City of Ryde

Water Quality Monitoring Report

Spring 2023

This report was produced by Sydney Water Monitoring Services™
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Report version: Spring 2023

Report Name: City of Ryde Water Quality Monitoring Report Spring 2023

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Cover image: Terrys Creek (Core Site, CR3T) upstream at Somerset Park, Spring 2023

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Executive summary

This report provides Spring 2023 water quality results for the Ryde Council area. For this project, five catchment zones were sampled (Shrimptons, Archers, Buffalo, Terrys, and Porters creeks) to provide an overall representation of waterway health in the region. A range of methods were used to collect data for the following parameters: (i) Macroinvertebrate community indices, (ii) Physico-chemical water quality and (iii) Rapid Riparian Assessment. Results from the current season were compared with Spring 2022 data to identify seasonal changes.

Freshwater Macroinvertebrate community assessment was conducted at the five core sampling sites. The two parameters used for this assessment were SIGNAL_SF scores and Taxa Richness scores. The SIGNAL method assigns a numerical score to each Macroinvertebrate family derived from their tolerance to environmental conditions (higher SIGNAL score = higher sensitivity). Average SIGNAL scores were found to be consistent between Spring 2022 and Spring 2023 seasons. During Spring 2023 the highest SIGNAL result was observed at Buffalo Creek (4.54), while the lowest was observed at Shrimptons Creek (4.04). Taxa Richness scores (total number of taxa identifed) are used as an indicator of Macroinvertebrate community diversity. Average Richness results were variable between sites and sampling years. The highest Richness result was observed at Buffalo Creek (10) while the lowest was at Porters Creek (6).

At each of the 14 sampling sites physico-chemical monitoring was conducted in-field on the day of sampling. All results were collected and compared to the threshold limits outlined in the ANZECC guidelines for waterways (2000). Metrics such as pH were relatively stable across sampling sites and most sites recorded low turbidity. Nutrient results were elevated above threshold limits for most sites. Dissolved oxygen results were highly variable including those for sites located in the same catchment zone.

Further analytical water quality testing was conducted at the Sydney Water laboratories. For most sites microbiological analysis indicated that faecal coliform concentrations were within ANZECC (2000) guidelines, although there were exceedances at two Buffalo Creek sites and Porters Creek core site. In general, nutrient results were elevated above guideline limits for most sites. Additional heavy metals analysis was conducted at the four sites within the Porters Creek catchment. Most test analytes were observed to be within threshold limits however, consistent with Spring 2022, there were some exceedances for Copper and Zinc concentrations.

Rapid Riparian Assessment (RRA) was also performed at the five core sites. This metric provides a picture of the overall creek environment. This includes assessing the composition of waterway features (substrate complexity, presence of detritus) as well as the structure of adjacent vegetation (vegetation type, percentage coverage). During this season most sites had RRA scores consistent with the previous Spring season, however Shrimptons Creek core site at Wilga Park saw a decline in score from 26.3 in Spring 2022 to 2.4 in Spring 2023. In contrast, Porters Creek saw an improvement in RRA scores from Spring 2022 to Spring 2023.

Water quality data was also collected throughout the year by the City of Ryde's Streamwatch program. This data has been collated and provided in the appendix of this report.

1 Background

Water quality monitoring is carried out by the City of Ryde to inform environmental management and development decisions. The aims of this report are:

- Assess physical and chemical water properties of five major creeks (Shrimptons, Archers, Terrys, Buffalo and Porters creeks) within the City of Ryde local government area during dry and wet weather conditions
- Assess diversity and abundance of macroinvertebrate communities at five creeks within the study area
- Analyse environmental and ecosystem health data which will assist in monitoring the impact of future developments, creek restoration, stormwater management, bushland rehabilitation and general anthropogenic activities and incidents within the catchment
- Provide on-going information to assist the direction of future water quality monitoring plans
- Provide an easy to interpret report for the community
- Report any relevant environmental initiatives carried out by City of Ryde

Biological and chemical monitoring enables the City of Ryde to:

- Build on baseline data that enables the temporal evaluation and analysis of the health of the catchments of the strategy
- Identify and track new and existing impacts affecting the catchments
- Provide direction and monitor potential infrastructural works within the LGA, i.e. in-stream or riparian rehabilitation and stormwater treatment projects
- Build on the known taxa list for each catchment and to aid in the identification of key indicator taxa

The format and style of this annual report is a simplified version of the reports produced from 2004-2019. The technical details for the methods used, the quality procedures, accreditation and journal references are the same as previous years and are available in the Appendix.

2 Study Area

The City of Ryde is located 12 km North-West of central Sydney with a local government area of 40.651 km². It consists primarily of residential housing and is comprised of 16 suburbs and 14 separate stormwater catchments. It includes several important commercial and industrial sectors.

Limited areas of natural bushland border urban infrastructure, including several significant natural bush corridors and areas of open space that support recreation and sporting activities. There are small sections of Lane Cove National Park present on the eastern and northern borders of Shrimptons, Porters and Buffalo creeks. All five creeks drain into the greater Parramatta River catchment. Archers Creek enters Parramatta River directly and the remaining creeks flow through the Lane Cove River catchment.

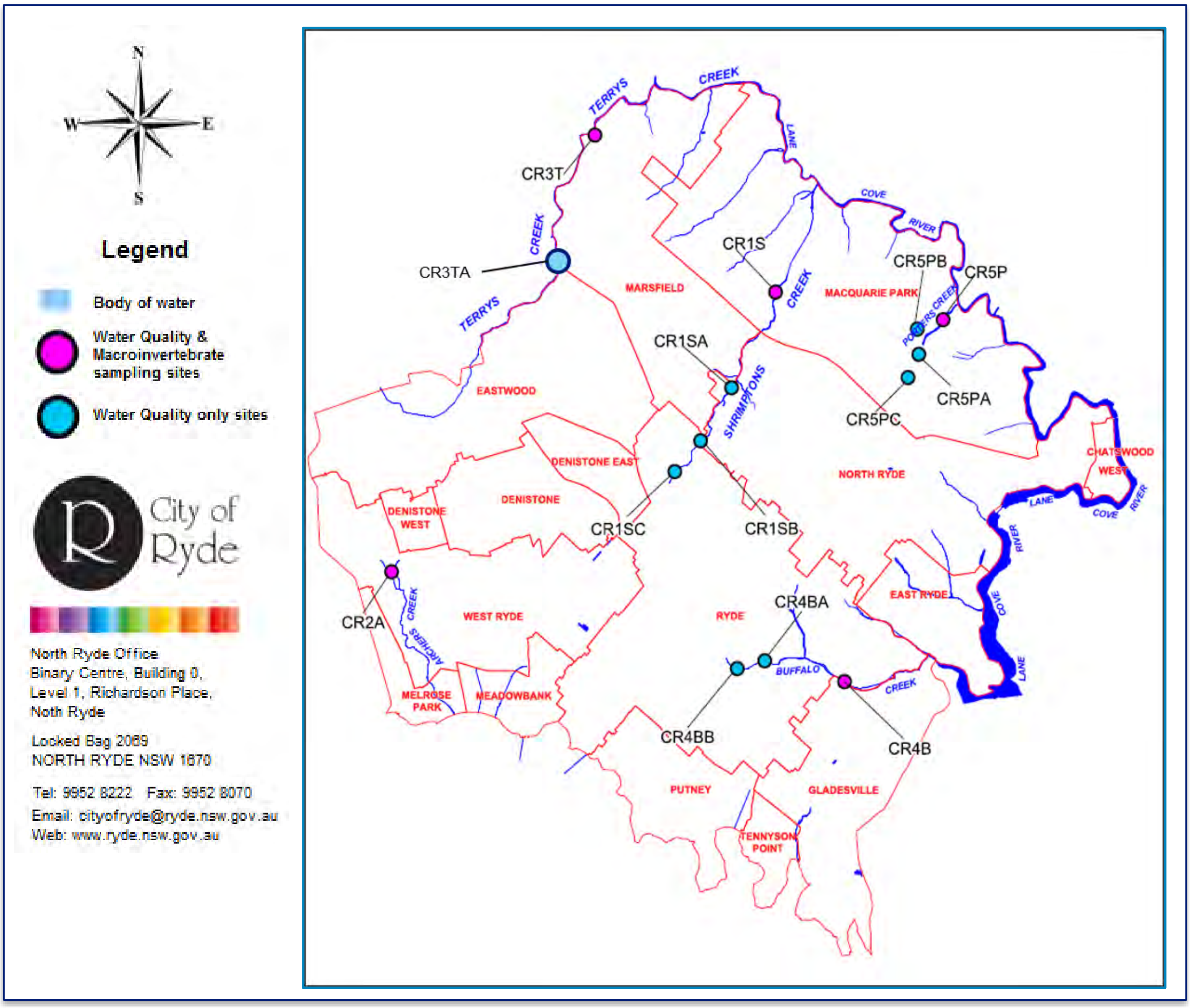


Figure 1 City of Ryde Water Quality Management Program Sites Map of sites for chemical and ecological monitoring across five creeks.

3 Sampling Sites

At each of the five catchments there is one core sampling site. At each core site macroinvertebrate sampling, rapid riparian assessment (Spring only), and water quality sampling are conducted (Table 1). The remaining nine sites are water quality sampling only.

Table 1 Survey sites for monitoring chemical and ecological attributes. Core sites are denoted by (*)

Site	Location	Coordinates		Water Quality (wet & dry weather)	Macroinvertebrates	Rapid Riparian Assessment
CR1S*	Shrimptons Ck at Wilga Park	-33.78053,	151.118628	✓	✓	✓
CR1SA	Shrimptons Creek at Kent Rd	-33.789246	151.113419	✓		
CR1SB	Shrimptons Creek at Bridge St	-33.794061	151.109779	✓		
CR1SC	Shrimptons Creek at Quarry Rd	-33.796856	151.106775	✓		
CR2A*	Archers Creek at Maze Park	-33.805555	151.074272	✓	✓	✓
CR3T*	Terrys Creek at Somerset Park	-33.765792	151.098345	✓	✓	✓
CR3TA	Terrys Creek at Forrester Park	-33.777417	151.093497	✓		
CR4B*	Buffalo Creek	-33.816451	151.125705	✓	✓	✓
CR4BA	Buffalo Creek d/s Burrows Park	-33.814392	151.116656	✓		
CR4BB	Buffalo Creek u/s Burrows Park	-33.81506	151.113502	✓		
CR5P*	Porters Creek d/s of depot	-33.783362	151.137671	✓	✓	✓
CR5PA	Porters Creek main branch	-33.7865	151.134839	✓		
CR5PB	Porters Creek spur branch	-33.784181	151.134708	✓		
CR5PC	Porters Creek at Wicks Rd	-33.788613	151.133557	✓		

4 Method descriptions

4.1 Macroinvertebrates

Aquatic macroinvertebrates are small (>1mm), spineless animals that naturally occur in water bodies. Macroinvertebrates are useful as bioindicators because some are more sensitive to pollution than others. As a result, a water pollution problem may be indicated if a stream is found to have a macroinvertebrate community dominated by pollution-tolerant animals and missing the more pollution-sensitive animals.

For this project, two replicate macroinvertebrate samples were collected at each of the five core sampling sites. Collection was performed using a fine mesh net to upwell the water and dislodge the animals. After sampling macroinvertebrates were picked out from the debris, preserved, and taken to the laboratory for identification and enumeration.

Figure 2 Collecting macroinvertebrates from Buffalo Creek (Spring 2023)

4.1(i) SIGNAL SF

SIGNAL SF stands for *Stream Invertebrate Grade Number Average Level- Sydney Family.* It is a biotic index for freshwater macroinvertebrates examined at the family level to assess stream health.

This index assigns *sensitivity scores* to each individual family. They range from “1” being tolerant to poor stream health to “10” being very sensitive to poor stream health.

Figure 3 Preserved macroinvertebrates

4.1(ii) Taxa Richness

This is the total number of different types of animals or taxa collected. In healthier ecosystems there is typically a greater variety of different animals collected, and therefore a higher taxa diversity.

Figure 4 Macroinvertebrate collection; this water bug is a backswimmer (*Notonectidae*)

4.2 Water Quality

Physical, chemical, and biological conditions of the five main catchments in the City of Ryde local government area were assessed following the same methods as previous years (See Appendix for detailed methodology). This provides information that can create a snapshot of what was happening in the creek at that point in time.

Figure 5 In-field water quality testing

Water quality samples were collected at the same time as the macroinvertebrate samples to ensure the data was accurate for comparison.

Water quality samples were collected at all 14 sites. Several analyses were conducted in the field and additional water was collected for lab analysis. Laboratory analysis was performed at the Sydney Water Laboratories located in West Ryde.

Water quality results are then compared to the Australian and New Zealand Environment and Conservation Council (ANZECC, 2000) guidelines. These guidelines outline a framework for assessing water quality in terms of whether the water is suitable for a range of environmental and community values. Exceedances of the ANZECC guidelines may indicate environmental disturbance.

Historical data is used during result analysis to compare the current results over what would be expected. The analytes measured during this project are summarised in Table 2.

Figure 6 Collecting water samples for analysis

Table 2 Water quality testing parameters

Parameter Measured	Examples
Physicochemical	Temperature, Dissolved Oxygen, pH, Turbidity, Conductivity, Alkalinity
Nutrients	Ammonia, Total Nitrogen, Total Kjeldahl Nitrogen, Oxidised Nitrogen, Total Phosphorus
Metals	Total Magnesium, Total Calcium, Total Hardness
Biological	Faecal Coliforms

4.3 Rapid Riparian Assessment

The riparian zone is the area where a body of water or stream, meets the land. The Rapid Riparian Assessment (RRA) provides a comprehensive picture of the features of a stream and the vegetation community surrounding it.

The methods used were originally developed by Ku-ring-gai Council and researchers from Macquarie University.

The main categories assessed are:

- Site features
- Channel features
- Depositional features
- Erosional features
- Riparian vegetation
- Vegetation structure

Each variable within these categories is ranked and the individual ranks are collated to form an overall site score. This final numerical score is associated with a final riparian health result ranging from 'very poor' to 'excellent'. This scoring system is summarised in Table 3.

Table 3 Riparian health categories

Category	Score range	Colour code
Excellent	≥60	
Good	27 to 59.99	
Fair	-6 to 26.99	
Poor	-39 to -6.99	
Very Poor	-72 to -39.99	

Figure 7 Archers Creek core site at Maze Park (CR2) looking upstream (Spring 2023). Displaying a variety of riparian structure types (ground cover, shrubs, tree canopy) and creek features including a steep sloping bank and bedrock channel.

5 Rainfall and Sampling

Rainfall can significantly influence both biological and chemical indicators of waterway health. High flow events can cause a disturbance in established aquatic habitats especially in smaller creek environments. These flushing events can impact aquatic fauna communities leading to a decline in taxa abundance and diversity. Prolonged periods of heavy rainfall can dilute concentrations of soluble compounds in water. Conversely, it can also lead to the influx of contaminants from adjacent environments such as park spaces and roadways.

Regular rainfall also plays a crucial role in maintaining waterway flows. Periods of drought with low rainfall can negatively impact waterways by reducing water volume leading to stagnant conditions. This can lead to the development of an anoxic environment and the proliferation of algal blooms. It is important to monitor rainfall prior to sampling and avoid sampling closely after heavy rainfall. This ensures the accurate collection of a sample representative of the macroinvertebrate community during typical environmental conditions. Figure 8 provides a summary of the rainfall data from 1st May 2023 to 20th September 2023. During this period the highest total monthly rainfall occurred in August (45 mm). Spring sampling was conducted on the 5th of September 2023.

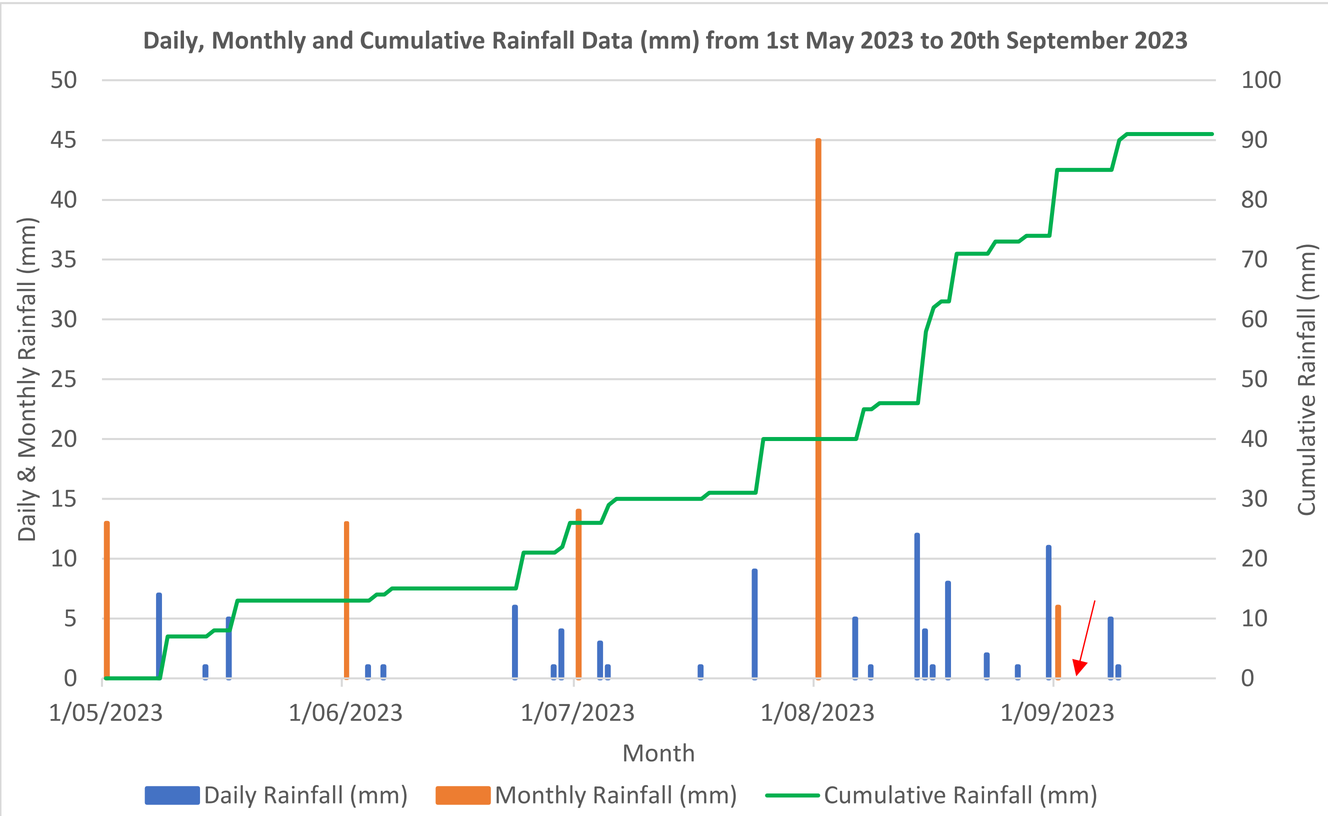


Figure 8 Rainfall data from 1st May 2023 to 20th September 2023. Note cumulative rainfall scale is on the right. ➘ Signifies date of sampling (05/09/2023)

6 Shrimptons Creek

6.1 Sites CR1S, CR1SA, CR1SB, CR1SC

The Shrimptons Creek catchment (Figure 9) contains three water quality sites and one core site (macroinvertebrate, water quality and riparian assessment).

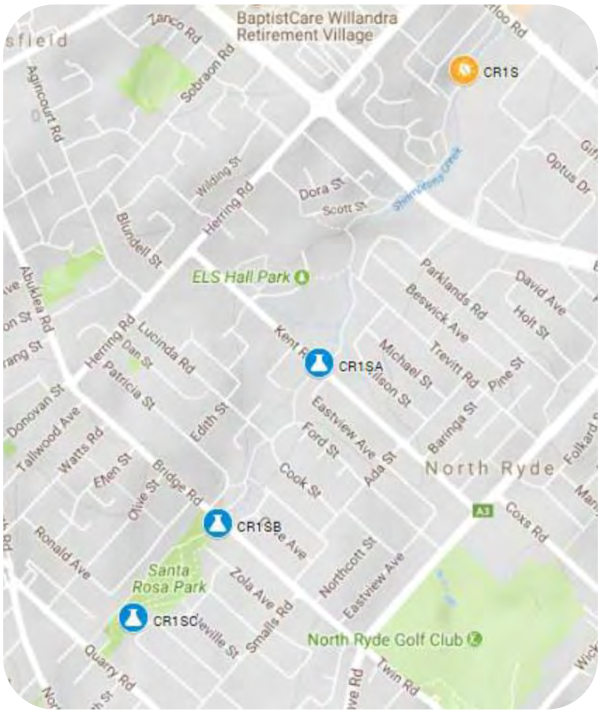


Figure 9 Shrimptons Creek Catchment Area

CR1S Shrimptons Creek Wilga Park (Core Site)

The Shrimptons Creek core site is located within Wilga Park in the suburb of Macquarie Park. Land use in this area is primarily residential, commercial, and light industrial.

The creek flows through a thin riparian corridor, which is a combination of native and exotic species. The creek bed is predominately bedrock and sand/silt.

Figure 10 Shrimptons Creek at Wilga Park (Spring 2023)

CR1SA Shrimptons Creek at Kent Road

The Kent Road site is situated at ELS Hall Park amongst a residential area and is lined by a thin section of riparian vegetation that completely shades the creek and comprises a mix of native and exotic species.

Figure 11 Shrimptons Creek at Kent Rd facing downstream

CR1SB Shrimptons Creek at Bridge Road

This site is located at the downstream section of Santa Rosa Park, just before it flows under Bridge Road and is surrounded by residential areas. The revegetation of the riparian area is now established adding to bank stabilisation, physical buffer, and filtration.

Figure 12 Shrimptons Creek at Bridge Road facing downstream

CR1SC Shrimptons Creek at Quarry Road

The Quarry Road site is located at the upstream section of Santa Rosa Park, at the point where Shrimptons Creek emerges from the underground stormwater system. This site has sandstone blocks around the drain for bank stabilisation.

Figure 13 Shrimptons Creek at Quarry Rd facing downstream

6.2 Results and Interpretation

Macroinvertebrates

SIGNAL SF

During Spring 2023, Shrimptons Creek had an average SIGNAL SF result of 4.04 (Figure 14). This was lower than the average recorded during the previous Spring (4.84, 2022). However, the current result was still consistent with the historical seasonal average for the site (3.9).

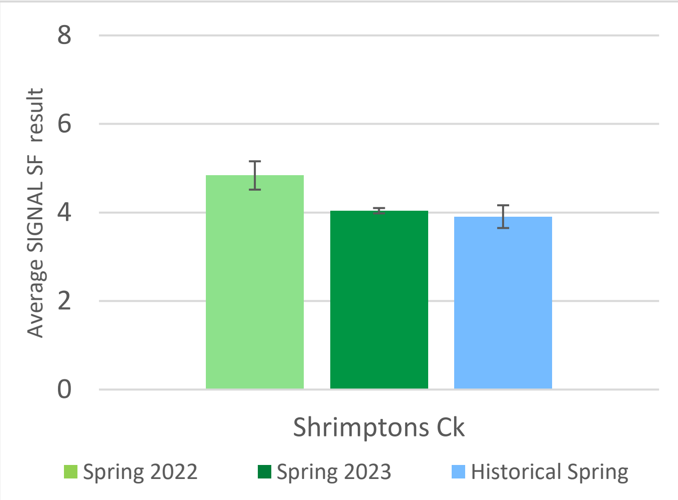


Figure 14 Shrimptons Creek average SIGNAL SF scores

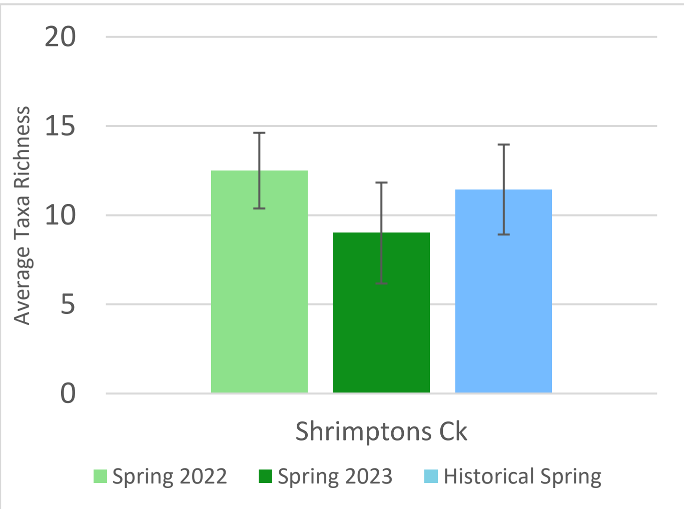


Figure 15 Shrimptons Creek Taxa Richness scores

Taxa Richness

The average taxa richness result for Shrimptons Creek for Spring 2023 was 9 (Figure 15). The Richness result for this season was lower than the previous Spring (12.5, 2022), however, it was still consistent with the seasonal average for this site (11.4). Macroinvertebrate community composition during this season is represented in Figure 15A below. During this season the site was relatively diverse and dominated by the 'True Flies' and 'Aquatic Snails' groups.

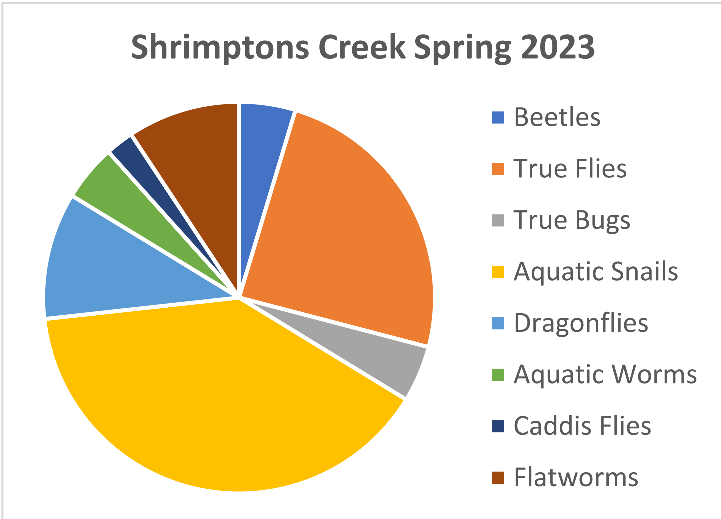


Figure 15A Shrimptons Creek Macroinvertebrate community composition

Macroinvertebrates summary

Average SIGNAL SF results were slightly lower than the previous season but consistent with the historical average. Taxa Richness results indicated a reduced level of diversity compared to Spring 2022.

Water Quality

In-field measurements indicated that Shrimptons Creek core site at Wilga Park (CR1S) had the lowest observed dissolved oxygen result (36.8%) during the Spring 2023 season. In contrast, the three other Shrimptons Creek sites have dissolved oxygen results ranging between 73% and 81%. Shrimptons Creek core site also had the lowest conductivity result for the season at 270 µS/cm. In contrast, another site in the catchment; Santa Rosa Park upstream (CR1SC) had the highest conductivity result for this season (979 µS/cm).

Faecal coliform results for each of the four sampling sites were below the ANZECC guideline limit (1000 CFU/mL) and most results were lower than those recorded during the previous Spring period. Wilga Park site (CR1S) had the highest result (950 CFU/mL). The ELS Hall Park site (CR1SA) had the lowest observed coliform concentration result for this catchment (54 CFU/100mL). Santa Rosa Park upstream site (CR1SC) had a coliform result of 300 CFU/100mL which was an improvement from the previous season where the result was above the ANZECC guideline limit (2800 CFU/100mL, 2022).

Nutrient loads in the Shrimptons catchment were elevated above threshold levels for most of the sites. This was consistent with previous Spring seasons with historical averages for this catchment were also elevated above threshold limits. Total Nitrogen results for Wilga Park (CR1S), Santa Rosa Park downstream (CR1SB) and Santa Rosa Park upstream (CR1SC) were all elevated above the ANZECC (2000) threshold of 350 µg/L. However, site ELS Hall Park site (CR1SA) had a result below this threshold (340 µg/L).

This was an improvement from the previous Spring season where this site had a Total Nitrogen result of 540 µg/L.

Similarly, Total Phosphorus results for this catchment exceeded the ANZECC (2000) guideline (25 µg/L) at all sites. Santa Rosa Park downstream and upstream sites had slightly elevated levels (33 µg/L and 31 µg/L, respectively). Sites CR1S and CR1SA were more than double the guideline limit (56 µg/L and 57 µg/L, respectively). This was comparable to the results observed in Spring 2022. For example, during 2022 the result at the core site (Wilga Park) was more than double the guideline value at 61 µg/L compared to the result at Santa Rosa Park upstream (CR1SC) with a value only slightly elevated at 26 µg/L.

Alkalinity results were consistent between most sites with values ranging between 60 and 66 mg/L. However, the result at Santa Rosa Park upstream (CR1SC) was more elevated at 92 mg/L. For this catchment, the highest Total Hardness result was at Santa Rosa Park upstream (170mg CaCO3/L, CR1SC). The lowest result was at the Wilga Park core site (69 mg CaCO3/L, CR1S).

Water quality summary

Dissolved oxygen results were generally high aside from site Wilga Park site (CR1S). Faecal coliform results were within ANZECC guideline limits for all sites and most results were lower than those observed during Spring 2022. Nutrient results were elevated above threshold limits for most sites in the catchment.

7 Archers Creek

7.1 Site CR2A (core site)

This site is located in Maze Park, West Ryde and is upstream of the Victoria Rd crossing (Figure 16). The land use upstream of this site is largely residential while a golf course is present downstream. The creek bed is mostly bedrock bordered by banks of sediment (sand, silt and organic matter, Figure 17,18). The creek channel has been previously relined with sandstone blocks. The vegetation within and adjacent to the creek is a combination of native and introduced species.

Figure 16 Archers Creek Catchment Area

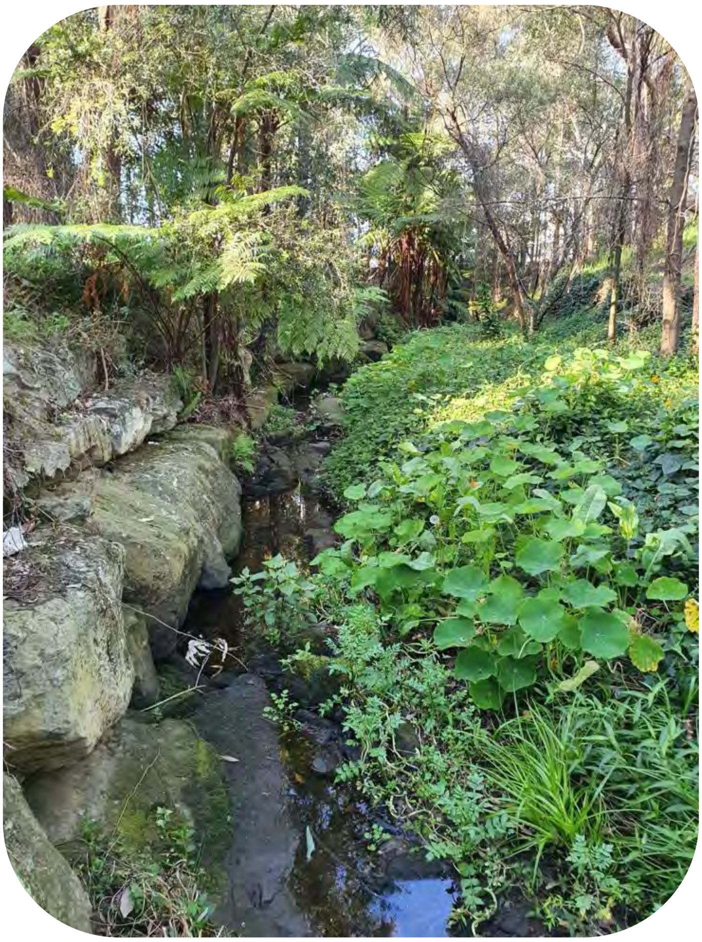


Figure 17 Archers Creek Core site (CR2A) looking downstream (Spring 2023)

Figure 18 Archers Creek Core site (CR2A) looking upstream (Spring 2023)

7.2 Results and Interpretation

Macroinvertebrates

SIGNAL SF

The average SIGNAL SF result at Archers Creek was 4.26 which was slightly higher than the previous Spring (3.82, Figure 19). Furthermore, the SIGNAL SF result for this season was within range of the historical average for the Spring season (4.46). This was an improvement from the previous Spring season, where SIGNAL results fell below the seasonal average.

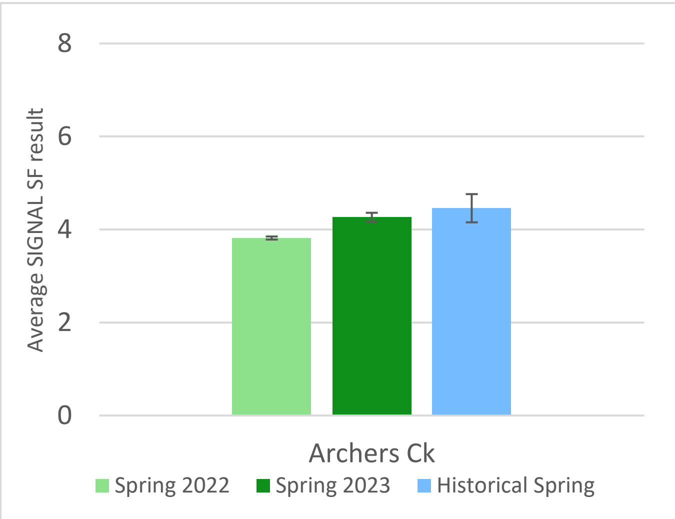


Figure 19 Archers Creek SIGNAL scores

Taxa richness

The average number of macroinvertebrate taxa observed at Archers Creek site during the current season was 9. This was comparable with the result from the previous Spring (10 observed taxa, Figure 20). Macroinvertebrate community composition at Archers Creek is shown in Figure 20A.

Macroinvertebrate families highly represented in the samples collected this season included Argiolestidae (Dragonflies), Chironomidae (True Flies) and Physidae (Aquatic Snails).

Both current Spring seasons had taxa richness results below the historical average for this site.

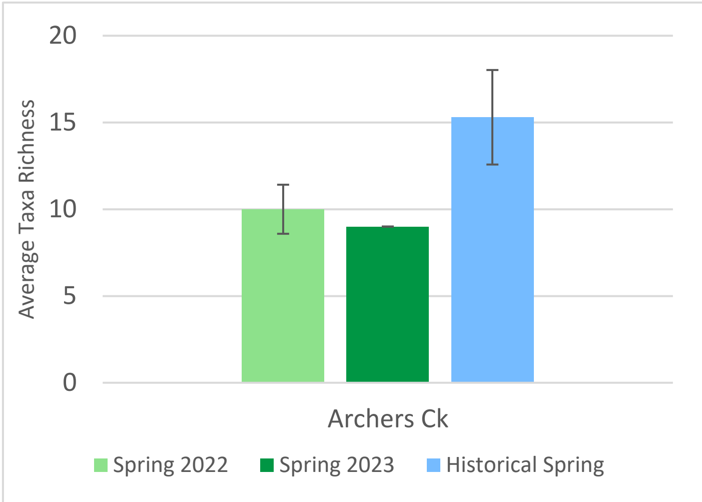


Figure 20 Archers Creek Taxa Richness scores

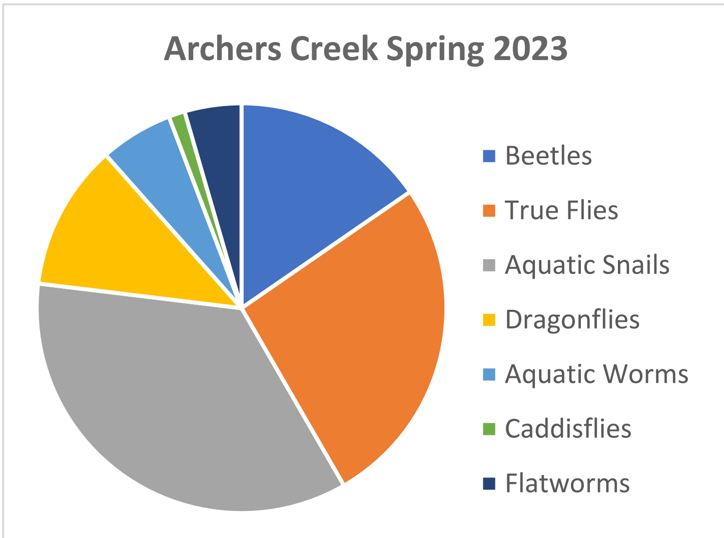


Figure 20A Archers Creek Macroinvertebrate community composition

Macroinvertebrates summary

The average SIGNAL SF score during Spring 2023 was higher than that of Spring 2022. Taxa richness results were consistent between both periods, although they were also lower than the historical site average.

Water Quality

The catchment had a low dissolved oxygen result (51.2%) which was below the ANZECC guideline threshold of 85%. This was far lower than the result observed during Spring 2022 (90.2%). Furthermore, Archers Creek also had a low in-stream turbidity reading of 2.00 NTU. This may be attributed to the low flow in the channel during the current season (Figures 17, 18). In contrast, the conductivity result at this site was relatively high (838 μS/cm).

Analytical testing indicated that Archers Creek site had a very low faecal coliform result (17 CFU/100mL). This was far lower than the result of Spring 2022 (580 CFU/100mL) and was one of the lowest on record when compared to data collected from 2004 to current seasons. Nutrient results were also observed to be below ANZECC guidelines. Total Nitrogen was 290 μg/L which was lower than the guideline value of 350 μg/L. This was an improvement from the previous Spring season where the Total Nitrogen result was above the guideline limit with a value of 1260 μg/L.

This was also the case with the Total Phosphorus result. During the Spring 2023 season Total Phosphorus was recorded at 16 μg/L which was below the guideline limit of 25 μg/L. This contrasts to the result from Spring 2022 where the result was above the guideline limit at 42 μg/L.

The alkalinity result for Archers Creek during this season was 69 mg/L which was comparable to the previous season (73mg/L). The Total Hardness result for this season was 140mg CaCO3/L which was higher than the result during Spring 2022 (100mg CaCO3/L).

Water quality summary

In-field dissolved oxygen and turbidity readings were low. Coliform results were very low and within ANZECC guideline thresholds. Total nitrogen and total phosphorus results were both below the ANZECC guideline threshold which was an improvement for the results of the previous Spring period.

8 Terrys Creek

8.1 Sites CR3T, CR3TA

CR3T Terrys Creek (core site)

This site is located within Somerset Park under the M2 overpass in the suburb of Epping (Figure 21). The surrounding land use is residential, and the creek flows through a bushland corridor. The riparian area bordering the creek contains both native and exotic plant species. The creek bed is predominately bedrock, gravel, and sand.

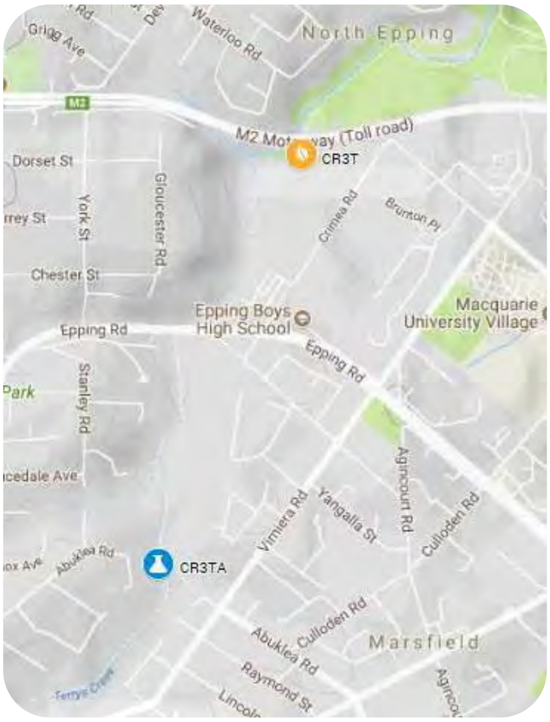


Figure 21 Terrys Creek Catchment Area

CR3TA Terrys Creek at Forrester Park

This site is located downstream of Terrys Creek Waterfall, which is an area surrounded by bushland. Dense vegetation covers both banks and consists of a mixture of native and introduced species. The bank is comprised of sediment (mostly sand and silt) and river rocks, which create areas of broken water.

Figure 22 Terrys Creek core site at Somerset Park (CR3T) looking downstream (Spring 2023)

Figure 23 Terrys Creek site at Forrester Park (CR3T) looking upstream

8.2 Results and Interpretation

Macroinvertebrates

SIGNAL SF

The average SIGNAL SF score for Spring 2023 was 4.14 (Figure 24). This result was consistent with the result of the previous Spring period (4.09) as well as the historical average for this site (4.17).

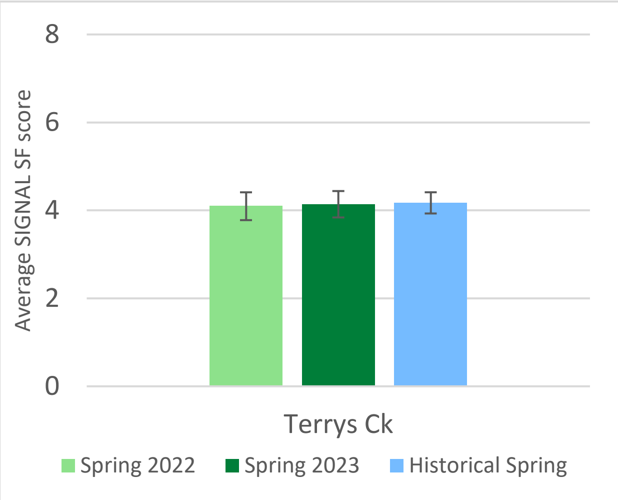


Figure 24 Terrys Creek Average SIGNAL-SF scores

Taxa richness

The average taxa richness result at Terrys Creek at Somerset Park (CR3T) was 9 (Figure 25). This value was higher than the previous the result of the previous season (6, Spring 2022).

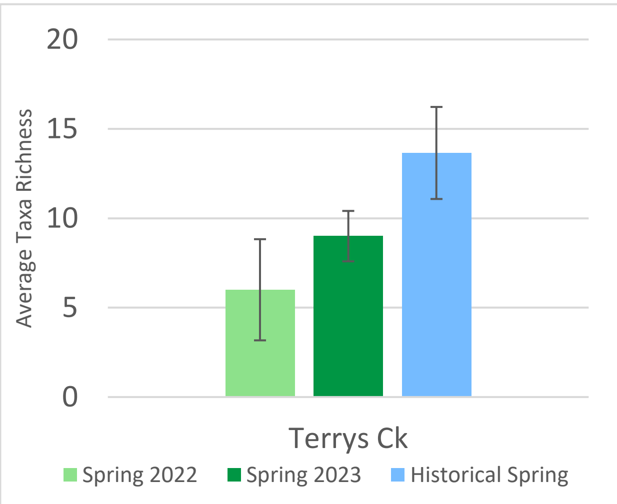


Figure 25 Terrys Creek Average Taxa Richness

As with Spring 2022, the average richness result observed at Spring 2023 was lower than the seasonal average for this site. The macroinvertebrate community composition at Terrys Creek site is summarised in Figure 25A below. The site was dominated by the 'Aquatic Snails' and 'Dragonflies' groups with highly abundant families including Physidae (snails) and Argiolestidae (dragonflies).

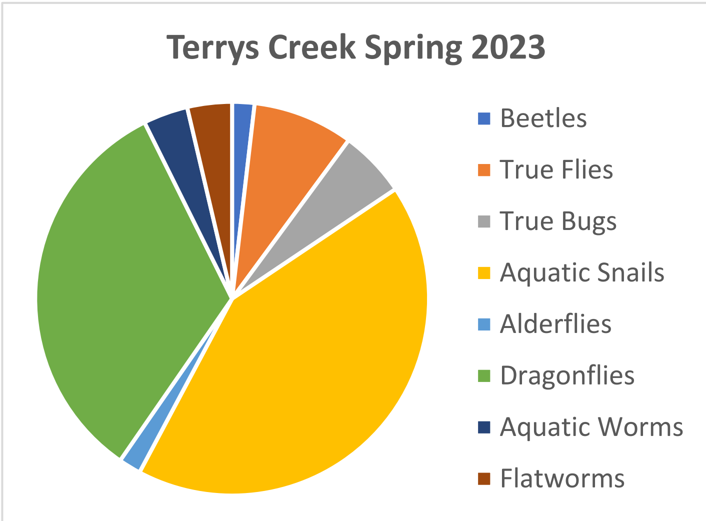


Figure 25A Terrys Creek Macroinvertebrate community composition

Macroinvertebrates summary

Average SIGNAL-SF scores for Spring 2023 were consistent with Spring 2022 and the historical average for this site. The Taxa richness score was higher than that of the previous season.

Water Quality

Dissolved oxygen results were highly variable between Terrys Creek sites. At the core site of this catchment (Terrys Creek at Somerset Park, CR3T) the dissolved oxygen result was low at 53.4%. In contrast, Forrester Park site (CR3TA) had a higher result of 86.2%. Turbidity readings were low at both sites (<3.00 NTU). Forrester Park (CR3TA) had a slightly higher pH result (7.52 pH units) when compared to the result at Terrys Creek core site (7.07 pH units).

Analytical testing indicated variability in faecal coliform results between the sampling sites. Terrys Creek at Somerset Park (CR3T) had a low coliform detection of 28 CFU/100mL. In contrast, site Forrester Park (CR3TA) had more elevated observed coliform level (600 CFU/100mL), however, this result was still below the ANZECC guideline limit (<1000 CFU/100mL). Furthermore, the result at Forrester Park was an improvement from the previous season where the result for this site was above guideline limits (2500 CFU/100mL).

Terrys Creek core site at Somerset Park (CR3T) had a Total Nitrogen result of 260 µg/L which was below the ANZECC guideline limit (350 µg/L). In contrast, Terrys Creek at Forresters Park site (CR3TA) had a result of 610 µg/L which was elevated above the guideline value. Total Phosphorus results were similar between sampling sites. Terrys Creek core site (CR3T) result was the same as the recommended ANZECC guideline value (25 µg/L). The result at Forrester Park was slightly elevated above the threshold at a 35 µg/L.

The alkalinity result at Forresters Park was higher than that of Terrys Creek core site (80 mg/L and 66 mg/L, respectively). This was also the case with Total Hardness results; Forresters Park had a result of 110 mg $CaCO_3$/L in contrast to Terrys Creek core site which had a result of 71 mg $CaCO_3$/L.

Water quality summary

Dissolved oxygen results were variable between sites. Faecal coliform results were below ANZECC guideline limits for both sites. Terrys Creek at Forrester Park (CR3TA) had nutrient results outside of guideline limits.

9 Buffalo Creek

9.1 Sites CR4B, CR4BA, CR4BB

Buffalo Creek catchment has one core site in the Field of Mars Reserve. The two remaining sites are water quality only and are located upstream in Burrows Park (Figure 26).

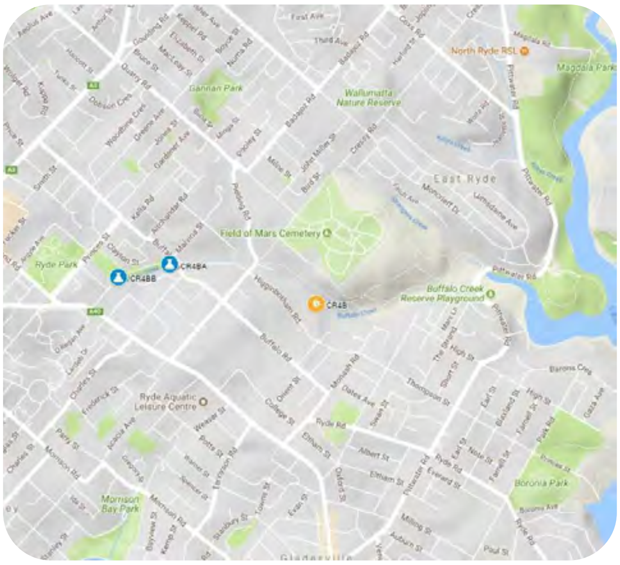


Figure 26 Buffalo Creek Catchment Area

CR4B Buffalo Creek (core site)

The Buffalo Creek core sampling site is located along the Southern border of the Field of Mars Reserve in the suburb of Gladesville and is accessed through private property. The surrounding land use is a mix of residential, light industry/commercial and reserves. The surrounding vegetation is a mix of native and exotic species, with exotic species dominating. The southern bank is mostly residential lawns.

The creek bed is a mixture of sand, silt, and gravel. There is usually some macrophyte growth, (*Egeria* and *Potamogeton*), and a small amount of algal growth observed in the channel. Sedimentation has occurred in the creek channel periodically.

Figure 27 Buffalo Creek core site (CR4B) looking upstream, Spring 2023

Figure 28 Buffalo Creek core site (CR4B) looking downstream, Spring 2023

CR4BA Buffalo Creek Downstream of Burrows Park

The downstream Burrows Park site is accessed off Buffalo Rd and is positioned just before the creek flows under the road. The surrounding land use is residential, and Burrows Park consists mostly of a bush corridor. There are usually obvious signs of bird activity around this site, including extensive bird droppings.

Figure 29 Buffalo Creek Downstream of Burrows Park

CR4BB Buffalo Creek Upstream of Burrows Park

The upstream Burrows Park site is about 300 metres upstream of Buffalo Road and lies in the middle of a bush corridor. The site is surrounded by vegetation that completely shades the creek. The creek is shallow at this point and has little flow. The site is positioned just downstream from a stormwater tributary/pipe.

Figure 30 Buffalo Creek Upstream of Burrows Park

9.2 Results and Interpretation

Macroinvertebrates

SIGNAL SF

The average SIGNAL SF result for Spring 2023 (4.54, Figure 31) was higher than the result of the previous Spring (3.51). Both recent Spring seasons had SIGNAL results consistent with the historical average for this site (4.16).

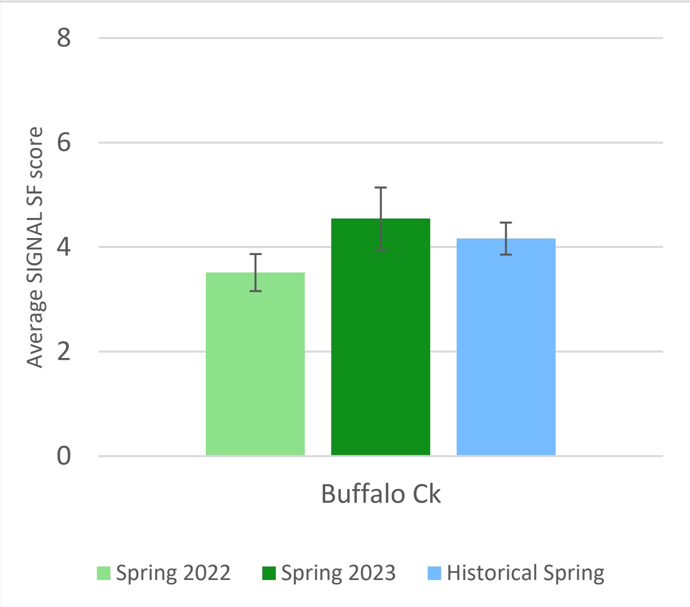


Figure 31 Buffalo Creek Average SIGNAL-SF scores

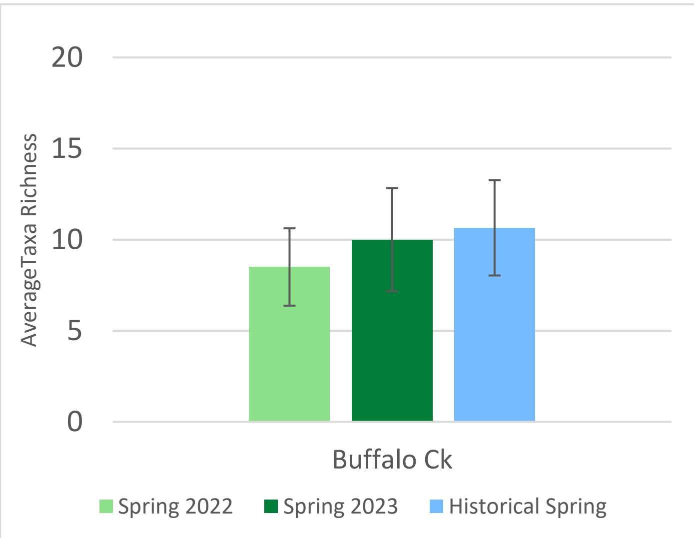


Figure 32 Buffalo Creek Taxa Richness scores

Taxa richness

As with the SIGNAL result, Buffalo Creek also had an observed increase in taxa richness from an average score of 8.5 in Spring 2022 to 10 in Spring 2023 (Figure 32). For both seasons, richness results were consistent with the historical average (10.7). The macroinvertebrate community composition observed at Buffalo Creek is summarised in Figure 32A. During Spring 2023 this site was dominated bythe 'True Flies' and 'Aquatic Snails' groups.

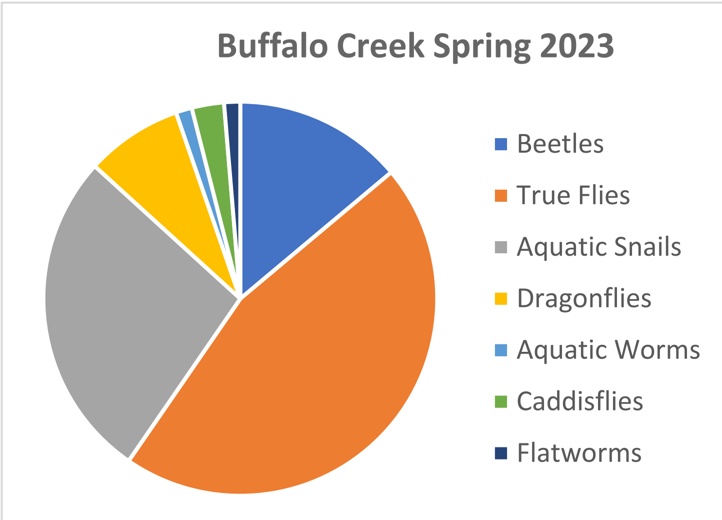


Figure 32A Buffalo Creek Average Macroinvertebrate community composition

Macroinvertebrates summary

Average SIGNAL score and taxa richness results increased from Spring 2022 to Spring 2023. Results for both indices were consistent with historical averages.

Water Quality (CR4B, CR4BA, CR4BB)

Dissolved oxygen (%) results were relatively consistent between sampling sites. Both Buffalo Creek Downstream of Burrows Park (CR4BA) and Buffalo Creek Upstream of Burrows Park (CR4BB) had results of 78% and 84% respectively which were slightly lower than the lower guideline limit of 85%. Buffalo Creek core site (CR4B) had a result of 89.6% which was within guideline limits. Turbidity results in the catchment were relatively low ranging from 2.72 NTU at the core site (CR4B) to 5.79 NTU at the site downstream of Burrows Park (CR4BA). The highest conductivity result was 611 µS/cm at Buffalo Creek core site (CR4B) while the lowest was seen at site Buffalo Creek Upstream of Burrows Park (CR4BB) with a result of 436 µS/cm.

Faecal coliform results were elevated above threshold limits (>1000 CFU/100mL) for two sites in this catchment. Downstream of Burrows Park site (CR4BA) had a faecal coliform result of 24,000 CFU/100mL. The upstream site of Burrows Park (CR4BB) also had an elevated faecal coliform result of 11,000 CFU/100mL. In contrast, the core site of this catchment at the Field of Mars Reserve (CR4B) had a faecal coliform result within threshold at 240 CFU/100mL.

Nutrient results for each site in the Buffalo Creek catchment were elevated above ANZECC guideline thresholds. The highest Total Nitrogen result in the catchment was 1780 µg/L and observed at Buffalo Creek downstream of Burrows Park (CR4BA). This was higher than the guideline limit of 350 µg/L. Buffalo Creek core site (CR4B) and Buffalo Upstream of Burrows Park (CR4BB) also had elevated nitrogen results of 670 µg/L and 1400 µg/L respectively. Buffalo Creek core site had the lowest observed Total Phosphorus result for the season which was equal to the ANZECC guideline (25 µg/L). For the remaining Buffalo Creek sites Total Phosphorus results were 110 µg/L for CR4BA (downstream of Burrows Park) and 121 µg/L for CR4BB (upstream of Burrows Park).

Alkalinity results were consistent across all three sites within the catchment ranging between 62 mg/L and 67 mg/L. Similarly, Total Hardness results were also consistent between sites. Both Buffalo Creek core site and Downstream of Burrows Park site had a result of 110 mg CaCO3/L, while the Upstream of Burrows Park site result was 90 mg CaCO3/L.

Water quality summary

Most dissolved oxygen results were below ANZECC guideline limits. Turbidity results were low for each site in the catchment. Faecal coliform results exceeded guideline limits at two sites in the catchment. All sites had exceedances in nutrient results.

10 Porters Creek

10.1 Sites CR5P, CR5PA, CR5PB, CR5PC

There is one core site and three water quality only sites within the Porters Creek Catchment (Figure 33). From 1969 to 1986 the Council's Porters Creek site operated as a landfill site. It now operates as a construction waste recycling facility.

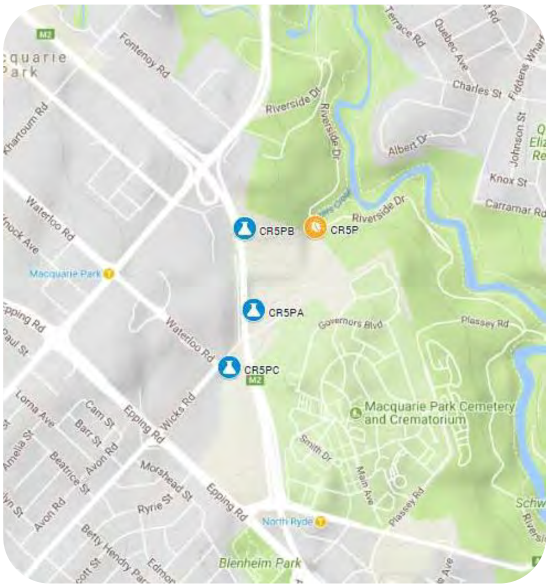


Figure 33 Porters Creek Catchment Area

CR5P Porters Creek (core site)

This site is in the Lane Cove National Park, North of the Council's Environmental Construction Materials Recycling Facility. It is at this point that Porters Creek emerges after flowing mostly underground in its upper section. Water quality and macroinvertebrate sampling was conducted near the Porters Creek Bridge. The surrounding riparian area is dominated by native plants with a small number of exotic species. The creek bed is mostly bedrock with some cobble, boulder and sand. No macrophyte growth has been observed although there has been algal growth present.

Figure 34 Porters Creek core site (CR5P) looking upstream, Spring 2023

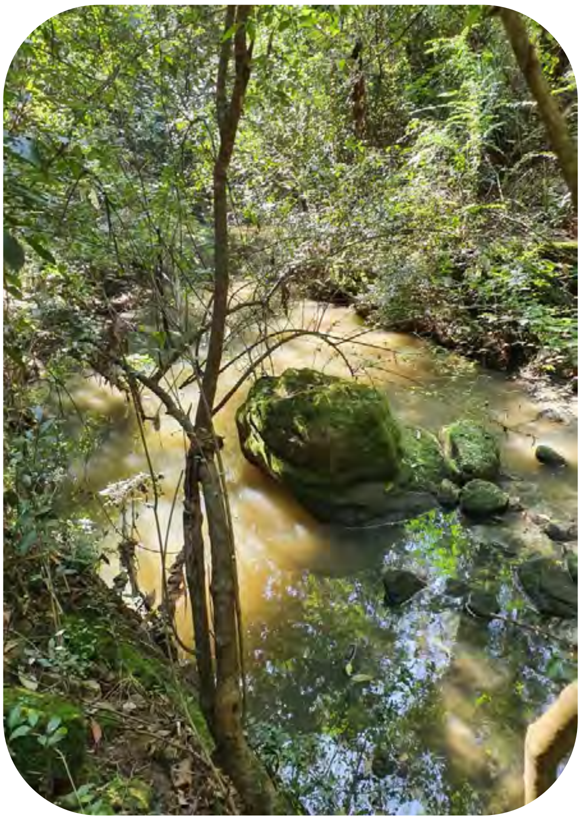


Figure 35 Porters Creek core site (CR5P) looking downstream, Spring 2023

CR5PA Porters Creek at Main Branch

This site is located on the western boundary of the construction waste recycling facility and consists of an open concrete channel. Samples are collected from the retention basin at the end of the channel.

Figure 36 Porters Creek at Main Branch facing downstream

CR5PB Porters Creek at Spur Branch

This site is in the north-western corner of the centre in an underground drainage pit where several underground stormwater lines meet before joining and draining to the main Porters Creek line. The exact location has changed over the years due to access issues.

Figure 37 Porters Creek at Spur Branch

CR5PC Porters Creek at Wicks Road

This site is the first point that Porters Creek daylights from the underground stormwater system. The site is surrounded by commercial and industrial land uses. The banks have been re-lined with sandstone and surrounding area vegetated with native plants.

Figure 38 Porters Creek at Wicks Road

10.2 Results and Interpretation

Macroinvertebrates

SIGNAL SF

The average SIGNAL score for Porters Creek core site during Spring 2023 was 4.5. This was consistent with the Spring 2022 result (4.3) as well as the historical average for the season (4.3, Figure 39).

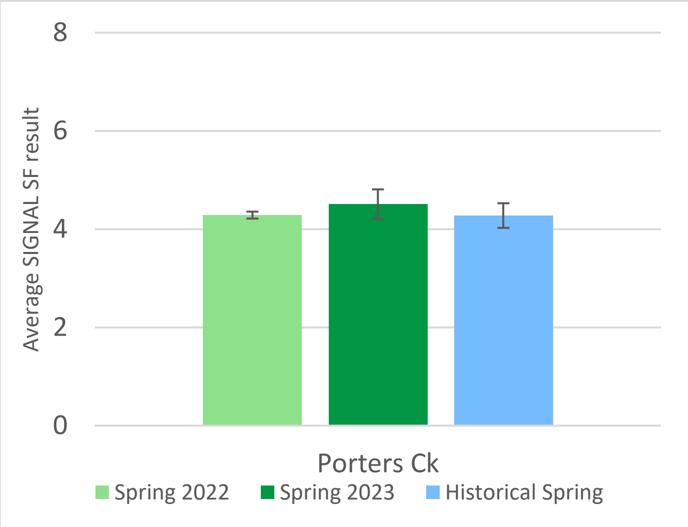


Figure 39 Porters Creek Average SIGNAL-SF scores

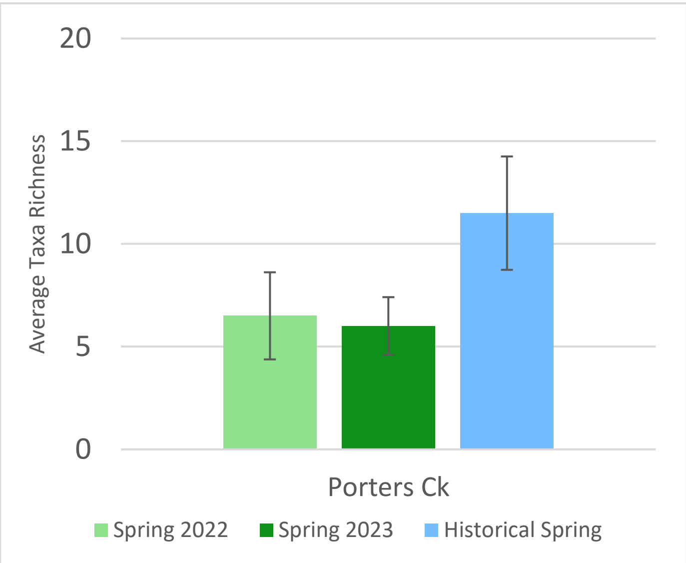


Figure 40 Porters Creek Average Taxa Richness scores

Taxa Richness

Porters Creek average Taxa Richness result for Spring 2023 was 6 (Figure 40) which was slightly lower than the previous Spring (6.5, 2022). The result was also lower than the historical average for this site. During this season, the macroinvertebrate community was almost entirely comprised of families from the True Flies group (Figure 40A). An over-representation of a highly tolerant taxa group is indicative of impacted environment.

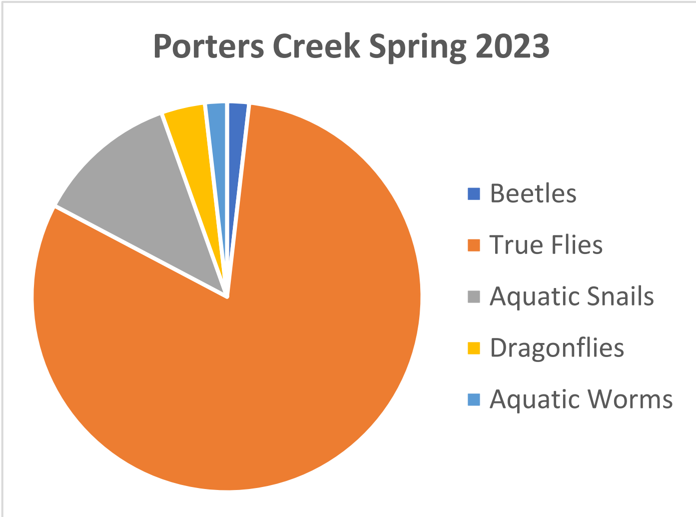


Figure 40A Porters Creek Average Macroinvertebrate community composition

Macroinvertebrates summary

SIGNAL SF scores were consistent between Spring seasons and the historical average for the site. The average Taxa Richness result for Spring 2023 was comparable to Spring 2022 but was lower than the historical site average.

Water Quality

In-field water quality measurements within Porters Creek catchment were variable between sites. The highest dissolved oxygen result (%) was observed at Porters Creek at Wicks Road (100.9% CR5PC) while the lowest result was observed at Porters Creek core site (64.3%, CR5P). Turbidity results were observed to be generally low for most sites in the Porters Creek catchment.

At Porters Creek core site (CR5P) evidence of a potential sewer overflow event was observed. The in-field turbidity reading was very high (91.40 NTU) and above the guideline limit (<50 NTU). This was also the case with the faecal coliform result which was also elevated well above the ANZECC guideline limit at 100,000 CFU/100mL. This was reported and additional sampling was conducted by Sydney Water to ascertain the source and extent of the event.

Total nitrogen and total phosphorous results were elevated above ANZECC guideline limits for three sites in the catchment. However, Porters Creek at spur branch site (CR5PB) had both nitrogen and phosphorus results below guideline limits. Total Nitrogen was 330 µg/L (<350 µg/L limit), and Total Phosphorus was 14 µg/L (<25 µg/L limit).

Porters Creek at main branch site (CR5PA) had the highest alkalinity result for the season (319 mg $CaCO_3$/L). Porters Creek core site (CR5P) had the second highest result at 147 mg $CaCO_3$/L.

Porters Creek heavy metals testing

At each of the four Porters Creek sites, additional heavy metals testing was conducted, with results listed in Table 4 below. The result of each test analyte was compared with ANZECC guideline value limits. Exceedances above standard guideline values have been denoted in 'RED'. The results of the previous Spring season (2022) have also been added for comparison. In general, most test analytes were below detection limits at each of the four sites. This included total results for: Mercury, Arsenic, Cadmium, Chromium, Iron and Manganese.

ANZECC (2000) recommends that the toxicity trigger values for hardness-related metals (in this study: cadmium, copper, lead, and zinc) are adjusted to account for local water hardness. This is because standard trigger values for these metals have been derived for soft waters (30 g/m³ $CaCO_3$). The relevant adjustment factors for water hardness categories are detailed in the Appendix. Total hardness results could not be derived for Porters Creek core site (CR5PB) and for this reason standard trigger limits have been used.

Total Copper results exceeded the standard ANZECC guideline (>1.4 µg/L) at Porters Creek core site (90 µg/L, CR5P). Moderate water hardness adjusted the ANZECC Total Copper guideline limit to 3.5 µg/L for sites CR5PB and CR5PC. This limit was exceeded at both with concentration results at 5 µg/L and 7 µg/L respectively. These results were comparable to those observed during Spring 2022.

At Porters Creek core site (CR5P) the Total Lead result was 10 µg/L which exceeded the standard guideline limit of 3.4 µg/L. This was an increase from the previous Spring season which had all sites with lead results below detection level.

In general, zinc concentration results were similar between Spring seasons however, Porters Creek core site (CR5P) saw a spike in Zinc from 10 µg/L (2022) to 130 µg/L (2023). Site CR5PA had very hard water (290 mg $CaCO_3$/L). This adjusted the ANZECC threshold limit for zinc to 41.6 µg/L. Zinc results for this site were below this adjusted limit (10 µg/L). The moderate water hardness at sites CR5PB and CR5PC adjusted the ANZECC Zinc threshold limit to 20 µg/L. Site CR5PB had a zinc concentration below this limit (10 µg/L) while site CR5PC had a result the same as the limit (20 µg/L).

Table 4 Additional heavy metals analyses for Porters Creek sites Spring 2023 and Spring 2022 (results reported as mg/L)

Spring season	Test Analyte (mg/L)								
Spring 2023	Total Mercury	Total Arsenic	Total Cadmium	Total Chromium	Total Copper	Total Iron	Total Lead	Total Manganese	Total Zinc
CR5P	<0.0003	<0.02	<0.005	<0.005	0.09	2.39	0.01	0.209	0.13
CR5PA	<0.0003	<0.02	<0.005	<0.005	<0.005	1.01	<0.01	0.253	0.01
CR5PB	<0.0003	<0.02	<0.005	<0.005	0.005	0.18	<0.01	0.031	0.01
CR5PC	<0.0003	<0.02	<0.005	<0.005	0.007	0.26	<0.01	0.016	0.02
Spring 2022									
CR5P	<0.0003	<0.02	<0.005	<0.005	0.005	0.99	<0.01	0.035	0.01
CR5PA	<0.0003	<0.02	<0.005	<0.005	<0.005	0.47	<0.01	0.019	0.01
CR5PB	<0.0003	<0.02	<0.005	<0.005	0.01	3.25	<0.01	0.292	0.04
CR5PC	<0.0003	<0.02	<0.005	<0.005	0.005	0.42	<0.01	0.03	0.02

Water quality summary

In-field observations were variable across sampling sites. Nutrient results were elevated above ANZECC limits for most sites. Porters Creek core site (CR5P) had highly elevated turbidity and faecal coliform results. Heavy metals results were generally consistent between Spring seasons with similar elevated results.

11 Rapid Riparian Assessment

Rapid Riparian Assessments (RRA) are conducted annually during the Spring sampling season at each of the five catchments. The process of this assessment involves the observation of stream features and vegetation community surrounding the stream. Table 5 (below) provides a summary of the results from the two most recent Spring sampling seasons. Most rapid riparian scores were found to be consistent between Spring 2023 and Spring 2022 seasons with most sites maintaining the same score category.

Shrimptons Creek catchment RRA score category for the Spring 2023 season was 'Fair'. This was consistent with the result of the previous Spring season. However, the individual site score declined from 26 in 2022 to 2.4 in 2023. This could be attributed to the nearby State Significant Development that has involved vegetation removal in the riparian zone and in-creek works associated with the construction of the bridge. Additionally, during Spring 2023 there was an observed reduction in organic material and woody debris within the creek channel.

The 'Fair' score achieved by Archers Creek in Spring 2022 was maintained in Spring 2023. The high density and complex riparian vegetation observed in Spring 2022 was also present during the current sampling period.

Category	Score range	Colour code
Excellent	≥60	
Good	27 to 59.99	
Fair	-6 to 26.99	
Poor	-39 to -6.99	
Very Poor	-72 to -39.99	

In Spring 2023, Terrys, and Buffalo Creek sites both maintained the 'Good' RRA score observed during the previous Spring period. Terrys Creek catchment is situated in a bushland corridor with extensive vegetation bordering both creek banks. The creek runs through a complex natural channel containing pool and riffle sequences. The channel has a high level of overhanging vegetation, and weed infiltration in the site was minimal.

The high score associated with Buffalo Creek catchment can be attributed to factors including the high density of bushland on the left creek bank, a moderate amount of in-channel woody debris present, the presence of both pool and riffle sequences as well as low litter presence.

During Spring 2023, the RRA score at Porters Creek increased from "Good" to 'Excellent". This improvement was associated with a higher presence of woody debris in-channel, an increase in the density of over-hanging vegetation and a reduction in the presence of weeds.

Table 5 Rapid Riparian Scores and categories for Spring 2023 and Spring 2022 seasons

	Season	
Catchment	**Spring 2023**	**Spring 2022**
Shrimptons	2	26
Archers	14	13
Terrys	57	56
Buffalo	38	37
Porters	68	50

12 Discussion / Conclusion

12.1 Macroinvertebrates

In general, SIGNAL_SF and Taxa Richness results for the Spring 2023 season were found to be consistent with historical Spring data and there was a general improvement in Spring 2023 scores when compared with results from Spring 2022. As with previous seasons, macroinvertebrate communities were dominated by more tolerant groups such as the 'True Flies' and 'Aquatic Snails' which is typical for urban impacted streams.

The average SIGNAL score at Shrimptons Creek during this season was observed to be lower than the previous Spring. This was also the case with the Taxa Richness score for this season. The current sampling season saw a reduction in Hemipteran (True Bugs) and Dipteran (True Flies) families. This may be attributed to the adjoining State Significant Development and the associated vegetation removal in the riparian zone and in-creek works. In contrast to Shrimptons, the average SIGNAL result for the Archers Creek catchment was higher than the previous Spring. This can be attributed to a higher abundance of moderately sensitive taxa. For example, Argiolestidae (damselfly) nymphs (SIGNAL grade score – 5) occurred as 1 individual in a replicate sample in Spring 2022, while in Spring 2023 there were 8 and 10 individuals of this taxa in replicate samples 1 and 2, respectively. Spring 2023 saw lower rainfall prior to the date of sampling when compared to Spring 2022. Reduced rainfall would reduce the likelihood of flushing events in small creeks such as Archers which is formed as a steep and narrow channel. Less disturbance of habitat (ie; organic matter, detritus, riffle sequences) can maintain a more stable macroinvertebrate community.

At Terrys Creek catchment Taxa Richness results were higher in Spring 2023 than in the previous Spring. This can be attributed to a higher diversity of Dipteran families observed during Spring 2023. This was also the case with Buffalo Creek. This result can be attributed to the presence of more sensitive families during Spring 2023. This includes the Veliidae (Hemiptera) and Corydalidae (Megaloptera) families.

Porters Creek site saw a decline in both SIGNAL SF and taxa richness results during the Spring 2023 sampling period. The site was also found to be dominated by more tolerant taxa including Chironomidae (Diptera) and Tateidae (Mollusca). This is likely to be attributed to the reduction in water quality at the time of sampling associated with a sewer overflow event in the catchment. Factors such as increased flow and turbidity and reduced dissolved oxygen can adversely impact macroinvertebrate communities. This often results in lower overall community diversity and an over-representation of tolerant taxa.

12.2 Water Quality

Water quality testing was conducted at each of the 14 sampling sites. Both in-field and analytical laboratory methods were used to test a range of analytes. Result variability was observed across sites within the same catchment and when compared to data from the previous Spring season. As with previous seasons, dissolved oxygen results had a high level of variability for both sites located in the same catchment and between different catchments. Dissolved oxygen is influenced by water flow. High flows see a higher observed oxygen result while waterways in stagnant conditions will have lower oxygen results. For example, Shrimptons Ck at Wilga Park (Core site) had the lowest observed dissolved oxygen for the season. On the day of sampling water flow was very low and there was a high density of organic matter in the stream channel. Archers Creek also had a low dissolved oxygen reading (51.2%) far lower than the result observed during Spring 2022 (90.2%). As with Shrimptons Creek, flow in the channel was low with ponded areas present. Flow in Terrys Creek core site (CR3T) was also low with ponded areas. It had a much lower oxygen result than Terrys Creek Forrester Park site (CR3TA) which had a higher flow including riffle sequences.

In general, nutrient results exceeded guideline limits at most sampling sites. This has been observed consistently in previous reporting periods during both Spring and Autumn seasons. Porters Creek site had the highest exceedances for nutrient concentrations. This can be associated with the sewer overflow incident that was observed on the day of sampling. Most of the remaining sampling sites also had exceedances for this parameter. Streams situated in urban environments can be influenced by a range of factors. Proximity to residential backyards, public parks, roadways, and industry can lead to an influx of nutrients into waterways. For example, the upstream and downstream sites at Burrows Park (Buffalo Creek catchment) had elevated nitrogen and ammonia results. The location of these sites in a public park adjacent to residential zones may have contributed to these results. Natural elements including bird droppings can also contribute to the nutrient load in creek environments.

Faecal coliform results were highly variable across sites. The lowest result was observed at Archers Creek site (17 CFU/100mL). During the day of sampling, water flow was low in the channel. Reduced flow would minimise the likelihood of contaminant influx into the channel. The creek is also located in a dense riparian zone which can provide a buffer during rain events. The highest coliform result was observed at Porters Creek core site where results were far above ANZECC guideline limits. This was associated with an overflow event within the catchment. Follow-up sampling and remediation were carried out to minimise impact. Additional heavy metals testing at the four Porters Creek sites during Spring 2023 saw exceedances in Total Copper results (>1.4µg/L) at sites CR5P, CR5PB and CR5PC. Copper is used in a range of applications including the manufacture of metal alloys, wiring and pesticides. Porters Creek catchment also had observed exceedances in zinc concentrations. The core site (CR5P) saw a spike in Zinc from 10 µg/L (2022) to 130 µg/L (2023). Zinc is a common component in construction materials, automotive parts, plumbing and stormwater pipes. These results were comparable to the heavy metal concentrations observed during the Spring 2022 sampling season and are indicative of the influence of urban activities.

12.3 Rapid Riparian Assessment

At each of the five core sites Rapid Riparian Assessments (RRA) were performed to assess a range of environmental characteristics. These included features such as in-channel structures and bank vegetation composition. RRA scores were collated and compared to results from the previous Spring. Results for four of the five catchments indicated no change in score. Archers catchment recorded a “Fair” score while Terrys and Buffalo catchments each maintained a “Good” score. The only site that saw a major score decline was Shrimptons Creek core site at Wilga Park. The score declined from 26.3 (2022) to 2.4 (2023), although the site was still categorised with a ‘fair’ score Only Porters Creek core site saw an improvement in Riparian score from “Good” to “Excellent”. This improvement was associated with a higher presence of woody debris in-channel, an increase in the density of over-hanging vegetation and a reduction in the presence of weeds.

13 Recommendations

- At each of the established sampling sites, continue to monitor:

i) Macroinvertebrate communities (SIGNAL SF and Taxa Richness indices)

ii) Chemical water quality parameters

iii) Riparian condition

iv) Additional heavy metals analysis at Porters Creek sites

- Continue Gross Pollutant Trap maintenance and rubbish removal
- Consider collecting pre-and post-work water quality data on any Council projects that aim to improve water quality
- Continued collection of Stream-watch data, sampled in parallel with Sydney Water sites and time periods

14 Appendix: Detailed Methodology

1 Water Quality

City of Ryde council provided the water quality monitoring design and study locations for this sampling program. The procedures are consistent with their previous monitoring programs. Water quality sampling was conducted by trained Sydney Water staff who conformed to standard [AS/NZS 5667:1998] and relevant Sydney Water occupational health and safety procedures. Samples were collected in bottles pre-labelled with a unique identifying laboratory number as well as the sample site code, location, and date of collection. Field measurements and observations for each site were recorded at the time of sampling. The sampling procedures used for this program are detailed below.

(i) Sampling schedule and frequency

A bi-annual sampling schedule was prepared by the Aquatic Ecology Project Leader in communication with the client to ensure milestones and deliverables were met according to the agreed timeframes. Routine water quality monitoring was undertaken in September 2023 (Spring) at the five core sites and nine water quality only sites. Autumn sampling has been scheduled for March 2024.

(ii) Sampling procedure

The below procedure was followed to avoid contamination during sample collection:

- sampling officers wore disposable latex gloves
- samples were collected using aseptic techniques
- sampling equipment was sterilised and rinsed between sites
- sample bottles not containing preservative were rinsed before filling
- microbiological samples were collected before other samples

The following procedures were followed to ensure the representativeness of samples:

- disturbed areas of the creek bank were avoided; where disturbance was evident the sample was collected upstream
- rinse water was discarded downstream or away from the sampling point
- issues impacting sample integrity, such as distance from bank(s), number and distribution of samples, substrate, ponds and aeration, were considered in determining sampling sites
- surface scum was avoided

Samples were collected from 20-30 cm below the water surface. Where the depth was less than 50 cm, the sample was taken at half the depth. In the instance where the waterway was shallow, surface samples were collected to allow sampling without disturbing the sediment. This has the potential to compromise sample quality as surface samples may contain surface contaminates, such as scum, dust or pollen, which may not be present below the waterway surface. Therefore, where applicable, collection of surface samples was noted on the Water

Quality Sampling Field Sheet. A sampling pole and/or jug were used to collect samples. A list of water chemistry analytes sampled, along with their unit of measurement and collection container are provided in Table 3.

(iii) Field measurements

It is necessary to measure some water chemistry analytes in the field using various instruments (Table 1). To ensure accuracy of results, instruments are calibrated according to the manufacturers' recommendations, field procedure requirements, relevant sections of NATA ISO/IEC 17025 Field Application Document and other reference material.

Table 1 Water chemistry parameters and field analysis methods

Analyte	Method
Dissolved Oxygen (% saturation)	WTW Multiliner Universal Meter
Dissolved Oxygen (mg/L)	WTW Multiliner Universal Meter
Conductivity (µS/cm)	WTW Multiliner Universal Meter
pH (pH units)	WTW Multiliner Universal Meter
Turbidity (NTU)	HACH Turbidimeter
Temperature (°C)	Digital Thermometer

To ensure traceability of calibration in accordance with NATA ISO/IEC 17025 Sydney Water uses both in-house and purchased calibration standards. In-house standards are made only from analytical grade materials of appropriate purity. The assays of these materials are traceable to the National Institute of Standards & Testing (NIST). Purchased calibration standards are regarded as critical materials and are accompanied with a certificate of analysis showing traceability to NIST.

(iiii) Field observations

Field observations were recorded to assist in the interpretation of results. At each site the field observations listed below were recorded:

- sample clarity
- algae presence
- recent rain
- visual pollution
- flow rate (visual assessment)

(v) Sample preservation and transportation

Water samples collected for laboratory analysis that required refrigeration were placed in an ice filled esky immediately after collection. Samples were delivered to the Sydney Water analytical laboratory at West Ryde with the appropriate Chain of Custody form.

(vi) Analysis

All Sydney Water laboratory analytical work was performed as per the requirements of AS ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories. In general, most of the methodologies used are American Public Health Association (APHA) or United States Environmental Protection Agency (USEPA) standard methods. Where standard methods are not available, analytical procedures have been developed from in-house research or published methods from analytical journals. All analysis was carried out according to the requirements of the customer and the laws and regulations of relevant authorities. Sydney Water laboratories' NATA technical accreditation numbers are listed in Table 2 below.

Table 2 Sydney Water laboratories NATA accreditation numbers

Field of Testing	Number	Accredited	Standard
Chemical testing	63	1952	ISO/IEC 17025
Biological testing	610	1966	ISO/IEC 17025

2 Macroinvertebrates

The Sydney Water Biology Group carry out sampling activities according to the requirements of the in-house test method *SS0001 Rapid Field Assessment of Macroinvertebrates for River, Stream (lotic) and Wetland (lentic) Waters*. All field sampling staff must be competent in identifying macroinvertebrates to a family-level. This requirement ensures that field staff are experienced in identifying animals of varying morphologies to facilitate high quality field sampling and processing techniques. As identifiers they must comply with the requirements of the In-house test method *SSWI433 Macroinvertebrate Cataloguing, Identification and Counting*.

(i) Sampling Procedure

At each of the five core sampling sites, two replicate macroinvertebrate samples were collected from edge habitat using a hand-held dip net. An 'edge' habitat is defined as a zone with little to no current, for example, areas adjacent to stream banks. The sampling net was swept from open water towards the stream bank, working over a bank length of approximately 10 meters. This process stirs up deposits of silt and detritus so that benthic and surface-dwelling animals are suspended and caught in the net.

(ii) Qualitative sample collection

The net contents were emptied into a large white sorting tray with a small amount of water to allow live macroinvertebrate specimens to be picked out with fine forceps and pipettes for a minimum period of 40 minutes. If new taxa were collected between 30 and 40 minutes, sorting continued for a further 10 minutes. If no new taxa were found after 10 minutes, picking ceased. If new taxa were found, the 10-minute processing cycle continued up to a maximum total sorting time of 1 hour. All specimens collected were preserved in small glass specimen jars containing 85% un-denatured ethanol with a clear label indicating site code and location, date, habitat, and initials of both the sampler and picker. Sampling equipment was washed thoroughly between samples to prevent the cross contamination of animals.

(ii) Sample processing

Macroinvertebrate samples were processed as per *SSWI433 In-house Test Method Macroinvertebrate Cataloguing, Identification and Counting*. Quality assurance was conducted as per *SSWI434 In-house test method Quality Control of Macroinvertebrate Identification, Counting and Archiving of Collections.* Both methods comply with the requirements of AS ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories under technical accreditation number 610 issued by the National Association of Testing Authorities (NATA). Macroinvertebrate identifications were performed using compound and stereo microscopes (Leica Microsystems) that are maintained via a strict calibration schedule.

Reference material used in the Aquatic Ecology laboratory includes:

- Current published taxonomic keys
- Voucher specimens, many confirmed by national experts
- Sydney Water in-house keys and digital voucher photographic database

Macroinvertebrates were identified and enumerated to the family taxonomic level, except Chironomids which were identified to sub-family. Aquatic worms were identified to Naididae sub-families as required while Aquatic mites were identifed to Order level (Acarina). Identification data was verified before being entered into Sydney Water's electronic database (LIMNOS). Raw macroinvertebrate data files were extracted and verified by a senior staff member before analyses were performed. At the end of this process, quality assurance was conducted on 5% of edge samples identified for this study. Identifications are chosen at random for quality assessment.

(iii) Rainfall data

Rainfall data was extracted from the Australian Bureau of Meteorology website. The North Ryde Bureau station (066213) data was used for this report. Daily, monthly, and cumulative rainfall data prior to the sampling date was collated and graphed. Rainfall levels were observed to ensure that rainfall volume did not exceed 10 mm in the days preceding sampling to ensure representative sample collection.

3 Analysis Methods

(i) Water quality

Water quality results were used to characterise each study creek against ANZECC (2000) guidelines for Aquatic Ecosystems (Lowland River in South-Eastern Australia), Recreational Water Quality and Aesthetics (Secondary) and toxicants (95% species protection level). The ANZECC (2000) toxicant trigger values have been used for metals. These guidelines provide four sets of protection levels derived as chemical-specific estimates of the concentrations of contaminants that should have no adverse effects on aquatic ecosystems (ANZECC 2000). The 95% species protection level is commonly applied to aquatic ecosystems that have been modified in some way and has been used in this report as a comparison for the stream water quality results. ANZECC (2000) recommends that the toxicity trigger values for hardness-related metals (in this study: cadmium, copper, lead, and zinc) are adjusted to account for local water hardness. This is important because the trigger values for these metals have been derived for soft waters (30 g/m3 CaCO3), corresponding to high toxicity. The adjustment values for water hardness categories are detailed in Table 4.

Table 3 ANZECC (2000) indicator analytes and associated trigger values

Indicator	Guideline value	Unit	Analysis	Source
Dissolved oxygen	85 to 110	% saturation and mg/L	In-field	Protection of aquatic ecosystem (ANZECC 2000)
pH	6.5 to 8.5	pH unit	In-field	Protection of aquatic ecosystem (ANZECC 2000)
Turbidity	50	NTU	In-field	Protection of aquatic ecosystem (ANZECC 2000)
Conductivity	125 – 2500	µS/cm	In-field	Protection of aquatic ecosystem (ANZECC 2000)
Ammonia nitrogen	20	µg/L	Laboratory	Protection of aquatic ecosystem (ANZECC 2000)
Oxidised nitrogen	40	µg/L	Laboratory	Protection of aquatic ecosystem (ANZECC 2000)
Total nitrogen	350	µg/L	Laboratory	Protection of aquatic ecosystem (ANZECC 2000)
Total phosphorus	25	µg/L	Laboratory	Protection of aquatic ecosystem (ANZECC 2000)
Faecal coliforms	1000	CFU/100mL	Laboratory	Secondary contact recreation (ANZECC 2000)
Chromium	0.001	mg/L	Laboratory	Toxicants at 95% level of protection (ANZECC 2000)
Manganese	1.9	mg/L	Laboratory	Toxicants at 95% level of protection (ANZECC 2000)
Iron	ID	mg/L	Laboratory	Toxicants at 95% level of protection (ANZECC 2000)
Copper	0.0014	mg/L	Laboratory	Toxicants at 95% level of protection (ANZECC 2000)
Zinc	0.008	mg/L	Laboratory	Toxicants at 95% level of protection (ANZECC 2000)
Arsenic	0.013	mg/L	Laboratory	Toxicants at 95% level of protection (ANZECC 2000)
Cadmium	0.002	mg/L	Laboratory	Toxicants at 95% level of protection (ANZECC 2000)
Lead	0.0034	mg/L	Laboratory	Toxicants at 95% level of protection (ANZECC 2000)
Mercury	ID	mg/L	Laboratory	Toxicants at 95% level of protection (ANZECC 2000)

Table 4 Relevant ANZECC (2000) trigger value (TV) adjustments for water hardness

Hardness category mg/L as $CaCO_3$)	Hardness range (mg/L as $CaCO_3$)	Cadmium	Copper	Lead	Zinc
Soft	0 – 59	TV	TV	TV	TV
Moderate	60 -119	x 2.7	x 2.5	x 4.0	x 2.5
Hard	120 – 179	x 4.2	x 3.9	x 7.6	x 3.9
Very hard	180 – 240	x 5.7	x 5.2	x 11.8	x 5.2
Extremely hard	400	x 10.0	x 9.0	x 26.7	x 9.0

3 Analysis Methods

(ii) Macroinvertebrates

Two biological indices were used to analyse macroinvertebrate data: SIGNAL_SF and Taxa Richness.

SIGNAL

The SIGNAL (*Stream Invertebrate Grade Number Average Level*) biotic index is a relatively simple and inexpensive method to assess stream health. This index assigns 'sensitivity scores' to macroinvertebrate taxa that are collected using the rapid assessment sampling method. The original version was developed for Sydney Water for assessing the Hawkesbury-Nepean catchment and required identifications to the Family taxonomic level (Chessman, 1995). The original SIGNAL index was refined to include the response of SIGNAL to natural and anthropogenic environmental factors (Growns et al. 1995), variations in sampling and sample processing methods (Growns et al. 1997;) and the objective setting of sensitivity grades of the taxa (Chessman et al. 1997; Chessman et al. 2002).

SIGNAL_SF

Chessman et al. (2007) saw the development of a Sydney-specific SIGNAL biotic index that drew on family and genus level macroinvertebrate data from the greater Sydney region. The water quality status of ‘clean water’ was established using data from near pristine reference sites in the bushland fringes of Sydney and determining the 10th percentile of the average score of those sites (Table 5). SIGNAL-SF allows a direct measure of test site condition and incorporates abundance information gathered from the rapid assessment sampling. ‘S’ indicates the Sydney region version and ‘F’ indicates that the taxonomy is at the family level. The first step in calculating a SIGNAL-SF score is to apply predetermined sensitivity grade numbers (from 1, tolerant to 10, highly sensitive) to each family count for a given habitat sample. Families without a grade score that are present in a sample are removed from the SIGNAL-SF calculation. The square root transformed count (treated to remove bias of taxa with high abundance counts) of each family is then multiplied by the sensitivity grade. The products are summed and then divided by the total square root transformed number of individuals in all families. A location-specific average is then calculated for each sampling site.

Table 5 Interpretation of SIGNAL-SF scores (Chessman *et al.,* 2007)

SIGNAL-SF score	Water quality status
>6.5	Clean water
5.2 – 6.5	Possible mild organic pollution
3.8 – 5.2	Possible moderate organic pollution
<3.8	Possible severe organic pollution

Taxa Richness

Taxa richness is the overall variety (total taxa) of macroinvertebrates observed in a community assemblage. It is an indicator of stream health that can be measured at any specific taxonomic level and operates under the assumption that taxa richness will be higher in healthy streams and lower in streams of poor health. The composition of macroinvertebrate abundances within taxa groups was included in this report. Taxa were for the most part placed into Class and Order groups.

The composition of macroinvertebrate abundance at the basic level is limited in its ability to indicate water body health. However, it can give an indication of the habitat and biological holding capacity of the waterways being studied. Taxa richness can be a useful tool for indicating the general health of a water body. However, it should be used with caution, as taxa numbers may be attributable to factors other than stream health and/or anthropogenic impacts. For example, taxa richness may increase with elevated levels of organic pollution and may not be a good indication that stream health is better than areas with lower levels of organic pollution.

14 Appendix: Streamwatch

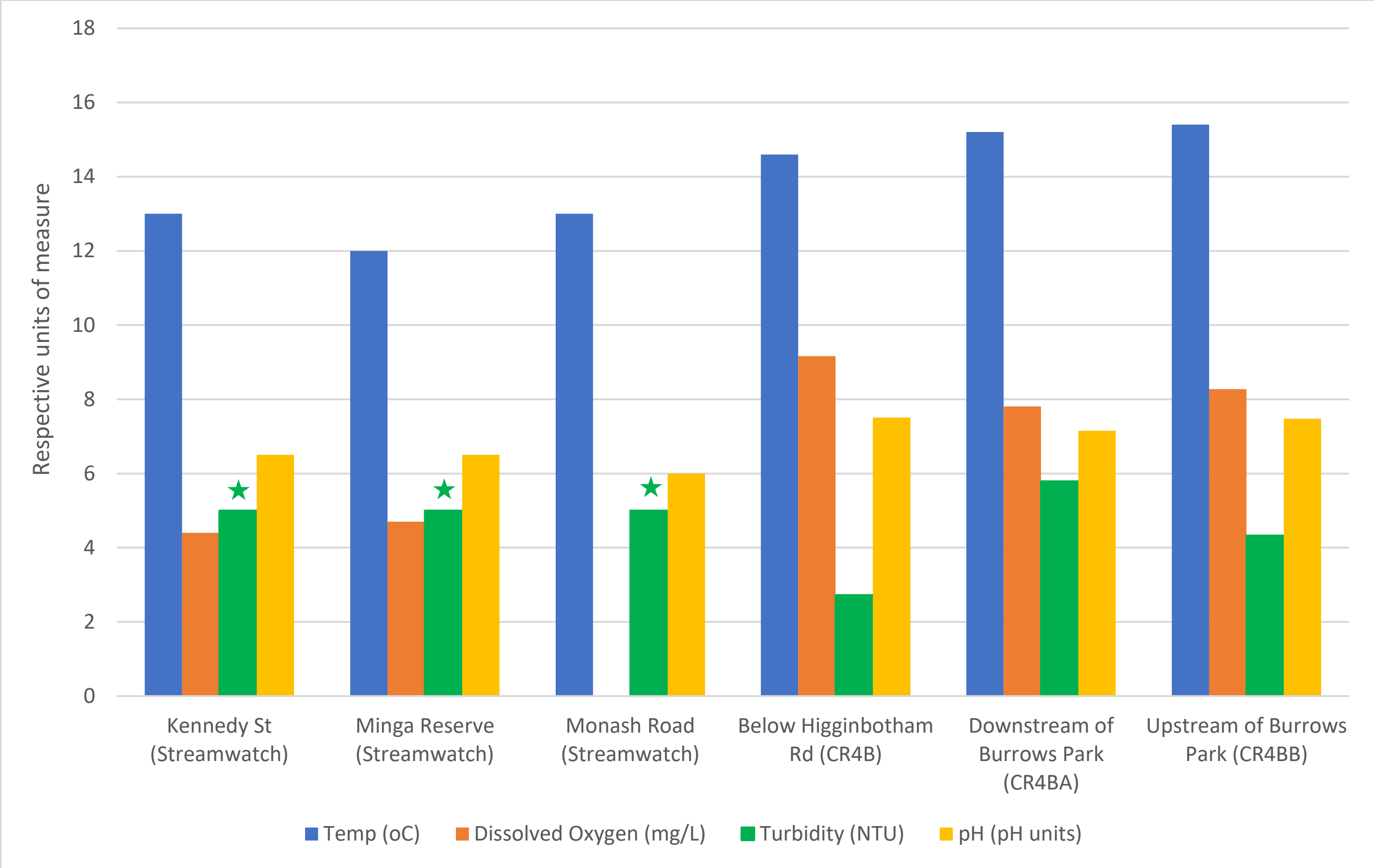
City of Ryde Council provided Streamwatch water quality data for several sites within the catchment zones currently sampled by Sydney Water. It is to be noted that the Streamwatch data was collected by trained Bushcare groups throughout the year using standardised equipment and methodologies. Data from the Council is verified before being stored as a permanent public record that is available for non-commercial purposes. Sydney Water and the Sydney Catchment Authority do not accept responsibility for the use of this information. Data is uncontrolled if printed or downloaded. Comparisons cannot be drawn between the two sets of data as the water quality sampling was conducted at different locations and on different sampling dates. From the Streamwatch dataset provided by City of Ryde Council, a best-match approach was taken when selecting data for general comparisons. Streamwatch data that was collected closest to the Sydney Water sampling date (5^{th} September) was selected.

Buffalo Creek

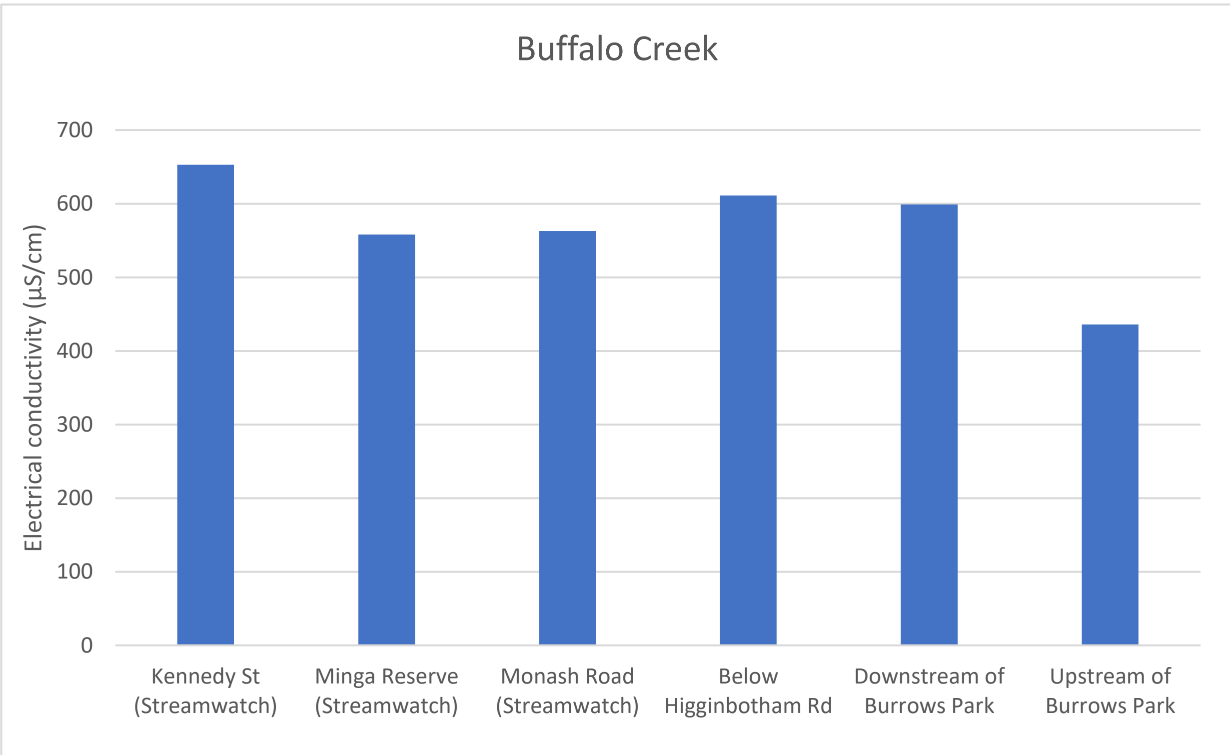
Data from the selected Streamwatch sites below were compared to the three Buffalo Creek catchment sites (CR4B, CR4BA, CR4BB) sampled by Sydney Water and presented in Graph 1:

- Buffalo Creek at Kennedy Street (sampled 26/08/23)
- Buffalo Creek at Minga Reserve (02/09/2023)
- Buffalo Creek at Monash Road (22/08/2023)

Temperature was relatively consistent between sampling sites and sampling days (Graph 1). There was variability in pH results. Sydney Water sites CR4B and CR4BB had the highest result (7.5 pH units) while the lowest was observed at the Monash Road Streamwatch site (6.0 pH units). Turbidity at each of the sites were observed to be low. (*Note: Streamwatch sites had turbidity results of <10 NTU, graphed as ~5 NTU). The dissolved oxygen result was observed to be lowest at the Streamwatch Kennedy St site (4.4mg/L) in contrast to the results of the three Sydney Water sites where results ranged between 7.8 - 9.2 mg/L. Conductivity results were variable between sites. The conductivity result at the Kennedy Street Streamwatch site (653 µS/cm, Graph 2) was the highest result and was comparable to the result at the Sydney Water core site (653 µS/cm).



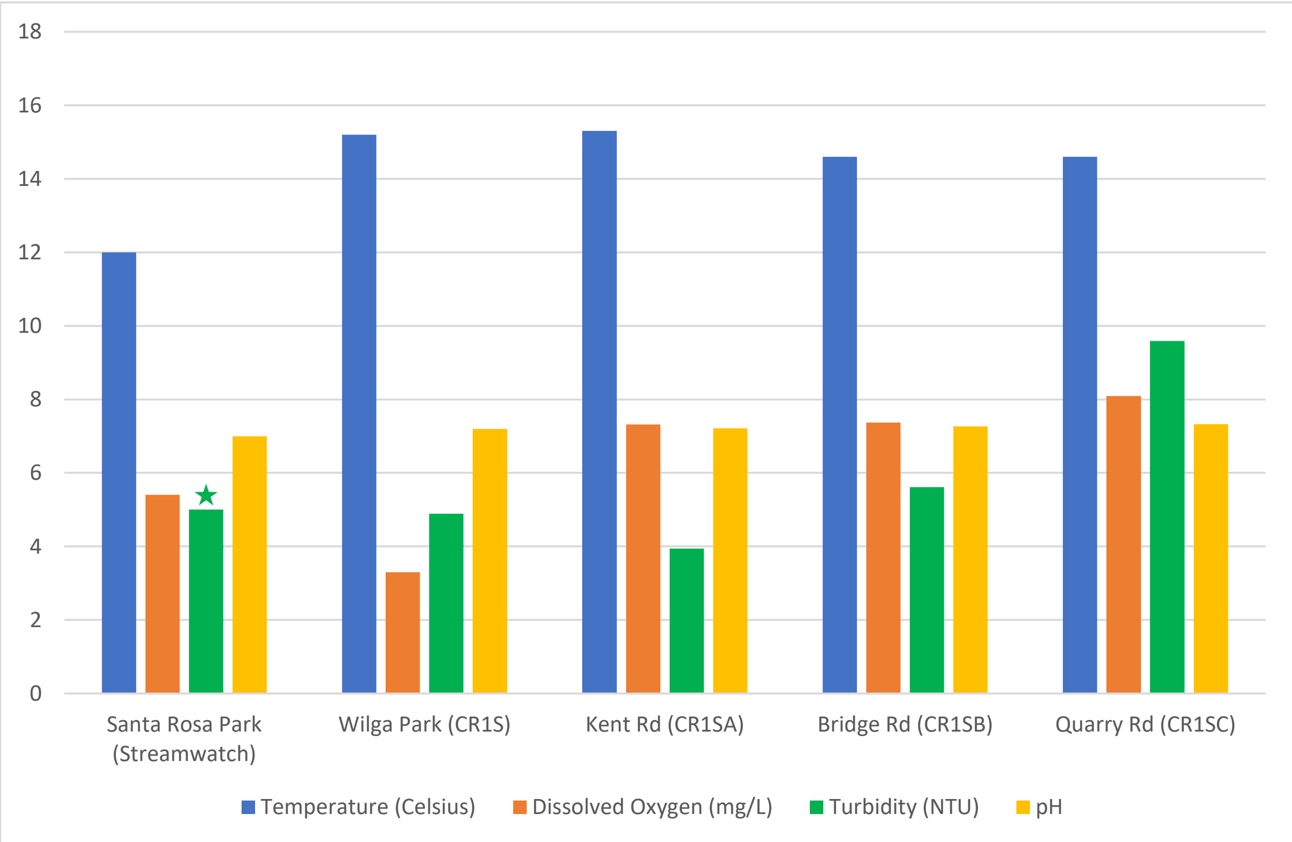
Graph 1 Summary of water quality parameter results from Streamwatch and Sydney Water Buffalo Creek sites



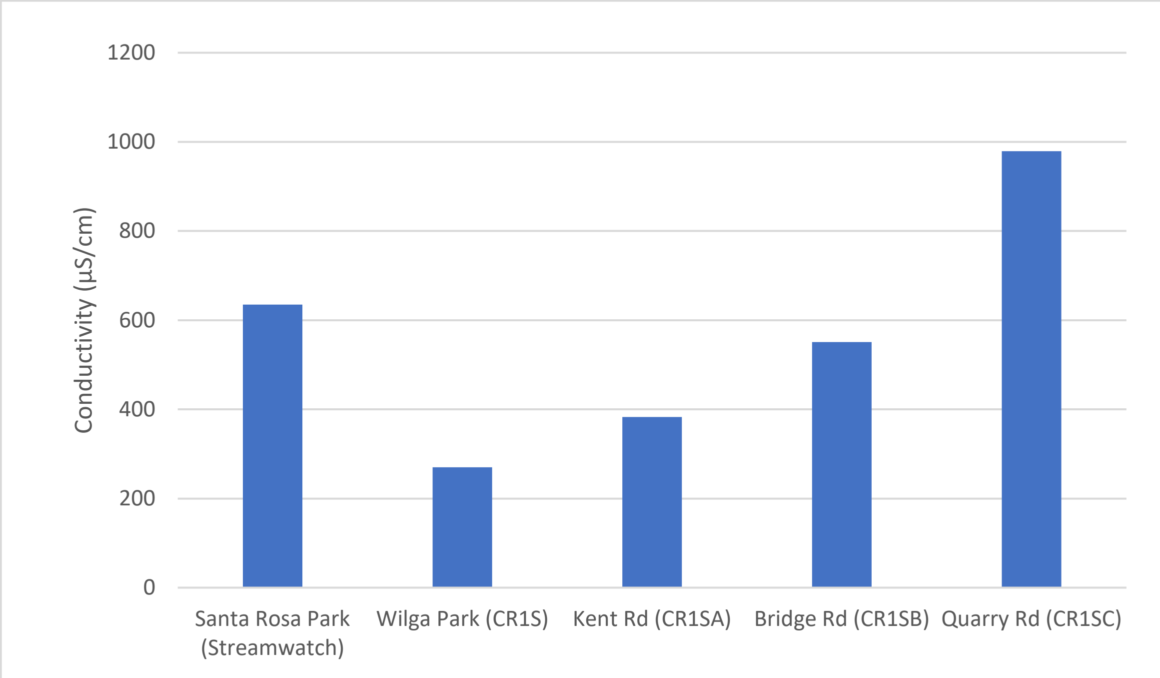
Graph 2 Summary of Conductivity (µS/cm) results for Streamwatch and Sydney Water Buffalo Creek sites

Shrimptons Creek

The results of the Streamwatch site at Santa Rosa Park (sampled on 26th of August) were compared with the four Sydney Water sampling sites (Wilga Park, Kent Road, Bridge Road and Quarry Road) and are shown in Graph 3 below. Temperature and pH results were observed to be consistent across sampling sites. Turbidity results at all the sites were below 10 NTU units (*Note: Santa Rosa Park site had a turbidity result of <10 NTU, graphed as ~5 NTU). The highest turbidity was observed at the Quarry Road site (9.59 NTU). The dissolved oxygen result for the Streamwatch site at Santa Rosa Park was 5.4 mg/L. This was higher than the result observed at Wilga Park (3.3mg/L). In contrast, dissolved oxygen results at Kent Road, Bridge Road and Quarry Road sites were higher and ranged between 7.3 mg/L and 8.1 mg/L. Conductivity results were variable across the Sydney Water sampling sites and when compared to Streamwatch data. The lowest result was at Wilga Park (270 μS/cm, Graph 4) while the highest was 979 μS/cm at the Quarry Road site. The Streamwatch site at Santa Rosa Park had a conductivity result (635 μS/cm) that was most comparable to the Sydney Water site at Bridge Road (551 μS/cm).



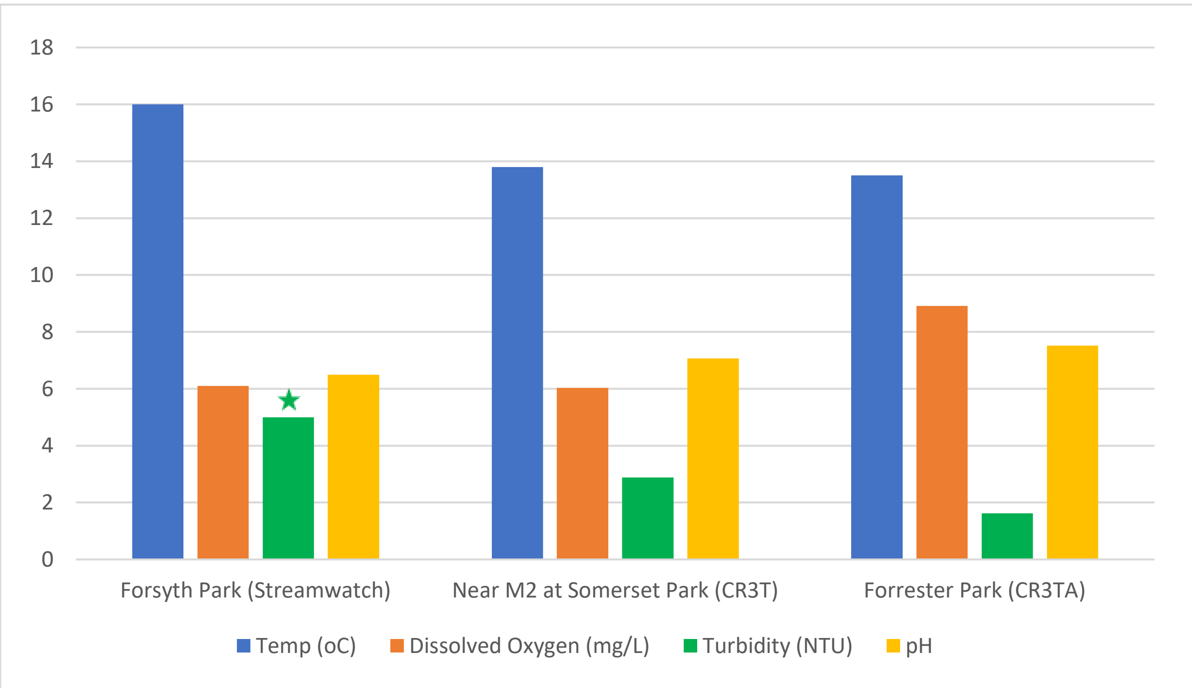
Graph 3 Summary of water quality parameter results from Streamwatch and Sydney Water Shrimptons Creek sites



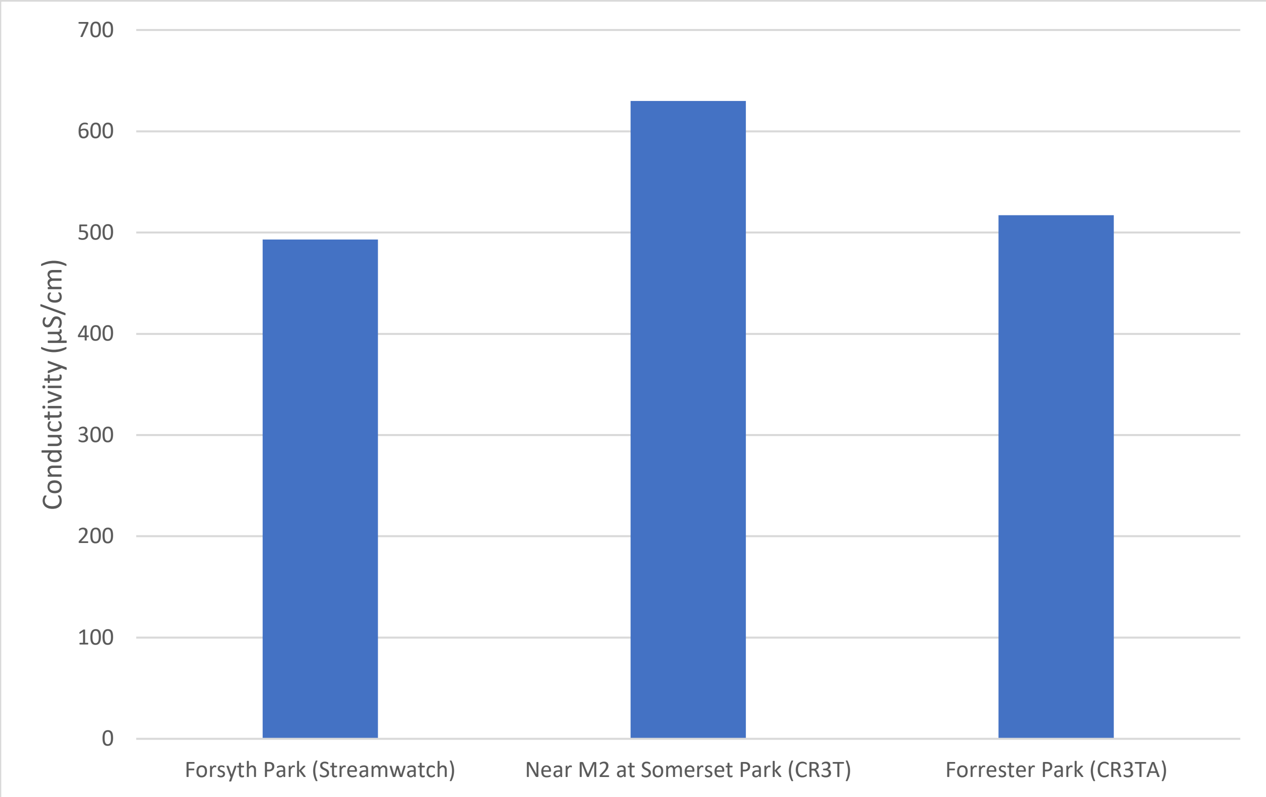
Graph 4 Summary of Conductivity (µS/cm) results for Streamwatch and Sydney Water Shrimptons Creek sites

Terrys Creek

Sydney Water sampled two sites in the Terrys Creek catchment (CR3T and CR3TA). Water quality results for these sites were compared with data from the Streamwatch site at Forsyth Park sampled on the 10th of September. Turbidity results were observed to be low across each site (*Note: Forsyth Park site had a turbidity result of <10 NTU, graphed as ~5 NTU) and pH results were also consistent (Graph 5). Dissolved oxygen results were similar between Forsyth Park (6.1 mg/L, Streamwatch) and Somerset Park (6.0 mg/L). The result at Forrester Park was slightly more elevated at 8.9 mg/L. Conductivity results were consistent across sites (Graph 6). Conductivity at both Forsyth Park and Forrester Park was approximately 500 µS/cm while the result was higher at Somerset Park (630 µS/cm).



Graph 5 Summary of water quality parameter results from Streamwatch and Sydney Water Terrys Creek sites



Graph 6 Summary of Conductivity (µS/cm) results for Streamwatch and Sydney Water Terrys Creek sites

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Glossary

Item	Meaning
Abundance	The total number of individual specimens; in a sample, community, ecosystem etc.
Algae	Comparatively simple chlorophyll-bearing plants, most of which are aquatic and microscopic in size.
Alkalinity	The ability of a solution to neutralise acid (or buffer).
Ammonia	A colourless gas. In the aquatic environment, it exists in the relatively harmless form ammonium (NH4) and the toxic form ammonia (NH3).
Analyte	The physical and chemical parameters (indicators) to be measured.
Anthropogenic	Impacts on an environment that are produced or caused by humans
ANZECC	ANZECC is a forum for member governments to develop coordinated policies about national and international environment and conservation issues.
Catchment	The area that is drained by a river, lake or other water body.
Community	Assemblage of organisms characterised by a distinctive combination of species occupying a common environment and interacting with one another.
Concentration	The quantifiable amount of a chemical divided by the total volume of a mixture.
Conductivity	The measure of salt content in soil or water; it refers to the ability of the substance to transfer an electrical charge.
Dissolved Oxygen	The measurement of the concentration of oxygen that is dissolved in a water body.
Diversity (Biological)	The measure of the number and/or degree of available organisms in an environment.
Eutrophication	Enrichment of a water body with nutrients that results in increased aquatic plant growth and low oxygen levels.
Faecal Coliforms	Bacteria which inhabit the intestines of humans and other vertebrates and are present in faeces. Used as a primary indicator of sewage pollution in the environment.
Guideline (water quality)	Concentration limit or narrative statement recommended to support and maintain a designated water use.
Habitat	The place where a population lives and its surroundings, both living and non-living.
Indicator	A parameter (chemical, biological or geological) that can be used to provide a measure of the quality of water or the condition of an ecosystem.
Macroinvertebrate (Aquatic)	Animals without backbones that when mature are greater than 1 millimetre; live in the water column, on the water surface or on the bottom of a waterway.

Item	Meaning
Nitrogen (Aquatic)	An element that is essential for plant and animal growth, it occurs in three forms Nitrate, Nitrite and ammonium.
Nutrients	Compounds required for growth by plants and other organisms. Major plant nutrients are phosphorus and nitrogen.
pH	A measure of the degree of acidity or alkalinity; expressed on a logarithmic scale of 1 to 14 (1 is most acid, 7 neutral and 14 most alkaline).
Phosphorus	Is an element that is essential for plant and animal growth, excess concentrations can lead to eutrophication.
Physico-Chemical (Aquatic)	The measure and relationship between the physical and chemical identities of a water body.
Sensitive organism	An organism that's survival is highly susceptible to shifts in environmental conditions.
Sewage	The waste water from homes, offices, shops, factories and other premises discharged to the sewer. Is usually 99% water.
SIGNAL SF	SIGNAL (Stream Invertebrate Grade Number Average Level) is a biotic index using aquatic macroinvertebrates to assess stream health.
Stormwater	Rainwater that runs off the land, frequently carrying various forms of pollution such as litter and detritus, animal droppings and dissolved chemicals. This untreated water is carried in stormwater channels and discharged directly into water bodies.
Stormwater system	The system of pipes, canals and other channels used to carry stormwater to bodies of water, such as rivers or oceans. The system does not usually involve any significant form of treatment.
Tolerant organism	Is an organism that can survive in highly variable environmental conditions.
Turbidity	A measure of the amount of suspended solids (usually fine clay or silt particles) in water and thus the degree of scattering or absorption of light in the water.

Acronyms and abbreviations

Acronyms/ Abbreviation	Meaning
ANZECC	Australian and New Zealand Environment and Conservation Council
CFU	Colony Forming Unit
mg/L	Milligrams per litre
NTU	Nephelometric Turbidity Units
SIGNAL SF	Stream Invertebrate Grade Number Average Level – Sydney Family
µg/L	Micrograms per litre
µS/cm	Micro-siemens per centimetre (unit of conductivity)