ENVIRONMENTAL MONITORING ANNUAL REPORT

PREPARED FOR T&T LANDFILL LTD.

July 2019

Stantec

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QUALITY STATEMENT

PROJECT MANAGER	PROJECT TECHNICAL LEAD
Tom Kerr	David Cameron

PREPARED BY		
Julia O'Brien		14/08/2019
CHECKED BY		
Amanda O'Brien		14/08/2019
REVIEWED BY		
David Cameron		14/08/2019
APPROVED FOR ISSUE BY		
David Cameron		14/08/2019

WELLINGTON
Level 13, 80 The Terrace, Wellington 6011
PO Box 13-052, Armagh, Christchurch 8141
TEL +64 4 381 6700

T&T Landfill Ltd.

Environmental Monitoring Annual Report

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1. Introduction

T&T Landfills Ltd. holds a resource consent for the discharge of contaminants to a tributary of the Owhiro Stream. Condition 9 of the discharge permit WGN070260 [30627] (attached in full as Appendix A) states that:

"*The permit holder shall ensure that a person suitably qualified to the satisfaction of the Manager, Environmental Regulation, Wellington Regional Council prepares and submits a report by 30 June each year detailing the items required by conditions 6 and 7 and the approved DMP.*

The report shall include, but not be limited to:

- The results and comparison of the contaminants sampled for with the relevant limits approved under the Discharge Management Plan (DMP) and condition 8 of the consent.
- A comparison of the concentration of contaminants of the latest year of sampling with the baseline ecology survey results as required by condition 12 of the discharge permit to determine whether there may have been a degradation in the quality of the aquatic ecosystem as a result of the discharge.
- Any other relevant information; and
- Any recommendations for approval to the Manager, Environmental Regulation, Wellington Regional Council to remedy or mitigate any significant adverse effects that have occurred, or to avoid unforeseen significant adverse effects as a result of the discharge of contaminants from the landfill area to the tributaries of Owhiro Stream. Examples of these could be:
    - Changes to the management or site protocols;
    - Methods to remedy adverse effects that may have been transported into the Owhiro Stream catchment; and
    - Mitigation measures to offset or minimize the significant adverse effects."

This report covers monitoring undertaken in the year ending 1 July 2019 (note, the requirement to submit this report by the end of June was not achieved because results from the June monitoring round were not received until part way through July).

Conditions 6 details the requirement to provide a DMP, which was approved and subsequently amended in 2012 and again in 2017.

Condition 7 details the minimum groundwater and surface water sampling parameters, timeframes and locations.

2. Adaptive Management Overview

The adaptive management arrangement for surface water samples, as outlined in conditions 8 to 14 of the consent, includes the following steps:

a) Determination, on a quarterly basis, of contaminant levels in surface water of the two tributaries upstream of the landfill at TTE & TTW, and in the combined stream flow downstream of the landfill at TTD, and in Owhiro Stream at OSU and OSD;

b) Comparison of results with ANZECC (2000) trigger values;

c) Determination of contaminant contribution from the landfill;

d) Comparison of that contribution with pre-determined tolerance limits;

e) Identification of any determinant which exceeds both the relevant ANZECC (2000) trigger value at TTD and the relevant tolerance limit;

f) In the event that a result exceeds both a tolerance limit and trigger value, undertake two rounds of follow-up sampling testing (these are called 'Additional Monitoring Rounds');

g) In the event that the average of these two follow-up values continues to exceed the relevant tolerance limit and the ANZECC trigger values the permit holder is required to implement the adaptive management conditions as required by conditions 13 and 14 of the discharge consent.

The adaptive management conditions triggered during the last quarter of 2016 prompted an assessment of the ecological effects of the discharges from the site as stated in Condition 13. This assessment was carried out in 2016 and is discussed in Section 5.

The adaptive management response also included bringing forward construction of stream diversion channels, construction of a treatment wetland, and updating the DMP to provide a stronger focus on wet weather events. The updated DMP (updated 2017) details changes to the monitoring as follows:

- Monthly surface water monitoring for the duration until stream diversion works are operating effectively, quarterly for groundwater. (These are called 'Monthly Monitoring Rounds' and replace the 'Quarterly' and 'Additional Monitoring Rounds' while in place)
- Analysis of both dissolved and total concentrations of surface water metals
- Addition of COD to the suite of parameters analysed.
- Additional surface water monitoring triggered by high rainfall events (>45 mm with 24 hrs at Karori Reservoir)
- A follow up ecological survey during summer once diversion works are complete.

Works to complete a stream diversion and construction of the wetland treatment system (condition 17) had been partially implemented but not completed by the end of June 2019. Currently the channels effectively divert wet weather flows over the landfill but a significant proportion of the dry weather baseflow continues to seep under the landfill and exits out into the wetland. The wetland has been constructed and planted but is assumed incomplete until signed off by Greater Wellington Regional Council. Monthly monitoring will continue until such time as these works have been completed.

An additional trend analysis covering the last three reporting periods (from June 2016) has been included in this report at the request of GWRC and two rounds of sampling within the wetland were completed at the request of T&T Landfill.

3. Water Quality Monitoring Results

3.1 Methods

The routine sampling methodology is described in the Discharge Management Plan (DMP).

3.2 Surface Water Monitoring Results

This annual report covers 12 monthly sampling rounds at five surface water quality monitoring sites, four sampling rounds at one groundwater quality monitoring site. The sampling sites are provided in Appendix B and described as:

- TTW western gully stream (true right branch) at the northern end of the landfill
- TTE eastern gully stream (true left branch) at the northern end of the landfill
- TTD lower stream, 100m downstream from the toe of the landfill
- TTG groundwater bore 100m downstream from the toe of the landfill
- OSU Owhiro Stream upstream of the T&T landfill stream
- OSD Owhiro Stream downstream of the T&T landfill stream

It is noted that sites TTW and TTE are now inundated by ponded water behind constructed dams. Samples were collected at the outlet from the dam overflow structure, or if there is no flow at the outlet, from ponded water.

Figure 3-1 shows when monitoring samples were taken along with the daily rainfall at Karori Reservoir. Most sampling was carried out during dry weather as the rainfall trigger was not reached. The first rainfall trigger was activated in July 2018, however, due to a complication in the alerting system, sampling was not carried out within the 7-day period following rainfall. The next rainfall triggers were reached in March 2019 and April 2019, with successful sampling within the timeframe. A fourth rainfall trigger was reached a few days after sampling in April 2019 however, this was considered to be part of the same weather event as the April event already sampled.

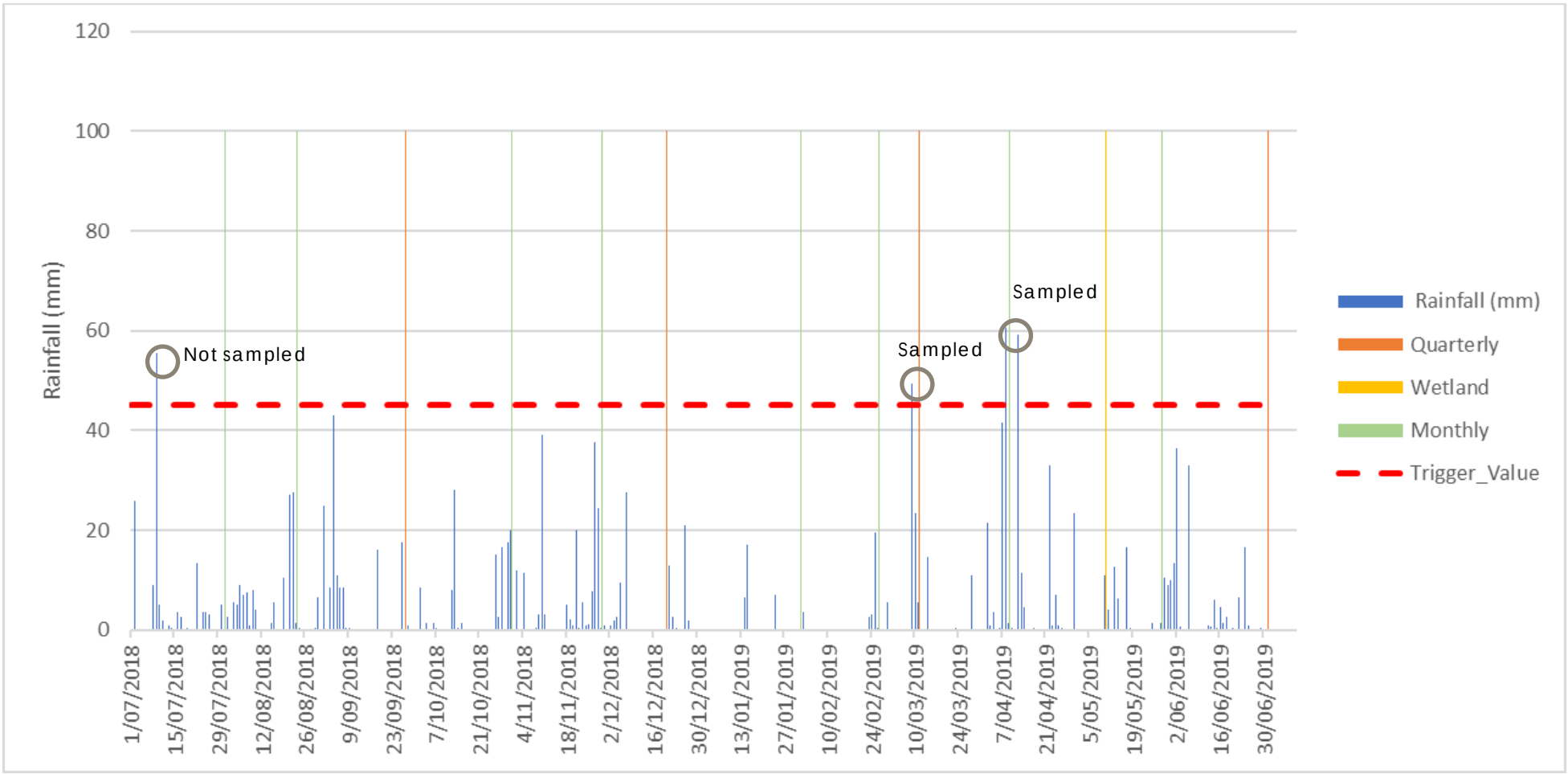

Figure 3-1: Daily rainfall at Karori Reservoir and the types of monitoring from July 2018 to July 2019. Vertical bars indicated quarterly and monthly sampling events, as well as wetland sampling events. The grey circles represent rainfall triggered sampling.

3.2.1 Surface Water Field Observations

Consent condition 11 states that the discharges shall not give rise to any of the following effects after reasonable mixing:

- The production of conspicuous oil or grease films, scums or foams, or floatable or suspended materials
- Any conspicuous change in colour or visual clarity
- Any emission of objectionable odour
- The rendering of freshwater unsuitable for consumption by farm animals
- Any significant adverse effects on aquatic life; or
- Any visible deposition of iron oxide or other heavy metals

Site photographs, provided in Appendix C, were taken at each site during each monitoring round. A summary of the field observations is noted below, and the field sheets can be found in Appendix D:

- For the entire monitoring period orange precipitate was observed at sites OSD and TTD. The only exception to this was for August, when no orange precipitate was recorded at OSD.
- Cloudy water was noted throughout the monitoring period at the various sites. However, over the last two months, only OSD and TTD were noted with cloudy water.
- Foam was present at TTD throughout the monitoring period, excluding February, December, and August. Occasional foam was present at other sites earlier in the monitoring period though not within the last four months.
- The bore samples at TTG was noted in March and December as having high sediment.
- A green tint in the water was noted at TTW in April.
- Rubbish and odour were observed throughout the reporting period at most sites. The type of odour was specified for OSD in October as 'Chlorine odour', and for TTD, 'metallic' in January, 'landfill' in August, and 'organic' in July.

Significant adverse effects on aquatic life were not specifically tested during the reporting period, however, are discussed in Section 5.

The ANZECC 2000 recommendations for water quality trigger values for heavy metals and metalloids in livestock drinking water and ANZECC 2000 recommendations for major ions of concern for livestock (total dissolved solids and dissolved magnesium) were used to identify risk of consumption by farm animals. No sampling round, for any site, exhibited concentrations that rendered the freshwater unsuitable for consumption by farm animals (Table 3-1).

Table 3-1: ANZECC 2000 recommendations for water quality trigger values for livestock drinking water (green tick indicates acceptable).

Determinant	Trigger value (mg/L)	30/07/2018	23/08/2018	27/09/2018	31/10/2018	29/11/2018	20/12/2018	01/02/2019	26/02/2019	11/03/2019	09/04/2019	28/05/2019	01/07/2019
Dissolved Arsenic	0.5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dissolved Cadmium	0.01	Not sampled	Not sampled	Not sampled	Not sampled	Not sampled	Not sampled	Not sampled	Not sampled	Not sampled	Not sampled	Not sampled	Not sampled
Dissolved Copper[1]	0.4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dissolved Iron	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dissolved Lead	0.1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dissolved Manganese	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dissolved Zinc	20	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
TDS[2]	2000	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dissolved Magnesium	2000	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

[1] Most conservative tolerance - Sheep

[2] Using electrical conductivity (µS/cm *0.67). Most conservative tolerance – Poultry: No adverse effects on animals expected between 0 and limit.

The development of a conspicuous orange colouration in the pond (now constructed wetland) at the toe of the landfill and in the stream further downstream has been evident since approximately 2009 and has continued through the current reporting period.

The orange colouration is caused by elevated concentrations of iron and/or manganese in stream water below the landfill leading to precipitation of iron floc. An iron oxide-accumulating bacterium (*Leptothrix*) facilitates the precipitation of iron floc and formation of the gelatinous masses observed in the stream.

Leptothrix are non-disease producing bacteria which commonly colonise the transition zone where deoxygenated water from an anaerobic environment flows into an aerobic environment, i.e., where the stream emerges at the surface after passing more than 1km under the landfill. The area affected by iron floc became extensive during 2009 and 2010, probably indicating the onset of anoxic conditions in the landfill at that time.

Visible deposition of iron oxide was noted throughout most of the reporting period at TTD (100 m downstream of the landfill) and further downstream at OSD. Table 3-2 details the stream bed at TTD during each of the sampling periods. No orange precipitation was present at OSD during the August 2018 sampling round. The requirement of Consent Condition 11 that the discharge shall cause no "*visible deposition of iron oxide or other heavy metals*" has not been consistently achieved during this reporting period.

Should any of the effects in Condition 11 occur, the permit holder shall commission an updated DMP exploring the relevant methodologies as require by condition 6. Accordingly, the DMP was updated and put into action in September 2017.

Table 3-2: Visual deposition of iron oxide at TTD over the reporting period.

Date/Assessment	Photo
July 2018 Orange/brown precipitate on stream bed	
August 2018 Orange/brown precipitate on bed	
September 2018 Orange/brown precipitate on bed	

October 2018 Orange/brown precipitate on stream bed. Middle of bed clear of precipitate.	
November 2018	No Image
December 2018 Orange/brown precipitate on bed	
January 2019 Dark brown, orange at edge of stream	
February 2019 Muted orange precipitate	
March 2019 Strong orange precipitate. Less orange at OSD	

April 2019	
May 2019	
June 2019	

3.3 Comparison with Tolerance Limits and Trigger Values

3.3.1 Tolerance limits

The eastern and western branches of the T&T gully are each drained by headwater streams which have historically joined beneath the landfill, flowing out from the toe of the landfill as a single watercourse above the sampling site known as TTD. The two gullies are now dammed upstream of the landfill so as to divert surface water into constructed channels which run across the surface of the landfill re-joining the stream downstream of landfill and constructed wetland, approximately 80m upstream of TTD.

Any contamination recorded at TTD is derived from sources upstream of the landfill (measured at TTE and TTW) and from the landfill itself. For each parameter, the contribution derived from the landfill can be calculated by subtracting the average concentration upstream of the landfill from that recorded downstream of the landfill:

$$\text{Contaminant increment from landfill} = TTD - (TTE + TTW)/2$$

The contaminant increments from the landfill were determined from all monitoring rounds (using the total metal concentrations) and are compared against the specified tolerance limits in Table 3-3 below[3].

[3] The tolerance limits are specified in Condition 8 of the discharge permit and have been calculated from monitoring data collected between March 2004 and November 2008, inclusive except for total hardness and total suspended solids (TSS) which were calculated using monitoring data collected between December 2009 and January 2012. These tolerance intervals have been calculated on the difference between the downstream and upstream samples such that they contain 95% of the data distribution with 95% probability. Arsenic and chromium 'tolerance limits' were not derived from previous monitoring results but were arbitrarily selected in the 2011 consent variation.

Total ammoniacal nitrogen, total iron and total manganese exceeded the upper tolerance limit on all twelve sampling occasions. These results indicate that the total ammoniacal nitrogen, total manganese, and total iron contribution from the landfill was high during the 2018/19 year compared with the 2004 to 2008 baseline period.

Alkalinity exceeded the upper tolerance limit for three sampling occasions, and pH was at the limit on two occasions.

3.3.2 Trigger values

Condition 8 of the consent requires that any monitoring result which exceeds a relevant tolerance limit must be compared with 'the latest ANZECC Guidelines for Ecosystem Protection (90%) trigger levels'. Results for all monitoring sites are included in Appendix E and graphed in Appendix F.

Results for site TTD, 100 m downstream of the landfill, are compared against ANZECC (2000) 90% protection default trigger levels and calculated site specific values (Table 3-4). Note that ANZECC provides 90% trigger values only for stressors which are considered to be directly toxic to biota (such as total ammoniacal nitrogen, lead, copper and zinc). Table 3-4 also includes a trigger value for the sum of dissolved iron and manganese recommended by Hickey (2012) to prevent bed smothering.

The results in Table 3-4 show that the trigger value for dissolved iron and manganese was consistently exceeded at site TTD. High concentrations of dissolved iron and/or manganese have resulted in extensive covering of the streambed by an orange coloured precipitate at TTD on most sampling occasions, potentially degrading the habitat of invertebrates and fish.

Table 3-3: Contaminant increments from the landfill compared with specified tolerance limits (exceedances are red).

Parameter	TTD – (TTE + TTW)/2 Results												Lower Tolerance Limit (LTL)	Upper Tolerance Limit (UTL)
	30/07/18	23/08/18	27/09/18	31/10/18	29/11/18	20/12/18	01/02/19	26/02/19	11/03/19	09/04/19	28/05/19	01/07/19		
pH	0.10	0.20	-0.40	-0.15	-0.15	-0.15	-0.15	0.05	0.05	-0.40	-0.05	0.25	-0.4	0.4
Electrical Conductivity (mS/m)	55.10	60.80	50.85	58.25	70.40	54.35	50.10	44.45	56.85	62.20	49.75	52.10		72.4
Alkalinity (g/m^3 $CaCO_3$)	217.00	218.50	209.00	217.50	259.00	220.00	218.50	196.00	224.50	237.00	221.00	226.50		226
Total suspended solids (g/m^3)	8.50	6.00	6.75	13.00	14.50	22.50	10.00	14.50	15.50	14.75	18.25	6.50		32
COD (g O2/m^3)	8	8	5	5	7	11	17	3	7	12	13	8		21
Total Hardness (g/m^3 $CaCO_3$)	253	274	225	257	335	249	233	192	239	298	246	242		465
Total Ammoniacal Nitrogen (g/m^3)	1.01	0.98	0.85	0.69	0.95	1.01	0.56	0.42	0.81	1.05	1.09	1.01		0.346
Total Iron (g/m^3)	3.61	3.76	2.92	4.77	4.88	5.08	4.87	6.74	9.75	7.44	7.36	3.11		2.748
Total Manganese (g/m^3)	2.03	1.94	1.88	1.70	1.98	2.06	2.11	1.81	1.86	1.88	2.43	2.16		1.461
Total Lead (g/m^3)	-0.000250	-0.000530	-0.000005	0.000445	0.000493	0.000243	0.000090	0.000160	0.000135	-0.000315	0.000360	0.000115		0.0059
Total Copper (g/m^3)	0.000000	-0.000490	-0.000143	-0.000163	0.000373	-0.000463	-0.000353	-0.001010	-0.000870	-0.001115	0.000315	-0.000148		0.004
Total Zinc (g/m^3)	0.000900	-0.003900	-0.001450	-0.000550	0.001000	-0.002500	0.000750	0.000250	0.000550	0.019550	-0.000200	-0.002100		0.130
Total Arsenic (g/m^3)	0.001450	0.001325	0.001450	0.001950	0.001750	0.002450	0.002350	0.002250	0.003225	0.002525	0.002650	0.001250		0.013
Total Chromium (g/m^3)	0.000818	0.000663	0.000335	0.000118	0.000923	0.000688	0.000533	0.000160	0.000290	0.000055	0.000565	0.000270		0.001

Table 3-4: Monthly sampling results compared with ANZECC trigger values (exceedances are red).

Parameter	Site TTD												ANZECC 90% TV
	30/07/18	23/08/18	27/09/18	31/10/18	29/11/18	20/12/18	01/02/19	26/02/19	11/03/19	09/04/19	28/05/19	01/07/19	
pH	7.3	7.5	7.3	7.2	7.2	7.4	7.6	7.7	7.3	7.2	7.4	7.5	Not specified
Electrical Conductivity (mS/m)	84.0	83.5	77.4	77.3	91.3	79.0	82.9	71.4	75.7	81.8	79.3	79.1	Not specified
Alkalinity (g/m^3 $CaCO_3$)	260	250	250	250	290	260	270	240	250	260	270	270	Not specified
Total suspended solids (g/m^3)	10.0	14.0	9.0	18.0	16.0	27.0	18.0	27.0	27.0	23.0	19.0	8.0	Not specified
COD (g O2/m^3)	11	16	8	13	15	16	22	8	15	26	23	11	Not specified
Total Hardness (g/m^3 $CaCO_3$)	300	310	270	290	370	290	290	240	270	330	300	290	Not specified
Total Ammoniacal Nitrogen (g/m^3)	1.070	1.000	0.860	0.690	0.960	1.010	0.570	0.540	0.850	1.060	1.130	1.050	2.34[1] (1.43)[2]
Dissolved manganese (g/m^3)	2.200	1.960	1.900	1.790	2.000	2.000	2.300	1.620	1.810	1.950	2.300	2.300	2.5
Dissolved Iron + Manganese (g/m^3)	2.21	1.99	1.92000	1.82000	2.03000	2.03000	2.35000	1.67000	1.85000	1.99000	2.33000	2.33000	1.0[3]
Dissolved Lead (g/m^3)	0.00005	0.00005	0.00005	<0.0001	<0.00010	<0.0001	<0.0001	<0.00010	<0.00010	0.00005	0.00005	0.00005	0.011[1] (0.0056)[2]
Dissolved Copper (g/m^3)	0.00003	0.00003	0.00003	<0.0005	<0.0005	<0.0005	<0.00050	<0.00050	<0.00050	0.00025	0.00025	0.00060	0.0028[1] (0.0018)[2]
Dissolved Zinc (g/m^3)	0.00140	0.00340	0.00180	0.00340	0.00440	<0.0010	<0.0010	0.00150	0.00240	0.00250	0.00110	0.00180	0.027[1] (0.015)[2]
Dissolved Arsenic (g/m^3)	0.00100	0.00050	0.00110	<0.0010	0.00100	0.00110	<0.0010	<0.0010	0.00130	0.00100	0.00140	0.00050	0.042[2]
Dissolved Chromium (g/m^3)	0.00003	0.00050	0.00003	<0.0005	0.00060	<0.0005	<0.0005	<0.0005	<0.0005	0.00060	0.00025	0.00060	0.006[2]

Notes: [1]Calculated site specific 90% protection trigger values based on a methodology from ANZECC 2000: total ammoniacal nitrogen is calculated for pH 7.6 which is the maximum value at TTD; hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 g/m^3 CaCo.

[2]Default 90% protection trigger values from ANZECC (2000)

[3]Hickey (2012) recommended that the sum of dissolved iron and manganese should be below 1.0 g/m^3 to prevent bed smothering

3.3.3 Adaptive management response

If the average of the two recoveries continues to exceed the relevant tolerance limit and TVs, the permit holder is required to implement the adaptive management actions under conditions 13 and 14 of the discharge permit (refer Appendix A). The adaptive management strategy was triggered in 2016/17 at which time the construction of diversion channels and a wetland were brought forward, and monthly sampling implemented. These works are partially completed and the adaptive management response still in progress. A summary of tolerance limit and ANZECC 90% TV limit exceedances is provided in Table 3-5.

Total ammoniacal nitrogen, total iron, and total manganese exceeded tolerance limits in all twelve samples. Alkalinity also exceeded tolerance limits in three samples, and dissolved manganese exceeded the site specific ANZECC trigger value in all twelve samples.

A dissolved iron + dissolved manganese trigger value was added to the DMP in the 2017 review. Hickey (2012) recommended that the sum of iron and manganese should be below 1.0 g/m^3 to prevent bed smothering. During this reporting period, all twelve samples exceeded this limit. Diversion channels were designed to further reduce the volume of water passing under the landfill and increase the volume being diverted around the landfill which, in combination with the wetland treatment system, should achieve further reductions in stream concentrations of dissolved iron and manganese.

When the diversion becomes fully operational, it should sufficiently lower dissolved iron and manganese levels to prevent iron oxide precipitation on the streambed (Table 3-2). A readily achievable target would be to ensure that oxide precipitation of the streambed is limited to the landfill tributary and does not extend into Owhiro Stream. Photographs of the stream diversion system and constructed wetland are shown in Figure 3-2 to Figure 3-5.

Table 3-5: Compliance record from twelve sampling rounds for the year to July 2019

Parameter	Tolerance limit exceeded?[4]	ANZECC 90% TV Exceeded at TTD?	Additional sampling required?	Adaptive Management action required?
pH	0/12	Not Applicable	Not Applicable	No
Electrical conductivity (mS/m)	0/12	Not Applicable	Not Applicable	No
Alkalinity (g/m^3 $CaCO_3$)	3/12	Not Applicable	Not Applicable	No
TSS (g/m^3)	0/12	Not Applicable	Not Applicable	No
COD (g O2/m^3)	0/12	Not Applicable	Not Applicable	No
Total Hardness (g/m^3 $CaCO_3$)	0/12	Not Applicable	Not Applicable	No
Total ammoniacal N (g/m^3)	12/12	0/12	Not Applicable	No
Dissolved Iron (g/m^3)	12/12	0/12	Not Applicable	No
Dissolved Manganese (g/m^3)	12/12	0/12	Not Applicable	No
Dissolved Iron + Manganese (g/m^3)[5]	N/A	12/12	Not Applicable	Yes, in progress
Dissolved Lead (g/m^3)	0/12	0/12	Not Applicable	No
Dissolved Copper (g/m^3)	0/12	0/12	Not Applicable	No
Dissolved Zinc (g/m^3)	0/12	0/12	Not Applicable	No
Dissolved Chromium (g/m^3)	0/12	0/12	Not Applicable	No
Dissolved Arsenic (g/m^3)	0/12	0/12	Not Applicable	No

[4] Tolerance limits are assessed against totals, while ANZECC (2000) 90% trigger values are assessed against dissolved.

[5] Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m^3 to prevent bed smothering

Figure 3-2: TTE dam (left) and outlet culvert (right) as of January 2019

Figure 3-3: TTW Dam (left) and the outlet culvert (left) as of January 2019

Figure 3-4: Diversion flow near wetland (left) and near TTW (Right) as of January 2019

Figure 3-5: Wetland outflow (left) and wetland (right) as of June 2019

By the end of June 2019, the diversion channels were effectively diverting wet weather stream flows around the landfill, however considerable quantities of water continued to seep through the base of both dams into the landfill, eventually exiting from the toe of the landfill into the wetland treatment system. As of January 2019, our observation was that in dry weather the entire base flow seeps under the landfill, with no surface flow in the diversion channels reaching the landfill stream.

3.4 Surface water spatial and temporal trends

The surface water quality results for the year to 30 June 2019, together with historical results collected previously since December 2009, are graphed in Appendix F.

Temporal trends within this section also assessed for the period July 2016 through to June 2019 (the last three reporting periods) to show the benefits achieved by the diversion channels and the constructed wetland system.

3.4.1 Trends not associated with T & T Landfill operations.

No temporal trends were observed for pH, TSS, DOC or total lead. pH values were consistently between 6.5 and 9 and OSD conditions were slightly more basic than the other samples sites at the landfill. TTD conditions were slightly more acidic than the other samples. TSS was slightly lower at sites OSU and TTE than at other monitoring sites.

Total and dissolved copper, and dissolved lead and zinc concentrations were all highest in Owhiro Stream upstream of the landfill tributary, at site OSU (Figure 3-6). The likely source of these contaminants is stormwater runoff from road and roofs from the urban area of Brooklyn. Concentration of these contaminants in the landfill tributary at site TTD are consistently lower than in Owhiro Stream. Over the last two years no clear trend can be discerned for these constituents at any of the monitoring sites.

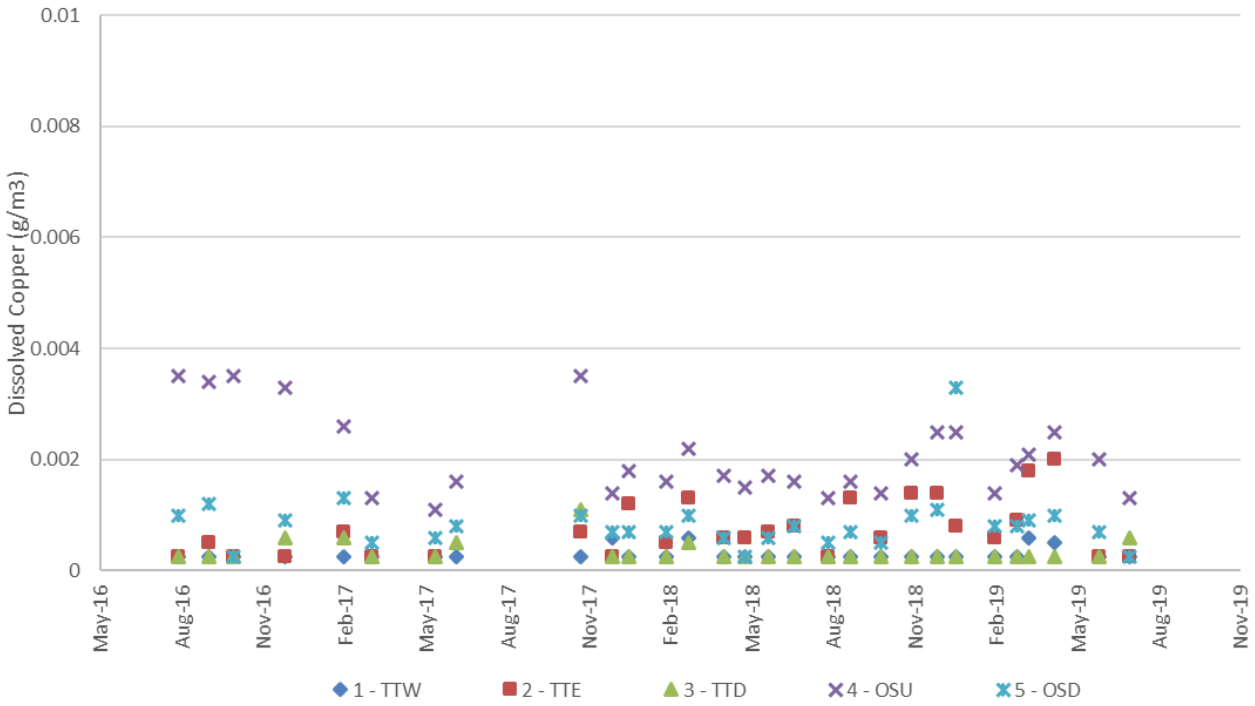

Figure 3-6: Dissolved copper from July 2016 through to June 2019.

3.4.2 Trends likely associated with T & T Landfill operations

General temporal trends

The general trend for most constituents at sites TTD and OSD is for a sharp increase through the third and fourth quarters of 2016 followed by a decline in the first quarter of 2017, and mostly stable results through 2017 and the first half of 2018 and is mostly stable through to 2019. Specific details are described below.

Increased water hardness below landfill

No temporal trends were observed in the monitoring results for the three years to June 2019. Concentrations were stable (though consistently higher for OSD and TTD) in alkalinity, electrical conductivity (EC), dissolved magnesium and, and dissolved calcium concentrations.

Water hardness at TDD appears to be stable from August 2017 through to July 2019 (Figure 3-7). There is some fluctuation though this is small. Between July 2016 and August 2017, the concentrations observed, fluctuated more with a couple of spikes throughout this time. This is attributed to the channel diversion and wetland construction works. It is expected that completion of these works will divert a greater proportion of the stream flow around the landfill and further reduce leachate quantities and consequent impacts on downstream habitats.

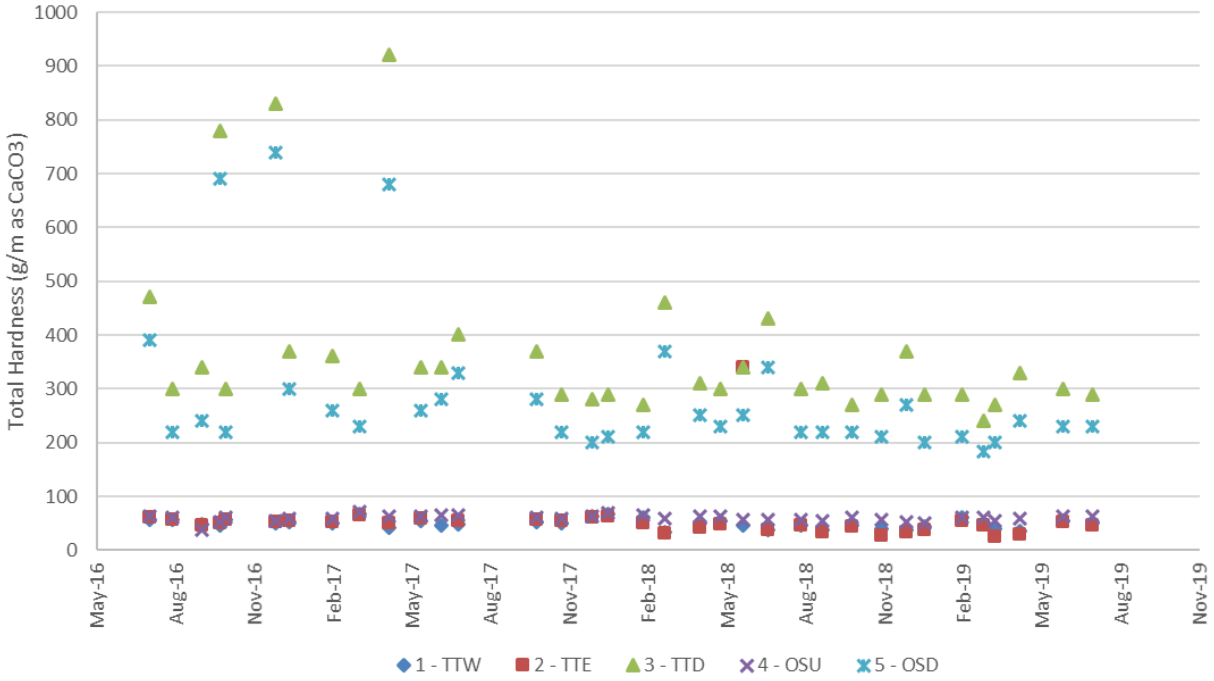

Figure 3-7: Total hardness July 2009 through to June 2019.

Total ammoniacal nitrogen

A trend of increasing total ammoniacal nitrogen levels at TTD began during 2011 and is characterised by a series of peaks (in mid-2012, mid-2013 and mid/late 2016) which coincide with heavy rainfall (Figure 3-8).

During 2016 total ammoniacal nitrogen concentrations increased sharply after a heavy rainfall event and then remained high until a decline in the first quarter 2017. Throughout 2017, 2018, and 2019 total ammoniacal nitrogen concentrations remained below the site specific ANZECC (2000) 90% trigger level despite significant rainfall events in that period (Figure 3-9).

It is likely that the diversion works, and constructed wetland have contributed to lower total ammoniacal nitrogen concentrations, and that there is scope for achieving further reductions by diverting a higher proportion of stream flow around the landfill.

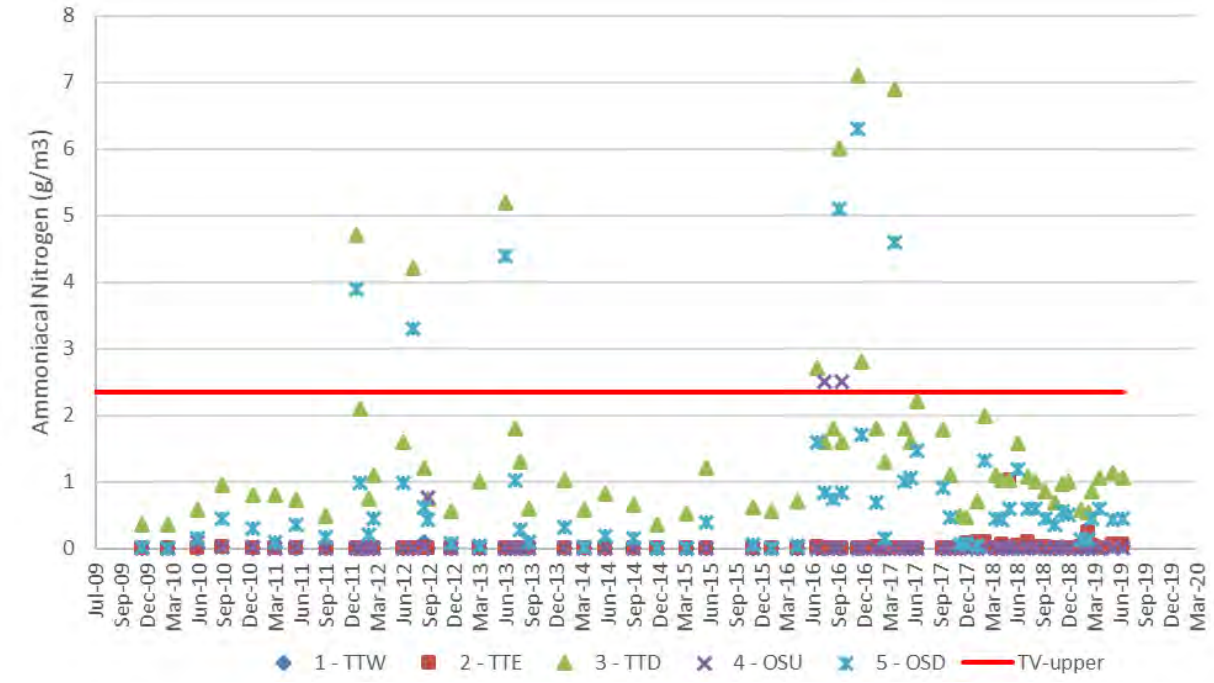

Figure 3-8: Historical total ammoniacal nitrogen from Dec 2010 through to June 2019.

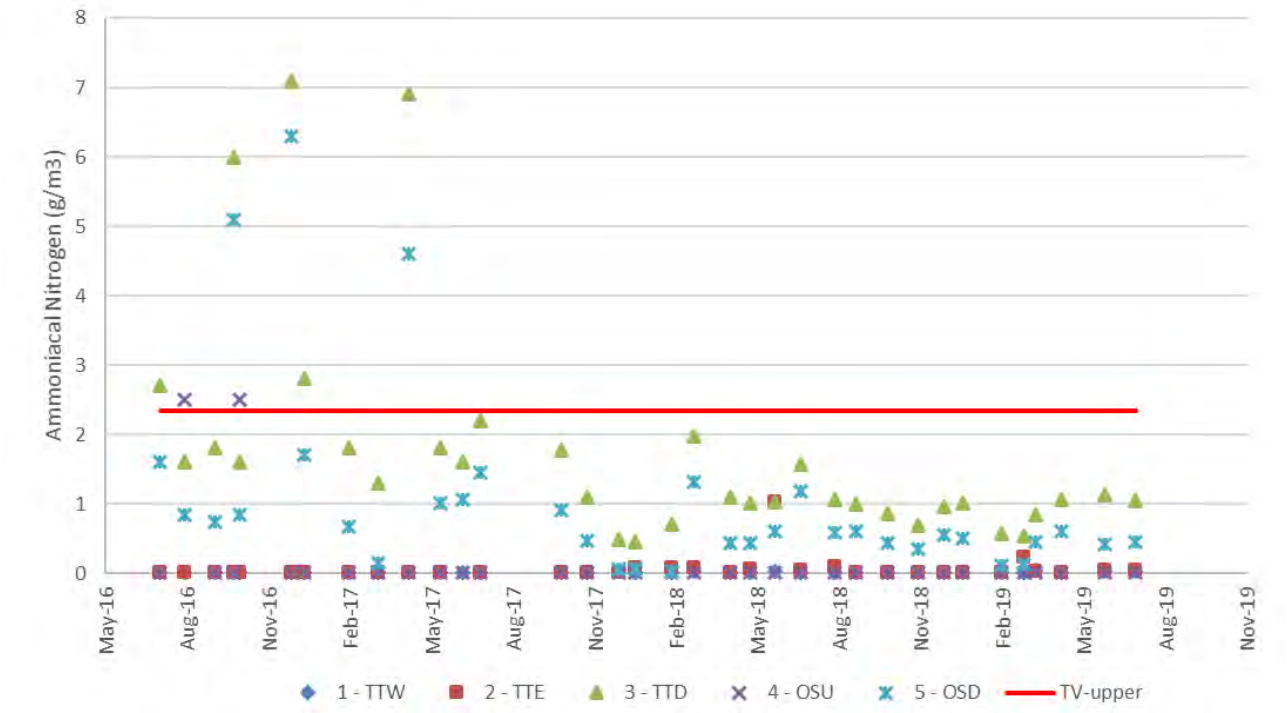

Figure 3-9: Total ammoniacal nitrogen over last two reporting periods (July 2016 – June 2019)

Iron and Manganese

Historically, both total and dissolved manganese has remained consistently above 1.0 g/m^3 in most samples collected at TTD (Figure 3-10, Figure 3-11). Both upstream sites, TTW and TTE are not elevated in total or dissolved manganese, indicating the effect is the result of water moving through the landfill.

Previously, monitoring has shown that the majority of manganese at TTD is in the dissolved form. From June 2016 to June 2018 dissolved manganese levels spiked in November 2016 followed by a rapid decline and then a slow gradual increase through to June 2018, stabilising between 2.0 and 2.5 g/m^3 over the current reporting period.

During the current reporting period the sum of dissolved iron and dissolved manganese exceeded the trigger limit of 1.0 g/m^3 in all 12 samples collected at TTD.

There is no clear evidence from monitoring results to date that the diversion channels and constructed wetland have reduced stream concentrations of manganese. Nevertheless, it is expected that some reduction can be achieved by diverting a greater proportion of the stream flow around the landfill and reducing seepage through the landfill.

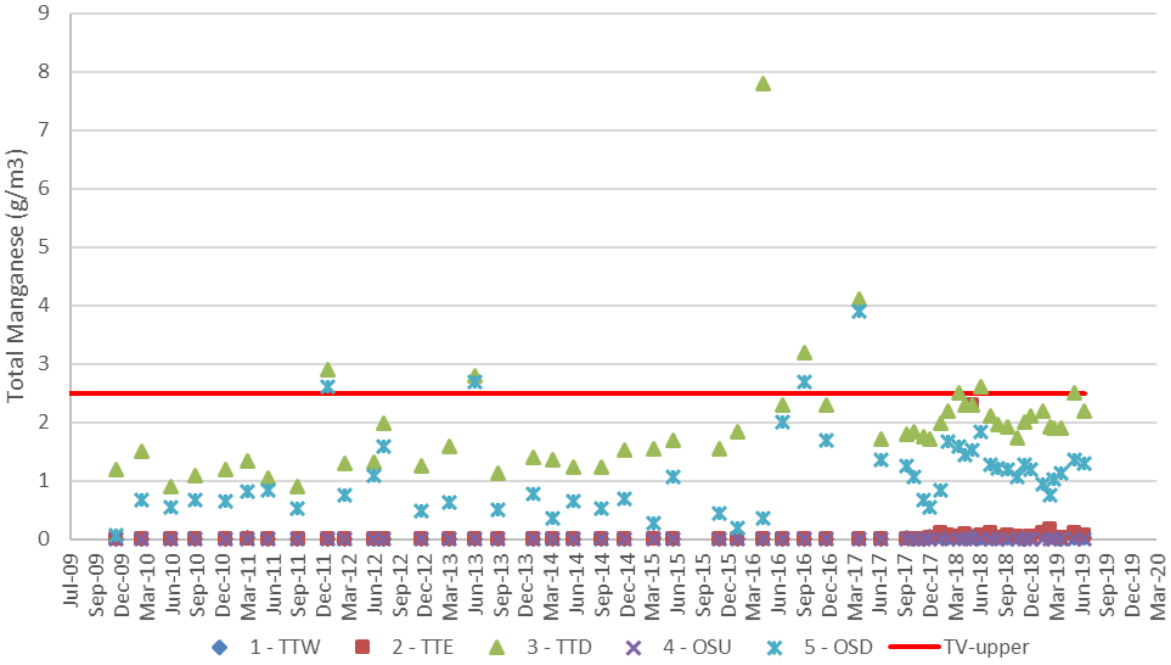

Figure 3-10: Total Manganese from Dec 2010 through to June 2019

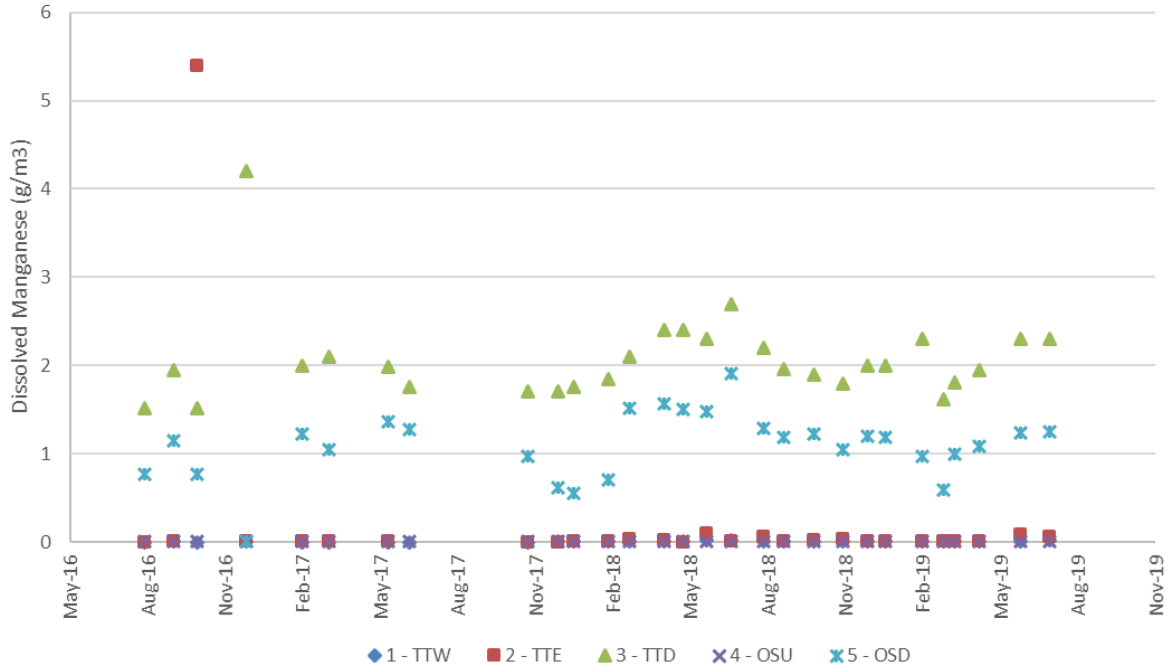

Figure 3-11: Dissolved Manganese over last two reporting periods (July 2016 – June 2019)

3.5 Groundwater Monitoring Results

Groundwater quality monitoring results summarised in Table 3-6 show contaminant concentrations were variable through the monitoring year. Over the longer term there has been considerable variation in concentrations of iron and manganese in particular, and to a lesser extent copper, zinc and lead. Results of total iron and manganese in Figure 3-12 show two main peaks in concentrations since September 2009, in December 2014 and December 2017. This correlates with peaks in lead, copper, and zinc in Figure 3-13. There is very little correlation between groundwater and surface water concentrations of these metals.

Table 3-6: Groundwater monitoring results for the year to June 2019

Parameter	Unit	TTG Results			
		01/07/2019	11/03/2019	20/12/2018	27/09/2018
pH	pH	6.7	6.6	6.7	6.6
Chloride	g/m3	98	98	84	102
Conductivity	µS/m	47.9	50.7	43.9	49.6
Nitrate Nitrogen	g/m3	1.93	2.1	1.86	2.6
Total Ammoniacal Nitrogen	g/m3	0.005	0.005	0.04	0.005
Total Lead	g/m3	0.0119	0.039	0.031	0.044
Total Zinc	g/m3	0.022	0.178	0.149	0.128
Total Iron	g/m3	5.9	18.7	15.6	24
Total Manganese	g/m3	0.77	5.9	6.2	3.4
Total Copper	g/m3	0.0054	0.021	0.0135	0.0196

Note: Results below detection limits are halved.

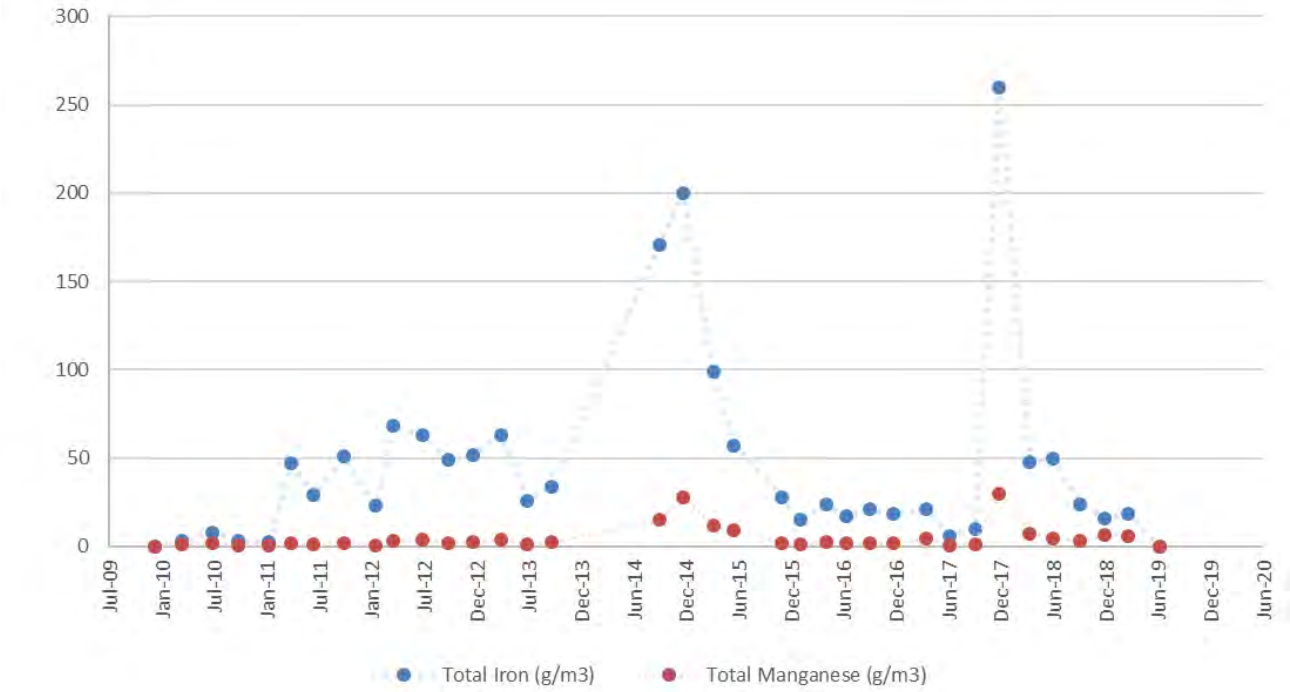

Figure 3-12: Total Iron and Total manganese concentrations in groundwater samples collected downstream of the landfill at site TTG

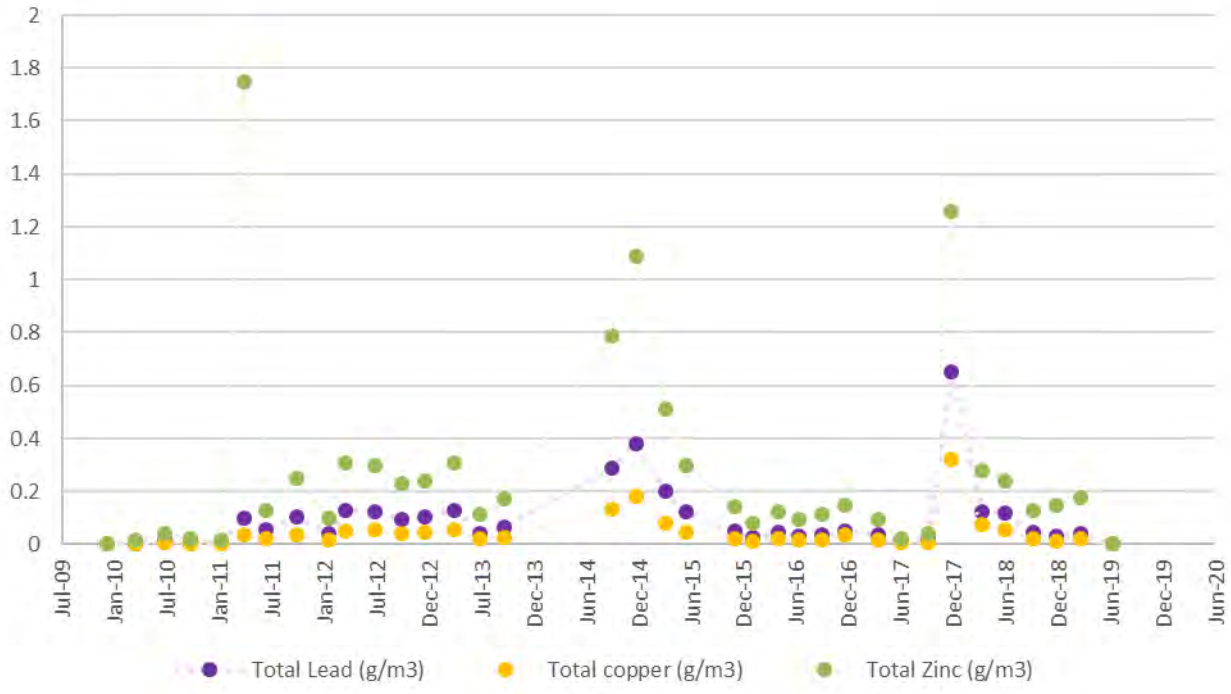

Figure 3-13: Total lead, total copper and total zinc concentrations in groundwater samples collected downstream of the landfill at site TTG

4. Wetland sampling

On Thursday 1 August 2019, Stantec undertook in-situ water quality measurements including dissolved oxygen (DO), temperature, pH and conductivity at eight locations around the wetland (Figure 4-1).

Water quality grab samples were taken at the wetland inlet (Site 1) and wetland outlet (Site 8) on 10 May 2019 with a second round of sampling on 1 July 2019 which included a sample at Site 7 immediately prior to water flowing down culvert outlet.

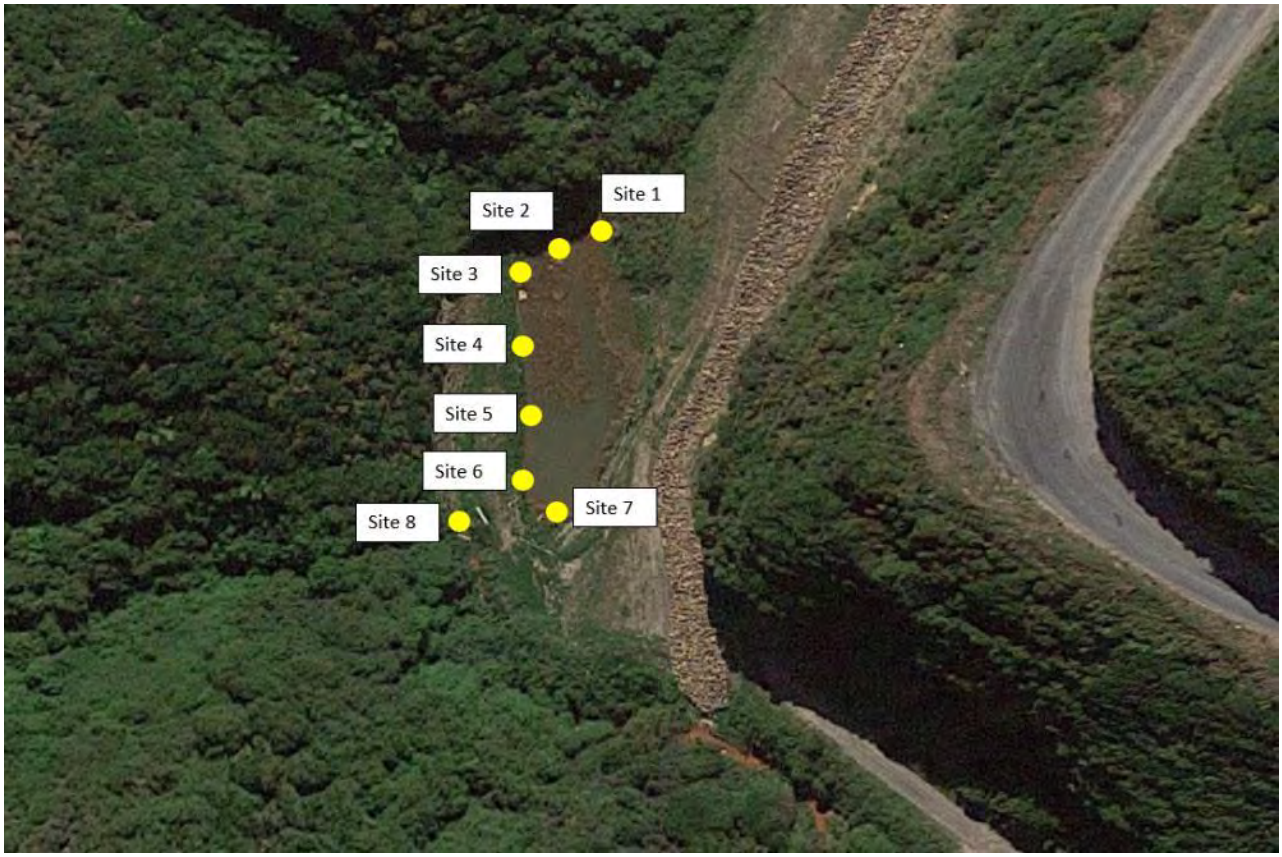

Figure 4-1: Wetland water quality sampling locations

Results from in-situ water quality sampling show pH, temperature and conductivity were consistent across the wetland and when compared to laboratory analysed grab samples taken on 10 May and 01 July 2019.

Dissolved oxygen percent saturation (% sat) was consistently low across the wetland perimeter at sites 1 through to 7, at under 14%. This is indicative of water that has moved under the cleanfill as groundwater in a low oxygen environment. Site 8 is in the stream channel downstream of the outlet culvert, where dissolved oxygen increased to 56.4%. Further downstream at sites TTD and OSD the dissolved oxygen concentrations increased further to 74.9 % and 79.7% respectively.

The Australian and New Zealand Environmental Conservation Council's *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC 2000) guidelines for median DO (percent saturation) in lowland streams in New Zealand is 98-105% with >80% being a level generally required to support healthy aquatic life. Against these guidelines the wetland DO levels are low, while the unnamed stream below the wetland is much improved, but still sub-optimal is terms of life supporting capacity.

Table 4-1: In-situ water quality results for sites around wetland 01 August 2019

Parameter/Site	1	2	3	4	5	6	7	8
pH	6.74	6.8	6.8	6.8	6.76	6.75	6.77	6.92
Temperature (°C)	14	13.9	13.9	13.8	13.7	13.7	13.9	13.8
DO (% sat)	5.8	4.9	7.6	9.8	11	11.6	6.6	56.4
DO (mg/l)	0.59	0.5	0.78	1.01	1.13	1.2	0.69	5.82

Conductivity SPC (mS/m)	102.7	102.6	102.4	102.1	101.6	101.5	101.9	101.6
Conductivity C (mS/m)	81.0	81.0	80.6	80.2	79.6	79.6	80.2	80.0

Results from a series of grab samples collected from the wetland and stream are presented in Table 4-2. The following was observed at the wetlands during the site visit:

- There is orange precipitate in all three Wetland locations, in particular in the wetland outfall.
- The water was cloudy in all three wetland locations sampled.
- Foam and bubbles were present at the wetland outflow.
- An odour was observed at the wetland outflow.
- A medium flow was observed at all three wetland locations sampled.

Iron was largely present in particulate form with dissolved iron being a small fraction, except for site 8 on 10 May 2019 where 46% was dissolved iron, higher than the dissolved iron noted at the inflow. The opposite was seen for manganese where the majority, if not all, of the manganese was presented as dissolved manganese.

Total ammoniacal nitrogen was consistent between the inflow and outflow of the wetland and below the site-specific consent limit of 2.34 mg/l (at pH 7.6, which is the maximum recorded at site TTD). COD was also consistent across the wetland and similar to historic monthly monitoring results for TTD.

Table 4-2: Water quality wetland grab sample results

Date/Site		10-05-19	01-07-19	01-07-19	10-05-19	01-07-19
Parameter	units	Site 1	Site 1	Site 7	Site 8	Site 8
pH	-	6.8	6.6	6.7	6.6	6.9
Total Alkalinity	g/m³ as $CaCO_3$	290	280	280	300	280
Total Hardness	g/m³ as $CaCO_3$	330	290	290	320	290
Electrical Conductivity	mS/m	85.2	78.7	78.2	84.9	79.0
TSS	g/m³	18	6	8	15	13
Dissolved Arsenic	g/m³	0.0015	0.001	0.0005	0.0024	0.0005
Total Arsenic	g/m³	0.0036	0.0027	0.0023	0.0035	0.0022
Dissolved Calcium	g/m³	100	87	86	97	86
Dissolved Chromium	g/m³	0.0005	0.0005	0.0006	0.00025	0.0005
Total Chromium	g/m³	0.00137	0.00109	0.00081	0.00097	0.00096
Dissolved Copper	g/m³	0.00025	0.00025	0.00025	0.00025	0.00025
Total Copper	g/m³	0.000265	0.000265	0.000265	0.000265	0.000265
Dissolved Iron	g/m³	0.05	0.8	0.29	3.1	0.06
Total Iron	g/m³	6.3	4.4	3.7	6.7	3.8
Dissolved Lead	g/m³	0.00005	0.00005	0.00005	0.00005	0.00005
Total Lead	g/m³	0.00039	0.000055	0.00012	0.00017	0.00025
Dissolved Magnesium	g/m³	19.7	18.5	17.8	19.8	18.5
Dissolved Manganese	g/m³	2.3	2.3	2.3	2.4	2.4
Total Manganese	g/m³	2.4	2.2	2.2	2.5	2.3
Dissolved Zinc	g/m³	0.0018	0.0015	0.0014	0.0005	0.0026
Total Zinc	g/m³	0.0032	0.0017	0.0018	0.0019	0.0039
Total Ammoniacal Nitrogen	g/m³	1.52	1.3	1.3	1.58	1.3

Date/Site		10-05-19	01-07-19	01-07-19	10-05-19	01-07-19
Parameter	units	Site 1	Site 1	Site 7	Site 8	Site 8
Dissolved Manganese + Dissolved Iron	g/m^3	2.35	3.1	2.59	5.5	2.46
COD	$g\ O_2/m^3$	22	15	15	18	16
DOC	g/m^3	4.8	16.2	8.6	13.2	10.1
Comments	N/A	Monthly Monitoring	Quarterly Monitoring	Quarterly Monitoring	Monthly Monitoring	Quarterly Monitoring

Note: Results below detection limits are halved.

5. Annual Discharges in Relation to Ecology Assessment 2016

Condition 9 of the discharge consent requires that the annual report include:

"A comparison of the concentration of contaminants of the latest year of sampling with the baseline ecology survey results as required by condition 12 of this permit to determine whether there may have been a degradation in the quality of the aquatic ecosystem as a result of the discharge."

T&T Landfills commissioned an ecological study of the tributary stream upstream and downstream of the landfill during 2010 pursuant to condition 12 of the consent. A second ecological survey was conducted in December 2016 following an exceedance of trigger values during the last quarter of 2016. The next survey was due to be completed during the summer of 2018-19, however this was deferred until the summer of 2019-2020 or until the diversion is fully operational.

A comparison between results of 2016 and 2019 show that:

- Concentrations of most contaminants at site TTD including electrical conductivity, alkalinity, total hardness, TSS, total ammonia nitrogen, COD, copper, zinc and lead, have decreased since 2016. For several contaminants including dissolved arsenic, dissolved copper, dissolved chromium, total chromium and dissolved lead there was no measurable change during passage under or around the landfill.
- The contaminants of most concern at TTD are iron and manganese. High levels of dissolved iron and manganese have, in combination with elevated levels of dissolved organic matter (DOM), resulted in ferric iron precipitation covering streambed substrates in the reach below the landfill, extending downstream beyond site OSD. The extent of streambed affected by iron bacteria appears to have stabilised since 2016 but continues to have the potential to smother benthic habits in this reach.

A benthic ecology survey is required once the stream diversion works and wetland construction is completed, presumably early in 2020.

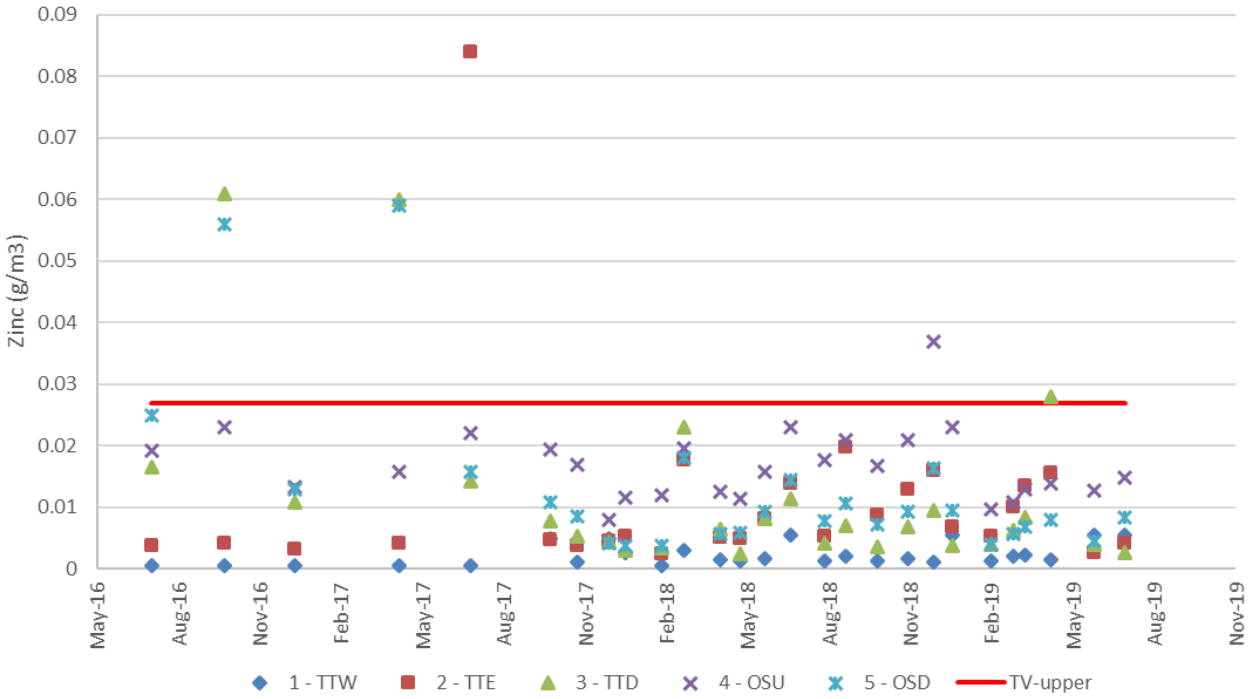

Figure 5-1 Total Zinc concentrations from July 2016 through to June 2019

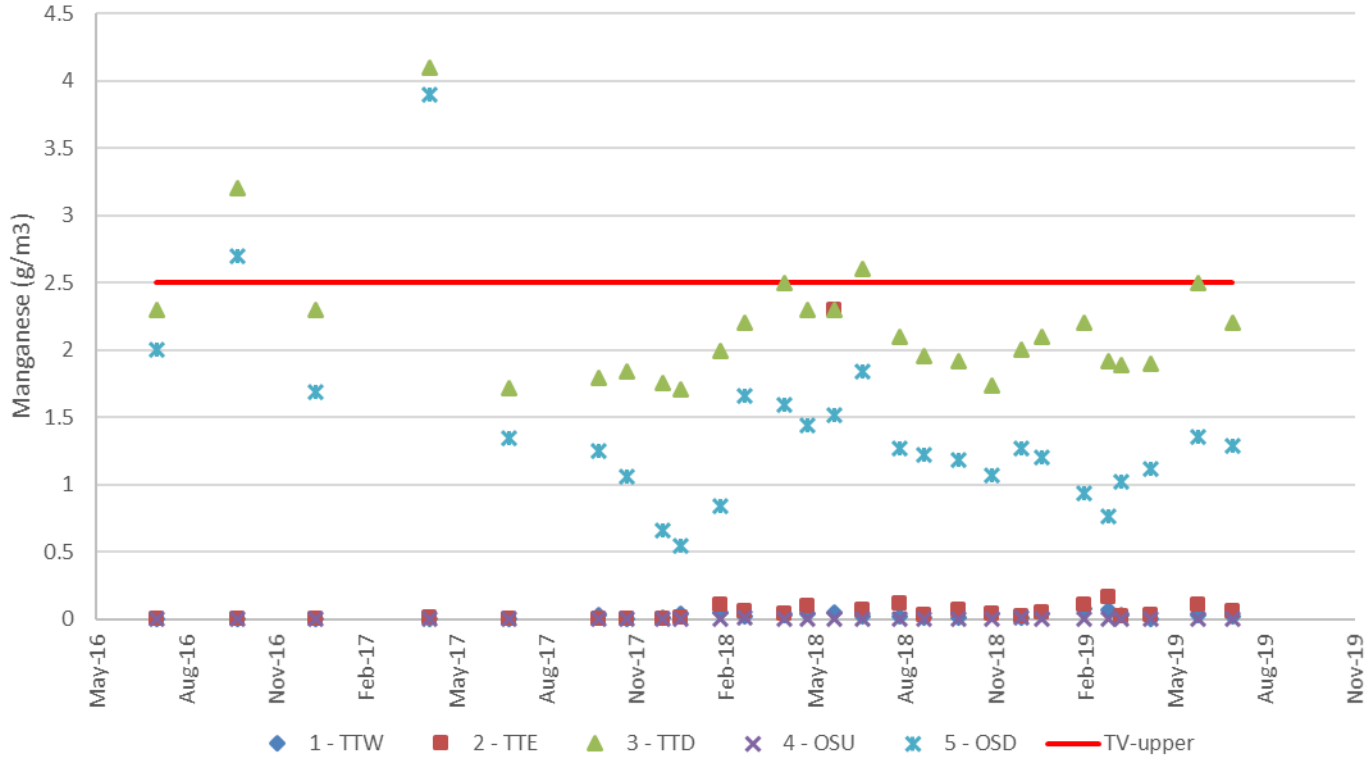

Figure 5-2 Total Manganese from July 2016 through to June 2019

6. Conclusion and Recommendation

Leachate generation in the landfill continues to have some impact on downstream water quality in the unnamed tributary and Owhiro Stream through elevated levels of dissolved iron and dissolved manganese. High levels of dissolved iron and manganese have formed a conspicuous orange precipitate on the streambed downstream of the landfill, which has the potential to adversely affect the quality of habitat for invertebrates and fish, and to reduce amenity values.

The diversion of stream water and local stormwater around the landfill has already reduced leachate volumes, but diversion of a greater proportion of the stream flow is needed. It is recommended that mitigation actions should include the following:

- Reduced seepage through the base of dams at TTW and TTE, and in the stream reach immediately upstream of the dam, to ensure that dry weather base flows are diverted in the constructed channels and that flow under the landfill is minimised.
- Maintenance planting of the constructed wetland with appropriate, locally sourced wetland plants to ensure a substrate (roots, stems leaves) upon which microorganisms can grow and break down organic materials.
- A benthic ecology survey to be conducted during the 2019/20 summer that is comparable to the survey conducted in December 2016 (Cameron, 2016) in order to assess the condition of Owhiro Stream following completion of stream diversion works and constructed wetland.
- No change should be made to the daily rainfall trigger of 45mm, but an increased level of vigilance is required to ensure that a water quality survey is conducted within seven days of each trigger level exceedance.

Appendices

Appendix A Consent Conditions

Conditions to Resource Consent WGN070260 [30627]

1[1]. The location, design, implementation and operation of the discharge shall be in general accordance with the application, associated documents and further information lodged with Wellington Regional Council on:

- 14 June 2007 (consent application)
- 14 June 2007 (plans, including final stormwater discharge plan E04-1000-FL)
- 21 June 2007 (microalgae investigation report)
- 6 September 2007 (second microalgae investigation report)
- 7 September 2007 (executive summary)
- 4 June 2008 (Wellington City Council application)
- 27 February 2009 (Further information)
- 18 August 2010 (change of conditions application); and
- 14 June 2011 (Further information)

Where there may be contradictions or inconsistencies between the application and further information provided by the applicant, the most recent information applies. In addition, where there may be inconsistencies between information provided by the applicant and conditions of consent, the conditions apply.

Note: Any change from the location, design concepts and parameters implemented and/or operation may require a change in consent conditions pursuant to Section 127 of the Resource Management Act 1991.

2. The permit holder shall provide a copy of this permit and any documents referred to in this permit to each operator or contractor undertaking works authorised by this permit before that operator or contractor starts any works.

Note: It is recommended that the contractor(s) undertaking the works be verbally briefed on the conditions of this and all other associated permits prior to the works being undertaken.

3. The permit holder shall ensure that a copy of this permit and all other permits granted under the Wellington Regional Council resource consent suite WGN070260 is kept within the site office, and presented to any Wellington Regional Council officer on request.

4. The permit holder shall keep a permanent record of any complaints received alleging adverse effects from the permit holder's operations. The complaints record shall contain the following where practicable:

- The name and address of the complainant, if supplied
- Identification of the nature of the complaint
- Date and time of the complaint and alleged event
- Weather conditions at the time of the alleged event
- Results of the permit holder's investigations; and
- Any mitigation measures adopted.

The complaints record shall be made available to the Wellington Regional Council on request.

Site Operations and Maintenance Condition

5. The permit holder shall, at all times, operate, maintain, supervise and control all processes and equipment on site to ensure compliance with all conditions of this permit and the Operations Management Plan required by condition 6 of permit WGN070260 [26122].

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[1] Condition changed under section 127 of the Act, granted 28/07/11

Monitoring of Discharge

6. Within six months of the grant of this permit, the permit holder shall engage a suitably qualified person to prepare and submit a **Discharge Management Plan (DMP)** for approval, to the Manager, Environmental Regulation, Wellington Regional Council.

The purpose of the DMP is to establish and implement a more scientifically robust quantification at representative locations of the effects of the discharge coming from the landfill, and the effects of the discharge to the downstream unnamed tributaries of Owhiro Stream.

The DMP shall include, but not be limited to, the following:

- The provision of maps and monitoring locations (GPS locations or NZMS 260 grid references) that provide for an upstream control sample from both the eastern (TTE) and western arm (TTW) tributaries, downstream of the discharge point (TTD/TTG) and the main trunk of Owhiro Stream (upstream and downstream of the confluence of the landfill tributary with the main trunk of Owhiro Stream); and
- A monitoring methodology for surface and ground water quality sampling, including, but not limited to:
  - The technique used to recover the contaminants from the samples
  - The location and area the sampling will be undertaken over; and
  - A comparison with relevant tolerance limits (including method of calculation) and guidelines (e.g. surface water quality values against the ANZECC 2000 90% ecosystem protection values for freshwater quality) and the upstream control samples for the protection and maintenance of ecosystem services within the Owhiro Stream

Note: The DMP is to be included in the OMP alongside the other required plans under condition 6 of permit WGN070260 [26122].

7[2]. At a minimum, the groundwater contaminants at the location TTG (as total recoveries) to be sampled in March, June, October and December of each year shall include, but not be limited to:

• pH	
• Conductivity	µS/m
• Chloride	g/m^3
• Ammoniacal Nitrogen	g/m^3
• Nitrate Nitrogen	g/m^3
• Iron	mg/m^3
• Manganese	mg/m^3
• Lead	mg/m^3
• Copper	mg/m^3
• Zinc	mg/m^3
• Chromium	µg/L
• arsenic	µg/L

At a minimum, the **surface water** contaminants at the locations TTW, TTE, TTD and the two new locations on the main branch of the Owhiro Stream (as total recoveries) to be sampled in March, June, October and December of each year shall include, but not be limited to:

• pH	
• Conductivity	µS/m
• Alkalinity	g/m^3
• Total suspended solids	g/m^3
• COD	
• Total Hardness	g/m^3
• Ammoniacal Nitrogen	g/m^3
• Iron	mg/m^3
• Manganese	mg/m^3

[2] Condition changed under section 127 of the Act, granted 28/07/11

- Lead mg/m³
- Copper mg/m³
- Zinc mg/m³
- Chromium µg/L
- Arsenic µg/L

All sampling techniques employed in respect of the conditions of this permit shall be to the satisfaction of the Manager, Environmental Regulation, Wellington Regional Council. All analyses shall be performed by an International Accreditation New Zealand (IANZ) registered laboratory or otherwise as specifically approved by the Manager, Environmental Regulation, Wellington Regional Council.

8[3]. The quality of the surface water discharge as sampled under condition 7 of this permit shall be compared with the following tolerance range, determined from *total recoveries*:

Contaminant and unit		**Lower tolerance range**	**Upper tolerance range**
pH		-0.4	0.4
Conductivity	µS/m		72.4
Alkalinity	g/m³		226
Total suspended solids	g/m³		
COD	g/m³		21
Total Hardness	g/m³		
Ammoniacal Nitrogen	g/m³		0.346
Total Iron	mg/m³		2748
Total Manganese	mg/m³		1461
Total Lead	mg/m³		5.9
Total Copper	mg/m³		4.0
Total Zinc	mg/m³		130
Total Arsenic	µg/L		13.0
Total Chromium	µg/L		1.0

The limits for Total Suspended Solids and Total Hardness shall be calculated once the number of samples reaches 10. The same calculations to determine the upper and lower tolerance limits shall be applied as is detailed in the DMP in condition 6 of this permit.

Should the tolerance limit for any parameter be exceeded, and where that parameter also exceeds the latest ANZECC Guidelines for Ecosystem Protection (90%) trigger levels, the permit holder shall, within one month of the receipt of the laboratory report:

- Undertake a second sample and analyse this for the exceeded parameter, and
- Undertake a third sample within one month of the second sample being taken, and analyse this for the exceeded parameter
- In these instances, the *dissolved metal* fraction, rather than the total metal fraction shall be tested for
- If the average of these two samples continues to exceed the relevant tolerance limits and the latest ANZECC Guidelines for Ecosystem Protection (90%) trigger levels, the permit holder shall implement the **adaptive management** conditions as required by conditions 13 and 14 of this permit.

9. The permit holder shall ensure that a person suitably qualified to the satisfaction of the Manager, Environmental Regulation, Wellington Regional Council prepares and submits a report by 30 June of each year detailing the items as required by conditions 6 and 7 and the approved DMP.

The report shall include, but not be limited to:

- The results and comparisons of the contaminants sampled for with the relevant limits approved under the DMP and condition 8 of this permit

[3] Condition changed under section 127 of the Act, granted 28/07/11

- A comparison of the concentration of contaminants of the latest year of sampling with the base line ecology survey results as required by condition 12 of this permit to determine whether there may have been a degradation in the quality of the aquatic ecosystem as a result of the discharge
- Any other relevant information; and
- Any recommendations for approval to the Manager, Environmental Regulation, Wellington Regional Council, to remedy or mitigate any significant adverse effects that have occurred, or to avoid foreseen significant adverse effects as a result of the discharge of contaminants from the landfill area to the tributaries of Owhiro Stream. Examples of these could be:

  Changes to the management or site acceptance protocols;
  - Methods to remedy adverse effects that may have been transported into the Owhiro Stream catchment; and
  - Mitigation measures to offset or minimise the significant adverse effects.

Note 1: For the purposes of this condition, 'significant adverse effects' are those effects which are determined to be significant in the professional opinion of the engaged independent expert.

Note 2: Annual reports can be bundled and submitted as one large report, providing that the relevant sections are clearly defined within the one document.

10. Should any recommendations arise from the report produced under condition 9 of this permit, the permit holder shall undertake to provide for the recommendations in a manner and timeframe that meets the satisfaction of the Manager, Environmental Regulation, Wellington Regional Council.

Note: These activities may require further resource consents.

Mixing zones

11. The discharges shall not give rise to any of the following effects after reasonable mixing:

- The production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials
- Any conspicuous change in colour or visual clarity
- Any emission of objectionable odour
- The rendering of fresh water unsuitable for consumption by farm animals
- Any significant adverse effects on aquatic life; or
- Any visible deposition of iron oxide or other heavy metals

For the purposes of this condition and permit, the discharges shall be reasonably mixed at 100 metres downstream of the discharge point from the stilling basin within the unnamed tributary of Owhiro Stream.

Should any of these effects occur, the permit holder shall commission an updated DMP exploring the relevant treatment methodologies as required by condition 6 of this permit.

Baseline Ecological Survey Condition

12. During the period 1 December 2009 to 30 April 2010 inclusive, and following at least a two week period without a significant flood event (defined as 3x median stream flow) the permit holder shall have an appropriately experienced and qualified freshwater ecologist that meets the satisfaction of the Manager, Environmental Regulation, Wellington Regional Council carry out a semi-quantitative ecological survey of the landfill tributary upstream and downstream of the landfill discharge and the Owhiro Stream upstream and downstream of the confluence of the landfill tributary.

The survey shall comprise as a minimum:

- A macroinvertebrate survey following protocols C1 and P2 from the Ministry for the Environment's report on protocols for sampling macroinvertebrates in wadeable streams (Stark et al. 2001) involving the collection of a 3 replicate samples (a minimum of 5 kicknet samples per replicate) within riffle habitat at each site, fixed count of macroinvertebrate taxa to the taxonomic resolution specified for use of the MCI and enumeration of the results as taxa richness, MCI, SQMCI, number of EPT taxa, %EPT taxa and %EPT individuals

- Macroinvertebrate surveys should also be accompanied by visual assessment of periphyton cover and substrate characteristics. Survey sites should share similar habitat characteristics in terms of substrate, flow and depth; and
- A full fish survey including electrofishing and spotlighting within the unnamed tributaries of the Owhiro Stream downstream of the landfill, and within the western and eastern arms of the tributaries upstream of the landfill

Note: The results of the Baseline Ecological Survey are to be included in the OMP alongside the other required plans under condition 6 of permit WGN070260 [26122].

Adaptive Management Conditions

13[4]. Should the tolerance limits, the latest ANZECC Guidelines for the protection of aquatic ecosystems (90%) trigger levels and additional sampling show an increase in the level of any one contaminant as described in condition 8 of this permit, the permit holder shall engage a suitably qualified, independent ecologist to provide an assessment of the ecological effects of the discharges from the site.

The qualifications of and methods employed by the ecologist or other suitably qualified person (in the case of recommendations on the practicable treatment of the discharged contaminants) shall meet the satisfaction of the Manager, Environmental Regulation, Wellington Regional Council.

The ecologist or other suitably qualified person shall provide specific assessment recommendation and implementation of the following:

- A monitoring methodology for *macroinvertebrate* sampling, including, but not limited to:
  - The techniques that will be used to carry out the surveys;
  - The location and area the sampling will be undertaken over;
  - The analysis methodology used to record and present the data; and
  - Other physical habitat quantifications used to assess the local ecosystem.
- An assessment of the potential effects of the discharge of contaminants to the unnamed tributary of Owhiro Stream;
- A recommendation of the number of sampling events that need to be undertaken (along with timeframes) to adequately gauge the effects of the discharges from the site;
- An assessment, once the invertebrate sampling has been undertaken, whether the existing treatment methodology for the discharge to the unnamed tributary of Owhiro Stream is the best practicable option for the treatment of the contaminants arising from either the historical or current land use of the area (i.e. both the fill placed by the permit holder, and the fill that existed on site prior to the operator's activities at the site) to feed back into the DMP as approved under condition 6 of this permit; and
- Provide recommendations on methods that could be used to further treat the discharge to ensure they remain within the tolerance limits specified in condition 8 of this permit.
- In the case of the limits for Total Chromium and /or Total Arsenic being exceeded, provide a recommendation as to whether or not the consent holder should cease the disposal of processed timber (both treated and untreated) to the landfill.

Note: Some recommended viable adaptive management measures could include the installation of a treatment wetland, sand filter system or enlargement of the stilling basin.

Note: The consent holder may store treated timber on site in the event arsenic and/or chromium tolerance limits are exceeded; however, all in-ground disposal must cease until informed otherwise.

14. The recommendations approved from the report prepared under the DMP and ecological assessment undertaken under conditions 6, 12 and 13 of this permit shall be undertaken by the permit holder to the satisfaction of the Manager, Environmental Regulation, Wellington Regional Council and within timeframes specified by the manager, Environmental Regulation, Wellington Regional Council.

Note: Further resource consents may be required to undertake the works recommended.

[4] Condition changed under section 127 of the Act, granted 28/07/11

Long term Management Conditions

15. The permit holder shall, no less than **twelve** months prior to the expiry or surrender of this permit for the closure of the landfill, make application(s) for such consent(s) as are required for the future management of the site.

This requirement shall also be complied with should filling activities at the site cease for a continuous twelve month period.

16. The permit holder shall continue to sample and provide monitoring results as required by conditions 6, 7, 8 and 9 until the expiry of this permit.

Water quality management - wetland creation

17[5]. The permit holder shall lodge application(s) for such consent(s) as are required for the creation of a wetland area at the location as shown on drawing numbers S02-0752-41 Rev.A and S02-0752-42 Rev.A, submitted as evidence at the change of conditions application hearing on 7 July 2011. The application must be lodged with and accepted by the Wellington Regional Council by **31 October 2011**.

The application(s) for such consent(s) shall provide information on, but not be limited to:

Design

- The wetland shall be designed in accordance with NIWA's '*New Zealand Constructed Wetland Planting Guidelines, 2006*'.
- Evidence to show how the wetland will improve the water quality of the discharges from the landfill.
- Details of how the proposed wetland will treat the following list of contaminants:
  - Ammoniacal Nitrogen
  - Iron
  - Manganese
  - Lead
  - Copper
  - Zinc
  - Chromium
  - Arsenic

Construction

- A 'step by step' construction methodology and timeline for the creation of the wetland
- Details of the amount of earthworks required to increase the size of the stilling basin (volumes of cut and fill)
- How any unsuitable material from the stream bed will be removed from the site and disposed of
- Erosion and sediment control measures to be implemented prior to works starting
- Erosion and sediment control measures to be used during construction to ensure sedimentation effects on the unnamed tributary of Owhiro Stream will be mitigated while works are occurring;, and
- Identifying person(s) who will be responsible for managing each part of the construction operation (including sediment control).

Planting

- Details of pre-planting site preparation;
- A to scale design plan(s) clearly showing:
  - The location and extent where planting will be undertaken around the stilling basin; and
  - The browse resistant native wetland plants species (sedges and rushes etc) that are proposed to be planted to aid in the treatment of the landfill's discharge, the size of the plants and the density of planting.
- A Monitoring and Maintenance Plan which shall be undertaken for the first 12 months upon completion of the planting, including, but not be limited to, the following:
  - Details of how plants will be irrigated during their establishment;

[5] Condition changed under section 127 of the Act, granted 28/07/11

  - Details of how the site will be maintained and how often, including the ongoing replacement of plants that do not survive and eradication of evasive weeds from the planting site to ensure adequate growth (e.g. weeding, spraying, mulching); and
  - Details of how plants will be protected from animal pests (e.g. goats).
- A list of the key responsibilities and identification of the suitably experienced persons responsible for implementing the wetland planting.

Note 1: The intent of the wetland area is to improve water quality downstream of the landfill. The wetland is expected to help treat the heavy metals and other contaminants that will percolate through and discharge from the landfill.

Note 2: The wetland area shall be made a large as possible.

Note 3: The construction of the wetland shall be completed within two years of the grant of the resource consent(s) required from the Wellington Regional Council, or within a different timeframe on assessment of the consent application.

Note 4: The approved RMP as required under condition 9 of WGN070260 [26129] and ongoing ecological assessment as required under various conditions of WGN070260 [26124] may provide information that is helpful to the development of the wetland.

Review Conditions

18. The Wellington Regional Council may review any or all conditions of this permit by giving notice of its intention to do so, pursuant to section 128 of the Resource Management Act 1991 at any time within the life of the landfill for any of the following purposes:

- To deal with any adverse effects on the environment which may arise from the exercise of this permit, and which it is appropriate to deal with at a later stage;
- To review the adequacy of any plan prepared for this permit and/or the monitoring requirements so as to incorporate into the permit any modification to any plan or monitoring which may be necessary to deal with any adverse effects on the environment arising from the management or operation of the landfill and recycling centre;
- To impose limits on the discharge of contaminants in light of the results obtained from previous monitoring; or
- To enable consistency with any relevant Regional Plans or any National Environmental Standards.

Note: Following review, conditions or restrictions on the use of the site may be set by the Council if deemed necessary.

19. Wellington Regional Council shall be entitled to recover from the permit holder the costs of the conduct of any review, calculated in accordance with and limited to the council's scale of charges in force and application at the time, pursuant to section 36 of the Resource Management Act 1991.

Appendix B Monitoring Locations

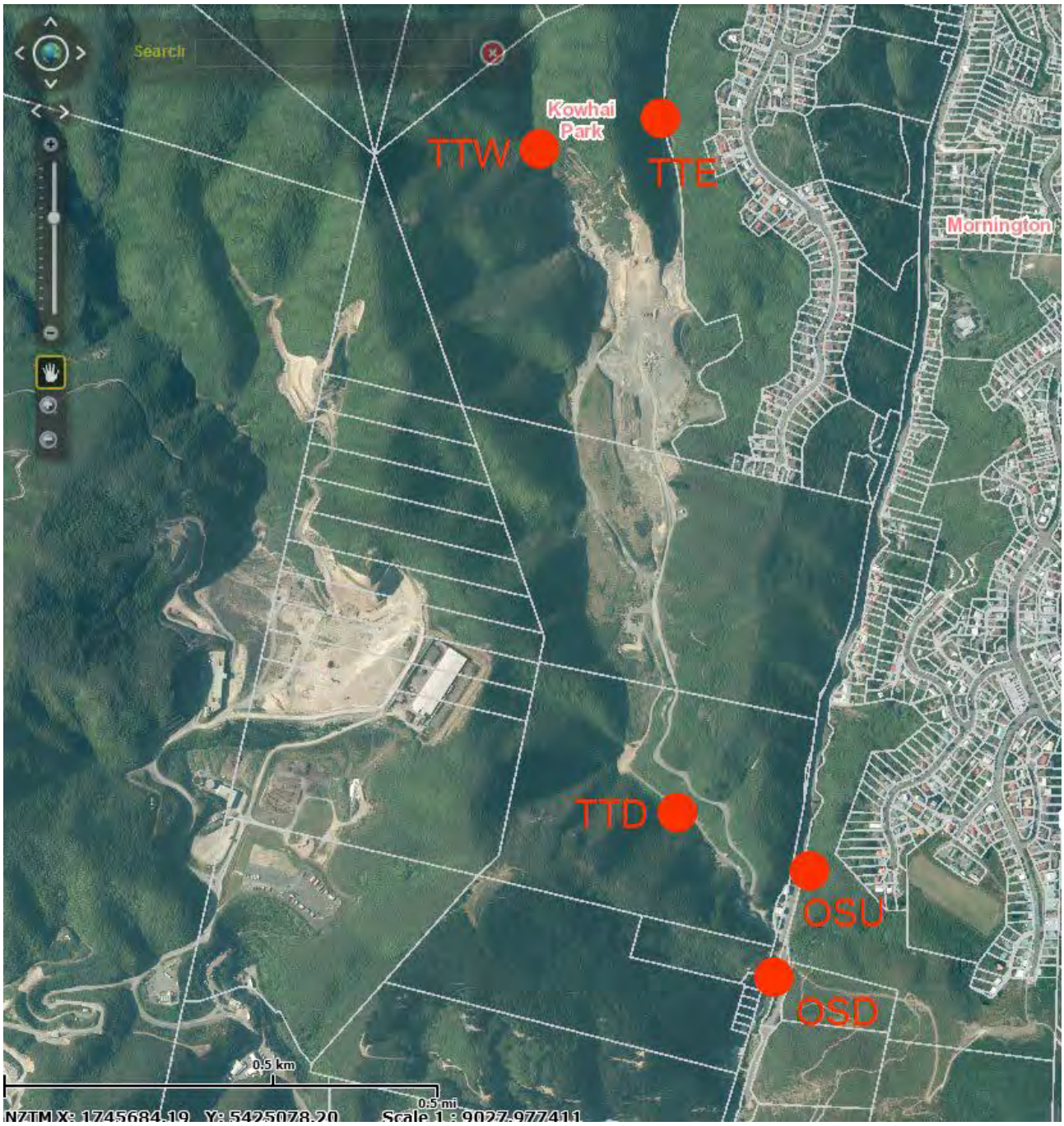
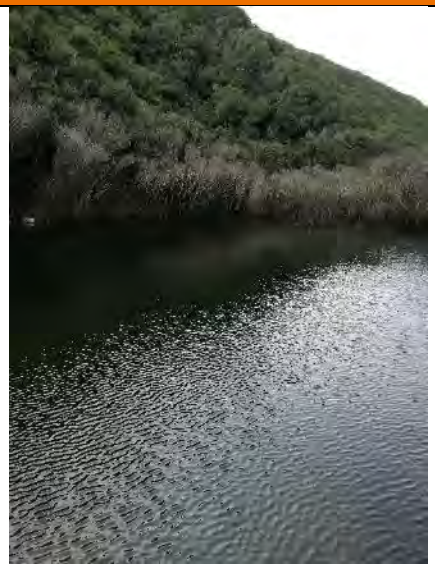


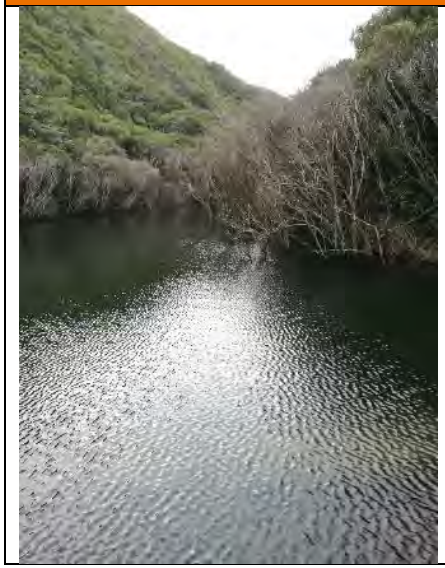
Figure 6-1: Location of T&T Landfill monitoring sites (TTG is located at TTD)

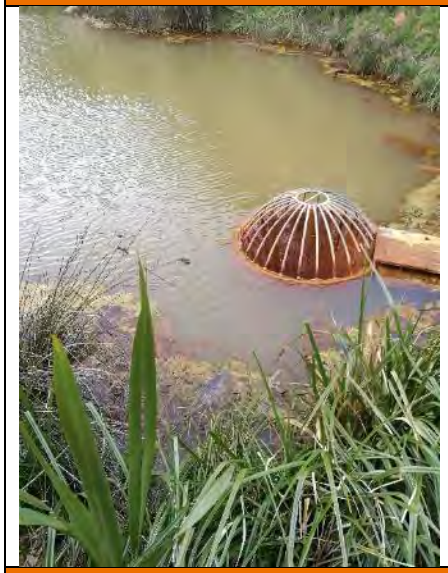
Appendix C Site Photographs

June 2019 OSD downstream	June 2019 OSD upstream	June 2019 OSD
		
June 2019 OSU downstream	**June 2019 OSU upstream**	**June 2019 OSU**
		

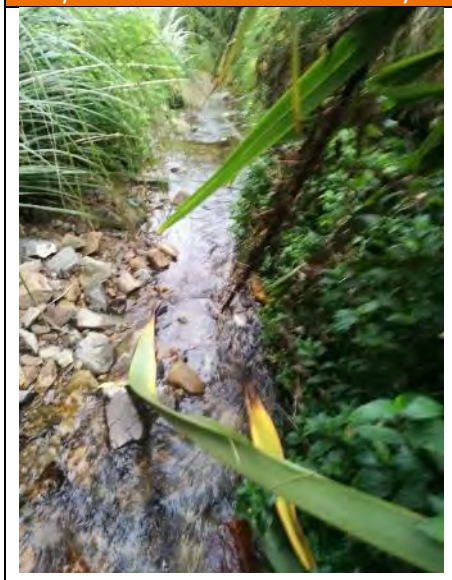
June 2019 TTD bubbles close up	June 2019 TTD downstream	June 2019 TTD upstream
		
June 2019 TTD	**June 2019 TTE 2**	**June 2019 TTE no flow through culvert 2**
		

June 2019 TTE no flow through culvert	June 2019 TTE	June 2019 TTW close up clarity
		
June 2019 TTW close up	**June 2019 TTW culvert**	**June 2019 TTW flow through culvert**
		

June 2019 TTW		
		

June 2019 Wetland 2	June 2019 Wetland 3	June 2019 Wetland Inflow 2
		
June 2019 Wetland Inflow close up	**June 2019 Wetland Inflow**	**June 2019 Wetland Outflow 2**
		

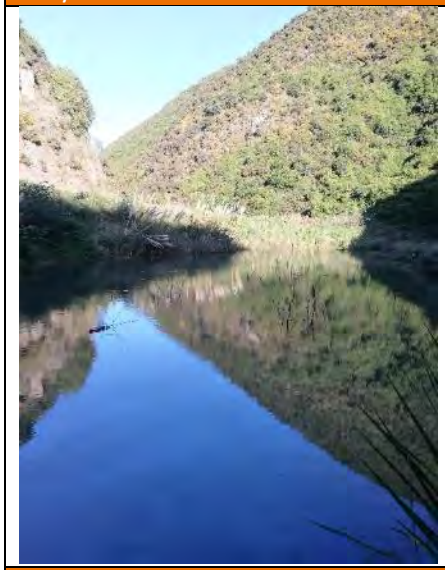
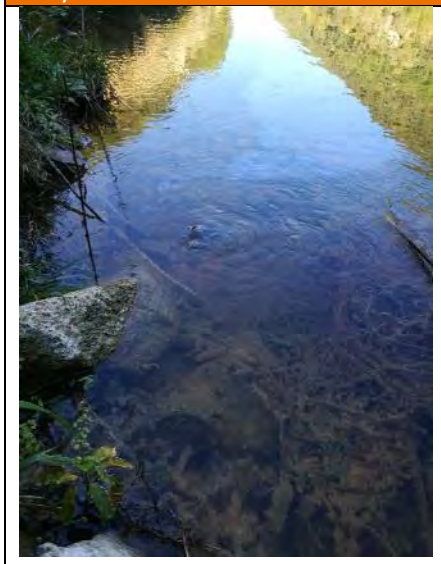
June 2019 Wetland Outflow 3	June 2019 Wetland Outflow Clarity	June 2019 Wetland Outflow Close Up
		
June 2019 Wetland Outflow	**June 2019 Wetland**	
		

May 2019 OSD downstream May19	May 2019 OSD May19	May 2019 OSD upstream May19
		
May 2019 OSU downstream May19	**May 2019 OSU May19**	**May 2019 OSU upstream May19**
		

May 2019 TTD downstream May19	May 2019 TTD foam trapped by debris May19	May 2019 TTD May19
		
May 2019 TTD upstream May19	**May 2019 TTE downstream- no flow May19**	**May 2019 TTE May19**
		

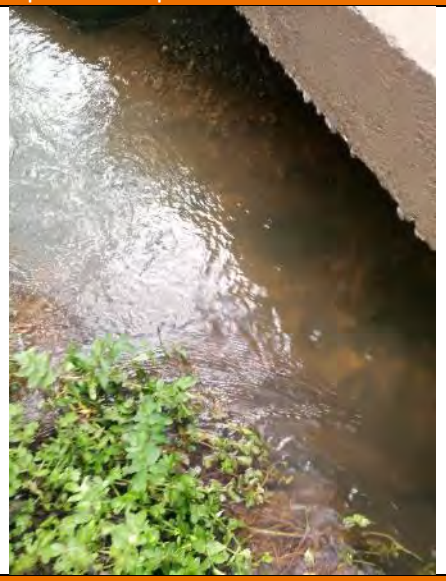
May 2019 TTE upstream May19	May 2019 TTW May19	May 2019 TTW downstream - no flow May19
		
May 2019 TTW downstream - no flow 2 May19	**May 2019 TTW upstream May19**	**May 2019 TTW vegetation growth May19**
		

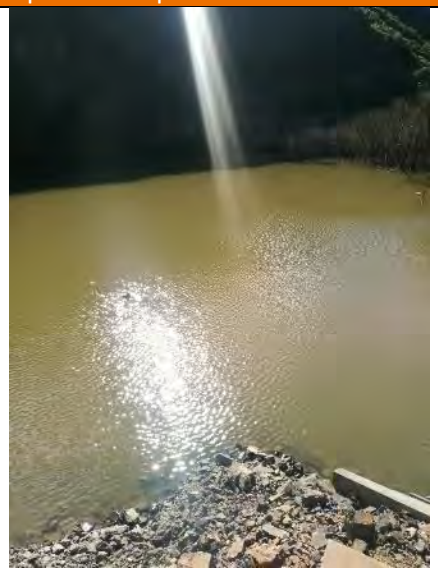
May 2019 Wetland May19	May 2019 Wetland 2 May19	May 2019 Wetland no flow over boulders May19
		
May 2019 Wetland outflow 2 May19	**May 2019 Wetland outflow May19**	
		

May 2019 Wetland inflow 1	May 2019 Wetland inflow 2	May 2019 Wetland inflow 3
		
May 2019 Wetland inflow 4	**May 2019 Wetland inflow close 1**	**May 2019 Wetland inflow close 2**
		

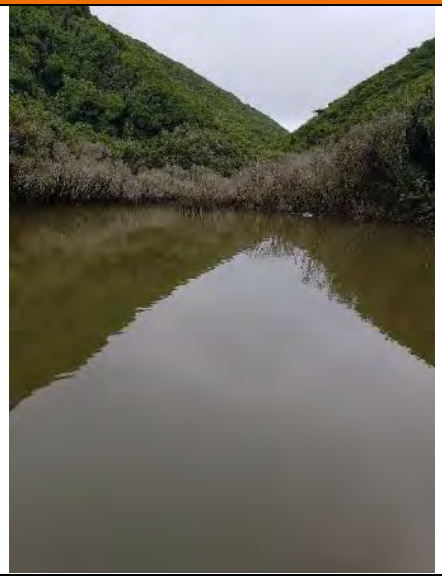
May 2019 Wetland inflow close 3	May 2019 Wetland outflow 1	May 2019 Wetland outflow 2
		
May 2019 Wetland outflow 3	**May 2019 Wetland outflow bubbles**	**May 2019 Wetland outflow inlet bubbles**
		

May 2019 Wetland outflow inlet		
		

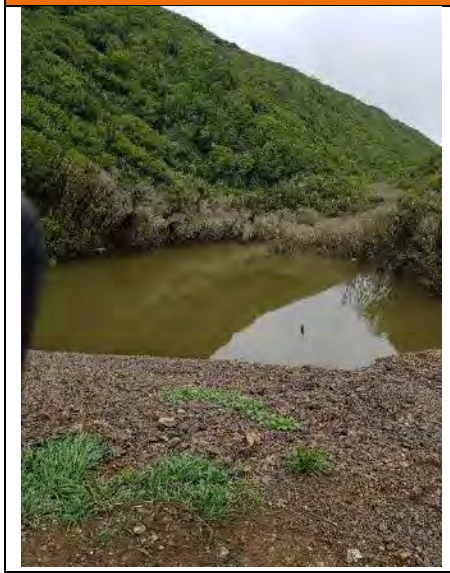
April 2019 April OSD downstream	April 2019 April OSD upstream	April 2019 April OSD
		
April 2019 April OSU downstream	**April 2019 April OSU upstream**	**April 2019 April OSU**
		

April 2019 April TTD upstream foam	April 2019 April TTD upstream	April 2019 April TTD
		
April 2019 April TTE upstream_no_flow	**April 2019 April TTE**	**April 2019 April TTW downstream**
		

April 2019 April TTW upstream	April 2019 April TTW	
		

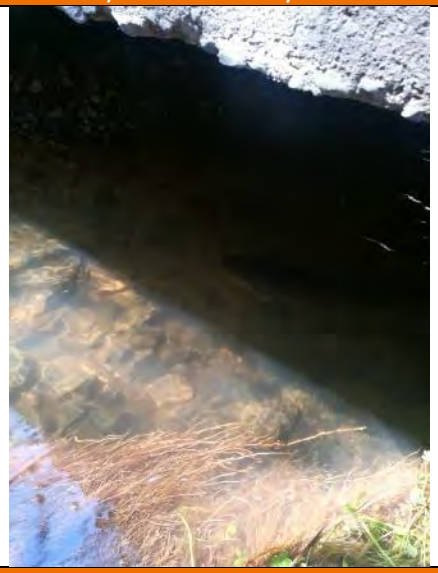
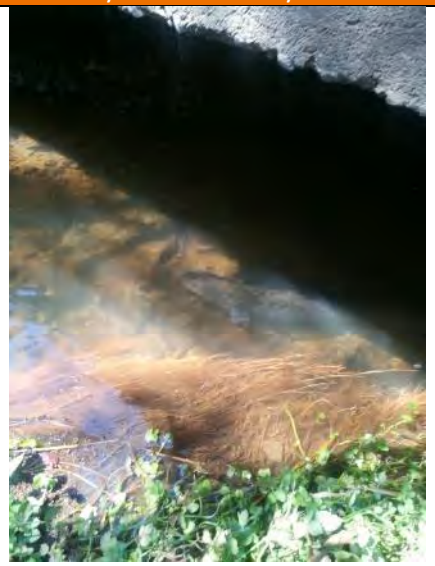
March 2019 TTD	March 2019 TTD	March 2019 TTD
		
March 2019 TTE	**March 2019 TTE**	**March 2019 TTE**
		

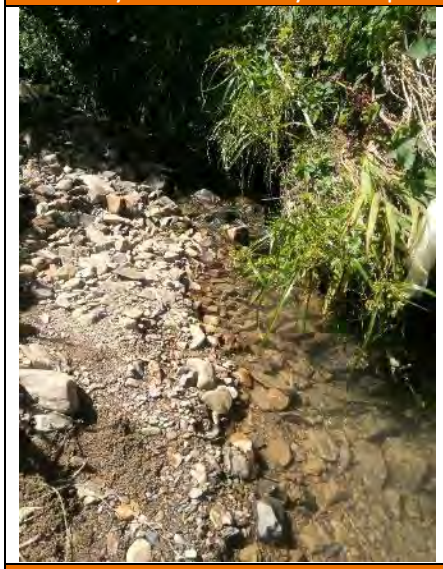
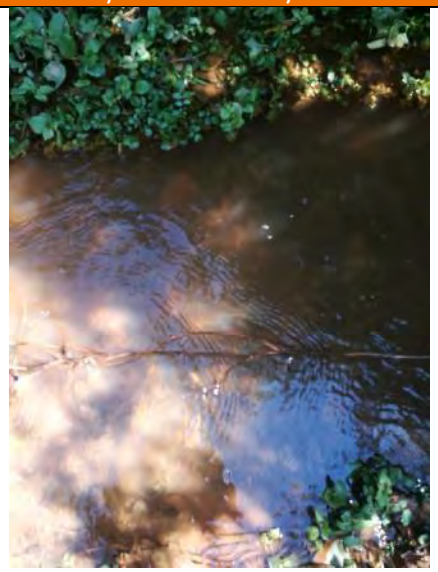
March 2019 TTE	March 2019 TTE	March 2019 TTE
		
March 2019 TTE	**March 2019 TTE**	**March 2019 TTE**
		

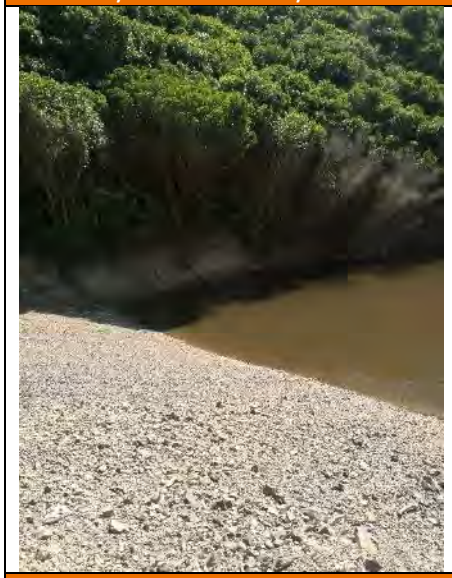
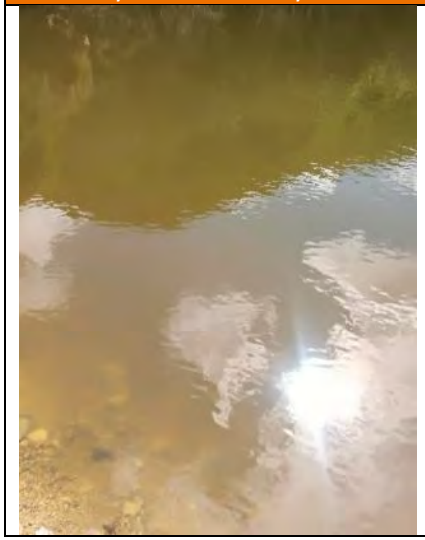
March 2019 TTW	March 2019 TTW	March 2019 TTW
		
March 2019 TTW	**March 2019 TTW**	**March 2019 TTW**
		

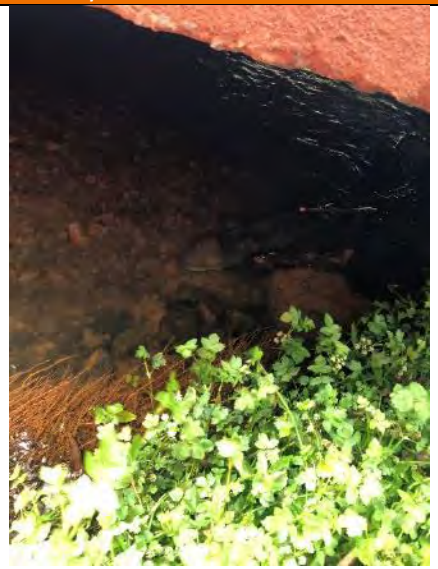
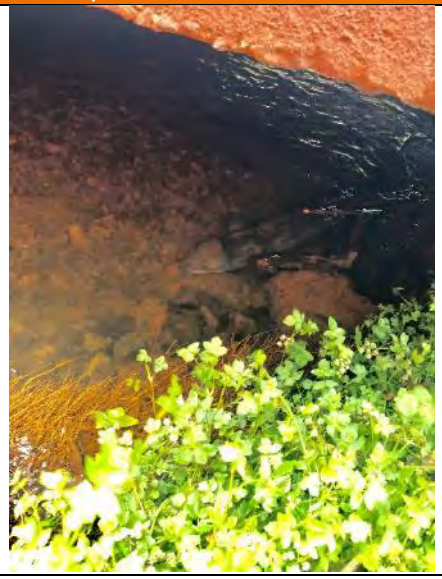
March 2019 OSD	March 2019 ODS	March 2019 OSD
		
March 2019 OSD	**March 2019 OSD**	**March 2019 OSU**
		

March 2019 OSU	March 2019 OSU	March 2019 OSU
		

February 2019 February OSD downstream	February 2019 February OSD eel 2	February 2019 February OSD eel
		
February 2019 February OSD upstream	**February 2019 February OSD**	**February 2019 February OSU downstream**
		

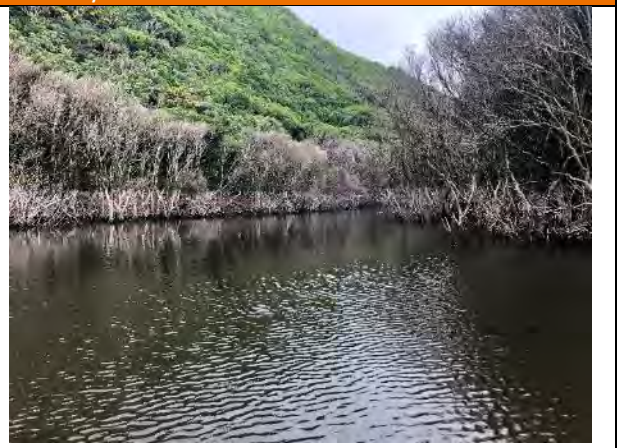
February 2019 February OSU upstream	February 2019 February OSU	February 2019 February TTD downstream
		
February 2019 February TTD upstream	**February 2019 February TTD**	**February 2019 February TTE 1**
		

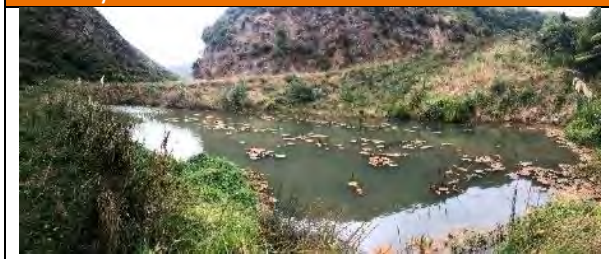
February 2019 February TTE 2	February 2019 February TTW 1	February 2019 February TTW 2
		
February 2019 February TTW 3		
		

January 2019 Diversion 1	January 2019 Diversion 2	January 2019 Diversion 3
		
January 2019 Diversion 4	**January 2019 Eel**	**January 2019 eel**
		

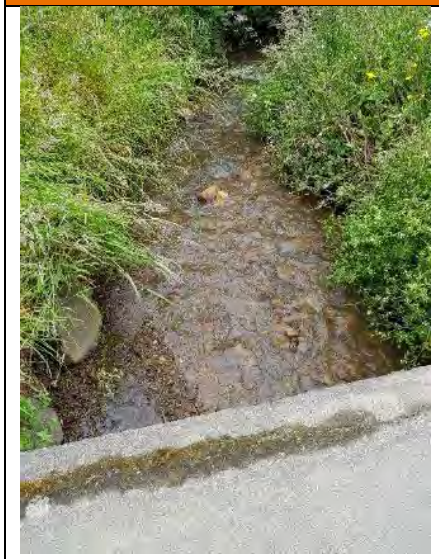
January 2019 OSD DS	January 2019 OSD Stream Bed	January 2019 OSD US
		
January 2019 OSU DS	**January 2019 OSU Stream Bed**	**January 2019 OSU US**
		

January 2019 TTD DS	January 2019 TTD Stream Bed	January 2019 TTD US
		
January 2019 TTE Dam Outlet	**January 2019 TTE Dam**	**January 2019 TTE Outlet2**
		

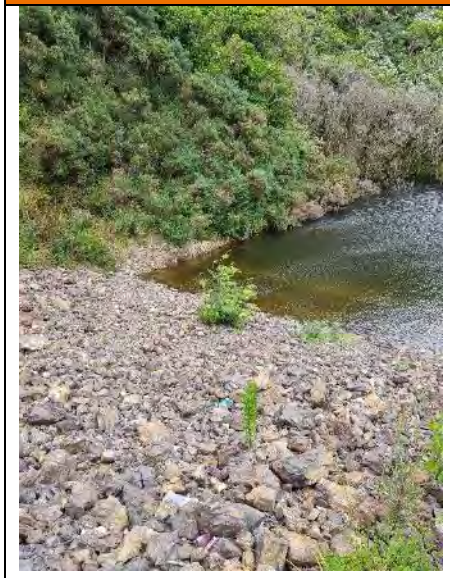
January 2019 TTE	January 2019 TTW Below Culvert	January 2019 TTW Culvert Inlet
		
January 2019 TTW Culvert	**January 2019 TTW Dam**	**January 2019 TTW Dam2**
		

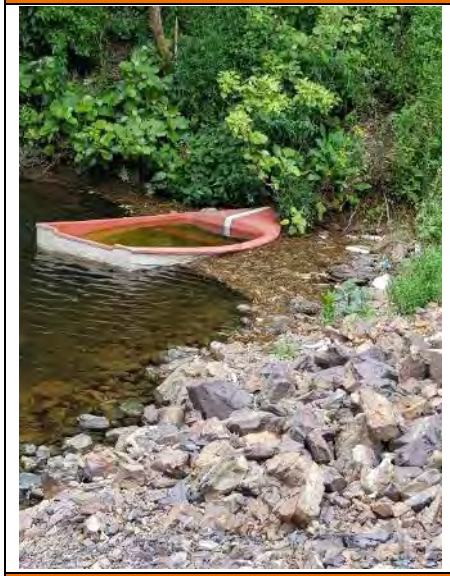
January 2019 Wetland 1	January 2019 Wetland 2	January 2019 Wetland 3
		
January 2019 Wetland 4	**January 2019 Wetland 5**	**January 2019 Wetland 6**
		

December 2018 OSU	December 2018 OSU	December 2018 OSU
		
December 2018 OSU	**December 2018 OSU**	**December 2018 OSU**
		

December 2018 OSU	December 2018 OSD	December 2018 OSD
		
December 2018 OSD	**December 2018 TTD**	**December 2018 TTD**
		

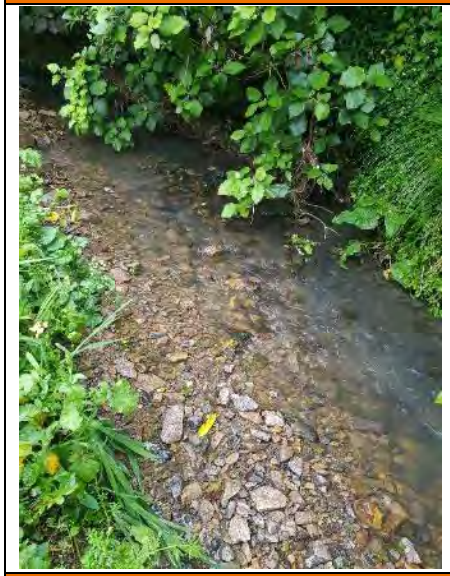
December 2018 TTD	December 2018 TTD	December 2018 TTD
		
December 2018 TTG	**December 2018 TTG**	**December 2018 TTW**
		

December 2018 TTW	December 2018 TTW	December 2018 TTW
		
December 2018 TTW	**December 2018 TTW**	**December 2018 TTW**
		

December 2018 TTW	December 2018 TTE	December 2018 TTE
		
December 2018 TTE	**December 2018 TTE**	**December 2018 TTE**
		

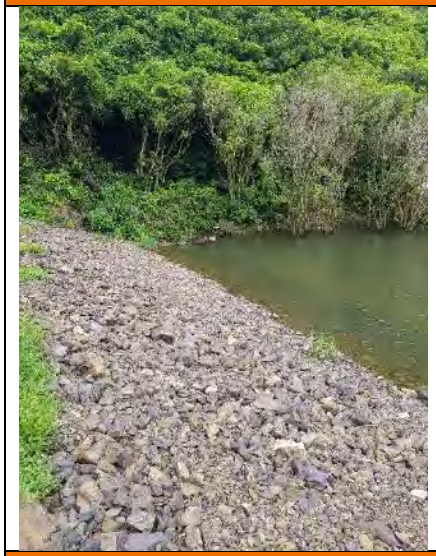
December 2018 TTE	December 2018 TTE	December 2018 TTE
		
December 2018 TTE	**December 2018 TTE**	**December 2018 TTE**
		

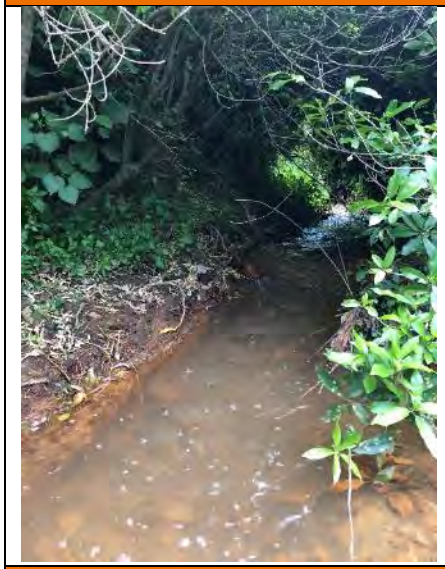
December 2018 TTE	December 2018 TTE	
		

November 2018 OSU	November 2018 OSU	November 2018 OSU
		
November 2018 OSD	**November 2018 OSD**	**November 2018 OSD**
		

November 2018 OSD	November 2018 TTW	November 2018 TTW
		
November 2018 TTW	**November 2018 TTW**	**November 2018 TTW**
		

November 2018 TTW	November 2018 TTW	November 2018 TTE
		
November 2018 TTE	**November 2018 TTE**	**November 2018 TTE**
		

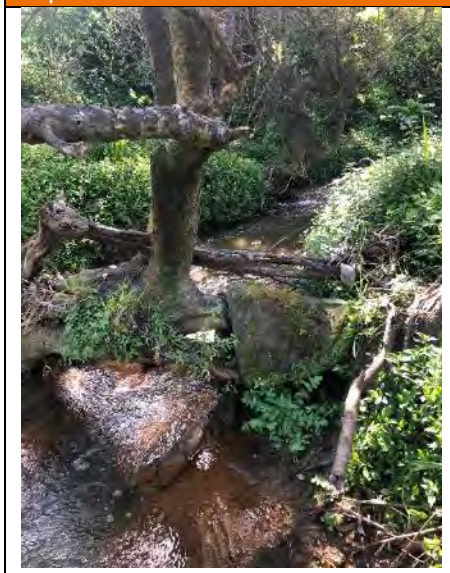
November 2018 TTE	November 2018 TTE	November 2018 TTE
		
November 2018 TTE		
		

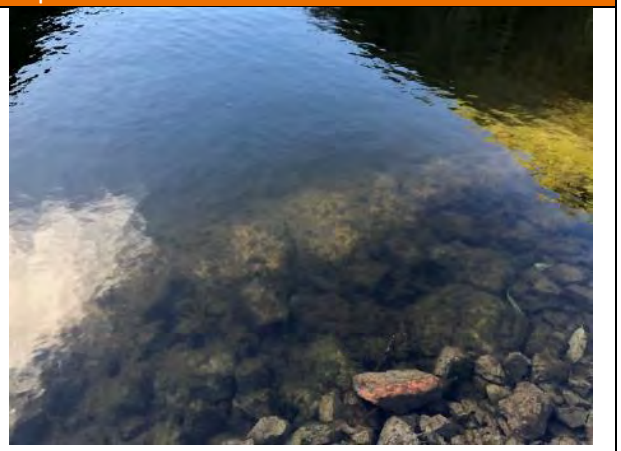
October 2018 TTD	October 2018 TTD	October 2018 TTD
		
October 2018 Wetland	**October 2018 Wetland**	**October 2018 diversion**
		

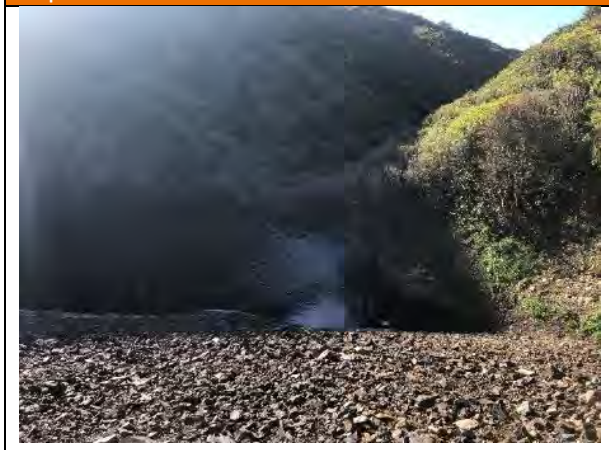
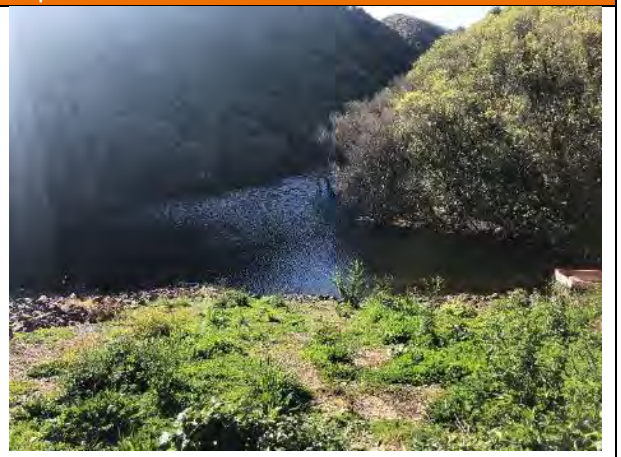
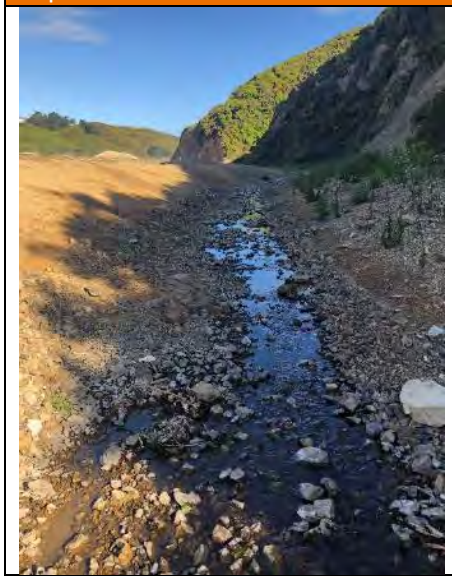
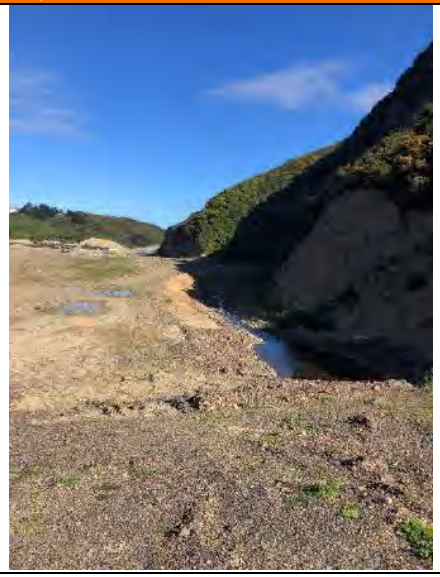
October 2018 diversion	October 2018 wetland	October 2018 wetland
		
October 2018 TTW	**October 2018 TTW**	**October 2018 TTW**
		

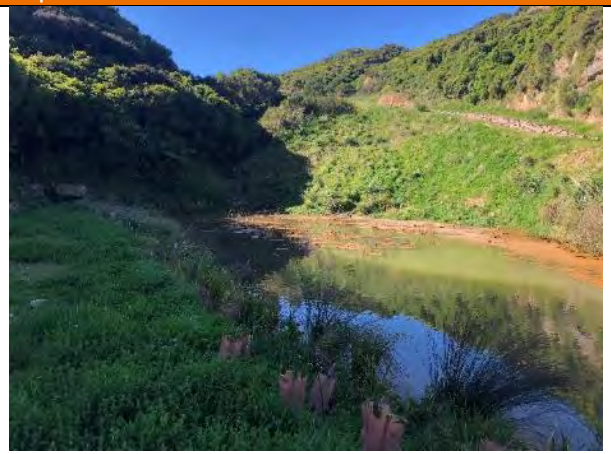
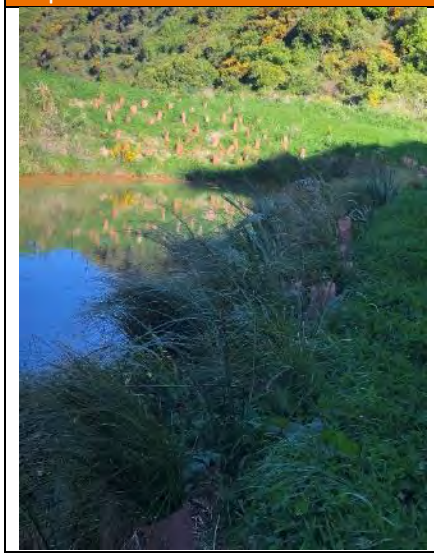
October 2018 TTW	October 2018 TTW	October 2018 TTW
		
October 2018 TTW	**October 2018 TTE**	**October 2018 TTE**
October 2018 TTE	October 2018 OSD	October 2018 OSD
		

October 2018 OSD	October 2018 OSU	October 2018 OSU
		
October 2018 OSU		
		

September 2018 Diversion	September 2018 OSD DS	September 2018 OSD Stream Bed
		
September 2018 OSD US	**September 2018 OSU DS**	**September 2018 OSU Stream Bed**
		

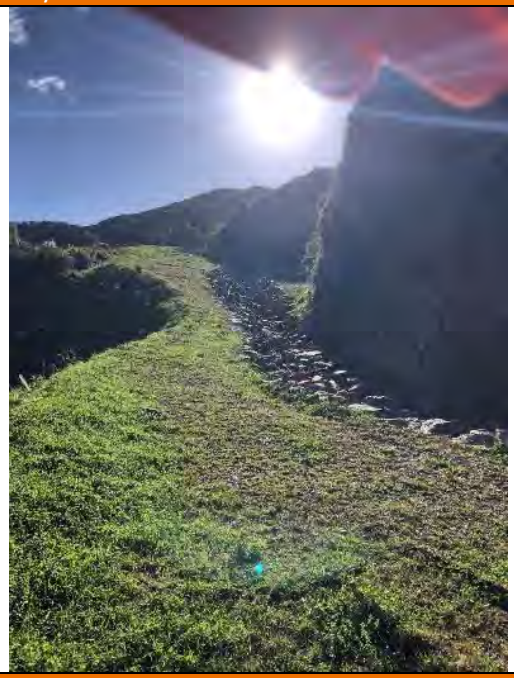
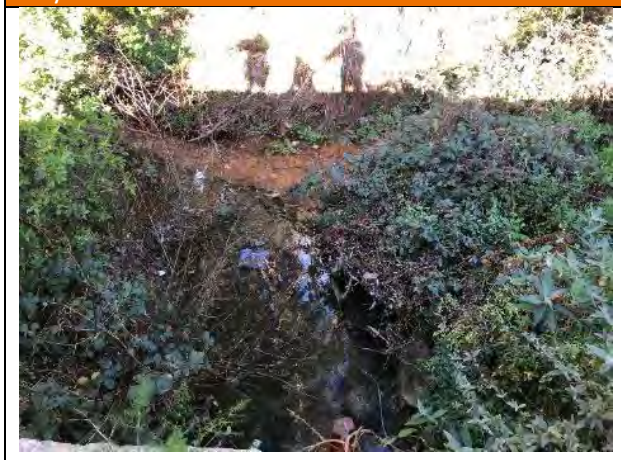
September 2018 OSU US	September 2018 TTD DS	September 2018 TTD Stream Bed
		
September 2018 TTD US	**September 2018 TTE Culvert**	**September 2018 TTE Dam Bed**
		

September 2018 TTE Dam	September 2018 TTE DS	September 2018 TTW Dam
		
September 2018 TTW DS	**September 2018 TTW Green Patch DS**	**September 2018 TTW Stream Bed**
		

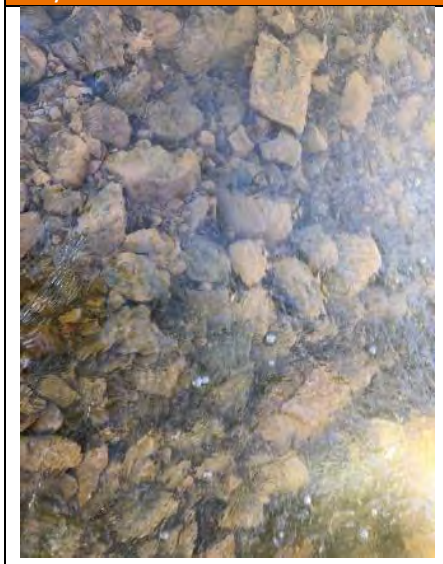
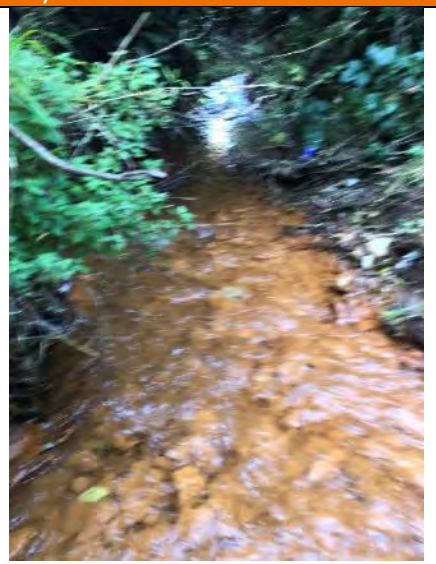
September 2018 TTW US	September 2018 Wetland 1	September 2018 Wetland 2
		
September 2018 Wetland 3	**September 2018 Wetland 4**	**September 2018 Wetland 5**
		

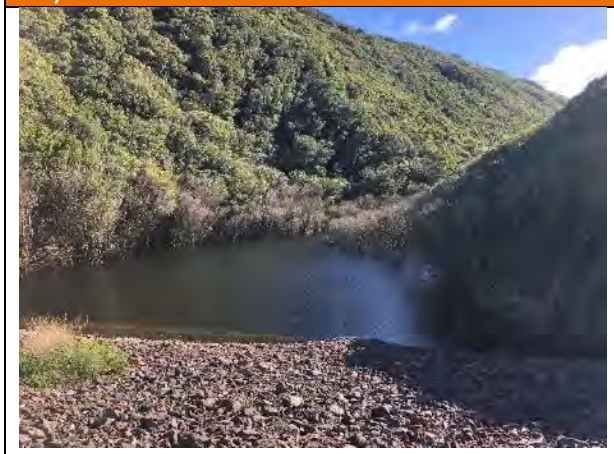
August 2018 DS wetland	August 2018 OSD-1	August 2018 OSD-2
		
August 2018 OSU	**August 2018 OSU-2**	**August 2018 TTD**
		

August 2018 TTE pond	August 2018 TTW channel- 2	August 2018 TTW channel
		
August 2018 TTW pond	**August 2018 Wetland -2**	**August 2018 wetland**
		

July 2018 Confluence and eels	July 2018 Diversion 1	July 2018 Diversion 2
		
July 2018 eels 1	**July 2018 eels 2**	**July 2018 eels 3**
		

July 2018 eels 4	July 2018 eels 5	July 2018 eels 6
		
July 2018 eels 7	**July 2018 eels 8**	**July 2018 OSD DS**
		

July 2018 OSD Stream Bed	July 2018 OSD US	July 2018 OSU DS
		
July 2018 OSU Stream Bed	**July 2018 OSU US**	**July 2018 TTD DS**
		

July 2018 TTD Stream Bed	July 2018 TTD US	July 2018 TTE Dam bed
		
July 2018 TTE Dam	**July 2018 TTE Diversion 2**	**July 2018 TTE Diversion**
		

July 2018 TTW Dam	July 2018 TTW Diversion 2	July 2018 TTW Diversion Bed
		
July 2018 TTW Diversion	**July 2018 Wetland 1**	**July 2018 Wetland 2**
		

July 2018 Wetland 3	July 2018 Wetland 4	July 2018 Wetland 5
		
July 2018 Wetland bed		
		

Appendix D Field Notes

D.1 June 2019

(June)

27982

Date	01/07/19	Rainfall Event?	No	Rainfall within last 24 hours?		No
	OSU	OSD	~~TTE~~ TTW	TTE	TTW	~~TTW~~ TTD
Time	15:35	15:25	~~13:35~~ 14:45	15:10	15:15	~~14:55~~ 14:55
pH						
Temperature						
Conductivity						
DO %						
DO mg/L						
Stream bed conditions						
Periphyton	No	No		No	No	No
Orange precipitate	No	Yes		No	No	Yes
Water clarity	Clear	Slightly cloudy		Clear	Clear	Semi-cloudy
Foam/bubbles	No foam No bubbles	No foam No bubbles		No foam No bubbles	No foam No bubbles	Little bubbles Some foam
Rubbish/odour	Rubbish present No odour	Some rubbish No odour		Some rubbish No odour	Rubbish present No odour	No rubbish No odour
Flow	Very low	Low.		Low	Low-medium.	Medium

No flow through culvert.

Flow through culvert → no foam, bubbles, rubbish or odour. → clear.

Wetland inflow	Wetland	Wetland outflow
14:15	14:25	14:35
No	No	No
Yes	Yes	Yes (ish)
Semi-cloudy	Cloudy	Cloudy.
No foam	No foam	Foam present
No bubbles	No bubbles	Bubbles present
No rubbish	No rubbish	Some odour
No odour	No odour	No rubbish
Medium	Medium.	Medium.

D.2 May 2019

Date	28/05/19	Rainfall Event?	No	Rainfall within last 24 hours?		No
	OSU	OSD	TTD	TTE	TTW	~~TEG~~ Wetland.
Time	08:30 am	08:50 am	09:10 am	09:30 am	09:50 am	
pH						
Temperature						
Conductivity						
DO %						
DO mg/L						
Stream bed conditions						
Periphyton	No	No	No	No	No	No
Orange precipitate	No	Yes	Yes	No	No	Yes - outflow from wetland bright orange
Water clarity	Clear	Slightly cloudy	Cloudy	Clear	Clear	Cloudy
Foam/bubbles	No foam No bubbles	No foam No bubbles	No bubbles, Foam *	No foam No bubbles	No foam No bubbles	No foam No bubbles
Rubbish/odour	No rubbish No odour	Some rubbish No odour.	No rubbish No odour	Some rubbish No odour	Some rubbish No odour	No rubbish Yes (odour)
Flow	Low	Low	Low.	Very Low	Very Low	Very Low.

* foam blocked upstream, photo taken.

No flow through culvert.

No flow through culvert

D.3 April 2019

Car Start: (?)
End: 24877

Date	09/04/19	Rainfall Event?	yes	Rainfall within last 24 hours?		~~Yes No~~ ?
	OSU	OSD	TTD	TTE	TTW	TTG
Time	13:30	13:45	14:10	~~14:20~~ 14:30	14:20	
pH						
Temperature						
Conductivity						
DO %						
DO mg/L						
Stream bed conditions						
Periphyton	No	No	No	No	No	
Orange precipitate	No	Yes	Yes	No	No	
Water clarity	Clear	Cloudy	Semi-Cloudy	~~Clear~~ Cloudy	~~Slightly cloudy~~ Clear	
Foam/bubbles	No foam No bubbles	No foam No bubbles	Some foam Some bubbles (small amount)	No foam No bubbles	No foam No bubbles	
Rubbish/odour	No odour Some litter	No odour Medium litter	No odour No litter	No odour Some litter	No odour Some litter	
Flow	Medium.	Medium.	Low.	High - no through culvert	Low - through culvert. Green tint to water ↓ high in	

D.4 March 2019

TTE			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
11/3/19	12.00	Yes	
Stream bed conditions			
periphyton	—		
Orange precipitate	—		
Water clarity	Cloudy Brown		
Foam/bubbles	No		
Rubbish/odour	Some		
Flow	High		

TTW			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
11/3/19	12.15	Yes	
Stream bed conditions			
periphyton	—		
Orange precipitate	—		
Water clarity	Cloudy		
Foam/bubbles	No		
Rubbish/odour	Some		
Flow	high. low down overflow		

TTD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
11/3/19	11.50	Yes	
Stream bed conditions			
periphyton	—		
Orange precipitate	Yes		
Water clarity	Cloudy Brown/Orange		
Foam/bubbles	Minor		
Rubbish/odour	Some		
Flow	Low - moderate		

OSU			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
11/3/19	12.40	Yes	
Stream bed conditions			
periphyton	—		
Orange precipitate	—		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	No		
Flow	Low - moderate		

OSD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
11/3/19	12.30	Yes	
Stream bed conditions			
periphyton	—		
Orange precipitate	Some		
Water clarity	Clear - cloudy		
Foam/bubbles	No		
Rubbish/odour	Yes		
Flow	Low - moderate		

TTG			
Date 11/3/19	Time	Triggered rainfall event?	Rainfall within last 24 hours?
	11.50	Yes	
Comments	Sediment in samples.		

Sophie Gray 027-443-4292.

SG

D.5 February 2019

TTE			
Date 26/02/19	Time	Triggered rainfall event?	Rainfall within last 24 hours?
	15:05	Yes	No
Stream bed conditions			
periphyton	No		
Orange precipitate	No		
Water clarity	Slightly cloudy		
Foam/bubbles	No		
Rubbish/odour	Some litter, no odour		
Flow	No flow through culvert as dam reconstructed.		

TTW			
Date 26/02/19	Time	Triggered rainfall event?	Rainfall within last 24 hours?
	14:55	Yes	No
Stream bed conditions			
periphyton	No		
Orange precipitate	No		
Water clarity	Slightly cloudy		
Foam/bubbles	No		
Rubbish/odour	Some litter, no odour		
Flow	No flow through culvert. Low water line.		

TTD			
Date 26/02/19	Time	Triggered rainfall event?	Rainfall within last 24 hours?
	14:45	Yes	No
Stream bed conditions			
periphyton	No		
Orange precipitate	Yes		
Water clarity	Cloudy		
Foam/bubbles	No		
Rubbish/odour	Litter, no odour		
Flow	Low		

OSU			
Date 26/02/19	Time 14:05	Triggered rainfall event?	Rainfall within last 24 hours?
"	"	Yes	No
Stream bed conditions			
periphyton	Yes		
Orange precipitate	No		
Water clarity	Slightly cloudy		
Foam/bubbles	No		
Rubbish/odour	Litter, no odour		
Flow	Low		

OSD			
Date 26/02/19	Time 14:20	Triggered rainfall event?	Rainfall within last 24 hours?
"	"	Yes	No.
Stream bed conditions			
periphyton	No		
Orange precipitate	Yes		
Water clarity	Slightly cloudy.		
Foam/bubbles	No		
Rubbish/odour	Litter, no odour		
Flow	Low.		

~~TTG~~			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
Comments			

D.6 January 2019

TTE			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
1/02/2019		NO	None
Stream bed conditions			
periphyton	No		
Orange precipitate	No		
Water clarity	~~clear~~ slightly cloudy.		
Foam/bubbles	No, some scum at side of ponded water.		
Rubbish/odour	Minor rubbish.		
Flow	No flow through culvert, Dam being re-constructed.		

TTW			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
1/02/2019		No	None
Stream bed conditions			
periphyton	No		
Orange precipitate	No		
Water clarity	slightly cloudy		
Foam/bubbles	No		
Rubbish/odour	No		
Flow	No flow through the culvert. Water ~1m below inlet		

TTD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
1/02/2019	2:05	No	None
Stream bed conditions			
periphyton	No		
Orange precipitate	Yes.		
Water clarity	cloudy		
Foam/bubbles	Small amount of bubbles		
Rubbish/odour	Metalic odour.		
Flow	low.		

OSU			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
1/02/2019	13:35	No	None
Stream bed conditions			
periphyton	Yes		
Orange precipitate	No		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	Litter, no odour.		
Flow	Low		

OSD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
1/02/2019	13:50	No	None
Stream bed conditions			
periphyton	No		
Orange precipitate	yes		
Water clarity	Slightly cloudy.		
Foam/bubbles	No		
Rubbish/odour	Litter, no odour		
Flow	Low.		

TTG			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
Comments			

D.7 December 2018

TTD

~~TTE~~			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
20/12/18	2:10	Yes	Yes
Stream bed conditions			
periphyton	No		
Orange precipitate	Yes		
Water clarity	Cloudy brown		
Foam/bubbles	No		
Rubbish/odour	No		
Flow	Slow - Moderate		

TTW			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
20/12/18	2:30	Yes	Yes
Stream bed conditions			
periphyton	No		
Orange precipitate	No		
Water clarity	Cloudy brown		
Foam/bubbles	No		
Rubbish/odour	Small amount debris in eastern corner.		
Flow	Low flow downstream		

~~TTD~~ TTE			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
20/12/18	2.40	yes	Yes
Stream bed conditions			
periphyton	No		
Orange precipitate	No		
Water clarity	Clear / Cloudy		
Foam/bubbles	No		
Rubbish/odour	Small amount.		
Flow	Low - no flow through culvert		

OSU			
Date 20/12/18	Time	Triggered rainfall event?	Rainfall within last 24 hours?
	1:45	Yes	Yes
Stream bed conditions			
periphyton	No		
Orange precipitate	No		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	Small rubbish		
Flow	low - Moderate		

OSD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
20/12/18	1:55	yes	Yes
Stream bed conditions			
periphyton	No		
Orange precipitate	Small amount		
Water clarity	Cloudy brown		
Foam/bubbles	No		
Rubbish/odour	Small litter		
Flow	Moderate.		

TTG			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
20/12/18	2:20	Yes	Yes.
Comments	Located correct bore, but bore was disturbed. Lots of sediment.		

D.8 November 2018

TTE			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
29/11/18	11.10	No	Yes - Minor
Stream bed conditions			
periphyton	No		
Orange precipitate	No		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	No	Small amount of rubbish	
Flow	Same swamped culvert		

TTW			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
29/11/18	11.00	No	Yes - Minor
Stream bed conditions			
periphyton	No		
Orange precipitate	No		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	No		
Flow	Yes - low.		

TTD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
29/11/18	10.50	No	Yes - minor
Stream bed conditions			
periphyton	No		
Orange precipitate	Yes		
Water clarity	Clear/Cloudy grey		
Foam/bubbles	Yes		
Rubbish/odour	Small amount rubbish.		
Flow	Low - Moderate. Very overgrown.		

OSU			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
29/11/18	10.25	No	Small amount
Stream bed conditions			
periphyton	No		
Orange precipitate	No		
Water clarity	Cloudy grey (slight)		
Foam/bubbles	No		
Rubbish/odour	No		
Flow	Medium		

OSD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
29/11/18	10.35	No	Small amount
Stream bed conditions			
periphyton	No		
Orange precipitate	Yes		
Water clarity	Cloudy Grey		
Foam/bubbles	Small amount		
Rubbish/odour	Small amount rubbish		
Flow	Medium - high		

TTG			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
Comments			

D.9 October 2018

October

TTE			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
31/10/2018	2:15 pm	No	~36 mm in last 48 hrs
Stream bed conditions			
periphyton	No		
Orange precipitate	No		
Water clarity	Clear in Dam.		
Foam/bubbles	No.		
Rubbish/odour	Small amount of rubbish, No odour		
Flow	No flow through swale, Dam level higher than ~~last week~~		

TTW			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
31/10/2018	2:00pm	No	~36mm in last 48hrs
Stream bed conditions			
periphyton	No		
Orange precipitate	No		
Water clarity	Clear in ~~stace~~ swale.		
Foam/bubbles	No.		
Rubbish/odour	small amount of rubbish around, No odour		
Flow	Low flow in swale, ~~flow~~ flow ends @ junction.		

TTD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
31/10/2018	1:45 pm	No	~36mm in last 48 hrs
Stream bed conditions			
periphyton	No		
Orange precipitate	Yes - clear through middle of stream.		
Water clarity	cloudy.		
Foam/bubbles	Small amount of bubbles		
Rubbish/odour	No odour, No rubbish		
Flow	Moderate - low		

OSU			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
31/10/18	2:30pm	No	~36mm in last 48hrs
Stream bed conditions			
periphyton	Small amounts of periphyton		
Orange precipitate	No		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	No odour, some rubbish		
Flow	Moderate		

OSD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
31/10/18	2:45pm	No	~36mm in last 48hrs.
Stream bed conditions			
periphyton	No		
Orange precipitate	Yes, small amount on edge of bank		
Water clarity	slightly turbid.		
Foam/bubbles	Some bubbles.		
Rubbish/odour	some rubbish, chlorine odour.		
Flow	Moderate		

TTG			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
Comments	Not required		

D.10 September 2018

TTE			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
27/09/2018	2:55.	No	—
Stream bed conditions			
periphyton	No.		
Orange precipitate	Yes —		
Water clarity	slightly cloudy,		
Foam/bubbles	Some bubbles.		
Rubbish/odour	No odour, minor rubbish		
Flow	Moderate.		

TTW			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
27/09/2018	3:20	No	—
Stream bed conditions			
periphyton	algae growth in ponded water after culvert.		
Orange precipitate	No		
Water clarity	clear,		
Foam/bubbles	None		
Rubbish/odour	No odour, rubbish present		
Flow	low, small amount through culvert		

TTD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
27/09/2018	3:40.	No	—
Stream bed conditions			
periphyton	algae growth in pam water		
Orange precipitate	No		
Water clarity	clear		
Foam/bubbles	None		
Rubbish/odour	No odour, Rubbish present		
Flow	No. flow through culvert.		

Rego start.
012453

OSU			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
27/09/2018	2:20 pm	No	—
Stream bed conditions			
periphyton	small 10% cover; green		
Orange precipitate	No		
Water clarity	clear, Not turbid or cloudy.		
Foam/bubbles	very small amount of bubbles in coves		
Rubbish/odour	rubbish noted, plastic, bricks, other, No odour		
Flow	Moderate flow.		

OSD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
27/09/2018.	2:30pm	No	—
Stream bed conditions			
periphyton	No		
Orange precipitate	yes., orange near banks, light orange near middle.		
Water clarity	& slightly cloudy.		
Foam/bubbles	bubbles		
Rubbish/odour	rubbish., No odour.		
Flow	Moderate.		

TTG			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
27/09/2018.	3105.	No	—
Comments	water taken from correct bore		

3 litres purged before sample taken.

D.11 August 2018

TTE			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
23/8/18	9:15	Yes	0
Stream bed conditions			
periphyton	None		
Orange precipitate	none		
Water clarity	turbid		
Foam/bubbles	none		
Rubbish/odour	none		
Flow	Slight overflow from culvert into constructed channel		

TTW			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
23/8/18	9:20	Yes	0
Stream bed conditions			
periphyton	30% cover brown filamentous algae		
Orange precipitate	None		
Water clarity	Slightly turbid		
Foam/bubbles	none		
Rubbish/odour	none		
Flow	Good flow from culvert in to constructed channel		

TTD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
23/8/18	9:00	Yes	0
Stream bed conditions			
periphyton	None		
Orange precipitate	Slight		
Water clarity	Slightly turbid		
Foam/bubbles	none		
Rubbish/odour	Slight ‘landfill;’ odour		
Flow	high		

OSU			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
23/8/18	10:00	Yes	0
Stream bed conditions			
periphyton	None		
Orange precipitate	None		
Water clarity	Clear		
Foam/bubbles	None		
Rubbish/odour	None		
Flow	Moderately elevated		

OSD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
23/8/18	9:50	Yes	0
Stream bed conditions			
periphyton	None		
Orange precipitate	None		
Water clarity	Slightly turbid		
Foam/bubbles	none		
Rubbish/odour	none		
Flow			

TTG			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
Comments			

D.12 July 2018

TTE			
Date 30/7/18	Time	Triggered rainfall event?	Rainfall within last 24 hours?
	10:55	No	—
Stream bed conditions			
periphyton	Yes		
Orange precipitate	No		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	No		
Flow	None. WL below culvert.		

TTW			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
30.7.18	10:45	No	—
Stream bed conditions			
periphyton	Yes Brown & Green.		
Orange precipitate	No		
Water clarity	Clear		
Foam/bubbles	No		
Rubbish/odour	No odour. Some cardboard.		
Flow	3 / ltr/s.		

TTD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
30/7/18	10:15	No	—
Stream bed conditions			
periphyton	no		
Orange precipitate	Yes on stream bed.		
Water clarity	clear - to lightly turbid.		
Foam/bubbles	no bubbles / some foam.		
Rubbish/odour	Organic odour		
Flow	low - mod. ≈ 15 / ltr/s		

OSU			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
30/7/18	9:30	NO	? —
Stream bed conditions			
periphyton	Small amounts, no Mats		
Orange precipitate	No		
Water clarity	clear		
Foam/bubbles	no		
Rubbish/odour	Some plastic / no odour.		
Flow	low - moderate.		

April 'SLUR'

OSD			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
30/07/18	9:35 am	No	—
Stream bed conditions			
periphyton	No		
Orange precipitate	Yes, very light coverage, light brown		
Water clarity	slightly cloudy		
Foam/bubbles	small amount of bubbles		
Rubbish/odour	Rubbish noted, No odour.		
Flow	Moderate		

TTG			
Date	Time	Triggered rainfall event?	Rainfall within last 24 hours?
Comments			

Appendix E Comparison with ANZECC 2000 Guidelines

Table C1: June 2019 Quarterly Monitoring Results and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD		WLDI	WLDO	WLD
pH	pH	NA (6-9)	7.5	7.1	7.4	7.6	8		6.6	6.9	6.7
Conductivity	mS/m	NA	79.1	26.6	27.4	34.4	65.2		78.7	79	78.2
Total Alkalinity	g/m^3CaCO_3	NA	270	44	43	52	200		280	280	280
TSS	g/m^3	NA	8	1.5	1.5	1.5	5		6	13	8
COD	g O2/m^3	NA	11	6	<6	3	12		15	16	15
Total Hardness	g/m^3CaCO_3	NA	290	46	51	62	230		290	290	290
Total Ammoniacal Nitrogen	g/m^3	1.430 (2.34)	1.05	0.053	0.035	0.005	0.45		1.3	1.3	1.3
Total Iron	g/m^3	NA	3.2	0.124	0.056	0.028	2.9		4.4	3.8	3.7
Dissolved Iron	g/m^3	NA	0.03	0.06	0.02	0.01	0.03		0.8	0.06	0.29
Total Manganese	g/m^3	NA	2.2	0.063	0.026	0.00159	1.29		2.2	2.3	2.2
Dissolved Manganese	g/m^3	2.5	2.3	0.058	0.021	0.0012	1.25		2.3	2.4	2.3
Dissolved iron + Dissolved manganese	g/m^3	1.0	2.33	0.118	0.041	0.0112	1.28		3.1	2.46	2.59
Total Lead	g/m^3	NA	0.00017	0.000055	0.000055	0.00024	0.00046		0.000055	0.00025	0.00012
Dissolved Lead	g/m^3	0.0056 (0.011)	0.00005	0.00005	0.00005	0.00005	0.00005		0.00005	0.00005	0.00005
Total Copper	g/m^3	NA	0.000265	0.00056	0.000265	0.00189	0.00073		0.000265	0.000265	0.000265
Dissolved Copper	g/m^3	0.0018 (0.0028)	0.0006	0.00025	0.00025	0.0013	0.00025		0.00025	0.00025	0.00025
Total Zinc	g/m^3	NA	0.0027	0.0041	0.0055	0.0148	0.0083		0.0017	0.0039	0.0018
Dissolved Zinc	g/m^3	0.015 (0.027)	0.0018	0.0038	0.0005	0.0133	0.0028		0.0015	0.0026	0.0014
Total Arsenic	g/m^3	NA	0.0018	0.00055	0.00055	0.00055	0.0016		0.0027	0.0022	0.0023
Dissolved Arsenic	g/m^3	0.042	0.0005	0.0005	0.0005	0.0005	0.0005		0.001	0.0005	0.0005

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD		WLDI	WLDO	WLD
Total Chromium	g/m^3	NA	0.00089	0.00056	0.00068	0.00054	0.0012		0.00109	0.00096	0.00081
Dissolved Chromium	g/m^3	0.006	0.0006	0.00025	0.00025	0.00025	0.00025		0.0005	0.0005	0.0006

* Notes: 1. Site specific total ammoniacal nitrogen is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 g/m$_3$ $CaCO_3$

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m^3 to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as half of the detection limit

Table C2: May 2019 Monthly Monitoring Results and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.4	7.4	7.5	7.6	8
Conductivity	mS/m	NA	79.3	29.6	29.5	32.9	65.7
Total Alkalinity	$g/m^3 CaCO_3$	NA	270	50	48	51	210
TSS	g/m^3	NA	19	1.5	<3	3	7
COD	$g\ O2/m^3$	NA	23	9	11	9	17
Total Hardness	$g/m^3 CaCO_3$	NA	300	53	55	62	230
Total Ammoniacal Nitrogen	g/m^3	1.430 (2.34)	1.13	0.055	0.035	0.005	0.42
Total Iron	g/m^3	NA	7.5	0.22	0.065	0.024	2.3
Dissolved Iron	g/m^3	NA	0.03	0.09	0.02	0.01	0.04
Total Manganese	g/m^3	NA	2.5	0.111	0.03	0.00097	1.36
Dissolved Manganese	g/m^3	2.5	2.3	0.078	0.0085	0.0007	1.24
Dissolved iron + manganese	g/m^3	1.0	2.33	0.168	0.0285	0.0107	1.28
Total Lead	g/m^3	NA	0.00049	0.00014	0.00012	0.00022	0.00026
Dissolved Lead	g/m^3	0.0056 (0.011)	0.00005	0.00005	0.00005	0.0001	0.00005
Total Copper	g/m^3	NA	0.00058	0.000265	0.000265	0.00187	0.00088
Dissolved Copper	g/m^3	0.0018 (0.0028)	0.00025	0.00025	0.00025	0.002	0.0007
Total Zinc	g/m^3	NA	0.0039	0.0027	0.0055	0.0128	0.0046
Dissolved Zinc	g/m^3	0.015 (0.027)	0.0011	0.0028	0.0005	0.0126	0.0019
Total Arsenic	g/m^3	NA	0.0032	0.00055	0.00055	0.00055	0.0016
Dissolved Arsenic	g/m^3	0.042	0.0014	0.0005	0.0005	0.0005	0.0005
Total Chromium	g/m^3	NA	0.00083	0.000265	0.000265	0.00066	0.00098
Dissolved Chromium	g/m^3	0.006	0.00025	0.00025	0.00025	0.00025	0.00025

* Notes: 1. Site specific total ammoniacal nitrogen is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 $g/m_3 CaCO_3$

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m^3 to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as half of the detection limit

Table C3: May 2019 Additional Monitoring of wetland and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	WLDI	WLDO
pH	pH	NA (6-9)	6.8	6.6
Conductivity	mS/m	NA	85.2	84.9
Total Alkalinity	g/m³CaCO₃	NA	290	300
TSS	g/m³	NA	18	15
COD	g O2/m³	NA	22	18
Total Hardness	g/m³CaCO₃	NA	330	320
Total Ammoniacal Nitrogen	g/m³	1.430 (2.34)	1.52	1.58
Total Iron	g/m³	NA	6.3	6.7
Dissolved Iron	g/m³	NA	0.05	3.1
Total Manganese	g/m³	NA	2.4	2.5
Dissolved Manganese	g/m³	2.5	2.3	2.4
Dissolved iron + manganese	g/m³	1.0	2.35	5.5
Total Lead	g/m³	NA	0.00039	0.00017
Dissolved Lead	g/m³	0.0056 (0.011)	0.00005	0.00005
Total Copper	g/m³	NA	0.000265	0.000265
Dissolved Copper	g/m³	0.0018 (0.0028)	0.00025	0.00025
Total Zinc	g/m³	NA	0.0032	0.0019
Dissolved Zinc	g/m³	0.015 (0.027)	0.0018	0.0005
Total Arsenic	g/m³	NA	0.0036	0.0035
Dissolved Arsenic	g/m³	0.042	0.0015	0.0024
Total Chromium	g/m³	NA	0.00137	0.00097
Dissolved Chromium	g/m³	0.006	0.0005	0.00025

* Notes: 1. Site specific total ammoniacal nitrogen is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 g/m₃ CaCO₃

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m³ to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as half of the detection limit

Table C4: April 2019 Monthly Monitoring Results and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.2	7.5	7.7	7.5	7.7
Conductivity	mS/m	NA	81.8	17	22.2	31.9	66.8
Total Alkalinity	g/m^3CaCO_3	NA	260	20	26	43	192
TSS	g/m^3	NA	23	15	1.5	1.5	10
COD	$g\ O2/m^3$	NA	26	20	8	6	8
Total Hardness	g/m^3CaCO_3	NA	330	29	36	59	240
Total Ammoniacal Nitrogen	g/m^3	1.430 (2.34)	1.06	0.005	0.02	0.005	0.6
Total Iron	g/m^3	NA	7.9	0.82	0.108	0.076	3.3
Dissolved Iron	g/m^3	NA	0.04	0.14	0.04	0.04	0.07
Total Manganese	g/m^3	NA	1.9	0.029	0.0072	0.0024	1.12
Dissolved Manganese	g/m^3	2.5	1.95	0.0024	0.0015	0.0015	1.08
Dissolved iron + manganese	g/m^3	1.0	1.99	0.1424	0.0415	0.0415	1.15
Total Lead	g/m^3	NA	0.00072	0.00188	0.00019	0.00047	0.00059
Dissolved Lead	g/m^3	0.0056 (0.011)	0.00005	0.00026	0.00005	0.00021	0.00005
Total Copper	g/m^3	NA	0.0006	0.0027	0.00073	0.0032	0.00134
Dissolved Copper	g/m^3	0.0018 (0.0028)	0.00025	0.002	0.0005	0.0025	0.001
Total Zinc	g/m^3	NA	0.028	0.0155	0.0014	0.0138	0.008
Dissolved Zinc	g/m^3	0.015 (0.027)	0.0025	0.0074	0.0005	0.0136	0.0026
Total Arsenic	g/m^3	NA	0.0036	0.0016	0.00055	0.00055	0.0019
Dissolved Arsenic	g/m^3	0.042	0.001	0.0013	0.0005	0.0005	0.0005
Total Chromium	g/m^3	NA	0.00117	0.00155	0.00068	0.00056	0.00096
Dissolved Chromium	g/m^3	0.006	0.0006	0.0007	0.00025	0.00025	0.00025

* Notes: 1. Site specific total ammoniacal nitrogen is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 $g/m_3\ CaCO_3$

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m^3 to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as half of the detection limit

Table C5: February 2019 Monthly Monitoring Results and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.7	7.5	7.8	7.9	8.1
Conductivity	mS/m	NA	71.4	26	27.9	30.8	58.2
Total Alkalinity	g/m^3CaCO_3	NA	240	44	44	55	174
TSS	g/m^3	NA	27	10	15	1.5	6
COD	$g\ O2/m^3$	NA	8	7	3	3	3
Total Hardness	g/m^3CaCO_3	NA	240	45	51	61	183
Total Ammoniacal Nitrogen	g/m^3	1.430 (2.34)	0.54	0.24	0.005	0.005	0.14
Total Iron	g/m^3	NA	7.1	0.42	0.3	0.26	1.32
Dissolved Iron	g/m^3	NA	0.05	0.05	0.05	0.04	0.05
Total Manganese	g/m^3	NA	1.92	0.16	0.069	0.0037	0.76
Dissolved Manganese	g/m^3	2.5	1.62	0.0023	0.0011	0.002	0.59
Dissolved iron + manganese	g/m^3	1.0	1.67	0.0523	0.0511	0.042	0.64
Total Lead	g/m^3	NA	0.0007	0.00073	0.00035	0.00029	0.00027
Dissolved Lead	g/m^3	0.0056 (0.011)	0.00005	0.00005	0.00005	0.00005	0.00005
Total Copper	g/m^3	NA	0.000265	0.00161	0.00094	0.00187	0.00089
Dissolved Copper	g/m^3	0.0018 (0.0028)	0.00025	0.0009	0.00025	0.0019	0.0008
Total Zinc	g/m^3	NA	0.0063	0.01	0.0021	0.0108	0.0057
Dissolved Zinc	g/m^3	0.015 (0.027)	0.0015	0.0038	0.0005	0.0101	0.0022
Total Arsenic	g/m^3	NA	0.0028	0.00055	0.00055	0.00055	0.00055
Dissolved Arsenic	g/m^3	0.042	0.0005	0.0005	0.0005	0.0005	0.0005
Total Chromium	g/m^3	NA	0.00093	0.00076	0.00078	0.00069	0.000265
Dissolved Chromium	g/m^3	0.006	0.00025	0.00025	0.00025	0.00025	0.00025

* Notes: 1. Site specific total ammoniacal nitrogen is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 $g/m_3\ CaCO_3$

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m^3 to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as half of the detection limit

Table C6: January 2019 Monthly Monitoring Results and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.6	7.5	8	7.7	8
Conductivity	mS/m	NA	82.9	33	32.6	34.5	65.3
Total Alkalinity	g/m^3CaCO_3	NA	270	50	53	53	185
TSS	g/m^3	NA	18	4	12	1.5	5
COD	g O2/m^3	NA	22	3	7	3	3
Total Hardness	g/m^3CaCO_3	NA	290	55	60	60	210
Total Ammoniacal Nitrogen	g/m^3	1.430 (2.34)	0.57	0.012	0.005	0.005	0.123
Total Iron	g/m^3	NA	5	0.063	0.2	0.03	1.39
Dissolved Iron	g/m^3	NA	0.05	0.01	0.03	0.01	0.03
Total Manganese	g/m^3	NA	2.2	0.109	0.081	0.0021	0.94
Dissolved Manganese	g/m^3	2.5	2.3	0.0006	0.0016	0.0013	0.97
Dissolved iron + manganese	g/m^3	1.0	2.35	0.0106	0.0316	0.0113	1
Total Lead	g/m^3	NA	0.00032	0.00015	0.00031	0.00017	0.00025
Dissolved Lead	g/m^3	0.0056 (0.011)	0.00005	0.00005	0.00005	0.00005	0.00005
Total Copper	g/m^3	NA	0.000265	0.00097	0.000265	0.002	0.00088
Dissolved Copper	g/m^3	0.0018 (0.0028)	0.00025	0.0006	0.00025	0.0014	0.0008
Total Zinc	g/m^3	NA	0.004	0.0052	0.0013	0.0096	0.0039
Dissolved Zinc	g/m^3	0.015 (0.027)	0.0005	0.0015	0.0005	0.0087	0.0017
Total Arsenic	g/m^3	NA	0.0029	0.00055	0.00055	0.00055	0.0012
Dissolved Arsenic	g/m^3	0.042	0.0005	0.0005	0.0005	0.0005	0.0005
Total Chromium	g/m^3	NA	0.00096	0.000265	0.00059	0.000265	0.00066
Dissolved Chromium	g/m^3	0.006	0.00025	0.00025	0.00025	0.00025	0.00025

* Notes: 1. Site specific total ammoniacal nitrogen is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 $g/m_3 CaCO_3$

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m^3 to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as half of the detection limit

Table C7: December 2018 Quarterly Monitoring Results and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.4	7.5	7.6	7.7	7.9
Conductivity	mS/m	NA	79	23.5	25.8	28.1	61.6
Total Alkalinity	g/m^3CaCO_3	NA	260	40	40	40	176
TSS	g/m^3	NA	27	6	3	1.5	7
COD	g O2/m^3	NA	16	8	3	3	12
Total Hardness	g/m^3CaCO_3	NA	290	38	44	50	200
Total Ammoniacal Nitrogen	g/m^3	1.430 (2.34)	1.01	0.005	0.005	0.005	0.5
Total Iron	g/m^3	NA	5.2	0.153	0.097	0.067	2
Dissolved Iron	g/m^3	NA	0.03	0.03	0.03	0.04	0.08
Total Manganese	g/m^3	NA	2.1	0.047	0.038	0.0028	1.2
Dissolved Manganese	g/m^3	2.5	2	0.0009	0.0008	0.0011	1.18
Dissolved iron + manganese	g/m^3	1.0	2.03	0.0309	0.0308	0.0411	1.26
Total Lead	g/m^3	NA	0.00042	0.0003	0.000055	0.00048	0.00036
Dissolved Lead	g/m^3	0.0056 (0.011)	0.00005	0.00005	0.00005	0.00026	0.00005
Total Copper	g/m^3	NA	0.000265	0.00119	0.000265	0.003	0.00134
Dissolved Copper	g/m^3	0.0018 (0.0028)	0.00025	0.0008	0.00025	0.0025	0.0033
Total Zinc	g/m^3	NA	0.0037	0.0069	0.0055	0.023	0.0094
Dissolved Zinc	g/m^3	0.015 (0.027)	0.0005	0.0038	0.0005	0.021	0.0059
Total Arsenic	g/m^3	NA	0.003	0.00055	0.00055	0.00055	0.0016
Dissolved Arsenic	g/m^3	0.042	0.0011	0.0005	0.0005	0.0005	0.0005
Total Chromium	g/m^3	NA	0.00118	0.00072	0.000265	0.00074	0.00074
Dissolved Chromium	g/m^3	0.006	0.00025	0.00025	0.00025	0.0005	0.001

* Notes: 1. Site specific total ammoniacal nitrogen is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 $g/m_3 CaCO_3$

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m^3 to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as half of the detection limit

Table C8: November 2018 Monthly Monitoring Results and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.2	7.3	7.4	7.6	7.7
Conductivity	mS/m	NA	91.3	20	21.8	30.3	70.2
Total Alkalinity	g/m^3CaCO_3	NA	290	31	31	40	193
TSS	g/m^3	NA	16	1.5	1.5	4	13
COD	$g\ O2/m^3$	NA	15	13	3	3	8
Total Hardness	g/m^3CaCO_3	NA	370	34	37	52	270
Total Ammoniacal Nitrogen	g/m^3	1.430 (2.34)	0.96	0.005	0.019	0.005	0.56
Total Iron	g/m^3	NA	5	0.172	0.06	0.39	2.2
Dissolved Iron	g/m^3	NA	0.03	0.08	0.04	0.07	0.04
Total Manganese	g/m^3	NA	2	0.022	0.0121	0.009	1.27
Dissolved Manganese	g/m^3	2.5	2	0.0073	0.0066	0.003	1.2
Dissolved iron + manganese	g/m^3	1.0	2.03	0.0873	0.0466	0.073	1.24
Total Lead	g/m^3	NA	0.00078	0.00052	0.000055	0.0018	0.00096
Dissolved Lead	g/m^3	0.0056 (0.011)	0.00005	0.00015	0.00005	0.0004	0.00005
Total Copper	g/m^3	NA	0.00137	0.00173	0.000265	0.0033	0.00163
Dissolved Copper	g/m^3	0.0018 (0.0028)	0.00025	0.0014	0.00025	0.0025	0.0011
Total Zinc	g/m^3	NA	0.0095	0.0159	0.0011	0.037	0.0163
Dissolved Zinc	g/m^3	0.015 (0.027)	0.0044	0.015	0.0005	0.027	0.0082
Total Arsenic	g/m^3	NA	0.0023	0.00055	0.00055	0.00055	0.0014
Dissolved Arsenic	g/m^3	0.042	0.001	0.0005	0.0005	0.0005	0.0005
Total Chromium	g/m^3	NA	0.00133	0.00055	0.000265	0.00087	0.00093
Dissolved Chromium	g/m^3	0.006	0.0006	0.00025	0.00025	0.00025	0.00025

* Notes: 1. Site specific total ammoniacal nitrogen is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 $g/m_3\ CaCO_3$

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m^3 to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as half of the detection limit

Table C9: October 2018 Monthly Monitoring Results and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.2	7.2	7.5	7.5	7.8
Conductivity	mS/m	NA	77.3	16.2	21.9	31.3	62.7
Total Alkalinity	g/m^3CaCO_3	NA	250	30	35	45	180
TSS	g/m^3	NA	18	6	4	1.5	8
COD	g O2/m^3	NA	13	3	13	8	16
Total Hardness	g/m^3CaCO_3	NA	290	28	39	56	210
Total Ammoniacal Nitrogen	g/m^3	1.430 (2.34)	0.69	0.005	0.005	0.005	0.35
Total Iron	g/m^3	NA	5	0.25	0.21	0.077	1.77
Dissolved Iron	g/m^3	NA	0.03	0.08	0.06	0.03	0.06
Total Manganese	g/m^3	NA	1.74	0.04	0.039	0.0027	1.07
Dissolved Manganese	g/m^3	2.5	1.79	0.027	0.0097	0.0019	1.05
Dissolved iron + manganese	g/m^3	1.0	1.82	0.107	0.0697	0.0319	1.11
Total Lead	g/m^3	NA	0.00082	0.00058	0.00017	0.00033	0.00039
Dissolved Lead	g/m^3	0.0056 (0.011)	0.00005	0.00017	0.00005	0.00018	0.00005
Total Copper	g/m^3	NA	0.00065	0.00136	0.000265	0.0023	0.00121
Dissolved Copper	g/m^3	0.0018 (0.0028)	0.00025	0.0014	0.00025	0.002	0.001
Total Zinc	g/m^3	NA	0.0068	0.013	0.0017	0.021	0.0093
Dissolved Zinc	g/m^3	0.015 (0.027)	0.0034	0.0094	0.001	0.0192	0.0046
Total Arsenic	g/m^3	NA	0.0025	0.00055	0.00055	0.00055	0.0013
Dissolved Arsenic	g/m^3	0.042	0.0005	0.0005	0.0005	0.0005	0.0005
Total Chromium	g/m^3	NA	0.00067	0.00084	0.000265	0.00057	0.000265
Dissolved Chromium	g/m^3	0.006	0.00025	0.00025	0.00025	0.00025	0.00025

* Notes: 1. Site specific total ammoniacal nitrogen is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 $g/m_3 CaCO_3$

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m^3 to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as half of the detection limit

Table C10: September 2018 Quarterly Monitoring Results and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.3	7.1	8.3	7.5	7.8
Conductivity	mS/m	NA	77.4	25.9	27.2	35.4	66
Total Alkalinity	g/m^3CaCO_3	NA	250	41	41	48	190
TSS	g/m^3	NA	9	3	1.5	1.5	4
COD	$g\ O2/m^3$	NA	8	3	3	3	3
Total Hardness	g/m^3CaCO_3	NA	270	43	47	61	220
Total Ammoniacal Nitrogen	g/m^3	1.430 (2.34)	0.86	0.017	0.005	0.005	0.44
Total Iron	g/m^3	NA	3	0.118	0.052	0.021	1.45
Dissolved Iron	g/m^3	NA	0.02	0.03	0.01	0.01	0.05
Total Manganese	g/m^3	NA	1.92	0.067	0.0153	0.00185	1.18
Dissolved Manganese	g/m^3	2.5	1.9	0.0199	0.0012	0.0014	1.22
Dissolved iron + manganese	g/m^3	1.0	1.92	0.0499	0.0112	0.0114	1.27
Total Lead	g/m^3	NA	0.00037	0.0002	0.000055	0.00011	0.00028
Dissolved Lead	g/m^3	0.0056 (0.011)	0.00005	0.00005	0.00005	0.00005	0.00005
Total Copper	g/m^3	NA	0.000265	0.00055	0.000265	0.00148	0.000265
Dissolved Copper	g/m^3	0.0018 (0.0028)	0.00025	0.0006	0.00025	0.0014	0.0005
Total Zinc	g/m^3	NA	0.0036	0.0088	0.0013	0.0168	0.0072
Dissolved Zinc	g/m^3	0.015 (0.027)	0.0018	0.0069	0.0005	0.0157	0.0032
Total Arsenic	g/m^3	NA	0.002	0.00055	0.00055	0.00055	0.0012
Dissolved Arsenic	g/m^3	0.042	0.0011	0.0005	0.0005	0.0005	0.0005
Total Chromium	g/m^3	NA	0.0006	0.000265	0.000265	0.000265	0.000265
Dissolved Chromium	g/m^3	0.006	0.00025	0.00025	0.00025	0.00025	0.00025

* Notes: 1. Site specific total ammoniacal nitrogen is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 $g/m_3\ CaCO_3$

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m^3 to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as half of the detection limit

Table C11: August 2018 Monthly Monitoring Results and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.5	7.3	7.3	7.4	7.7
Conductivity	mS/m	NA	83.5	21.5	23.9	32.5	67.4
Total Alkalinity	g/m^3CaCO_3	NA	250	29	34	41	179
TSS	g/m^3	NA	14	10	6	1.5	8
COD	g O2/m^3	NA	16	10	6	3	7
Total Hardness	g/m^3CaCO_3	NA	310	34	38	55	220
Total Ammoniacal Nitrogen	g/m^3	1.430 (2.34)	1	0.019	0.016	0.005	0.6
Total Iron	g/m^3	NA	4.1	0.55	0.135	0.084	1.77
Dissolved Iron	g/m^3	NA	0.03	0.11	0.04	0.04	0.05
Total Manganese	g/m^3	NA	1.96	0.029	0.0165	0.0029	1.22
Dissolved Manganese	g/m^3	2.5	1.96	0.0026	0.0037	0.0019	1.19
Dissolved iron + manganese	g/m^3	1.0	1.99	0.1126	0.0437	0.0419	1.24
Total Lead	g/m^3	NA	0.00064	0.00139	0.00095	0.00043	0.00045
Dissolved Lead	g/m^3	0.0056 (0.011)	0.00005	0.00023	0.00005	0.00017	0.00005
Total Copper	g/m^3	NA	0.00071	0.00168	0.00072	0.00199	0.00119
Dissolved Copper	g/m^3	0.0018 (0.0028)	0.00025	0.0013	0.00025	0.0016	0.0007
Total Zinc	g/m^3	NA	0.007	0.0198	0.002	0.021	0.0106
Dissolved Zinc	g/m^3	0.015 (0.027)	0.0034	0.0136	0.0005	0.0181	0.0051
Total Arsenic	g/m^3	NA	0.0023	0.0014	0.00055	0.00055	0.0012
Dissolved Arsenic	g/m^3	0.042	0.0005	0.001	0.0005	0.0005	0.0005
Total Chromium	g/m^3	NA	0.00123	0.00087	0.000265	0.000265	0.00056
Dissolved Chromium	g/m^3	0.006	0.0005	0.0006	0.00025	0.00025	0.00025

* Notes: 1. Site specific total ammoniacal nitrogen is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 $g/m_3 CaCO_3$

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m^3 to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as half of the detection limit

Table C12: July 2018 Monthly Monitoring Results and ANZECC (2000) trigger values

Parameter	Unit	ANZECC guidelines*	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.3	7.3	7.1	7.4	7.8
Conductivity	mS/m	NA	84	29.3	28.5	32	67.7
Total Alkalinity	g/m^3CaCO_3	NA	260	46	40	46	194
TSS	g/m^3	NA	10	1.5	1.5	1.5	4
COD	$g\ O2/m^3$	NA	11	3	3	3	9
Total Hardness	g/m^3CaCO_3	NA	300	47	47	57	220
Total Ammoniacal Nitrogen	g/m^3	1.430 (2.34)	1.07	0.101	0.017	0.005	0.59
Total Iron	g/m^3	NA	3.7	0.127	0.056	0.037	1.58
Dissolved Iron	g/m^3	NA	0.01	0.03	0.01	0.01	0.04
Total Manganese	g/m^3	NA	2.1	0.116	0.024	0.0021	1.27
Dissolved Manganese	g/m^3	2.5	2.2	0.06	0.01	0.0018	1.29
Dissolved iron + manganese	g/m^3	1.0	2.21	0.09	0.02	0.0118	1.33
Total Lead	g/m^3	NA	0.0003	0.000055	0.000055	0.00017	0.00033
Dissolved Lead	g/m^3	0.0056 (0.011)	0.00005	0.00005	0.00005	0.00005	0.00005
Total Copper	g/m^3	NA	0.000265	0.000265	0.000265	0.00138	0.00054
Dissolved Copper	g/m^3	0.0018 (0.0028)	0.00025	0.00025	0.00025	0.0013	0.0005
Total Zinc	g/m^3	NA	0.0042	0.0053	0.0013	0.0176	0.0077
Dissolved Zinc	g/m^3	0.015 (0.027)	0.0014	0.0047	0.0011	0.0163	0.004
Total Arsenic	g/m^3	NA	0.002	0.00055	0.00055	0.00055	0.0012
Dissolved Arsenic	g/m^3	0.042	0.001	0.0005	0.0005	0.0005	0.0005
Total Chromium	g/m^3	NA	0.00122	0.000265	0.00054	0.000265	0.0009
Dissolved Chromium	g/m^3	0.006	0.00025	0.00025	0.00025	0.00025	0.00025

* Notes: 1. Site specific total ammoniacal nitrogen is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 $g/m_3\ CaCO_3$

2. Hickey (2012 memo) recommended that the sum of iron and manganese should be below 1.0 g/m^3 to prevent bed smothering

3. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered

4. Samples below detection limit are shown as half of the detection limit

Appendix F Additional Monitoring Graphs

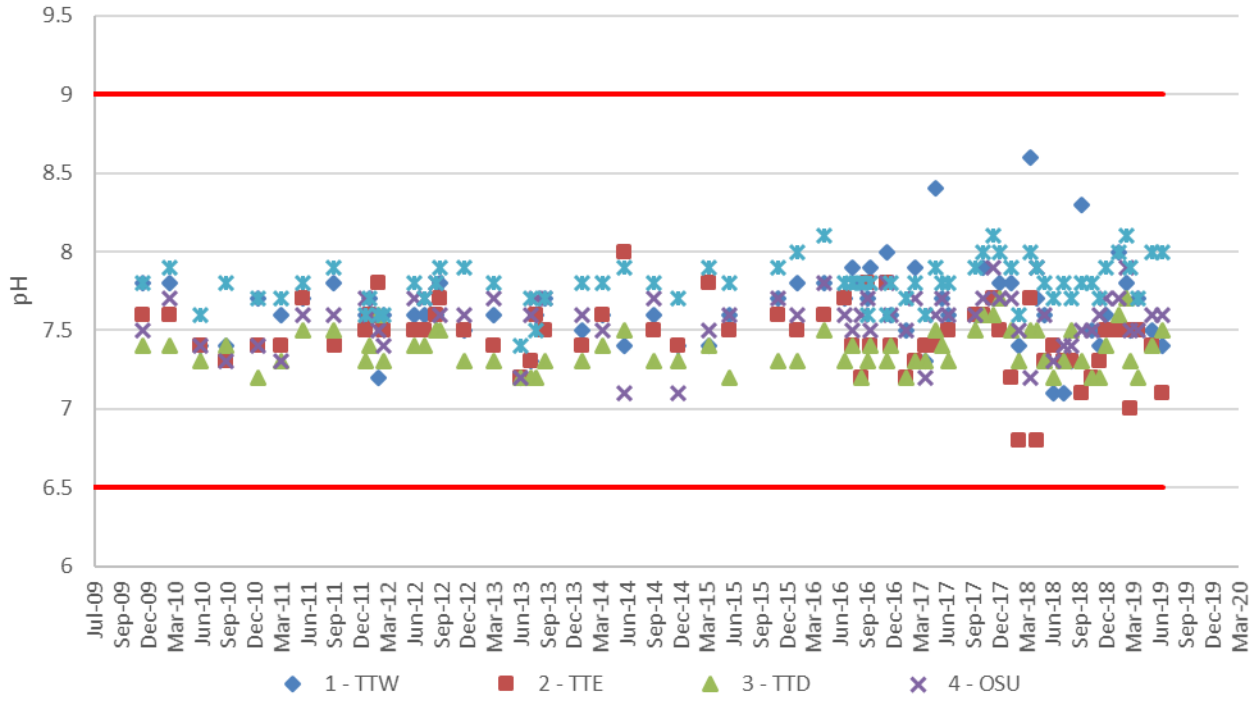


Figure D1: pH for monthly surface water quality monitoring sites. The red lines indicate GWRC recommended guideline levels (Perrie et al, 2012).

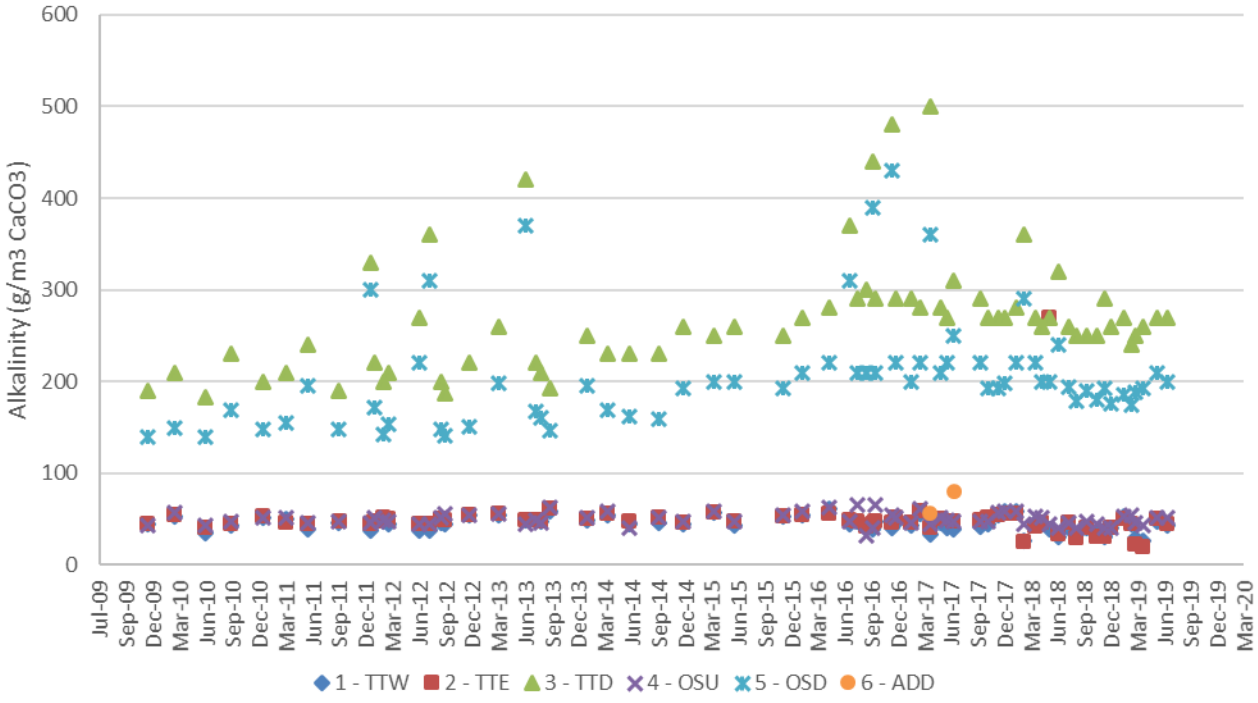


Figure D2: Alkalinity for monthly surface water quality monitoring sites.

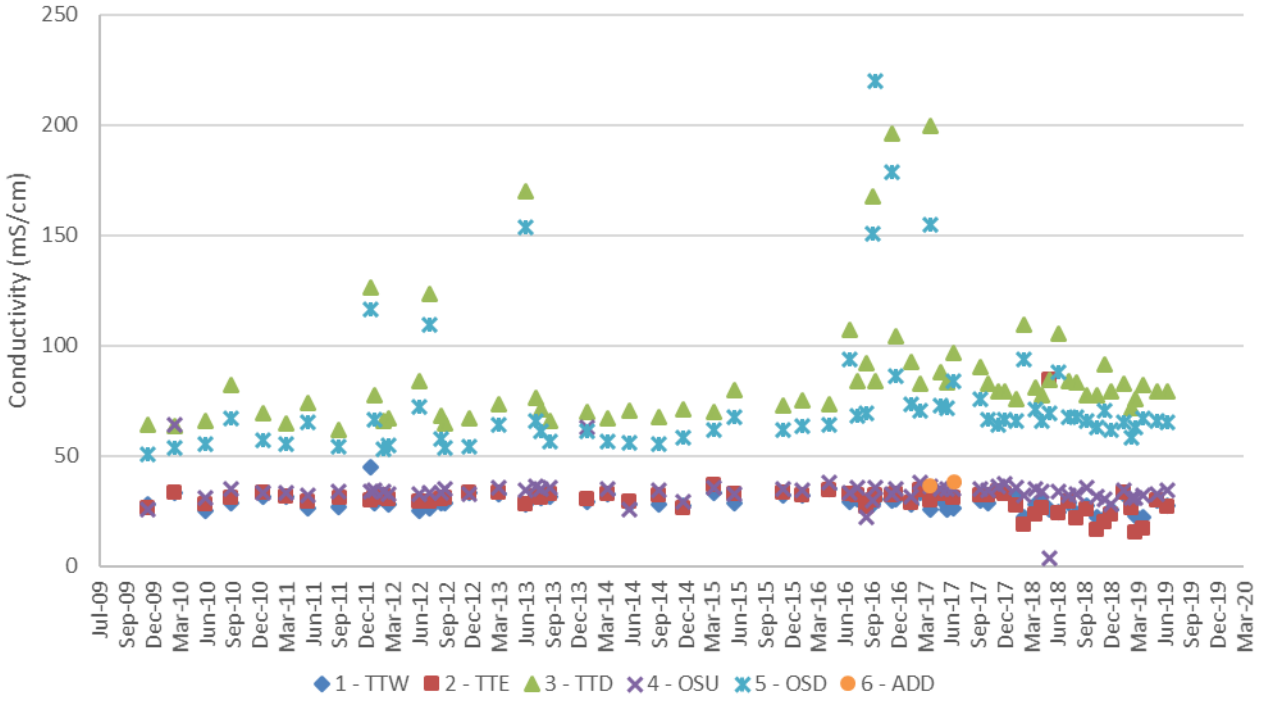


Figure D3: Conductivity for monthly surface water quality monitoring sites.

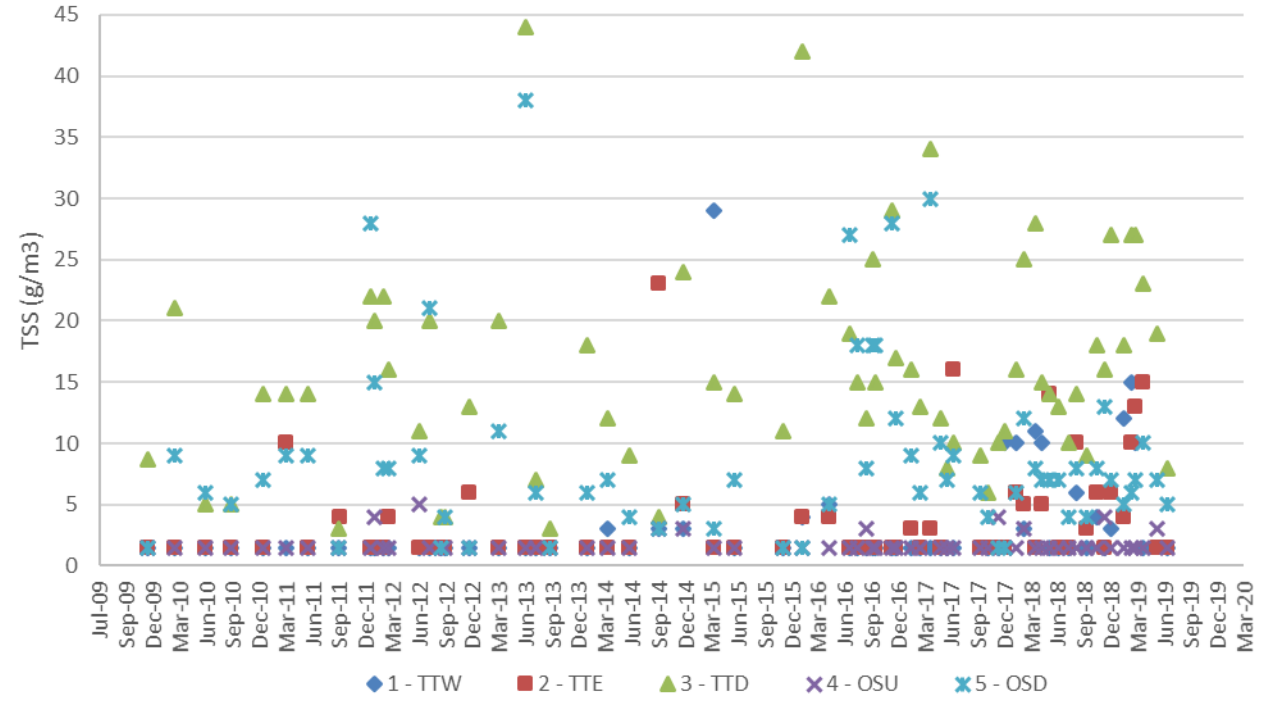


Figure D4: Total Suspended Solids for monthly surface water quality monitoring sites.

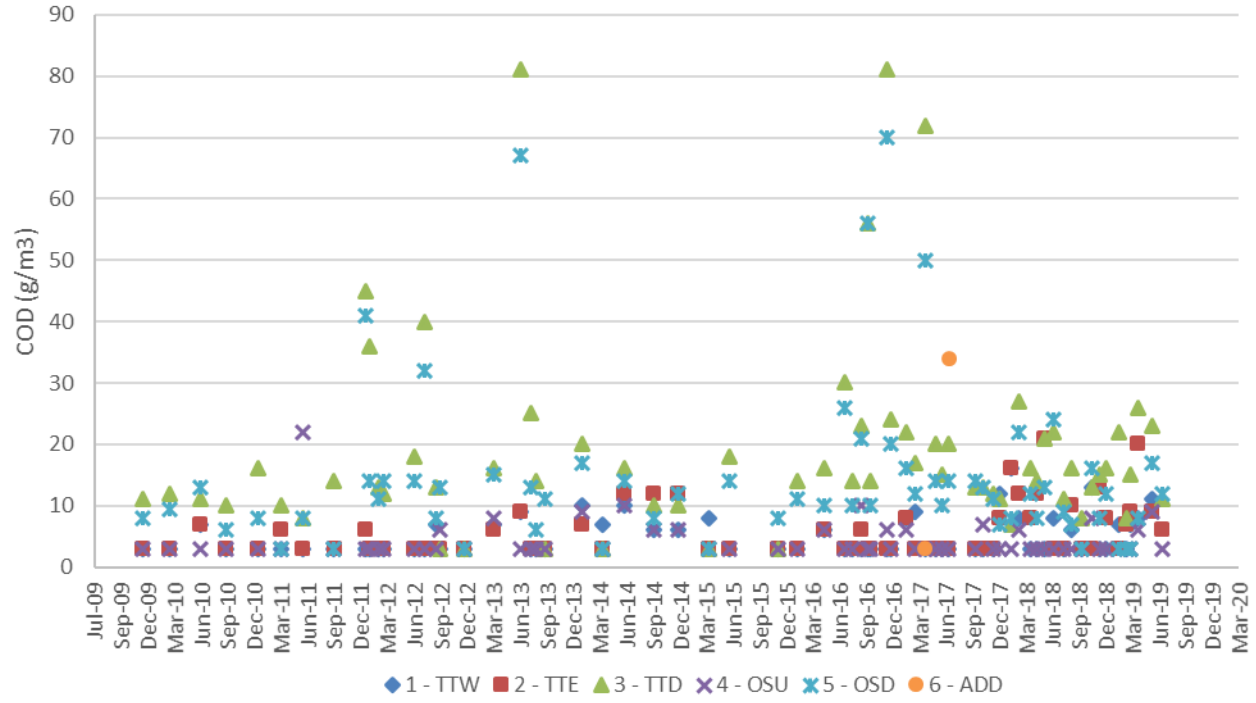


Figure D5: COD for monthly surface water quality monitoring sites.

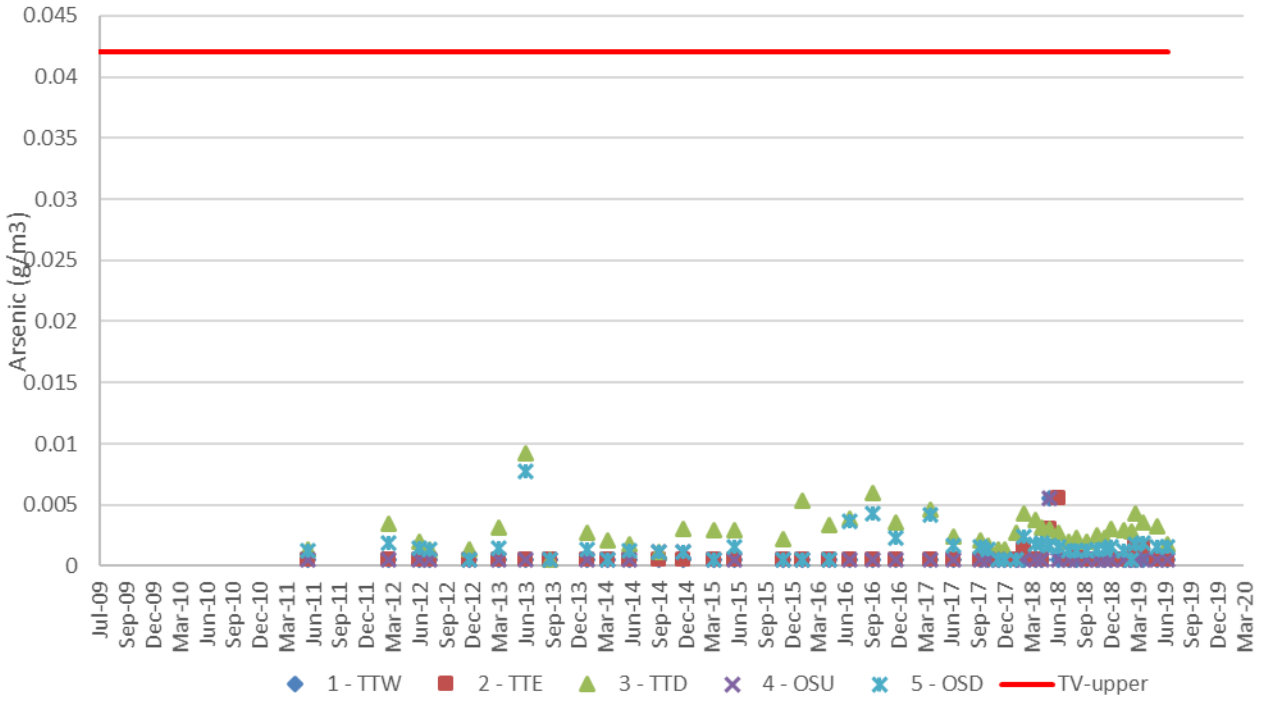


Figure D6: Total arsenic for monthly surface water quality monitoring sites. The red line indicates the ANZECC 90% protection TV as dissolved arsenic V.

Note: Results are shown for total arsenic, while TV is based on dissolved arsenic V.

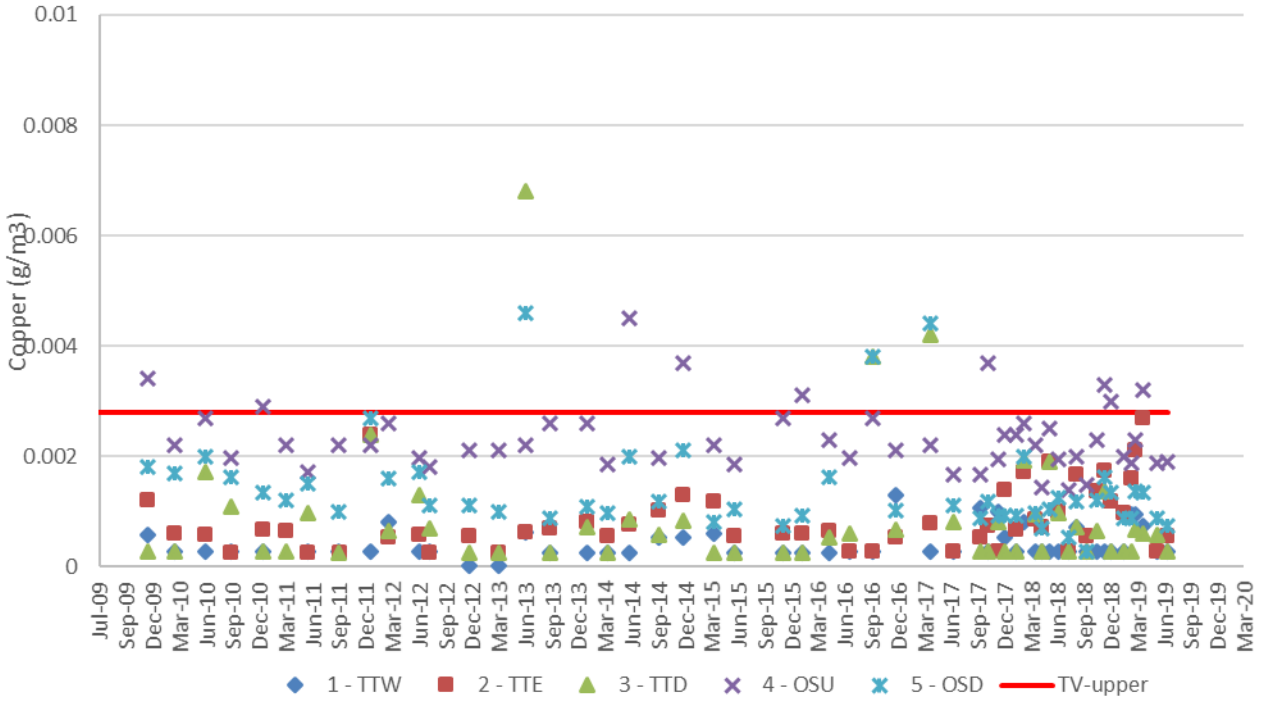


Figure D7: Total copper for monthly surface water quality monitoring sites. The red line indicates site specific TV.

Note: Results are shown for total copper, while TV is based on site specific dissolved copper. One outlier removed in 2011.

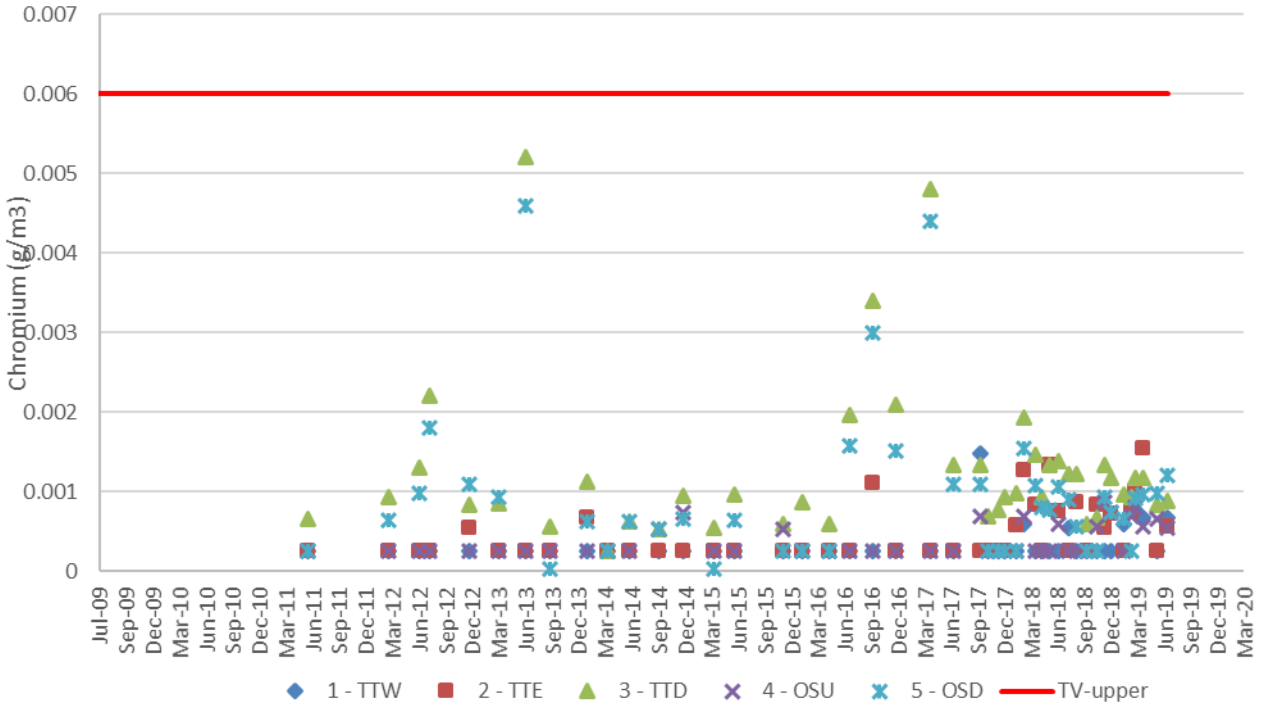


Figure D8: Total chromium for monthly surface water quality monitoring sites. The red line indicates ANZECC 90% protection TVs.

Note: Results are shown for total chromium while TV is based on dissolved chromium.

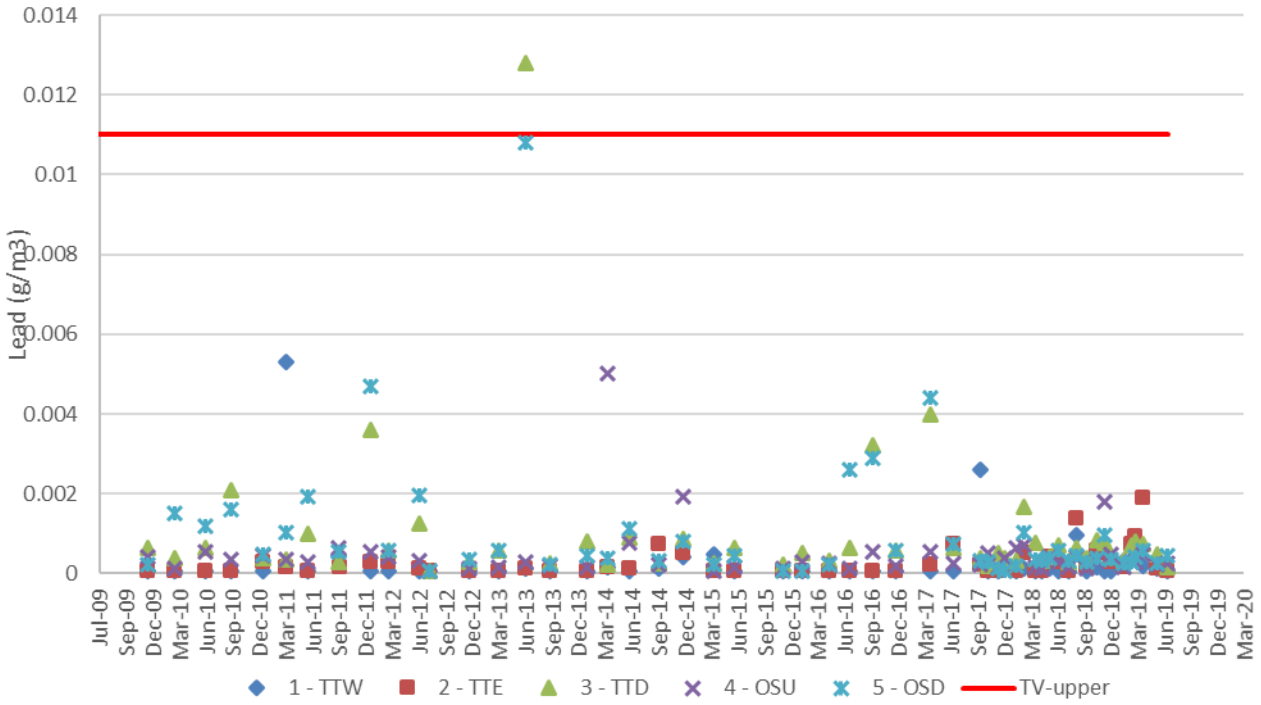


Figure D9: Total Lead for monthly surface water quality monitoring sites. The red line indicates site specific TVs.

Note: Results are shown for total lead, while TV is based on site specific dissolved lead.

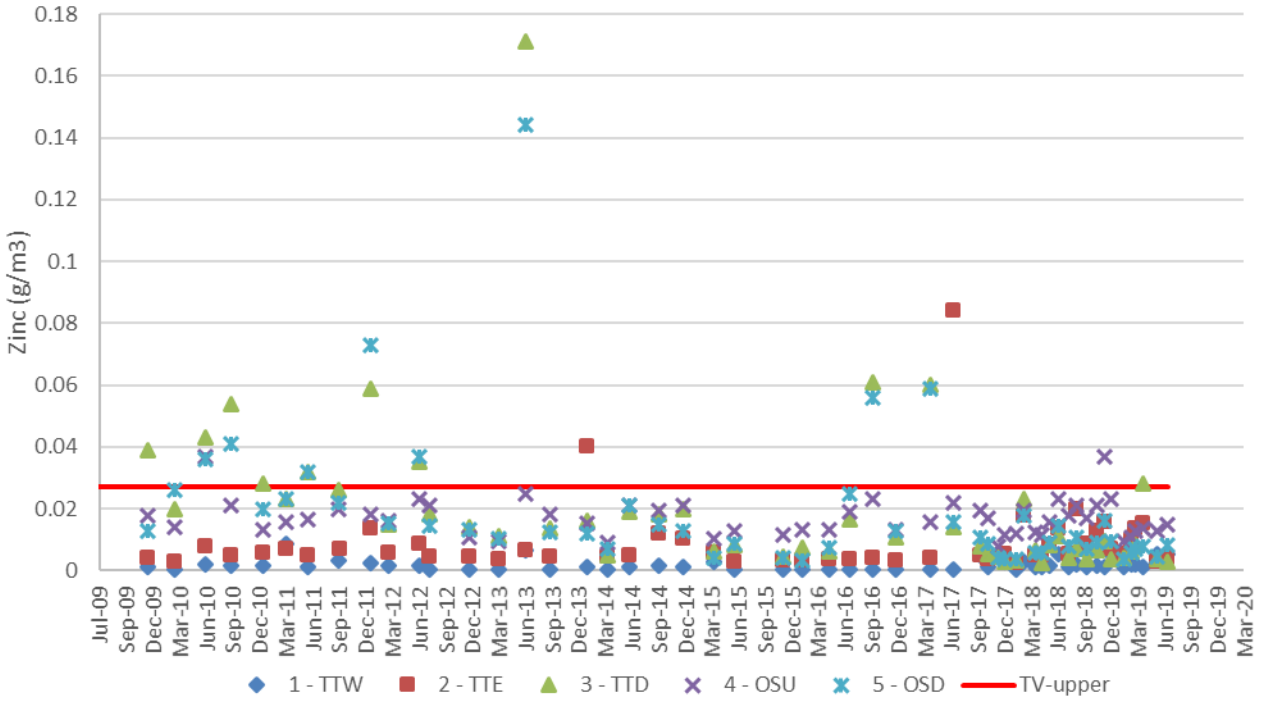


Figure D10: Total zinc for monthly surface water quality monitoring sites. The red line indicates site specific TVs.

Note: Results are shown for total zinc, while TV is based on site specific dissolved zinc.

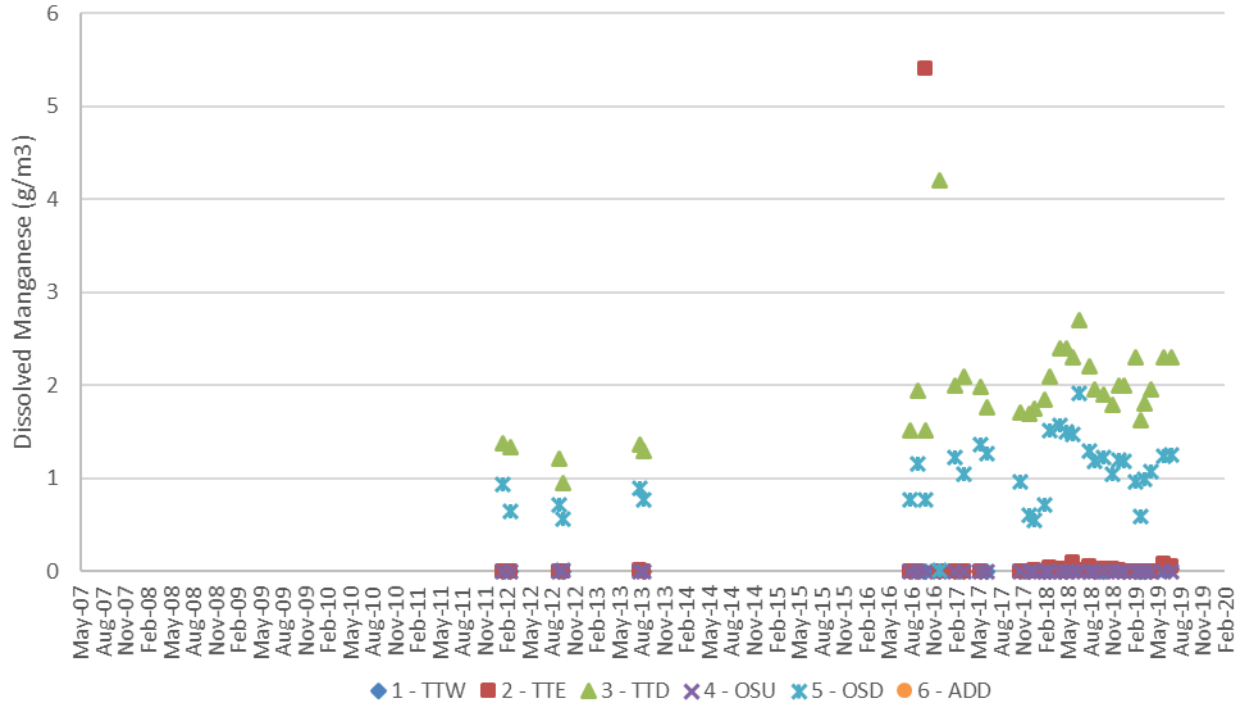


Figure D11: Dissolved manganese for monthly surface water quality monitoring sites. The red line indicates ANZECC 90% protection TVs.

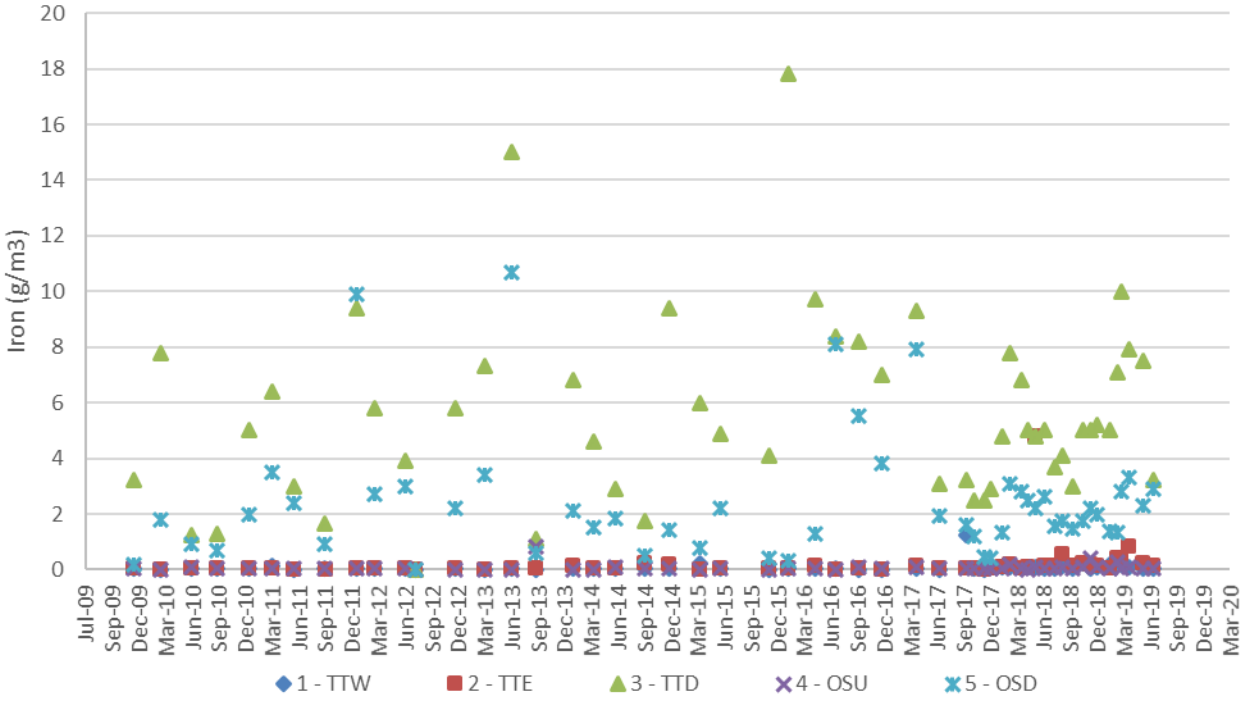


Figure D12: Total iron for monthly surface water quality monitoring sites.

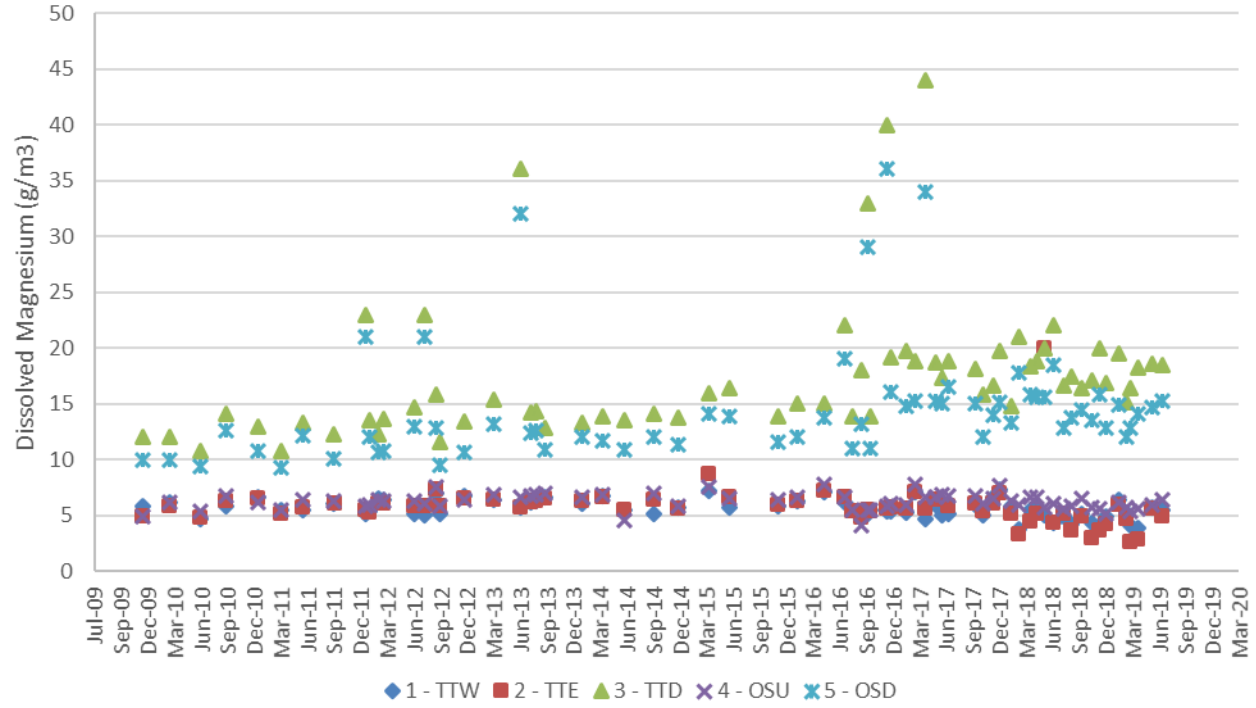


Figure D13: Dissolved Magnesium for monthly surface water quality monitoring sites.

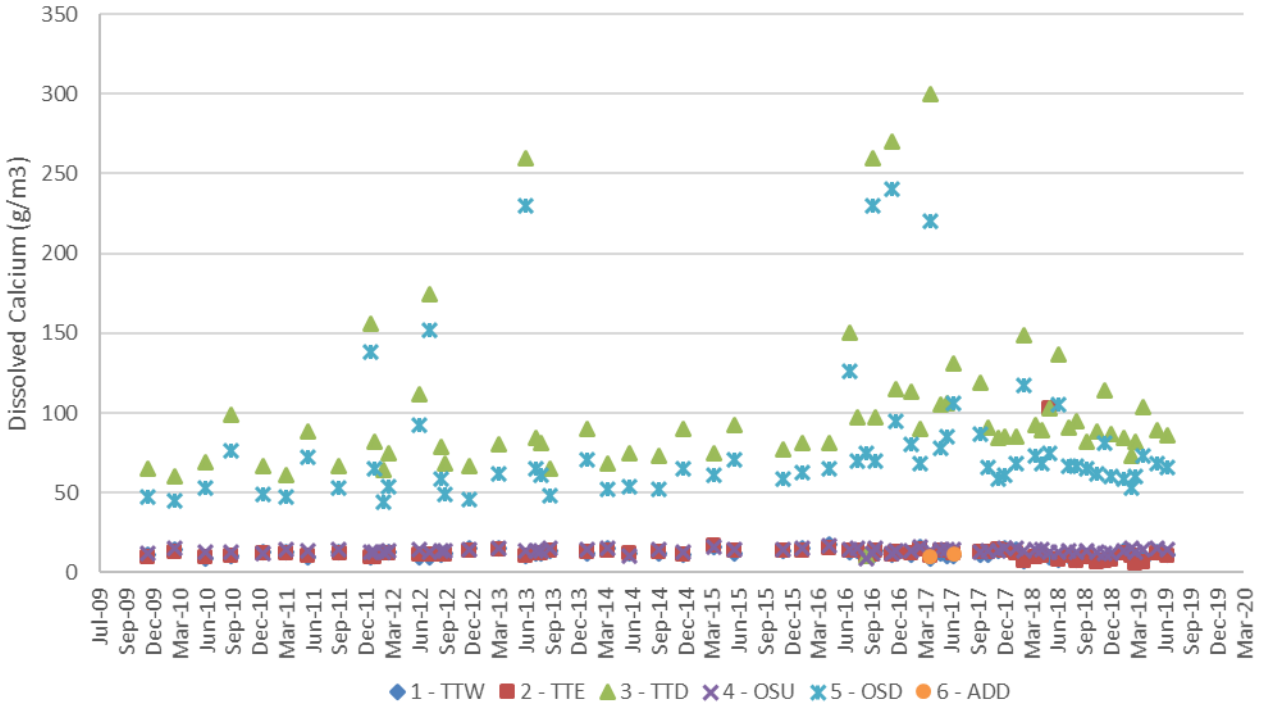


Figure D14: Dissolved Calcium for monthly surface water quality monitoring sites.

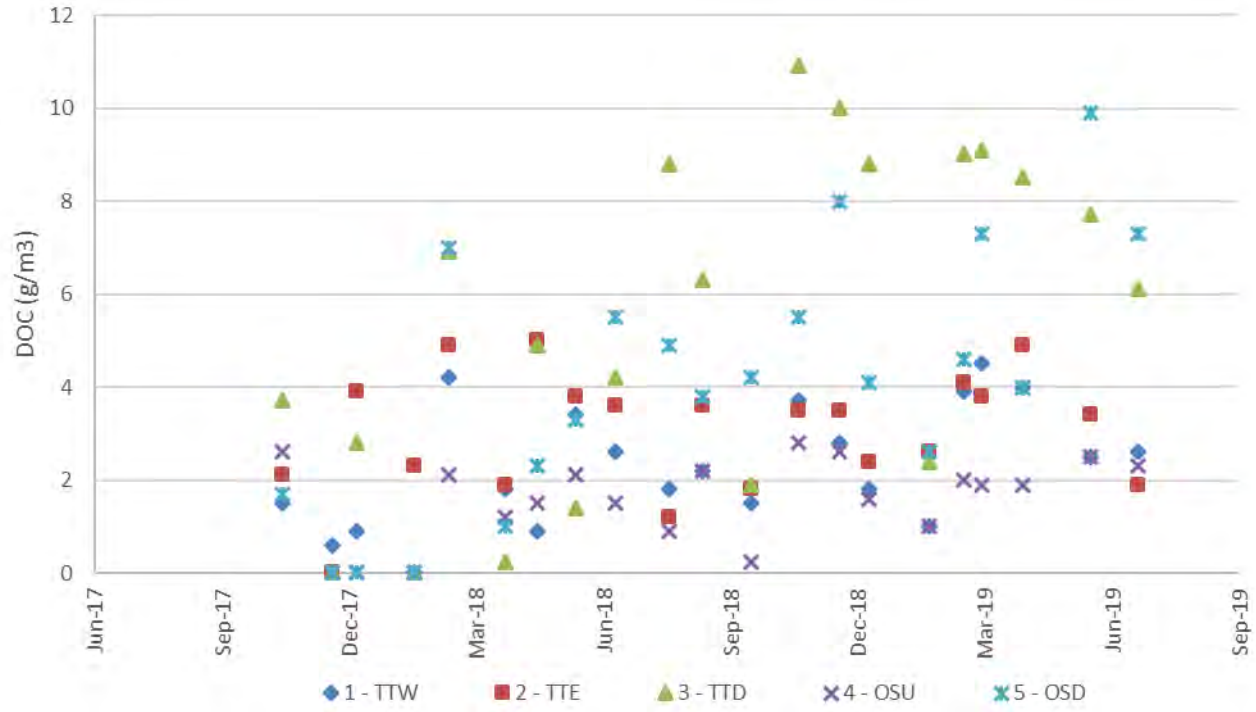


Figure D15: Dissolved Organic Carbon (DOC) for monthly surface water quality monitoring sites.

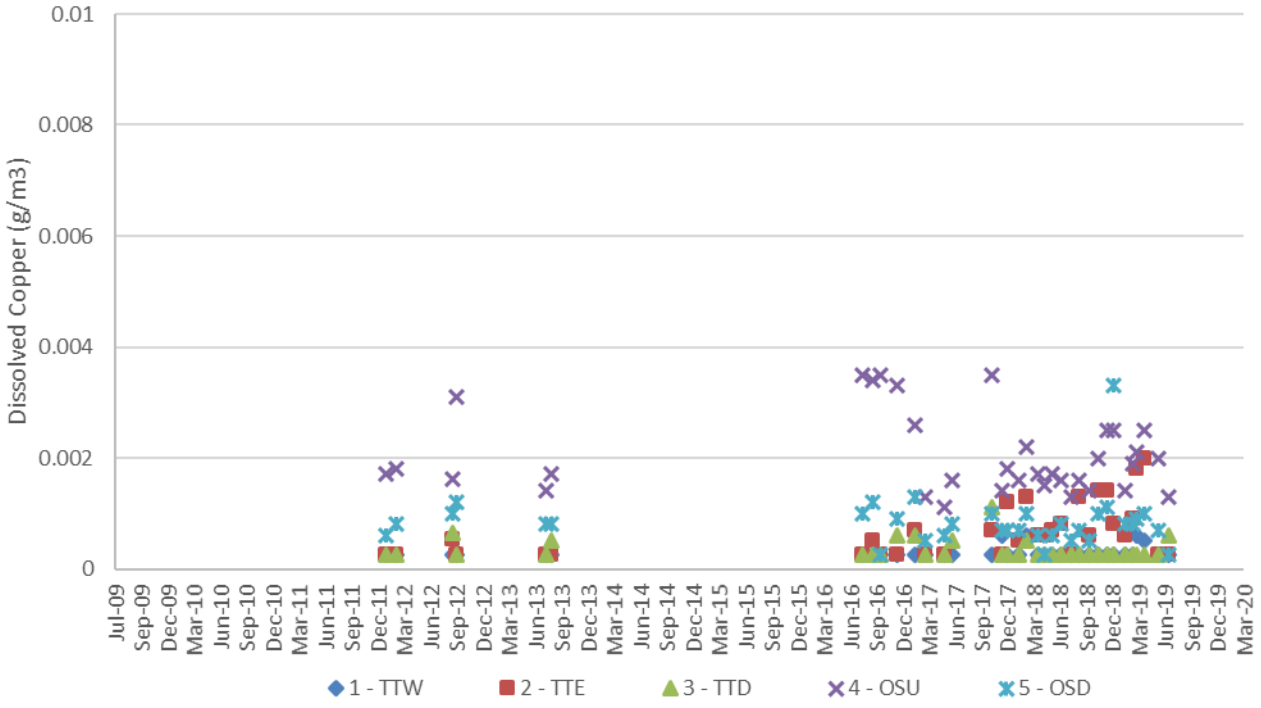


Figure 6-2 Dissolved copper from July 2009 through to June 2019

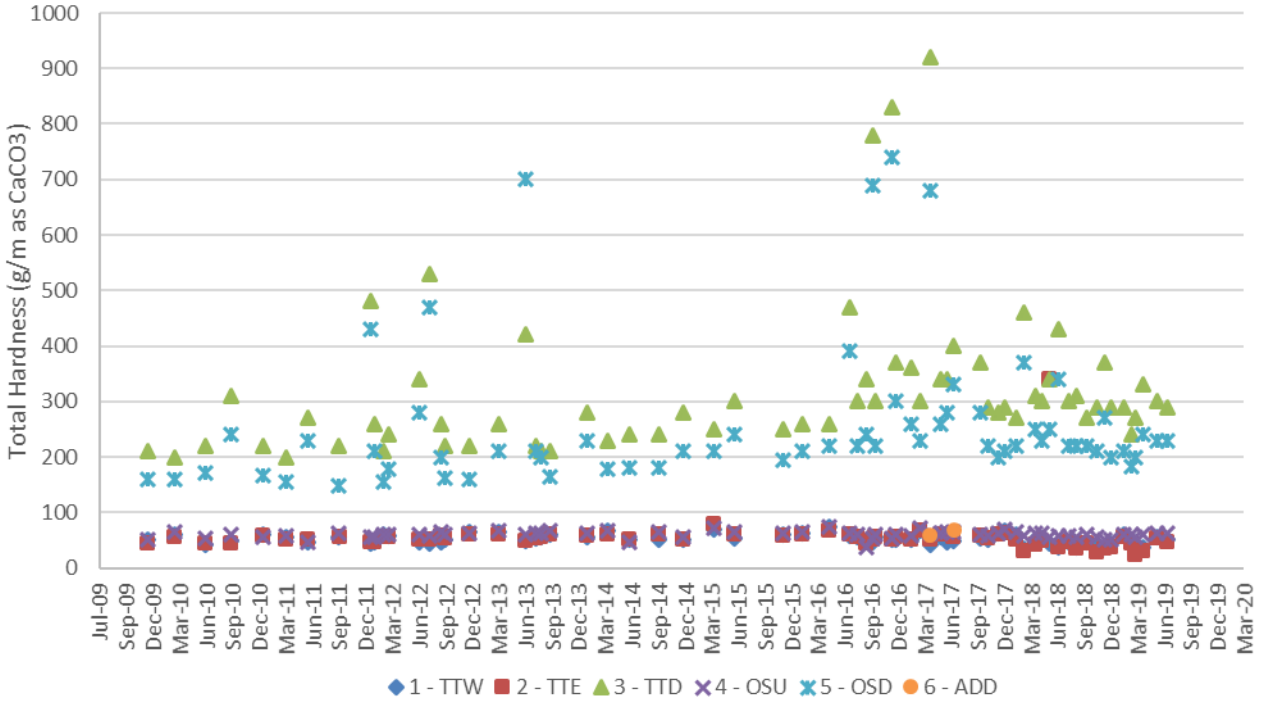


Figure 6-3 Total hardness July 2009 through to June 2019

Wellington
Level 13, 80 The Terrace
Wellington 6011
PO Box 13-052, Armagh
Christchurch 8141
Tel +64 4 381 6700

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