MOOREBANK PRECINCT EAST STAGE 2: BIODIVERSITY MONITORING IN ANZAC CREEK

AUTUMN 2022 SURVEY

Report Prepared for
ARCADIS

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EXECUTIVE SUMMARY

Introduction

The Sydney Intermodal Terminal Alliance (SIMTA) received approval for the construction and operation of Stage 2 (the Project) of the Moorebank Precinct East (MPE) Project, which comprises the second stage of development under the MPE Concept Approval (MP10_0193) and approved under Development Approval SSD 7628.

The MPE site, including the Project site, is located approximately 27 km south-west of the Sydney Central Business District (CBD) and approximately 26 km west of Port Botany and includes the former Defence National Storage and Distribution Centre (DNSDC) site. The MPE site is situated within the Liverpool Local Government Area (LGA), in Sydney's South West subregion, approximately 2.5 km from the Liverpool City Centre.

The MPE Project involves the development of an intermodal facility including warehouse and distribution facilities, freight village (ancillary site and operational services), stormwater infrastructure, landscaping, servicing and associated works on the eastern side of Moorebank Avenue. Stage 2 of the MPE Project (MPES2) involves the construction and operation of warehousing and distribution facilities on the MPE site and upgrades to approximately 2.1 kilometres of Moorebank Avenue.

A Baseline Aquatic Ecological Monitoring Program (BAEMP) was developed by Biosis Pty Ltd for Arcadis in March 2018, to address Condition of Consent (CoC) B106. The purpose of the BAEMP was to establish baseline stream health and water quality conditions within selected sites along Anzac Creek prior to commencement of Early Works. This was undertaken in autumn 2018.

The baseline monitoring forms the basis for the ongoing Biodiversity Monitoring Strategy (BMS) to assess stream health in accordance with CoC B106, to determine any change in stream health or water quality throughout the life of the Project and to ascertain whether these changes can be attributed to the Project works. The BMS outlines monitoring requirements and includes the Stormwater Monitoring Strategy required by CoC B43 and B44.

BIO-ANALYSIS Pty Ltd was commissioned by Arcadis on behalf of Tactical Group to assess stream health and water quality at six monitoring sites along Anzac Creek (the Study Area) in autumn 2022, in accordance with the BMS to satisfy the CoC B43, B44 and B106.

Methods

The BMS required that stream health monitoring focus on four main indicators:

- Aquatic habitat, including riparian habitat, aquatic macrophytes and fish habitat;
- Surface water quality and sediment characteristics;
- Aquatic macroinvertebrates sampled using the Australian River Assessment System (AUSRIVAS) protocol;
- Fish sampled using a backpack electro-fisher.

The results of the autumn 2022 monitoring events were compared with those obtained in autumn 2018 (baseline), spring 2018, autumn 2019, spring 2019, autumn 2020, spring 2020, autumn 2021 and spring 2021 (during construction). There has been no construction on the MPES2 since December 2020. Warehouses 1, 3, 4 and 5 are now operational and the location of Warehouses 6-8 have been left as compacted pads. Any water sheets off into the sediment (SED) Basins and discharges into Anzac Creek (via DP5 and DP7).

Results

Within the study area, Anzac Creek is mostly ephemeral with the exception of a relatively large pool downstream of the Project area (Site AQ12), opposite Wattle Grove. Sites downstream of the refuge pool have appeared to be in a more degraded state than those further upstream. At the time of the autumn 2022 monitoring events, the condition of aquatic habitat appeared similar to that observed by previous surveys, in that the majority of the creek appeared stable and not subject to significant erosional processes. Water visibility was good.

The noxious plant, Alligator Weed, continues to be abundant at the most upstream site (Site AQ1). The popular aquarium plant, *Egeria densa* (Egeria), collected within the large refuge pool (Site AQ12) in spring 2020, has not been observed by subsequent surveys.

Reduced dissolved oxygen levels, elevated nitrogen, aluminium and copper measured at the refuge pool within the study area, including prior to commencement of the Project, have consistently suggested that aquatic habitat and biota within Anzac Creek are influenced by various types of anthropogenic disturbance. The data collected to date indicate that there has been no further degradation of water quality since the Project related construction work began.

Concentrations of lead in sediments collected at the most upstream site sampled on Anzac Creek (Site AQ1) continue to exceed the guideline value (50 mg/kg) but not the baseline value measured by the BAEMP survey (91 mg/kg). Importantly, the levels of lead recorded at Site AQ1 have not increased since commencement of the Project.

Approximately 400 m downstream of AQ1 and immediately downstream of the Project area, concentrations of lead, nickel and zinc measured in sediments at Site AQ4 exceeded the ANZECC/ARMCANZ (2000) guideline values and BAEMP survey results during 2022 autumn Survey 1 (5 May 2022) but not 2022 autumn Survey 2 (31 May 2022). While the Project may also have influenced sediment quality within the creek, there has been no construction at the MPES2 site since December 2020. It is possible that recent prolonged rainfall contributed to the higher concentrations of heavy metals, by redistributing sediments along the stream channel. Irrespectively, heavy metals bound in sediments were not identified as specific contaminants of concern by the BAEMP for the MPES2 Project, so no additional testing of heavy metals at Site AQ4 is considered necessary at this stage.

PFOA (perfluoro-octanoic acid) and PFOS (perfluorooctance sulphonate) have been detected in water and sediment samples collected throughout the survey period, but concentrations remain similar to baseline values and within the recommended Australian-derived guidelines for water and soil.

Low diversity of aquatic macroinvertebrates, Australian River Assessment System (AUSRIVAS) and Stream Invertebrate Grade Number Average Level (SIGNAL2) scores were also indicative of a site suffering from one or more forms of human impact. Despite this, some pollution tolerant taxa have commonly been identified, including dragonfly and caddis fly families. Comparison of the AUSRIVAS and SIGNAL2 scores between the baseline and construction phase indicate an overall stability in aquatic health.

Altogether, nine species of fish have been collected from within the refuge pool: three native species of gudgeon, two native species of eel, one native galaxiid species and three introduced species (Gambusia, Goldfish and Oriental weatherloach), confirming that the creek does provide some habitat for native species of fish. All of the species caught are common within NSW. No threatened species of fish listed under the *NSW Fisheries Management Act, 1994* or the *Environment Protection and Biodiversity Conservation Act, 1999* have been recorded.

Conclusions

Examination of the results from the autumn 2022 monitoring event found no evidence of changes in the indicator variables (bed and bank stability, water quality, assemblages of aquatic macroinvertebrates and fish) that could be attributed to the Project works. Thus, in accordance with the Biodiversity Monitoring Strategy, no adaptive management contingency measure was triggered.

Recommendations

It is recommended that Land managers focus on containment and on-going suppression of the Alligator Weed infestation at Site AQ1. Signage and public information at popular points of entry by the public to the creek and other local waterways may reduce the chance of unintentional human-assisted introductions (e.g. by using live bait, or by being released by aquaria).

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1.0 INTRODUCTION

The Sydney Intermodal Terminal Alliance (SIMTA) received approval for the construction and operation of Stage 2 (the Project) of the Moorebank Precinct East (MPE) Project, which comprises the second stage of development under the MPE Concept Approval (MP10_0193) and approved under Development Approval SSD 7628.

The MPE site, including the Project site, is located approximately 27 km south-west of the Sydney Central Business District (CBD) and approximately 26 km west of Port Botany and includes the former Defence National Storage and Distribution Centre (DNSDC) site. The MPE site is situated within the Liverpool Local Government Area (LGA), in Sydney's South West subregion, approximately 2.5 km from the Liverpool City Centre.

The MPE Project involves the development of an intermodal facility including warehouse and distribution facilities, freight village (ancillary site and operational services), stormwater infrastructure, landscaping, servicing and associated works on the eastern side of Moorebank Avenue. Stage 2 of the MPE Project involves the construction and operation of warehousing and distribution facilities on the MPE site and upgrades to approximately 2.1 kilometres of Moorebank Avenue. There has been no construction on the MPES2 since December 2020. Warehouses 1, 3, 4 and 5 are now operational and the location of Warehouses 6-8 have been left as are compacted pads. Any water sheets off into the sediment (SED) Basins and discharges into Anzac Creek (via DP5 and DP7).

BIO-ANALYSIS Pty Ltd has been commissioned by Arcadis on behalf of Tactical Group to assess stream health and water quality along Anzac Creek (the Study Area) in autumn 2022. Monitoring is to be done in accordance with a Biodiversity Monitoring Strategy (BMS) developed by Biosis (2018) to satisfy the Minister's Conditions of Consent (CoC) B106. The BMS also includes the Stormwater Monitoring Strategy required by CoC B43 and B44.

The primary aim of monitoring is to determine whether any change in stream health or water quality occur throughout the life of the MPE Stage 2 (MPES2) Project in accordance with the BMS and to ascertain whether these changes can be attributed to the Project works. Sampling commenced in autumn 2018 (Biosis, 2018).

Figure 1. Project Location.

2.0 METHODS

2.1 Study Area

Anzac Creek is a small tributary of the Georges River, and lies entirely within the Liverpool Local Government Area. The catchment covers an area of approximately 10.6 km^2 (Figure 1).

The headwaters of Anzac Creek lie within the Commonwealth Department of Defence Lands in Moorebank. The creek is approximately 4 km long and highly urbanised: it flows past the suburb of Wattle Grove, underneath the M5 and Heathcote Road intersection, through the Moorebank Industrial Area and underneath Newbridge Road.

While predominantly ephemeral, Anzac Creek has been noted to hold permanent water in isolated pools (Arcadis, 2016). An unnamed first order tributary of Anzac Creek flows from south to north along the eastern boundary of the MPE Project area (GHD, 2016).

Surface water from the MPES2 site is expected to enter Anzac Creek as licensed discharge between Site AQ4 and AQ8 (Figure 1). It was also considered likely that runoff from some areas of the MPES2 site would be collected by a vegetated dam situated within Commonwealth Department of Defence land (Biosis, 2018). Flow from this dam enters Anzac Creek upstream of Site AQ14 via a culvert (Figure 1).

2.2 Sampling Dates

The dates and phases of the stream health monitoring program for the MPES2 Project are outlined in Table 1.

Table 1. Date and information on aquatic ecology monitoring completed for the Project.

Project Phase	Event	Dates	Comments
Baseline	Autumn 2018	12&19 April 2018	Only one Baseline survey was able to be sampled in autumn 2018, due to the May 2018 bushfire.
Construction	Spring 2018	6&12 December 2018	
Construction	Autumn 2019	14&30 May 2019	Construction of culvert upstream of Site AQ1 largely completed on 30 May 2019. Site AQ12 was inaccessible to undertake Survey 2 due to restricted access.
Construction	Spring 2019	24 September 2019 21 November 2019	Warehouses 3 and 4 under construction. Moorebank Ave upgrade works ongoing.
Construction /Operation	Autumn 2020	25 May 2020 2 September 2020	Sampling required for the autumn 2020 survey season was unable to commence until late May 2020 due to COVID-19 related delays. The second survey was further delayed due to the time taken to receive parts required to repair the Electrofisher. Warehouses 3 and 4 were operational whilst Warehouse 5 was under construction. Moorebank Ave upgrade works ongoing.
Construction /Operation	Spring 2020	11&30 November 2020	Warehouses 3, 4 and 5 were operational. No further warehouses were being constructed at the time of monitoring
Construction /Operation	Autumn 2021	28 April 2021 11 June 2021	There has been no construction on the MPES2 since December 2020. Warehouses 3, 4 and 5 are now operational and the location of Warehouses 6-8 have been left as compacted pads. Any water sheets off into the SED Basin and discharges into ANZAC Creek (via DP5 and DP7).
Construction /Operation	Spring 2021	21 September 2021 8 November 2021	As above
Construction /Operation	Autumn 2022	5 & 31 May 2022	As above

2.3 Performance Measures and Indicators

No instream or riparian works are being undertaken as part of the Project. Alteration to hydrology (increased stormwater inputs from both the stormwater network and surface flows from increases in non-permeable surfaces) and earthworks that have the potential to mobilise sediments into Anzac Creek were identified as potential impacts associated with the construction phase of the project (Biosis, 2018).

Biosis (2018) indicated that increased stormwater inputs to Anzac Creek could result in:

- Bed and bank scour as a result of increased volume and velocity of water during rainfall events;
- Alterations in vegetation structure as a result of altered hydrological regime;
- Introduction of sediments and pollutants via stormwater, with common pollutants including nitrogen, phosphorous, copper, aluminium and zinc.

Water Sensitive Urban Design (WSUD) measures such as onsite detention basins and rainwater gardens were incorporated into designs for the Project to mitigate impacts. A key outcome of this monitoring program was to determine whether these measures functioned as intended. Six monitoring sites (Sites AQ1, AQ4, AQ8, AQ12, AQ13 and AQ14; Figure 1) are to be assessed in accordance with the BMS to satisfy the CoC B43, B44 and B106. The assessment types to be applied at each site are outlined in

Table 2.

Should an indicator variable deteriorate below the range for its baseline value, a stream health investigation protocol is to be initiated under the BAEMPs Adaptive Management Plan (Table 3).

Baseline values are presented in Table 4, Table 5 and Table 6 (Section 3: Results).

Table 2. Assessment types recommended for each monitoring site (Biosis, 2018).

Assessment Type	Assessment Protocol/ Indicator Variable	AQ1	AQ4	AQ8	AQ12	AQ13	AQ14
Visual	DPI Classification	√	√	√	√	√	√
	NSW AUSRIVAS	√	√	√	√	√	√
	HABSCORE	√	√	√	√	√	√
	Ephemeral Stream Assessment	√	√	√	√	√	√
Surface Water & Sediment Quality Monitoring	*In situ* water quality				√		
	Nutrient, dissolved metal & PFAS				√		
	Sediment & PFAS	√	√				√
Aquatic Macroinvertebrates	NSW AUSRIVAS & Signal2				√		
Fish	Assemblage structure				√		

Table 3. Indicator variables and adaptive management contingency measures.

Result	Potential Problem	Contingency measure
Increases in results of water quality parameters	Introduction or exacerbation of pollutants entering Anzac Creek.	Identify source and undertake corrective measures.
Reduction in results of biological monitoring	Subtle effects of construction and operation are influencing stream health within Anzac Creek.	Identify components causing decline. Assess feasibility of suitable corrective actions. If corrective measures can be implemented, these aspects are to be the focus of future monitoring. If corrective measures cannot be implemented, regulatory authority to be notified of change.
Increase scour of bed and banks of waterways	Reduction in bed and bank stability or loss of instream vegetation.	Identify point source/s of increased flow velocities or changes in stream hydraulics and discuss with project engineers to determine best methods for flow reduction or rectification of stream hydraulics

2.4 Field Methods

To fulfil the requirements of the BMS, monitoring is to be undertaken at 6 sites along Anzac Creek (Figure 1) four times annually during the pre-construction and construction phases of the Project, with the frequency reduced to twice annually during the operational phase of the Project. Surveys should take place during autumn and spring (Biosis, 2018). Sites are to be assessed using the methods outlined below, in accordance with

Table 2.

2.4.1 Visual Stream Assessments

A visual assessment was undertaken at each site regardless of the availability of aquatic habitat (i.e. wet or dry). The condition of aquatic habitat at each site was assessed according to the *NSW Department of Primary Industries Policy and Guidelines for Fish Habitat Conservation and Management* (DPI NSW, 2013). The two key indices were habitat *type* and *class*.

Information on stream characteristics was recorded at each site in accordance with the New South Wales (NSW) Australian River Assessment System (AUSRIVAS) protocol (Turak et al., 2004). Characteristics recorded included a visual assessment of surrounding landforms, instream features, presence, extent and type of aquatic vegetation, stream substratum, potential areas of refuge during low flow periods, presence of fish habitat, presence of barriers to fish movement, indicators of point source and diffuse pollution.

HABSCORE assessments were also completed at each site, based on the presence and condition of pool substrate characteristics, pool variability, channel flow status, bank vegetation and stability, width of riparian zone, and epifaunal substrate/cover. The *CSIRO Ephemeral Stream Assessment* guideline was also used to provide an assessment of the geomorphic integrity of each site and to identify the processes operating within each site.

Each site was photographed and the locations recorded with a hand-held GPS (satellite-based Global Positioning System).

2.4.2 Surface Water Quality & Sediment Monitoring

Where sufficient amounts of water are present, *in situ* water quality was measured using a Yeo-Kal 611 probe. Physico-chemical properties measured included electrical conductivity (µS/cm), dissolved oxygen (% saturation and mg/L), pH (pH units), temperature (°C) and turbidity (NTU). Three replicate measures of each variable were collected from just below the water surface at each site.

Alkalinity was also determined in the field at Site AQ12, using a CHEMetrics' total alkalinity field kit.

As required by the BMS, water chemical and sediment sampling were undertaken for a range of nutrients, metals and hydrocarbons:

- Total Phosphorus (surface water only);
- Total Kjeldahl Nitrogen (TKN) (Total Organic Nitrogen + Total Ammonia) (surface water only);
- Total Nitrogen (TKN + (Nitrate + Nitrite) (surface water only);
- Dissolved metals (standard 19 relevant to aquatic assessment) (surface water);
- Total metals (standard 19 relevant to aquatic assessment) (sediment only);
- Total petroleum hydrocarbons, BTEX (benzene, toluene, ethylbenzene, trimethylbenzenes and three xylene isomers) hydrocarbons;
- PFAS: Poly-fluoroalkyl substances (including Perfluorohexane sulfonate PFHxS).

Samples were sent to the National Measurement Institute (NMI) laboratory (a NATA accredited laboratory) for analysis.

Construction Discharges

Construction discharge records (i.e. dewatering permits) were requested from contractors from the MPES2 Project in order to assess water quality and quantity performance for construction discharges, as required by the Stormwater Monitoring Program, CoC B44(a)). Records were requested for the time period between 9 November 2021 and 31 May 2022.

2.4.3 Aquatic Macroinvertebrates

Aquatic macroinvertebrates were required to be collected by the BMS at Site AQ12 (Biosis, 2018) using the NSW AUSRIVAS protocol (Turak et al., 2004). Biosis (2018) considered this large pool provides reliable and valuable aquatic habitat.

Stream edge habitats were sampled using a 250 µm dip net.

The contents of each net sample were placed into a white sorting tray and animals collected for a minimum period of 30 minutes. Thereafter, removals were done in 10-minute periods, up to a total of one hour (Turak et al., 2004). If no new taxa were found within a 10-minute period, removals ceased (Turak et al., 2004).

The animals collected were placed inside a labelled container and preserved with 70 % alcohol.

In the laboratory, taxa were identified to family level with the exception of Acarina (to order), Chironomidae (to sub-family), Nematoda (to phylum), Nemertea (to phylum), Oligochaeta (to class), Ostracoda (to subclass) and Polychaeta (to class). Some families of Anisoptera (dragonfly larvae) were identified to species, because they could potentially include threatened aquatic species.

2.4.4 Fish Community Survey

Fish sampling is done at Site AQ12 using a Smith Root LR-24 backpack electrofisher. The Electrofisher is used to stun fish in open water, around the edge of the pool, around snags and aquatic vegetation and any overhanging banks. All fish caught are identified and the length of up to 30 individuals of each species measured. Incidental observations such as evidence of disease are also noted before native fish species are subsequently returned to the water.

2.4.5 Data Analysis

Water quality measurements were used to assess health of the aquatic ecosystem by comparison with guideline values recommended by ANZECC[1] and ARMCANZ[2] (2000) for the protection of lowland streams (i.e. systems at < 150 m altitude) in south-east Australia.

For aquatic macroinvertebrates, data was analysed using the appropriate AUSRIVAS predictive models developed for NSW. The ecological health of a waterway is assessed by comparing the macroinvertebrates collected at a site (i.e. Observed) to those predicted to occur (Expected) if the site is in an undisturbed or 'reference' condition.

The principal outputs of the AUSRIVAS model include:

- Observed to Expected ratio (OE50): the ratio of the number of macroinvertebrate families collected at a site which had a predicted probability of occurrence of greater than 50 % (i.e. Observed) to the sum of the probabilities of all of the families predicted with greater than a 50 % chance of occurrence (i.e. Expected) (Ransom et al., 2004);
- BAND: for each model, the OE50 taxa ratios are divided into bands representing different levels of impairment. Band X represents a more diverse assemblage of macroinvertebrates than control sites; Band A is considered equivalent to reference condition; Band B represents sites below reference condition (i.e. significantly impaired); Band C represents sites well below reference condition (i.e. severely impaired); and Band D represents impoverished sites (i.e. extremely impaired) (Ransom et al., 2004).

The SIGNAL2 biotic index (Stream Invertebrate Grade Number Average level) developed by Chessman (2003) was also used to give an indication of water quality at the sites sampled. The SIGNAL score for a macroinvertebrate sample is calculated by averaging the pollution sensitivity grade numbers of the families present, which may range from 10 (most sensitive) to 1 (most tolerant). The SIGNAL2 scores from samples collected between autumn 2018 and autumn 2022 are presented graphically to provide an indication of changes over time.

[1] ANZECC – Australian and New Zealand Environment and Conservation Council
[2] ARMCANZ – Agriculture and Resource Management Council of Australia and New Zealand

2.4.6 Quality Assurance/Quality Control (QA/QC)

Data collected in the field was checked for accuracy and completeness before leaving each site. In the office, field data and other records were incorporated into appropriate excel data sheets and checked. Spreadsheets were locked prior to analysis to prevent accidental over-writes or corruption.

In the laboratory, macroinvertebrate samples were identified by an appropriately qualified staff member. Data for each sample were entered into an excel spreadsheet and then checked.

3.0 RESULTS

For the autumn 2022 monitoring event, sites were sampled on 5 May (Survey 1) and 31 May 2022 (Survey 2). Each site was approximately 100 m in length with their GPS co-ordinates listed in Appendix A. Collections of fish and macroinvertebrates were completed in accordance with Section 37 of the *NSW Fisheries Management Act 1994* using Scientific Collection Permit Number P03/0032(B) and NSW Agriculture, Animal Research Authority Care and Ethics Certificate of Approval Number 03/2445.

3.1 Aquatic Habitat Characteristics

The section of Anzac Creek within the study area is not mapped as Key Fish Habitat (KFH) under the NSW DPI Key Fish Habitat mapping for the Sydney LGA (DPI 2007; Appendix A). Nevertheless, this section of Anzac Creek is ranked as TYPE 1 KFH according to the DPI (2013) classification scheme due to the presence of native aquatic plants and snags. According to the waterway CLASS scheme, a permanent pool with freshwater aquatic vegetation situated at Site AQ12 is considered CLASS 2 KFH. The remaining reaches of Anzac Creek within the Study Area are considered to be CLASS 3 KFH despite the presence of aquatic vegetation, due to the ephemeral nature of any pools that are present (DPI, 2013).

Vegetation within the channel and banks of Anzac Creek has been classified as Parramatta Red Gum woodland in high condition (GHD, 2016).

Within the two months prior to the 2022 autumn Survey 1 (5 May 2022) and 2022 autumn Survey 2 (31 May 2022), a total of 903 mm and 797 mm rainfall was recorded respectively by the meteorological station situated near Bankstown Airport (Station ID: 66137) (Figure 2).

There has been no construction on the MPES2 since December 2020. Warehouses 1, 3, 4 and 5 are now operational and the location of Warehouses 6-8 have been left as compacted pads. Any water sheets off into the sediment (SED) Basins and discharges into Anzac Creek (via DP5 and DP7).

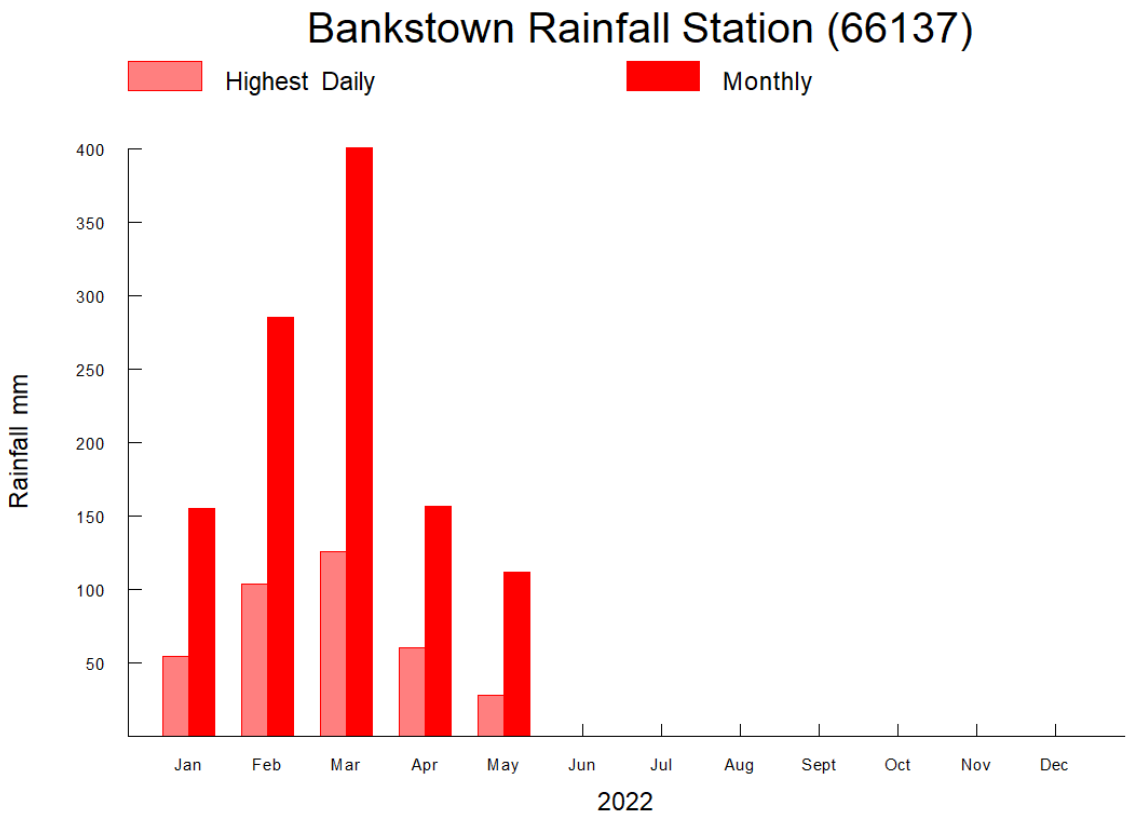

Figure 2. Rainfall (mm) measured at Bankstown Rainfall Station (66137) between 1 January and 31 May 2022.

Site AQ1

Site AQ1 is situated approximately 750 m downstream of the source of Anzac Creek (Figure 1), and approximately 100 m downstream of a culvert built across Anzac Creek as part of the MPE Stage 1 project (Plate 1). The culvert is composed of box culverts to a length of 15 m and supports one rail track and a maintenance access footway. Construction of the culvert was completed by CPB and handed over to the proponent, Qube, in July 2019.

Flow was apparent at the time of the autumn 2022 surveys and the channel was almost full-to-bank (up to approximately 0.4 m deep) (Plates 1&2). The active channel zone at this site (up to approximately 5 m wide) remains stable (i.e. no signs of active erosion), mostly due to dense cover of the shallow, relatively narrow stream channel by emergent macrophytes and the relatively intact woody riparian vegetation (Appendix 2). The channel consisted of fine sediment.

The stream channel at Site AQ1 is mostly colonised by the noxious plant, Alligator Weed (*Alternanthera philoxeroides*), and the native species, Slender knotweed (*Persicaria decipiens*) (Plates 1&2). Other species of aquatic plant observed at Site AQ1 included Marsh Club-rush (*Bolboschoenus fluviatilis*) and Typha (*Typha* sp.). The tree canopy was mostly comprised by *Melaleuca* spp. and *Eucalyptus* spp. (Plates 1&2).

Plate 1: AQ1 – View across-stream (31/05/22)

Plate 2: AQ1 – View downstream (5/05/22)

Site AQ4

Site AQ4 is situated approximately 400 m downstream of Site AQ1 (Figure 1).

The stream channel at Site AQ4 has occasionally been dry, including at the time of the Baseline survey (i.e. autumn 2018). Since the autumn 2020 surveys, surface water has been observed along the study reach (up to approximately 0.4 m deep), including in autumn 2022 (Plates 3&4). Water clarity was considered good at the time of the autumn 2022 surveys (Plate 3).

Since the baseline survey, stands of the emergent macrophyte, Jointed Twig Rush (*Baumea articulata*) and Twig Rush (*Baumea rubiginosa*) have formed across the downstream reaches of stream channel (Plate 4). Jointed Twig Rush, Slender Knotweed and Frog's Mouth (*Philydrum lanuginosum*) are common in the upstream reaches (Plate 4).

The active channel zone, composed of fine sediments, was up to approximately 4 m wide (Plates 3&4). No indicators of significant erosion were observed suggesting that Anzac Creek continues to be relatively stable at this site, particularly since colonisation of the stream channel by emergent macrophytes (Plate 3&4, Appendix 2).

Plate 3: AQ4 – View downstream (5/05/22)

Plate 4: AQ4 – View upstream (5/05/22)

Site AQ8

Site AQ8 is situated approximately 1 km downstream of Site AQ4 (Figure 1). At the time of Surveys 1 and 2, surface water (up to 20 cm deep) was present.

Similar to previous surveys, the study reach was mostly colonised by Heron Bristle Sedge (*Chorizandra cymbaria*), Jointed Twig Rush and Tall Spikerush (*Eleocharis sphacelata*), with occasional Frogsmouth (*Philydrum lanuginosum*), Slender Knotweed and the introduced species, Umbrella Sedge (*Cyperus eragrostis*), present throughout (Plates 5&6). Riparian vegetation was dominated by *Casuarina* trees. Common Reed/Phragmites (*Phragmites australis*) was present at the downstream end of the site (Plate 6).

The stream channel at Site AQ8 (up to approximately 20 m wide) continues to be classified as stable, mostly due to dense cover by emergent macrophytes in addition to a relatively intact, woody riparian zone (Appendix 2).

Plate 5: Site AQ8 – view upstream (31/05/22)

Plate 6: Site AQ8 – view downstream (31/05/22)

Site AQ12

Site AQ12 is situated approximately 750 km downstream of Site AQ8 (Figure 1). Similar to the findings of biodiversity surveys done since autumn 2018, a large pool (approximately 20 m wide) and a relatively diverse assemblage of aquatic plants, including submerged species, were present (Plates 7&8). The pool substratum was composed primarily of fine sediment with a considerable cover of detritus.

Water level in the pool was up to approximately 0.9 m deep and flow was apparent at the relatively narrow, downstream end of the pool at the time of both surveys. Water clarity was considered good. Extensive cover by vegetation within the riparian zone contributes stability to the pool edges at Site AQ12, although an area of active erosion was apparent at the downstream end of the pool, similar to the findings of the autumn 2020 surveys, most likely due to recent overbank flows after heavy rain.

The submerged macrophyte species, Ribbonweed (*Vallisneria* sp.) and *Potamogeton ochreatus* were common, in addition to Slender Knotweed and dense stands of Typha, Phragmites and Tall Spike Rush (Plate 7). *Nymphoides geminata* (Entire Marshwort), with mostly floating leaves, was common close to the shore. Accumulations of green filamentous algae were apparent in areas close to the shore (Plates 7&8). Egeria (*Egeria densa*), which was collected close to the left-bank (facing downstream) of the pool in spring 2020, has not been collected subsequently.

Riparian vegetation included Casuarina, Eucalyptus and Melaleuca trees and Spiny-head Mat-rush/Basket Grass (*Lomdandra longifolia*) (Plates 7&8).

Plate 7: Site AQ12 – view downstream (5/05/22)

Plate 8: Site AQ12 – view upstream (5/05/22)

Site AQ13

Site AQ13 is situated approximately 200 m downstream of Site AQ12 (Figure 1). This site is located approximately 150 m downstream from an overflow channel that enters the creek from Wattle Grove.

Water to a depth of approximately 0.8 m was present at Site AQ13 at the time of both surveys, and flow was apparent (Plates 9&10). Unlike the findings of previous surveys, there was no apparent iron floc or anoxic layer covering the stream substratum and visibility was good.

A large proportion of the stream channel and edges were colonised by Typha and Slender Knotweed. River Clubrush (*Schoenoplectus validus*) and Whorled Pennywort/Shield Pennywort (*Hydrocotyle* cf *verticillata*) were also common. The stream channel appeared stable (Appendix 2).

Plate 9: Site AQ13 – view downstream (5/05/22)

Plate 10: Site AQ13 – view upstream (5/05/22)

Site AQ14

Site AQ14 is situated approximately 150 m downstream of Site AQ13 and immediately downstream of the culvert that links the dam within Commonwealth Department of Defence Lands to Anzac Creek (Figure 1). Flow was apparent at the time of both autumn 2022 surveys and water clarity was good (Plates 11&12).

Typha, Slender Knotweed, River Clubrush and Whorled Pennywort/Shield Pennywort were common (Plates 11&12). This section of Anzac Creek remains mostly stable due to dense instream vegetation and vegetated banks (Appendix 2).

Plate 11: Site AQ14 – view upstream (5/05/22)

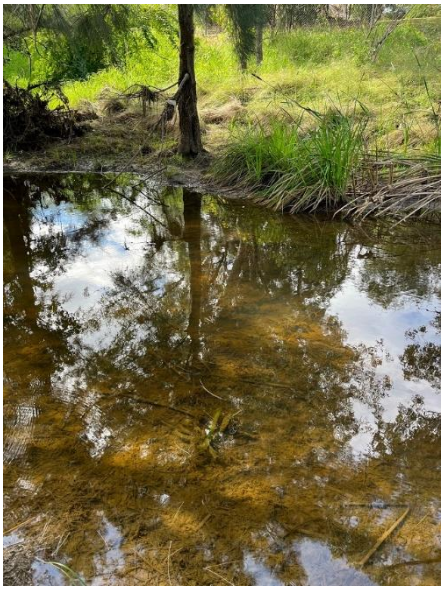

Plate 12: Site AQ14 – view across-stream (5/05/22)

3.2 Water & Sediment Characteristics

3.2.1 Water Quality

Physico-chemical measurements were collected at Site AQ12 in accordance with the requirements of the BMS (cf Biosis, 2018) and at sampling sites where sufficient water was present to submerge a water quality instrument probe. The data were compared to the default trigger values (DTVs) recommended by ANZECC/ARMCANZ (2000) for the protection of slightly disturbed lowland river ecosystems in southeast Australia (Table 4).

Results from this investigation (2022 autumn survey 1 and 2022 autumn survey 2) indicated that:

- Water temperature ranged from 9.5 to 17.3 °C;
- pH (range = 6.6 to 8.2) was above the recommended DTV at site AQ12 during Survey 2;
- Conductivity (range = 176 to 303 µS/cm) was within the recommended DTVs at all of the sites sampled;

- With the exception of Site AQ12 at the time of Survey 2 (i.e. 127 % saturation), dissolved oxygen (DO) measurements (range = 12 to 127 % saturation) were below the lower DTV;
- Turbidity levels were within the recommended DTVs at the sites sampled in autumn 2022 (range = 6 to 41 NTU);
- Concentrations of total phosphorous (range = <0.05 mg/L) were within the recommended DTV (0.05 mg/L) at Site AQ12;
- Total nitrogen marginally exceeded the upper DTV (0.5 mg/L) at Site AQ12 at the time of Survey 2 (0.65 mg/L) but not Survey 1 (0.5 mg/L);
- Total Kjeldahl Nitrogen (TKN) (Total Organic Nitrogen + Ammonia) measured at AQ12 during Survey 2 (i.e. 0.28 mg/L) was considerably lower than for Total Nitrogen (TKN + (Nitrate + Nitrite), indicating that the source of nitrogen within the refuge pool was most likely inorganic (e.g. fertilizer) rather than organic (e.g. algae or decomposing plant material) (Table 4).

Most notably, the majority of dissolved oxygen measurements collected at Site AQ12 were below the lower limit of the ANZECC/ARMCANZ (2000) range, including at the time of the baseline survey (Table 4). Nitrogen levels have commonly exceeded the upper limit, including at the time of the baseline survey (Table 4).

A range of toxicants have also been measured in water between autumn 2018 (baseline) and spring 2021 (during construction) within the vicinity of Site AQ12 (Table 5&6) in accordance with the BMS (cf Biosis, 2018).

Results indicate that:

- Aluminium has commonly exceeded the DTV (80 µg/L) (i.e. 11 of 15 surveys), including at the time of the baseline survey (260 µg/L) and during autumn 2022 (Survey 2: 200 µg/L) (Table 5);
- Cadmium exceeded the DTV (0.4 µg/L) at Site AQ12 in autumn 2019 (Survey 1: 0.49 µg/L; Survey 2: 0.41 µg/L) and autumn 2021 Survey 1 (3.8 µg/L), but not during autumn 2022 (Survey 1: <0.1 µg/L; Survey 2: 0.13 µg/L (Table 5);
- Copper has commonly exceeded the DTV (1.8 µg/L) (i.e. 9 of 15 surveys, including the baseline survey: 2 µg/L), but not during autumn 2022 (Table 5);

- Zinc exceeded the DTV during autumn 2021 (Survey 2: 20 µg/L: but not during autumn 2022) (Table 5);
- BTEX compounds and total recoverable hydrocarbons have not been detected (Table 6);
- PFOA (perfluoro-octanoic acid) and PFOS (perfluorooctance sulphonate) have occasionally been detected (Table 6). PFOA was not detected during autumn 2022 (Table 6). PFOS was detected during autumn 2022 (Survey 1: 0.047 µg/L; Survey 2: 0.054 µg/L) but continues to be within the recommended DTVs (Table 6).

Table 4. Mean (± SE) physico-chemical water quality and nutrient values recorded at the time of the Baseline (autumn 2018, *n* = 1) and the autumn 2022 (*n* = 3) surveys and the appropriate Default Trigger Values (DTV). Values highlighted in bold type indicate where results were outside the recommended DTV.

Indicator Variable	DTV*	Baseline[A]	Survey 1 (5/05/22)					
			AQ1	AQ4	AQ8	AQ12	AQ13	AQ14
Temperature °C (*n* =3)	-	-	16.5 (0.0)	16.6 (0.0)	16.7 (0.0)	16.4 (0.0)	17.3 (0.0)	17.3 (0.0)
pH (*n* =3)	**6.5-8.0**	7.01	6.6 (0.0)	6.7 (0.0)	7.0 (0.0)	6.9 (0.0)	6.9 (0.0)	7.1 (0.0)
Conductivity (µS/cm) (*n* = 3)	**125-2200**	354	227.0 (0.0)	182.3 (0.3)	213.0 (0.0)	236.7 (2.3)	246.3 (0.3)	303.3 (0.3)
Dissolved Oxygen (%) (*n* = 3)	**85-110**	**62**	**11.8** (0.1)	**29.9** (0.4)	**59.5** (0.1)	**16.5** (2.0)	**54.2** (0.5)	**61.2** (0.2)
Turbidity (NTU) (*n* = 3)	**6-50**	**91**	6.4 (0.2)	10.0 (0.2)	9.0 (0.1)	18.0 (0.0)	40.7 (0.7)	7.2 (0.1)
Alkalinity (mg/L) *(n* = 1)	-	-	N/R	N/R	N/R	45	N/R	N/R
Total Phosphorous (mg/L) *(n* = 1)	**0.05**	**0.58**	N/R	N/R	N/R	<0.05	N/R	N/R
Total Nitrogen (mg/L) *(n* = 1)	**0.5**	**8.2**	N/R	N/R	N/R	0.50	N/R	N/R
Total Kjeldahl (mg/L) *(n* = 1)	-	-	N/R	N/R	N/R	0.50	N/R	N/R
Indicator Variable	**DTV***	**Baseline**	**Survey 2 (31/05/22)**					
			AQ1	**AQ4**	**AQ8**	**AQ12**	**AQ13**	**AQ14**
Temperature °C (*n* =3)	-	-	9.5 (0.0)	10.8 (0.0)	11.1 (0.0)	12.4 (0.0)	12.6 (0.0)	12.7 (0.0)
pH (*n* =3)	**6.5-8.0**	7.01	7.4 (0.0)	7.2 (0.0)	7.2 (0.0)	**8.2** (0.0)	7.6 (0.0)	7.4 (0.0)
Conductivity (µS/cm) (*n* = 3)	**125-2200**	354	275.0 (0.0)	175.7 (0.3)	178.3 (0.3)	289.7 (0.9)	273.0 (0.6)	270.0 (1.0)
Dissolved Oxygen (%) (*n* = 3)	**85-110**	**62**	**49.0** (0.3)	**45.8** (0.2)	**78.6** (0.1)	**126.9** (0.3)	**74.5** (0.1)	**75.4** (0.1)
Turbidity (NTU) (*n* = 3)	**6-50**	**91**	11.1 (0.3)	8.1 (0.7)	7.6 (0.0)	11.2 (0.2)	7.5 (0.1)	8.00 (0.0)
Alkalinity (mg/L) *(n* = 1)	-	-	N/R	N/R	N/R	22	N/R	N/R
Total Phosphorous (mg/L) *(n* = 1)	**0.05**	**0.58**	N/R	N/R	N/R	<0.05	N/R	N/R
Total Nitrogen (mg/L) *(n* = 1)	**0.5**	**8.2**	N/R	N/R	N/R	**0.65**	N/R	N/R
Total Kjeldahl (mg/L) *(n* = 1)	-	-	N/R	N/R	N/R	0.28	N/R	N/R

*ANZECC/ARMCANZ (2000) – slightly disturbed systems

[A] Baseline values for pH, conductivity, dissolved oxygen and turbidity were obtained from Site AQ12, whilst baseline data for phosphorous and total nitrogen were obtained from Site AQ11 (Biosis, 2018)

I/A: Insufficient Aquatic Habitat; N/R: Not Required

Table 5. Summary of dissolved metal compound results for Site AQ12 in autumn 2018 (Baseline), autumn and spring 2019, autumn and spring 2020, autumn and spring 2021 and autumn and autumn 2022 (*n* = 1).

Indicator Variable	**DTV* (µg/L)**	**Baseline Site AQ11**	**Autumn 2019 Site AQ12**		**Spring 2019 Site AQ12**	
		April 2018	**14/05/19**	**30/05/19**	**24/09/19**	**21/11/19**
Aluminium pH >6.5	**80**	**260**	**150**	68	**2730**	**280**
Aluminium pH <6.5	**-**	**-**	**-**	-	**-**	-
Arsenic Total (µg/L)	**42**	<1	<1	<1	1.1	<1
Barium	**-**	2	55	34	21	32
Beryllium	**-**	<1	<1	<1	<1	<1
Boron	**680**	<50	20	17	14	14
Cadmium (µg/L)	**0.4**	<0.1	**0.49**	**0.41**	<0.1	<0.1
Chromium	**6**	<1	<1	<1	2.3	<1
Cobalt	**-**	<1	<1	<1	<1	<1
Copper (µg/L)	**1.8**	**2**	**2**	1.1	**3**	**2.3**
Iron	**-**	450	300	100	1650	900
Lead (µg/L)	**5.6**	<1	<1	<1	2.6	<1
Manganese	**2500**	3	33	6.2	60	47
Mercury (µg/L)	**1.9** [A]	<0.1	<0.1	<0.1	0.12	<0.1
Molybdenum	**-**	<1	<1	<1	<1	<1
Nickel (µg/L)	**13**	<1	<1	N/R	1.7	1.1
Selenium Total	**18**	<10	<2	<1	<1	<1
Strontium	**-**	52	120	120	73	53
Vanadium	**-**	<10	<1	<1	3.8	1.4
Zinc (µg/L)	**15**	<5	6.8	N/R	13	14

*ANZECC/ARMCANZ (2000) – slightly disturbed systems (90% species protection)
[A] = inorganic mercury; N/R: not recorded

Table 5 (Cont'd). Summary of dissolved metal compound results for Site AQ12 (*n* = 1).

Indicator Variable	DTV* (µg/L)	Baseline Site AQ11	Autumn 2020 Site AQ12		Spring 2020 Site AQ12	
		April 2018	25/05/20	2/09/20	11/11/20	30/11/20
Aluminium pH >6.5	**80**	**260**	**230**	70	**230**	**100**
Aluminium pH <6.5	**-**	**-**	-	**-**	**-**	-
Arsenic Total (µg/L)	**42**	<1	<1	<1	<1	<1
Barium	**-**	2	31	19	36	39
Beryllium	**-**	<1	<1	<1	<1	<1
Boron	**680**	<50	21	<5	32	31
Cadmium (µg/L)	**0.4**	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	**6**	<1	<1	<1	<1	<1
Cobalt	**-**	<1	<1	<1	<1	<1
Copper (µg/L)	**1.8**	**2**	**1.9**	<1	**2**	1.3
Iron	**-**	450	620	270	460	280
Lead (µg/L)	**5.6**	<1	1.5	<1	<1	<1
Manganese	**2500**	3	19	8.8	6.9	12
Mercury (µg/L)	**1.9** [A]	<0.1	<0.1	<0.1	<0.1	<0.1
Molybdenum	**-**	<1	1.3	<1	<1	1.1
Nickel (µg/L)	**13**	<1	1.1	<1	1.1	<1
Selenium Total	**18**	<10	<1	<1	<1	<1
Strontium	**-**	52	120	140	120	130
Vanadium	**-**	<10	<1	<1	<1	<1
Zinc (µg/L)	**15**	<5	8.5	3.6	5.7	2.9

*ANZECC/ARMCANZ (2000) – slightly disturbed systems (90% species protection)

[A] = inorganic mercury; N/R: not recorded

Table 5 (Cont'd). Summary of dissolved metal compound results for Site AQ12 (*n* = 1).

Indicator Variable	DTV* (µg/L)	Baseline Site AQ11	Autumn 2021 Site AQ12		Spring 2021 Site AQ12	
		April 2018	28/04/21[3]	11/06/21	21/9/21	8/11/21
Aluminium pH >6.5	**80**	**260**	**150**	**1260**	62	**200**
Aluminium pH <6.5	**-**	**-**				
Arsenic Total (µg/L)	**42**	<1	<1	<1	<1	<1
Barium	**-**	2	29	<1	31	13
Beryllium	**-**	<1	<1	<1	<1	<1
Boron	**680**	<50	20	10	20	15
Cadmium (µg/L)	**0.4**	<0.1	**3.8**	<0.1	<0.1	<0.1
Chromium	**6**	<1	<1	1.5	<1	<1
Cobalt	**-**	<1	<1	<1	<1	<1
Copper (µg/L)	**1.8**	**2**	**2.1**	**3.3**	1.7	**3.2**
Iron	**-**	450	160	420	150	180
Lead (µg/L)	**5.6**	<1	<1	<1	<1	<1
Manganese	**2500**	3	6.9	4.7	10	2
Mercury (µg/L)	**1.9** [A]	<0.1	<0.1	<0.1	<0.1	0.15
Molybdenum	**-**	<1	<1	<1	<1	<1
Nickel (µg/L)	**13**	<1	1.1	<1	<1	<1
Selenium Total	**18**	<10	<1	<1	<1	<1
Strontium	**-**	52	130	46	110	40
Vanadium	**-**	<10	<1	2.7	<1	1.9
Zinc (µg/L)	**15**	<5	9	**20**	8.3	12

*ANZECC/ARMCANZ (2000) – slightly disturbed systems (90% species protection)

[A] = inorganic mercury; N/R: not recorded

[3] NB Data reported here for autumn 2021 Survey 1 and Survey 2 differ from those reported in the autumn 2021 report. Data had been entered incorrectly in the autumn 2021 report but have since been corrected.

Table 5 (Cont'd). Summary of dissolved metal compound results for Site AQ12 (*n* = 1).

Indicator Variable	DTV* (µg/L)	Baseline Site AQ11	Autumn 2022 Site AQ12			
		April 2018	5/05/22	31/05/22		
Aluminium pH >6.5	**80**	**260**		**200**		
Aluminium pH <6.5	**-**	**-**	70			
Arsenic Total (µg/L)	**42**	<1	<1	<1		
Barium	**-**	2	18	19		
Beryllium	**-**	<1	<1	<1		
Boron	**680**	<50	21	18		
Cadmium (µg/L)	**0.4**	<0.1	<0.1	0.13		
Chromium	**6**	<1	<1	<1		
Cobalt	**-**	<1	<1	<1		
Copper (µg/L)	**1.8**	**2**	1.4	1.5		
Iron	**-**	450	560	320		
Lead (µg/L)	**5.6**	<1	<1	<1		
Manganese	**2500**	3	99	5.9		
Mercury (µg/L)	**1.9** [A]	<0.1	<0.1	<0.1		
Molybdenum	**-**	<1	<1	<1		
Nickel (µg/L)	**13**	<1	<1	<1		
Selenium Total	**18**	<10	<1	<1		
Strontium	**-**	52	93	56		
Vanadium	**-**	<10	<1	<1		
Zinc (µg/L)	**15**	<5	8	6.7		

*ANZECC/ARMCANZ (2000) – slightly disturbed systems (90% species protection)
[A] = inorganic mercury; N/R: not recorded

Table 6. Summary of BTEX and perfluoronated compound results (n = 1).

Indicator Variable	DTV* (µg/L)	Baseline Site AQ11	Spring 2018 Site AQ12		Autumn 2019 Site AQ12	
		April 2018	6/12/18	12/12/18	14/05/19	30/05/19
BTEXN (µg/L)						
Benzene (µg/L)	**1300**	<1	<1	<1	<1	<1
Toluene (µg/L)	**-**	<2	<1	<1	<1	<1
Ethylbenzene (µg/L)	**-**	<2	<1	<1	<1	<1
Ortho-Xylene (µg/L)	**470**	<2	<1	<1	<1	<1
Perfluoronated Compounds (µg/L)						
PFHxS (µg/L)	**-**	0.02	0.02	0.12	0.039	0.039
PFOS (µg/L)	**0.13**	0.03	0.043	0.070	0.068	0.069
PFOA (µg/L)	**220**	<0.01	<0.01	0.011	0.011	0.010
Sum of PFHxS and PFOS	**-**	0.05	0.063	0.19	0.107	0.108
Sum of PFAS (WA DER List)[B]	**-**	0.05	0.128[C]	0.185[C]	0.188[C]	0.19[C]
Indicator Variable	**DTV* (µg/L)**	**Baseline Site AQ11**	**Spring 2019 Site AQ12**		**Autumn 2020 Site AQ12**	
		April 2018	**24/9/19**	**21/11/19**	**25/5/20**	**2/9/20**
BTEXN (µg/L)						
Benzene (µg/L)	**1300**	<1	<1	<1	<1	<1
Toluene (µg/L)	**-**	<2	<1	<1	<1	<1
Ethylbenzene (µg/L)	**-**	<2	<1	<1	<1	<1
Ortho-Xylene (µg/L)	**470**	<2	<1	<1	<1	<1
PFHxS (µg/L)	**-**	0.02	0.091	0.025	0.044	0.068
PFOS (µg/L)	**0.13**	0.03	0.084	0.057	0.055	0.076
PFOA (µg/L)	**220**	<0.01	<0.01	0.013	<0.01	<0.01
Sum of PFHxS and PFOS	**-**	0.05	0.175	0.082	0.099	0.144
Sum of PFAS (WA DER List)[B]	**-**	0.05	0.252[C]	0.164[C]	0.178[C]	0.219[C]

*BTEXN: ANZECC/ARMCANZ (2000) – slightly disturbed systems (90% species protection); PFAS suite: DEE (2016) – Freshwater (95 % species protection – slightly to moderately disturbed ecosystems).

[B] = PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTS and 8:2 FTS.

[C] For any site, where a value has been recorded as less than the detection limit, it was assigned a value of half the detection limit in order to calculate the mean (e.g. <0.02 taken as 0.01).

Table 6 (Cont'd).

Indicator Variable	DTV* (µg/L)	Baseline Site AQ11	Spring 2020 Site AQ12		Autumn 2021 Site AQ12	
		April 2018	11/11/20	30/11/20	28/04/21	11/06/21
Benzene (µg/L)	**1300**	<1	<1	<1	<1	<1
Toluene (µg/L)	**-**	<2	<1	<1	<1	<1
Ethylbenzene (µg/L)	**-**	<2	<1	<1	<1	<1
Ortho-Xylene (µg/L)	**470**	<2	<1	<1	<1	<1
PFHxS (µg/L)	**-**	0.02	0.026	0.041	0.065	0.011
PFOS (µg/L)	**0.13**	0.03	0.054	0.062	0.065	<0.02
PFOA (µg/L)	**220**	<0.01	0.005[C]	0.014	<0.01	<0.01
Sum of PFHxS and PFOS	**-**	0.05	0.080	0.103	0.13	0.021[C]
Sum of PFAS (WA DER List)[B]	**-**	0.05	0.151[C]	0.196[C]	0.222[C]	0.086[C]
Indicator Variable	**DTV* (µg/L)**	**Baseline Site AQ11**	**Spring 2021 Site AQ12**		**Autumn 2022 Site AQ12**	
		April 2018	**21/9/21**	**8/11/21**	**5/05/22**	**31/05/22**
BTEXN (µg/L)						
Benzene (µg/L)	**1300**	<1	<1	<1	<1	<1
Toluene (µg/L)	**-**	<2	<1	<1	<1	<1
Ethylbenzene (µg/L)	**-**	<2	<1	<1	<1	<1
Ortho-Xylene (µg/L)	**470**	<2	<1	<1	<1	<1
PFHxS (µg/L)	**-**	0.02	0.037	<0.01	0.044	0.039
PFOS (µg/L)	**0.13**	0.03	0.032	0.021	0.047	0.054
PFOA (µg/L)	**220**	<0.01	0.013	<0.01	<0.01	<0.01
Sum of PFHxS and PFOS	**-**	0.05	0.069	0.026[C]	0.091	0.093
Sum of PFAS (WA DER List)[B]	**-**	0.05	0.169[C]	0.091[C]	0.166	0.176

*BTEXN: ANZECC/ARMCANZ (2000) – slightly disturbed systems (90% species protection); PFAS suite: DEE (2016) – Freshwater (95 % species protection – slightly to moderately disturbed ecosystems).

[B] = PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTS and 8:2 FTS.

[C] For any site, where a value has been recorded as less than the detection limit, it was assigned a value of half the detection limit in order to calculate the mean (e.g. <0.02 taken as 0.01).

3.2.2 Sediment Characteristics

Sediment samples have been collected at Site AQ1, AQ4, AQ14 between autumn 2018 (baseline) and autumn 2022 (during construction) (Table 7&8).

Results indicate that:

- The majority of measurements of lead at AQ1 (range = 21 to 130 mg/kg) have exceeded the threshold limit (50 mg/kg) detailed in the Interim Sediment Quality Guidelines (ISQG) (ANZECC/ARMCANZ 2000), including at the time of the baseline (91 mg/kg) survey (discussed further in Section 5.1). Concentrations of lead measured at Site AQ1 during autumn 2022 (Survey 1: 54 mg/kg; Survey 2: 55 mg/kg) also exceeded the guideline value;
- Concentrations of mercury measured at AQ1 (Survey 1: <0.2 mg/kg; Survey 2: 0.29 mg/kg) exceeded the recommended trigger level for the first time since sampling commenced (Table 7), given that Site AQ1 is situated upstream of the Project area, it is unlikely that this result is related to Project activities;
- Concentrations of lead (56 mg/kg), nickel (23 mg/kg) and zinc (220 mg/kg) measured at AQ4 marginally exceeded the ANZECC/ARMCANZ (2000) guidelines levels during Survey 1 but not Survey 2 (Table 7);
- A spike in barium was detected at Site AQ14 in autumn 2019 (Survey 1: 902 mg/kg) but not subsequently. There are no guideline criteria for barium in sediments or water (ANZECC/ARMCANZ 2000);
- PFOS has consistently been detected at the sites sampled (range = <0.002 to 0.044 mg/kg) but concentrations continue to be below the recommended guideline value for Urban Residential/Public Open Spaces (32 mg/kg) as well as National Parks/Areas with High Ecological Values (6.6 mg/L);
- PFAS (range = <0.001 to 0.0483 mg/kg) measured at each site continues to be similar to baseline values and below the recommended guideline value for Urban Residential/Public Open Spaces (29 mg/kg) and National Parks/Areas with High Ecological Values (1.0 mg/L) (Tables 7&8).

Table 7. Mean (± SE) sediment metal results (mg/L) for surveys done between autumn 2018 (*n* = 1) and autumn 2022 (*n* = 2).

Indicator Variable	Trigger Value*	Baseline (Autumn 2018)			Autumn 2019			Spring 2019		
		AQ1	AQ4	AQ14	AQ1	AQ4	AQ14	AQ1	AQ4	AQ14
Aluminium	-	-	-	-	26,800	24,300 (700)	2,295 (365)	-	-	-
Antimony	-	-	-	-	<0.5	<0.5 (0)	<0.5 (0)	-	-	-
Arsenic	**20**	<5	<5	<5	4	6 (0.9)	1 (0.2)	3.90 (0.6)	2.75 (0.5)	2.65 (0.3)
Barium	-	110	60	<10	100	66 (4.5)	455 (447)	135 (15)	76.5 (7.5)	29.5 (1.5)
Beryllium	-	<1	1	<1	0.96	1.2 (0.0)	<0.5 (0)	1.20 (0.1)	1.01 (0.1)	<0.5 (0.00)
Boron	-	<50	<50	<50	2.9	0.8 (0.3)	<1 (0)	<1.0 (0.0)	<1.0 (0.0)	<1.0 (0.0)
Cadmium	**1.5**	<1	<1	<1	<0.5	<0.5 (0)	<0.5 (0)	0.43[A] (0.2)	<0.5 (0.0)	<0.5 (0.0)
Chromium	**80**	23	21	3	21	23 (2.0)	3 (0.4)	21.0 (2.0)	13.5 (0.5)	6.3 (0.7)
Cobalt	-	8	6	<2	9	8 (1.9)	1 (0.1)	-	-	-
Copper	**65**	31	12	<5	28	11 (2.1)	2 (0.3)	30.0 (5.0)	6.1 (1.7)	9.0 (1.0)
Lead	**50**	**91**	44	<5	**72**	35 (0.0)	4 (0.2)	**78.0** (32.0)	21.5 (0.5)	12.0 (1.0)
Manganese	-	45	69	16	32	80 (2.0)	7 (0.8)	85.0 (55.0)	50.0 (15.0)	32.5 (12.5)
Mercury	**0.15**	<0.1	<0.1	<0.1	<0.2	<0.2 (0)	<0.2 (0)	<0.2 (0.0)	<0.2 (0.0)	<0.2 (0.0)
Molybdenum		-	-	-	2.2	1.0 (0.4)	<0.5 (0)	-	-	-
Nickel	**21**	14	9	<2	16	9 (0.0)	1 (0.0)	20.5 (0.5)	10.6 (1.4)	3.85 (0.2)
Selenium Total	-	<5	<5	<5	1	1 (0.0)	<0.5 (0)	2.65 (1.4)	1.59 (0.9)	0.63[A] (0.4)
Strontium	-	-	-	-	23	17 (4.5)	1 (0.1)	-	-	-
Vanadium	-	48	54	10	36	60 (9.5)	9 (0.9)	-	-	-
Zinc	**200**	93	96	17	100	64 (4.0)	14 (1.5)	119 (61.5)	29 (17.5)	74 (17.0)

***Interim Sediment Quality Guideline – Low (Trigger value) (ANZECC/ARMCANZ 2000)**

[A] For any site, where a value has been recorded as less than the detection limit, it was assigned a value of half the detection limit in order to calculate the mean (e.g. <0.02 taken as 0.01)

NB Aluminium, Antimony, Molybdenum, Strontium and Vanadium were not tested for by the Spring 2019 surveys because they were not required by the BMS (cf Biosis, 2018)

Table 7 (Cont'd).

Indicator Variable	Trigger Value*	Baseline (Autumn 2018)			Autumn 2020			Spring 2020		
		AQ1	AQ4	AQ1	AQ1	AQ4	AQ14	AQ1	AQ4	AQ14
Aluminium	-	-	-	-	-	-	-	-	-	-
Antimony	-	-	-	-	-	-	-	-	-	-
Arsenic	**20**	<5	<5	<5	1.90 (0.2)	3.4 (0.4)	5.1 (3.1)	1.90 (0.4)	3.4 (1.2)	2.4 (0.3)
Barium	-	110	60	<10	83 (15)	63.5 (3.5)	41.3 (31.7)	87.0 (33.0)	69.5 (9.5)	37.5 (9.5)
Beryllium	-	<1	1	<1	0.72 (0.1)	0.98 (0.0)	0.5 (0.3)	0.71 (0.2)	0.79 (0.1)	<0.5 (0.0)
Boron	-	<50	<50	<50	0.85 (0.4)	0.5 (0.0)	0.5 (0.0)	1.95 (0.4)	1.25 (0.2)	0.75
Cadmium	**1.5**	<1	<1	<1	0.25 (0.0)	0.25 (0.0)	0.3 (0.0)	<0.05 (0.0)	<0.5 (0.0)	1.0[B] (0.5)
Chromium	**80**	23	21	3	14.5 (0.5)	18.5 (0.5)	12.9 (8.2)	13.5 (3.5)	13.0 (0.0)	6.2 (0.3)
Cobalt	-	8	6	<2	-	-	-	-	-	-
Copper	**65**	31	12	<5	16.5 (0.5)	11.0 (2.0)	16.7 (12.3)	16.5 (6.5)	7.9 (0.2)	7.2 (1.2)
Lead	**50**	**91**	44	<5	**71** (5.0)	33.5 (3.5)	23.5 (15.6)	**53.5** (10.5)	26.0 (1.0)	11.5 (0.5)
Manganese	-	45	69	16	38.5 (0.5)	66.5 (10.5)	49.5 (38.5)	56.5 (16.5)	52.5 (4.5)	31.0 (3.0)
Mercury	**0.15**	<0.1	<0.1	<0.1	0.10 (0.0)	0.10 (0.0)	0.1 (0.0)	<0.2 (0.0)	<0.2 (0.0)	<0.2 (0.0)
Molybdenum		-	-	-	-	-	-	-	-	-
Nickel	**21**	14	9	<2	10.7 (1.3)	8.65 (0.5)	5.4 (3.3)	11.5 (2.6)	6.5 (0.5)	2.8 (0.6)
Selenium Total	-	<5	<5	<5	0.70 (0.0)	0.44 (0.2)	0.6 (0.4)	0.63[B] (0.4)	0.40[B] (0.2)	<0.5 (0.0)
Strontium	-	-	-	-	-	-	-	-	-	-
Vanadium	-	48	54	10	25 (1.0)	41 (2.0)	36.0 (21)	23 (5.0)	32 (5.5)	19.0 (1.0)
Zinc	**200**	93	96	17	78 (6.0)	144 (46.5)	111.0 (79)	86 (24)	58 (6.0)	45.5 (19.5)

***Interim Sediment Quality Guideline – Low (Trigger value) (ANZECC/ARMCANZ 2000**

[A] For any site, where a value has been recorded as less than the detection limit, it was assigned a value of half the detection limit in order to calculate the mean (eg. <0.02 taken as 0.01)
NB Aluminium, Antimony, Molybdenum, Strontium and Vanadium were not tested for by the Spring 2019 surveys because they were not required by the BMS (cf Biosis, 2018)

Table 7 (Cont'd).

Indicator Variable	Trigger Value*	Baseline (Autumn 2018)			Autumn 2021			Spring 2021		
		AQ1	AQ4	AQ1	AQ1	AQ4	AQ14	AQ1	AQ4	AQ14
Aluminium	-	-	-	-	-	-	-	-	-	-
Antimony	-	-	-	-	-	-	-	-	-	-
Arsenic	**20**	<5	<5	<5	3.65 (1.3)	6.10 (0.0)	4.30 (0.8)	14.55 (9.5)	3.5 (2.6)	2.85 (0.7)
Barium	-	110	60	<10	116.5(23.5)	99.5 (10.5)	68.0 (5.0)	74.5 (18.5)	48.0 (41.0)	84.5 (11.5)
Beryllium	-	<1	1	<1	1.20 (0.2)	0.87 (0.1)	0.50[A] (0.2)	0.81 (0.2)	0.38 (0.4)	0.44[A] (0.4)
Boron	-	<50	<50	<50	2.00 (0.9)	1.75[A] (1.3)	1.40[A] (0.9)	0.80[A] (0.3)	<1 (0.0)	0.95[A] (0.5)
Cadmium	**1.5**	<1	<1	<1	0.41[A] (0.2)	<0.5 (0.0)	<0.5 (0.0)	<0.5 (0.0)	<0.5 (0.0)	<0.5 (0.0)
Chromium	**80**	23	21	3	24 (7.0)	24.5 (1.5)	13.0 (2.0)	17.5 (0.5)	12.7 (10.3)	12.0 (1.0)
Cobalt	-	8	6	<2	-	-	-	-	-	-
Copper	**65**	31	12	<5	23 (8.0)	13.5 (1.5)	12.8 (3.3)	13.0 (2.0)	6.55 (5.5)	12.3 (2.8)
Lead	**50**	**91**	44	<5	**80** (50)	31.5 (2.5)	27.5 (7.5)	25.5 (4.5)	16.2 (12.9)	27.0 (7.0)
Manganese	-	45	69	16	28 (8)	150 (40)	46 (5)	95 (75)	57.1 (53)	27.5 (13.5)
Mercury	**0.15**	<0.1	<0.1	<0.1	<0.2 (0.0)	<0.2 (0.0)	<0.2 (0.0)	<0.2 (0.0)	<0.2 (0.0)	<0.2 (0.0)
Molybdenum		-	-	-	-	-	-	-	-	-
Nickel	**21**	14	9	<2	17.5 (3.5)	9.75 (2.3)	5.85 (1.4)	10.5 (3.6)	4.1 (3.4)	7.3 (2.8)
Selenium Total	-	<5	<5	<5	1.20 (0.00)	0.88 (0.00)	0.41 (0.2)	0.88 (0.3)	0.44 [A] (0.4)	1.18 [A] (0.9)
Strontium	-	-	-	-	-	-	-	-	-	-
Vanadium	-	48	54	10	10 (13)	56 (2.0)	31 (3.0)	34 (7.0)	32 (22.4)	26 (2.0)
Zinc	**200**	93	96	17	92 (68)	77 (14.0)	94.5 (35.5)	46 (22.0)	35 (28.2)	43 (16.0)

***Interim Sediment Quality Guideline – Low (Trigger value) (ANZECC/ARMCANZ 2000**

A For any site, where a value has been recorded as less than the detection limit, it was assigned a value of half the detection limit in order to calculate the mean (eg. <0.02 taken as 0.01)

NB Aluminium, Antimony, Molybdenum, Strontium and Vanadium were not tested for by the Spring 2019 surveys because they were not required by the BMS (cf Biosis, 2018)

Table 7 (Cont'd).

Indicator Variable	Trigger Value*	Baseline (Autumn 2018)			Autumn 2022 (5/5/22)			Autumn 2022 (31/5/22)		
		AQ1	AQ4	AQ1	AQ1	AQ4	AQ14	AQ1	AQ4	AQ14
Aluminium	-	-	-	-	-	-	-	-	-	-
Antimony	-	-	-	-	-	-	-	-	-	-
Arsenic	**20**	<5	<5	<5	4.3	10	6	2.9	3.6	4.6
Barium	-	110	60	<10	140	150	61	87	71	52
Beryllium	-	<1	1	<1	1.2	1.7	0.61	0.84	0.83	<0.5
Boron	-	<50	<50	<50	3.7	5	1.8	2	1.8	1
Cadmium	**1.5**	<1	<1	<1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium	**80**	23	21	3	23	49	11	17	20	9.9
Cobalt	-	8	6	<2	-	-	-	-	-	-
Copper	**65**	31	12	<5	24	32	14	19	14	13
Lead	**50**	**91**	44	<5	**54**	**56**	30	**55**	29	17
Manganese	-	45	69	16	28	320	66	25	110	41
Mercury	**0.15**	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	**0.29**	<0.2	<0.2
Molybdenum		-	-	-	-	-	-	-	-	-
Nickel	**21**	14	9	<2	17	**23**	5.1	13	8.8	4.2
Selenium Total	-	<5	<5	<5	3.4	3	1.3	1.1	0.68	0.57
Strontium	-	-	-	-	-	-	-	-	-	-
Vanadium	-	48	54	10	37	99	31	35	46	33
Zinc	**200**	93	96	17	48	**220**	73	76	96	56

***Interim Sediment Quality Guideline – Low (Trigger value) (ANZECC/ARMCANZ 2000**

A For any site, where a value has been recorded as less than the detection limit, it was assigned a value of half the detection limit in order to calculate the mean (eg. <0.02 taken as 0.01)

NB Aluminium, Antimony, Molybdenum, Strontium and Vanadium were not tested for by the Spring 2019 surveys because they were not required by the BMS (cf Biosis, 2018)

Table 8. Mean (± SE) sediment results for perfluoronated compounds between autumn 2018 (*n* = 1) and spring 2021 (*n* = 2).

Indicator Variable	Trigger Value*	Baseline (Autumn 2018)			Spring 2018			Autumn 2019		
		AQ1	AQ4	AQ14	AQ1	AQ4	AQ14	AQ1[C]	AQ4	AQ14
Perfluoronated compound (mg/kg)										
PFHxS	-	0.0036	0.0007	<0.0002	0.0023 (0.00)	<0.001 (0.00)	<0.001 (0.00)	0.0037	<0.001 (0.00)	<0.001 (0.00)
PFOS	32	0.0444	0.0061	0.0005	0.0310 (0.01)	0.0049 (0.00)	<0.002 (0.00)	0.0220	0.0085 (0.01)	<0.002 (0.00)
PFOA	29	-	-	-	<0.001 (0.00)	<0.001 (0.00)	<0.001 (0.00)	<0.001	<0.001 (0.00)	<0.001 (0.00)
Sum of PFHxS and PFOS	-	0.0480	0.0068	0.0005	0.0333 (0.01)	0.0055 [B] (0.00)	0.002 [B] (0.00)	0.0257	0.0090 [B] (0.01)	0.0015 [B] (0.00)
Sum of PFAS (WA DER List) [A,B]	-	0.0483	0.0068	0.0005	0.0369 [B] (0.01)	0.0096 [B] (0.00)	0.0058 [B] (0.00)	0.0329	0.0150 [B] (0.01)	0.0075 [B] (0.00)
Indicator Variable	**Trigger Value***	**Baseline (Autumn 2018)**			**Spring 2019**			**Autumn 2020**		
		AQ1	**AQ4**	**AQ14**	**AQ1**	**AQ4**	**AQ14**	**AQ1**	**AQ4**	**AQ14**
Perfluoronated compound (mg/kg)										
PFHxS	-	0.0036	0.0007	<0.0002	0.0016 (0.00)	<0.001 (0.00)	<0.001 (0.00)	0.0005 (0.00)	0.0005 (0.00)	0.0005 (0.00)
PFOS	32	0.0444	0.0061	0.0005	0.0075 (0.01)	0.0062 (0.00)	0.0028 (0.00)	0.0115 (0.00)	0.0015 (0.00)	0.0052 (0.00)
PFOA	29	-	-	-	<0.001 (0.00)	<0.001 (0.00)	<0.001 (0.00)	<0.001 (0.00)	<0.001 (0.00)	<0.001 (0.00)
Sum of PFHxS and PFOS	-	0.0480	0.0068	0.0005	0.0231 (0.08)	0.0067 [B] (0.00)	0.0033[B] (0.00)	0.0120 (0.00)	0.0020 (0.00)	0.0057 (0.00)
Sum of PFAS (WA DER List) [A,B]	-	0.0483	0.0068	0.0005	0.0281 [B] (0.08)	0.0117 [B] (0.00	0.0083 [B] (0.00)	0.0170 (0.00)	0.0070 (0.00)	0.0107 (0.00)

*DEE (2016) - Urban residential/public open spaces

[A] = PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTS and 8:2 FTS

[B] For any site, where a value has been recorded as less than the detection limit, it was assigned a value of half the detection limit in order to calculate the mean (e.g. <0.02 taken as 0.01), the Sum of PFHxS and PFOS and the Sum of PFAS.

[C] Only one survey was undertaken at Site AQ1 in autumn 2019.

Table 8 (Cont'd).

Indicator Variable	Trigger Value*	Baseline (Autumn 2018)			Spring 2020			Autumn 2021		
		AQ1	AQ4	AQ14	AQ1	AQ4	AQ14	AQ1[C]	AQ4	AQ14
Perfluoronated compound (mg/kg)										
PFHxS	-	0.0036	0.0007	<0.0002	<0.001 (0.00)	<0.001 (0.00)	<0.001 (0.00)	<0.001[B] (0.00)	<0.001 (0.00)	<0.001 (0.00)
PFOS	32	0.0444	0.0061	0.0005	0.0070 (0.00)	0.0022[B] (0.00)	<0.002 (0.00)	0.016 (0.004)	0.006 (0.002)	0.004 (0.003)
PFOA	29	-	-	-	<0.001 (0.00)	<0.001 (0.00)	<0.001 (0.00)	<0.001 (0.00)	<0.001 (0.00)	<0.001 (0.00)
Sum of PFHxS and PFOS	-	0.0480	0.0068	0.0005	0.0075[B] (0.00)	0.0032[B] (0.00)	0.0015[B] (0.00)	0.0164[B] (0.003)	0.0069[B] (0.002)	0.0042[B] (0.003)
Sum of PFAS (WA DER List) [A,B]	-	0.0483	0.0068	0.0005	0.0125[B] (0.00)	0.0082[B] (0.00)	0.0065[B] (0.00)	0.021[B] (0.003)	0.0119[B] (0.002)	0.0090[B] (0.003)
Indicator Variable	**Trigger Value***	**Baseline (Autumn 2018)**			**Spring 2021**			**Autumn 2022**		
		AQ1	**AQ4**	**AQ14**	**AQ1**	**AQ4**	**AQ14**	**AQ1**	**AQ4**	**AQ14**
PFHxS	-	0.0036	0.0007	<0.0002	<0.001 (0.00)	<0.001 (0.00)	<0.001 (0.00)	0.0015 (0.0010)	<0.001 (0.00)	<0.001 (0.00)
PFOS	32	0.0444	0.0061	0.0005	0.0090 (0.00)	0.0030[B] (0.00)	0.009 [B] (0.01)	0.0265 (0.0075)	0.0056 (0.0014)	0.0038 (0.0033)
PFOA	29	-	-	-	<0.001 (0.00)	<0.001 (0.00)	<0.001 (0.00)	<0.001 (0.00)	<0.001 (0.00)	<0.001 (0.00)
Sum of PFHxS and PFOS	-	0.0480	0.0068	0.0005	0.0075[B] (0.00)	0.0032[B] (0.00)	0.0015[B] (0.00)	0.0280 (0.01)	0.0056 (0.00)	0.0036 (0.0036)
Sum of PFAS (WA DER List) [A,B]	-	0.0483	0.0068	0.0005	0.0168[B] (0.01)	0.0089[B] (0.00)	0.0148[B] (0.01)	0.034[B] (0.0075)	0.0111[B] (0.0014)	0.0096 [B] (0.0031)

*DEE (2016) - Urban residential/public open spaces

[A] = PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTS and 8:2 FTS

[B] For any site, where a value has been recorded as less than the detection limit, it was assigned a value of half the detection limit in order to calculate the mean (e.g. <0.02 taken as 0.01), the Sum of PFHxS and PFOS and the Sum of PFAS.

[C] Only one survey was undertaken at Site AQ1 in autumn 2019.

3.3 Aquatic Macroinvertebrates

A total of 15 taxon were identified from edge habitat samples collected at Site AQ12 in autumn 2022 (Survey 1: 13 taxon; Survey 2: 7 taxon) (Table 11, Appendix 3). Five taxa, Acarina (Water mites), Chironominae (True flies), Coenagrionidae (Damselflies), Corixidae (Water boatmen) and Leptoceridae (Caddis flies) were collected on both sampling occasions (Appendix 3).

Site AQ12 obtained an OE50 score of 0.49 (Survey 1) and 0.31 (Survey 2) during autumn 2022 (Table 11, Figure 3), indicating that the macroinvertebrate assemblage at Site AQ12 ranged between significantly impaired (Band B) and severely impaired (Band C) relative to reference sites selected by the AUSRIVAS model. The most recent OE50 scores were within the range of scores obtained since the baseline survey (Figure 3).

Similar to the findings of the previous survey, taxon with > 0.80 probability of occurrence but not collected at the Anzac Creek site were the mayfly family, Leptophlebiidae, the true fly sub-family, Tanypodinae, and the aquatic bug family, Veliidae, on both sampling occasions.

SIGNAL 2 scores obtained for Site AQ12 have changed little over time and indicate that the macroinvertebrate assemblage at AQ12 has commonly been dominated by pollution-tolerant taxa since the commencement of sampling in autumn 2018 (Table 11, Figure 4).

Table 9. Total number of taxa, AUSRIVAS & SIGNAL 2 outputs for Site AQ12 (*n* = 1).

Survey	No Taxa	SIGNAL-2	OE50	Band
Autumn 2018	13	4.00	0.49	B
Spring 2018 – Survey 1	9	3.25	0.39	C
Spring 2018 – Survey 2	5	3.07	0.10	D
Autumn 2019 – Survey 1	10	2.69	0.41	C
Autumn 2019 – Survey 2	8	3.41	0.20	C
Spring 2019 – Survey 1	11	2.09	0.38	C
Spring 2019 – Survey 2	11	2.18	0.19	D
Autumn 2020 – Survey 1	19	3.00	0.68	B
Autumn 2020 – Survey 2	13	3.33	0.49	B
Spring 2020 – Survey 1	10	3.10	0.40	C
Spring 2020 – Survey 2	13	3.33	0.40	C
Autumn 2021 – Survey 1	13	3.38	0.49	B
Autumn 2021 – Survey 2	12	3.64	0.41	C
Spring 2021 – Survey 1	10	2.41	0.30	C
Spring 2021 – Survey 2	6	3.00	0.30	C
Autumn 2022 – Survey 1	13	3.86	0.49	B
Autumn 2022 – Survey 2	7	4.58	0.31	C

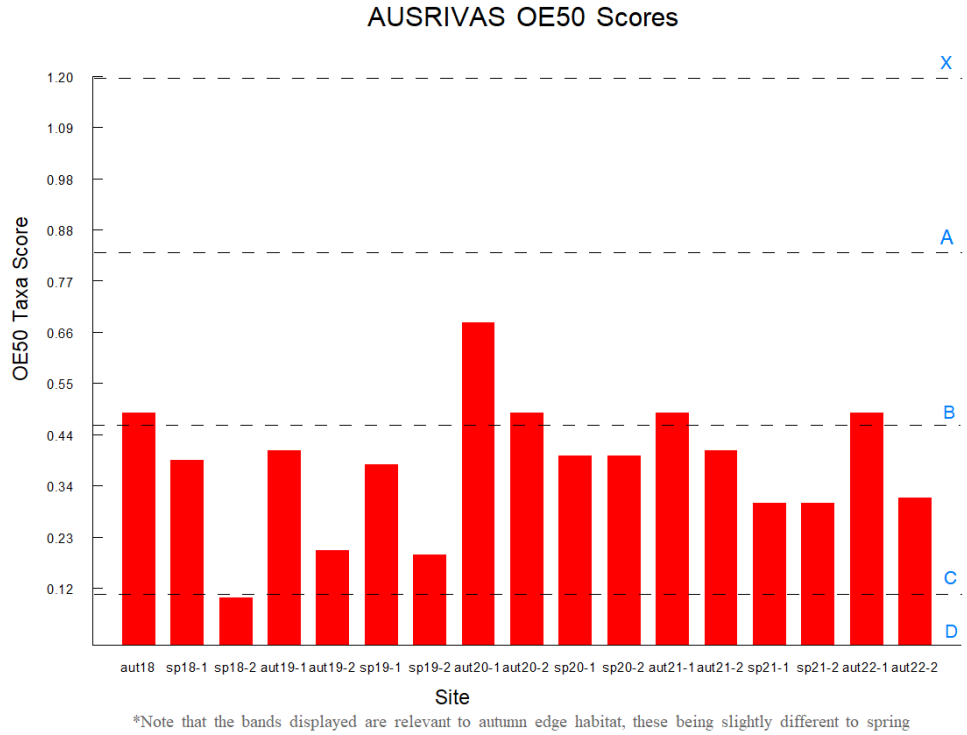

Figure 3. OE50 Taxa Scores and their respective Band Scores (B-D) for AUSRIVAS samples collected from edge habitat at Site AQ12 since autumn 2018.

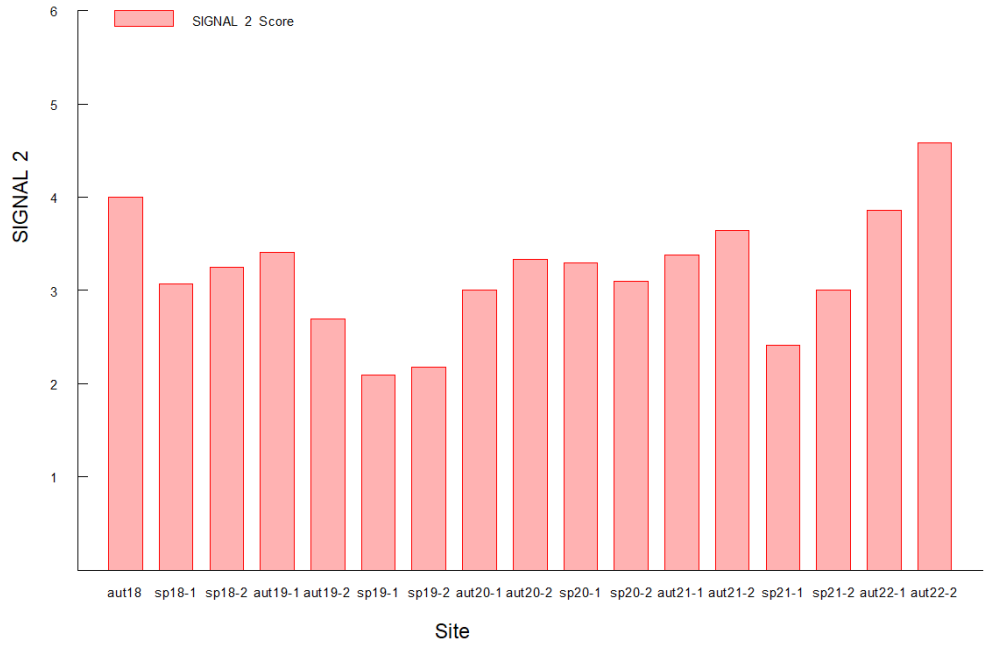

Figure 4. Quadrant diagram showing SIGNAL 2 results for Site AQ12 sampled in Anzac Creek since autumn 2018.

3.4 Fish

Six species of fish were observed while electro-fishing at Site AQ12 in autumn 2022 (Table 10). Gambusia (*Gambusia holbrooki*) were common and were also caught in dip nets used to sample aquatic macroinvertebrates in autumn 2022 (Table 6). Other species collected during autumn 2022 included Short-finned (*Anguilla australis*) and Long-finned eels (*Anguilla reinhardtii*) (<30cm in length), small numbers of Common galaxias (*Galaxias maculatus*) and Striped gudgeon (*Gobiomorphus australis*) and the introduced species, Oriental waterloach (*Misgurnus anguillicaudatus*) (Table 10).

In total, nine species of fish, including three introduced species, have been collected since sampling commenced in autumn 2018 (Table 10). All of the species caught are common within NSW (McDowall, 1996; DPI 2006; Howell and Creese, 2010). No threatened species of fish listed under the *NSW Fisheries Management Act, 1994* or the *Environment Protection and Biodiversity Conservation Act, 1999* were recorded.

Plate 13: Common galaxias collected at Site AQ12 (31/05/2022).

Table 7. Fish collected at Site AQ12 between autumn 2018 and spring 2019[#], spring 2020 and spring 2021.

Species	Common Name	Aut-18 (Biosis, 2018)	Sp-18	Aut-19	Sp-19	Sp-20	Aut-21	Sp-21	Aut-22
Anguilla reinhardtii	Long-finned eel	2	3	2	-	4	1	2	1
Anguilla australis	Short-finned eel	-	13	-	9	13	2	4	2
Gobiomorphus australis	Striped gudgeon	28	8	3	2	-	-	-	2
Galaxias maculatus	Common galaxias	-	-	-	-	-	-	-	8
*Carassius auratus**	Goldfish	-	2	-	-	-	1	-	-
*Gambusia holbrooki**	Gambusia	328	100's	10's	10's	100's	100's	100's	10's
Hypseleotris compressa	Empire gudgeon	13	-	-	-	-	-	-	-
*Misgurnus anguillicaudatus**	Oriental weatherloach	-	-	-	1	-	-	-	2
Hypseleotris cf *galii*	Firetail gudgeon	-	-	-	1	1	-	-	-
Unidentified sp.		-	-	-	-	-	-	1	-

*Introduced species; [#]Fish were unable to be sampled at Site AQ12 within the autumn 2020 survey period due to instrument malfunction.

3.5 Limitations

- Only one Baseline survey was able to be sampled in autumn 2018, due to the May 2018 bushfire (Biosis, 2018);
- Due to restricted access through the construction worksite, it was not possible to access Site AQ1 on 30 May 2019 to undertake the 2019 autumn survey 2. Whilst the collection of replicate samples at each site provides important measures of variability in habitat characteristics and concentrations of toxicants, the results from Survey 1 and subsequent surveys were within the range of results collected by the Baseline survey. Therefore, it is considered that the missing sample did not detract from being able to interpret the findings of the 2019 autumn sampling event, and that the intent and outcomes of the MPES2 monitoring survey were achieved;
- Sampling required for the 2020 autumn event was unable to commence until late May 2020 due to COVID-19 related delays. The 2020 autumn survey 2 was further delayed due to repairs required to the Electrofisher;
- Water quality measurements collected during the biological sampling only provide a snapshot of quality at the time of sampling under the prevailing flow conditions;
- In the absence of external reference sites (i.e. similar sites but in systems not subject to the Project activities), it is not possible to account for changes in the variable examined that may occur naturally at a broader regional scale.

5.0 DISCUSSION

There has been no construction on MPES2 since December 2020. Warehouses 1, 3, 4 and 5 are now operational and the location of Warehouses 6-8 have been left as compacted pads. Any water sheets off into the SED Basin and discharges into Anzac Creek (via DP5 and DP7).

5.1 Aquatic Habitat & Environmental Conditions

Similar to the findings of surveys done since spring 2020, areas of standing water were present at the study sites and flow was apparent along some reaches. The majority of Anzac Creek continues to display stable environments, although an area of active erosion was again apparent at the downstream end of the refuge pool[4]. Large stands of Typha in the downstream channel are likely to have impeded waterflow after heavy rain, resulting in overflow of water from the blocked channel and bank erosion.

Reduced dissolved oxygen levels, elevated nitrogen, aluminium, and copper measured in surface water in the refuge pool, including prior to commencement of the Project, suggests that aquatic habitat and biota within Anzac Creek are the reflection of historic and current activities (ALS, 2011; Biosis, 2018). Importantly, measurements taken by the autumn 2022 surveys indicate that additional degradation of water quality has not occurred since the Project related construction work began.

Concentrations of lead in sediments collected at the most upstream site sampled on Anzac Creek (Site AQ1) continue to exceed the guideline value (50 mg/kg) but not the baseline value measured by the BAEMP survey (91 mg/kg). Importantly, the levels of lead recorded at Site AQ1 have not increased since commencement of the Project.

Also of relevance to Site AQ1 is the continued infestation of the stream channel by Alligator Weed (*Alternanthera philoxeroides*). Due to its highly invasive nature, Alligator weed is listed as a noxious plant and considered a threat to waterways, wetlands, floodplains and irrigation systems in Australia. The “Regional Recommended Measure” applicable to the area

[4] Flooding and erosion were noted at the downstream end of the refuge pool during autumn 2020

is “Land managers prevent spread of Alligator Weed from their land where feasible” and “Land managers reduce the impact on priority assets” (DPI, 2018).

Approximately 400 m downstream of AQ1 and immediately downstream of the Project area, concentrations of lead, nickel and zinc measured in sediments at Site AQ4 exceeded the ANZECC/ARMCANZ (2000) guideline values and BAEMP survey results during Survey 1 but not Survey 2. Investigations done prior to commencement of development of the MPES2 site also reported results for heavy metals (copper, lead, nickel, zinc, and some cadmium results) above ANZECC/ANZECC guidelines (2000) (JBS&G, 2016; Golder, 2016). JBS&G (2016) and Biosis (2018) attributed these impacts to historical contributions from Commonwealth Department of Defence Lands, industrial and urban run-off, among others. While the Project may also have influenced sediment quality within the creek, there has been no construction at the MPES2 site since December 2020. It is possible that recent prolonged rainfall contributed to the higher concentrations of heavy metals, by redistributing sediments along the stream channel.

Importantly, concentrations of lead, nickel and zinc measured in surface water and sediments sampled at the downstream sampling sites (Sites AQ12 and AQ14) did not exceed baseline values. Concentrations of PFOA (perfluoro-octanoic acid) and PFOS (perfluorooctance sulphonate) remain similar to baseline values and within the recommended Australian-derived guidelines for water and soil. Given that heavy metals bound in sediments are not identified as specific contaminants of concern for the MPES2 Project (Biosis, 2018), no additional testing of heavy metals at Site AQ4 is considered necessary at this stage.

5.2 Biological Monitoring

The OE50 Taxa Scores and Bands have generally been indicative of a macroinvertebrate assemblage that is less diverse compared to reference sites selected by the AUSRIVAS model. Low values of the SIGNAL 2 score and the number of macroinvertebrate types were also indicative of a site suffering from one or more forms of human impact. In particular, elevated levels of nitrogen have consistently been measured in the refuge pool. Biologically available nitrogen can cause excessive algal and aquatic plant growth, which can facilitate oxygen depletion within the water column and at the sediment-water interface (by increasing the organic content of bottom sediments) (Lake, 2011; Vilas et al., 2017). Generally, more

pollution tolerant taxa replace taxa more sensitive to fluctuations in stream health (including availability of dissolved oxygen) (Boulton, 2003; Lake, 2003) and which have been expected by the AUSRIVAS model but not collected.

Also notable was that several individuals (10's to 100's) of the introduced fish, Gambusia (*Gambusia holbrooki*), have consistently been observed within the refuge pool. Gambusia commonly thrive in disturbed habitats and still waters (McDowall 1996). Predation by Gambusia is listed as a Key Threatening Process by the NSW *Biodiversity Conservation Act 2016*, because of known effects on frogs, freshwater fishes and aquatic macroinvertebrates, among others.

Nevertheless, some pollution sensitive taxa were identified (including caddis fly and dragonfly larvae) and nine species of fish, including six native species, have been collected, confirming that the creek does provide important habitat for aquatic species. Of the species collected, all are common within NSW.

6.0 CONCLUSION & RECOMMENDATIONS

Examination of the results from the autumn 2022 monitoring event found no evidence of changes in the indicator variables (bed and bank stability, water quality, assemblages of aquatic macroinvertebrates and fish) that could be attributed to the Project works. Thus, in accordance with the Biodiversity Monitoring Strategy, no adaptive management contingency measure was triggered.

It is recommended that:

- Sampling of the stream health monitoring program is repeated in spring 2022
- Land managers focus on containment and on-going suppression of the Alligator Weed infestation at Site AQ1 and programs such as public education to reduce the chance of unintentional human-assisted introductions of aquatic plants or fish (e.g. by using live bait, or by being released by aquaria).

7.0 REFERENCES

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APPENDICES

Appendix 1 - GPS positions (UTMs) for stream monitoring sites (autumn 2022).

Site Code	Easting	Northing
AQ1	308120	6240239
AQ4	308556	6240283
AQ8	309220	6240814
AQ12	309385	6241601
AQ13	309367	6241784
AQ14	309370	6241871

Datum: WGS 84, Zone 56H

Appendix 2 – Visual Assessment Scores

Appendix 2a – Ephemeral stream assessment results

	Autumn 2018		Spring 2018		Autumn 2019	
Site	**Score (%)**	**Category**	**Score (%)**	**Category**	**Score (%)**	**Category**
AQ1	88	Very Stable	75	Stable	80	Stable
AQ4	88	Very Stable	75	Stable	78	Stable
AQ8	91	Very Stable	93	Very Stable	93	Very Stable
	Spring 2019		**Autumn 2020**		**Spring 2020**	
Site	**Score (%)**	**Category**	**Score (%)**	**Category**	**Score (%)**	**Category**
AQ1	88	Very Stable	90	Very Stable	90	Very Stable
AQ4	80	Stable	88	Very Stable	89	Very Stable
AQ8	92	Very Stable	93	Very Stable	93	Very Stable
	Autumn 2021		**Spring 2021**		**Autumn 2022**	
Site	**Score (%)**	**Category**	**Score (%)**	**Category**	**Score (%)**	**Category**
AQ1	80	Very Stable	90	Very Stable	92	Very Stable
AQ4	89	Very Stable	89	Very Stable	90	Very Stable
AQ8	93	Very Stable	93	Very Stable	93	Very Stable

Appendix 2b – HABSCORE assessment results

	Autumn 2018		Spring 2018		Autumn 2019	
Site	**Score (%)**	**Category**	**Score (%)**	**Category**	**Score (%)**	**Category**
AQ1	27	Marginal	29	Marginal	32	Marginal
AQ4	28	Marginal	25	Marginal	25	Marginal
AQ8	41	Marginal	38	Marginal	38	Marginal
AQ12	55	Suboptimal	51	Suboptimal	53	Suboptimal
AQ13	21	Poor	23	Poor	21	Poor
AQ14	22	Poor	23	Poor	22	Poor
	Spring 2019		**Autumn 2020**		**Spring 2020**	
Site	**Score (%)**	**Category**	**Score (%)**	**Category**	**Score (%)**	**Category**
AQ1	30	Marginal	32	Marginal	27	Marginal
AQ4	26	Marginal	29	Marginal	28	Marginal
AQ8	41	Marginal	41	Marginal	41	Marginal
AQ12	51	Suboptimal	50	Suboptimal	53	Suboptimal
AQ13	19	Poor	21	Poor	22	Poor
AQ14	21	Poor	22	Poor	23	Poor
	Autumn 2021		**Spring 2021**		**Autumn 2022**	
Site	**Score (%)**	**Category**	**Score (%)**	**Category**	**Score (%)**	**Category**
AQ1	29	Marginal	31	Marginal	31	Marginal
AQ4	36	Marginal	38	Marginal	40	Marginal
AQ8	41	Marginal	41	Marginal	41	Marginal
AQ12	55	Suboptimal	55	Suboptimal	50	Suboptimal
AQ13	23	Poor	23	Poor	25	Poor
AQ14	24	Poor	24	Poor	25	Poor

Appendix 3 - Macroinvertebrate taxa collected at Site AQ12 in autumn 2022 using the NSW AUSRIVAS protocol.

Taxa	Survey 1 (5 May 2022)	Survey 2 (31 May 2022)
Acarina	20	20
Atyidae	1	0
Ceratopogonidae	1	0
Chironomidae - Chironominae	10	5
Coenagrionidae	2	1
Corixidae	1	1
Dytiscidae	1	0
Hemicorduliidae	0	1
Hydrobiidae	3	0
Hydroptilidae	0	1
cf Isostictidae	1	0
Leptoceridae	1	4
Libellulidae	3	0
Naurcoridae	1	0
Oligochaete	1	0
Number of Taxa	**13**	**7**