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Waipawa, Waipukurau and Otane Wastewater Treatment Plants: Compliance with consent conditions and Plan Change 6 targets

Summary

Context

Central Hawke's Bay District Council (CHBDC) own and operate the Waipawa, Waipukurau and Otane Wastewater Treatment Plants (WWTPs) which discharge treated effluent to the Waipawa River, the Tukituki River and the Te Aute Drain respectively. The purpose of this memorandum is to assess the compliance of the WWTP discharges with the effluent quality and quantity limits set out in the relevant discharge permits, and to determine the contribution of the discharges to any non-compliance with Tukituki Plan Change 6 (PC6) limits/targets in the receiving waterbodies.

Assessment undertaken

This assessment is based on effluent quantity, effluent quality and instream water quality monitoring data collected by CHBDC for the period May 2005 to April 2019. Compliance with consent limits and PC6 limits and targets were assessed using the following methods:

- The discharge permits for both the Waipawa and Waipukurau WWTPs set limits for annual average and 90th percentile daily discharge volumes. Accordingly, these statistics were calculated for each 12-month period (July to June inclusive) and compared to the consent limits.
- Compliance with the effluent quality consent limits were assessed on a rolling basis by calculating the number of exceedances over the preceding 12 months (Waipawa and Waipukurau) or 48 weeks (Otane) for each sample, and comparing that to the number of exceedances allowed by the consent.

- The majority of the PC6 limits/targets are based on the average, median or 95th percentile value over a specified period or number of samples. Accordingly, for each sample collected from surface water the relevant compliance statistic for each parameter was calculated based on the results of previous samples collected within the prescribed assessment period.

Results – Waipawa

From the monitoring data collected within, upstream and downstream of the Waipawa WWTP discharge between May 2005 and April 2019 the following conclusions were made about the Waipawa WWTP discharge:

- The Waipawa WWTP discharge frequently did not meet the consent limits for discharge volume. This non-compliance was driven by frequent spikes in discharge volume rather than consistently elevated volumes. Thus, to achieve compliance with the discharge volume limits in the consent, effluent management should focus on reducing the frequency of these spikes (to less than 10% of the time) rather than reducing baseline volumes.
- The Waipawa WWTP discharge did not comply with the effluent quality limits for total suspended solids (TSS), ammoniacal nitrogen (NH_4-N), dissolved reactive phosphorus (DRP) or *E. coli* . However, these non-compliances do not appear to have had a meaningful effect on water quality and ecology in the Waipawa River.
- The discharge of NH_4-N and nitrate (NO_3-N) from the Waipawa WWTP to the Waipawa River is unlikely to have increased the risk of ammonia/nitrate toxicity effects or excessive/nuisance plant growth in the Waipawa River, and the PC6 limits for dissolved inorganic nitrogen (DIN), NH_4-N and NO_3-N were all met downstream of the discharge.
- The discharge of DRP from the WWTP did not increase the risk of plant growth in the Waipawa River, and had little effect on the river's compliance with the PC6 limit, as it was already exceeded upstream of the discharge due to other human activities. Based on the most recent five years of monitoring data, a ~50% reduction in DRP downstream of the discharge at flows below the median would be needed to meet the PC6 limit, and completely removing the discharge would achieve a ~28% reduction.
- TSS and 5-day carbonaceous biochemical oxygen demand ($cBOD_5$) from the Waipawa WWTP did not cause a degradation in visual clarity, 5-day soluble carbonaceous biochemical oxygen demand ($ScBOD_5$), particulate organic matter (POM) or dissolved oxygen (DO) in the Waipawa River, and did not prevent compliance with the PC6 limits for these parameters.
- The effects of the discharge on *E. coli* in the Waipawa River has been explored previously by Ausseil and Hicks (2017), who concluded that the discharge does not increase the risk of human health effects in the Waipawa River or the risk of the river not meeting the PC6 *E. coli* limits. The analysis conducted for this memorandum supports those conclusions.
- The maximum reduction in quantitative macroinvertebrate community index (QMCI) observed between sites on the Waipawa River upstream and downstream of the Waipawa WWTP discharge was just 2.8%. Thus, it can be concluded that the discharge was compliant with the PC6 QMCI limits.

Results – Waipukurau

Based on monitoring data collected between May 2005 and April 2019, the following conclusions were made about the Waipukurau WWTP discharge:

- The Waipukurau WWTP discharge frequently did not meet the discharge volume consent limits. This non-compliance was driven by consistently elevated volumes rather than spikes in discharge volume. Thus, to comply with the discharge volume limits, effluent management should focus on reducing the baseline volumes.
- The Waipukurau WWTP discharge did not comply with the effluent quality consent limits for TSS, NH_4-N, DRP and *E. coli*, but the effects of these exceedances on the Tukituki River were likely limited to an increased risk of ammonia toxicity.
- The discharge of NH_4-N to the Tukituki River from the Waipukurau WWTP resulted in the occasional exceedance of the PC6 limit and had the potential to cause chronic (but not acute) toxicity effects.
- Non-compliance with the PC6 NH_4-N limit downstream of the Waipukurau WWTP discharge generally occurred between November and May when flow was below the median. Thus, non-compliances could be avoided by either not discharging to the Tukituki River over the summer period when flows are below the median (or at the very least half median), and/or reducing the concentration of NH_4-N in the discharge by way of additional treatment during this period.
- NO_3-N and DIN in the discharge does not appear to have increased the risk of nitrate toxicity or plant growth in the Tukituki River, or have affected compliance with the PC6 limits for those parameters. The NO_3-N PC6 limits were met both upstream and downstream of the discharge, and nutrient sources other than the WWTP meant that the DIN limit was already exceeded upstream of the discharge. For the PC6 DIN limit to be met downstream of the discharge, concentrations would need to reduce by ~51% (based on data collected between 2016 and 2019). Completely removing the discharge from the river would achieve a ~10% reduction.
- The discharge of DRP from the Waipukurau WWTP is unlikely to have increased the risk of plant growth in the Tukituki River, and had limited influence on the river's compliance with the PC6 limit, which was already exceeded upstream due to other human activities. Based on the most recent five years of monitoring data, a ~53% reduction in DRP at flows below the median would be needed to meet the PC6 limit downstream of the discharge. Completely removing the discharge from the river would achieve an ~11% reduction.
- TSS and $cBOD_5$ from the Waipukurau WWTP did not cause a degradation in visual clarity, $ScBOD_5$, POM or DO saturation in the Tukituki River and did not affect whether the PC6 limits for these parameters were met downstream.
- *E. coli* in the Waipukurau WWTP discharge does not appear to have increased the risk of human health effects in the Tukituki River or the risk of the river not meeting the PC6 *E. coli* limits.
- Macroinvertebrate monitoring data from the Tukituki River suggest that the Waipukurau WWTP discharge was generally compliant with the PC6 QMCI limits.

Results – Otane

Monitoring data collected for the Otane WWTP between May 2005 and April 2019 suggests:

- The Otane WWTP discharge did not comply with the effluent quality limits for TSS, DRP and *E. coli*. However, this non-compliance does not appear to have had a meaningful effect on water quality and ecology in the Te Aute Drain.
- The discharge of NH_4-N and NO_3-N from the Otane WWTP did not increase the risk of ammonia/nitrate toxicity effects or plant growth in the Te Aute Drain, and exceedances of the PC6 limits for DIN, NH_4-N and NO_3-N appear to be have been driven by activities upstream rather than the discharge. In order to meet the PC6 DIN limit, concentrations downstream of the discharge would need to reduce by ~25% (based on the most recent five years of monitoring data). Completely removing the discharge from the drain would achieve a ~7% reduction.
- The discharge of DRP from the Otane WWTP did not increase the risk of plant growth in the Te Aute Drain, and had little influence on the drain's compliance with the PC6 limit, which was already exceeded upstream of the discharge due to other human activities. Based on the most recent five years of monitoring data, a ~93% reduction in DRP at flows below the median would be needed to meet the PC6 limit, and completely removing the discharge would achieve a ~9% reduction.
- *E. coli* in the Otane WWTP discharge did not increase the risk of human health effects in the Te Aute Drain or the risk of the stream not meeting the PC6 *E. coli* limits.
- TSS and $cBOD_5$ from the Otane WWTP are unlikely to have resulted in the PC6 $ScBOD_5$ limit being exceeded in the Te Aute Drain, However, an absence of monitoring data means its effects on instream visual clarity and POM are unclear.
- The limited macroinvertebrate monitoring data available for the Te Aute Drain indicate that the Otane WWTP discharge was compliant with the PC6 QMCI limits.

1 Introduction

1.1 Background

Central Hawke's Bay District Council (CHBDC) own and operate the Waipawa, Waipukurau and Otane Wastewater Treatment Plants (WWTPs), which discharge treated effluent to the Waipawa River, the Tukituki River and the Te Aute Drain respectively. The discharges from all three WWTPs are allowed by discharge permits granted by Hawke's Bay Regional Council (HBRC), and are subject to a suite of conditions, including limits for effluent quality and quantity. In addition to those consent limits, the Regional Plan – Tukituki Plan Change 6 (PC6) defines a number of in-stream water quality limits/targets[1] that apply to the waterbodies that receive the discharges.

1.1 Scope

The purpose of this memorandum is to assess the compliance of the Waipawa, Waipukurau and Otane WWTP discharges with the effluent quality and quantity limits set out in the relevant discharge permits. Water quality in the waterbodies that receive discharges from the aforementioned WWTPs is also compared with the PC6 limits/targets, and the contribution of the discharges to any non-compliance is determined.

2 Data and methods

2.1 Data available

CHBDC provided the following data for the Waipawa, Waipukurau and Otane WWTPs:

- Daily discharge volume (m^3/day) between January 2008 to May 2019;
- Discharge quality data ("end of pipe") collected between May 2005 and April 2019 (samples collected fortnightly by CHBDC); and
- Water quality data collected from the Waipawa River, Tukituki River and Te Aute Drain at sites upstream and downstream of the WWTP discharges between May 2005 and April 2019 (samples collected monthly by CHBDC).

The following data were sourced from HBRC:

- Daily mean flow in the Waipawa River at the RDS flow monitoring site between January 2009 and May 2019;
- Daily mean flow in the Tukituki River at the Tapairu Road flow monitoring site between January 2009 and May 2019; and
- Synthetic daily mean flow in the Papanui Stream at the Middle Road water level monitoring site between May 2004 and July 2014

Daily mean flow in the Papanui Stream at the Middle Road water level monitoring site between July 2014 and May 2019 was calculated based on the relationship between synthetic flows at that

[1] The numerical values in PC6 are to be treated as "limits" at locations where the existing water quality is better than the relevant numerical value and as "targets" at locations where the existing water quality is worse than the relevant numerical value.

site and the site on the Tukituki River at Tapairu Road between January 2008 and July 2014 ($0.0014 \times$ Tapairu Road$^{1.3574}$; $R^2 = 0.76$). As these data were calculated from a synthetic flow record and data from a site which is very different hydrologically, they are unlikely to be highly accurate. However, they represent the best available at the time of writing.

2.2 Approach

2.2.1 *Effluent quantity*

The discharge permits for both the Waipawa and Waipukurau WWTPs set limits for average and 90th percentile daily discharge volume (see Table 1 for limits), and compliance with these limits is to be assessed annually based on data collected between the 1st of July and the 30th of June. Accordingly, average and 90th percentile daily effluent volume were calculated for year (July to June inclusive) that data are available. The discharge permit for the Otane WWTP does not include limits for discharge volume.

Table 1: Effluent volume limits set for the Waipawa and Waipukurau WWTPs.

WWTP	Limit/target	Compliance statistic	Assessment period
Waipawa	1500 m^3/day	90th %tile	Annually between 1 July and 30 June
	1300 m^3/day	Average	
Waipukurau	4,000 m^3/day	90th %tile	
	2,200 m^3/day	Average	

2.2.2 *Effluent quality*

For each of WWTP, descriptive statistics, such as mean, median, distribution percentiles, standard error and confidence intervals, were calculated for each parameter monitored in discharge between May 2005 and April 2019.

The discharge permits for the Waipawa, and Waipukurau WWTPs set pre-upgrade limits for pH, total suspended solids (TSS), 5-day carbonaceous biochemical oxygen demand ($cBOD_5$) and faecal coliforms, and set post-upgrade limits for pH, TSS, $cBOD_5$, dissolved reactive phosphorus (DRP), total ammoniacal nitrogen (NH_4-N) and *Escherichia coli* (*E. coli*). The discharge permit for the Otane WWTP sets limits for TSS and $cBOD_5$ that apply up until the 31st of April 2019, and limits for TSS, $cBOD_5$ DRP, NH_4-N and *E. coli* that apply after that date. Table 2 to Table 4 describes the consent limits for each of the WWTPs.

The effluent quality consent limits for all three WWTPs are based on an allowable number of exceedances over a specified period (12 months for Waipawa and Waipukurau and 48 weeks for Otane). Accordingly, for each effluent sample taken from the WWTP's the number of times each consent limit was exceeded over the preceding assessment period was calculated and compared to the relevant limit. This information was then used to calculate an overall compliance rate. Where the discharge permits set different pre and post-upgrade limits for a parameter, data were assessed against both limits.

Table 2: Effluent quality limits set for the Waipawa WWTP in Discharge Permit DP03232Wb & DP030860Ab.

Stage	Parameter	Limit/target	Compliance statistic	Assessment period
All	pH	6.5-8.5	Min-max	Rolling based on previous 12 months of data
Pre-upgrade	Faecal coliforms	75,000 CFU/100mL	16 exceedances	
	TSS	45 g/m^3	16 exceedances	
		76 g/m^3	5 exceedances	
	$cBOD_5$	30 g/m^3	16 exceedances	
		36 g/m^3	5 exceedances	
Post-upgrade	TSS	30 g/m^3	16 exceedances	
		50 g/m^3	5 exceedances	
	$cBOD_5$	20 g/m^3	16 exceedances	
		30 g/m^3	5 exceedances	
	DRP	0.25 g/m^3	16 exceedances	
		0.5 g/m^3	5 exceedances	
	NH_4-N	6 g/m^3	16 exceedances	
		10 g/m^3	5 exceedances	
	E. coli	800 CFU/100mL	16 exceedances	
		4,000 CFU/100mL	5 exceedances	

Table 3: Effluent quality limits set for the Waipukurau WWTP in Discharge Permit DP030231Wc & DP030859Ac.

Stage	Parameter	Limit/target	Compliance statistic	Assessment period
All	pH	6.5-8.5	Min-max	Rolling based on previous 12 months of data
Pre-upgrade	Faecal coliforms	75,000 CFU/100mL	16 exceedances	
	TSS	45 g/m^3	16 exceedances	
		96 g/m^3	5 exceedances	
	$cBOD_5$	30 g/m^3	16 exceedances	
		39 g/m^3	5 exceedances	
Post-upgrade	TSS	30 g/m^3	16 exceedances	
		50 g/m^3	5 exceedances	
	$cBOD_5$	20 g/m^3	16 exceedances	
		30 g/m^3	5 exceedances	
	DRP	0.25 g/m^3	16 exceedances	
		0.5 g/m^3	5 exceedances	
	NH_4-N	6 g/m^3	16 exceedances	
		10 g/m^3	5 exceedances	
	E. coli	800 CFU/100mL	16 exceedances	
		4,000 CFU/100mL	5 exceedances	

Table 4: Effluent quality limits set for the Otane WWTP in Discharge Permit DP150206L, DP150207W & DP150208A.

Stage	Parameter	Limit/target	Compliance statistic	Assessment period
Prior to 31st April 2019	TSS	55 g/m^3	15 exceedances	Rolling based on previous 48 weeks of data
		100 g/m^3	4 exceedances	
	$cBOD_5$	30 g/m^3	15 exceedances	
		40 g/m^3	4 exceedances	
After 31st April 2019	TSS	30 g/m3	15 exceedances	
		50 g/m3	4 exceedances	
	$cBOD_5$	20 g/m3	15 exceedances	
		30 g/m3	4 exceedances	
	DRP	0.25 g/m3	15 exceedances	
		0.5 g/m3	4 exceedances	
	NH_4-N	30 g/m3	15 exceedances	
		40 g/m3	4 exceedances	
	E. coli	800 CFU/100mL	15 exceedances	
		4,000 CFU/100mL	4 exceedances	

2.2.3 Water quality

For each parameter, descriptive statistics, such as mean, median, distribution percentiles, standard error and confidence intervals were calculated for sites on the Waipawa River, Tukituki River and Te Aute Drain at sites upstream and downstream of the WWTP discharges. Paired upstream and downstream data were also compared using Wilcoxon Signed Rank Tests (TimeTrends v6.3).

PC6 sets in-stream limits/targets[2] for DRP, SIN, *E. coli*, nitrate (NO_3-N), NH_4-N, dissolved organic nitrogen (DIN), dissolved oxygen (DO) saturation, water clarity, clarity change, 5-day soluble carbonaceous biochemical oxygen demand ($ScBOD_5$), particulate organic matter (POM) and quantitative macroinvertebrate community index (QMCI) change. With the exception of DO, clarity change and QMCI change, all of the PC6 limits/targets are based on the average, median or 95th percentile value over a specified period or number of samples. Accordingly, for each sample collected the relevant compliance statistic for each parameter was calculated based on the results of previous samples collected within the prescribed assessment period. This information was then used to calculate an overall compliance rate. Table 5 describes the PC6 limits/targets for each waterbody that the CHBDC WWTPs discharge to.

The PC6 DO limit/target is an absolute minimum, while the clarity and QMCI change limits are an absolute maximum. Thus, compliance for these parameters was assessed from the raw data, rather than calculated statistics. The PC6 limit/target for NH_4-N is based on pH 8 and temperature of 20^{o}C; concentrations need to be adjusted for these parameters to assess compliance. Accordingly, NH_4-N concentrations recorded in the Waipawa River, Tukituki River and Te Aute Drain were converted to un-ionised ammonia (NH_3-N) concentrations[3] and assessed against NH_3-N threshold that corresponds to the PC6 NH_4-N limit/target[4].

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[2] The listed parameters are those that can be assessed from the available data. It is not an exhaustive list of all of the PC6 targets.
[3] Based on the measured water pH and temperature measured on the day of sampling
[4] Calculated from percentage of total ammoniacal nitrogen composed of unionised ammonia nitrogen at pH of 8 and 20^{o}C (3.8%)

Table 5: Summary of PC6 limits/targets used in this assessment.

Parameter	Compliance statistic	Assessment period	Flow	Limit/target		
				Waipawa River (Waipawa WWTP)	Tukituki River (Waipukurau WWTP)	Te Aute Drain (Otane WWTP)
DO saturation (%)	Min.	Single sample	All	80		N/A
E. coli (CFU/100mL)	95th %ile	≥20 sample from 1st Nov. – 30th April	< median	260		
			Median - 3× median	550		
		≥20 data samples from 1st May – 31st Oct.	< 3× median	550		
NH_3-N (ppb)	95th %ile	12 months	All	12.2		
NO_3-N (g/m^3)	Median		All	3.8		2.4
	95th %ile			5.6		3.5
DRP (g/m^3)	Average	5 years	≤ 3× median	0.010		0.015
SIN (g/m^3)	Average		All	0.8		
Water clarity (m)	Median		< median	3.0		1.6
Water clarity (%Δ)	Max.	Single sample	< median	20		30
$ScBOD_5$ (g/m^3)	Average	Not specified	< median	2		
POM (g/m^3)	Average		< median	5		
QMCI (%Δ)	Max.	Single sample	All	20		

3 Waipawa WWTP results

3.1 Effluent quantity

Between July 2008 and May 2019, the Waipawa WWTP discharge frequently did not meet the discharge volume limits set out in the consent. While the annual average daily discharge volume was always below the limit of 1,300 m^3/day; in 2010, 2011, 2012, 2014, 2017 and 2018 daily discharge volume exceeded 1,500 m^3/day for more than 10% of the time (Table 6). That the average discharge volume limit was always met while the 90th percentile limit was frequently exceeded indicates that non-compliance was driven by frequent spikes in discharge volume, rather than consistently elevated volumes (this is depicted in Figure 1). Thus, to comply with the discharge volume limits in the consent, effluent management should focus on reducing the frequency of these spikes rather than reducing baseline volumes.

Table 6: Assessment of compliance with the discharge volume limit set out in Condition 5 and Condition 7 of Discharge Permit DP03232Wb & DP030860Ab

12-m period ending 30th June	Days over 1,500 m^3/day	% of time over 1,500 m^3/day	Average (limit = 1,300 m^3/day)	Compliant
2009	23	6%	796.5	✓
2010	89	24%	1163.6	×
2011	86	24%	1201.4	×
2012	53	14%	999.8	×
2013	35	9.6%	813.4	✓
2014	48	13%	1015.5	×
2015	10	3%	878.6	✓
2016	13	4%	920.6	✓
2017	45	12%	1133.5	×
2018	38	10.4%	1192.2	×

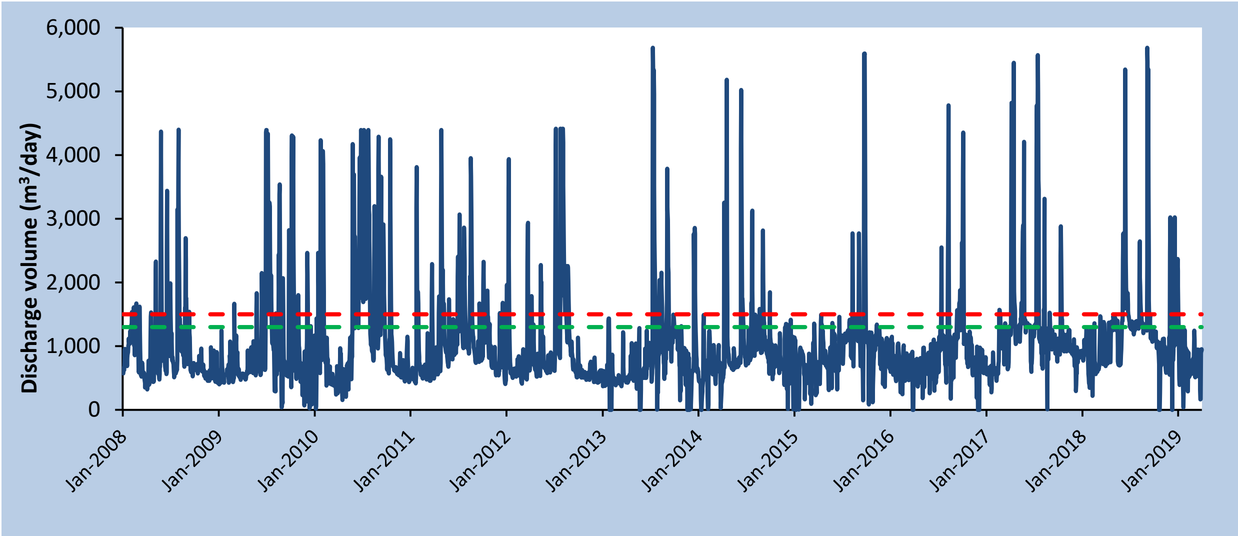

Figure 1: Daily discharge volume from the Waipawa WWTP (January 2008 - May 2019). The green and red dashed line represents the limits for average and 90th percentile volume respectively.

3.2 Effluent quality

The treated wastewater quality data collected by CHBDC between May 2005 and April 2019 are summarised in Table 7 and depicted in Figure 2 to Figure 15.

Table 7: Summary of effluent quality from the Waipawa oxidation pond, May 2005 – April 2019.

	TSS	$cBOD_5$	NH_4-N	DRP	*E. coli*	Faecal coli.	
	(g/m^3)				(CFU/100mL)		pH
Average	44.8	16.7	14.5	4.00	41,998	60,817	7.4
Min	2.9	0.5	0.0	0.00	3	3	3.4
25%ile	16.0	5.9	9.0	0.53	1,800	2,500	7.2
50%ile (median)	33.0	12.0	15.4	4.05	9,000	12,000	7.4
95%ile	120.0	46.0	26.6	9.00	161,000	260,000	7.9
Max	270.0	95.0	44.0	12.80	960,000	1,100,000	9.0
N. of Samples	359	359	358	357	359	359	359
Pre-upgrade lower/upper limit	45/76	30/36	NA	NA	NA	75,000/N/A	6.5-8.5
Post-upgrade lower/upper limit	30/50	20/30	6/10	0.25/0.5	800/4000	NA	6.5-8.5
Pre-upgrade compliance (%)	88/65	100/83	NA	NA	NA	54	97
Post-upgrade compliance (%)	51/30	82/72	25/5	28/19	25/0	NA	

3.2.1 5-day carbonaceous biochemical oxygen demand

$cBOD_5$ concentrations in the discharge from the Waipawa WWTP have been improving since records began and decreased noticeably in July 2013 when the plant was upgraded (Figure 2); as a consequence the Waipawa WWTP is now compliant with both the pre-upgrade and post-upgrade $cBOD_5$ consent limits. Between May 2005 and April 2019 $cBOD_5$ concentrations never exceeded the pre-upgrade lower limit of 30 g/m^3 more than 16 times in any 12 month period (Figure 3 and Table 7), and while the post-upgrade lower limit of 20 g/m^3 was exceeded more than 16 times in 62 of the 354 12-month periods covered by the analysis (82% compliance), all instances of non-compliance occurred prior to July 2009 (Figure 3). Similarly, while the pre-upgrade (36 g/m^3) and post-upgrade (30 g/m^3) upper limits were exceeded in 57 (84% compliance) and 97 (73% compliance) 12-month periods respectively, all non-compliances were prior to July 2010 (Figure 4).

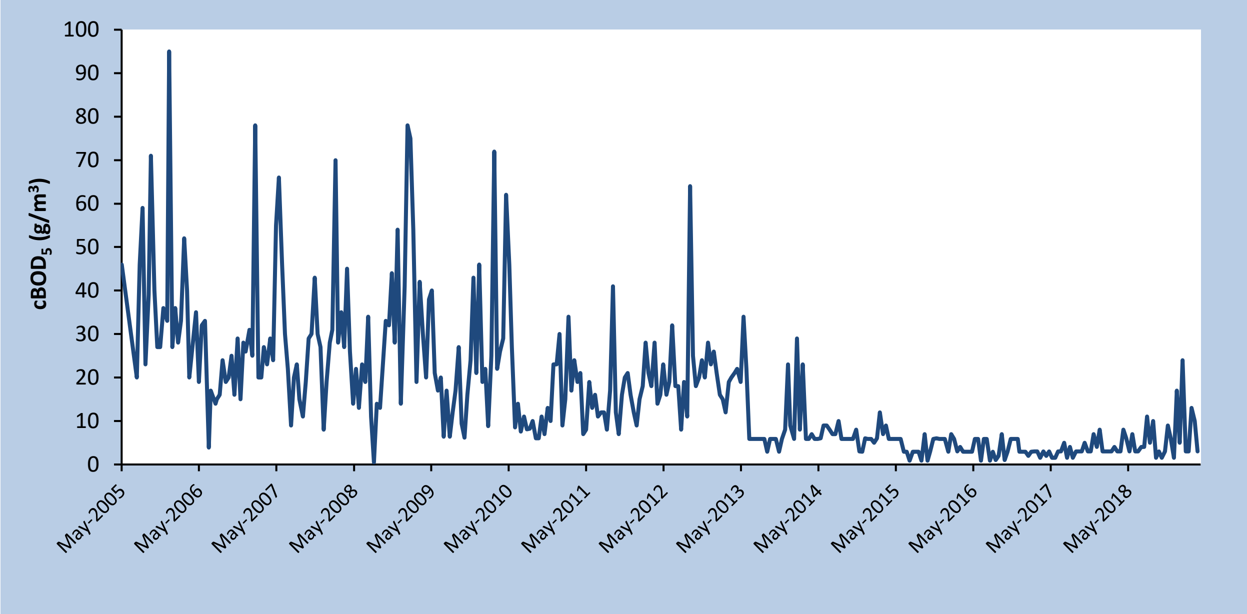

Figure 2: $cBOD_5$ concentrations from the Waipawa oxidation pond prior to discharge (May 2005 – April 2019).

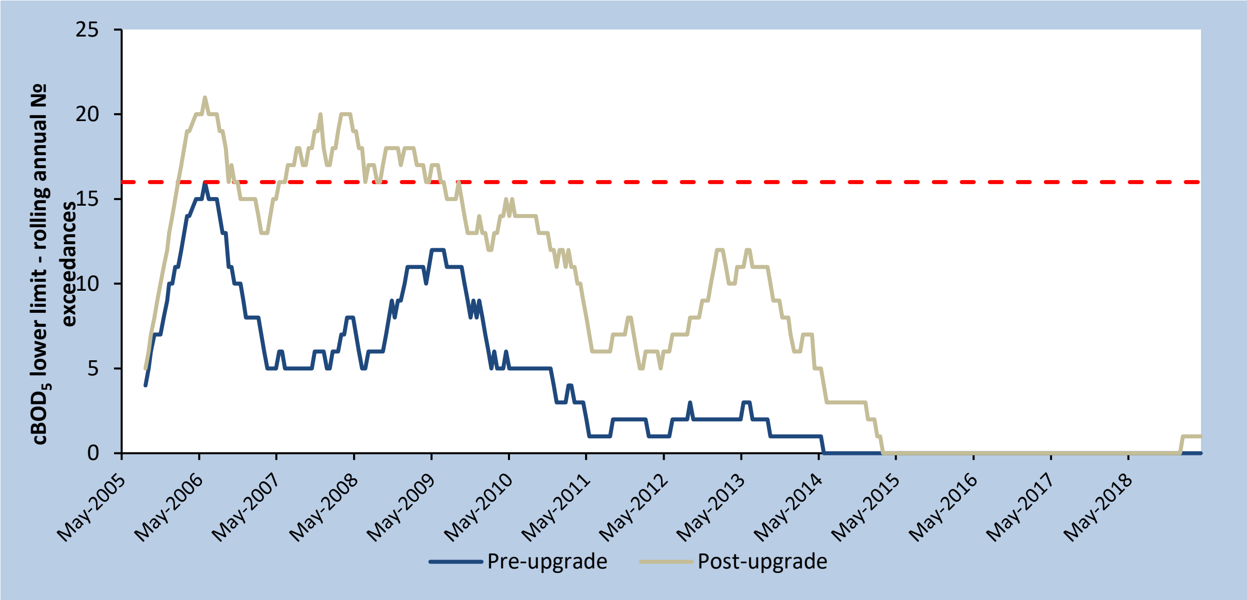

Figure 3: The number of times in each 12-month period that the pre-upgrade and post-upgrade lower consent limits for $cBOD_5$ were exceeded. The red dashed line represents the allowable number of exceedances.

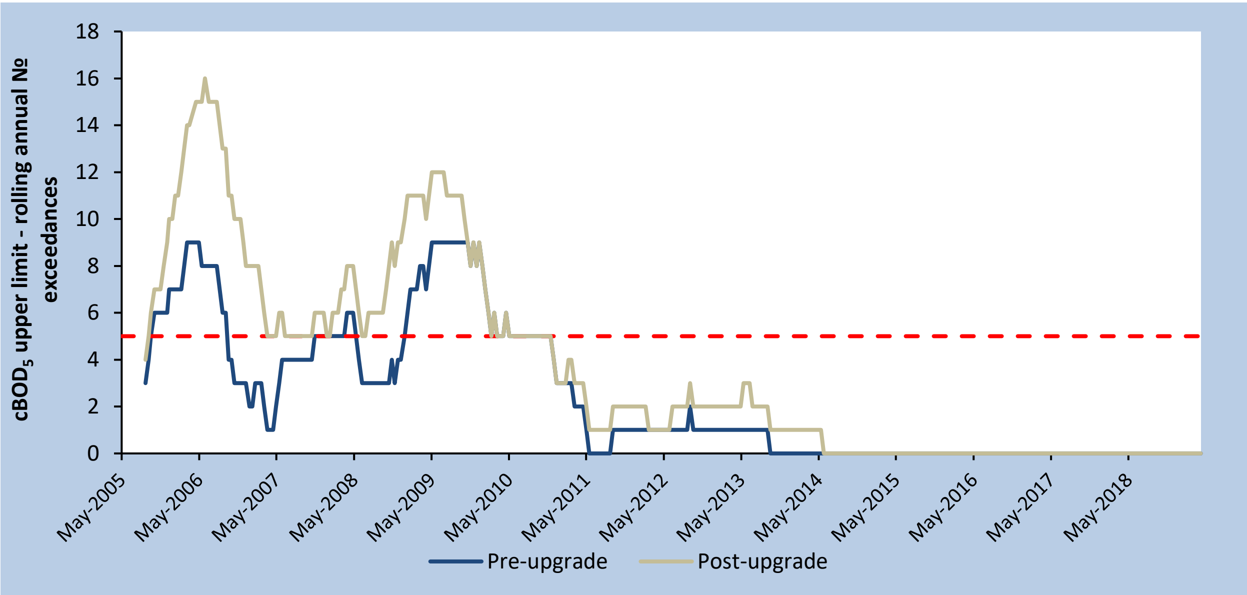

Figure 4: The number of times in each 12-month period that the pre-upgrade and post-upgrade upper consent limits for $cBOD_5$ were exceeded. The red dashed line represents the allowable number of exceedances.

3.2.2 Total suspended solids

While TSS concentrations in the discharge appear to have improved since the upgrades in July 2013 (Figure 5), they are still frequently non-compliant with both the pre-upgrade and post-upgrade consent limits (Table 7). Between May 2005 and April 2019, TSS concentrations exceeded the pre-upgrade (45 g/m^3) and post-upgrade (30 g/m^3) more than 16 times in 42 (88% compliance) and 172 (52% compliance) 12-month periods respectively, with the most recent non-compliance of the post-upgrade lower limit occurring in October 2018 (Figure 6). The pre-upgrade (76 g/m^3) and post-upgrade (50 g/m^3) upper limits were exceeded in 124 (65% compliance) and 246 (31% compliance) 12 month periods respectively, with both limits being breached multiple times in the last 18 months (Figure 7).

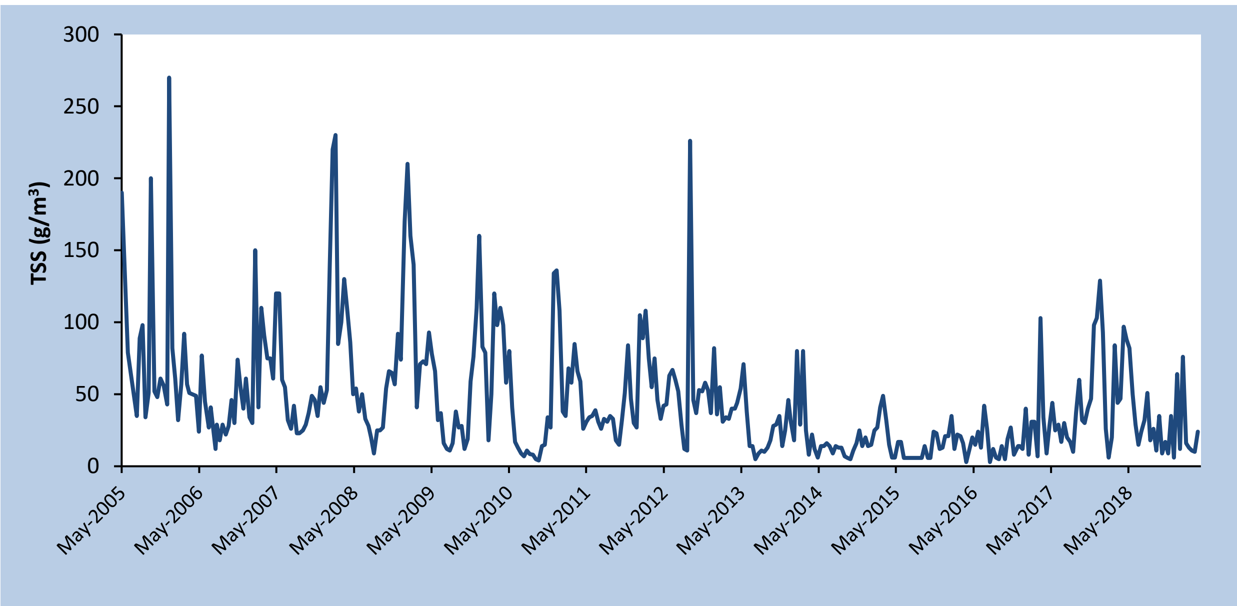

Figure 5: TSS concentrations from the Waipawa oxidation pond prior to discharge (May 2005 – April 2019)

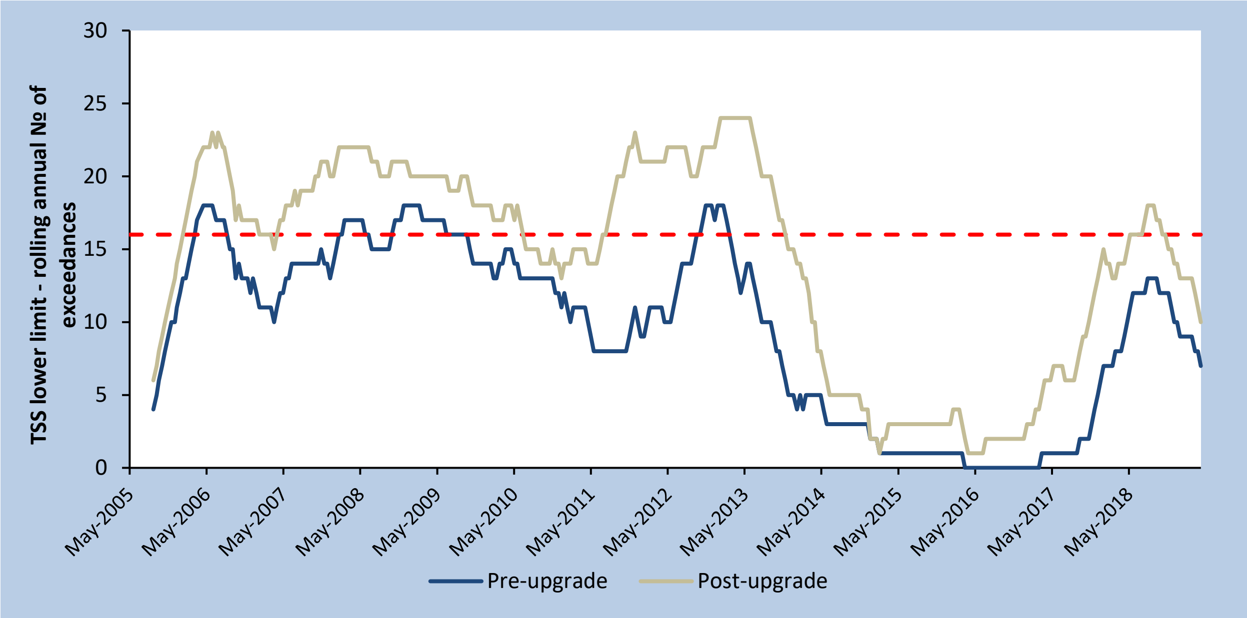

Figure 6: The number of times in each 12-month period that the pre-upgrade and post-upgrade lower consent limits for TSS were exceeded. The red dashed line represents the allowable number of exceedances.

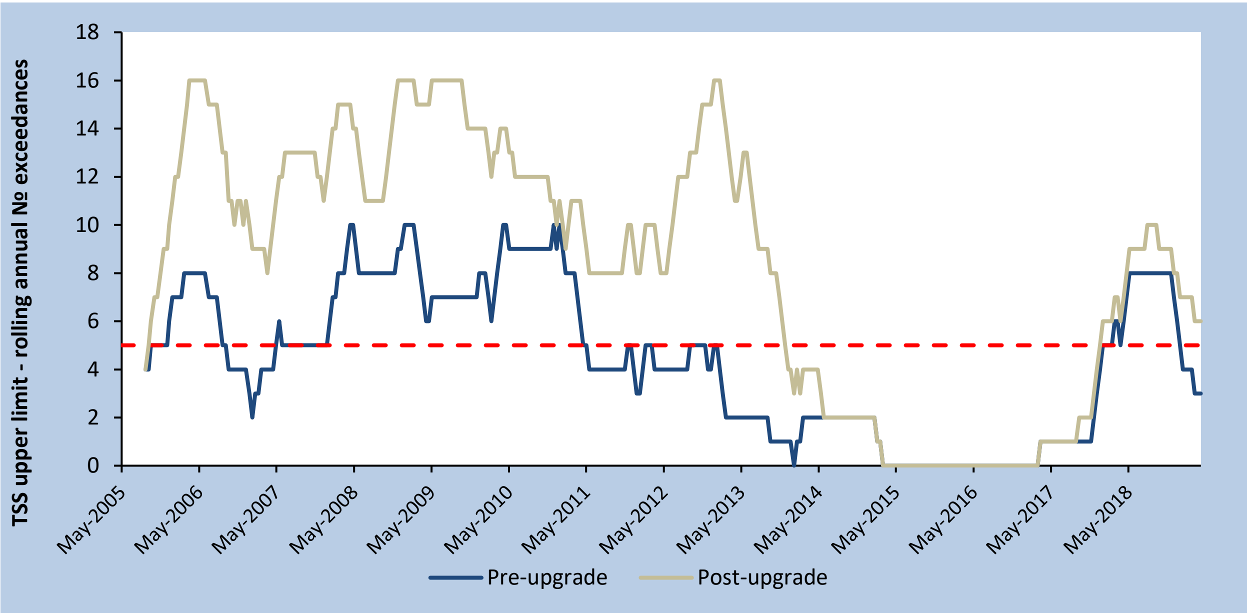

Figure 7: The number of times in each 12-month period that the pre-upgrade and post-upgrade upper consent limits for TSS were exceeded. The red dashed line represents the allowable number of exceedances.

3.2.3 Ammoniacal nitrogen, dissolved reactive phosphorus and E. coli

The Waipawa WWTP discharge does not currently comply with any of the NH_4-N, DRP and *E. coli* consent limits. Between May 2005 and April 2019, concentrations all three parameters regularly exceeded the lower (Figure 8) and upper limits (Figure 9) more frequently than allowed by the consent (16 and 5 times in a 12-month period respectively), and rate of compliance was less than 30% for all specified limits (Table 7).

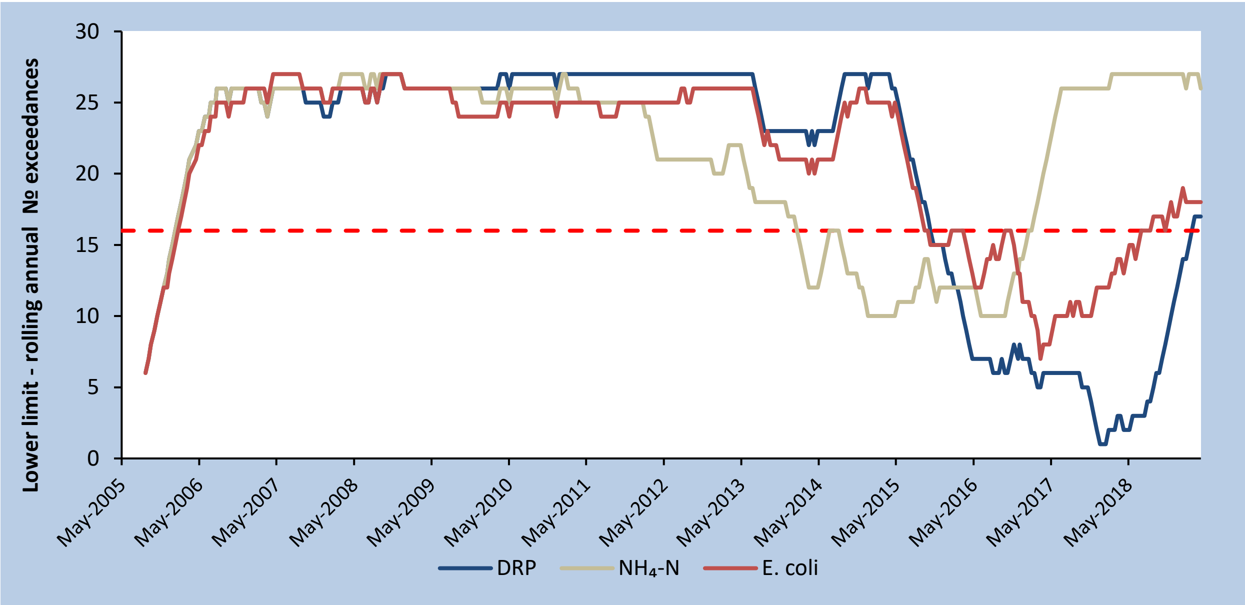

Figure 8: The number of times in each 12-month period that the post-upgrade lower consent limits for DRP, NH_4-N and *E. coli* were exceeded. The red dashed line represents the allowable number of exceedances.

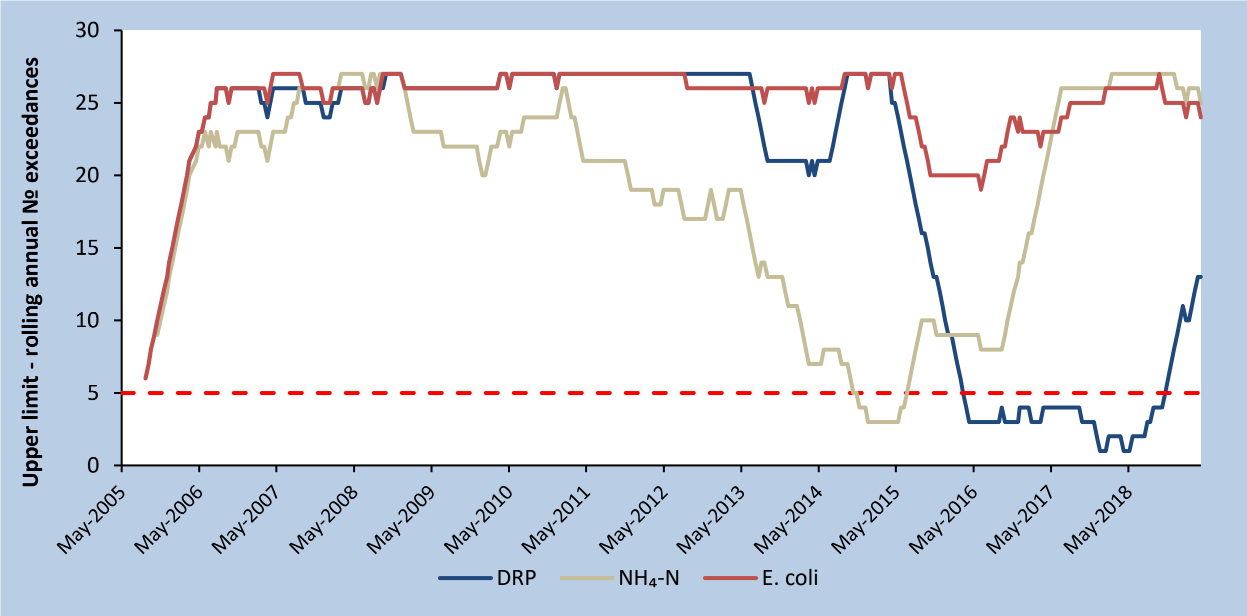

Figure 9: The number of times in each 12-month period that the post-upgrade upper consent limits for DRP, NH_4-N and *E. coli* were exceeded. The red dashed line represents the allowable number of exceedances.

While DRP and *E. coli* concentrations in the Waipawa WWTP discharge do not currently comply with consent limits, they have improved noticeably since the Waipawa WWTP was upgraded in July 2013 (Figure 10 and Figure 11). However, while *E. coli* responded rapidly to the upgrades and have not increased since (Figure 11), DRP concentrations took almost two years to improve and have been increasing since mid-2018 (Figure 10). NH_4-N concentrations in the discharge do not appear to have decreased meaningfully since the upgrades (Figure 12)

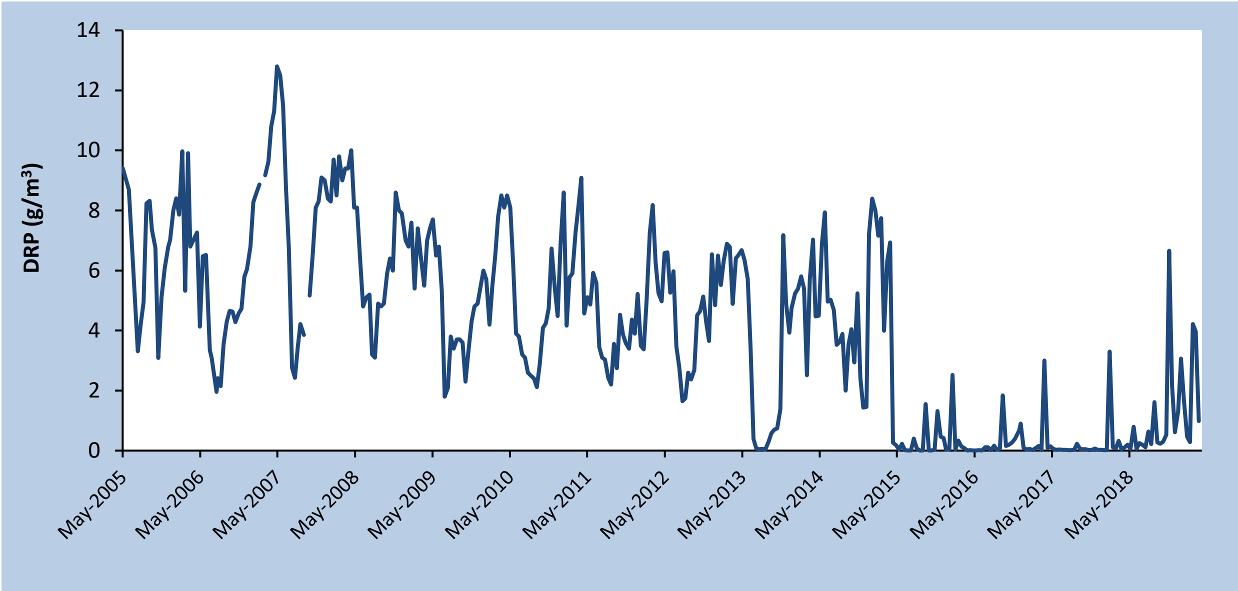

Figure 10: DRP concentrations from the Waipawa oxidation pond prior to discharge (May 2005 – April 2019)

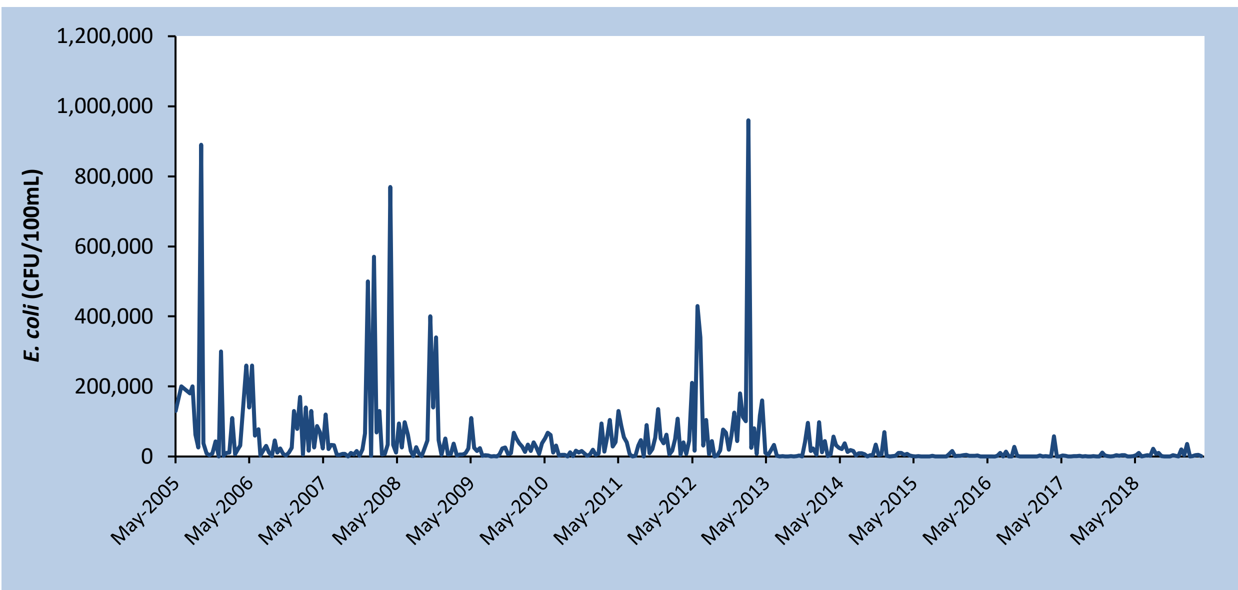

Figure 11: *E. coli* concentrations from the Waipawa oxidation pond prior to discharge (May 2005 – April 2019)

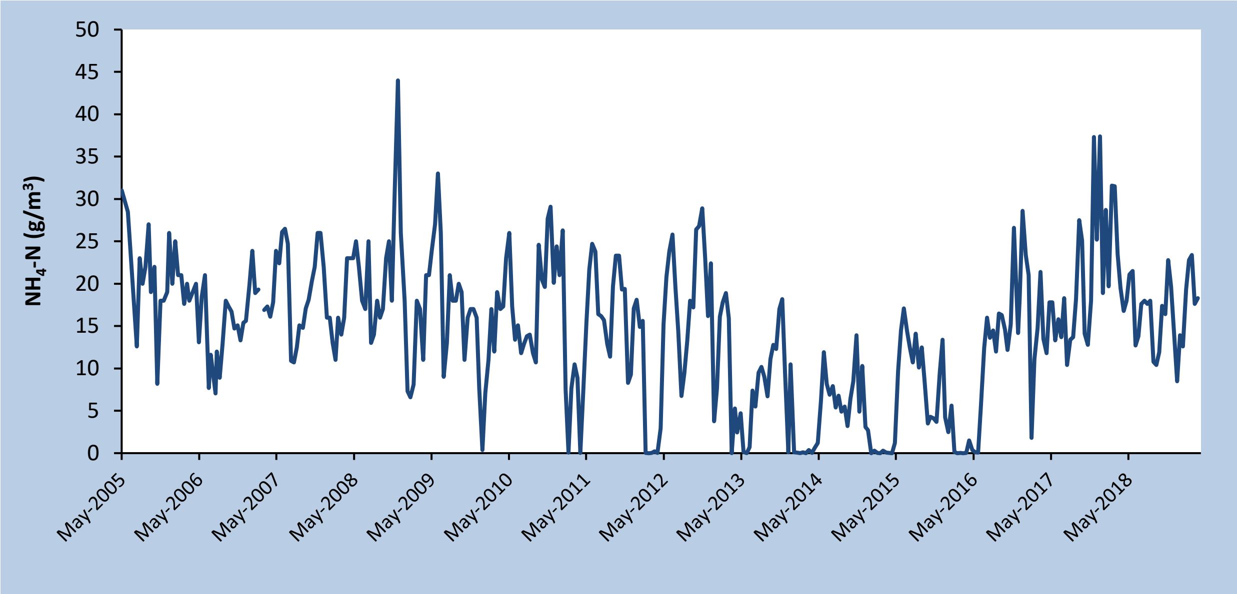

Figure 12: NH_4-N concentrations from the Waipawa oxidation pond prior to discharge (May 2005 – April 2019).

3.2.4 Faecal coliforms

There has been a marked improvement in faecal coliform concentrations in the Waipawa WWTP discharge since the upgrades in July 2013 (Figure 13), and they are now compliant with the pre-upgrade consent limit of 75,000 CFU/100. While faecal coliform concentrations did exceed the limit more than five times in 163 12-month periods between May 2005 and April 2019 (97% compliance), all instances on non-compliance occurred prior to July 2014 (Figure 14).

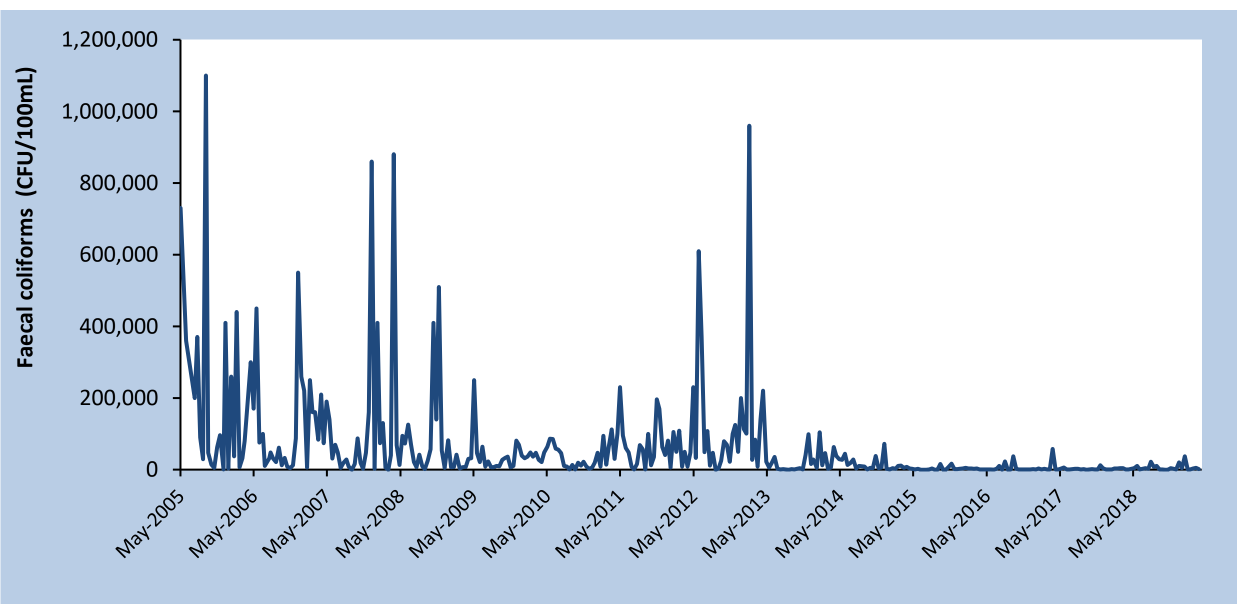

Figure 13: Faecal coliform concentrations from the Waipawa oxidation pond prior to discharge (May 2005 – April 2019)

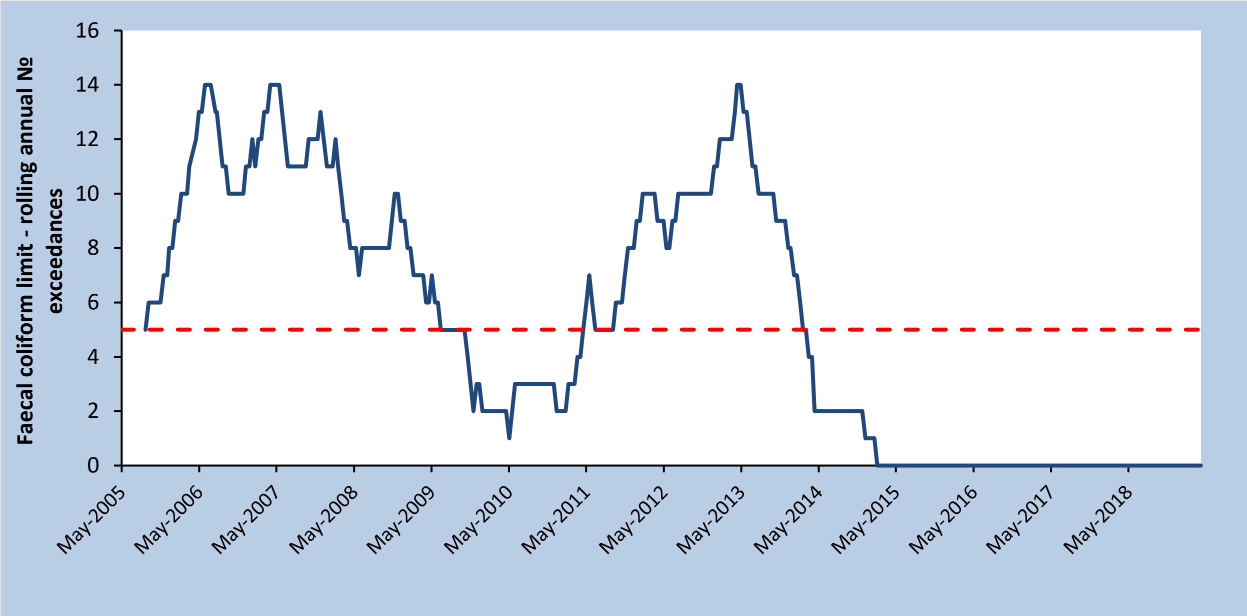

Figure 14: The number of times in each 12-month period that the pre-upgrade consent limit for faecal coliforms were exceeded. The red dashed line represents the allowable number of exceedances.

3.2.5 pH

pH in discharge from the Waipawa WWTP is generally compliant with the consent limit (Figure 15 and Table 7), and between May 2005 and April 2019 pH was only outside the limit range of 6.5 – 8.5 on seven occasions (97% compliance) (Figure 15).

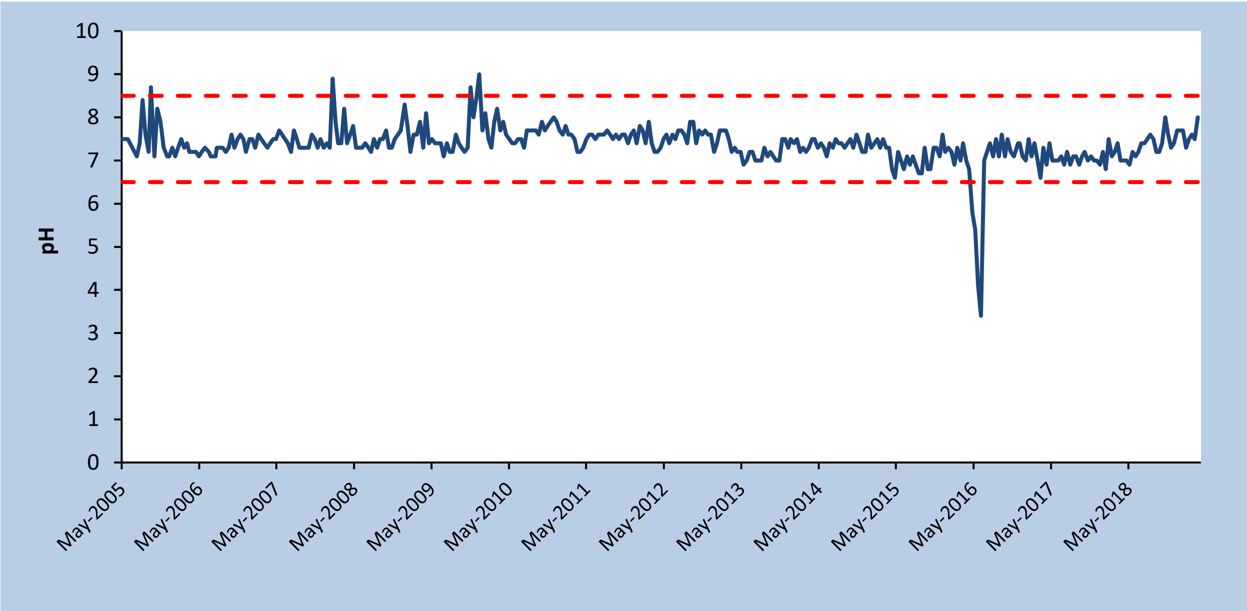

Figure 15: pH in the Waipawa oxidation pond prior to discharge (May 2005 – April 2019). The dashed red lines represent the upper and lower consent limits

3.3 In-stream water quality

Water quality data collected between May 2005 and April 2019 upstream and downstream of where the Waipawa WWTP discharge enters the Waipawa River are presented in Figure 16 to Figure 29. Key water quality parameters are summarised and assessed against the relevant PC6 limits/targets in Table 8.

Table 8: Summary of key water quality determinants measured in the Waipawa River upstream and downstream of the Waipawa WWTP discharge, and assessment against PC6 limits/targets. May 2005 – April 2019. The most relevant assessment statistics are shaded.

Para.	Unit	PC6 Target	Statistic	Applicable Flow	Site	Av.	Min.	Med.	95th %ile	N. samples	PC6 Target met?
NH_3-N	ppb	12.22	95th %ile.	All flows	U/S	0.53	0.01	0.13	0.71	166	✓
					D/S	0.79	0.01	0.41	2.67	166	✓
DIN	g/m³	<0.8	Av.	All flows	U/S	0.71	0.26	0.63	1.49	85	✓
					D/S	0.72	0.28	0.66	1.40	86	✓
NO_3-N	g/m³	3.6	Median	All flows	U/S	0.41	0.01	0.40	0.92	85	✓
		5.8	95th %ile		D/S	0.68	0.27	0.64	1.39	86	✓
DRP	g/m³	<0.01	Av.	<3× median	U/S	0.021	0.002	0.012	0.026	166	×
					D/S	0.028	0.003	0.022	0.066	166	×
E. coli	MPN/100 mL	<260	95th %ile	< median Summ.	U/S	403	0	32	1020	165	×
		<550		Median – 3× median Summ. <3× median Wint.	D/S	212	0	64	658	166	×
$ScBOD_5$	g/m³	2	Av.	<median	U/S	0.6	0.5	0.5	1.5	39	✓
					D/S	0.6	0.5	0.5	1.5	39	✓
POM	g/m³	5	Av.	<median	U/S	1.7	1.5	1.5	3.1	39	✓
					D/S	1.7	1.5	1.5	3.1	39	✓
Clarity	m	>3.0m	Median	< median	U/S	2.13	0.1	2.1	3.9	32	✓
					D/S	2.25	0.1	2.1	4.5	32	✓
DO sat.	%	>80	Min.	All flows	U/S	97.9	47.0	97.6	113.4	161	✓
					D/S	97.1	48.5	96.4	113.2	161	✓

3.3.1 Ammoniacal nitrogen

Between May 2005 and April 2019 statistically significant increases in NH_4-N were observed between sites on the Waipawa River upstream and downstream of the Waipawa WWTP (average increase = 0.016 g/m^3; Wilcoxon signed rank test: Z = 7.808, P <0.001). However, the magnitude of these increases appear to have reduced since July 2013 when the WWTP was upgraded (Figure 16). This is noteworthy, as the upgrades do not appear to have significantly improved NH_4-N concentrations in the discharge (see Section 3.2.3)

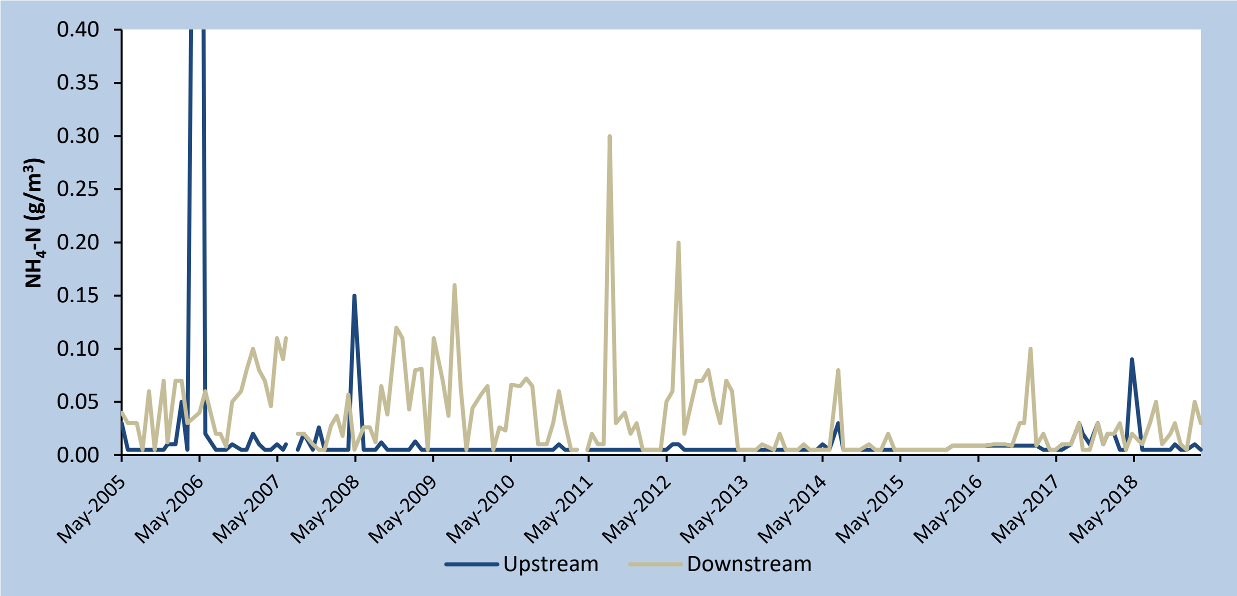

Figure 16: NH_4-N concentrations for sites sampled upstream and downstream of the Waipawa WWTP (May 2005 – April 2019)

Although NH_4-N concentrations in the Waipawa River were generally higher downstream of the Waipawa WWTP than upstream, rolling 12-month 95th percentile unionised ammonia (NH_3-N) concentrations at the downstream site between May 2005 and April 2019 were consistently below the PC6 limit[5] (maximum concentration = 4.3 ppb) (Figure 17 and Table 8). The PC6 limits are based on the application of the ANZECC (2000) guidelines with a 99% species protection level. This limit was met downstream of the Waipawa WWTP, indicating that the risk of ammonia from the discharge causing toxicity effects on aquatic fauna is low. It also indicates that the Waipawa WWTPs non-compliance with the post-upgrade effluent NH_4-N consent limits is probably not causing adverse effects on aquatic life.

[5] When converted to NH_3-N based on pH and temperature

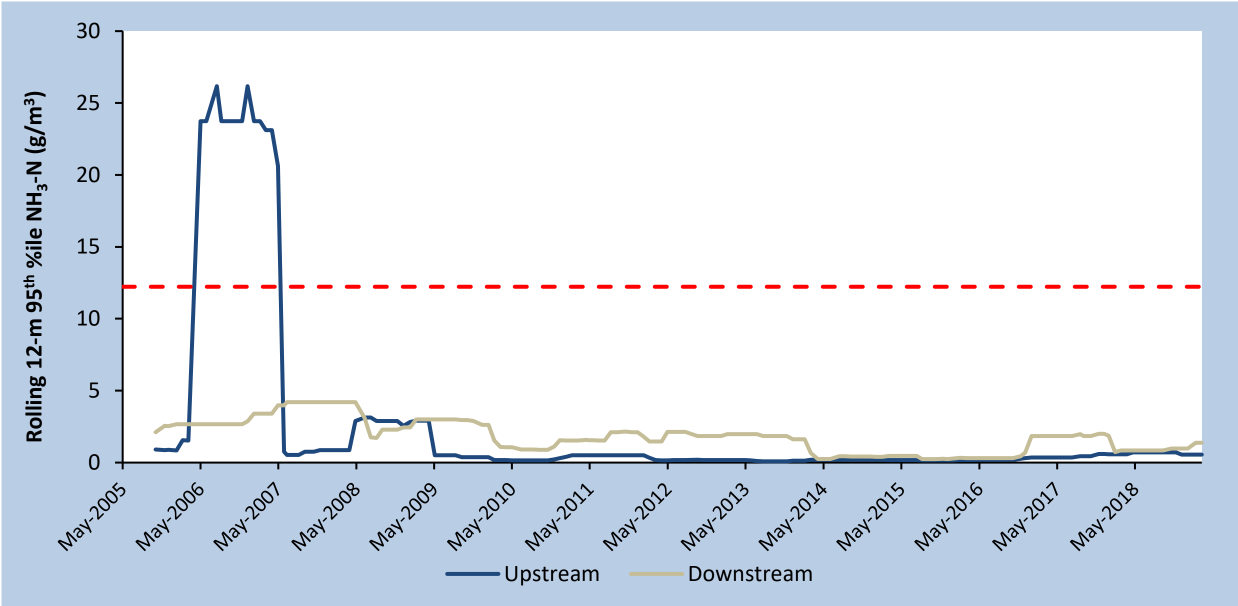

Figure 17: Rolling 12-month 95th percentile NH_3-N concentrations for sites sampled upstream and downstream of the Waipawa WWTP (May 2005 – April 2019). The red dashed line represents the PC6 limit.

3.3.2 Nitrate nitrogen

Between May 2005 and April 2019 statically significant differences in NO_3-N concentrations were not detected between sites on the Waipawa River upstream and downstream of the Waipawa WWTP (average Δ = -0.1 g/m^3; Wilcoxon signed rank test: Z = 1.526, P = 0.13) (Figure 18 and Table 8).

Rolling 12-month median and 95th percentile NO_3-N concentrations at both the upstream and downstream sites between May 2005 and April 2019 were consistently below the PC6 limits by a considerable margin (Figure 19 and Figure 20). The PC6 limits are based on the application of the Hickey (2013) guideline for the protection of 90% species from chronic nitrate toxicity. That NO_3-N concentrations at the downstream site were below these guidelines, and the guidelines for the protection of 95% of species (median = 2.4 mg/L; 95th percentile = 3.5 mg/L) indicates that the risk of nitrate from the discharge causing toxicity effects on aquatic fauna in the Waipawa River is low, and within the range deemed acceptable under the provisions of PC6.

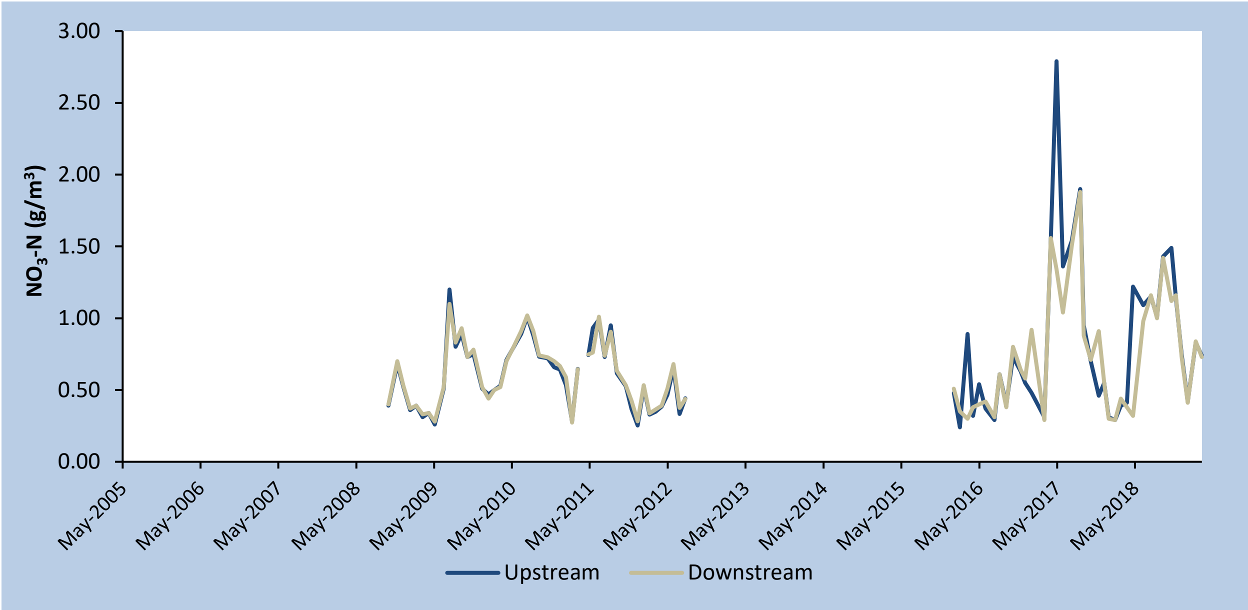

Figure 18: NO_3-N concentrations for sites sampled upstream and downstream of the Waipawa WWTP (May 2005 – April 2019)

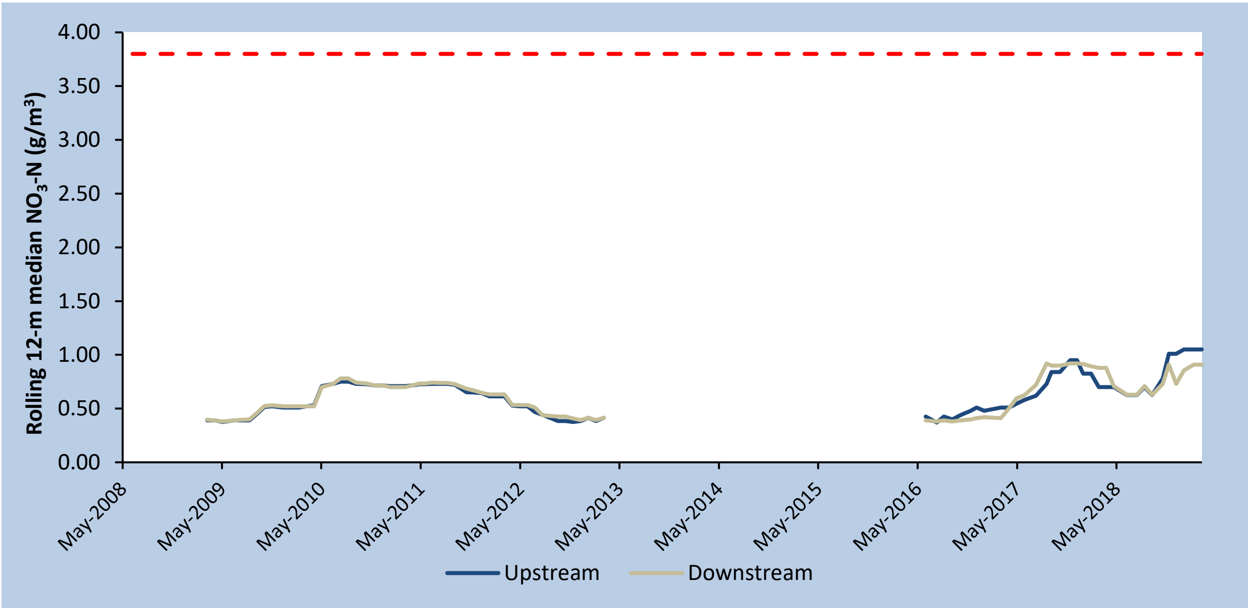

Figure 19: Rolling 12-month median NO_3-N concentrations for sites sampled upstream and downstream of the Waipawa WWTP (May 2005 – April 2019). The red dashed line represents the PC6 limit.

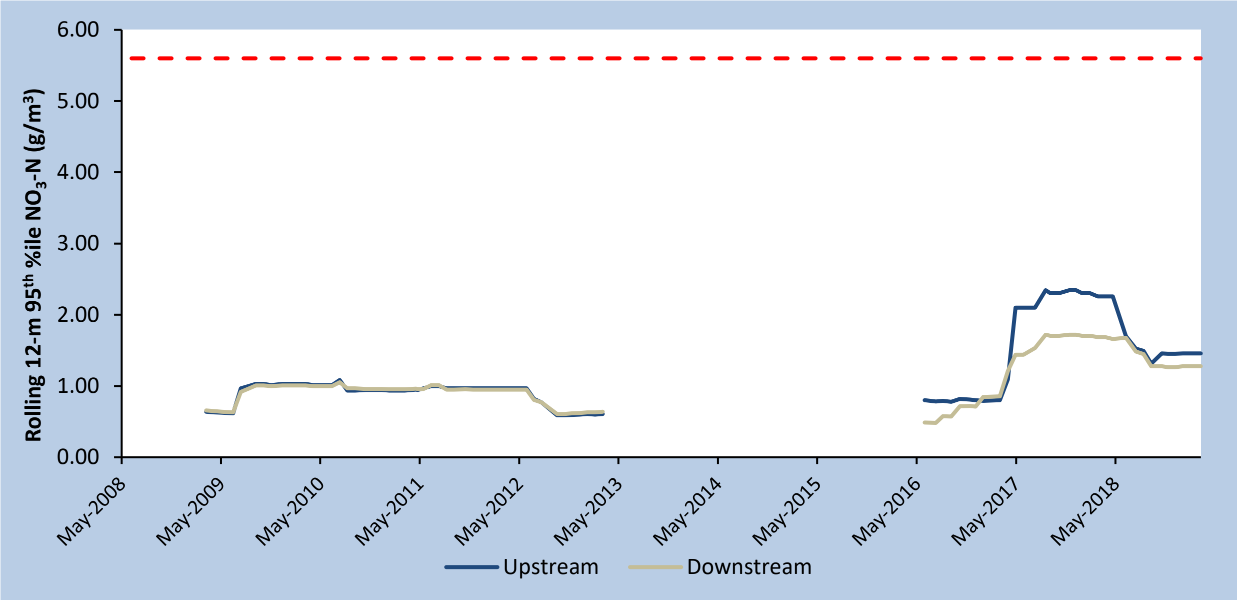

Figure 20: Rolling 12-month 95th percentile NO_3-N concentrations for sites sampled upstream and downstream of the Waipawa WWTP (May 2005 – April 2019). The red dashed line represents the PC6 limit.

3.3.3 Dissolved inorganic nitrogen

From a statistical perspective, concentrations of DIN in the Waipawa River between May 2005 and April 2019 were significantly higher downstream of the Waipawa WWTP discharge than at the upstream monitoring site (Wilcoxon signed rank test: $Z = 3.746$, $P < 0.001$). However, these increases were generally very small (average increase = 0.01 g/m^3) (Figure 21 and Table 8), and the available data suggests they were driven by the discharge of NH_4-N from the Waipawa WWTP, which only makes up a small proportion of in-river DIN compared to NO_3-N.

Between May 2005 and April 2019, rolling 5-year average DIN concentrations downstream of the discharge were consistently below the PC6 limit of 0.8 g/m^3 (maximum average concentration = 0.78 g/m^3), despite upstream concentrations exceeding the limit on 15 occasions (88% compliance) (Figure 22). Accordingly, the discharge of NH_4-N and NO_3-N from the Waipawa River does not appear to increase the risk of the PC6 DIN limit being exceeded, despite the effluent NH_4-N limit not being complied with (see Section 3.2.3). Furthermore, as DIN concentrations only increase very slightly downstream of the Waipawa WWTP, the discharge is unlikely to increase the risk of nitrogen driven nuisance periphyton growths.

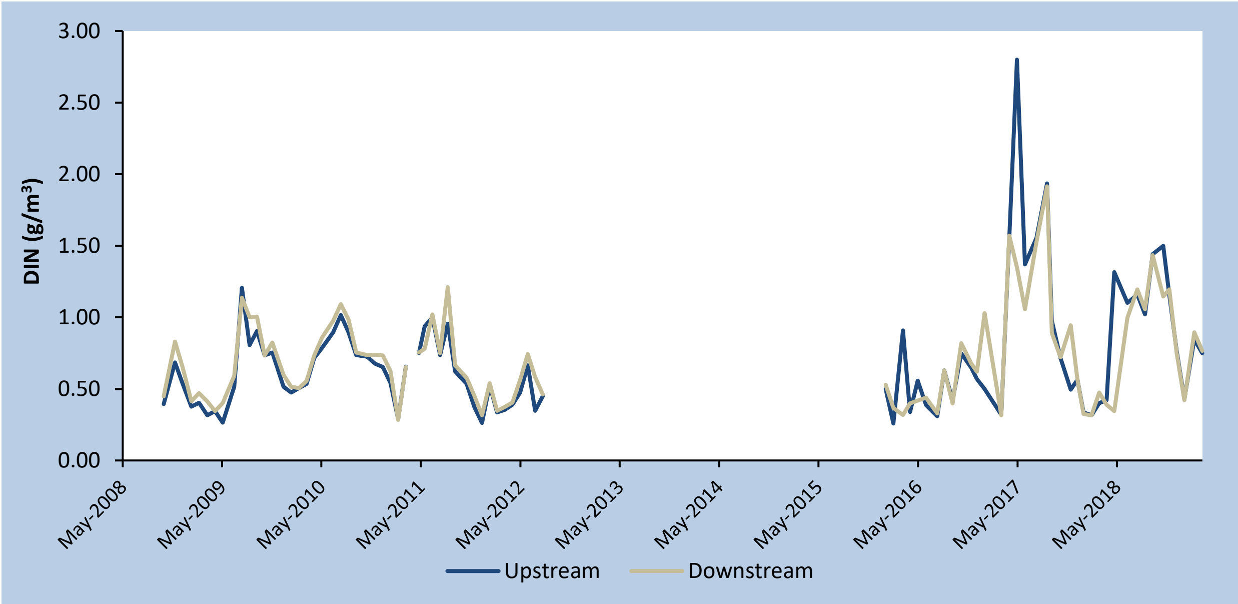

Figure 21: DIN concentrations for sites sampled upstream and downstream of the Waipawa WWTP (May 2005 – April 2019)

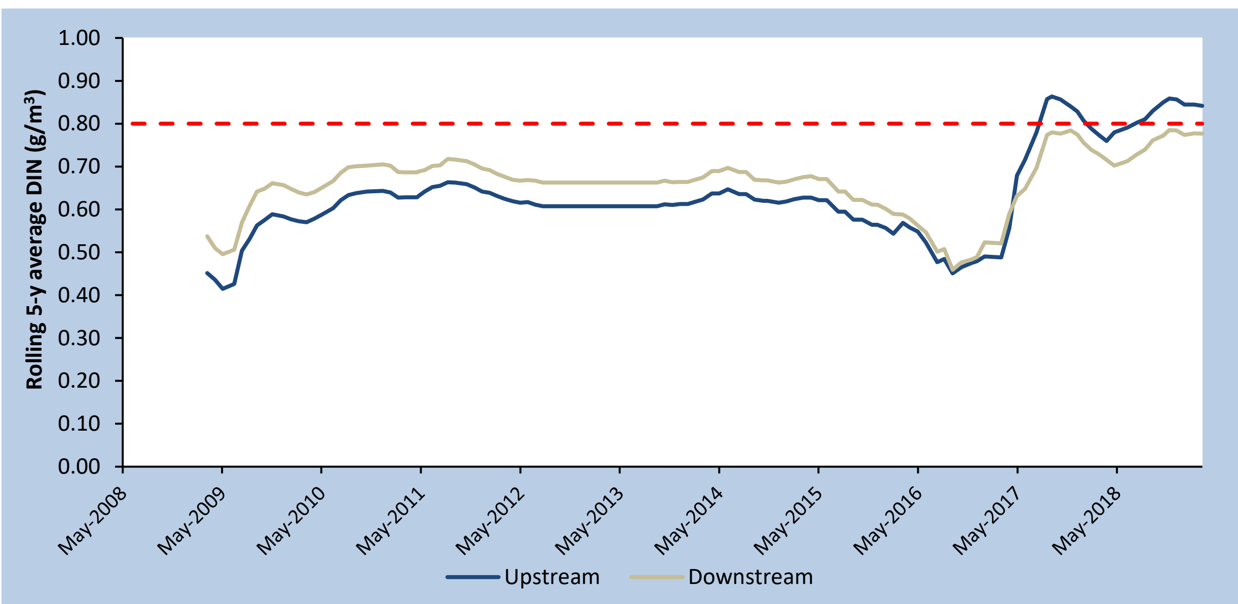

Figure 22: Rolling 5-year DIN concentrations for sites sampled upstream and downstream of the Waipawa WWTP (May 2005 – April 2019). The red dashed line represents the PC6 limit.

3.3.4 Dissolved reactive phosphorus

Between May 2005 and April 2019 statistically significant increases in DRP concentration were observed between sites upstream and downstream of the Waipawa WWTP (average increase = 0.016 g/m^3; Wilcoxon signed rank test: $Z = 12.39$, $P < 0.001$). However, the magnitude of these increases appear to have reduced since the Waipawa WWTP was upgraded in July 2013 (average Δ since = -0.006 g/m^3; median Δ = + 0.001 g/m^3) (Figure 23 and Table 8).

Since 2011, rolling 5-year average DRP concentrations in the Waipawa River at flows below 3 × median have consistently exceeded the PC6 limit of 0.01 g/m^3 both upstream and downstream of the downstream of the Waipawa WWTP discharge (Figure 24). The consistent and large exceedances of the limit at the upstream site suggests that it is not the Waipawa WWTP discharge that is causing DRP concentrations in the Waipawa River to exceed the limit; rather it is activities further upstream. Based on the most recent five years of monitoring data, a ~50% reduction in DRP downstream of the discharge at flows below the median would be needed to meet the PC6 limit, and completely removing the discharge from the river would achieve a ~28% reduction.

As DRP concentrations at the upstream and downstream sites have been similar since the plant was upgraded in 2013 (Figure 24), DRP in the discharge is unlikely to increase the risk of nuisance periphyton growths in the river. Thus, while DRP in the discharge from the Waipawa WWTP may not comply with effluent consent limits (See Section 3.2.3), this is unlikely to be affecting the river in a meaningful way.

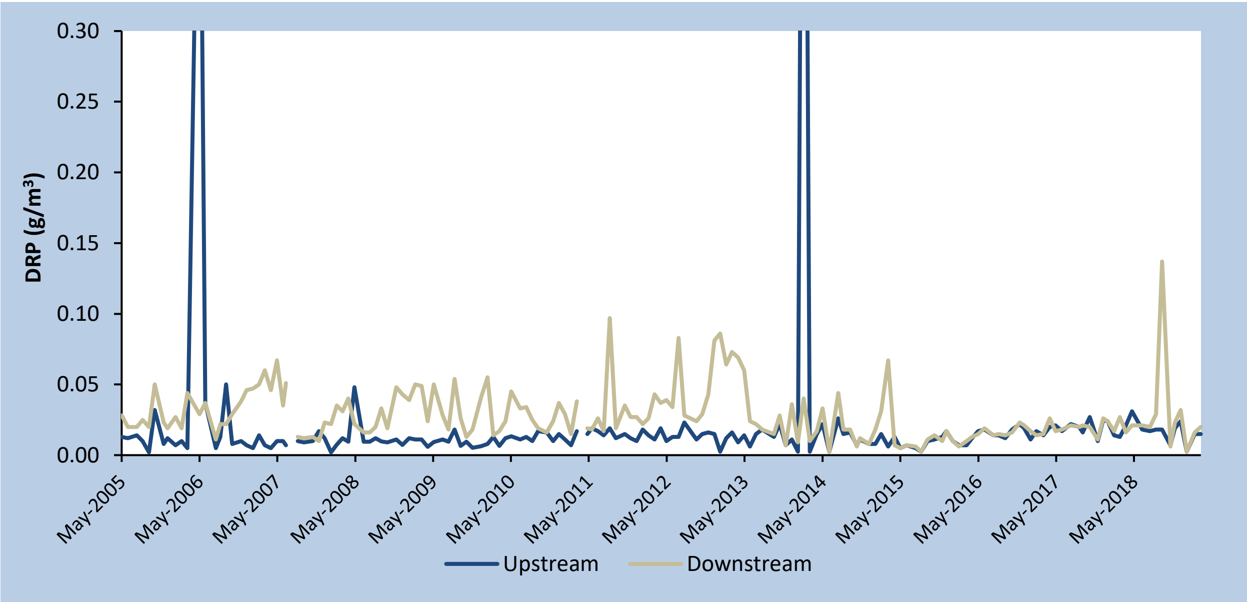

Figure 23: DRP concentrations for sites sampled upstream and downstream of the Waipawa WWTP (May 2005 – April 2019).

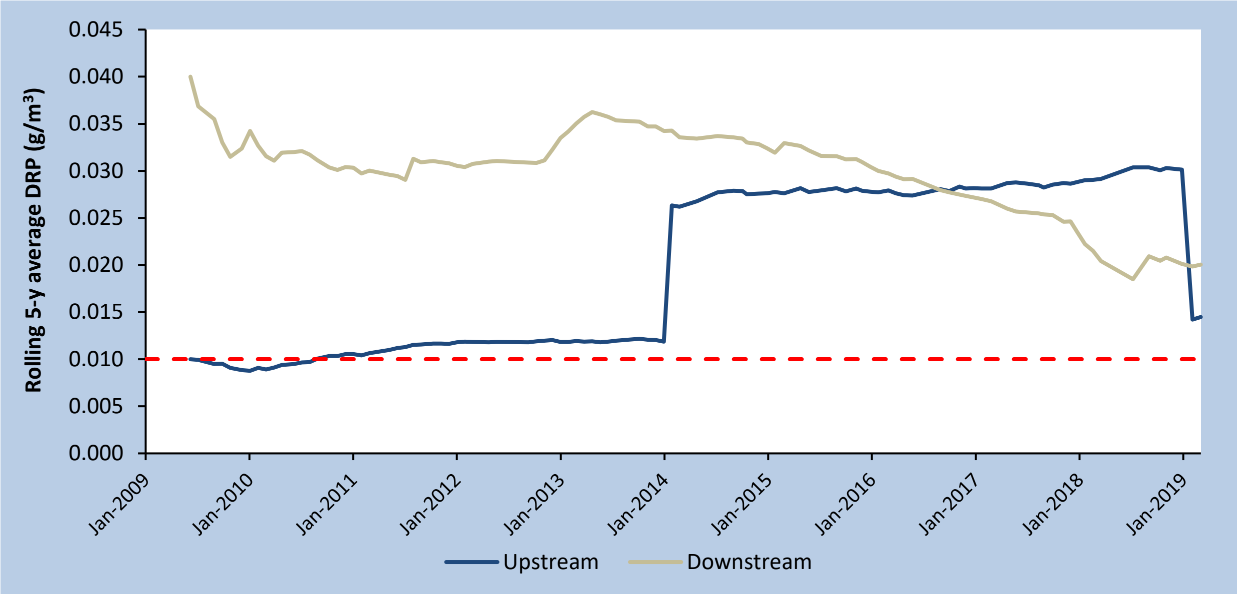

Figure 24: Rolling 5-year DRP concentrations for sites sampled upstream and downstream of the Waipawa WWTP at flows below 3× median (May 2005 – April 2019). The red dashed line represents the PC6 limit.

3.3.5 E. coli

The effects of the Waipawa WWTP discharge on *E. coli* concentrations in the Waipawa River has previously been assessed by Ausseil & Hicks (2017). They found that although the quality of the discharge exceeded the "end of pipe" *E.coli* limits set by consent conditions, these exceedances did not appear to have caused a statistically significant increase in *E. coli* concentration in the river, or an increase in the proportion of time the in-river regional plan limits were exceeded. Indeed, they found that the median increase in *E. coli* caused by the discharge was likely to be less than 1 CFU/100mL. In the analysis conducted for this memorandum, statistically significant **decreases** in *E. coli* concentrations were detected between sites on the Waipawa River upstream and downstream of the Waipawa WWTP (average decrease = 191 CFU/100mL; Wilcoxon signed rank test: $Z = 6.23$, $P < 0.001$) despite the Waipawa WWTP regularly not complying with effluent *E. coli* consent limits (Figure 25). Thus, Ausseil & Hicks (2017) conclusion that this non-compliance does not increase the risk of human health effects in the Waipawa River, or the risk of the river not meeting the PC6 *E. coli* limits, stands.

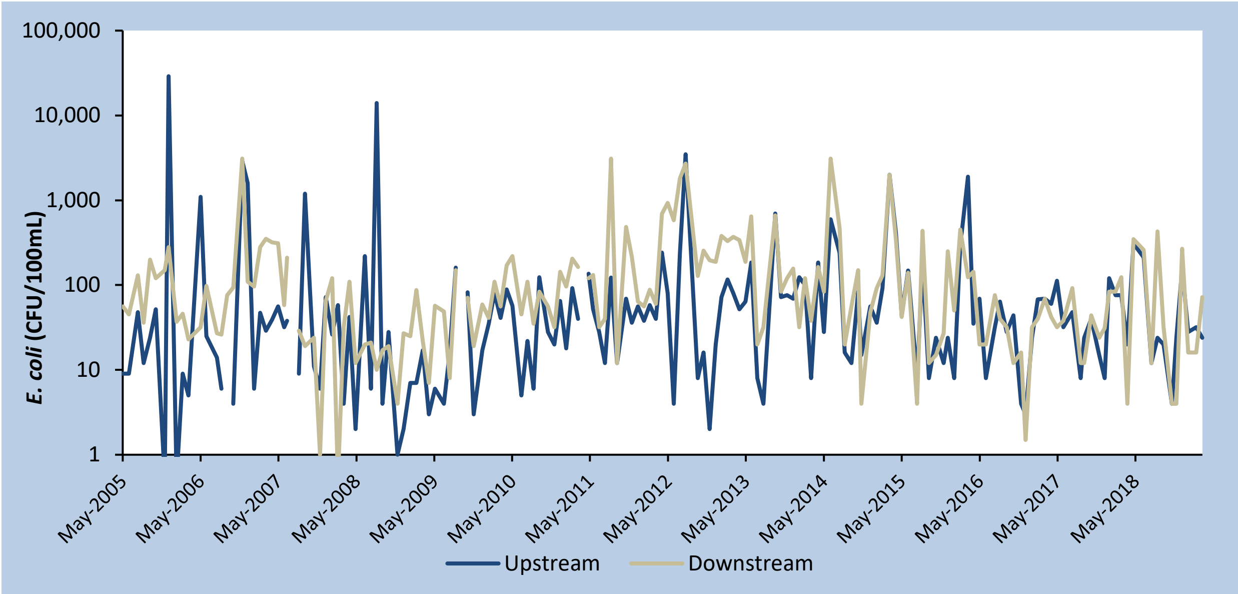

Figure 25: *E. coli* concentrations for sites sampled upstream and downstream of the Waipawa WWTP (May 2005 – April 2019).

3.3.6 Visual clarity

Between March 2016 when records began, and April 2019, visual clarity did not differ in a statistically significant manner between sites on the Waipawa River upstream and downstream of the Waipawa WWTP (average Δ = +0.012 m; Wilcoxon signed rank test: $Z = 0.956$, $P = 0.34$) (Figure 26 and Table 8).

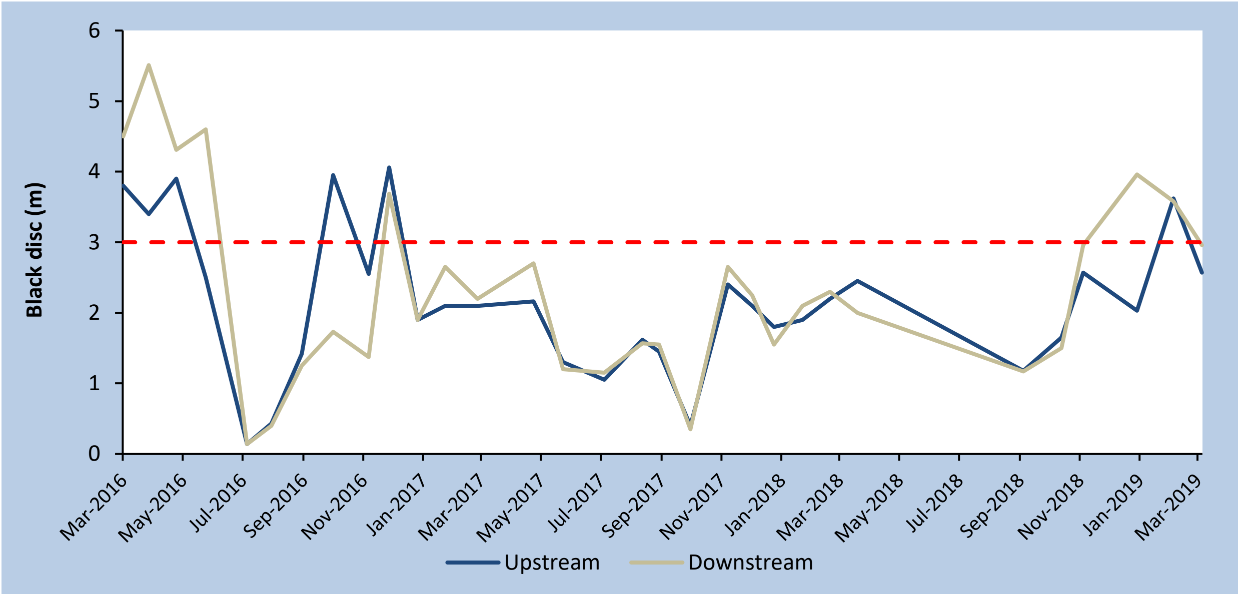

Figure 26: Visual clarity (m) measured with a black disc at sites sampled upstream and downstream of the Waipawa WWTP (March 2016 – April 2019). The red dashed line represents the PC6 indicator.

There is insufficient visual clarity data for the Waipawa River at flows below the median to calculate robust 5-year rolling averages that can be assessed against the PC6 indicator of 3.0 metres. However, when individual data points collected across all flows are considered it is likely that both sites are compliant as the indicator has only been exceeded on six occasions at the upstream site (81% compliance) and seven occasions at the downstream site (78% compliance). Furthermore, the Waipawa WWTP discharge does not generally cause non-compliance with the clarity change limit in PC6 as visual clarity has only reduced by more than 20% at flows below the median on one occasion (94% compliance). As visual clarity does not decrease significantly downstream of the discharge, or regularly drop below 3.0 metres, it is unlikely that non-compliance with the effluent TSS consent limit (see Section 3.2.3) affects the aesthetics of the river in a meaningful way, or increases the risk of the non-compliance with the PC6 water clarity indicator and limit.

3.3.7 Dissolved oxygen

Between May 2005 and April 2019 very small but statistically significant decreases in DO saturation were observed between sites on the Waipawa River upstream and downstream of the Waipawa WWTP (average decrease = 0.8%; Wilcoxon signed rank test: Z = 2.903, P = 0.004) (Figure 27 and Table 8).

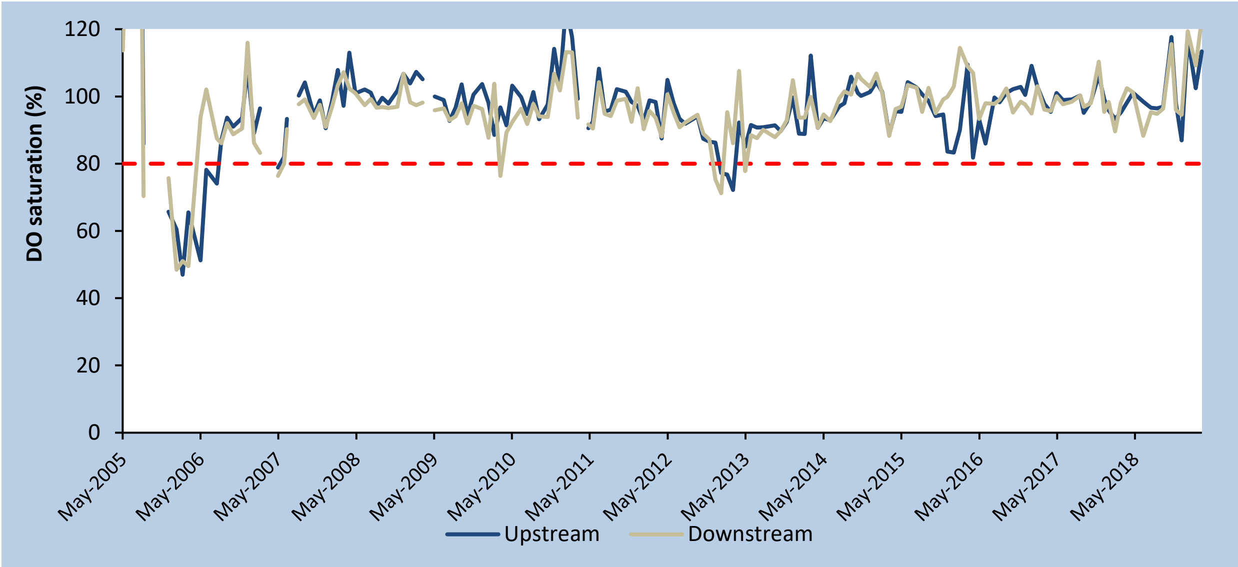

Figure 27: DO saturation for sites sampled upstream and downstream of the Waipawa WWTP (May 2005 – April 2019). The red dashed line represents the PC6 limit.

Both the upstream and downstream monitoring sites met the PC6 limit on all but 11 occasions (93% compliance) (Figure 27). Thus, compliance with the current effluent $cBOD_5$ consent limit appears to be sufficient to prevent adverse effects arising from deoxygenation of downstream receiving waters.

3.3.8 5-day carbonaceous biochemical oxygen demand and particulate organic matter

Between May 2005 and April 2019 $ScBOD_5$ and POM concentrations did not differ in a statistically significant manner between sites on the Waipawa River upstream and downstream of the Waipawa WWTP (average $ScBOD_5$ and POM Δ =0.00 g/m^3; Wilcoxon signed rank test: Z = 0.000, P = 1.00) (Figure 28, Figure 29 and Table 8).

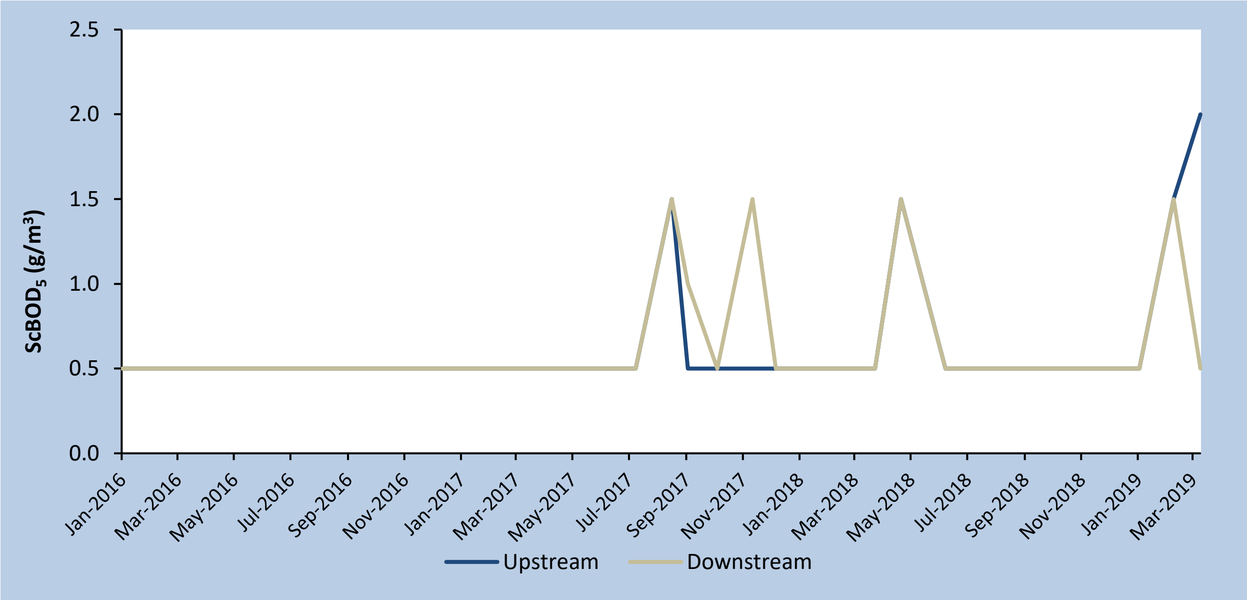

Figure 28: ScBOD5 concentrations for sites sampled upstream and downstream of the Waipawa WWTP (May 2005 – April 2019)

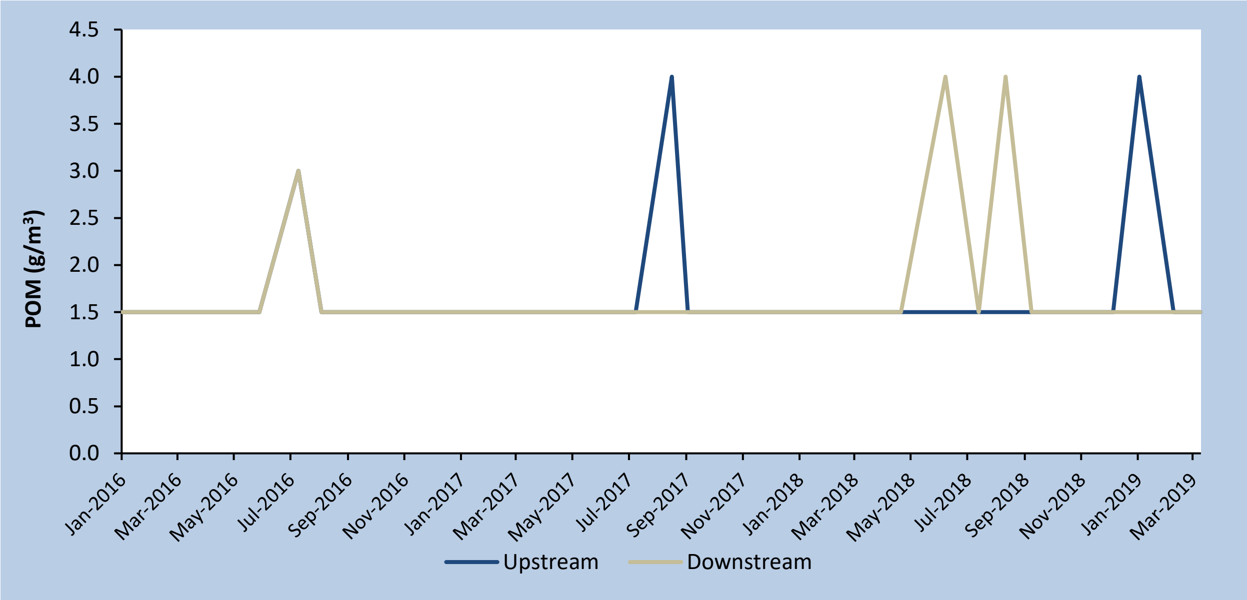

Figure 29: POM concentrations for sites sampled upstream and downstream of the Waipawa WWTP (May 2005 – April 2019)

There is insufficient $ScBOD_5$ and POM data for the Waipawa River at flows below the median to calculate robust rolling averages that can be assessed against the PC6 limits. However, when all data points collected at flows below the median are considered, average concentrations for both parameters met the limits. Thus, it can be concluded that $cBOD_5$ and TSS concentrations in the Waipawa WWTP discharge are not preventing the PC6 instream limits from being met

Table 9: Assessment of average $ScBOD_5$ and POM concentrations in the Waipawa River at flows below the median against the PC6 limits.

Parameter	Site	Average conc.	Limit	Compliant
$ScBOD_5$ (g/m^3)	U/S	0.62	2	✓
	D/S	0.60		✓
POM (g/m^3)	U/S	1.63	5	✓
	D/S	1.50		✓

3.3.9 *Quantitative macroinvertebrate community index*

Macroinvertebrate data were collected from the Waipawa River in March 2017 (Strong, 2017a) and February 2019 (Aquanet data for CHBDC) at sites 50 metres upstream of the WWTP discharge, 400 metres downstream and 1,000 metres downstream. In both 2017 and 2019, QMCI was not reduced by more than 20% between the upstream and downstream sites, and the maximum reduction observed was just 2.8% (Table 10). Thus, it can be concluded that the discharge is compliant with the PC6 QMCI limits.

Table 10: Assessment of QMCI data collected in the Waipawa River at sites upstream and downstream of the Waipawa WWTP discharge against the PC6 limit.

Year	Site	Average QMCI	%Δ	Limit %Δ	Compliant
2017	50m U/S	4.57	N/A	20	-
	400m D/S	6.64	+45		✓
	1,000m D/S	5.95	+30		✓
2019	50m U/S	7.32	N/A		-
	400m D/S	7.12	-2.8		✓
	1,000m D/S	7.49	+2.3		✓

3.4 Conclusions

From the monitoring data collected within, upstream and downstream of the Waipawa WWTP discharge between May 2005 and April 2019 the following conclusions can be made about the Waipawa WWTP discharge:

- The Waipawa WWTP discharge frequently did not meet the consent limits for discharge volume. This non-compliance was driven by frequent spikes in discharge volume rather than consistently elevated volumes. Thus, to achieve compliance with the discharge volume limits in the consent, effluent management should focus on reducing the frequency of these spikes (to less than 10% of the time) rather than reducing baseline volumes.
- The Waipawa WWTP discharge did not comply with the effluent quality limits for TSS, NH_4-N, DRP or *E. coli* . However, these non-compliances do not appear to have had a meaningful effect on water quality and ecology in the Waipawa River.
- The discharge of NH_4-N and NO_3-N from the Waipawa WWTP to the Waipawa River is unlikely to have increased the risk of ammonia/nitrate toxicity effects or excessive/nuisance plant growth in the Waipawa River, and the PC6 limits for DIN, NH_4-N and NO_3-N were all met downstream of the discharge.
- The discharge of DRP from the WWTP did not increase the risk of plant growth in the Waipawa River, and had little effect on the river's compliance with the PC6 limit, as it was already exceeded upstream of the discharge due to other human activities. Based on the most recent five years of monitoring data, a ~50% reduction in DRP downstream of the discharge at flows below the median would be needed to meet the PC6 limit. Completely removing the discharge from the river would achieve a ~28% reduction.
- TSS and $cBOD_5$ from the Waipawa WWTP did not cause a degradation in visual clarity, $ScBOD_5$, POM or DO in the Waipawa River, and did not prevent compliance with the PC6 limits for these parameters.
- The effects of the discharge on *E. coli* in the Waipawa River has been explored previously by Ausseil and Hicks (2017), who concluded that the discharge does not increase the risk of human health effects in the Waipawa River or the risk of the river not meeting the PC6 *E. coli* limits. The analysis conducted for this memorandum supports those conclusions.
- The maximum reduction in QMCI observed between sites on the Waipawa River upstream and downstream of the Waipawa WWTP discharge was just 2.8%. Thus, it can be concluded that the discharge was compliant with the PC6 QMCI limits.

4 Waipukurau WWTP results

4.1 Effluent quantity

Between July 2008 and May 2019, the Waipukurau WWTP discharge frequently did not meet the discharge volume consent limits. Annual average daily discharge volume was above the limit of 2,200 m^3/day in 2009, 2011, 2012 and 2018 and daily discharge volume exceeded 4,000 m^3/day for more than 10% of the time in 2010 (Table 11). That the average discharge volume limit was exceeded more frequently than the 90th percentile limit suggests that the main reason for non-compliance is consistently elevated volumes rather than spikes in discharge volume, (this is depicted in Figure 30).

Table 11: Assessment of compliance with the discharge volume limit set out in Condition 5 and Condition 7 of Discharge Permit DP03232Wb & DP030860Ab

12-m period ending 30th June	Days over 4,000 m^3/day	% of time over 4,000 m^3/day	Average (limit = 2,200 m^3/day)	Compliant
2009	10	3%	2321.7	✓
2010	48	13%	2174.6	×
2011	30	8%	2565.9	×
2012	13	4%	2408.2	×
2013	19	5.2%	2033.4	✓
2014	18	5%	1910.1	×
2015	10	3%	2095.5	✓
2016	9	2%	2066.4	✓
2017	17	5%	1927.4	✓
2018	23	6.3%	2337.5	×

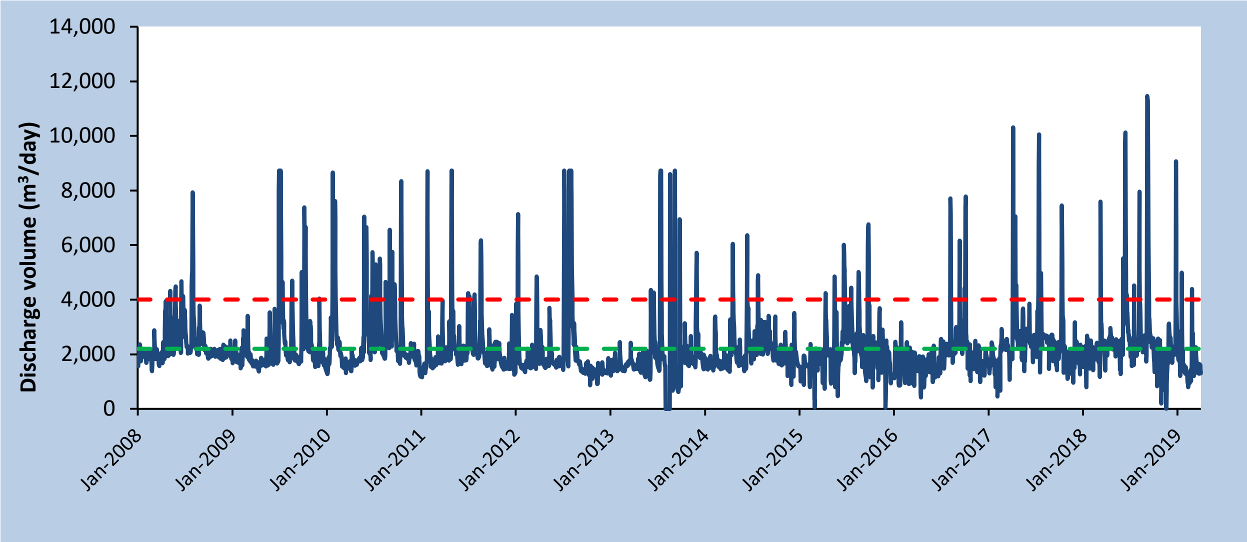

Figure 30: Daily discharge volume from the Waipukurau WWTP (January 2008 - April 2017). The green and red dashed line represents the limits for average and 90th percentile volume respectively.

4.2 Effluent quality

The treated wastewater quality data collected by CHBDC between May 2005 and April 2019 are summarised in Table 12 and depicted in Figure 31 to Figure 44.

Table 12: Summary of effluent quality from the Waipukurau oxidation pond, May 2005 – April 2019.

	TSS	$cBOD_5$	NH4-N	DRP	*E. coli*	Faecal coli.	
	(g/m³)				(CFU/100mL)		pH
Average	44.8	16.7	14.5	4.00	41,998	60,817	7.4
Min	2.9	0.5	0.0	0.00	3	3	3.4
25%ile	16.0	5.9	9.0	0.53	1,800	2,500	7.2
50%ile (median)	33.0	12.0	15.4	4.05	9,000	12,000	7.4
95%ile	120.0	46.0	26.6	9.00	161,000	260,000	7.9
Max	270.0	95.0	44.0	12.80	960,000	1,100,000	9.0
N. of Samples	359	359	358	357	359	359	359
Pre-upgrade lower/upper limit	45/96	30/39	NA	NA	NA	75,000/N/A	6.5-8.5
Post-upgrade lower/upper limit	30/50	20/30	6/10	0.25/0.5	800/4000	NA	6.5-8.5
Pre-upgrade compliance (%)	75/85	98/79	NA	NA	NA	48	98
Post-upgrade compliance (%)	41/24	59/49	3/0	13/3	25/0	NA	

4.2.1 <u>5-day carbonaceous biochemical oxygen demand</u>

$cBOD_5$ concentrations in the discharge from the Waipukurau WWTP have been improving since August 2014, when the plant was upgraded (Figure 31), and are generally compliant with both the pre-upgrade and post-upgrade $cBOD_5$ consent limits. Between May 2005 and April 2019, $cBOD_5$ concentrations only exceeded the pre-upgrade lower limit of 30 g/m^3 more than 16 times in eight 12-month periods (98% compliance), and while the post-upgrade lower limit of 20 g/m^3 was exceeded more than 16 times in 145 12-month periods (59% compliance), all instances of non-compliance occurred prior to the plant being upgraded in August 2014 (Figure 32). Similarly, while the pre-upgrade (39 g/m^3) and post-upgrade (30 g/m^3) upper limits were exceeded in 73 (79% compliance) and 182 (49% compliance) 12-month periods respectively, all non-compliances were prior to the 2014 upgrades (Figure 33)

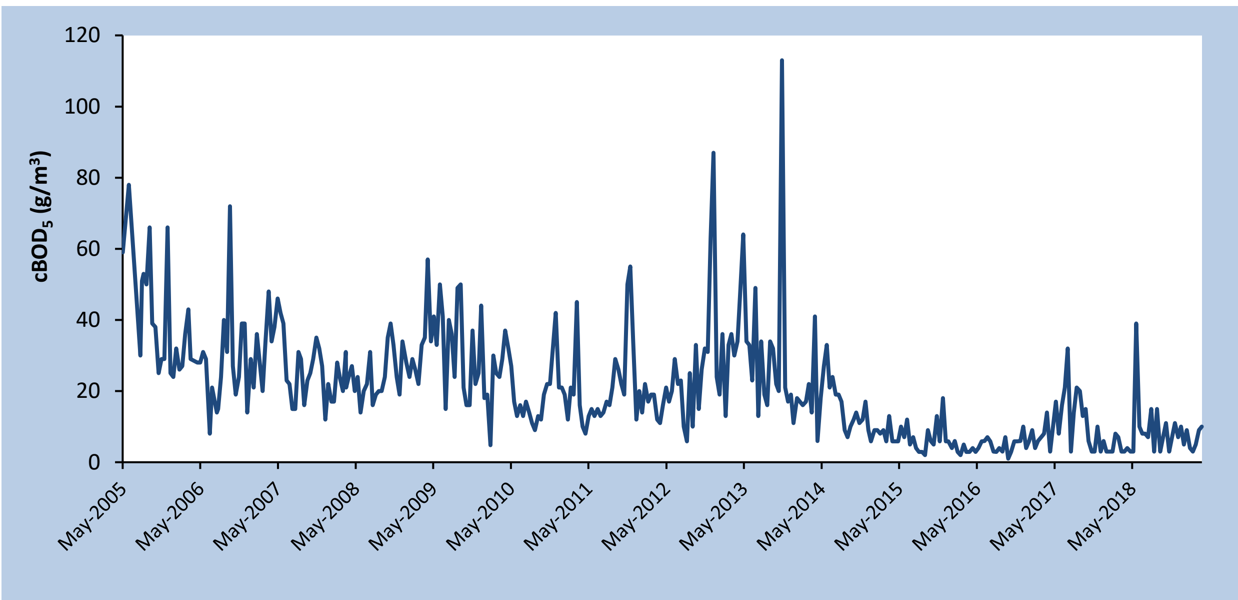

Figure 31: $cBOD_5$ concentrations from the Waipukurau oxidation pond prior to discharge (May 2005 – April 2019).

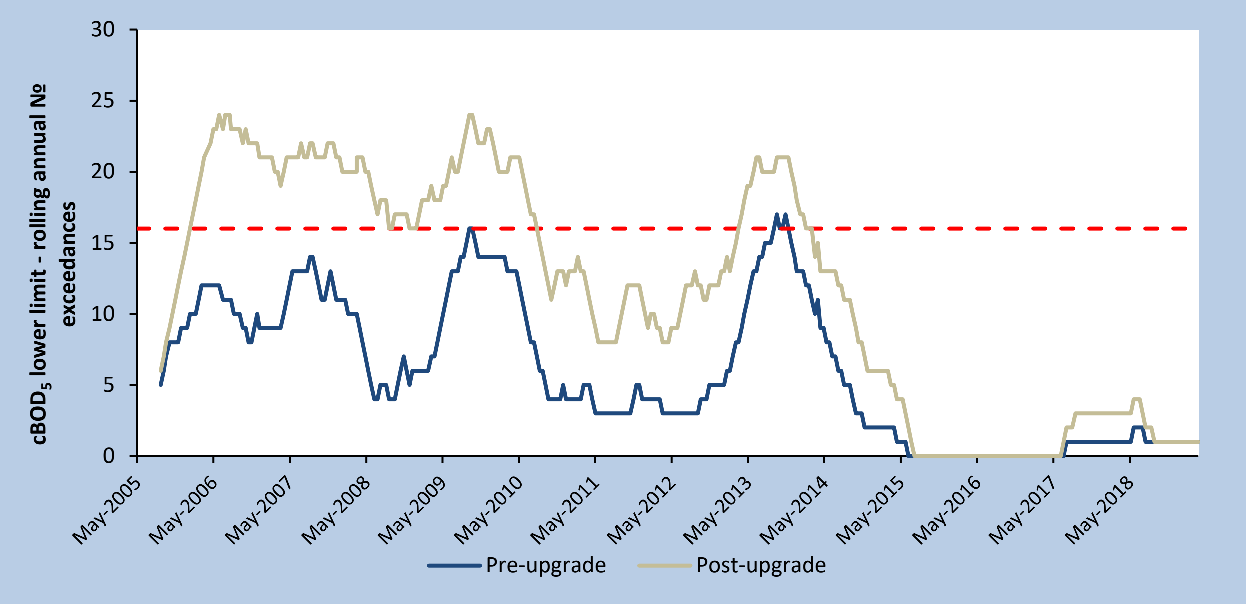

Figure 32: The number of times in each 12-month period that the pre-upgrade and post-upgrade lower consent limits for cBOD$_5$ were exceeded. The red dashed line represents the allowable number of exceedances.

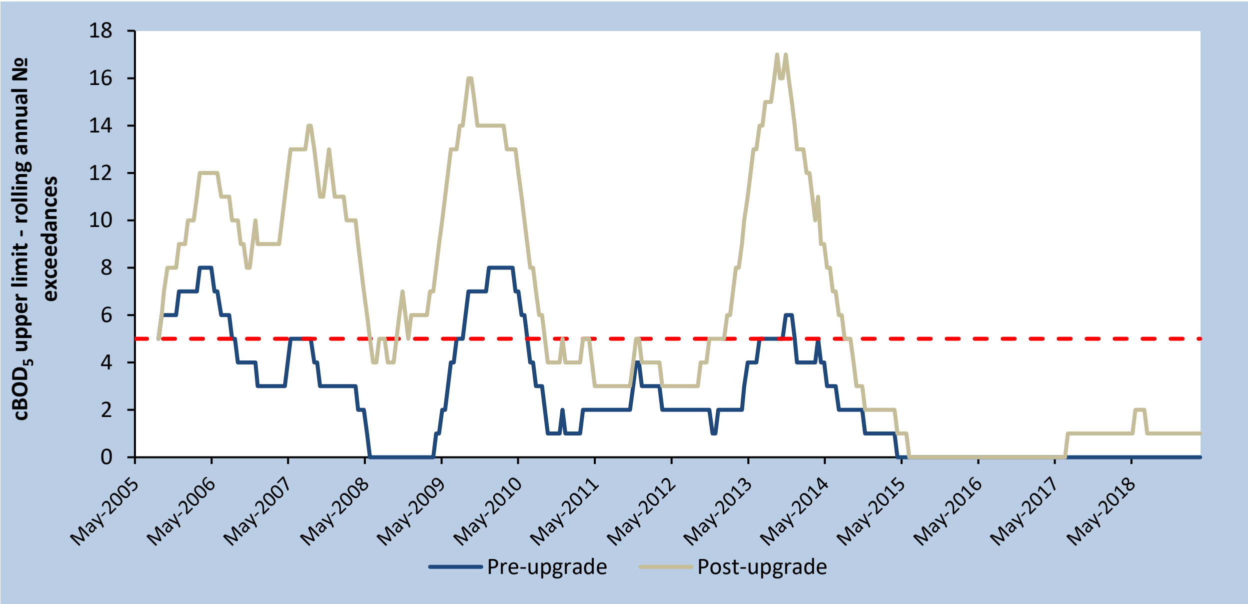

Figure 33: The number of times in each 12-month period that the pre-upgrade and post-upgrade upper consent limits for cBOD$_5$ were exceeded. The red dashed line represents the allowable number of exceedances.

4.2.2 *Total suspended solids*

As with $cBOD_5$, TSS concentrations in the discharge improved noticeably after the WWTP was upgraded in August 2014 (Figure 34). However, TSS concentrations appear to have increased again since mid-2017. As a result, whilst the upgrades temporarily improved compliance with the pre-upgrade and post-upgrade consent limits, both are now generally not complied with. Between May 2005 and April 2019, TSS concentrations exceeded the pre-upgrade (45 g/m^3) and post-upgrade (30 g/m^3) lower limits more than 16 times in 90 (41% compliance) and 210 (75% compliance) 12-month periods respectively, with the most recent non-compliance of the post-upgrade lower limit occurring in April 2019 (Figure 35 and Table 12). The pre-upgrade (96 g/m^3) and post-upgrade (50 g/m^3) upper limits were exceeded on 55 (85% compliance) and 270 (24% compliance) 12 month periods respectively (Table 12), with the post-upgrade limit being breached multiple times in the last 18 months (Figure 36).

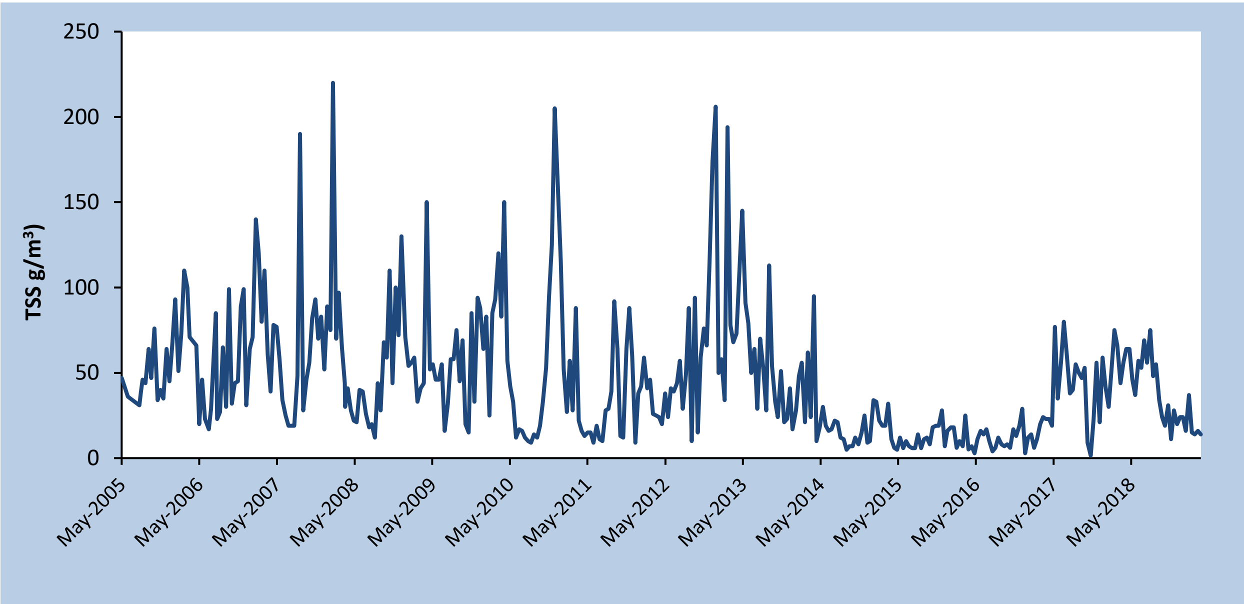

Figure 34: TSS concentrations from the Waipukurau oxidation pond prior to discharge (May 2005 – April 2019)

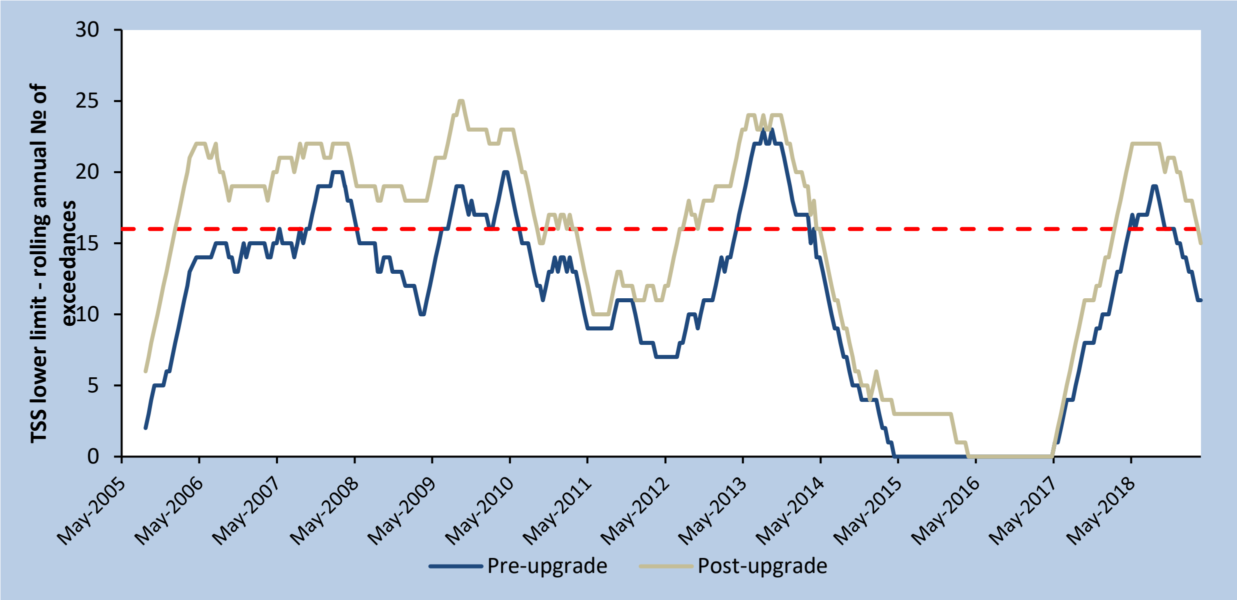

Figure 35: The number of times in each 12-month period that the pre-upgrade and post-upgrade lower consent limits for TSS were exceeded. The red dashed line represents the allowable number of exceedances.

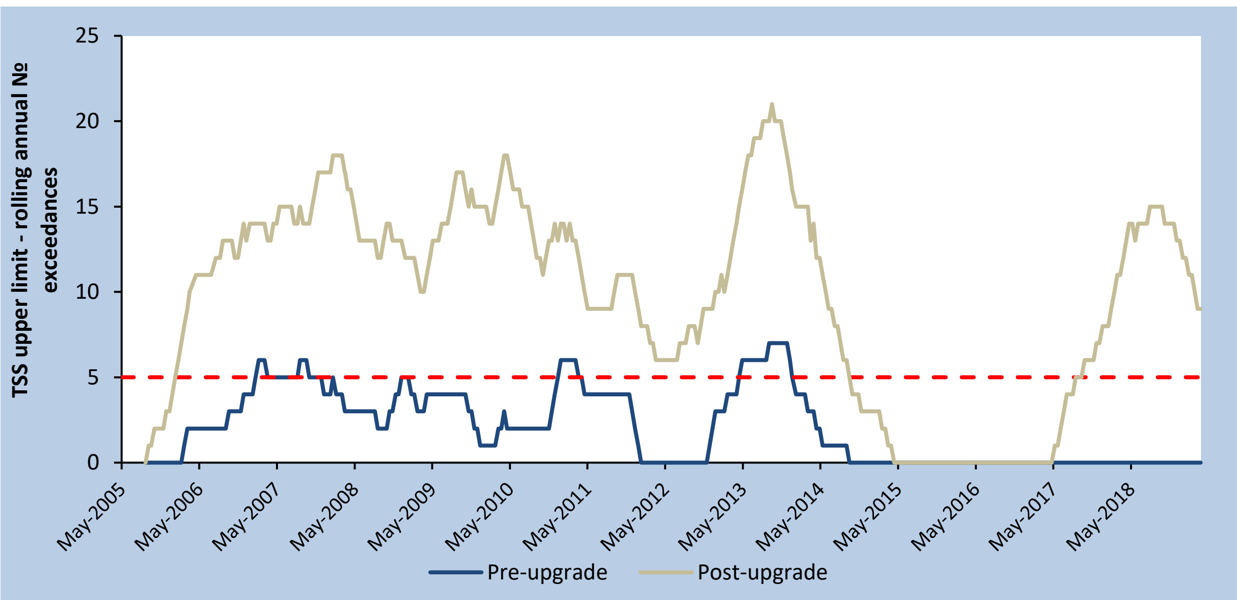

Figure 36: The number of times in each 12-month period that the pre-upgrade and post-upgrade upper consent limits for TSS were exceeded. The red dashed line represents the allowable number of exceedances.

4.2.3 Ammoniacal nitrogen, dissolved reactive phosphorus and E. coli

NH_4-N, DRP and *E. coli* concentrations in the Waipukurau WWTP discharge do not comply with the limits set in the conditions of the consent. Between May 2005 and April 2019, concentrations of all three parameters regularly exceeded the lower (Figure 37) and upper limits (Figure 38) more frequently than allowed by the consent (16 and 5 times in a 12-month period respectively), and the rate of compliance was less than 25% for all specified limits (Table 12).

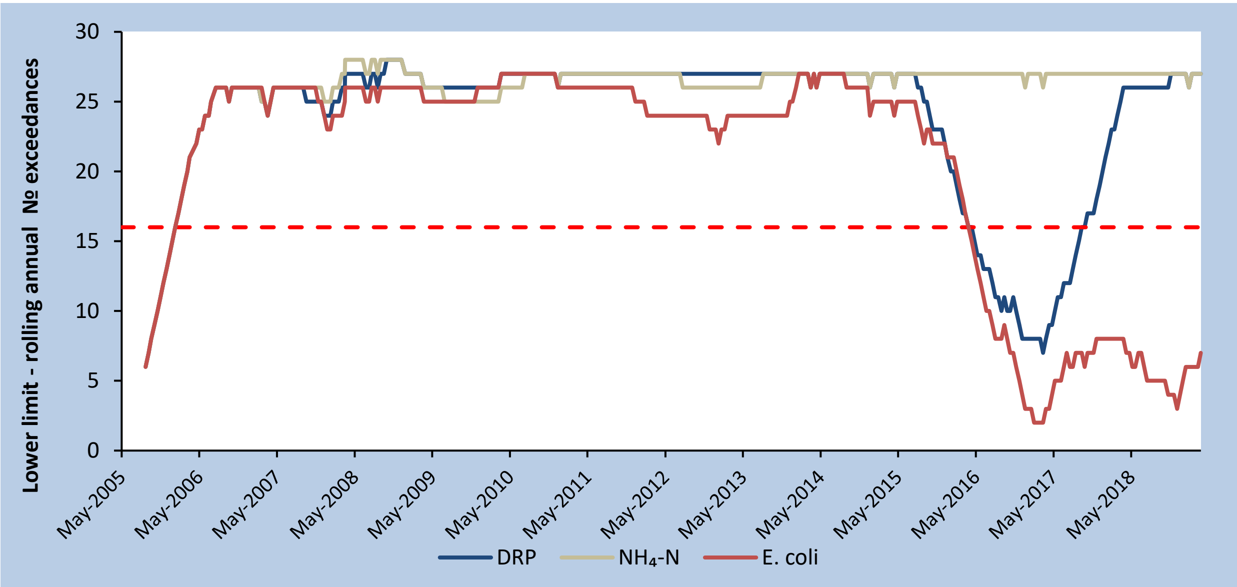

Figure 37: The number of times in each 12-month period that the post-upgrade lower consent limits for DRP, NH_4-N and *E. coli* were exceeded. The red dashed line represents the allowable number of exceedances.

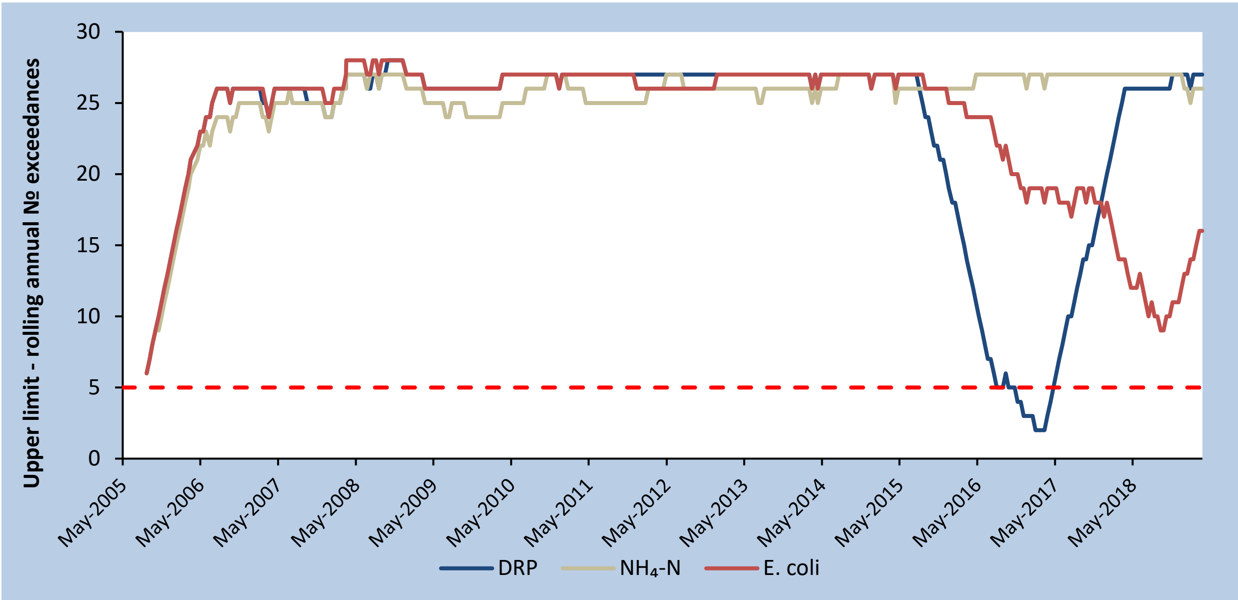

Figure 38: The number of times in each 12-month period that the post-upgrade upper consent limits for DRP, NH_4-N and *E. coli* were exceeded. The red dashed line represents the allowable number of exceedances.

While DRP and *E. coli* concentrations in the Waipukurau WWTP discharge do not currently comply with consent limits, they did improve noticeably after the August 2014 plant upgrades (Figure 39 and Figure 40). DRP concentrations responded rapidly after the upgrades, but have been increasing since early 2017 (Figure 39). In contrast, *E. coli* concentrations have reduced over a greater period of time, with the most noticeable effect of the upgrades being smaller peaks in the dataset (Figure 40). Unlike with DRP, *E. coli* levels have not started increasing again after the initial decline (Figure 40). NH_4-N concentrations in the discharge do not appear to have decreased significantly since the upgrades (Figure 41)

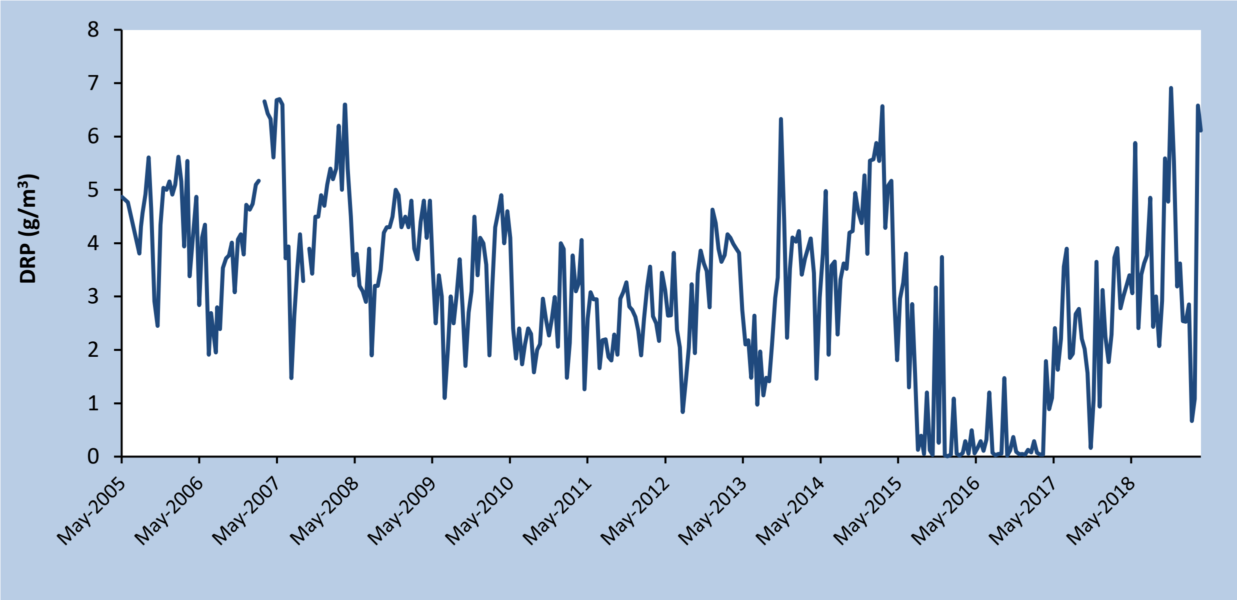

Figure 39: DRP concentrations from the Waipukurau oxidation pond prior to discharge (May 2005 – April 2019)

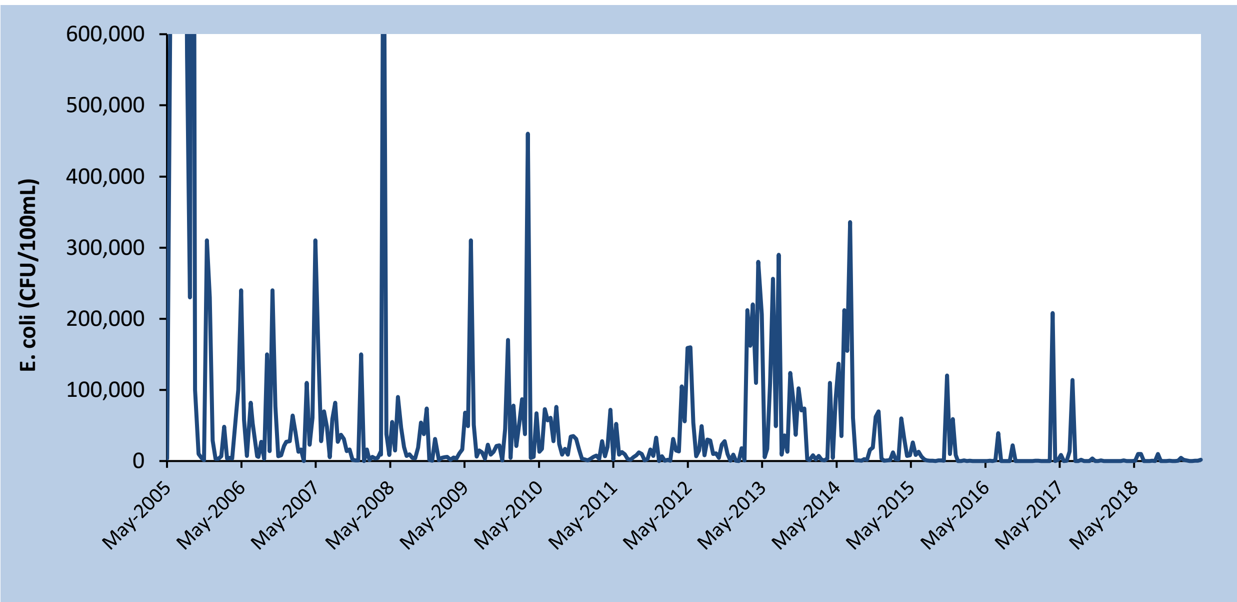

Figure 40: *E. coli* concentrations from the Waipukurau oxidation pond prior to discharge (May 2005 – April 2019)

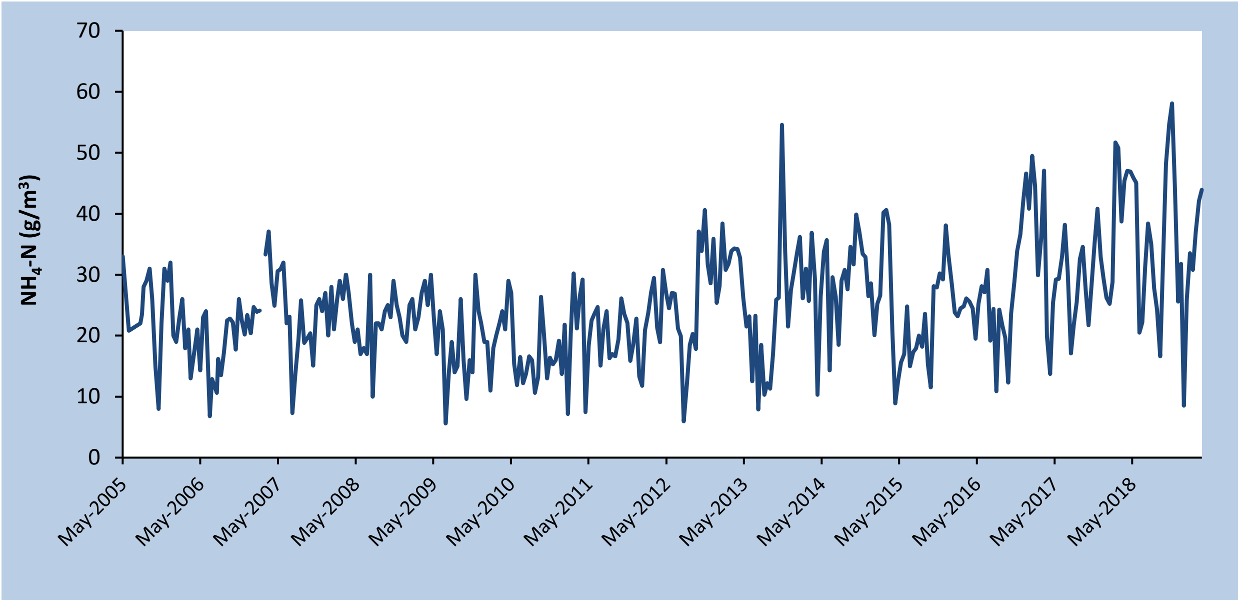

Figure 41: NH_4-N concentrations from the Waipukurau oxidation pond prior to discharge (May 2005 – April 2019).

4.2.4 Faecal coliforms

Since the Waipukurau WWTP was upgraded in August 2014, the magnitude of faecal coliform concentration spikes have noticeably reduced (Figure 42), and concentrations are now compliant with the pre-upgrade consent limit of 75,000 CFU/100mL. Between May 2005 and April 2019 faecal coliform exceeded the pre-upgrade limit of 75,000 CFU/100mL more than five times in 183 12-month periods (Figure 43 and Table 12), but all instances of non-compliance occurred prior to August 2015 (Figure 43).

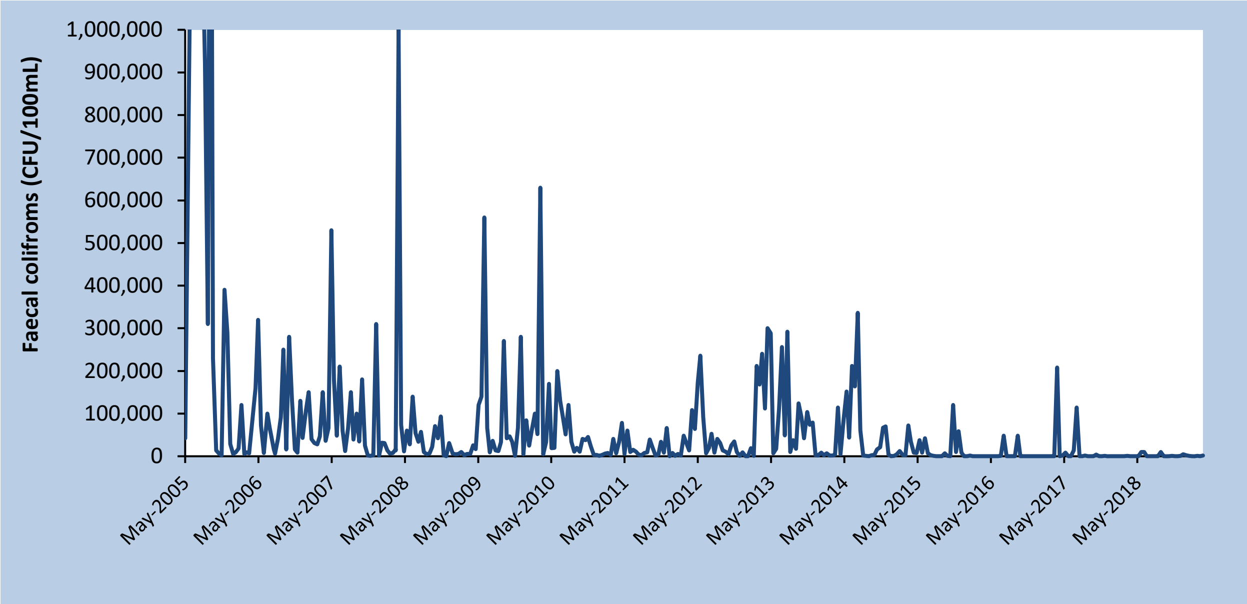

Figure 42: Faecal coliform concentrations from the Waipukurau oxidation pond prior to discharge (May 2005 – April 2019)

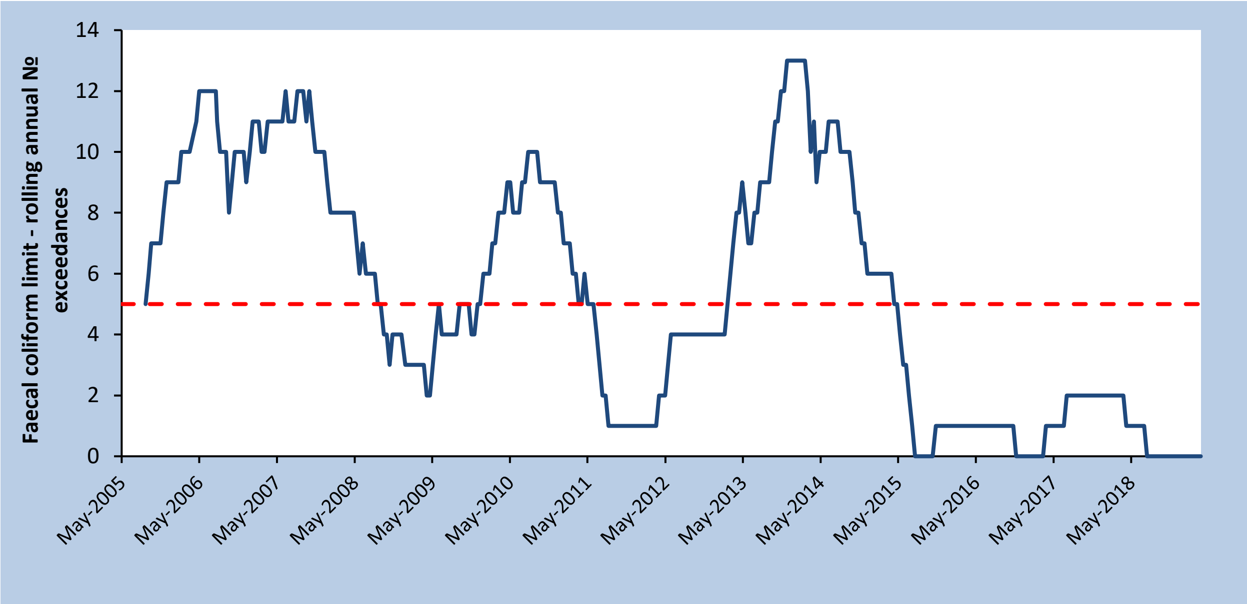

Figure 43: The number of times in each 12-month period that the pre-upgrade consent limit for faecal coliforms were exceeded. The red dashed line represents the allowable number of exceedances.

4.2.5 pH

pH in discharge from the Waipukurau WWTP is generally compliant with the limits set out in the conditions of the consent, and between May 2005 and April 2019 pH was only outside the limit range of 6.5 – 8.5 on eight occasions (98% compliance) (Figure 44 and Table 12).

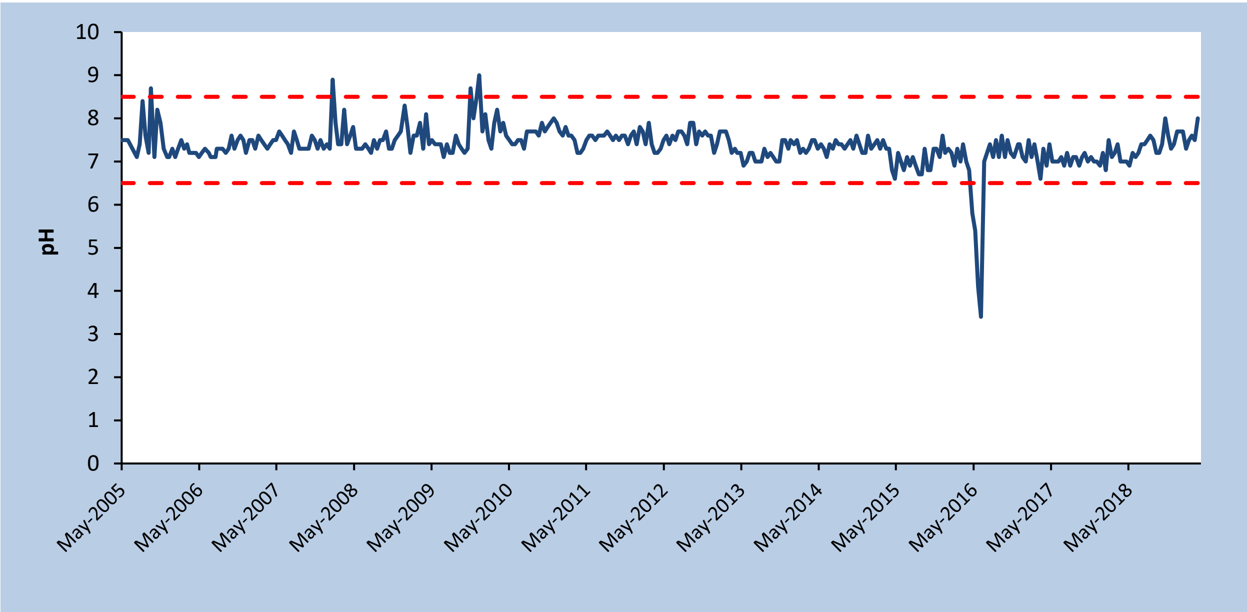

Figure 44: pH in the Waipukurau oxidation pond prior to discharge (May 2005 – April 2019). The dashed red lines represent the upper and lower consent limits

4.3 In-stream water quality

Water quality data collected between May 2005 and April 2019 upstream and downstream of where the Waipukurau WWTP discharge enters the Tukituki River are presented in Figure 45 to Figure 62. Key water quality parameters are summarised and assessed against the relevant PC6 limits/targets in Table 13.

Table 13: Summary of key water quality determinants measured in the Tukituki River upstream and downstream of the Waipukurau WWTP discharge, and assessment against PC6 limits/targets. May 2005 – April 2019. The most relevant assessment statistics are shaded.

Para.	Unit	PC6 Target	Statistic	Applicable Flow	Site	Av.	Min.	Med.	95th %ile	N. samples	PC6 Target met?
NH_3-N	ppb	12.22	95th %ile.	All flows	U/S	1.67	0.02	0.18	7.93	166	✓
					D/S	3.21	0.02	1.53	12.24	166	×
DIN	g/m³	<0.8	Av.	All flows	U/S	1.47	0.26	1.21	3.08	39	×
					D/S	1.63	0.43	1.44	3.12	39	×
NO_3-N	g/m³	3.6	Median	All flows	U/S	1.41	1.16	2.98	3.21	39	✓
		5.8	95th %ile		D/S	1.52	1.36	3.05	3.86	39	✓
DRP	g/m³	<0.01	Av.	<3× median	U/S	0.03	0.00	0.02	0.07	166	×
					D/S	0.04	0.00	0.03	0.09	166	×
E. coli	MPN/100 mL	<260	95th %ile	< median Summ.	U/S	326	0	56	1150	166	✓
		<550		Median – 3× median Summ. <3× median Wint.	D/S	417	0	84	1250	166	✓
ScBOD₅	g/m³	2	Av.	<median	U/S	0.6	0.5	0.5	1.1	39	✓
					D/S	0.5	0.5	0.5	1.0	39	✓
POM	g/m³	5	Av.	<median	U/S	1.7	1.5	1.5	1.9	39	✓
					D/S	1.6	1.5	1.5	1.7	39	✓
Clarity	m	>3.0m	Median	< median	U/S	2.0	0.1	2.0	3.7	27	×
					D/S	1.8	0.1	1.9	3.16	30	×
DO sat.	%	>80	Min.	All flows	U/S	97.3	40.8	94.9	121.5	162	✓
					D/S	98.3	5.2	96.4	123.6	162	✓

4.3.1 Ammoniacal nitrogen

Between May 2005 and April 2019 statistically significant increases in NH_4-N were observed between sites on the Tukituki River upstream and downstream of the Waipukurau WWTP (average increase = 0.09 g/m^3; Wilcoxon signed rank test: Z = 6.503, P <0.001). However, the magnitude of these increases appear to have reduced since August 2014 when the plant upgrades were installed (Figure 45 and Table 13). As with Waipawa, this is unusual as the upgrades do not appear to have significantly improved NH_4-N concentrations in the discharge (see Section 4.2.3)

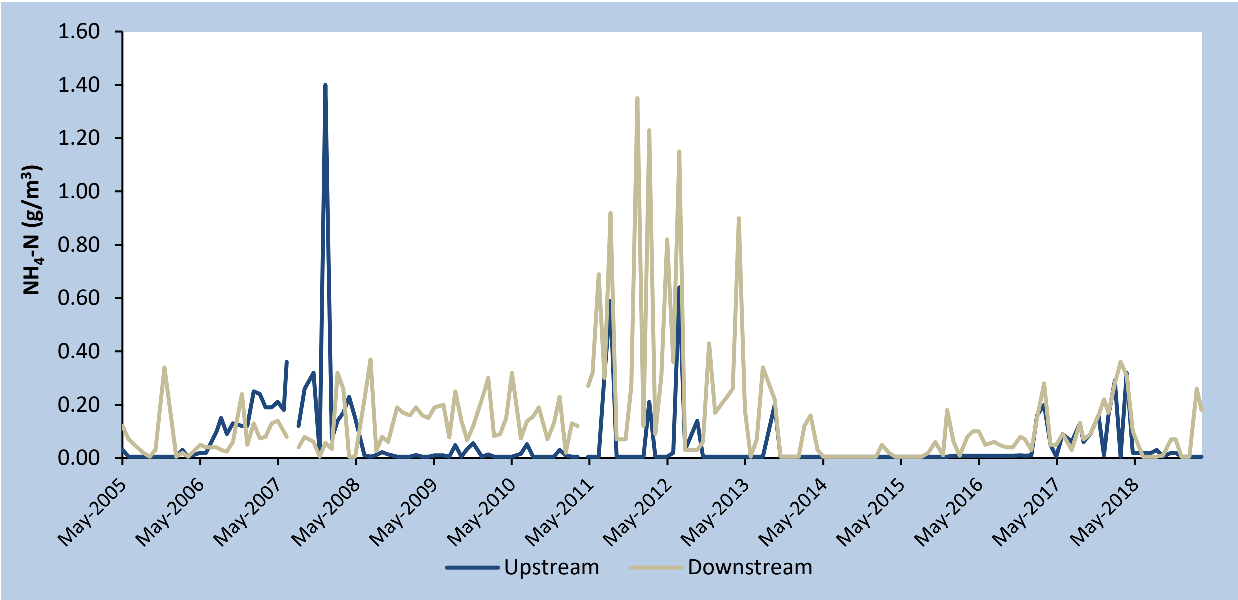

Figure 45: NH_4-N concentrations for sites sampled upstream and downstream of the Waipukurau WWTP (May 2005 – April 2019)

Between May 2005 and April 2019, rolling 12-month 95th percentile NH_3-N concentrations upstream of the Waipukurau WWTP were below the PC6 limit[6] of 12.2 ppb 91% of the time (Figure 46 and Table 12), and all non-compliances were the result of two spikes in concentration in June and December 2007 (Figure 46). In contrast, rolling 12-month 95th percentile NH_3-N concentrations downstream of the discharge exceeded the PC6 limit 26% of the time (Figure 46 and Table 12), and it appears that the currently non-compliant effluent NH_4-N concentrations (see Section 4.2.3) are resulting in the exceedance of the PC6 limit and have the potential to cause toxicity effects. This is supported by the results of more in-depth analysis of the available pH, temperature and NH_4-N concentrations previously undertaken by Ausseil & Death (2016 & 2017), who also demonstrated that the discharge causes the PC6 limit to be exceeded on occasion.

[6] When converted to NH_3-N based on pH and temperature

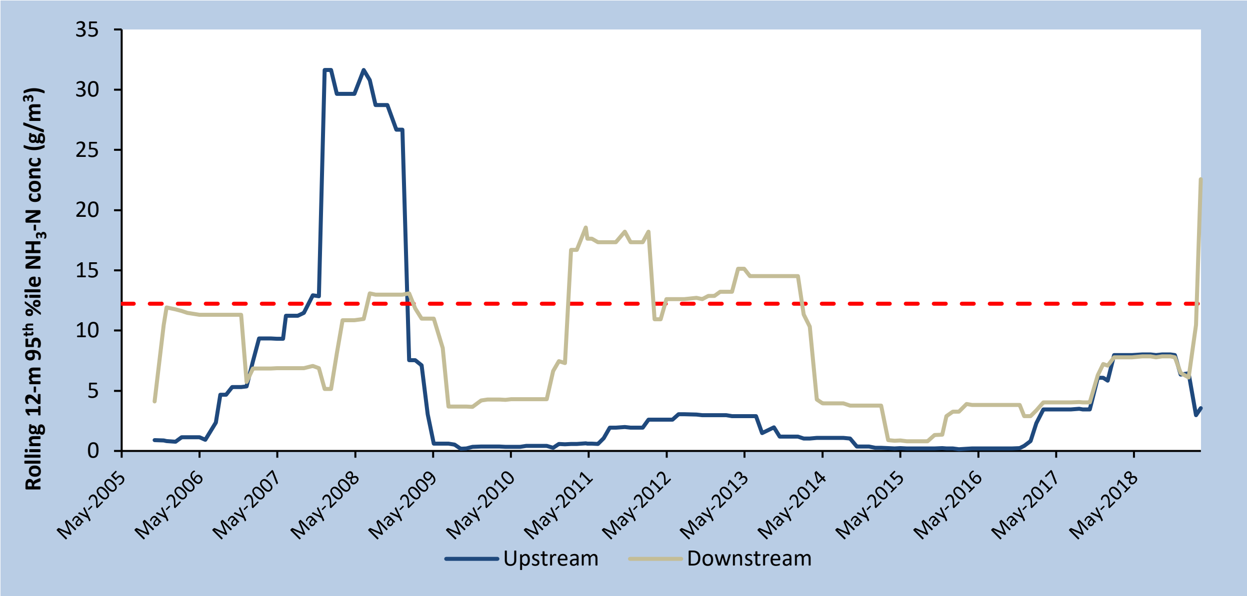

Figure 46: Rolling 12-month 95th percentile NH_3-N concentrations for sites sampled upstream and downstream of the Waipukurau WWTP (May 2005 – April 2019). The red dashed line represents the PC6 limit.

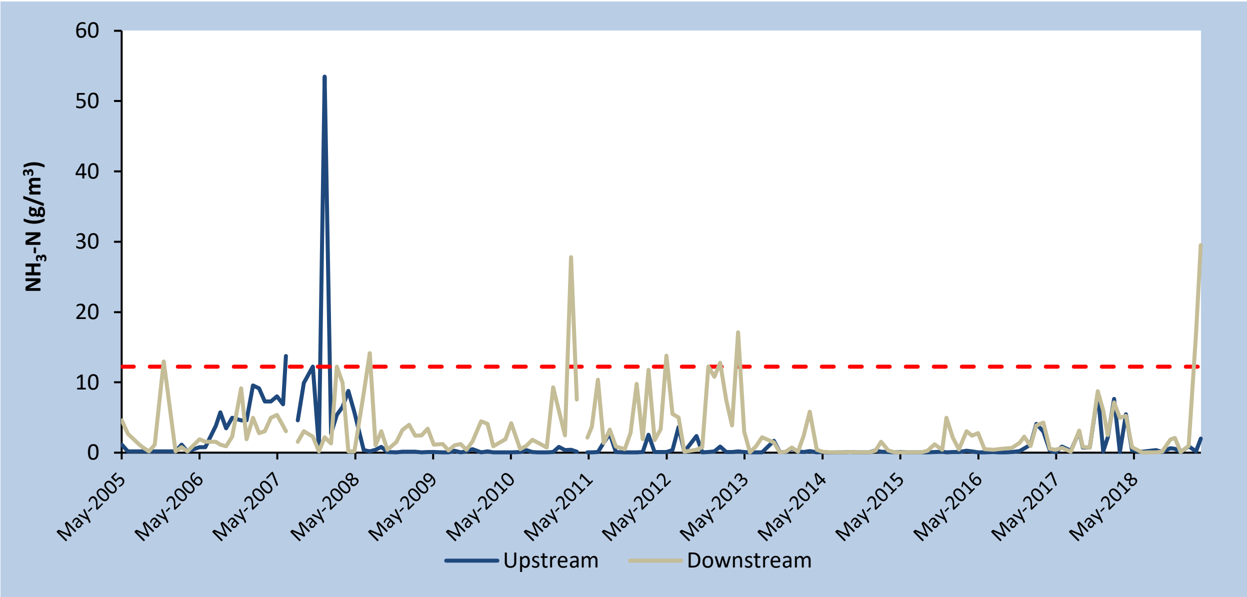

Figure 47: NH_3-N concentrations for sites sampled upstream and downstream of the Waipukurau WWTP (May 2005 – April 2019). The red dashed line represents the PC6 limit.

It is noted that non-compliance with the PC6 limit was the result of concentrations exceeding the limit on just 10 occasions, nine of which occurred between November and May (Table 14). Furthermore, on all seven occasions when NH_3-N concentrations exceeded the PC6 limit and flow in the Tukituki River was measured, it was below median flow. Indeed, on five occasions flow was near or below half median. Thus, non-compliances could be avoided by either not discharging to the Tukituki River over the summer period when flows are below the median (or at the very least half median), and/or reducing the concentration of NH4-N in the discharge by way of additional treatment during that period.

Table 14: Assessment of the seasonal and river-flow conditions when NH_3-N concentrations in the Tukituki River exceeded the PC6 limit below the Waipukurau WWTP.

Date	Month	River Flow (L/s)	Flow bin	NH_3-N (ppb)
24/11/2005	November	-	-	13.0
14/02/2008	February	-	-	12.26
18/07/2008	July	-	-	14.14
17/02/2011	February	4683.90	~half median	27.82
10/05/2012	May	9237.39	<median	13.81
22/11/2012	November	6619.26	<median	12.25
17/01/2013	January	2521.66	<half median	12.80
11/04/2013	April	1529.05	<half median	17.11
27/02/2019	February	3758.38	<half median	16.87
21/03/2019	March	3338.02	<half median	29.52

4.3.2 Nitrate nitrogen

NO_3-N concentrations in the Tukituki River between May 2005 and April 2019 did not differ in a statistically significant manner between sites upstream and downstream of the Waipukurau WWTP (average increase = 0.11 g/m^3; Wilcoxon signed rank test: Z = 1.889, P = 0.06) (Figure 48 and Table 13).

Rolling 12-month median and 95th percentile NO_3-N concentrations at both the upstream and downstream sites were consistently well below the PC6 limits, which correspond to the 90% species protection guideline in Hickey (2013) (Figure 49 and Figure 50). They were also below the guidelines for the protection of 95% of species (median = 2.4 mg/L; 95th percentile = 3.5 mg/L). This indicates that the risk of nitrate in the discharge causing toxicity effects on aquatic fauna in the Tukituki River is low and within the range deemed acceptable under the provisions of PC6.

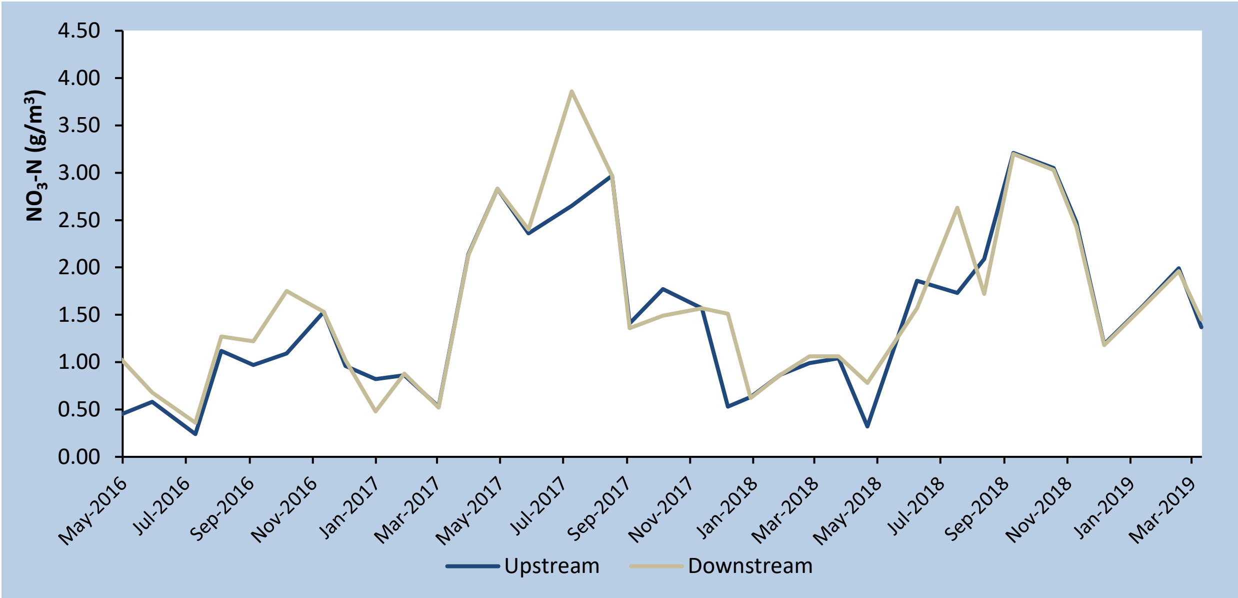

Figure 48: NO_3-N concentrations for sites sampled upstream and downstream of the Waipukurau WWTP (May 2005 – April 2019)

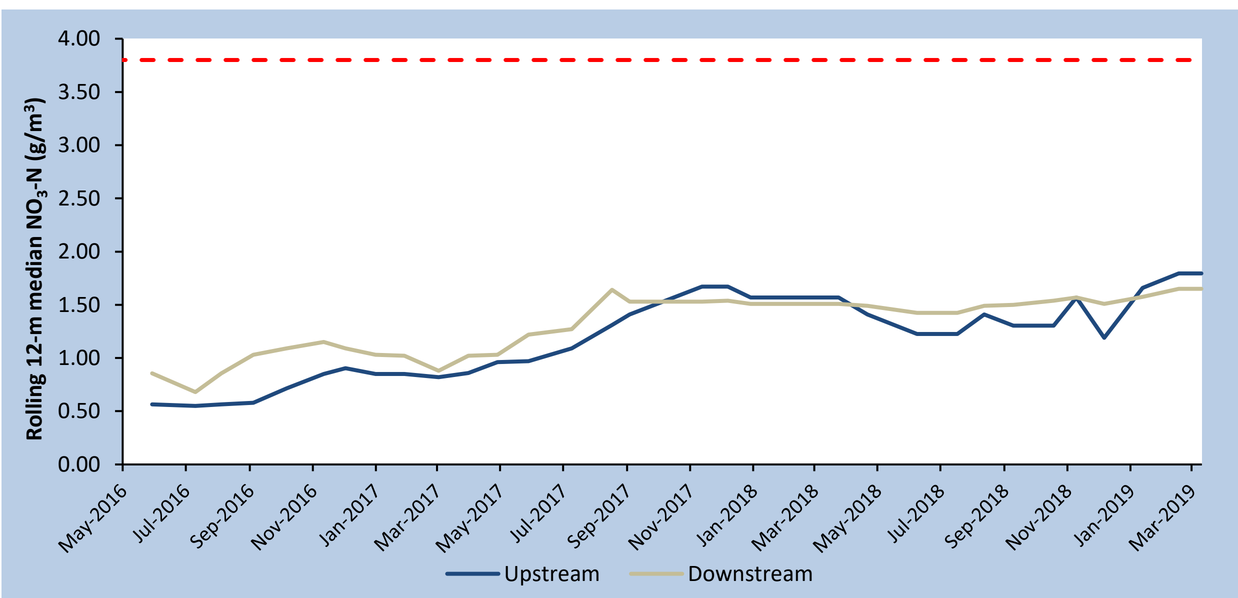

Figure 49: Rolling 12-month median NO_3-N concentrations for sites sampled upstream and downstream of the Waipukurau WWTP (May 2005 – April 2019). The red dashed line represents the PC6 limit.

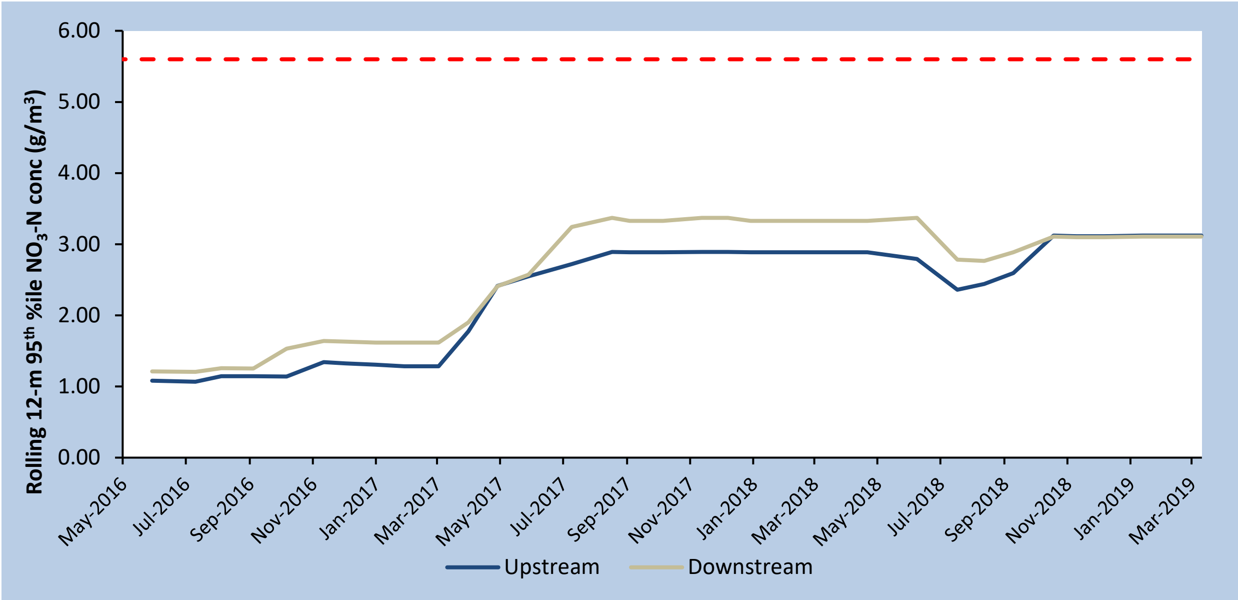

Figure 50: Rolling 12-month 95th percentile NO_3-N concentrations for sites sampled upstream and downstream of the Waipukurau WWTP (May 2005 – April 2019). The red dashed line represents the PC6 limit.

4.3.3 *Dissolved inorganic nitrogen*

Between May 2005 and April 2019 moderate and statistically significant increases in DIN were observed between sites on the Tukituki River upstream and downstream of the Waipukurau WWTP (average increase = 0.16 g/m^3; Wilcoxon signed rank test: Z = 2.801, P = 0.005) (Figure 51 and Table 13).

Since November 2011, rolling 5-year average DIN concentrations in the Tukituki River have consistently exceeded the PC6 limit of 0.8 g/m^3 both upstream and downstream of the downstream of the Waipukurau WWTP discharge (Figure 52). The consistent and increasingly large exceedances of the limit at the upstream site suggests that it is not NH_4-N or NO_3-N from the Waipukurau WWTP discharge that is causing DIN concentrations in the Tukituki River to exceed the limit; rather it is activities further upstream. For the PC6 DIN limit to be met downstream of the discharge, concentrations would need to reduce by ~51% (based on data collected between 2016 and 2019). Completely removing the discharge from the river would achieve a ~10% reduction.

As DIN concentrations are noticeably higher downstream of the discharge, the discharge has the potential to increase the risk of nitrogen driven nuisance periphyton growths in the river. However, this is not supported by the results of ecological monitoring conducted in March 2015 (Strong, 2015), March 2017 (Strong, 2017b) and February 2019 (Aquanet data for CHBDC), which showed that while periphyton biomass was slightly higher downstream of the Waipukurau WWTP, it was still well below the PC6 limit of 120 mg/m^2. Accordingly, the discharge of DIN from the Waipukurau WWTP does not appear to increase the risk of nuisance periphyton growths based on the limited periphyton monitoring data, despite the effluent NH_4-N limit not being complied with (see Section 4.2.3).

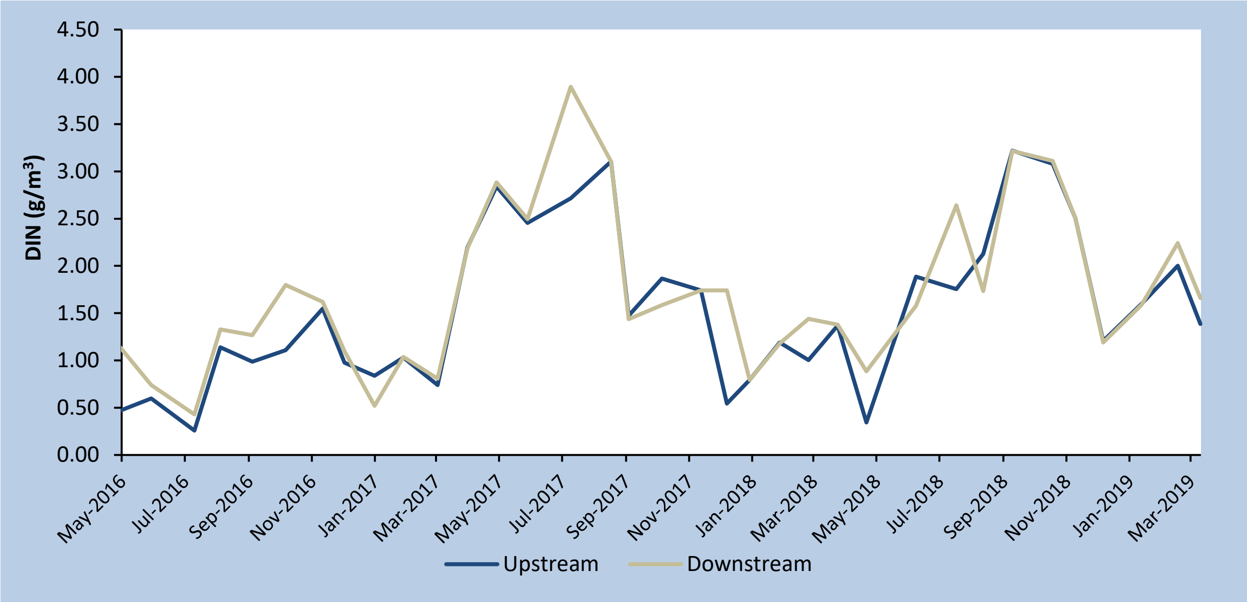

Figure 51: DIN concentrations for sites sampled upstream and downstream of the Waipukurau WWTP (May 2005 – April 2019)

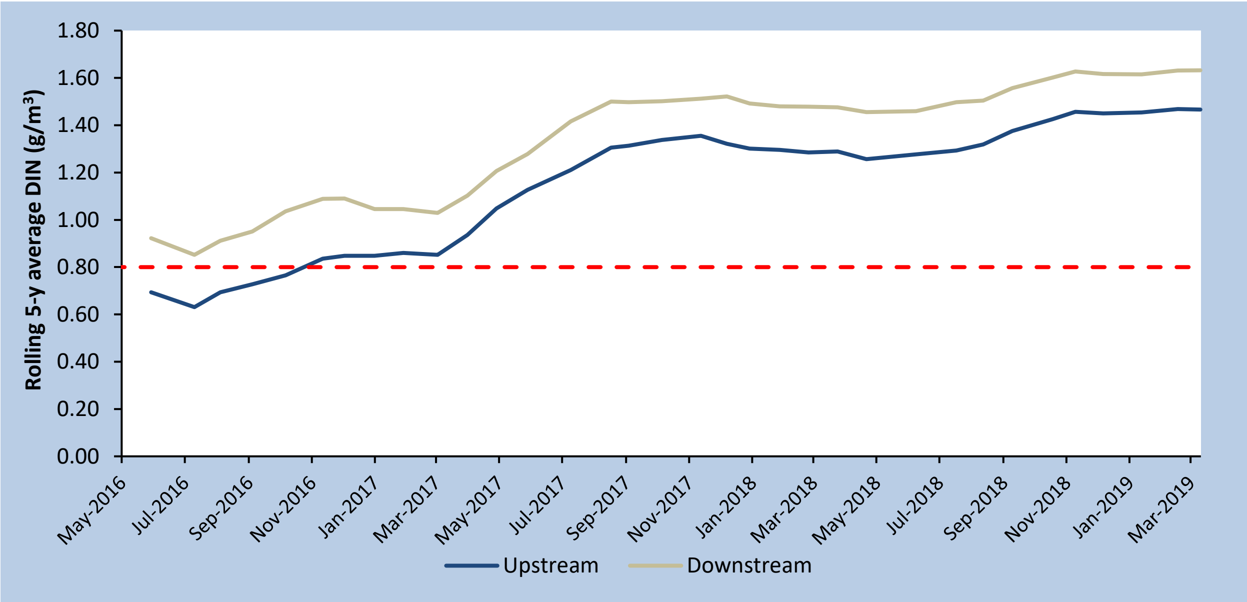

Figure 52: Rolling 5-year DIN concentrations for sites sampled upstream and downstream of the Waipukurau WWTP (May 2005 – April 2019). The red dashed line represents the PC6 limit.

4.3.4 *Dissolved reactive phosphorus*

Statistically significant increases in DRP concentrations were observed between sites on the Tukituki River upstream and downstream of the Waipukurau WWTP in the period May 2005 to April 2019 (average increase = 0.01 g/m^3; Wilcoxon signed rank test: Z =6.315, P <0.001) (Figure 53 and Table 13). However, the magnitude of these increases appears to have reduced since the upgrade of the plant in August 2014 (Figure 53).

Rolling 5-year average DRP concentrations in the Tukituki River at flows below 3 × median have consistently exceeded the PC6 limit of 0.01 g/m^3 both upstream and downstream of the discharge since 2009 (Figure 54). As with DIN, exceedances of the DRP limit at the upstream site suggests it is activities further upstream that it is driving non-compliance rather than the Waipukurau WWTP discharge. Based on the most recent five years of monitoring data, a ~53% reduction in DRP at flows below the median would be needed to meet the PC6 limit downstream of the discharge, and completely removing the discharge would achieve an ~11% reduction.

As DRP concentrations have been similar at the upstream and downstream sites since the plant was upgraded in 2014 (Figure 53), the discharge is also unlikely to increase the risk of phosphorus driven nuisance periphyton growths. Thus, while DRP in the discharge from the Waipukurau WWTP may not comply with effluent consent limits (see Section 4.2.3), it is unlikely to be affecting the river in a meaningful way.

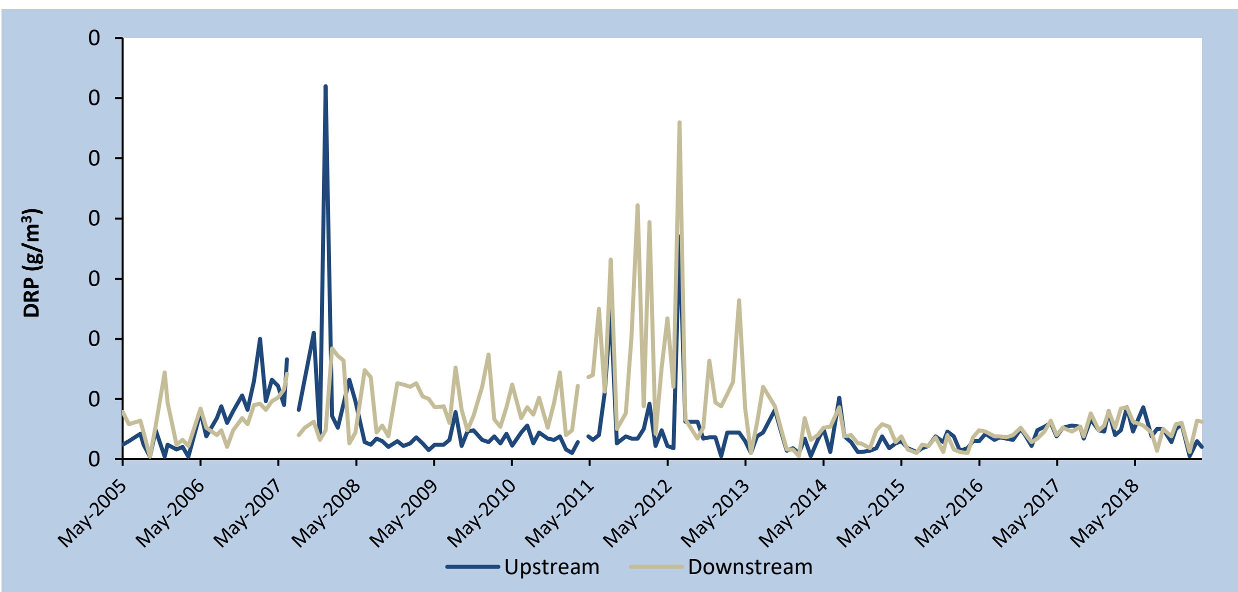

Figure 53: DRP concentrations for sites sampled upstream and downstream of the Waipukurau WWTP (May 2005 – April 2019).

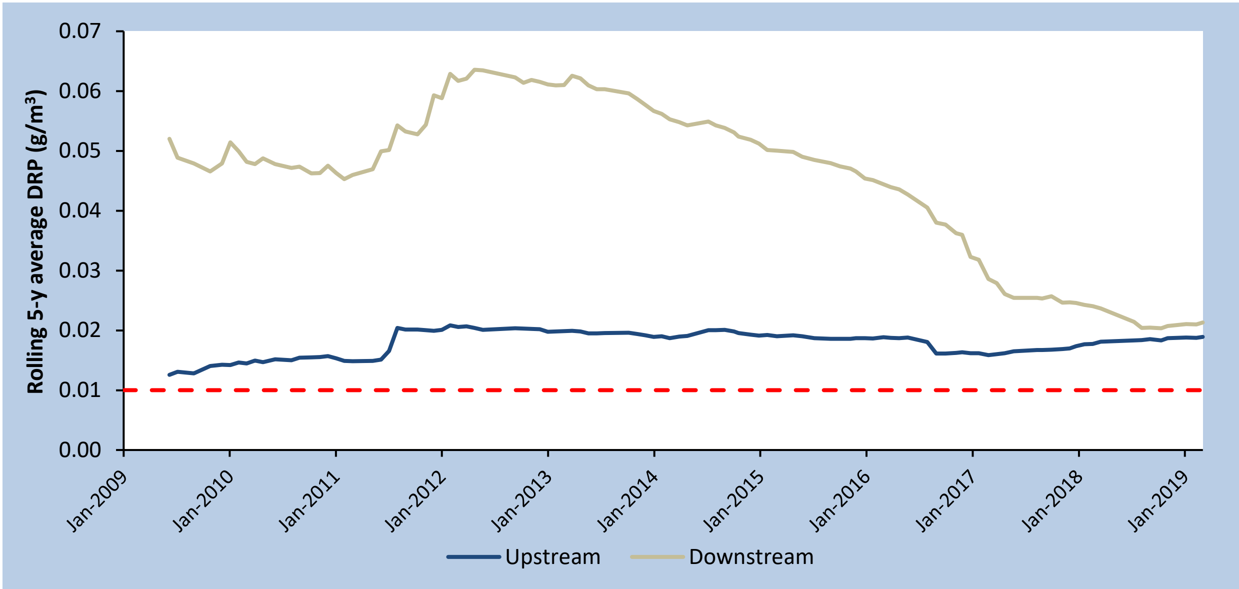

Figure 54: Rolling 5-year DRP concentrations for sites sampled upstream and downstream of the Waipukurau WWTP at flows below 3× median (May 2005 – April 2019). The red dashed line represents the PC6 limit.

4.3.5 E. coli

Between May 2005 and April 2019 statistically significant increases in *E. coli* were observed between sites on the Tukituki River upstream and downstream of the Waipukurau WWTP (average increase =91 CFU/100mL; Wilcoxon signed rank test: $Z = 3.747$, $P < 0.001$) (Figure 55 and Table 13).

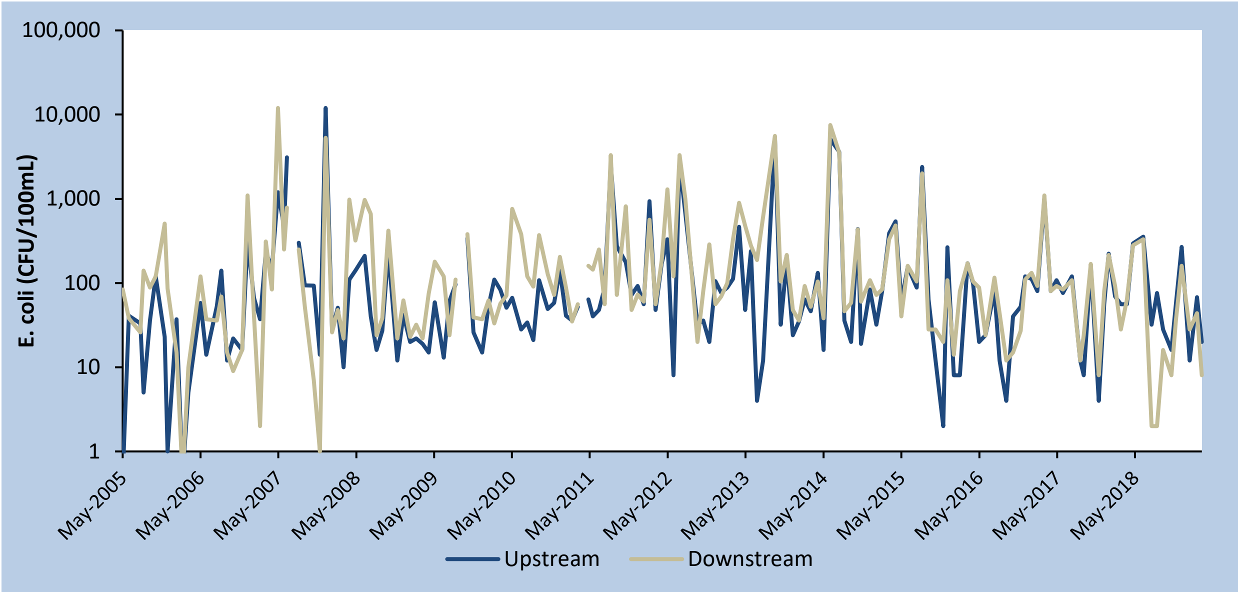

Figure 55: *E. coli* concentrations for sites sampled upstream and downstream of the Waipukurau WWTP (May 2005 – April 2019).

The Tukituki River is generally compliant with the PC6 *E. coli* limits both upstream and downstream of the Waipukurau WWTP. Between May 2005 and April 2019, *E. coli* concentrations at flows below the median met the summertime limit of 260 CFU/100mL on all but two occasions at the upstream site (96% compliance) and three occasions at the downstream site (94% compliance) (Figure 56). Furthermore, the other summertime *E. coli* limit of 550 CFU/100ml at flows between the median and 3× median was only exceeded twice at both sites (85% compliance) (Figure 57). The wintertime target of 550 CFU/100mL at flows below 3× median was exceeded twice at the upstream site (96% compliance), but was exceeded a further four times at the downstream site (88% compliance) (Figure 58). However, all exceedances at the downstream site were prior to the WWTP being upgraded in August 2014 (Figure 58). As the available data suggests that *E. coli* in the Tukituki River is now compliant with all three PC6 limits, it is unlikely that the Waipukurau WWTP discharge increases the risk of human health effects, or the risk of the river not meeting the PC6 limits, despite the effluent regularly not complying with *E. coli* consent limits (see Section 4.2.3).

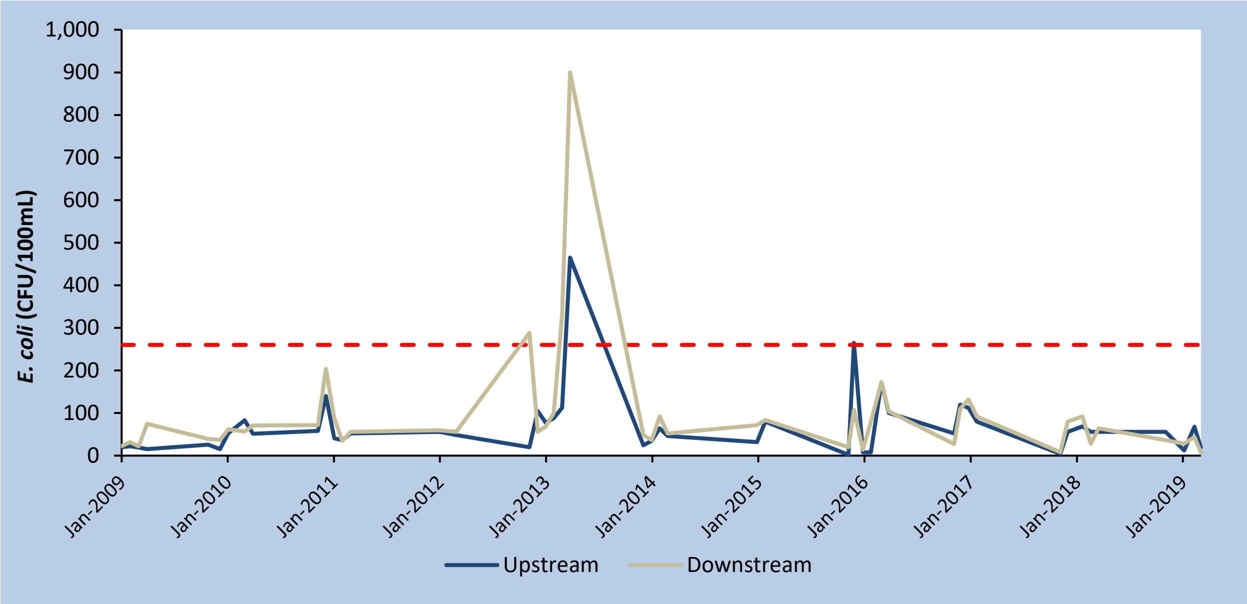

Figure 56: Summertime (November to April inclusive) *E. coli* concentrations for sites sampled upstream and downstream of the Waipukurau WWTP at flows below the median (May 2005 – April 2019). The dashed redline represents the PC6 limit.

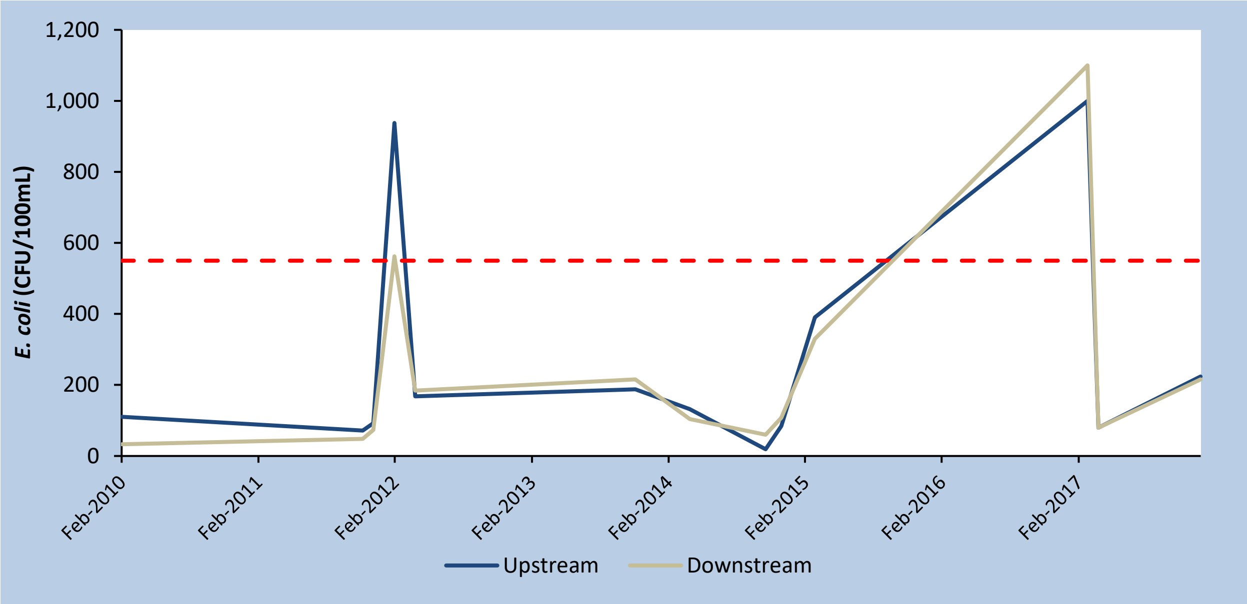

Figure 57: Summertime (November to April inclusive) *E. coli* concentrations for sites sampled upstream and downstream of the Waipukurau WWTP at flows between the median and 3× median (May 2005 – April 2019). The dashed redline represents the PC6 limit.

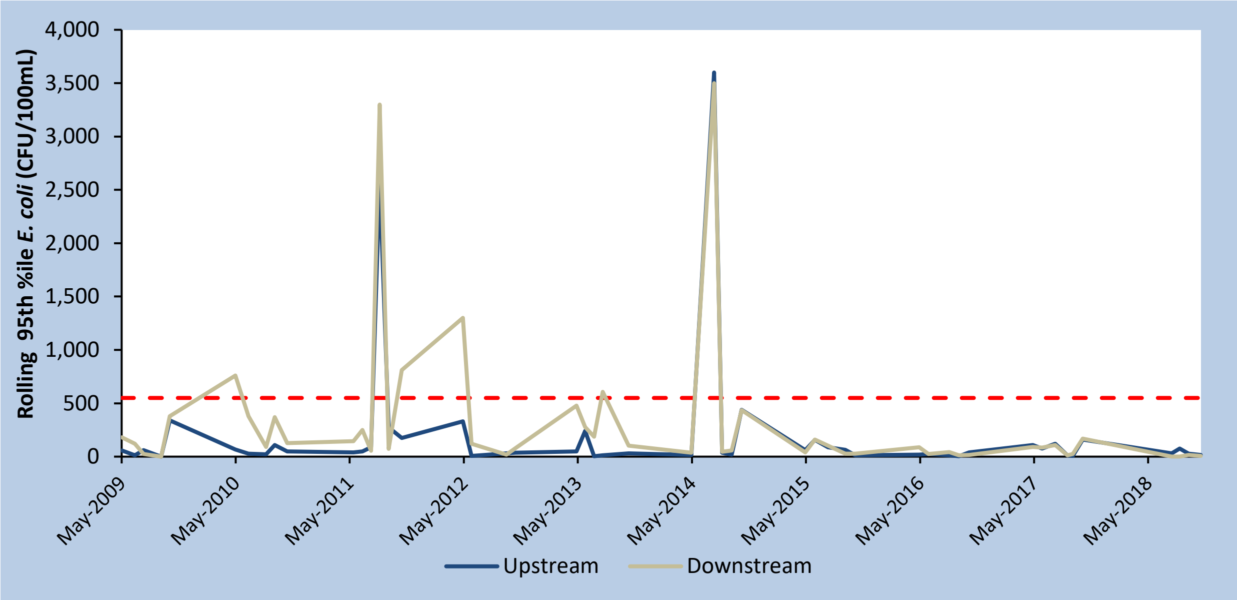

Figure 58: Wintertime (May to October inclusive) *E. coli* concentrations for sites sampled upstream and downstream of the Waipukurau WWTP at flows below 3× median (May 2005 – April 2019). The dashed redline represents the PC6 limit.

4.3.6 Visual clarity

Between March 2016 when records began, and April 2019, visual clarity did not differ in a statistically significant manner between sites on the Tukituki River upstream and downstream of the Waipukurau WWTP (average Δ = +0.3 m; Wilcoxon signed rank test: $Z = 1.206$, $P = 0.23$) (Figure 59 and Table 13).

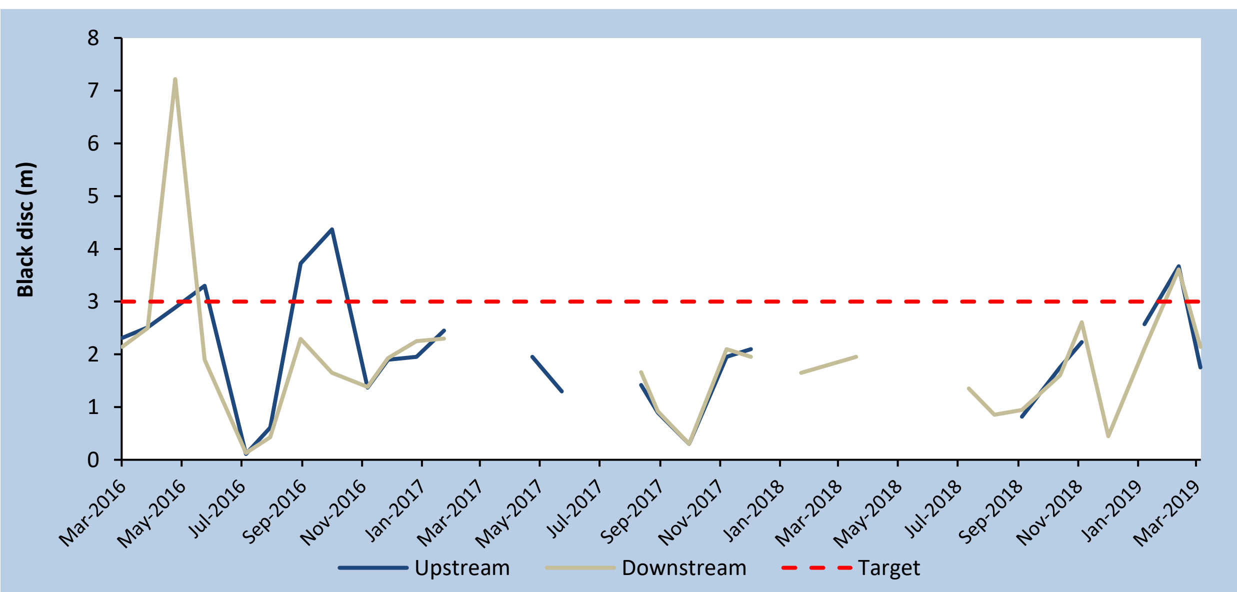

Figure 59: Visual clarity (m) measured with a black disc at sites sampled upstream and downstream of the Waipukurau WWTP (March 2016 – April 2019)

There is insufficient visual clarity data for the Tukituki River at flows below the median to calculate robust 5-year rolling averages that can be assessed against the PC6 indicator of 3.0 metres. However, when individual data points collected across all flows are considered it is likely that the Tukituki River in non-compliant both upstream and downstream of the Waipukurau WWTP, as the indicator has not been met on 23 occasions at the upstream site (15% compliance) and 27 occasions at the downstream site (10% compliance). Furthermore, the Waipukurau WWTP discharge does not generally cause non-compliance with the clarity change limit in PC6 as visual clarity has only reduced by more than 20% at flows below the median on one occasion (95% compliance). As visual clarity does not decrease significantly downstream of the discharge, and is regularly less than three meters at the upstream site, it is unlikely that non-compliance with the effluent TSS consent limit affects the aesthetics of the river in a meaningful way, or affects whether the PC6 water clarity indicator and limit is met.

4.3.7 Dissolved oxygen

Between May 2005 and April 2019, statistically significant decreases in DO saturation were not observed between sites on the Tukituki River upstream and downstream of the Waipukurau WWTP (average Δ = +1%; Wilcoxon signed rank test: $Z = 758$, $P = 0.45$) (Figure 60 and Table 13).

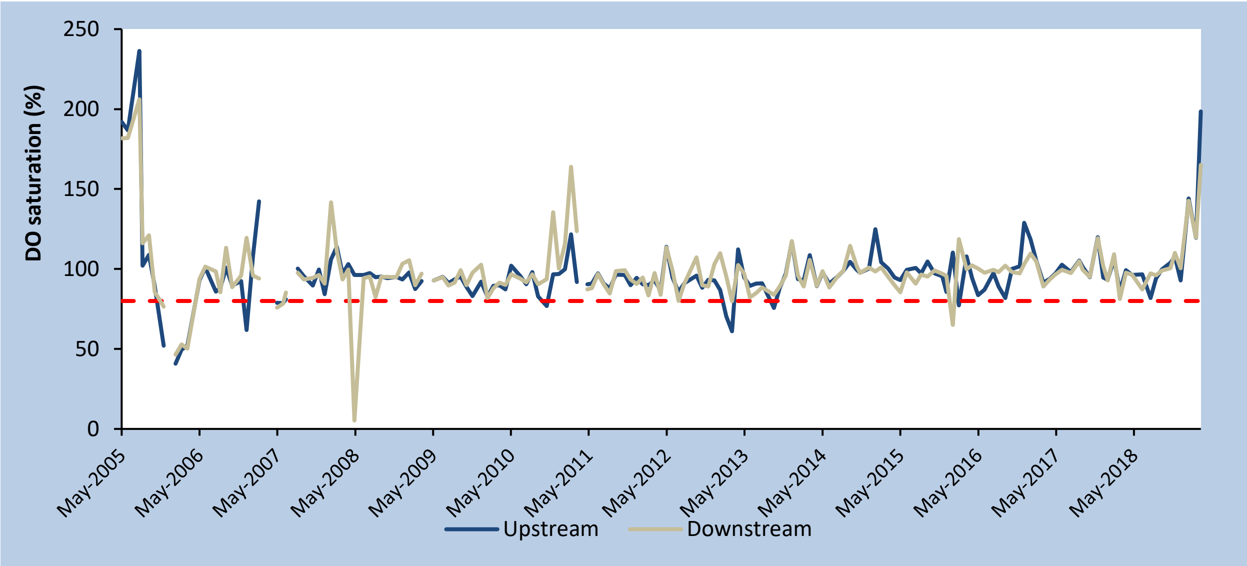

Figure 60: DO saturation for sites sampled upstream and downstream of the Waipukurau WWTP (May 2005 – April 2019). The red dashed line represents the PC6 limit.

The upstream and downstream monitoring sites met the PC6 limit on all but 12 (93% compliance) and nine occasions respectively (94% compliance) (Figure 60). Thus, compliance with the current effluent $cBOD_5$ consent limit appears to be sufficient to prevent adverse effects arising from deoxygenation of downstream receiving waters (see Section 4.2.1).

4.3.8 5-day carbonaceous biochemical oxygen demand and particulate organic matter

In the period of May 2005 to April 2019, statistically significant differences in $ScBOD_5$ and POM concentrations were not observed in the Tukituki River between sites upstream and downstream of the Waipukurau WWTP (Wilcoxon signed rank tests: $ScBOD_5$ $Z = 0.913$, $P = 0.36$, av. $\Delta = 0.1$ g/m^3; POM $Z = 1.069$, $P = 0.29$, av. $\Delta = 0.1$ g/m^3) (Figure 28, Figure 29 and Table 13).

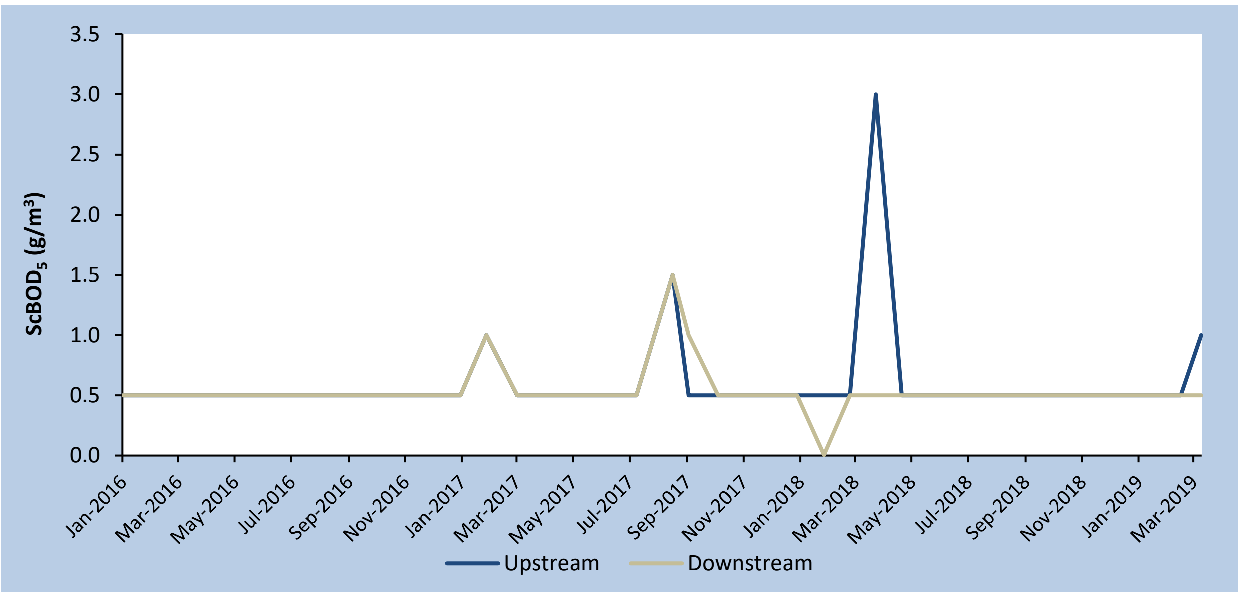

Figure 61: $ScBOD_5$ concentrations for sites sampled upstream and downstream of the Waipukurau WWTP (May 2005 – April 2019).

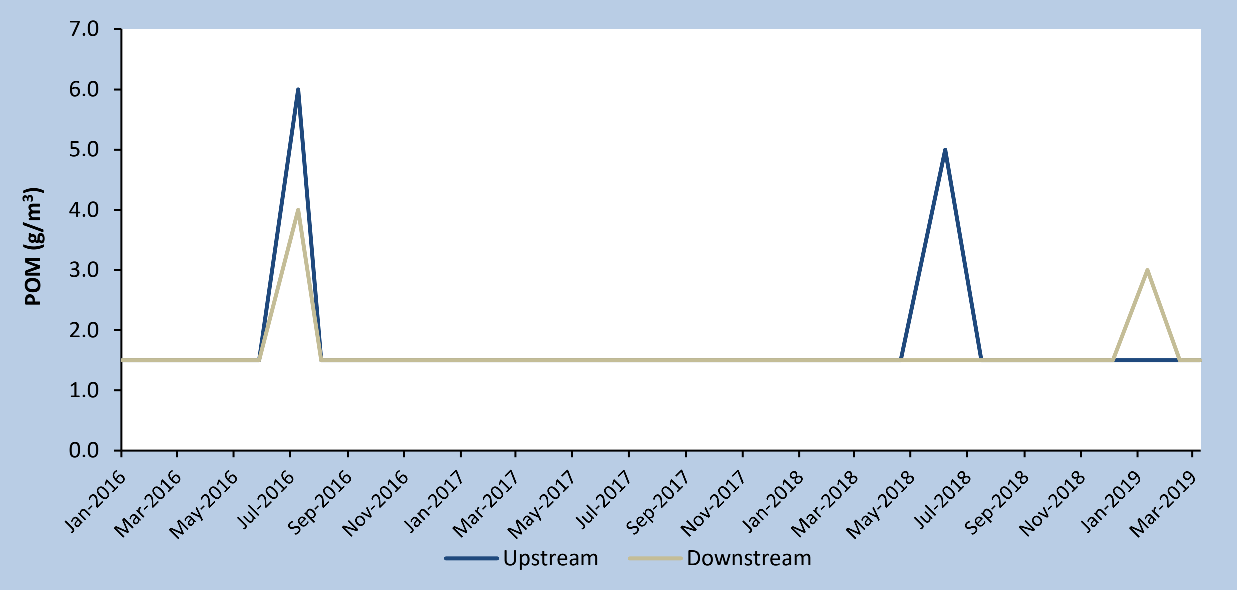

Figure 62: POM concentrations for sites sampled upstream and downstream of the Waipukurau WWTP (May 2005 – April 2019).

As with the Waipawa River, there are insufficient $ScBOD_5$ and POM data for the Tukituki River at flows below the median to calculate rolling averages that can be assessed against the PC6 limits. However, when an overall average is calculated from all data points collected at flows below the median, both parameters met the limits (Table 15)

Table 15: Assessment of average $ScBOD_5$ and POM concentrations in the Tukituki River at flows below the median against the PC6 limits.

Parameter	Site	Average conc.	Limit	Compliant
$ScBOD_5$ (g/m^3)	U/S	0.71	2	✓
	D/S	0.55		✓
POM (g/m^3)	U/S	1.5	5	✓
	D/S	1.57		✓

4.3.9 *Quantitative macroinvertebrate community index*

Macroinvertebrate data were collected from the Tukituki River in February 2015, March 2017 (Strong, 2015 & 2017b) and February 2019 (Aquanet data for CHBDC) at sites located 50 metres upstream of the discharge, 400 metres downstream and 1,000 metres downstream. While QMCI was reduced by more than 20% between the upstream site and the most downstream site in 2015, in 2017 and 2019 the reduction observed between these sites was ≤10% (Table 16). Furthermore, the maximum reduction observed between the upstream site and the downstream site closest to the discharge was just 6% (Table 16). Thus, it can be concluded that the discharge is generally compliant with the PC6 QMCI limits.

Table 16: Assessment of QMCI data collected in the Tukituki River at sites upstream and downstream of the Waipukurau WWTP discharge against the PC6 limit.

Year	Site	Average QMCI	% change	Limit %Δ	Compliant
2015	50m U/S	5.72	-	20	-
	400m D/S	5.51	-4		✓
	1,000m D/S	4.14	-28		×
2017	50m U/S	5.13	-	20	-
	400m D/S	7.24	+41		✓
	1,000m D/S	6.17	+20		✓
2019	50m U/S	7.1	-		-
	400m D/S	6.7	-6		✓
	1,000m D/S	6.4	-10		✓

4.4 Conclusions

Based on monitoring data collected between May 2005 and April 2019, the following conclusions can be made about the Waipukurau WWTP discharge:

- The Waipukurau WWTP discharge frequently did not meet the discharge volume consent limits. This non-compliance was driven by consistently elevated volumes rather than spikes in discharge volume. Thus, to comply with the discharge volume limits, effluent management should focus on reducing the baseline volumes.
- The Waipukurau WWTP discharge did not comply with the effluent quality consent limits for TSS, NH_4-N, DRP and *E. coli*, but the effects of these exceedances on the Tukituki River were likely limited to an increased risk of ammonia toxicity.
- The discharge of NH_4-N to the Tukituki River from the Waipukurau WWTP resulted in the occasional exceedance of the PC6 limit and had the potential to cause chronic (but not acute) toxicity effects.
- Non-compliance with the PC6 NH_4-N limit downstream of the Waipukurau WWTP discharge generally occurred between November and May when flow was below the median. Thus, non-compliances could be avoided by either not discharging to the Tukituki River over the summer period when flows are below the median (or at the very least half median), and/or reducing the concentration of NH_4-N in the discharge by way of additional treatment during this period.
- NO_3-N and DIN in the discharge does not appear to have increased the risk of nitrate toxicity or plant growth in the Tukituki River, or have affected compliance with the PC6 limits for those parameters. The NO_3-N PC6 limits were met both upstream and downstream of the discharge, and nutrient sources other than the WWTP meant that the DIN limit was already exceeded upstream of the discharge. For the PC6 DIN limit to be met downstream of the discharge, concentrations would need to reduce by ~51% (based on data collected between 2016 and 2019). Completely removing the discharge from the river would achieve a ~10% reduction.
- The discharge of DRP from the Waipukurau WWTP is unlikely to have increased the risk of plant growth in the Tukituki River, and had limited influence on the river's compliance

with the PC6 limit, which was already exceeded upstream due to other human activities. Based on the most recent five years of monitoring data, a ~53% reduction in DRP at flows below the median would be needed to meet the PC6 limit downstream of the discharge, and completely removing the discharge from the river would achieve an ~11% reduction.

- TSS and $cBOD_5$ from the Waipukurau WWTP did not cause a degradation in visual clarity, $ScBOD_5$, POM or DO saturation in the Tukituki River and did not affect whether the PC6 limits for these parameters were met downstream.
- *E. coli* in the Waipukurau WWTP discharge does not appear to have increased the risk of human health effects in the Tukituki River or the risk of the river not meeting the PC6 *E. coli* limits.
- Macroinvertebrate monitoring data from the Tukituki River suggest that the Waipukurau WWTP discharge was generally compliant with the PC6 QMCI limits.

5 Otane WWTP results

5.1 Effluent quality

The treated wastewater quality data collected by CHBDC between May 2005 and April 2019 are summarised in Table 17 and depicted in Figure 63 to Figure 73.

Table 17: Summary of effluent quality from the Otane oxidation pond, May 2005 – April 2019.

	TSS	$cBOD_5$	NH4-N	DRP	*E. coli*
	(g/m³)				(CFU/100mL)
Average	45.0	19.3	19.9	4.42	34613
Min	1.5	2.0	0.0	1.13	42
25%ile	24.0	12.0	15.2	3.25	6218
50%ile (median)	35.0	18.0	20.4	4.12	17000
95%ile	120.0	35.0	30.8	7.62	116650
Max	170.0	88.0	37.8	9.11	870000
N. of Samples	362	362	361	360	362
Pre-upgrade lower/upper limit	55/100	30/40	NA	NA	NA
Post-upgrade lower/upper limit	30/50	20/30	30/40	0.25/0.5	800/4000
Pre-upgrade compliance (%)	85/67	100/90	NA	NA	NA
Post-upgrade compliance (%)	55/49	75/61	100/100	3/0	3/0

5.1.1 5-day carbonaceous biochemical oxygen demand

The Otane WWTP is generally compliant with the $cBOD_5$ effluent consent limits. Between May 2005 and April 2019, $cBOD_5$ concentrations never exceeded the pre-upgrade lower limit of 30 g/m^3 more than 15 times in a 48-week period (100% compliance), but the post-upgrade lower limit of 20 g/m^3 was exceeded more than 15 times in 90 48-week periods (75% compliance) (Figure 64 and Table 17). However. all instances of non-compliance occurred prior to May 2010 (Figure 64). The pre-upgrade (39 g/m^3) and post-upgrade (30 g/m^3) upper limits were exceeded in 34 (90% compliance) and 138 (61% compliance) 48-week periods (Table 17), but with the exception of a short period in late 2018 when the post upgrade limit was not met, non-compliances ceased in 2010 (Figure 65).

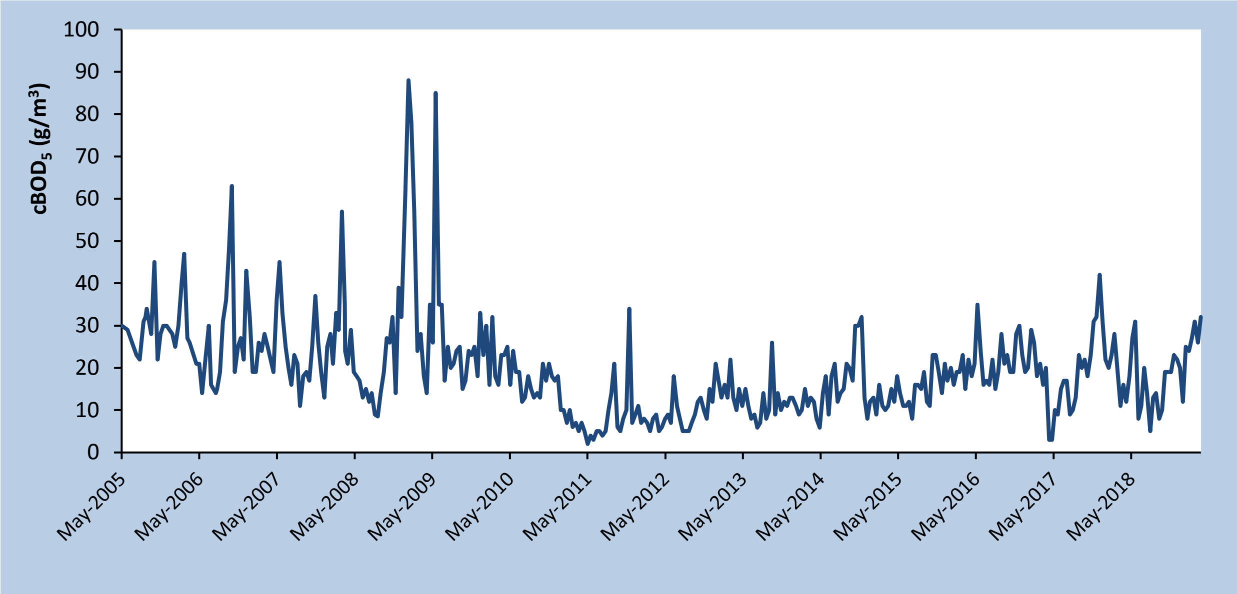

Figure 63: cBOD$_5$ concentrations from the Otane oxidation pond prior to discharge (May 2005 – April 2019).

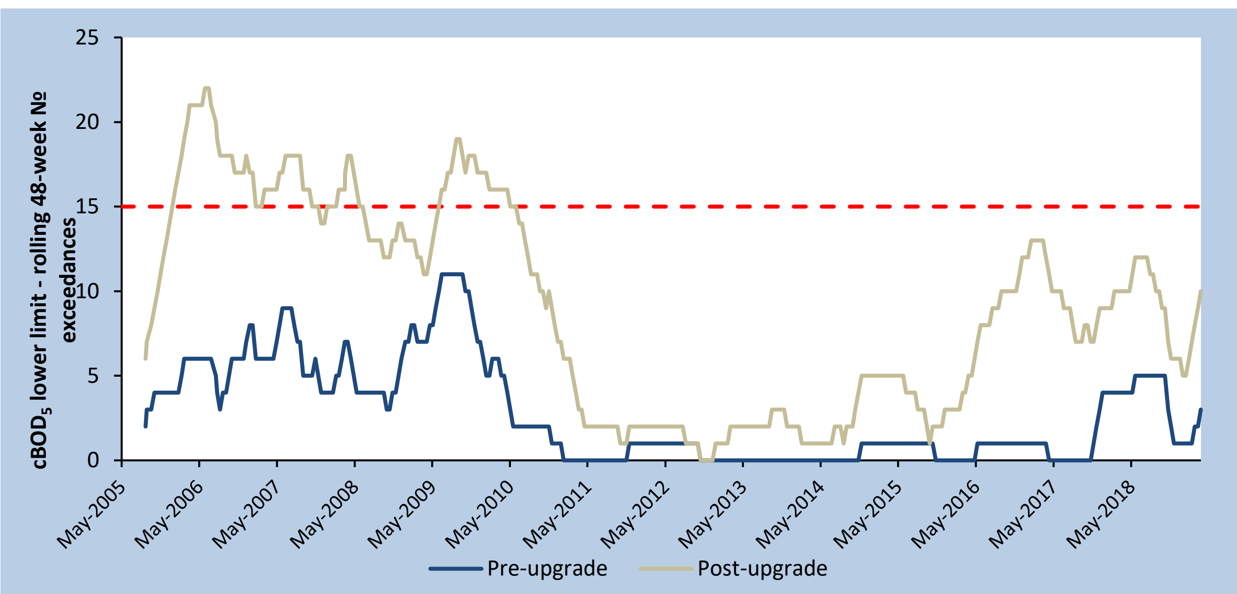

Figure 64: The number of times in each 48-week period that the pre-upgrade and post-upgrade lower consent limits for cBOD$_5$ were exceeded. The red dashed line represents the allowable number of exceedances.

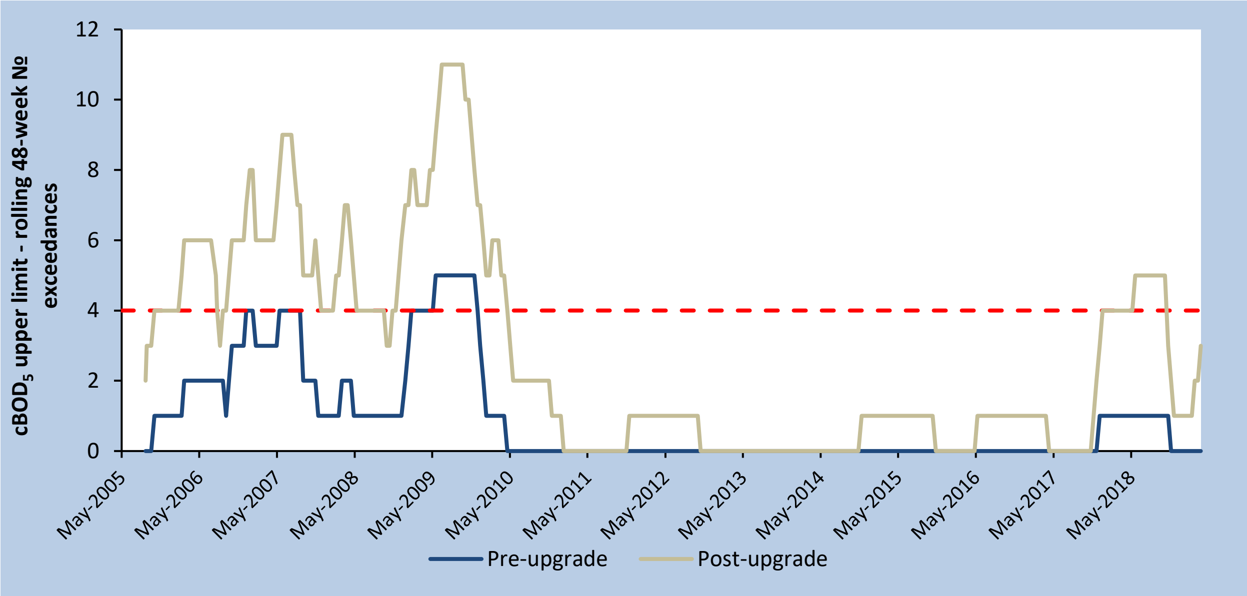

Figure 65: The number of times in each 48-week period that the pre-upgrade and post-upgrade upper consent limits for $cBOD_5$ were exceeded. The red dashed line represents the allowable number of exceedances.

5.1.2 Total suspended solids

Both the pre-upgrade and post-upgrade TSS consent limits were generally not complied with. Between May 2005 and April 2019, TSS concentrations exceeded the pre-upgrade (55 g/m^3) and post-upgrade (30 g/m^3) lower limits more than 15 times in 52 (85% compliance) and 158 (55% compliance) 48-week periods respectively, with the most recent non-compliance of the post-upgrade lower limit occurring in May 2018 (Figure 67). The pre-upgrade (100 g/m^3) and post-upgrade (50 g/m^3) upper limits were exceeded in 117 (67% compliance) and 180 (49% compliance) 48-week periods respectively, with the post-upgrade limit being breached multiple times in the last 18 months (Figure 68).

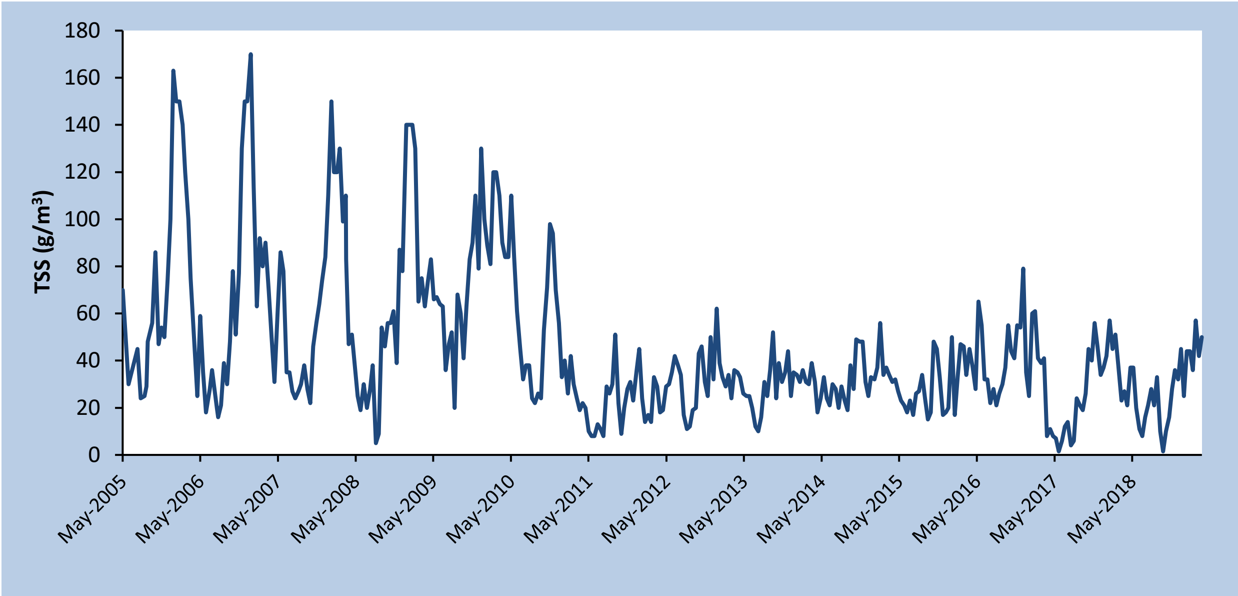

Figure 66: TSS concentrations from the Otane oxidation pond prior to discharge (May 2005 – April 2019)

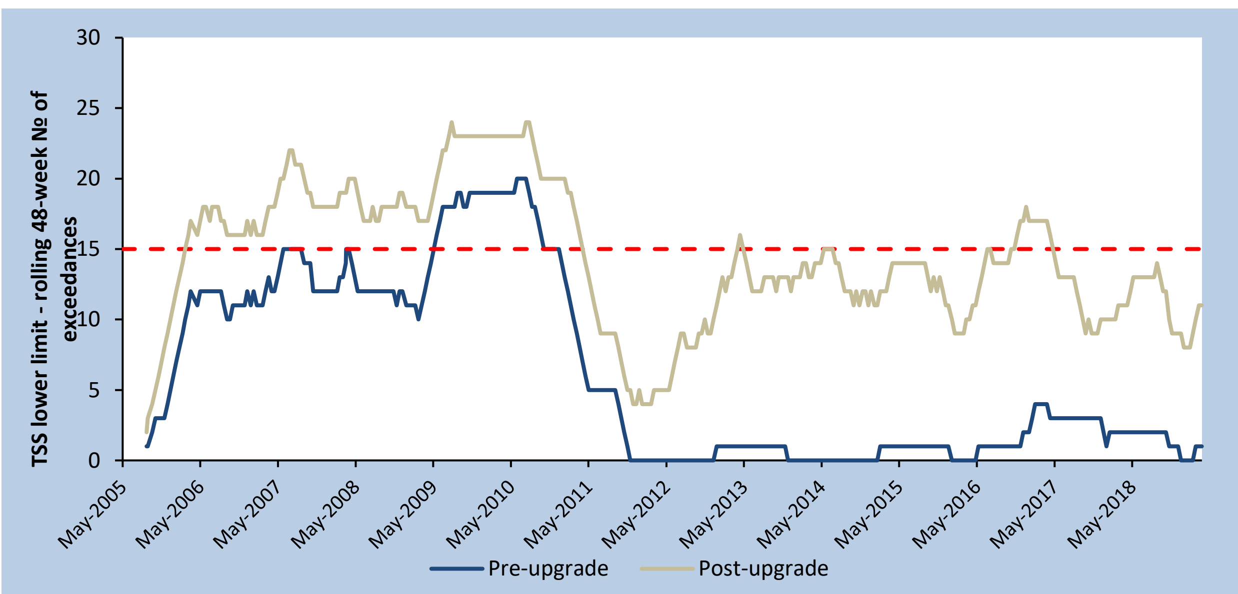

Figure 67: The number of times in each 48-week period that the pre-upgrade and post-upgrade lower consent limits for TSS were exceeded. The red dashed line represents the allowable number of exceedances.

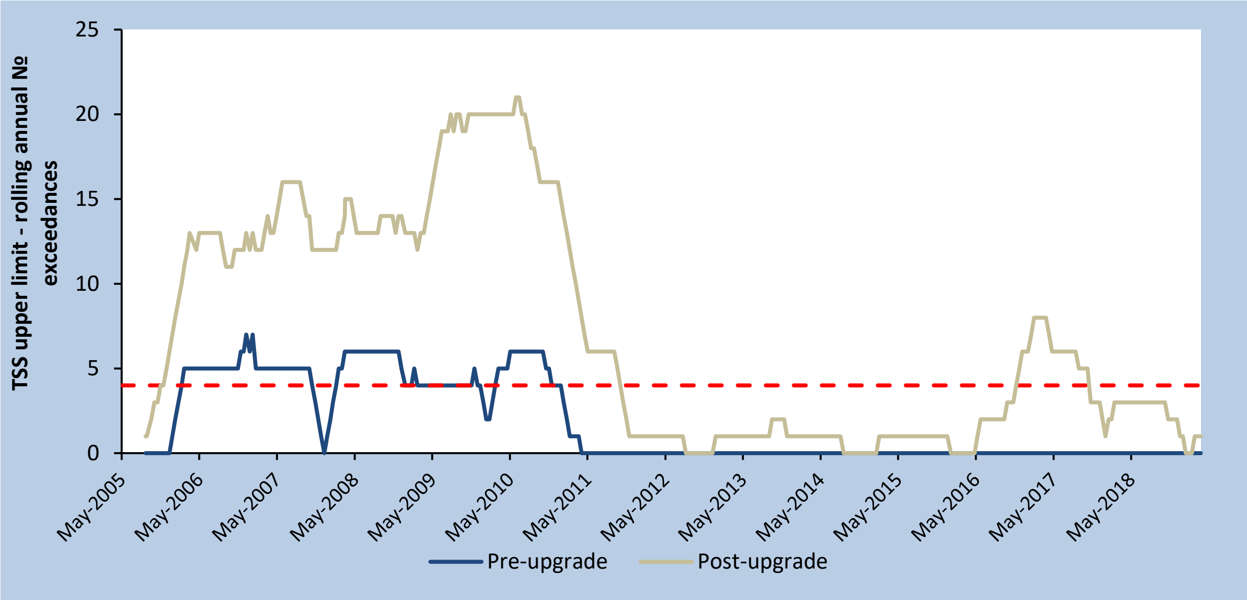

Figure 68: The number of times in each 48-week period that the pre-upgrade and post-upgrade upper consent limits for TSS were exceeded. The red dashed line represents the allowable number of exceedances.

5.1.3 Ammoniacal nitrogen, dissolved reactive phosphorus and E. coli

DRP and *E. coli* concentrations in the Otane WWTP discharge do not comply with the limits in the conditions of the consent. Between May 2005 and April 2019, concentrations both parameters regularly exceeded the lower (Figure 69) and upper limits (Figure 70) more frequently than allowed by the consent (15 and 4 times in a 48 week period respectively), and the rate of compliance was less than 5% for all specified limits (Table 17). In contrast, NH_4-N concentrations in the discharge always complied with the lower (Figure 69) and upper (Figure 70) consent limits (Table 17). There is no obvious trends in DRP, *E. coli* or NH_4-N concentrations in the discharge (Figure 71, Figure 72 and Figure 73).

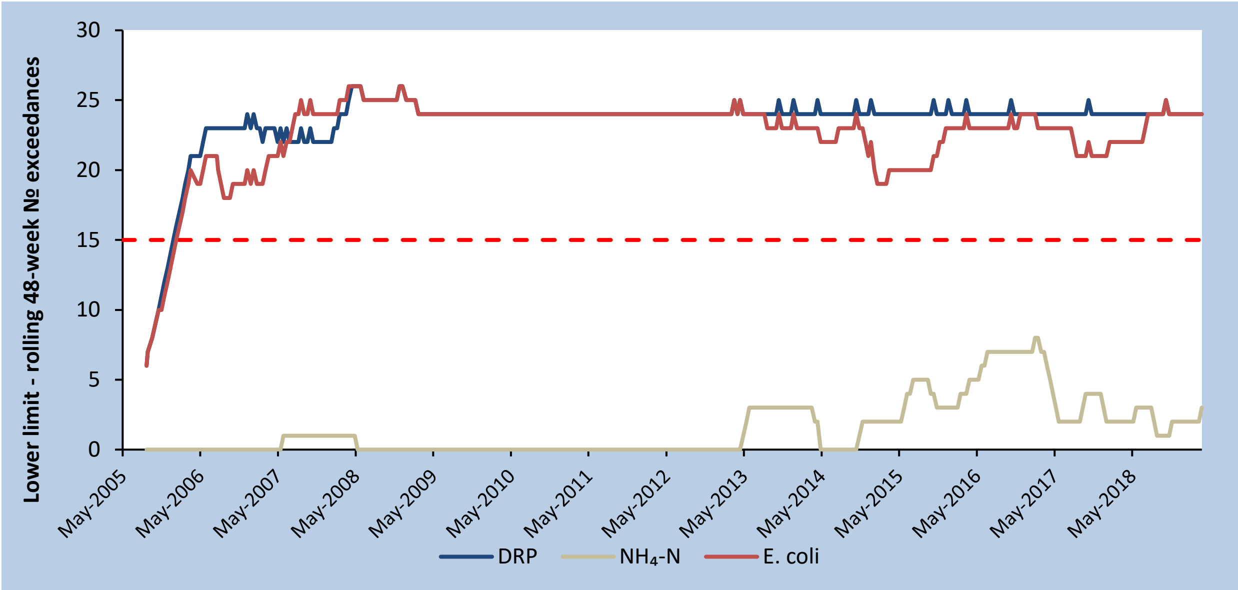

Figure 69: The number of times in each 48-week period that the post-upgrade lower consent limits for DRP, NH_4-N and *E. coli* were exceeded. The red dashed line represents the allowable number of exceedances.

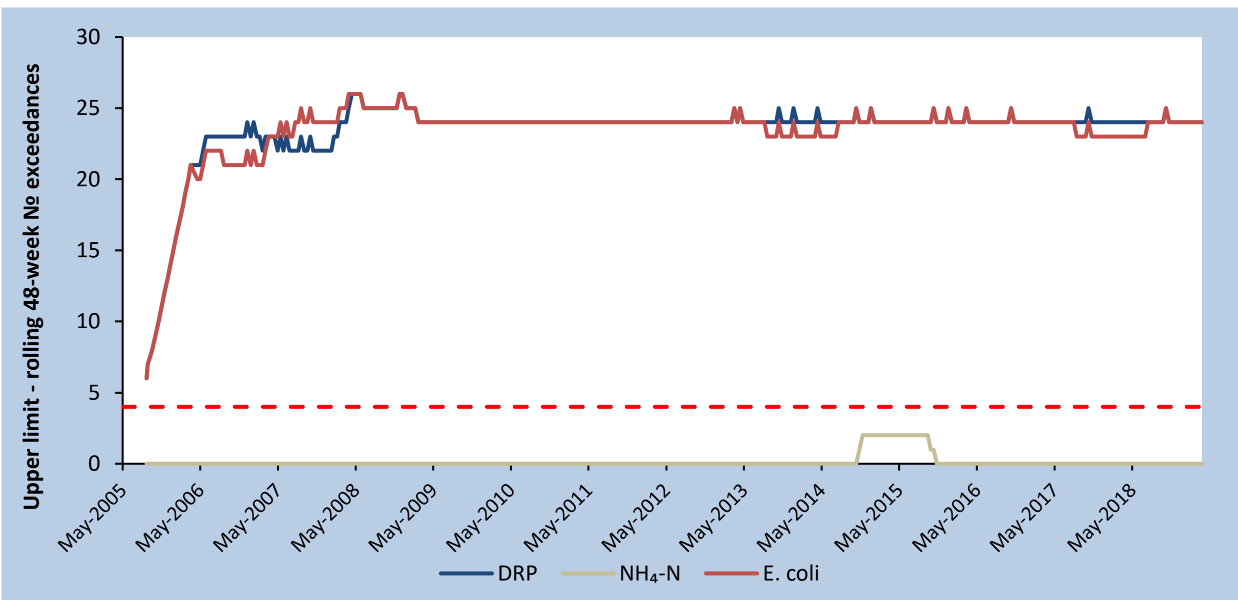

Figure 70: The number of times in each 48-week period that the post-upgrade upper consent limits for DRP, NH_4-N and *E. coli* were exceeded. The red dashed line represents the allowable number of exceedances.

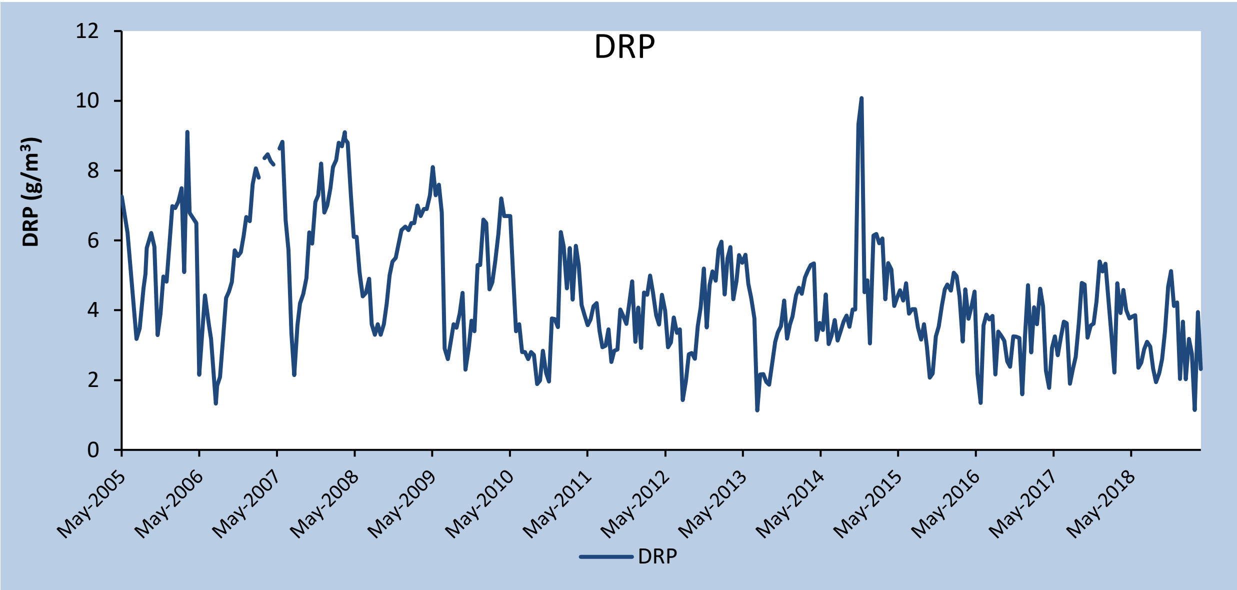

Figure 71: DRP concentrations from the Otane oxidation pond prior to discharge (May 2005 – April 2019)

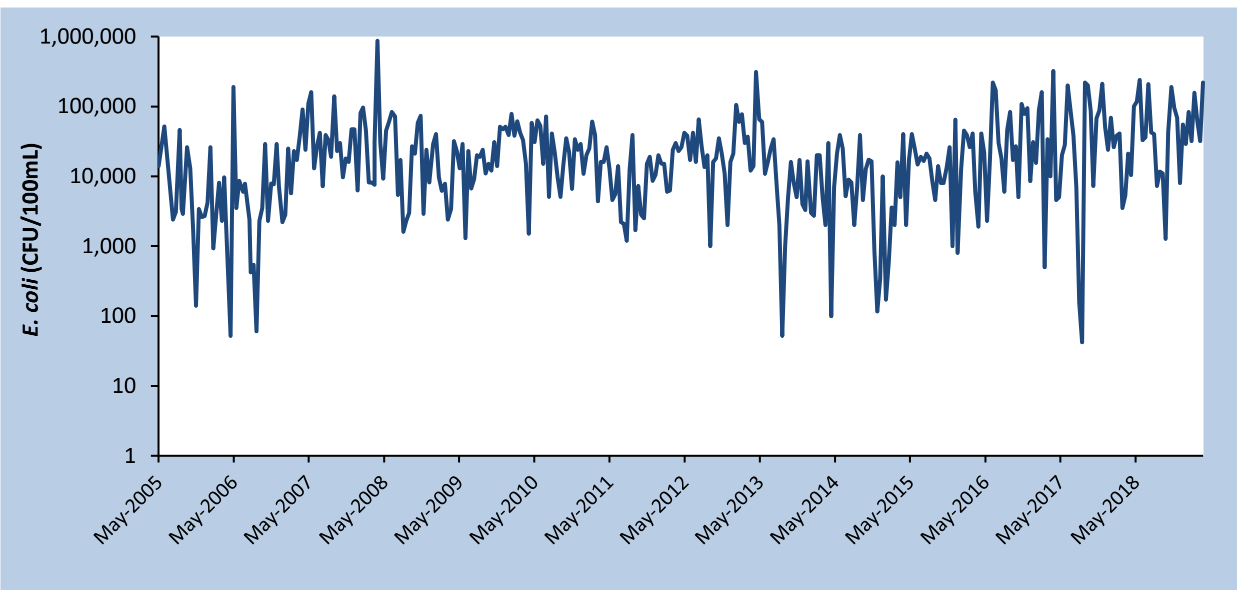

Figure 72: *E. coli* concentrations from the Otane oxidation pond prior to discharge (May 2005 – April 2019)

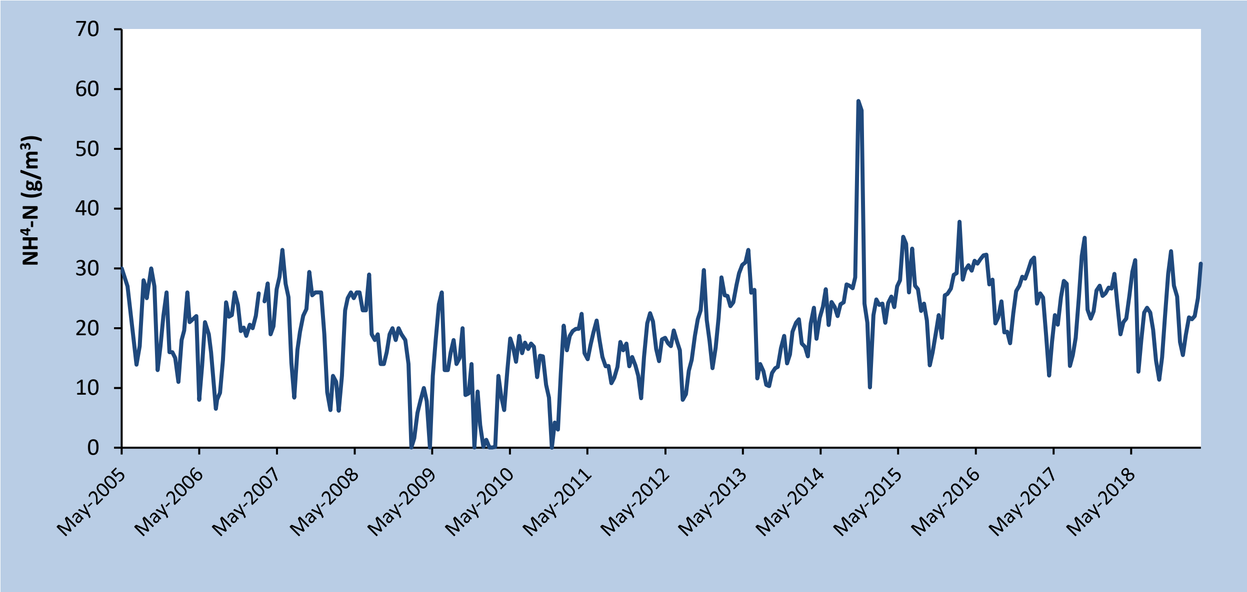

Figure 73: NH_4-N concentrations from the Otane oxidation pond prior to discharge (May 2005 – April 2019).

5.2 In-stream water quality

Water quality data collected between May 2005 and April 2019 upstream and downstream of where the Otane WWTP discharge enters the Te Aute Drain are presented in Figure 74 to Figure 85. Key water quality parameters are summarised and assessed against the relevant PC6 limits/targets in Table 18.

Table 18: Summary of key water quality determinants measured in the Te Aute Drain upstream and downstream of the Otane WWTP discharge, and assessment against PC6 limits/targets. May 2005 – April 2019. The most relevant assessment statistics are shaded.

Para.	Unit	PC6 limit	Statistic	Applicable Flow	Site	Av.	Min.	Med.	95th %ile	N. samples	PC6 Target met?
NH_3-N	ppb	12.22	95th %ile.	All flows	U/S	3.43	0.02	1.25	13.18	95	×
					D/S	3.49	0.04	0.82	13.33	95	×
DIN	g/m³	0.8	Av.	All flows	U/S	1.00	0.02	0.44	3.52	58	×
					D/S	1.08	0.02	0.43	4.37	58	×
NO_3-N	g/m³	3.6	Median	All flows	U/S	0.75	0.01	0.10	3.32	58	✓
		5.8	95th %ile		D/S	0.83	0.01	0.13	3.66	58	✓
DRP	g/m³	0.01	Av.	<3× median	U/S	0.184	0.008	0.110	0.524	94	×
					D/S	0.202	0.011	0.140	0.535	95	×
$cBOD_5$	g/m³	2 ($ScBOD_5$)	Av.	<median	U/S	2.2	0.5	1.5	4.6	69	✓
					D/S	1.9	0.5	1.5	4.0	69	✓
E. coli	MPN/100 mL	260	95th %ile	< median Summ.	U/S	910	1	51	1770	94	✓
		550		Median – 3× median Summ. <3× median Wint.	D/S	1072	1	60	1230	95	✓

5.2.1 *Ammoniacal nitrogen*

Between May 2005 and April 2019, NH_4-N concentrations did not differ in a statistically significant manner between sites on the Te Aute Drain upstream and downstream of the Otane WWTP discharge (average Δ = +0.06 g/m^3; Wilcoxon signed rank test: Z = 0.687, P = 0.49) (Figure 74 and Table 18).

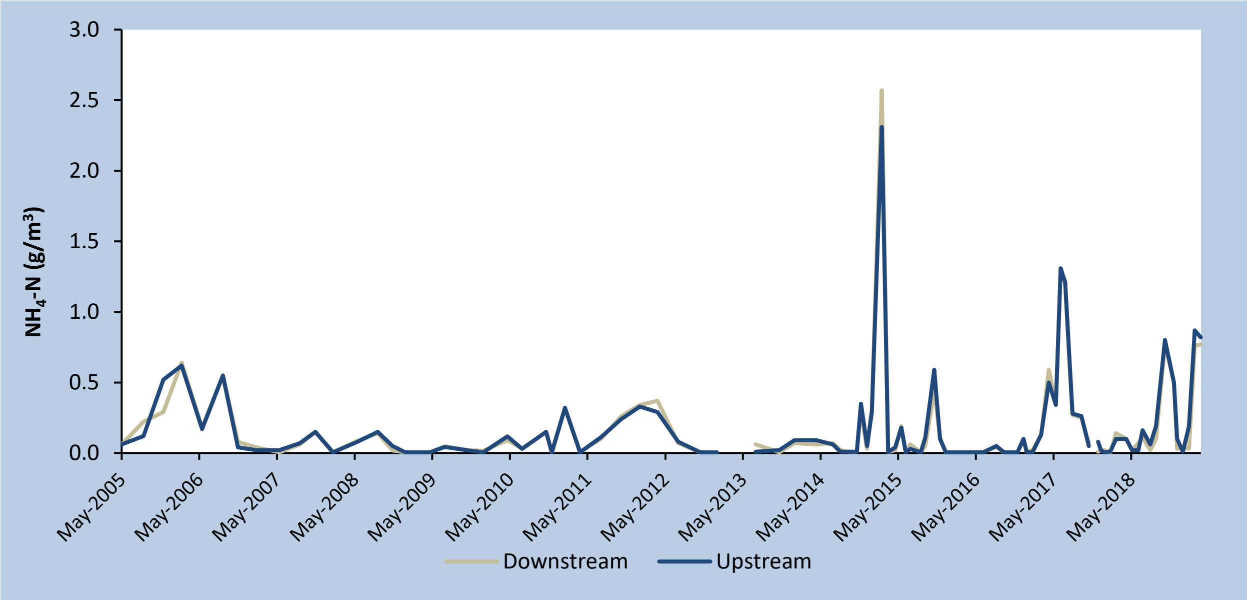

Figure 74: NH_4-N concentrations for sites sampled upstream and downstream of the Otane WWTP (May 2005 – April 2019).

Since 2014 (when monthly water quality sampling began), rolling 12-month 95th percentile NH_3-N concentrations in the Te Aute Drain have exceeded the PC6 limit[7] of 12.2 ppb 14 times, both upstream and downstream of the Otane WWTP discharge (75% compliance) (Figure 75 and Table 18). This suggests that there is a potential risk of adverse effects on aquatic life in the drain due to ammonia toxicity. However, as exceedances of the PC6 limit occur at the same frequency upstream and downstream of the Otane WWTP and NH_4-N concentrations do not differ significantly between sites, is unlikely to be the discharge that is causing concentrations in the Te Aute Drain to exceed the limit; rather it is activities further upstream. Thus, compliance with the current effluent NH_4-N consent limit appears to be sufficient to prevent adverse effects arising from ammonia toxicity (see Section 5.1.3).

[7] When converted to NH_3-N based on pH and temperature

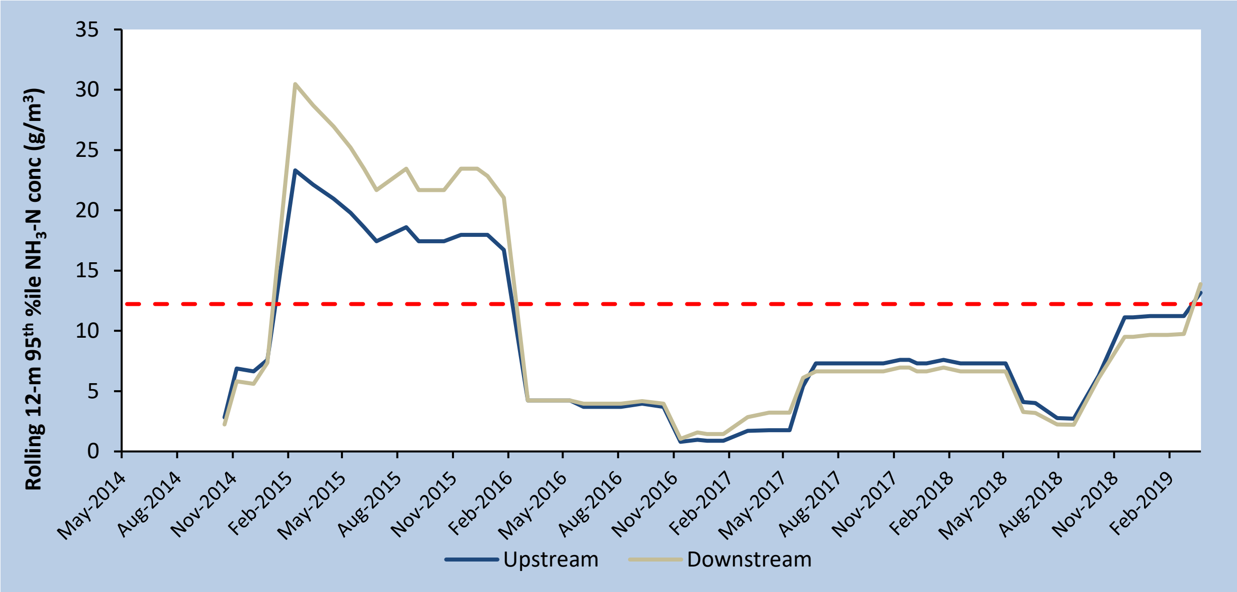

Figure 75: Rolling 12-month 95th percentile NH_3-N concentrations for sites sampled upstream and downstream of the Otane WWTP (May 2005 – April 2019). The red dashed line represents the PC6 limit.

5.2.2 *Nitrate nitrogen*

Between May 2005 and April 2019 small but statistically significant increases in NO_3-N concentrations were observed between sites on the Te Aute Drain upstream and downstream of the Otane WWTP (average increase = 0.08 g/m^3; Wilcoxon signed rank test: Z =2.71, P = 0.007) (Figure 76 and Table 18).

NO_3-N concentrations in the Te Aute Drain were consistently below the PC6 rolling 12-month median limit both upstream and downstream of the Otane WWTP (Figure 77), and were 87% and 85% compliant with the 95th percentile limit at the upstream and downstream sites respectively (Figure 78). As NO_3-N concentrations were generally compliant with the PC6 limits and most exceedances were observed at both the upstream and downstream sites, the risk of nitrate in the discharge causing toxicity effects on aquatic fauna in the Te Aute Drain is very low.

It should be noted that effluent from the Otane WWTP discharges to the Te Aute Drain via a long lateral drain, and NH_4-N rather than NO_3-N is the predominate nitrogen species in wastewater. Thus, it is entirely possible that the observed differences in NO_3-N concentration between the upstream and downstream sites was the result of diffuse discharges to the lateral drain from the surrounding intensive land-use, rather than the WWTP discharge.

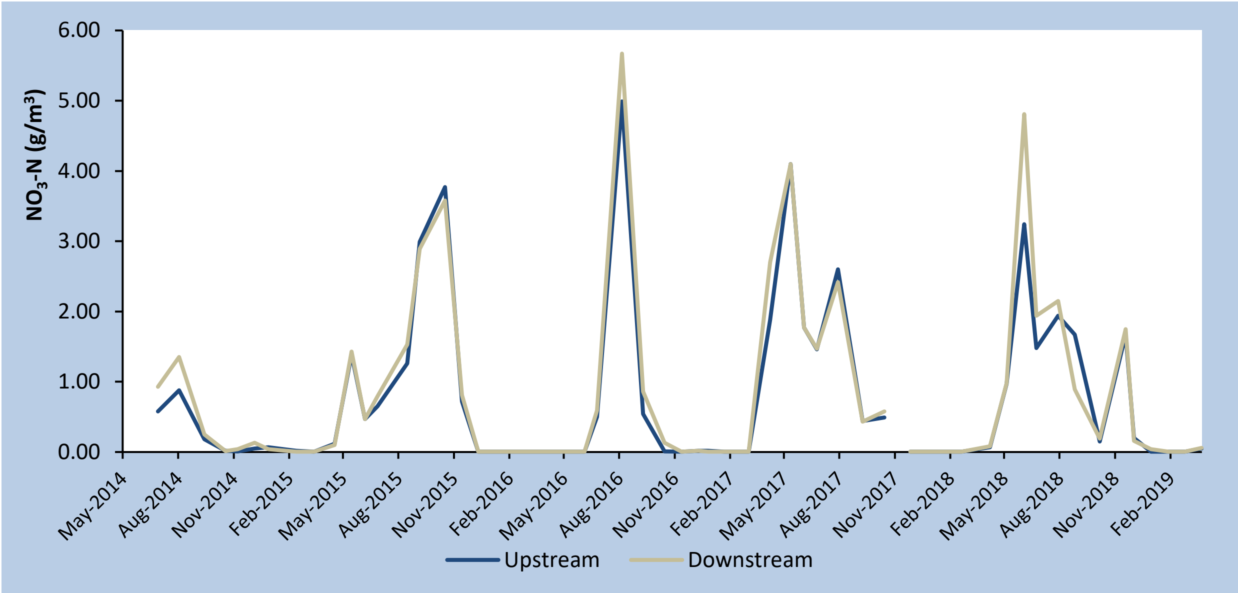

Figure 76: NO_3-N concentrations for sites sampled upstream and downstream of the Otane WWTP (May 2005 – April 2019)

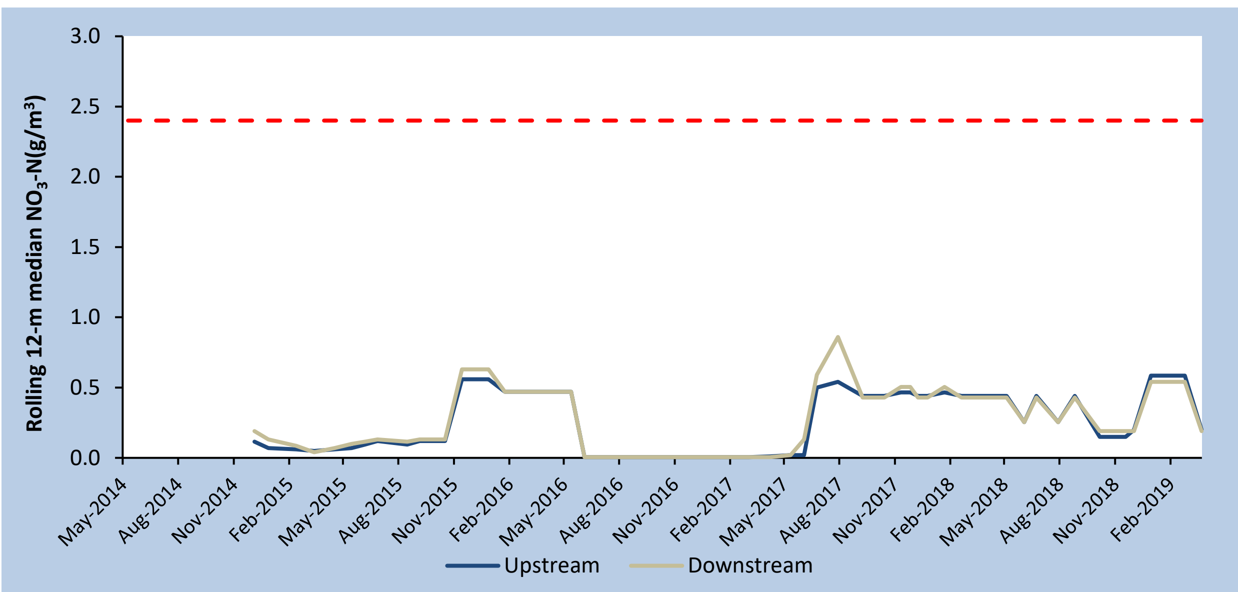

Figure 77: Rolling 12-month median NO_3-N concentrations for sites sampled upstream and downstream of the Otane WWTP (May 2005 – April 2019). The red dashed line represents the PC6 limit.

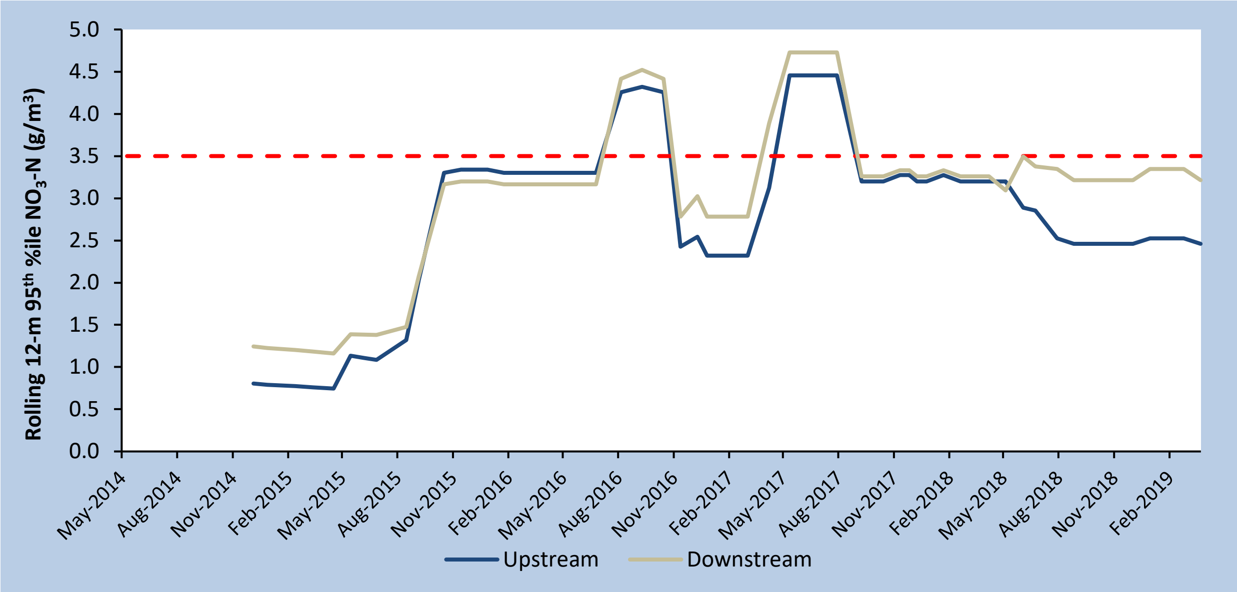

Figure 78: Rolling 12-month 95th percentile NO_3-N concentrations for sites sampled upstream and downstream of the Otane WWTP (May 2005 – April 2019). The red dashed line represents the PC6 limit.

5.2.3 Dissolved inorganic nitrogen

Between May 2005 and April 2019, small but statistically significant increases in DIN were observed between sites on the Te Aute Drain upstream and downstream of the Otane WWTP (average increase = 0.08 g/m^3; Wilcoxon signed rank test: $Z = 2.101$, $P = 0.04$) (Figure 79 and Table 18).

Since November 2014, rolling 5-year average DIN concentrations in the Te Aute Drain have frequently exceeded the PC6 limit of 0.8 g/m^3 both upstream and downstream of the Otane WWTP discharge (Figure 80). The consistent exceedances of the limit at the upstream site suggests that it is not NH_4-N or NO_3-N in the Otane WWTP discharge that is causing DIN concentrations in the Te Aute Drain to exceed the limit; rather it is activities further upstream. In order to meet the PC6 DIN limit, concentrations downstream of the discharge would need to reduce by ~25% (based on the most recent five years of monitoring data), and completely removing the discharge from the drain would achieve a ~7% reduction.

The Te Aute Drain is a macrophyte dominated system, and DIN concentrations upstream are already sufficiently high to facilitate nuisance growths. Thus, the small increases in DIN concentration caused by the Otane WWTP discharge is unlikely to increase macrophyte biomass.

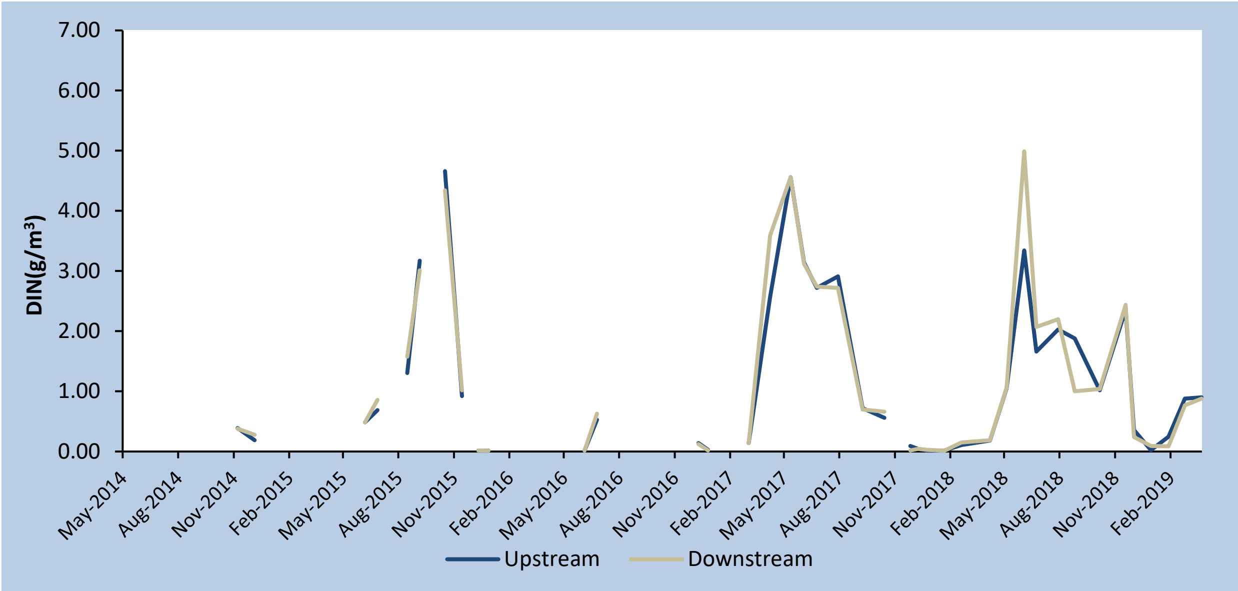

Figure 79: DIN concentrations for sites sampled upstream and downstream of the Otane WWTP (May 2005 – April 2019)

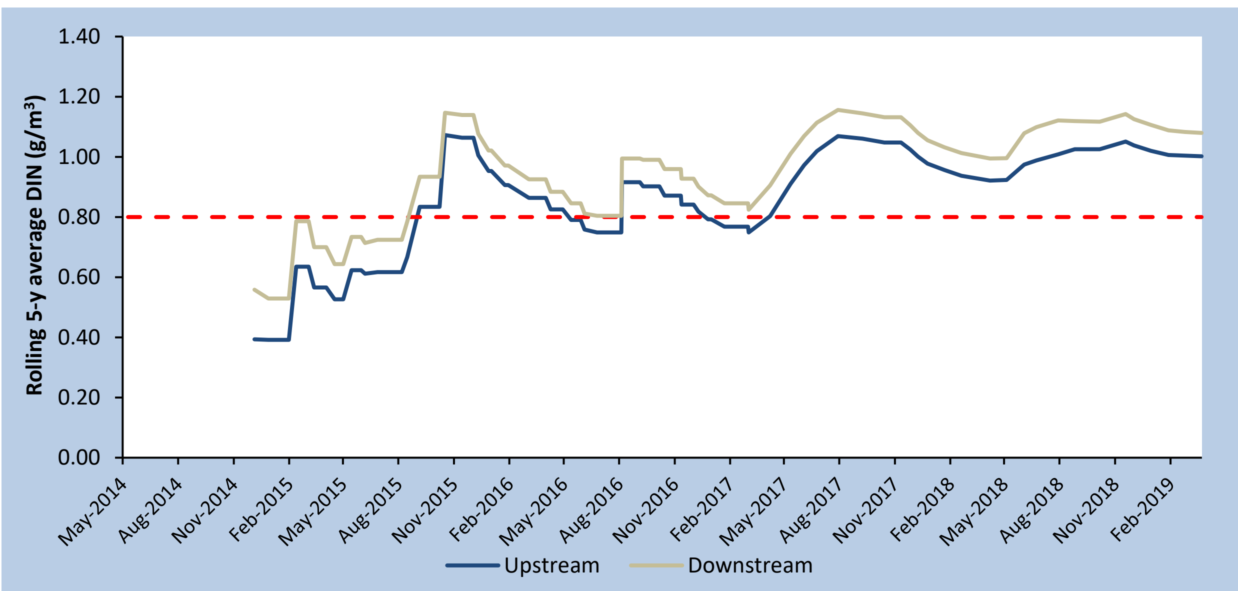

Figure 80: Rolling 5-year DIN concentrations for sites sampled upstream and downstream of the Otane WWTP (May 2005 – April 2019). The red dashed line represents the PC6 limit.

5.2.4 Dissolved reactive phosphorus

Statistically significant increases in DRP concentrations were observed between sites on the Te Aute Drain upstream and downstream of the Otane WWTP in the period May 2005 to April 2019 (average increase = 0.019 g/m^3; Wilcoxon signed rank test: $Z = 4.69$, $P < 0.001$) (Figure 81).

Rolling 5-year average DRP concentrations in the Te Aute Drain at flows below 3 × median have consistently exceeded the PC6 limit of 0.015 g/m^3 both upstream and downstream of the downstream discharge since 2009 (Figure 82). As with DIN, exceedances of the DRP limit at the upstream site suggests it is activities further upstream that it is driving non-compliance in the Te Aute Drain rather than the Otane WWTP discharge and increases in DRP concentration caused by the discharge are unlikely to increase macrophyte biomass. Thus, while DRP in the discharge from the Otane WWTP may not comply with effluent consent limits (see Section 5.1.3), it is not affecting the Te Aute Drain in a meaningful way. Based on the most recent five years of monitoring data, a ~93% reduction in DRP downstream of the discharge at flows below the median would be needed to meet the PC6 limit, and completely removing the discharge from the drain would achieve a ~9% reduction.

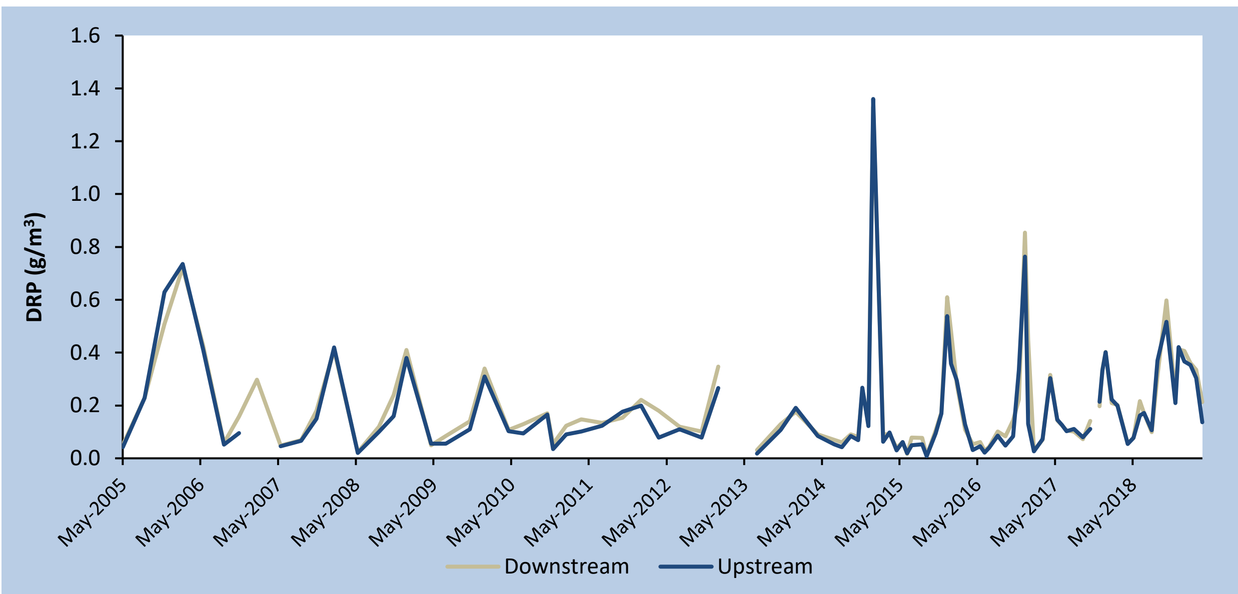

Figure 81: DRP concentrations for sites sampled upstream and downstream of the Otane WWTP (May 2005 – April 2019).

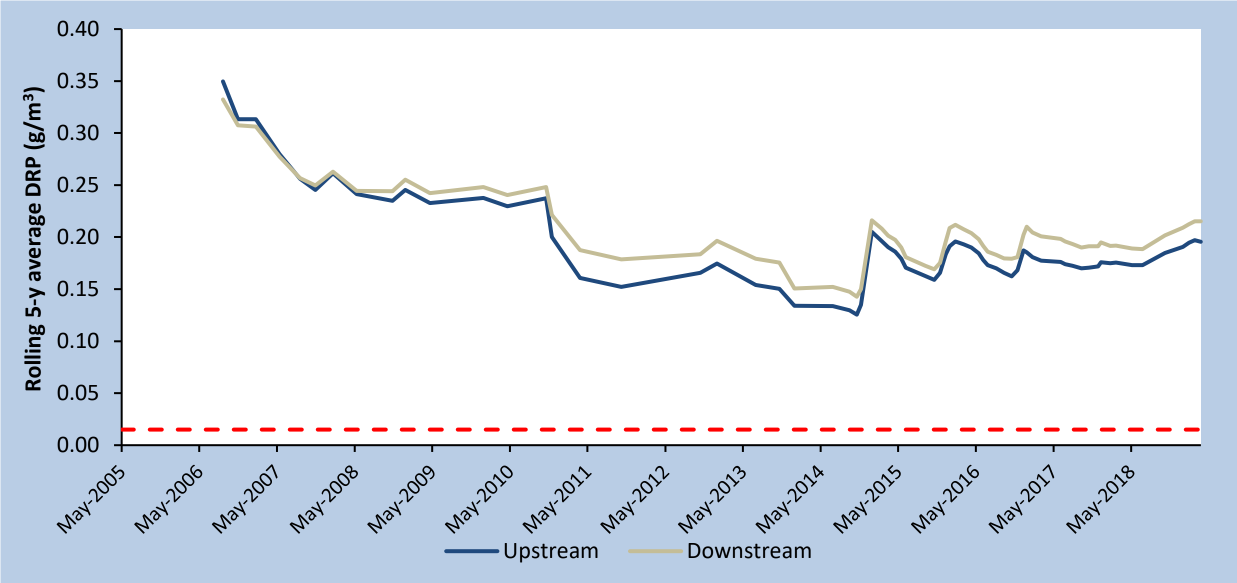

Figure 82: Rolling 5-year DRP concentrations for sites sampled upstream and downstream of the Otane WWTP at flows below 3× median (May 2005 – April 2019). The red dashed line represents the PC6 limit.

5.2.5 E. coli

Between May 2005 and April 2019 *E. coli* concentrations did not differ in a statistically significant manner between sites on the Te Aute Drain upstream and downstream of the Otane WWTP (average Δ =162 CFU/100mL; Wilcoxon signed rank test: Z = 1.227, P = 0.22) (Figure 83 and Table 18).

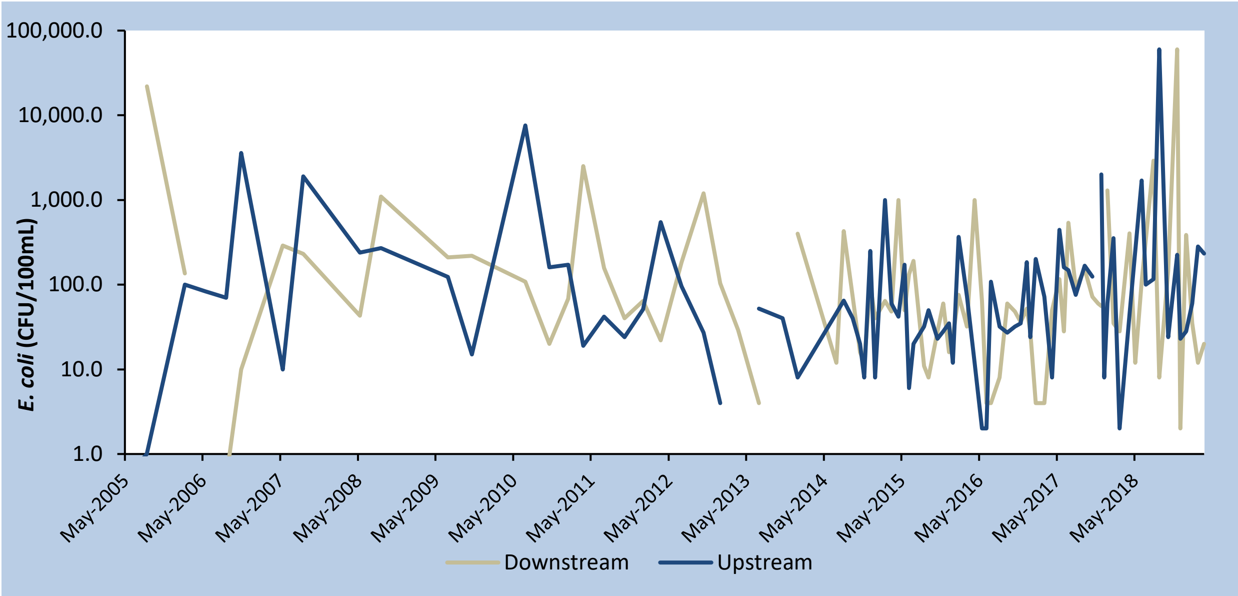

Figure 83: *E. coli* concentrations for sites sampled upstream and downstream of the Otane WWTP (May 2005 – April 2019).

The Te Aute Drain is generally compliant with the PC6 *E. coli* limits both upstream and downstream of the Otane WWTP. Between May 2005 and April 2019 *E. coli* concentrations at flows below the median met the summertime limit of 260 CFU/100mL on all but two occasions at the upstream site (94% compliance) and four occasions at the downstream site (88% compliance) (Figure 84)[8]. Furthermore, the wintertime target of 550 CFU/100mL at flows below 3× median was met on all but one occasion both upstream and downstream of the discharge (97% compliance). As the available data suggests that *E. coli* in the Te Aute Drain is generally compliant with the PC6 limits downstream of the Otane WWTP and that the discharge does not increase concentrations significantly, it is unlikely to increase the risk of human health effects in the Te Aute Drain or the risk of the stream not meeting the PC6 limits, despite the Otane WWTP regularly not complying with effluent *E. coli* consent limits (see Section 5.1.3).

[8] Data cannot be assessed against the other summertime target of 550 CFU/100mL as only three samples have been collected between November and April when flow was between the median and 3× median.

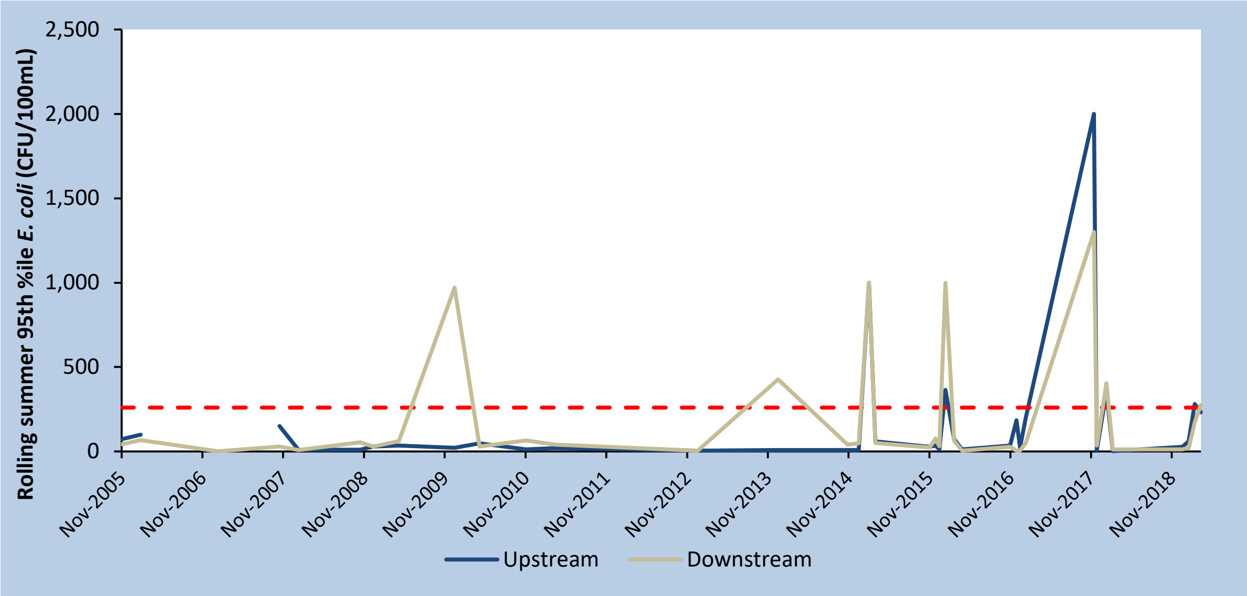

Figure 84: Summertime (November to April inclusive) *E. coli* concentrations for sites sampled upstream and downstream of the Otane WWTP at flows below the median (May 2005 – April 2019). The dashed redline represents the PC6 limit.

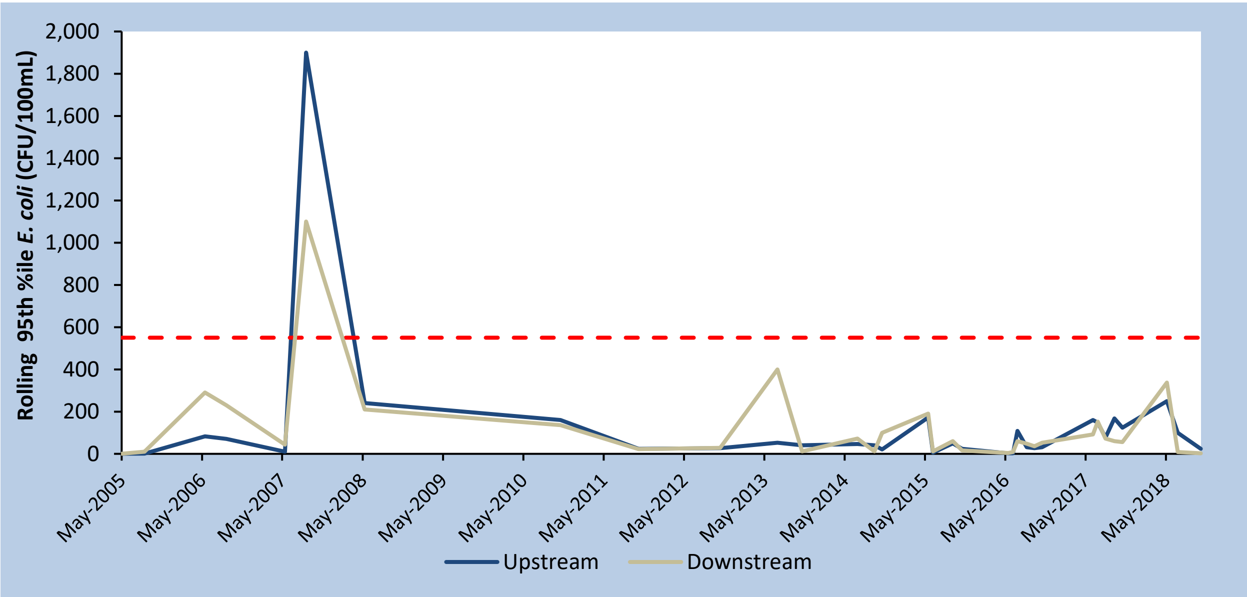

Figure 85: Wintertime (May to October inclusive) *E. coli* concentrations for sites sampled upstream and downstream of the Otane WWTP at flows below 3× median (May 2005 – April 2019). The dashed redline represents the PC6 limit.

5.2.6 *Visual clarity, 5-day carbonaceous biochemical oxygen demand and particulate organic matter*

Visual clarity, $ScBOD_5$ and POM have not been monitored in the Te Aute Drain upstream and downstream of the discharge. Thus, a quantitative assessment against the PC6 limits for these parameters is not possible. However, $cBOD_5$, which includes $ScBOD_5$, has been monitored, and the available data indicates that concentrations do not change significantly between sites upstream and downstream of the discharge (Wilcoxon signed rank tests: $Z = 1.887$, $P = 0.06$, av. $\Delta = -0.1$ g/m^3), and that average concentrations at both sites at flows below the median are only just above the PC6 target for $ScBOD_5$ (upstream = 2.54 g/m^3; downstream = 2.02 g/m^3). Thus, it is unlikely that the discharge is causing the PC6 limits for $ScBOD_5$ to be exceeded in the Te Aute Drain.

5.2.7 *Quantitative macroinvertebrate community index*

It is my understanding that recent macroinvertebrate data does not exist for the Te Aute Drain near the Otane WWTP discharge, and that data is limited to semi quantitative macroinvertebrate community index (SQMCI) scores recorded at sites 50 metres upstream and downstream of the discharge in March 2006 and March 2009 (Strong 2006 & 2009). Those somewhat old data indicate that the Otane WWTP discharge was compliant with the PC6 QMCI limits at the time of collection, as the maximum reduction in SQMCI observed between sites was 17% (Table 19).

Table 19: Assessment of SQMCI data collected in the Te Aute Drain at sites upstream and downstream of the Otane WWTP discharge against the PC6 limit.

Year	Site	Average SQMCI	%Δ	Limit %Δ	Compliant
2006	50m U/S	3.66	N/A	20	-
	400m D/S	3.95	-8		✓
2009	50m U/S	3.51	N/A		-
	400m D/S	2.93	-17		✓

5.3 Conclusions

Monitoring data collected for the Otane WWTP between May 2005 and April 2019 suggests:

- The Otane WWTP discharge did not comply with the effluent quality limits for TSS, DRP and *E. coli*. However, this non-compliance does not appear to have had a meaningful effect on water quality and ecology in the Te Aute Drain.
- The discharge of NH_4-N and NO_3-N from the Otane WWTP did not increase the risk of ammonia/nitrate toxicity effects or plant growth in the Te Aute Drain, and exceedances of the PC6 limits for DIN, NH_4-N and NO_3-N appear to be have been driven by activities upstream rather than the discharge. In order to meet the PC6 DIN limit, concentrations downstream of the discharge would need to reduce by ~25% (based on the most recent five years of monitoring data). Completely removing the discharge from the drain would achieve a ~7% reduction.

- The discharge of DRP from the Otane WWTP did not increase the risk of plant growth in the Te Aute Drain, and had little influence on the drain's compliance with the PC6 limit, which was already exceeded upstream of the discharge due to other human activities. Based on the most recent five years of monitoring data, a ~93% reduction in DRP downstream of the discharge at flows below the median would be needed to meet the PC6 limit, and completely removing the discharge from the drain would achieve a ~9% reduction.
- *E. coli* in the Otane WWTP discharge did not increase the risk of human health effects in the Te Aute Drain or the risk of the stream not meeting the PC6 *E. coli* limits.
- TSS and $cBOD_5$ from the Otane WWTP are unlikely to have resulted in the PC6 $ScBOD_5$ limit being exceeded in the Te Aute Drain, However, an absence of monitoring data means its effects on instream visual clarity and POM are unclear.
- The limited macroinvertebrate monitoring data available for the Te Aute Drain indicate that the Otane WWTP discharge was compliant with the PC6 QMCI limits.

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