosystems.

6.1 Nitrogen

Nitrogen in waterways can exist in both inorganic forms, including oxidised nitrogen (encompassing nitrate (NO_3^-) and nitrite (NO_2^-)) and ammonia nitrogen (including both ammonium (NH_4^+) and ammonia (NH_3)), and dissolved and particulate organic forms. Nitrogen is converted between these forms, as well as nitrogen gas (N_2), via physical and biological processes known collectively as the nitrogen cycle. When plants and animals die or when animals excrete their wastes, organic nitrogen in the water is converted by bacteria to ammonium/ammonia (mineralisation), then to nitrite and nitrate (nitrification). Ammonium can be converted to ammonia gas (volatilisation) in alkaline conditions and nitrate can be converted to nitrogen gas (denitrification) in anoxic conditions, with the release of these gasses into the atmosphere resulting in a loss of nitrogen from the water.

Graphs for total nitrogen (TN), total oxidised nitrogen (NOx-N), nitrogen as ammonia/ammonium (NH_3/NH^{4+}-N), total oxidised nitrogen (TON) concentrations and dissolved oxygen (DON) concentrations, as well as nitrogen speciation, in the Melville Bull Creek catchment in 2018 are displayed in **Figure 6.1-1** and tables containing concentrations of the above parameters from the 2007-2018 sampling period are displayed in **Table 6-1.** For all graphs, a value equal to half the limit of reporting was substituted for those occasions where concentrations were recorded as 'below the laboratory limit of reporting' which is a standard technique to allow these 'unknown' values to be represented graphically and to differentiate them from those samples that recorded concentrations equal to the limit of reporting.

Total nitrogen (TN) concentrations exceeded ANZECC trigger values for lowland rivers (1.2 mg/L) or wetlands (1.5 mg/L) in 23 of 55 samples collected from Melville Bull Creek catchment sites (**Figure 6.1-1-A** and **Table D-7, Appendix D**). The highest concentrations were recorded at Brockman Park (site 2, 6.2 mg/L, 5.1 mg/L, 4.6 mg/L and 4.0 mg/L in July, October, September and August respectively). Exceeding concentrations were recorded on all sampling occasions at sites 2, PSDTBCMD, 7 and 12 (Brockman Park and Bull Creek MD and Blue Gum Lake), and on at least one sampling occasion at sites 5, 16, 8, and 9 (John Creaney Park, downstream Elizabeth Manion Park, Piney Lakes outlet and Quenda Lake outlet). The lowest concentration of 0.32 mg/L was recorded at site 11 (Marmion Reserve) in September.

Total oxidised nitrogen (NOx-N) concentrations above relevant ANZECC trigger values (lowland rivers: 0.15 mg/L, wetlands: 0.1 mg/L) were recorded at 33 of the 55 samples from 11 sites (**Figure 6.1-1-B** and **Table D-8, Appendix D**). The four highest concentrations in the catchment were all recorded at site PSDTBCMD: 2.3 mg/L (15 times greater than the trigger value), 1.8 mg/L, 1.7 mg/L and 1.5 mg/L in in July, October, August and September respectively. Sites PSDTBCMD, 13 and 6 (Bull Creek Main Drain, Brentwood drain and Bateman Park) also recorded exceeding NOx-N concentrations at all sampling occasions when samples were collected. Six samples recorded concentrations below the limit of reporting of 0.01 mg/L.

Nitrogen as ammonium/ammonia (NH^{4+}/NH_3-N) concentrations exceeded or equalled relevant ANZECC trigger values (lowland rivers: 0.08 mg/L, wetlands: 0.04 mg/L) in 43 samples from all 14 sites (**Figure 6.1-1-C** and **Table D-9, Appendix D**). Sites 15, 5, 2, PSDTBCMD, 13, 6, 7 and 12 (John Creaney Park inlet, John Creaney Park, Brockman Park, Bull Creek Main Drain, Brentwood Drain, Bateman Park, Booragoon Lake outlet and Blue Gum Lake outlet) recorded NH4+/NH3-N concentrations exceeding the trigger value for lowland rivers and wetlands on all sampling occasions. All four samples from site 2 recorded NH^{4+}/NH_3-N concentrations (5.7 mg/L, 4.7 mg/L, 4 mg/L and 3.2 mg/L in July, October, September and August respectively) exceeding adjusted ANZECC trigger values for 95% level of protection (**Figure 6.1-1-C**) and the July sample from site 2 also recorded a concentration exceeding the NHMRC (2008) recreational trigger value of 5 mg/L. Two samples, from sites 9 and 11 (Quenda Lake outlet and Marmion Reserve), recorded concentrations below the limit of reporting of 0.01 mg/L.

No trigger values exist for **total oxidised nitrogen** (TON) or **dissolved oxidised nitrogen** (DON). Site 8 (Piney Lakes outlet) recorded the highest concentrations of both TON (3.8 mg/L) and DON (2.4 mg/L) in October, with sites 7 and 9 (Booragoon Lake outlet and Quenda Lake outlet) also recording DON concentrations of 2.4 mg/L (**Figure 6.1-1-D** and **Figure 6.1-1-E**). Site 2 (Brockman Park) recorded the lowest TON concentration (0.12 mg/L in October) and site 10 (Frederick Baldwin) recorded the lowest DON concentration (0.032 mg/L in September).

Organic nitrogen (and mainly dissolved organic nitrogen) comprised the majority (or the highest proportion) of total nitrogen at most sites (**Figure 6.1-1-F).** However, inorganic forms of nitrogen comprised the majority (or the highest proportion) of total nitrogen at several sites on average:

- Site 16 (Downstream Elizabeth Manion Park): average 54% oxidised nitrogen;
- Site 2 (Brockman Park): average 88% ammonia/ammonium nitrogen;
- PSDTBCMD (Bull Creek Main Drain): average 57% oxidised nitrogen;
- Site 13 (Brentwood Drain): average 46% oxidised nitrogen; and
- Site 6 (Bateman Park): average 44% oxidised nitrogen.

TN concentrations recorded in 2018 are generally similar to those recorded in the preceding 11 years of monitoring (**Table 6-1**). The main exception to this is that TN concentrations recorded at site 8 (Piney Lakes outlet) in 2018 were significantly higher than in previous years, with the predominant portion of this nitrogen in a dissolved organic form.

Comparing the two main drainage branches in the catchment that discharge into the Canning River, total nitrogen concentrations in the most downstream Bull Creek Main Drain site (PSDTBCMD) have consistently exceeded the ANZECC lowland rivers trigger value throughout the eleven year sampling period, whereas concentrations at the most downstream Brentwood Drain site (Bateman Park) have almost always been below the trigger value (**Table 6-1**). The majority of nitrogen entering the Bull Creek Main Drain appears to come from between John Creaney Park (site 5) or Elizabeth Manion Park (site 16) and Brockman Park (site 2), where concentrations are consistently very high and are predominantly in the form of ammonia/ammonium. As water flows from site 2 to the most downstream site PSDTBCMD, total nitrogen concentrations reduce by an average of approximately 50% with the remaining nitrogen predominantly in the form of oxidised nitrogen rather than ammonia nitrogen.

TN concentrations are also consistently high at Booragoon Lake (site 7) and Blue Gum Lake (site 12) (**Table 6-1**). This is usually predominantly in the form of organic nitrogen, with nitrogen as ammonium/ammonia concentrations also often exceeding the wetlands trigger value at these sites and on occasion exceeding the trigger value for protection of biota at Booragoon Lake. High total nitrogen concentrations tend to correspond with high phosphorus concentrations at these sites, and particularly at Blue Gum Lake (see **Section 6.2**). It should be noted that Booragoon Lake, while still recording very high and variable concentrations, has recorded significantly lower maximum concentrations of total nitrogen from 2012 to 2018 (excepting a high maximum concentration recorded in 2017) than from 2007 to 2011. Furthermore, at site 12, higher yearly maximum concentrations of total nitrogen were recorded from 2012 to 2017 than from 2007 to 2011, although, the maximum concentrations of these parameters recorded in 2018 are in the range of those recorded from 2007 to 2011.

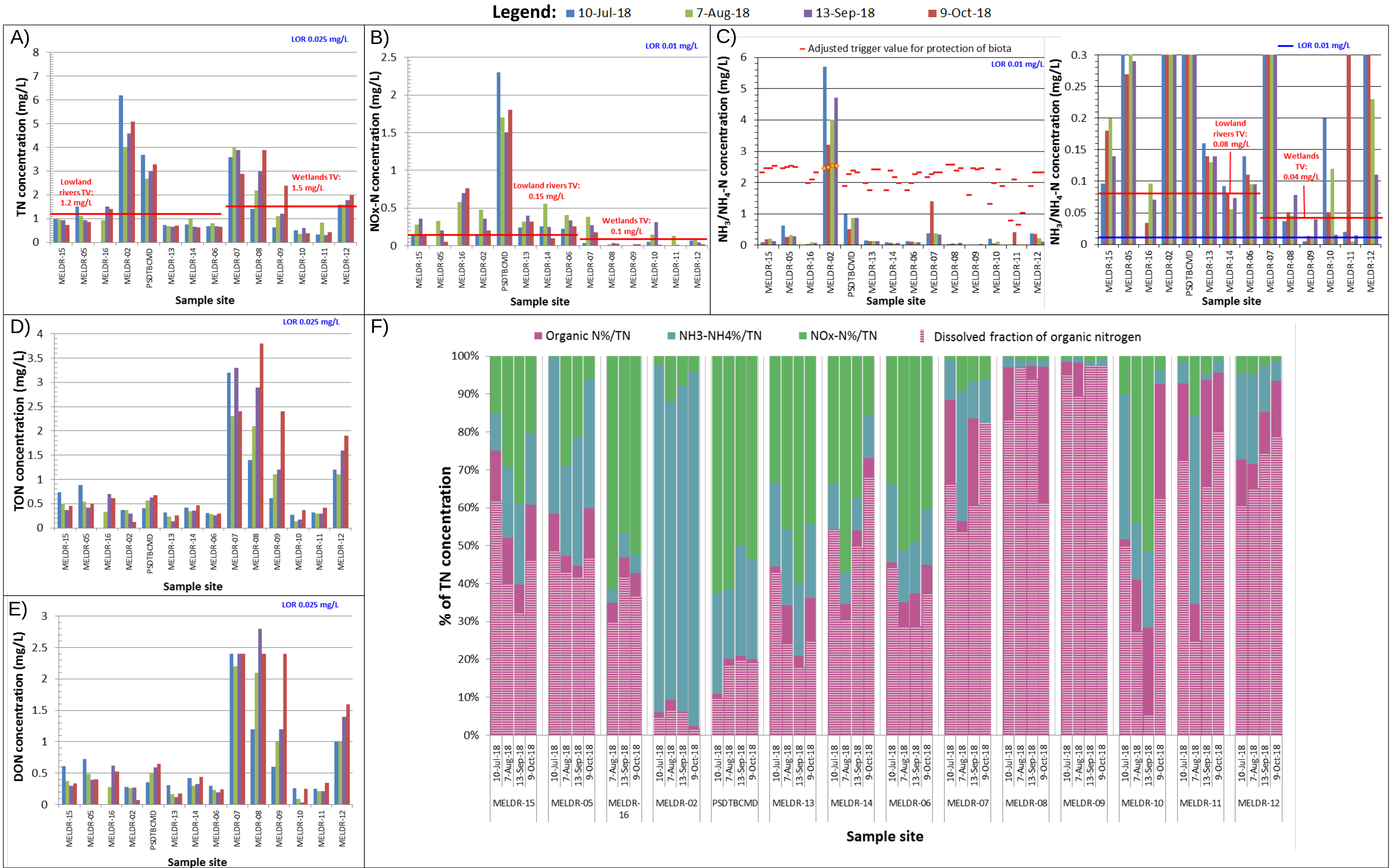

Figure 6.1-1: A) Total nitrogen concentrations (mg/L); B) Total oxidised nitrogen (NOx-N) concentrations (mg/L); C) nitrogen as ammonia/ammonium (NH_3/NH^{4+}-N) concentrations (mg/L); D) Total oxidised nitrogen (TON) concentrations (mg/L); E) Dissolved oxygen (DON) concentrations (mg/L); and F) nitrogen speciation; recorded in Melville Bull Creek catchment sites in 2018.

Table 6-1: Total nitrogen (TN), total oxidised nitrogen (NOx-N), nitrogen as ammonia/ammonium (NH3/NH4+-N), total organic nitrogen (TON) and dissolved organic oxygen (DON) concentrations recorded in Melville Bull Creek catchment sites from 2007 to 2018

	Site	Jul-07	Oct-07	Jan-08	Apr-08	Sep-08	Nov-08	Jan-09	Mar-09	Sep-09	Nov-09	Jan-10	Mar-10	Aug-10	Sep-10	Oct-10	Nov-10	Jul-11	Aug-11	Sep-11	Oct-11	Jul-12	Aug-12	Sep-12	Oct-12	Aug-13	Sep-13	Oct-13	Nov-13	Aug-14	Sep-14	Oct-14	Nov-14	Aug-15	Sep-15	Oct-15	Nov-15	Jul-16	Aug-16	Sep-16	Oct-16	Jul-17	Aug-17	Sep-17	Oct-17	Jul-18	Aug-18	Sep-18	Oct-18	Median
	MELDR-15																														0.77	0.75	0.67	1	0.82	1	1.1	1.1	0.76	0.48	0.69	0.58	0.96	0.86	0.8	0.98	0.96	0.93	0.74	0.82
Total Nitrogen (TN) (mg/L)	MELDR-05	0.89	1			1.5	1.9	2.4		1.3	1.1			1.4	1.3	2.1	2.5	0.45	1	1.4	1.4	1.5	0.27	1.3	1.4	0.87	0.94	0.83	1.1	0.91	1.1	0.88	1.4	1.3	1.3	1.6	1.6	0.91	0.87	0.32	0.82	0.79	1.2	0.9	0.92	1.5	1.1	0.94	0.85	1.1
	MELDR-16																														0.7	0.63	0.81	0.82	11	1.4	2.9	0.64	0.37	0.37			2	2.1	1.2		0.94	1.5	1.4	1.07
	MELDR-02	5.3	3.8	5.8	6.1	4.4	5.5	7.2	6.8	4.5	5.8	6.9	6.8	3.9	6	6.8	7.8	6.5	6	6.4	5.8	8.3	6.5	7.2	8.2	5.2	5	4.8	6.3	2.7	5.4	5.2	7	6.6	7	9.1	9.6	6.9	5.9	4.8	6.8	5.1	5.2	5.7	5.8	6.2	4	4.6	5.1	5.95
	PSDTBCMD	2.7	2.4	0.63	3.5	2.6	2.9	4	2.9	2.8	3.1	3.8	4.1	1.7	3	3.9	3.9	3	3	3.1	3	4.4	2.9	4	4.4	2.1	3	3.3	3.7	2.6	3.3	3.2	4.2	3.8	3.8	4.5	4.5	3.5	3.2	2	3.5	3	4.3	3.5	3.4	3.7	2.7	3	3.3	3.25
ANZECC trigger value for lowland rivers: 1.2 mg/L for wetlands: 1.5 mg/L	MELDR-13																											0.64	0.6	0.47	0.66	0.62	0.53	0.51	0.51	0.55	0.52	0.69	0.63	0.66	0.67	0.65	0.9	0.58	0.64	0.73	0.69	0.66	0.72	0.64
	MELDR-14																											0.75	0.69	0.71	0.96	0.73	0.59	0.49	0.49	0.59	0.59	0.68	0.63	0.62	0.55	0.58	1.2	0.73	0.64	0.77	0.98	0.67	0.64	0.655
	MELDR-06	1	0.87	3.3	0.63	0.77	0.7	0.56	0.61	0.95	0.62	0.58	0.54	0.75	0.6	0.6	0.64	0.74	0.81	0.85	0.58	0.57	0.43	0.53	0.51	0.64	0.79	0.65	0.6	0.51	0.62	0.63	0.53	0.6	0.53	0.59	0.49	0.78	0.63	0.66	0.64	0.55	0.89	0.62	0.61	0.68	0.8	0.69	0.65	0.63
	MELDR-07	1.1	10			6.3	11	11		3	7.6			2.7	6.1	16	20		2.5	6.4	10			0.52	0.45		0.55	2.8	3.3	0.76	1.6	2.2	3.5	0.37	0.31	3.5	3	1.2	0.5	0.44	3		7.9	5.2	3.5	3.6	4	3.9	2.9	3.15
	MELDR-08	1.1	1.7			2.3	0.62			0.78										0.61	0.65		0.62	0.76	0.62	1.6	1.4	0.79	0.71	1.2	0.95	1.3	0.78	0.73	0.58	0.66	0.65	0.76	0.85	1.1	0.83	0.82	1	0.92	1.2	1.4	2.2	3	3.9	0.84
	MELDR-09	0.81	0.81			0.61	0.79	1.3	1.2	0.71	0.74	0.85		0.49	0.54	0.6	0.95	1.1	0.73	0.85	0.75	0.4	0.4	0.48	0.5	0.4	0.62	1.2	1.4	1.3	1.2	1.3	1.5	0.77	0.89	0.98	1	0.67	0.68	1	1.2	0.72	1	1.3	1.4	0.63	1.1	1.2	2.4	0.85
	MELDR-10	0.67	0.31			0.37	0.46	1	1.3	0.32	0.55	1.1		0.33	0.29	0.65	0.77	0.38	0.28	0.46	0.34	0.32	0.41	0.32	0.52	0.3	0.25	0.29	0.44	0.67	0.34	0.32	0.56	0.24	0.33	0.63	0.49	0.31	0.27	0.28	0.48	0.37	0.22	0.88	0.26	0.52	0.35	0.6	0.39	0.37
Min 0.22	MELDR-11	0.8	0.56			0.45	0.49	0.66	1.2	0.53	0.52	1.3	1.9	1	0.6	0.63	1.2	0.55	0.44	0.61	0.39	0.4	0.42	0.34	0.46	0.65	0.38	0.31	0.44	0.43	0.43	0.42	0.44	0.32	0.35	0.73	0.72	0.35	0.26	0.32	0.47	0.45	0.26	0.51	0.47	0.34	0.84	0.32	0.44	0.455
Max 20	MELDR-12	2.6	2			1.3	1.4	1.7		1.4	1.2	2.4		1.3	1	1.2	1.7	0.78	0.22	1.2	3.3	3.9	7.1	3.7	3	1.5	2.3	2.6	3.2	2.2	2.1	2.4	5.4	3.9	3.5	2.4	3	0.86	0.63	2.2	2.6	2.7	2.5	3.5	2.1	1.6	1.6	1.8	2	2.15
	MELDR-15																														0.071	0.1	0.1	0.22	0.14	0.17	0.15	0.37	0.21	0.14	0.13	0.12	0.13	0.11	0.12	0.15	0.28	0.36	0.15	0.14
Total Oxidised Nitrogen (NOx N) (mg/L)	MELDR-05	<0.01	0.075			0.056	0.019	<0.01		0.063	0.029			0.21	0.023	0.025	<0.01	0.05	0.073	0.029	0.068	<0.01	0.051	0.031	<0.01	0.099	0.12	0.074	0.051	0.079	0.057	0.077	0.019	0.062	0.015	0.005	0.01	0.036	0.082	0.059	0.038	0.12	0.11	0.035	0.049	<0.01	0.33	0.2	0.052	0.051
	MELDR-16																														0.17	0.16	0.14	0.2	0.67	0.8	1.7	0.15	0.16	0.15		0.1	0.92	0.92	0.46		0.58	0.7	0.76	0.46
	MELDR-02	0.078	0.13	0.089	0.065	0.13	0.098	0.055	0.04	0.12	0.1	0.074	0.083	0.18	0.082	0.068	0.16	0.13	0.14	0.14	0.15	0.057	0.087	0.06	0.076	0.12	0.23	0.22	0.13	0.097	0.14	0.13	0.089	0.13	0.45	0.099	0.1	0.16	0.19	0.22	0.16	0.12	0.24	0.16	0.16	0.14	0.48	0.36	0.2	0.13
	PSDTBCMD	1.9	1.2	0.078	2.3	1.2	1.6	2.2	2	1.5	2.3	3.2	3.7	0.95	2.3	2.8	2.7	1.8	1.8	2.2	1.9	2.5	1.6	2.1	2.4	1.2	2.1	1.8	2.8	1.1	1.9	2.1	2.8	2.5	2.3	3.4	3.7	2.4	2.1	1.3	2.6	1.6	1.9	2.1	2.2	2.3	1.7	1.5	1.8	2.1
ANZECC trigger value for lowland rivers: 0.15 mg/L for wetlands: 0.10 mg/L	MELDR-13																											0.2	0.19	0.12	0.22	0.19	0.16	0.13	0.11	0.089	0.11	0.3	0.32	0.34	0.26	0.19	0.29	0.2	0.23	0.24	0.32	0.4	0.32	0.21
	MELDR-14																											0.23	0.077	0.23	0.43	0.21	0.06	0.12	0.071	0.038	0.029	0.31	0.25	0.24	0.066	0.12	0.4	0.16	0.11	0.26	0.56	0.25	0.1	0.185
	MELDR-06	0.32	0.35	2.1	0.068	0.24	0.08	0.051	0.086	0.31	0.12	0.062	0.049	0.22	0.15	0.11	0.093	0.2	0.25	0.23	0.14	0.19	0.15	0.12	0.11	0.23	0.35	0.23	0.16	0.14	0.21	0.18	0.14	0.15	0.13	0.078	0.097	0.34	0.26	0.31	0.21	0.16	0.34	0.2	0.2	0.23	0.41	0.34	0.26	0.195
	MELDR-07	<0.01	0.018			0.022	0.51	0.3		0.015	0.15			<0.01	0.01	0.11	0.19		<0.01	<0.01	0.26			<0.01	<0.01		<0.01	<0.01	0.014	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.082	<0.01	0.01	<0.01	0.015	<0.01		0.077	0.34	0.21	0.037	0.38	0.27	0.18	0.012
	MELDR-08	<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	0.011	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.011	<0.01	0.016	<0.01	<0.01	<0.01	<0.01	0.018	0.035	0.031	<0.01
	MELDR-09	<0.01	0.011			<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	<0.01	<0.01	<0.01	<0.01	<0.01	0.014	<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	<0.01	0.012	<0.01	0.015	<0.01	<0.01	<0.01	<0.01	<0.01	0.018	0.02	<0.01
	MELDR-10	0.036	0.011			<0.01	0.018	0.026	0.43	0.01	<0.01	<0.01		0.016	<0.01	<0.01	0.019	0.037	<0.01	0.011	<0.01	0.018	0.11	<0.01	<0.01	0.021	<0.01	0.021	<0.01	0.036	0.014	<0.01	0.15	0.017	<0.01	<0.01	<0.01	0.022	0.019	0.018	<0.01	0.037	<0.01	<0.01	<0.01	0.053	0.15	0.31	0.014	0.014
Min 0.01	MELDR-11	<0.01	<0.01			0.01	<0.01	<0.01	0.14	0.011	0.01	0.013	0.01	0.16	0.086	0.017	<0.01	0.034	0.034	<0.01	<0.01	<0.01	0.014	<0.01	<0.01	0.071	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.056	0.019	0.013	<0.01	0.016	<0.01	<0.01	<0.01	<0.01	0.13	0.015	<0.01	<0.01
Max 3.7	MELDR-12	<0.01	0.012			0.01	<0.01	<0.01		0.052	0.013	<0.01		<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	0.017	0.011	0.01	0.013	<0.01	<0.01	0.013	<0.01	<0.01	<0.01	<0.01	0.11	0.2	0.005	0.14	0.012	0.011	0.03	0.011	0.095	0.065	0.045	0.022	0.071	0.075	0.047	0.024	0.011
	MELDR-15																														0.094	0.14	0.098	0.062	0.079	0.058	0.074	0.068	0.047	0.039	0.091	0.016	0.081	0.1	0.11	0.096	0.18	0.2	0.14	0.0925
Nitrogen as ammonia/ ammonium (NH_3-N/NH_4^+-N) (mg/L)	MELDR-05	0.014	0.24			0.53	0.73	0.049		0.2	0.076			0.15	0.44	0.1	1.3	0.01	0.086	0.052	0.044	0.45	0.044	0.31	0.43	0.15	0.19	0.14	0.25	0.27	0.45	0.28	0.13	0.51	0.52	0.32	0.1	0.4	0.22	0.048	0.16	0.063	0.33	0.23	0.22	0.62	0.27	0.32	0.29	0.23
	MELDR-16																														0.037	0.035	0.093	0.057	9.7	0.073	0.41	0.061	0.014	0.043		0.015	0.049	0.022	0.039		0.034	0.096	0.071	0.049
	MELDR-02	4.8	2.9	4.9	5.4	4	4.4	5.8	6.3	3.3	4.7	6.8	6.5	3.3	5.6	6.2	7	5.6	4.9	4.9	4.9	7.6	6	5.8	6.8	4	4	3.8	5.5	2	4.7	4.6	5.9	6.1	6.2	7.6	7.8	6.2	5.1	4	5.7	4.2	4.2	4.8	4.6	5.7	3.2	4	4.7	4.9
	PSDTBCMD	0.5	0.39	0.27	0.1	1.2	0.47	0.7	0.12	0.25	0.13	0.21	0.039	0.27	0.48	0.54	0.26	0.3	0.53	0.43	0.39	1.6	0.85	1.3	1.3	0.35	0.46	0.54	0.75	0.88	0.72	0.55	1	0.63	0.76	0.37	0.34	0.6	0.55	0.23	0.48	0.59	0.62	0.79	0.55	0.98	0.51	0.88	0.88	0.535
ANZECC trigger value for lowland rivers: 0.08 mg/L for wetlands: 0.04 mg/L	MELDR-13																											0.12	0.15	0.075	0.16	0.14	0.19	0.16	0.16	0.14	0.15	0.16	0.15	0.13	0.16	0.14	0.14	0.12	0.14	0.16	0.14	0.13	0.14	0.14
	MELDR-14																											0.023	0.045	0.047	0.066	0.066	0.098	0.05	0.05	0.047	0.041	0.059	0.035	0.019	0.043	0.055	0.062	0.061	0.044	0.092	0.082	0.056	0.074	0.0525
	MELDR-06	0.31	0.22	0.32	0.25	0.22	0.22	0.28	0.24	0.16	0.2	0.24	0.24	0.18	0.2	0.2	0.26	0.2	0.17	0.18	0.12	0.22	0.11	0.15	0.11	0.14	0.13	0.11	0.13	0.089	0.16	0.14	0.17	0.14	0.14	0.12	0.13	0.15	0.12	0.085	0.12	0.094	0.11	0.094	0.094	0.14	0.11	0.095	0.095	0.145
	MELDR-07	0.065	7.2			4.3	6.5	5		0.044	3.6			<0.01	3.4	12	14		<0.01	3.1	6.9			<0.01	0.022		<0.01	0.32	0.3	0.026	0.1	0.021	1.2	0.031	0.028	1.2	0.055	0.043	0.028	0.023	0.64		4.3	2.3	0.63	0.38	1.4	0.38	0.34	0.36
	MELDR-08	<0.01	0.038			0.014	0.023			0.013										<0.01	0.016		<0.01	<0.01	0.013	0.027	0.013	0.016	0.026	0.025	0.028	0.025	0.017	0.028	0.023	0.02	0.025	0.028	0.023	0.011	0.022	0.018	<0.01	0.013	0.033	0.037	0.051	0.045	0.078	0.0225
	MELDR-09	0.017	0.015			0.011	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	0.01	0.013	0.018	0.63	<0.01	0.076	0.046	<0.01	<0.01	<0.01	<0.01	<0.01	0.014	0.014	<0.01	<0.01	0.033	0.024	0.027	0.019	0.02	<0.01	<0.01	0.017	0.013	0.027	0.027	0.013	<0.01	0.012	0.019	0.005	0.013	0.012	0.04	0.012
	MELDR-10	0.18	0.013			<0.01	<0.01	0.05	0.078	<0.01	0.017	0.36		0.041	0.013	0.21	0.26	0.05	<0.01	0.05	0.03	0.068	0.07	0.015	0.023	0.05	<0.01	<0.01	<0.01	0.034	0.033	0.017	0.059	0.031	0.021	0.018	0.035	0.055	0.04	<0.01	0.037	0.048	0.02	<0.01	0.015	0.2	0.051	0.12	0.015	0.033
Min 0.01	MELDR-11	0.024	<0.01			<0.01	0.018	<0.01	0.017	<0.01	0.013	<0.01	0.011	0.54	0.15	0.026	<0.01	0.12	0.016	0.016	<0.01	0.015	<0.01	<0.01	<0.01	0.15	0.026	<0.01	<0.01	0.01	0.013	0.013	0.028	0.021	0.023	0.015	0.02	0.049	0.017	<0.01	0.01	0.005	0.005	<0.01	0.014	0.02	0.42	<0.01	0.014	0.0135
Max 14	MELDR-12	0.37	0.31			0.087	0.089	<0.01		0.18	0.021	0.023		0.051	0.056	0.031	0.043	0.56	<0.01	<0.01	1.4	1.6	1	0.021	0.026	0.85	0.083	<0.01	0.027	0.027	0.043	0.07	0.034	2.1	1.4	0.021	0.9	0.028	0.05	0.11	0.34	1.1	0.39	0.53	0.33	0.38	0.36	0.23	0.11	0.088
Total Organic Nitrogen (TON) (mg/L)	MELDR-15																														0.61	0.51	0.47	0.73	0.61	0.81	0.89	0.63	0.5	0.3	0.46	0.44	0.75	0.64	0.57	0.74	0.5	0.37	0.45	0.57
	MELDR-05																	0.39	0.86	1.4	1.3	1	0.18	0.96	1	0.62	0.62	0.61	0.77	0.56	0.59	0.52	1.3	0.74	0.8	1.3	1.5	0.47	0.58	0.22	0.62	0.6	0.8	0.64	0.65	0.88	0.54	0.42	0.51	0.63
	MELDR-16																														0.49	0.44	0.58	0.56	0.85	0.51	0.86	0.42	0.2	0.17		0.22	1	1.1	0.66		0.33	0.7	0.62	0.56
	MELDR-02																	0.83	0.88	1.3	0.77	0.62	0.41	1.4	1.3	1	0.81	0.79	0.63	0.64	0.46	0.47	0.96	0.47	0.29	1.4	1.7	0.51	0.58	0.56	0.94	0.82	0.76	0.68	1	0.37	0.37	0.29	0.12	0.72
	PSDTBCMD																	0.98	0.76	0.48	0.77	0.35	0.48	0.6	0.79	0.6	0.53	1	0.15	0.65	0.66	0.6	0.33	0.61	0.72	0.75	0.38	0.56	0.58	0.47	0.44	0.8	1.8	0.63	0.63	0.4	0.56	0.63	0.67	0.605
	MELDR-13																											0.32	0.26	0.27	0.27	0.29	0.17	0.22	0.24	0.33	0.25	0.22	0.16	0.19	0.25	0.32	0.46	0.26	0.28	0.32	0.24	0.14	0.26	0.26
Highest concentration of the year	MELDR-14																											0.5	0.57	0.43	0.46	0.46	0.44	0.32	0.37	0.51	0.52	0.32	0.35	0.37	0.44	0.4	0.73	0.51	0.48	0.42	0.34	0.36	0.47	0.44
	MELDR-06																	0.34	0.39	0.44	0.32	0.16	0.17	0.26	0.29	0.27	0.31	0.31	0.32	0.28	0.24	0.31	0.21	0.31	0.27	0.39	0.27	0.29	0.25	0.27	0.31	0.3	0.43	0.32	0.32	0.31	0.28	0.26	0.29	0.295
Lowest concentration of the year	MELDR-07																		2.5	3.3	3.2			0.51	0.42		0.55	2.5	3	0.73	1.4	2.2	2.4	0.33	0.28	2.3	2.9	1.1	0.47	0.4	2.3		3.5	2.6	2.7	3.2	2.3	3.3	2.4	2.3
	MELDR-08																			0.6	0.63		0.62	0.75	0.6	1.6	1.4	0.77	0.68	1.2	0.91	1.3	0.77	0.7	0.56	0.65	0.64	0.73	0.82	1.1	0.81	0.79	1	0.9	1.1	1.4	2.1	2.9	3.8	0.81
	MELDR-09																	0.42	0.72	0.77	0.7	0.39	0.39	0.47	0.48	0.4	0.61	1.1	1.4	1.3	1.1	1.3	1.4	0.75	0.87	0.97	1	0.65	0.66	1	1.2	0.69	1	1.3	1.4	0.62	1.1	1.2	2.4	0.92
	MELDR-10																	0.29	0.28	0.4	0.3	0.24	0.24	0.31	0.49	0.23	0.24	0.26	0.43	0.6	0.29	0.29	0.34	0.19	0.32	0.61	0.45	0.23	0.21	0.26	0.43	0.28	0.19	0.87	0.24	0.27	0.14	0.17	0.37	0.285
Min 0.12	MELDR-11																	0.4	0.39	0.59	0.39	0.38	0.41	0.33	0.45	0.43	0.35	0.31	0.43	0.42	0.41	0.4	0.41	0.29	0.33	0.72	0.7	0.24	0.23	0.31	0.46	0.43	0.25	0.5	0.45	0.32	0.29	0.3	0.42	0.4
Max 6	MELDR-12																	0.2	0.21	1.2	1.9	2.3	6	3.6	3	0.59	2.2	2.6	3.2	2.1	2.1	2.3	5.3	1.7	1.9	2.4	1.9	0.82	0.57	2.1	2.2	1.6	2	2.9	1.8	1.2	1.1	1.6	1.9	1.95
Dissolved Organic Nitrogen (DON) (mg/L)	MELDR-15																														0.4	0.39	0.46	0.59	0.6	0.65	0.79	0.62	0.41	0.28	0.39	0.32	0.56	0.46	0.45	0.61	0.38	0.3	0.34	0.55
	MELDR-05	<0.01	0.075			0.76	0.81	1.4		0.71	0.65			0.42	0.57	1.1	1	0.23	0.57	0.77	0.56	0.68	0.11	0.72	0.7	0.46	0.53	0.45	0.51	0.43	0.5	0.45	0.57	0.64	0.76	0.84	0.9	0.45	0.46	0.21	0.52	0.49	0.69	0.52	0.54	0.73	0.49	0.39	0.4	0.43
	MELDR-16																														0.37	0.43	0.48	0.41	0.75	0.35	0.6	0.3	0.15	0.16		0.18	0.69	0.77	0.59		0.28	0.62	0.53	0.53
	MELDR-02	0.078	0.13	0.089	0.065	0.25	1	1.1	0.3	1.1	0.93	0.44	0.23	<0.025	<0.025	<0.025	0.43	0.5	0.71	1.1	0.57	0.6	0.39	1.1	1.3	0.82	0.71	0.79	0.62	0.41	0.43	0.45	0.94	0.38	0.19	0.46	1.6	0.18	0.56	0.53	0.9	0.8	0.7	0.66	0.86	0.28	0.26	0.27	0.077	0.535
	PSDTBCMD	1.9	1.2	0.078	2.3	0.083	0.74	0.92	0.76	0.99	0.57	0.34	0.36	0.32	0.19	0.45	0.89	0.68	0.74	0.41	0.61	0.34	0.48	0.59	0.76	0.5	0.53	0.76	0.099	0.39	0.57	0.57	0.26	0.53	0.7	0.64	0.35	0.43	0.43	0.43	0.39	0.78	1.1	0.48	0.54	0.36	0.51	0.59	0.65	0.215
	MELDR-13																											0.23	0.22	0.2	0.27	0.22	0.16	0.21	0.24	0.31	0.25	0.18	0.13	0.18	0.19	0.28	0.23	0.2	0.22	0.31	0.17	0.12	0.18	0.415
Highest concentration of the year	MELDR-14																											0.43	0.56	0.35	0.43	0.43	0.39	0.29	0.37	0.49	0.46	0.28	0.22	0.34	0.42	0.35	0.42	0.45	0.41	0.42	0.3	0.33	0.44	0.255
	MELDR-06	0.32	0.35	2.1	0.068	0.3	0.28	0.15	0.18	0.45	0.26	0.2	0.24	0.24	0.22	0.22	0.28	0.29	0.32	0.4	0.28	0.16	0.17	0.23	0.26	0.21	0.28	0.23	0.28	0.19	0.24	0.25	0.18	0.24	0.24	0.37	0.26	0.2	0.18	0.26	0.28	0.28	0.3	0.27	0.28	0.3	0.23	0.2	0.24	1.7
Lowest concentration of the year	MELDR-07	<0.01	0.018			0.92	3.5	5.3		0.64	3.3			1.5	2.7	3.5	1.2		1.1	3.1	2.9			0.32	0.29		0.28	1.7	2.8	0.58	1	1.4	2.2	0.3	0.24	1.6	2.6	0.64	0.27	0.28	2		2.4	2.5	2.5	2.4	2.2	2.4	2.4	0.705
	MELDR-08	<0.01	<0.01			0.64	0.5			0.69										0.6	0.6		0.54	0.72	0.57	1.5	1.2	0.76	0.63	1.1	0.88	1.3	0.69	0.65	0.56	0.48	0.55	0.73	0.82	0.99	0.77	0.78	1	0.9	1.1	1.2	2.1	2.8	2.4	0.24
	MELDR-09	<0.01	0.011			0.54	0.66	0.92	1.1	0.69	0.66	0.74		0.44	0.5	0.55	0.89	0.38	0.43	0.7	0.68	0.39	0.35	0.44	0.48	0.35	0.54	1.1	1.3	1.2	1.1	1.1	1.4	0.71	0.84	0.71	0.91	0.58	0.65	0.99	1.2	0.66	0.98	1.3	1.3	0.6	1	1.2	2.4	0.29
	MELDR-10	0.036	0.011			0.26	0.34	0.37	0.24	0.28	0.34	0.41		0.16	0.21	0.41	0.41	0.25	0.18	0.4	0.25	0.2	0.16	0.25	0.35	0.13	0.13	0.18	0.36	0.25	0.23	0.23	0.26	0.16	0.23	0.4	0.29	0.18	0.2	0.19	0.32	0.2	0.19	0.27	0.21	0.26	0.094	0.032	0.25	1.4
Min 0.011	MELDR-11	<0.01	<0.01			0.3	0.38	0.52	0.62	0.37	0.4	0.76	0.94	0.22	0.27	0.43	0.67	0.3	0.28	0.44	0.32	0.24	0.23	0.25	0.35	0.22	0.24	0.23	0.37	0.26	0.23	0.26	0.34	0.17	0.27	0.49	0.57	0.21	0.2	0.26	0.41	0.27	0.25	0.45	0.38	0.25	0.21	0.21	0.35	0.275
Max 5.3	MELDR-12	<0.01	0.012			1.1	1.2	1.2		1	1.1	1.4		0.82	0.89	1.1	1.4	0.18	0.13	0.92	1.9	1.2	0.69	0.75	2.1	0.35	1.4	1.9	1.9	1.6	1.6	1.6	1.5	1.4	1.5	1.6	1.9	0.29	0.29	1.6	2	1.5	1.5	1.8	1.7	1	1	1.4	1.6	1.4

SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY ABOVE ANZECC TRIGGER VALUE
SITES RECORDING 40-60% of concentrations ABOVE ACCEPTABLE RANGE
SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY BELOW ANZECC TRIGGER VALUE

Concentration ABOVE trigger value
Concentration BELOW trigger value

Concentration < LOR
NO sample taken

6.2 Phosphorus

Phosphorus in water can exists in both soluble and particulate forms. Soluble phosphorus is largely comprised of inorganic phosphate ions (PO_4^{3-}, also known as orthophosphate) but small amounts of condensed phosphate (polyphosphates and metaphosphates) and dissolved organic forms of phosphorus may be present. Filterable reactive phosphorus (FRP) is a measure of the phosphates that pass through a 0.45 µm filter and respond to colorimetric tests without preliminary hydrolysis or oxidative digestions of the sample and is largely a measure of orthophosphate. Particulate phosphorus is comprised of organic material (decaying plant and animal matter), phosphorus adsorbed to particulate material and phosphorus minerals (e.g. apatite).

Total phosphorus (TP) is a measure of all phosphorus in the water including soluble forms and particulate forms. TP concentrations recorded in Melville Bull Creek catchment sites in 2018 exceeded relevant ANZECC trigger values (lowland rivers: 0.065 mg/L, wetlands: 0.06 mg/L) in 12 out of 55 samples from six sites (15 (John Creaney Park inlet), 5 (John Creaney Park), 16 (downstream Elizabeth Manion Park), 7 (Booragoon Lake), 8 (Piney Lake outlet) and 12 (Blue Gum Lake)) (**Figure 6.2-1-A** and **Table D-12, Appendix D**). TP concentrations exceeded the wetlands trigger value on all sampling occasions at sites 7 and 12, and the highest concentrations by far were recorded at site 7 (5.5 mg/L, 4.5 mg/L, 3.8 mg/L and 3.1 mg/L in October, September, August and July respectively). Concentrations below the limit of reporting (0.005 mg/L) were recorded at sites 2, 13, 6 and 9 (Brockman Park, Brentwood Drain, Bateman Park and Quenda Lake outlet respectively) in July.

Filterable reactive phosphorus (FRP) concentrations exceeded relevant ANZECC trigger values (lowland rivers: 0.04 mg/L, wetlands: 0.03 mg/L) in eight of 55 samples: all samples from sites 7 and 12 (Booragoon Lake and Blue Gum Lake respectively) (**Figure 6.2-1-B** and **Table D-12, Appendix D**). The highest concentrations were recorded at site 7 (4.7 mg/L, 3.7 mg/L, 3.1 mg/L and 2.1mg/L in October, September, August and July respectively). 34 samples recorded a concentration below the limit of reporting (0.005 mg/L).

TP and FRP concentrations recorded at most sites in 2018 are generally similar to those recorded in the preceding 11 years of monitoring, with exceedances of the ANZECC trigger value for wetlands consistently recorded at sites 7 and 12 (Booragoon Lake and Blue Gum Lake respectively) (**Table 6-2**). However, TP and FRP concentrations recorded at site 7 in 2017 and 2018 are higher than those recorded from 2012 to 2016, and closer to the higher concentrations recorded from 2007 to 2011. FRP also constituted an average of 76% of TP at site 7 for all sampling occasions in 2017 and 2018, whereas in previous years FRP has only sporadically been such a high proportion of TP, with an average proportion of 22% calculated from preceding samples prior to 2018. Furthermore, while TP concentrations recorded at site 12 still exceeded the ANZECC trigger value on all sampling occasions in 2018, the maximum concentration recorded (0.25 mg/L) was at least 50% lower than the maximum concentrations recorded within each sampling year from 2012 to 2017.

Throughout the twelve year monitoring period, TP and FRP concentrations recorded at drain sites have generally been below the lowland rivers trigger value. Although TP concentrations often exceed at site 5 (John Creaney Park) which may cause local problems in the lake (particularly as high nitrogen is also often recorded here), phosphorus levels are usually low in the most downstream site along the Bull Creek main drain (PSDTBCMD).

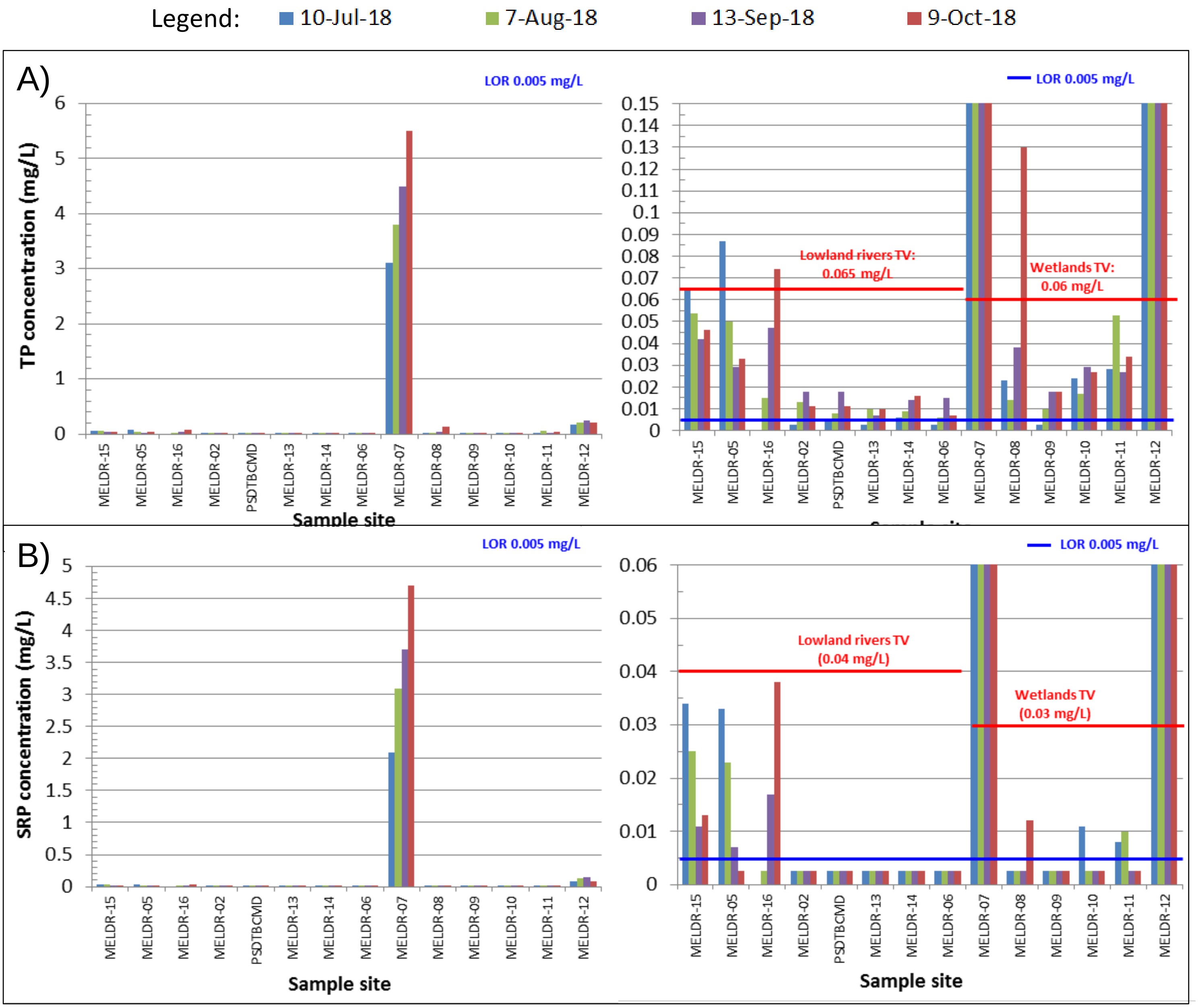

Figure 6.2-1: Graphs of A) Total phosphorus (TP) concentrations (mg/L); and B) filterable reactive phosphorus (FRP) concentrations (mg/L) recorded in Melville Bull Creek catchment sites in 2018.

Table 6-2: Total phosphorus (TP) and filterable reactive phosphorus (FRP) concentrations (mg/L) recorded in Melville Bull Creek catchment sites from 2007to 2018.

	Site	Jul-07	Oct-07	Jan-08	Apr-08	Sep-08	Nov-08	Jan-09	Mar-09	Sep-09	Nov-09	Jan-10	Mar-10	Aug-10	Sep-10	Oct-10	Nov-10	Jul-11	Aug-11	Sep-11	Oct-11	Jul-12	Aug-12	Sep-12	Oct-12	Aug-13	Sep-13	Oct-13	Nov-13	Aug-14	Sep-14	Oct-14	Nov-14	Aug-15	Sep-15	Oct-15	Nov-15	Jul-16	Aug-16	Sep-16	Oct-16	Jul-17	Aug-17	Sep-17	Oct-17	Jul-18	Aug-18	Sep-18	Oct-18	Median
	MELDR-15																														0.048	0.044	0.014	0.047	0.041	0.025	0.027	0.015	0.028	0.015	0.035	0.046	0.075	0.067	0.045	0.065	0.054	0.042	0.046	0.044
	MELDR-05	0.14	0.025			0.041	0.086	0.12		0.059	0.049			0.095	0.059	0.17	0.16	0.048	0.078	0.13	0.12	0.1	0.032	0.052	0.064	0.073	0.071	0.042	0.034	0.083	0.052	0.05	0.088	0.043	0.051	0.076	0.069	0.098	0.036	0.022	0.035	0.058	0.059	0.034	0.032	0.087	0.05	0.029	0.033	0.059
Total Phosphorus	MELDR-16																														0.059	0.043	0.037	0.042	0.051	0.063	0.12	0.057	0.02	0.016		0.029	0.069	0.21	0.087		0.015	0.047	0.074	0.051
(TP) (mg/L)	MELDR-02	0.01	0.009	0.008	0.014	0.01	0.01	0.008	0.014	0.015	0.013	0.013	0.072	0.028	0.01	0.011	0.017	0.007	0.012	0.016	0.016	<0.005	<0.005	<0.005	<0.005	0.023	0.018	0.03	0.012	0.051	0.019	0.019	0.011	0.006	0.008	<0.005	0.006	0.006	0.007	0.01	0.018	0.018	0.014	0.011	0.013	<0.005	0.013	0.018	0.011	0.0115
	PSDTBCMD	0.017	0.012	0.008	0.016	0.019	0.015	0.014	0.022	0.02	0.016	0.014	0.022	0.039	0.014	0.02	0.015	0.011	0.013	0.018	0.018	0.013	0.006	0.012	0.011	0.029	0.016	0.034	0.017	0.024	0.02	0.014	0.012	0.011	0.008	0.008	0.008	0.009	0.01	0.012	0.009	0.015	0.012	0.015	0.013	0.005	0.008	0.018	0.011	0.014
ANZECC trigger	MELDR-13																											0.016	0.005	0.026	0.011	0.013	<0.005	0.011	0.008	0.005	0.008	0.009	0.006	0.007	0.008	0.013	0.01	0.009	0.012	<0.005	0.01	0.007	0.01	0.009
value for lowland	MELDR-14																											0.009	0.017	0.013	0.014	0.012	0.011	0.014	0.012	0.016	0.02	0.011	0.012	0.01	0.009	0.019	0.012	0.015	0.012	0.006	0.009	0.014	0.016	0.012
rivers: 0.065 mg/L	MELDR-06	0.013	0.008	0.027	0.016	0.012	0.023	0.008	0.013	0.013	0.01	0.01	0.012	0.03	0.012	0.016	0.021	0.013	0.014	0.018	0.013	<0.005	0.012	0.008	0.006	0.014	0.011	0.01	0.007	0.019	0.008	0.011	<0.005	0.016	0.006	0.006	0.009	0.01	0.009	0.011	0.01	0.014	0.012	0.011	0.013	<0.005	0.006	0.015	0.007	0.012
for wetlands:	MELDR-07	0.12	3.2			1.3	2.6	8.3		0.66	3.2			1	1.5	0.95	3.9		0.81	1.2	2.9			0.45	0.081		0.21	0.91	1.5	0.33	1.1	0.77	2.3	0.02	0.025	0.73	0.64	0.22	0.12	0.11	1.2		1.6	3.6	4	3.1	3.8	4.5	5.5	1.15
0.06 mg/L	MELDR-08	0.077	0.11			0.15	0.024			0.021										0.029	0.031		0.034	0.034	0.025	0.12	0.069	0.013	0.016	0.016	0.014	0.015	0.01	0.01	0.008	0.01	0.017	0.019	0.013	0.015	0.015	0.012	0.006	0.013	0.017	0.023	0.014	0.038	0.13	0.017
	MELDR-09	0.02	0.018			0.014	0.014	0.017	0.02	0.012	0.012	0.013		0.012	0.015	0.02	0.028	0.025	0.03	0.025	0.017	<0.005	<0.005	<0.005	<0.005	0.005	0.007	0.013	0.016	0.007	0.013	0.021	0.017	0.009	0.013	0.009	0.012	0.008	<0.005	0.01	0.009	0.006	0.014	0.019	0.017	<0.005	0.01	0.018	0.018	0.013
	MELDR-10	0.03	0.018			0.026	0.035	0.059	0.1	0.016	0.041	0.062		0.025	0.022	0.042	0.045	0.024	0.025	0.024	0.025	0.031	0.028	0.023	0.039	0.027	0.022	0.017	0.025	0.054	0.024	0.023	0.02	0.022	0.023	0.031	0.031	0.025	0.025	0.021	0.043	0.03	0.017	0.082	0.015	0.024	0.017	0.029	0.027	0.025
Min 0.01	MELDR-11	0.036	0.032			0.03	0.039	0.042	0.077	0.033	0.038	0.11	0.16	0.042	0.034	0.049	0.089	0.039	0.033	0.044	0.027	0.035	0.03	0.027	0.029	0.066	0.025	0.024	0.033	0.039	0.04	0.04	0.03	0.027	0.025	0.048	0.094	0.026	0.019	0.021	0.054	0.05	0.041	0.074	0.048	0.028	0.053	0.027	0.034	0.037
Max 8.3	MELDR-12	0.18	0.31			0.28	0.19	0.19		0.12	0.089	0.21		0.12	0.076	0.073	0.14	0.008	0.017	0.26	1.1	0.15	0.65	0.73	0.54	0.036	0.36	0.67	0.55	0.59	0.72	0.51	0.85	0.44	0.58	0.3	0.7	0.14	0.077	0.48	0.91	0.17	0.25	0.56	0.41	0.18	0.21	0.25	0.21	0.255
	MELDR-15																														0.011	0.016	0.012	0.011	0.013	<0.005	0.006	0.011	0.006	<0.005	0.011	0.014	0.028	0.009	0.016	0.034	0.025	0.011	0.013	0.011
Filterable	MELDR-05	0.017	<0.005			<0.005	<0.005	<0.005		<0.005	<0.005			0.021	<0.005	<0.005	0.066	0.006	0.015	<0.005	0.01	0.081	0.01	<0.005	<0.005	0.026	0.03	<0.005	<0.005	0.032	0.005	0.016	<0.005	0.019	0.009	<0.005	0.005	0.061	0.015	0.006	<0.005	0.016	0.03	0.007	0.008	0.033	0.023	0.007	<0.005	0.007
Reactive	MELDR-16																														0.018	0.018	0.008	0.008	0.013	0.014	0.019	0.01	<0.005	<0.005		0.011	0.015	0.061	0.048		<0.005	0.017	0.038	0.014
Phosphorus	MELDR-02	0.009	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.012	<0.005	<0.005	0.008	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.01	0.007	0.014	<0.005	0.019	<0.005	0.006	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	0.01	0.007	<0.005	0.009	<0.005	<0.005	<0.005	<0.005	<0.005
(FRP) (mg/L)	PSDTBCMD	0.009	<0.005	<0.005	<0.005	<0.005	0.007	<0.005	<0.005	0.009	<0.005	0.009	<0.005	0.008	<0.005	<0.005	0.009	<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	<0.005	<0.005	<0.006	<0.005	<0.005	<0.005	0.006	0.01	<0.005	<0.005	<0.005	0.007	0.007	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	<0.005
	MELDR-13																											<0.005	<0.005	<0.005	<0.005	<0.005	<0.007	<0.005	<0.005	<0.005	0.007	0.006	<0.005	<0.005	0.005	0.009	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
ANZECC trigger	MELDR-14																											<0.005	<0.005	<0.005	<0.005	<0.005	<0.008	0.005	<0.005	<0.005	0.008	0.006	<0.005	<0.005	<0.005	0.008	0.005	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005
value for lowland	MELDR-06	0.008	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	<0.005	<0.005	0.009	<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	<0.005	<0.005	<0.009	0.005	<0.005	<0.005	0.008	0.007	<0.005	<0.005	0.006	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
rivers: 0.04 mg/L	MELDR-07	0.015	0.048			0.13	1	1.2		<0.005	0.67			0.056	0.46	0.21	0.083		0.059	0.27	1.6			0.043	0.022		0.011	0.37	1.1	0.13	0.87	0.23	1.7	0.008	0.009	0.53	0.3	0.018	0.006	0.005	0.61		1.1	2.4	3.3	2.1	3.1	3.7	4.7	0.3
for wetlands:	MELDR-08	0.008	<0.005			<0.005	<0.005			<0.005										<0.005	0.01		0.007	0.008	<0.005	0.047	0.015	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	0.007	<0.005	<0.005	0.006	<0.005	0.006	<0.005	0.007	<0.005	<0.005	<0.005	0.012	<0.005
0.03 mg/L	MELDR-09	0.007	<0.005			<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005		<0.005	0.006	<0.005	0.01	<0.005	<0.005	<0.005	0.014	<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	<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	<0.005	<0.005	<0.005
	MELDR-10	0.01	<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	<0.005	<0.005	0.014	0.008	0.006	<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	<0.005	0.005	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	<0.005	0.011	<0.005	<0.005	<0.005	<0.005
Min 0.01	MELDR-11	0.007	<0.005			<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.01	<0.005	<0.005	0.01	0.009	0.005	<0.005	0.016	<0.005	<0.005	<0.005	<0.005	0.024	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.01	0.039	0.005	<0.005	<0.005	0.015	0.008	0.016	0.02	0.011	0.008	0.01	<0.005	<0.005	<0.005
Max 4.7	MELDR-12	0.008	0.16			0.18	0.078	0.048		0.064	0.021	0.022		0.042	0.033	0.018	0.081	<0.005	<0.005	0.077	0.73	<0.005	<0.005	<0.005	0.09	<0.005	0.073	0.3	0.12	0.22	0.45	0.17	0.23	0.32	0.4	0.025	0.56	0.006	<0.005	0.16	0.62	0.1	0.15	0.43	0.31	0.081	0.13	0.15	0.089	0.085

SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY ABOVE ANZECC TRIGGER VALUE
SITES RECORDING 40-60% of concentrations ABOVE ACCEPTABLE RANGE
SITES RECORDING CONCENTRATIONS ALWAYS/GENERALLY BELOW ANZECC TRIGGER VALUE

Concentration ABOVE trigger value
Concentration BELOW trigger value

Concentration < LOR
NO sample taken

7. Metals

Refer to **Tables D-14 to D-28 in Appendix D** for all metal and hardness concentration data collected in the Melville Bull Creek catchments for the 2018 water quality sampling program. **Table F-1, Appendix F** outlines potential sources of metals and hardness and the impacts of these parameters on aquatic ecosystems. For all graphs, a value equal to half the limit of reporting was substituted for those occasions where concentrations were recorded as 'below the laboratory limit of reporting' (<LOR) to allow these 'unknown' values to be represented graphically and to differentiate them from those samples that recorded concentrations equal to the limit of reporting.

7.1 Hardness

Total hardness, expressed as calcium carbonate ($CaCO_3$), is the combined concentration of earth-alkali metals, predominantly magnesium (Mg^{2+}) and calcium (Ca^{2+}), and some strontium (Sr^{2+}) in the water. Other metal ions (such as aluminium, iron, zinc and manganese) also contribute to water hardness. The source of this hardness is limestone dissolved by water that is rich in carbon dioxide. Increasing calcium and magnesium in water (hardness) is frequently associated with increases in alkalinity (as calcium and/or magnesium carbonate), and thus, pH (ANZECC and ARMCANZ 2000).

In 2018 water hardness in the surface water of the Melville Bull Creek catchments varied from a minimum of 51 mg/L recorded at site 10 (Marmion Reserve) in July to a maximum of 350 mg/L recorded at site 7 (Booragoon Lake) in July (**Figure 7.1-1** and **Table D-14:, Appendix D**). As classified by ANZECC (2000), of the 55 samples collected, two can be classified as "soft" (0 to 59 mg/L), 11 as "moderate" hardness (60 to 119 mg/L), 33 as "hard" (120 to 179 mg/L), five as "very hard" (180 to 240 mg/L) and four as "extremely hard" (>240 mg/L).

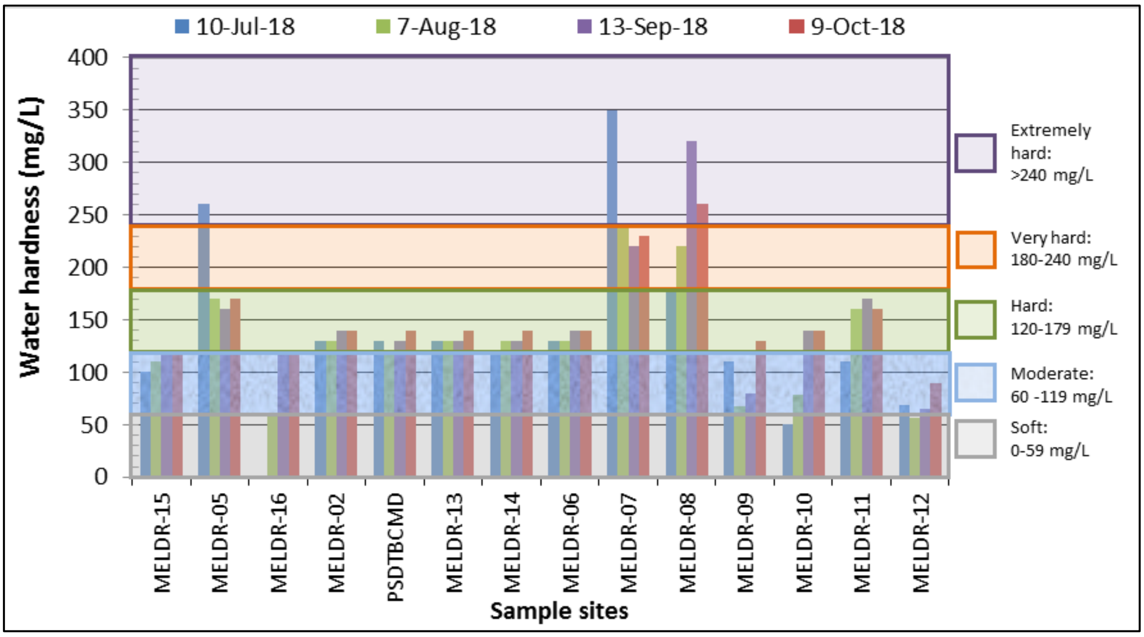

Figure 7.1-1: Water hardness concentrations (mg/L) recorded in Melville Bull Creek catchment sites in 2018

Water hardness values recorded in Melville Bull Creek catchment sites in 2018 are generally similar to those recorded in the preceding 11 years of monitoring (**Table 7-1**). Most sites have usually recorded concentrations classified as moderate or hard and have only sporadically recorded concentrations classified as very hard or extremely hard; with the exception of site 5 (hardness varies from moderate to extremely hard), site 7 (generally extremely hard, although somewhat softer in 2018) and site 10 (often soft).

7.2 Aluminium

Concentrations of **total aluminium** were high across the catchment, with 12 out of 14 sites recording exceedances the ANZECC trigger value for 95% level of protection of 0.055 mg/L (and therefore for samples with pH <6.5, the low reliability interim value for freshwater protection of 0.0008 mg/L) (**Figure 7.2-1-A** and **Table D-15, Appendix D**). Similarly, 46 of 55 samples recorded **soluble aluminium** concentrations exceeding the ANZECC trigger value for 95% level of protection (and therefore for samples with pH <6.5, the low reliability interim value for freshwater protection) (**Figure 7.2-1-B** and **Table D-15**, **Appendix D**). The highest total aluminium concentration (0.57 mg/L) was recorded at both site 13 (Brentwood drain) and site 8 (Piney Lakes outlet) and the highest soluble aluminium concentration of 1 mg/L was recorded at site 8 in August. The lowest concentrations of both total (0.027 mg/L) and soluble aluminium (0.0108 mg/L) were recorded at site 11 (Marmion Reserve).

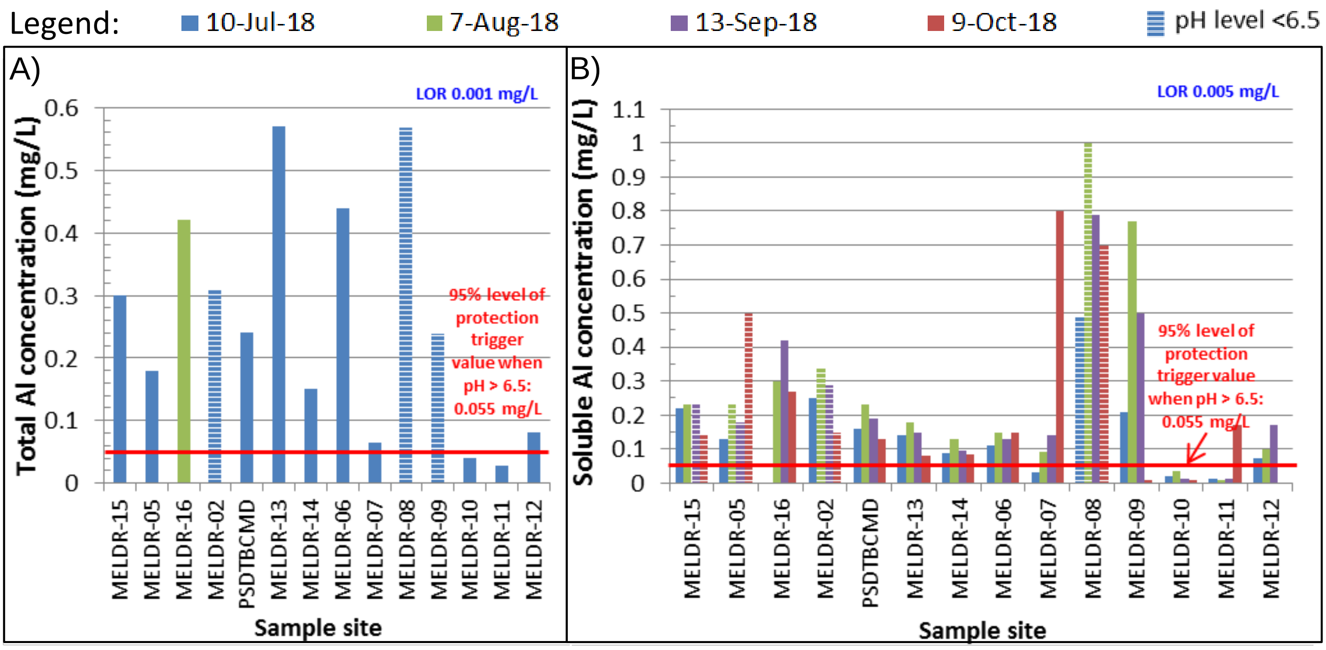

Figure 7.2-1: A) Total and B) soluble aluminium (Al) concentrations (mg/L) recorded in Melville Bull Creek catchment sites in 2018

Total and soluble aluminium concentrations recorded in Melville Bull Creek catchment sites in 2018 are generally similar to those recorded in the preceding 11 years of monitoring (**Table 7-1**). Concentrations of both total and soluble aluminium exceeding the trigger values for protection of biota have generally been recorded at all sites except 10 (Frederick Baldwin) and 11 (Marmion Reserve). Total and soluble aluminium concentrations throughout the 11 year sampling period have generally been higher at site 2 (Brockman Park) than site 5 (John Creaney Park), which appears to be due to high inputs from the drainage branch running through Elizabeth Manion Park (and downstream site 16). However, concentrations are then somewhat lower at the most downstream Bull Creek main drain site (PSDTBCMD). In the Brentwood drain, total and soluble aluminium concentrations coming from the Brentwood drain site before the living stream (site 13) are generally greater than those coming from the Mandala Crescent branch/RAAF drain (site 14), with concentrations at Bateman Park (site 6) similar to those at site 13.

7.3 Chromium

Total chromium and **soluble chromium** (which both include Cr^{3+} and Cr^{6+} chromium fractions) concentrations recorded at all Melville Bull Creek catchment sites were below ANZECC hardness adjusted trigger values for 95% protection of biota (unmodified trigger value for chromium: 0.0033 mg/L) in 2018 (**Figure 7.3-1-A and B, Table D-17, Appendix D** and **Table D-18, Appendix D**). The highest total chromium concentration of 0.0026 mg/L was recorded at site 8 (Piney Lakes outlet) and the highest soluble chromium concentration of 0.0041 mg/L was recorded at site 9 (Quenda Lake outlet) in October. The lowest total chromium concentration of 0.0002 mg/L was recorded at sites 10 and 11 (Frederick Baldwin and Marmion Reserve), and samples from sites 10 and 11 recorded soluble chromium concentrations below the limit of reporting (0.0001 mg/L) in September and October. No total or soluble chromium concentration exceeded the NHMRC recreational guideline value for health (0.5 mg/L).

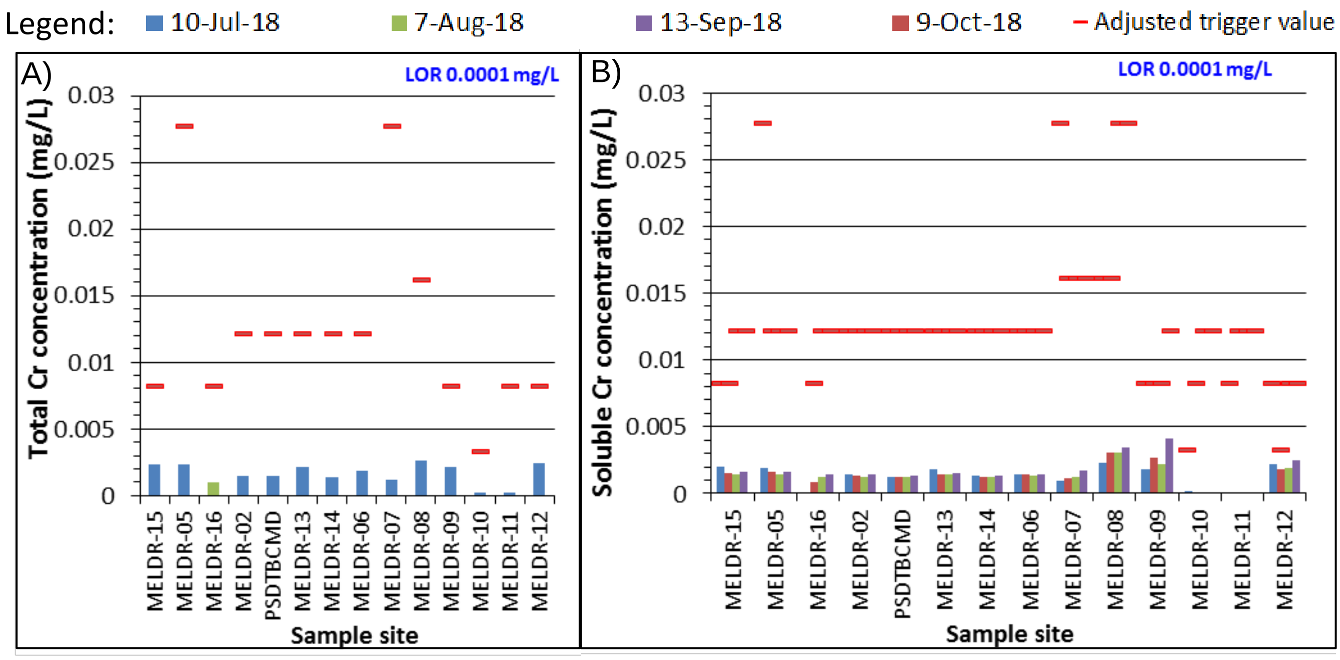

Figure 7.3-1: A) Total and B) soluble chromium (Cr) concentrations (mg/L) recorded in Melville Bull Creek catchment sites in 2018

Soluble chromium concentration have always been below adjusted ANZECC trigger values since sampling of this parameter began in 2009, and total chromium concentrations have only exceeded adjusted ANZECC trigger values in 2007 at Bateman Park (site 6) and Blue Gum Lake (site 12) and in 2008 at Bateman Park and Bull Creek main drain (PSDTBCMD) (**Table 7-1**).

7.4 Copper

Concentrations of **total copper** exceeded hardness adjusted ANZECC trigger values for 95% protection of biota (unmodified trigger value: 0.0014 mg/L) at three out of 14 sites: 15, 16 and 10 (John Creaney Park inlet, downstream Elizabeth Manion Park and Frederick Baldwin respectively) (**Figure 7.4-1-A** and **Table D-19, Appendix D**). However only out of the 55 samples analysed for **soluble copper,** only the August sample collected from site 16 recorded a concentration exceeding the hardness adjusted ANZECC trigger value of 0.037 mg/L, the highest result in the catchment (**Figure 7.4-1-B** and **Table D-20, Appendix D**).The highest total copper concentrations of 0.0049 mg/L and 0.0045 mg/L were recorded at sites 15 and 16. The lowest concentration of total copper (0.0004 mg/L) was recorded at site 2 (Brockman Park) and the lowest concentration of soluble copper (0.0002 mg/L) was recorded at site 10 in September. No total or soluble copper concentration exceeded the NHMRC recreational guideline for aesthetic value (10 mg/L) or health value (20 mg/L).

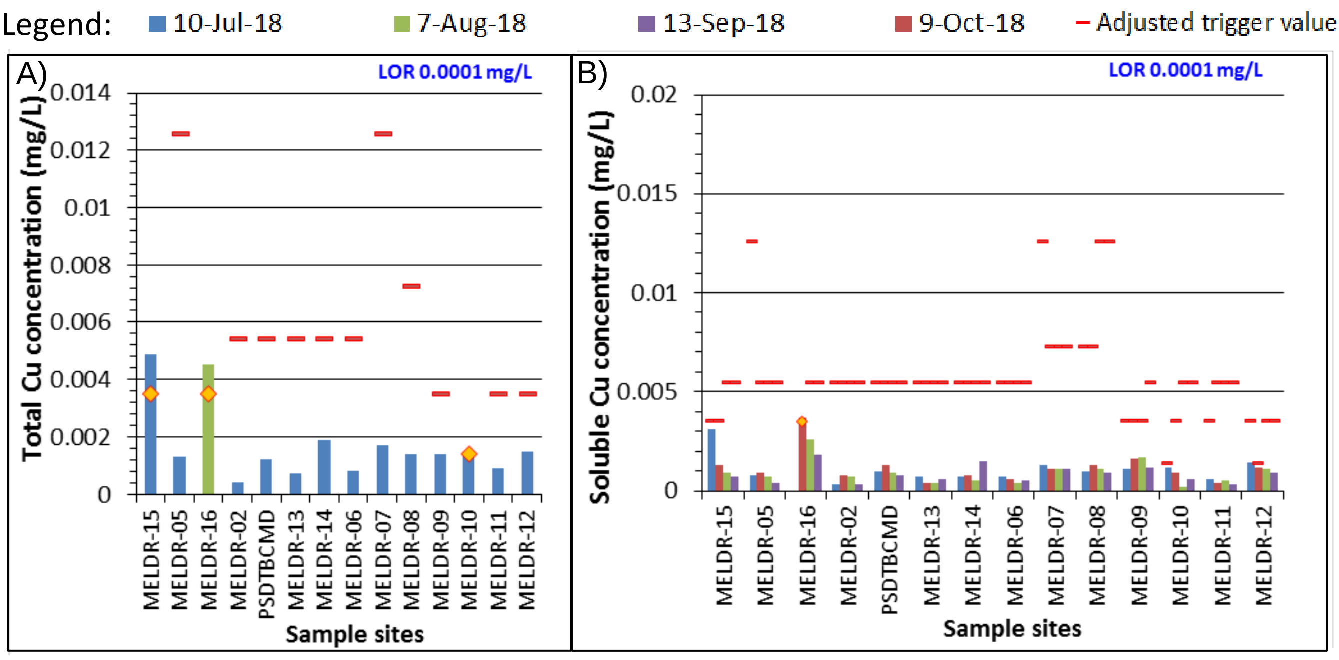

Figure 7.4-1: A) Total and B) soluble copper (Cu) concentrations (mg/L) recorded in Melville Bull Creek catchment sites in 2018

Total and soluble copper concentrations recorded in Melville Bull Creek catchment sites in 2018 are similar to those recorded in the preceding 11 years of monitoring (**Table 7-1**). The often relatively high total copper concentrations recorded during the twelve year monitoring period in the two upstream branches of at Bull Creek main drain at sites 16 (downstream Elizabeth Manion Park) and 15 and 5 (John Creaney Park inlet and John Creaney Park) do not appear to be resulting in high concentrations at downstream sites 2 (Brockman Park) and PSDTBCMD (Bull Creek main drain). Although copper concentrations at site 10 (Frederick Baldwin) are similar to those recorded at other wetland sites, this site has recorded the greatest number of exceedances of total and soluble copper of any site, which is partially a consequence of the relatively soft water found at the site. Soluble and total copper exceedances have only been recorded sporadically at other sites over the eleven year sampling period.

7.5 Iron

13 out of 14 Melville Bull Creek catchment sites recorded **total iron** concentrations exceeding the ANZECC interim guideline value for iron (0.3 mg/L) in 2018 (**Figure 7.5-1-A** and **Table D-21, Appendix D)** and 50 of 55 samples from all sites recorded **soluble iron** concentrations exceeding the interim guideline value for iron (**Figure 7.5-1-B** and **Table D-22, Appendix D**). The highest total iron concentration (4.4 mg/L) was recorded at site 5 (John Creaney Park) and the highest soluble iron concentrations (4.3 mg/L, 3.7 mg/L and 3.3 mg/L) were recorded at site 7 (Booragoon Lake) in September, October and August respectively. The lowest total iron concentration (0.19 mg/L) was recorded at site 9 (Quenda Lake outlet) and the lowest soluble iron concentration (0.025 mg/L) was recorded at site 11 (Marmion Reserve) in September. Two total iron concentrations and four soluble iron concentrations also equalled or exceeded the NHMRC recreational guideline for aesthetic value (3 mg/L).

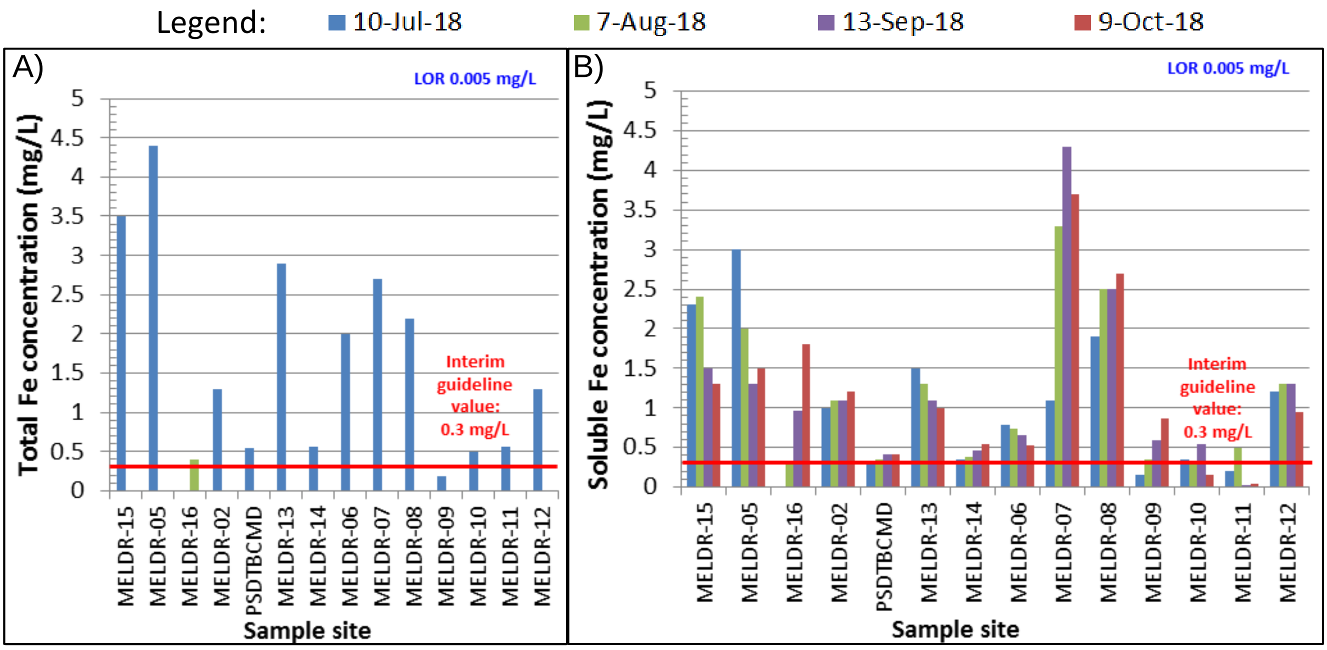

Figure 7.5-1: A) Total and B) soluble iron (Fe) concentrations (mg/L) recorded in Melville Bull Creek catchment sites in 2018

Total and soluble iron concentrations recorded in Melville Bull Creek catchment sites in 2018 are similar to those recorded in the preceding 11 years of monitoring (**Table 7-1**)**.** Throughout the twelve year monitoring period, total iron concentrations have always or often exceeded the interim trigger value at all Melville Bull Creek catchment sites. Soluble iron concentrations have also always or often exceeded the interim trigger value at all sites except 10 and 11 (Frederick Baldwin and Marmion Reserve); however in recent years exceedances have been more common at these sites. Total and soluble iron concentrations are generally highest at sites 15, 13, 6, 7 and 12 (John Creaney Park, John Creaney Park inlet, Brentwood Drain, Bateman Park, Booragoon Lake and Blue Gum Lake).

Total and soluble iron concentrations appear to reduce as water moves through the Bull Creek Main Drain, with soluble iron concentration generally only slightly greater than the interim value at the most downstream Bull Creek main drain site (PSDTBCMD). In the Brentwood drain, total and soluble iron concentrations coming from the Brentwood drain site before the living stream (site 13) are generally greater than those coming from the Mandala Crescent branch/RAAF drain (site 14), with concentrations at Bateman Park (site 6) similar to those at site 13.

7.6 Lead

All samples collected from Melville Bull Creek catchment sites in 2018 recorded **total lead** and **soluble lead** concentrations below adjusted ANZECC trigger values for 95% protection of biota (unadjusted trigger value: 0.0034 mg/L) (**Figure 7.6-1-A and B, Table D-23, Appendix D** and **Table D-24, Appendix D**). The highest total lead concentration (0.0038 mg/L) was recorded at site 12 (Blue Gum Lake) and the highest soluble lead concentration (0.0058 mg/L) was recorded at site 8 (Piney Lakes outlet) in August. The lowest total lead concentration of 0.007 mg/L was recorded at four sites and sites 10 and 11 (Frederick Baldwin and Marmion Reserve) recorded soluble lead concentrations below the limit of reporting (0.0001 mg/L) in September and October. All recorded total and soluble lead concentrations were below the NHMRC recreational guideline for health value (0.1 mg/L).

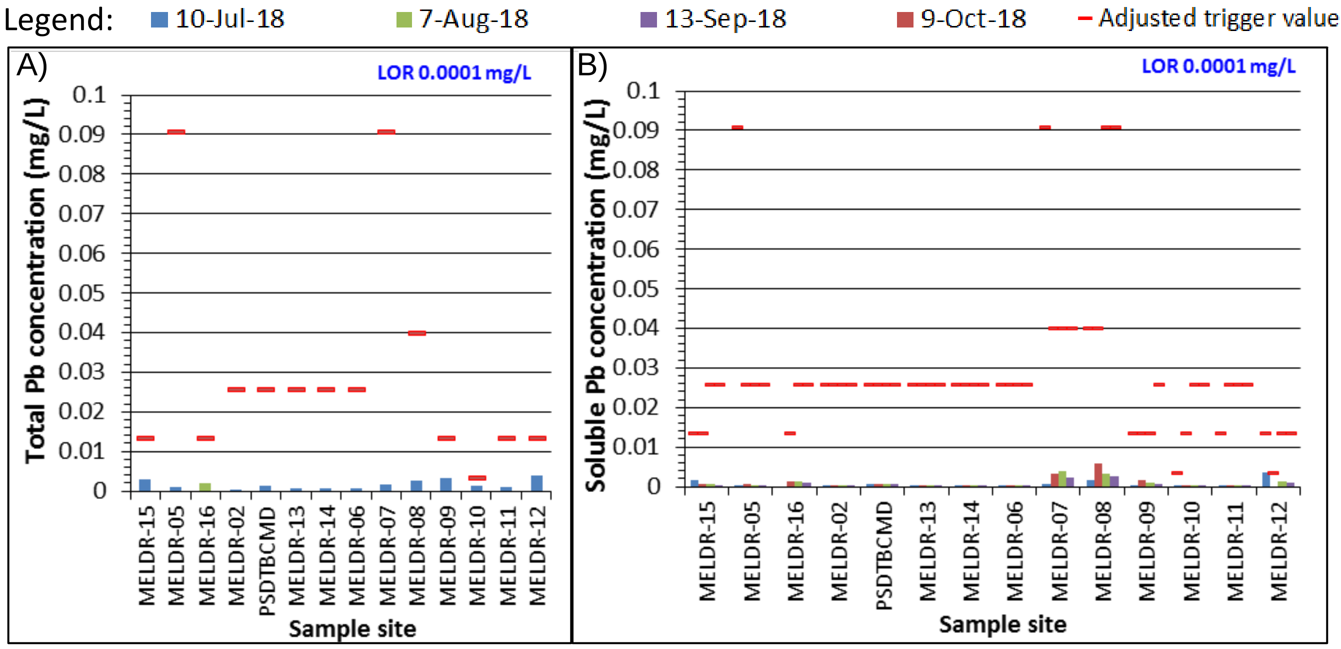

Figure 7.6-1: A) Total and B) soluble lead (Pb) concentrations (mg/L) recorded in Melville Bull Creek catchment sites in 2018

Total and soluble lead concentrations recorded in Melville Bull Creek catchment sites in 2018 are similar to those recorded in the preceding 11 years of monitoring (**Table 7-1**). Concentrations of total and soluble lead exceeding the hardness modified trigger values have sporadically been recorded throughout the twelve year sampling period at sites 5, 10, 11 and 12 (John Creaney Park, Marmion Reserve, Frederick Baldwin and Blue Gum Lake) with the highest total and soluble lead concentrations generally recorded at site 12.

7.7 Mercury

Total mercury and **soluble mercury** concentrations were below the limits of reporting (0.0001 mg/L in July, August and September and 0.00005 mg/L in October) and therefore the ANZECC trigger value for 95% protection of biota (0.0006 mg/L) and the NHMRC recreational guideline health value (0.01 mg/L) at all sites where these parameters were analysed: 13, 14 and 6 (Brentwood drain, RAAF drain and Bateman Park) (**Figure 7.7-1-A and B**, **Table D-25, Appendix D** and **Table D-26, Appendix D**).

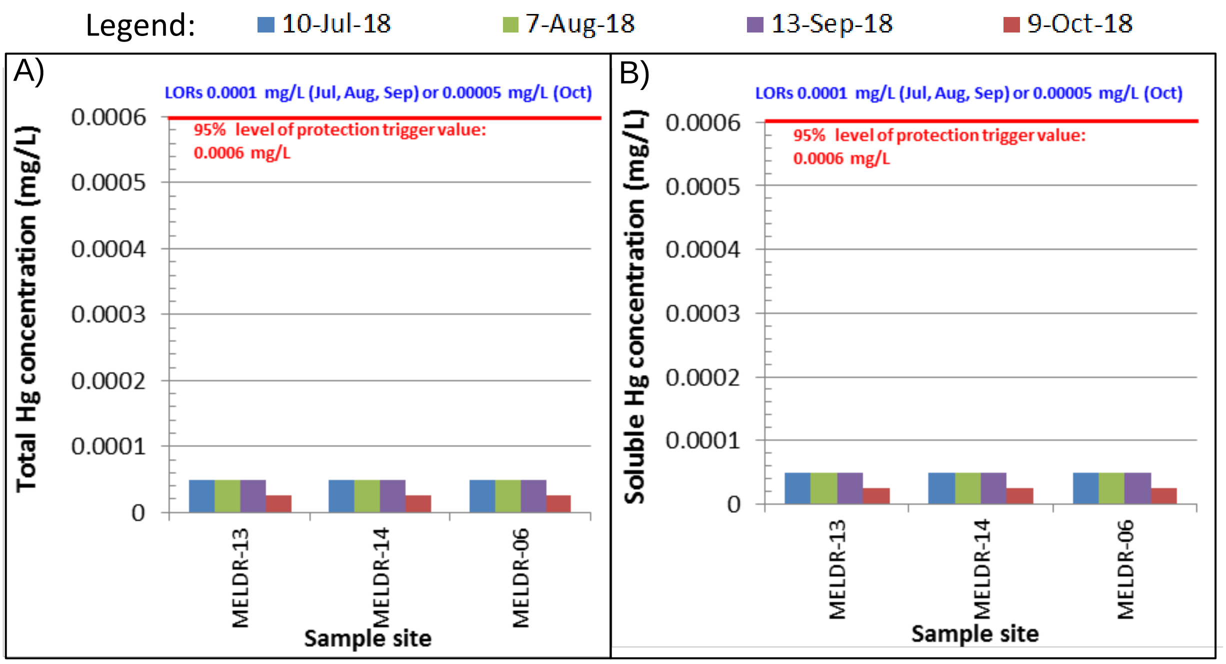

Figure 7.7-1: A) Total and B) soluble mercury (Pb) concentrations (mg/L) recorded in Melville Bull Creek catchment sites in 2018

Total and soluble mercury concentrations recorded in sites 15, 16, 13, 14 and 6 (John Creaney Park inlet, downstream Elizabeth Manion Park, Brentwood drain, RAAF drain and Bateman Park) have always been below the trigger value for protection of biota on all occasions at which samples have been taken (**Table 7-1**).

7.8 Zinc

Concentrations of **total zinc** exceeded hardness adjusted ANZECC trigger values for 95% level of protection (unmodified trigger value: 0.008 mg/L) at three out of 14 Melville Bull Creek catchment sites in 2018: 15, 16 and 10 (John Creaney Park inlet, downstream Elizabeth Manion Park, and Marmion Reserve respectively) (**Figure 7.8-1-A** and **Table D-27 Appendix D**). 11 of 55 samples recorded **soluble zinc**[2] concentrations exceeding hardness adjusted ANZECC trigger values at the same sites, as well as site 12 (Blue Gum Lake) (**Figure 7.8-1-B** and **Table D-28, Appendix D**). Sites 15 and 16 recorded exceeding soluble zinc concentrations on all four sampling occasions. The highest total zinc (0.11 mg/L) and soluble zinc (0.17 mg/L in August) concentrations were recorded at site 15 (John Creaney Park inlet). Four sites recorded the lowest total zinc concentration of 0.007 mg/L and site 11 (Marmion reserve) recorded the lowest soluble zinc concentration (0.004 mg/L) in October. No total or soluble copper concentration exceeded the NHMRC recreational guideline for aesthetic value (30 mg/L).

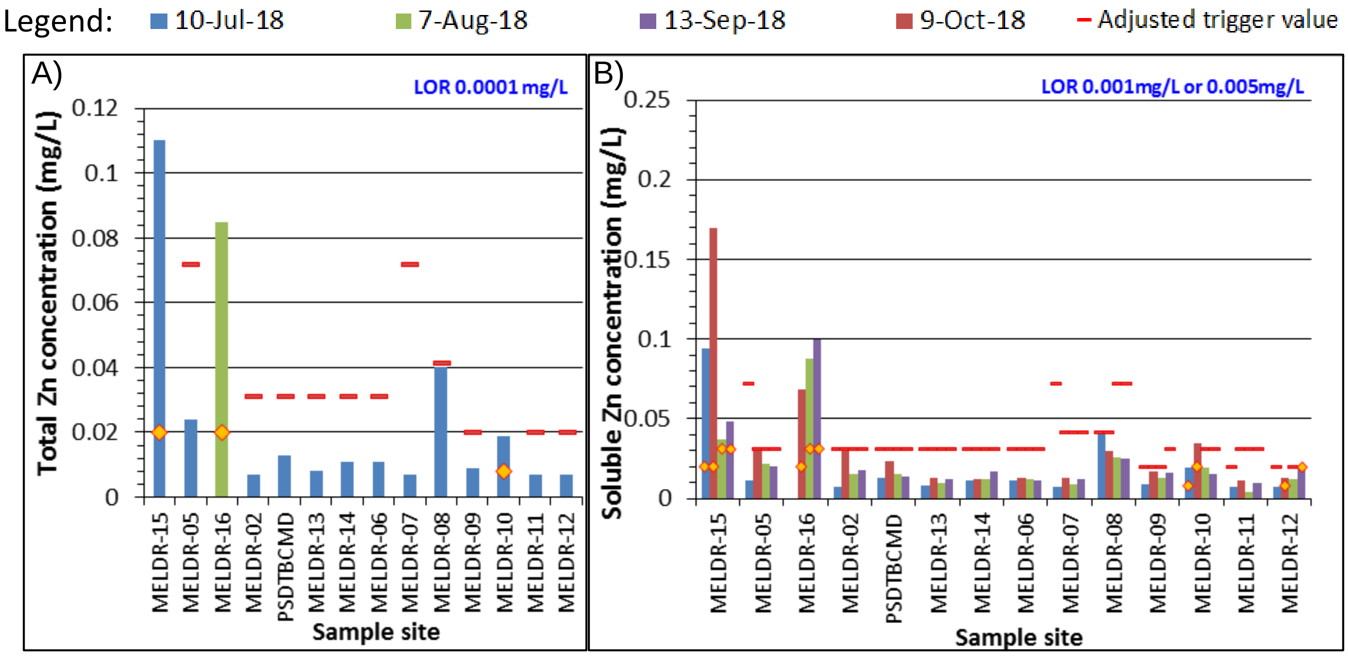

Figure 7.8-1: Total and B) soluble zinc (Zn) concentrations (mg/L) recorded in Melville Bull Creek catchment sites in 2018

Soluble and total zinc concentrations recorded in 2018 are similar to those recorded in the previous 11 years of monitoring (**Table 7-1**). Sites 15 (John Creaney Park inlet) and 16 (downstream Elizabeth Manion Park) on the upstream branches of the Bull Creek main drain have generally recorded total zinc and soluble zinc concentrations exceeding hardness adjusted trigger values, and the highest concentrations in the catchment, since 2014 and 2017 respectively when analysis of these parameters was initiated at these sites. Despite this, concentrations recorded at downstream sites 2 and PSDTBCMD (Brockman Park and Bull Creek Main Darin respectively) have generally not exceeded trigger values and are significantly lower. Site 10 (Frederick Baldwin) has also regularly recorded exceedances of total and soluble zinc hardness adjusted trigger values, however concentrations at this site are lower than at sites 15 and 16 and exceedances are partially the result of the softer water recorded at this site (see **Section 7.1**).

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[2] Recorded soluble zinc concentrations may be up to approximately 0.01 mg/L greater than true soluble zinc concentrations, as blank quality control samples in 2018 across multiple catchments contained zinc concentrations of an average of 0.01 mg/L. Samples can be very easily contaminated during the filtering process with small amounts of zinc present in dust. This difference of 0.01 mg/L does not significantly impact the overall understanding of which sites tend to record zinc concentrations exceeding hardness adjusted trigger values.

Table 7-1: Hardness and metal (total and soluble aluminium (Al), total and soluble chromium (Cr), total and soluble copper (Cu), total and soluble iron (Fe), total and soluble lead (Pb), total and soluble zinc (Zn)) concentrations (mg/L) recorded in Melville Bull Creek catchment sites from 2007 to 2018

	Site	Jul-07	Oct-07	Jan-08	Apr-08	Sep-08	Nov-08	Jan-09	Mar-09	Sep-09	Nov-09	Jan-10	Mar-10	Aug-10	Sep-10	Oct-10	Nov-10	Jul-11	Aug-11	Sep-11	Oct-11	Jul-12	Aug-12	Sep-12	Oct-12	Aug-13	Sep-13	Oct-13	Nov-13	Aug-14	Sep-14	Oct-14	Nov-14	Aug-15	Sep-15	Oct-15	Nov-15	Jul-16	Aug-16	Sep-16	Oct-16	Jul-17	Aug-17	Sep-17	Oct-17	Jul-18	Aug-18	Sep-18	Oct-18	Median
Total Hardness	MELDR-15																														110	130	140	100	100	150	150	130	98	65	99	25	89	110	120	100	110	120	120	110
(mg/L)	MELDR-05	20	180			220	270	290		140	200			63	74	240	170	7	98	210	100	120	22	220	190	100	130	150	200	100	180	200	220	180	200	220	250	93	140	46	140	67	180	200	190	260	170	160	170	170
	MELDR-16																														76	110	120	110	130	130	150	68	69	33		24	85	110	82		62	120	120	110
NO sample taken	MELDR-02	120	130	130	130	130	1,100	120	130	120	120	120	140	92	130	130	75	120	120	140	120	120	100	130	120	110	130	130	150	94	130	180	150	120	130	110	130	120	130	100	110	100	130	120	130	130	130	140	140	130
Soft 0-59 mg/L	PSDTBCMD	130	120	160	130	120	140	110	110	120	120	120	130	75	120	120	110	120	710	130	120	110	95	130	120	78	130	130	140	99	130	170	140	120	130	110	130	130	120	91	110	96	130	120	120	130	120	130	140	120
Moderate 60-119	MELDR-13																											130	160	49	140	180	150	120	130	140	140	130	140	130	120	110	130	130	140	130	130	130	140	130
Hard 120-179	MELDR-14																											130	160	100	140	170	150	93	100	130	130	94	100	110	110	94	130	130	140	120	130	130	140	130
Very Hard 180-240	MELDR-06	170	160	110	200	150	190	150	150	130	140	140	160	87	130	130	140	130	140	130	130	170	100	150	150	130	150	140	160	65	140	180	150	120	130	140	140	130	130	120	120	91	140	130	140	130	130	140	140	140
Extremely Hard > 240	MELDR-07	1,000	600			580	180	660		620	700			910	850	1,100	970		1,100	870	760			1,400	1,500		770	530	620	640	620	650	530	880	900	130	850	890	800	650	410		440	410	360	350	240	220	230	650
	MELDR-08	170	110			80	82			110										220	150		150	170	150	230	200	140	140	150	140	180	130	140	140	100	130	270	220	200	140	190	160	140	120	180	220	320	260	150
	MELDR-09	190	130			120	200	220	270	130	180	260		130	140	160	1,300	220	180	170	150	150	140	150	170	150	130	150	180	110	100	120	140	110	120	130	130	150	140	110	130	130	71	97	99	110	67	80	130	140
	MELDR-10	70	69			80	120	120	150	76	70	130		56	71	130	160	29	29	51	53	41	20	38	99	32	24	67	130	35	71	110	140	36	39	85	64	20	32	37	71	31	37	83	76	51	78	140	140	70
Min 7	MELDR-11	120	160			130	170	93	120	75	83	98	180	130	150	170	110	91	100	120	84	110	110	110	140	100	86	110	98	74	90	130	76	82	91	50	55	58	77	110	66	61	40	67	79	110	160	170	160	100
Max 1500	MELDR-12	230	98			100	160	130		92	110	210		98	110	120	140	210	140	100	110	280	210	110	130	150	73	75	120	73	78	110	120	94	110	810	150	180	130	95	91	83	62	77	88	69	56	65	89	110
	MELDR-15																														0.047	0.31	0.21	0.53	0.48	0.23	0.6	0.42	0.19	0.22	0.21	0.18				0.3				0.2
	MELDR-05	0.065	0.24			0.18	0.13	0.084		0.22	0.095			0.19	0.14	0.12	0.14	0.14	0.31	0.38	0.21	0.16	0.16	0.15	0.1	0.23	0.23	0.18	0.16	0.21	0.2	0.22	0.14	0.22				0.16				0.25				0.18				0.2
Total Aluminium	MELDR-16																														0.11	0.75	0.34	0.94	0.33	0.14	0.49	0.51	0.14	0.27		0.053					0.42			0.3
(Al) (mg/L)	MELDR-02	0.31	0.39	0.32	0.31	0.32	0.9	0.3	0.3	0.34	0.31	0.36	2.1	0.3	0.31	0.37	0.35	0.36	0.36	0.34	0.39	0.37	0.31	0.28	0.3	0.31	0.36	0.26	0.3	0.15	0.29	0.34	0.27	0.3				0.29				0.32				0.31				0.3
	PSDTBCMD	0.21	0.3	3.2	0.16	0.29	0.17	0.2	0.22	0.29	0.17	0.19	0.21	0.3	0.19	0.23	0.17	0.2	0.19	0.23	0.22	0.22	0.22	0.24	0.21	0.33	0.25	0.24	0.24	0.26	0.26	0.24	0.21	0.22				0.2				0.23				0.24				0.2
ANZECC trigger	MELDR-13																											1.1	0.76	0.43	0.83	0.79	0.48	0.48				0.54				0.55				0.57				0.6
value: 0.055	MELDR-14																											0.13	0.22	0.13	0.18	0.13	0.08	0.12				0.11				0.11				0.15				0.1
mg/L (if pH >6.5)	MELDR-06	3.6	3.2	0.3	2.6	2.2	1.5	1.4	1.3	1.2	1.1	0.97	0.87	0.58	0.76	0.85	0.73	0.66	0.89	0.96	0.71	0.77	0.64	0.6	0.54	0.94	0.77	0.9	0.69	0.49	0.77	0.62	0.42	0.71				0.42				0.33				0.44				0.8
or 0.0008 mg/L	MELDR-07	3.9	0.058			0.05	0.066	0.16		0.072	0.05			0.022	0.03	0.028	0.21		0.17	0.029	0.037			0.55	0.24		0.37	0.033	0.039	0.14	0.064	0.041	0.07	0.67				1					0.067			0.064				0.1
(if pH <6.5)	MELDR-08	0.3	0.29			0.3	0.13			0.25										0.37	0.24		0.2	0.2	0.14	0.35	0.35	0.29	0.25	0.37	0.37	0.57	0.3	0.37				0.29				0.33				0.57				0.3
	MELDR-09	0.058	0.17			0.28	0.052	0.1	0.11	0.27	0.086	0.043		0.054	0.05	0.052	0.037	0.72	0.2	0.19	0.18	0.05	0.049	0.11	0.041	0.083	0.37	0.46	0.4	0.87	0.51	0.6	0.35	0.38				0.39				0.31				0.24				0.2
	MELDR-10	0.079	0.065			0.053	0.029	0.031	0.056	0.055	0.051	0.053		0.048	0.06	0.097	0.072	0.084	0.035	0.041	0.044	0.039	0.17	0.079	0.053	0.049	0.032	0.035	0.032	0.045	0.036	0.03	0.018	0.03				0.03				0.029				0.04				0.0
Min 0.01	MELDR-11	0.067	0.032			0.041	0.035	0.053	0.16	0.056	0.044	0.11	0.089	0.038	0.04	0.052	0.36	0.04	0.044	0.051	0.041	0.018	0.043	0.04	0.049	0.034	0.034	0.022	0.12	0.01	0.019	0.028	0.026	0.03				0.03				0.057				0.027				0.0
Max 2.1	MELDR-12	0.22	0.062			0.058	0.039	0.036		0.059	0.035	0.2		0.052	0.06	0.062	0.16	1.8	0.61	0.074	0.11	0.32	0.18	0.052	0.038	0.12	0.072	0.097	0.083	0.054	0.12	0.16	0.15	0.12				0.9				0.096				0.081				0.1
	MELDR-15																																									0.077	0.24	0.15	0.19	0.22	0.23	0.23	0.19	0.205
Soluble	MELDR-05																	0.037	0.14	0.16	0.12	0.11	0.057	0.13		0.073	0.15	0.18	0.09	0.15	0.14	0.2	0.096	0.18	0.13	0.073	0.067	0.12	0.13	0.06	0.11	0.13	0.18	0.13	0.15	0.13	0.23	0.18	0.14	0.13
Aluminium (Al)	MELDR-16																																									0.03	0.54	0.34	0.36		0.3	0.42	0.5	0.36
(mg/L)	MELDR-02																																	0.3	0.23	0.25	0.22	0.24	0.24	0.25	0.21	0.23	0.29	0.25	0.3	0.25	0.34	0.29	0.27	0.25
	PSDTBCMD									0.16	0.87	0.085	0.071	0.098	0.13	0.12	0.11	0.15	0.16	0.15	0.15	0.13	0.14	0.13	0.12	0.09	0.16	0.15	0.12	0.13	0.14	0.17	0.12	0.15	0.12	0.11	0.087	0.14	0.15	0.18	0.12	0.15	0.23	0.17	0.17	0.16	0.23	0.19	0.15	0.145
ANZECC trigger	MELDR-13																											0.12	0.093	0.057	0.1	0.12	0.097	0.14	0.11	0.31	0.081	0.12	0.11	0.14	0.19	0.12	0.17	0.11	0.29	0.14	0.18	0.15	0.13	0.12
value: 0.055	MELDR-14																											0.094	0.079	0.095	0.09	0.099	0.054	0.082	0.061	0.068	0.039	0.059	0.065	0.078	0.059	0.068	0.13	0.09	0.1	0.087	0.13	0.095	0.08	0.081
mg/L (if pH >6.5)	MELDR-06									0.091	0.083	0.22	0.16	0.098	0.2	0.19	0.15	0.13	0.16	0.17	0.093	0.071	0.084	0.096	0.12	0.09	0.086	0.084	0.087	0.056	0.097	0.11	0.088	0.15	0.095	0.26	0.066	0.1	0.089	0.11	0.077	0.078	0.15	0.093	0.23	0.11	0.15	0.13	0.085	0.0975
or 0.0008 mg/L	MELDR-07																		0.15	0.016	0.023			0.56	0.23		0.37	0.022	0.039	0.14	0.056	0.032	0.082	0.61	0.4	0.067	0.011	0.89	0.78	0.32	0.047		0.053	0.058	0.084	0.03	0.091	0.14	0.15	0.084
(if pH <6.5)	MELDR-08																																	0.36	0.24	0.16	0.16	0.24	0.36	0.46	0.29	0.31	0.45	0.41	0.32	0.49	1	0.79	0.8	0.36
	MELDR-09																																	0.38	0.28	0.11	0.12	0.32	0.35	0.99	0.38	0.25	1	0.67	0.64	0.21	0.77	0.5	0.7	0.38
	MELDR-10																	0.033	0.018	0.026	0.026	0.021	0.042	0.057	0.022	0.014	0.012	0.017	0.014	0.045	0.022	0.022	0.011	0.019	0.019	0.054	0.029	0.013	0.021	0.029	0.016	0.015	0.021	0.023	0.017	0.019	0.037	0.013	0.01	0.021
Min 0.005	MELDR-11																	0.013	0.018	0.012	0.022	<0.005	0.0067	0.014	0.016	0.005	0.006	0.009	0.044	0.01	0.01	0.011	0.02	0.011	0.013	0.05	0.062	0.012	0.018	0.026	0.043	0.039	0.049	0.11	0.072	0.013	0.008	0.011	0.008	0.013
Max 1.8	MELDR-12																	1.8	0.62	0.044	0.077	0.31	0.16	0.023	0.019	0.1	0.041	0.082	0.057	0.054	0.11	0.11	0.089	0.072	0.065	0.006	0.05	0.86	0.15	0.12	0.14	0.071	0.13	0.19	0.22	0.072	0.1	0.17	0.17	0.1
	MELDR-15																														<0.001	0.002	0.002	0.003	0.002	0.002	0.003	0.002	0.001	<0.001	0.002	0.0004				0.0023				0.002
	MELDR-05	<0.001	0.002			0.002	0.002	0.0018		0.002	0.001			<0.001	0.002	0.002	<0.001	<0.001	0.001	0.0022	0.001	<0.001	<0.001	0.0014	0.0014	0.002	0.001	0.001	0.001	<0.001	0.002	0.001	0.002	0.002				0.001				0.0008				0.0023				0.001
Total Chromium	MELDR-16																														<0.001	0.001	0.001	0.003	0.001	<0.001	0.002	0.001	<0.001	<0.001		0.0003					0.001			0.001
(Cr) (mg/L)	MELDR-02	<0.001	0.001	<0.001	<0.001	0.001	0.002	0.002	0.001	0.001	0.001	0.001	0.002	<0.001	0.001	0.001	<0.001	<0.001	<0.001	0.0014	0.001	<0.001	0.0016	0.0011	0.0012	<0.001	0.001	0.001	0.001	<0.001	0.002	0.001	0.002	0.002				0.001				0.0009				0.0015				0.001
	PSDTBCMD	<0.001	0.001	0.004	<0.001	0.001	0.001	0.002	0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.001	<0.001	<0.001	<0.001	0.0014	0.001	<0.001	0.0013	0.0013	0.0013	0.002	0.001	0.001	0.001	0.001	<0.001	0.001	0.001	0.002				<0.001				0.0008				0.0015				0.001
ANZECC trigger	MELDR-13																											0.004	0.002	0.003	0.003	0.003	0.002	0.002				0.002				0.0016				0.0021				0.00205
value	MELDR-14																											0.001	0.002	0.001	0.002	0.001	0.001	0.001				<0.001				0.0008				0.0014				0.001
(unmodified):	MELDR-06	0.006	0.005	<0.001	0.003	0.004	0.003	0.003	0.003	0.003	0.002	0.002	0.002	<0.001	0.002	0.003	0.001	<0.001	0.002	0.0028	0.002	0.0015	0.0027	0.002	0.002	0.003	0.002	0.003	0.002	0.003	0.003	0.002	0.002	0.003				0.002				0.0011				0.0018				0.002
0.0033 mg/L	MELDR-07	0.001	0.001			<0.001	0.001	0.002		<0.001	<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	<0.001	<0.001	0.001	0.002	0.002				0.002					0.0006			0.0012				<0.001
	MELDR-08	<0.001	0.002			0.002	0.001			<0.001										<0.001	<0.001		0.0011	<0.001	<0.001	0.001	0.002	0.001	0.001	0.001	0.002	0.002	0.002	0.002				<0.001				0.0009				0.0026				0.001
	MELDR-09	<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	<0.001	<0.001	0.001	<0.001	<0.001	0.0011	<0.001	<0.001	<0.001	0.001	0.002	0.002	0.003	0.004	0.003	0.003	0.003				0.001				0.0016				0.0021				<0.001
	MELDR-10	<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	<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	0.001	<0.001	<0.001	<0.001				<0.001				0.0001				0.0002				<0.001
Min 0.0001	MELDR-11	<0.001	0.002			<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	<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	<0.001	<0.001	<0.001				<0.001				0.0001				0.0002				<0.001
Max 0.006	MELDR-12	0.001	0.003			0.002	0.002	0.001		0.002	<0.001	0.001		0.002	0.002	0.002	<0.001	<0.001	<0.001	0.0019	0.004	<0.001	0.0011	<0.001	<0.001	<0.001	0.004	0.006	0.005	0.003	0.004	0.004	0.004	0.003				0.001				0.0019				0.0024				0.002
	MELDR-15																																									0.0004	0.0013	0.0007	0.0013	0.002	0.0015	0.0014	0.0016	0.00135
	MELDR-05																	<0.001	<0.001	0.0014	0.001	<0.001	<0.001	0.0012	0.0011	<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	0.001	<0.001	<0.001	0.0007	0.0013	0.0004	0.0017	0.0019	0.0016	0.0014	0.0016	0.001
Soluble	MELDR-16																																									0.0003	0.001	0.0038	0.0012		0.0009	0.0012	0.0014	0.0012
Chromium (Cr)	MELDR-02																																	0.001	0.001	<0.001	0.007	<0.001	0.001	<0.001	<0.001	0.0009	0.0009	0.0003	0.001	0.0014	0.0013	0.0012	0.0014	0.001
(mg/L)	PSDTBCMD									<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	0.001	<0.001	0.0013	<0.001	<0.001	<0.001	0.001	0.001	0.001	0.001	<0.001	<0.001	0.001	0.0015	0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.0008	0.001	0.0006	0.0011	0.0012	0.0012	0.0012	0.0013	<0.001
	MELDR-13																											0.001	0.001	0.001	<0.001	<0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	<0.001	0.001	0.0012	0.0012	0.0004	0.0013	0.0018	0.0014	0.0014	0.0015	0.001
ANZECC trigger	MELDR-14																											0.001	0.001	0.001	0.002	<0.001	0.001	<0.001	<0.001	0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.0008	0.0011	0.0006	0.0012	0.0013	0.0012	0.0012	0.0013	0.001
value	MELDR-06									<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	0.0011	<0.001	<0.001	0.001	0.001	0.001	0.001	<0.001	<0.001	<0.001	0.001	0.001	0.001	0.002	0.001	0.001	<0.001	<0.001	<0.001	0.0008	0.0011	0.0004	0.0013	0.0014	0.0014	0.0013	0.0014	0.001
(unmodified):	MELDR-07																		<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	<0.001	0.002	<0.001	0.001	<0.001	<0.001	<0.001		0.0006	0.0006	0.0012	0.001	0.0011	0.0012	0.0017	<0.001
0.0033 mg/L	MELDR-08																																	0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.001	0.0011	0.0008	0.0021	0.0023	0.0031	0.0031	0.0034	0.001
	MELDR-09																																	0.002	0.002	0.001	0.004	0.001	0.002	0.002	0.002	0.0016	0.0029	0.0007	0.0029	0.0018	0.0027	0.0022	0.0041	0.002
	MELDR-10																	<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	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	0.0001	<0.0001	0.0006	<0.0001	0.0002	0.0001	<0.0001	<0.0001	<0.001
Min <0.0001	MELDR-11																	<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	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0001	0.0001	0.0006	0.0001	0.0001	0.0001	<0.0001	<0.0001	<0.001
Max 0.007	MELDR-12																	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.004	0.004	0.003	0.004	0.003	0.003	0.002	0.003	<0.001	0.002	0.001	<0.001	<0.001	0.003	0.0018	0.0025	0.0008	0.0035	0.0022	0.0018	0.0019	0.0025	0.00195
	MELDR-15																														<0.001	<0.001	0.002	0.007	0.005	0.001	0.003	0.005	0.003	0.002	<0.001	0.0044				0.0049				0.003
	MELDR-05	0.003	<0.001			<0.001	0.001	0.002		0.003	<0.001			0.008	0.002	0.002	0.002	0.004	0.002	0.0015	0.002	0.0031	0.0035	<0.001	0.0028	0.004	0.002	<0.001	0.001	0.002	0.002	0.001	0.001	0.003				0.002				0.0037				0.0013				0.002
Total Copper	MELDR-16																														<0.001	0.001	0.003	0.007	0.003	0.004	0.013	0.005	0.003	0.003		0.0024					0.0045			0.003
(Cu) (mg/L)	MELDR-02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0018	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.002	0.001	<0.001	<0.001	<0.001				<0.001				0.0011				0.0004				<0.001
	PSDTBCMD	<0.001	0.002	<0.001	0.001	0.001	0.002	0.001	0.002	0.002	0.001	<0.001	<0.001	0.004	0.001	0.001	0.001	0.0015	0.001	0.0011	0.001	<0.001	0.0021	0.001	0.001	0.003	0.002	0.001	0.001	0.002	0.002	0.002	0.001	0.001				0.001				0.0012				0.0012				0.001
ANZECC trigger	MELDR-13																											0.001	<0.001	0.005	<0.001	<0.001	<0.001	0.001				<0.001				0.0007				0.0007				<0.001
value	MELDR-14																											0.001	0.001	0.001	0.001	0.001	<0.001	<0.001				0.001				0.0007				0.0019				<0.001
(unmodified):	MELDR-06	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	0.0011	<0.001	<0.001	<0.001	<0.001	0.0025	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.005	<0.001	<0.001	<0.001	0.001				<0.001				0.0015				0.0008				<0.001
0.0014 mg/L	MELDR-07	0.006	0.001			0.002	0.002	<0.001		<0.001	<0.001			<0.001	<0.001	<0.001	0.003		<0.001	0.0027	0.001			0.0034	0.0014		0.003	<0.001	0.001	<0.001	0.0015	0.002	0.002	0.025				0.013					0.0013			0.0017				0.0014
	MELDR-08	0.003	0.001			0.001	<0.001			<0.001										0.0018	0.002		0.0015	<0.001	<0.001	0.001	<0.001	0.002	<0.001	<0.001	0.002	0.002	0.001	0.002				0.001				0.0007				0.0014				0.001
	MELDR-09	<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	0.0011	<0.001	0.0011	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.001	0.002	0.001	<0.001	0.001				0.001				0.0004				0.0014				<0.001
	MELDR-10	0.001	0.001			0.001	0.001	<0.001	0.004	0.001	<0.001	<0.001		0.002	0.001	<0.001	0.001	0.003	0.002	0.001	0.002	0.0017	0.0045	0.0029	0.0024	0.001	0.002	<0.001	0.001	0.002	0.001	0.001	<0.001	0.002				0.002				0.0015				0.0015				0.001
Min 0.0004	MELDR-11	<0.001	<0.001			<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.003	<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	<0.001	<0.001	<0.001	0.001				0.001				0.0007				0.0009				<0.001
Max 0.025	MELDR-12	0.002	<0.001			<0.001	<0.001	<0.001		<0.001	<0.001	<0.001		0.001	<0.001	<0.001	<0.001	0.01	0.004	<0.001	0.002	0.004	0.0032	0.0015	0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.001	0.001	<0.001				0.007				0.0012				0.0015				<0.001
	MELDR-15																																									0.0042	0.0013	0.0007	0.0012	0.0031	0.0013	0.0009	0.0007	0.00125
	MELDR-05																	0.003	0.002	<0.001	0.002	0.002	0.0025	<0.001	0.0018	0.002	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	<0.001	0.0033	0.0006	0.0004	0.0007	0.0008	0.0009	0.0007	0.0004	<0.001
Soluble Copper	MELDR-16																																									0.0024	0.005	0.0038	0.0046		0.0037	0.0026	0.0018	0.0037
(Cu) (mg/L)	MELDR-02																																	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0008	0.0003	0.0003	0.0003	0.0003	0.0008	0.0007	0.0003	<0.001
	PSDTBCMD									0.001	<0.001	<0.001	<0.001	0.003	0.001	0.001	0.002	0.0013	0.001	<0.001	0.001	<0.001	0.0018	0.001	0.001	0.001	<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	0.001	<0.001	0.0012	0.0009	0.0006	0.0007	0.001	0.0013	0.0009	0.0008	0.001
ANZECC trigger	MELDR-13																											<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.0005	0.0011	0.0004	0.0002	0.0007	0.0004	0.0004	0.0006	<0.001
value	MELDR-14																											0.001	0.001	0.001	0.001	<0.001	<0.000	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.0007	0.0009	0.0006	0.0005	0.0007	0.0008	0.0005	0.0015	<0.001
(unmodified):	MELDR-06									0.002	<0.001	0.002	<0.001	0.002	0.001	0.002	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0014	0.0006	0.0004	0.0004	0.0007	0.0006	0.0004	0.0005	<0.001
0.0014 mg/L	MELDR-07																		<0.001	0.0022	0.001			0.0034	0.0014		<0.001	<0.001	<0.001	<0.001	0.0015	<0.001	0.002	0.021	0.009	<0.001	<0.001	0.013	0.009	0.002	<0.001		0.0005	0.0006	0.0007	0.0013	0.0011	0.0011	0.0011	0.0011
	MELDR-08																																	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.0007	0.0008	0.0008	0.0008	0.001	0.0013	0.0011	0.0009	<0.001
	MELDR-09																																	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.0004	0.0011	0.0007	0.0007	0.0011	0.0016	0.0017	0.0012	<0.001
	MELDR-10																	0.003	0.001	0.0013	0.002	0.0016	0.0033	0.0024	0.0012	0.001	<0.001	<0.001	<0.001	0.002	0.001	0.001	<0.001	0.002	0.001	0.001	0.001	<0.001	0.002	0.002	<0.001	0.0014	0.001	0.0006	0.0008	0.0012	0.0009	0.0002	0.0006	0.001
Min 0.0002	MELDR-11																	<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	<0.001	<0.001	<0.001	0.001	<0.001	0.001	0.001	<0.001	0.002	0.001	<0.001	0.0007	0.0008	0.0006	0.0007	0.0006	0.0004	0.0005	0.0003	<0.001
Max 0.021	MELDR-12																	0.011	0.004	<0.001	0.001	0.0023	0.0029	0.0015	<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	0.007	0.002	0.001	<0.001	0.0012	0.0019	0.0008	0.0007	0.0014	0.0012	0.0011	0.0009	<0.001

SITES RECORDING >60% CONCENTRATIONS ABOVE ADJUSTED TRIGGER VALUE
SITES RECORDING 40-60% OF CONCENTRATIONS ABOVE ADJUSTED TRIGGER VALUE
SITES RECORDING <40% CONCENTRATIONS ABOVE ADJUSTED TRIGGER VALUE

Concentration ABOVE ADJUSTED trigger value
Concentration BELOW ADJUSTED trigger value

Concentration < LOR
NO sample taken

Table 7-1 (continued): Hardness and metal (total and soluble aluminium (Al), total and soluble chromium (Cr), total and soluble copper (Cu), total and soluble iron (Fe), total and soluble lead (Pb), total and soluble zinc (Zn)) concentrations (mg/L) recorded in Melville Bull Creek catchment sites from 2007 to 2018

	Site	Jul-07	Oct-07	Jan-08	Apr-08	Sep-08	Nov-08	Jan-09	Mar-09	Sep-09	Nov-09	Jan-10	Mar-10	Aug-10	Sep-10	Oct-10	Nov-10	Jul-11	Aug-11	Sep-11	Oct-11	Jul-12	Aug-12	Sep-12	Oct-12	Aug-13	Sep-13	Oct-13	Nov-13	Aug-14	Sep-14	Oct-14	Nov-14	Aug-15	Sep-15	Oct-15	Nov-15	Jul-16	Aug-16	Sep-16	Oct-16	Jul-17	Aug-17	Sep-17	Oct-17	Jul-18	Aug-18	Sep-18	Oct-18	Median
	MELDR-15																														5.1	3.8	2.3	2.5	5.7	0.46	2.4	0.24	0.63	0.64	1.6	0.19				3.5				2.3
	MELDR-05	1.2	2.7			1.9	1.3	0.51		1.8	0.93			0.71	2.0	1.0	1.1	0.25	4.3	2.2	1.5	4.3	0.33	1.2	0.92	1.2	2.3	2.5	2.1	2.8	2.4	2.1	1.6	1.3				6.3				0.43				4.4				1.6
	MELDR-16																														6.5	7.5	3.3	1.4	1.5	0.68	2.7	1.1	0.33	0.55		0.053					0.4			1.3
Total Iron (Fe)	MELDR-02	1.1	2.0	1.2	1.1	1.6	1.2	1.2	1.2	1.4	1.2	1.5	15.0	1.1	1.3	1.1	1.3	1.2	1.5	1.4	1.4	1.9	1.2	1.0	1.2	1.3	1.5	1.7	1.4	1.5	1.7	1.6	1.3	1.1				1.5				0.59				1.3				1.3
(mg/L)	PSDTBCMD	0.76	1.0	13.0	0.68	1.6	0.6	0.88	0.97	0.79	0.64	0.85	0.88	1.2	0.68	0.78	0.58	0.58	0.82	0.88	0.65	0.9	0.59	0.78	0.75	1.2	0.9	1.2	1.1	1.1	1.2	0.8	0.86	0.53				0.54				0.34				0.55				0.8
	MELDR-13																											4.4	4.1	1.9	4.1	4.3	3.2	3.2				2.3				1.5				2.9				3.2
ANZECC interim	MELDR-14																											0.9	1.5	0.6	0.9	0.9	0.86	0.56				0.45				0.42				0.56				0.7
trigger value: 0.3	MELDR-06	16.0	12.0	1.4	12.0	8.3	6.6	7.0	6.4	4.3	4.9	6.2	5.6	2.8	4.5	4.5	5.1	4.1	4.6	4.6	3.4	7.0	3.7	4.0	3.1	4.7	3.9	3.8	3.4	2.2	3.6	3.3	2.8	2.7				2.1				0.81				2				4.2
mg/L	MELDR-07	3.9	15.0			9.5	7.3	16.0		5.4	6.9			4.8	6.3	4.5	19.0		3.3	4.5	3.3			5.4	1.3		4.7	5.8	2.8	2.0	5.9	5.0	2.8	6.9				5.2					6.8			2.7				5.2
	MELDR-08	0.95	5.6			0.99	0.41			0.63										0.91	1.3		0.59	1.2	0.63	3.5	2.6	0.91	0.91	1.3	1.0	1.30	0.68	0.68				1.3				0.99				2.2				1.0
	MELDR-09	0.82	0.61			0.45	0.11	0.13	0.08	0.26	0.06	0.12		0.07	0.05	0.06	0.1	0.7	1.0	1.6	1.9	0.15	0.13	0.22	0.14	0.1	0.22	0.93	0.72	0.9	1.00	0.59	0.58	0.58				0.44				0.22				0.19				0.2
	MELDR-10	0.39	0.34			0.7	0.31	1.1	1.8	0.14	0.34	2.7		0.22	0.29	0.9	1.1	0.24	0.19	0.49	0.41	0.46	0.41	0.7	0.53	0.32	0.23	0.5	0.70	0.35	0.52	0.3	0.34	0.37				0.23				0.18				0.49				0.4
Min 0.1	MELDR-11	0.39	0.59			0.53	0.7	0.91	1.6	0.32	0.99	1.7	1.8	0.43	0.37	0.4	2.0	0.26	0.33	0.36	0.32	0.53	0.62	0.47	0.69	0.34	0.13	0.18	0.4	0.12	0.13	0.09	0.23	0.082				0.091				0.16				0.56				0.4
Max 19.0	MELDR-12	1.4	3.7			2.5	1.1	0.61		1.6	0.58	0.68		1.4	1.2	0.69	0.55	1.6	2.2	7.6	6.0	1.9	4.8	4.3	5.6	1.4	3.6	5.3	3.2	2.7	4.0	1.9	1.7	5.3				2.4				3.4				1.3				2.1
	MELDR-15																																									0.12	2.20	1.60	1.80	2.3	2.40	1.50	1.30	1.7
	MELDR-05																	0.1	2.9	1	0.73		0.22	0.77	0.57	0.66	1.6	1.2	0.64	2.7	1.2	1.8	0.7	1	0.96	0.44	0.35	6	1.40	0.34	1.10	0.36	2.00	1.60	1.40	3	2.00	1.30	1.50	1.1
	MELDR-16																																									0.039	0.75	2.20	2.20		0.32	0.97	1.80	0.97
Soluble Iron (Fe)	MELDR-02																																	1	1.1	0.93	0.88	1	1.3	1.00	0.99	0.59	1.1	1.10	1.20	1	1.1	1.10	1.20	1.1
(mg/L)	PSDTBCMD									0.35	0.25	0.24	0.2	0.3	0.29	0.25	0.25	0.35	0.48	0.36	0.3	0.34	0.27	0.31	0.32	0.24	0.42	0.5	0.37	0.3	0.46	0.37	0.33	0.26	0.34	0.34	0.14	0.30	0.34	0.32	0.33	0.25	0.46	0.42	0.40	0.32	0.35	0.41	0.41	0.33
	MELDR-13																											2.7	2.3	0.6	2.0	1.7	1.1	1.7	1.3	2.6	0.87	1.9	2.3	1.7	1.30	1.3	1.4	1.0	2.50	1.5	1.3	1.1	1.00	1.45
ANZECC interim	MELDR-14																											0.68	0.56	0.4	0.6	0.57	0.5	0.42	0.55	0.77	0.39	0.30	0.40	0.26	0.36	0.28	0.46	0.49	0.53	0.34	0.38	0.46	0.54	0.46
trigger value: 0.3	MELDR-06									3.4	2.8	3.7	2.6	1.3	3.1	2.6	3.1	2.7	2.7	3.1	1.8	5.2	2.2	2.7	1.7	2.6	2.9	2.6	1.8	0.55	1.7	1.4	0.96	1.2	1.4	2	0.47	1.2	1.2	1	0.59	0.5	0.9	1	1.70	0.79	0.7	1	0.52	1.7
mg/L	MELDR-07																		0.99	1.3	1.1			3.9	1.2		4.1	2.5	2.2	1.7	5.6	2.3	2.1	5.7	2.4	2.3	1.7	3.9	3.7	2.7	3.0		6.0	3.9	4.3	1.1	3.3	4.3	3.7	2.7
	MELDR-08																																	0.66	0.44	0.49	0.59	1.10	1.40	1.20	0.81	0.91	0.99	0.88	3.80	1.9	2.50	2.50	2.70	1.045
	MELDR-09																																	0.41	0.45	0.37	0.3	0.38	0.36	0.34	0.5	0.18	0.29	0.76	0.6	0.16	0.35	0.59	0.9	0.375
	MELDR-10																	0.21	0.16	0.37	0.26	0.37	0.19	0.51	0.24	0.19	0.14	0.32	0.28	0.24	0.38	0.19	0.077	0.24	0.12	0.41	0.11	0.17	0.37	0.21	0.33	0.11	0.23	0.35	0.14	0.35	0.30	0.55	0.15	0.24
Min 0.025	MELDR-11																	0.19	0.2	0.081	0.081	0.21	0.11	0.085	0.11	0.16	0.05	0.066	0.14	0.12	0.037	0.026	0.096	0.04	0.03	0.19	0.22	0.06	0.11	0.18	0.48	0.078	0.10	0.63	0.44	0.21	0.49	0.03	0.04	0.11
Max 6	MELDR-12																	1.6	1.9	5.3	4.1	0.81	1.8	0.34	1.9	0.72	1.3	3.2	1.3	1.8	3.4	1.1	1.1	3.9	2.9	1.6	1.7	2.1	1.2	5.1	3.1	2.9	3.0	3.7	2.9	1.2	1.3	1.3	1.0	1.8
	MELDR-15																														<0.001	<0.001	<0.001	0.009	0.006	0.001	0.009	0.007	0.003	0.001	<0.001	0.0005				0.003				0.001
	MELDR-05	0.004	0.003			0.002	0.002	0.003		0.003	0.002			0.005	0.002	0.005	0.006	0.003	0.005	0.002	0.002	0.0068	0.0022	<0.001	<0.001	0.003	0.002	<0.001	0.001	0.002	0.001	<0.001	0.001	0.002				0.002				0.0011				0.001				0.002
Total Lead (Pb)	MELDR-16																														<0.001	0.002	<0.001	0.011	0.003	<0.001	0.01	0.01	<0.001	<0.001		0.0008					0.0019			<0.001
(mg/L)	MELDR-02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	0.002	<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	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001				<0.001				0.0003				0.0003				<0.001
	PSDTBCMD	0.002	0.004	0.003	0.003	0.004	0.001	0.003	0.004	0.002	0.003	0.003	0.004	0.006	0.002	0.003	0.002	0.002	0.001	0.0022	0.002	0.0034	0.0028	0.0027	0.0029	0.006	0.003	0.004	0.004	0.007	<0.001	0.003	0.003	0.002				0.002				0.0006				0.0014				0.003
ANZECC trigger	MELDR-13																											0.002	0.001	0.003	<0.001	0.001	<0.001	<0.001				<0.001				0.0001				0.0007				<0.001
value	MELDR-14																											0.001	0.002	<0.001	0.001	<0.001	<0.001	<0.001				<0.001				0.0003				0.0006				<0.001
(unmodified):	MELDR-06	0.003	0.004	0.006	0.002	0.002	<0.001	0.001	0.001	0.002	0.002	0.001	<0.001	0.003	0.001	0.002	0.001	0.0015	0.001	0.0014	<0.001	0.0025	0.0028	0.0012	<0.001	0.002	0.001	0.002	0.001	0.003	<0.001	<0.001	<0.001	0.002				<0.001				0.0001				0.0007				0.0011
0.0034 mg/L	MELDR-07	0.032	0.001			0.001	0.001	0.008		<0.001	0.002			0.002	<0.001	<0.001	0.012		0.002	<0.001	<0.001			0.004	0.003		0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005				0.002					0.0007			0.0015				0.001
	MELDR-08	0.002	0.003			0.002	<0.001			<0.001										0.0014	0.001		<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.001	0.001	0.002	<0.001	0.001				0.001				0.0004				0.0027				0.001
	MELDR-09	<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	0.0014	<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	<0.001	<0.001	<0.001				<0.001				0.0002				0.0033				<0.001
	MELDR-10	0.002	0.003			0.002	<0.001	0.001	0.009	<0.001	0.001	0.003		0.002	0.002	0.005	<0.001	0.003	0.001	0.0024	0.002	0.0023	0.0039	0.006	0.0028	0.002	0.001	0.002	0.002	0.002	0.001	<0.001	<0.001	<0.001				0.001				0.0002				0.0012				0.002
Min <0.00001	MELDR-11	0.004	0.003			0.001	0.001	0.002	0.008	0.0013	0.002	0.005	0.003	0.001	0.002	0.003	0.014	0.002	0.002	0.0025	0.001	<0.001	0.0015	0.0021	0.0021	0.001	0.001	0.001	0.005	<0.001	<0.001	<0.001	<0.001	<0.001				<0.001				<0.00001				0.001				0.0015
Max 0.095	MELDR-12	0.029	0.009			0.003	0.005	0.003		0.0056	0.005	0.019		0.011	0.01	0.011	0.014	0.065	0.026	0.0012	0.003	0.051	0.036	0.0065	0.008	0.019	0.003	0.001	<0.001	0.003	0.001	0.002	0.003	0.008				0.095				0.0073				0.0038				0.0069
	MELDR-15																																									0.0005	0.001	0.0003	0.0006	0.0017	0.0008	0.0006	0.0004	0.0006
	MELDR-05																	<0.001	0.002	<0.001	<0.001	0.0015	0.0011	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.002	0.001	<0.001	<0.001	0.001	0.0005	0.0002	0.0004	0.0004	0.0006	0.0004	0.0003	<0.001
	MELDR-16																																									0.0002	0.0017	0.0013	0.0025		0.0012	0.0012	0.0011	0.0012
Soluble Lead	MELDR-02									<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0016	0.0011	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	<0.001	<0.001	<0.001	<0.001	<0.001	0.0003	0.0003	0.0001	0.0002	0.0002	0.0005	0.0004	0.0002	<0.001
(Pb) (mg/L)	PSDTBCMD																																	0.002	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.001	0.0005	0.0007	0.0004	0.0007	0.0006	0.0008	0.0007	0.0007	<0.001
ANZECC trigger	MELDR-13																											<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	<0.001	<0.0001	0.0001	<0.0001	<0.0001	0.0001	0.0001	0.0001	0.0001	<0.001
value	MELDR-14																											<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	<0.001	0.0002	0.0003	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	<0.001
(unmodified):	MELDR-06									<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	<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	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0001	0.0002	<0.0001	0.0001	0.0002	0.0002	0.0002	0.0001	<0.001
0.0034 mg/L	MELDR-07																		<0.001	<0.001	<0.001			0.004	0.003		0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	0.005	0.008	<0.001	0.002	0.006	0.003	<0.001		0.0007	0.0005	0.0009	0.0007	0.0032	0.0039	0.0024	<0.001
	MELDR-08																																	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.0004	0.0007	0.0006	0.0012	0.0015	0.0058	0.0033	0.0025	<0.001
	MELDR-09																																	<0.001	<0.001	<0.001	0.001	<0.001	0.001	0.001	<0.001	0.0002	0.0011	0.0004	0.0006	0.0003	0.0016	0.0009	0.0008	<0.001
	MELDR-10																	0.002	<0.001	0.0016	<0.001	0.002	0.0019	0.0038	<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	<0.001	0.001	<0.001	<0.001	0.0002	0.0004	0.0002	0.0001	0.0005	0.0003	<0.0001	<0.0001	<0.001
Min <0.0001	MELDR-11																	<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	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	0.002	<0.0001	0.0004	0.0013	0.0018	0.0002	0.0002	<0.0001	<0.0001	<0.001
Max 0.092	MELDR-12																	0.066	0.024	<0.001	0.002	0.046	0.026	<0.001	0.0031	0.018	<0.001	<0.001	<0.001	0.001	0.001	<0.001	<0.001	0.006	0.006	<0.001	0.006	0.092	0.011	0.006	0.002	0.0067	0.0061	0.0018	0.0017	0.0036	0.0028	0.0014	0.0009	0.0024
Total Mercury (Hg) (mg/L)	MELDR-15																													<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001									
ANZECC trigger value: 0.0006 mg/L	MELDR-16																													<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002										
	MELDR-13																													<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.00005	
Min <0.00005	MELDR-14																													<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.00005	
Max 0.0003	MELDR-15																													<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0003	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.00005	
Soluble Mercury (Hg) (mg/L)	MELDR-15																													<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001													
ANZECC trigger value: 0.0006 mg/L	MELDR-16																													<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001													
	MELDR-13																													<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.00005	
Min <0.00005	MELDR-14																													<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.00005	
Max 0.0002	MELDR-15																													<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	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.00005	
	MELDR-15																														0.029	0.041	0.041	0.09	0.094	0.057	0.055	0.041	0.092	0.044	0.09	0.14				0.11				0.001
	MELDR-05	0.006	0.011			0.005	0.006	0.003		0.021	0.008			0.054	0.004	0.005	0.008	0.024	0.05	0.018	0.017	0.014	0.027	0.0084	0.012	0.03	0.03	0.028	0.014	0.031	0.021	0.018	0.007	0.023				0.016				0.042				0.024				0.017
Total Zinc (Zn)	MELDR-16																														0.024	0.039	0.023	0.18	0.074	0.051	0.072	0.12	0.084	0.032		0.1					0.085			<0.001
(mg/L)	MELDR-02	0.002	0.003	<0.001	<0.001	0.003	0.004	0.004	0.004	0.01	0.004	0.003	0.009	0.015	0.002	0.005	0.004	0.008	0.012	0.007	0.009	<0.001	0.011	0.0037	0.0019	0.021	0.019	0.03	0.035	0.021	0.012	0.01	0.005	0.009				0.005				0.015				0.007				<0.001
	PSDTBCMD	0.006	0.007	0.011	0.012	0.006	0.009	0.005	0.009	0.015	0.008	0.002	0.005	0.02	0.006	0.008	0.006	0.017	0.014	0.011	0.01	0.0092	0.016	0.01	0.009	0.02	0.02	0.012	0.011	0.021	0.012	0.01	0.008	0.014				0.013				0.018				0.013				0.0105
	MELDR-13																											0.019	0.008	0.033	0.011	0.012	0.008	0.01				0.007				0.01				0.008				<0.001
ANZECC trigger	MELDR-14																											0.008	0.005	0.046	0.01	0.005	0.004	0.008				0.008				0.016				0.011				<0.001
value	MELDR-06	0.01	0.01	0.009	0.011	0.007	0.006	0.004	0.008	0.011	0.008	0.002	0.004	0.021	0.005	0.006	0.006	0.02	0.014	0.011	0.008	0.009	0.017	0.01	0.0053	0.02	0.01	0.015	0.0081	0.032	0.011	0.01	0.008	0.011				0.008				0.017				0.011				0.0011
(unmodified):	MELDR-07	1.2	0.02			0.016	0.002	<0.001		0.058	0.002			0.009	0.002	<0.001	0.018		0.092	0.005	0.002			0.14	0.05		0.12	0.002	0.001	0.048	0.013	0.004	0.003	0.21				0.2					0.007			0.007				0.001
0.008 mg/L	MELDR-08	0.13	0.026			0.024	0.009			0.031										0.07	0.026		0.05	0.011	0.0031	0.1	0.023	0.02	0.012	0.024	0.031	0.037	0.021	0.041				0.043				0.027				0.04				0.0265
	MELDR-09	0.004	0.003			0.006	0.004	0.003	0.002	0.007	0.001	<0.001		<0.001	<0.001	0.002	0.002	0.22	0.091	0.033	0.01	0.014	0.014	0.012	0.0044	0.007	0.013	0.011	0.004	0.006	0.008	0.005	0.003	0.011				0.009				0.01				0.009				<0.001
	MELDR-10	0.006	0.004			0.003	0.003	0.003	0.012	0.003	0.003	<0.001		0.004	0.002	0.004	0.007	0.02	0.041	0.009	0.007	0.011	0.023	0.014	0.0058	0.02	0.013	0.007	0.003	0.03	0.009	0.006	0.007	0.016				0.019				0.019				0.019				0.007
Min 0.001	MELDR-11	0.007	0.003			0.001	0.001	<0.001	0.008	0.0023	0.002	0.001	0.002	0.004	0.003	0.002	0.017	0.006	0.003	0.005	0.002	0.002	0.0058	0.0024	0.002	0.003	0.004	0.001	0.003	0.003	0.003	0.003	0.002	0.004				0.008				0.0025				0.007				0.0015
Max 1.200	MELDR-12	0.19	0.001			0.001	0.002	<0.001		0.003	<0.001	0.004		0.003	0.002	0.003	0.002	0.65	0.22	0.013	0.003	0.16	0.11	0.016	<0.001	0.1	0.002	0.003	0.002	0.002	0.003	0.005	0.008	0.003				0.24				0.009				0.007				0.0069
	MELDR-15																																									0.097	0.049	0.071	0.052	0.094	0.17	0.037	0.048	0.0615
	MELDR-05																	0.025	0.05	0.016	0.026	0.0064	0.027	0.011	0.012	0.03	0.02	0.028	0.014	0.028	0.021	0.018	0.03	0.02	0.015	0.01	0.011	0.016	0.029	0.04	0.028	0.04	0.017	0.016	0.022	0.011	0.03	0.022	0.02	0.0205
	MELDR-16																																									0.044	0.089	0.052	0.054		0.068	0.088	0.1	0.068
Soluble Zinc (Zn)	MELDR-02									0.015	0.01	0.011	0.009	0.02	0.015	0.01	0.013	0.019	0.014	0.01	0.017	0.007	0.016	0.01	0.009	0.02	0.02	0.012	0.011	0.021	0.012	0.01	0.008	0.009	0.016	0.012	0.015	0.005	0.028	0.021	0.019	0.013	0.015	0.011	0.013	0.007	0.031	0.015	0.018	0.013
(mg/L)	PSDTBCMD																																	0.014	0.019	0.015	0.013	0.013	0.025	0.025	0.02	0.011	0.019	0.01	0.013	0.013	0.023	0.015	0.014	0.0145
ANZECC trigger	MELDR-13																											0.019	0.008	0.028	0.011	0.012	0.008	0.01	0.017	0.007	0.015	0.007	0.025	0.021	0.022	0.007	0.014	0.014	0.012	0.008	0.013	0.01	0.012	0.012
value	MELDR-14																											0.008	0.005	0.02	0.01	0.005	0.004	0.008	0.014	0.005	0.014	0.008	0.03	0.019	0.013	0.008	0.014	0.009	0.008	0.011	0.012	0.012	0.017	0.0105
(unmodified):	MELDR-06									0.015	0.015	0.015	0.012	0.02	0.016	0.018	0.02	0.02	0.014	0.013	0.022	0.009	0.017	0.01	0.0053	0.02	0.01	0.015	0.0081	0.032	0.011	0.01	0.008	0.011	0.015	0.006	0.014	0.008	0.066	0.022	0.015	0.012	0.015	0.012	0.01	0.011	0.013	0.012	0.011	0.0135
0.008 mg/L	MELDR-07																		0.092	0.006	0.012			0.14	0.05		0.12	0.002	0.001	0.048	0.013	0.004	0.003	0.18	0.13	0.01	0.014	0.2	0.17	0.099	0.019		0.0025	0.008	0.009	0.007	0.013	0.009	0.012	0.013
	MELDR-08																																	0.038	0.029	0.023	0.021	0.043	0.042	0.038	0.034	0.022	0.035	0.025	0.019	0.04	0.03	0.026	0.025	0.0295
	MELDR-09																																	0.011	0.015	0.012	0.011	0.009	0.026	0.019	0.018	0.006	0.018	0.011	0.014	0.009	0.017	0.013	0.016	0.0135
	MELDR-10																	0.022	0.039	0.012	0.01	0.011	0.021	0.015	0.0055	0.02	0.013	0.007	0.003	0.03	0.009	0.006	0.007	0.016	0.02	0.006	0.008	0.019	0.026	0.021	0.021	0.013	0.02	0.01	0.012	0.019	0.035	0.019	0.015	0.015
Min 0.001	MELDR-11																	0.006	0.003	0.005	0.002	0.002	0.0055	0.0024	0.002	0.003	0.004	0.001	0.001	0.003	0.003	0.003	0.002	0.004	0.008	0.002	0.003	0.008	0.017	0.009	0.003	0.0025	0.0025	0.004	0.01	0.007	0.011	0.004	0.01	0.003
Max 0.580	MELDR-12																	0.58	0.0024	0.018	0.013	0.16	0.11	0.016	<0.001	0.1	0.002	0.003	0.002	0.002	0.003	0.005	0.008	0.003	0.011	0.018	0.009	0.24	0.11	0.029	0.013	0.0025	0.014	0.007	0.01	0.007	0.013	0.012	0.02	0.0115

SITES RECORDING >60% CONCENTRATIONS ABOVE ADJUSTED TRIGGER VALUE
SITES RECORDING 40-60% OF CONCENTRATIONS ABOVE ADJUSTED TRIGGER VALUE
SITES RECORDING <40% CONCENTRATIONS ABOVE ADJUSTED TRIGGER VALUE

Concentration ABOVE ADJUSTED trigger value
Concentration BELOW ADJUSTED trigger value

Concentration < LOR
NO sample taken

8. Metals in sediment

A study of sediments in Bull Creek (Nice 2009) identified sediment concentrations of zinc, mercury, lead and selenium concentrations exceeding ANZECC guidelines. Following this, an ecotoxicological investigation by Nice (2011) found that sediments collected in Bull Creek in the vicinity of the Bull Creek Main Drain and the Brentwood Main Drain were toxic to test organisms (mussels (*Mytils edulis planulatus*), copepods (*Gladioferans imparipes*), amphipods (*Grandidiella japonica)* and pink snapper (*Pagrus auratus*)). This investigation subsequently recommended investigation of disturbance in the Bull Creek catchment. This water and sediment quality assessment will help to determine the source of these metals in the catchment.

Refer to **Tables D-29 to D-38** in **Appendix D** for all sediment metal concentration data collected in the Melville Bull Creek catchments in the 2016. **Table F-1, Appendix F** outlines potential sources of these metals.

For all graphs, a value equal to half the limit of reporting was substituted for those occasions where concentrations were recorded as 'below the laboratory limit of reporting' which is a standard technique to allow these 'unknown' values to be represented graphically and to differentiate them from concentrations equal to the limit of reporting.

8.1 Aluminium

No guideline currently exists for aluminium concentrations in sediment; therefore, it is difficult to gauge the severity of any potential impacts arising from the concentrations recorded in the sediment of the Bull Creek catchment. Sediment total aluminium concentrations in 2018 varied across the catchment, with the highest concentration of 6,770 mg/kg recorded at site 5 (John Creaney Park) and the lowest concentration of 534 mg/kg was recorded at site PSDTBCMD (Bull Creek Main Drain).

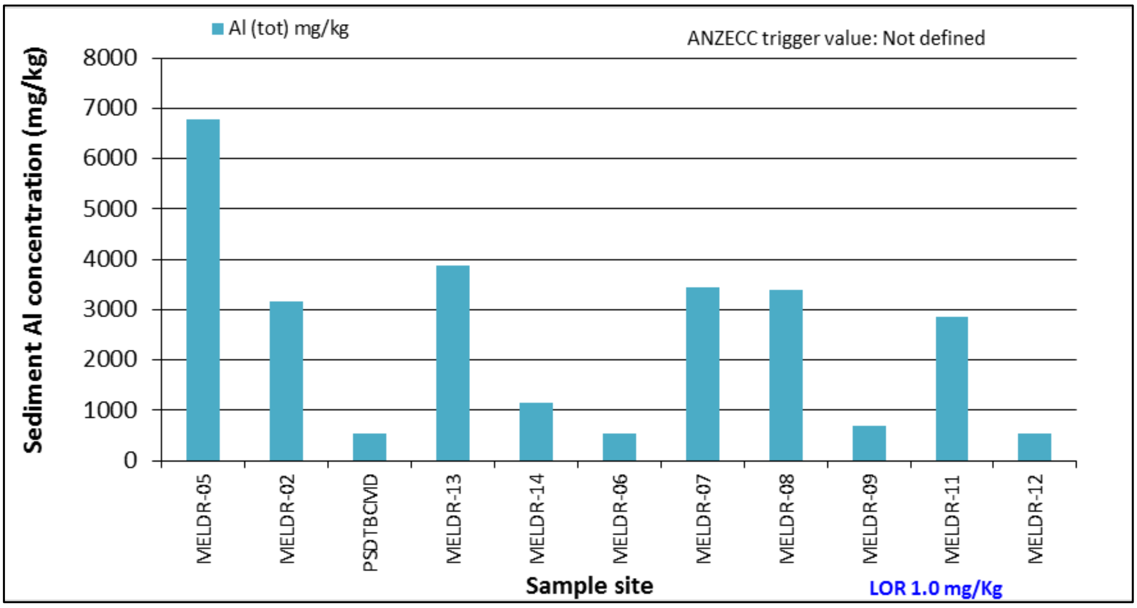

Figure 8.1-1: Sediment total aluminium concentrations (mg/kg) recorded in Melville Bull Creek catchment sites in 2018

Total aluminium concentrations have varied greatly in sediments of Melville Bull Creek catchment sites (over the last six years of monitoring, with no strong patterns evident (**Table 8-1**). It is notable that the very high result (30,000 mg/kg) recorded at site 13 (Brentwood drain) in 2016 is significantly higher than all other recorded concentrations, including those recorded in other years at site 13.

8.2 Arsenic

Total arsenic concentrations in sediments in 2018 were all below the ANZECC low (20 mg/kg) and high (70 mg/kg) trigger values (**Figure 8.2-1** and **Table D-30, Appendix D**). The highest concentration of 4.4 mg/kg was recorded at site 5 (John Creaney Park) and the lowest of 0.2 mg/kg at site 9 (Quenda Lake outlet).

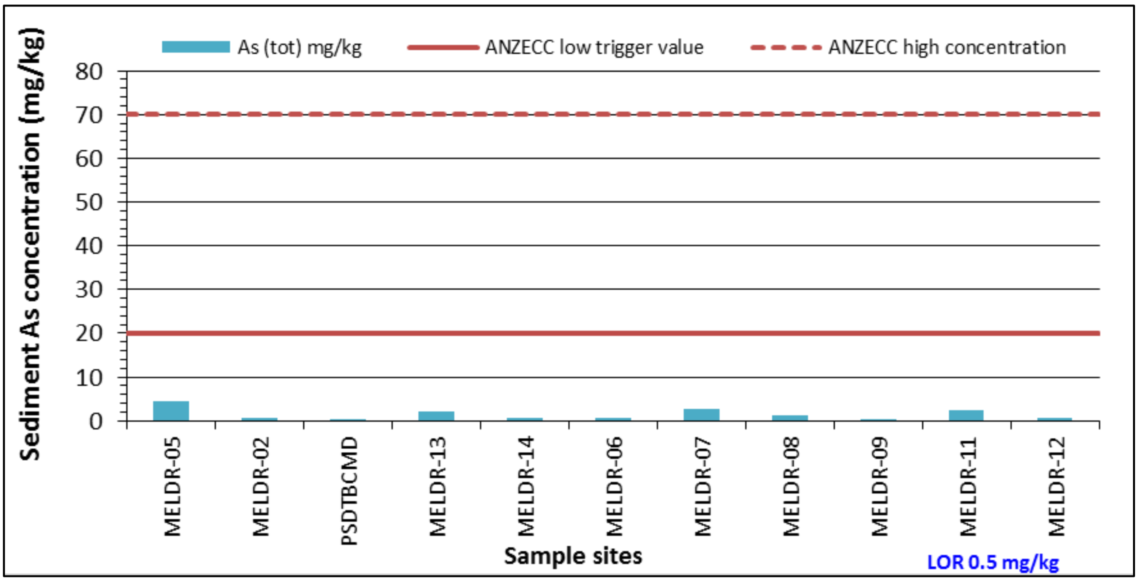

Figure 8.2-1: Sediment total arsenic concentrations (mg/kg) recorded in Melville Bull Creek catchment sites in 2018

Total arsenic concentrations in sediments at Melville Bull Creek catchment sites have generally been low throughout the six years of monitoring (**Table 8-1**). Site 7 (Booragoon Lake outlet) has recorded the highest concentrations in the catchment each years year that sediment was collected from this site except 2018 and has been the only site to record exceedances of the low trigger value (in 2015).

8.3 Chromium

Total chromium (including Cr^{3+} and Cr^{6+}) concentrations in sediments at all Melville Bull Creek catchment sites were below ANZECC low (80 mg/kg) and high (370 mg/kg) trigger values in 2018 (**Figure 8.3-1** and **Table D-31 Appendix D**). The highest concentration in the catchment of 16 mg/kg was recorded at site 13 (Brentwood drain) and the lowest concentration of 0.88 mg/kg was recorded at site PSDTBCMD (Bull Creek Main Drain).

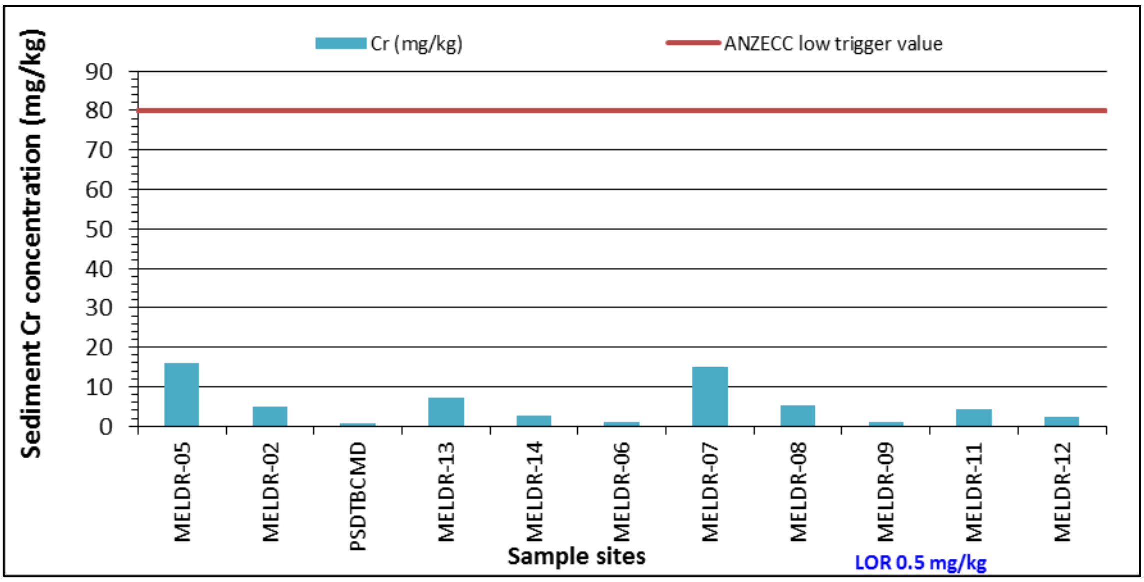

Figure 8.3-1: Sediment total chromium concentrations (mg/kg) recorded in Melville Bull Creek catchment sites in 2018

Total chromium concentrations in sediments at Melville Bull Creek catchment sites have been generally low throughout the six years of monitoring (**Table 8-1**). The concentration of 180 mg/kg recorded at site 13 (Brentwood drain) in 2016 is by far the highest concentration recorded in catchment over the six year period and has been the only sample to exceed the low trigger value.

8.4 Copper

Total copper concentrations in sediments collected from all Melville Bull Creek catchment sites in 2018 were below ANZECC low (65 mg/kg) and high (270 mg/kg) trigger values (**Figure 8.3-1** and **Table D-32, Appendix D**). The highest concentration in the catchment (33 mg/kg) was recorded at site 5 (John Creaney Park) and site 6 (Bateman Park) recorded a concentration below the limit of reporting (0.5 mg/kg).

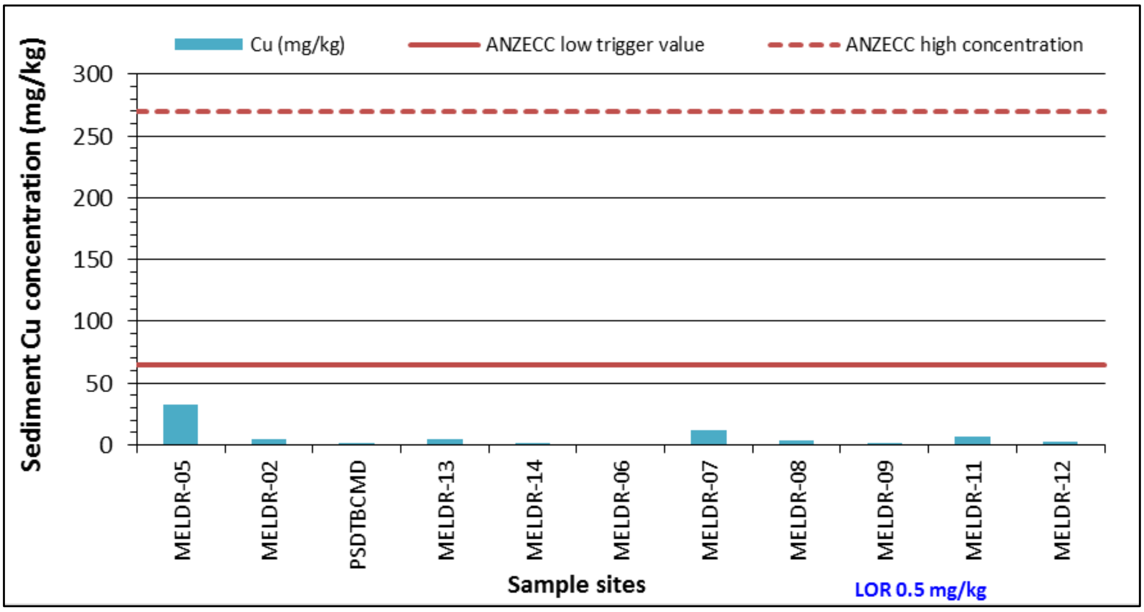

Figure 8.4-1: Sediment total copper concentrations (mg/kg) recorded in Melville Bull Creek catchment sites in 2018

Total copper concentrations in sediments at Melville Bull Creek catchment sites have been generally low in the previous six years of monitoring (**Table 8-1**). Only three samples (site 13 (Brentwood drain) in 2016, site 7 (Booragoon Lake) in 2015 and site 10 (Frederick Baldwin) in 2016) have recorded exceedances of the low trigger value in the five years of monitoring. Concentrations in these three samples were significantly higher than other concentrations recorded at these sites over the years.

8.5 Iron

No guideline currently exists for iron concentrations in sediment; therefore it is difficult to gauge the severity of any potential impact arising from the concentrations recorded in the sediment collected from Melville Bull Creek catchment sites. In 2018 total iron concentrations in sediment were varied (**Figure 8.5-1** and **Table D-33, Appendix D**). The highest concentration of 24,000 mg/kg was recorded at site 5 (John Creaney Park) and the lowest concentration of 230 mg/kg was at site 9 (Quenda Lake outlet).

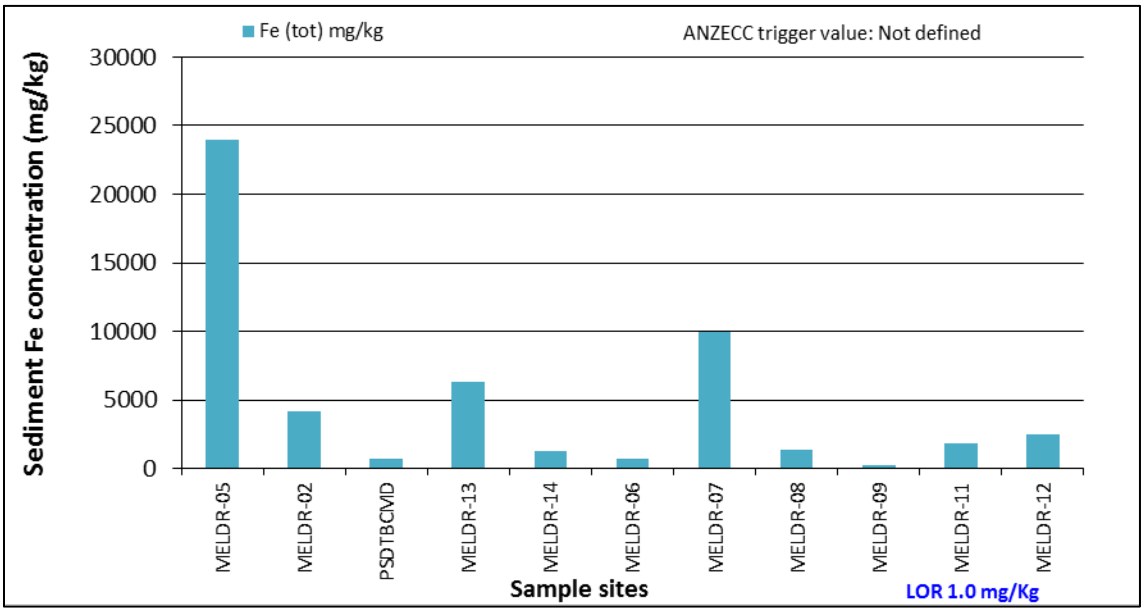

Figure 8.5-1: Sediment total iron concentrations (mg/kg) recorded in Melville Bull Creek catchment sites in 2018

Sediment total iron concentrations recorded in 2018 are within the range of those collected in the preceding five years of monitoring, although concentrations have varied somewhat between years (**Table 8-1**). Sites PSDTBCMD (the most downstream site in Bull Creek main drain) and site 7 (Booragoon Lake) have generally recorded the highest concentrations and site 9 (Quenda Lake outlet) has always recorded the lowest concentrations.

8.6 Lead

Lead concentrations in sediments collected from Melville Bull Creek catchment sites in 2018 were all below the ANZECC low trigger value (50 mg/kg) except for samples from sites 5 and 7 (John Creaney Park and Booragoon Lake outlet respectively), which recorded concentrations of 60 mg/kg and 80 mg/kg respectively (**Figure 8.6-1** and **Table D-34, Appendix D**). No sample recorded an exceedance of the high trigger value (220 mg/kg). The lowest concentration of 1.3 mg/kg was recorded at site 6 (Bateman Park).

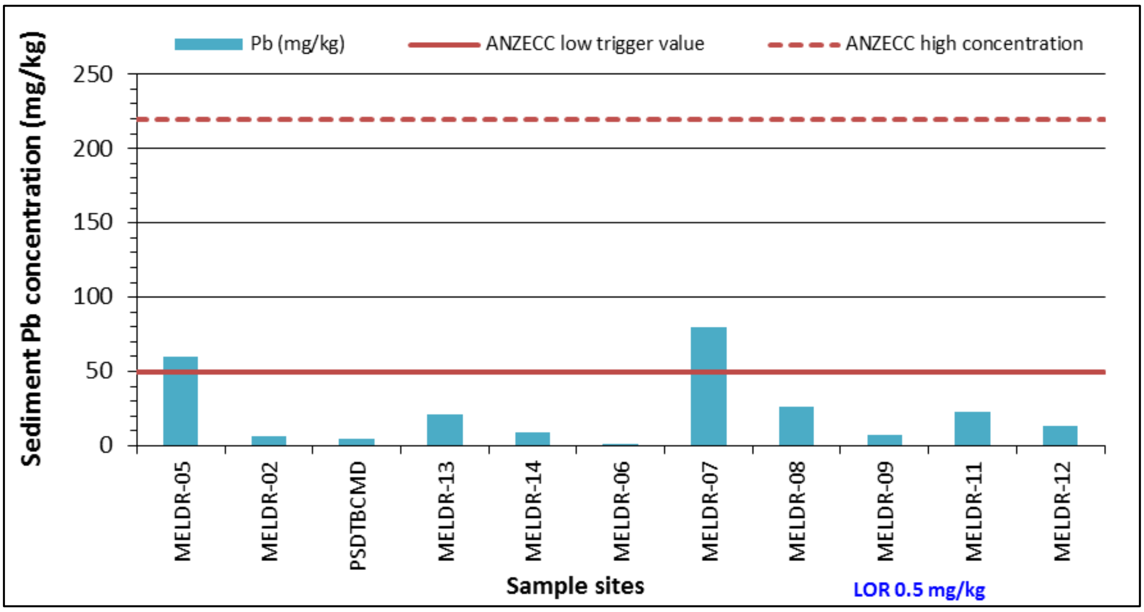

Figure 8.6-1: Sediment total lead concentrations (mg/kg) recorded in Melville Bull Creek catchment sites in 2018

Total lead concentrations in sediments collected in 2018 are similar to those collected in the preceding five years of monitoring (**Table 8-1**). Concentrations exceeding the low trigger value have been recorded at six sites (5 (John

Creaney Park), 13 (Brentwood drain), 7 (Booragoon Lake), 8 (Piney Lakes outlet), 10 (Frederick Baldwin) and 12 (Blue Gum Lake) on at least one sampling occasion throughout the six year monitoring period, and at Booragoon Lake on all sampling occasions.

8.7 Mercury

Total mercury concentrations in sediment were all below the ANZECC low (0.15 mg/kg) and high (1.0 mg/kg) trigger values at Melville Bull Creek catchment sites in 2018 (**Figure 8.7-1** and **Table D-35, Appendix D**). Only two sites recorded concentrations greater than the limit of reporting (0.02 mg/kg): sites 7 and 8 (Booragoon Lake outlet and Piney Lakes outlet respectively) with concentrations of 0.05 mg/L and 0.04 mg/L.

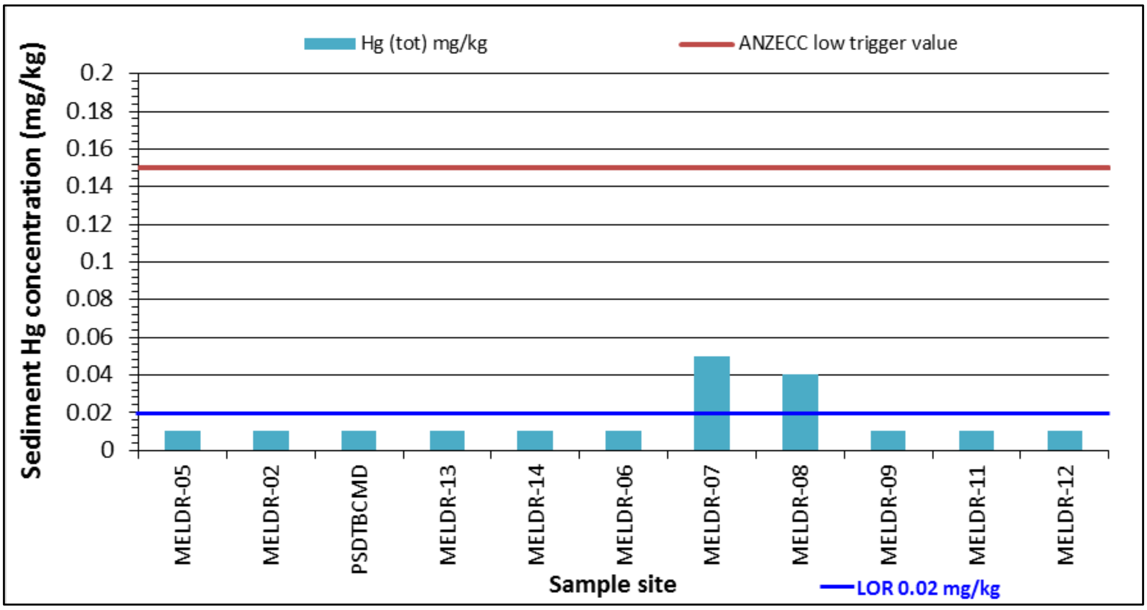

Figure 8.7-1: Sediment total mercury concentrations (mg/kg) recorded in Melville Bull Creek catchment sites in 2018

Concentrations of total mercury in sediments of the Melville Bull Creek catchment throughout the six years of monitoring have generally been low (**Table 8-1**). The only exceedance of the ANZECC low trigger value during this time was recorded at site 7 (Booragoon Lake) in 2016.

8.8 Nickel

Total nickel concentrations in sediment were all below the ANZECC low (21 mg/kg) and high (52 mg/kg) trigger values at Melville Bull Creek catchment sites in 2018 (**Figure 8.8-1** and **Table D-36, Appendix D**). The highest total nickel concentration of 4.1 mg/kg was recorded at site 5 (John Creaney Park) and sites PSDTBCMD and 6 (Bull Creek Main Darin and Bateman Park) recorded concentrations less than the limit of reporting (0.1 mg/kg).

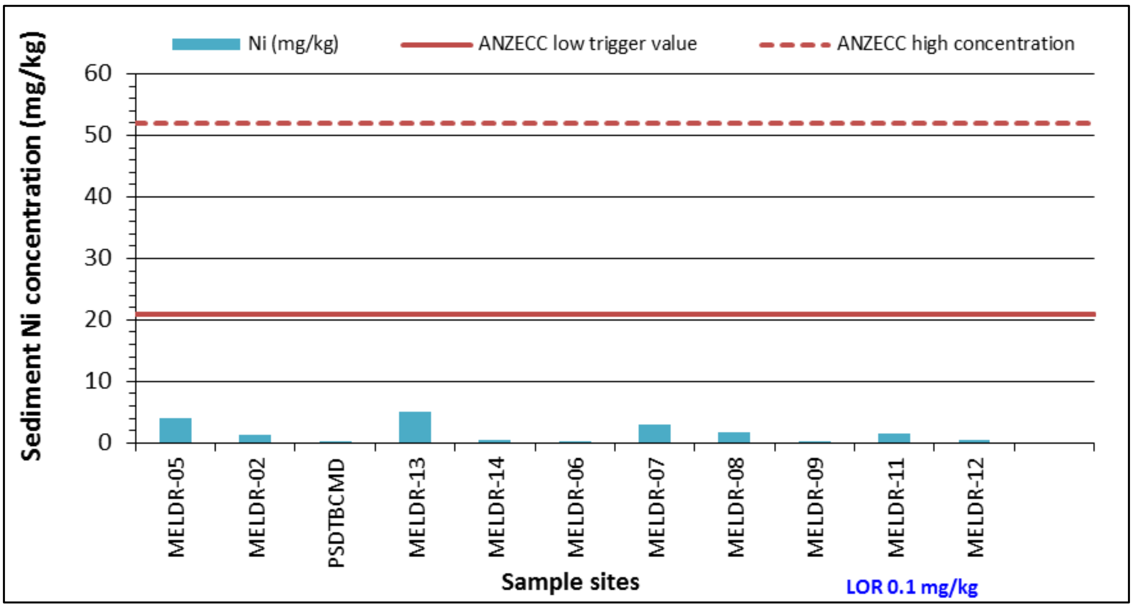

Figure 8.8-1: Sediment total nickel concentrations (mg/kg) recorded in Melville Bull Creek catchment sites in 2018

Concentrations of total mercury in sediments of the Melville Bull Creek catchment recorded throughout the six years of monitoring have generally been low (**Table 8-1**). The only exceedances of the ANZECC low trigger value recorded during this time were at site 13 (Brentwood drain) in 2016 and site 7 (Booragoon Lake) in 2015.

8.9 Selenium

No guideline currently exists for selenium concentrations in sediment; therefore it is difficult to gauge the severity of any potential impact arising from the concentrations recorded Melville Bull Creek catchment sediments in 2018. The highest selenium concentration (0.98 mg/L) was recorded at site 7 (Booragoon Lake outlet) and six sites recorded concentrations below the limit of reporting (0.5 mg/kg) (**Figure 8.9-1** and **Table D-37, Appendix D**).

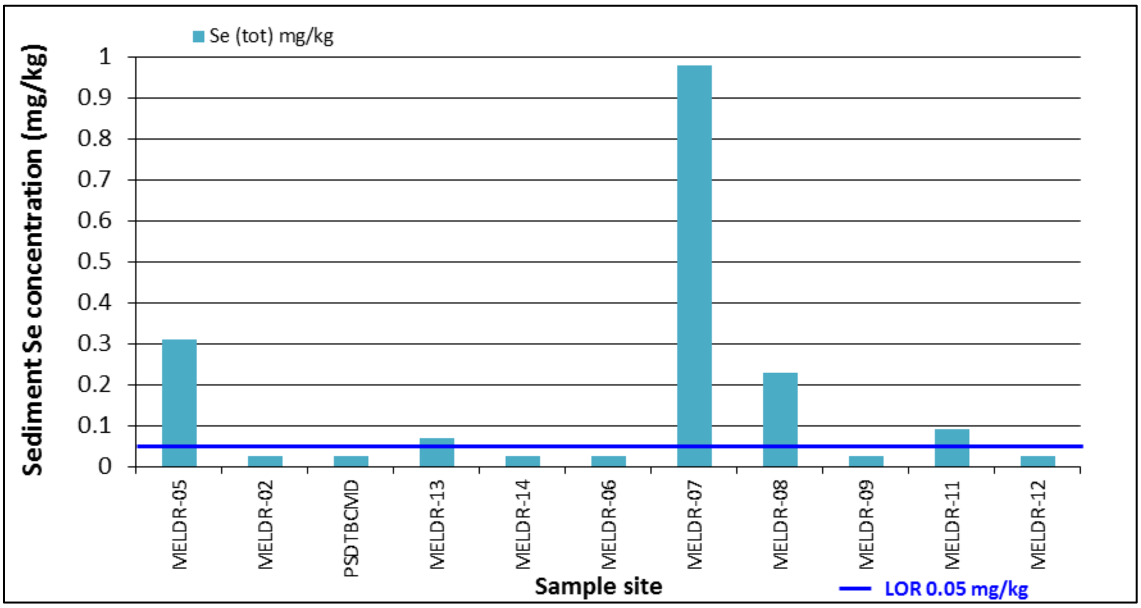

Figure 8.9-1: Sediment total selenium concentrations (mg/kg) recorded in Melville Bull Creek catchment sites in 2018

Total selenium concentrations recorded in 2018 are similar to those recorded in the preceding five years (**Table 8-1**). Site 7 (Booragoon Lake outlet) has always recorded the highest concentration in the catchment.

8.10 Zinc

Sediment total zinc concentrations in Melville Bull Creek catchment sites in 2018 were low, with all concentrations below ANZECC low (200 mg/kg) and high (410 mg/kg) trigger values (**Figure 8.10-1** and **Table D-38, Appendix D**). The highest concentration (150 mg/kg) was recorded at site 5 (John Creaney Park) and the lowest (3.6 mg/kg) at site 9 (Quenda Lake outlet).

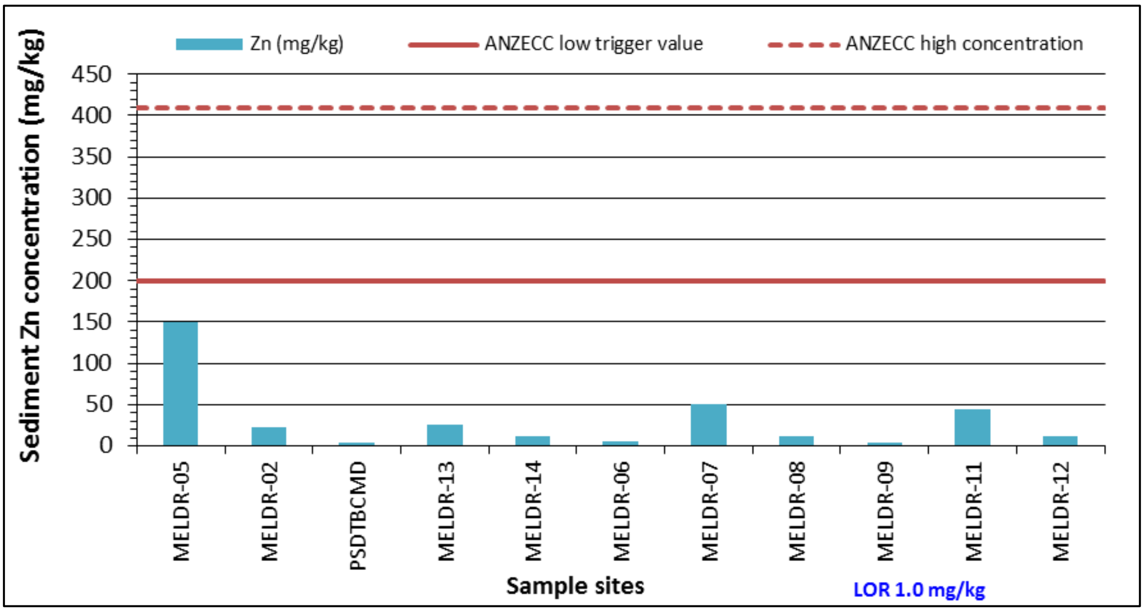

Figure 8.10-1: Sediment total zinc concentrations (mg/kg) recorded in Melville Bull Creek catchment sites in 2018

Sediment total zinc concentrations recorded in 2018 are similar to those recorded in the preceding five years of monitoring (**Table 8-1**). During the six years of monitoring, only sites 13 and 10 (Brentwood drain and Frederick Baldwin respectively) have recorded zinc concentrations in exceedance of the low trigger value, recording anomalously high concentrations in 2016.

Table 8-1: Metal (aluminium (Al), arsenic (As), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), mercury (Hg), nickel (Ni), selenium (Se) and zinc (Zn)) concentrations (mg/L) recorded in Melville Bull Creek catchment sites from 2013 to 2018

	Site name	Nov-13	Sep-14	Oct-15	Oct-16	Oct-17	Oct-18
	MELDR-05	2,300	1,300	630	5100	3270	6770
Sediment aluminium (Al)	MELDR-02	1,400	1,500	2,100	1200	1470	3170
(mg/kg)	PSDTBCMD	500	1,300	8,200	8100	1300	534
	MELDR-13	360	470	760	30000	1460	3880
	MELDR-14	560	460	470	1000	1260	1140
	MELDR-06	620	500	640	510	485	540
Highest concentration of the year	MELDR-07	6,500		2,300	7000	5290	3440
Lowest concentration of the year	MELDR-08	3,200	2,900	5,000	4600	383	3400
	MELDR-09	1,000	1,000	720	1100	774	692
	MELDR-10	1,100	1,500	2,200	6500		
Max (red) 30,000	MELDR-11	1,100		2,900	1900	2420	2860
Min (blue) 360.0	MELDR-12	2,200	820	1,000	720	938	537
	MELDR-05	0.8	<0.5	<0.5	1.9	0.8	4.4
Sediment arsenic (As)	MELDR-02	<0.5	<0.5	0.6	<0.5	0.4	0.7
(mg/kg)	PSDTBCMD	<0.5	0.8	2.6	4.1	0.6	0.4
	MELDR-13	0.7	0.8	<0.5	0.7	0.6	2.2
ANZECC low TV:	MELDR-14	<0.5	<0.5	<0.5	0.6	0.6	0.7
20 mg/kg	MELDR-06	1.4	0.7	<0.5	<0.5	0.4	0.7
high TV:	MELDR-07	18		20	7.1	4.9	2.6
70 mg/kg	MELDR-08	1.4	0.8	1.4	1.5	0.1	1.2
	MELDR-09	<0.5	<0.5	<0.5	<0.5	0.1	0.2
	MELDR-10	1.1	1.3	1.4	5.1		2.5
Max (red) 20	MELDR-11	1		2.8	2.5	1.4	2.5
Min (blue) 0.1	MELDR-12	1.4	<0.5	0.7	<0.5	1.7	0.6
	MELDR-05	12	4.3	2	18	8	16
Sediment chromium (Cr)	MELDR-02	3.3	3.4	4.2	11.0	2.2	4.8
(mg/kg)	PSDTBCMD	0.9	3.1	12	11	1.9	0.72
	MELDR-13	1	1.5	1.7	180.0	2.4	7.2
ANZECC low TV:	MELDR-14	1.7	1.3	1.3	1.2	2.3	2.6
72 mg/kg	MELDR-06	2.1	2.5	1.6	1.2	0.88	1
high TV:	MELDR-07	64		72	35	26	15
0.72 mg/kg	MELDR-08	9.4	6.5	12	10	1	5.2
	MELDR-09	2.8	1.7	1.5	1.6	0.96	1.2
	MELDR-10	3.6	3.9	4.6	23.0		
Max (red) 180	MELDR-11	4.4		5	3	4.2	4.2
Min (blue) 0.72	MELDR-12	11	2.1	4.7	2.0	5.9	2.4
	MELDR-05	20	11	4.3	50.0	16.0	33.0
Sediment copper (Cu)	MELDR-02	7.9	3.6	7.0	16.0	3.3	4.8
(mg/kg)	PSDTBCMD	<0.5	4.2	1.3	2.4	0.8	0.6
	MELDR-13	<0.5	0.7	<0.5	95.0	0.9	4.3
ANZECC low TV:	MELDR-14	<0.5	0.8	0.8	<0.5	<0.5	1.6
65 mg/kg	MELDR-06	0.9	2.1	0.5	<0.5	<0.5	<0.5
high TV:	MELDR-07	38		250.0	28.0	12.0	12.0
270 mg/kg	MELDR-08	13	10	16.0	14.0	<0.5	3.3
	MELDR-09	<0.5	0.7	1.2	1.2	<0.5	1.1
	MELDR-10	4.9	8	7.3	72.0		
Max (red) 250	MELDR-11	2.6		1.3	1.0	3.9	6.3
Min (blue) <0.5	MELDR-12	11	3.2	4.2	1.2	6.0	2.1
	MELDR-05	6,200	3,400	1,700	7000	3500	24000
Sediment iron (Fe)	MELDR-02	3,000	3,500	4,000	1400	2700	4200
(mg/kg)	PSDTBCMD	810	3,700	56,000	57000	1700	710
	MELDR-13	1,800	2,700	760	54000	1400	6300
	MELDR-14	650	560	620	1700	800	1300
	MELDR-06	3,400	2,500	1,200	730	590	720
Highest concentration of the year	MELDR-07	17,000		17,000	13000	8200	10000
Lowest concentration of the year	MELDR-08	2,100	1,500	2,100	1800	310	1400
	MELDR-09	85	170	350	180	180	230
	MELDR-10	3,300	3,900	3,600	11000		
Max (red) 57,000	MELDR-11	1,100		3,000	1700	1500	1800
Min (blue) 85	MELDR-12	3,700	880	1,400	850	1400	2500

Record >LOW Trigger Value | Concentration < LOR

Record >HIGH Trigger Value | NO sample taken

Record <LOW Trigger Value

Table 8-1 (continued): Metal (aluminium (Al), arsenic (As), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), mercury (Hg), nickel (Ni), selenium (Se) and zinc (Zn)) concentrations (mg/L) recorded in Melville Bull Creek catchment sites from 2013 to 2018

	Site number	Nov-13	Sep-14	Oct-15	Oct-16	Oct-17	Oct-18
	MELDR-05	220	80	14	130	52	60
Sediment lead (Pb)	MELDR-02	8.6	4.5	20	8.5	5.5	6.3
(mg/kg)	PSDTBCMD	4.2	29	9.6	14	6.8	4.6
	MELDR-13	2.3	21	2.1	170	4.3	21
ANZECC low TV:	MELDR-14	7.4	8.3	9.2	3.5	4.5	9.3
50 mg/kg	MELDR-06	6.5	5.5	2.2	1.2	1.1	1.3
high TV:	MELDR-07	120		50	56	66	80
220 mg/kg	MELDR-08	44	36	66	50	4.4	26
	MELDR-09	1.7	2.9	7.7	3.5	1.8	7.1
	MELDR-10	48	54	54	200		
Max (red) 220	MELDR-11	19		8.6	5.7	33	23
Min (blue) 1.1	MELDR-12	150	12	59	15	19	13
	MELDR-05	<0.1	<0.1	<0.1	0.1	<0.02	<0.02
Sediment mercury (Hg)	MELDR-02	<0.1	<0.1	<0.1	<0.1	<0.02	<0.02
(mg/kg)	PSDTBCMD	<0.1	<0.1	<0.1	0.1	<0.02	<0.02
	MELDR-13	<0.1	<0.1	<0.1	<0.1	<0.02	<0.02
ANZECC low TV:	MELDR-14	<0.1	<0.1	<0.1	<0.1	<0.02	<0.02
0.15 mg/kg	MELDR-06	<0.1	<0.1	<0.1	<0.1	<0.02	<0.02
high TV:	MELDR-07	<0.1		0.1	0.2	0.03	0.05
1 mg/kg	MELDR-08	<0.1	<0.1	0.1	0.1	<0.02	0.04
	MELDR-09	<0.1	<0.1	<0.1	<0.1	<0.02	<0.02
	MELDR-10	<0.1	<0.1	<0.1	0.1		
Max (red) 0.2	MELDR-11	<0.1		<0.1	<0.1	<0.02	<0.02
Min (blue) <0.02	MELDR-12	<0.1	<0.1	<0.1	<0.1	<0.02	<0.02
	MELDR-05	2.9	1.4	<1.0	5.5	2.4	4.1
Sediment nickel (Ni)	MELDR-02	1.2	1.8	2.1	<1.0	0.7	1.3
(mg/kg)	PSDTBCMD	<1.0	1.3	1.8	1.6	0.5	<0.1
	MELDR-13	<1.0	<1.0	<1.0	21	1	5
ANZECC low TV:	MELDR-14	<1.0	<1.0	<1.0	<1.0	0.4	0.4
21 mg/kg	MELDR-06	<1.0	<1.0	<1.0	<1.0	0.2	<0.1
high TV:	MELDR-07	8.2		31	7.6	4.2	2.9
52 mg/kg	MELDR-08	4.8	2.7	5.5	5.1	0.5	1.7
	MELDR-09	<1.0	<1.0	<1.0	<1.0	<0.1	0.2
	MELDR-10	1.6	1.8	2.2	8.2		
Max (red) 31	MELDR-11	1.3		1.2	<1.0	1.2	1.5
Min (blue) <0.1	MELDR-12	2.3	<1.0	<1.0	<1.0	0.8	0.4
	MELDR-05	<1.0	<1.0	<1.0	<1.0	0.14	0.31
	MELDR-02	<1.0	<1.0	<1.0	<1.0	<0.05	<0.05
Sediment selenium (Se)	PSDTBCMD	<1.0	<1.0	<1.0	1.1	<0.05	<0.05
(mg/kg)	MELDR-13	<1.0	<1.0	<1.0	<1.0	<0.05	0.07
	MELDR-14	<1.0	<1.0	<1.0	<1.0	<0.05	<0.05
	MELDR-06	<1.0	<1.0	<1.0	<1.0	<0.05	<0.05
Highest concentration of the year	MELDR-07	2.8		1.3	2.9	1.3	0.98
Lowest concentration of the year	MELDR-08	<1.0	<1.0	<1.0	<1.0	<0.05	0.23
	MELDR-09	<1.0	<1.0	<1.0	<1.0	<0.05	<0.05
	MELDR-10	<1.0	<1.0	<1.0	<1.0		
Max (red) 3	MELDR-11	<1.0		<1.0	<1.0	0.1	0.09
Min (blue) <0.05	MELDR-12	<1.0	<1.0	<1.0	<1.0	<0.05	<0.05
	MELDR-05	49	24	20	120	58	150
Sediment zinc (Zn)	MELDR-02	26	15	49	19	7.2	22
(mg/kg)	PSDTBCMD	3.7	22	18	35	5.6	4.5
	MELDR-13	13	27	6.8	390	5.7	26
ANZECC low TV:	MELDR-14	6.1	6.4	9.4	5.5	3.9	11
200 mg/kg	MELDR-06	14	22	4.4	4.2	3.1	4.7
high TV:	MELDR-07	95		120	57	42	51
410 mg/kg	MELDR-08	34	25	39	49	<0.25	11
	MELDR-09	1.0	<1.0	3.7	1.4	<0.25	3.6
	MELDR-10	30	39	48	320		
Max (red) 390	MELDR-11	17		13	16	23	44
Min (blue) <0.25	MELDR-12	37	9.9	13	5.6	21	12

Record >LOW Trigger Value	Concentration < LOR
Record >HIGH Trigger Value	NO sample taken
Record <LOW Trigger Value	

8.11 Particle size analysis

Sediment particles were been classified into the following size classes according to the Wentworth scale (Wentworth 1992):

- Clay <4 µm;
- Silt 4-62 µm;
- Fine sand 62-250 µm;
- Medium sand 250-500 µm;
- Coarse sand 500-2,000 µm; and
- Gravel >2,000 µm.

The dominant sediment particle size fractions for nine of the 11 sites where sediment sampled were collected were medium sand and coarse sand (see **Table 8-2** and **Figure 8.11-1** for details). The only exceptions were sediments from sites 5 and 7 (John Creaney Park and Booragoon Lake outlet respectively), which can be described as silty gravel and sandy gravel respectively.

It should be noted that sediments from sites 5 and 7, which contained the highest proportions of fine particles in 2018, recorded the highest concentrations of most metals (aluminium, arsenic, chromium, copper, iron and zinc at site 5 and selenium, mercury and lead at site 12). This is likely to be because finer sediments are able to bind greater concentrations of trace metals due to their greater surface area to volume ratio (Parizanganeh 2008). Concentrations of these metals in water, other than for iron and aluminium, were below relevant trigger values and were similar to concentrations at other sites. This may indicate that the fine sediments are acting as a store for metals at these sites and preventing them from entering the water column.

Table 8-2: Particle size analysis results from Melville Bull Creek catchment sites in October 2018

Site Name	Site Ref No.	Date Collected	Clay % (<4 µm)	Silt % (4-62 µm)	Fine sand % (62-250 µm)	Medium sand % (250-500 µm)	Coarse sand % (500-2,000 µm)	Gravel % (>2,000 µm)
JOHN CREANEY PARK	MELDR-05	9-Oct-18	3.57	**21.78**	8.45	2.51	8.30	**55.40**
BROCKMAN PARK	MELDR-02	9-Oct-18	0.00	0.00	0.01	**24.49**	**64.60**	10.90
BULL CREEK MD	PSDTBCMD	9-Oct-18	0.00	0.00	0.06	**42.14**	**57.70**	0.10
BRENTWOOD DRAIN	MELDR-13	9-Oct-18	0.00	0.00	0.13	**38.27**	**53.50**	8.10
RAAF DRAIN	MELDR-14	9-Oct-18	0.00	1.31	4.43	**57.56**	**35.20**	1.50
BATEMAN PARK	MELDR-06	9-Oct-18	0.00	0.00	0.92	**59.88**	**39.10**	0.10
BOORAGOON LAKE OUTLET	MELDR-07	9-Oct-18	2.87	19.37	4.99	**22.08**	13.70	**37.00**
PINEY LAKES OUTLET	MELDR-08	9-Oct-18	3.20	18.90	4.25	**22.05**	**39.60**	12.00
QUENDA LAKE OUTLET	MELDR-09	9-Oct-18	1.37	7.68	7.30	**63.35**	**15.90**	4.40
MARMION RESERVE	MELDR-11	9-Oct-18	1.49	8.34	5.32	**39.75**	**40.10**	5.00
BLUE GUM LAKE OUTLET	MELDR-12	9-Oct-18	1.13	7.38	2.40	**26.08**	**58.50**	4.50

Highest particle size %
Second highest particle size %

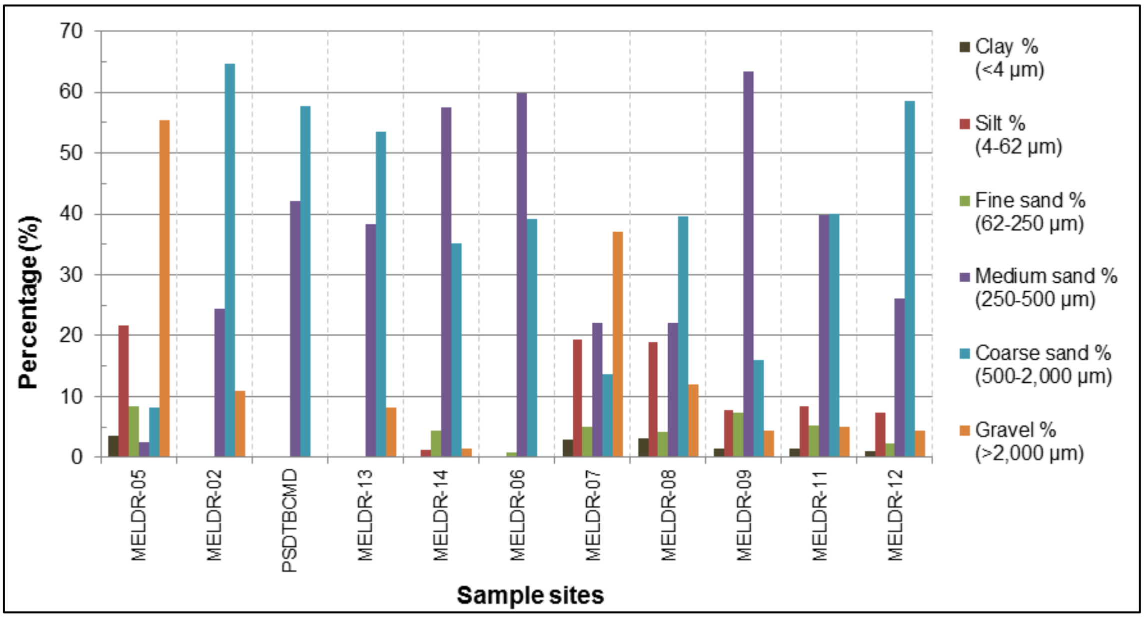

Figure 8.11-1: Sediment particle size distribution (%) in Melville Bull Creek catchment sites in October 2018.

9. Summary of 2018 results

Figure 8.11-1, Figure 8.11-2, Figure 8.11-3 and Figure 8.11-4 include catchment maps showing sites sampled in 2018 with water physicochemical properties, water nutrients, metals in water and metals in sediment respectively exceeding relevant trigger values/outside acceptable ranges. **Table 9-1, Table 9-2** and **Figure 8.11-3** contain summaries of the physicochemical, nutrient and metal water quality data, and **Table 9-4** contains a summary of sediment metal concentrations, recorded in Melville Bull Creek catchment sites in 2018.

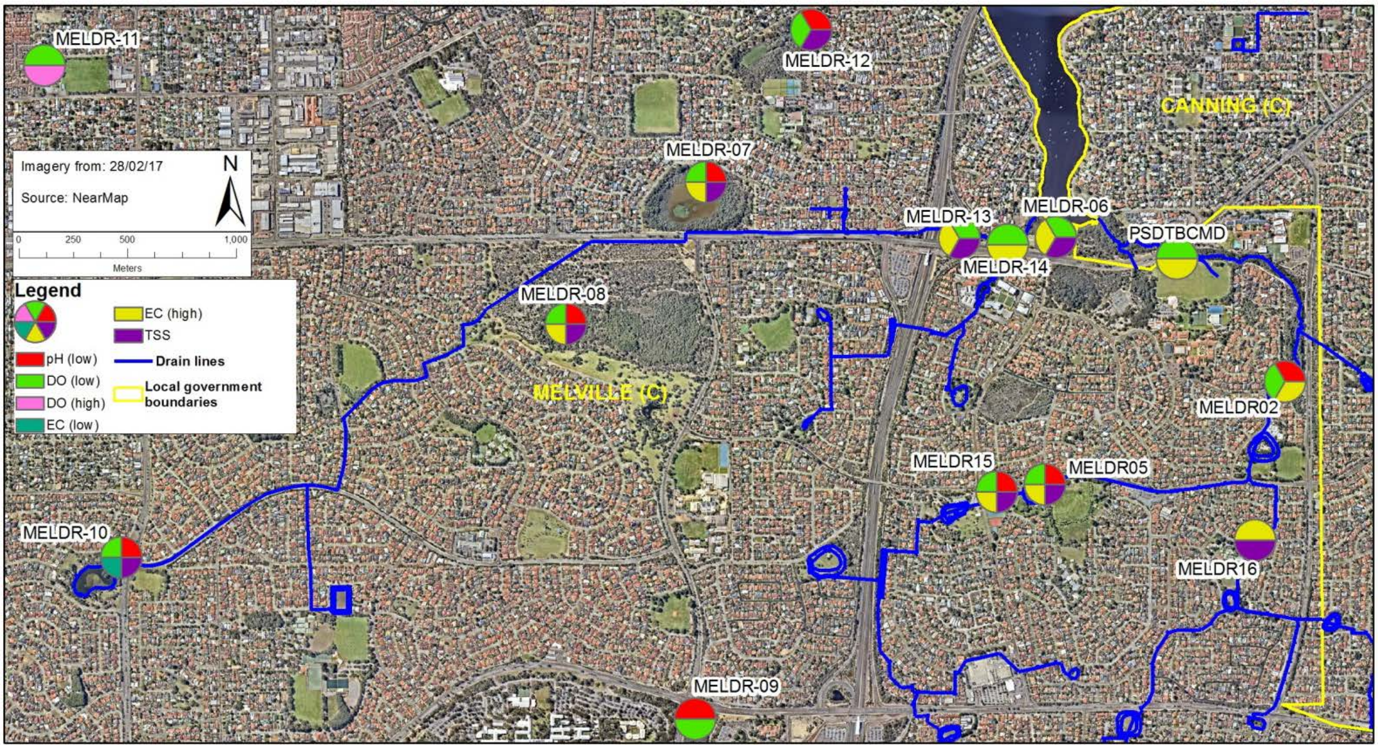

Figure 8.11-1: Map of Melville Bull Creek catchment sites with values outside of ANZECC acceptable ranges for lowland rivers for pH, dissolved oxygen % (DO) and electrical conductivity (EC) and exceeding the DWER interim for total suspended solids (TSS) in 2018.

Table 9-1: Summary of physicochemical parameter data recorded in Melville Bull Creek catchment sites in 2018.

		Parameter	pH	Dissolved Oxygen (%)	Conductivity (uS/cm)	TSS (mg/L)
		Acceptable range/trigger value	ANZECC acceptable range: lowland rivers: 6.5-8 wetlands: 7.0 - 8.5	ANZECC acceptable range: lowland rivers: 80 - 120 wetlands: 90 - 120	ANZECC acceptable range: lowland rivers: 6.5-8 wetlands: 7.0 - 8.5	DWER interim trigger value: 6
Site			Number outside range/above trigger value			
Drain sites	JOHN CREANEY PARK INLET	MELDR-15	3 (low)	4 (low)	4 (high)	2
	JOHN CREANEY PARK	MELDR-5	1 (low)	4 (low)	4 (high)	1
	DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	0	0	3 (high)	1
	BROCKMAN PARK	MELDR-2	3 (low)	4 (low)	4 (high)	
	BULL CREEK MD	PSDTBCMD	0	4 (low)	4 (high)	
	BRENTWOOD DRAIN	MELDR-13	0	3 (low)	4 (high)	4
	RAAF DRAIN	MELDR-14	0	1 (low)	4 (high)	
	BATEMAN PARK	MELDR-06	0	4 (low)	4 (high)	2
Wetland sites	BOORAGOON LAKE OUTLET	MELDR-07	3 (low)	4 (low)	1 (high)	1
	PINEY LAKES OUTLET	MELDR-08	4 (low)	4 (low)	1 (high)	1
	QUENDA LAKE OUTLET	MELDR-09	3 (low)	4 (low)		
	FREDERICK BALDWIN	MELDR-10	1 (low)	3 (low)	2 (low)	1
	MARMION RESERVE	MELDR-11	0	3 (1 low, 2 high)		
	BLUE GUM LAKE OUTLET	MELDR-12	3 (low)	4 (low)		1
		Total above acceptable range/trigger value	0	2	33	
		Total below acceptable range	21	44	2	
		Total below LOR	NA	NA	NA	6
		Min (site)	5.92 (MELDR-08)	3.7 (MELDR-05)	0.1951 (MELDR-10)	<1 (4 sites)
		Max (site)	8.28 (MELDR-11)	135.5 (MELDR-11)	1.583 (MELDR-08)	54 (MELDR-08)

Key			
Key	Unacceptable values for this parameter on all sampling occasions when analysed	Unacceptable values for this parameter on at least one sampling occasion	Unacceptable values not recorded for this parameter

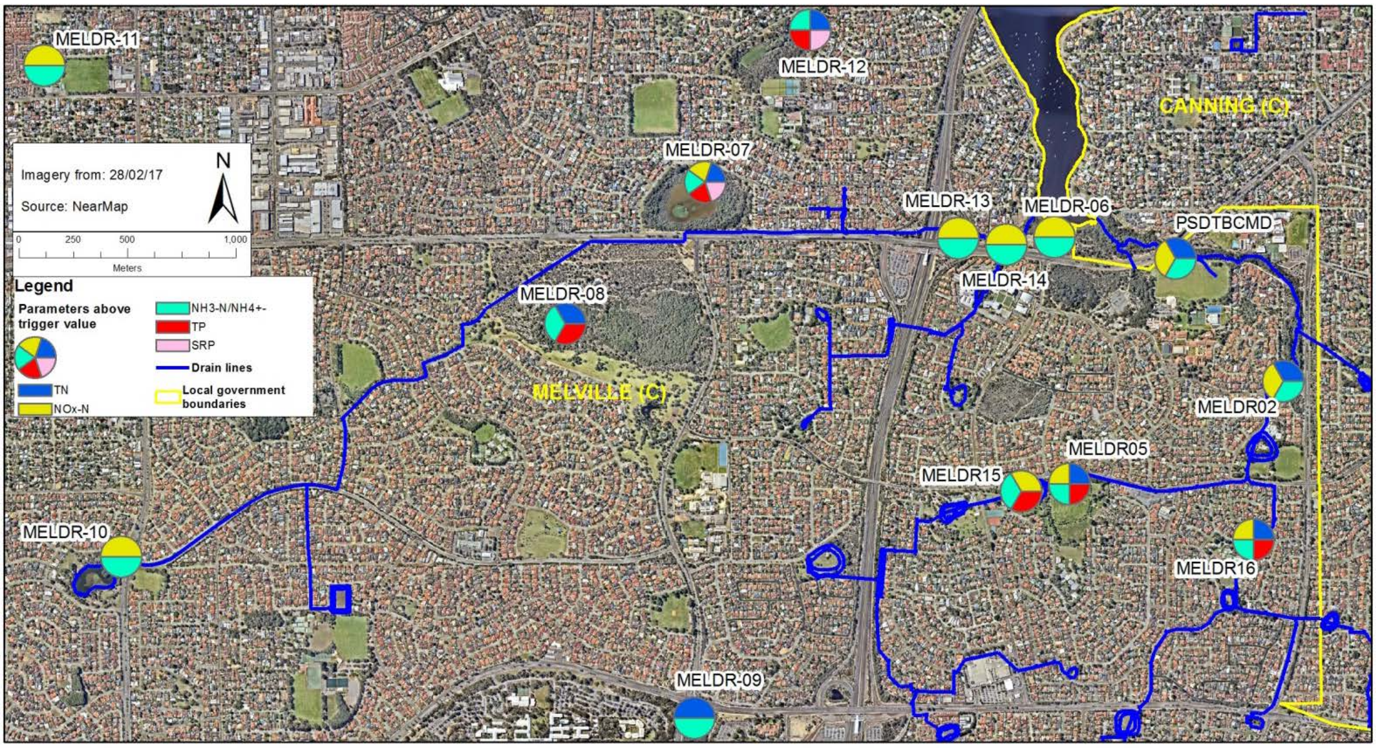

Figure 8.11-2: Map of Melville Bull Creek catchment sites with total nitrogen (TN), total oxidised nitrogen (NOx-N), ammonia nitrogen (NH_3/NH^{4+}-N), total phosphorus (TP) and filterable reactive phosphorus (FRP) concentrations (mg/L) exceeding ANZECC trigger values for lowland rivers or wetlands in 2018.

Table 9-2: Summary of nutrient data recorded in Melville Bull Creek catchment sites in 2018.

		Parameter	Total Nitrogen (mg/L)	Total Oxidised Nitrogen (mg/L)	Ammonia Nitrogen (mg/L)		Dissolved Organic Nitrogen (mg/L)	Total Organic Nitrogen (mg/L)	Total Phosphorus (mg/L)	Soluble Reactive Phosphorus (mg/L)
		Trigger value	ANZECC stressor TVs: lowland rivers: 1.2 wetlands: 1.5	ANZECC stressor TVs: lowland rivers: 0.15 wetlands: 0.1	ANZECC stressor TVs: lowland rivers: 0.08 wetlands: 0.04	ANZECC TV for protection of biota (unadjusted): 0.9	No TV	No TV	ANZECC stressor TVs: lowland rivers: 0.065 wetlands: 0.06	ANZECC stressor TVs: lowland rivers: 6.5-8 wetlands: 7.0 - 8.5
Site			Number of samples above trigger value							
Drain sites	JOHN CREANEY PARK INLET	MELDR-15	0	4	4	0			1	0
	JOHN CREANEY PARK	MELDR-05	1	2	4	0			1	0
	DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	2	3	1	0			1	0
	BROCKMAN PARK	MELDR-02	4	3	4	4			0	0
	BULL CREEK MD	PSDTBCMD	4	4	4	0			0	0
	BRENTWOOD DRAIN	MELDR-13	0	4	4	0			0	0
	RAAF DRAIN	MELDR-14	0	3	2	0			0	0
	BATEMAN PARK	MELDR-06	0	4	4	0			0	0
Wetland sites	BOORAGOON LAKE OUTLET	MELDR-07	4	3	4	0			4	4
	PINEY LAKES OUTLET	MELDR-08	3	0	3	0			1	0
	QUENDA LAKE OUTLET	MELDR-09	1	0	1	0			0	0
	FREDERICK BALDWIN	MELDR-10	0	2	3	0			0	0
	MARMION RESERVE	MELDR-11	0	1	1	0			0	0
	BLUE GUM LAKE OUTLET	MELDR-12	4	0	4	0			4	4
		Total above trigger value	23	33	43	4	NA	NA	12	8
		Total below LOR	0	6	2		0	0	4	34
		Min (site)	0.32 (MELDR-11)	<0.01 (4 sites)	<0.01 (2 sites)		0.032 (MELDR-10)	0.12 (MELDR-02)	<0.005 (4 sites)	<0.005 (11 sites)
		Max (site)	6.2 (MELDR-02)	2.3 (PSDTBCMD)	5.7 (MELDR-02)		2.8 (MELDR-08)	3.8 (MELDR-08)	5.5 (MELDR-07)	4.7 (MELDR-07)

Key				
	Unacceptable values for this parameter on all sampling occasions when analysed	Unacceptable values for this parameter on at least one sampling occasion	Unacceptable values not recorded for this parameter	No trigger value for parameter

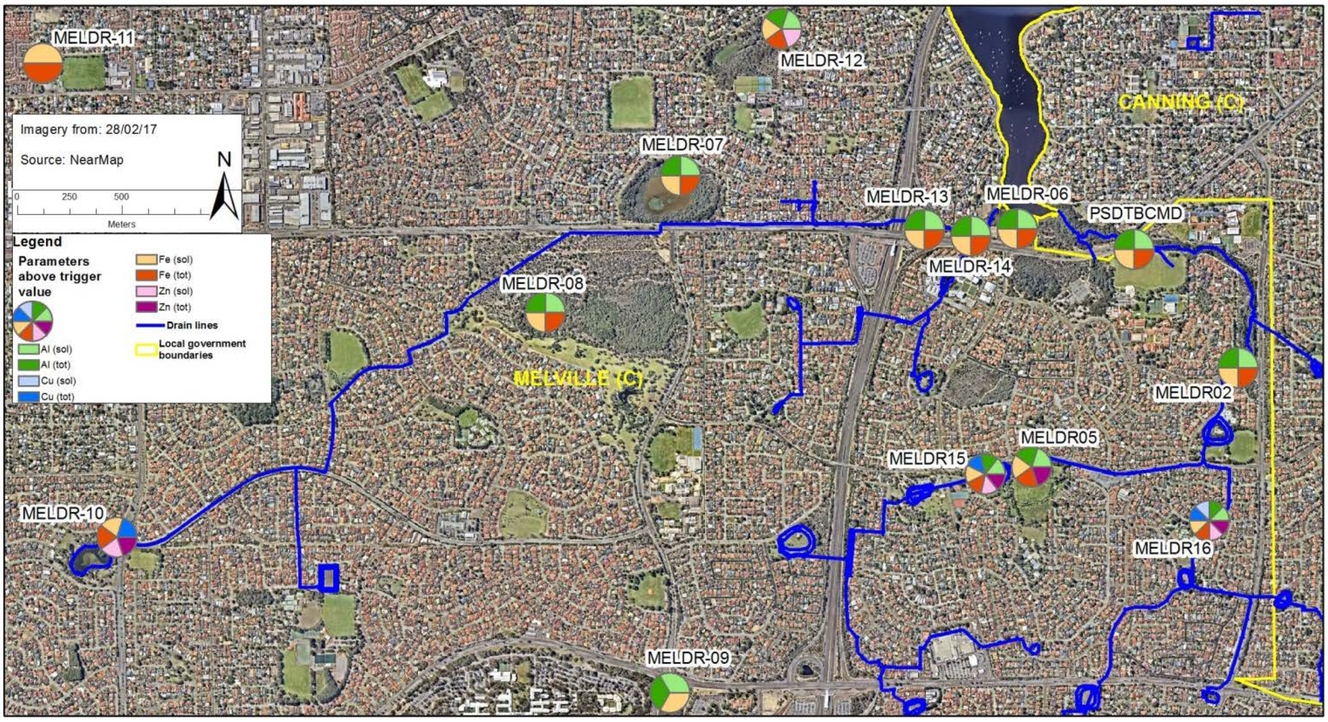

Figure 8.11-3: Map of Melville Bull Creek catchment sites with total and soluble aluminium, copper, iron, and zinc concentrations exceeding the ANZECC trigger value for protection of biota in 2018.

Table 9-3: Summary of metal and hardness data in Melville Bull Creek catchment sites in 2018.

		Parameter	Aluminium (mg/L)		Chromium (mg/L)		Copper (mg/L)		Iron (mg/L)		Lead (mg/L)		Mercury (mg/L)		Zinc (mg/L)		Hardness (mg/L)
		Trigger value for protection of biota	0.055		0.0033 (unadjusted)		0.0014 (unadjusted)		0.3		0.0034 (unadjusted)		0.0006		0.008 (unadjusted)		No TV
			Total	Soluble	Total	Soluble	Total	Soluble	Total	Soluble	Total	Soluble	Total	Soluble	Total	Soluble	
Site			Number of samples above trigger value														
Drain sites	JOHN CREANEY PARK INLET	MELDR-15	1	4	0	0	1	0	1	4	0	0			1	4	
	JOHN CREANEY PARK	MELDR-05	1	4	0	0	0	0	1	4	0	0			0	0	
	DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	1	3	0	0	1	1	1	3	0	0			1	3	
	BROCKMAN PARK	MELDR-02	1	4	0	0	0	0	1	4	0	0			0	0	
	BULL CREEK MD	PSDTBCMD	1	4	0	0	0	0	1	4	0	0			0	0	
	BRENTWOOD DRAIN	MELDR-13	1	4	0	0	0	0	1	4	0	0	0	0	0	0	
	RAAF DRAIN	MELDR-14	1	4	0	0	0	0	1	4	0	0	0	0	0	0	
	BATEMAN PARK	MELDR-06	1	4	0	0	0	0	1	4	0	0	0	0	0	0	
Wetland sites	BOORAGOON LAKE OUTLET	MELDR-07	1	3	0	0	0	0	1	4	0	0			0	0	
	PINEY LAKES OUTLET	MELDR-08	1	4	0	0	0	0	1	4	0	0			0	0	
	QUENDA LAKE OUTLET	MELDR-09	1	4	0	0	0	0	0	3	0	0			0	0	
	FREDERICK BALDWIN	MELDR-10	0	0	0	0	1	0	1	3	0	0			1	2	
	MARMION RESERVE	MELDR-11	0	0	0	0	0	0	1	1	0	0			0	0	
	BLUE GUM LAKE OUTLET	MELDR-12	1	4	0	0	0	0	1	4	0	0			0	2	
		Total above trigger value	12	46	0	0	3	1	13	50	0	0	0	0	3	11	NA
		Total below LOR	0	0	0	4	0	0	0	0	0	4	12	12	0	0	0
		Min (site)	0.027 (MELDR-11)	0.008 (MELDR-11)	0.0002 (MELDR-10 & MELDR-11)	<0.0001 (MELDR-10 & MELDR-11)	0.0004 (MELDR-02)	0.0002 (MELDR-10)	0.19 (MELDR-09)	0.025 (MELDR-11)	0.0003 (MELDR-02)	<0.0001 (MELDR-10 & MELDR-11)	<0.00005 (all sites)	<0.00005 (all sites)	0.007 (4 sites)	0.004 (MELDR-11)	51 (MELDR-10)
		Max (site)	0.57 (MELDR-08 & MELDR-13)	1 (MELDR-08)	0.0026 (MELDR-08)	0.0042 (MELDR-09)	0.0049 (MELDR-15)	0.0037 (MELDR-16)	4.4 (MELDR-05)	4.3 (MELDR-07)	0.0038 (MEDR-12)	0.0058 (MELDR-08)	<0.0001 (all sites)	<0.0001 (all sites)	0.11 (MELDR-15)	0.17 (MELDR-15)	350 (MELDR-07)

Key					
	Unacceptable values for this parameter on all sampling occasions when analysed	Unacceptable values for this parameter on at least one sampling occasion	Unacceptable values not recorded for this parameter	No trigger value for parameter	Parameter not analysed at this site

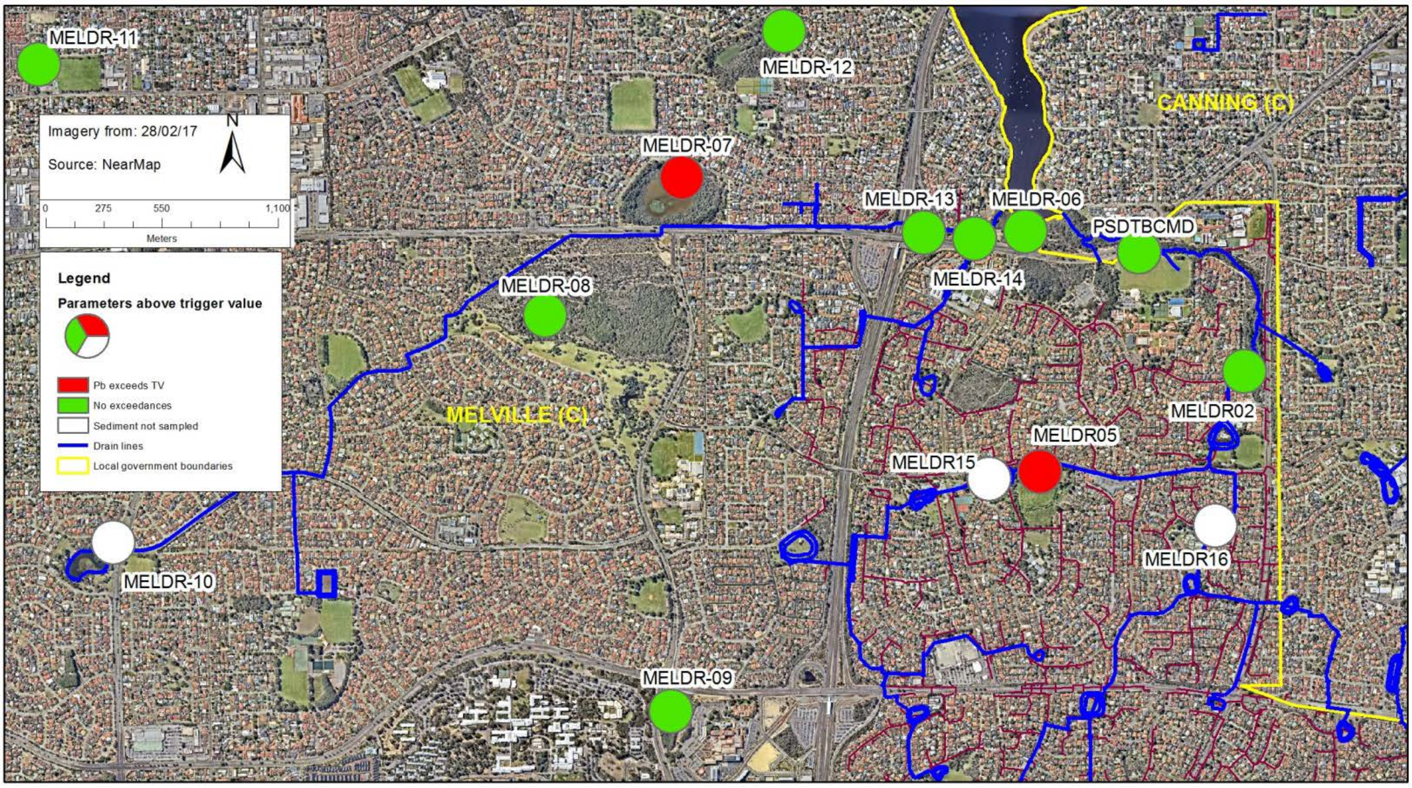

Figure 8.11-4: Map of Melville Bull Creek catchment sites with sediment metal concentrations exceeding ANZECC trigger values for protection of biota in 2018.

Table 9-4: Summary of sediment metal data in Melville Bull Creek catchment sites in 2018.

		Parameter	Total Aluminium (mg/kg)	Total Arsenic (mg/kg)	Total Chromium (mg/kg)	Total Copper (mg/kg)	Total Iron (mg/kg)	Total Lead (mg/kg)	Total Mercury (mg/kg)	Total Nickel (mg/kg)	Total Selenium (mg/kg)	Total Zinc (mg/kg)
		Trigger value	No TV	Low TV: 20 High TV: 70	Low TV: 80 High TV: 370	Low TV: 65 High TV: 270	No TV	Low TV: 50 High TV: 220	Low TV: 0.15 High TV: 1	Low TV: 21 High TV: 52	No TV	Low TV: 200 High TV: 410
Site			Number of samples above low trigger value									
Drain sites	JOHN CREANEY PARK INLET	MELDR-15										
	JOHN CREANEY PARK	MELDR-5		0	0	0		1	0	0		0
	DOWNSTREAM ELIZABETH M	MELDR-16										
	BROCKMAN PARK	MELDR-2		0	0	0		0	0	0		0
	BULL CREEK MD	PSDTBCMD		0	0	0		0	0	0		0
	BRENTWOOD DRAIN	MELDR-13		0	0	0		0	0	0		0
	RAAF DRAIN	MELDR-14		0	0	0		0	0	0		0
	BATEMAN PARK	MELDR-06		0	0	0		0	0	0		0
Wetland sites	BOORAGOON LAKE OUTLET	MELDR-07		0	0	0		1	0	0		0
	PINEY LAKES OUTLET	MELDR-08		0	0	0		0	0	0		0
	QUENDA LAKE OUTLET	MELDR-09		0	0	0		0	0	0		0
	FREDERICK BALDWIN	MELDR-10										
	MARMION RESERVE	MELDR-11		0	0	0		0	0	0		0
	BLUE GUM LAKE OUTLET	MELDR-12		0	0	0		0	0	0		0
		Total above trigger value	0	0	0	0	0	2	0	0	0	0
		Total below LOR	0	0	0	1	0	0	9	2	6	0
		Min (site)	534 (PSDTBCMD)	0.3 (MELDR-09)	0.72 (PSDTBCMD)	<0.5 (MELDR-06)	230 (MELDR-09)	1.3 (MELDR-06)	<0.02 (9 sites)	<0.1 (PSDTBCMD & MELDR-06)	<0.05 (6 sites)	3.6 MELDR-09)
		Max (site)	6770 (MELDR-05)	4.4 (MELDR-05)	16 (MELDR-05)	33 (MELDR-05)	24000 (MELDR-05)	80 (MELDR-07)	0.05 (MELDR-07)	5 (MELDR-13)	0.98 (MELDR-07)	150 (MELDR-05)

Key				
Key	Unacceptable values for this parameter on all sampling occasions when analysed	Unacceptable values not recorded for this parameter	No trigger value for parameter	Parameter not analysed at this site

10. Discussion

10.1 Comparison of 2018 data to previous data

Water and sediment results from samples collected in 2018 were generally similar to results recorded in previous years, with the following exceptions:

- Sites 7 (Booragoon Lake) and 12 (Blue Gum Lake), although still recording three of four pH values less than the ANZECC acceptable range, did not record any particularly low pH values (i.e. less than 5) in 2018 as these sites have done in years prior to 2017;
- Site 11 (Marmion Reserve) recorded acceptable pH values on all four sampling occasions in 2018, whereas high values have been recorded at this site on at least one sampling occasion in 2015, 2016 and 2017;
- Site 7 recorded slightly lower electrical conductivity in 2018 than preceding years;
- Site 11 recorded slightly higher electrical conductivity in 2018 than preceding years;
- Site 8 (Piney Lakes outlet) recorded higher total nitrogen (and nitrogen as ammonia/ammonium and dissolved organic nitrogen) concentrations in 2018 than in previous years. Three of four recorded samples recorded total nitrogen concentrations in exceedance of the ANZECC trigger value when samples at this site have previously recorded acceptable concentrations on most sampling occasions;
- Site 7 recorded particularly high total phosphorus (and filterable reactive phosphorus) concentrations in both 2017 and 2018 compared to preceding years of monitoring data, and especially compared to concentrations recorded between 2012 and 2016. Filterable reactive phosphorus also comprised a higher proportion of total phosphorus in site 7 samples collected in 2017 and 2018 (average 76%) than in samples collected in all preceding years (average 22%).
- While still recording concentrations in exceedance of the ANZECC trigger value, the maximum total phosphorus concentration recorded at site 12 (Blue Gum Lake) in 2018 was at half as low as the maximum concentrations recorded at this site from 2012 to 2017.

10.2 Long term patterns

Monitoring of some sites in the Melville Bull Creek catchment has been occurring for over ten years, allowing long term patterns to be assessed. The following noteworthy long term patterns have been observed in the catchment:

- Dissolved oxygen saturations and pH values are lower, and total nitrogen (and dissolved organic nitrogen) and total aluminium concentrations are higher at site 9 (Quenda Lake outlet) from 2014 to 2018 when compared to 2007 to 2013;
- Site 7 (Booragoon Lake), while still recording very high and variable concentrations, has recorded significantly lower maximum concentrations of total nitrogen from 2012 to 2018 (excepting a high maximum concentration recorded in 2017) than from 2007 to 2011;
- Site 12 (Blue Gum Lake), recorded higher yearly maximum concentrations of total nitrogen and total phosphorus from 2012 to 2017 than from 2007 to 2011. However, the maximum concentrations of these parameters recorded in 2018 are in the range of those recorded from 2007 to 2011. Dissolved oxygen saturations have also been lower at site 12 (Blue Gum Lake) since 2013 than in the preceding years.

10.3 Key Issues

Based on the results, it is considered that Bull Creek main drain, Booragoon Lake and Blue Gum Lake have the poorest water quality in the catchment and therefore management responses should be focussed on improvement of these sites.

10.3.1 Drainage branches

Bull Creek main drain

High total nitrogen concentrations, well in exceedance of the ANZECC trigger value for lowland rivers, have been recorded over the years at particular sites along the Bull Creek main drain since monitoring began in 2007. Total nitrogen is often high at sites along the two upstream branches of the Bull Creek main drain (represented by John Creaney Park outlet (site 5) and downstream Elizabeth Manion Park (site 16)). However a significant portion of nitrogen, predominantly as ammonia/ammonium, is being introduced to the drainage line between the convergence of these two branches and Brockman Park (site 2). This may be originating from groundwater, as high concentrations of ammonia have been recorded in the Jandakot Mound (Larsen et al 1998), and could possibly be even higher in this area as a result of the historical landfill at John Creaney Park (DWER 2017). As water flows from Brockman Park to the most downstream Bull Creek site (PSDTBCMD), total nitrogen concentrations tend to reduce by an average of approximately 50%, perhaps due to uptake of nitrogen by macrophytes, loss to the environment as nitrogen gas or dilution from the drainage branch coming from Rossmoyne Senior High School. The remaining nitrogen at PSDTBCMD is predominantly in the form of oxidised nitrogen rather than ammonia nitrogen, perhaps due to the slight oxygenation of the water occurring between these two sites. The exceeding total nitrogen concentrations consistently recorded at PSDTBCMD are of concern as this nitrogen would contribute to eutrophication of the Swan River. Furthermore, the ammonia concentrations in exceedance of the freshwater protection trigger value at Brockman Park are concerning as the portion of Bull Creek main drain downstream of Brockman Park is known to support a variety of native fauna species including frogs, fish and macroinvertebrates (City of Melville 2014).

The often high phosphorus concentrations at John Creaney Park lake, while not resulting in high phosphorus concentrations in downstream Bull Creek main drain sites, could, in conjunction with high nitrogen concentrations, result in algal and nuisance macrophyte growth in the lake. Filamentous algae has often been observed at this lake over the years of sampling.

Sediment samples collected from John Creaney Park lake have recorded lead concentrations exceeding the ANZECC low trigger value in five out of the last six years. These high concentrations may be a legacy of previous contamination (possibly from the previous landfill at the site) persisting in the sediments due to their fine, organic nature, as lead is strongly bound by fine and organic particles (ANZECC and ARMCANZ 2000). Although lead concentrations in samples from this site have only once exceeded 95% freshwater protection hardness modified trigger values in the previous eleven years of monitoring (in 2007), under certain conditions (e.g. low pH) it could be released from the sediments and into the water column and have toxic effects on biota within the lake, as well as contributing to lead contamination in downstream Bull Creek main drain and the Canning River.

The high concentrations of iron and aluminium recorded at Bull Creek main drain sites are concerning as these metals can have negative effects on biota, however the concentrations recorded are similar to those recorded across all Swan and Canning River drainage catchments (Nice et al 2009). High concentrations of total zinc have been regularly recorded at John Creaney Park inlet and downstream Elizabeth Manion Park, and high total copper concentrations have often been recorded at downstream Elizabeth Manion Park since monitoring of these sites began in 2014. Soluble zinc and copper concentrations recorded at these sites in 2017 and 2018 indicate a significant proportion of these total metals are likely to be soluble. Again however, high exceedances of the trigger values for these metals is common across Swan and Canning River drainage catchments (Nice et al 2009), and concentrations have generally been acceptable at downstream Bull Creek Main Drain sites.

Low oxygen saturations have been consistently recorded in Bull Creek main drain sites over the previous eleven years of sampling catchment. This is a common finding with heavily piped catchments and/or wetlands with excessively high organic loads (either from animal waste or vegetation decomposition), however this is still a concerning issue as low oxygen saturations can be directly harmful to biota, result in increased toxicity of some metals to biota, and result in phosphorus release from sediments and subsequent eutrophication. Dissolved oxygen saturations are particularly low at John Creaney Park, and much lower than at the inlet to the lake. When sampled, the lake at John Creaney Park always contains a large amount of leaf litter and organic debris, which may be contributing to high oxygen demand as this material decomposes. Groundwater, which is generally lower in oxygen than stormwater, may also be filling this lake.

Brentwood drain

Water quality is comparatively good in the Brentwood and Mandala Crescent Branch drain sites (13, 14 and 6). Concentrations of nitrogen as ammonia/ammonium, total and soluble iron and total aluminium have been declining over the twelve years of monitoring at Bateman Park, the most downstream site sampled along the Brentwood Drain. It is too early to determine whether the Brentwood Living Stream project has resulted in improvement of water quality at Bateman Park, as this project was only completed in early 2018. However it should be noted that a preliminary macrophyte study conducted by North Metropolitan TAFE Diploma of Environmental Monitoring and Technology students and staff at Brentwood Living Stream in April and May 2017 recorded the presence of juvenile stoneflies (*Plecoptera*) and hydras (North Metropolitan TAFE 2017), species that are very sensitive to pollution and disturbance, indicating that the Living Stream is already providing a good macroinvertebrate habitat.

Although exceedances of total nitrogen are generally not recorded at these sites, the exceedances of total oxidised nitrogen and nitrogen as ammonia and ammonium (i.e. forms of nitrogen highly available for plant growth) generally recorded in Brentwood drain sites could result in algal or nuisance macrophyte growth in areas of the drains where water is still. The high concentrations of iron and aluminium recorded at these sites are also concerning as these metals can have negative effects on biota, however the concentrations recorded are representative of those recorded across all Swan and Canning River drainage catchments (Nice et al 2009). Dissolved oxygen has also generally been below the ANZECC acceptable range at the three monitored Brentwood and Mandala Crescent Branch drain sites.

10.3.2 Melville lakes

Booragoon Lake and Blue Gum Lake (sites 7 and 12) have usually recorded high total nitrogen (and ammonia) concentrations and almost always recorded high total phosphorus (and filterable reactive phosphorus) concentrations over the past eleven years of sampling. Concentrations of these nutrients recorded since 2007 have been highly variable between years, however often concentrations are higher in spring months than autumn months, which may be due to an accumulation of nutrients in the lakes over the rainy period or due to large waterbird populations in the lakes in spring. The combination of high soluble phosphorus and nitrogen is likely to be a contributing factor to the algae often observed in these lakes, such as the blue-green algal bloom (*Microcystis aeruginosa*) that occurred in Blue Gum Lake in 2018. This is of concern as these lakes have high conservation value and algal blooms can negatively impact upon both the biota and aesthetic value of the lakes.

Although still usually below the trigger value, total nitrogen (largely total organic nitrogen) concentrations at Quenda Lake (site 9) have been higher at the lake since 2014 than in the years prior to this. Total aluminium concentrations have also been higher since 2014 (with concentrations often the highest of all the Melville Lakes) and pH values somewhat lower. It is possible that the lake be receiving more nutrient rich runoff as a result of the surrounding development in the previous five years (Fiona Stanley hospital and surrounding infrastructure). Natural Area Consulting (2016) noted that “stormwater drainage from the hospital car park to the east is causing erosion of the Water Corporation sewerage line embankment, with dislodged soil being washed across the limestone path and into the wetland”, which may be resulting in these changes to water quality.

Although pH values recorded in 2018 (and 2017) at Booragoon Lake outlet and Blue Gum lake outlet were greater than 6.5 on all sampling occasions, pH values at these sites (as well as Piney Lakes outlet to a lesser extent) have often been particularly low (<5) in the previous eleven years of monitoring. These low pH levels are of concern as low pH can increase the toxicity of some metals, and can also have a direct negative effect on biota. The cause of the low pH in these winter to early spring months may be due to oxidation of acid sulfate soils proven at Booragoon Lake (Oldweather 2012) or likely at Blue Gum Lake and Piney Lakes (Department of Environment Regulation 2016) to be present at the lakes and acidification of the overlying lake waters due to generally lowered lake levels and seasonally fluctuating water levels. Lowered lake levels are likely to be as a result of both reduced stormwater flow and lower groundwater levels in the Jandakot Mound resulting from lower rainfall in recent years (Natural Area Consulting 2012a, 2012b). It is possible that the somewhat higher water levels observed at these lakes in winter and spring of 2017 and 2018 may be resulting in less oxidation of acid sulfate soils in the lake beds and therefore less acidity entering the lake waters. Low pH can also be caused by the presence of high concentration of tannins in the water. Tannins are organic compounds derived from plant materials that give water a brown (often described as “tea coloured”) hue, and break down into humic and fulvic acids. The presence of excess plant material in the water is likely to result in the production of high concentrations of tannins. Tannin staining was noted in 2018 on various sampling occasions at sites 7, 8 and 12. Pine needles are known to be a rich source of acidic tannins (Northup et al 1995) and the pine trees adjacent to the wetland at Piney Lakes reserve may be partly responsible for the low pH values at this site.

Regular exceedances of soluble zinc have been recorded at Frederick Baldwin Lake (site 10), partially as a result of the soft water at this site. Exceedances of adjusted trigger values for zinc are reasonably common across the Swan and Canning River drainage catchments (Nice et al 2009). Metal speciation testing could determine the proportion of labile (not complexed) zinc complexed to organic material in water at this site, and thus its actual potential for toxicity (CSIRO 2015); however this speciation testing is relatively costly. Unfortunately sediment could not sampled at this site in 2018 to ascertain sediment metal concentrations. Sediment lead concentrations have always exceeded the trigger value at Booragoon Lake; however lead concentrations in Booragoon Lake waters have always been below adjusted trigger values. This may be because the comparatively fine-grained and organic sediments at Booragoon Lake are effectively trapping lead within the sediments so it is not easily released into the water column.

The high concentrations of iron and aluminium recorded at many Melville lakes sites are concerning as these metals can have negative effects on biota, although the concentrations recorded at most Melville lakes sites are generally similar to those recorded across all Swan and Canning River drainage catchments (Nice et al 2009). Possibly as a result of acid sulfate soil oxidation (DER 2015), total iron concentrations at Booragoon Lake and Blue Gum Lake are particularly high and thus may be more likely to result in damage to biota and/or unsightly iron flocs that compromise water clarity. It is noted that comparatively high concentrations of sediment aluminium and iron been recorded at Booragoon Lake within the previous five years.

Dissolved oxygen has generally been below the ANZECC acceptable range for wetlands at all Melville lakes sites throughout the past twelve years of monitoring, with particularly low median values at Booragoon Lake outlet, Piney Lakes outlet and Blue Gum Lake outlet. Low oxygen can occur in wetlands as a result of excessively high organic loads (either from animal waste or vegetation decomposition), or interaction with groundwater, which is generally comparatively low in oxygen. The lower oxygen at Quenda Lake outlet and Blue Gum Lake outlet in recent years could indicate an increase in oxygen demand at these sites. The low oxygen in these lakes is concerning issue as low oxygen saturations can be directly harmful to biota, result in increased toxicity of some metals to biota, and result in phosphorus release from sediments and subsequent eutrophication.

11. Recommendations

11.1 Site specific recommendations

Bull Creek main drain (PSDTBCMD):

1. Continue to implement the current Bull Creek Reserves Strategic Management Plan: 2014-2019 (City of Melville 2014) to ensure that the restoration of the foreshore is congruent with the long term stability of the natural waterway's ecological and drainage functions.
2. Continue and extend the current floodplain restoration works throughout the Bull Creek reserve.
3. A macroinvertebrate assessment in the restored portion of Bull Creek main drain (starting at site 2 through to PSDTBCMD) is recommended to assess ecological health of the waterway. Annual assessments would allow the effect of changes to the Creek (i.e. water quality changes and habitat development as plants become established) on macroinvertebrates to be assessed.
4. It is understood that riffles are to be installed along Bull Creek to improve dissolved oxygen levels and enhance nitrification (conversion of ammonia to nitrate) in the future. Hydrological studies would need to be conducted to inform riffle construction. Potential locations within the Creek at which these riffles could be installed (as shown in **Figure 11.1-1**) include:
    a. At the beginning of the Bull Creek Reserve at Brockman Park: This location is considered ideal as it easily accessible to plant and is visible to the public;
    b. At the point in the creek in line with the end of the cul-de-sac Forster Court;
    c. Near the amphitheatre of Rossmoyne Senior High School.
5. Riffles should be alternated with deeper pools with anoxic zones to allow denitrification (conversion of nitrate to nitrogen gas).

Figure 11.1-1: Approximate potential location riffles could be installed in Bull Creek.

Brockman Park (MELDR-02):

1. Continue to implement the current Bull Creek Reserves Strategic Management Plan: 2014-2019 (City of Melville 2014b) to ensure that the restoration of the foreshore is congruent with the long term stability of the natural waterway's ecological and drainage functions.
2. Continue and extend the current floodplain restoration works throughout the Bull Creek reserve.
3. Further investigation to determine the source of the very high nitrogen as ammonia/ammonium concentrations at Brockman Park is recommended, as this ammonia/ammonium appears to be contributing a significant amount of the total nitrogen into Bull Creek. This could include the following:
    a. Review of detailed stormwater drainage maps in the area;
    b. Review of groundwater flow maps;
    c. Groundwater monitoring upstream of Brockman Park.
4. Primary physical treatment is required prior to the Brockman Park stormwater pipe inlet to prevent gross pollutants, particulate matter and sediment entering Bull Creek Park waterway and its foreshore. The existing inlet structure requires regular maintenance to remove gross pollutants and sediment. Maintenance should be conducted once a year at minimum, preferably in autumn.
5. Sediment deposition at the Brockman Park outlet structure into Bull Creek has been observed by SERCUL staff on multiple occasions. A source investigation was conducted by SERCUL and Water Corporation staff, which identified that sediment was entering the Bull Creek drainage line as far upstream as Earnest Wild Park. Trevor Gribble Park has also been identified as a potential source of this sediment, as it has a large sandy compensation basin directly connected to the main drainage line upstream. Further investigation into the source is required to develop appropriate management actions.
6. It is understood that planting will be undertaken by the City of Melville in the near future in Trevor Gribble basin to stabilise bare sand areas (see **Figure 11.1-2A**) and thus prevent sediment runoff into the basin outlet and drain during storm events. A sediment and gross pollutant trapping structure could also be installed in the outlet, which would require regular maintenance to remove trapped sediment and gross material. Large amounts of leaf litter and sediment have been observed sitting on top of the outlet grate (see **Figure 11.1-2B**).

Figure 11.1-2: A) Sandy area in Trevor Gribble Park compensation basin where planting is recommended; B) grate in Trevor Gribble Park compensation basin with leaf litter and sediment sitting on top.

John Creaney Park (inlet: MELDR-15, outlet: MELDR-05)

1. Redesign and/or restoration of the lake at John Creaney Park is recommended to improve its water quality, as well as that of the downstream receiving environment (Bull Creek main drain and the Canning River). This restoration could include planting fringing in lake bed vegetation to take up nutrients and metals, installation of a circulator or aerator to improve oxygenation and dredging and disposing of excess silty, organic sediment at this site.
2. In previous years, significant amounts of lawn clippings were observed to be entering the water at John Creaney Park from adjacent park management. Restoration should include creating a larger buffer between lawn and wetland area to reduce organic load entering the basin.
3. Conduct groundwater sampling at John Creaney Park to determine whether contaminated groundwater from the previous landfill at the site is the source of the often high nutrients and poor sediment quality at the site.
4. Drain stencilling may be beneficial at sites along the drainage line such as Stocklands Shopping Centre and West Leeming Primary School to prevent discharge of contaminants into this drainage.

Downstream Elizabeth Manion Park (MELDR 16):

1. Drain stencilling may be beneficial at sites along the drainage line such as Leeming Senior High School and Leeming Primary School to prevent discharge of contaminants into the drainage here;
2. The catchment for the branch of Bull Creek main drain containing site 16 is quite large, and encompasses several stormwater basins, Leeming Senior High School and a portion of drainage from Karel Ave. Sampling upstream of site 16 to determine the source of metal (copper and zinc) and nutrient (total nitrogen and phosphorus) contamination may be difficult (as two of the closest drainage basins upstream at Barracuda Park and William Hall Park were unable be sampled when attempted in 2007 due to lack of flow) but if after five years monitoring contamination at this site is found to be significant consider investigating suitable additional upstream sampling sites.
3. Consider “opening up” closed pipe systems beneath upstream stormwater compensating basins that are generally dry to incorporate some form of treatment to water passing through the site. This may be appropriate for the basin at William Hall Park; however the feasibility of this would require further investigation.

Bateman Park (MELDR-06), Brentwood drain (MELDR-13) and RAAF drain (site 14):

1. Facilitate the maintenance of the Brentwood Living Stream restoration site: the rock riffles installed as part of the Brentwood Living stream project will trap sediment that will require routine removal by the Water Corporation as part of its ongoing maintenance plan agreement. It is understood the City of Melville has installed a fence along Leach Highway to train gross pollutants/rubbish and stop it blowing into the site.
2. Following construction of the Brentwood drain, it is very important to continue monitoring this site for changes to the water quality to assess the impact/effectiveness of the restoration works. It may take several years before the Living Stream’s capacity to improve water quality reaches full effectiveness. Furthermore, Water Corporation and Main roads are in the planning stages for the reconstruction of the upstream Cloverleaf compensating basin (located at the off ramp of Leach Highway to Kwinana Freeway South bound) to mitigate the poor water quality issues from the freeway runoff and subsequently reduce negative impacts in the Brentwood drain downstream. Water quality monitoring results at site 13 will allow for the assessment of the impact of these works on the overall outcome of the Brentwood Living Stream project.
3. It may of benefit to consider providing education materials to the grounds staff at the RAAF nursing home facility to ensure optimal management of the lake there to reduce nitrogen entering this drainage line. This could include the City of Melville’s Protecting Your Wetlands brochure, which is understood to have been recently updated, or SERCUL’s Phosphorus Awareness Project brochure (http://sercul.org.au/docs/PAP.pdf).

Booragoon Lake outlet (MELDR-07)

1. Continue the replacement of grass surrounding the Lake with native species to prevent further ingress of grass into the Lake and help to filter runoff entering the lake from the surrounding area. It is understood that grass removal has most recently been conducted along the Lake’s southern edge and this area will be revegetated in winter 2019.
2. Continue the removal and control of other invasive species, which contribute to the large loads of organic material to the lake and prevent the growth of native understorey species, and replacement of these with native species.

3. It is recommended that all drainage outlets to the lake are revegetated in a similar manner to the recently redesigned outlets on the western side of the lake in an effort to improve gross pollution management.
4. Ensure that excess sediment and litter is periodically removed from the drainage basin in the north-east corner of the Lake as necessary. This will decrease sediments (and associated nutrients and metals) entering the Lake body (DoE 2004).
5. Considering the excessively high levels of total and soluble phosphorus it is recommended to investigate possible treatment methods for the control/removal of phosphorus in a wetland environment such as an application program for Phoslock.
6. Potential and existing acid sulfate soils have be shown to be present in Lake sediments in a preliminary acid sulfate soil investigation, and in combination with relatively low and fluctuating water levels are likely to be producing low pH levels in the lake (Oldweather 2012). It may be possible to neutralise acidity in the Lake originating from oxidation of acid sulfate soils with materials such as aglime, sodium bicarbonate, hydrated lime or quicklime as described by Department of Environment Regulation (2015). Increasing Lake pH may also reduce mobilisation of metals from sediment, resulting in lower water concentrations of some metals. It is understood that the applicability of these products to lakes within the City of Melville is currently being investigated. DWER may be able to provide some advice regarding these products. However if pH levels in the lake remain similar to those recorded in 2017 and 2018 this may not be necessary.
7. In future monitoring programs, consider analysis of water samples for arsenic, mercury and nickel, as exceedances of trigger values for these metals have been recorded in sediments collected from this site in previous years.
8. Consider speciation testing for zinc and copper to determine the labile (and therefore bioavailable) proportion of these metal concentrations, as a proportion of the metals present may be complexed with dissolved organic material and therefore may not be toxic.
9. Macroinvertebrate sampling is recommended to provide an indication of eutrophic status and species richness in this lake of high conservation value.
10. It is understood the existing Booragoon Lake Management Plan (Natural Area Consulting 2012a) is currently being updated. It is recommended that the above actions are considered by the report authors for inclusion into the new management plan.

Piney Lakes outlet (MELDR-08):

1. As low water levels have been observed at this lake in previous years (although not in 2017 and 2018) consider monitoring of water levels throughout the year to allow for appropriate planning to occur.
2. Further to the above, investigation into ecological water requirements (EWRs) for this EPP (WA 073) groundwater dependant wetland is required to determine the possible risk-of-impact of drawdown on the key elements of wetland ecosystem integrity (ecosystem processes, biodiversity, abundance and biomass of biota and quality of water and sediment) and allow for appropriate mitigation strategies to be devised.
3. Reducing the amount of grass and implementing hydrozoning of vegetation in parklands surrounding Piney Lakes will help to reduce groundwater abstraction. It is understood hydrozoning is currently being trialled at parks within the City of Melville. Reducing groundwater abstraction may help to increase maintain sufficient water levels at the Lakes.

Blue Gum Lake outlet (MELDR-12):

1. Continue with the current restoration works on the foreshore of the lake with native species particularly with native sedges and wetland plants.
2. Continue the removal and control of other invasive species, which contribute to the large loads of organic material to the lake and prevent the growth of native understorey species, and replacement of these with native species.
3. Several outlets to the Lake have been redesigned in recent years to incorporate nutrient stripping plant species. Consider undertaking similar works in the remaining outlets to the Lake as outlined in the Blue Gum Lake Reserve Strategic Management Plan (Natural Area Consulting 2012b).
4. Reticulation and fertiliser application practices of upstream Karoonda Park should be reviewed to ensure that a minimum of nutrient enriched runoff is entering the lake from this park.
5. Considering the excessively high levels of total and soluble phosphorus it is recommended to investigate possible treatment methods for the control/removal of phosphorus in a wetland environment such as an application program for Phoslock.
6. Where this has not already been done, create a barrier between the foreshore and lawn verge to prevent encroachment of lawn grasses and weeds to facilitate a definite edge for more efficient park management.

7. The City of Melville has established an MOU with the Blue Gum Park Tennis Club in regards to fertiliser use and the storage of fertiliser within the tennis club precinct which involves regular inspections of the premises and annual meeting to discuss the progress and improvements. The City has established a good working relationship with the club and indicated this is an ongoing commitment to reduce the risk of impact to the Blue Gum Lake and its foreshore.
8. Given the particularly low pH of waters previously recorded at the site (although less so in 2017 and 2018), consider conducting an acid sulfate soil investigation at the lake to determine the extent of acid sulfate soils and consider options for mitigation.
9. Consider speciation testing for aluminium, zinc and copper to determine the labile (and therefore bioavailable) proportion of these metal concentrations, as some of the metals present may be complexed with dissolved organic material.
10. Macroinvertebrate sampling is recommended to provide an indication of eutrophic status and species richness in this lake of high conservation value.
11. It is understood the existing Blue Gum Lake Management Plan (Natural Area Consulting 2012b) is currently being updated. It is recommended that the above actions are considered by the report authors for inclusion into the new management plan.

Quenda Lake outlet (MELDR-09):

1. Continued monitoring of this site is recommended to see the long term impact of the new drainage works from Main Roads, road construction and new building infrastructure upgrades in the surrounding areas.
2. As recommended by Natural Area Consulting (2016), it is recommended the City determine an appropriate management solution for the erosion caused by the stormwater entering the site from the hospital car park in liaison with stakeholders from St. Johns Hospital and the Water Corporation.
3. Continue implementing the other objectives included in the Quenda Wetland Reserve Strategic Management Plan (Natural Area Consulting 2016).

Frederick Baldwin (MELDR-10):

1. Continue consideration of the replacement of *Casuarina cunninghamiana* (Sydney she-oak) with local wetland tree species (*Melaleuca rhaphiophylla, Eucalyptus rudis*) in a staged fashion to reduce the weed seeding of downstream wetlands and waterways and increase nutrient uptake. Removing these trees will remove the needles which prevent the growth of understorey riparian vegetation.
2. Implement a foreshore revegetation program simultaneously with installation of bio-filtration sedge plantings to provide a buffer between the lawn recreational area and the lake foreshore. This will improve the aesthetics as well as improving the filtration of surface water entering the lake.
3. Signage is currently being developed at the lake to increase community awareness of where this lake's water comes from and where the lake water flows to encourage the community to consider responsible use of stormwater drainage.
4. Consider the placement of an aeration fountain to improve oxygen levels within the lake.

Marmion Reserve (MELDR-11):

1. It may be of benefit to consider providing educational materials to the grounds staff at the adjacent retirement villages on the west side of Marmion reserve to ensure gardening activities do not result in additional pollution to the lake. This could include the City of Melville's Protecting Your Wetlands brochure, which is understood to have been recently updated, or SERCUL's Phosphorus Awareness Project brochure (http://sercul.org.au/docs/PAP.pdf).
2. Continue to maintain the completed City of Melville foreshore restoration project. This project included the planting of island and large areas surrounding the lake with sedges and other dryland species and the removal of weeds.
3. It is understood that the City of Melville has removed collapsed and aging willows on the Lake island and from around the lake as well as older shrubs and weedy shrubs from around the lake and plans to replace this with native tree species. As willow trees are deciduous and known to produce large volumes of leaf litter (Latta 1974), this should provide a positive benefit to lake water quality by reducing the leaf litter entering the lake.

11.2 Catchment wide recommendations

1. Continue with the implementation of the Bull Creek Water Quality Improvement Plan (WQIP).
2. Continue monitoring the water and sediment quality at all sites in the catchment to generate more interpretable data about the condition of the catchment, to determine patterns and changes that may be happening over time and to detect anomalies in the concentrations of parameters that may occurring in response to events.
3. The City of Melville is preparing Stormwater Management Guidelines in 2019. These guidelines will reference appropriate guidelines and regulations and prescribe ideal structural and non-structural practices for managing stormwater to ensure the best environmental outcomes for the City's waterbodies as well as the Swan Canning River system. It is recommended that these guidelines are considered by the City when making decisions that may impact stormwater quality.
4. Low oxygen saturations within the wetlands, lakes and waterways of this catchment are common. This is a consistent finding with heavily piped catchments and/or wetlands with excessively high organic loads (either from animal waste or vegetation decomposition). It is recommended that wherever possible open water inlets and if possible outlets should flow over loosely arrange rocky substrate that provides some oxygenation during medium to high flow events. This, along with open water areas that allow wind driven oxygen transfer and appropriate wetland designs which allow for seasonal wetting/drying processes to assist microbial activity (breaking down organic matter) may provide a collective improvement in oxygenation over time.
5. It is recommended that audits of industrial premises, consistent with the Light Industry Program (LIP), are continued to be conducted by trained City of Melville officers. As part of the LIP program, a joint initiative between DWER, DBCA and local governments (including the City of Melville) conducted from 2015 to 2018, inspections of premises were conducted with the aim of reducing contaminants being released into groundwater and stormwater drainage.
6. It is understood that City of Melville parks and gardens staff have undertaken SERCUL's Fertilise Wise training in the past (http://www.fertilisewise.com.au/docs/FWFertiliserTrainingAdvert.pdf). It is recommended that all parks and gardens staff who have not previously attended this training (or a similar course) should do so. The best management practices taught as part of this training should be implemented when managing parks, including optimal timing of fertiliser application and calculation of optimal rates of fertiliser application.
7. Four schools in the City of Melville have participated in SERCUL's Phosphorus Awareness Program in 2018, which involves education of both primary and high school students about how actions undertaken in the home and garden can impact the environment (https://www.sercul.org.au/for-educators/incursions-and-excursions/). It is recommended that other schools in the Melville Bull Creek catchment are encouraged to participate in this program.
8. Continue to educate residents about appropriate plant species, fertiliser and water use (Piney programs, brochures, mail outs and work with community groups);
9. As proposed in the WQIP for Bull Creek Catchment, review historical and current land use data, in particular contaminated and old tip sites, to identify potential sources of contaminants, prioritise areas requiring further investigation and identify management options;
10. As recommended in the Stormwater Management Manual for Western Australia (DoE 2004), coordinate road sweeping with maintenance activities (i.e. road or construction works) and specific events (i.e. storm events or public major events). Best results can be achieved by focusing on 'hot spots' rather than routinely sweeping all streets;
11. Continue to regularly remove accumulated pollutants (e.g. sediment and gross pollutants) from nodes in the stormwater network, such as pits and infiltration sumps;
12. Incorporate water sensitive urban design techniques into management practices when upgrading the catchment (e.g. permeable paving, bio-retention swales, pipe-less streets and rain gardens);
13. Continue to ensure the use of herbicides and insecticides on roadsides in undertaken as per manufacturer's recommendations, and ensure maintenance staff use appropriate handling and application procedures for these materials;
14. Continue to regularly conduct soil test and leaf tissue analysis on turf areas before applying fertilisers;
15. Continue to use native vegetation along roadsides, paths and in swales.
16. Continue to revegetate natural areas and remove weeds to increase biodiversity.
17. The following issues should be considered when formulating ASS environmental management strategies:

a) The sensitivity and environmental values of the receiving environment. This includes the conservation, protected or other relevant status of the receiving environment (e.g. wetlands, Marine Parks, etc.).
b) Whether groundwater and/or surface water are likely to be directly or indirectly affected.
c) The heterogeneity, geochemical and textural properties of soils on site.
d) The management and planning strategies of local government and/or state government.

18. The following examples of structural best management practices to be incorporated into management plans where appropriate:
    - Onsite detention;
    - Stormwater infiltration systems;
    - Buffer strips;
    - Pollutant traps;
    - Grass or reed swale drains;
    - Broken or flush kerbing;
    - Pervious paving materials;
    - Nutrient intervention installation
    - Native landscaping; and
    - Ponds and wetlands including implementation of living streams with the involvement of the community to provide multiple positive effects by increasing public awareness and further improving water quality.

12. References

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Appendix A ANZECC Trigger Values and Guidelines

Table A-1: Trigger values for physicochemical parameters and nutrients

Guideline	pH	DO % Sat	EC (mS/cm)	TSS (mg/L)	TN (mg/L)	NO_x-N (mg/L)	NH_3-N/NH_4-N (mg/L)	TP (mg/L)	FRP (mg/L)
Guideline values for recreational use (NHMRC 2008)	6.5-8.5	>80	-	-	-	30 (for NO_2^-) 500 (for NO_3^-) (health)	5 (aesthetic)	-	-
ANZECC Water Quality Trigger Values - lowland river (2000)	6.5-8.0	80-120	0.12-0.3	-	1.2	0.15	0.08	0.065	0.04
ANZECC Water Quality Trigger Values wetland (2000)	7-8.5	90-120 (>6mg/L)	0.3-1.5	-	1.5	0.10	0.04	0.06	0.03
ANZECC Water Quality Trigger Values - freshwater protection (2000)	-	-	-	-	-	-	0.9	-	-
DoW (n.d.) interim guideline	-	-	-	6	-	-	-	-	
Chemcentre Limit of Reporting	-	-	-	1	0.025	0.01	0.01	0.005	0.005

[1]Trigger value not adjusted for pH and temperature

Table A-2: Trigger values for metals in water

Guideline	Al (mg/L)	Cr (mg/L)	Co (mg/L)	Cu (mg/L)	Fe (mg/L)	Pb (mg/L)	Hg (mg/L)	Zn (mg/L)	Hardness (mg/L)
Recreational use guideline values (NHMRC 2008, NHMRC 2016)	-	0.5[5] (health)	-	10 (aesthetic) 20 (health)	3 (aesthetic)	0.1 (health)	0.01 (health)	30 (aesthetic)	-
ANZECC Water quality trigger value – Freshwater 95% (2000)	0.055[1]	0.0033[2,3]	0.0028[3]	0.0014[2]	0.3[4]	0.0034[2]	0.0006	0.008[2]	-
Chemcentre Limit of Reporting (required)	0.005	0.0001	0.001	0.0001	0.005	0.0001	0.0001	0.001	5

[1]Applicable only when pH>6.5, when pH<6.5 a low reliability interim value of 0.0008 mg/L is applicable
[2]Trigger values not adjusted for water hardness.
[3]Low reliability interim value
[4]Interim guideline
[5] Value for Cr^{6+} used

Table A-3: ANZECC trigger values for metals in sediment

Guideline	Al (mg/kg)	As (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	Hg (mg/kg)	Pb (mg/kg)	Ni (mg/kg)	Se (mg/kg)	Zn (mg/kg)
ANZECC Low Trigger Value (2013)	N.D.	20	80	65	N.D.	0.15	50	21	N.D.	200
ANZECC High trigger value (2013)	N.D.	70	370	270	N.D.	1.0	220	52	N.D.	410
Chemcentre Limit of Reporting	1	0.5	0.5	0.5	1	0.02	0.05	0.1	0.05	1

Appendix B Changes to the monitoring program since 2007

In 2008 the following changes were made:

- Sites MELDR-03, MELDR-04 and MELDR-05 were dropped from the project as they were always dry in 2007 and are only overflow points from the drains rather than being representatives of the drainage network itself.
- The collection of organic carbon samples was discontinued due to insufficient funds.
- Analysis for polycyclic aromatic hydrocarbons, benzene, ethyl benzene, toluene and xylene (BTEX) and total petroleum hydrocarbons in water samples was discontinued from all sites, as they were rarely detected above laboratory limits of reporting in 2007 and due to reduced budget.
- Sampling frequency was altered from quarterly in 2007 to once every two months for 4 events in total in 2008. This is due to the very late start for the project in 2008 due to funding uncertainty.
- Sampling for sediment was discontinued as the City of Melville could not provide sufficient funds to continue this component of the sampling program.

The project started very late in 2008 (September) due to funding uncertainty from the major stakeholder and as a result all winter rains and flows have been missed for the 2008 sampling project. It is possible that this may have an effect on the water quality of the collected samples and the number of samples that can be collected.

In 2009 the following change was made:

- Soluble metals analysis (for soluble aluminium, chromium, copper, iron, lead and zinc) was added at two sites (MELDR-01 and MELDR -06) based on the recommendations from the previous year's results.

In 2010 the following change was made:

- Sampling frequency was altered from every two months to monthly during the winter for four events in total during 2010. This is due to the dry conditions at most of the sites throughout the year.

In 2011 the following changes were made:

- Sampling for metals that have recorded concentrations below the limit of report during the four-year sampling period was discontinued. Therefore, only eight total metals were included in the 2011 sampling program (aluminium, arsenic, chromium, copper, iron, nickel, lead and zinc) and cadmium and mercury were dropped. Surveillance monitoring of arsenic and nickel will be continued as these metals have consistently been detected above the LORs at some sites (particularly arsenic at Bateman Park, Booragoon lake, Frederick Baldwin, Marmion Reserve and Blue Gum Lake and nickel at John Creaney, Bateman Park and Booragoon Lake), despite having not been detected above trigger values.
- Considering the consistent, sometimes widespread, contamination of some metals in the catchment, soluble metals were included to provide data about the concentrations of these metals that may be available for biological uptake and therefore potentially impact on the biota. Soluble metals analysis for aluminium, chromium, copper, iron, lead and zinc was added at four more sites (MELDR-05, MELDR-10, MELDR-11 and MELDR-12). These four sites have consistently recorded concentrations above the trigger value.
- The City of Melville included soluble metals analysis for a fifth site; Booragoon Lake (MELDR-07) due to the works that the City has undertaken there.

There were additional changes to those included in the 2011 SAP due to some very low pH values (<4.5) recorded in Booragoon and Blue Gum Lakes and turtle deaths at Blue Gum lake.

- Addition of six new sites, one at Booragoon Lake (MELDR-BL1) and five at Blue Gum Lake (MELDR-BGL1, MELDR-BGL2, MELDR-BGL3, MELDR-BGL4 and MELDR-BGL5).
- Sampling for total acidity and total alkalinity in water at two existing sites (MELDR-07 and MELDR-12) and the new six sites (listed above).
- Sampling for titratable actual acidity (TAA) in sediment at these two lakes at two existing sites (MELDR-07 and MELDR-12) and the new six sites.

In 2012 the following change was made:

- Sampling at the six new sites (included in 2011) at Booragoon Lake (MELDR-BL1) and Blue Gum Lake (MELDR-BGL1, MELDR-BGL2, MELDR-BGL3, MELDR-BGL4 and MELDR-BGL5) was discontinued. However, if Blue Gum Lake pH falls rapidly again after a period of drying and rewetting, these sites would be sampled for the same parameters than in 2011.

In 2013 the following change were made:

- Due to proposed restoration works upstream Bateman Park site (site 6) two new sites were added upstream this site to collect baseline data from the two drains (Brentwood drain and RAAF drain) before they merge. These two new sites (sites 13 and 14) were sampled during October and November 2013 sampling events and were continued in the 2014 sampling monitoring program. These sites were sampled for the same parameters included at Bateman Park site (site 6).

In 2014 the following changes were made:

- Total metal analysis for mercury (Hg) (originally discontinued in 2011) was added to Bateman Park, Brentwood Drain and RAAF Drain (sites 6, 13 and 14) for suspicions of elevated levels where the proposed earth works may occur in the pending Brentwood MD restoration project. Earlier sediment testing conducted by SRT indicated Hg contamination at the site but subsequent testing was not consistent.
- In an effort to isolate the pollution source/s that were contributing with the poor water quality entering at Brockman Park site (site 2) two new sites were added to the last three sampling events. John Creaney Park inlet and Down Stream Elizabeth Manion Park (site 15 and 16) were tested for the same nutrients and physical parameters included in Brockman Park: dissolved oxygen, pH, temperature and electrical conductivity, total and soluble nutrients and total suspended solids. Additionally, these two sites were tested for the 14 total metals suite recommended by the Department of Water for new sites: aluminium, cadmium, arsenic, chromium, cobalt, copper, iron, mercury, nickel, lead, manganese, molybdenum, selenium, and zinc. Since soluble metals were not included in Brockman Park, they were also no included at the two new sites.
- The eastern side of the catchment (within the City of Canning) was monitored for the first time in 2014 including the Brockman Park inlet (ROSSTAFE) which enters the Bull Creek main drain downstream Brockman Park (site 2) and before Bull Creek MD (PSDTBCMD). The inclusion of the analysis of Brockman Park inlet in this report will provide insight into the relative contributions from the individual segments (Brockman Park in the City of Melville and Rossmoyne Drain in the City of Canning) and their impact downstream on Bull Creek MD (site1).

In 2015 the following changes were made:

- Total arsenic and total nickel in water were discontinued at the 12 original sites (1, 2, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14) as they have always recorded concentrations below the trigger values and on many occasions they have been equal to the limits of reporting at all sites. At the above mentioned 12 sites, six total metals (aluminium, chromium, copper, iron, lead and zinc) were included on one sampling occasion for surveillance, and six soluble metals (aluminium, chromium, copper, iron, lead and zinc) were included on all four sampling occasions.
- The addition of particle size analysis in sediment samples to enable better interpretation of metals concentrations in these samples. Particle size analysis was performed on the same sampling event when sediment samples were taken at 12 of the 15 sites included in the SAP.

Appendix C Temperature and rainfall data

Rain fell on the following Melville Bull Creek sampling dates: 7th August (0.2 mm) and 13th September (0.8 mm) (**Figure** C-1). Significant rainfall (totals of 12.2, 65.2, 10.6 and 9.2 mm respectively) also occurred in the five days prior to each of sampling events respectively. The maximum air temperatures recorded for the four sampling days were 22.8°C on July 10th, 19.4°C on August 7th, and 19.1°C on September 13th and 29.7°C on 9th October (Australian Bureau of Meteorology 2018a).

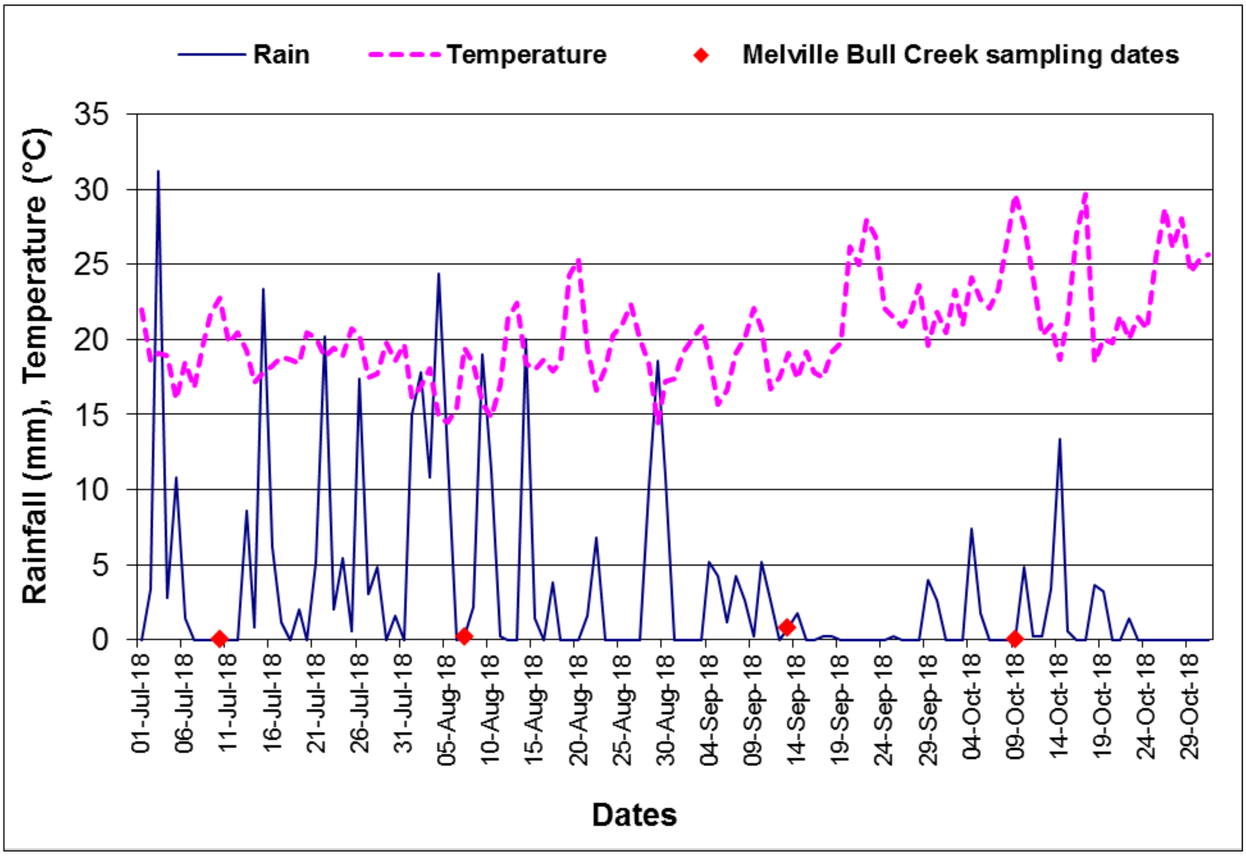

Figure C-1: Daily rainfall (mm) and temperature (°C) in Perth (a combination of observations from Mount Lawley and Perth Airport Metropolitan region) from beginning of July to the end of September 2018 (Source: BOM 2018a)

The Perth metro area recorded above average winter rainfall in 2018 (BOM 2018b), but below average rainfall (and a particularly dry September) in spring (BOM 2018c). Perth Metro recorded above average minimum and overnight maximum temperatures in winter 2018 (BOM 2018b) and slightly below average maximum temperatures in spring 2018 (BOM 2018c).

Appendix D Water quality results tables

Physicochemical parameters in water

Table D-1: pH values recorded in Melville Bull Creek catchment sites in 2018

pH Max (red) 8.28 Min (blue) 5.92

ANZECC trigger value for lowland rivers of SW Australia 6.5 - 8.0; for wetlands 7.0 - 8.5; for recreational value 6.5 - 8.5

Site Name	Site Number	Collect Date	pH (pH units)	Comparison to ANZECC lower limit: 6.5 (lowland rivers) or 7 (wetlands)	Comparison to ANZECC upper limit: 8 (lowland rivers) or 8.5 (wetlands)	Comparison to NHMRC recreational lower limit: 6.5	Comparison to NHMRC recreational upper limit: 8.5	Collect Date	pH (pH units)	Comparison to ANZECC lower limit: 6.5 (lowland rivers) or 7 (wetlands)	Comparison to ANZECC upper limit: 8 (lowland rivers) or 8.5 (wetlands)	Comparison to NHMRC recreational lower limit: 6.5	Comparison to NHMRC recreational upper limit: 8.5
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	6.83	Acceptable	Acceptable	Acceptable	Acceptable	13-Sep-18	6.5	Acceptable	Acceptable	Acceptable	Acceptable
JOHN CREANEY PARK	MELDR-05	10-Jul-18	6.52	Acceptable	Acceptable	Acceptable	Acceptable	13-Sep-18	6.36	Does not meet guidelines	Acceptable	Does not meet guidelines	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	10-Jul-18	NOT SAMPLED					13-Sep-18	7.11	Acceptable	Acceptable	Acceptable	Acceptable
BROCKMAN PARK	MELDR-02	10-Jul-18	6.59	Acceptable	Acceptable	Acceptable	Acceptable	13-Sep-18	6.35	Does not meet guidelines	Acceptable	Does not meet guidelines	Acceptable
BULL CREEK MD	PSDTBCMD	10-Jul-18	7.38	Acceptable	Acceptable	Acceptable	Acceptable	13-Sep-18	6.79	Acceptable	Acceptable	Acceptable	Acceptable
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	7.27	Acceptable	Acceptable	Acceptable	Acceptable	13-Sep-18	6.67	Acceptable	Acceptable	Acceptable	Acceptable
RAAF DRAIN	MELDR-14	10-Jul-18	7.45	Acceptable	Acceptable	Acceptable	Acceptable	13-Sep-18	7.07	Acceptable	Acceptable	Acceptable	Acceptable
BATEMAN PARK	MELDR-06	10-Jul-18	7.47	Acceptable	Acceptable	Acceptable	Acceptable	13-Sep-18	6.91	Acceptable	Acceptable	Acceptable	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	7.05	Acceptable	Acceptable	Acceptable	Acceptable	13-Sep-18	6.81	Does not meet guidelines	Acceptable	Acceptable	Acceptable
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	6.08	Does not meet guidelines	Acceptable	Does not meet guidelines	Acceptable	13-Sep-18	6.78	Does not meet guidelines	Acceptable	Acceptable	Acceptable
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	7.56	Acceptable	Acceptable	Acceptable	Acceptable	13-Sep-18	6.64	Does not meet guidelines	Acceptable	Acceptable	Acceptable
FREDERICK BALDWIN	MELDR-10	10-Jul-18	7.84	Acceptable	Acceptable	Acceptable	Acceptable	13-Sep-18	6.68	Does not meet guidelines	Acceptable	Acceptable	Acceptable
MARMION RESERVE	MELDR-11	10-Jul-18	8.18	Acceptable	Acceptable	Acceptable	Acceptable	13-Sep-18	8.28	Acceptable	Acceptable	Acceptable	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	7.36	Acceptable	Acceptable	Acceptable	Acceptable	13-Sep-18	6.81	Does not meet guidelines	Acceptable	Acceptable	Acceptable
JOHN CREANEY PARK INLET	MELDR-15	7-Aug-18	6.51	Acceptable	Acceptable	Acceptable	Acceptable	9-Oct-18	6.32	Does not meet guidelines	Acceptable	Does not meet guidelines	Acceptable
JOHN CREANEY PARK	MELDR-05	7-Aug-18	6.45	Does not meet guidelines	Acceptable	Does not meet guidelines	Acceptable	9-Oct-18	6.4	Does not meet guidelines	Acceptable	Does not meet guidelines	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	7.27	Acceptable	Acceptable	Acceptable	Acceptable	9-Oct-18	6.85	Acceptable	Acceptable	Acceptable	Acceptable
BROCKMAN PARK	MELDR-02	7-Aug-18	6.45	Does not meet guidelines	Acceptable	Does not meet guidelines	Acceptable	9-Oct-18	6.3	Does not meet guidelines	Acceptable	Does not meet guidelines	Acceptable
BULL CREEK MD	PSDTBCMD	7-Aug-18	6.97	Acceptable	Acceptable	Acceptable	Acceptable	9-Oct-18	6.84	Acceptable	Acceptable	Acceptable	Acceptable
BRENTWOOD DRAIN	MELDR-13	7-Aug-18	7.41	Acceptable	Acceptable	Acceptable	Acceptable	9-Oct-18	6.69	Acceptable	Acceptable	Acceptable	Acceptable
RAAF DRAIN	MELDR-14	7-Aug-18	6.75	Acceptable	Acceptable	Acceptable	Acceptable	9-Oct-18	7.21	Acceptable	Acceptable	Acceptable	Acceptable
BATEMAN PARK	MELDR-06	7-Aug-18	7.23	Acceptable	Acceptable	Acceptable	Acceptable	9-Oct-18	6.83	Acceptable	Acceptable	Acceptable	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	7-Aug-18	6.93	Does not meet guidelines	Acceptable	Acceptable	Acceptable	9-Oct-18	6.87	Does not meet guidelines	Acceptable	Acceptable	Acceptable
PINEY LAKES OUTLET	MELDR-08	7-Aug-18	5.92	Does not meet guidelines	Acceptable	Does not meet guidelines	Acceptable	9-Oct-18	6.56	Does not meet guidelines	Acceptable	Acceptable	Acceptable
QUENDA LAKE OUTLET	MELDR-09	7-Aug-18	6.51	Does not meet guidelines	Acceptable	Acceptable	Acceptable	9-Oct-18	6.57	Does not meet guidelines	Acceptable	Acceptable	Acceptable
FREDERICK BALDWIN	MELDR-10	7-Aug-18	7.2	Acceptable	Acceptable	Acceptable	Acceptable	9-Oct-18	7.31	Acceptable	Acceptable	Acceptable	Acceptable
MARMION RESERVE	MELDR-11	7-Aug-18	7.15	Acceptable	Acceptable	Acceptable	Acceptable	9-Oct-18	7.99	Acceptable	Acceptable	Acceptable	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	7-Aug-18	6.82	Does not meet guidelines	Acceptable	Acceptable	Acceptable	9-Oct-18	6.86	Does not meet guidelines	Acceptable	Acceptable	Acceptable

Table D-2: Dissolved oxygen saturations recorded in Melville Bull Creek catchment sites in 2018

Dissolved oxygen (saturation) Max (red) 135.5 Min (blue) 3.7

ANZECC acceptable range for lowland rivers: 80-120%, wetlands: 90-120%; NHMRC recreational value: >80%

Site Name	Site Number	Collect Date	DO (%)	Comparison to ANZECC lower limit: 80 % (lowland rivers) or 90 % (wetlands	Comparison to ANZECC upper limit: 120% (lowland rivers and wetlands)	Collect Date	DO (%)	Comparison to ANZECC lower limit: 80 % (lowland rivers) or 90 % (wetlands	Comparison to ANZECC upper limit: 120% (lowland rivers and wetlands)
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	60.6	Does not meet guidelines	Acceptable	13-Sep-18	54.2	Does not meet guidelines	Acceptable
JOHN CREANEY PARK	MELDR-05	10-Jul-18	3.7	Does not meet guidelines	Acceptable	13-Sep-18	20.5	Does not meet guidelines	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	10-Jul-18	NOT SAMPLED			13-Sep-18	89.8	Acceptable	Acceptable
BROCKMAN PARK	MELDR-02	10-Jul-18	47.1	Does not meet guidelines	Acceptable	13-Sep-18	56.9	Does not meet guidelines	Acceptable
BULL CREEK MD	PSDTBCMD	10-Jul-18	55.7	Does not meet guidelines	Acceptable	13-Sep-18	62.1	Does not meet guidelines	Acceptable
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	67.7	Does not meet guidelines	Acceptable	13-Sep-18	69.4	Does not meet guidelines	Acceptable
RAAF DRAIN	MELDR-14	10-Jul-18	90.2	Acceptable	Acceptable	13-Sep-18	91.3	Acceptable	Acceptable
BATEMAN PARK	MELDR-06	10-Jul-18	74.4	Does not meet guidelines	Acceptable	13-Sep-18	75.9	Does not meet guidelines	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	18.8	Does not meet guidelines	Acceptable	13-Sep-18	12.3	Does not meet guidelines	Acceptable
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	20.4	Does not meet guidelines	Acceptable	13-Sep-18	39.8	Does not meet guidelines	Acceptable
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	64.1	Does not meet guidelines	Acceptable	13-Sep-18	35.3	Does not meet guidelines	Acceptable
FREDERICK BALDWIN	MELDR-10	10-Jul-18	44.8	Does not meet guidelines	Acceptable	13-Sep-18	18	Does not meet guidelines	Acceptable
MARMION RESERVE	MELDR-11	10-Jul-18	104.5	Acceptable	Acceptable	13-Sep-18	131.4	Acceptable	Does not meet guidelines
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	41.4	Does not meet guidelines	Acceptable	13-Sep-18	26.5	Does not meet guidelines	Acceptable
JOHN CREANEY PARK INLET	MELDR-15	7-Aug-18	42.6	Does not meet guidelines	Acceptable	9-Oct-18	53	Does not meet guidelines	Acceptable
JOHN CREANEY PARK	MELDR-05	7-Aug-18	16.2	Does not meet guidelines	Acceptable	9-Oct-18	6.8	Does not meet guidelines	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	91.2	Acceptable	Acceptable	9-Oct-18	92.6	Acceptable	Acceptable
BROCKMAN PARK	MELDR-02	7-Aug-18	55.7	Does not meet guidelines	Acceptable	9-Oct-18	48.8	Does not meet guidelines	Acceptable
BULL CREEK MD	PSDTBCMD	7-Aug-18	57.8	Does not meet guidelines	Acceptable	9-Oct-18	56.4	Does not meet guidelines	Acceptable
BRENTWOOD DRAIN	MELDR-13	7-Aug-18	93.2	Acceptable	Acceptable	9-Oct-18	71.8	Does not meet guidelines	Acceptable
RAAF DRAIN	MELDR-14	7-Aug-18	68.8	Does not meet guidelines	Acceptable	9-Oct-18	88	Acceptable	Acceptable
BATEMAN PARK	MELDR-06	7-Aug-18	76.7	Does not meet guidelines	Acceptable	9-Oct-18	76.7	Does not meet guidelines	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	7-Aug-18	12.8	Does not meet guidelines	Acceptable	9-Oct-18	15.9	Does not meet guidelines	Acceptable
PINEY LAKES OUTLET	MELDR-08	7-Aug-18	55.2	Does not meet guidelines	Acceptable	9-Oct-18	23.3	Does not meet guidelines	Acceptable
QUENDA LAKE OUTLET	MELDR-09	7-Aug-18	22.7	Does not meet guidelines	Acceptable	9-Oct-18	5.8	Does not meet guidelines	Acceptable
FREDERICK BALDWIN	MELDR-10	7-Aug-18	66.3	Does not meet guidelines	Acceptable	9-Oct-18	101.8	Acceptable	Acceptable
MARMION RESERVE	MELDR-11	7-Aug-18	54.2	Does not meet guidelines	Acceptable	9-Oct-18	135.5	Acceptable	Does not meet guidelines
BLUE GUM LAKE OUTLET	MELDR-12	7-Aug-18	44.8	Does not meet guidelines	Acceptable	9-Oct-18	25.1	Does not meet guidelines	Acceptable

Table D-3: Dissolved oxygen concentrations (mg/L) recorded in Melville Bull Creek catchment sites in 2018

Dissolved oxygen (concentration)

Max (red) 12.52 Min (blue) 0.37

Site Name	Site Number	Collect Date	DO (mg/L)	Collect Date	DO (mg/L)
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	6	13-Sep-18	5.13
JOHN CREANEY PARK	MELDR-05	10-Jul-18	0.37	13-Sep-18	1.93
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	10-Jul-18	NOT SAMPLED	13-Sep-18	8.44
BROCKMAN PARK	MELDR-02	10-Jul-18	4.3	13-Sep-18	5.24
BULL CREEK MD	PSDTBCMD	10-Jul-18	5.5	13-Sep-18	5.9
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	6.49	13-Sep-18	6.49
RAAF DRAIN	MELDR-14	10-Jul-18	9.26	13-Sep-18	8.96
BATEMAN PARK	MELDR-06	10-Jul-18	7.4	13-Sep-18	7.27
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	2.05	13-Sep-18	1.22
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	2.22	13-Sep-18	3.83
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	7.03	13-Sep-18	3.59
FREDERICK BALDWIN	MELDR-10	10-Jul-18	4.62	13-Sep-18	1.68
MARMION RESERVE	MELDR-11	10-Jul-18	10.74	13-Sep-18	12.52
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	4.36	13-Sep-18	2.49
JOHN CREANEY PARK INLET	MELDR-15	7-Aug-18	4.1	9-Oct-18	4.9
JOHN CREANEY PARK	MELDR-05	7-Aug-18	1.55	9-Oct-18	0.62
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	8.97	9-Oct-18	8.41
BROCKMAN PARK	MELDR-02	7-Aug-18	5.17	9-Oct-18	4.44
BULL CREEK MD	PSDTBCMD	7-Aug-18	5.51	9-Oct-18	5.25
BRENTWOOD DRAIN	MELDR-13	7-Aug-18	9.2	9-Oct-18	6.53
RAAF DRAIN	MELDR-14	7-Aug-18	6.43	9-Oct-18	8.18
BATEMAN PARK	MELDR-06	7-Aug-18	7.38	9-Oct-18	7.15
BOORAGOON LAKE OUTLET	MELDR-07	7-Aug-18	1.33	9-Oct-18	1.46
PINEY LAKES OUTLET	MELDR-08	7-Aug-18	5.44	9-Oct-18	2.01
QUENDA LAKE OUTLET	MELDR-09	7-Aug-18	2.38	9-Oct-18	0.57
FREDERICK BALDWIN	MELDR-10	7-Aug-18	6.7	9-Oct-18	8.94
MARMION RESERVE	MELDR-11	7-Aug-18	5.45	9-Oct-18	12.04
BLUE GUM LAKE OUTLET	MELDR-12	7-Aug-18	4.42	9-Oct-18	2.08

Table D-4: Electrical conductivity (mS/cm) recorded in Melville Bull Creek catchment sites in 2018

Electrical Conductivity (EC) Max (red) 1.583 Min (blue) 0.1951

ANZECC trigger value 0.12-0.3 mS/cm for lowland rivers; 0.3 - 1.5 mS/cm for wetlands

Site Name	Site Number	Collect Date	EC (mS/cm)	Comparison to ANZECC lower limit: 0.12 (lowland rivers) or 0.3 (wetlands)	Comparison to ANZECC upper limit: 0.3 (lowland rivers) or 1.5 (wetlands)	Collect Date	EC (mS/cm)	Comparison to ANZECC lower limit: 0.12 (lowland rivers) or 0.3 (wetlands)	Comparison to ANZECC upper limit: 0.3 (lowland rivers) or 1.5 (wetlands)
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	0.5033	Acceptable	Does not meet guidelines	13-Sep-18	0.663	Acceptable	Does not meet guidelines
JOHN CREANEY PARK	MELDR-05	10-Jul-18	1.051	Acceptable	Does not meet guidelines	13-Sep-18	0.768	Acceptable	Does not meet guidelines
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	10-Jul-18	NOT SAMPLED			13-Sep-18	0.6	Acceptable	Does not meet guidelines
BROCKMAN PARK	MELDR-02	10-Jul-18	0.8023	Acceptable	Does not meet guidelines	13-Sep-18	0.779	Acceptable	Does not meet guidelines
BULL CREEK MD	PSDTBCMD	10-Jul-18	0.7704	Acceptable	Does not meet guidelines	13-Sep-18	0.733	Acceptable	Does not meet guidelines
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	0.5947	Acceptable	Does not meet guidelines	13-Sep-18	0.601	Acceptable	Does not meet guidelines
RAAF DRAIN	MELDR-14	10-Jul-18	0.6079	Acceptable	Does not meet guidelines	13-Sep-18	0.652	Acceptable	Does not meet guidelines
BATEMAN PARK	MELDR-06	10-Jul-18	0.6076	Acceptable	Does not meet guidelines	13-Sep-18	0.627	Acceptable	Does not meet guidelines
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	1.5501	Acceptable	Does not meet guidelines	13-Sep-18	1.063	Acceptable	Acceptable
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	1.3963	Acceptable	Acceptable	13-Sep-18	1.239	Acceptable	Acceptable
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	0.6414	Acceptable	Acceptable	13-Sep-18	0.464	Acceptable	Acceptable
FREDERICK BALDWIN	MELDR-10	10-Jul-18	0.1951	Does not meet guidelines	Acceptable	13-Sep-18	0.503	Acceptable	Acceptable
MARMION RESERVE	MELDR-11	10-Jul-18	0.3476	Acceptable	Acceptable	13-Sep-18	0.494	Acceptable	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	0.5926	Acceptable	Acceptable	13-Sep-18	0.502	Acceptable	Acceptable
JOHN CREANEY PARK INLET	MELDR-15	7-Aug-18	0.566	Acceptable	Does not meet guidelines	9-Oct-18	0.665	Acceptable	Does not meet guidelines
JOHN CREANEY PARK	MELDR-05	7-Aug-18	0.804	Acceptable	Does not meet guidelines	9-Oct-18	1.363	Acceptable	Does not meet guidelines
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	0.351	Acceptable	Does not meet guidelines	9-Oct-18	0.629	Acceptable	Does not meet guidelines
BROCKMAN PARK	MELDR-02	7-Aug-18	0.726	Acceptable	Does not meet guidelines	9-Oct-18	0.804	Acceptable	Does not meet guidelines
BULL CREEK MD	PSDTBCMD	7-Aug-18	0.674	Acceptable	Does not meet guidelines	9-Oct-18	0.757	Acceptable	Does not meet guidelines
BRENTWOOD DRAIN	MELDR-13	7-Aug-18	0.598	Acceptable	Does not meet guidelines	9-Oct-18	0.606	Acceptable	Does not meet guidelines
RAAF DRAIN	MELDR-14	7-Aug-18	0.577	Acceptable	Does not meet guidelines	9-Oct-18	0.692	Acceptable	Does not meet guidelines
BATEMAN PARK	MELDR-06	7-Aug-18	0.596	Acceptable	Does not meet guidelines	9-Oct-18	0.63	Acceptable	Does not meet guidelines
BOORAGOON LAKE OUTLET	MELDR-07	7-Aug-18	1.132	Acceptable	Acceptable	9-Oct-18	1.108	Acceptable	Acceptable
PINEY LAKES OUTLET	MELDR-08	7-Aug-18	1.583	Acceptable	Does not meet guidelines	9-Oct-18	1.477	Acceptable	Acceptable
QUENDA LAKE OUTLET	MELDR-09	7-Aug-18	0.401	Acceptable	Acceptable	9-Oct-18	0.75	Acceptable	Acceptable
FREDERICK BALDWIN	MELDR-10	7-Aug-18	0.295	Does not meet guidelines	Acceptable	9-Oct-18	0.524	Acceptable	Acceptable
MARMION RESERVE	MELDR-11	7-Aug-18	0.546	Acceptable	Acceptable	9-Oct-18	0.533	Acceptable	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	7-Aug-18	0.488	Acceptable	Acceptable	9-Oct-18	0.655	Acceptable	Acceptable

Table D-5: Total suspended solids (mg/L) recorded in Melville Bull Creek catchment sites in 2018

Total Suspended Solids (TSS) All data in blue were <1 (LOR)

DoW interim guideline 6 mg/L Max (red) 54 Min (blue) <1

Site Name	Site Number	Collect Date	TSS (mg/L)	Compaison to DWER interim guideline: 6	Collect Date	TSS (mg/L)	Compaison to DWER interim guideline: 6
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	8	Does not meet guidelines	13-Sep-18	4	Acceptable
JOHN CREANEY PARK	MELDR-05	10-Jul-18	15	Does not meet guidelines	13-Sep-18	3	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	10-Jul-18	NOT SAMPLED		13-Sep-18	2	Acceptable
BROCKMAN PARK	MELDR-02	10-Jul-18	3	Acceptable	13-Sep-18	3	Acceptable
BULL CREEK MD	PSDTBCMD	10-Jul-18	3	Acceptable	13-Sep-18	3	Acceptable
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	10	Does not meet guidelines	13-Sep-18	9	Does not meet guidelines
RAAF DRAIN	MELDR-14	10-Jul-18	1	Acceptable	13-Sep-18	2	Acceptable
BATEMAN PARK	MELDR-06	10-Jul-18	6	Does not meet guidelines	13-Sep-18	7	Does not meet guidelines
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	9	Does not meet guidelines	13-Sep-18	<1	Acceptable
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	4	Acceptable	13-Sep-18	<1	Acceptable
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	<1	Acceptable	13-Sep-18	<1	Acceptable
FREDERICK BALDWIN	MELDR-10	10-Jul-18	4	Acceptable	13-Sep-18	5	Acceptable
MARMION RESERVE	MELDR-11	10-Jul-18	2	Acceptable	13-Sep-18	<1	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	2	Acceptable	13-Sep-18	1	Acceptable
JOHN CREANEY PARK INLET	MELDR-15	7-Aug-18	5	Acceptable	9-Oct-18	15	Does not meet guidelines
JOHN CREANEY PARK	MELDR-05	7-Aug-18	4	Acceptable	9-Oct-18	4	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	3	Acceptable	9-Oct-18	8	Does not meet guidelines
BROCKMAN PARK	MELDR-02	7-Aug-18	3	Acceptable	9-Oct-18	3	Acceptable
BULL CREEK MD	PSDTBCMD	7-Aug-18	2	Acceptable	9-Oct-18	4	Acceptable
BRENTWOOD DRAIN	MELDR-13	7-Aug-18	9	Does not meet guidelines	9-Oct-18	16	Does not meet guidelines
RAAF DRAIN	MELDR-14	7-Aug-18	2	Acceptable	9-Oct-18	2	Acceptable
BATEMAN PARK	MELDR-06	7-Aug-18	5	Acceptable	9-Oct-18	5	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	7-Aug-18	3	Acceptable	9-Oct-18	1	Acceptable
PINEY LAKES OUTLET	MELDR-08	7-Aug-18	2	Acceptable	9-Oct-18	54	Does not meet guidelines
QUENDA LAKE OUTLET	MELDR-09	7-Aug-18	<1	Acceptable	9-Oct-18	3	Acceptable
FREDERICK BALDWIN	MELDR-10	7-Aug-18	6	Does not meet guidelines	9-Oct-18	4	Acceptable
MARMION RESERVE	MELDR-11	7-Aug-18	3	Acceptable	9-Oct-18	2	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	7-Aug-18	4	Acceptable	9-Oct-18	12	Does not meet guidelines

Table D-6: Water temperature (°C) recorded in Melville Bull Creek catchment sites in 2018

Water temperature

Max (red) 24.9 Min (blue) 11.2

Site Name	Site Number	Collect Date	Temperature (°C)	Collect Date	Temperature (°C)
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	15.7	13-Sep-18	17.9
JOHN CREANEY PARK	MELDR-05	10-Jul-18	15.4	13-Sep-18	18.1
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	10-Jul-18	NOT SAMPLED	13-Sep-18	18.3
BROCKMAN PARK	MELDR-02	10-Jul-18	19.7	13-Sep-18	19.3
BULL CREEK MD	PSDTBCMD	10-Jul-18	15.8	13-Sep-18	17.7
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	17.3	13-Sep-18	18.5
RAAF DRAIN	MELDR-14	10-Jul-18	14.1	13-Sep-18	16.2
BATEMAN PARK	MELDR-06	10-Jul-18	15.6	13-Sep-18	17.4
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	11.3	13-Sep-18	15.8
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	11.4	13-Sep-18	17.1
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	11.2	13-Sep-18	14.5
FREDERICK BALDWIN	MELDR-10	10-Jul-18	14	13-Sep-18	18.6
MARMION RESERVE	MELDR-11	10-Jul-18	14.1	13-Sep-18	17.6
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	13	13-Sep-18	18.3
JOHN CREANEY PARK INLET	MELDR-15	7-Aug-18	17.1	9-Oct-18	19.1
JOHN CREANEY PARK	MELDR-05	7-Aug-18	17.5	9-Oct-18	19.5
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	16.1	9-Oct-18	20
BROCKMAN PARK	MELDR-02	7-Aug-18	18.8	9-Oct-18	19.9
BULL CREEK MD	PSDTBCMD	7-Aug-18	17.6	9-Oct-18	18.7
BRENTWOOD DRAIN	MELDR-13	7-Aug-18	15.9	9-Oct-18	19.9
RAAF DRAIN	MELDR-14	7-Aug-18	18.6	9-Oct-18	18.8
BATEMAN PARK	MELDR-06	7-Aug-18	17.1	9-Oct-18	18.7
BOORAGOON LAKE OUTLET	MELDR-07	7-Aug-18	13.4	9-Oct-18	19.3
PINEY LAKES OUTLET	MELDR-08	7-Aug-18	15.8	9-Oct-18	22.5
QUENDA LAKE OUTLET	MELDR-09	7-Aug-18	13.2	9-Oct-18	15.9
FREDERICK BALDWIN	MELDR-10	7-Aug-18	14.9	9-Oct-18	21.7
MARMION RESERVE	MELDR-11	7-Aug-18	15.1	9-Oct-18	21.1
BLUE GUM LAKE OUTLET	MELDR-12	7-Aug-18	16	9-Oct-18	24.9

Nutrients in water

Table D-7: Total nitrogen concentrations (mg/L) recorded at Melville Bull Creek catchment sites in 2018

Total Nitrogen (TN) LOR <0.025

ANZECC trigger value for lowland rivers (1.2 mg/L); for wetlands (1.5 mg/L)

Max (red) 6.2 Min (blue) 0.32

Site Name	Site Number	Collect Date	TN (mg/L)	Comparison to ANZECC trigger value: 1.2 (lowland rivers) or 1.5 (wetlands)	Collect Date	TN (mg/L)	Comparison to ANZECC trigger value: 1.2 (lowland rivers) or 1.5 (wetlands)
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	0.98	Acceptable	13-Sep-18	0.93	Acceptable
JOHN CREANEY PARK	MELDR-05	10-Jul-18	1.5	Guideline exceeded	13-Sep-18	0.94	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	10-Jul-18	NOT SAMPLED		13-Sep-18	1.5	Guideline exceeded
BROCKMAN PARK	MELDR-02	10-Jul-18	6.2	Guideline exceeded	13-Sep-18	4.6	Guideline exceeded
BULL CREEK MD	PSDTBCMD	10-Jul-18	3.7	Guideline exceeded	13-Sep-18	3	Guideline exceeded
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	0.73	Acceptable	13-Sep-18	0.66	Acceptable
RAAF DRAIN	MELDR-14	10-Jul-18	0.77	Acceptable	13-Sep-18	0.67	Acceptable
BATEMAN PARK	MELDR-06	10-Jul-18	0.68	Acceptable	13-Sep-18	0.69	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	3.6	Guideline exceeded	13-Sep-18	3.9	Guideline exceeded
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	1.4	Acceptable	13-Sep-18	3	Guideline exceeded
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	0.63	Acceptable	13-Sep-18	1.2	Acceptable
FREDERICK BALDWIN	MELDR-10	10-Jul-18	0.52	Acceptable	13-Sep-18	0.6	Acceptable
MARMION RESERVE	MELDR-11	10-Jul-18	0.34	Acceptable	13-Sep-18	0.32	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	1.6	Guideline exceeded	13-Sep-18	1.8	Guideline exceeded
JOHN CREANEY PARK INLET	MELDR-15	7-Aug-18	0.96	Acceptable	9-Oct-18	0.74	Acceptable
JOHN CREANEY PARK	MELDR-05	7-Aug-18	1.1	Acceptable	9-Oct-18	0.85	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	0.94	Acceptable	9-Oct-18	1.4	Guideline exceeded
BROCKMAN PARK	MELDR-02	7-Aug-18	4	Guideline exceeded	9-Oct-18	5.1	Guideline exceeded
BULL CREEK MD	PSDTBCMD	7-Aug-18	2.7	Guideline exceeded	9-Oct-18	3.3	Guideline exceeded
BRENTWOOD DRAIN	MELDR-13	7-Aug-18	0.69	Acceptable	9-Oct-18	0.72	Acceptable
RAAF DRAIN	MELDR-14	7-Aug-18	0.98	Acceptable	9-Oct-18	0.64	Acceptable
BATEMAN PARK	MELDR-06	7-Aug-18	0.8	Acceptable	9-Oct-18	0.65	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	7-Aug-18	4	Guideline exceeded	9-Oct-18	2.9	Guideline exceeded
PINEY LAKES OUTLET	MELDR-08	7-Aug-18	2.2	Guideline exceeded	9-Oct-18	3.9	Guideline exceeded
QUENDA LAKE OUTLET	MELDR-09	7-Aug-18	1.1	Acceptable	9-Oct-18	2.4	Guideline exceeded
FREDERICK BALDWIN	MELDR-10	7-Aug-18	0.35	Acceptable	9-Oct-18	0.39	Acceptable
MARMION RESERVE	MELDR-11	7-Aug-18	0.84	Acceptable	9-Oct-18	0.44	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	7-Aug-18	1.6	Guideline exceeded	9-Oct-18	2	Guideline exceeded

Table D-8: Total oxidised nitrogen concentrations (mg/L) recorded at Melville Bull Creek catchment sites in 2018

Total Oxidised Nitrogen (NOx) All data in blue were <0.01 (LOR)

ANZECC trigger value: 0.15 mg/L for lowland rivers; 0.10 mg/L for wetlands

Max (red) 2.3 Min (blue) <0.01

Site Name	Site Number	Collect Date	NOx (mg/L)	Comparison to ANZECC trigger value: 0.15 (lowland rivers) or 0.1 (wetlands)	Collect Date	NOx (mg/L)	Comparison to ANZECC trigger value: 0.15 (lowland rivers) or 0.1 (wetlands)
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	0.15	Guideline exceeded	13-Sep-18	0.36	Guideline exceeded
JOHN CREANEY PARK	MELDR-05	10-Jul-18	<0.010	Acceptable	13-Sep-18	0.2	Guideline exceeded
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	10-Jul-18	NOT SAMPLED		13-Sep-18	0.7	Guideline exceeded
BROCKMAN PARK	MELDR-02	10-Jul-18	0.14	Acceptable	13-Sep-18	0.36	Guideline exceeded
BULL CREEK MD	PSDTBCMD	10-Jul-18	2.3	Guideline exceeded	13-Sep-18	1.5	Guideline exceeded
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	0.24	Guideline exceeded	13-Sep-18	0.4	Guideline exceeded
RAAF DRAIN	MELDR-14	10-Jul-18	0.26	Guideline exceeded	13-Sep-18	0.25	Guideline exceeded
BATEMAN PARK	MELDR-06	10-Jul-18	0.23	Guideline exceeded	13-Sep-18	0.34	Guideline exceeded
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	0.037	Acceptable	13-Sep-18	0.27	Guideline exceeded
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	<0.010	Acceptable	13-Sep-18	0.035	Acceptable
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	<0.010	Acceptable	13-Sep-18	0.018	Acceptable
FREDERICK BALDWIN	MELDR-10	10-Jul-18	0.053	Acceptable	13-Sep-18	0.31	Guideline exceeded
MARMION RESERVE	MELDR-11	10-Jul-18	<0.010	Acceptable	13-Sep-18	0.015	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	0.071	Acceptable	13-Sep-18	0.047	Acceptable
JOHN CREANEY PARK INLET	MELDR-15	7-Aug-18	0.28	Guideline exceeded	9-Oct-18	0.15	Guideline exceeded
JOHN CREANEY PARK	MELDR-05	7-Aug-18	0.33	Guideline exceeded	9-Oct-18	0.052	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	0.58	Guideline exceeded	9-Oct-18	0.76	Guideline exceeded
BROCKMAN PARK	MELDR-02	7-Aug-18	0.48	Guideline exceeded	9-Oct-18	0.2	Guideline exceeded
BULL CREEK MD	PSDTBCMD	7-Aug-18	1.7	Guideline exceeded	9-Oct-18	1.8	Guideline exceeded
BRENTWOOD DRAIN	MELDR-13	7-Aug-18	0.32	Guideline exceeded	9-Oct-18	0.32	Guideline exceeded
RAAF DRAIN	MELDR-14	7-Aug-18	0.56	Guideline exceeded	9-Oct-18	0.1	Acceptable
BATEMAN PARK	MELDR-06	7-Aug-18	0.41	Guideline exceeded	9-Oct-18	0.26	Guideline exceeded
BOORAGOON LAKE OUTLET	MELDR-07	7-Aug-18	0.38	Guideline exceeded	9-Oct-18	0.18	Guideline exceeded
PINEY LAKES OUTLET	MELDR-08	7-Aug-18	0.018	Acceptable	9-Oct-18	0.031	Acceptable
QUENDA LAKE OUTLET	MELDR-09	7-Aug-18	<0.010	Acceptable	9-Oct-18	0.02	Acceptable
FREDERICK BALDWIN	MELDR-10	7-Aug-18	0.15	Guideline exceeded	9-Oct-18	0.014	Acceptable
MARMION RESERVE	MELDR-11	7-Aug-18	0.13	Guideline exceeded	9-Oct-18	<0.010	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	7-Aug-18	0.075	Acceptable	9-Oct-18	0.024	Acceptable

Table D-9: Nitrogen as ammonia/ammonium concentrations (mg/L) recorded at Melville Bull Creek catchment sites in 2018

Nitrogen as ammonia/ammonium (sol mg/L) All data in blue were <0.01 (LOR)

ANZECC trigger value for lowland rivers: 0.08 mg/L, wetlands: 0.04 mg/L; NHMRC guideline for recreational value: 5 mg/L

Max (red) 5.70 Min (blue) <0.01

Site name	Site number	Date	NH3-N/NH4-N (sol) (mg/L)	pH	Adjusted ANZECC freshwater protection trigger value (mg/L)	Comparison to adjusted ANZECC freshwater protection trigger value	Comparison to ANZECC trigger value: 0.08 (lowland rivers) or 0.04 (wetlands)	Comparison to NHMRC trigger value for recreation: 5	Date	NH3-N/NH4-N (sol) (mg/L)	pH	Adjusted ANZECC freshwater protection trigger value (mg/L)	Comparison to adjusted ANZECC freshwater protection trigger value	Comparison to ANZECC trigger value: 0.08 (lowland rivers) or 0.04 (wetlands)	Comparison to NHMRC trigger value for recreation: 5
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	0.096	6.83	2.33	Acceptable	Guideline exceeded	Acceptable	13-Sep-18	0.2	6.5	2.46	Acceptable	Guideline exceeded	Acceptable
JOHN CREANEY PARK	MELDR-05	10-Jul-18	0.62	6.52	2.46	Acceptable	Guideline exceeded	Acceptable	13-Sep-18	0.32	6.36	2.54	Acceptable	Guideline exceeded	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	10-Jul-18	NOT SAMPLED						13-Sep-18	0.096	7.11	2.09	Acceptable	Guideline exceeded	Acceptable
BROCKMAN PARK	MELDR-02	10-Jul-18	5.7	6.59	2.46	Guideline exceeded	Guideline exceeded	Guideline exceeded	13-Sep-18	4	6.35	2.54	Guideline exceeded	Guideline exceeded	Acceptable
BULL CREEK MD	PSDTBCMD	10-Jul-18	0.98	7.38	1.88	Acceptable	Guideline exceeded	Acceptable	13-Sep-18	0.88	6.79	2.38	Acceptable	Guideline exceeded	Acceptable
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	0.16	7.27	1.99	Acceptable	Guideline exceeded	Acceptable	13-Sep-18	0.13	6.67	2.43	Acceptable	Guideline exceeded	Acceptable
RAAF DRAIN	MELDR-14	10-Jul-18	0.092	7.45	1.75	Acceptable	Guideline exceeded	Acceptable	13-Sep-18	0.056	7.07	2.18	Acceptable	Acceptable	Acceptable
BATEMAN PARK	MELDR-06	10-Jul-18	0.14	7.47	1.75	Acceptable	Guideline exceeded	Acceptable	13-Sep-18	0.095	6.91	2.26	Acceptable	Guideline exceeded	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	0.38	7.05	2.18	Acceptable	Guideline exceeded	Acceptable	13-Sep-18	0.38	6.81	2.33	Acceptable	Guideline exceeded	Acceptable
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	0.037	6.08	2.57	Acceptable	Acceptable	Acceptable	13-Sep-18	0.045	6.78	2.38	Acceptable	Guideline exceeded	Acceptable
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	<0.010	7.56	1.61	Acceptable	Acceptable	Acceptable	13-Sep-18	0.012	6.64	2.43	Acceptable	Acceptable	Acceptable
FREDERICK BALDWIN	MELDR-10	10-Jul-18	0.2	7.84	1.32	Acceptable	Guideline exceeded	Acceptable	13-Sep-18	0.12	6.68	2.43	Acceptable	Guideline exceeded	Acceptable
MARMION RESERVE	MELDR-11	10-Jul-18	0.02	8.18	0.78	Acceptable	Acceptable	Acceptable	13-Sep-18	<0.010	8.28	0.66	Acceptable	Acceptable	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	0.38	7.36	1.88	Acceptable	Guideline exceeded	Acceptable	13-Sep-18	0.23	6.81	2.33	Acceptable	Guideline exceeded	Acceptable
JOHN CREANEY PARK INLET	MELDR-15	7-Aug-18	0.18	6.51	2.46	Acceptable	Guideline exceeded	Acceptable	9-Oct-18	0.14	6.32	2.54	Acceptable	Guideline exceeded	Acceptable
JOHN CREANEY PARK	MELDR-05	7-Aug-18	0.27	6.45	2.49	Acceptable	Guideline exceeded	Acceptable	9-Oct-18	0.29	6.4	2.49	Acceptable	Guideline exceeded	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	0.034	7.27	1.99	Acceptable	Acceptable	Acceptable	9-Oct-18	0.071	6.85	2.33	Acceptable	Acceptable	Acceptable
BROCKMAN PARK	MELDR-02	7-Aug-18	3.2	6.45	2.49	Guideline exceeded	Guideline exceeded	Acceptable	9-Oct-18	4.7	6.3	2.54	Guideline exceeded	Guideline exceeded	Acceptable
BULL CREEK MD	PSDTBCMD	7-Aug-18	0.51	6.97	2.26	Acceptable	Guideline exceeded	Acceptable	9-Oct-18	0.88	6.84	2.33	Acceptable	Guideline exceeded	Acceptable
BRENTWOOD DRAIN	MELDR-13	7-Aug-18	0.14	7.41	1.75	Acceptable	Guideline exceeded	Acceptable	9-Oct-18	0.14	6.69	2.43	Acceptable	Guideline exceeded	Acceptable
RAAF DRAIN	MELDR-14	7-Aug-18	0.082	6.75	2.38	Acceptable	Guideline exceeded	Acceptable	9-Oct-18	0.074	7.21	1.99	Acceptable	Acceptable	Acceptable
BATEMAN PARK	MELDR-06	7-Aug-18	0.11	7.23	1.99	Acceptable	Guideline exceeded	Acceptable	9-Oct-18	0.095	6.83	2.33	Acceptable	Guideline exceeded	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	7-Aug-18	1.4	6.93	2.26	Acceptable	Guideline exceeded	Acceptable	9-Oct-18	0.34	6.87	2.33	Acceptable	Guideline exceeded	Acceptable
PINEY LAKES OUTLET	MELDR-08	7-Aug-18	0.051	5.92	2.57	Acceptable	Guideline exceeded	Acceptable	9-Oct-18	0.078	6.56	2.46	Acceptable	Guideline exceeded	Acceptable
QUENDA LAKE OUTLET	MELDR-09	7-Aug-18	0.013	6.51	2.46	Acceptable	Acceptable	Acceptable	9-Oct-18	0.04	6.57	2.46	Acceptable	Guideline exceeded	Acceptable
FREDERICK BALDWIN	MELDR-10	7-Aug-18	0.051	7.2	1.99	Acceptable	Guideline exceeded	Acceptable	9-Oct-18	0.015	7.31	1.88	Acceptable	Acceptable	Acceptable
MARMION RESERVE	MELDR-11	7-Aug-18	0.42	7.15	2.09	Acceptable	Guideline exceeded	Acceptable	9-Oct-18	0.014	7.99	1.03	Acceptable	Acceptable	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	7-Aug-18	0.36	6.82	2.33	Acceptable	Guideline exceeded	Acceptable	9-Oct-18	0.11	6.86	2.33	Acceptable	Guideline exceeded	Acceptable

Table D-10: Total organic nitrogen concentrations (mg/L) recorded at Melville Bull Creek catchment sites in 2018

Total Organic Nitrogen (TON) LOR <0.005

Max (red) 3.8 Min (blue) 0.12

Site Name	Site Number	Collect Date	TON (mg/L)	Collect Date	TON (mg/L)
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	0.74	13-Sep-18	0.37
JOHN CREANEY PARK	MELDR-05	10-Jul-18	0.88	13-Sep-18	0.42
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	10-Jul-18	NOT SAMPLED	13-Sep-18	0.7
BROCKMAN PARK	MELDR-02	10-Jul-18	0.37	13-Sep-18	0.29
BULL CREEK MD	PSDTBCMD	10-Jul-18	0.4	13-Sep-18	0.63
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	0.32	13-Sep-18	0.14
RAAF DRAIN	MELDR-14	10-Jul-18	0.42	13-Sep-18	0.36
BATEMAN PARK	MELDR-06	10-Jul-18	0.31	13-Sep-18	0.26
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	3.2	13-Sep-18	3.3
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	1.4	13-Sep-18	2.9
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	0.62	13-Sep-18	1.2
FREDERICK BALDWIN	MELDR-10	10-Jul-18	0.27	13-Sep-18	0.17
MARMION RESERVE	MELDR-11	10-Jul-18	0.32	13-Sep-18	0.3
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	1.2	13-Sep-18	1.6
JOHN CREANEY PARK INLET	MELDR-15	7-Aug-18	0.5	9-Oct-18	0.45
JOHN CREANEY PARK	MELDR-05	7-Aug-18	0.54	9-Oct-18	0.51
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	0.33	9-Oct-18	0.62
BROCKMAN PARK	MELDR-02	7-Aug-18	0.37	9-Oct-18	0.12
BULL CREEK MD	PSDTBCMD	7-Aug-18	0.56	9-Oct-18	0.67
BRENTWOOD DRAIN	MELDR-13	7-Aug-18	0.24	9-Oct-18	0.26
RAAF DRAIN	MELDR-14	7-Aug-18	0.34	9-Oct-18	0.47
BATEMAN PARK	MELDR-06	7-Aug-18	0.28	9-Oct-18	0.29
BOORAGOON LAKE OUTLET	MELDR-07	7-Aug-18	2.3	9-Oct-18	2.4
PINEY LAKES OUTLET	MELDR-08	7-Aug-18	2.1	9-Oct-18	3.8
QUENDA LAKE OUTLET	MELDR-09	7-Aug-18	1.1	9-Oct-18	2.4
FREDERICK BALDWIN	MELDR-10	7-Aug-18	0.14	9-Oct-18	0.37
MARMION RESERVE	MELDR-11	7-Aug-18	0.29	9-Oct-18	0.42
BLUE GUM LAKE OUTLET	MELDR-12	7-Aug-18	1.1	9-Oct-18	1.9

Table D-11: Dissolved organic nitrogen concentrations (mg/L) recorded at Melville Bull Creek catchment sites in 2018

Dissolved Organic Nitrogen (DON) All data in blue were <0.005 (LOR)

Max (red) 2.8 Min (blue) 0.032

Site Name	Site Number	Collect Date	DON (mg/L)	Site Number	Collect Date	DON (mg/L)
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	0.61	MELDR-15	13-Sep-18	0.3
JOHN CREANEY PARK	MELDR-05	10-Jul-18	0.73	MELDR-05	13-Sep-18	0.39
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	10-Jul-18	NOT SAMPLED	MELDR-16	13-Sep-18	0.62
BROCKMAN PARK	MELDR-02	10-Jul-18	0.28	MELDR-02	13-Sep-18	0.27
BULL CREEK MD	PSDTBCMD	10-Jul-18	0.36	PSDTBCMD	13-Sep-18	0.59
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	0.31	MELDR-13	13-Sep-18	0.12
RAAF DRAIN	MELDR-14	10-Jul-18	0.42	MELDR-14	13-Sep-18	0.33
BATEMAN PARK	MELDR-06	10-Jul-18	0.3	MELDR-06	13-Sep-18	0.2
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	2.4	MELDR-07	13-Sep-18	2.4
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	1.2	MELDR-08	13-Sep-18	2.8
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	0.6	MELDR-09	13-Sep-18	1.2
FREDERICK BALDWIN	MELDR-10	10-Jul-18	0.26	MELDR-10	13-Sep-18	0.032
MARMION RESERVE	MELDR-11	10-Jul-18	0.25	MELDR-11	13-Sep-18	0.21
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	1	MELDR-12	13-Sep-18	1.4
JOHN CREANEY PARK INLET	MELDR-15	7-Aug-18	0.38	MELDR-15	9-Oct-18	0.34
JOHN CREANEY PARK	MELDR-05	7-Aug-18	0.49	MELDR-05	9-Oct-18	0.4
DOWNSTREAM ELIZABETH	MELDR-16	7-Aug-18	0.28	MELDR-16	9-Oct-18	0.53
BROCKMAN PARK	MELDR-02	7-Aug-18	0.26	MELDR-02	9-Oct-18	0.077
BULL CREEK MD	PSDTBCMD	7-Aug-18	0.51	PSDTBCMD	9-Oct-18	0.65
BRENTWOOD DRAIN	MELDR-13	7-Aug-18	0.17	MELDR-13	9-Oct-18	0.18
RAAF DRAIN	MELDR-14	7-Aug-18	0.3	MELDR-14	9-Oct-18	0.44
BATEMAN PARK	MELDR-06	7-Aug-18	0.23	MELDR-06	9-Oct-18	0.24
BOORAGOON LAKE OUTLET	MELDR-07	7-Aug-18	2.2	MELDR-07	9-Oct-18	2.4
PINEY LAKES OUTLET	MELDR-08	7-Aug-18	2.1	MELDR-08	9-Oct-18	2.4
QUENDA LAKE OUTLET	MELDR-09	7-Aug-18	1	MELDR-09	9-Oct-18	2.4
FREDERICK BALDWIN	MELDR-10	7-Aug-18	0.094	MELDR-10	9-Oct-18	0.25
MARMION RESERVE	MELDR-11	7-Aug-18	0.21	MELDR-11	9-Oct-18	0.35
BLUE GUM LAKE OUTLET	MELDR-12	7-Aug-18	1	MELDR-12	9-Oct-18	1.6

Table D-12: Total phosphorus concentrations (mg/L) recorded at Melville Bull Creek catchment sites in 2018

Total Phosphorus (TP) (mg/L) All data in blue were <0.005 (LOR)

ANZECC trigger value: 0.065mg/L for lowland rivers; 0.06 mg/L for wetlands

Max (red) 5.5 Min (blue) 0.005

Site Name	Site Number	Collect Date	TP (mg/L)	Comparison to ANZECC trigger value: 0.065 (lowland rivers) or 0.06 (wetlands)	Collect Date	TP (mg/L)	Comparison to ANZECC trigger value: 0.065 (lowland rivers) or 0.06 (wetlands)
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	0.065	Guideline exceeded	13-Sep-18	0.042	Acceptable
JOHN CREANEY PARK	MELDR-05	10-Jul-18	0.087	Guideline exceeded	13-Sep-18	0.029	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	10-Jul-18	NOT SAMPLED		13-Sep-18	0.047	Acceptable
BROCKMAN PARK	MELDR-02	10-Jul-18	<0.005	Acceptable	13-Sep-18	0.018	Acceptable
BULL CREEK MD	PSDTBCMD	10-Jul-18	0.005	Acceptable	13-Sep-18	0.018	Acceptable
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	<0.005	Acceptable	13-Sep-18	0.007	Acceptable
RAAF DRAIN	MELDR-14	10-Jul-18	0.006	Acceptable	13-Sep-18	0.014	Acceptable
BATEMAN PARK	MELDR-06	10-Jul-18	<0.005	Acceptable	13-Sep-18	0.015	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	3.1	Guideline exceeded	13-Sep-18	4.5	Guideline exceeded
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	0.023	Acceptable	13-Sep-18	0.038	Acceptable
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	<0.005	Acceptable	13-Sep-18	0.018	Acceptable
FREDERICK BALDWIN	MELDR-10	10-Jul-18	0.024	Acceptable	13-Sep-18	0.029	Acceptable
MARMION RESERVE	MELDR-11	10-Jul-18	0.028	Acceptable	13-Sep-18	0.027	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	0.18	Guideline exceeded	13-Sep-18	0.25	Guideline exceeded
JOHN CREANEY PARK INLET	MELDR-15	7-Aug-18	0.054	Acceptable	9-Oct-18	0.046	Acceptable
JOHN CREANEY PARK	MELDR-05	7-Aug-18	0.05	Acceptable	9-Oct-18	0.033	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	0.015	Acceptable	9-Oct-18	0.074	Guideline exceeded
BROCKMAN PARK	MELDR-02	7-Aug-18	0.013	Acceptable	9-Oct-18	0.011	Acceptable
BULL CREEK MD	PSDTBCMD	7-Aug-18	0.008	Acceptable	9-Oct-18	0.011	Acceptable
BRENTWOOD DRAIN	MELDR-13	7-Aug-18	0.01	Acceptable	9-Oct-18	0.01	Acceptable
RAAF DRAIN	MELDR-14	7-Aug-18	0.009	Acceptable	9-Oct-18	0.016	Acceptable
BATEMAN PARK	MELDR-06	7-Aug-18	0.006	Acceptable	9-Oct-18	0.007	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	7-Aug-18	3.8	Guideline exceeded	9-Oct-18	5.5	Guideline exceeded
PINEY LAKES OUTLET	MELDR-08	7-Aug-18	0.014	Acceptable	9-Oct-18	0.13	Guideline exceeded
QUENDA LAKE OUTLET	MELDR-09	7-Aug-18	0.01	Acceptable	9-Oct-18	0.018	Acceptable
FREDERICK BALDWIN	MELDR-10	7-Aug-18	0.017	Acceptable	9-Oct-18	0.027	Acceptable
MARMION RESERVE	MELDR-11	7-Aug-18	0.053	Acceptable	9-Oct-18	0.034	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	7-Aug-18	0.21	Guideline exceeded	9-Oct-18	0.21	Guideline exceeded

Table D-13: Filterable reactive phosphorus concentrations (mg/L) recorded at Melville Bull Creek catchment sites in 2018

Filterable Reactive Phosphorus (SRP) All data in blue were <0.005 (LOR)

ANZECC trigger value: 0.04 mg/L for lowland rivers and 0.03 mg/L for wetlands

Max (red) 4.7 Min (blue) <0.005

Site Name	Site Number	Collect Date	SRP (mg/L)	Comparison to ANZECC trigger value: 0.04 (loalnd rivers) or 0.03 (wetlands)	Collect Date	SRP (mg/L)	Comparison to ANZECC trigger value: 0.04 (loalnd rivers) or 0.03 (wetlands)
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	0.034	Acceptable	13-Sep-18	0.011	Acceptable
JOHN CREANEY PARK	MELDR-05	10-Jul-18	0.033	Acceptable	13-Sep-18	0.007	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	10-Jul-18	NOT SAMPLED		13-Sep-18	0.017	Acceptable
BROCKMAN PARK	MELDR-02	10-Jul-18	<0.005	Acceptable	13-Sep-18	<0.005	Acceptable
BULL CREEK MD	PSDTBCMD	10-Jul-18	<0.005	Acceptable	13-Sep-18	<0.005	Acceptable
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	<0.005	Acceptable	13-Sep-18	<0.005	Acceptable
RAAF DRAIN	MELDR-14	10-Jul-18	<0.005	Acceptable	13-Sep-18	<0.005	Acceptable
BATEMAN PARK	MELDR-06	10-Jul-18	<0.005	Acceptable	13-Sep-18	<0.005	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	2.1	Guideline exceeded	13-Sep-18	3.7	Guideline exceeded
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	<0.005	Acceptable	13-Sep-18	<0.005	Acceptable
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	<0.005	Acceptable	13-Sep-18	<0.005	Acceptable
FREDERICK BALDWIN	MELDR-10	10-Jul-18	0.011	Acceptable	13-Sep-18	<0.005	Acceptable
MARMION RESERVE	MELDR-11	10-Jul-18	0.008	Acceptable	13-Sep-18	<0.005	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	0.081	Guideline exceeded	13-Sep-18	0.15	Guideline exceeded
JOHN CREANEY PARK INLET	MELDR-15	7-Aug-18	0.025	Acceptable	9-Oct-18	0.013	Acceptable
JOHN CREANEY PARK	MELDR-05	7-Aug-18	0.023	Acceptable	9-Oct-18	<0.005	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	<0.005	Acceptable	9-Oct-18	0.038	Acceptable
BROCKMAN PARK	MELDR-02	7-Aug-18	<0.005	Acceptable	9-Oct-18	<0.005	Acceptable
BULL CREEK MD	PSDTBCMD	7-Aug-18	<0.005	Acceptable	9-Oct-18	<0.005	Acceptable
BRENTWOOD DRAIN	MELDR-13	7-Aug-18	<0.005	Acceptable	9-Oct-18	<0.005	Acceptable
RAAF DRAIN	MELDR-14	7-Aug-18	<0.005	Acceptable	9-Oct-18	<0.005	Acceptable
BATEMAN PARK	MELDR-06	7-Aug-18	<0.005	Acceptable	9-Oct-18	<0.005	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	7-Aug-18	3.1	Guideline exceeded	9-Oct-18	4.7	Guideline exceeded
PINEY LAKES OUTLET	MELDR-08	7-Aug-18	<0.005	Acceptable	9-Oct-18	0.012	Acceptable
QUENDA LAKE OUTLET	MELDR-09	7-Aug-18	<0.005	Acceptable	9-Oct-18	<0.005	Acceptable
FREDERICK BALDWIN	MELDR-10	7-Aug-18	<0.005	Acceptable	9-Oct-18	<0.005	Acceptable
MARMION RESERVE	MELDR-11	7-Aug-18	0.01	Acceptable	9-Oct-18	<0.005	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	7-Aug-18	0.13	Guideline exceeded	9-Oct-18	0.089	Guideline exceeded

Metals and hardness in water

Table D-14: Water hardness (mg/L) recorded at Melville Bull Creek catchment sites in 2018

Water Hardness			LOR 1 mg/L
Max (red) 350		Min (blue) 51	
Site Name	**Site Number**	**Collect Date**	**Total Water Hardness (mg/L)**
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	100
JOHN CREANEY PARK	MELDR-05	10-Jul-18	260
BROCKMAN PARK	MELDR-02	10-Jul-18	130
BULL CREEK MD	PSDTBCMD	10-Jul-18	130
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	130
RAAF DRAIN	MELDR-14	10-Jul-18	120
BATEMAN PARK	MELDR-06	10-Jul-18	130
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	350
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	180
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	110
FREDERICK BALDWIN	MELDR-10	10-Jul-18	51
MARMION RESERVE	MELDR-11	10-Jul-18	110
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	69
JOHN CREANEY PARK INLET	MELDR-15	7-Aug-18	110
JOHN CREANEY PARK	MELDR-05	7-Aug-18	170
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	62
BROCKMAN PARK	MELDR-02	7-Aug-18	130
BULL CREEK MD	PSDTBCMD	7-Aug-18	120
BRENTWOOD DRAIN	MELDR-13	7-Aug-18	130
RAAF DRAIN	MELDR-14	7-Aug-18	130
BATEMAN PARK	MELDR-06	7-Aug-18	130
BOORAGOON LAKE OUTLET	MELDR-07	7-Aug-18	240
PINEY LAKES OUTLET	MELDR-08	7-Aug-18	220
QUENDA LAKE OUTLET	MELDR-09	7-Aug-18	67
FREDERICK BALDWIN	MELDR-10	7-Aug-18	78
MARMION RESERVE	MELDR-11	7-Aug-18	160
BLUE GUM LAKE OUTLET	MELDR-12	7-Aug-18	56
JOHN CREANEY PARK INLET	MELDR-15	13-Sep-18	120
JOHN CREANEY PARK	MELDR-05	13-Sep-18	160
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	13-Sep-18	120
BROCKMAN PARK	MELDR-02	13-Sep-18	140
BULL CREEK MD	PSDTBCMD	13-Sep-18	130
BRENTWOOD DRAIN	MELDR-13	13-Sep-18	130
RAAF DRAIN	MELDR-14	13-Sep-18	130
BATEMAN PARK	MELDR-06	13-Sep-18	140
BOORAGOON LAKE OUTLET	MELDR-07	13-Sep-18	220
PINEY LAKES OUTLET	MELDR-08	13-Sep-18	320
QUENDA LAKE OUTLET	MELDR-09	13-Sep-18	80
FREDERICK BALDWIN	MELDR-10	13-Sep-18	140
MARMION RESERVE	MELDR-11	13-Sep-18	170
BLUE GUM LAKE OUTLET	MELDR-12	13-Sep-18	65
JOHN CREANEY PARK INLET	MELDR-15	9-Oct-18	120
JOHN CREANEY PARK	MELDR-05	9-Oct-18	170
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	9-Oct-18	120
BROCKMAN PARK	MELDR-02	9-Oct-18	140
BULL CREEK MD	PSDTBCMD	9-Oct-18	140
BRENTWOOD DRAIN	MELDR-13	9-Oct-18	140
RAAF DRAIN	MELDR-14	9-Oct-18	140
BATEMAN PARK	MELDR-06	9-Oct-18	140
BOORAGOON LAKE OUTLET	MELDR-07	9-Oct-18	230
PINEY LAKES OUTLET	MELDR-08	9-Oct-18	260
QUENDA LAKE OUTLET	MELDR-09	9-Oct-18	130
FREDERICK BALDWIN	MELDR-10	9-Oct-18	140
MARMION RESERVE	MELDR-11	9-Oct-18	160
BLUE GUM LAKE OUTLET	MELDR-12	9-Oct-18	89

Table D-15: Total aluminium concentrations (mg/L) recorded in Melville Bull Creek catchment sites in 2018

Total Aluminium (Al) LOR 0.005 mg/L

ANZECC trigger value: 0.055mg/L for 95% Level of protection (or 0.0008 if pH<6.5)

Max (red) 0.57 Min (blue) 0.027

Site Name	Site Number	Collect Date	Al (tot) (mg/L)	pH	Comparison to ANZECC trigger value 95% Level of Protection: 0.055 (or 0.0008 if pH<6.5)
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	0.3	6.83	Guideline exceeded
JOHN CREANEY PARK	MELDR-05	10-Jul-18	0.18	6.52	Guideline exceeded
BROCKMAN PARK	MELDR-02	10-Jul-18	0.31	6.59	Guideline exceeded
BULL CREEK MD	PSDTBCMD	10-Jul-18	0.24	7.38	Guideline exceeded
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	0.57	7.27	Guideline exceeded
RAAF DRAIN	MELDR-14	10-Jul-18	0.15	7.45	Guideline exceeded
BATEMAN PARK	MELDR-06	10-Jul-18	0.44	7.47	Guideline exceeded
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	0.064	7.05	Guideline exceeded
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	0.57	6.08	Guideline exceeded
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	0.24	7.56	Guideline exceeded
FREDERICK BALDWIN	MELDR-10	10-Jul-18	0.04	7.84	Acceptable
MARMION RESERVE	MELDR-11	10-Jul-18	0.027	8.18	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	0.081	7.36	Guideline exceeded
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	07-Aug-18	0.42	7.27	Guideline exceeded

Table D-16: Soluble aluminium concentrations (mg/L) recorded in Melville Bull Creek catchment sites in 2018

Soluble Aluminium (Al) LOR 0.005 mg/L

ANZECC trigger value: 0.055mg/L for 95% Level of protection (or 0.0008 if pH<6.5)

Max (red) 1 Min (blue) 0.008

Site Name	Site Number	Collect Date	Al (sol) (mg/L)	pH	Comparison to ANZECC trigger value 95% Level of Protection: 0.055 (or 0.0008 if pH<6.5)	Collect Date	Al (sol) (mg/L)	pH	Comparison to ANZECC trigger value 95% Level of Protection: 0.055 (or 0.0008 if pH<6.5)
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	0.22	6.83	Guideline exceeded	13-Sep-18	0.23	6.5	Guideline exceeded
JOHN CREANEY PARK	MELDR-05	10-Jul-18	0.13	6.52	Guideline exceeded	13-Sep-18	0.18	6.36	Guideline exceeded
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	10-Jul-18	NOT SAMPLED			13-Sep-18	0.42	7.11	Guideline exceeded
BROCKMAN PARK	MELDR-02	10-Jul-18	0.25	6.59	Guideline exceeded	13-Sep-18	0.29	6.35	Guideline exceeded
BULL CREEK MD	PSDTBCMD	10-Jul-18	0.16	7.38	Guideline exceeded	13-Sep-18	0.19	6.79	Guideline exceeded
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	0.14	7.27	Guideline exceeded	13-Sep-18	0.15	6.67	Guideline exceeded
RAAF DRAIN	MELDR-14	10-Jul-18	0.087	7.45	Guideline exceeded	13-Sep-18	0.095	7.07	Guideline exceeded
BATEMAN PARK	MELDR-06	10-Jul-18	0.11	7.47	Guideline exceeded	13-Sep-18	0.13	6.91	Guideline exceeded
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	0.03	7.05	Acceptable	13-Sep-18	0.14	6.81	Guideline exceeded
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	0.49	6.08	Guideline exceeded	13-Sep-18	0.79	6.78	Guideline exceeded
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	0.21	7.56	Guideline exceeded	13-Sep-18	0.5	6.64	Guideline exceeded
FREDERICK BALDWIN	MELDR-10	10-Jul-18	0.019	7.84	Acceptable	13-Sep-18	0.013	6.68	Acceptable
MARMION RESERVE	MELDR-11	10-Jul-18	0.013	8.18	Acceptable	13-Sep-18	0.011	8.28	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	0.072	7.36	Guideline exceeded	13-Sep-18	0.17	6.81	Guideline exceeded
JOHN CREANEY PARK INLET	MELDR-15	07-Aug-18	0.23	6.51	Guideline exceeded	9-Oct-18	0.19	6.32	Guideline exceeded
JOHN CREANEY PARK	MELDR-05	07-Aug-18	0.23	6.45	Guideline exceeded	9-Oct-18	0.14	6.4	Guideline exceeded
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	07-Aug-18	0.3	7.27	Guideline exceeded	9-Oct-18	0.5	6.85	Guideline exceeded
BROCKMAN PARK	MELDR-02	07-Aug-18	0.34	6.45	Guideline exceeded	9-Oct-18	0.27	6.3	Guideline exceeded
BULL CREEK MD	PSDTBCMD	07-Aug-18	0.23	6.97	Guideline exceeded	9-Oct-18	0.15	6.84	Guideline exceeded
BRENTWOOD DRAIN	MELDR-13	07-Aug-18	0.18	7.41	Guideline exceeded	9-Oct-18	0.13	6.69	Guideline exceeded
RAAF DRAIN	MELDR-14	07-Aug-18	0.13	6.75	Guideline exceeded	9-Oct-18	0.08	7.21	Guideline exceeded
BATEMAN PARK	MELDR-06	07-Aug-18	0.15	7.23	Guideline exceeded	9-Oct-18	0.085	6.83	Guideline exceeded
BOORAGOON LAKE OUTLET	MELDR-07	07-Aug-18	0.091	6.93	Guideline exceeded	9-Oct-18	0.15	6.87	Guideline exceeded
PINEY LAKES OUTLET	MELDR-08	07-Aug-18	1	5.92	Guideline exceeded	9-Oct-18	0.8	6.56	Guideline exceeded
QUENDA LAKE OUTLET	MELDR-09	07-Aug-18	0.77	6.51	Guideline exceeded	9-Oct-18	0.7	6.57	Guideline exceeded
FREDERICK BALDWIN	MELDR-10	07-Aug-18	0.037	7.2	Acceptable	9-Oct-18	0.01	7.31	Acceptable
MARMION RESERVE	MELDR-11	07-Aug-18	0.008	7.15	Acceptable	9-Oct-18	0.008	7.99	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	07-Aug-18	0.1	6.82	Guideline exceeded	9-Oct-18	0.17	6.86	Guideline exceeded

Table D-17: Total chromium concentrations (mg/L) recorded at Melville Bull Creek catchment sites in 2018

Chromium (Cr III) (total) Max (red) 0.0026 Min (blue) 0.0002 LOR = 0.0001

ANZECC unmodified trigger value for protection of biota: 0.0033 mg/L
NHMRC guideline for recreational use (health value): 0.5 mg/L

Site name	Site number	Date	Cr (tot) (mg/L)	Hardness (mg/)	Adjust factor*	Adjusted trigger value	Comparison to ANZECC trigger ADJUSTED value
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	0.0023	100	2.5	0.00825	Acceptable
JOHN CREANEY PARK	MELDR-05	10-Jul-18	0.0023	260	8.4	0.02772	Acceptable
BROCKMAN PARK	MELDR-02	10-Jul-18	0.0015	130	3.7	0.01221	Acceptable
BULL CREEK MD	PSDTBCMD	10-Jul-18	0.0015	130	3.7	0.01221	Acceptable
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	0.0021	130	3.7	0.01221	Acceptable
RAAF DRAIN	MELDR-14	10-Jul-18	0.0014	120	3.7	0.01221	Acceptable
BATEMAN PARK	MELDR-06	10-Jul-18	0.0018	130	3.7	0.01221	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	0.0012	350	8.4	0.02772	Acceptable
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	0.0026	180	4.9	0.01617	Acceptable
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	0.0021	110	2.5	0.00825	Acceptable
FREDERICK BALDWIN	MELDR-10	10-Jul-18	0.0002	51	1	0.0033	Acceptable
MARMION RESERVE	MELDR-11	10-Jul-18	0.0002	110	2.5	0.00825	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	0.0024	69	2.5	0.00825	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	0.001	62	2.5	0.00825	Acceptable

* Hardness range (mg/L)	Adjust factor
0-59	1
60-119	2.5
120-179	3.7
180-240	4.9
>240	9

Table D-18: Soluble chromium concentrations (mg/L) recorded at Melville Bull Creek catchment sites in 2018

Chromium (Cr III) (soluble) Max (red) 0.0041 Min (blue) <0.0001

ANZECC unmodified trigger value for protection of biota: 0.0033 mg/L,
NHMRC guideline for recreational use (health value): 0.5 mg/L

All data in blue were <0.0001 mg/L (LOR)

Site name	Site number	Date	Cr (sol) (mg/L)	Hardness (mg/)	Adjust factor*	Adjusted trigger value	Comparison to ANZECC trigger ADJUSTED value	Date	Cr (sol) (mg/L)	Hardness (mg/)	Adjust factor	Adjusted trigger value	Comparison to ANZECC trigger ADJUSTED value
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	0.002	100	2.5	0.00825	Acceptable	13-Sep-18	0.0014	120	3.7	0.01221	Acceptable
JOHN CREANEY PARK	MELDR-05	10-Jul-18	0.0019	260	8.4	0.02772	Acceptable	13-Sep-18	0.0014	160	3.7	0.01221	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	10-Jul-18	NOT SAMPLED					13-Sep-18	0.0012	120	3.7	0.01221	Acceptable
BROCKMAN PARK	MELDR-02	10-Jul-18	0.0014	130	3.7	0.01221	Acceptable	13-Sep-18	0.0012	140	3.7	0.01221	Acceptable
BULL CREEK MD	PSDTBCMD	10-Jul-18	0.0012	130	3.7	0.01221	Acceptable	13-Sep-18	0.0012	130	3.7	0.01221	Acceptable
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	0.0018	130	3.7	0.01221	Acceptable	13-Sep-18	0.0014	130	3.7	0.01221	Acceptable
RAAF DRAIN	MELDR-14	10-Jul-18	0.0013	120	3.7	0.01221	Acceptable	13-Sep-18	0.0012	130	3.7	0.01221	Acceptable
BATEMAN PARK	MELDR-06	10-Jul-18	0.0014	130	3.7	0.01221	Acceptable	13-Sep-18	0.0013	140	3.7	0.01221	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	0.001	350	8.4	0.02772	Acceptable	13-Sep-18	0.0012	220	4.9	0.01617	Acceptable
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	0.0023	180	4.9	0.01617	Acceptable	13-Sep-18	0.0031	320	8.4	0.02772	Acceptable
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	0.0018	110	2.5	0.00825	Acceptable	13-Sep-18	0.0022	80	2.5	0.00825	Acceptable
FREDERICK BALDWIN	MELDR-10	10-Jul-18	0.0002	51	1	0.0033	Acceptable	13-Sep-18	<0.0001	140	3.7	0.01221	Acceptable
MARMION RESERVE	MELDR-11	10-Jul-18	0.0001	110	2.5	0.00825	Acceptable	13-Sep-18	<0.0001	170	3.7	0.01221	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	0.0022	69	2.5	0.00825	Acceptable	13-Sep-18	0.0019	65	2.5	0.00825	Acceptable
JOHN CREANEY PARK INLET	MELDR-15	7-Aug-18	0.0015	110	2.5	0.00825	Acceptable	9-Oct-18	0.0016	120	3.7	0.01221	Acceptable
JOHN CREANEY PARK	MELDR-5	7-Aug-18	0.0016	170	3.7	0.01221	Acceptable	9-Oct-18	0.0016	170	3.7	0.01221	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	0.0009	62	2.5	0.00825	Acceptable	9-Oct-18	0.0014	120	3.7	0.01221	Acceptable
BROCKMAN PARK	MELDR-2	7-Aug-18	0.0013	130	3.7	0.01221	Acceptable	9-Oct-18	0.0014	140	3.7	0.01221	Acceptable
BULL CREEK MD	PSDTBCMD	7-Aug-18	0.0012	120	3.7	0.01221	Acceptable	9-Oct-18	0.0013	140	3.7	0.01221	Acceptable
BRENTWOOD DRAIN	MELDR-13	7-Aug-18	0.0014	130	3.7	0.01221	Acceptable	9-Oct-18	0.0015	140	3.7	0.01221	Acceptable
RAAF DRAIN	MELDR-14	7-Aug-18	0.0012	130	3.7	0.01221	Acceptable	9-Oct-18	0.0013	140	3.7	0.01221	Acceptable
BATEMAN PARK	MELDR-06	7-Aug-18	0.0014	130	3.7	0.01221	Acceptable	9-Oct-18	0.0014	140	3.7	0.01221	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	7-Aug-18	0.0011	240	4.9	0.01617	Acceptable	9-Oct-18	0.0017	230	4.9	0.01617	Acceptable
PINEY LAKES OUTLET	MELDR-08	7-Aug-18	0.0031	220	4.9	0.01617	Acceptable	9-Oct-18	0.0034	260	8.4	0.02772	Acceptable
QUENDA LAKE OUTLET	MELDR-09	7-Aug-18	0.0027	67	2.5	0.00825	Acceptable	9-Oct-18	0.0041	130	3.7	0.01221	Acceptable
FREDERICK BALDWIN	MELDR-10	7-Aug-18	0.0001	78	2.5	0.00825	Acceptable	9-Oct-18	<0.0001	140	3.7	0.01221	Acceptable
MARMION RESERVE	MELDR-11	7-Aug-18	0.0001	160	3.7	0.01221	Acceptable	9-Oct-18	<0.0001	160	3.7	0.01221	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	7-Aug-18	0.0018	56	1	0.0033	Acceptable	9-Oct-18	0.0025	89	2.5	0.00825	Acceptable

* Hardness range (mg/L)	Adjust factor
0-59	1
60-119	2.5
120-179	3.7
180-240	4.9
>240	9

Table D-19: Total copper concentrations (mg/L) recorded at Melville Bull Creek catchment sites in 2018

Copper (Cu) (total mg/L) Max (red) 0.0049 Min (blue) 0.0004 LOR 0.0001

ANZECC unmodified freshwater 95% trigger value: 0.0014 mg/L,
NHMRC guidelines for recreational use - aesthetic: 10 mg/L, health: 20mg/L

Site name	Site number	Date	Cu (tot) (mg/L)	Hardness (mg/)	Adjust factor*	Adjusted trigger value	Comparison to ANZECC trigger ADJUSTED value
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	0.0049	100	2.5	0.0035	Guideline exceeded
JOHN CREANEY PARK	MELDR-05	10-Jul-18	0.0013	260	9	0.0126	Acceptable
BROCKMAN PARK	MELDR-02	10-Jul-18	0.0004	130	3.9	0.00546	Acceptable
BULL CREEK MD	PSDTBCMD	10-Jul-18	0.0012	130	3.9	0.00546	Acceptable
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	0.0007	130	3.9	0.00546	Acceptable
RAAF DRAIN	MELDR-14	10-Jul-18	0.0019	120	3.9	0.00546	Acceptable
BATEMAN PARK	MELDR-06	10-Jul-18	0.0008	130	3.9	0.00546	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	0.0017	350	9	0.0126	Acceptable
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	0.0014	180	5.2	0.00728	Acceptable
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	0.0014	110	2.5	0.0035	Acceptable
FREDERICK BALDWIN	MELDR-10	10-Jul-18	0.0015	51	1	0.0014	Guideline exceeded
MARMION RESERVE	MELDR-11	10-Jul-18	0.0009	110	2.5	0.0035	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	0.0015	69	2.5	0.0035	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	0.0045	62	2.5	0.0035	Guideline exceeded

* Hardness range (mg/L)	Adjust factor
0-59	1
60-119	2.5
120-179	3.9
180-240	5.2
>240	9

Table D-20: Soluble copper concentrations (mg/L) recorded at Melville Bull Creek catchment sites in 2018

Copper (Cu) (soluble mg/L) Max (red) 0.0037 Min (blue) 0.0002 LOR = 0.0001

ANZECC unmodified freshwater 95% trigger value: 0.0014 mg/L,
NHMRC guidelines for recreational use - aesthetic: 10 mg/L, health: 20mg/L

Site name	Site number	Date	Cu (sol) (mg/L)	Hardness (mg/)	Adjust factor*	Adjusted trigger value	Comparison to ANZECC trigger ADJUSTED value	Date	Cu (sol) (mg/L)	Hardness (mg/)	Adjust factor	Adjusted trigger value	Comparison to ANZECC trigger ADJUSTED value
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	0.0031	100	2.5	0.0035	Acceptable	13-Sep-18	0.0009	120	3.9	0.00546	Acceptable
JOHN CREANEY PARK	MELDR-05	10-Jul-18	0.0008	260	9	0.0126	Acceptable	13-Sep-18	0.0007	160	3.9	0.00546	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	10-Jul-18	NOT SAMPLED					13-Sep-18	0.0026	120	3.9	0.00546	Acceptable
BROCKMAN PARK	MELDR-02	10-Jul-18	0.0003	130	3.9	0.00546	Acceptable	13-Sep-18	0.0007	140	3.9	0.00546	Acceptable
BULL CREEK MD	PSDTBCMD	10-Jul-18	0.001	130	3.9	0.00546	Acceptable	13-Sep-18	0.0009	130	3.9	0.00546	Acceptable
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	0.0007	130	3.9	0.00546	Acceptable	13-Sep-18	0.0004	130	3.9	0.00546	Acceptable
RAAF DRAIN	MELDR-14	10-Jul-18	0.0007	120	3.9	0.00546	Acceptable	13-Sep-18	0.0005	130	3.9	0.00546	Acceptable
BATEMAN PARK	MELDR-06	10-Jul-18	0.0007	130	3.9	0.00546	Acceptable	13-Sep-18	0.0004	140	3.9	0.00546	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	0.0013	350	9	0.0126	Acceptable	13-Sep-18	0.0011	220	5.2	0.00728	Acceptable
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	0.001	180	5.2	0.00728	Acceptable	13-Sep-18	0.0011	320	9	0.0126	Acceptable
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	0.0011	110	2.5	0.0035	Acceptable	13-Sep-18	0.0017	80	2.5	0.0035	Acceptable
FREDERICK BALDWIN	MELDR-10	10-Jul-18	0.0012	51	1	0.0014	Acceptable	13-Sep-18	0.0002	140	3.9	0.00546	Acceptable
MARMION RESERVE	MELDR-11	10-Jul-18	0.0006	110	2.5	0.0035	Acceptable	13-Sep-18	0.0005	170	3.9	0.00546	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	0.0014	69	2.5	0.0035	Acceptable	13-Sep-18	0.0011	65	2.5	0.0035	Acceptable
JOHN CREANEY PARK INLET	MELDR-15	7-Aug-18	0.0013	110	2.5	0.0035	Acceptable	9-Oct-18	0.0007	120	3.9	0.00546	Acceptable
JOHN CREANEY PARK	MELDR-5	7-Aug-18	0.0009	170	3.9	0.00546	Acceptable	9-Oct-18	0.0004	170	3.9	0.00546	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	0.0037	62	2.5	0.0035	Guideline exceeded	9-Oct-18	0.0018	120	3.9	0.00546	Acceptable
BROCKMAN PARK	MELDR-2	7-Aug-18	0.0008	130	3.9	0.00546	Acceptable	9-Oct-18	0.0003	140	3.9	0.00546	Acceptable
BULL CREEK MD	PSDTBCMD	7-Aug-18	0.0013	120	3.9	0.00546	Acceptable	9-Oct-18	0.0008	140	3.9	0.00546	Acceptable
BRENTWOOD DRAIN	MELDR-13	7-Aug-18	0.0004	130	3.9	0.00546	Acceptable	9-Oct-18	0.0006	140	3.9	0.00546	Acceptable
RAAF DRAIN	MELDR-14	7-Aug-18	0.0008	130	3.9	0.00546	Acceptable	9-Oct-18	0.0015	140	3.9	0.00546	Acceptable
BATEMAN PARK	MELDR-06	7-Aug-18	0.0006	130	3.9	0.00546	Acceptable	9-Oct-18	0.0005	140	3.9	0.00546	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	7-Aug-18	0.0011	240	5.2	0.00728	Acceptable	9-Oct-18	0.0011	230	5.2	0.00728	Acceptable
PINEY LAKES OUTLET	MELDR-08	7-Aug-18	0.0013	220	5.2	0.00728	Acceptable	9-Oct-18	0.0009	260	9	0.0126	Acceptable
QUENDA LAKE OUTLET	MELDR-09	7-Aug-18	0.0016	67	2.5	0.0035	Acceptable	9-Oct-18	0.0012	130	3.9	0.00546	Acceptable
FREDERICK BALDWIN	MELDR-10	7-Aug-18	0.0009	78	2.5	0.0035	Acceptable	9-Oct-18	0.0006	140	3.9	0.00546	Acceptable
MARMION RESERVE	MELDR-11	7-Aug-18	0.0004	160	3.9	0.00546	Acceptable	9-Oct-18	0.0003	160	3.9	0.00546	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	7-Aug-18	0.0012	56	1	0.0014	Acceptable	9-Oct-18	0.0009	89	2.5	0.0035	Acceptable

* Hardness range (mg/L)	Adjust factor
0-59	1
60-119	2.5
120-179	3.9
180-240	5.2
>240	9

Table D-21: Total iron concentrations (mg/L) recorded at Melville Bull Creek catchment sites in 2018

Total Iron (Fe) LOR 0.005 mg/L

Interim guideline for biota protection: 0.3 mg/L,
NHMRC guideline for recreation (aesthetic): 3 mg/L

Max (red) 4.4 Min (blue) 0.19

Site Name	Site Number	Collect Date	Fe (mg/L)	Comparison to interim guideline: 0.3
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	3.5	Guideline exceeded
JOHN CREANEY PARK	MELDR-05	10-Jul-18	4.4	Guideline exceeded
BROCKMAN PARK	MELDR-02	10-Jul-18	1.3	Guideline exceeded
BULL CREEK MD	PSDTBCMD	10-Jul-18	0.55	Guideline exceeded
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	2.9	Guideline exceeded
RAAF DRAIN	MELDR-14	10-Jul-18	0.56	Guideline exceeded
BATEMAN PARK	MELDR-06	10-Jul-18	2	Guideline exceeded
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	2.7	Guideline exceeded
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	2.2	Guideline exceeded
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	0.19	Acceptable
FREDERICK BALDWIN	MELDR-10	10-Jul-18	0.49	Guideline exceeded
MARMION RESERVE	MELDR-11	10-Jul-18	0.56	Guideline exceeded
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	1.3	Guideline exceeded
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	07-Aug-18	0.4	Guideline exceeded

Table D-22: Soluble iron concentrations (mg/L) recorded at Melville Bull Creek catchment sites in 2018

Soluble Iron (Fe) LOR 0.005 mg/L

Interim guideline for biota protection: 0.3 mg/L, NHMRC guideline for recreation (aesthetic): 3 mg/L

Max (red) 4.3 Min (blue) 0.025

Site Name	Site Number	Collect Date	Fe (mg/L)	Comparison to interim guideline: 0.3	Collect Date	Fe (mg/L)	Comparison to interim guideline: 0.3
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	2.3	Guideline exceeded	13-Sep-18	1.5	Guideline exceeded
JOHN CREANEY PARK	MELDR-05	10-Jul-18	3	Guideline exceeded	13-Sep-18	1.3	Guideline exceeded
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	10-Jul-18	NOT SAMPLED		13-Sep-18	0.97	Guideline exceeded
BROCKMAN PARK	MELDR-02	10-Jul-18	1	Guideline exceeded	13-Sep-18	1.1	Guideline exceeded
BULL CREEK MD	PSDTBCMD	10-Jul-18	0.32	Guideline exceeded	13-Sep-18	0.41	Guideline exceeded
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	1.5	Guideline exceeded	13-Sep-18	1.1	Guideline exceeded
RAAF DRAIN	MELDR-14	10-Jul-18	0.34	Guideline exceeded	13-Sep-18	0.46	Guideline exceeded
BATEMAN PARK	MELDR-06	10-Jul-18	0.79	Guideline exceeded	13-Sep-18	0.65	Guideline exceeded
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	1.1	Guideline exceeded	13-Sep-18	4.3	Guideline exceeded
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	1.9	Guideline exceeded	13-Sep-18	2.5	Guideline exceeded
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	0.16	Acceptable	13-Sep-18	0.59	Guideline exceeded
FREDERICK BALDWIN	MELDR-10	10-Jul-18	0.35	Guideline exceeded	13-Sep-18	0.55	Guideline exceeded
MARMION RESERVE	MELDR-11	10-Jul-18	0.21	Acceptable	13-Sep-18	0.025	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	1.2	Guideline exceeded	13-Sep-18	1.3	Guideline exceeded
JOHN CREANEY PARK INLET	MELDR-15	07-Aug-18	2.4	Guideline exceeded	9-Oct-18	1.3	Guideline exceeded
JOHN CREANEY PARK	MELDR-05	07-Aug-18	2	Guideline exceeded	9-Oct-18	1.5	Guideline exceeded
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	07-Aug-18	0.32	Guideline exceeded	9-Oct-18	1.8	Guideline exceeded
BROCKMAN PARK	MELDR-02	07-Aug-18	1.1	Guideline exceeded	9-Oct-18	1.2	Guideline exceeded
BULL CREEK MD	PSDTBCMD	07-Aug-18	0.35	Guideline exceeded	9-Oct-18	0.41	Guideline exceeded
BRENTWOOD DRAIN	MELDR-13	07-Aug-18	1.3	Guideline exceeded	9-Oct-18	1	Guideline exceeded
RAAF DRAIN	MELDR-14	07-Aug-18	0.38	Guideline exceeded	9-Oct-18	0.54	Guideline exceeded
BATEMAN PARK	MELDR-06	07-Aug-18	0.74	Guideline exceeded	9-Oct-18	0.52	Guideline exceeded
BOORAGOON LAKE OUTLET	MELDR-07	07-Aug-18	3.3	Guideline exceeded	9-Oct-18	3.7	Guideline exceeded
PINEY LAKES OUTLET	MELDR-08	07-Aug-18	2.5	Guideline exceeded	9-Oct-18	2.7	Guideline exceeded
QUENDA LAKE OUTLET	MELDR-09	07-Aug-18	0.35	Guideline exceeded	9-Oct-18	0.86	Guideline exceeded
FREDERICK BALDWIN	MELDR-10	07-Aug-18	0.3	Guideline exceeded	9-Oct-18	0.15	Acceptable
MARMION RESERVE	MELDR-11	07-Aug-18	0.49	Guideline exceeded	9-Oct-18	0.042	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	07-Aug-18	1.3	Guideline exceeded	9-Oct-18	0.95	Guideline exceeded

Table D-23: Total lead concentrations (mg/L) recorded at Melville Bull Creek catchment sites in 2018

Lead (Pb) (total mg/L) Max (red) 0.0038 Min (blue) 0.0003 LOR 0.0001 mg/L

ANZECC unmodified freshwater 95% trigger value: 0.0034 mg/L,
NHMRC recreational guideline value (health value): 0.1 mg/L

Site name	Site number	Date	Pb (tot) (mg/L)	Hardness (mg/)	Adjust factor*	Adjusted trigger value	Comparison to ANZECC trigger ADJUSTED value
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	0.003	100	4	0.0136	Acceptable
JOHN CREANEY PARK	MELDR-05	10-Jul-18	0.001	260	26.7	0.09078	Acceptable
BROCKMAN PARK	MELDR-02	10-Jul-18	0.0003	130	7.6	0.02584	Acceptable
BULL CREEK MD	PSDTBCMD	10-Jul-18	0.0014	130	7.6	0.02584	Acceptable
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	0.0007	130	7.6	0.02584	Acceptable
RAAF DRAIN	MELDR-14	10-Jul-18	0.0006	120	7.6	0.02584	Acceptable
BATEMAN PARK	MELDR-06	10-Jul-18	0.0007	130	7.6	0.02584	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	0.0015	350	26.7	0.09078	Acceptable
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	0.0027	180	11.8	0.04012	Acceptable
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	0.0033	110	4	0.0136	Acceptable
FREDERICK BALDWIN	MELDR-10	10-Jul-18	0.0012	51	1	0.0034	Acceptable
MARMION RESERVE	MELDR-11	10-Jul-18	0.001	110	4	0.0136	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	0.0038	69	4	0.0136	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	0.0019	62	4	0.0136	Acceptable

* Hardness range (mg/L)	Adjust factor
0-59	1
60-119	4
120-179	7.6
180-240	11.8
>240	26.7

Table D-24: Soluble lead concentrations (mg/L) recorded at Melville Bull Creek catchment sites in 2018

Lead (Pb) (soluble mg/L) Max (red) 0.0058 Min (blue) <0.0001 All data in blue were <0.0001 mg/L (LOR)

ANZECC unmodified freshwater 95% trigger value: 0.0034 mg/L,
NHMRC recreational guideline value (health value): 0.1 mg/L

Site name	Site number	Date	Pb (sol) (mg/L)	Hardness (mg/)	Adjust factor*	Adjusted trigger value	Comparison to ANZECC trigger ADJUSTED value	Date	Pb (sol) (mg/L)	Hardness (mg/)	Adjust factor*	Adjusted trigger value	Comparison to ANZECC trigger ADJUSTED value
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	0.0017	100	4	0.0136	Acceptable	13-Sep-18	0.0006	120	7.6	0.02584	Acceptable
JOHN CREANEY PARK	MELDR-05	10-Jul-18	0.0004	260	26.7	0.09078	Acceptable	13-Sep-18	0.0004	160	7.6	0.02584	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	10-Jul-18	NOT SAMPLED					13-Sep-18	0.0012	120	7.6	0.02584	Acceptable
BROCKMAN PARK	MELDR-02	10-Jul-18	0.0002	130	7.6	0.02584	Acceptable	13-Sep-18	0.0004	140	7.6	0.02584	Acceptable
BULL CREEK MD	PSDTBCMD	10-Jul-18	0.0006	130	7.6	0.02584	Acceptable	13-Sep-18	0.0007	130	7.6	0.02584	Acceptable
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	0.0001	130	7.6	0.02584	Acceptable	13-Sep-18	0.0001	130	7.6	0.02584	Acceptable
RAAF DRAIN	MELDR-14	10-Jul-18	0.0003	120	7.6	0.02584	Acceptable	13-Sep-18	0.0003	130	7.6	0.02584	Acceptable
BATEMAN PARK	MELDR-06	10-Jul-18	0.0002	130	7.6	0.02584	Acceptable	13-Sep-18	0.0002	140	7.6	0.02584	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	0.0007	350	26.7	0.09078	Acceptable	13-Sep-18	0.0039	220	11.8	0.04012	Acceptable
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	0.0015	180	11.8	0.04012	Acceptable	13-Sep-18	0.0033	320	26.7	0.09078	Acceptable
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	0.0003	110	4	0.0136	Acceptable	13-Sep-18	0.0009	80	4	0.0136	Acceptable
FREDERICK BALDWIN	MELDR-10	10-Jul-18	0.0005	51	1	0.0034	Acceptable	13-Sep-18	<0.0001	140	7.6	0.02584	Acceptable
MARMION RESERVE	MELDR-11	10-Jul-18	0.0002	110	4	0.0136	Acceptable	13-Sep-18	<0.0001	170	7.6	0.02584	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	0.0036	69	4	0.0136	Acceptable	13-Sep-18	0.0014	65	4	0.0136	Acceptable
JOHN CREANEY PARK INLET	MELDR-15	7-Aug-18	0.0008	110	4	0.0136	Acceptable	9-Oct-18	0.0004	120	7.6	0.02584	Acceptable
JOHN CREANEY PARK	MELDR-5	7-Aug-18	0.0006	170	7.6	0.02584	Acceptable	9-Oct-18	0.0003	170	7.6	0.02584	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	0.0012	62	4	0.0136	Acceptable	9-Oct-18	0.0011	120	7.6	0.02584	Acceptable
BROCKMAN PARK	MELDR-2	7-Aug-18	0.0005	130	7.6	0.02584	Acceptable	9-Oct-18	0.0002	140	7.6	0.02584	Acceptable
BULL CREEK MD	PSDTBCMD	7-Aug-18	0.0008	120	7.6	0.02584	Acceptable	9-Oct-18	0.0007	140	7.6	0.02584	Acceptable
BRENTWOOD DRAIN	MELDR-13	7-Aug-18	0.0001	130	7.6	0.02584	Acceptable	9-Oct-18	0.0001	140	7.6	0.02584	Acceptable
RAAF DRAIN	MELDR-14	7-Aug-18	0.0003	130	7.6	0.02584	Acceptable	9-Oct-18	0.0003	140	7.6	0.02584	Acceptable
BATEMAN PARK	MELDR-06	7-Aug-18	0.0002	130	7.6	0.02584	Acceptable	9-Oct-18	0.0001	140	7.6	0.02584	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	7-Aug-18	0.0032	240	11.8	0.04012	Acceptable	9-Oct-18	0.0024	230	11.8	0.04012	Acceptable
PINEY LAKES OUTLET	MELDR-08	7-Aug-18	0.0058	220	11.8	0.04012	Acceptable	9-Oct-18	0.0025	260	26.7	0.09078	Acceptable
QUENDA LAKE OUTLET	MELDR-09	7-Aug-18	0.0016	67	4	0.0136	Acceptable	9-Oct-18	0.0008	130	7.6	0.02584	Acceptable
FREDERICK BALDWIN	MELDR-10	7-Aug-18	0.0003	78	4	0.0136	Acceptable	9-Oct-18	<0.0001	140	7.6	0.02584	Acceptable
MARMION RESERVE	MELDR-11	7-Aug-18	0.0002	160	7.6	0.02584	Acceptable	9-Oct-18	<0.0001	160	7.6	0.02584	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	7-Aug-18	0.0028	56	1	0.0034	Acceptable	9-Oct-18	0.0009	89	4	0.0136	Acceptable

* Hardness range (mg/L)	Adjust factor
0-59	1
60-119	4
120-179	7.6
180-240	11.8
>240	26.7

Table D-25: Total mercury concentrations (mg/L) recorded at Melville Bull Creek catchment sites in 2018

Soluble Mercury (Hg) All data in blue were <0.00005 (Oct LOR)

ANZECC trigger for 95% protection: 0.0006 mg/L, NHMRC guideline for recreation (health): 0.01 mg/L

Max <0.0001 Min (blue) <0.00005

Site Name	Site Number	Collect Date	Hg (mg/L)	Comparison to ANZECC trigger value 95% Level of Protection
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	<0.0001	Acceptable
RAAF DRAIN	MELDR-14	10-Jul-18	<0.0001	Acceptable
BATEMAN PARK	MELDR-06	10-Jul-18	<0.0001	Acceptable
BRENTWOOD DRAIN	MELDR-13	7-Aug-18	<0.0001	Acceptable
RAAF DRAIN	MELDR-14	7-Aug-18	<0.0001	Acceptable
BATEMAN PARK	MELDR-06	7-Aug-18	<0.0001	Acceptable
BRENTWOOD DRAIN	MELDR-13	13-Sep-18	<0.0001	Acceptable
RAAF DRAIN	MELDR-14	13-Sep-18	<0.0001	Acceptable
BATEMAN PARK	MELDR-06	13-Sep-18	<0.0001	Acceptable
BRENTWOOD DRAIN	MELDR-13	9-Oct-18	<0.00005	Acceptable
RAAF DRAIN	MELDR-14	9-Oct-18	<0.00005	Acceptable
BATEMAN PARK	MELDR-06	9-Oct-18	<0.00005	Acceptable

Table D-26: Soluble mercury concentrations (mg/L) recorded at Melville Bull Creek catchment sites in 2018

Total Mercury (Hg) All data in blue were <0.00005 (Oct LOR)

ANZECC trigger for 95% protection: 0.0006 mg/L, NHMRC guideline for recreation (health): 0.01 mg/L

Max <0.0001 Min (blue) <0.00005

Site Name	Site Number	Collect Date	Hg (mg/L)	Comparison to ANZECC trigger value 95% Level of Protection
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	<0.0001	Acceptable
RAAF DRAIN	MELDR-14	10-Jul-18	<0.0001	Acceptable
BATEMAN PARK	MELDR-06	10-Jul-18	<0.0001	Acceptable
BRENTWOOD DRAIN	MELDR-13	7-Aug-18	<0.0001	Acceptable
RAAF DRAIN	MELDR-14	7-Aug-18	<0.0001	Acceptable
BATEMAN PARK	MELDR-06	7-Aug-18	<0.0001	Acceptable
BRENTWOOD DRAIN	MELDR-13	13-Sep-18	<0.0001	Acceptable
RAAF DRAIN	MELDR-14	13-Sep-18	<0.0001	Acceptable
BATEMAN PARK	MELDR-06	13-Sep-18	<0.0001	Acceptable
BRENTWOOD DRAIN	MELDR-13	9-Oct-18	<0.00005	Acceptable
RAAF DRAIN	MELDR-14	9-Oct-18	<0.00005	Acceptable
BATEMAN PARK	MELDR-06	9-Oct-18	<0.00005	Acceptable

Table D-27: Total zinc concentrations (mg/L) recorded at Melville Bull Creek catchment sites in 2018

Zinc (Zn) (total mg/L) Max (red) 0.11 Min (blue) 0.007 LOR 0.005

ANZECC freshwater 95% trigger value: 0.008 mg/L,
NHMRC recreational use guideline (aesthetic value): 30 mg/L

Site name	Site number	Date	Zn (tot) (mg/L)	Hardness (mg/)	Adjust factor*	Adjusted trigger value	Comparison to ANZECC trigger ADJUSTED value
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	0.11	100	2.5	0.02	Guideline exceeded
JOHN CREANEY PARK	MELDR-05	10-Jul-18	0.024	260	9	0.072	Acceptable
BROCKMAN PARK	MELDR-02	10-Jul-18	0.007	130	3.9	0.0312	Acceptable
BULL CREEK MD	PSDTBCMD	10-Jul-18	0.013	130	3.9	0.0312	Acceptable
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	0.008	130	3.9	0.0312	Acceptable
RAAF DRAIN	MELDR-14	10-Jul-18	0.011	120	3.9	0.0312	Acceptable
BATEMAN PARK	MELDR-06	10-Jul-18	0.011	130	3.9	0.0312	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	0.007	350	9	0.072	Acceptable
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	0.04	180	5.2	0.0416	Acceptable
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	0.009	110	2.5	0.02	Acceptable
FREDERICK BALDWIN	MELDR-10	10-Jul-18	0.019	51	1	0.008	Guideline exceeded
MARMION RESERVE	MELDR-11	10-Jul-18	0.007	110	2.5	0.02	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	0.007	69	2.5	0.02	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	0.085	62	2.5	0.02	Guideline exceeded

* Hardness range (mg/L)	Adjust factor
0-59	1
60-119	2.5
120-179	3.9
180-240	5.2
>240	9

Table D-28: Soluble zinc concentrations (mg/L) recorded at Melville Bull Creek catchment sites in 2018

Zinc (Zn) (soluble mg/L) Max (red) 0.17 Min (blue) 0.004 LOR Oct=0.005 mg/L, LOR other months=0.001 mg/L

ANZECC freshwater 95% trigger value: 0.008 mg/L,
NHMRC recreational use guideline (aesthetic value): 30 mg/L

Site name	Site number	Date	Zn (sol) (mg/L)	Hardness (mg/)	Adjust factor*	Adjusted trigger value	Comparison to ANZECC trigger ADJUSTED value	Date	Zn (sol) (mg/L)	Hardness (mg/)	Adjust factor*	Adjusted trigger value	Comparison to ANZECC trigger ADJUSTED value
JOHN CREANEY PARK INLET	MELDR-15	10-Jul-18	0.094	100	2.5	0.02	Guideline exceeded	13-Sep-18	0.037	120	3.9	0.0312	Guideline exceeded
JOHN CREANEY PARK	MELDR-05	10-Jul-18	0.011	260	9	0.072	Acceptable	13-Sep-18	0.022	160	3.9	0.0312	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	10-Jul-18	NOT SAMPLED					13-Sep-18	0.088	120	3.9	0.0312	Guideline exceeded
BROCKMAN PARK	MELDR-02	10-Jul-18	0.007	130	3.9	0.0312	Acceptable	13-Sep-18	0.015	140	3.9	0.0312	Acceptable
BULL CREEK MD	PSDTBCMD	10-Jul-18	0.013	130	3.9	0.0312	Acceptable	13-Sep-18	0.015	130	3.9	0.0312	Acceptable
BRENTWOOD DRAIN	MELDR-13	10-Jul-18	0.008	130	3.9	0.0312	Acceptable	13-Sep-18	0.01	130	3.9	0.0312	Acceptable
RAAF DRAIN	MELDR-14	10-Jul-18	0.011	120	3.9	0.0312	Acceptable	13-Sep-18	0.012	130	3.9	0.0312	Acceptable
BATEMAN PARK	MELDR-06	10-Jul-18	0.011	130	3.9	0.0312	Acceptable	13-Sep-18	0.012	140	3.9	0.0312	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	10-Jul-18	0.007	350	9	0.072	Acceptable	13-Sep-18	0.009	220	5.2	0.0416	Acceptable
PINEY LAKES OUTLET	MELDR-08	10-Jul-18	0.04	180	5.2	0.0416	Acceptable	13-Sep-18	0.026	320	9	0.072	Acceptable
QUENDA LAKE OUTLET	MELDR-09	10-Jul-18	0.009	110	2.5	0.02	Acceptable	13-Sep-18	0.013	80	2.5	0.02	Acceptable
FREDERICK BALDWIN	MELDR-10	10-Jul-18	0.019	51	1	0.008	Guideline exceeded	13-Sep-18	0.019	140	3.9	0.0312	Acceptable
MARMION RESERVE	MELDR-11	10-Jul-18	0.007	110	2.5	0.02	Acceptable	13-Sep-18	0.004	170	3.9	0.0312	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	10-Jul-18	0.007	69	2.5	0.02	Acceptable	13-Sep-18	0.012	65	2.5	0.02	Acceptable
JOHN CREANEY PARK INLET	MELDR-15	7-Aug-18	0.17	110	2.5	0.02	Guideline exceeded	9-Oct-18	0.048	120	3.9	0.0312	Guideline exceeded
JOHN CREANEY PARK	MELDR-5	7-Aug-18	0.03	170	3.9	0.0312	Acceptable	9-Oct-18	0.02	170	3.9	0.0312	Acceptable
DOWNSTREAM ELIZABETH MANION PARK	MELDR-16	7-Aug-18	0.068	62	2.5	0.02	Guideline exceeded	9-Oct-18	0.1	120	3.9	0.0312	Guideline exceeded
BROCKMAN PARK	MELDR-2	7-Aug-18	0.031	130	3.9	0.0312	Acceptable	9-Oct-18	0.018	140	3.9	0.0312	Acceptable
BULL CREEK MD	PSDTBCMD	7-Aug-18	0.023	120	3.9	0.0312	Acceptable	9-Oct-18	0.014	140	3.9	0.0312	Acceptable
BRENTWOOD DRAIN	MELDR-13	7-Aug-18	0.013	130	3.9	0.0312	Acceptable	9-Oct-18	0.012	140	3.9	0.0312	Acceptable
RAAF DRAIN	MELDR-14	7-Aug-18	0.012	130	3.9	0.0312	Acceptable	9-Oct-18	0.017	140	3.9	0.0312	Acceptable
BATEMAN PARK	MELDR-06	7-Aug-18	0.013	130	3.9	0.0312	Acceptable	9-Oct-18	0.011	140	3.9	0.0312	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	7-Aug-18	0.013	240	5.2	0.0416	Acceptable	9-Oct-18	0.012	230	5.2	0.0416	Acceptable
PINEY LAKES OUTLET	MELDR-08	7-Aug-18	0.03	220	5.2	0.0416	Acceptable	9-Oct-18	0.025	260	9	0.072	Acceptable
QUENDA LAKE OUTLET	MELDR-09	7-Aug-18	0.017	67	2.5	0.02	Acceptable	9-Oct-18	0.016	130	3.9	0.0312	Acceptable
FREDERICK BALDWIN	MELDR-10	7-Aug-18	0.035	78	2.5	0.02	Guideline exceeded	9-Oct-18	0.015	140	3.9	0.0312	Acceptable
MARMION RESERVE	MELDR-11	7-Aug-18	0.011	160	3.9	0.0312	Acceptable	9-Oct-18	0.01	160	3.9	0.0312	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	7-Aug-18	0.013	56	1	0.008	Guideline exceeded	9-Oct-18	0.02	89	2.5	0.02	Guideline exceeded

* Hardness range (mg/L)	Adjust factor
0-59	1
60-119	2.5
120-179	3.9
180-240	5.2
>240	9

Sediment metals

Table D-29: Sediment total aluminium concentrations (mg/kg) recorded at Melville Bull Creek catchment sites in 2018

Aluminium (Al) (total) LOR 1.0 mg/Kg

ANZECC trigger value: ND

Max (red) 6,770 Min (blue) 534

Site name	Site number	Date	Al (tot) mg/kg
JOHN CREANEY PARK	MELDR-05	9-Oct-18	6770
BROCKMAN PARK	MELDR-02	9-Oct-18	3170
BULL CREEK MD	PSDTBCMD	9-Oct-18	534
BRENTWOOD DRAIN	MELDR-13	9-Oct-18	3880
RAAF DRAIN	MELDR-14	9-Oct-18	1140
BATEMAN PARK	MELDR-06	9-Oct-18	540
BOORAGOON LAKE OUTLET	MELDR-07	9-Oct-18	3440
PINEY LAKES OUTLET	MELDR-08	9-Oct-18	3400
QUENDA LAKE OUTLET	MELDR-09	9-Oct-18	692
MARMION RESERVE	MELDR-11	9-Oct-18	2860
BLUE GUM LAKE OUTLET	MELDR-12	9-Oct-18	537

Table D-30: Sediment total arsenic concentrations (mg/kg) recorded at Melville Bull Creek catchment sites in 2018

Arsenic (As) (total sediment) LOR 0.1 mg/kg

ANZECC trigger value: low 20 mg/kg and high 70 mg/Kg

Max (red) 4.4 Min (blue) 0.2

Site name	Site number	Date	As (tot) mg/kg	Comparison to ANZECC lower trigger value: 20
JOHN CREANEY PARK	MELDR-05	9-Oct-18	4.4	Acceptable
BROCKMAN PARK	MELDR-02	9-Oct-18	0.7	Acceptable
BULL CREEK MD	PSDTBCMD	9-Oct-18	0.4	Acceptable
BRENTWOOD DRAIN	MELDR-13	9-Oct-18	2.2	Acceptable
RAAF DRAIN	MELDR-14	9-Oct-18	0.7	Acceptable
BATEMAN PARK	MELDR-06	9-Oct-18	0.7	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	9-Oct-18	2.6	Acceptable
PINEY LAKES OUTLET	MELDR-08	9-Oct-18	1.2	Acceptable
QUENDA LAKE OUTLET	MELDR-09	9-Oct-18	0.2	Acceptable
MARMION RESERVE	MELDR-11	9-Oct-18	2.5	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	9-Oct-18	0.6	Acceptable

Table D-31: Sediment total chromium concentrations (mg/kg) recorded at Melville Bull Creek catchment sites in 2018

Chromium (Cr) (total)

LOR 0.05 mg/kg

ANZECC lower trigger value: 80 mg/kg and higher 370 mg/kg

Max (red) 16 Min (blue) 0.72

Site name	Site number	Date	Cr (mg/kg)	Comparison to ANZECC lower trigger value: 80
JOHN CREANEY PARK	MELDR-05	9-Oct-18	16	Acceptable
BROCKMAN PARK	MELDR-02	9-Oct-18	4.8	Acceptable
BULL CREEK MD	PSDTBCMD	9-Oct-18	0.72	Acceptable
BRENTWOOD DRAIN	MELDR-13	9-Oct-18	7.2	Acceptable
RAAF DRAIN	MELDR-14	9-Oct-18	2.6	Acceptable
BATEMAN PARK	MELDR-06	9-Oct-18	1	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	9-Oct-18	15	Acceptable
PINEY LAKES OUTLET	MELDR-08	9-Oct-18	5.2	Acceptable
QUENDA LAKE OUTLET	MELDR-09	9-Oct-18	1.2	Acceptable
MARMION RESERVE	MELDR-11	9-Oct-18	4.2	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	9-Oct-18	2.4	Acceptable

Table D-32: Sediment total copper concentrations (mg/kg) recorded at Melville Bull Creek catchment sites in 2018

Copper (Cu) (total)

All data in blue were <0.5 (LOR)

ANZECC lower trigger value: 65 mg/kg & higher 270 mg/kg

Max (red) 33 Min (blue) <0.5

Site name	Site number	Date	Cu (mg/kg)	Comparison to ANZECC lower trigger value: 65
JOHN CREANEY PARK	MELDR-05	9-Oct-18	33	Acceptable
BROCKMAN PARK	MELDR-02	9-Oct-18	4.8	Acceptable
BULL CREEK MD	PSDTBCMD	9-Oct-18	0.6	Acceptable
BRENTWOOD DRAIN	MELDR-13	9-Oct-18	4.3	Acceptable
RAAF DRAIN	MELDR-14	9-Oct-18	1.6	Acceptable
BATEMAN PARK	MELDR-06	9-Oct-18	<0.5	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	9-Oct-18	12	Acceptable
PINEY LAKES OUTLET	MELDR-08	9-Oct-18	3.3	Acceptable
QUENDA LAKE OUTLET	MELDR-09	9-Oct-18	1.1	Acceptable
MARMION RESERVE	MELDR-11	9-Oct-18	6.3	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	9-Oct-18	2.1	Acceptable

Table D-33: Sediment total iron concentrations (mg/kg) recorded at Melville Bull Creek catchment sites in 2018

Iron (Fe) (total)

LOR 1.0 mg/Kg

ANZECC trigger value: ND

Max (red) 24,000 Min (blue) 230

Site name	Site number	Date	Fe (tot) mg/kg
JOHN CREANEY PARK	MELDR-05	9-Oct-18	24000
BROCKMAN PARK	MELDR-02	9-Oct-18	4200
BULL CREEK MD	PSDTBCMD	9-Oct-18	710
BRENTWOOD DRAIN	MELDR-13	9-Oct-18	6300
RAAF DRAIN	MELDR-14	9-Oct-18	1300
BATEMAN PARK	MELDR-06	9-Oct-18	720
BOORAGOON LAKE OUTLET	MELDR-07	9-Oct-18	10000
PINEY LAKES OUTLET	MELDR-08	9-Oct-18	1400
QUENDA LAKE OUTLET	MELDR-09	9-Oct-18	230
MARMION RESERVE	MELDR-11	9-Oct-18	1800
BLUE GUM LAKE OUTLET	MELDR-12	9-Oct-18	2500

Table D-34: Sediment total lead concentrations (mg/kg) recorded at Melville Bull Creek catchment sites in 2018

Lead (Pb) (total)

LOR 0.5

ANZECC lower trigger value: 50 mg/kg & higher 220 mg/kg

Max (red) 80 Min (blue) 1.3

Site name	Site number	Date	Pb (mg/kg)	Comparison to ANZECC lower trigger value 50 mg/kg
JOHN CREANEY PARK	MELDR-05	9-Oct-18	60	Guideline exceeded
BROCKMAN PARK	MELDR-02	9-Oct-18	6.3	Acceptable
BULL CREEK MD	PSDTBCMD	9-Oct-18	4.6	Acceptable
BRENTWOOD DRAIN	MELDR-13	9-Oct-18	21	Acceptable
RAAF DRAIN	MELDR-14	9-Oct-18	9.3	Acceptable
BATEMAN PARK	MELDR-06	9-Oct-18	1.3	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	9-Oct-18	80	Guideline exceeded
PINEY LAKES OUTLET	MELDR-08	9-Oct-18	26	Acceptable
QUENDA LAKE OUTLET	MELDR-09	9-Oct-18	7.1	Acceptable
MARMION RESERVE	MELDR-11	9-Oct-18	23	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	9-Oct-18	13	Acceptable

Table D-35: Sediment total mercury concentrations (mg/kg) recorded at Melville Bull Creek catchment sites in 2018

Mercury (Hg) (total)

All data in blue w ere <0.02 mg/kg (LOR)

ANZECC lower trigger value: 0.15 mg/kg and higher 1.0 mg/kg

Max (red) 0.05 Min (blue) <0.02

Site name	Site number	Date	Hg (tot) mg/kg	Comparison to ANZECC lower trigger value 0.15 mg/kg
JOHN CREANEY PARK	MELDR-05	9-Oct-18	<0.02	Acceptable
BROCKMAN PARK	MELDR-02	9-Oct-18	<0.02	Acceptable
BULL CREEK MD	PSDTBCMD	9-Oct-18	<0.02	Acceptable
BRENTWOOD DRAIN	MELDR-13	9-Oct-18	<0.02	Acceptable
RAAF DRAIN	MELDR-14	9-Oct-18	<0.02	Acceptable
BATEMAN PARK	MELDR-06	9-Oct-18	<0.02	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	9-Oct-18	0.05	Acceptable
PINEY LAKES OUTLET	MELDR-08	9-Oct-18	0.04	Acceptable
QUENDA LAKE OUTLET	MELDR-09	9-Oct-18	<0.02	Acceptable
MARMION RESERVE	MELDR-11	9-Oct-18	<0.02	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	9-Oct-18	<0.02	Acceptable

Table D-36: Sediment total nickel concentrations (mg/kg) recorded at Melville Bull Creek catchment sites in 2018

Nickel (Ni) (total)

All data in blue w ere <0.1 mg/Kg(LOR)

ANZECC lower trigger value: 21 mg/kg & higher 52 mg/kg

Max (red) 5 Min (blue) <0.1

Site name	Site number	Date	Ni (mg/kg)	Comparison to ANZECC lower trigger value 21 mg/kg
JOHN CREANEY PARK	MELDR-05	9-Oct-18	4.1	Acceptable
BROCKMAN PARK	MELDR-02	9-Oct-18	1.3	Acceptable
BULL CREEK MD	PSDTBCMD	9-Oct-18	<0.1	Acceptable
BRENTWOOD DRAIN	MELDR-13	9-Oct-18	5	Acceptable
RAAF DRAIN	MELDR-14	9-Oct-18	0.4	Acceptable
BATEMAN PARK	MELDR-06	9-Oct-18	<0.1	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	9-Oct-18	2.9	Acceptable
PINEY LAKES OUTLET	MELDR-08	9-Oct-18	1.7	Acceptable
QUENDA LAKE OUTLET	MELDR-09	9-Oct-18	0.2	Acceptable
MARMION RESERVE	MELDR-11	9-Oct-18	1.5	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	9-Oct-18	0.4	Acceptable

Table D-37: Sediment total selenium concentrations (mg/kg) recorded at Melville Bull Creek catchment sites in 2018

Selenium (Se) (total)

All data in blue w ere <0.05 mg/kg (LOR)

ANZECC trigger value: ND

Max (red) 0.98 Min (blue) <0.05

Site name	Site number	Date	Se (tot) mg/kg
JOHN CREANEY PARK	MELDR-05	9-Oct-18	0.31
BROCKMAN PARK	MELDR-02	9-Oct-18	<0.05
BULL CREEK MD	PSDTBCMD	9-Oct-18	<0.05
BRENTWOOD DRAIN	MELDR-13	9-Oct-18	0.07
RAAF DRAIN	MELDR-14	9-Oct-18	<0.05
BATEMAN PARK	MELDR-06	9-Oct-18	<0.05
BOORAGOON LAKE OUTLET	MELDR-07	9-Oct-18	0.98
PINEY LAKES OUTLET	MELDR-08	9-Oct-18	0.23
QUENDA LAKE OUTLET	MELDR-09	9-Oct-18	<0.05
MARMION RESERVE	MELDR-11	9-Oct-18	0.09
BLUE GUM LAKE OUTLET	MELDR-12	9-Oct-18	<0.05

Table D-38: Sediment total zinc concentrations (mg/kg) recorded at Melville Bull Creek catchment sites in 2018

Zinc (Zn) (total)

All data in blue were <0.25 (LOR)

ANZECC lower trigger value: 200 mg/kg & higher 410 mg/kg

Max (red) 150 Min (blue) <0.25

Site name	Site number	Date	Zn (mg/kg)	Comparison to ANZECC lower trigger value 200 mg/kg
JOHN CREANEY PARK	MELDR-05	9-Oct-18	150	Acceptable
BROCKMAN PARK	MELDR-02	9-Oct-18	22	Acceptable
BULL CREEK MD	PSDTBCMD	9-Oct-18	4.5	Acceptable
BRENTWOOD DRAIN	MELDR-13	9-Oct-18	26	Acceptable
RAAF DRAIN	MELDR-14	9-Oct-18	11	Acceptable
BATEMAN PARK	MELDR-06	9-Oct-18	4.7	Acceptable
BOORAGOON LAKE OUTLET	MELDR-07	9-Oct-18	51	Acceptable
PINEY LAKES OUTLET	MELDR-08	9-Oct-18	11	Acceptable
QUENDA LAKE OUTLET	MELDR-09	9-Oct-18	3.6	Acceptable
MARMION RESERVE	MELDR-11	9-Oct-18	44	Acceptable
BLUE GUM LAKE OUTLET	MELDR-12	9-Oct-18	12	Acceptable

Appendix E Potential effects of stressors on aquatic environments

In the context of water quality, stressors can be described as chemical compounds or indicators that are naturally occurring in waterways, for which values outside of certain ranges can have multiple negative effects. Stressors often reach undesirable levels in waterways as a result of human intervention. Stressors analysed in this monitoring program included physicochemical parameters (pH, dissolved oxygen, electrical conductivity, total suspended solids and temperature), nutrients (nitrogen and phosphorus in their various forms) and hardness. **Table E-1** describes the undesirable effects that these stressors can have on surface water bodies.

Table E-1: Effects of stressors on aquatic environments

Parameter	Factors/sources impacting stressor levels	Ecosystem impacts
pH	• **Natural** • Rainfall - (CO_2) in atmosphere decreases pH of precipitation • Algal or plant growth (photosynthesis increases pH, respiration decreases pH) o pH often higher during the day (more photosynthesis) and lower at night (more respiration) • Salinity • Underlying soil type (e.g. Bassendean sands – acidic, limestone – alkaline) • Influence of groundwater • Presence of acidic tannins from vegetation – decreases pH • **Anthropogenic** • Oxidation of acid sulfate soils due to manual disturbance or anthropogenic change in water levels – decreases pH • Acidic or alkaline discharges from industry • Acidic mining runoff or exposure of acidic rocks from mining • Acid rain resulting from certain industrial processes	• High or low pH can result in increased toxicity of certain metals (ANZECC and ARMCANZ 2000) • High – e.g. aluminium (pH>9) • Low –e.g. chromium (VI), nickel • High or low levels can be directly toxic to biota – different species tolerate different ranges • → changes can result in altered compositions and/or reduced biodiversity of plants and animals • Mosquitoes can tolerate low pH waters and can therefore become a nuisance in acidic wetlands where other macroinvertebrate predators may not survive • Alkaline conditions can result in conversion of ammonium (generally non-toxic) to ammonia (toxic) • Low pH can weaken shells and exoskeletons and kill macroinvertebrates

Table E-1 (continued): Effects of stressors on aquatic environments

Parameter	Factors/sources impacting stressor levels	Ecosystem impacts

Dissolved Oxygen (DO)	• **Natural**
	  • Depth of waterbody (deeper waters more likely to have low oxygen levels)
	  • Depth of measurement - surface waters often higher, bottom often lower
	    o Stratification (e.g. different layers of salinity) can enhance this effect
	  • Algal or plant growth (photosynthesis increases pH, respiration decreases pH)
	    o DO often higher during the day (more photosynthesis) and lower at night (more respiration)
	  • Decomposition of organic material – process consumes DO
	  • Temperature
	  • Rain and wind can introduce oxygen into water
	  • Influence of groundwater
	• **Anthropogenic**
	  • Microbial breakdown of excess organic material (e.g. from grass clippings, sewage, industrial wastes or as a result of eutrophication) – decreases DO
	  • Oxidation of hydrocarbons, reduction of metals, microbial (bacterial and archaea) activity and nitrification – decreases DO.
	  • Excess plant/macroalgal growth on the water surface from eutrophication can smother water – decreasing DO
	  • Excess algal growth can also increase DO (high levels of photosynthesis)
	  • Aeration through fountains and subsurface aeration - increases DO
		• Low DO - directly toxic to biota
		  • Especially fish and molluscs
		• High DO saturations can also be harmful
		  • Oxygen bubbles can block blood vessels in fish resulting in death
		• Changes in DO result in altered redox conditions which can facilitate certain chemical reactions
		  • Low DO results in phosphorus release from sediments – can lead to eutrophication (Correll 1998)
		  • Low DO results in formation of reduced compounds, such as hydrogen sulphide, resulting in toxic effects on aquatic animals (Camargo & Alonso 2006)
		• Low DO can increase toxicity of certain metals (e.g. copper) and ammonia (ANZECC and ARMCANZ 2000)
		• Low DO levels also halt nitrogen loss from water by preventing nitrification of ammonia (Geoscience Australia 2015)

Table E-1 (continued): Effects of stressors on aquatic environments

Parameter	Factors/sources impacting stressor levels	Ecosystem impacts
Electrical Conductivity (EC)	• **Natural** • Communication with the ocean will increase EC • Proximity to ocean – fine sea spray or atmospheric salt can eventuate in waterbodies • Depth of measurement - salt water heavier than freshwater so will sink o Stratification (e.g. different layers of salinity) can enhance this effect • Underlying geology • Temperature • Influence of groundwater • Seasonal water level changes –increased rainfall and runoff can dilute water (decreasing EC) and evaporation concentrates ions (increasing EC) • **Anthropogenic** • Discharges from industry o E.g. sewage contamination can increase EC o Oil spills can decrease EC	• High or low levels can be directly toxic to biota – different species tolerate different ranges (Hart et al 1991) • → changes can result in altered compositions and/or reduced biodiversity of plants and animals • In this catchment water is naturally reasonably fresh, therefore high EC will result in loss of many endemic plant and animal species o Particularly leeches, flatworms and macroinvertebrates without impermeable skeletons (pulmonate gastropods) (Dunlop et al 2005).
Total Suspended Solids (TSS)	• **Natural** • Sources include soil particles and organic material (e.g. algae, microorganisms, decaying plant and animal matter) • Windy conditions can result in increased resuspension of bottom sediments and introduction of soil particles • Heavy rainfall will result in increased erosion of surrounding soils and increased introduction of particles through runoff • **Anthropogenic** • Discharges from industry from runoff and dust • Products of vehicle wear from road run-off • Increased amounts of soil particulate material entering waterbodies as a result of construction and demolition operations.	• Deposition of suspended solids can block pipes, change flow conditions in open channels (Institute of Engineers Australia (IEA 2006), alter streambed properties and aquatic habitat for fish, smother benthic organisms, and reduce the food supply and refuge for bottom feeding organisms, macrophytes, and benthic organisms (Chetia 2014) • High concentrations can reduce water clarity and light available to support photosynthesis → loss of submerged macrophytes (i.e. seagrasses) • High concentrations can impair the function of fish gills (ANZECC and ARMCANZ 2000) • Suspended solids can alter predator-prey relationships (e.g. could make it difficult for fish to see prey) • Suspended solids can also provide surface area for the sorption and transport of nutrients and other pollutants (e.g. metals and bacteria) • → often used as an "indicator" of nutrients/other pollutants

Table E-1 (continued): Effects of stressors on aquatic environments

Parameter	Factors/sources impacting stressor levels	Ecosystem impacts

Temperature	• **Natural**
	   • Air temperature and sun exposure
	      o Therefore time of day
	   • Turbidity – increases temperature through scattering of solar radiation
	   • Waterbody depth and depth of measurement
	   • Vegetation - temperatures in unvegetated water bodies will vary more than those with vegetation due to greater exposure to weather conditions, but will generally be higher due to lack of shade
	• **Anthropogenic**
	   • Industrial discharges – can increase or decrease temperature
	   • Stormwater runoff from hot surfaces (e.g. roads and carparks) could increase the temperature of receiving water bodies
	   • Reservoirs could discharge cooler water to waterbodies.
		• Higher rates of plant and algae growth
		   • As soon as the temperature cools or other supporting processes cease, growth declines and biological decay commences → increased oxygen demand
		• Influences sediment redox reactions
		   • E.g. increased temperatures result in increased sediment phosphorus release (Lehtoranta 1995).
		• Increased temperatures increase metabolic rate of bacteria and therefore mineralisation of organic matter → release of bioavailable phosphorus and nitrogen species into the water (Lehtoranta 1995).
		• High temperatures reduce oxygen solubility
		• High temperatures increase solubility of salts
		• Many chemicals exhibit between a two and four fold increase or decrease in toxicity for each 10°C rise in temperature (ANZECC and ARMCANZ 2000).
		• Some organisms become more vulnerable to toxic wastes, parasites and diseases at low water temperatures
		• Increased metabolic rate of organisms with increasing temperature → increased oxygen demand (compounded by decreased oxygen solubility)
		• Different species tolerant to different ranges → changes can result in differing biotic communities
		   • Fish and macro-invertebrates are ectotherms as their body temperature is controlled by the temperature of the surrounding environment (Marsh et al 2005) – as such they particularly sensitive to temperature changes
		• Low temperatures - loss of spawning trigger for fish

Table E-1 (continued): Effects of stressors on aquatic environments

Parameter	Factors/sources impacting stressor levels	Ecosystem impacts

Nitrogen	• **Natural**
	  • Soil type – e.g. highly mineral soils will store less nitrogen available to be mobilised into the water
	  • Fringing and emergent vegetation type and volume
	  • Seasonal conditions
	  • Hydrology – loss of nitrogen as N_2 gas may occur more readily in certain wetland hydrology
	  • Sources include plant and animal decomposition, faecal material, lightning and volcanic activity
	• **Anthropogenic**
	  • Fertilisers
	  • Sewerage
	  • Feed lots
	  • Pet droppings
	  • Combustion of fossil fuels
	  • Plant debris (e.g. from glass clippings)
	  • Industrial and household cleaning products (e.g. runoff from car washing)
	  • Ammonia/ammonium specific:
	    o Industrial processes including the preparation of synthetic fibres (e.g. nylons), plastics and explosives, resins, human and veterinary medicines, fuel cells, rocket fuel, dyes, metal treating operations, refrigeration, and petroleum (DoE 2016).
	    o Proportion of ammonia/ammonium in water varies with pH & temperature (ammonium is predominant at pH 5 to 8) and as such levels can vary throughout the day
		• Some nitrogen is required for life - wetlands with very low concentrations of nitrogen and phosphorus will support little life (oligotrophic)
		• High concentrations (particularly of bioavailable forms) in conjunction with high phosphorus result in nuisance growth of aquatic plants/algae/cyanobacteria (blue green algae) known as eutrophication, which can have flow-on negative effects:
		  • Toxic effects of cyanobacterial toxins (particularly due to cyanobacteria in fresh and brackish waters) to humans, birds and aquatic biota
		  • Decreased dissolved oxygen from surface growth acting as physical barrier and decomposition of excessive growth → harm to fish, macroinvertebrates and desirable macrophyte species
		  • Decreased light available to desirable macrophyte species
		  • Reduction in recreational amenity (phytoplankton blooms and macrophytes in wetlands and lakes) from cyanobacterial toxins and odours produced from decomposing material
		  • Physical blocking of waterways
		  • Reduction in biodiversity or change in species composition
		    o E.g. mosquitoes (tolerant to poor water quality) can become predominant in eutrophic waterways
		• Nitrogenous fertilisers and car emissions can lead to acidification of waterbodies
		• High levels of ammonia are directly toxic to fish & aquatic organisms

Table E-1 (continued): Effects of stressors on aquatic environments

Parameter	Factors/sources impacting stressor levels	Ecosystem impacts

Phosphorus	• **Natural**
	  • Decomposition of organic matter
	  • Weathering of rocks
	• **Anthropogenic**
	  • Motor vehicle exhaust, fuels, lubricants, fertilisers, detergents, car wash products, eroded soils, and industrial wastes (IEA 2006)
	  • Runoff from impervious surfaces such as roads, parking lots and rooftops (especially in commercial, industrial and high-density residential areas) can potentially contribute a large portion of phosphorus to the water bodies as this water is not filtered (Department of Environment (Western Australia) 2004a)
		• Some phosphorus is required for life - wetlands with very low concentrations of phosphorus and nitrogen will support little life (oligotrophic)
		• Excessive concentrations (particularly bioavailable forms (i.e. FRP)) in conjunction with high nitrogen concentrations, can result in eutrophication (see ecosystem impacts of nitrogen for more information)

Hardness	• **Natural**
	  • Underlying geology – e.g. wetlands over limestone generally have hard water
	• **Anthropogenic**
	  • Discharges from operating and disused rock quarries
	  • Inorganic chemical industry
		• Generally, hard waters are more alkaline, and waters with greater hardness are generally less susceptible to acidification
		• Increasing water hardness and alkalinity specifically reduces the uptake and toxicity to freshwater organisms of several metals (such as cadmium, chromium III, copper, lead, nickel and zinc)

Appendix F Potential sources, factors affecting toxicity and impacts of metals found in urban stormwater

The metals analysed as part of this monitoring program can be derived from a wide variety of sources, some natural and some anthropogenic. Understanding the sources of these metals can provide potential avenues for investigation if high concentrations are detected. Furthermore, if high metal concentrations are encountered, other water quality indicators and local factors may provide an indication of the severity of the impact of these concentrations. The impact of hardness on concentrations is has been quantified for some metals (see tables in **0**), but also, for example, for metals that adsorb to suspended particles, the presence of these particles may reduce the bioavailability of some (but not all) of these metals to biota, thus effectively reducing their toxicity. As metals are generally more bioavailable in soluble form, factors that increase solubility will increase their toxicity. Different functional groups of biota may also differ in their sensitivity to metals. The main impact of metals to surface waters is generally toxicity to biota, but some metals (such as iron) can have other negative environmental impacts.

Table F-1 describes the potential sources, factors affecting impacts and toxic and other impacts of metals. Information regarding sources of metals is taken from The National Pollutant Inventory (Australian Government Department of Environment (DoE) 2016) and information regarding factors affecting toxicity and impacts to biota are derived from ANZECC and ARMCANZ (2000) unless otherwise stated.

Table F-1: Potential sources, factors affecting impacts and impacts of metals typically found in urban stormwater

METAL	SOURCES/USES	FACTORS AFFECTING IMPACTS	IMPACTS
Aluminium (Al)	• Natural leaching from soil and rock • Increased in soluble groundwater concentrations under acidic conditions, therefore strongly linked to the presence of Acid Sulfate Soils (ASS) (DER 2015) • Anthropogenic sources include industrial discharges and corrosion of products containing aluminium • used in construction, automotive, aircraft and electrics industries, in the production of metal alloys, cooking utensils and food packaging (WHO 2010)	• Toxicity to fish and invertebrates increased at pH<5.5 and >9, with a maximum toxicity around pH 5.0-5.2 • Toxicity reduced by complexing with humic (organic) substances • Toxicity reduced at high water hardness • Toxicity possibly increased with increased temperature	• Toxic to biota at high concentrations • Among aquatic plants, single celled plants most susceptible • Fish more susceptible than aquatic macroinvertebrates • Can affect the function of fish gills (Exley et al 1991)

Table F-1 (continued): Potential sources, factors affecting impacts and impacts of metals typically found in urban stormwater

METAL	SOURCES/USES	FACTORS AFFECTING IMPACTS	IMPACTS

Arsenic (As)	• Naturally present in the earth's crust
	• Can enter waterways through wind-blown dust and water run-off
	• Naturally released into the environment through weathering of rocks and volcanic activity
	• High arsenic concentrations in groundwater (and communicating surface waters) linked to the presence of Acid Sulfate Soils (ASS) (DER 2015b)
	• Mining and metal manufacturing main anthropogenic source of arsenic in Australia
	  • Other uses of arsenic in industry include manufacturing of food, paper products, glass products, petroleum and coal products and chemicals
	• Also released from combustion of fuels and other incineration activities
		• Several valencies exist in water – most common are As (III) and As (V)
		  • both bond with carbon to form numerous organo-arsenic compounds, some of which are very toxic (e.g. methylarsine)
		• Valency state main factor affecting toxicity – As (III) most toxic form
		• Toxicity of As (V) increases with increasing temperature
		• As (III) removed by sulfides, As (V) by clays
			• Toxic to biota
			• Can bio-accumulate in some animals
			• Phytoplankton is among the most sensitive organisms to both forms of arsenic
			• Higher trophic levels are less sensitive to arsenic because they generally accumulate the element from food rather than the water column.
			• Adult freshwater fish are generally less sensitive to arsenic

Chromium (Cr)	• Exists naturally in low concentrations (rocks, soil, plants, animals, volcanic dust, gasses) • Enters waterways through settling of atmospheric particles and rainfall and contaminated water and soil • Chromium in stormwater is mostly associated with suspended solids (IEA 2006) • Two forms: The trivalent form (Cr^{3+}) is mainly discharged from the metal industry where it is used for chrome plating, and the hexavalent form (Cr^{6+}) is mainly discharged from tanning & painting (IEA 2006) • Predominant form of chromium in the environment is Cr^{3+} • It is also used in industry to produce the following: electrical products, engine parts, fungicides, wood treatment products, ceramics, clay, paper, glass, porcelain, pharmaceuticals/medicines/medical treatment, steam & air conditioning supplies and cement products Other sources include combustion of fossil fuels, incineration of waste and sewerage sludge	• Toxicity of both forms decreases with increasing water hardness and/or alkalinity • Cr^{6+} toxicity increases in freshwater at lower pH • Cr^{6+} not affected by presence of suspended material, whereas Cr^{3+} is readily removed from the water column with both dissolved organic matter and suspended material • Toxicity decreases with increasing salinity and sulfate • More toxic at high temperatures	• Chromium VI is toxic to aquatic organisms, and a carcinogen for animals & humans • Cr^{3+} is far less toxic than Cr^{6+} • Chromium VI may bio-accumulate to some degree • Freshwater algae & invertebrates are more sensitive to Cr^{6+} than fish, with crustaceans particularly sensitive

Table F-1 (continued): Potential sources, factors affecting impacts and impacts of metals typically found in urban stormwater

METAL	SOURCES/USES	FACTORS AFFECTING IMPACTS	IMPACTS
Copper (Cu)	• Copper compounds naturally occur in rocks, soil, water, plants, animals and humans • Enters water from settling of atmospheric particles or dissolved in waters • Natural sources include decaying vegetation, forest fires and sea spray • Mining and metal manufacturing largest sources of copper emissions in Australia • Other industrial sources include electricity supply and manufacturing of chemicals, cement, lime, plaster and concrete products, transport equipment, petroleum, coal, beverages, paper products, glass products, motor vehicles and parts, wood products, ceramic products, food and beverage products, and textiles (DoE 2016) • Found to be related to the flow of vehicles and road network characteristics (Beasley & Kneale 2002). • Also possible release from solid and liquid fuel combustion, lawn mowing, leaching from antifouling paint on ships and boats	• Toxicity increases when hardness, alkalinity & dissolved oxygen decrease • Strongly attaches to organic matter and suspended material • Levels of dissolved organic matter in freshwaters usually remove copper toxicity (except in very soft waters) • Its toxicity in algae, invertebrates & fish generally increases as salinity decreases • Copper and lead toxicity appear to interact in synergism	• It is a micro-nutrient and essential to life at low concentrations, toxic at higher concentrations to freshwater fish, invertebrates and plants • Some species of algae particularly sensitive • Negatively affects fish and macro-invertebrates in various body systems across multiple life stages • Can bio-accumulate in aquatic organisms
Iron (Fe)	• Fourth most abundant metal in earth's crust • Naturally present in water in varying quantities depending upon local geology and other chemical factors • Insoluble ferric state (Fe^{3+}) usually more prevalent in surface waters (ANZECC and ARMCANZ 2000) • Soluble ferrous state (Fe^{2+}) present in reducing (anaerobic) waters and usually originates from groundwater (ANZECC and ARMCANZ 2000) • Industrial production of the following iron containing products could produce anthropogenic iron pollution: pigments of paints and plastics, food colours, construction materials (WHO 2003) • Many pipes are constructed of cast iron, steel or galvanised iron which may become sources of iron (WHO 2003)	• Solubility increases in acidic water • Solubility higher in anaerobic waters	• Essential for both plants and animals • Has been shown to be toxic to some macroinvertebrate species • In aerobic waters, ferric iron can form colloidal suspensions which can either form suspended flocs or settle and harden • may cause problems with turbidity, decreased light penetration and smothering of benthic organisms

Table F-1 (continued): Potential sources, factors affecting impacts and impacts of metals typically found in urban stormwater

Lead (Pb)	• Rare in nature, anthropogenic sources outweigh natural sources (ANZECC and ARMCANZ 2000) • Lead reaches aquatic environment through rainfall, lead dust , street runoff and industrial discharges (ANZECC and ARMCANZ 2000) • Also fires and fuel combustion • Lead used to be used in water pipes, stained glass windows, paint and fuel and as such these products may be partially responsible for the legacy of lead in waterways • Mining and metal manufacturing greatest industrial emitters • Also used in production of cement, plaster, concrete, iron, steel, petroleum, coal products, paper products, glass products, metal products, motor vehicles and parts, wood products, yarn and fabric	• Toxicity increases when water hardness decreases • Low solubility in water reduces toxicity • Strongly adsorbed by suspended clay, humic substances and other suspended material • Strongly complexed by dissolved organic material • Toxicity possibly increased at low pH	• Non-essential, highly poisonous element • Shown to affects chlorophyll synthesis in plants (e.g. Mesmar and Jaber 1991) • Can potentially bioaccumulate but not generally present in great enough concentrations that bioaccumulation has much effect
Mercury (Hg)	• Naturally occurring element found in rocks and ores • Can enter waterways from atmospheric particles settling or deposited by rain, or through emissions in water and soil • Natural sources of mercury in waterways include emissions from volcanoes and evaporation of water from soil • Largest source of mercury emissions in Australia from manufacturing, mining and alumina production of non-ferrous metals • Also can be released from burning of fossil fuels, precious metal mining, cement manufacturing, chemical manufacturing and sewerage • Landfills and disposal of batteries, thermometers and other mercury containing products can emit mercury to land, which can eventually end up in water	• Present as inorganic Hg (II) and organomercurial compounds (such as methyl mercury) - microorganisms can convert Hg (II) to methyl mercury • Increased toxicity with decreased hardness • Strongly adsorbed by particles, often associated with sediments • Strong affinity for chloride – toxicity of inorganic mercury reduced in saline waters	• Inorganic mercury relatively low toxicity and low ability to bioaccumulate • Methyl mercury particularly toxic - can be absorbed quickly • Can bioaccumulate in fish and their food chains • In mercury polluted areas, larger and older fish tend to have higher levels
Nickel (Ni)	• Exists naturally in soils and rocks often with arsenic, antimony and sulfur • Found at background concentrations in natural waters (ANZECC and ARMCANZ 2000) • Can enter waterways from settling of atmospheric particles or dissolved compounds in waters • Natural sources include weathering of rocks (ANZECC and ARMCANZ 2000) and volcanoes • Anthropogenic sources of atmospheric nickel include combustion of fossil fuels, mining and refining operations, steel production, nickel alloy production, electroplating, municipal waste incineration and nickel refineries • Can enter water in wastewater from municipal sewage treatment plants, stormwater runoff and from groundwater near landfill sites	• Toxicity increases with decreased hardness • Toxicity usually increases with decreased pH • Complexed by dissolved organic material • Less bioavailable when adsorbed to suspended material • Toxicity increases with decreasing salinity	• Essential to life • Moderately toxic to freshwater organisms • Reduces growth of freshwater algae at relatively low concentrations • Fish less sensitive to nickel, but it differs between species

Table F-1 (continued): Potential sources, factors affecting impacts and impacts of metals typically found in urban stormwater

METAL	SOURCES/USES	FACTORS AFFECTING TOXICTY AND IMPACTS	IMPACTS
Selenium (Se)	• Occurs naturally in the environment at varying concentrations, usually combined with other compounds (such as sulphide ores of other metals) • Commonly found in sedimentary rock formations • Can enter waterways from settling of atmospheric particles or dissolved compounds in waters • Exists in water as oxyions selenate (selenium (VI)) and selenite (selenium (IV)) • Natural sources in water include weathering of rocks • Released into the air and water from combustion of fossil fuels, smelting and refining of metals, glass and ceramics manufacturing and refuse incinerators • Can also enter waterways from anti dandruff shampoos and application as fungicides and insecticides	• Toxicity of selenate increases with decreasing sulfate and phosphate concentrations • Selenite uptake increases at low pH • Toxicity ameliorated by mercury and copper • Binding of selenium to particles does not reduce bioavailability	• Toxicity dependent on valency state – Se (IV) more toxic than Se (VI) • Selenites readily removed form water column, but selenates can bioaccumulate in aquatic ecosystems • Food chain uptake more significant than water uptake
Zinc (Zn)	• Exists naturally in rocks, soil, air, waters, plants and humans • Can enter waterways from settling of atmospheric particles or dissolved compounds in waters • Natural sources in water include weathering of rocks • Anthropogenic sources include mining, steel production, waste incineration, chemical waste dumps & landfills, sewage treatment plants, corrosion of galvanised structures, fertilisers and herbicides • Urban runoff also potential source from wear of car tyres or fuel combustion	• Toxicity increases with decreasing hardness and alkalinity • Levels of organic matter present in freshwater generally sufficient to remove zinc toxicity • pH determines stability of these compounds • Adsorbed by suspended material • Toxicity generally decreases with decreasing pH when pH <8 • Uptake and toxicity decrease with increasing salinity	• Essential for life • Labile Zn^{+2} most toxic form • Bioaccumulates in freshwater animal tissues but not a major problem