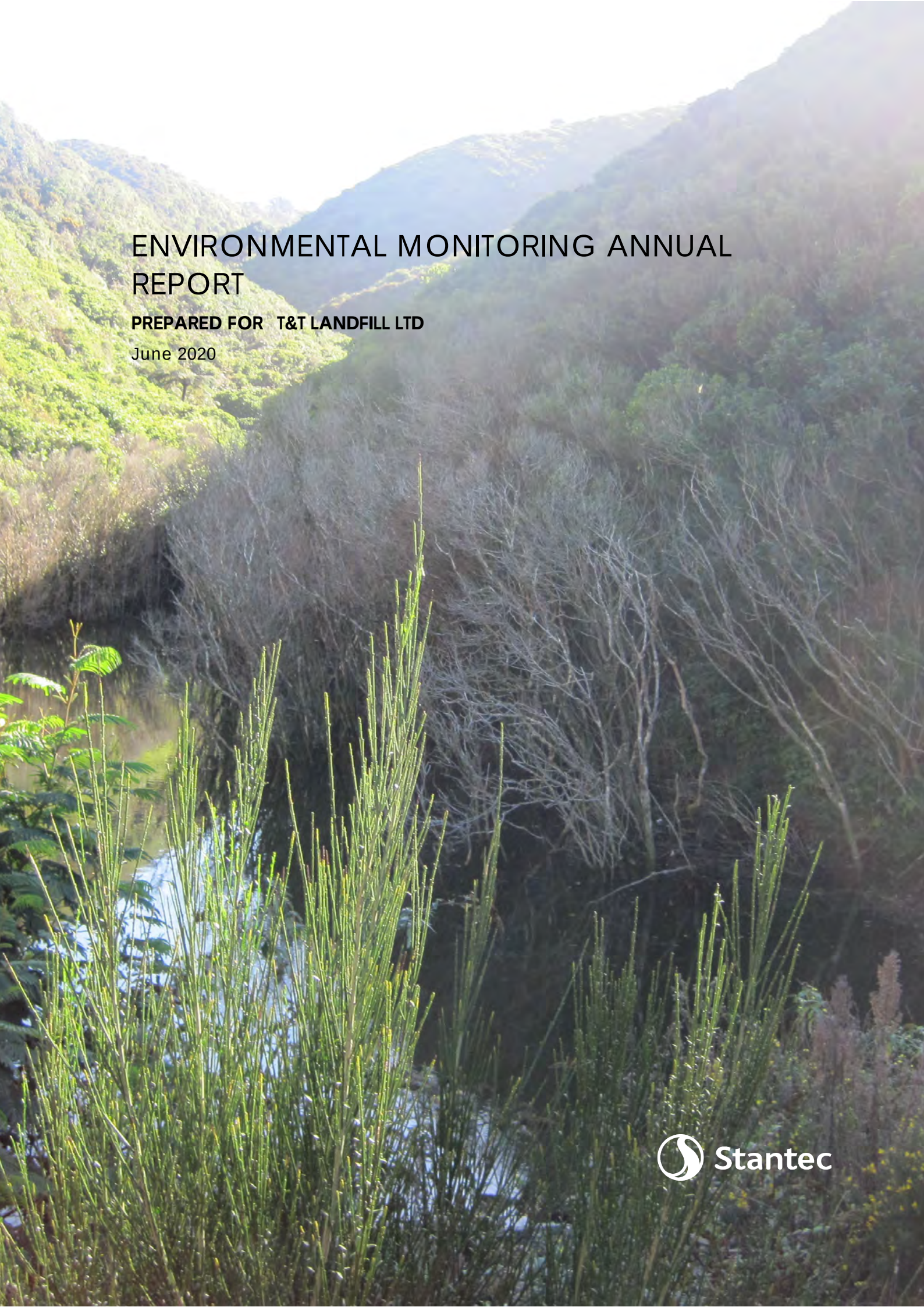

ENVIRONMENTAL MONITORING ANNUAL REPORT

PREPARED FOR T&T LANDFILL LTD

June 2020

Stantec

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T&T Landfill Ltd

Environmental Monitoring Annual Report

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APPENDICES

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 2020.

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.

As part of this annual report, the quarterly results for the June Quarter 2020 are also included and is discussed in Section 5 of this report.

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 2020. 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 four reporting periods (from June 2016) has been included in this report at the request of GWRC.

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 11 monthly sampling rounds at six surface water quality monitoring sites and two sampling rounds at one groundwater quality monitoring site. Please note, it was not possible to sample in March and April 2020 due to the COVID-19 lock down regulations.

- 1 August 2019 – Surface monthly sampling
- 27 August 2019 – Surface monthly sampling
- 19 September 2019 – Surface and groundwater sampling
- 4 October 2019 – Wetland additional sampling
- 24 October 2019 – Surface monthly sampling
- 14 November 2019 – Surface sampling triggered by rainfall
- 11 December 2019 –Surface and groundwater sampling triggered by rainfall
- 28 January 2020 – Surface monthly sampling
- 25 February 2020 - Surface monthly sampling
- 8 May 2020 – Surface sampling triggered by rainfall
- 29 May 2020 – Surface sampling triggered by rainfall

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
- Wetland at the base of the landfill (not required by the DMP but included at the request of T&T Landfill)

It is noted that original 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. The rainfall trigger was activated in November 2019, twice in December 2019, and twice in May 2019. The December 2019 rainfall triggers were within 7 days of each other and as such we only sampled once in December.

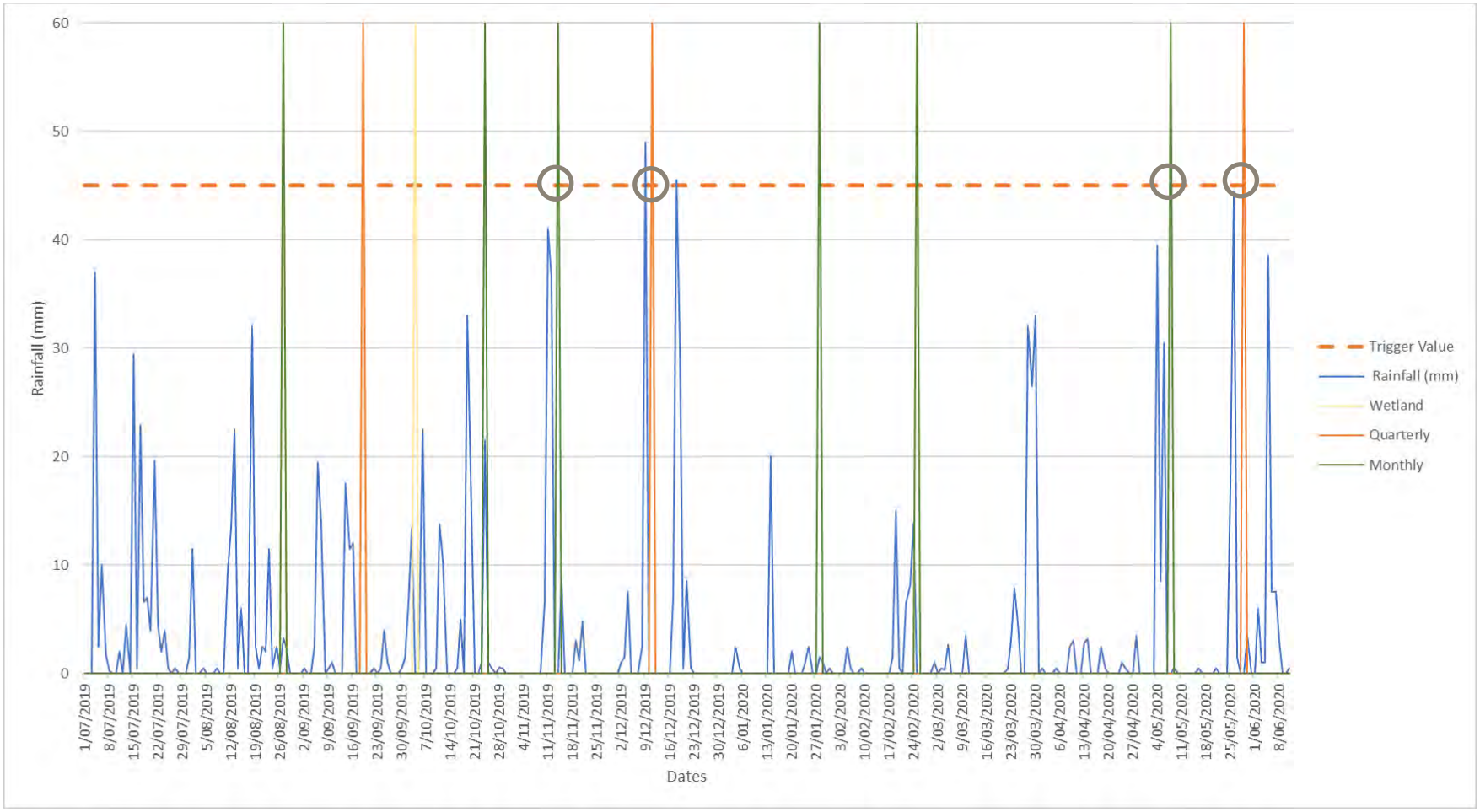


Figure 3-1: Daily rainfall at Karori Reservoir and the types of monitoring from 1 July 2019 to 11 June 2020. Vertical bars indicated quarterly and monthly sampling events, as well as wetland sampling events. The grey circles represent rainfall triggered sampling.

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:

- At OSU, rubbish was present in most of the samples, though this location was unable to be sampled from February 2020 onwards due to road works taking place nearby and preventing access to the stream. Periphyton and foam were also present during the September 2019 sampling.
- At OSD, cloudy water was observed during all sampling rounds, except October, December 2019, February, and 8 May 2020). Rubbish was observed during all sampling rounds except for September and October 2019, and May 2020. Foam was observed during all sampling rounds except for October and December 2019, and January and February 2020. Orange precipitate was observed during all sampling rounds except for August, October, November, and December 2019.
- At TTD, cloudy water was observed during the November 2019 to February 2020 sampling rounds. Foam was present for all sampling rounds except October and December 2019, and January and February 2020. An odour was observed during the August 2019, January 2020, and 29 May 2020 sampling rounds. Rubbish was noted only during the May 2020 sampling rounds. Periphyton was observed during the September 2019 sampling. Orange precipitate was observed during all sampling rounds, except for in September, October, and November 2019.
- At TTE, cloudy water was observed for most of the sampling rounds. Rubbish was observed during the August and November 2019 sampling rounds, and the May 2020 sampling rounds. A small amount of algae was noted upstream during the January 2020 sampling round.
- At TTW, cloudy water was observed for most sampling rounds. Rubbish was also observed during the August 2019, and May 2020 sampling rounds.
- At the wetland, and throughout the monitoring period, orange precipitate, cloudy water was observed. During the October 2019 sampling round, foam and an oil sheen were also observed.

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)	01/08/2019	27/08/2019	19/09/2019	04/10/2019	24/10/2020	14 /11/2019	11/12/2019	28/01/2020	25/02/2020	08/05/2020	29/05/2020
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
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
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
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.

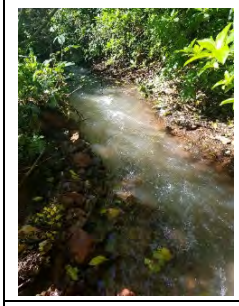
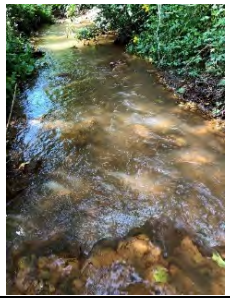
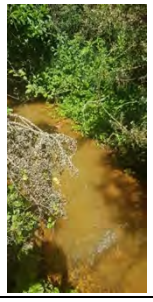
The orange colouration is caused by elevated concentrations of iron and/or manganese in stream water below the landfill leading to precipitation of iron floc. An iron oxide-accumulating bacterium (Leptothrix) facilitates the precipitation of iron floc and formation of the gelatinous masses observed in 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 during 14 November 2019 at TTD.

No orange precipitation was present at OSD during the July, August, September, October 2019 sampling rounds. 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.

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

			
1 August 2019	27 August 2019	19 September 2019	24 October 2019
			
14 November 2019	11 December 2019	28 January 2020	25 February 2020
			
8 May 2020	29 May 2020		

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 and are compared against the specified tolerance limits in Table 3-3 below[3].

Total ammoniacal nitrogen and total iron exceeded the upper tolerance limit on all ten sampling occasions. Total manganese also exceeded the upper tolerance limit on all but one sampling occasions. These results indicate that the total ammoniacal nitrogen, total manganese, and total iron contribution from the landfill was high during the 2019/20 year compared with the 2004 to 2008 baseline period.

For the other parameters:

- Total suspended solids exceeded the upper tolerance limit for one sampling occasion
- Alkalinity exceeded the upper tolerance limit for five sampling occasions
- Electrical conductivity exceeded the upper tolerance limit for two sampling occasions
- pH exceeded the upper tolerance limit on two occasions and exceeded the lower tolerance limit on one occasion

3.3.2 ANZECC 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 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 streambed 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.

[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.

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

Parameter	TTD – (TTE + TTW)/2 Results										Tolerance Limit	
	01/08/2019	27/08/2019	19/09/2019	24/10/2020	14 /11/2019	11/12/2019	28/01/2020	25/02/2020	08/05/2020	29/05/2020	Lower (LTL)	Upper (UTL)
pH	0.15	0.05	0.15	0.1	0.3	0.4	-0.9	0.55	0.2	0.45	-0.4	0.4
Electrical Conductivity (mS/m)	78.05	76.7	69.95	63.25	56.65	60.95	41.2	45.75	53.65	53.95		72.4
Alkalinity (g/m3 $CaCO^3$)	317.5	301.5	270	251	179	233.5	188.5	203.5	223.5	226		226
Total suspended solids (g/m^3)	20.75	10.75	10.75	5.75	32.75	7	4	14.5	6	15.75		32
COD (g O2/m^3)	18.5	14.5	17	8.5	8.5	3.5	-1.5	2.5	2.5	7		21
Total Hardness (g/m3 $CaCO^3$)	377	379	346.5	290.5	286.5	292	203.5	223	239.5	267.5		465
Total Ammoniacal Nitrogen (g/m^3)	2.236	2.183	1.875	1.575	1.045	1.162	0.761	0.5555	0.728	0.875		0.346
Total Iron (g/m^3)	5.664	4.307	5.246	4.6925	3.625	4.385	5.815	6.2745	5.423	7.536		2.748
Total Manganese (g/m^3)	2.611	2.469	2.28155	2.148	1.4221	2.062	1.899	1.5105	1.64	1.914		1.461
Total Lead (g/m^3)	0.0001125	0.000305	0.0001225	0.0001425	0.002385	-0.000045	0.00002	0.000045	-0.00018	-0.00005		0.0059
Total Copper (g/m^3)	-0.000558	-0.0002525	-0.0001625	-0.0003475	0.0011825	-0.00096	-0.0002225	-0.0003325	-0.00059	-0.0011		0.004
Total Zinc (g/m^3)	-0.01475	-0.001475	-0.000575	-0.001375	0.00555	-0.00315	0.001875	-0.000125	-0.00145	-0.0026		0.130
Total Arsenic (g/m^3)	0.00215	0.00175	0.00175	0.00175	0.00145	0.001025	0.00235	0.00155	0.00165	0.00195		0.013
Total Chromium (g/m^3)	0.0009225	0.00092	0.000955	-0.000335	0.0011225	0.0004475	0.000415	0.000385	0.0002525	0.0003625		0.001

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

Parameter	Site TTD										ANZECC 90% TV
	01/08/2019	27/08/2019	19/09/2019	24/10/2020	14 /11/2019	11/12/2019	28/01/2020	25/02/2020	08/05/2020	29/05/2020	
pH	7.3	7.3	7.7	7.5	7.4	7.6	7.5	7.9	7.4	7.6	Not specified
Electrical Conductivity (mS/m)	104.3	101.4	94.4	85.9	76.7	81.8	71.1	72.1	75	76.4	Not specified
Alkalinity (g/m^3 CaCO^3)	360	340	310	290	210	270	240	250	260	260	Not specified
Total suspended solids (g/m^3)	24	14	13	11	36	11	16	18	11	19	Not specified
COD (g O2/m3)	23	20	20	14	17	17	15	17	15	16	Not specified
Total Hardness (g/m^3 CaCO^3)	420	420	390	330	320	330	260	270	280	310	Not specified
Total Ammonia Nitrogen (g/m^3)	2.3	2.2	1.88	1.58	1.05	1.2	0.77	0.6	0.79	0.89	2.34[1] (1.43)[2]
Dissolved manganese (g/m^3)	2.7	2.6	2.3	1.95	1.33	2.1	1.88	1.56	1.64	1.89	2.5
Dissolved Iron + Manganese (g/m^3)	2.72	2.62	2.33	1.98	1.37	2.13	1.92	1.58	1.66	1.92	1.0[3]
Dissolved Lead (g/m^3)	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.011[1] (0.0056)[2]
Dissolved Copper (g/m^3)	0.00025	0.00025	0.00025	0.00025	0.0009	0.00025	0.00025	0.00025	0.00025	0.00025	0.0028[1] (0.0018)[2]
Dissolved Zinc (g/m^3)	0.0019	0.0013	0.0018	0.0023	0.0047	0.001	0.0005	0.0005	0.0011	0.002	0.027[1] (0.015)[2]
Dissolved Arsenic (g/m^3)	0.0011	0.0013	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.042[2]
Dissolved Chromium (g/m^3)	0.0007	0.0008	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	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.

pH, electrical conductivity, alkalinity, and TSS exceeded tolerance limits at various times throughout the monitoring period. Total ammoniacal nitrogen, total iron, and total manganese exceeded tolerance limits in all ten samples (except for one sample for total manganese). Dissolved manganese, and dissolved iron + manganese exceeded the ANZECC trigger value in 2 and 10 samples, respectively.

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, nine 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 realistic 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 ten sampling rounds for the year to July 2020

Parameter	Tolerance limit exceeded?[4]	ANZECC 90% TV Exceeded at TTD?	Additional sampling required?	Adaptive Management action required?
pH	**3/10**	Not Applicable	Not Applicable	No
Electrical conductivity (mS/m)	**2/10**	Not Applicable	Not Applicable	No
Alkalinity (g/m^3 $CaCO_3$)	**5/10**	Not Applicable	Not Applicable	No
TSS (g/m^3)	**1/10**	Not Applicable	Not Applicable	No
COD (g O2/m^3)	0/10	Not Applicable	Not Applicable	No
Total Hardness (g/m^3 $CaCO_3$)	0/10	Not Applicable	Not Applicable	No
Total ammoniacal N (g/m^3)	**10/10**	0/10	Not Applicable	No
Total Iron (g/m^3)	**10/10**	Not Applicable	Not Applicable	No
Total/dissolved Manganese (g/m^3)	**9/10**	**2/10**	Not Applicable	Yes, in progress
Dissolved Iron + Manganese (g/m^3)[5]	Not Applicable	**10/10**	Not Applicable	Yes, in progress
Total/Dissolved Lead (g/m^3)	0/10	0/10	Not Applicable	No
Total/Dissolved Copper (g/m^3)	0/10	0/10	Not Applicable	No
Total/Dissolved Zinc (g/m^3)	0/10	0/10	Not Applicable	No
Total/Dissolved Chromium (g/m^3)	0/10	0/10	Not Applicable	No
Total/Dissolved Arsenic (g/m^3)	0/10	0/10	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 June 2020

Figure 3-3: TTW Dam (left) and the outlet culvert (left) as of June 2020

Figure 3-4: Diversion flow near wetland as of January 2020

Figure 3-5: Wetland outflow (left) and wetland (right) as of January 2020

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 June 2020, 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 2020, 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 2017 through to June 2020 (the last three reporting periods) to show the benefits achieved by the diversion channels and the constructed wetland system, and no temporal trends were observed.

3.4.1 Contaminants not associated with T & T Landfill operations.

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 to Figure 3-9). 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 three years no clear trend can be discerned for these constituents at any of the monitoring sites.

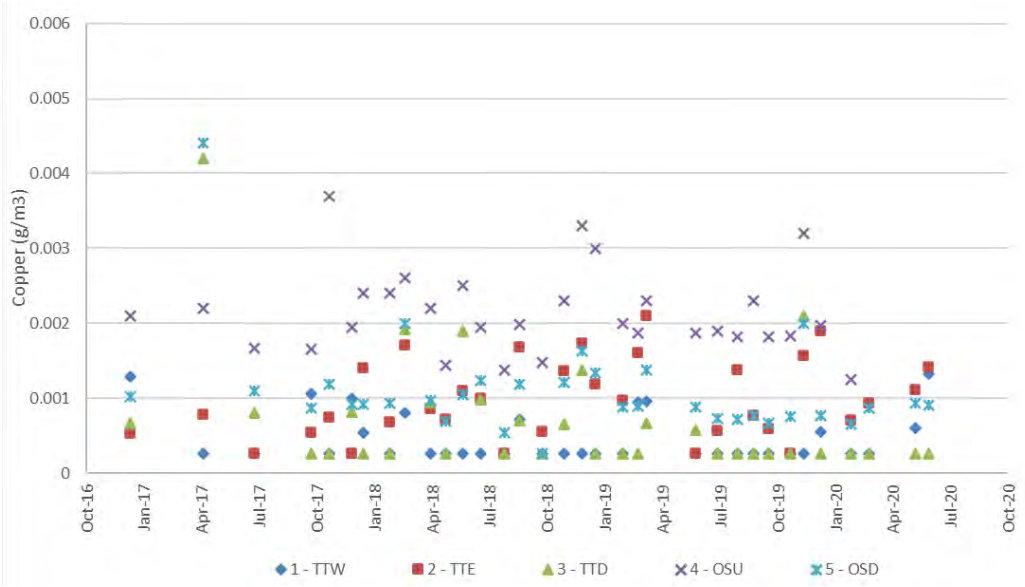


Figure 3-6: Total copper from July 2017 through to June 2020.

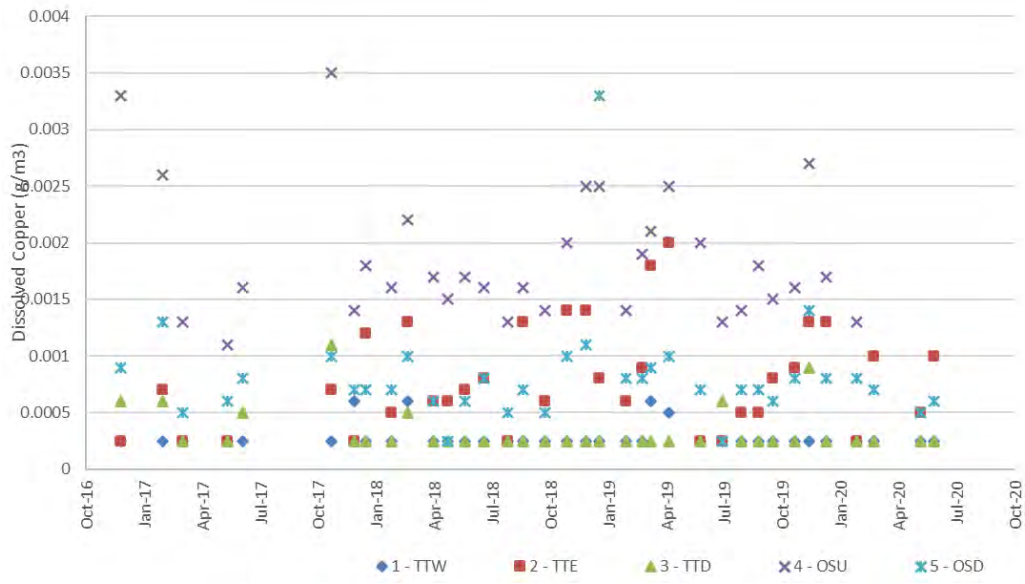


Figure 3-7: Dissolved copper from July 2017 through to June 2020.

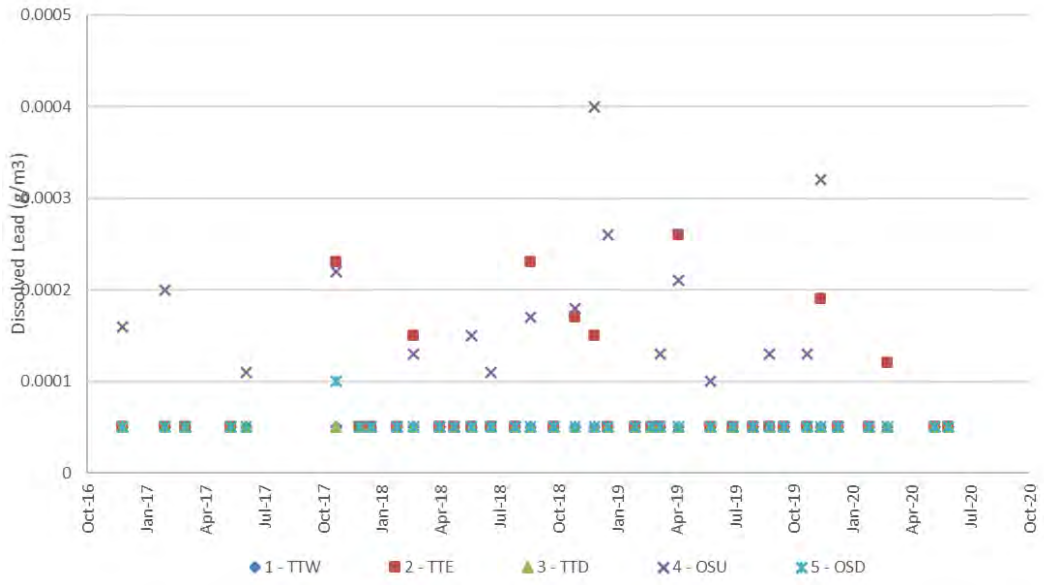


Figure 3-8: Dissolved lead from July 2017 through to June 2020.

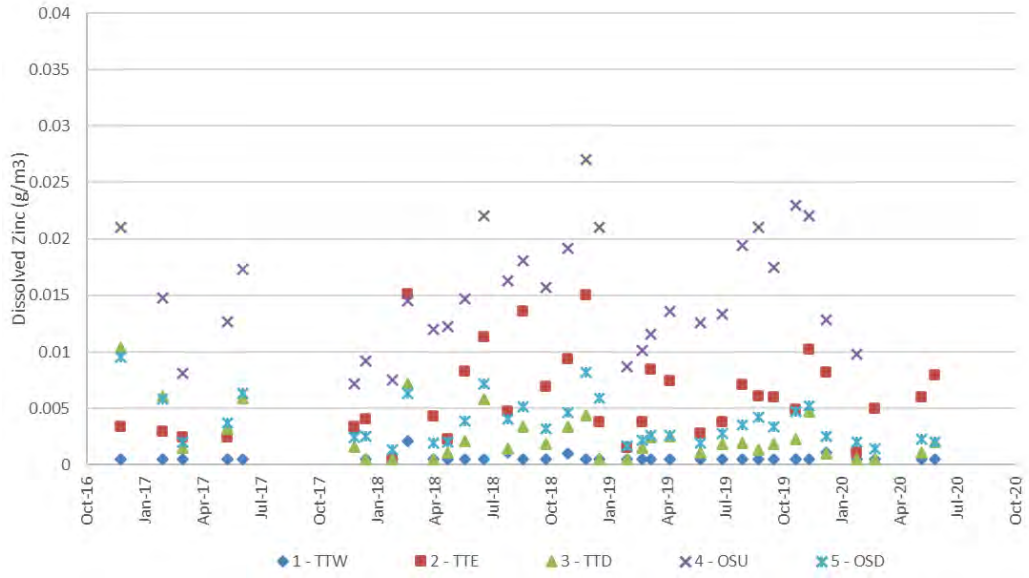


Figure 3-9: Dissolved zinc from July 2017 through to June 2020.

3.4.2 Contaminants associated with T & T Landfill operations

General temporal trends

Since July 2017 to June 2020 concentrations of total ammoniacal-N, total alkalinity, electrical conductivity, total arsenic, total manganese, dissolved calcium, total hardness, and total iron were observed as being consistently higher at TTD and OSD compared with the upstream sites (Figure 3-10 to Figure 3-17).

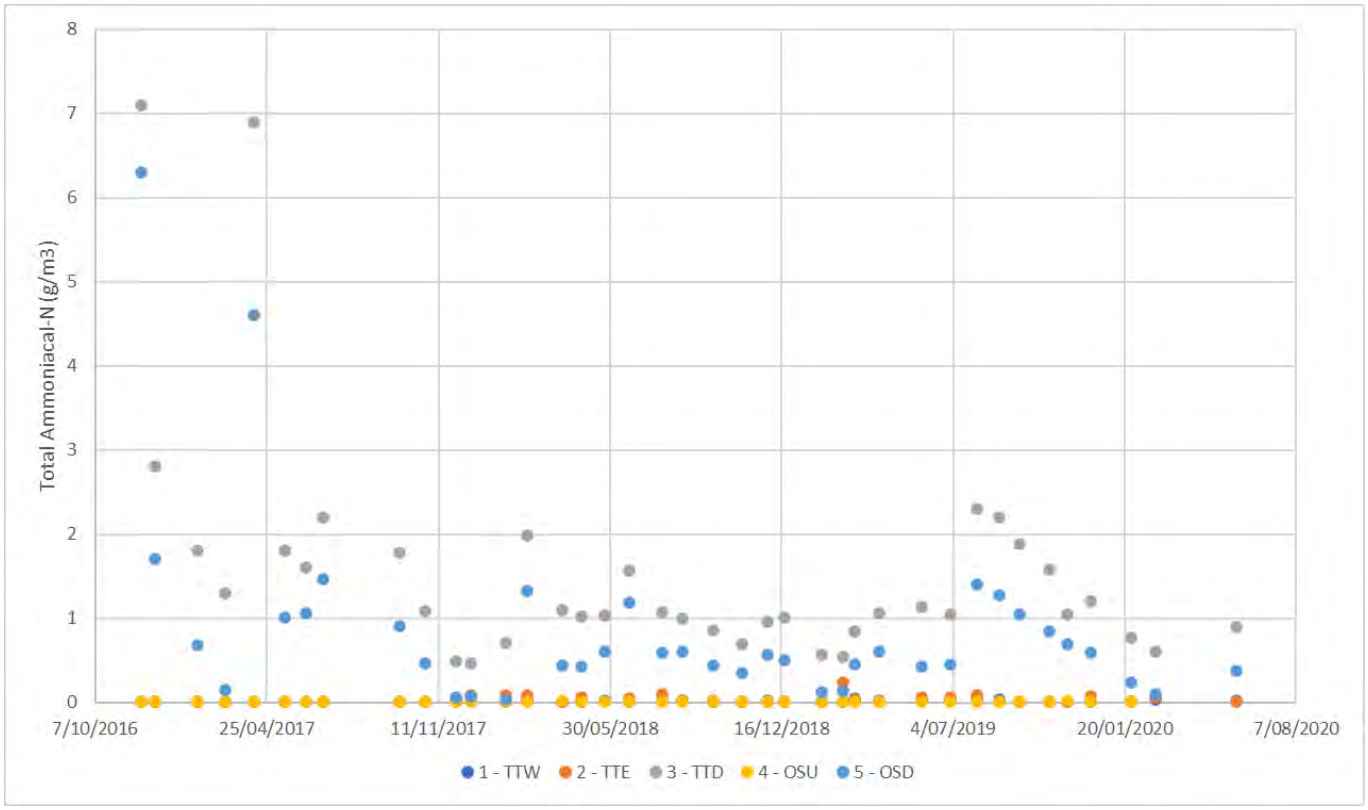


Figure 3-10: Total ammoniacal-N July 2017 through to June 2020.

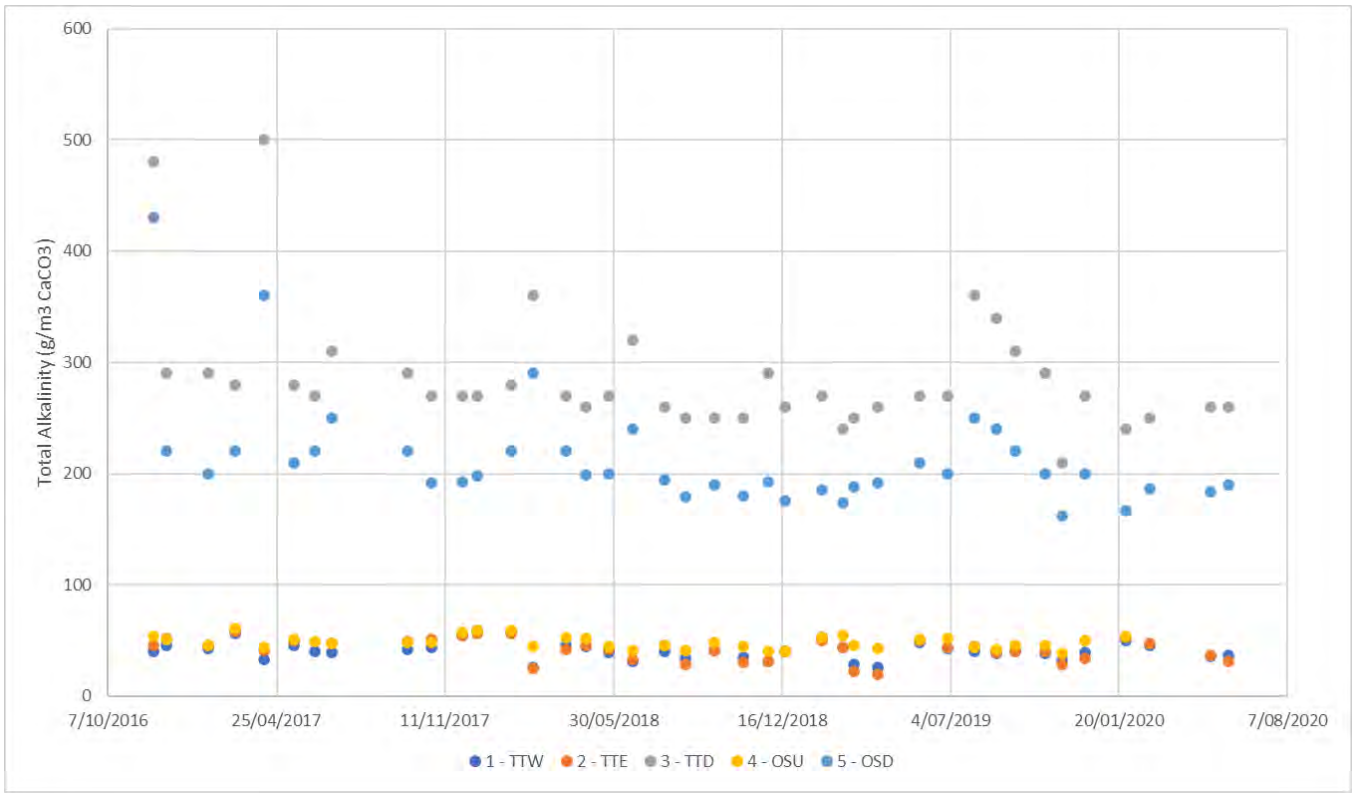


Figure 3-11: Total alkalinity July 2017 through to June 2020.

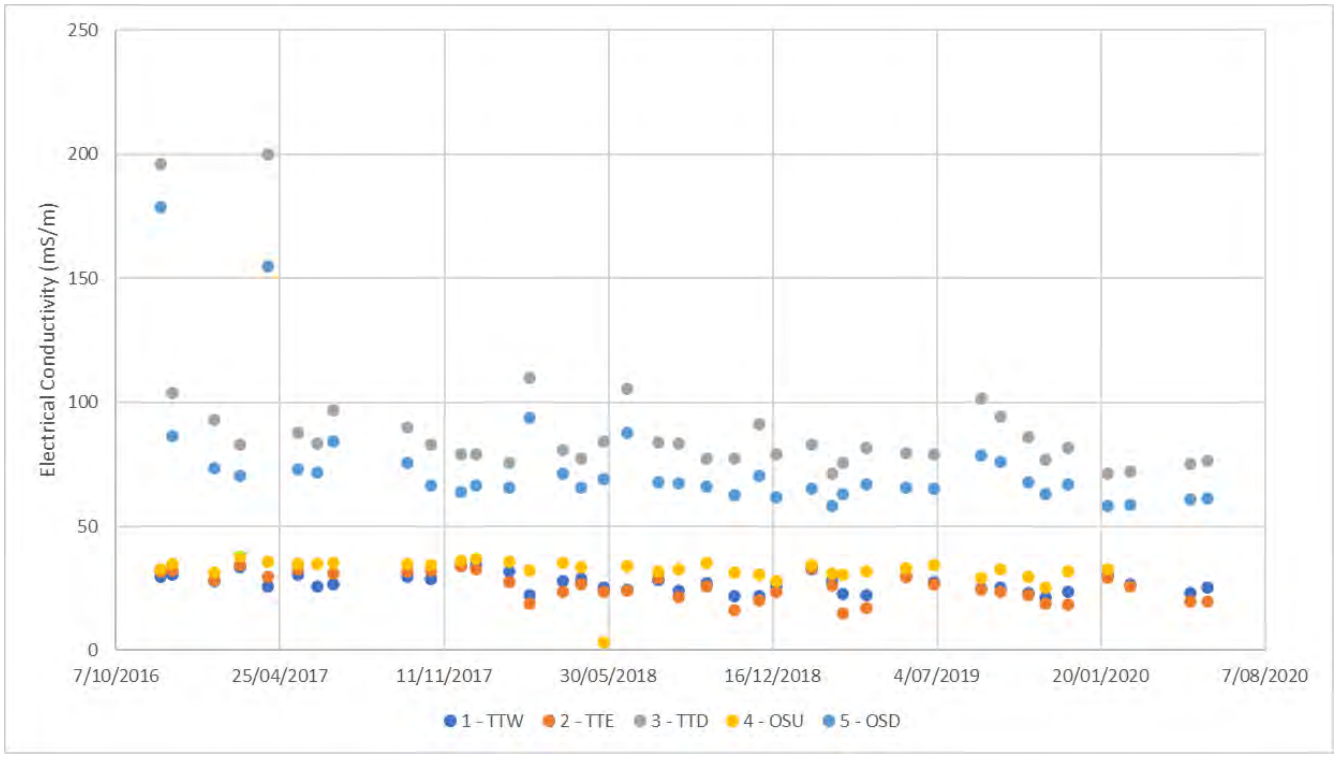


Figure 3-12: Electrical conductivity July 2017 through to June 2020.

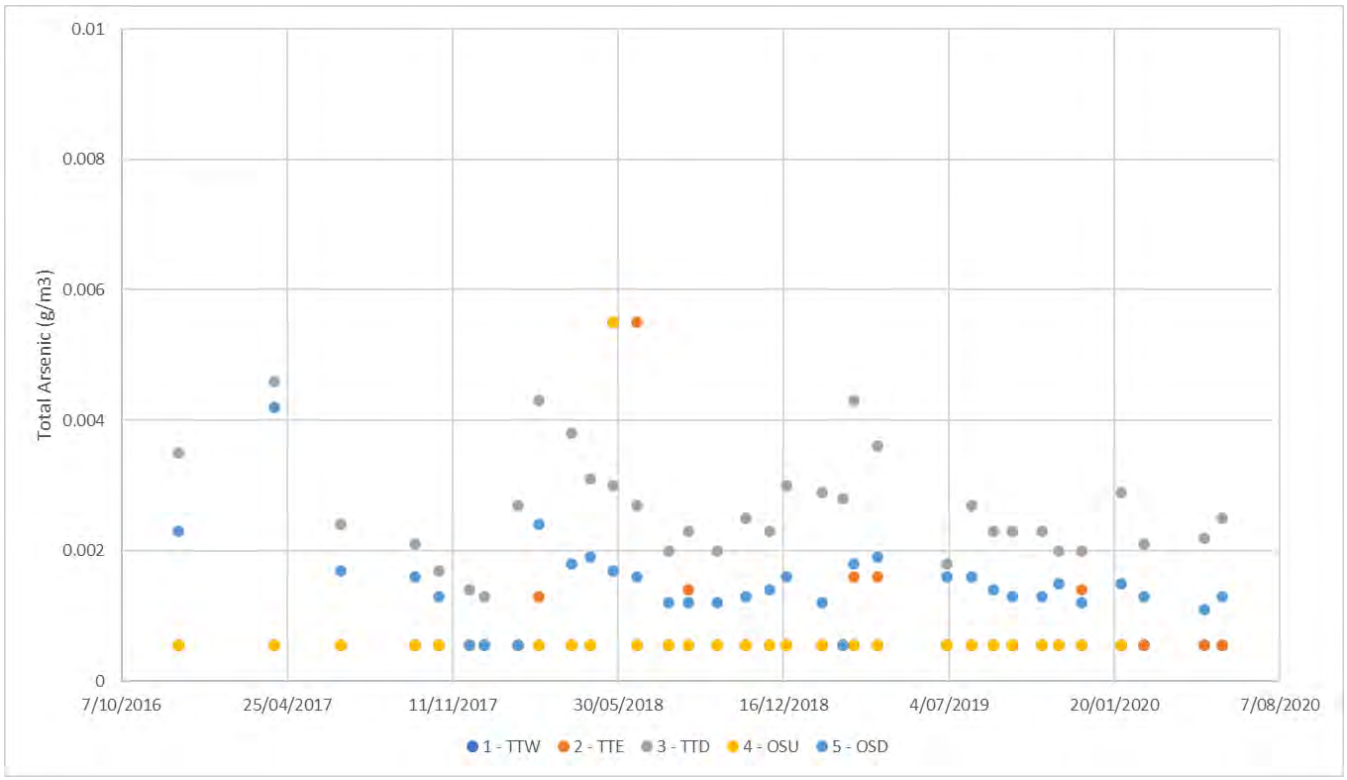


Figure 3-13: Total arsenic July 2017 through to June 2020.

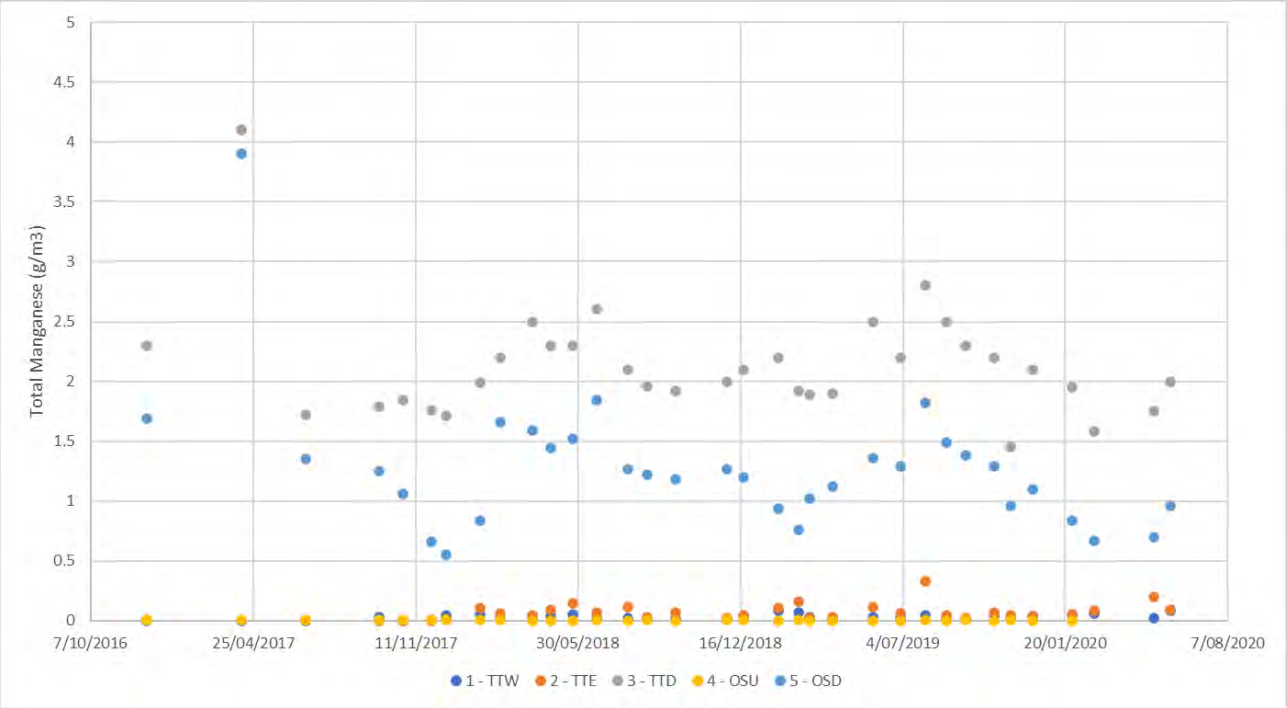


Figure 3-14: Total manganese 2017 through to June 2020.

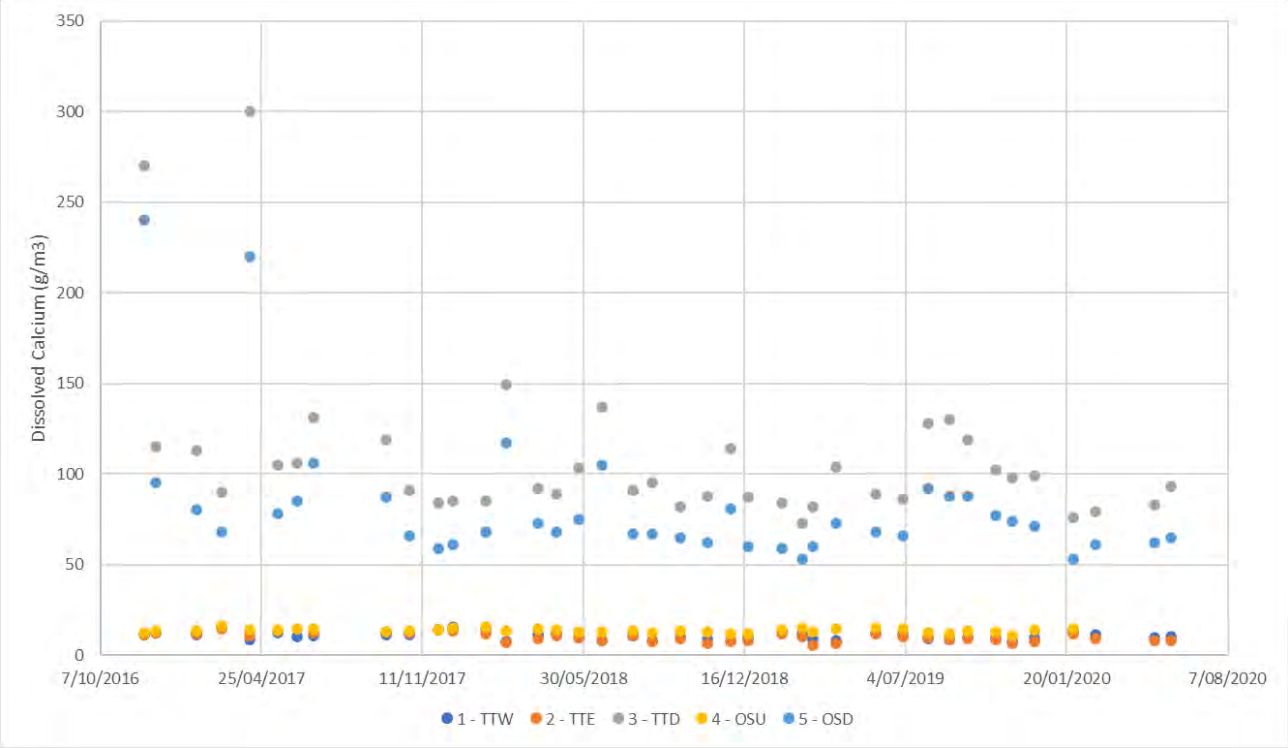


Figure 3-15: Dissolved calcium July 2017 through to June 2020.

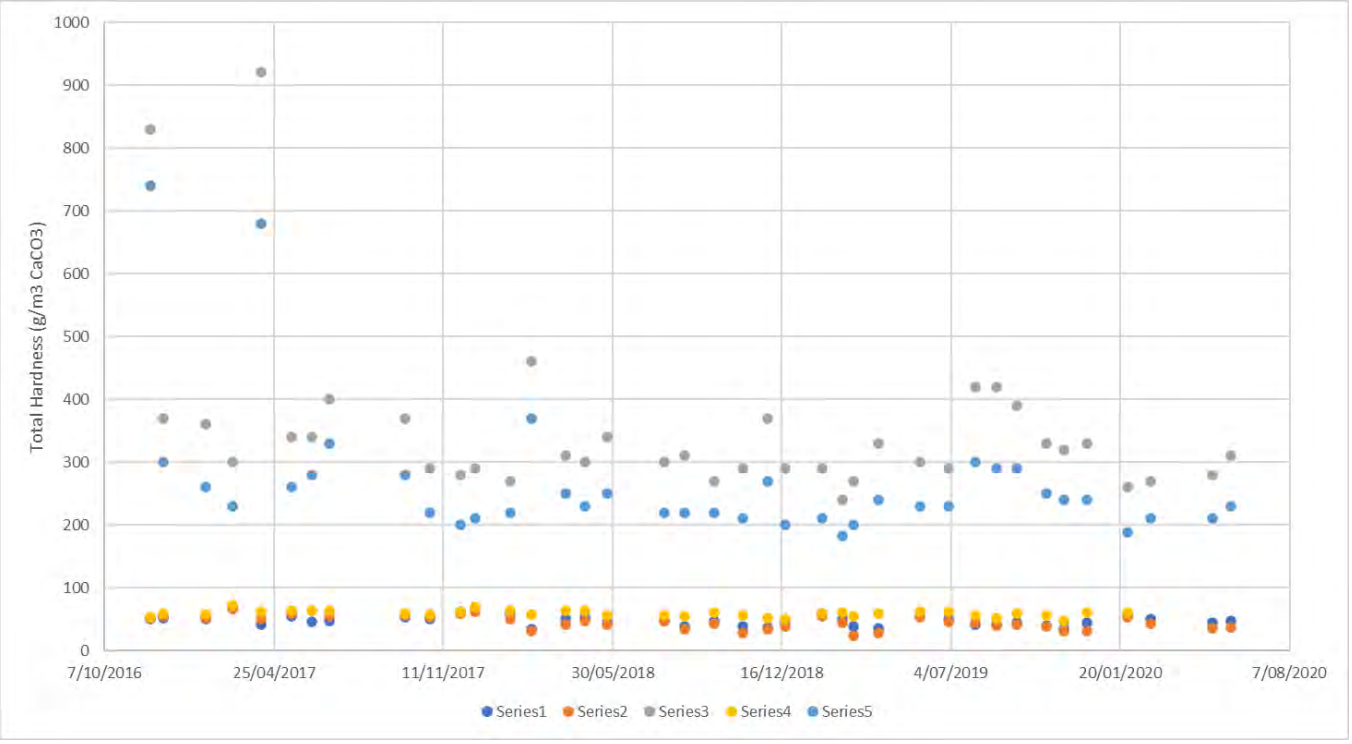


Figure 3-16: Total hardness July 2017 through to June 2020.

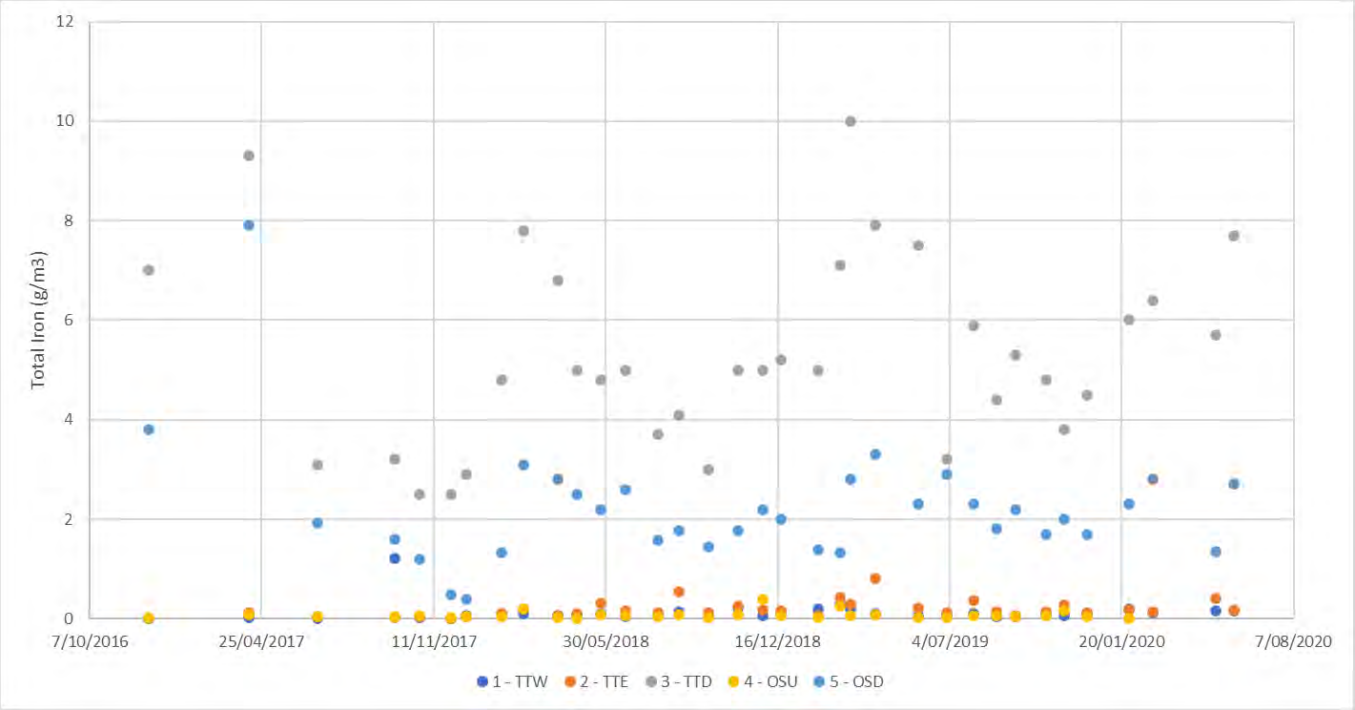


Figure 3-17: Total iron July 2017 through to June 2020.

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 3-18 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 3-19. 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 2020

Parameter	Unit	TTG Results	
		11/12/2019	19/09/2019
pH	pH	6.6	6.7
Chloride	g/m3	46	86
Conductivity	µS/m	31.3	43.4
Nitrate Nitrogen	g/m3	0.9	0.6
Total Ammoniacal Nitrogen	g/m3	0.11	0.013
Total Lead	g/m3	0.036	0.0102
Total Zinc	g/m3	0.112	0.02
Total Iron	g/m3	16.1	4.9
Total Manganese	g/m3	4.1	0.42
Total Copper	g/m3	0.0174	0.0052

Note: Results below detection limits are halved.

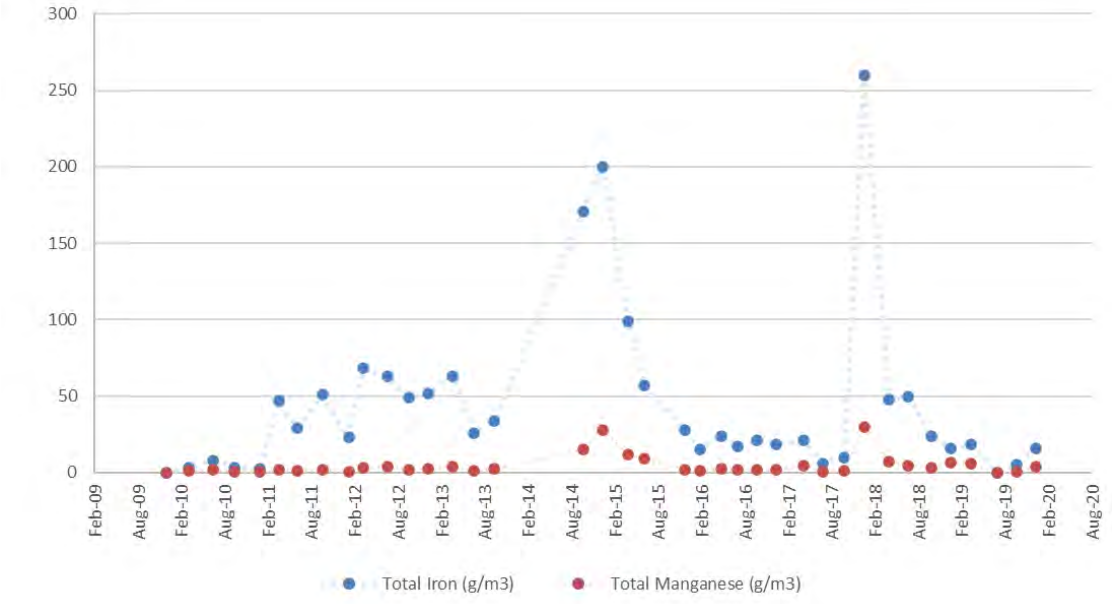


Figure 3-18: Total Iron and Total manganese concentrations in groundwater samples collected downstream of the landfill at site TTG

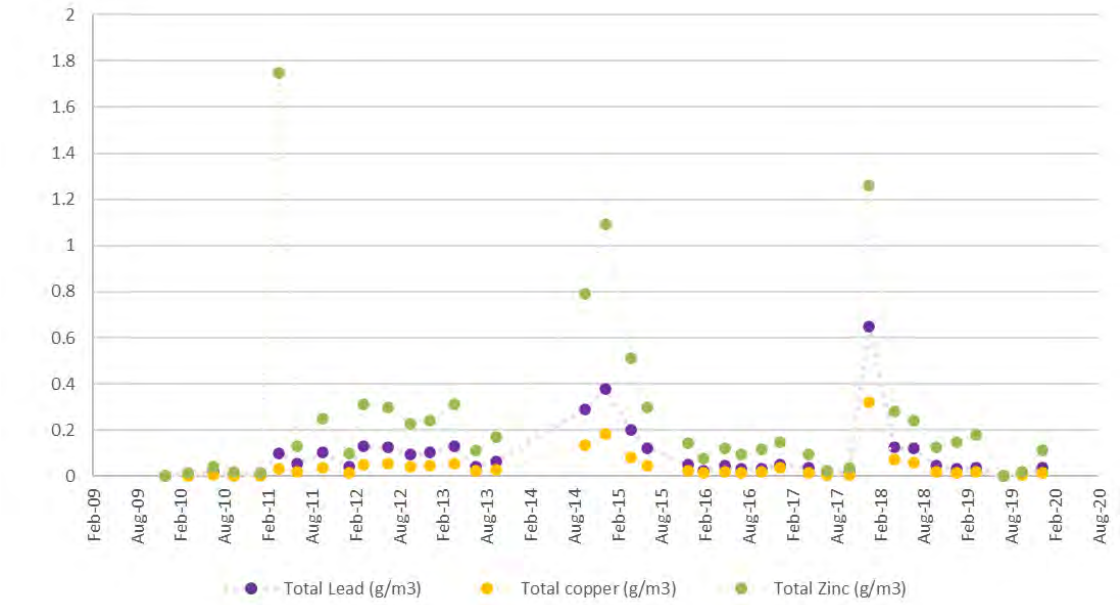


Figure 3-19: Total lead, total copper and total zinc concentrations in groundwater samples collected downstream of the landfill at site TTG

4. Wetland sampling

On the following days Stantec undertook in-situ water quality measurements including dissolved oxygen (DO), temperature, pH and conductivity around the wetland (Figure 4-1). The sites these were taken at are included next to the dates below:

- 1 August 2019 at all 8 locations
- 27 August 2019 at locations 1, 7, and 8
- 19 September 2019 at all 8 locations
- 4 October 2019 at all 8 locations
- 11 December 2019 at locations 1, 5, 7, and 8
- 25 February 2020 at locations 1, 7, and 8

Water quality grab samples were taken at the wetland on the following dates at the following locations

- 19 September at locations 1 (Wetland inlet) and 8 (Wetland outlet)
- 24 October 2019 at locations 1 and 8
- 11 December 2019 at locations 1, 5, and 8
- 25 February 2020 at locations 1, 7 (location of outflow culvert), and 8

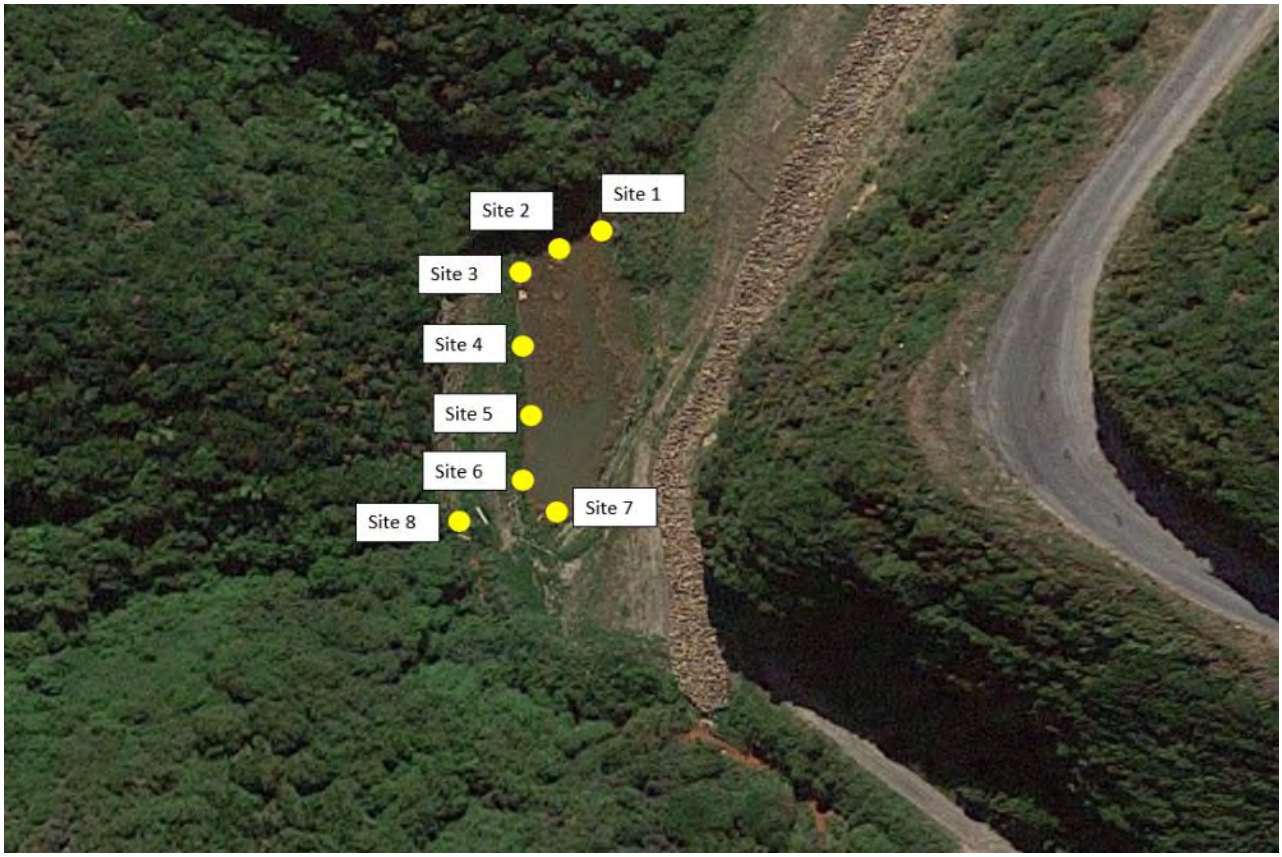


Figure 4-1: Wetland water quality sampling locations

Results from in-situ water quality sampling (Table 4-1 to Table 4-6) show pH and temperature were consistent across the wetland and when compared to laboratory analysed grab samples taken except for February 2020. The February 2020 in-situ sampling of pH was lower than other in-situ samples and the laboratory analysed grab sample, this is most likely due to equipment issues while measuring pH on site.

Dissolved oxygen percent saturation (% sat) varied across the sampling months and location in the wetland, but consistently showed an increase from the wetland inlet to the outlet. At Site 8 is in the stream

channel immediately downstream of the wetland outlet culvert, dissolved oxygen ranged from 56.4% to 83.7%. The compliance monitoring sites TTD is located 100m further downstream, at which point dissolved oxygen levels are expected to exceed 80% saturation.

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

Parameter/Site	1	2	3	4	5	6	7	8
pH	6.42	6.6	6.71	6.59	6.69	6.69	6.62	6.79
Temperature (°C)	13.2	12.9	13	13	13.2	13.1	13	13.1
DO (% sat)	24.9	31.8	37	31.8	38.4	35.7	34.2	83.7
DO (mg/l)	2.56	3.26	3.72	3.18	4	3.65	3.54	8.79
Conductivity SPC (mS/m)	648	723	718	719	726	724	722	726
Conductivity C (mS/m)	5.2	556	553	555	562	559	555	561

Table 4-2: In-situ water quality results for sites around wetland 27 August 2019

Parameter/Site	1	7	8
pH	6.94	6.95	7.07
Temperature (°C)	13.9	14.1	14.2
DO (% sat)	4.7	18.4	67.5
DO (mg/l)	0.48	1.9	6.92
Conductivity SPC (mS/m)	1089	1079	1083
Conductivity C (mS/m)	857	855	860

Table 4-3: In-situ water quality results for sites around wetland 19 September 2019

Parameter/Site	1	2	3	4	5	6	7	8
pH	6.41	6.67	6.39	6.73	6.4	6.19	6.44	6.65
Temperature (°C)	13.6	13.7	13.9	14	13.9	14	14	14.1
DO (% sat)	14	32	32.5	36.1	36.6	33.9	35.7	80.8
DO (mg/l)	1.46	3.15	3.62	3.7	3.75	3.47	3.64	8.28
Conductivity SPC (mS/m)	826	826	818	819	816	783	815	818
Conductivity C (mS/m)	645	648	645	647	643	610	644	648

Table 4-4: In-situ water quality results for sites around wetland 4 October 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	0.50	0.78	1.01	1.13	1.2	0.69	5.82
Conductivity SPC (mS/m)	1027	1026	1024	1021	1016	1015	1019	1016
Conductivity C (mS/m)	810	810	806	802	796	796	802	800

Table 4-5: In-situ water quality results for sites around wetland 11 December 2019

Parameter/Site	1	5	7	8
pH	6.49	6.77	7.15	6.84
Temperature (°C)	14.4	14.2	14.4	14.1
DO (% sat)	36.1	60.8	77.4	69.6

DO (mg/l)	3.69	6.06	7.84	6.98
Conductivity SPC (mS/m)	764	743	733	743
Conductivity C (mS/m)	604	589	584	588

Table 4-6: In-situ water quality results for sites around wetland 25 February 2020

Parameter/Site	1	7	8
pH	5.74	5.97	5.66
Temperature (°C)	14.8	16.4	16.6
DO (% sat)	10.9	55.3	80.4
DO (mg/l)	1.1	5.41	7.83
Conductivity SPC (mS/m)	731	717	716
Conductivity C (mS/m)	588	599	601

Results from a series of grab samples collected from the wetland and stream are presented in Table 4-7. The following was observed at the wetland during the site visit:

- There is orange precipitate in the Wetland and at the outfall.
- The water was cloudy in the wetland and the outfall.
- Foam and bubbles were present at the wetland outflow.

Iron was largely present in particulate form with dissolved iron being a small fraction. Total Manganese was very similar to dissolved manganese.

Total ammoniacal nitrogen and manganese (both total and dissolved) 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) and 2.5 g/m^3 respectively. COD was also consistent across the wetland .

Table 4-7: Water quality wetland grab sample results

Date/Site		19/09/2019		24/10/2019		11/12/2019			25/02/2020		
Parameter	units	Site 1	Site 8	Site 1	Site 8	Site 1	Site 5	Site 8	Site 1	Site 7	Site 8
pH	-	6.9	7.2	6.8	7.1	6.7	6.9	7.2	6.9	7	7.5
Total Alkalinity	g/m³ as $CaCO_3$	320	320	290	300	310	280	280	260	260	250
Total Hardness	g/m³ as $CaCO_3$	400	390	330	340	330	330	330	260	270	260
Electrical Conductivity	mS/m	97	95.7	88.1	87.5	86.6	82.9	83.3	72.5	72.7	72.2
TSS	g/m³	11	34	7	15	13	19	18	22	20	22
Dissolved Arsenic	g/m³	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Total Arsenic	g/m³	0.003	0.0041	0.0032	0.0036	0.0026	0.0028	0.0026	0.0034	0.0026	0.0029
Dissolved Calcium	g/m³	124	122	103	105	101	100	102	76	79	78
Dissolved Chromium	g/m³	0.0006	0.0006	0.0006	0.0006	0.0005	0.00025	0.00025	0.00025	0.00025	0.00025
Total Chromium	g/m³	0.00139	0.00182	0.00101	0.0013	0.0007	0.00105	0.00108	0.00064	0.0008	0.00056
Dissolved Copper	g/m³	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025
Total Copper	g/m³	0.000265	0.00058	0.000265	0.000265	0.000265	0.000265	0.000265	0.000265	0.000265	0.000265
Dissolved Iron	g/m³	0.03	0.02	0.03	0.02	0.51	0.02	0.02	0.2	0.04	0.04
Total Iron	g/m³	7.4	13.2	7.6	9.7	7.3	7.3	6.5	10.7	8.6	8.5
Dissolved Lead	g/m³	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Total Lead	g/m³	0.00021	0.00125	0.00023	0.00096	0.00017	0.00087	0.00062	0.000055	0.00021	0.00024
Dissolved Magnesium	g/m³	22	22	18.5	18.8	19.6	19	19.5	16.4	17	16.5
Dissolved Manganese	g/m³	2.5	2.3	2.1	2.1	2.3	2.2	2.2	1.87	1.81	1.73
Total Manganese	g/m³	2.4	2.5	2.2	2.5	2.3	2.2	2.2	1.83	1.75	1.71
Dissolved Zinc	g/m³	0.002	0.0034	0.0026	0.0037	0.0013	0.0017	0.0012	0.001	0.0017	0.0014
Total Zinc	g/m³	0.003	0.012	0.004	0.0087	0.0023	0.0039	0.0037	0.0067	0.0031	0.0034
Total Ammoni-N	g/m³	2.1	2	1.81	1.74	1.42	1.41	1.41	1.04	1	0.95
Dissolved Manganese + Dissolved Iron	g/m³	2.53	2.32	2.13	2.12	2.81	2.22	2.22	2.07	1.85	1.77
COD	g O_2/m³	26	28	18	18	23	19	18	17	15	16
DOC	g/m³	7.4	14.5	1.7	2.1	7.8	4.6	8.1	0.25	1.5	3.7

Note: Results below detection limits are halved.

5. June Quarterly Monitoring Results

Routine stream surface water and groundwater quality monitoring at T&T Landfill is required by conditions 7 and 8 of discharge permit WGN070260 [30627] and detailed in the Discharge Monitoring Plan (DMP). The monitoring locations are shown in Attachment 1.

The DMP requires monthly monitoring at the five surface water sites, and targeted storm event monitoring at all surface water sites within seven days of a major rainfall event (>45 mm in 24 hours).

Condition 8 of the consent requires the surface water quality results to be assessed against:

(a) specified tolerance limits (the contaminant contribution for T&T Landfill is calculated by subtracting the mean of TTW and TTE from TTD), and
(b) ANZECC 90% protection guidelines for water quality toxicants.

In the event that any sample from site TTD exceeds both (a) and (b), two follow-up sampling rounds are required to be collected in order to determine if the adaptive management provisions of the consent (in conditions 13 and 14) are triggered.

Condition 11 of the consent requires that discharges from the site shall not give rise to specified adverse effects beyond 100 m of the discharge point from the constructed wetland.

This annual report is considered to address these consent conditions and therefore can be used as the June quarterly report.

6. Comparison Against 2016 Baseline

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 has been deferred until the summer of 2020-2021 or until the diversion is fully operational.

A comparison between results of 2016 and 2020 (Figure 6-1 and Figure 6-2) show that:

- Concentrations of most contaminants at TTD have decreased since 2016, including total ammonia nitrogen, COD, copper, zinc and lead. For all other contaminants there is little change.
- 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.

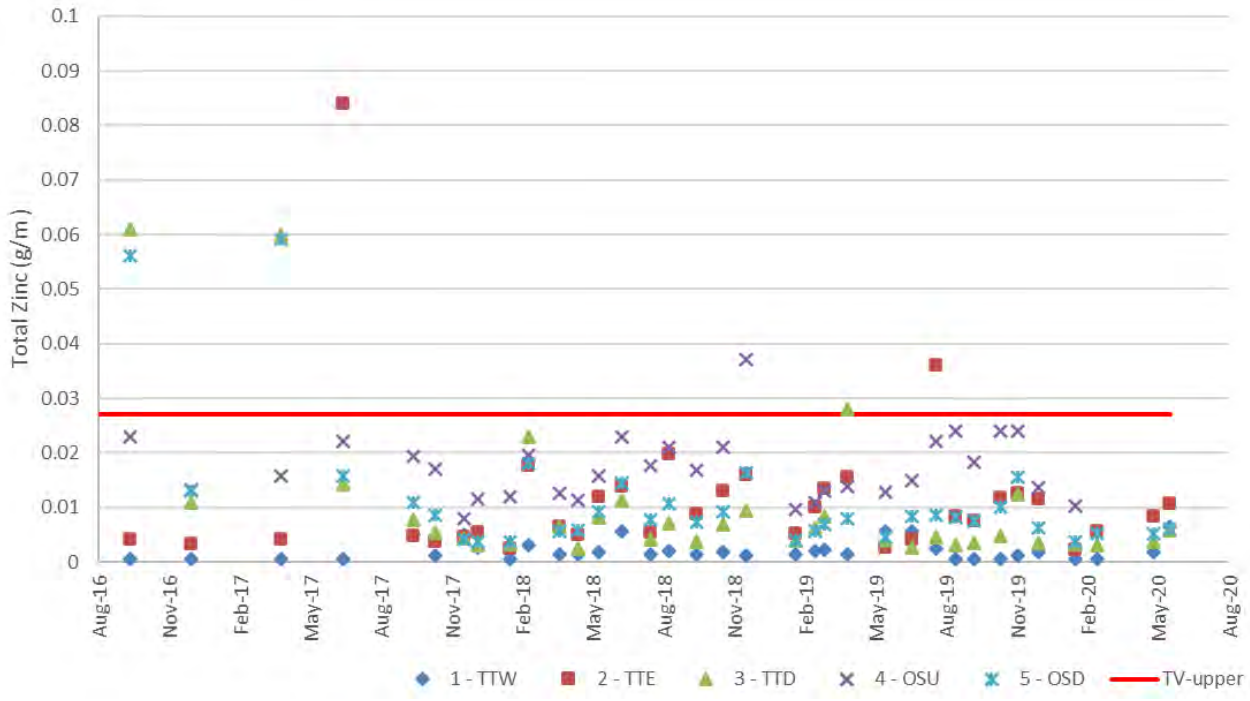


Figure 6-1 Total Zinc concentrations from July 2016 through to June 2020

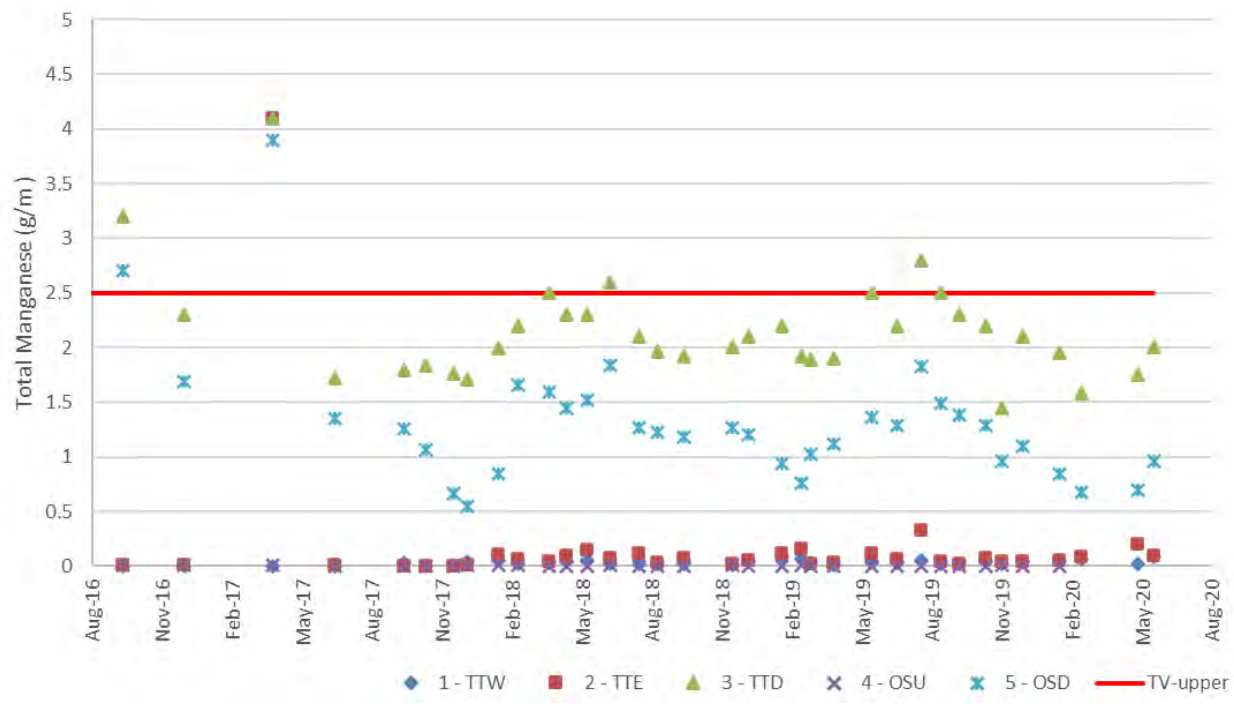


Figure 6-2 Total Manganese from July 2016 through to June 2020

7. 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. 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 reduced leachate volumes, but diversion of a greater proportion of the stream flow is likely to produce further improvement. 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.
- A benthic ecology survey to be conducted during the 2020/21 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

Appendix C Site Photographs

1 August 2019

Wetland location 1

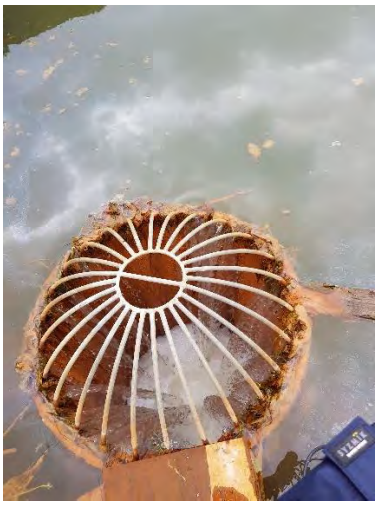
Wetland location 1

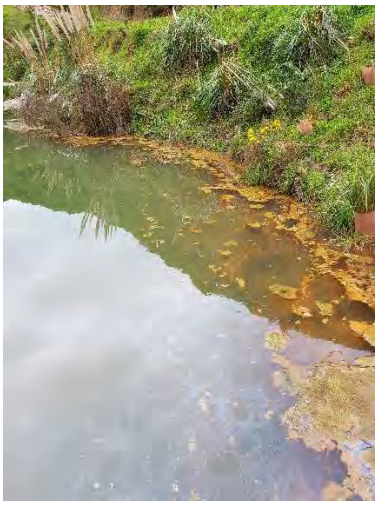
Wetland location 2

Wetland location 3

Wetland location 4

Wetland location 5





Wetland location 6

Wetland location 7

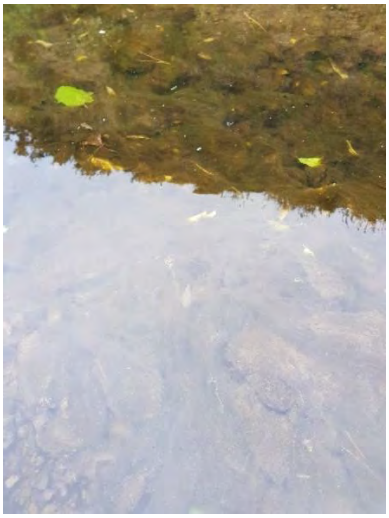
Wetland location 7

Wetland location 8

Wetland location 8

TTW upstream

TTW vegetation upstream



TTW flow through culvert

TTW flow through culvert 2

TTW algae after culvert

TTE

TTE upstream

TTE 2

TTE culvert flow

TTD

TTD upstream

TTD downstream

OSU

OSU upstream

OSU periphyton

OSU litter

OSU litter

OSU downstream

OSD

OSD upstream

OSD downstream

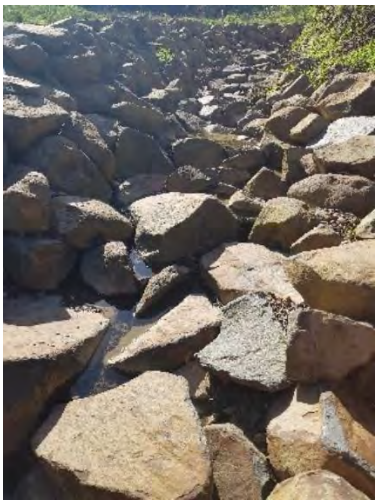
27 August 2019

Wetland

Wetland outflow

Wetland outflow foam and bubbles

Wetland inflow



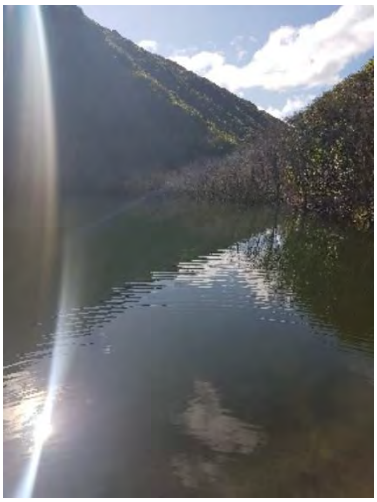
Wetland - flow down boulders

TTW

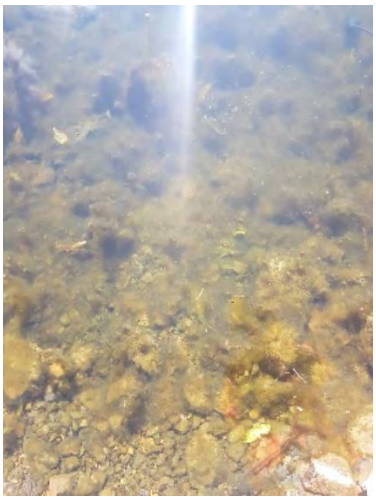
TTW upstream

TTW flow through culvert

TTW downstream



TTE upstream



TTE

TTE flow through culvert

TTE downstream

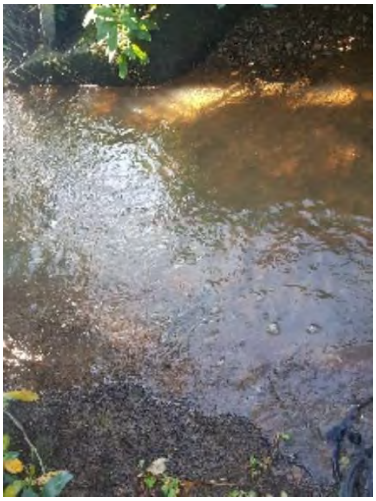
TTD upstream

TTD downstream

OSU

OSU upstream

OSU downstream

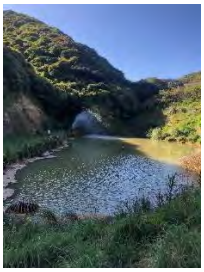


OSD

OSD upstream

OSD downstream

19 September 2019



Wetland

Wetland

Wetland Downstream

TTW Dam

TTW Weir

TTW Downstream

TTW Outlet

TTW Upstream

TTE_Dam

TTE Dam Bed

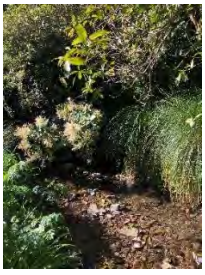
TTE

TTE

TTG

TTD Upstream

TTD Downstream



OSD Downstream

OSD Stream Bed

4 October 2019

Wetland Location 8

Wetland Location 8

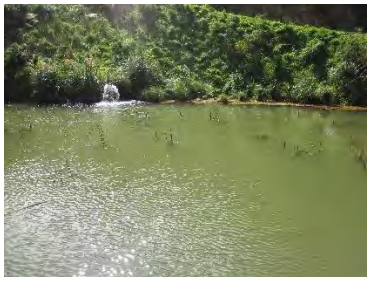
Wetland Location 7

Wetland Location 7

Wetland Location 6

Wetland Location 5

Wetland Location 5



Wetland Location 4

Wetland Location 4

Wetland Location 3

Wetland Location 3

Wetland Location 3

Wetland Location 2

Wetland Location 2

Wetland Location 1

Wetland Location 1

Wetland Location 1

24 October 2019

Wetland Outflow

Wetland Outflow

Wetland Inlet

Wetland Inlet

Wetland Inlet

TTW

TTW

TTE

TTE

TTD

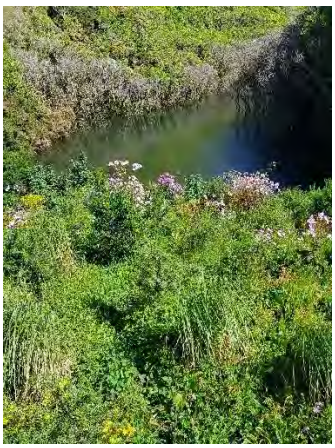
TTD

OSU

OSD

OSD

14 November 2019



TTW Vegetation

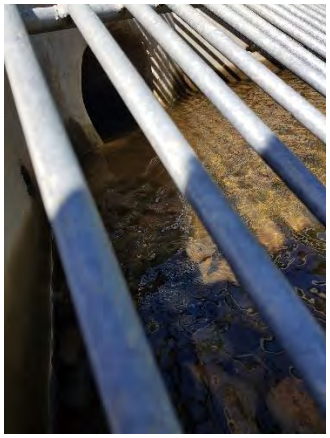
TTW Upstream

TTW Downstream Culvert

TTW Culvert

TTE Upstream

TTE Downstream Culvert



TTE Culvert

TTD Upstream

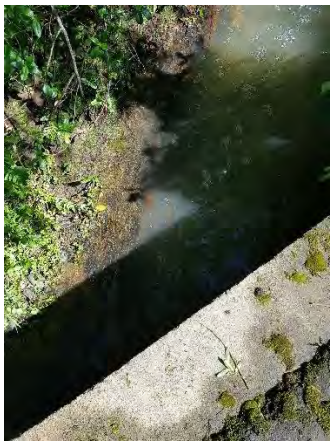
TTD Downstream

OSU Upstream

OSU Downstream

OSD Upstream

OSD Downstream



OSD

OSD Litter

11 December 2019

Wetland Location 8

Wetland Location 8

Wetland Location 8

Wetland Location 7

Wetland Location 5

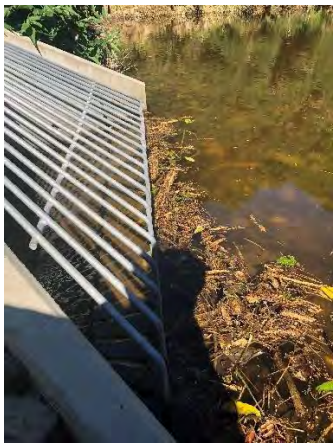
Wetland Location 1

Wetland Inflow

Wetland Boulders

Wetland

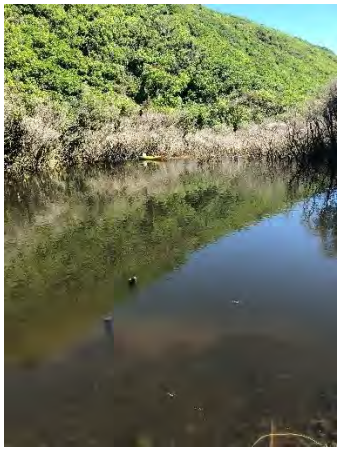
TTW



TWW Culvert

TTW Downstream

TTW Downstream



TTE Upstream

TTE Culvert

TTE Downstream

TTE Limited Flow Downstream

TTD Upstream

TTD Downstream

OSU Upstream

OSU Downstream

OSD Downstream

OSD Litter

28 January 2020

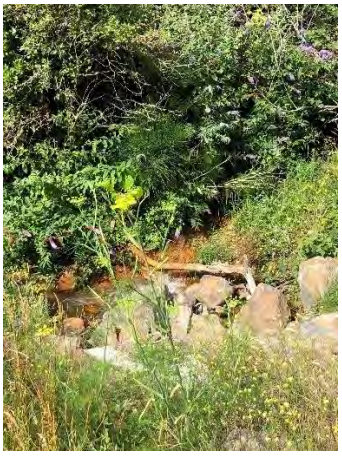
Wetland

Wetland

Wetland

Wetland Outflow

Wetland Outflow



Wetland Orange Precipitate

Wetland No Flow

TTW

TTW Low Waterline

TTW Low Waterline

TTW Culvert

TTW Culvert Downstream

TTE Upstream

TTE No Flow Debris

TTE Algae

TTE Culvert

TTE Culvert Downstream

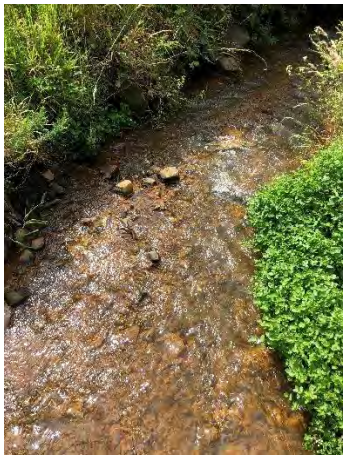
TTD Upstream

TTD Downstream

OSU Upstream

OSU Downstream

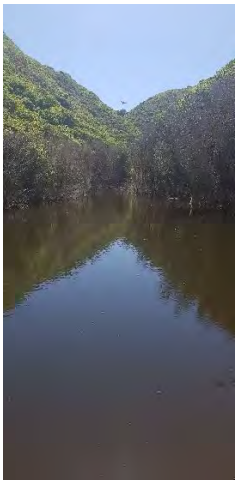
OSD Upstream



OSD Downstream

25 February 2020

TTW Waterline Below Culvert



TTW Upstream

TTE

TTE Culvert

TTE Downstream

TTE Sediment Build-up Downstream

TTD Upstream

TTD Downstream

OSD

OSD

Wetland

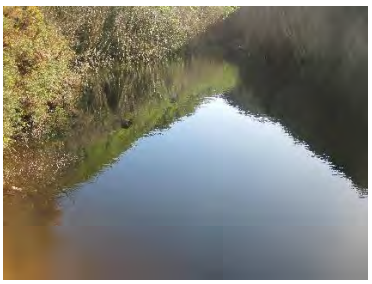
Wetland

Wetland Downstream

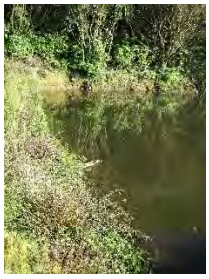
8 May 2020

TTW Dam

TTW Dam



TTW Dam



TTE Dam

TTE Dam

TTE Dam

TTE Dam Outlet

TTD view from road

TTD downstream

Eel at OSD

Foaming at OSD

OSD

29 May 2020

TTW

TTW Upstream

TTW Rubbish

TTW Culvert

TTE Upstream

TTE Below Culvert Line

TTE Culvert Outflow

TTE Downstream

TTD Upstream

TTD Downstream

TTD Rubbish

OSD Upstream

OSD Downstream

Appendix D Field Notes

Appendix E Comparison with ANZECC 2000 Guidelines

E.1 1/08/2019 Sampling

Parameter	Unit	ANZECC 90% TV	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.3	7	7.3	7.6	7.9
Conductivity	mS/m	NA	104.3	27.1	25.4	31.8	82.6
Total Alkalinity	g/m^{3}CaCO$_3$	NA	360	45	40	44	250
TSS	g/m^3	NA	24	5	1.5	1.5	7
COD	g O2/m^3	NA	23	6	3	3	18
Total Hardness	g/m^{3}CaCO$_3$	NA	420	44	42	56	300
Total Ammoniacal Nitrogen	g/m^3	1.430 (2.34)	**2.3**	0.082	0.046	0.005	1.4
Total Iron	g/m^3	NA	5.9	0.37	0.102	0.06	2.3
Dissolved Iron	g/m^3	NA	0.02	0.1	0.04	0.01	0.03
Total Manganese	g/m^3	NA	2.8	0.33	0.048	0.0029	1.82
Dissolved manganese	g/m^3	2.5	**2.7**	0.125	0.032	0.0015	1.7
Dissolved Iron + Manganese	g/m^3	1.0	**2.72**	0.225	0.072	0.0115	**1.73**
Total Lead	g/m^3	NA	0.00033	0.00038	0.000055	0.00031	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	0.00138	0.000265	0.00182	0.00072
Dissolved Copper	g/m^3	0.0018 (0.0028)	0.00025	0.0005	0.00025	0.0014	0.0007
Total Zinc	g/m^3	NA	0.0045	0.036	0.0025	0.022	0.0085
Dissolved Zinc	g/m^3	0.015 (0.027)	0.0019	0.0071	0.0005	**0.0194**	0.0035
Total Arsenic	g/m^3	NA	0.0027	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	0.00137	0.00063	0.000265	0.00094	0.00103
Dissolved Chromium	g/m^3	0.006	0.0007	0.00025	0.00025	0.00025	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

E.2 27/08/2019 Sampling

Parameter	Unit	ANZECC 90% TV	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.3	7.2	7.3	7.6	7.9
Conductivity	mS/m	NA	101.4	24.4	25	29.3	78.8
Total Alkalinity	g/m^{3}CaCO$_3$	NA	340	39	38	42	240
TSS	g/m^3	NA	14	5	1.5	1.5	5
COD	g O2/m^3	NA	20	8	3	3	14

Parameter	Unit	ANZECC 90% TV	TTD	TTE	TTW	OSU	OSD
Total Hardness	g/m³CaCO₃	NA	420	40	42	52	290
Total Ammoniacal Nitrogen	g/m³	1.430 (2.34)	**2.2**	0.005	0.029	0.014	1.27
Total Iron	g/m³	NA	4.4	0.136	0.05	0.054	1.81
Dissolved Iron	g/m³	NA	0.02	0.03	0.02	0.01	0.03
Total Manganese	g/m³	NA	2.5	0.042	0.02	0.0022	1.49
Dissolved manganese	g/m³	2.5	**2.6**	0.02	0.0149	0.0017	1.54
Dissolved Iron + Manganese	g/m³	1.0	**2.62**	0.05	0.0349	0.0117	**1.57**
Total Lead	g/m³	NA	0.00056	0.00039	0.00012	0.0003	0.00035
Dissolved Lead	g/m³	0.0056 (0.011)	0.00005	0.00005	0.00005	0.00013	0.00005
Total Copper	g/m³	NA	0.000265	0.00077	0.000265	0.0023	0.00077
Dissolved Copper	g/m³	0.0018 (0.0028)	0.00025	0.0005	0.00025	0.0018	0.0007
Total Zinc	g/m³	NA	0.003	0.0084	0.00055	0.024	0.0082
Dissolved Zinc	g/m³	0.015 (0.027)	0.0013	0.0061	0.0005	**0.021**	0.0042
Total Arsenic	g/m³	NA	0.0023	0.00055	0.00055	0.00055	0.0014
Dissolved Arsenic	g/m³	0.042	0.0013	0.0005	0.0005	0.0005	0.0005
Total Chromium	g/m³	NA	0.00173	0.00093	0.00069	0.000265	0.00106
Dissolved Chromium	g/m³	0.006	0.0008	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/m³CaCO₃
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

E.3 19/09/2019 Sampling

Parameter	Unit	ANZECC 90% TV	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.7	7.5	7.6	7.5	8
Conductivity	mS/m	NA	94.4	23.6	25.3	32.7	75.9
Total Alkalinity	g/m³CaCO₃	NA	310	40	40	46	220
TSS	g/m³	NA	13	1.5	3	37	7
COD	g O2/m³	NA	20	3	3	3	12
Total Hardness	g/m³CaCO₃	NA	390	42	45	60	290
Total Ammoniacal Nitrogen	g/m³	1.430 (2.34)	**1.88**	0.005	0.005	0.011	1.04
Total Iron	g/m³	NA	5.3	0.07	0.038	0.038	2.2
Dissolved Iron	g/m³	NA	0.03	0.03	0.01	0.01	0.04
Total Manganese	g/m³	NA	2.3	0.0195	0.0174	0.0026	1.38
Dissolved manganese	g/m³	2.5	2.3	0.0017	0.0016	0.0014	1.35
Dissolved Iron + Manganese	g/m³	1.0	**2.33**	0.0317	0.0116	0.0114	**1.39**
Total Lead	g/m³	NA	0.00024	0.00018	0.000055	0.00029	0.00023

Parameter	Unit	ANZECC 90% TV	TTD	TTE	TTW	OSU	OSD
Dissolved Lead	g/m³	0.0056 (0.011)	0.00005	0.00005	0.00005	0.00005	0.00005
Total Copper	g/m³	NA	0.000265	0.00059	0.000265	0.00182	0.00066
Dissolved Copper	g/m³	0.0018 (0.0028)	0.00025	0.0008	0.00025	0.0015	0.0006
Total Zinc	g/m³	NA	0.0035	0.0076	0.00055	0.0183	0.0075
Dissolved Zinc	g/m³	0.015 (0.027)	0.0018	0.006	0.0005	**0.0175**	0.0034
Total Arsenic	g/m³	NA	0.0023	0.00055	0.00055	0.00055	0.0013
Dissolved Arsenic	g/m³	0.042	0.0005	0.0005	0.0005	0.0005	0.0005
Total Chromium	g/m³	NA	0.00152	0.00056	0.00057	0.000265	0.00102
Dissolved Chromium	g/m³	0.006	0.00025	0.00025	0.00025	0.00025	0.00025

*Notes:

5. 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$CaCO_3$
6. Hickey (2012 memo) recommended that the sum of Iron and Manganese should be below 1.0 g/m³ to prevent bed smothering
7. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered
8. Samples below detection limit are shown as half of the detection limit

E.4 24/10/2019 Sampling

Parameter	Unit	ANZECC 90% TV	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.5	7.5	7.3	7.6	8
Conductivity	mS/m	NA	85.9	22.2	23.1	29.8	67.6
Total Alkalinity	g/m³$CaCO_3$	NA	290	40	38	46	200
TSS	g/m³	NA	11	9	1.5	1.5	4
COD	g O2/m³	NA	14	8	< 6	< 6	14
Total Hardness	g/m³$CaCO_3$	NA	330	39	40	56	250
Total Ammoniacal Nitrogen	g/m³	1.430 (2.34)	**1.58**	0.005	0.005	0.005	0.84
Total Iron	g/m³	NA	4.8	0.136	0.079	0.067	1.7
Dissolved Iron	g/m³	NA	0.03	0.02	0.03	0.02	0.03
Total Manganese	g/m³	NA	2.2	0.067	0.037	0.0022	1.29
Dissolved manganese	g/m³	2.5	1.95	0.0005	0.0021	0.0012	1.14
Dissolved Iron + Manganese	g/m³	1.0	**1.98**	0.0205	0.0321	0.0212	**1.17**
Total Lead	g/m³	NA	0.00032	0.0003	0.000055	0.00035	0.00027
Dissolved Lead	g/m³	0.0056 (0.011)	0.00005	0.00005	0.00005	0.00013	0.00005
Total Copper	g/m³	NA	0.000265	0.00096	0.000265	0.00183	0.00075
Dissolved Copper	g/m³	0.0018 (0.0028)	0.00025	0.0009	0.00025	0.0016	0.0008
Total Zinc	g/m³	NA	0.0048	0.0118	0.00055	0.024	0.0101
Dissolved Zinc	g/m³	0.015 (0.027)	0.0023	0.0049	0.0005	**0.023**	0.0047
Total Arsenic	g/m³	NA	0.0023	0.00055	0.00055	0.00055	0.0013
Dissolved Arsenic	g/m³	0.042	0.0005	0.0005	0.0005	0.0005	0.0005
Total Chromium	g/m³	NA	0.00095	0.00058	0.00199	0.000265	0.00096

Parameter	Unit	ANZECC 90% TV	TTD	TTE	TTW	OSU	OSD
Dissolved Chromium	g/m³	0.006	0.00025	0.00025	0.00025	0.00025	0.00025

*Notes:

9. 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$CaCO_3$
10. Hickey (2012 memo) recommended that the sum of Iron and Manganese should be below 1.0 g/m³ to prevent bed smothering
11. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered
12. Samples below detection limit are shown as half of the detection limit

E.5 14/11/2019 Sampling

Parameter	Unit	ANZECC 90% TV	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.4	7	7.2	7.4	7.7
Conductivity	mS/m	NA	76.7	18.8	21.3	25.3	62.8
Total Alkalinity	g/m³$CaCO_3$	NA	210	29	33	38	162
TSS	g/m³	NA	36	5	1.5	1.5	20
COD	g O2/m³	NA	17	7	10	< 6	15
Total Hardness	g/m³$CaCO_3$	NA	320	31	36	48	240
Total Ammoniacal Nitrogen	g/m³	1.430 (2.34)	1.05	0.005	0.005	0.019	0.69
Total Iron	g/m³	NA	3.8	0.28	0.07	0.158	2
Dissolved Iron	g/m³	NA	0.04	0.12	0.03	0.06	0.12
Total Manganese	g/m³	NA	1.45	0.042	0.0138	0.0049	0.96
Dissolved manganese	g/m³	2.5	1.33	0.0054	0.0012	0.002	0.88
Dissolved Iron + Manganese	g/m³	1.0	**1.37**	0.1254	0.0312	0.062	1
Total Lead	g/m³	NA	0.0028	0.0007	0.00013	0.0009	0.0021
Dissolved Lead	g/m³	0.0056 (0.011)	0.00005	0.00019	0.00005	0.00032	0.00005
Total Copper	g/m³	NA	0.0021	0.00157	0.000265	0.0032	0.002
Dissolved Copper	g/m³	0.0018 (0.0028)	0.0009	0.0013	0.00025	**0.0027**	0.0014
Total Zinc	g/m³	NA	0.0124	0.0126	0.0011	0.024	0.0156
Dissolved Zinc	g/m³	0.015 (0.027)	0.0047	0.0102	0.0005	**0.022**	0.0052
Total Arsenic	g/m³	NA	0.002	0.00055	0.00055	0.00055	0.0015
Dissolved Arsenic	g/m³	0.042	0.0005	0.0005	0.0005	0.0005	0.0005
Total Chromium	g/m³	NA	0.00155	0.00059	0.000265	0.00064	0.00112
Dissolved Chromium	g/m³	0.006	0.00025	0.00025	0.00025	0.00025	0.00025

*Notes:

13. 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$CaCO_3$
14. Hickey (2012 memo) recommended that the sum of Iron and Manganese should be below 1.0 g/m³ to prevent bed smothering
15. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered
16. Samples below detection limit are shown as half of the detection limit

E.6 11/12/2019 Sampling

Parameter	Unit	ANZECC 90% TV	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.6	7.1	7.3	7.4	7.9
Conductivity	mS/m	NA	81.8	18.3	23.4	31.8	67.1
Total Alkalinity	g/m³$CaCO_3$	NA	270	34	39	50	200
TSS	g/m³	NA	11	3	5	1.5	5
COD	g O2/m³	NA	17	12	15	< 6	11
Total Hardness	g/m³$CaCO_3$	NA	330	32	44	61	240
Total Ammoniacal Nitrogen	g/m³	1.430 (2.34)	1.2	0.071	0.005	0.005	0.59
Total Iron	g/m³	NA	4.5	0.129	0.101	0.038	1.7
Dissolved Iron	g/m³	NA	0.03	0.03	0.02	0.01	0.04
Total Manganese	g/m³	NA	2.1	0.037	0.039	0.00163	1.1
Dissolved manganese	g/m³	2.5	2.1	0.0011	0.0006	0.0008	1.1
Dissolved Iron + Manganese	g/m³	1.0	**2.13**	0.0311	0.0206	0.0108	**1.14**
Total Lead	g/m³	NA	0.00023	0.0004	0.00015	0.00023	0.00023
Dissolved Lead	g/m³	0.0056 (0.011)	0.00005	0.00005	0.00005	0.00005	0.00005
Total Copper	g/m³	NA	0.000265	0.0019	0.00055	0.00197	0.00077
Dissolved Copper	g/m³	0.0018 (0.0028)	0.00025	0.0013	0.00025	0.0017	0.0008
Total Zinc	g/m³	NA	0.0035	0.0115	0.0018	0.0137	0.0062
Dissolved Zinc	g/m³	0.015 (0.027)	0.001	0.0082	0.0011	0.0128	0.0025
Total Arsenic	g/m³	NA	0.002	0.0014	0.00055	0.00055	0.0012
Dissolved Arsenic	g/m³	0.042	0.0005	0.0011	0.0005	0.0005	0.0005
Total Chromium	g/m³	NA	0.00101	0.00086	0.000265	0.00054	0.00054
Dissolved Chromium	g/m³	0.006	0.00025	0.00025	0.00025	0.00025	0.00025

*Notes:

17. 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$CaCO_3$
18. Hickey (2012 memo) recommended that the sum of Iron and Manganese should be below 1.0 g/m³ to prevent bed smothering
19. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered
20. Samples below detection limit are shown as half of the detection limit

E.7 28/01/2020 Sampling

Parameter	Unit	ANZECC 90% TV	TTD	TTE	TTW	OSU	OSD
pH	pH	NA (6-9)	7.5	7.8	9	7.7	8
Conductivity	mS/m	NA	71.1	29.4	30.4	32.8	58.3
Total Alkalinity	g/m³$CaCO_3$	NA	240	53	50	54	167
TSS	g/m³	NA	16	8	16	1.5	6
COD	g O2/m³	NA	15	17	16	6	10
Total Hardness	g/m³$CaCO_3$	NA	260	53	60	61	189
Total Ammoniacal Nitrogen	g/m³	1.430 (2.34)	0.77	0.013	0.005	0.005	0.24
Total Iron	g/m³	NA	6	0.178	0.192	0.0105	2.3

Parameter	Unit	ANZECC 90% TV	TTD	TTE	TTW	OSU	OSD
Dissolved Iron	g/m³	NA	0.04	0.06	0.06	0.01	0.04
Total Manganese	g/m³	NA	1.95	0.052	0.05	0.00088	0.84
Dissolved manganese	g/m³	2.5	1.88	0.0154	0.0055	0.00025	0.82
Dissolved Iron + Manganese	g/m³	1.0	**1.92**	0.0754	0.0655	0.01025	0.86
Total Lead	g/m³	NA	0.00024	0.0002	0.00024	0.000055	0.00018
Dissolved Lead	g/m³	0.0056 (0.011)	0.00005	0.00005	0.00005	0.00005	0.00005
Total Copper	g/m³	NA	0.000265	0.00071	0.000265	0.00125	0.00065
Dissolved Copper	g/m³	0.0018 (0.0028)	0.00025	0.00025	0.00025	0.0013	0.0008
Total Zinc	g/m³	NA	0.0033	0.0023	0.00055	0.0102	0.0038
Dissolved Zinc	g/m³	0.015 (0.027)	0.0005	0.0011	0.0005	0.0098	0.002
Total Arsenic	g/m³	NA	0.0029	0.00055	0.00055	0.00055	0.0015
Dissolved Arsenic	g/m³	0.042	0.0005	0.0005	0.0005	0.0005	0.0005
Total Chromium	g/m³	NA	0.00068	0.000265	0.000265	0.000265	0.000265
Dissolved Chromium	g/m³	0.006	0.00025	0.00025	0.00025	0.00025	0.00025

*Notes:

21. 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$CaCO_3$
22. Hickey (2012 memo) recommended that the sum of Iron and Manganese should be below 1.0 g/m³ to prevent bed smothering
23. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered
24. Samples below detection limit are shown as half of the detection limit

E.8 25/02/2020 Sampling

Parameter	Unit	ANZECC 90% TV	TTD	TTE	TTW	OSD
pH	pH	NA (6-9)	7.9	7.3	7.4	8
Conductivity	mS/m	NA	72.1	25.9	26.8	58.6
Total Alkalinity	g/m³$CaCO_3$	NA	250	47	46	186
TSS	g/m³	NA	18	4	3	8
COD	g O2/m³	NA	17	19	10	12
Total Hardness	g/m³$CaCO_3$	NA	270	43	51	210
Total Ammoniacal Nitrogen	g/m³	1.430 (2.34)	0.6	0.056	0.033	0.103
Total Iron	g/m³	NA	6.4	0.137	0.114	2.8
Dissolved Iron	g/m³	NA	0.02	0.09	0.03	0.03
Total Manganese	g/m³	NA	1.58	0.082	0.057	0.67
Dissolved manganese	g/m³	2.5	1.56	0.071	0.0014	0.59
Dissolved Iron + Manganese	g/m³	1.0	**1.58**	0.161	0.0314	0.62
Total Lead	g/m³	NA	0.00024	0.00023	0.00016	0.00026
Dissolved Lead	g/m³	0.0056 (0.011)	0.00005	0.00012	0.00005	0.00005
Total Copper	g/m³	NA	0.000265	0.00093	0.000265	0.00087
Dissolved Copper	g/m³	0.0018 (0.0028)	0.00025	0.001	0.00025	0.0007

Parameter	Unit	ANZECC 90% TV	TTD	TTE	TTW	OSD
Total Zinc	g/m³	NA	0.003	0.0057	0.00055	0.0052
Dissolved Zinc	g/m³	0.015 (0.027)	0.0005	0.005	0.0005	0.0014
Total Arsenic	g/m³	NA	0.0021	0.00055	0.00055	0.0013
Dissolved Arsenic	g/m³	0.042	0.0005	0.0005	0.0005	0.0005
Total Chromium	g/m³	NA	0.00065	0.000265	0.000265	0.000265
Dissolved Chromium	g/m³	0.006	0.00025	0.00025	0.00025	0.00025

*Notes:

25. 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$CaCO_3$
26. Hickey (2012 memo) recommended that the sum of Iron and Manganese should be below 1.0 g/m³ to prevent bed smothering
27. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered
28. Samples below detection limit are shown as half of the detection limit

E.9 08/05/2020 Sampling

Parameter	Unit	ANZECC 90% TV	TTD	TTE	TTW	OSD
pH	pH	NA (6-9)	7.4	6.9	7.5	7.8
Conductivity	mS/m	NA	75	19.6	23.1	60.8
Total Alkalinity	g/m³$CaCO_3$	NA	260	37	36	184
TSS	g/m³	NA	11	7	3	1.5
COD	g O2/m³	NA	15	12	13	13
Total Hardness	g/m³$CaCO_3$	NA	280	36	45	210
Total Ammoniacal Nitrogen	g/m³	1.430 (2.34)	0.79	0.082	0.042	0.27
Total Iron	g/m³	NA	5.7	0.4	0.154	1.34
Dissolved Iron	g/m³	NA	0.02	0.1	0.04	0.03
Total Manganese	g/m³	NA	1.75	0.197	0.023	0.7
Dissolved manganese	g/m³	2.5	1.64	0.08	0.0055	0.63
Dissolved Iron + Manganese	g/m³	1.0	**1.66**	0.18	0.0455	0.66
Total Lead	g/m³	NA	0.00017	0.00046	0.00024	0.00021
Dissolved Lead	g/m³	0.0056 (0.011)	0.00005	0.00005	0.00005	0.00005
Total Copper	g/m³	NA	0.000265	0.00111	0.0006	0.00093
Dissolved Copper	g/m³	0.0018 (0.0028)	0.00025	0.0005	0.00025	0.0005
Total Zinc	g/m³	NA	0.0036	0.0084	0.0017	0.0052
Dissolved Zinc	g/m³	0.015 (0.027)	0.0011	0.006	0.0005	0.0023
Total Arsenic	g/m³	NA	0.0022	0.00055	0.00055	0.0011
Dissolved Arsenic	g/m³	0.042	0.0005	0.0005	0.0005	0.0005
Total Chromium	g/m³	NA	0.00073	0.00069	0.000265	0.000265
Dissolved Chromium	g/m³	0.006	0.00025	0.00025	0.00025	0.00025

*Notes:

29. 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$CaCO_3$

30. Hickey (2012 memo) recommended that the sum of Iron and Manganese should be below 1.0 g/m³ to prevent bed smothering
31. Bold indicates ANZECC guidelines triggered, red indicates site specific ANZECC guidelines triggered
32. Samples below detection limit are shown as half of the detection limit

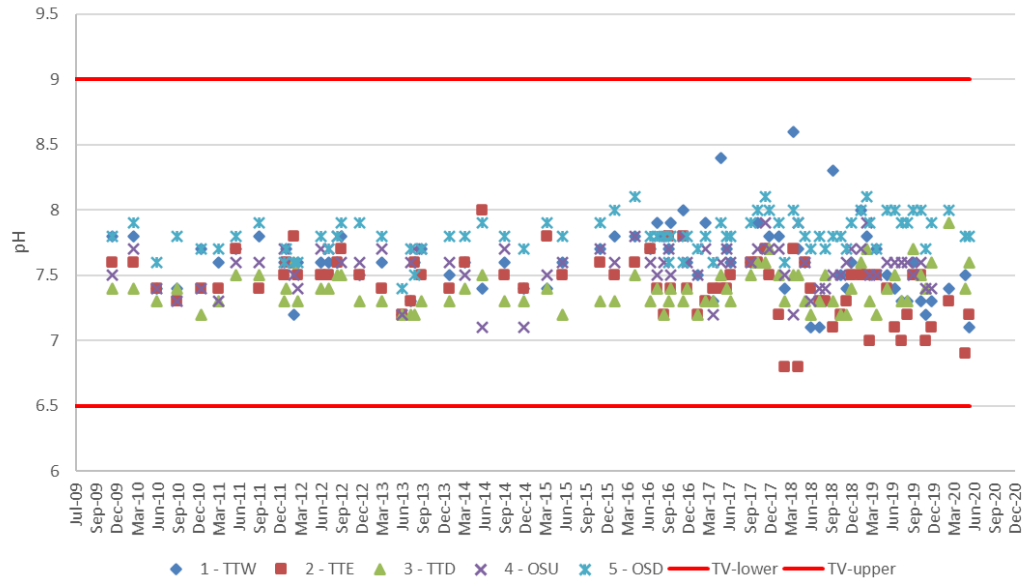
E.10 29/05/2020 Sampling

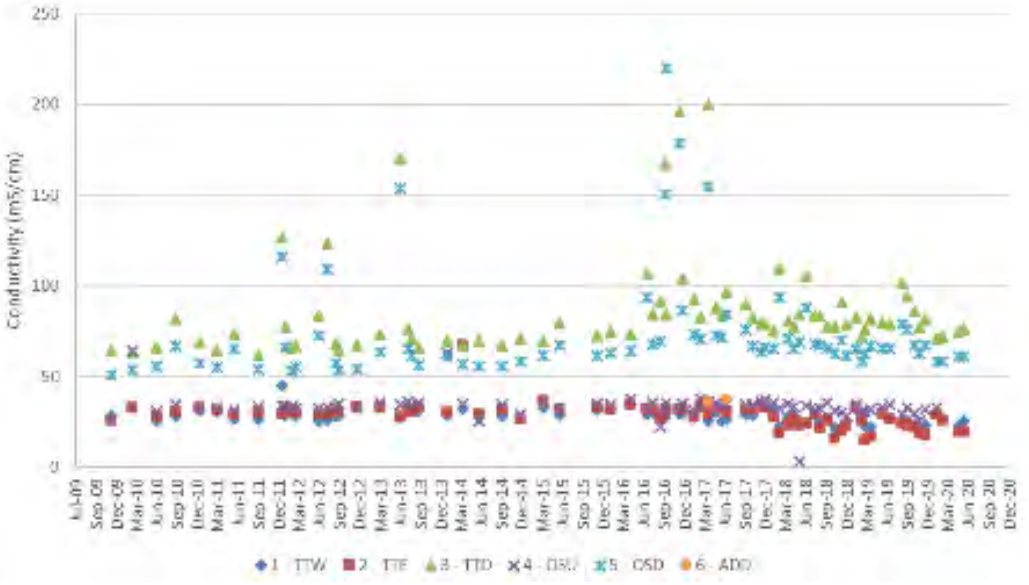
Parameter	Unit	ANZECC 90% TV	TTD	TTE	TTW	OSD
pH	pH	NA (6-9)	7.6	7.2	7.1	7.8
Conductivity	mS/m	NA	76.4	19.6	25.3	61.2
Total Alkalinity	g/m³CaCO₃	NA	260	31	37	190
TSS	g/m³	NA	19	5	< 3	7
COD	g O2/m³	NA	16	11	7	11
Total Hardness	g/m³CaCO₃	NA	310	37	48	230
Total Ammoniacal Nitrogen	g/m³	1.430 (2.34)	0.89	0.005	0.025	0.37
Total Iron	g/m³	NA	7.7	0.171	0.157	2.7
Dissolved Iron	g/m³	NA	0.03	0.07	0.03	0.03
Total Manganese	g/m³	NA	2	0.092	0.08	0.96
Dissolved manganese	g/m³	2.5	1.89	0.048	0.0109	0.89
Dissolved Iron + Manganese	g/m³	1.0	**1.92**	0.118	0.0409	0.92
Total Lead	g/m³	NA	0.0002	0.00035	0.00015	0.0004
Dissolved Lead	g/m³	0.0056 (0.011)	0.00005	0.00005	0.00005	0.00005
Total Copper	g/m³	NA	0.000265	0.00141	0.00132	0.00091
Dissolved Copper	g/m³	0.0018 (0.0028)	0.00025	0.001	0.00025	0.0006
Total Zinc	g/m³	NA	0.0059	0.0106	0.0064	0.006
Dissolved Zinc	g/m³	0.015 (0.027)	0.002	0.0079	0.0005	0.002
Total Arsenic	g/m³	NA	0.0025	0.00055	0.00055	0.0013
Dissolved Arsenic	g/m³	0.042	0.0005	0.0005	0.0005	0.0005
Total Chromium	g/m³	NA	0.00086	0.00073	0.000265	0.00056
Dissolved Chromium	g/m³	0.006	0.00025	0.00025	0.00025	0.00025

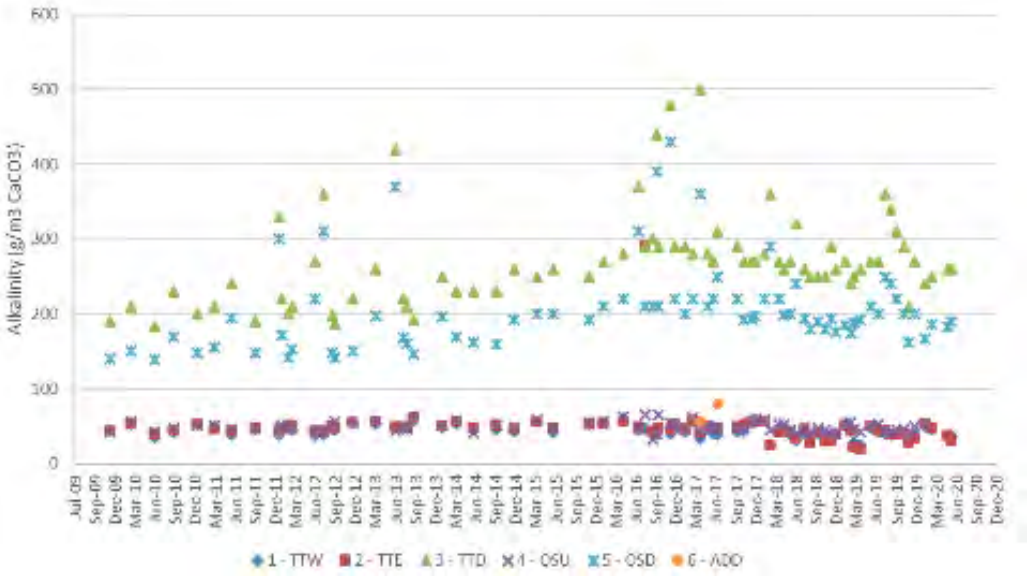
*Notes:

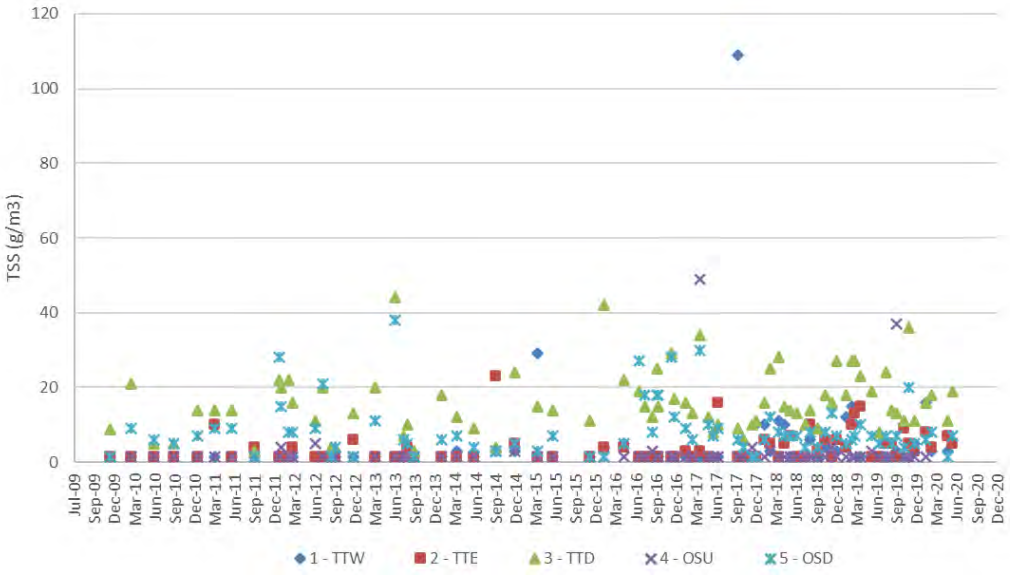
1. Site specific total ammoniacal nitrogen is calculated for pH 7.6, which is the maximum value recorded at site TTD; Hardness related metals (copper, lead, zinc) are adjusted to upstream hardness of 50 g/m³CaCO₃
2. Hickey (2012 memo) recommended that the sum of Iron and Manganese should be below 1.0 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

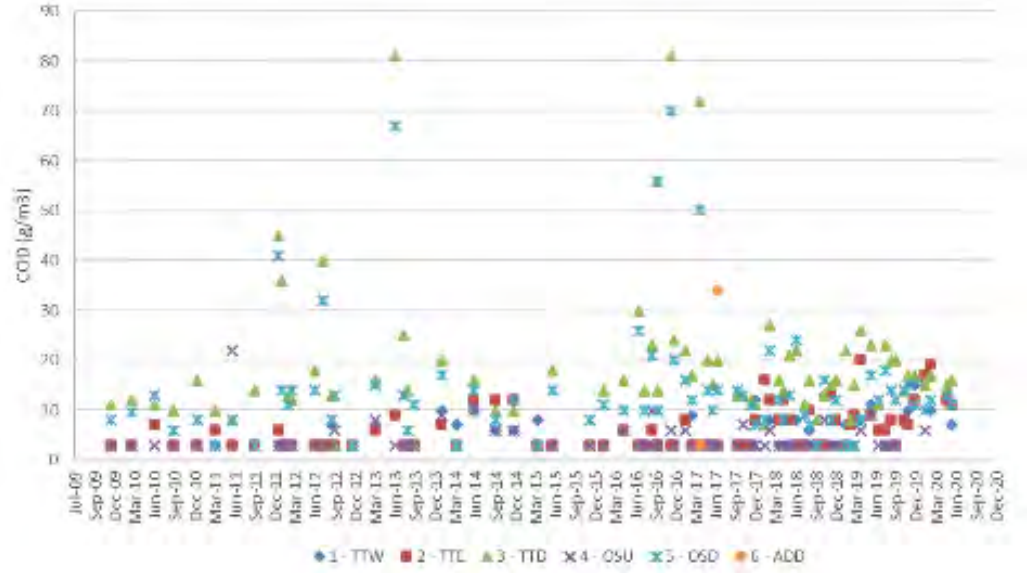
Appendix F Additional Monitoring Graphs

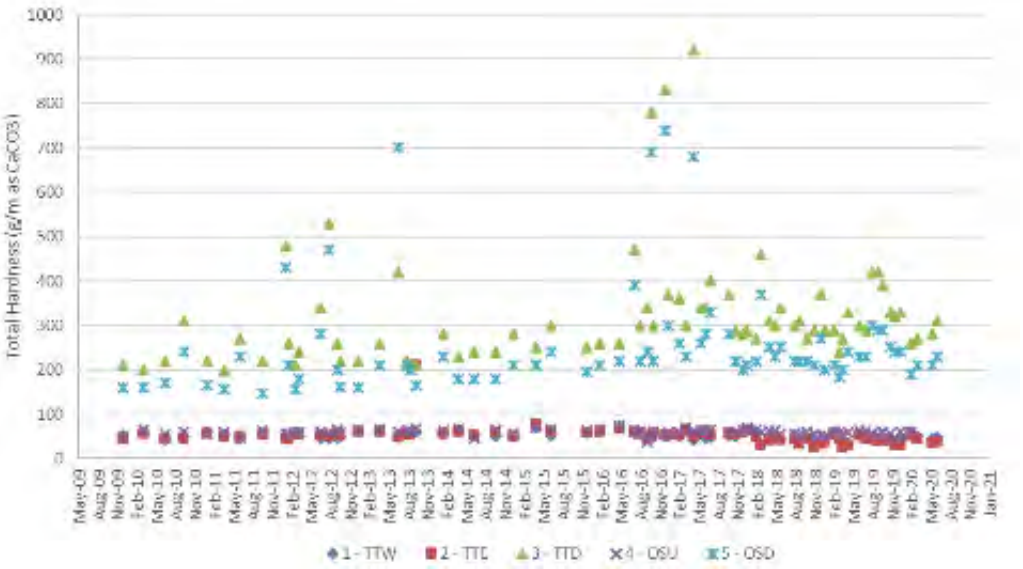


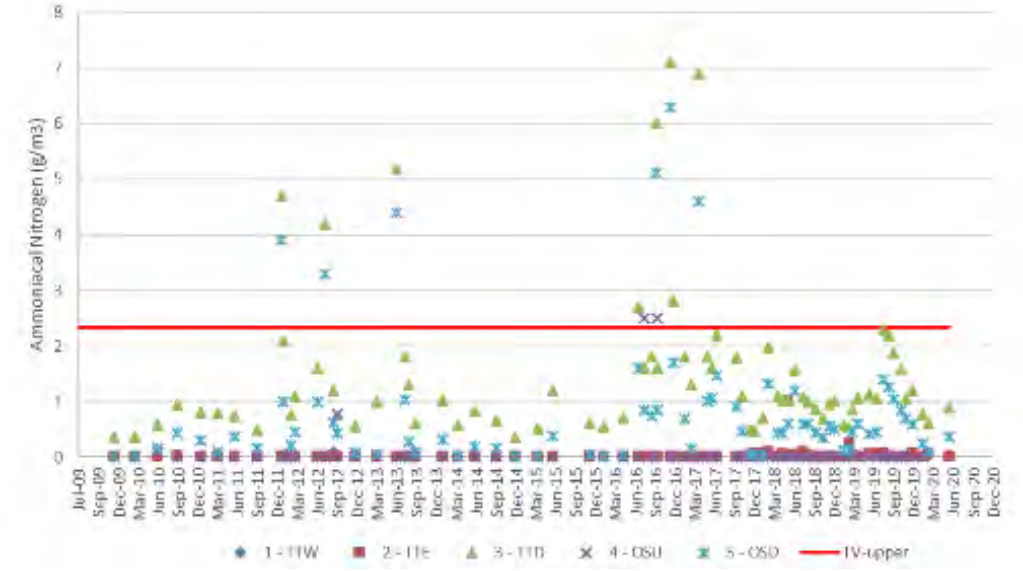


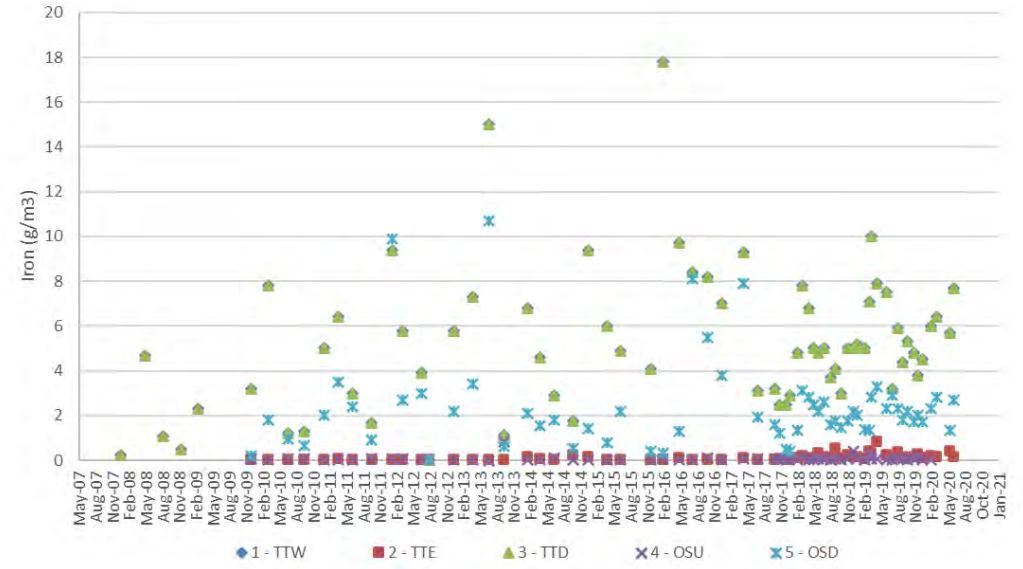

Alkalinity (g/m3 CaCO3)
1 - TTW
2 - TTE
3 - TTD
4 - OSU
5 - OSD
6 - ADD

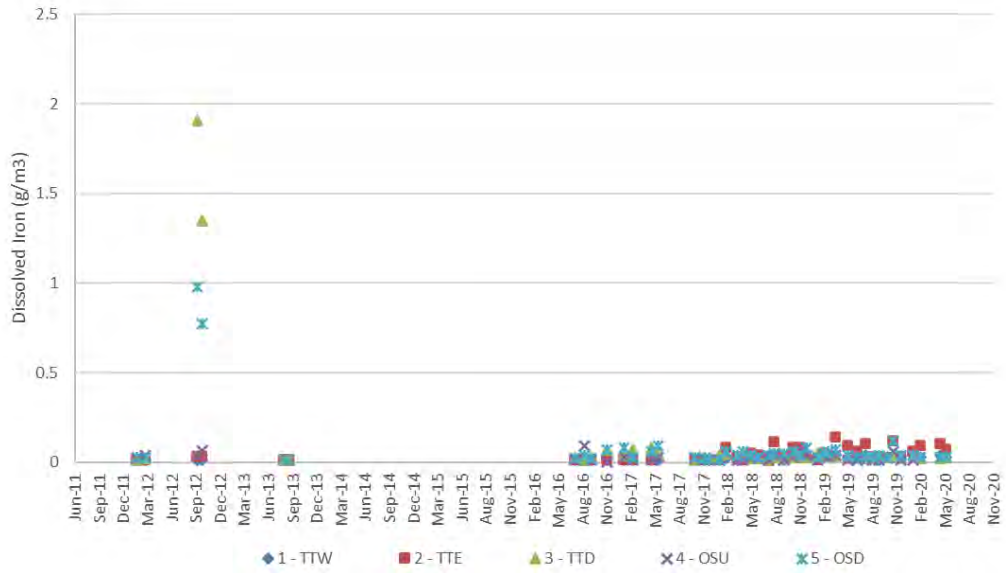

TSS (g/m3)
1 - TTW
2 - TTE
3 - TTD
4 - OSU
5 - OSD

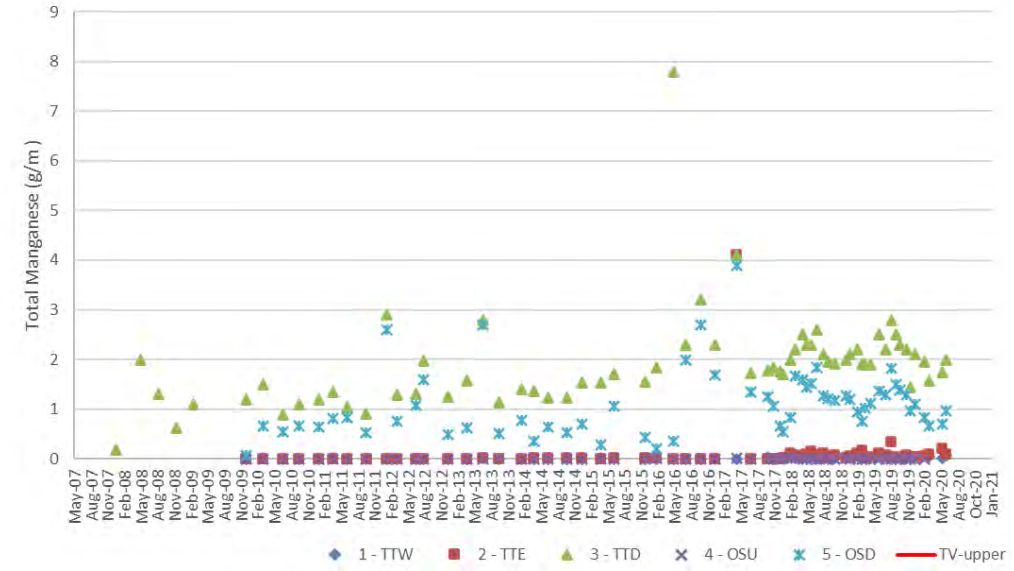

COD (g/m3)
1 - TTW
2 - TTE
3 - TTD
4 - OSU
5 - OSD
6 - ADD

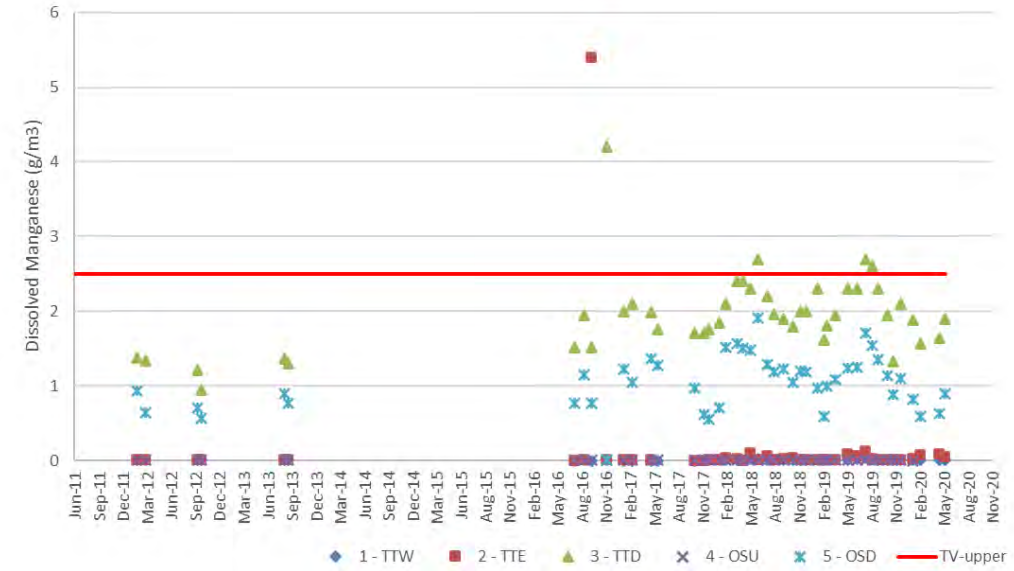

Total Hardness (g/m as CaCO3)
1000
900
800
700
600
500
400
300
200
100
0
1 - TTW
2 - TTE
3 - TTD
4 - OSU
5 - OSD

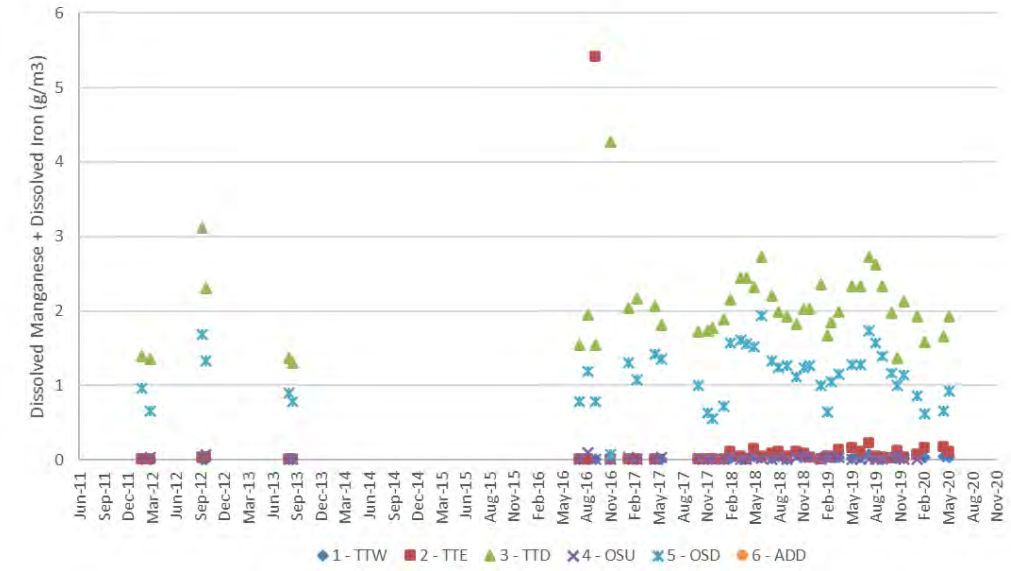

Ammoniacal Nitrogen (g/m3)
8
7
6
5
4
3
2
1
0
1 - TTW
2 - TTE
3 - TTD
4 - OSU
5 - OSD
TV-upper

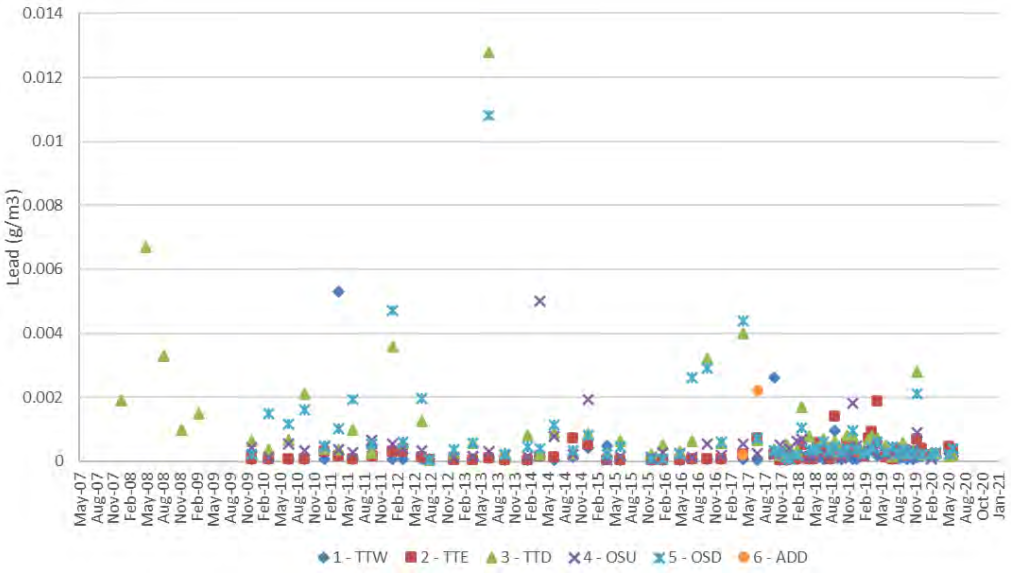

Iron (g/m3)
20
18
16
14
12
10
8
6
4
2
0
1 - TTW
2 - TTE
3 - TTD
4 - OSU
5 - OSD

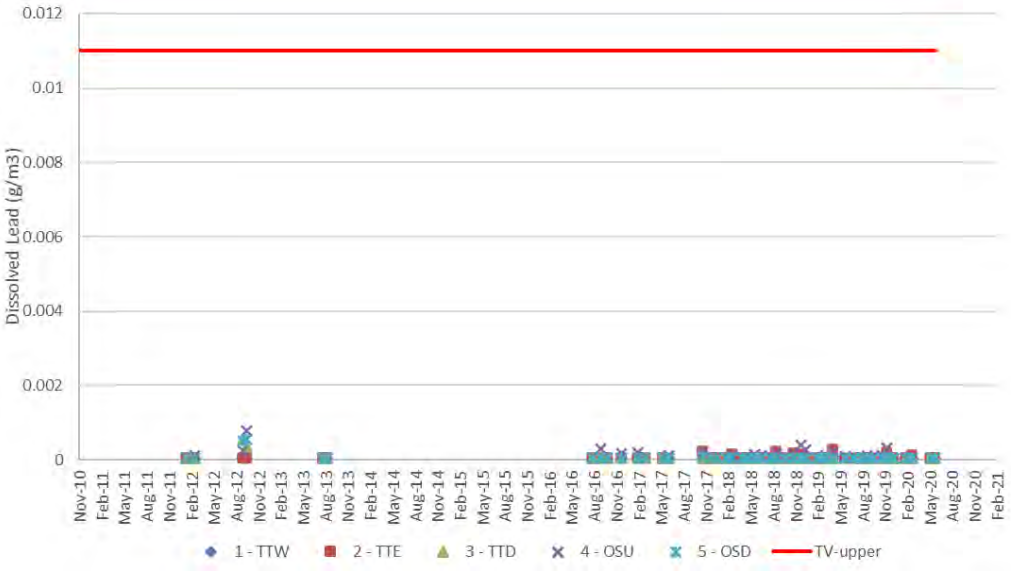

Dissolved Iron (g/m3)
2.5
2
1.5
1
0.5
0
Jun-11
Sep-11
Dec-11
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
Dec-13
Mar-14
Jun-14
Sep-14
Dec-14
Mar-15
Jun-15
Aug-15
Nov-15
Feb-16
May-16
Aug-16
Nov-16
Feb-17
May-17
Aug-17
Nov-17
Feb-18
May-18
Aug-18
Nov-18
Feb-19
May-19
Aug-19
Nov-19
Feb-20
May-20
Aug-20
Nov-20
1 - TTW
2 - TTE
3 - TTD
4 - OSU
5 - OSD

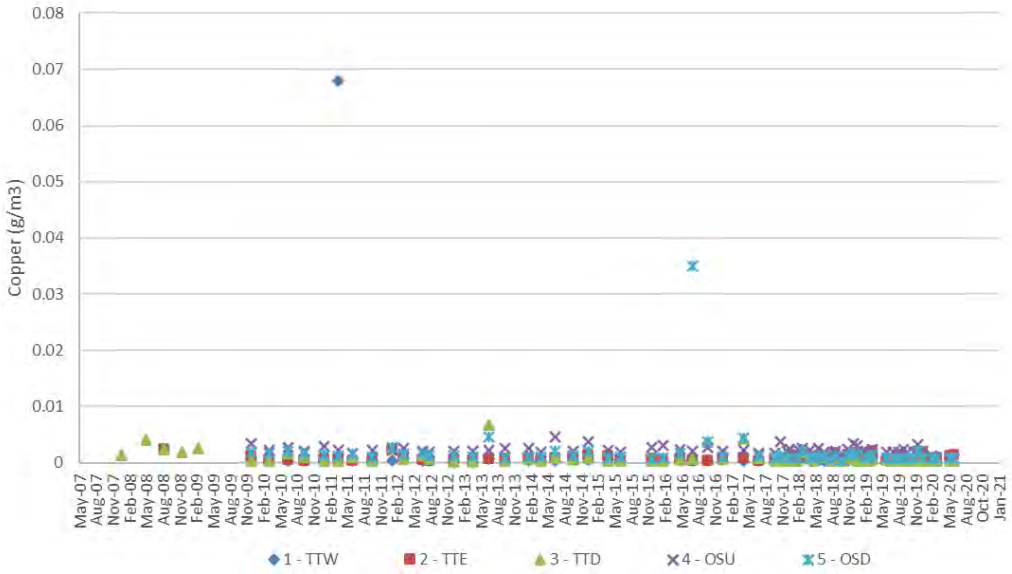

Total Manganese (g/m)
9
8
7
6
5
4
3
2
1
0
May-07
Aug-07
Nov-07
Feb-08
May-08
Aug-08
Nov-08
Feb-09
May-09
Aug-09
Nov-09
Feb-10
May-10
Aug-10
Nov-10
Feb-11
May-11
Aug-11
Nov-11
Feb-12
May-12
Aug-12
Nov-12
Feb-13
May-13
Aug-13
Nov-13
Feb-14
May-14
Aug-14
Nov-14
Feb-15
May-15
Aug-15
Nov-15
Feb-16
May-16
Aug-16
Nov-16
Feb-17
May-17
Aug-17
Nov-17
Feb-18
May-18
Aug-18
Nov-18
Feb-19
May-19
Aug-19
Nov-19
Feb-20
May-20
Aug-20
Oct-20
Jan-21
1 - TTW
2 - TTE
3 - TTD
4 - OSU
5 - OSD
TV-upper

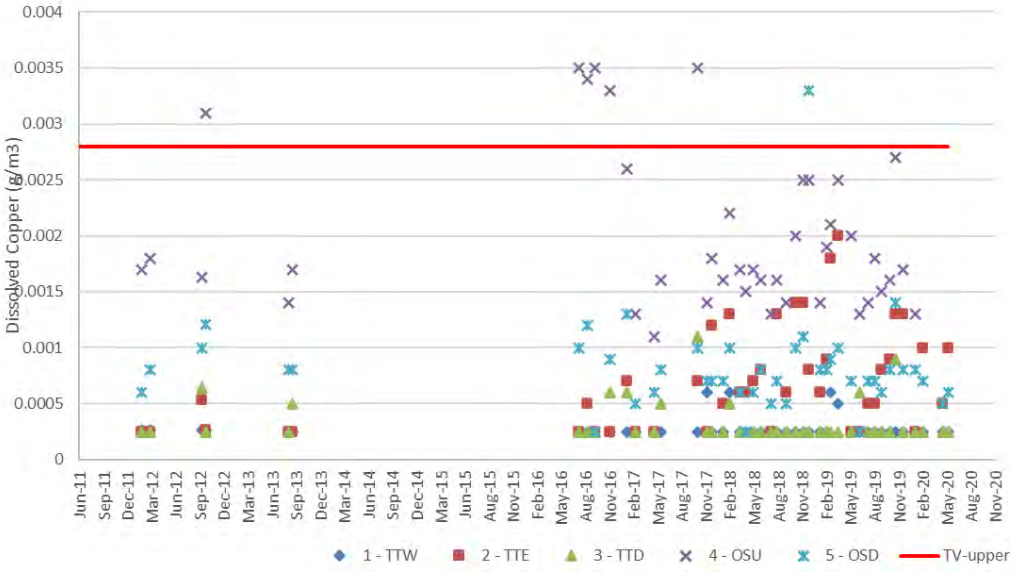

Dissolved Manganese (g/m3)
6
5
4
3
2
1
0
Jun-11
Sep-11
Dec-11
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
Dec-13
Mar-14
Jun-14
Sep-14
Dec-14
Mar-15
Jun-15
Aug-15
Nov-15
Feb-16
May-16
Aug-16
Nov-16
Feb-17
May-17
Aug-17
Nov-17
Feb-18
May-18
Aug-18
Nov-18
Feb-19
May-19
Aug-19
Nov-19
Feb-20
May-20
Aug-20
Nov-20
1 - TTW
2 - TTE
3 - TTD
4 - OSU
5 - OSD
TV-upper

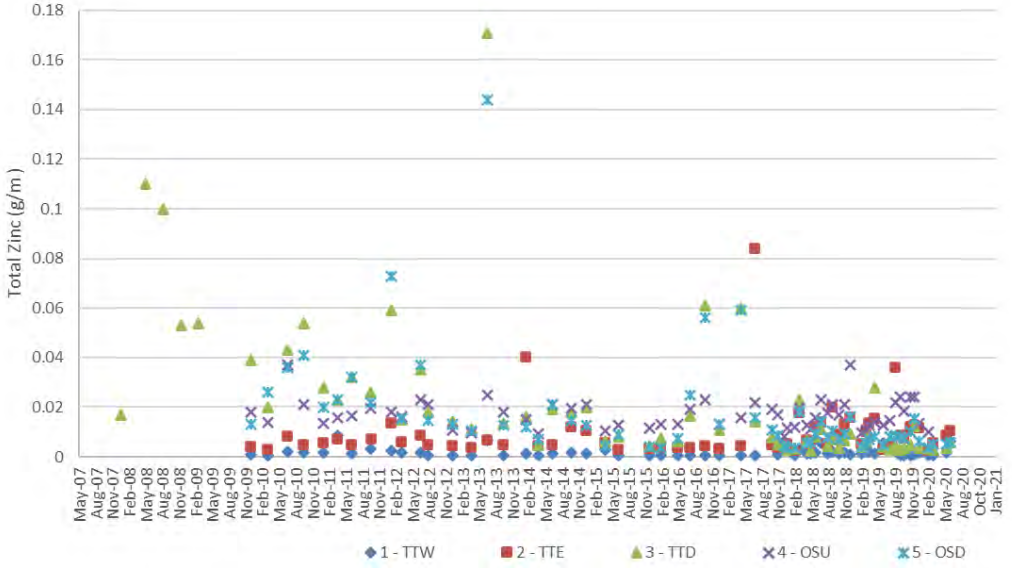

Dissolved Manganese + Dissolved Iron (g/m3)
0
1
2
3
4
5
6
Jun-11
Sep-11
Dec-11
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
Dec-13
Mar-14
Jun-14
Sep-14
Dec-14
Mar-15
Jun-15
Aug-15
Nov-15
Feb-16
May-16
Aug-16
Nov-16
Feb-17
May-17
Aug-17
Nov-17
Feb-18
May-18
Aug-18
Nov-18
Feb-19
May-19
Aug-19
Nov-19
Feb-20
May-20
Aug-20
Nov-20
1 - TTW
2 - TTE
3 - TTD
4 - OSU
5 - OSD
6 - ADD

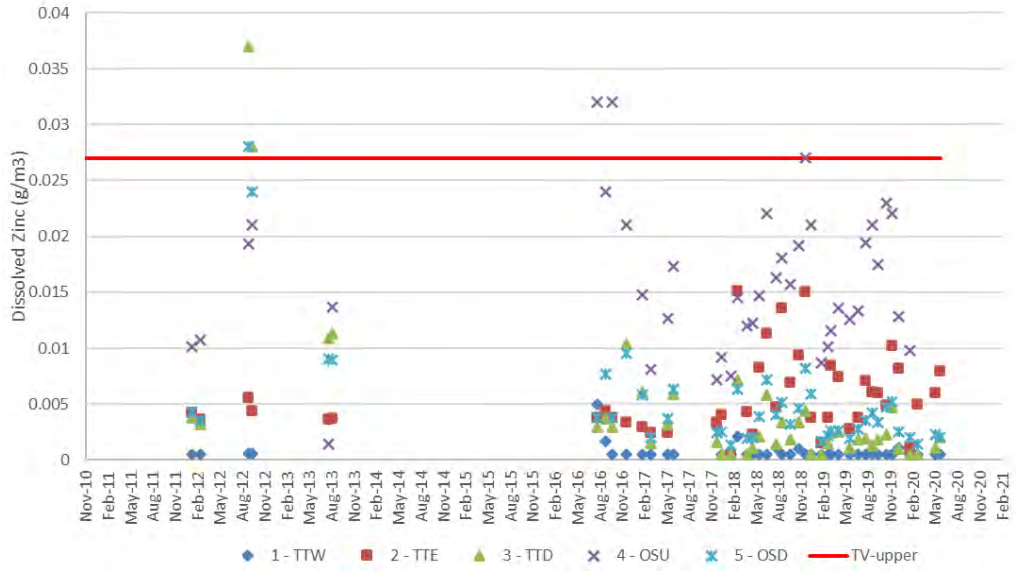

Lead (g/m3)
0
0.002
0.004
0.006
0.008
0.01
0.012
0.014
May-07
Aug-07
Nov-07
Feb-08
May-08
Aug-08
Nov-08
Feb-09
May-09
Aug-09
Nov-09
Feb-10
May-10
Aug-10
Nov-10
Feb-11
May-11
Aug-11
Nov-11
Feb-12
May-12
Aug-12
Nov-12
Feb-13
May-13
Aug-13
Nov-13
Feb-14
May-14
Aug-14
Nov-14
Feb-15
May-15
Aug-15
Nov-15
Feb-16
May-16
Aug-16
Nov-16
Feb-17
May-17
Aug-17
Nov-17
Feb-18
May-18
Aug-18
Nov-18
Feb-19
May-19
Aug-19
Nov-19
Feb-20
May-20
Aug-20
Oct-20
Jan-21
1 - TTW
2 - TTE
3 - TTD
4 - OSU
5 - OSD
6 - ADD

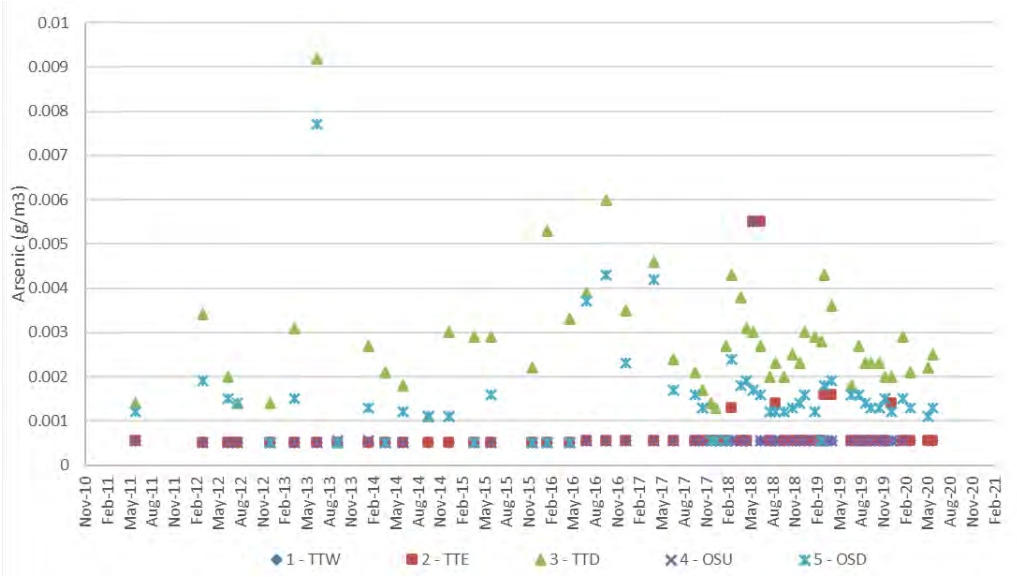

Dissolved Lead (g/m3)
0
0.002
0.004
0.006
0.008
0.01
0.012
Nov-10
Feb-11
May-11
Aug-11
Nov-11
Feb-12
May-12
Aug-12
Nov-12
Feb-13
May-13
Aug-13
Nov-13
Feb-14
May-14
Aug-14
Nov-14
Feb-15
May-15
Aug-15
Nov-15
Feb-16
May-16
Aug-16
Nov-16
Feb-17
May-17
Aug-17
Nov-17
Feb-18
May-18
Aug-18
Nov-18
Feb-19
May-19
Aug-19
Nov-19
Feb-20
May-20
Aug-20
Nov-20
Feb-21
1 - TTW
2 - TTE
3 - TTD
4 - OSU
5 - OSD
TV-upper

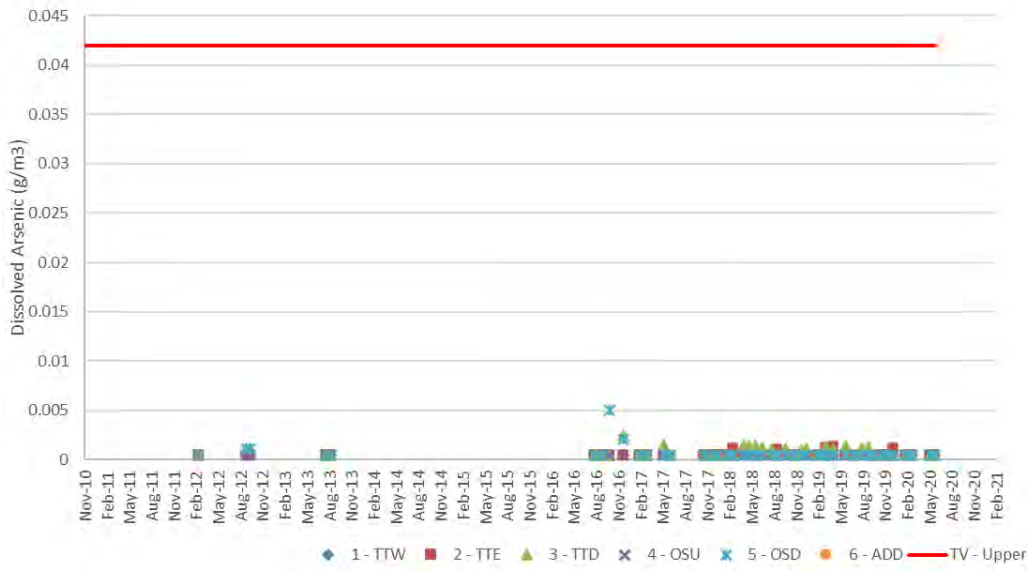

Copper (g/m3)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
May-07
Aug-07
Nov-07
Feb-08
May-08
Aug-08
Nov-08
Feb-09
May-09
Aug-09
Nov-09
Feb-10
May-10
Aug-10
Nov-10
Feb-11
May-11
Aug-11
Nov-11
Feb-12
May-12
Aug-12
Nov-12
Feb-13
May-13
Aug-13
Nov-13
Feb-14
May-14
Aug-14
Nov-14
Feb-15
May-15
Aug-15
Nov-15
Feb-16
May-16
Aug-16
Nov-16
Feb-17
May-17
Aug-17
Nov-17
Feb-18
May-18
Aug-18
Nov-18
Feb-19
May-19
Aug-19
Nov-19
Feb-20
May-20
Aug-20
Oct-20
Jan-21
1 - TTW
2 - TTE
3 - TTD
4 - OSU
5 - OSD

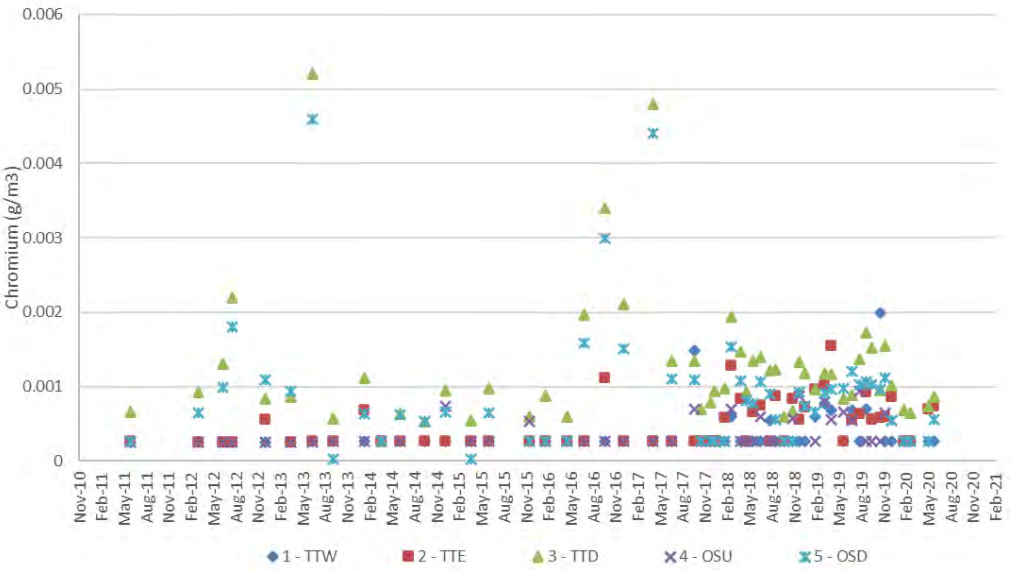

Dissolved Copper (g/m3)
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
Jun-11
Sep-11
Dec-11
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
Dec-13
Mar-14
Jun-14
Sep-14
Dec-14
Mar-15
Jun-15
Aug-15
Nov-15
Feb-16
May-16
Aug-16
Nov-16
Feb-17
May-17
Aug-17
Nov-17
Feb-18
May-18
Aug-18
Nov-18
Feb-19
May-19
Aug-19
Nov-19
Feb-20
May-20
Aug-20
Nov-20
1 - TTW
2 - TTE
3 - TTD
4 - OSU
5 - OSD
TV-upper

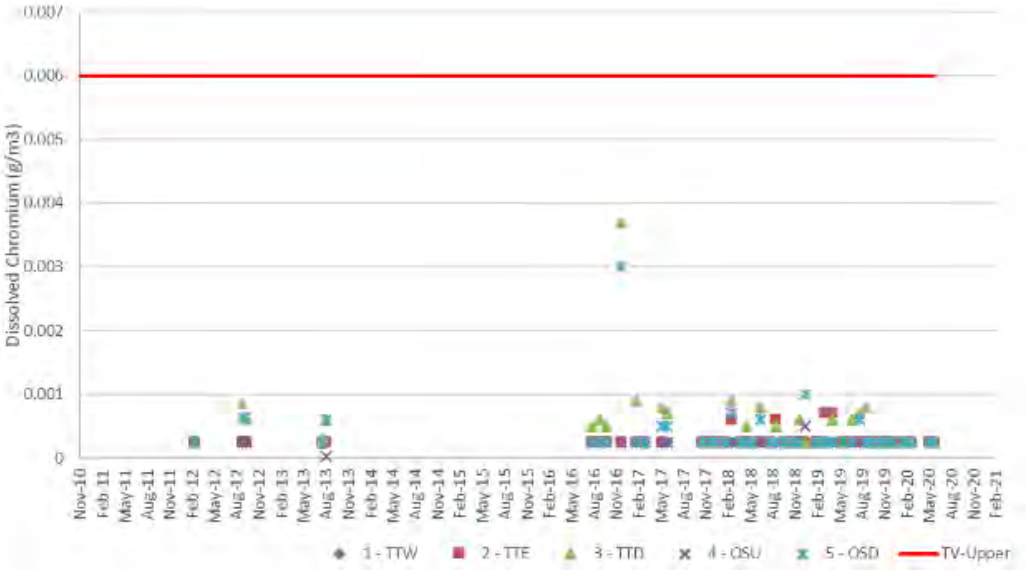

Total Zinc (g/m)
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
May-07
Aug-07
Nov-07
Feb-08
May-08
Aug-08
Nov-08
Feb-09
May-09
Aug-09
Nov-09
Feb-10
May-10
Aug-10
Nov-10
Feb-11
May-11
Aug-11
Nov-11
Feb-12
May-12
Aug-12
Nov-12
Feb-13
May-13
Aug-13
Nov-13
Feb-14
May-14
Aug-14
Nov-14
Feb-15
May-15
Aug-15
Nov-15
Feb-16
May-16
Aug-16
Nov-16
Feb-17
May-17
Aug-17
Nov-17
Feb-18
May-18
Aug-18
Nov-18
Feb-19
May-19
Aug-19
Nov-19
Feb-20
May-20
Aug-20
Oct-20
Jan-21
1 - TTW
2 - TTE
3 - TTD
4 - OSU
5 - OSD


Dissolved Zinc (g/m3)
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Nov-10 Feb-11 May-11 Aug-11 Nov-11 Feb-12 May-12 Aug-12 Nov-12 Feb-13 May-13 Aug-13 Nov-13 Feb-14 May-14 Aug-14 Nov-14 Feb-15 May-15 Aug-15 Nov-15 Feb-16 May-16 Aug-16 Nov-16 Feb-17 May-17 Aug-17 Nov-17 Feb-18 May-18 Aug-18 Nov-18 Feb-19 May-19 Aug-19 Nov-19 Feb-20 May-20 Aug-20 Nov-20 Feb-21
1 - TTW
2 - TTE
3 - TTD
4 - OSU
5 - OSD
TV-upper


Arsenic (g/m3)
0.01
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Nov-10 Feb-11 May-11 Aug-11 Nov-11 Feb-12 May-12 Aug-12 Nov-12 Feb-13 May-13 Aug-13 Nov-13 Feb-14 May-14 Aug-14 Nov-14 Feb-15 May-15 Aug-15 Nov-15 Feb-16 May-16 Aug-16 Nov-16 Feb-17 May-17 Aug-17 Nov-17 Feb-18 May-18 Aug-18 Nov-18 Feb-19 May-19 Aug-19 Nov-19 Feb-20 May-20 Aug-20 Nov-20 Feb-21
1 - TTW
2 - TTE
3 - TTD
4 - OSU
5 - OSD


Dissolved Arsenic (g/m3)
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Nov-10 Feb-11 May-11 Aug-11 Nov-11 Feb-12 May-12 Aug-12 Nov-12 Feb-13 May-13 Aug-13 Nov-13 Feb-14 May-14 Aug-14 Nov-14 Feb-15 May-15 Aug-15 Nov-15 Feb-16 May-16 Aug-16 Nov-16 Feb-17 May-17 Aug-17 Nov-17 Feb-18 May-18 Aug-18 Nov-18 Feb-19 May-19 Aug-19 Nov-19 Feb-20 May-20 Aug-20 Nov-20 Feb-21
1 - TTW
2 - TTE
3 - TTD
4 - OSU
5 - OSD
6 - ADD
TV - Upper


Chromium (g/m3)
0.006
0.005
0.004
0.003
0.002
0.001
0
Nov-10
Feb-11
May-11
Aug-11
Nov-11
Feb-12
May-12
Aug-12
Nov-12
Feb-13
May-13
Aug-13
Nov-13
Feb-14
May-14
Aug-14
Nov-14
Feb-15
May-15
Aug-15
Nov-15
Feb-16
May-16
Aug-16
Nov-16
Feb-17
May-17
Aug-17
Nov-17
Feb-18
May-18
Aug-18
Nov-18
Feb-19
May-19
Aug-19
Nov-19
Feb-20
May-20
Aug-20
Nov-20
Feb-21
1 - TTW
2 - TTE
3 - TTD
4 - OSU
5 - OSD


Dissolved Chromium (g/m3)
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Nov-10
Feb-11
May-11
Aug-11
Nov-11
Feb-12
May-12
Aug-12
Nov-12
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Feb-21
1 - TTW
2 - TTE
3 - TTD
4 - OSU
5 - OSD
TV-Upper

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