Transport Roads & Maritime Services

Aquatic Monitoring

Annual Report 2018

FOXGROUND AND BERRY BYPASS

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1 INTRODUCTION

Roads and Maritime Services (Roads and Maritime) upgraded 12.9 km of the Princess Highway between Toolijooa Road north of Foxground, to Schofields Lane (the Foxground and Berry Bypass Project), and between Croziers Lane south of Berry (the Southern Extension).

Roads and Maritime have contracted NGH Environmental to provide Post-Construction Ecological services broadly including the following:

- Nest box monitoring
- Aquatic monitoring
- Weed monitoring
- Summer monitoring
- Specialist advice on ecological matters as required by Roads and Maritime

1.1 PURPOSE OF THE REPORT

The purpose of this Annual Aquatic Monitoring Report is to present data collected over four sessions of aquatic monitoring during 2018 (two in Autumn, two in Spring).

A number of requirements regarding aquatic monitoring during the post-construction period are outlined in the following documents:

- Minister's Conditions of Approval (CoA)
- The Roads and Maritime Statement of Commitments (SoC)
- Construction Flora and Fauna Management Plan sub-plan (CFFMP) (Fulton Hogan, 2014)
- Ecological Monitoring Program (EcMP) (PB 2014)

In accordance with Section 6.2 of the Ecological Monitoring Program (EcMP) (PB 2014), annual reporting is to be completed for all monitoring surveys outlined in the EcMP. This includes aquatic monitoring post-construction.

The EcMP requires that the following aquatic monitoring be undertaken post construction:

Table 1-1 Aquatic monitoring requirements as stated in the EcMP.

Monitoring method	Data to be collected
Habitat assessments – at each creek to determine the suitability of the site to support listed species and based on AUSRIVAS protocols.	Identify habitat variables such as benthic substrate, water depth and vegetation/water % coverage (including shading).
Water quality – will be measured with a Yoekal hand held multi-probe at each site undertaken in accordance with the appropriate guidelines (AS/NZS 6557.1:1998, AS/NZS 5667.6:1998 and Australian Guidelines for Water Quality Monitoring and Reporting (2000).	pH, turbidity (NTU), conductivity (s/cm), temperature (°C) and dissolved oxygen (% saturation and mg/L).
Macrophyte and emergent vegetation – will be identified and mapped at each site. Species abundance will also be quantitatively surveyed using five metre wide 25 m long transects.	Species identified, mapping and species abundance.

Monitoring method	Data to be collected
Macroinvertebrates – at each site following the AUSRIVAS protocols for NSW.	Macroinvertebrates would be sampled and identified to family species level and enumerated.
Fish assessment - at each site a single wing fyke net (12mm or 20mm) and six bait traps would be deployed and set to ensure a diversity of structural habitats are surveys where possible. Mesh seine nets (5-6mm bar) can also be used.	Fish would be identified to species, enumerated, weighed and measured.

In accordance with the EcMP, the surveys were undertaken directly downstream of the creek crossings to monitor downstream impacts of construction. Upstream water quality monitoring via sampling control sites were also monitored to provide background water quality levels. Aquatic monitoring was conducted biannually (within Autumn and Spring) for a 3 year period to commence at the start of the operational phase (2018). This monitoring is a continuation of surveys undertaken between 2014 (pre-construction) and 2015-2017 (Construction period). Previous years involved four sessions, two in Autumn and two in Spring, including this year (2018). All results are included in this Annual Monitoring Report. Results will be assessed yearly during the operational phase of the Bypass, if more than one session per season is recommended.

Aquatic monitoring has been undertaken at eight sites (See Figure 1-1)

- 13 – Broughton Creek
- 16 – Broughton Creek
- 17 – Broughton Creek
- 22 – Bundewallah Creek
- 25 – Broughton Mill Creek
- 27 – Bundewallah Creek
- Control 1 – Broughton Mill Creek
- Control 2 – Broughton Creek

The annual reports must include the following information:

- **Introduction** – background description of the monitoring session (refer to Section 1)
- **Methodology** – description of methodology undertaken including site location and specific survey site locations (refer to Section 2)
- **Results and discussion** – description of monitoring results and comparison of results to performance indicators (refer to Section 3)
- **Review of mitigation measures** – the effectiveness of each mitigation measure will be reviewed (where appropriate) at the end of the monitoring period (refer to Section 4)
- **Recommendations** – suggestion of adaptive responses and contingency measures potentially required (where appropriate) based on the results of the monitoring session such as the implementation of contingency measures or modification of monitoring timing, frequency or methodology (refer to Section 5).

This report provides the results of the first year of aquatic monitoring undertaken during the post-construction phase (2018) and provides recommendations for the remaining 2 years of monitoring.

Figure 1-1 Eight Aquatic Monitoring Sites (Foxground and Berry Bypass)

2 MONITORING METHODOLOGY

2.1 AQUATIC MONITORING SITES

Aquatic monitoring was undertaken twice during Autumn and twice during Spring in 2018 (Table 2-1). In accordance with AUSRIVAS aquatic monitoring protocols, Autumn is considered to be between 15 March and 15 June and Spring between 15 September and 15 December). Six downstream aquatic monitoring sites, 100 metres in length, were monitored. It should be noted that while the site identification numbers have been kept from previous reports, the location of sites 13 and 25 have been modified compared to the pre-construction aquatic assessment undertaken by JSA Environmental in Spring 2014 (JSA 2016) to account for access restrictions (Appendix A). In addition, two control sites were monitored as per the recommendations in the 2015 annual report: Control Site 1 along Broughton Mill Creek (upstream of site 25) and Control Site 2 along Broughton Creek (upstream of site 13). Control Site 2 was not monitored until Spring 2016; approval from Fulton Hogan to monitor the site was not received until Spring 2016.

Table 2-1 Dates of monitoring

	Post-construction 1
Autumn	Session 1: 16-18 April 2018
	Session 2: 5-7 June 2018
Spring	Session 1: 24-26 September 2018
	Session 2: 20-22 November 2018

2.2 HABITAT ASSESSMENT

The AUSRIVAS field data sheets were completed for each site to obtain an overview of the site attributes. The following was recorded:

- Riparian vegetation structure
- Shading of river
- Water levels
- Description of natural substrate
- Detritus cover
- Percentage cover of Algae/Moss/Macrophytes in 100 metre section
- Other instream habitats
- Land use
- Visual assessment of disturbance related to human activities

2.3 WATER QUALITY

Water quality was monitored using a handheld multiparameter water quality meter. The following data was taken:

- Temperature ^{o}C
- pH
- Conductivity ms/cm
- Turbidity NTU
- Dissolved oxygen in mg/L and %

2.4 MACROPHYTE AND EMERGENT VEGETATION

Macrophyte and emergent aquatic vegetation within the creek were identified within the 100 metre section of creek at each site. Furthermore, a 25 metre by 5 metre transect within the creek was surveyed at each site and abundance of macrophytes and emergent vegetation recorded. The location of each transect is provided in Appendix B. A photograph of each transect was also taken for comparison purposes between monitoring sessions.

Cover/abundance assessments were based on visual estimates of foliage cover (after Carnahan 1997), scored using a modified Braun-Blanquet 6-point scale:

1. 1 to a few individuals present, less than 5% cover
2. many individuals present, but still less than 5% cover
3. 5 - < 20% cover
4. 20 - < 50% cover
5. 50 - < 75% cover
6. 75 - 100% cover

2.5 MACROINVERTEBRATES

Macroinvertebrates were sampled in edge and riffle habitats in accordance with the NSW AUSRIVAS Sampling and Processing Manual (Department of Environment and Conservation, 2004). A kick net (250 micron mesh size) was used and a 10 metre section of each type of habitat was sampled. The samples

were then sorted in accordance with AUSRIVAS on site for a minimum of 40 minutes and preserved in 70% ethanol. Macroinvertebrate samples were identified to family. The resulting data was analysed using SIGNAL and EPT scores (see below) to provide an assessment of the existing 'health' of the waterway based on the water quality and abundance and diversity of the macroinvertebrate families present.

SIGNAL score

Families of aquatic invertebrates have been awarded sensitivity scores, according to their tolerance or intolerance to various pollutants. These scores have been determined by examining data from studies of various pollutants in south-eastern Australian streams. The scores are a compromise in cases where species within a family respond in different ways to a pollutant, and where the family responds differently to different types of pollutants. The index is calculated by totalling these scores and dividing by the number of graded families present (most, but not all, families have SIGNAL grades). Waterways with high SIGNAL scores are likely to have low levels of salinity, turbidity and nutrients such as nitrogen and phosphorus.

EPT score

The EPT score is named for three orders of aquatic insects that are common in the benthic macroinvertebrate community: Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). The EPT score is equal to the total number of families represented within these three orders in the sample (Mandaville 2002). Any loss of families in these groups usually indicates disturbance.

The grading guidelines for each score that are used to describe the health of a stream or river are provided in Table 2-2.

Table 2-2 Grading guideline

SIGNAL Score	Stream health	EPT Score	Stream health
<4	Severe pollution	0-6	Poor
4-5	Moderate pollution	7-13	Fair
5-6	Mild pollution	14-20	Good-fair
6-7	Clean	21-27	Good
>7	Excellent	>27	Excellent

2.6 FISH ASSESSMENT

Fish surveys were undertaken using passive trapping and netting techniques. A single wing fyke net, and six bait traps were deployed at each site. All nets were set to ensure a diversity of habitat available to fish was sampled at each site. The surveys included:

- 1 x Single wing fyke net with a central wing with a stretched mesh size of 19 mm. The fyke nets were set with the cod end on one bank with the wing stretched across the creek. The nets were set across the creeks so that they funnel fish moving both upstream and downstream. The cod-end of the net was always suspended out of the water to avoid the mortality of captured air breathing vertebrates.

- 6 x Bait traps with a funnelled opening at each end were set close to emergent vegetation, submerged macrophytes and woody debris. Bait traps are a quick and easy method of sampling fish amongst woody debris, dense vegetation, steep banks and deep waters.

Fish were identified to species level, measured, weighed and released.

2.7 LIMITATIONS

All nets were deployed and left out only during the day to avoid capturing fauna overnight.

The monitoring plan required that the diversion channel between Town Creek and Bundewallah Creek be monitored. This was not undertaken as it does not provide aquatic habitat that allows monitoring in accordance with the monitoring plan and was generally dry during the monitoring sessions. It should be noted that at the time when the monitoring plan was prepared, the diversion was meant to replicate a natural creek with a sequence of pools and riffles. The design was subsequently changed to a concrete and rock lined channel which does not contain the necessary habitat for macroinvertebrates.

During surveys in June 2018, flash flooding caused by a sudden downpoor of rain, washed two fyke nets downstream. The nets were unable to be located that day due to the high water and flow rate after an extensive search of the area. One of the nets (Site 13 on Broughton Creek) was located during later surveys and recovered. The other net (Site 16 on Broughton Creek) has not been located.

During the November 2018 survey, turbitidy was not recorded as the handheld multiparameter water quality meter did not have turbidity included.

3 RESULTS AND DISCUSSION

The results of the 2018 monitoring have been compared with the results of the pre-construction and during construction surveys where available and where meaningful comparisons can be made (refer to Section 2.7 for limitations). Two pre-construction surveys were undertaken in Spring 2014, with no Autumn surveys undertaken (JSA 2016). This was due to a limited timeframe where monitoring was only possible in Spring 2014 (Parsons Brinkerhoff 2014). The following, therefore, compares the results of the 2014 preconstruction monitoring (Spring 2014), the 2015 (Spring and Autumn) monitoring, the 2016 (Spring and Autumn) monitoring, the 2017 (Spring and Autumn) monitoring, and the 2018 (Spring and Autumn) monitoring.

3.1 HABITAT ASSESSMENT

The following figures present the attributes of each site during each session. Photographs of each site are provided in Appendix C. Data from 2016 and 2017 for levels of disturbance and instream vegetation were collated for graphing. The most common categorical data recorded for level of disturbance across 2016 and 2017 surveys was used, where an average of Algae, Moss, and Macrophytes was used for the instream vegetation graphs.

Substrate levels of the six subject sites (Site 13, 16, 17, 22, 25, and 27) can be seen below in Figure 3-1. A trendline has been added to the substrate's "boulder", "cobble", "pebble", "gravel", and "silt". Cobble typically had the largest proportion across all sites and all survey periods. The overall trendline suggests a decreasing proportion of cobble overtime. Similarly, Silt had a decreasing trend overtime. In contrast, boulder, pebble, and gravel slightly increased in proportion overtime.

Substrate levels in the two upstream control sites (1 and 2) can be seen below in Figure 3-2. A trendline has been added to the substrate's "boulder", "cobble", "pebble", "gravel", and "silt". Similarly to the subject sites, cobble largely decreased in proportion over the survey periods. Important to note, data was only recorded for these sites between 2016 and 2018, where the subject sites also included 2014 and 2015 data. Boulder, gravel and silt slightly increased in proportion over time. Whereas pebble remained consistent over time.

Substrate proportions in upstream control sites varied slightly from the downstream subject sites, however, trendlines were similar. In cases where trendlines varied between upper and lower stream sites (pebble and silt), a possible explanation is that barriers and water catchment structures built during the installation of the bypass may be preventing some waterflow to downstream sites and therefore the potential substrates that may be dislodged during high flow events. The increase in certain substrates in our upstream control sites could potentially be originating from further upstream, however stop or reduce in velocity as they approach the bypass structure and therefore may not influence the lower stream subject sites in the same way.

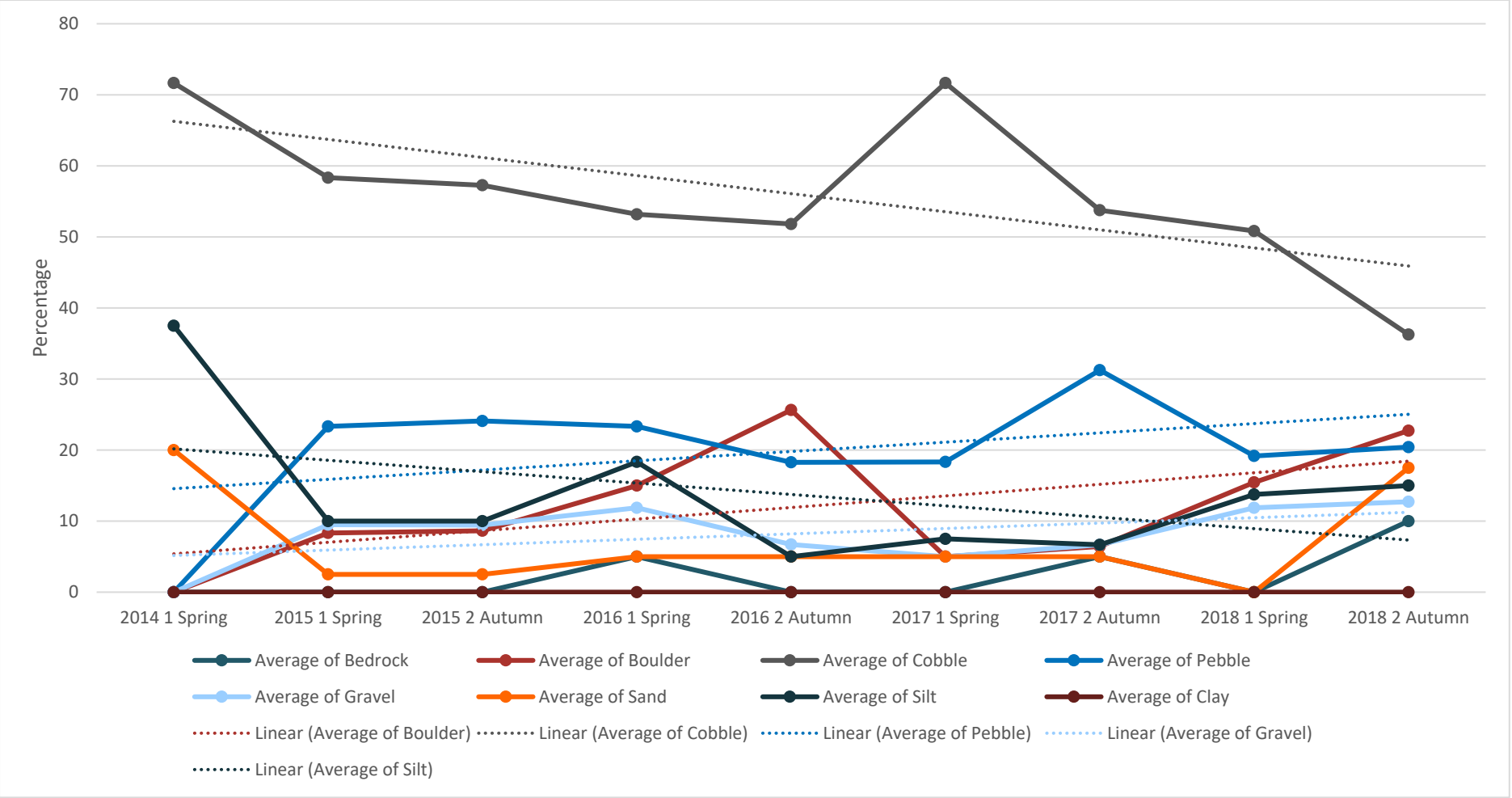

Figure 3-1 Substrate data of Sites 13, 16, 17, 22, 25, 27 between 2014 and 2018.

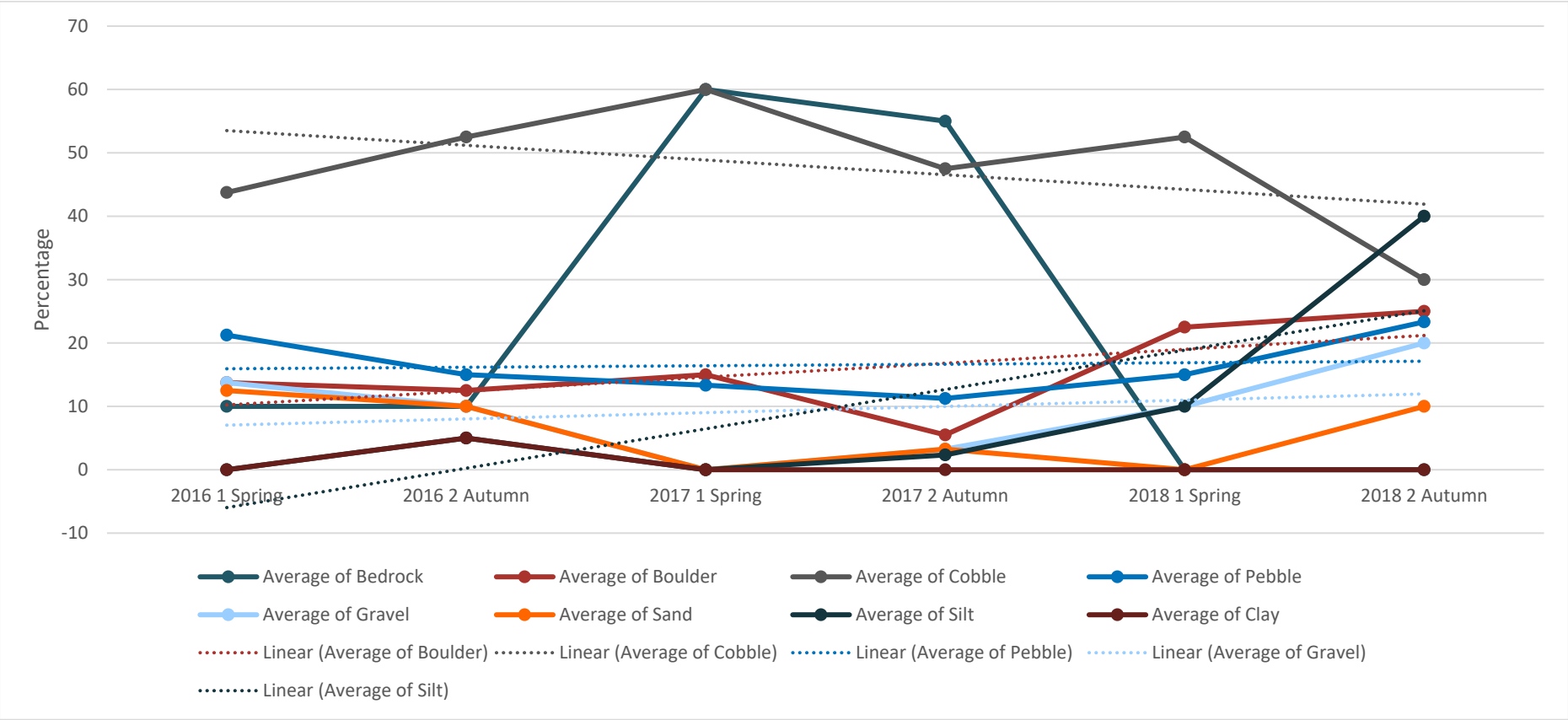

Figure 3-2 Substrate data of Control Sites 1 and 2 over survey period

Site13 – Broughton Creek

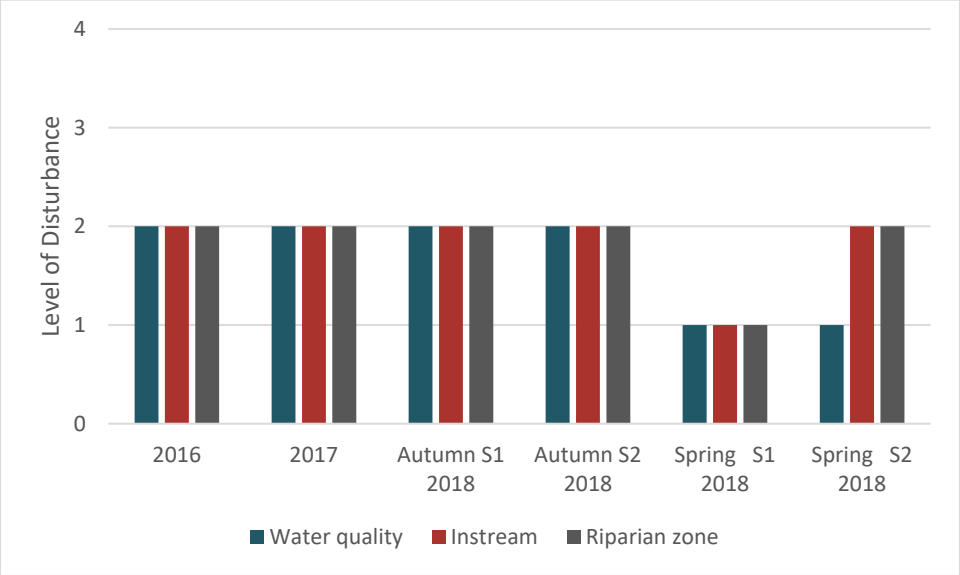

Figure 3-3 Site 13 Level of Disturbance (Water Quality, Instream, Riparian zone).

Level of disturbance 0 = no evidence of disturbance, 1= little disturbance, 2 = moderate disturbance, 3 = high disturbance, 4 = extreme disturbance

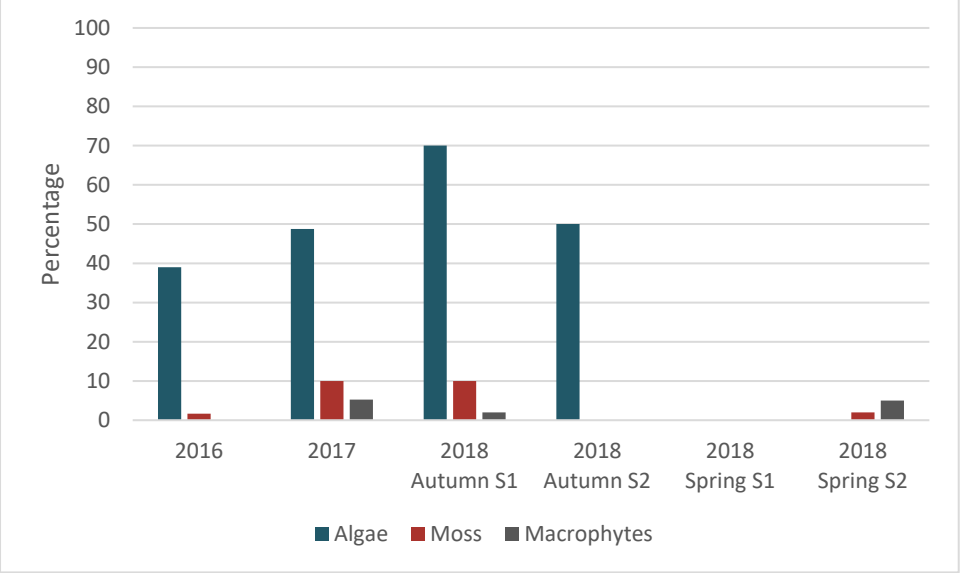

Figure 3-4 Site 13 Instream Vegetation (Algae, Moss, and Macrophytes) across sample sessions

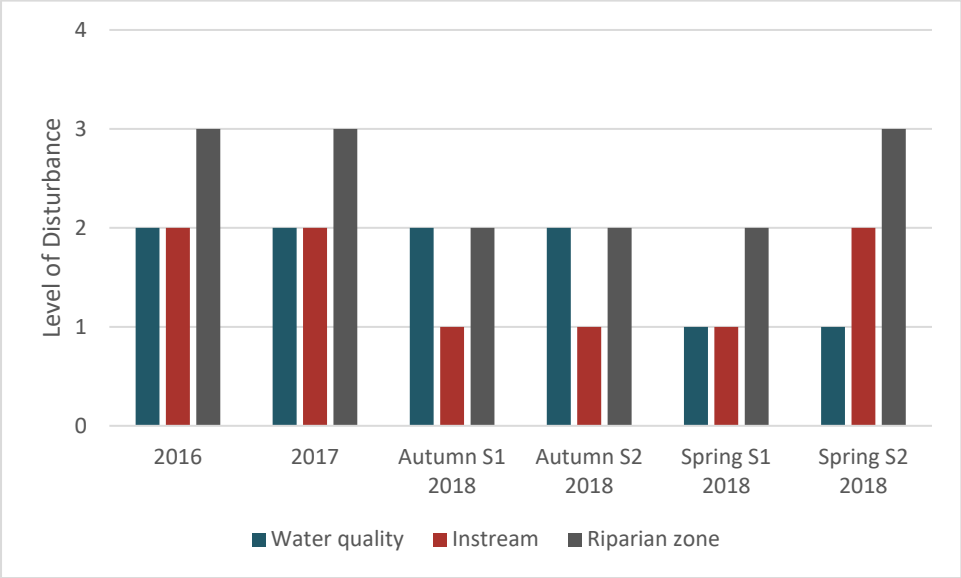

Figure 3-5 Site 16 Level of Disturbance (Water Quality, Instream, Riparian zone).

Level of disturbance 0 = no evidence of disturbance, 1= little disturbance, 2 = moderate disturbance, 3 = high disturbance, 4 = extreme disturbance

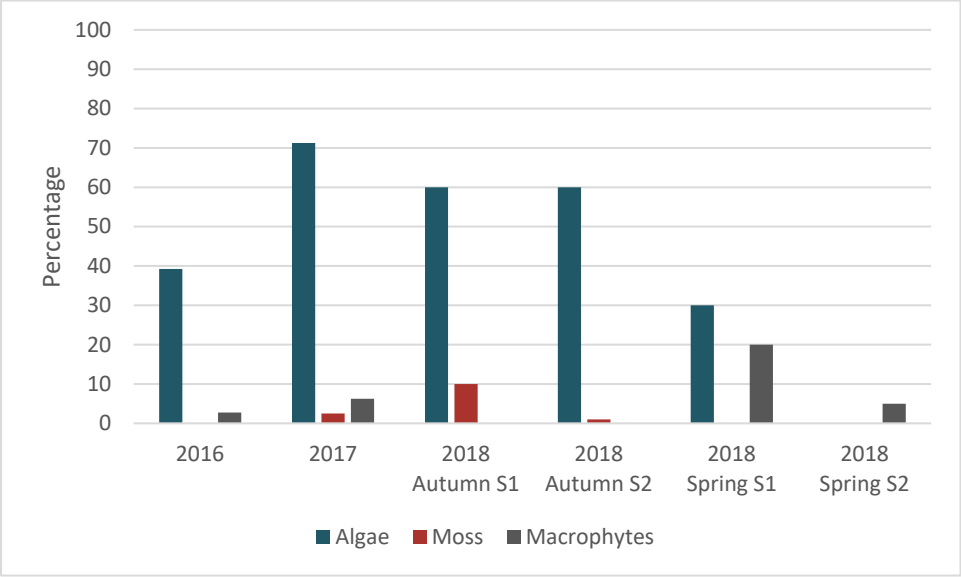

Figure 3-6 Site 16 Instream Vegetation (Algae, Moss, and Macrophytes) across sample sessions

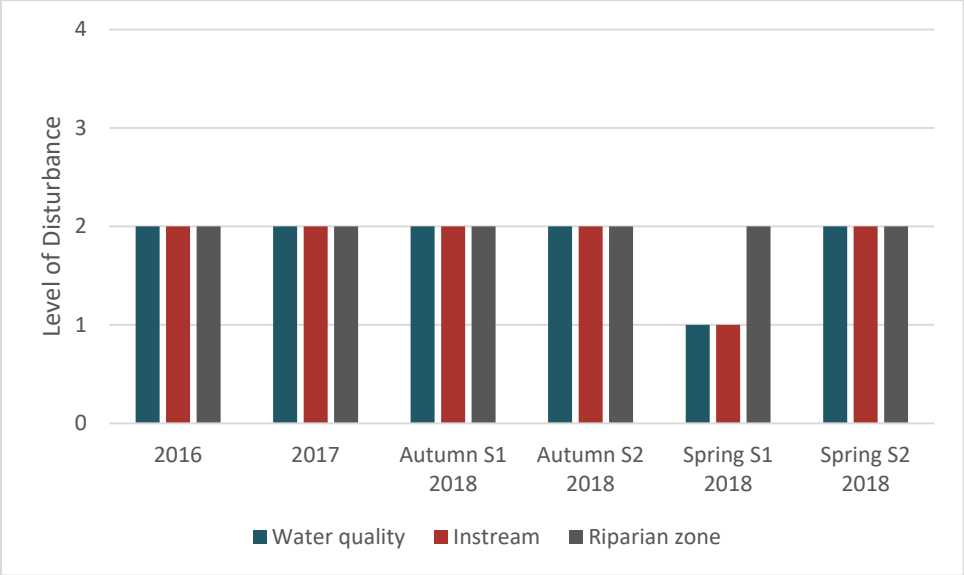

Figure 3-7 Site 17 Level of Disturbance (Water Quality, Instream, Riparian zone).

Level of disturbance 0 = no evidence of disturbance, 1= little disturbance, 2 = moderate disturbance, 3 = high disturbance, 4 = extreme disturbance

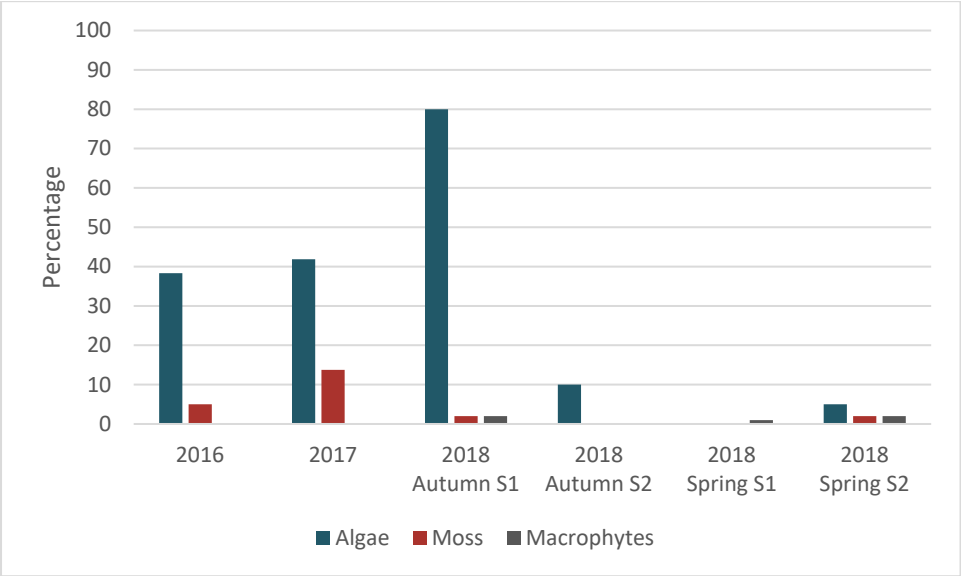

Figure 3-8 Site 17 Instream Vegetation (Algae, Moss, and Macrophytes) across sample sessions

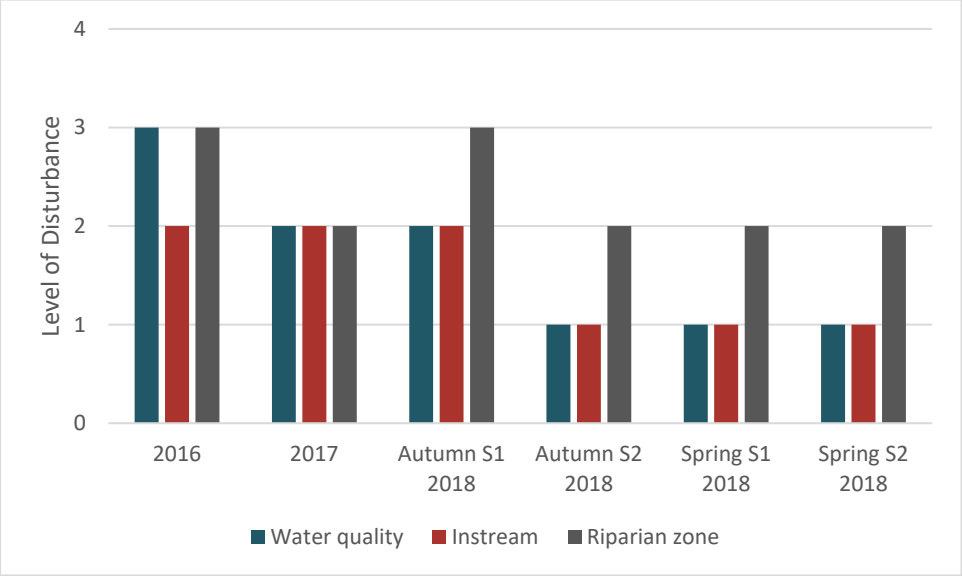

Figure 3-9 Site 22 Level of Disturbance (Water Quality, Instream, Riparian zone).

Level of disturbance 0 = no evidence of disturbance, 1= little disturbance, 2 = moderate disturbance, 3 = high disturbance, 4 = extreme disturbance

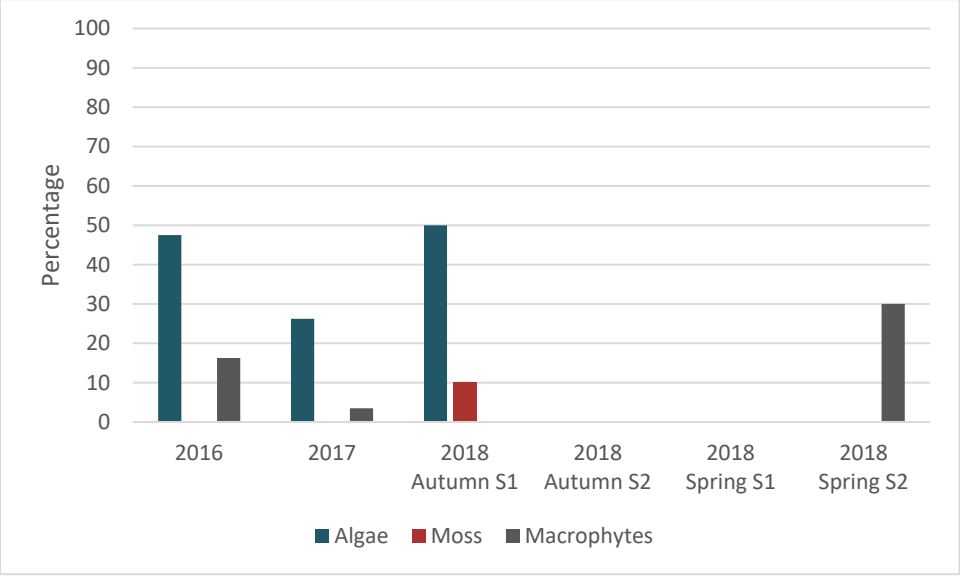

Figure 3-10 Site 22 Instream Vegetation (Algae, Moss, and Macrophytes) across sample sessions

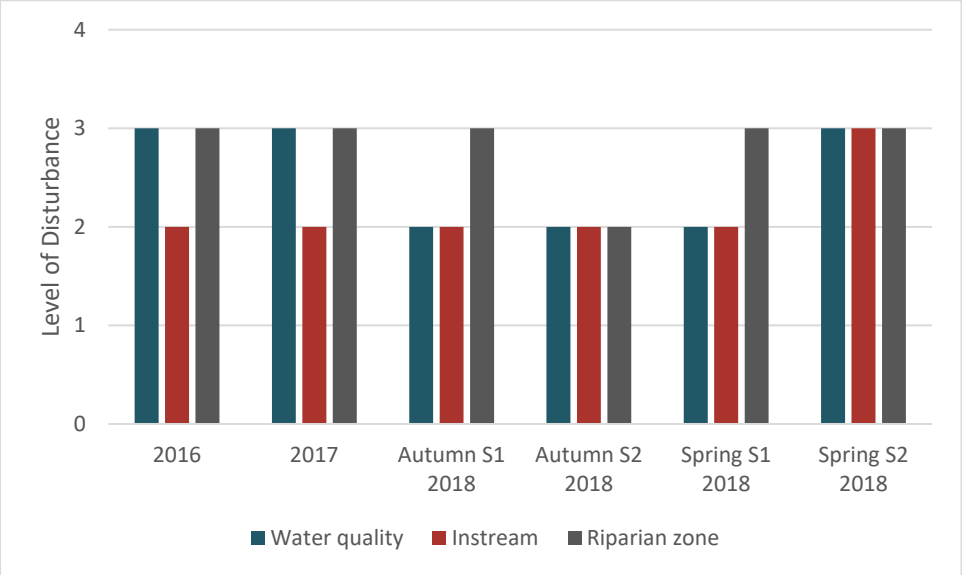

Figure 3-11 Site 25 Level of Disturbance (Water Quality, Instream, Riparian zone).

Level of disturbance 0 = no evidence of disturbance, 1= little disturbance, 2 = moderate disturbance, 3 = high disturbance, 4 = extreme disturbance

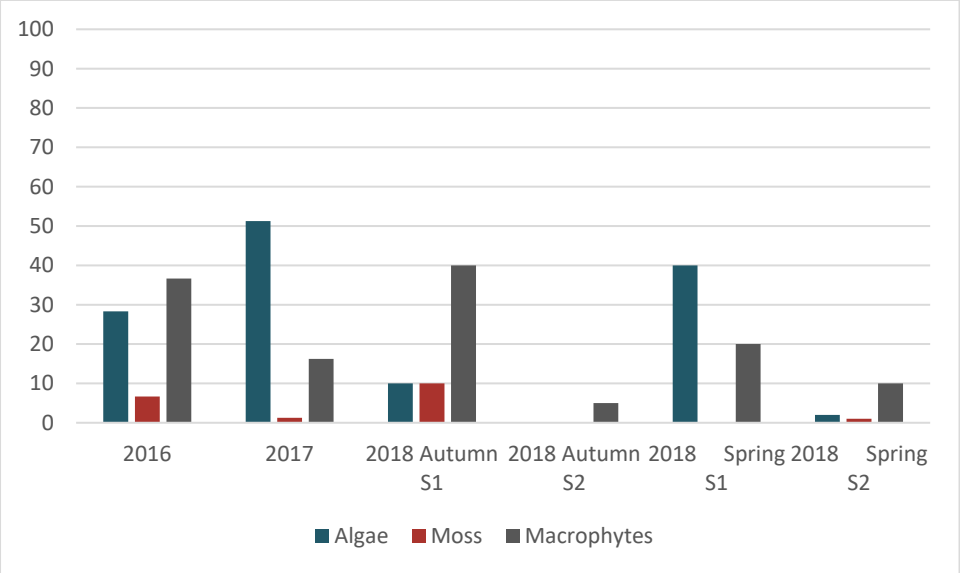

Figure 3-12 Site 25 Instream Vegetation (Algae, Moss, and Macrophytes) across sample sessions

Site 27 – Bundewallah Creek

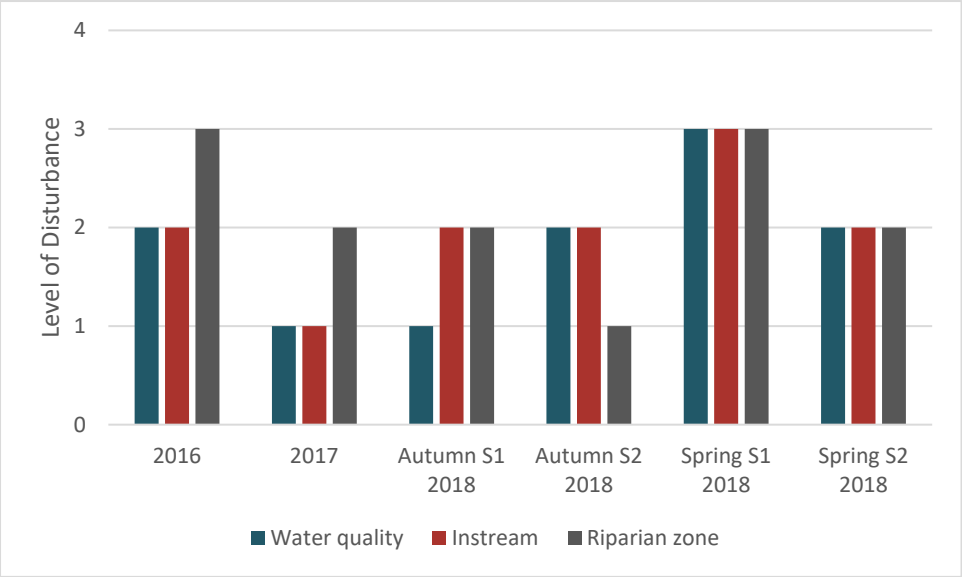

Figure 3-13 Site 27 Level of Disturbance (Water Quality, Instream, Riparian zone).

Level of disturbance 0 = no evidence of disturbance, 1= little disturbance, 2 = moderate disturbance, 3 = high disturbance, 4 = extreme disturbance

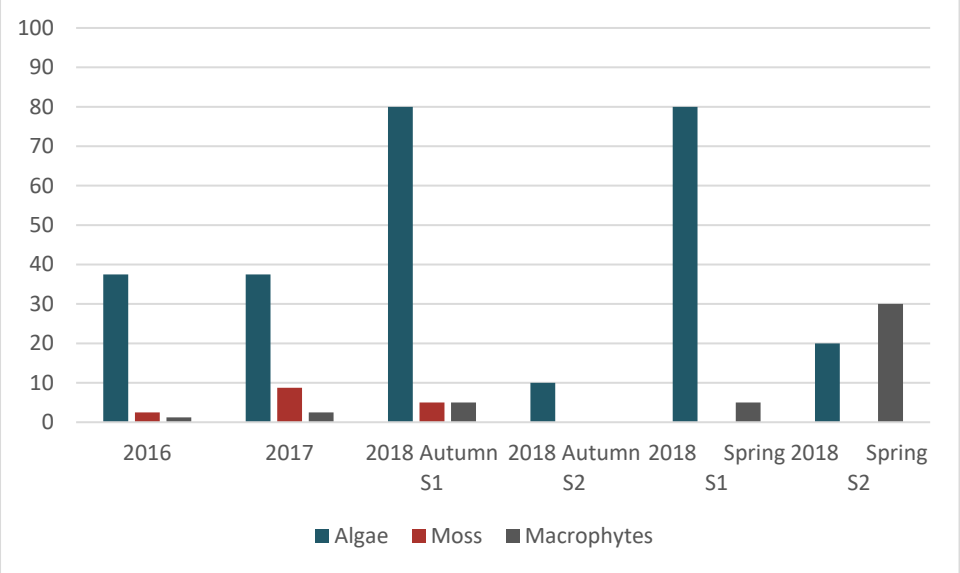

Figure 3-14 Site 27 Instream Vegetation (Algae, Moss, and Macrophytes) across sample sessions

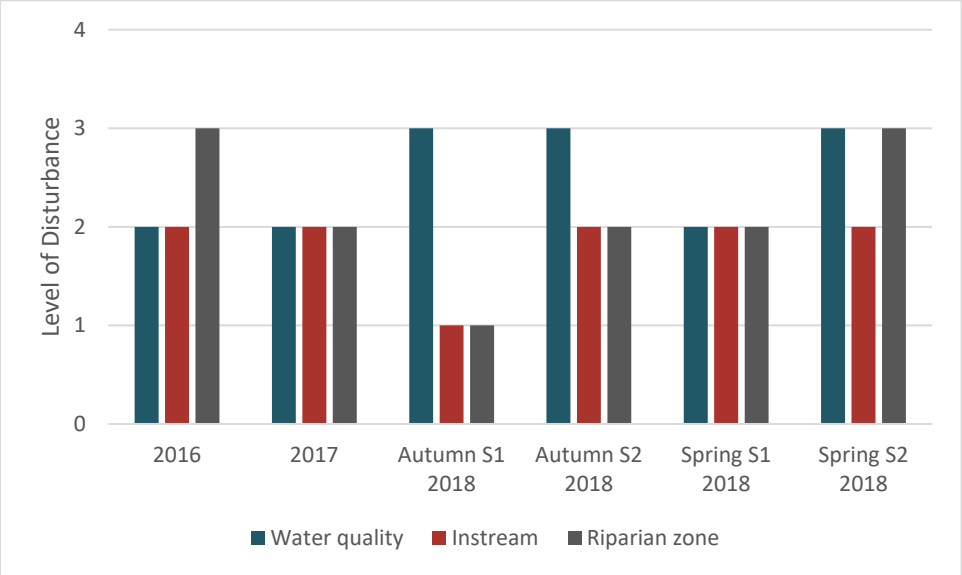

Figure 3-15 Control Site 1 Level of Disturbance (Water Quality, Instream, Riparian zone).

Level of disturbance 0 = no evidence of disturbance, 1= little disturbance, 2 = moderate disturbance, 3 = high disturbance, 4 = extreme disturbance

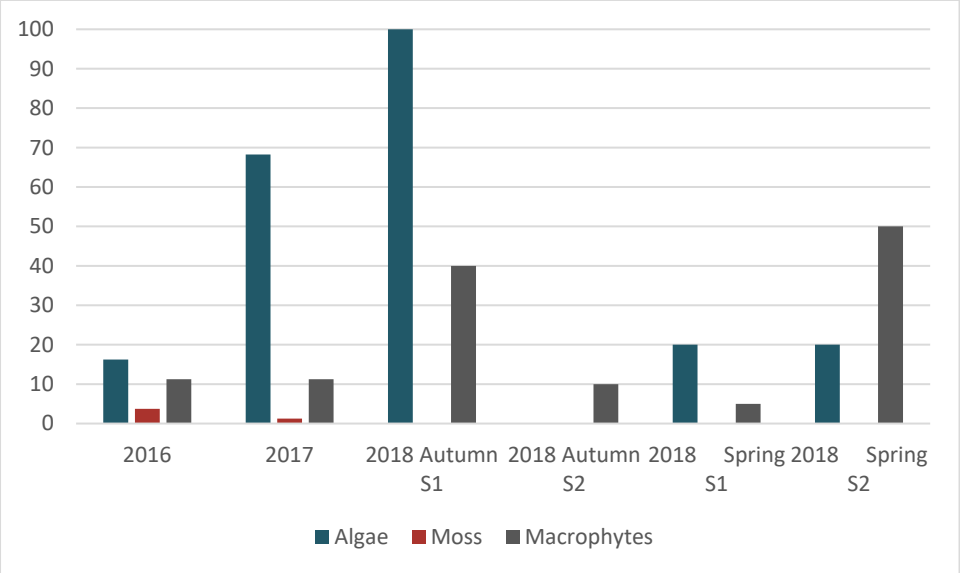

Figure 3-16 Control Site 1 Instream Vegetation (Algae, Moss, and Macrophytes) across sample sessions

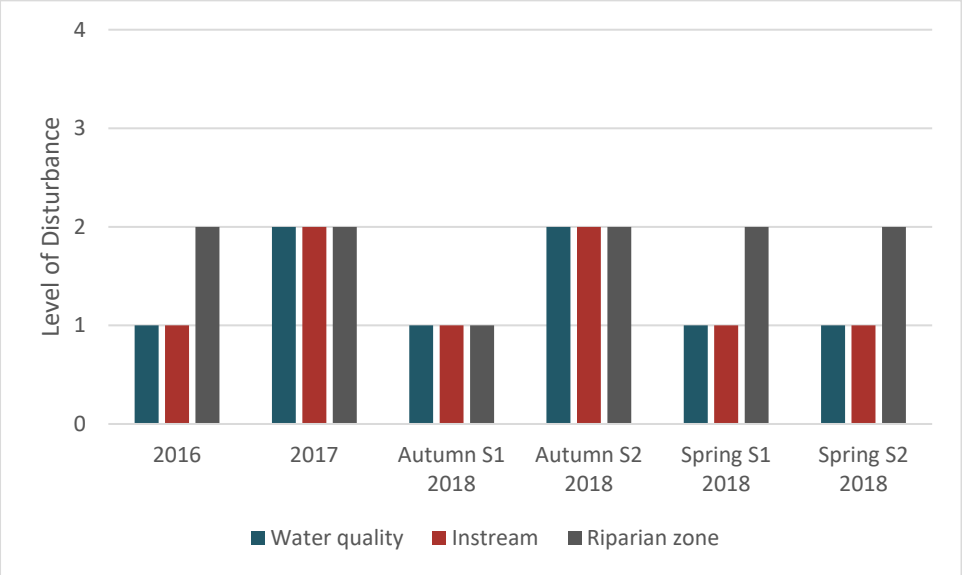

Figure 3-17 Control Site 2 Level of Disturbance (Water Quality, Instream, Riparian zone).

Level of disturbance 0 = no evidence of disturbance, 1= little disturbance, 2 = moderate disturbance, 3 = high disturbance, 4 = extreme disturbance

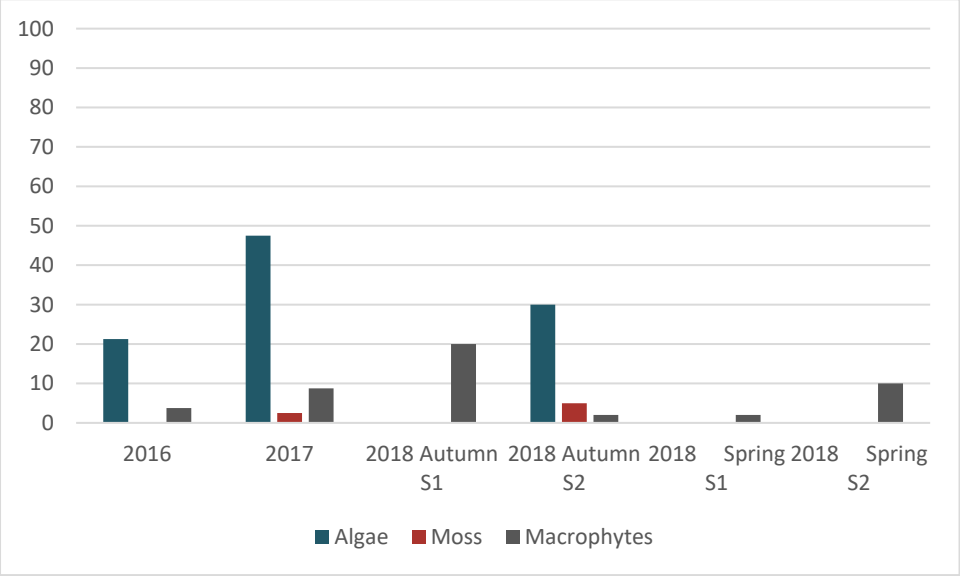

Figure 3-18 Control Site 2 Instream Vegetation (Algae, Moss, and Macrophytes) across sample sessions

All sites were considered to have moderate to low habitat values. This is due to historical clearing within riparian corridors and adjacent vegetation as well as ongoing agricultural land uses adjacent to waterways. Algae were present constantly, however generally decreased in most sites in 2018. This is an unexpected trend in Spring with an increase in sunlight and water temperatures, combined with low flow rates and high nutrient levels as a result of adjacent agricultural practices.

The following was observed during the 2018 monitoring habitat assessments:

- Water flow rates were typically low to moderate across all sites during the sampling sessions except for Autumn Session 2 where sampling occurred immediately after heavy rain (as stated in limitations).
- Most sites throughout the survey period maintained no oily film or foam present.
- Aquatic macrophytes were present at the majority of sites in low densities. In most cases there was an increase in macrophyte proportions in Spring which is expected due to the increases in nutrient load and sunlight during these months.
- All sites recorded the presence of exotic riparian vegetation. Typically occurring species included Lantana *Lantana camara*, Small-leaf Privet *Ligustrum sinense* and Wandering Jew *Tradescantia fluminensis*. Sites with previously identified exotic riparian areas remained at similar/consistent proportions into and during 2018.
- Detritus cover was generally lower in 2018 than in 2017 and 2016, except at sites 22 and 25 in Autumn 2018 where they were recorded at their highest proportion since Autumn 2017. This may have been due to seasonal variation.
- Rubbish was recorded as nil or low at all sites in 2018.
- Reduced water clarity and flow was observed frequently in 2018 similarly to what was observed in 2017.
- Site 22 had a similar level of riparian disturbance in 2018 to previous years, where a reduction in instream and water quality disturbance was observed.

3.2 WATER QUALITY

The following was observed during the 2018 monitoring period (with all results in Table 3-1 below):

- Water temperatures recorded at the sites were between 11.8^{o}C and 22.7^{o}C and varied according to the season and the conditions of the waterway. This variation was consistent throughout the pre-construction and construction period.
- pH readings in 2018 were variable ranging between 5.25 and 7.84 across all sites and survey sessions. Soil and animal health will not generally be affected by water with pH in the range of 4-9, however values between 4 and 6 should be regarded with caution due to the potential for corrosion and fouling (ANZECC/ARMCANZ 2000). Levels below 6 were seen at all sites excluding site 17 (ph 6.09), all of which occurred during Autumn 2018 Session 2. As mentioned in the limitations, sampling during this time occurred immediately after heavy rainfall which most likely skewed the results. pH values fell within the ANZECC/ARMCANZ 2000 guidelines trigger value range 50% of the time during the 2018 surveys.
- Conductivity had the lowest proportion of values fall within the guideline levels (12.5% of 2018 results). Most of the readings had low conductivity. Low conductivity values are often observed following seasonal rainfall (ANZECC/ARMCANZ 2000), while high conductivity is an indication of low flow conditions. High conductivity is not uncommon in agricultural areas due to factors such as gradual runoff from cultivated land, and stock faeces and urine (Biggs *et al.* 2002).
- Of the data recorded for turbidity levels in 2018, 33.33% fell within the guidelines. Important to note, eight (8) values were missing from this data set due to complications with equipment in Spring Session 2 2018, as stated in the limitations. Only two values from 2018 were recorded at higher levels than the upper limit of the guidelines (Control site 2 and Site 13 both in Autumn Session 2), with the rest falling below.
- The percent saturation of dissolved oxygen was lower than ANZECC/ARMCANZ guidelines 75% of the time across all sites in 2018, as well as control sites. Only site 27 lacked a result within the guidelines. Control site 1 had two readings of four fall within the guidelines, the highest proportion of any site. The low flow conditions and pooling of water would lower the dissolved oxygen which would result in potentially stressful conditions for some species, but due to consistency throughout the monitoring period this is unlikely to be attributed to construction activities.

Table 3-1 2018 Water quality results across sites 13, 16, 17, 22, 25, 27 and Control sites 1 and 2.

*Note: Trigger values are concentrations that, if exceeded, would indicate a potential environmental problem, and so 'trigger' a management response (ANZECC/ARMCANZ Guidelines 2000). Green cells indicate results that are within the ANZECC/ARMCANZ trigger value range, where red cells are those results that have fallen outside the trigger value range and indicate a *potential* environmental problem. The results below were recorded within a previously disturbed and degraded system which accounts for the prevalence red cells. There were no significant variations at sites post-construction (see Figure 3-19 below).

Site	Timing	Session 1	Temperature oC	pH	Conductivity ms/cm	Turbidity NTU	Dissolved oxygen % saturation
ANZECC/AR MCANZZ Trigger value				**6.5-8**	**200-300**	**6-504**	**85-110%**
Control site 1	Autumn 2018	Session 1	16.9	6.71	125.1	19.6	68.73
Control site 1	Autumn 2018	Session 2	12.7	5.47	31.5	34.7	89.05
Control site 1	Spring 2018	Session 1	12.4	7.33	110.6	16.4	60.37
Control site 1	Spring 2018	Session 2	21.9	7.38	106.9	NA	98.3
Control site 2	Autumn 2018	Session 1	17.2	6.39	148.2	1.4	28.77
Control site 2	Autumn 2018	Session 2	11.8	5.9	45	99.6	93.91
Control site 2	Spring 2018	Session 1	14.8	7.51	118	1.2	57.24
Control site 2	Spring 2018	Session 2	21	7.51	127.4	NA	93.3
Site 13	Autumn 2018	Session 1	16.6	7	148.4	2.2	80.2
Site 13	Autumn 2018	Session 2	14.8	5.24	25.7	141.6	89.71
Site 13	Spring 2018	Session 1	12.4	7.59	112.7	0.6	53.45
Site 13	Spring 2018	Session 2	21.1	7.26	130.1	NA	82
Site 16	Autumn 2018	Session 1	16.9	6.35	159.7	5.5	67.29
Site 16	Autumn 2018	Session 2	12.7	5.46	71.7	1.4	97.06
Site 16	Spring 2018	Session 1	12.9	7.67	115.7	2.7	53.77

Site	Timing	Session 1	Temperature oC	pH	Conductivity ms/cm	Turbidity NTU	Dissolved oxygen % saturation
ANZECC/AR MCANZZ Trigger value				**6.5-8**	**200-300**	**6-504**	**85-110%**
Site 16	Spring 2018	Session 2	20.7	7.84	137	NA	80
Site 17	Autumn 2018	Session 1	17.2	6.68	151.7	1.4	80.69
Site 17	Autumn 2018	Session 2	12.5	6.09	63.6	32	96.53
Site 17	Spring 2018	Session 1	14.3	7.64	125.7	0.5	58.87
Site 17	Spring 2018	Session 2	19.9	7.31	132.3	NA	78
Site 22	Autumn 2018	Session 1	16.2	6.55	251.8	5	30.61
Site 22	Autumn 2018	Session 2	14.3	5.36	1.1	8.5	86.11
Site 22	Spring 2018	Session 1	14	7.73	356.7	11.1	61.01
Site 22	Spring 2018	Session 2	22.7	6.71	216.3	NA	50.3
Site 25	Autumn 2018	Session 1	17.8	6.37	119.3	1.5	43.95
Site 25	Autumn 2018	Session 2	12.4	5.52	58.5	10.3	86.21
Site 25	Spring 2018	Session 1	14.3	7.17	124.1	2.2	61.99
Site 25	Spring 2018	Session 2	22.2	6.3	112.6	NA	84.2
Site 27	Autumn 2018	Session 1	19.2	6.03	241.3	0.5	41.22
Site 27	Autumn 2018	Session 2	13.6	5.74	112	22	44.61
Site 27	Spring 2018	Session 1	13.6	6.32	163.4	0.9	63.07
Site 27	Spring 2018	Session 2	19.7	6.19	214.4	NA	65.2

Table 3-2 Water quality comparison of treatment sites between pre-construction and post-construction

Site	*Water Quality Parameters*	2014 pre construction average	2014 pre-construction average plus (+)10%	2014 pre-construction average minus(-)10%	2018 post construction average	Pass/Fail
Site 13	Temperature °C	16.225	17.8475	14.6025	16.85	Pass
	pH	6.7725	7.44975	6.09525	7.055	Pass
	Conductivity µs/cm	104.225	114.6475	93.8025	113.5	Pass
	Turbidity NTU	48.13333333	52.9466667	43.32	15	Pass
	Dissolved oxygen % saturation	76.34	83.974	68.706	69.75	Pass
Site 16	Temperature °C	15.8	17.38	14.22	18.1	Fail
	pH	6.83	7.513	6.147	5.935	Fail
	Conductivity µs/cm	121.025	133.1275	108.9225	96.5	Pass
	Turbidity NTU	3.2	3.52	2.88	17.85	Fail
	Dissolved oxygen % saturation	74.53	81.983	67.077	80.75	Pass
Site 17	Temperature °C	15.975	17.5725	14.3775	16.205	Pass
	pH	6.93	7.623	6.237	6.1	Fail
	Conductivity µs/cm	118.325	130.1575	106.4925	118	OK
	Turbidity NTU	11.3	12.43	10.17	18.6	Fail
	Dissolved oxygen % saturation	78.5225	86.37475	70.67025	64.8	Fail
Site 22	Temperature °C	16.8	18.48	15.12	18.05	Pass
	pH	6.5875	7.24625	5.92875	5.045	Fail
	Conductivity µs/cm	206.475	227.1225	185.8275	127	Pass
	Turbidity NTU	8.2	9.02	7.38	36.25	Fail
	Dissolved oxygen % saturation	57.0075	62.70825	51.30675	89.7	Pass
Site 25	Temperature °C	16.675	18.3425	15.0075	15.9	Pass
	pH	6.34	6.974	5.706	5.75	Pass
	Conductivity µs/cm	103.625	113.9875	93.2625	123.5	Fail

Site	*Water Quality Parameters*	2014 pre construction average	2014 pre-construction average plus (+)10%	2014 pre-construction average minus(-)10%	2018 post construction average	Pass/Fail
	Turbidity NTU	4.666666667	5.13333333	4.2	40.2	Fail
	Dissolved oxygen % saturation	69.0875	75.99625	62.17875	58.75	Fail
Site 27	Temperature ^{o}C	16.525	18.1775	14.8725	16.5	Pass
	pH	6.07	6.677	5.463	5	Fail
	Conductivity µs/cm	182.775	201.0525	164.4975	124.5	Pass
	Turbidity NTU	7.8	8.58	7.02	18.2	Fail
	Dissolved oxygen % saturation	53.525	58.8775	48.1725	57.25	Pass

Table 3-2 above shows the comparison of water quality parameters between pre construction (2014) data and current post construction data (2018). Columns for +/- 10% as well as a pass/fail column have been included to address the performance target criteria . This is discussed further in Table 3-21.

Table 3-3 Water quality comparison of control sites between during construction and post-construction

		During Construction average (2016-2017)	During Construction average (2016-2017) Plus (+) 10%	During Construction average (2016-2017) Minus (-) 10%	2018 Post construction average	Pass/Fail
Control site 1	Temperature oC	16.56875	14.911875	18.225625	15.975	PASS
	pH	6.8625	6.17625	7.54875	6.7225	PASS
	Conductivity ms/cm	142.875	128.5875	157.1625	93.525	PASS
	Turbidity NTU	2.875	2.5875	3.1625	23.56666667	FAIL
	Dissolved oxygen % saturation	65.72625	59.153625	72.298875	79.1125	FAIL
Control site 2	Temperature oC	17.415	15.6735	19.1565	16.2	PASS
	pH	6.786666667	6.108	7.465333333	6.8275	PASS
	Conductivity ms/cm	151.8333333	136.65	167.0166667	109.65	PASS
	Turbidity NTU	0.683333333	0.615	0.751666667	34.06666667	FAIL
	Dissolved oxygen % saturation	59.26166667	53.3355	65.18783333	68.31	FAIL

Table 3-3 above shows the comparison of water quality parameters of the control sites between during construction (2016 and 2017) and post-construction data (2018). Columns for +/- 10% as well as a pass/fail column have been included to address the performance target and criteria. This is discussed further in Table 3-21.

Trendlines of each water quality parameter across all years of survey are presented in the figures below. There is a slight increase in both water temperature and pH over time with very similar trends at both the subject sites and the control sites (Figure 3-19 and Figure 3-20). Dissolved Oxygen (Figure 3-21) is seen to decrease overtime at both the subject sites and the control sites. Conductivity (Figure 3-22) is seen to increase over time at subject sites however has decreased at the control sites. There is a very slight upward trend in Turbidity (Figure 3-23) at the subject sites, and downward trend at the control sites. This trend could be potentially explained by the Bypass acting as a large catchment of rain water where runoff flows downstream toward the treatment sites.

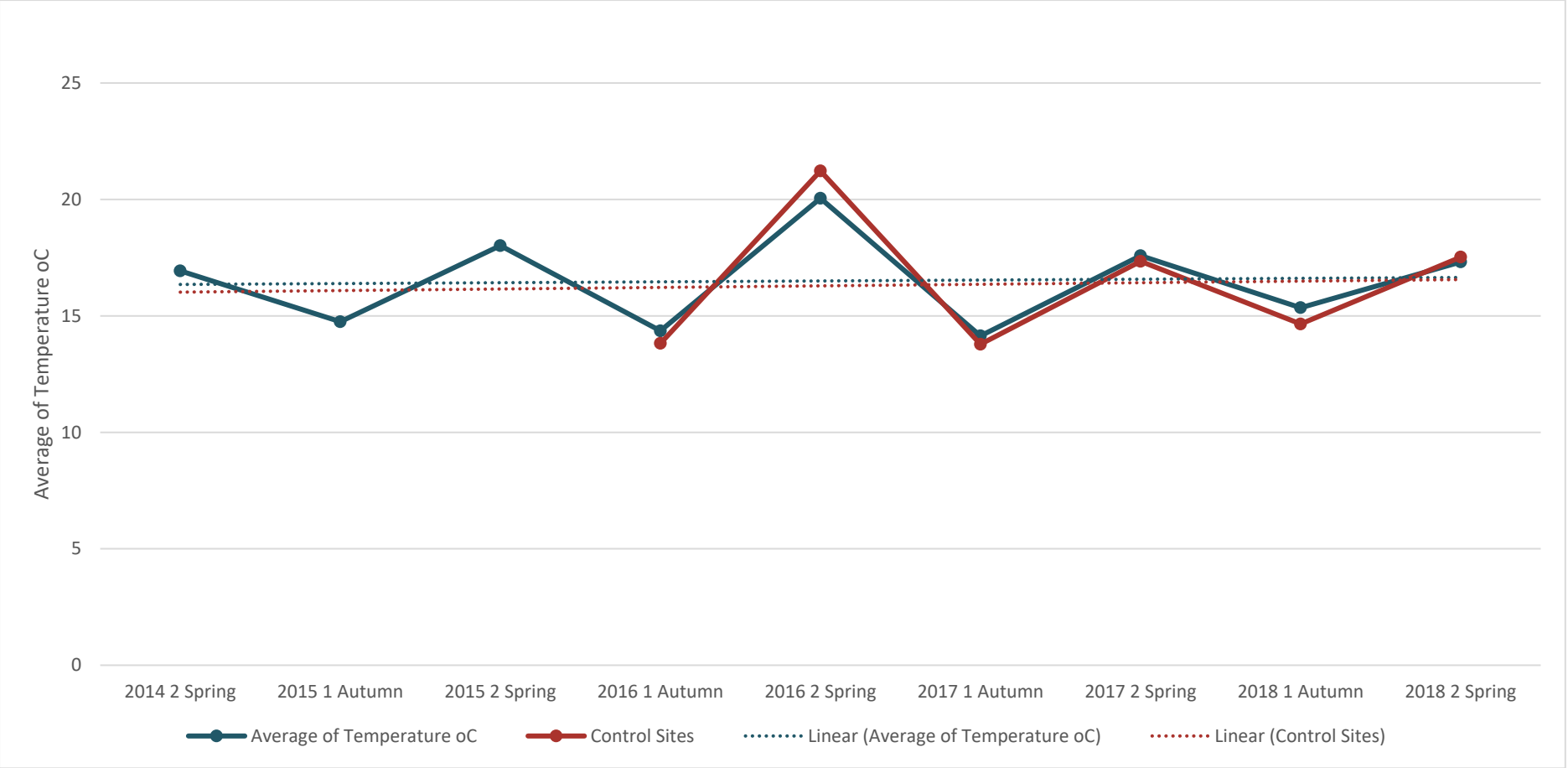

Figure 3-19 Water temperature across sites 13, 16, 17, 22, 25, 27, and control sites 1 and 2 over 2016, 2017, and 2018 sampling season

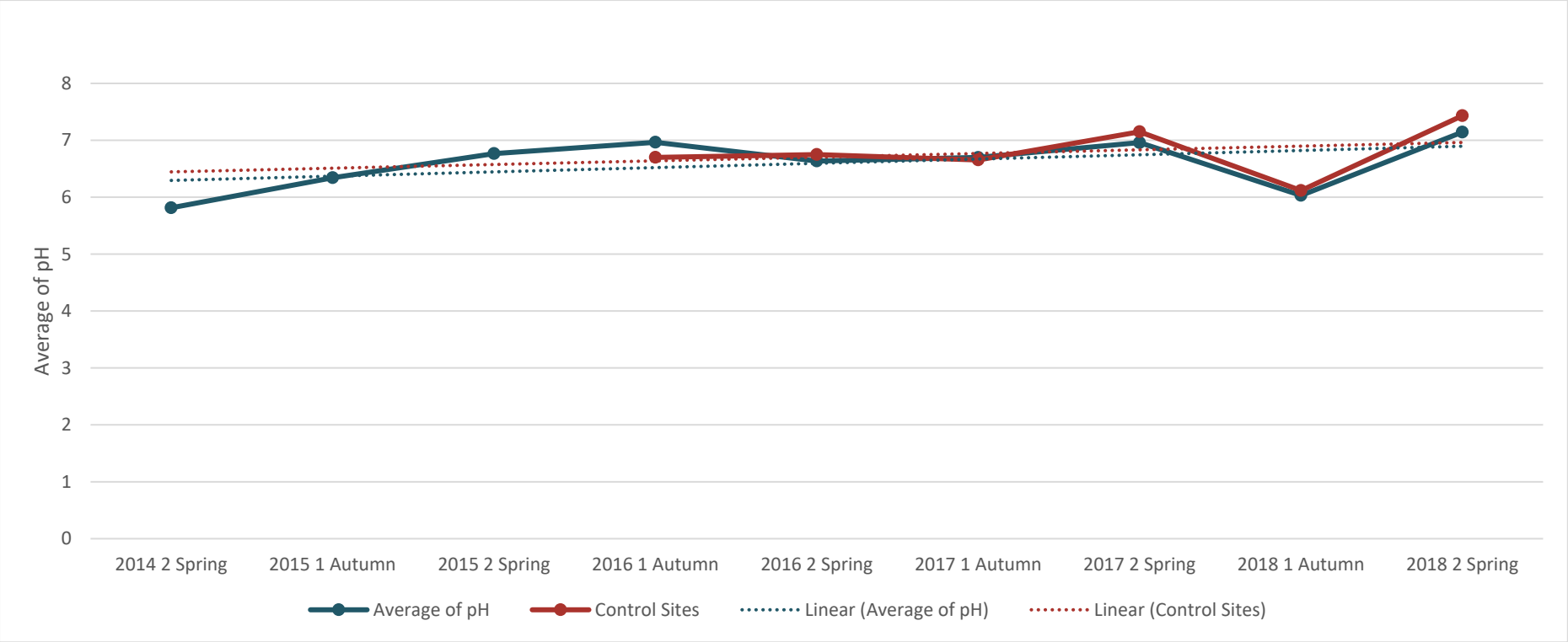

Figure 3-20 pH across sites 13, 16, 17, 22, 25, 27, and control sites 1 and 2 over 2016, 2017, and 2018 sampling season

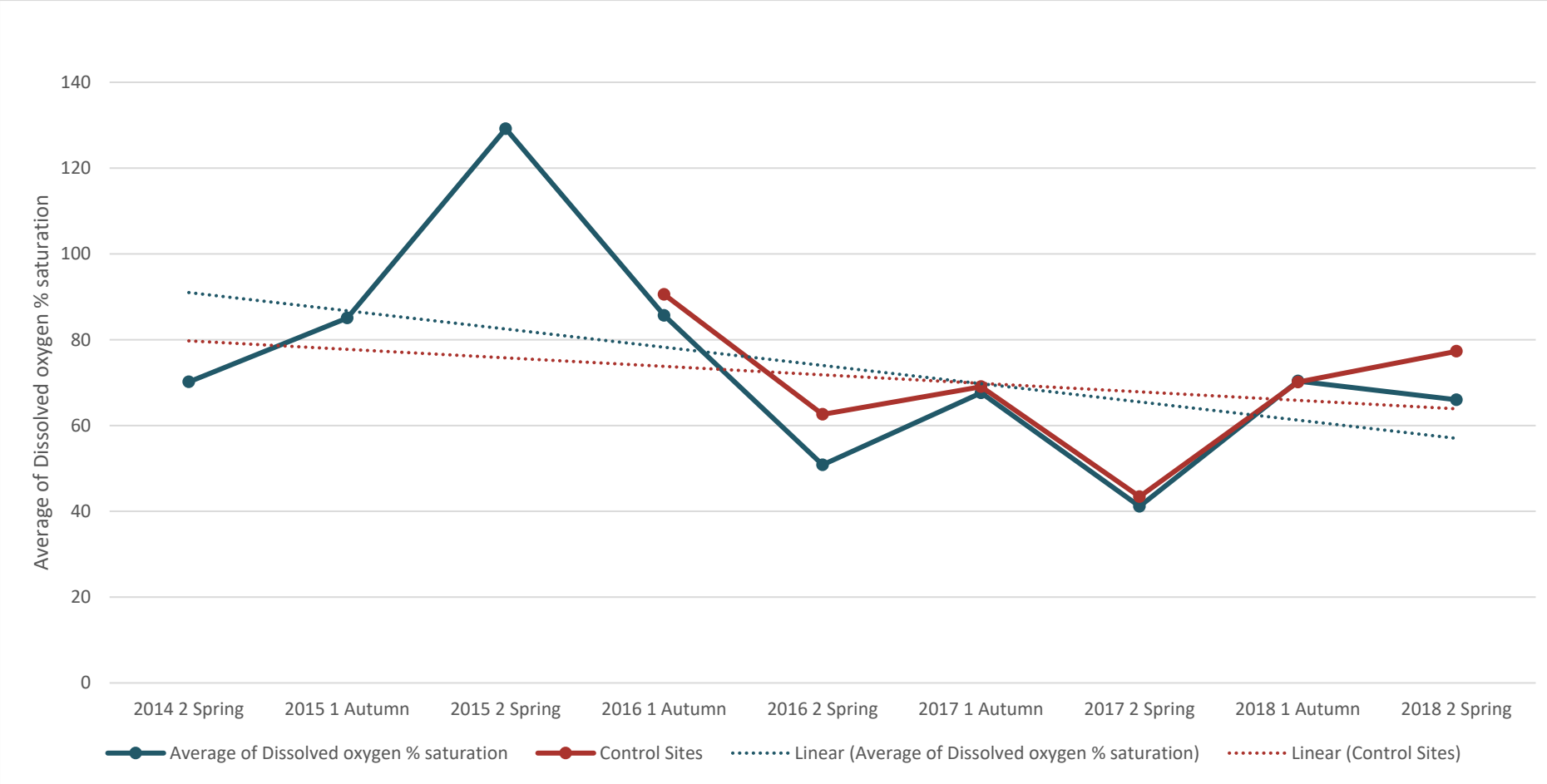

Figure 3-21 Dissolved Oxygen (%) across sites 13, 16, 17, 22, 25, 27, and control sites 1 and 2 over 2016, 2017, and 2018 sampling season

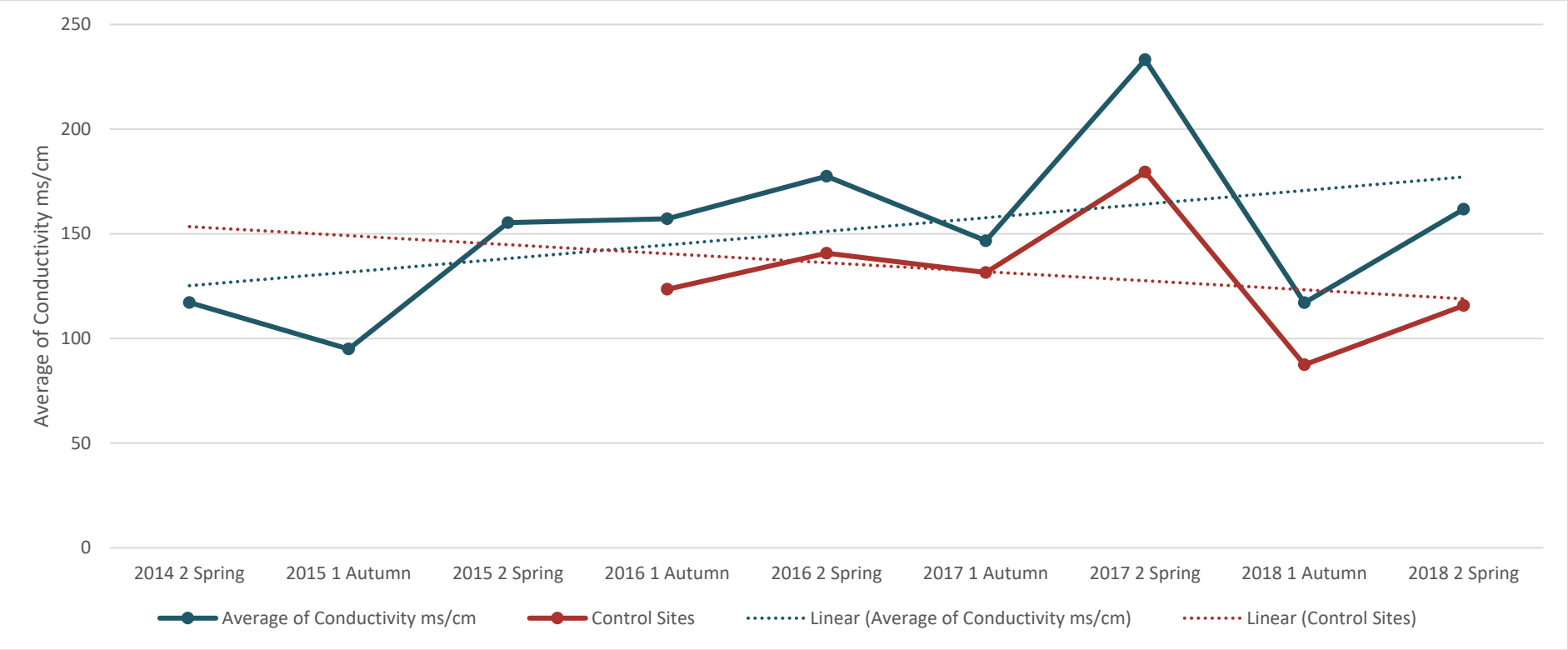

Figure 3-22 Conductivity (NTU) across sites 13, 16, 17, 22, 25, 27, and control sites 1 and 2 over 2016, 2017, and 2018 sampling season

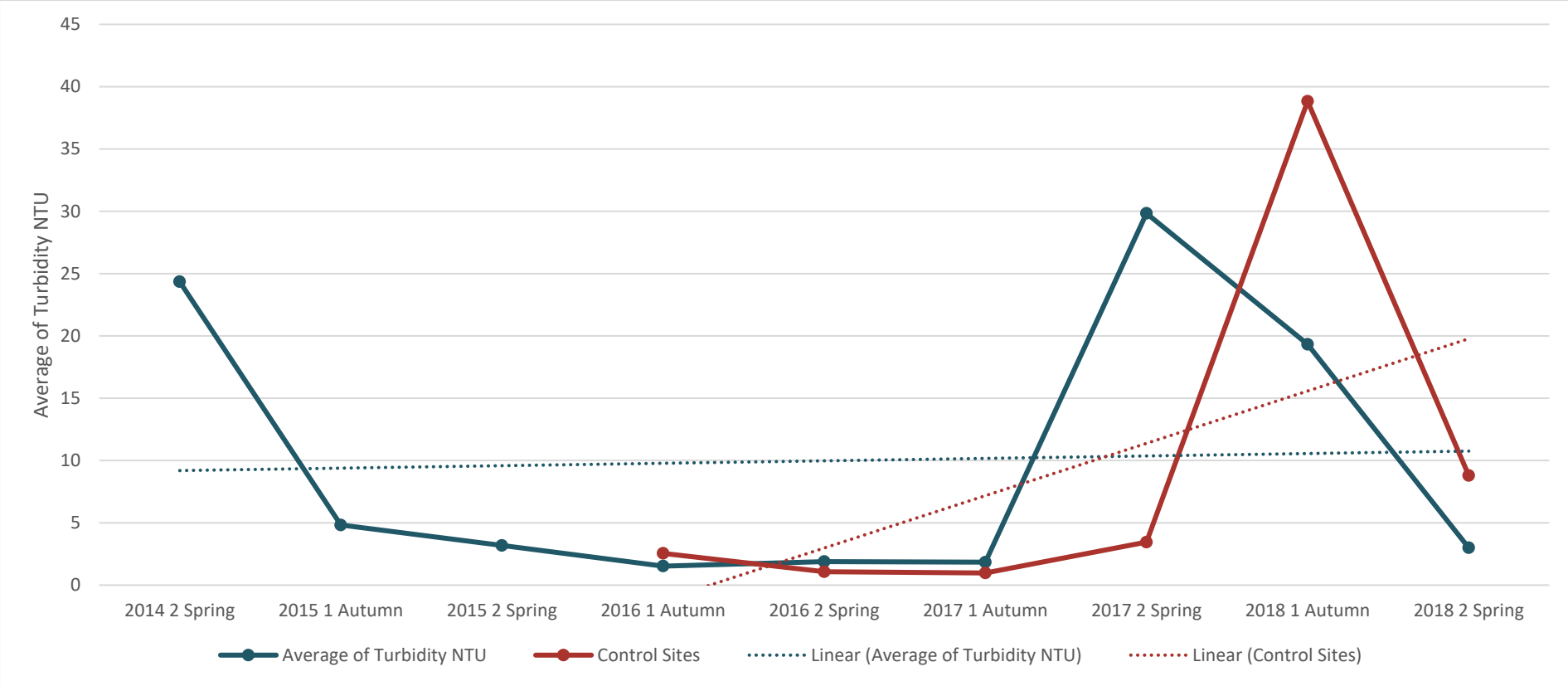

Figure 3-23 Turbidity across sites 13, 16, 17, 22, 25, 27, and control sites 1 and 2 over 2016, 2017, and 2018 sampling season

3.3 MACROPHYTE AND EMERGENT VEGETATION

The following presents the macrophyte and emergent vegetation data of each site during each session as collected within the fixed quadrats (Appendix B).

Table 3-4 Site 13 Broughton Creek macrophyte and emergent vegetation abundances according to Braun-Blanquet 6-point scale (refer to Section 2.4).

Site13 – Broughton Creek												
	Autumn 2016		Spring 2016		Autumn 2017		Spring 2017		Autumn 2018		Spring 2018	
Species	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance
Ottelia ovalifolia Swamp lily								1				
*Sagittaria platyphylla** Sagittaria								1				
*Colocasia sp.** Elephants ear												
Lemna disperma Duckweed	1		1	2		1	1					
*Altenanthera philoxeroides** Aligator weed									2			
**Cyperus eragrostis* Umbrella Sedge												2
Juncus usitatus Common rush												2

*Exotic

Table 3-5 Site 16 – Broughton Creek macrophyte and emergent vegetation abundances according to Braun-Blanquet 6-point scale (refer to Section 2.4).

Site 16 – Broughton Creek												
	Autumn 2016		**Spring 2016**		**Autumn 2017**		**Spring 2017**		**Autumn 2018**		**Spring 2018**	
Species	**Session 1 Abundance**	**Session 2 Abundance**	**Session 1 Abundance**	**Session 2 Abundance**	**Session 1 Abundance**	**Session 2 Abundance**	**Session 1 Abundance**	**Session 2 Abundance**	**Session 1 Abundance**	**Session 2 Abundance**	**Session 1 Abundance**	**Session 2 Abundance**
Persicaria hydropiper Water pepper												
Lemna disperma Duckweed		1										
*Sagittaria platyphylla** Sagittaria	1	1	1	2	2	1	1	1				
*Colocasia sp.** Elephants ear	1	1	1	1	1	1	1	1				
Damasonium minus Starfruit	1	1										
**Rorippa nasturtium-aquaticum* Watercress						1	1	1				
Juncus usitatus Common rush											3	2
**Cyperus eragrostis* Umbrella Sedge												2

*Exotic

Table 3-6 Site 17 – Broughton Creek macrophyte and emergent vegetation abundances according to Braun-Blanquet 6-point scale (refer to Section 2.4).

Site 17 – Broughton Creek												
	Autumn 2016		**Spring 2016**		**Autumn 2017**		**Spring 2017**		**Autumn 2018**		**Spring 2018**	
Species	**Session 1 Abundance**	**Session 2 Abundance**	**Session 1 Abundance**	**Session 2 Abundance**	**Session 1 Abundance**	**Session 2 Abundance**	**Session 1 Abundance**	**Session 2 Abundance**	**Session 1 Abundance**	**Session 2 Abundance**	**Session 1 Abundance**	**Session 2 Abundance**
Lemna disperma Duckweed			2	3		2						
Juncus usitatus Common rush							1	1				1
Maidenia rubra Maidenia	1		1	2		1		1				
*Sagittaria platyphylla** Sagittaria									2			1
*Colocasia sp.** Elephants ear											1	1
**Myriophyllum aquaticum* Parrots feather											1	
**Cyperus eragrostis* Umbrella Sedge												1

*Exotic

Table 3-7 Site 22 – Bundewallah Creek macrophyte and emergent vegetation abundances according to Braun-Blanquet 6-point scale (refer to Section 2.4).

Site 22 – Bundewallah Creek												
	Autumn 2016		Spring 2016		Autumn 2017		Spring 2017		Autumn 2018		Spring 2018	
Species	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance
Persicaria hydropiper Water pepper												
Lemna disperma Duckweed	2	1	2	1		3	1					
Ludwigia peploides Water primrose												
*Rorippa palustris** Marsh watercress		1										
Eleocharis acuta Common Spike Rush												
Vallisenaria australis Ribbonweed		1	1	3	1	1	1					
*Nasturtium officinale** Watercress												
Maidenia	1		1	1		1						

Site 22 – Bundewallah Creek												
	Autumn 2016		Spring 2016		Autumn 2017		Spring 2017		Autumn 2018		Spring 2018	
Species	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance
rubra Maidenia												
**Cyperus eragrostis* Umbrella Sedge												4

*Exotic

Table 3-8 Site 25 – Broughton Mill Creek macrophyte and emergent vegetation abundances according to Braun-Blanquet 6-point scale (refer to Section 2.4).

Site 25 – Broughton Mill Creek												
	Autumn 2016		Spring 2016		Autumn 2017		Spring 2017		Autumn 2018		Spring 2018	
Species	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance
Ottelia ovalifolia Swamp lily	2	3	2	3	3	2	3	2				
*Sagittaria platyphylla** Sagittaria			2	3	3	3	3	3		3	3	2
*Glyceria maxima** Reed sweetgrass												
Potamogeton crispus Curly Pond Weed	3											
**Elodea canadensis* Elodea	3	2	3	5	4	4	2	2		2	2	3
Vallisenaria australis Ribbonweed			3	2	2	2	2	1				
*Altenanthera philoxerioudes** Aligator weed									2			

*Exotic

Table 3-9 Site 27 – Bundewallah Creek macrophyte and emergent vegetation abundances according to Braun-Blanquet 6-point scale (refer to Section 2.4).

Site 27 – Bundewallah Creek												
	Autumn 2016		Spring 2016		Autumn 2017		Spring 2017		Autumn 2018		Spring 2018	
Species	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance
Persicaria diceptans Slender knotweed												
Ludwigia peploides Water primrose												
Lemna disperma Duckweed	1	2	1	2	2	1	1					
Juncus usitatus Common rush												
**Rorippa palustris* Marsh Watercress		1										
*Altenanthera philoxeroides** Aligator weed										1	1	
Azolla pinnata Mosquitofern											3	
**Cyperus eragrostis*												2

Table 3-10 Control Site 1 macrophyte and emergent vegetation abundances according to Braun-Blanquet 6-point scale (refer to Section 2.4)

Control Site 1												
	Autumn 2016		Spring 2016		Autumn 2017		Spring 2017		Autumn 2018		Spring 2018	
Species	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance
**Sagittaria platyphylla* Sagittaria	3	1	3	3	3	3	2	1	2	2	2	2
Persicaria strigose Knotweed	1	1	1	1	2	2	2	2				
Ottelia ovalifolia Swamp Lily	1	1										
Maidenia rubra Maidenia	1	1	1	1	1	1						
**Myriophyllum aquaticum* Parrots feather	1	1	1	1	1	1	1					
Vallisneria australis Ribbonweed	1	1	1	1	1	1	1	1		2		
Triglochin procerum Water ribbon	1	1										
Eleocharis acuta Common Spike-rush		3	2	2	2	2	2	1				

Control Site 1												
	Autumn 2016		Spring 2016		Autumn 2017		Spring 2017		Autumn 2018		Spring 2018	
Species	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance
**Elodea canadensis* Elodea									3		2	
Baumea articulata *Jointed rush*									2		1	2

*Exotic

Table 3-11 Control Site 2 macrophyte and emergent vegetation abundances according to Braun-Blanquet 6-point scale (refer to Section 2.4)

Control Site 2												
	Autumn 2016		Spring 2016		Autumn 2017		Spring 2017		Autumn 2018		Spring 2018	
Species	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance
**Sagittaria platyphylla* Sagittaria			2	2	2	2	2	1	2	2	1	2
Eleocharis acuta Common Spike-rush			1									
Eleocharis sphacelata Tall Spike-rush				2		1	1	1				
**Colocasia sp.* Elephant's Ear				1					2		1	

Control Site 2												
	Autumn 2016		Spring 2016		Autumn 2017		Spring 2017		Autumn 2018		Spring 2018	
Species	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance	Session 1 Abundance	Session 2 Abundance
Ottelia ovalifolia Swamp Lily				3	2		1				1	
Baumea articulata *Jointed rush*									2			
*Altenanthera philoxerioudes** Aligator weed									2			
**Cyperus eragrostis* Umbrella Sedge												2

*Exotic

A total of 11 different species were recorded during 2018 across all sites, compared to 13 species in 2017, and 10 species during 2016. Of the 11 species recorded in 2018, six were exotic species. Sites included between 0 and 4 species at any one time.

Overall abundance was generally similar to the 2017 results, however generally more species were recorded during the Spring survey of both years. It is considered likely that low water levels would be contributing to the changes in species composition and abundance, and potentially high rainfall events could wash away species not well established at sites. Higher water levels may have also made some species more difficult to see. This would explain the low data recorded Autumn Session 2 where surveys occurred immediately after heavy rainfall for most sites as stated in our limitations.

Two new exotic species were identified *Cyperus eragrostis* Umbrella sedge and *Alternanthera philoxeroides* Alligator weed during the 2018 surveys. *C. eragrostis* was identified at all sites (including both control sites) but Site 22 in 2018. *A. philoxeroides* was identified in sites 13, 25, 27, and Control Site 2 in 2018. Site 22 had the largest recorded abundance of any exotic macrophyte identified, *C. eragrostis* 4 (20- <50% modified Braun-Blanquet 6-point scale). It is likely that these species were present in 2017 but were not recorded as macrophytes for the purposes of the survey due to their semiaquatic and terrestrial distribution.

A total of seven species, including five exotic species, were recorded at the control sites in 2018. Six of these species occurred in Control Site 2 alone, which had a relatively low abundance throughout 2018, however two identified exotic species (*Cyperus eragrostis* Umbrella sedge and *Alternanthera philoxeroides* Alligator weed) were never previously recorded at this site. *Sagittaria platyphylla* Sagittaria remained at a consistent abundance in both Control site 1 and Control site 2 throughout 2018. There was no significant variation between the control sites and the subject sites regarding weed species and distribution.

3.4 MACROINVERTEBRATES

The following presents the macroinvertebrate results of each site during each session.

Table 3-12 Site 13 – Broughton Creek macroinvertebrates

Site13 – Broughton Creek														
	Preconstruction survey[1]		Autumn 2015		Spring 2015		Autumn 2016		Spring 2016		Autumn 2017		Spring 2017	
	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2
SIGNAL score[2]	Approx. 3.3 Severe	Approx. 4.2 Moderate	4.94 Moderate	4.75 Moderate	5.17 Mild	5.66 Mild	5.1 Mild	5.27 Mild	4.89 Moderate	4.49 Moderate	5.04 Mild	5.07 Mild	4.76 Moderate	5.13 Mild
EPT score	8 Fair	4 Poor	8 Fair	6 Poor	8 Fair	9 Fair	9 Fair	9 Fair	9 Fair	11 Fair	6 Poor	8 Fair	8 Fair	5 Poor
Number of taxa	6	6	21	18	25	20	22	24	31	29	23	23	26	23

Note 1 Site 13 during preconstruction was located upstream of 2015 surveys

Note 2 Preconstruction, 2016 and 2017 results are SIGNAL2 scores. 2015 results are SIGNAL scores

Site13 – Broughton Creek				
	Autumn 2018		Spring 2018	
	Session 1	Session 2	Session 1	Session 2
SIGNAL score[2]	5.09 Mild	3.5 Severe	4.26 Moderate	4.81 Moderate
EPT score	8 Fair	4 Poor	4 Poor	6 Poor
Number of taxa	20	20	12	10

Table 3-13 Site 16 – Broughton Creek macroinvertebrates

Site 16 – Broughton Creek														
	Preconstruction survey		Autumn 2015		Spring 2015		Autumn 2016		Spring 2016		Autumn 2017		Spring 2017	
	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2
SIGNAL score[1]	Approx. 4.2 Moderate	Approx. 2.9 Severe	4.47 Moderate	4.99 Moderate	4.66 Moderate	4.55 Moderate	4.84 Moderate	5.30 Mild	4.58 Moderate	4.63 Moderate	5.07 Mild	5.18 Mild	5.37 Mild	4.72 Moderate
EPT score	3 Poor	0 Poor	8 Fair	11 Fair	9 Fair	6 Poor	8 Fair	9 Fair	11 Fair	9 Fair	8 Fair	8 Fair	8 Fair	6 Poor
Number of taxa	8	4	20	22	30	15	16	24	37	26	28	26	17	19

Note 1 Preconstruction, 2016 and 2017 results are SIGNAL2 scores. 2015 results are SIGNAL scores

Site16 – Broughton Creek				
	Autumn 2018		Spring 2018	
	Session 1	Session 2	Session 1	Session 2
SIGNAL score[2]	4.43 Moderate	5.39 Mild	4.61 Moderate	4.42 Moderate
EPT score	9 Fair	9 Fair	7 Fair	8 Fair
Number of taxa	24	24	20	21

Table 3-14 Site 17 – Broughton Creek macroinvertebrates

Site 17 – Broughton Creek														
	Preconstruction survey		Autumn 2015		Spring 2015		Autumn 2016		Spring 2016		Autumn 2017		Spring 2017	
	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2
SIGNAL score[1]	N/A	Approx.2.9 Severe	NA	5.28 Mild	4.88 Moderate	4.74 Moderate	4.96 Moderate	5.08 Mild	4.88 Moderate	4.24 Moderate	5.03 Mild	5.43 Mild	4.76 Moderate	4.86 Moderate
EPT score	N/A	7 Fair	NA	8 Fair	10 Fair	6 Poor	9 Fair	8 Fair	8 Fair	10 Fair	7 Fair	9 Fair	6 Poor	5 Poor
Number of taxa	N/A	N/A	NA	16	29	19	23	20	31	28	21	21	18	23

Note 1 Preconstruction, 2016 and 2017 results are SIGNAL2 scores. 2015 results are SIGNAL scores

Site17 – Broughton Creek				
	Autumn 2018		Spring 2018	
	Session 1	Session 2	Session 1	Session 2
SIGNAL score[2]	4.18 Moderate	4.39 Moderate	4.11 Moderate	4.15 Moderate
EPT score	7 Fair	6 Poor	5 Poor	5 Poor
Number of taxa	25	17	23	19

Table 3-15 Site 22 – Bundewallah Creek macroinvertebrates

Site 22 – Bundewallah Creek														
	Preconstruction survey		Autumn 2015		Spring 2015		Autumn 2016		Spring 2016		Autumn 2017		Spring 2017	
	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2
SIGNAL score[1]	Approx. 4.2 Moderate	Approx. 3 Severe	4.64 Moderate	4.26 Moderate	4.44 Moderate	3.71 Severe	5.27 Mild	4.23 Moderate	4.49 Moderate	3.63 Severe	4.05 Moderate	4.27 Moderate	3.82 Severe	3.11 Severe
EPT score	2 Poor	4 Poor	7 Fair	6 Poor	6 Poor	6 Poor	6 Poor	8 Fair	6 Poor	1 Poor	7 Fair	7 Fair	4 Poor	4 Poor
Number of taxa	4	8	24	17	27	17	21	25	28	10	23	22	17	17

Note 1 Preconstruction, 2016 and 2017 results are SIGNAL2 scores. 2015 results are SIGNAL scores

Site22 – Bundewallah Creek				
	Autumn 2018		Spring 2018	
	Session 1	Session 2	Session 1	Session 2
SIGNAL score[2]	4.32 Moderate	3.83 Severe	3.08 Severe	3.06 Severe
EPT score	4 Poor	4 Poor	1 Poor	2 Poor
Number of taxa	19	21	6	17

Table 3-16 Site 25 – Broughton Mill Creek macroinvertebrates

Site 25 – Broughton Mill Creek														
	Preconstruction survey[1]		Autumn 2015		Spring 2015		Autumn 2016		Spring 2016		Autumn 2017		Spring 2017	
	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2
SIGNAL score[2]	Approx. 3.5 Severe	Approx. 3.3 Severe	4.46 Moderate	4.93 Moderate	4.70 Moderate	3.57 Severe	4.96 Moderate	5.03 Mild	4.88 Moderate	4.53 Moderate	4.93 Moderate	5.19 Mild	4.05 Moderate	4.01 Moderate
EPT score	4 Poor	1 Poor	7 Fair	8 Fair	8 Fair	5 Poor	6 Poor	10 Fair	10 Fair	10 Fair	8 Fair	12 Fair	7 Fair	3 Poor
Number of taxa	13	4	22	22	25	20	15	28	33	31	29	32	28	24

Note 1 Site 25 during preconstruction was located upstream of 2015 surveys

Note 2 Preconstruction, 2016 and 2017 results are SIGNAL2 scores. 2015 results are SIGNAL scores

Site25 – Broughton Mill Creek				
	Autumn 2018		Spring 2018	
	Session 1	Session 2	Session 1	Session 2
SIGNAL score[2]	5.02 Mild	3.77 severe	5.24 Mild	4.8 Poor
EPT score	7 Fair	5 Poor	4 Poor	3 Poor
Number of taxa	28	14	15	17

Table 3-17 Site 27 – Bundewallah Creek macroinvertebrates

Site 27 – Bundewallah Creek														
	Preconstruction survey		Autumn 2015		Spring 2015		Autumn 2016		Spring 2016		Autumn 2017		Spring 2017	
	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2
SIGNAL score[1]	Approx. 3.6 Severe	Approx. 2.9 Severe	4.96 Moderate	4.98 Moderate	4.79 Moderate	4.75 Moderate	4.98 Moderate	4.64 Moderate	4.63 Moderate	3.32 Severe	5.07 Mild	5.54 Mild	4.51 Moderate	4.61 Moderate
EPT score	2 Poor	0 Poor	9 Fair	8 Fair	9 Fair	6 Poor	5 Poor	9 Fair	8 Fair	3 Poor	9 Fair	10 Fair	6 Poor	5 Poor
Number of taxa	7	4	25	20	25	17	18	28	27	18	31	25	20	26

Note 1 Preconstruction, 2016 and 2017 results are SIGNAL2 scores. 2015 results are SIGNAL scores

Site 27 – Bundewallah Creek				
	Autumn 2018		Spring 2018	
	Session 1	Session 2	Session 1	Session 2
SIGNAL score[2]	4.78 Moderate	4.10 Moderate	4.75 Moderate	4.22 Moderate
EPT score	7 Fair	3 Poor	1 Poor	3 Poor
Number of taxa	32	15	16	18

Table 3-18 Control Site 1 macroinvertebrates

Control Site 1								
	Autumn 2016		Spring 2016		Autumn 2017		Spring 2017	
	Session 1	Session 2[2]	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2
SIGNAL 2 score[1]	4.9 Moderate	5.67 Mild	4.95 Moderate	4.55 Moderate	4.63 Moderate	5.46 Mild	4.44 Moderate	4.71 Moderate
EPT score	3 Poor	7 Fair	10 Fair	9 Fair	6 Poor	11 Fair	7 Fair	6 Poor
Number of taxa	6	27	37	33	27	28	28	20

Note 1 1 Preconstruction, 2016 and 2017 results are SIGNAL2 scores

Control Site 1				
	Autumn 2018		Spring 2018	
	Session 1	Session 2	Session 1	Session 2
SIGNAL score[2]	4.08 Moderate	4.13 Moderate	4.11 Moderate	3.91 Severe
EPT score	2 Poor	4 Poor	4 Poor	3 Poor
Number of taxa	20	21	20	19

Table 3-19 Control Site 2 macroinvertebrates

Control Site 2								
	Autumn 2016[2]		Spring 2016		Autumn 2017		Spring 2017	
	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2	Session 1	Session 2
SIGNAL 2 score[1]	N/A	N/A	4.7 Moderate	4.3 Moderate	4.74 Moderate	5.25 Mild	5.03 Mild	4.56 Moderate
EPT score	N/A	N/A	8 Fair	9 Fair	8 Fair	8 Fair	8 Fair	5 Poor
Number of taxa	N/A	N/A	32	29	25	28	23	23

Note 1 Preconstruction, 2016 and 2017 results are SIGNAL2 scores

Note 2 Access to Control Site 2 was not granted until Spring 2016

Control Site 2				
	Autumn 2018		Spring 2018	
	Session 1	Session 2	Session 1	Session 2
SIGNAL score[2]	4.71 Moderate	4.19 Moderate	4.52 Moderate	4.58 Moderate
EPT score	6 Poor	4 Poor	7 Fair	5 Poor
Number of taxa	25	12	17	12

Table 3-20 Pre and Post construction Signal, EPT Scores and Taxa Number comparison

	Parameter	Pre- Construction Average	Pre- Construction Average minus (-)20%	Post- Construction Average	PASS/FAIL
Site 13	SIGNAL score	3.75	3	4.415	PASS
	EPT score	6	4.8	5.5	PASS
	Number of taxa	6	4.8	15.5	PASS
Site 16	SIGNAL score	3.55	2.84	4.7125	PASS
	EPT score	1.5	1.2	8.25	PASS
	Number of taxa	6	4.8	22.25	PASS
Site 17	SIGNAL score	2.9	2.32	4.2075	PASS
	EPT score	7	5.6	5.75	PASS
	Number of taxa	No Data	No Data	21	NA
Site 22	SIGNAL score	3.6	2.88	3.5725	PASS
	EPT score	3	2.4	2.75	PASS
	Number of taxa	6	4.8	15.75	PASS
Site 25	SIGNAL score	3.4	2.72	4.7075	PASS

	Parameter	Pre- Construction Average	Pre- Construction Average minus (-)20%	Post- Construction Average	PASS/FAIL
	EPT score	2.5	2	4.75	PASS
	Number of taxa	8.5	6.8	18.5	PASS
Site 27	SIGNAL score	3.25	2.6	4.4625	PASS
	EPT score	1	0.8	3.5	PASS
	Number of taxa	5.5	4.4	20.25	PASS
Control Site 1	SIGNAL score	5.285	4.228	4.0575	FAIL
	EPT score	5	4	3.25	FAIL
	Number of taxa	16.5	13.2	20	PASS
Control Site 2	SIGNAL score	No Data	No Data	4.5	NA
	EPT score	No Data	No Data	5.5	NA
	Number of taxa	No Data	No Data	16.5	NA

A total of 64 and 56 different taxa were sampled during Autumn and Spring 2018 respectively; this is slightly below data recorded in 2017 but remains greater than all previous years (31 taxa collected in Spring preconstruction surveys, 46 in Autumn 2015 and 56 in Spring 2015, and 49 in Autumn 2016 and 59 during Spring 2016. 68 taxa in Autumn 2017, 61 taxa in Spring 2017). However, the number of taxa collected per site and session varied. In previous years there has often been an increase in taxa diversity during Spring, however in 2017 and 2018 there was a general decline. This decline was also evident at the control sites in 2017 and 2018, which indicates that the reasons behind this reduction in the diversity of taxa is unlikely to be related to construction activities. The full list of taxa collected is provided in Appendix D.

The EPT scores indicate that in 2018 the majority of sites were in fair to poor condition and were similar to the 2015, 2016 and 2017 results. The overall EPT scores decreased between 2017 and 2018 at all sites, except for Site 16 which slightly increased. Site 22 had two fair and two poor readings from 2017, compared to four poor readings in 2018. Additionally, Site 25 had three fair and one poor reading in 2017, compared to four poor in 2018. Both Control sites were seen to decrease in EPT Scores between 2017 and 2018. Control site 1: two fair, two poor in 2017 compared to four poor in 2018. Control Site 2: three fair, 1 poor in 2017 compared to one fair and three poor in 2018.

The SIGNAL 2 scores during 2018 indicate the waterways to be in mild or moderate condition, with six severe pollution conditions being recorded; Site 13 Autumn Session 2, Site 22 Autumn Session 2, Spring Session 1 and 2, Site 25 Autumn Session 2, and Control Site 1 Spring Session 2. Data acquired during Autumn Session 2 may have been confounded by the large rainfall event prior to the survey. The high-water levels and rapid flow may have prevented a truly representative sample of the sites to be taken. Half of the severe readings occurred during this time.

It is not possible to determine the reason for the large increase in diversity between preconstruction surveys and the first three years of construction. However, diversity levels have stayed relatively consistent between 2017 and the first year of the Bypass' operational phase.

Table 3-20 shows the comparison between EPT and SIGNAL scores and number of taxa observed between pre-construction data and post construction data. A column for Pre-construction averages minus 20% has been included to specifically address performance targets/indicators, furthermore a PASS/FAIL column has been added. EPT scores passed in all treatment sites (13,16, 17,22,25, and 27) between pre and post construction. That is, the EPT score either increased since, or decreased by less than 20% of the pre-construction recordings. Similarly, the Signal Score had all treatment sites pass. No data was recorded for number of taxa site 17 pre-construction which means no comparison can be made. Control site 1 was the only control site to have data recorded during pre-construction, moreover a comparison with post-construction data presented fails in both EPT and Signal Scores. That is, both the EPT and Signal Scores of Control site 1 decreased between pre-construction and post-construction by more than 20%. This therefore suggests, that any decrease observed in treatment sites would not be specific to the bypass' introduction.

3.5 FISH ASSESSMENT

The following presents the fish assessment results of each site during each session.

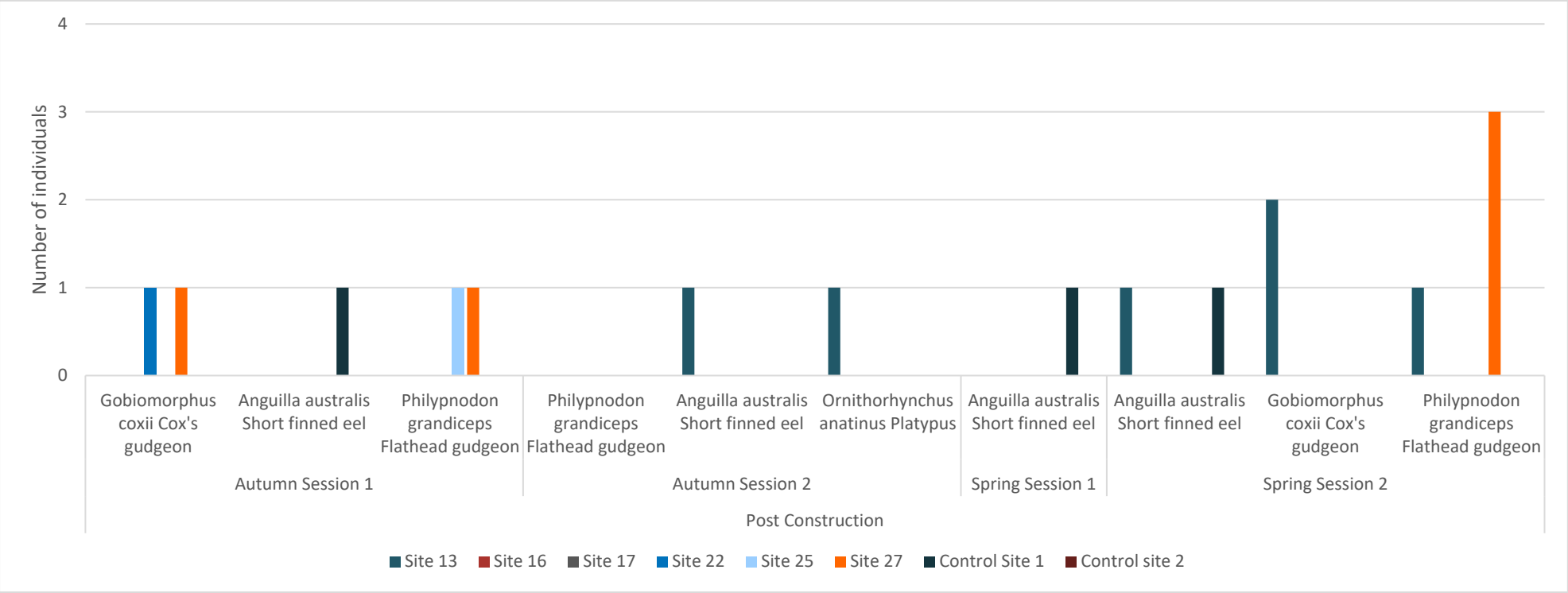

Figure 3-24 Fauna species observed across all sites and seasons in 2018

A small number of fish (10) were collected/observed from two common fish species throughout 2018. The only other fish species observed in 2018 were five Short-finned Eels observed at Control site 1 (Autumn Session 1, Spring Session 1, and Spring Session 2) and Site 13 (Autumn Session 2, and Spring Session 1).

Species recorded in previous years that were not recorded in 2018 include Australian Bass, Striped Gudgeon, Firetail Gudgeon, and Small-mouthed Hardyhead.

There was a reduction in species diversity and abundance recorded in 2018 compared to previous years. This trend was also observed in control site surveys between 2017 (abundance 6, diversity 3) and 2018 (abundance 3, diversity 1). This therefore may indicate that factors that may be affecting species diversity and abundance are not a result of construction activities, but may be attributed to conditions of this generally disturbed aquatic ecosystem. Factors that typically influence aquatic ecosystems include water supply, water quality, turbidity, pollution and alien species.

Previous year data can be seen in 6Appendix E.

3.5.1 Other fauna

The only other fauna recorded in 2018 was one Platypus (*Ornithorhynchus anatinus*) which was identified at Site 17 during the Autumn Session 2 survey. Its carcass was identified within a fyke net when found and retrieved during later surveys after it was dislodged and washed downstream during heavy floods in June 2018.

A Red-bellied Black Snake (*Pseudechis porphyriacus*) was recorded at Control Site 2 during Spring 2017 (Session 2). A mature Diamond Python *Morelia spilota* was identified in riparian vegetation at Site 17 during Spring 2016. Platypus and a long-necked turtle were recorded in 2015.

3.6 COMPARISON WITH PERFORMANCE CRITERIA

The following performance criteria relevant to aquatic monitoring are taken from the EcMP (PB 2014). It should be noted that these do not relate specifically to the post-construction period monitoring rather they relate to the lifetime of the monitoring program, including post construction.

Of note is the fact that the water quality varies across sites between surveys by more than 10% in some years. Examples of this include turbidity changing from approximately 25 NTU to 5 NTU between 2014 Spring and 2015 Autumn, and Dissolved Oxygen changing from approximately 70 to 130 between Spring 2014 and Spring 2015. As such, the comparison of pre and post construction values may not be informative about the relative impact of the project, as the quality values of the whole waterway may change by more than 10% in any given season. The comparison to control sites allows for comparison upstream and downstream of the project, and it is suggested that this measure is more informative about the impacts of the project than comparison with conditions over time.

As can be seen from the 3-19 to 3-21, conductivity is the only measure where control sites have consistently better values than treatment sites. It is suggested that this may be as a result of the importation of fill and rocks for the construction of the project, and potentially from inorganic compounds resulting from the construction and use of the road.

Table 3-21 Performance criteria

Measure	Performance criteria	Performance target	Comment
Aquatic and riparian monitoring	Water quality maintained between impact sites and control sites as a result of the Project's operations	Water quality is maintained at preconstruction data levels, or increases. Any decrease in water quality does not exceed 10% difference when compared to preconstruction data levels.	The performance criteria and performance target in this case vary. The performance target should not solely be used as a guideline on the overall water quality assessment of the project. Rather, it should additionally include the comparison between control and treatment site data. This comparison would assess whether trends are consistent between treatment and control sites. We could suggest that although downstream treatment sites have decreased in water quality, if this is similarly seen in upstream control sites, disturbance would not be a result of the bypass' construction and use. A discussion of the water quality analysis is given below. The treatment sites are highly disturbed as a result of surrounding land uses. The water quality values at all the sites generally fell outside the ANZECC/ARMCANZ Guideline levels (ANZECC 2000) for disturbed aquatic ecosystems. This occurred during both preconstruction surveys and during construction and is therefore likely a reflection of the agricultural land uses in the catchment rather than the bypass' construction. An analysis (Table 3-2) has been conducted to assess whether the performance target of water quality has been met, which is summarised below. • Site 13: PASS in all water quality parameters • Site 16: FAIL for Temperature, pH, and Turbidity • Site 17: FAIL for pH, Turbidity, and

Measure	Performance criteria	Performance target	Comment
			Dissolved Oxygen • Site 22: FAIL for pH, and Turbidity • Site 25: Fail for Conductivity, Turbidity, and Dissolved Oxygen • Site 27: Fail for pH and Turbidity • Control Sites: No control site data was obtained pre-construction and therefore cannot be compared As mentioned above, this performance target should not solely be used as a determining factor of the overall water quality assessment of the project. Rather, trends between treatment sites and control sites additionally need to be compared before overall conclusions can be made. Although no control site data was obtained pre-construction, a comparison has been made between control site data during construction and post-construction (Table 3-3) and are summarised below. • Control Site 1: PASS Temperature, pH, and Conductivity, FAIL-Turbidity, and Dissolved oxygen • Control Site 2: PASS-Temperature, pH, and Conductivity, FAIL- Turbidity, and Dissolved oxygen Temperature: Passed in both control sites, failed only in Site 16. Figure 3-19 shows a very similar trend between treatment sites and control sites between surveys. pH: Passed in both control sites, failed in sites 16, 17, 22, and 27. Figure 3-20 shows a very similar trend line between treatment sites and the control sites between surveys. Conductivity: Passed in both control sites, failed only in site 25. Figure 3-22 shows a similar trend in control and treatment sites. However, treatment sites always had a higher recorded conductivity than control sites throughout the survey times. Important to note, average trendlines in the graph are different to actual trendlines as treatment sites included pre-construction data, where none was recorded for control sites. Turbidity: Failed in both control sites, Passed in only site 13. Figure 3-23 shows a similar trend line except for Spring 2017 where a much higher turbidity was recorded in treatment sites than control sites. This change was not permanent as from Autumn 2018 trend lines restored to similar levels. Dissolved oxygen: Failed for both control sites, failed in sites 17, and 25. Figure 3-21 shows a very similar trendline between treatment and control

Measure	Performance criteria	Performance target	Comment
			sites across surveys.
	No emergent vegetation or macrophyte dieback	None observed during the life of the monitoring program.	The overall abundance was similar across survey years, with a total number of 11 different species recorded in 2018 across all sites compared to 13 in 2017, 10 species in 2016, and 14 species during 2015. Some sites seemed to experience some dieback with some species disappearing and reappearing and/or other species appearing. This could be due to natural temporal variations. Two new exotic species were identified in 2018 *Cyperus eragrostis* Umbrella sedge and *Alternanthera philoxeroides* Aligator weed. *C. eragrostis* was identified at all sites (including both control sites) but Site 22 in 2018. *A. philoxeroides* was identified in sites 13, 25, 27, and Control Site 2 in 2018. Site 22 had the largest recorded abundance of any exotic macrophyte identified, *C. eragrostis* 4 (20- <50% modified Braun-Blanquet 6-point scale). As mentioned previously, these weeds may have been present in recent years but may have not been recorded as macrophytes due to their semiaquatic and terrestrial distribution. As upstream control sites also contained similar abundance and richness of macrophytes to the downstream sites, this suggests results may not necessarily be construction caused. A total of seven species, including five exotic species, were recorded at the control sites in 2018. Six of these species occurred in Control Site 2 alone, which had a relatively low abundance throughout 2018, however two identified exotic species (*Cyperus eragrostis* Umbrella sedge and *Altenanthera philoxeroides* Aligator weed) were never previously recorded at this site. *Sagittaria platyphylla* Sagittaria remained at a consistent abundance in both Control site 1 and Control site 2 throughout 2018.
	Macroinvertebrates maintained	Macroinvertebrates are maintained at preconstruction data levels, or increase during the life of the monitoring program. Any decrease in macroinvertebrates does not exceed 20% difference when compared to preconstruction data levels.	Table 3-20 shows the comparison between EPT and SIGNAL scores and number of macroinvertebrate taxa observed between pre-construction data and post construction data. A column for Pre-construction averages minus 20% has been included to specifically address performance targets/indicators, furthermore a PASS/FAIL column has been added. PASS: EPT scores passed in all treatment sites (13,16, 17,22,25, and 27) between pre and post construction. That is, the EPT score either increased since, or decreased by less than 20% of the pre-construction recordings. PASS: Signal Scores in all treatment sites passed. No data was recorded for number of taxa site 17 pre-construction which means no comparison can be made.

Measure	Performance criteria	Performance target	Comment
			Control site 1 was the only control site to have data recorded during pre-construction, moreover a comparison with post-construction data presented fails in both EPT and Signal Scores. That is, both the EPT and Signal Scores of Control site 1 decreased between pre-construction and post-construction by more than 20%. This therefore suggests, that any decrease observed in treatment sites would not be specific to the bypass' introduction.
	Native fish species diversity maintained	Fish species diversity is maintained at preconstruction data levels, or increases during the life of the monitoring program. Any decrease in fish species diversity does not exceed 20% difference when compared to preconstruction data levels.	A small number of fish (10) were collected/observed from two common fish species throughout 2018. The only other fish species observed in 2018 were five Short-finned Eels observed at Control site 1 (Autumn Session 1, Spring Session 1, and Spring Session 2) and Site 13 (Autumn Session 2, and Spring Session 1). A platypus was also recorded at Site 17 in Autumn Session 2. There was a reduction in species diversity and abundance recorded in 2018 compared to previous years (2016, and 2017). This trend was also observed in Control site surveys between 2017 (Abundance 6, Diversity 3) and 2018 (Abundance 3, Diversity 1). This therefore may indicate that factors that may be affecting species diversity and abundance are not a result of construction activities, but may be attributed to conditions of this generally disturbed aquatic ecosystem. Factors that typically influence aquatic ecosystems include water supply, water quality, turbidity, pollution and alien species. PASS: There was no loss of diversity between pre-construction monitoring (4 species) and 2018 monitoring (4 species).

4 REVIEW OF MITIGATION MEASURES

The EcMP and the CFFMP, including the Weed Management Plan, include a number of mitigation measures and actions from the environmental assessment and Statement of Commitments to be undertaken to avoid and/or minimise water quality and aquatic biodiversity impacts during construction. These are detailed in Table 4-1 along with notes on whether these have been implemented.

Table 4-1 Mitigation measures

Mitigation measure	Implementation
EcMP	
Consider lopping or relocation of large woody debris in streams as a first priority before removal. Should removal of large woody debris be necessary, consider the introduction of engineered woody debris as compensation within the offset strategy for residual impacts.	Cut stump methodology has been used to retain root balls in situ around waterways. Coarse woody debris has been salvaged and has been re-introduced to the project during stream rehabilitation works.
Consult with the DPI (Fishing and Aquaculture) for input in relation to matters relevant to Fisheries, where appropriate	DPI and Fisheries attended the project four times in 2015 and on at least three occasions in 2016. They have also been consulted periodically via email and on the telephone for all creek works.
Where feasible use low hollow-core bridges or short lengths of pipe culverts for temporary crossings to maintain fish passage with reference to guidelines for the design and construction of waterway crossings to maintain fish passage.	Fish passage in the major creeks of the project has been maintained through the construction of temporary bridges. These bridges allow for full connectivity of upstream and downstream flows and have been installed at; Broughton Creek 1, Broughton Creek 2, Broughton Mill Creek, The other main creek on the project Bundewallah Creek had piped culverts installed below the waterline so passage for fish is maintained. This crossing was approved by NSW DPI Fisheries. All other waterways on the project are ephemeral.
Manage weeds where identified	Weed management is ongoing across the site in accordance with the CFFMP and relevant legislation. Specific details on weed management can be assessed in the Weed monitoring report. Aquatic weed management should be considered.
Minimise impacts to water quality during operation of the project through the combination of swales, water quality basins and biofiltration.	The operational design includes the following water quality features: Basins Bioswales Vegetated swales Hard rock scour protection

Mitigation measure	Implementation
	The effectiveness of these design features can be assessed during the operational phase of the project.
Implement erosion and scour protection in the design and construction of bridges and culverts. Manage erosion and sedimentation impacts and conduct surface water quality monitoring during construction of the project to monitor water quality	A PESCP has been prepared and implemented across the site. EWMS's have been prepared and implemented during works within and adjacent to waterways. All bridge structures have scour protection designed around them. Surface water quality monitoring completed throughout 2018 did not show any impacts on the receiving waterways which can be attributed to construction.
Design transverse drainage structures to allow unrestricted passage of most natural flows and allow for changes in the natural flow regime as a result of climate change. This would be achieved by designing bridges and culverts to provide flood immunity from the 100 year flood event and the 50 year flood event respectively.	This has been completed and is included in the design at Broughton Creek, Bundewallah Creek and Broughton Mill creek.
In areas close to or upstream from sensitive receiving waters, implement additional treatment measures to ensure no net increase in pollutant load from road runoff.	Pollution control basins and attenuation swales have been designed to manage long term road runoff pollutants.
Conduct regular water quality monitoring in accordance with the Foxground and Berry Bypass Water Quality Monitoring Program (GHD, 2014).	Ongoing. Monitoring completed to date.
Conduct aquatic ecology monitoring during the pre-construction, construction and operational periods.	Ongoing. Monitoring completed to date.
Periodically review and evaluate the results of the monitoring to identify improvements to existing mitigation measures or maintenance regimes. Use the results of the monitoring to identify the need for additional mitigation or management responses to address any unforeseen impacts on biodiversity.	Ongoing. Refer to this annual report and the 2015, 2016, and 2017 annual reports.
CFFMP	
Periodically review and evaluate the results of the monitoring to identify improvements to existing mitigation measures or maintenance regimes. Use the results of the monitoring to identify the need for additional mitigation or management responses to address any unforeseen impacts on biodiversity.	Additional controls will be put in place where monitoring shows they are required. Current results at this stage indicate that weed control and further weed monitoring are necessary.
Retain stumps in riparian zones and aquatic habitats where practicable to reduce the potential for bank erosion. Even dead stumps and root systems may act to reduce erosion during construction and operation periods.	• Cut stump clearing has been undertaken across the project within 5 m of waterways as a minimum.
Subject to consultation with NOW and DPI (Fishing and Aquaculture), utilise trees removed as a consequence of the project for fish habitat and bank stability within the creeks of the project area.	Coarse woody debris has been salvaged and has been re-introduced to the project as part of the creek rehabilitation works. Riparian rehabilitation is ongoing in consultation with DPI (fisheries) and NSW Office of Water.

Mitigation measure	Implementation
For temporary water crossings over all Class 1 and 2 waterways install temporary bridge structures instead of box culverts to reduce the potential for scouring.	Temporary bridge structures were installed over Broughton Creek crossing one and two, and Broughton Mill creek.
Follow the relevant EWMS and PESCP for the construction of all temporary bridges to minimise the potential of erosion and sedimentation impacts.	Adhered to.
Locate all refuelling areas at least 50 metres away from waterways.	Refuelling of mobile plant is undertaken more than 50 m from a waterway. Cranes, pilling rigs and other less mobile plant is refuelled closer than 50 m to the waterway in accordance with the Fulton Hogan refuelling procedure.
Progressively revegetate batters and other disturbed areas with cover crop species to stabilise the soil and provide vegetation cover as a method to minimise sedimentation of waterways and impacts on fish. Use Rye Corn during the months of April to August or Japanese Millet during the months of September to March. Also refer to the UDLP where necessary.	Cover crops are applied to temporarily stabilise batters, design seed is applied as efficiently as construction allows in all areas.

5 RECOMMENDATIONS

The safeguards detailed in Section 4 should continue to be implemented. Additionally, aquatic weed control should commence immediately across all sites. Please refer to the below guidelines.

Mitigation Measure	Implementation
Control aquatic weeds in riparian zones and aquatic habitats to prevent further spread.	Undertake aquatic weed management in accordance with the DPI guidelines (2008; 2018) and the 2018 FBB Weed Monitoring Report recommendations, across the project. This includes: • Mechanically or physically removing plants when they first appear; • Treating any remnants with spot applications of a recommended herbicide; • Diverting nutrient run off away from the riparian zones as nutrient rich waters encourage aquatic weed growth; • Plant trees to shade the riparian zones and reduce available light to the weeds; • Use biological control agents if they are available and are suitable to the particular situation; • Strategic placement of barriers or booms to contain the weeds and to prevent them from spreading; • Continual weed monitoring of the sites.

NGH recommend that use of fyke nets be removed from aquatic surveying methodology due the ethical risks on animals associated with their use.

Monitoring should continue in accordance with the Ecological monitoring program, total of three years post-construction (Parsons Brinkerhoff 2014).

6 REFERENCES

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APPENDIX A SITE PHOTOS

Site 13

2018 Autumn Session 1

2018 Autumn Session 2

2018 Spring Session 1

2018 Spring Session 2

Site 16

2018 Autumn Session 1

2018 Autumn Session 2

2018 Spring Session 1

2018 Spring Session 2

Site 17

2018 Autumn Session 1

2018 Autumn Session 2

2018 Spring Session 1

2018 Spring Session 2

Site 22

2018 Autumn Session 1

2018 Autumn Session 2

2018 Spring Session 1

2018 Spring Session 2

Site 25

2018 Autumn Session 1

2018 Autumn Session 2

2018 Spring Session 1

2018 Spring Session 2

Site 27

2018 Autumn Session 1

2018 Autumn Session 2

2018 Spring Session 1

2018 Spring Session 2

Control site 1

2018 Autumn Session 1

2018 Autumn Session 2

2018 Spring Session 1

2018 Spring Session 2

Control site 2

2018 Autumn Session 1

2018 Autumn Session 2

2018 Spring Session 1

2018 Spring Session 2

APPENDIX B WATER QUALITY MEASUREMENTS

Site	Timing	Session	Temperature oC	pH	Conductivity ms/cm	Turbidity NTU	Dissolved oxygen % saturation
Control site 1	Autumn 2016	Session 1	15.9	6.7	132	1.9	90
	Autumn 2016	Session 2	11.74	6.7	115	3.2	91.1
	Spring 2016	Session 1	17.2	6.9	133	0.7	80.6
	Spring 2016	Session 2	23	6.7	156	3.5	31
	Autumn 2017	Session 1	14.81	7.1	124	1.8	69.3
	Autumn 2017	Session 2	12.49	6.41	123	0.7	66.22
	Spring 2017	Session 1	17.46	7.13	159	9.1	55.3
	Spring 2017	Session 2	19.95	7.26	201	2.1	42.29
	Autumn 2018	Session 1	16.9	6.71	125.1	19.6	68.73
	Autumn 2018	Session 2	12.7	5.47	31.5	34.7	89.05
	Spring 2018	Session 1	12.4	7.33	110.6	16.4	60.37
	Spring 2018	Session 2	21.9	7.38	106.9	NA	98.3
Control site 2	Autumn 2016	Session 1	n/a	n/a	n/a	n/a	n/a
	Autumn 2016	Session 2	n/a	n/a	n/a	n/a	n/a
	Spring 2016	Session 1	21.2	6.6	116	0.1	80.1
	Spring 2016	Session 2	23.5	6.8	158	0	58.7
	Autumn 2017	Session 1	14.72	7.09	143	1	63.84

Site	Timing	Session	Temperature oC	pH	Conductivity ms/cm	Turbidity NTU	Dissolved oxygen % saturation
	Autumn 2017	Session 2	13.11	6.02	136	0.4	76.84
	Spring 2017	Session 1	14.18	7.16	170	1.6	37.1
	Spring 2017	Session 2	17.78	7.05	188	1	38.99
	Autumn 2018	Session 1	17.2	6.39	148.2	1.4	28.77
	Autumn 2018	Session 2	11.8	5.9	45	99.6	93.91
	Spring 2018	Session 1	14.8	7.51	118	1.2	57.24
	Spring 2018	Session 2	21	7.51	127.4	NA	93.3
Site 13	Spring 2014	2014 Spring session 1	16.3	6.9	114	19.3	67.3
	Spring 2014	2014 Spring session 2	17.4	7.21	113	10.7	72.2
	Autumn 2015	Session 1	15.7	6.3*	78.3	NA	91
	Autumn 2015	Session 2	13.2	6.4	82.7	5.3	86.4
	Spring 2015	Session 1	NA	NA	NA	NA	NA
	Spring 2015	Session 2	16.7	7.1	142	1.4	178.93
	Autumn 2016	Session 1	14.7	7.2	150	0.5	86.5
	Autumn 2016	Session 2	12.26	6.64	128	0	98.6
	Spring 2016	Session 1	17.3	6.39	111	0	64.2
	Spring 2016	Session 2	21.2	6.67	162	0	24
	Autumn	Session 1	14.77	7.66	144	1.1	62.43

Site	Timing	Session	Temperature oC	pH	Conductivity ms/cm	Turbidity NTU	Dissolved oxygen % saturation
	2017						
	Autumn 2017	Session 2	13.6	6.39	127	0.3	79.8
	Spring 2017	Session 1	14.69	7.36	179	1.5	32.1
	Spring 2017	Session 2	18.57	6.7	187	1.1	24.36
	Autumn 2018	Session 1	16.6	7	148.4	2.2	80.2
	Autumn 2018	Session 2	14.8	5.24	25.7	141.6	89.71
	Spring 2018	Session 1	12.4	7.59	112.7	0.6	53.45
	Spring 2018	Session 2	21.1	7.26	130.1	NA	82
Site 16	Spring 2014	Spring session 1	17.1	6.4	96	15.3	77.9
	Spring 2014	Spring session 2	19.1	5.47	97	20.4	83.6
	Autumn 2015	Session 1	NA	NA	NA	NA	NA
	Autumn 2015	Session 2	NA	NA	NA	NA	NA
	Spring 2015	Session 1	NA	NA	NA	NA	NA
	Spring 2015	Session 2	17.2	6.8	144	6.5	120.13
	Autumn 2016	Session 1	15.8	7.23	152	0.8	95.5
	Autumn 2016	Session 2	11.1	7.01	131	0	86
	Spring 2016	Session 1	17.4	6.31	110	0.9	73.6
	Spring 2016	Session 2	21.6	6.56	167	1.1	29.6

Site	Timing	Session	Temperature oC	pH	Conductivity ms/cm	Turbidity NTU	Dissolved oxygen % saturation
	Autumn 2017	Session 1	15.63	7.31	131	5.1	77.66
	Autumn 2017	Session 2	12.02	6.36	132	0.5	76.75
	Spring 2017	Session 1	17.14	7.35	177	4.2	0.732
	Spring 2017	Session 2	21.11	7.02	205	2.1	51.25
	Autumn 2018	Session 1	16.9	6.35	159.7	5.5	67.29
	Autumn 2018	Session 2	12.7	5.46	71.7	1.4	97.06
	Spring 2018	Session 1	12.9	7.67	115.7	2.7	53.77
	Spring 2018	Session 2	20.7	7.84	137	NA	80
Site 17	Spring 2014	2014 Spring session 1	15.21	5.9	117	14.3	67.3
	Spring 2014	2014 Spring session 2	17.2	6.3	119	22.9	62.3
	Autumn 2015	Session 1	15.9	6.2	79.5	NA	88.5
	Autumn 2015	Session 2	13.1	6.4	81.4	6.8	68.7
	Spring 2015	Session 1	NA	NA	NA	NA	NA
	Spring 2015	Session 2	16.5	6.9	146	1.3	12.23
	Autumn 2016	Session 1	14.6	7.62	158	2	96.7
	Autumn 2016	Session 2	12.73	6.62	131	0	79.5
	Spring 2016	Session 1	20.2	6.88	108	1.1	75.3
	Spring	Session 2	22.4	7.04	171	0	50.9

Site	Timing	Session	Temperature oC	pH	Conductivity ms/cm	Turbidity NTU	Dissolved oxygen % saturation
	2016						
	Autumn 2017	Session 1	15.29	7.67	143	3.2	74.61
	Autumn 2017	Session 2	12.32	6.73	147	0.6	65.5
	Spring 2017	Session 1	14.99	7.39	182	2.8	84.5
	Spring 2017	Session 2	16.14	7.28	211	1.8	24.48
	Autumn 2018	Session 1	17.2	6.68	151.7	1.4	80.69
	Autumn 2018	Session 2	12.5	6.09	63.6	32	96.53
	Spring 2018	Session 1	14.3	7.64	125.7	0.5	58.87
	Spring 2018	Session 2	19.9	7.31	132.3	NA	78
Site 22	Spring 2014	2014 Spring session 1	16.3	5.3	127	22.4	81.3
	Spring 2014	2014 Spring session 2	19.8	4.79	127	50.1	98.1
	Autumn 2015	Session 1	16.8	6.3	101.2	NA	91
	Autumn 2015	Session 2	13.3	6.4	110	5.6	86.2
	Spring 2015	Session 1	NA	NA	NA	NA	NA
	Spring 2015	Session 2	20.7	6.5	169	4	165.73
	Autumn 2016	Session 1	16.6	6.92	292	6.5	50.5
	Autumn 2016	Session 2	14	6.91	144	1.5	91.9
	Spring 2016	Session 1	16.9	6.72	204	0.1	28.4

Site	Timing	Session	Temperature oC	pH	Conductivity ms/cm	Turbidity NTU	Dissolved oxygen % saturation
	Spring 2016	Session 2	21.3	6.99	448	9.6	55.7
	Autumn 2017	Session 1	15.86	5.81	154	2.6	51.69
	Autumn 2017	Session 2	12.5	6.65	179	3.6	45.97
	Spring 2017	Session 1	16.32	7.43	415	19.3	57.2
	Spring 2017	Session 2	18.33	7.9	503	15.2	47.84
	Autumn 2018	Session 1	16.2	6.55	251.8	5	30.61
	Autumn 2018	Session 2	14.3	5.36	1.1	8.5	86.11
	Spring 2018	Session 1	14	7.73	356.7	11.1	61.01
	Spring 2018	Session 2	22.7	6.71	216.3	NA	50.3
Site 25	Spring 2014	2014 Spring session 1	15.2	6.1	120	23.1	58.3
	Spring 2014	2014 Spring session 2	16.6	5.4	127	57.3	59.2
	Autumn 2015	Session 1	NA	NA	NA	NA	NA
	Autumn 2015	Session 2	NA	NA	NA	NA	NA
	Spring 2015	Session 1	NA	NA	NA	NA	NA
	Spring 2015	Session 2	19.6	6.5	158	3.1	149.33
	Autumn 2016	Session 1	16.2	6.9	132	5	79.8
	Autumn 2016	Session 2	13	6.97	119	0	101.4
	Spring	Session 1	19	6.43	134	0.1	47.4

Site	Timing	Session	Temperature oC	pH	Conductivity ms/cm	Turbidity NTU	Dissolved oxygen % saturation
	2016						
	Spring 2016	Session 2	22.3	6.88	155	4	42.7
	Autumn 2017	Session 1	15.41	6.32	125	1	78.1
	Autumn 2017	Session 2	10.9	6.84	128	1.1	65.58
	Spring 2017	Session 1	19.44	5.89	158	303	46.75
	Spring 2017	Session 2	18.78	6.97	191	3	22.53
	Autumn 2018	Session 1	17.8	6.37	119.3	1.5	43.95
	Autumn 2018	Session 2	12.4	5.52	58.5	10.3	86.21
	Spring 2018	Session 1	14.3	7.17	124.1	2.2	61.99
	Spring 2018	Session 2	22.2	6.3	112.6	NA	84.2
Site 27	Spring 2014	Session 1	15.3	5.3	122	18.9	61.3
	Spring 2014	Session 2	17.7	4.7	127	17.5	53.2
	Autumn 2015	Session 1	16	6.4	108.4	NA	88.5
	Autumn 2015	Session 2	14	6.3	118.2	1.6	80.1
	Spring 2015	Session 1	NA	NA	NA	NA	NA
	Spring 2015	Session 2	17.4	6.8	173	2.8	148.73
	Autumn 2016	Session 1	17.8	6.96	190	2	80.1
	Autumn 2016	Session 2	13.5	6.61	159	0	81.5

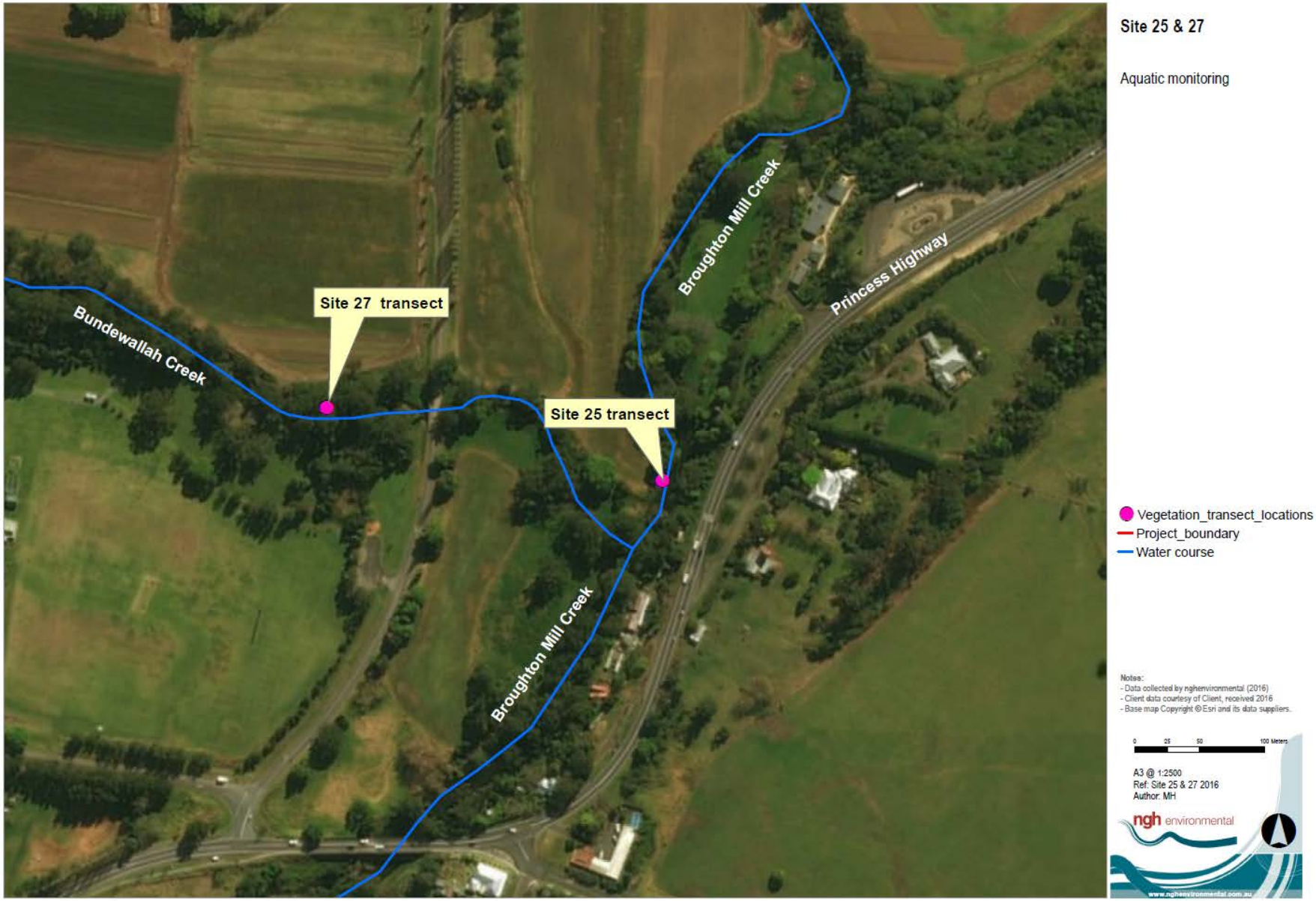
Site	Timing	Session	Temperature oC	pH	Conductivity ms/cm	Turbidity NTU	Dissolved oxygen % saturation
	Spring 2016	Session 1	19.5	6.5	178	0	87.3
	Spring 2016	Session 2	21.5	6.26	182	5.8	30.8
	Autumn 2017	Session 1	17.22	5.74	168	1.5	68.26
	Autumn 2017	Session 2	14.17	6.91	182	1.5	65.03
	Spring 2017	Session 1	19.14	6.31	183	2.2	79.64
	Spring 2017	Session 2	16.35	5.92	207	1.8	22.44
	Autumn 2018	Session 1	19.2	6.03	241.3	0.5	41.22
	Autumn 2018	Session 2	13.6	5.74	112	22	44.61
	Spring 2018	Session 1	13.6	6.32	163.4	0.9	63.07
	Spring 2018	Session 2	19.7	6.19	214.4	NA	65.2

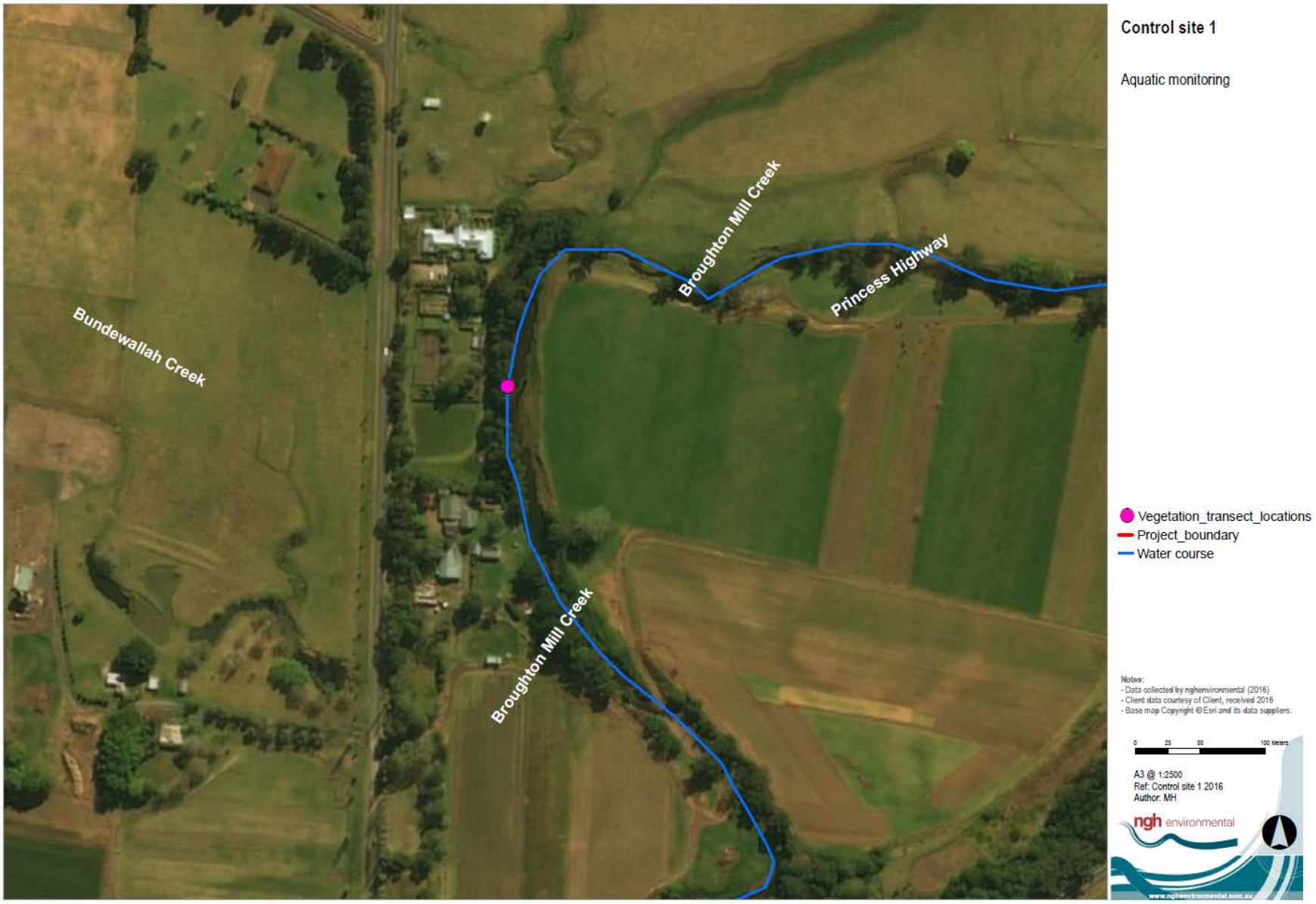
APPENDIX C SITE LOCATIONS


Site 16
Aquatic monitoring
Broughton Creek
Vegetation transect locations
Project_boundary
Water course
Notes:
- Data collected by nghenvironmental (2016)
- Client data courtesy of Client, received 2016
- Base map Copyright © Esri and its data suppliers.
0
37.5
75
150 Meters
A3 @ 1:3000
Ref: Site 16 2016
Author: MH
ngh environmental
www.nghenvironmental.com.au


Site 17
Aquatic monitoring
Broughton Creek
Vegetation transect locations
Project_boundary
Water course
Notes:
- Data collected by nghenvironmental (2016)
- Client data courtesy of Client, received 2016
- Base map Copyright © Esri and its data suppliers.
0 37.5 75 150 Meters
A3 @ 1:4000
Ref: Site 17 2016
Author: MH
ngh environmental
www.nghenvironmental.com.au


Site 22
Aquatic monitoring
Bundewallah Creek
Rawlings Lane
Vegetation transect locations
Project_boundary
Watercourse
Notes:
- Data collected by nghenvironmental (2016)
- Client data courtesy of Client, received 2016
- Base map Copyright © Esri and its data suppliers.
0
50
100
200 Meters
A3 @ 1:4000
Ref: Site 22 2016
Author: MH
ngh environmental
www.nghenvironmental.com.au


Site 25 & 27
Aquatic monitoring
Site 27 transect
Site 25 transect
Bundewallah Creek
Broughton Mill Creek
Broughton Mill Creek
Princess Highway
Vegetation_transect_locations
Project_boundary
Water course
Notes:
- Data collected by nghenvironmental (2016)
- Client data courtesy of Client, received 2016
- Base map Copyright © Esri and its data suppliers.
0 25 50 100 Meters
A3 @ 1:2500
Ref: Site 25 & 27 2016
Author: MH
ngh environmental
www.nghenvironmental.com.au


Control site 1
Aquatic monitoring
Bundewallah Creek
Broughton Mill Creek
Princess Highway
Broughton Mill Creek
Vegetation_transect_locations
Project_boundary
Water course
Notes:
- Data collected by nghenvironmental (2016)
- Client data courtesy of Client, received 2016
- Base map Copyright © Esri and its data suppliers.
0 25 50 100 Meters
A3 @ 1:2500
Ref: Control site 1 2016
Author: MH
ngh environmental


Princess Highway
Broughton Creek
Control site 2
Aquatic monitoring
Vegetation transect locations
Project_boundary
Water course
Notes:
- Data collected by nghenvironmental (2016)
- Client data courtesy of Client, received 2016
- Base map Copyright © Esri and its data suppliers.
0 37.5 75 150 Meters
A3 @ 1:4000
Ref: Control site 2 2016
Author: MH
ngh environmental

APPENDIX D MACROINVERTEBRATE DATA

D.1 APRIL 2018 (AUTUMN SESSION 1)

	SITE	Ctrl 1	Ctrl 1	Ctrl 2	Ctrl 2	Site 13	Site 13	Site 16	Site 16	Site 17	Site 17	Site 22	Site 22	Site 25	Site 25	Site 27	Site 27
	HABITAT	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle
	DATE	17/04/2018	17/04/2018	17/04/2018	17/04/2018	18/04/2018	18/04/2018	17/04/2018	17/04/2018	18/04/2018	18/04/2018	17/04/2018	17/04/2018	16/04/2018	16/04/2018	16/04/2018	16/04/2018
GROUP/ORDER	FAMILY																
Acarina	Arrenuridae	1												1		5	
Acarina	Hydrachnidae			2													
Acarina	Hygrobatidae	2	4									1		13	6	42	13
Acarina	Momoniidae															10	
Acarina	Oxidae											1		1	1		
Acarina	Pionidae		1										2				
Acarina	Unionicolidae	3	2	9		7				1		1		12	2	13	2
Amphipoda	Talitridae (not aquatic)																
Coleoptera	Dytiscidae	1	2			6		3		11		8			1	2	
Coleoptera	Elmidae	1			1	2	4		1						17	1	
Coleoptera	Hydraenidae													2			
Coleoptera	Hydrophilidae							1		6							
Coleoptera	Psephenidae										1						
Coleoptera	Scirtidae				1			1					1	5			2
Collembola	Isotomatidae																1

	SITE	Ctrl 1	Ctrl 1	Ctrl 2	Ctrl 2	Site 13	Site 13	Site 16	Site 16	Site 17	Site 17	Site 22	Site 22	Site 25	Site 25	Site 27	Site 27
	HABITAT	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle
	DATE	17/04/2018	17/04/2018	17/04/2018	17/04/2018	18/04/2018	18/04/2018	17/04/2018	17/04/2018	18/04/2018	18/04/2018	17/04/2018	17/04/2018	16/04/2018	16/04/2018	16/04/2018	16/04/2018
Decapoda	Atyidae	20	1	3	3	3	1	13	34	14		6		1	4	7	3
Decapoda	immature specimen																
Diptera	Ceratopgonidae															1	
Diptera	Chironomid pupa	1		1	1			2				1			2		3
Diptera	Chironomidae, Chironominae				2	2		1			4	8	47	1		20	31
Diptera	Chironomidae, Orthocladinae				11		3				5		1	1	14		16
Diptera	Chironomidae, Tanypodinae	1	1	1	1											4	2
Diptera	Culicidae	1		3						1							1
Diptera	Sciomyzidae																1
Diptera	Simuliidae								1						34		
Diptera	Stratiomyidae																
Diptera	Tipulidae										1						
Ephemeroptera	Baetidae		9	12	5	4	10	5	31	20	7	6			26	4	4
Ephemeroptera	Caenidae				2		2		4		4				1		
Ephemeroptera	Leptophlebidae			9	4	8	2	3	6	11	6		3		3	6	4

	SITE	Ctrl 1	Ctrl 1	Ctrl 2	Ctrl 2	Site 13	Site 13	Site 16	Site 16	Site 17	Site 17	Site 22	Site 22	Site 25	Site 25	Site 27	Site 27
	HABITAT	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle
	DATE	17/04/2018	17/04/2018	17/04/2018	17/04/2018	18/04/2018	18/04/2018	17/04/2018	17/04/2018	18/04/2018	18/04/2018	17/04/2018	17/04/2018	16/04/2018	16/04/2018	16/04/2018	16/04/2018
Gastropoda	Lymnaeidae															1	1
Gastropoda	Physidae	3		2	1			2			2			1			
Gastropoda	Planorbidae									1							
Hemiptera	Corixidae																
Hemiptera	Corixidae/Micronectidae juv.			3		3		4		6		4				29	10
Hemiptera	Gerridae	1	1	2				2									
Hemiptera	Hydrometridae																
Hemiptera	Micronectidae							1		11						5	2
Hemiptera	Notonectidae																
Hemiptera	Veliidae	18		1	2	5	1	6	7	3	2	1	2	34	1		1
Hirudinea	Glossiphoniidae		1														
Lepidoptera	Pyralidae																
Megaloptera	Corydalidae							1			1				1		
Megaloptera	Sialidae			1		2								1			
Nematoda															1		

	SITE	Ctrl 1	Ctrl 1	Ctrl 2	Ctrl 2	Site 13	Site 13	Site 16	Site 16	Site 17	Site 17	Site 22	Site 22	Site 25	Site 25	Site 27	Site 27
	HABITAT	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle
	DATE	17/04/2018	17/04/2018	17/04/2018	17/04/2018	18/04/2018	18/04/2018	17/04/2018	17/04/2018	18/04/2018	18/04/2018	17/04/2018	17/04/2018	16/04/2018	16/04/2018	16/04/2018	16/04/2018
Odonata	Coenagrionidae	18		1						1		2		6		3	
Odonata	Corduliidae	1												3		3	
Odonata	immature Epiprocta							1								2	
Odonata	immature Zygoptera																
Odonata	Isostictidae			1		5											
Odonata	Libellulidae																
Odonata	Synlestidae																
Oligochaeta	Lumbriculidae				1		2				1						
Oligochaeta	Naididae		1		1							1		1	2		2
Oligochaeta	Opisthopora												3				
Platyhelminthes	Dugesiidae		1			1				1				1	1	4	1
Plecoptera	Gripopterygidae				3		4		2	1	3		1				11
Trichoptera	Atriplectidae					1											
Trichoptera	Conoesucidae																
Trichoptera	Ecnomidae							1	2					1	3		
Trichoptera	Hydropsychidae			8	43	1	30		37	5	21				23		5

	SITE	Ctrl 1	Ctrl 1	Ctrl 2	Ctrl 2	Site 13	Site 13	Site 16	Site 16	Site 17	Site 17	Site 22	Site 22	Site 25	Site 25	Site 27	Site 27
	HABITAT	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle
	DATE	17/04/2018	17/04/2018	17/04/2018	17/04/2018	18/04/2018	18/04/2018	17/04/2018	17/04/2018	18/04/2018	18/04/2018	17/04/2018	17/04/2018	16/04/2018	16/04/2018	16/04/2018	16/04/2018
Trichoptera	Hydroptilidae							1							2	1	4
Trichoptera	Leptoceridae		2	13	2	11	1	3	4	1	3	3		1			1
Trichoptera	Philopotamidae						4		1		3						1

D.2 JUNE 2018 (AUTUMN SESSION 2)

	SITE	Ctrl 1	Ctrl 1	Ctrl 2	Ctrl 2	Site 13	Site 13	Site 16	Site 16	Site 17	Site 17	Site 22	Site 22	Site 25	Site 25	Site 27	Site 27
	HABITAT	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle
	DATE	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	5/06/2018	5/06/2018	5/06/2018	5/06/2018
GROUP/ORDER	FAMILY																
Acarina	Arrenuridae																
Acarina	Hydrachnidae		4										1				
Acarina	Hygrobatidae		2				3	5		18						3	1
Acarina	Momoniidae																
Acarina	Oxidae																
Acarina	Pionidae		1										1			2	
Acarina	Unionicolidae	5						5					1			2	
Amphipoda	Talitridae (not aquatic)			1		2	1										
Coleoptera	Dytiscidae			2	1		1			4		2			2	1	
Coleoptera	Elmidae																
Coleoptera	Hydraenidae									1							
Coleoptera	Hydrophilidae			5		1	1			1							

	SITE	Ctrl 1	Ctrl 1	Ctrl 2	Ctrl 2	Site 13	Site 13	Site 16	Site 16	Site 17	Site 17	Site 22	Site 22	Site 25	Site 25	Site 27	Site 27
	HABITAT	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle
	DATE	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	5/06/2018	5/06/2018	5/06/2018	5/06/2018
Coleoptera	Psephenidae								1								
Coleoptera	Scirtidae					1	1						10			1	3
Collembola	Isotomatidae																
Decapoda	Atyidae	4	1	18	8	39	4	3	1	53	6	1	6	1	1		
Decapoda	immature specimen											1					
Diptera	Ceratopgonidae		1														
Diptera	Chironomid pupa	1			1					1		1	4				
Diptera	Chironomidae, Chironominae	2	1				6		1		7	1	16	1		1	2
Diptera	Chironomidae, Orthocladinae													1			
Diptera	Chironomidae, Tanypodinae						1		1	1						1	
Diptera	Culicidae	2				3	1										
Diptera	Sciomyzidae						1						1				
Diptera	Simuliidae																

	SITE	Ctrl 1	Ctrl 1	Ctrl 2	Ctrl 2	Site 13	Site 13	Site 16	Site 16	Site 17	Site 17	Site 22	Site 22	Site 25	Site 25	Site 27	Site 27
	HABITAT	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle
	DATE	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	5/06/2018	5/06/2018	5/06/2018	5/06/2018
Diptera	Stratiomyidae							1									
Diptera	Tipulidae						4										
Ephemeroptera	Baetidae	2	16	5	4	3	11		3	6	2	3		2	2	4	4
Ephemeroptera	Caenidae					1	1		2		4						
Ephemeroptera	Leptophlebidae	1		8	17		2	1	28	7	9		4		1	1	1
Gastropoda	Lymnaeidae					1				1			2				
Gastropoda	Physidae	1											8				
Gastropoda	Planorbidae																
Hemiptera	Corixidae											3	2				
Hemiptera	Corixidae/Micronectidae juv.		1	1			1	1		7		7					
Hemiptera	Gerridae							1		13	4						
Hemiptera	Hydrometridae														1		
Hemiptera	Micronectidae		3	7		19	1			27	1				2		27

	SITE	Ctrl 1	Ctrl 1	Ctrl 2	Ctrl 2	Site 13	Site 13	Site 16	Site 16	Site 17	Site 17	Site 22	Site 22	Site 25	Site 25	Site 27	Site 27
	HABITAT	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle
	DATE	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	5/06/2018	5/06/2018	5/06/2018	5/06/2018
Hemiptera	Notonectidae									1							
Hemiptera	Veliidae			2				2					1		8	3	
Hirudinea	Glossiphoniidae																
Lepidoptera	Pyralidae		1			1											
Megaloptera	Corydalidae								3								
Megaloptera	Sialidae																
Nematoda																	
Odonata	Coenagrionidae	10					1					1			6	3	
Odonata	Corduliidae																
Odonata	immature Epiprocta																
Odonata	immature Zygoptera	1															
Odonata	Isostictidae																
Odonata	Libellulidae															1	

	SITE	Ctrl 1	Ctrl 1	Ctrl 2	Ctrl 2	Site 13	Site 13	Site 16	Site 16	Site 17	Site 17	Site 22	Site 22	Site 25	Site 25	Site 27	Site 27
	HABITAT	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle
	DATE	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	6/06/2018	5/06/2018	5/06/2018	5/06/2018	5/06/2018
Odonata	Synlestidae							1									
Oligochaeta	Lumbriculidae	2	1	1			2		11			2	1				
Oligochaeta	Naididae	2							2			1			3		
Oligochaeta	Opisthopora								5								
Platyhelminthes	Dugesiidae															2	1
Plecoptera	Gripopterygidae								1								
Trichoptera	Atriplectidae																
Trichoptera	Conoesucidae												1				
Trichoptera	Ecnomidae								6		1			8	1		3
Trichoptera	Hydropsychidae		1		1		1		9		9			1			
Trichoptera	Hydroptilidae								1								
Trichoptera	Leptoceridae		2	3				9	1	10			2		2		
Trichoptera	Philopotamidae								3								

D.3 SEPTEMBER 2018 (SPRING SESSION 1)

	SITE	Ctrl 1	Ctrl 1	Ctrl 2	Ctrl 2	Site 13	Site 13	Site 16	Site 16	Site 17	Site 17	Site 22	Site 22	Site 25	Site 25	Site 27	Site 27
	HABITAT	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle
	DATE	25/09/2018	25/09/2018	25/09/2018	25/09/2018	26/09/2018	26/09/2018	26/09/2018	26/09/2018	24/09/2018	24/09/2018	24/09/2018	24/09/2018	25/09/2018	25/09/2018	25/09/2018	25/09/2018
GROUP/ORDER	FAMILY																
Acarina	Hygrobatidae	1		1			1			3			1	3	10	4	5
Acarina	Limnesiidae								1								
Acarina	Oxidae		5					1			1				1		1
Acarina	Pionidae		1													1	
Acarina	Trombidiidae							1									
Acarina	Unionicolidae	3	5	1		5		2	1	1				2	4	4	5
Coleoptera	Dytiscidae	3	5	1				2	1	4		1	1				
Coleoptera	Hydrophilidae		1														
Coleoptera	Scirtidae													1		3	1
Decapoda	Atyidae	4	3	7	4	2	3	19	6	1	1				1		1
Diptera	Ceratopgonidae	1												1		1	1
Diptera	Chironomid pupa		1		1			2		1		1					
Diptera	Chironomidae, Chironominae		2			1				1					1	1	1
Diptera	Chironomidae, Tanypodinae				1					1	1				1		
Diptera	Culicidae	5				3		5		13				2			1

	SITE	Ctrl 1	Ctrl 1	Ctrl 2	Ctrl 2	Site 13	Site 13	Site 16	Site 16	Site 17	Site 17	Site 22	Site 22	Site 25	Site 25	Site 27	Site 27
	HABITAT	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle
	DATE	25/09/2018	25/09/2018	25/09/2018	25/09/2018	26/09/2018	26/09/2018	26/09/2018	26/09/2018	24/09/2018	24/09/2018	24/09/2018	24/09/2018	25/09/2018	25/09/2018	25/09/2018	25/09/2018
Ephemeroptera	Baetidae	1	16	4	11	7		2	3	1	2	4		1	1		3
Ephemeroptera	Caenidae	1	1	1	7	3		4	1		4				1		
Ephemeroptera	Leptophlebidae	2	2	2	2	4	11	4	8	7							
Gastropoda	Lymnaeidae									1							
Gastropoda	Physidae									3							
Hemiptera	Corixidae												1				
Hemiptera	Corixidae/Micronectidae juv.			2	1	1	25	1		1							1
Hemiptera	Gelastocoridae															1	
Hemiptera	Gerridae			4		1				2							
Hemiptera	Micronectidae					1	47		1		3	3	22				5
Hemiptera	Pleidae	3						2									
Hemiptera	Veliidae	1			1					2	1			2		4	
Hirudinea	Erpobdellidae	1								1							
Hirudinea	Glossiphoniidae									1							
Megaloptera	Corydalidae							1									

	SITE	Ctrl 1	Ctrl 1	Ctrl 2	Ctrl 2	Site 13	Site 13	Site 16	Site 16	Site 17	Site 17	Site 22	Site 22	Site 25	Site 25	Site 27	Site 27
	HABITAT	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle
	DATE	25/09/2018	25/09/2018	25/09/2018	25/09/2018	26/09/2018	26/09/2018	26/09/2018	26/09/2018	24/09/2018	24/09/2018	24/09/2018	24/09/2018	25/09/2018	25/09/2018	25/09/2018	25/09/2018
Odonata	Coenagrionidae	7	8											5			2
Odonata	Isostictidae			1													1
Odonata	Megapodagrionidae									1							
Odonata	Synlestidae	1															
Oligochaeta	Lumbriculidae								4								
Oligochaeta	Naididae								1								
Plecoptera	Gripopterygidae								3								
Trichoptera	Calamoceratidae			1													
Trichoptera	Ecnomidae				1				1		2				1		
Trichoptera	Hydropsychidae				1				1						1		
Trichoptera	Leptoceridae	3	2	4		6	1	3	1	10	1						

D.4 NOVEMBER 2018 (SPRING SESSION 2)

	SITE	Ctrl 1	Ctrl 1	Ctrl 2	Ctrl 2	Site 13	Site 13	Site 16	Site 16	Site 17	Site 17	Site 22	Site 22	Site 25	Site 25	Site 27	Site 27
	HABITAT	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle
	DATE	22/11/2018	22/11/2018	21/11/2018	21/11/2018	21/11/2018	21/11/2018	21/11/2018	21/11/2018	22/11/2018	22/11/2018	20/11/2018	20/11/2018	20/11/2018	20/11/2018	20/11/2018	20/11/2018
GROUP/ORDER	FAMILY																
Acarina	Hygrobatidae	1			2			5	5		8	8		4			
Acarina	Limnesiidae																
Acarina	Oxidae		2									2		3		1	
Acarina	Pionidae													5		5	
Acarina	Trombidiidae																
Acarina	Unionicolidae	3	2					2						11		1	
Coleoptera	Dytiscidae		4					4		1	2	6				1	
Coleoptera	Elmidae				1												
Coleoptera	Hydraenidae				1												
Coleoptera	Hydrophilidae		1														
Coleoptera	Psphenidae										1						
Coleoptera	Scirtidae													1			
Decapoda	Atyidae	5					1	6		2	4	1		2	5		
Diptera	Ceratopgonidae																1
Diptera	Chironomid pupa		1									1					
Diptera	Chironomidae, Chironominae		12		1		5	10	8	1	6	4	2		4	7	2

	SITE	Ctrl 1	Ctrl 1	Ctrl 2	Ctrl 2	Site 13	Site 13	Site 16	Site 16	Site 17	Site 17	Site 22	Site 22	Site 25	Site 25	Site 27	Site 27
	HABITAT	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle
	DATE	22/11/2018	22/11/2018	21/11/2018	21/11/2018	21/11/2018	21/11/2018	21/11/2018	21/11/2018	22/11/2018	22/11/2018	20/11/2018	20/11/2018	20/11/2018	20/11/2018	20/11/2018	20/11/2018
Diptera	Chironomidae, Orthocladinae		1				3		2								
Diptera	Chironomidae, Tanypodinae		3														
Diptera	Culicidae		1								1	4		1		2	
Diptera	Dixidae										1						
Diptera	Simulidae														2		
Diptera	Stratiomyidae													1			
Ephemeroptera	Baetidae	2	5	4	7		6	2		1			1	3			
Ephemeroptera	Caenidae			2	1		2		3		1						
Ephemeroptera	Leptophlebidae	1		11	3	1		5	11	5	1			1	1		
Gastropoda	Lymnaeidae			1										1			
Gastropoda	Physidae		1							1		1	5				
Hemiptera	Corixidae							2				2	7				
Hemiptera	Corixidae/Micronectidae juv.		4	4	3			23	6	16	16	5	114				14
Hemiptera	Gelastocoridae																1
Hemiptera	Gerridae										1						
Hemiptera	Micronectidae		1	5	4			22	1	1	1		8				

	SITE	Ctrl 1	Ctrl 1	Ctrl 2	Ctrl 2	Site 13	Site 13	Site 16	Site 16	Site 17	Site 17	Site 22	Site 22	Site 25	Site 25	Site 27	Site 27
	HABITAT	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle
	DATE	22/11/2018	22/11/2018	21/11/2018	21/11/2018	21/11/2018	21/11/2018	21/11/2018	21/11/2018	22/11/2018	22/11/2018	20/11/2018	20/11/2018	20/11/2018	20/11/2018	20/11/2018	20/11/2018
Hemiptera	Notonectidae									1			1				
Hemiptera	Pleidae																
Hemiptera	Veliidae	1	4			7		2		2	2	5	1	6		1	2
Hirudinea	Erpobdellidae											1					
Hirudinea	Glossiphoniidae																
Lepidoptera	Pyralidae													1		1	
Megaloptera	Corydalidae																
Odonata	Aeshnidae															1	
Odonata	Coenagrionidae	1												4		1	
Odonata	Gomphidae								1								
Odonata	Isostictidae									1							
Odonata	Libellulidae															1	
Odonata	Megapodagrionidae																
Odonata	Synlestidae								1								
Oligochaeta	Lumbriculidae								1			1					
Oligochaeta	Naididae																
Platyhelminthes	Dugesiidae															1	
Plecoptera	Gripopterygidae							1	1			1					7

	SITE	Ctrl 1	Ctrl 1	Ctrl 2	Ctrl 2	Site 13	Site 13	Site 16	Site 16	Site 17	Site 17	Site 22	Site 22	Site 25	Site 25	Site 27	Site 27
	HABITAT	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle	Edge	Riffle
	DATE	22/11/2018	22/11/2018	21/11/2018	21/11/2018	21/11/2018	21/11/2018	21/11/2018	21/11/2018	22/11/2018	22/11/2018	20/11/2018	20/11/2018	20/11/2018	20/11/2018	20/11/2018	20/11/2018
Trichoptera	Calamoceratidae																
Trichoptera	Ecnomidae				1				3		2						
Trichoptera	Hydrobiosidae						2										
Trichoptera	Hydropsychidae						1		1							1	
Trichoptera	Leptoceridae	2	7	5				3	8	1	4			1			
Trichoptera	Philopotamidae						1		2								1

APPENDIX E FISH AND OTHER FAUNA

			2016						2017								2018							
		Taxa	Site 13	Site 16	Site 17	Site 22	Site 25	Site 27	Site 13	Site 16	Site 17	Site 22	Site 25	Site 27	CS1	CS2	Site 13	Site 16	Site 17	Site 22	Site 25	Site 27	CS1	CS2
Preconstruction	Spring session 1	*Atherinosoma microstoma* Small-mouthed Hardyhead	0	0	0	0	0	0							0	0	0	0	0	0	0	0	0	0
		Gobiomorphus coxii Cox's Gudgeon	0	0	0	0	0	0							0	0	0	0	0	0	0	0	0	0
		Hypseleotris galli Firetail Gudgeon	0	0	0	0	0	0							0	0	0	0	0	0	0	0	0	0

			2016						2017								2018							
		Taxa	**Site 13**	**Site 16**	**Site 17**	**Site 22**	**Site 25**	**Site 27**	**Site 13**	**Site 16**	**Site 17**	**Site 22**	**Site 25**	**Site 27**	**CS1**	**CS2**	**Site 13**	**Site 16**	**Site 17**	**Site 22**	**Site 25**	**Site 27**	**CS1**	**CS2**
		Macquaria novemaculeata Australian Bass	0	0	0	0	0	0							0	0	0	0	0	0	0	0	0	0
	Spring session 2	*Anguilla australis* Short-finned Eel	0	0	0	0	0	0							0	0	0	0	0	0	0	0	0	0
		Atherinosoma microstoma Small-mouthed Hardyhead	0	0	0	0	0	0							0	0	0	0	0	0	0	0	0	0

			2016						2017								2018							
		Taxa	**Site 13**	**Site 16**	**Site 17**	**Site 22**	**Site 25**	**Site 27**	**Site 13**	**Site 16**	**Site 17**	**Site 22**	**Site 25**	**Site 27**	**CS1**	**CS2**	**Site 13**	**Site 16**	**Site 17**	**Site 22**	**Site 25**	**Site 27**	**CS1**	**CS2**
		Gobiomorphus coxii Cox's Gudgeon	0	0	0	0	0	0							0	0	0	0	0	0	0	0	0	0
		Macquaria novemaculeata Australian Bass	0	0	0	0	0	0							0	0	0	0	0	0	0	0	0	0
Construction	Autumn Session 1	*Macquaria novemaculeata* Australian bass	0	0	0	0	3	0							0	0	0	0	0	0	0	0	0	0

			2016						2017								2018							
		Taxa	Site 13	Site 16	Site 17	Site 22	Site 25	Site 27	Site 13	Site 16	Site 17	Site 22	Site 25	Site 27	CS1	CS2	Site 13	Site 16	Site 17	Site 22	Site 25	Site 27	CS1	CS2
		Gobiomorphus australis Striped gudgeon	0	0	1	2	1	1							0	0	0	0	0	0	0	0	0	0
		Philypnodon grandiceps Flathead gudgeon	0	0	0	0	0	0							0	0	0	0	0	0	0	0	0	0
	Autumn Session 2	*Gobiomorphus australis* Striped gudgeon	0	0	0	0	0	0							0	0	0	0	0	0	0	0	0	0

			2016						2017								2018							
		Taxa	**Site 13**	**Site 16**	**Site 17**	**Site 22**	**Site 25**	**Site 27**	**Site 13**	**Site 16**	**Site 17**	**Site 22**	**Site 25**	**Site 27**	**CS1**	**CS2**	**Site 13**	**Site 16**	**Site 17**	**Site 22**	**Site 25**	**Site 27**	**CS1**	**CS2**
	Spring session 1	*Macquaria novemaculeata* Australian bass	0	0	0	0	0	0							0	0	0	0	0	0	0	0	0	0
		Gobiomorphus australis Striped gudgeon	0	0	0	2	0	3							0	0	0	0	0	0	0	0	0	0
		Philypnodon grandiceps Flathead gudgeon	1	1	0	0	1	0							0	0	0	0	0	0	0	0	0	0

			2016						2017								2018							
		Taxa	Site 13	Site 16	Site 17	Site 22	Site 25	Site 27	Site 13	Site 16	Site 17	Site 22	Site 25	Site 27	CS1	CS2	Site 13	Site 16	Site 17	Site 22	Site 25	Site 27	CS1	CS2
		Anguilla australis Short finned eel	0	0	0	0	0	1							1	1	0	0	0	0	0	0	0	0
	Spring session 2	*Macquaria novemaculeata* Australian bass	0	0	2	0	2	0							1	0	0	0	0	0	0	0	0	0
	Spring session 2	*Gobiomorphus australis* Striped gudgeon	3	0	1	2	1	1							1	0	0	0	0	0	0	0	0	0

			2016						2017								2018							
		Taxa	**Site 13**	**Site 16**	**Site 17**	**Site 22**	**Site 25**	**Site 27**	**Site 13**	**Site 16**	**Site 17**	**Site 22**	**Site 25**	**Site 27**	**CS1**	**CS2**	**Site 13**	**Site 16**	**Site 17**	**Site 22**	**Site 25**	**Site 27**	**CS1**	**CS2**
		Anguilla australis Short finned eel	0	0	0	0	0	0							2	0	0	0	0	0	0	0	0	0
		Gobiomorphus coxii Cox's Gudgeon	0	0	0	0	0	0							0	0	0	0	0	0	0	0	0	0
		Philypnodon grandiceps Flathead gudgeon	0	1	1	0	1	0							0	0	0	0	0	0	0	0	0	0

			2016						2017								2018							
		Taxa	**Site 13**	**Site 16**	**Site 17**	**Site 22**	**Site 25**	**Site 27**	**Site 13**	**Site 16**	**Site 17**	**Site 22**	**Site 25**	**Site 27**	**CS1**	**CS2**	**Site 13**	**Site 16**	**Site 17**	**Site 22**	**Site 25**	**Site 27**	**CS1**	**CS2**
		Atherinosoma microstoma Small-mouthed Hardyhead	0	0	0	0	0	1							0	0	0	0	0	0	0	0	0	0