Water quality study:
Waiwera River Catchment

June 2017

Otago Regional Council

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Technical summary

The Waiwera River is a medium-sized river, which rises in the Wisp Range and flows in a northerly direction to its confluence with the Clutha River/Mata-Au downstream of Clydevale. The river is fed by rainfall of up to 1400mm per annum in the Kaihiku Ranges, while the lower catchment receives lower levels of rainfall (<700 mm per annum).

The objectives of this report are to:

- Assess water quality in the Waiwera Catchment and identify where Schedule 15 limits in the Regional Plan: Water (RPW) are exceeded.
- Assess spatial and temporal patterns in water quality and to relate water quality patterns to land-use activities, where possible.
- Assess in-stream habitat quality and macroinvertebrate communities.

Most of the intensive farming in the lower Waiwera Catchment takes place on very poorly drained soils, farming in these areas would not be possible without the construction of extensive artificial drainage (tile drains) to convey water to the nearest watercourse, in the upper catchment to the west of the Kaihiku Ranges the land supports extensive sheep and beef grazing.

Water quality shows elevated concentrations of nutrients and bacteria that generally exceed the Schedule 15 limit set out in the Regional Plan Water (RPW), see table below. Inorganic nitrogen or Nitrate/Nitrite Nitrogen (NNN) concentrations were at concentrations sufficient to stimulate the growth rate of algae, typically being well above the Biggs (2000) 30-day accrual threshold concentration of 0.075 mg/L. Dissolved Reactive Phosphorus (DRP) concentrations were also high in the Waiwera River, typically being 0.01 to 0.04 mg/L. Bacteria concentrations were high and exceeded the Schedule 15 limit at ten of the thirteen sites and in addition six of the thirteen sites monitored exceeded the Schedule 15 turbidity limit. These results are very high for Otago rivers and streams.

Analysis of trends in water-quality parameters at the Maw's Farm SoE site show that most water quality variables had not changed between July 2006 and February 2017, with the exception of total phosphorus (TP) which declined significantly over this period. When compared to Schedule 15 limits, all of the variables considered at the Maw's Farm site exceeded the Schedule 15 limits other than turbidity.

Although much of the lower catchment has artificial drainage, the monitoring results show little change in N concentrations between the upper and lower catchment. What is evident is the seasonal variation in N, which indicates indirect losses of nutrients associated with farming activities including application of farm dairy effluent (FDE) due to nutrient enrichment of the soil during the summer-autumn period followed by leaching during the subsequent winter-spring drainage period. The Clinton oxidation pond discharge to the Kuriwao Stream, downstream of Clinton is responsible for the sharp increase in concentrations of TP, DRP and NH_4-N in the Kuriwao Stream.

The results of the catchment periphyton survey showed that long (>2 cm), filamentous algae cover, indicative of eutrophic waters, was generally low at most sites, however three sites exceeded guideline levels (>30% cover); Waiwera at Maw's Farm (36%), Waiwera at Owaka Valley Road (38%) and Waiwera at Robertson Road (31%). The percentage of the bed covered by other periphyton types (including unconsolidated algae, medium and thick mats, didymo and short, (<2 cm) filamentous algae) was exceeded at four mainstem Waiwera River sites.

The in-stream visual estimate of % sediment cover showed that only the two tributaries exceeded the recommended guideline (20% cover). All other sites had between 1.3% and 13.3% sediment cover. Resuspendible sediment was determined by the Quorer method, the results showed that of the mainstem sites, the Waiwera at Robertson Road had the most elevated inorganic sediment concentrations which exceeded the recommended guideline of 450g/m^2.

Comparison of the 80th percentiles of water-quality parameters with Schedule 15 (RPW). Values that exceeded the limit are highlighted in grey. All values calculated using samples collected when flows were at, or below, the appropriate reference flow.

Site Name	Ammoniacal Nitrogen (mg/L)	Dissolved Reactive Phosphorus (mg/L)	E-Coli (MPN/100ml)	Nitrite/ Nitrate Nitrogen (mg/L)	Turbidity (NTU)
Schedule 15 limit	0.100	0.026	260	0.444	5
Waiwera at Owaka Valley Rd	0.017	0.0308	524	1.34	6.28
Waiwera River Hillfoot Rd	0.017	0.0168	116	1.14	3.30
Waiwera River at Kuriwao Siding Rd	0.022	0.0172	318	1.16	3.04
Kuriwao Stream Old Coach Rd	0.023	0.0318	940	1.42	7.54
Kuriwao Stream Hillfoot Rd	0.018	0.0268	450	1.32	5.28
Awakia Stream at Hillfoot Road	0.107	0.0370	1030	0.38	6.56
Kuriwao Stream u/s Kuriwao Siding Rd	0.033	0.0804	648	1.22	4.60
Waiwera trib at Blaike Rd	0.035	0.0372	564	3.04	19.60
Waiwera trib d/s quarry	0.057	0.0506	1360	1.52	10.08
Waiwera River at Robertson Rd	0.032	0.0338	364	1.16	3.62
Waiwera River at SH1 bridge	0.031	0.0324	378	1.15	3.30
Waiwera River near Clifton	0.035	0.0366	464	1.08	3.60
Waiwera River at Maw's Farm	0.021	0.0280	246	1.30	3.36

Substrate with a good mix of boulders, cobbles, gravels and sand, which is essential for macroinvertebrate health and diversity, was present at most sites, other than the two tributaries. Macroinvertebrate communities in the March 2017 catchment survey reflected generally 'poor water quality' (Stark, 2007). It is likely that sediment and algae covering the substrate and filling in interstitial spaces is to blame for a paucity of invertebrates at these sites, particularly the sensitive Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) species. Trend analysis indicated that macroinvertebrate metrics at Maw's Farm site had been stable from 2007 to 2016.

Fine sediment accumulation seems to be the main cause of losses in abundance and diversity of macroinvertebrate communities and fish populations in the Waiwera Catchment, particularly the mainstem Waiwera. Appropriate mitigation measures need to be implemented to protect the river from further degradation and to aid recovery. This may include the provision of stock water.

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1. Introduction

The Waiwera River is a medium-sized river, which rises in the Wisp Range and flows in a northerly direction to its confluence with the Clutha River/Mata-Au downstream of Clydevale.

The river is fed by consistent rainfall throughout the year (700mm in the low altitude parts of the catchment through to nearly 1400mm in the upper catchment). Much of the catchment above the Kaihiku Range consists of extensively grazed grasslands and scrub, native forest and plantation forestry. Intensive agriculture in the catchment generally occurs in the lower catchment with ten dairy farms operating downstream of the Kaihiku Range.

In the Waiwera Catchment water quality is monitored at the Waiwera River at Maw's Farm as part of Otago Regional Council's larger programme of State of the Environment (SoE) monitoring which is a specific requirement of regional councils under Section 35(2)(a) of the Resource Management Act (RMA) 1991. Schedule 15 of the Regional Plan Water (RPW) sets out water-quality limits and targets for receiving waters in the Otago region, all of the water quality variables considered at the Maw's Farm site exceed the Schedule 15 limit other than turbidity. Macroinvertebrate community health is monitored on an annual basis at Maw's Farm, results from the last 10 years indicate that the macroinvertebrate community has low numbers of sensitive (to nutrient enrichment and fine sediment) taxa and is reflective of a degraded ecosystem.

This report is a targeted water quality/ecological study which focuses on monitoring data collected over the period November 2015 to November 2016, the objectives are to:

- Assess water quality in the Waiwera Catchment and identify where Schedule 15 limits in the Regional Plan: Water (RPW) are exceeded.
- Assess spatial and temporal patterns in water quality and to relate water quality patterns to land-use activities, where possible.
- Assess in-stream habitat quality and macroinvertebrate communities.

2. Background

2.1 Catchment description

The Waiwera Catchment is located in South Otago. It extends for approximately 30km and has an area of approximately 207 km^2. The Waiwera Catchment is known to have relatively high, reliable rainfall. Its headwaters are found in the Wisp Range from which it flows in a northerly direction to its junction with the Clutha River/Mata-Au downstream of Clydevale (Figure 2.1)

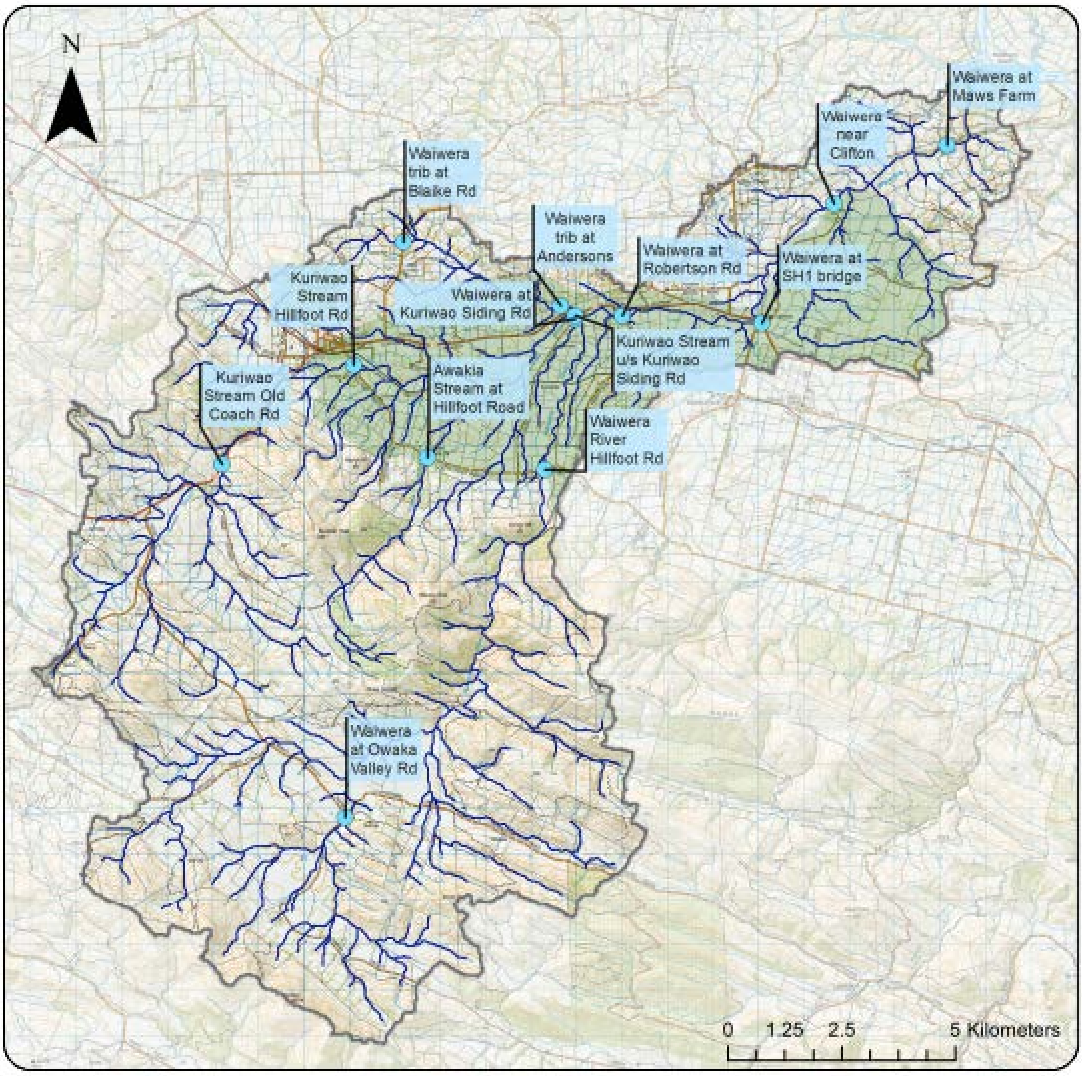

Figure 2.1 Map showing the SoE monitoring site at Maw's Farm and the additional twelve catchment monitoring sites

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2.2 Climate

The climate within the Waiwera Catchment is classified as either 'cool-dry' (mean annual temperature <12°C, mean annual effective precipitation ≤500 mm) or 'cool-wet' (mean annual temperature <12°C, mean annual effective precipitation 500-1500 mm) (River Environment Classification, Ministry for the Environment & NIWA, 2004).

Rainfall statistics from Waipahi at Cairns Peak and Clutha at Balclutha show consistent rainfall throughout the year (Table 2.1) and Figure 2.2 shows the distribution of rainfall within the Waiwera Catchment. Rainfall intensities varies from around 700 mm in the low altitude parts of the catchment through to nearly 1400mm in the upper catchment (Table 2.1) due to a combination of factors including altitude, aspect and topography.

Table 2.1 Rainfall statistics at Waipahi at Cairns Peak (1990-2016) and Clutha at Balclutha (1988 to 2016)

Waipahi at Cairns Peak													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	27	18	26	15	62	34	29	15	19	61	36	4	1036
Mean	111	85	102	96	143	135	101	98	93	129	122	112	1364
Max.	283	194	194	201	367	259	271	201	197	200	278	273	1782
Clutha at Balclutha													
Min.	9	13	13	5	12	14	12	8	9	17	13	8	498
Mean	69	68	47	48	69	58	45	43	47	59	54	69	677
Max.	144	197	97	141	146	131	101	110	112	124	94	133	897

Long-term air temperature records from the Tapanui and Balclutha weather stations, the closest long-term weather stations to the Waiwera Catchment, show that air temperatures do not have a marked variation throughout the year, with the mean daily summer temperatures (January) being almost 15°C, while the mean daily winter temperature (July) is 5°C (Table 2.2).

Table 2.2 Mean temperature statistics (mean, minimum, maximum) at Tapanui weather station (5686) and Balclutha weather station (5867) between 1981 and 2010

Tapanui	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mean	14.6	14.3	12.6	10.3	7.7	5.5	4.7	6.3	8.2	9.8	11.4	13.3	9.9
Max	20.4	20.2	18.4	15.8	12.5	9.8	9	11	13.6	15.4	17.1	18.8	15.2
Min	8.8	8.3	6.8	4.9	2.9	1.2	0.4	1.6	2.9	4.2	5.7	7.7	4.6
Balclutha	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mean	15.1	14.8	13.3	10.7	8.1	5.8	5.2	6.8	8.8	10.5	12.2	13.9	10.4
Max	20.3	19.9	18.4	15.8	12.5	9.9	9.4	11.4	13.9	15.6	17.2	18.8	15.3
Min	10	9.7	8.2	5.7	3.7	1.7	1	2.1	3.7	5.5	7.2	8.9	5.6

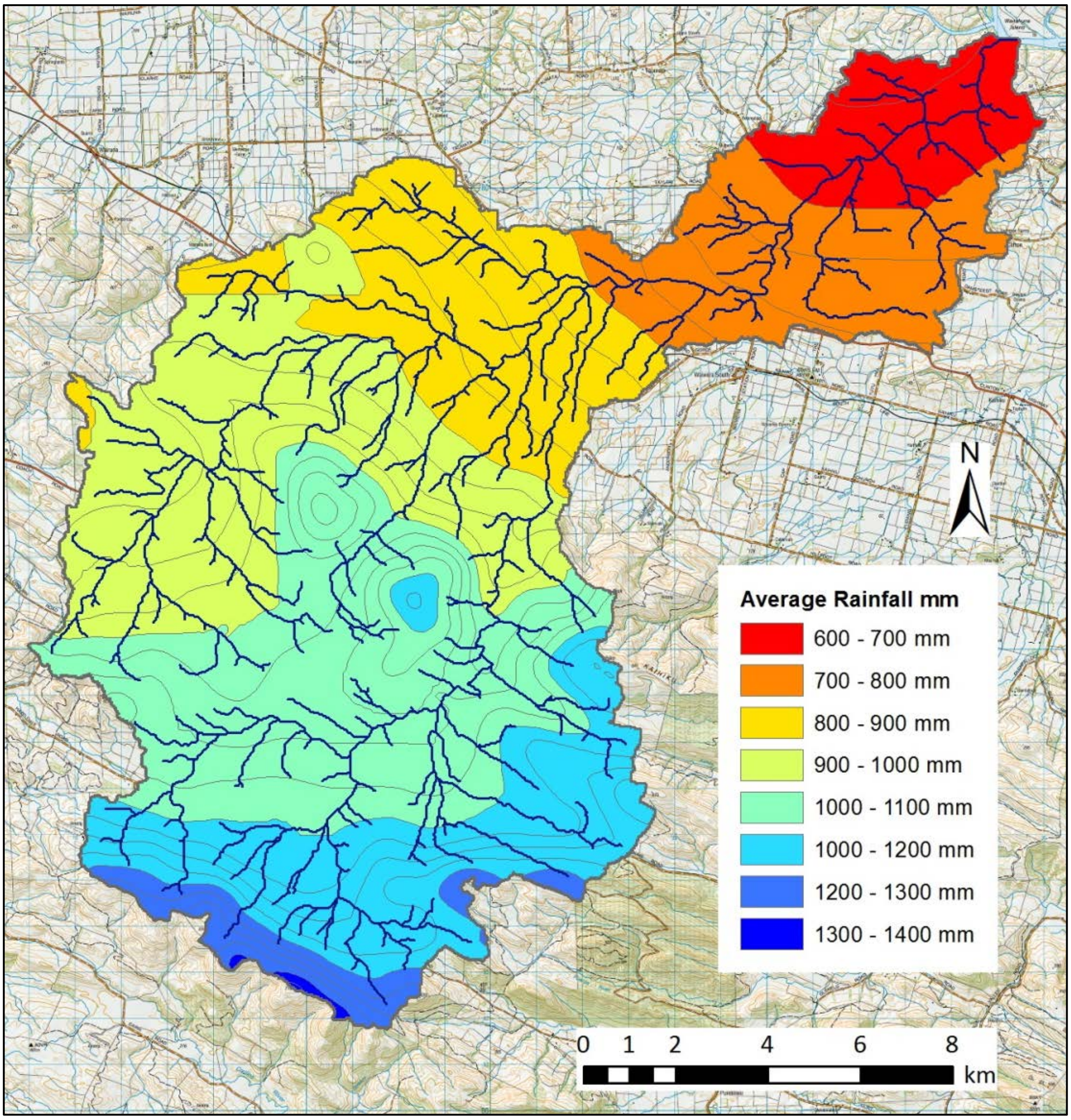


Figure 2.2 Modelled rainfall in the Waiwera Catchment

2.3 Topography and soils

The Waiwera River rises in the steep valleys and swampy flats of the Southland syncline area, before making its way through the rolling hill country and low-lying areas around Clinton. The land to the east and west is generally rolling pasture land. Soils within the Waiwera Catchment, particularly on the river flats and terraces are considered fertile.

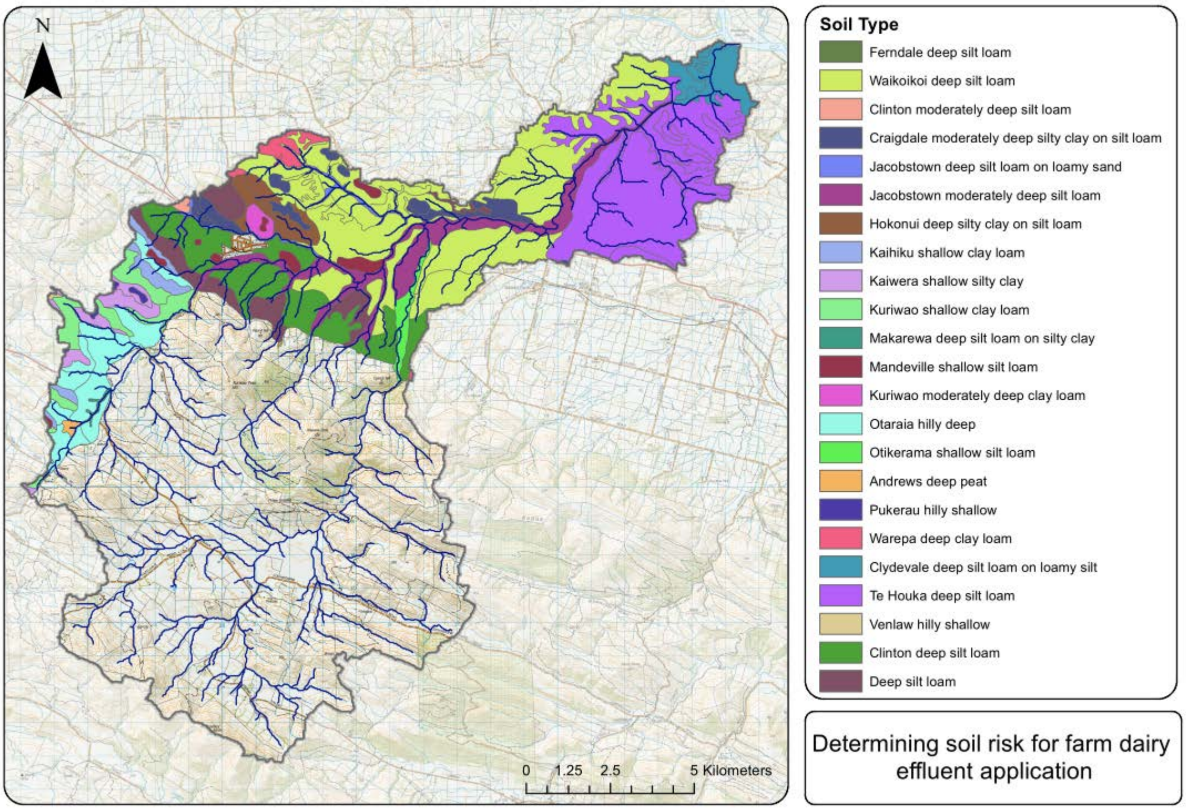


Figure 2.3 S-map soil coverage, Waiwera Catchment

S-map does not cover the whole catchment, however it can be seen (Figure 2.3) that the lower Waiwera Catchment is dominated by pallic soils. Timaru soils are shown as purple and Claremont soils are shown as light green. The parent material of these soils is hard sandstone and schist rock. These soils can only infiltrate a small amount of water at the soil surface before water begins to pond or run off (Table 2.3).

Below the Kaihiku Range brown soils dominate, the brown Waikiwi soils are shown as dark green. These soils are poorly drained, have a higher topsoil phosphorus (P) retention than the pallic soils, a low nitrogen (N) leaching vulnerability and associated low dairy effluent run-off risk. The soils along Owaka Valley Road are Otaraia soils, shown in light blue. These are also brown soils, with much the same characteristics as the Waikiwi soils.

Table 2.3 Soil characteristics in the Waiwera Catchment

Soil characteristics	Purple	Light Green	Dark Green	Blue
S-map classification	Timu_35a.1	Clar_34a.1	Waiki_20a.1	Otari_3a.1
Soil classification	Fragic Pallic	Perch Gley Pallic	Firm Brown	Acidic Brown
Water logging vulnerability	High	High	Low	Low
N leaching vulnerability	Medium	Medium	Low	Low
Dairy effluent risk category*	C (High)	B (High)	D (Low)	D (low)
Relative runoff potential	High	Very high	Very low	Very low
Rooting barrier	Pan 50-70cm	Pan 50-70cm	None to 1m	None to 1m
Topsoil P retention	Low (21%)	Low – 22%	Medium (43%)	Medium (43%)
Profile Available Water	High (54mm)	High (52mm)	High (63mm)	High (63mm)

*Five soil classes (A to E) based on the DairyNZ guide to determining soil risk for farm dairy effluent application

2.4 Geomorphology

All three branches of the upper Waiwera River consist of confined, meandering channels cutting into schist bedrock, with a mixed gravel and bedrock bed (ORC, 2008). In the lower catchment, the channel is mostly a mobile single-thread, with some partially braided sections incised into an elevated gravel floodplain (ORC, 2008). Gravel extraction takes place in several locations in the North Branch (Sharpes Bend and upstream of Graves Dam), a 1 km section of the South Branch upstream of the SH1 bridge; and at two locations downstream of the confluence of the North and South branches (ORC, 2008). Historical river management activities have included channel realignment and willow planting (ORC, 2008).

2.5 Catchment land cover

Vegetation cover in the catchment is high producing exotic grassland, much of which is extensively grazed (Figure 2.4). The Kaihiku Ranges, in the middle of the catchment supports low producing grassland and exotic forestry, this range includes Kuriwao Peak (639m) and Waiwera Cone (626m).

In the upper catchment tall tussock grassland is supported, particularly in the low lying swampy area below Lochindorb Runs Road and around Owaka Valley Road.

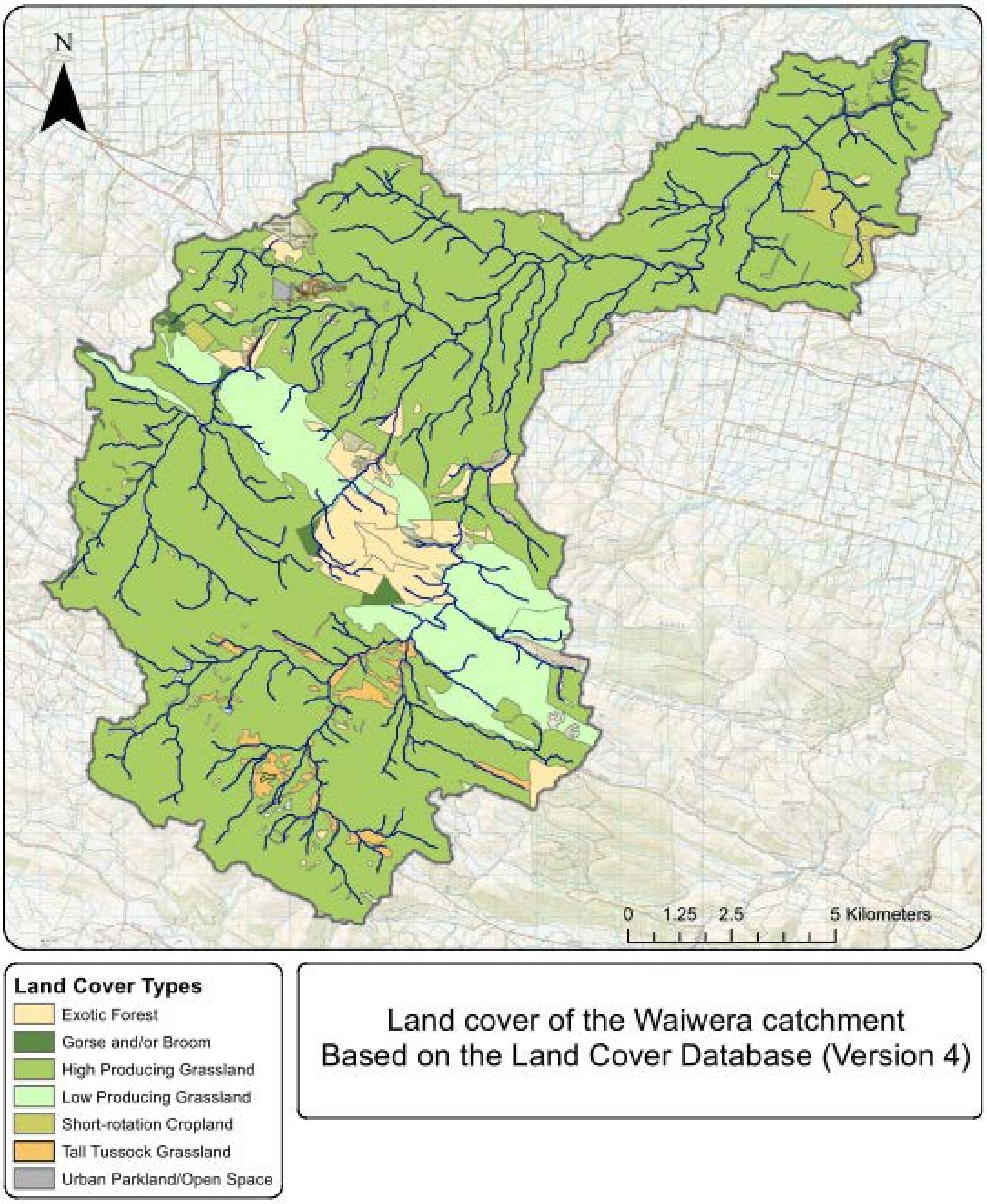


Figure 2.4 Land cover of the Waiwera Catchment, based on the Land Cover Database (Version 4)

Based on LIC/dairy statistics (www.lic.co.nz), the number of dairy cows in the Clutha district has increased from 56,479 in 2000/2001 to 109,949 in 2015/2016 (Table 2.4). Some of this increase will have occurred in the Waiwera Catchment. Based on information from Otago Regional Council dairyshed effluent inspections in 2015/2016, there are in the order of 6079 cows in the Waiwera Catchment, which is approximately 5.5% of the total cow numbers in the Clutha district. All the dairy farms are located to the east of the Kaihuku range.

Table 2.4 Clutha District herd analysis

Year	Total herds	Total cows	Total	Average	Average
2000/2001	136	56,479		415	2.70
2005/2006	155	74,673	27,459	482	2.74
2010/2011	183	98,543	36,780	538	2.68
2015/2016	202	109,949	39,469	544	2.63

Most of the intensive farming in the lower catchment takes place on very poorly drained soils (Figure 2.5), farming in these areas would not be possible without the construction of extensive artificial drainage (tile drains) to convey water to the nearest watercourse. Dairy farmers generally have tile drains below areas to which Farm Dairy Effluent (FDE) is applied.

Direct losses of FDE occur when effluent is applied to soils that have a limited capacity to store the applied moisture, direct losses of FDE are particularly undesirable as nutrient and bacteria concentrations are high and if ponding or runoff occurs, these contaminants are transferred directly to drainage courses, streams and rivers.

Under wet soil conditions, all soils carry a high risk of direct losses if FDE is applied. However, soils with artificial drainage pose the greatest risk as there is a high degree of potential loss for N, P and bacteria as there is a direct connection between the drains and the water courses. In comparison, well drained soils are unlikely to contaminate surface water bodies as excess water will drain through the soil profile and associated contaminants will be trapped and attenuated as the water and associated contaminants percolate through the soil profile.

Above Hillfoot Road and to the west of the Kaihiku Range, more extensive sheep and beef farming occurs (Figure 2.6) on generally well drained soils.

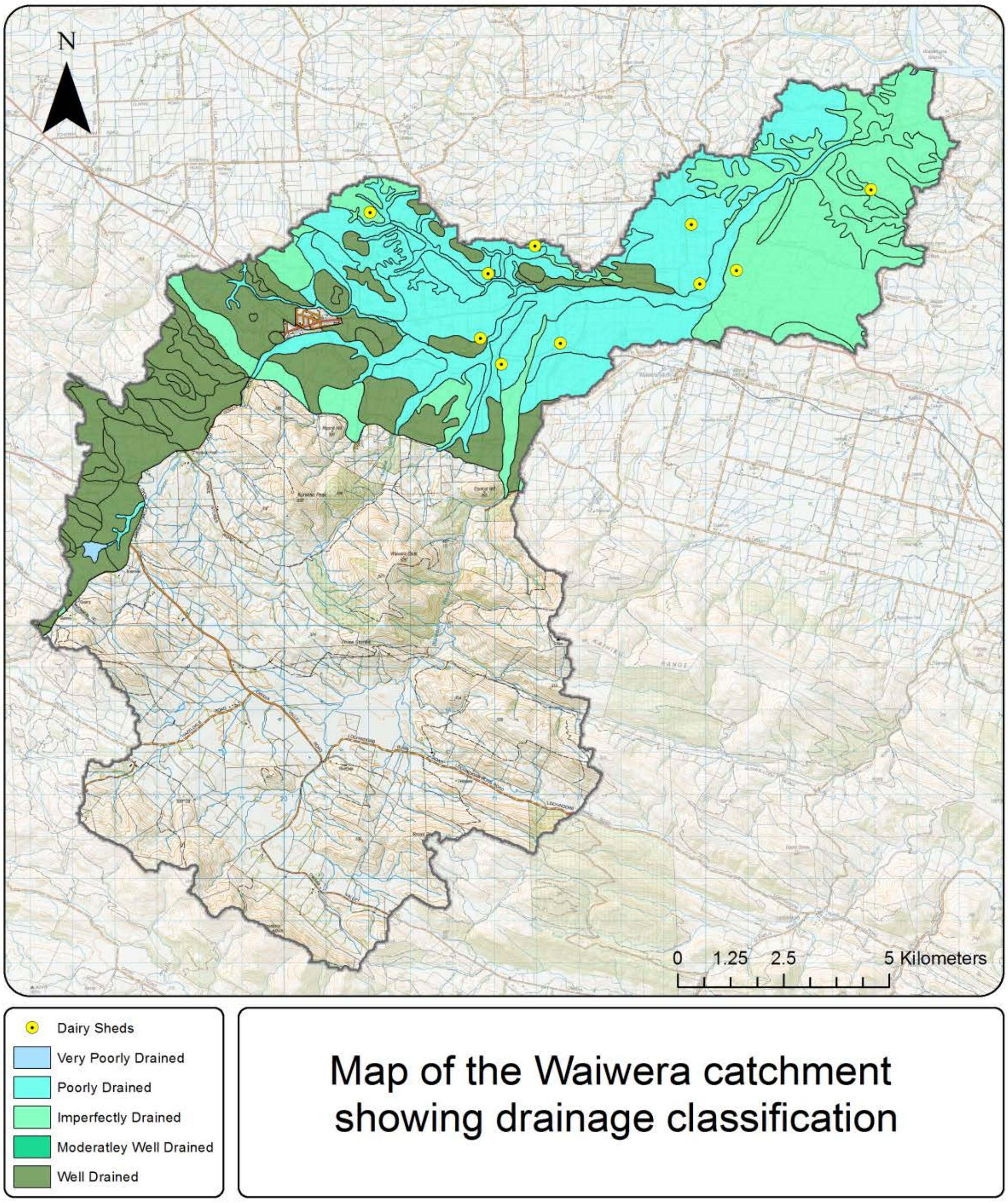


Figure 2.5 Waiwera Catchment showing poor drainage in the lower catchment

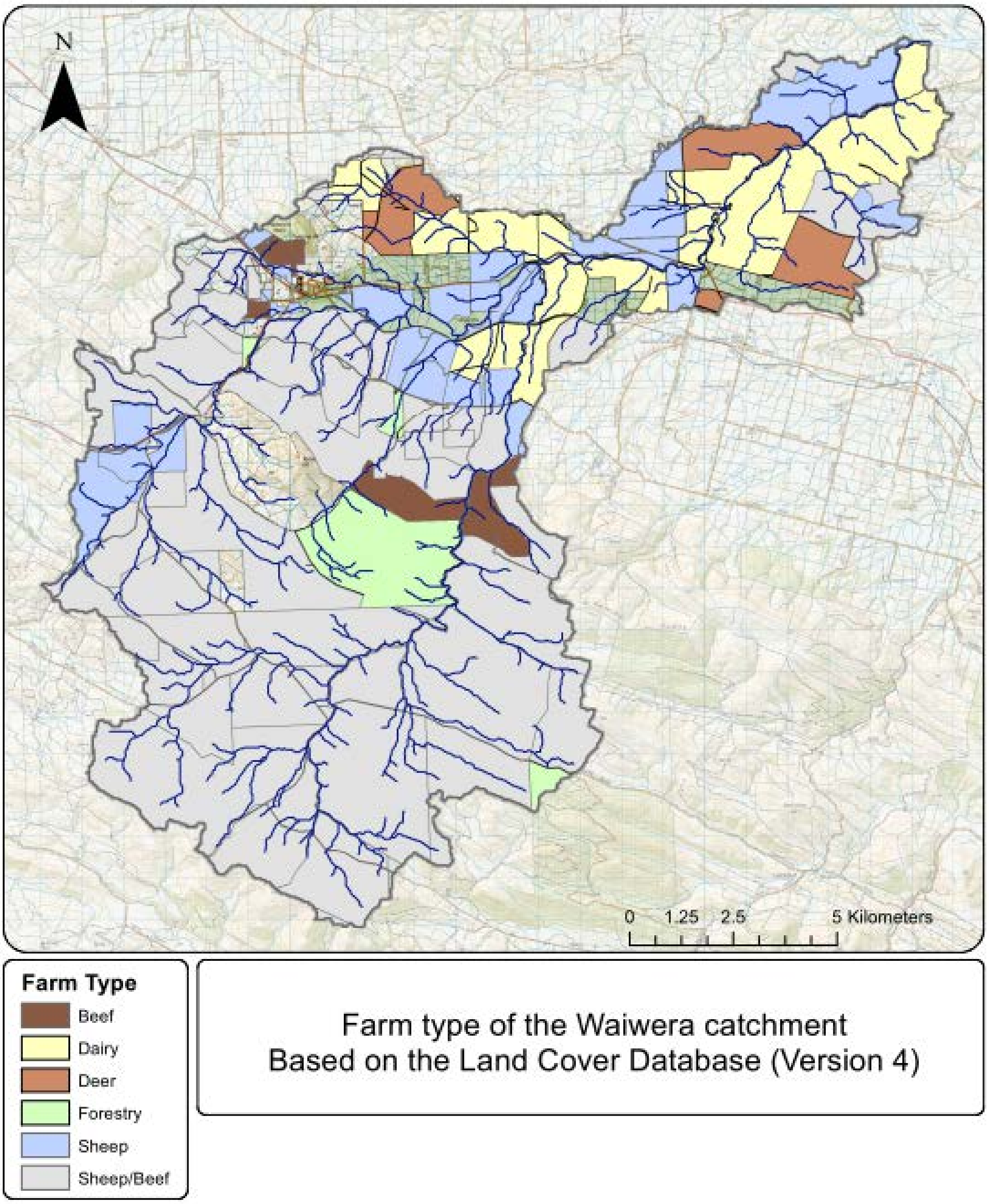


Figure 2.6 Farm type of the Waiwera Catchment, based on the Land Cover Database (Version 4)

2.6 Significant wetlands

There are two significant wetlands in the Waiwera Catchment listed in Schedule 9 (RPW) . Hazeldale Fens and Three Stones fens complex, both are shown in Figure 2.7. These wetlands, and many others which are not identified within the Water Plan, are an important part of the hydrological functioning within the catchment and help to control downstream flood peaks and low flows. They act to filter water passing through them while providing habitat for a range of different bird species and other aquatic lifeforms.

Both wetlands have a high degree of wetland naturalness, in addition the Three Stones Fen Complex is a habitat for the listed sedge *Carex tenuiculmis* (at risk-declining) and Spaniard *Aciphylla subflabellata* (at risk-declining) which are nationally or internationally rare or threatened species or communities.

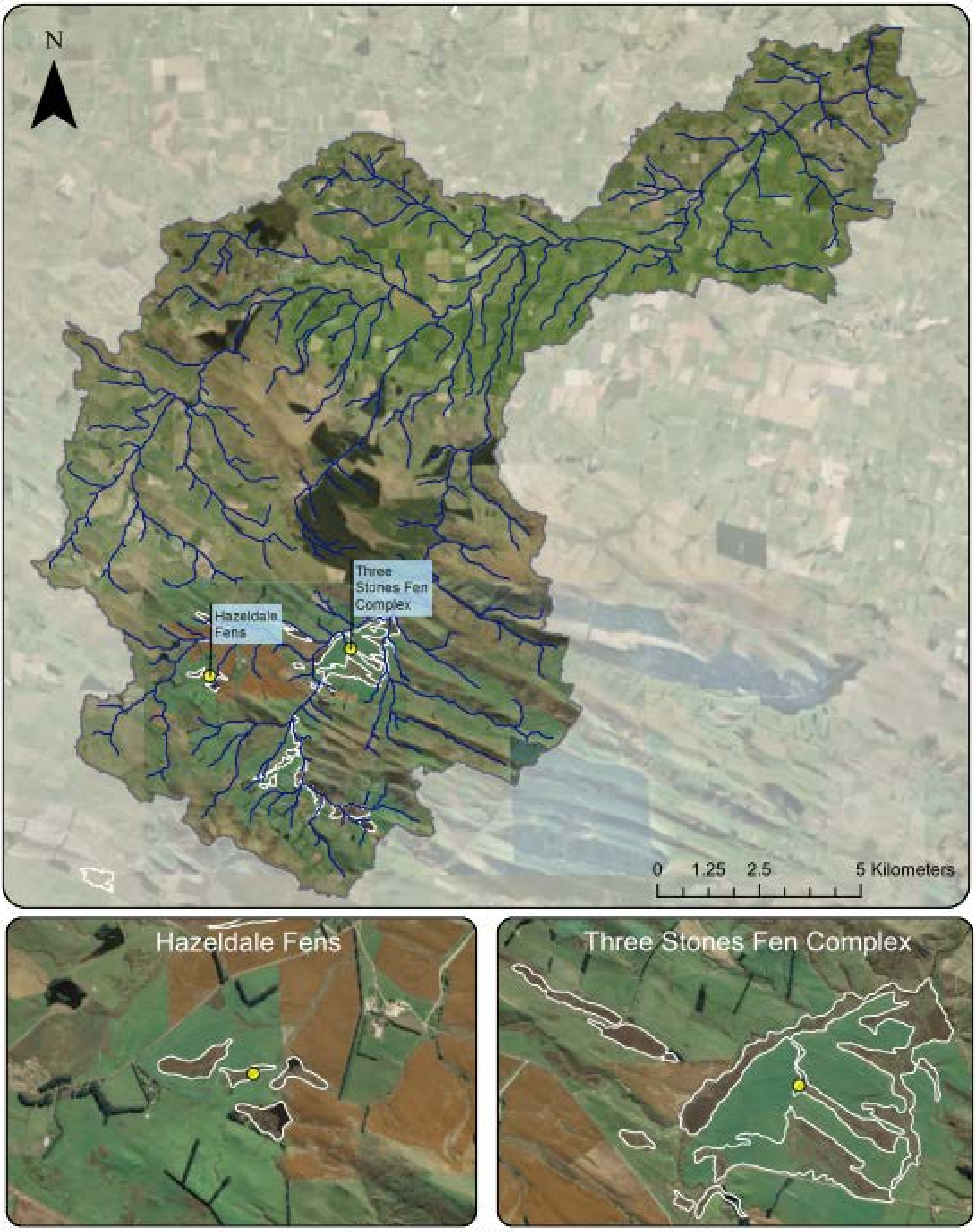


Figure 2.7 Name and locations of Schedule 9 wetlands in Waiwera Catchment

2.7 Instream ecological values

Schedule 1A of the Water Plan identifies the Waiwera River and tributaries as having high natural values. The areas identified in Schedule 1A are shown in Table 2.5:

Table 2.5 Ecosystem values of the Waiwera River

Ecosystem values	
Waiwera River	Provides access unimpeded by artificial means such as weirs and culverts; free of aquatic pest plants; significant habitat for trout and salmon spawning and juveniles; riparian vegetation of significance to aquatic habitat; significant presence of trout, eel, and the threatened roundhead galaxiid; significant range of indigenous invertebrates
Kuriwao Stream	Provides access unimpeded by artificial means such as weirs and culverts; significant habitat for trout spawning and juveniles; significant presence of trout and eel

2.8 Recreational values

Recreational activities in the Waiwera River include swimming and trout fishing. The Waiwera River is considered a locally significant fishery, the Pomahaka River, the adjacent catchment has a regionally significant trout fishery. Historically the Waiwera River was considered a good fishery, but angling effort is in decline (Table 2.6).

Many lowland rivers in Otago have suffered a marked deterioration in water quality resulting primarily from the effects of more intensive use of agricultural land, and as a result, the sports fisheries in these catchments are in decline. Fish and Game have the Waiwera River listed as a particular river of concern.

Table 2.6 Angler effort (angler days ± standard error), Unwin 2009

Season	Waiwera River	Pomahaka River
1994/1995	110 ± 100	6780 ± 1210
2001/2002	320 ± 250	6000 ± 1440
2007/2008	120 ± 80	3630± 970
2014/2015	Not recorded	3020 ± 840

2.7 Hydrology of the Waiwera River

Between April 2000 to September 2016 the mean flow in the Waiwera River at Maw's Farm was 2,669 l/s, while the median flow was 1459 l/s. The lowest recorded flow was 118 l/s, recorded in Jan 2015.

Minimum flows for the whole of the catchment are set at Maw's Farm. The minimum flow at this site is 260 l/s (1 October to 30 April) and 400l/s (1 May to 30 September). The primary water allocation limit for the Waiwera Catchment is 150 l/s.

The minimum flow is the flow below which the holder of any resource consent to take water must cease taking water. The Waiwera River still has water available for primary allocation.

3. Methods

3.1 Water quality guidelines

Schedule 15 (RPW) sets out numerical water quality limits for all catchments in the Otago region. The RPW also establishes discharge thresholds for all discharges to lakes, rivers, wetlands and drains (Schedule 16).

The receiving water limits outlined in Table 3.1 are applied as 5-year, 80th percentiles when flows are at or below median flow (1.58 m^3/s), with the flows in the Waiwera Catchment being set at the gauging site at Maw's Farm.

Table 3.1 Receiving water numerical standards and timeframe for achieving 'good' water quality in the Waiwera Catchment

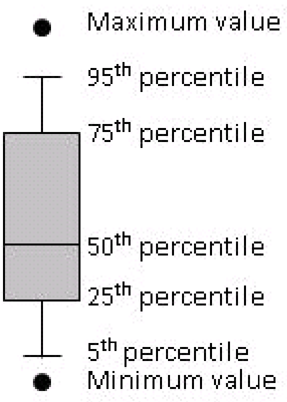
	Nitrate-Nitrite Nitrogen	Dissolved Reactive Phosphorus	Ammoniacal Nitrogen	*Escherichia coli*	Turbidity
Numerical limit	0.444 mg/L	0.026 mg/L	0.1 mg/L	260 cfu/100 mL	5 NTU
Timeframe	31 March 2012	31 March 2012	31 March 2012	31 March 2012	31 March 2012

3.2 Trend analysis

Long-term trends in water-quality parameters were considered, using a seasonal Kendall trend test in Time Trends statistical software (Version 6.1, Jowett 2017). Tests for water-quality variables were performed with six seasons per year (fitting with the historic bimonthly SoE sampling), and the median value for each season was used in the analysis.

Long-term trends in macroinvertebrate metrics (taxonomic richness, %EPT, MCI and SQMCI) were considered, using a Mann-Kendall trend test in Time Trends (Version 6.1, Jowett 2017).

3.3 Box plots



Where sufficient water-quality data were available, they were presented as box plots, as these provide information on data distribution (Figure 3.1).

Monitoring sites included in the water-quality box plot summaries are ordered from upstream main stem (left of plot) to downstream main stem. Main-stem river-monitoring sites are listed first, followed by the three tributary sites. The tributary sites, like the main-stem sites, are listed from left to right with the most upstream tributary site listed first. The location of water-quality monitoring sites are shown in Figure 2.1.

Figure 3.1 The interpretation of the various components of a box plot, as presented in this report

3.4 Long-term monitoring

ORC's SoE monitoring network includes one site on the Waiwera River at Maw's's Farm, where water quality monitoring has been undertaken since 25 July 2006 (Table 3.2 and Figure 2.1). The Maw's's Farm site is located at the bottom of the catchment and is representative of all land-use effects on water quality before the Waiwera River discharges to the Clutha/Mata Au.

A further eleven sites were monitored between 12 Nov 2015 and 5 November 2016, as part of this study to better understand variability in water quality across the catchment (Table 3.2 and Figure 2.1).

3.5 Catchment water-quality sampling 2015 to 2016

Water quality samples were collected from Maw's's Farm once a month and from each of the remaining twelve monitoring sites every fortnight between 12 Nov 2015 and 5 November 2016. These samples were analysed for total nitrogen (TN), nitrate-nitrite nitrogen (NNN), ammoniacal nitrogen (NH_4-N), total phosphorus (TP), dissolved reactive phosphorus (DRP), suspended solids (SS) and *Escherichia coli* (*E. coli*), detection limits are given in Table 3.3. These analyses were conducted by Watercare Laboratory Services (Auckland, www.watercarelabs.co.nz). Detection limits for water quality analytes are given in Table 3.3.

Table 3.2 Location of sites monitored during this study, with the types of sampling undertaken at each site. 'Invert' corresponds to aquatic invertebrate sampling for MCI analysis

Monitoring site	Location	Easting	Northing	WQ	Invert	Algae
Waiwera at Maw's's Farm	Approximately 2.2km upstream Clutha	1334153	4881621	✓	✓	✓
Waiwera near Clifton	Approximately 3km upstream Maw's's Farm	1331671	4880338	✓	✓	✓
Waiwera SH1 Bridge	Approximately 3.5km upstream Clifton	1330075	4877707	✓	✓	✓
Waiwera at Roberston Road	Approximately 3km upstream Waiwera at SH1	1327013	4877876	✓	✓	✓
Waiwera at Kuriwao Siding Rd	Just upstream of the Waiwera/Kuriwao confluence	1325976	4877805	✓	✓	✓
Waiwera at Hillfoot Road	Approximately 3.5km upstream Kuriwao Siding Rd	1325310	4874473	✓	✓	✓
Waiwera at Owaka Valley Road	Approximately 10km upstream of Hillfoot Road	1320908	4866787	✓	✓	✓
Waiwera tributary at u/s Quarry	1.5km upstream confluence of Waiwera	1325660	4878093	✓	✓	✓
Waiwera tributary at Blaike Road	Approximately 4km upstream of Quarry	1322188	4879504	✓	✓	✓
Kuriwao Stream u/s Kuriwao Siding Rd	Just upstream of the Waiwera/Kuriwao confluence	1325970	4877873	✓	✓	✓
Kuriwao Stream at Hillfoot Road	Approximately 6km upstream of Siding Road	1321102	4876788	✓	✓	✓
Kuriwao Stream at Old Coach Road	Approximately 4km upstream of Hillfoot Road	1318198	4874590	✓	✓	✓
Awakia Stream at Hillfoot Road	Approximately 2km upstream of Kuriwao Stream	1322725	4874744	✓	✓	✓

Table 3.3 Detection limits, with the types of sampling undertaken at each site

Parameter	Detection Limit
Total nitrogen	0.01 mg/L
Nitrate-nitrite nitrogen (by calculation)	0.002 mg/L
Ammoniacal nitrogen	0.005 mg/L
Total phosphorus	0.004 mg/L
Dissolved reactive phosphorus	0.002 mg/L
Suspended solids	0.2 mg/L
Escherichia coli	2 cfu/100mL

3.6 Periphyton

3.6.1 SoE monitoring

Periphyton community composition is monitored at Maw's's Farm as part of the SoE monitoring program. The methods summarised as follows:

Three stones were collected at each site, taken from one-quarter, one-half and three-quarters of the stream width. A 5 cm x 5 cm (0.0025 m^2) area of each stone surface was scrubbed and the scrubbings from the three stones were pooled . Samples were analysed according to the 'relative abundance using an inverted microscope' method outlined in Biggs and Kilroy (2000). Algae were given an abundance score ranging from 1 (rare) to 8 (dominant), based on the protocol of Biggs and Kilroy (2000).

3.6.2 Catchment monitoring 2017

Periphyton cover assessments were undertaken at each site using a modified version of 'Rapid Assessment method 2 (RAM-2): Line transect-point method' outlined in Biggs and Kilroy (2000). The method is summarised as follows:

A measuring tape was laid out along the stream bank for 10m (or five x the stream width, whichever was the smaller) and four equally spaced intervals were calculated along its length. The width of the stream able to be sampled (i.e., <0.6 m depth) was divided into five equally spaced points. At the first point across the transect an underwater viewer (e.g., bathyscope was used to view the substrate and the percentage of the bed within the field of view covered by each periphyton colour and thickness category was estimated. This estimation was continued across the stream width and repeated moving upstream. The periphyton categories used in the assessments are shown in Table 3.4.

Table 3.4 Periphyton categories used in periphyton assessments (following RAM-2), with enrichment indicator scores. (* diatom epiphytes give the green filaments a brown colouring) (from Biggs & Kilroy 2000).)

Periphyton category		Periphyton enrichment indicator score	Typical taxa
Thin mat/film: (under 0.5 mm thick)	Green	7	*Cymbella*, *Achnanthidium*, *Cocconeis*, *Ulothrix*, *Stigeoclonium* (basal cells), young *Spirogyra*
	Light brown	10	Assorted diatoms and cyanobacteria (*Cocconeis*, *Fragilaria*, *Synedra*, *Cymbella*, *Lyngbya*, *Amphithrix*)
	Black/dark brown	10	Assorted cyanobacteria (*Schizothrix*, *Calothrix*, *Lyngbya*)
Medium mat: (0.5 – 3 mm thick)	Green	5	*Stigeoclonium*, *Bulbochaete*, *Chaetophora*, *Oedogonium*, *Spirogyra*, *Ulothrix*
	Light brown (± dark green/black bobbles)	7	*Gomphonema*, *Gomphoneis*, *Synedra*, *Cymbella*, , *Fragilaria*, *Navicula*, *Nostoc*
	Black/dark brown	9	*Tolypothrix*, *Schizothrix*, *Phormidium*, *Lyngbya*, *Rivularia*
Thick mat: (over 3 mm thick)	Green/light brown	4	*Navicula*, *Gomphoneis*, *Synedra*, *Rhoicosphenia*, *Ulothrix*, *Oedogonium*, *Microspora*, *Spirogyra*, *Vaucheria*
	Black/dark brown	7	*Phormidium*, *Schizothrix*, *Audouinella*, *Batrachospermum*, *Nostoc*
Filaments, short: (under 2 cm long)	Green	5	*Ulothrix*, *Oedogonium*, *Microspora*, *Spirogyra*, *Cladophora*
	Brown/reddish	5	*Cladophora**, *Oedogonium**, *Rhoicosphenia*, *Navicula*, *Batrachospermum*, *Diatoma*
Filaments, long: (over 2 cm long)	Green	1	*Ulothrix*, *Oedogonium*, *Microspora*, *Zygnema*, *Spirogyra*, *Cladophora*, *Rhizoclonium*
	Brown/reddish	4	*Melosira*, *Cladophora**, *Rhizoclonium**

3.7 Macroinvertebrates

Aquatic macroinvertebrates are organisms that live on or within the beds of rivers and streams. Examples include insect larvae (e.g. mayflies, stoneflies, caddisflies and beetles), aquatic oligochaetes (worms), snails and crustaceans (e.g. amphipods and crayfish). Macroinvertebrates are useful for assessing the biological health of a river because they are found everywhere, vary in their tolerance to temperature, dissolved oxygen, sediment and chemical pollution and are relatively long lived (taking six months to two years to complete their life-cycle). Therefore, the presence or absence of such taxa can provide significant insight into long-term changes in water quality.

3.7.1 SOE monitoring

Macroinvertebrate community composition is monitored at Maw's Farm annually as part of SoE monitoring. Benthic macroinvertebrate samples are collected according to collection protocol 'C1: hard-bottomed semi-quantitative', as described in the Ministry for the Environment's 'Protocols for sampling macroinvertebrates in wadeable streams' (Stark *et al.* 2001). Macroinvertebrate samples are processed for macroinvertebrate species identification and their relative abundance, using the semi-quantitative protocols outlined in the Ministry for the Environment's Protocols for sampling macroinvertebrates in wadeable streams (Stark *et al.* 2001). Protocol 'P1: Coded abundance' is used.

3.7.2 Catchment monitoring 2017

Benthic macroinvertebrate samples were collected according to the same collection protocols outlined in Section 3.7.1.

3.7.3 Macroinvertebrate indices

Species richness (or the total number of species/taxa): In general terms, high species richness may be considered 'good'; however, mildly impacted or polluted rivers, with slight nutrient enrichment, can have higher species richness than unimpacted, pristine streams.

Ephemeroptera plecoptera and trichoptera (EPT) richness: This index is the sum of the total number of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) species collected. These insects are often the most sensitive to organic pollution; therefore, low numbers might indicate a polluted environment. Comparing the percentage of EPT species to the total number of species found at a site can give an indication of the importance of these species in the overall community.

Macroinvertebrate community index (MCI): This index uses the occurrence of specific macroinvertebrate taxa to determine the level of organic enrichment in a stream. Taxa are assigned scores of between 1 and 10, depending on their tolerance. A score of 1 represents taxa that are highly tolerant of organic pollution, while 10 represents taxa that are sensitive to organic pollution. The MCI score is obtained by adding the scores of individual taxa and dividing the total by the number of taxa present at the site and multiplying this figure by 20 (a scaling factor). MCI scores can be interpreted based on the water quality classes proposed by Stark *et al.* (2001) (Table 3.5).

Semi-quantitative macroinvertebrate community index (SQMCI): This index is a variation of the MCI that accounts for the abundance of pollution sensitive and tolerant species. The SQMCI is calculated from coded-abundance data. Individual taxa counts are assigned to one of the following abundance classes: rare (R, 1-4 individuals), common (C, 5-19 individuals), abundant (A, 20-100 individuals), very abundant (VA, 100-500 individuals), very, very abundant (VVA, >500 individuals). SQMCI scores can be interpreted based on the water quality classes proposed by Stark et al. (2001),Table 3.6.

Table 3.5 Interpretation of MCI values from Boothroyd and Stark (2000) (quality class A) and Stark and Maxted (2007) (quality class B)

Quality class A	Quality class B	MCI	SQMCI
Clean water	Excellent	>120	>6
Doubtful quality	Good	100 to 119	5 to 5.99
Probable moderate pollution	Fair	80 to 99	4 to 4.99
Probable severe pollution	Poor	<80	<4

Table 3.6 Coded abundance scores used to summarise macroinvertebrate data (after Stark 1998)

Abundance	Coded Abundance	Weighting factor
1-4	Rare (R)	1
5-19	Common (C)	5
20-99	Abundant (A)	20
100-499	Very abundant (VA)	100
>500	Very very abundant (VVA)	500

3.7.4 Fish monitoring

Fish populations have been surveyed annually since 2009 at the Maw's Farm monitoring site, using a pulsed DC Kainga EFM300 backpack electric-fishing machine and following the New Zealand Freshwater Fish Sampling Protocols (Joy *et al.* 2013).

The monitoring entails dividing a 150 m reach into ten 15 m-long sub-reaches, and each section is electric fished in a single pass from downstream to upstream. When each section is fished, all fish caught are measured using a fish board and recorded. When 50 individuals of an individual species have been measured, individuals in subsequent sections are counted and recorded. An additional monitoring site at SH6 was monitored in 2009, following the protocol outlined above.

3.8 Habitat assessment

At each sampling site, instream and riparian habitats were assessed according to the National Rapid Habitat Assessment Protocol Development For Streams And Rivers (Clapcott 2015). This assessment covers ten parameters; bank vegetation, riparian width, riparian shade, deposited sediment, invertebrate habitat diversity, invertebrate habitat abundance, fish cover diversity, fish cover abundance, hydraulic heterogeneity and bank erosion. The ten parameters are scored between 1 and 10, with a total maximum 'habitat quality score' of 100 (Table 3.7).

Table 3.7 Habitat Assessment Score System

Bank vegetation	*The maturity, diversity and naturalness of bank vegetation.*									
Left bank AND Right bank	*Mature native trees with diverse and intact understorey*		*Regenerating native or flaxes/sedges/tussock > dense exotic*			*Mature shrubs, sparse tree cover > young exotic, long grass*			*Heavily grazed or mown grass > bare/impervious ground.*	
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Riparian width	*The width (m) of the riparian buffer constrained by vegetation, fence or other structure(s).*									
Left bank	*≥ 30*	*15*	*10*	*7*	*5*	*4*	*3*	*2*	*1*	*0*
Right bank	*≥ 30*	*15*	*10*	*7*	*5*	*4*	*3*	*2*	*1*	*0*
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Riparian shade	*The percentage of shading of the stream bed throughout the day due to vegetation, banks or other structure(s).*									
	≥ 90	*80*	*70*	*60*	*50*	*40*	*25*	*15*	*10*	*≤ 5*
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
TOTAL								(Sum of parameters 1-10)		
Deposited sediment	*The percentage of the stream bed covered by fine sediment.*									
	0	*5*	*10*	*15*	*20*	*30*	*40*	*50*	*60*	*≥ 75*
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Invertebrate habitat diversity	*The number of different substrate types such as boulders, cobbles, gravel, sand, wood, leaves, root mats, macrophytes, periphyton. Presence of interstitial space score higher.*									
	≥ 5	*5*	*5*	*4*	*4*	*3*	*3*	*2*	*2*	*1*
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Invertebrate habitat abundance	*The percentage of substrate favourable for EPT colonisation, for example flowing water over gravel-cobbles clear of filamentous algae/macrophytes.*									
	95	*75*	*70*	*60*	*50*	*40*	*30*	*25*	*15*	*5*
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Fish cover diversity	*The number of different substrate types such as woody debris, root mats, undercut banks, overhanging/encroaching vegetation, macrophytes, boulders, cobbles. Presence of substrates providing spatial complexity score higher.*									
	≥ 5	*5*	*5*	*4*	*4*	*3*	*3*	*2*	*2*	*1*
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Fish cover abundance	*The percentage of fish cover available.*									
	95	*75*	*60*	*50*	*40*	*30*	*20*	*10*	*5*	*0*
Deposited sediment	*The percentage of the stream bed covered by fine sediment.*									
	0	*5*	*10*	*15*	*20*	*30*	*40*	*50*	*60*	*≥ 75*
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Hydraulic heterogeneity	*The number of of hydraulic components such as pool, riffle, fast run, slow run, rapid, cascade/waterfall, turbulance, backwater. Presence of deep pools score higher.*									
	≥ 5	*5*	*4*	*4*	*3*	*3*	*2*	*2*	*2*	*1*
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Bank erosion	*The percentage of the stream bank recently/actively eroding due to scouring at the water line, slumping of the bank or stock pugging.*									
Left bank	*0*	*≤ 5*	*5*	*15*	*25*	*35*	*50*	*65*	*75*	*> 75*
Right bank	*0*	*≤ 5*	*5*	*15*	*25*	*35*	*50*	*65*	*75*	*> 75*
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**

3.9 Sediment assessment

3.9.1 Sediment cover assessment

Sediment cover assessments were undertaken at each site according to Sediment Assessment Method 2 (SAM2): In-stream visual estimate of % sediment cover outlined in Clapcott *et al*. (2011). This provides for a semi-quantitative assessment of the surface area of the streambed covered by sediment, with at least 20 readings made within a single habitat using an underwater viewer (e.g., bathyscope).

3.9.2 Deposited fine sediment (Quorer method)

A volumetric measure of sediment deposition on and within the stream bed can be gained by re-suspending sediment in the water column and then collecting and weighing the suspendible proportion of sediment deposited.

Deposited fine sediment assessments were undertaken at each site according to sediment Assessment Method 4 (SAM4). The quorer (Quinn corer) utilises an open-ended cylinder that isolates an area of gravel substrates in flowing water, typically in places corresponding to sites suitable for macroinvertebrate sampling (i.e., runs or riffles). After measuring the water depth within the cylinder, the top 5–10 cm of substrate is vigorously disturbed with a stirring rod, and a grab sample of the resulting slurry collected and analysed for the content of organic and inorganic sediments. The quantity of suspendable sediment in the surficial substrate (top 5–10 cm) can then be calculated.

3.9.3 Recommended Guidelines

Clapcott (2011) recommended guidelines (Table 3.8) for assessing the effects of deposited fine sediment on the in stream values of hard-bottomed streams.

Table 3.8 Recommended guidelines to protect stream biodiversity and fish (native and trout)

Sediment measure	Sediment value	Core method
Sediment cover %	<20% OR within 10% cover of reference	Bankside visual estimate
Suspendible sediment	<450 g/m^2	Quorer (SIS)

4. Results

4.1 Water Quality Long-term monitoring

4.1.1 Trend analyses

Analysis of trends in water-quality parameters at the Waiwera SoE site at Maw's Farm located in the bottom of the catchment (Table 4.1) shows that most variables had not changed significantly between July 2006 and February 2017, with the exception of total phosphorus which declined over this period.

Table 4.1 shows the *Z*-statistic which indicates the direction and strength of any trend detected, while the *P*-value indicates the probability of that trend occurring by chance. The PAC is the percent annual change of the variable in question.

Trends with a *P*-value of less than 0.05 and a probability of greater than 0.95 are considered to be statistically significant. In Table 4.1 only TP has a significant trend, although the other parameters show an 'increasing' or 'decreasing' trend, the slope line is not statistically significant.

Table 4.1 Trends in water-quality parameters at the Maw's Farm SoE monitoring site in the Waiwera Catchment

Variable	*Z*	*P*	PAC (% / yr)	Trend	Probability
NH_4-N	0.1446	0.850	-0.9428	Decreasing	0.75
NNN	0.6583	0.510	0.5494	Increasing	0.74
TN	0.1830	0.855	0.2901	Increasing	0.58
DRP	-1.6750	0.094	-2.0848	Decreasing	0.95
TP	-2.5568	0.011	-3.8718	Decreasing	0.99
E. coli	-1.3709	0.170	-5.0017	Decreasing	0.90
Turbidity	-1.0960	0.273	-2.5960	Decreasing	0.86

4.1.2 Compliance with Schedule 15 limits

Schedule 15 of the RPW sets out water-quality limits and targets for receiving waters in the Otago region (Section 3.1). These limits apply as running five-year, 80^{th} percentiles when flows are at, or below, the reference flow at the appropriate monitoring site. For the Waiwera Catchment, the reference flow is 1,580 l/s and the reference flow site is the Maw's's Farm flow-monitoring site (also the site that water-quality data is collected for the SoE monitoring programme).

Water-quality monitoring data collected from the Maw's's Farm SoE and flow-monitoring site, when flows were below the reference flow, were compared to receiving water limits. All of the variables considered at the Maw's Farm site exceeded the Schedule 15 limit (Figure 4.1 to Figure 4.2) other than turbidity and NH_4-N. Note that there was no flow data available before April 2010.

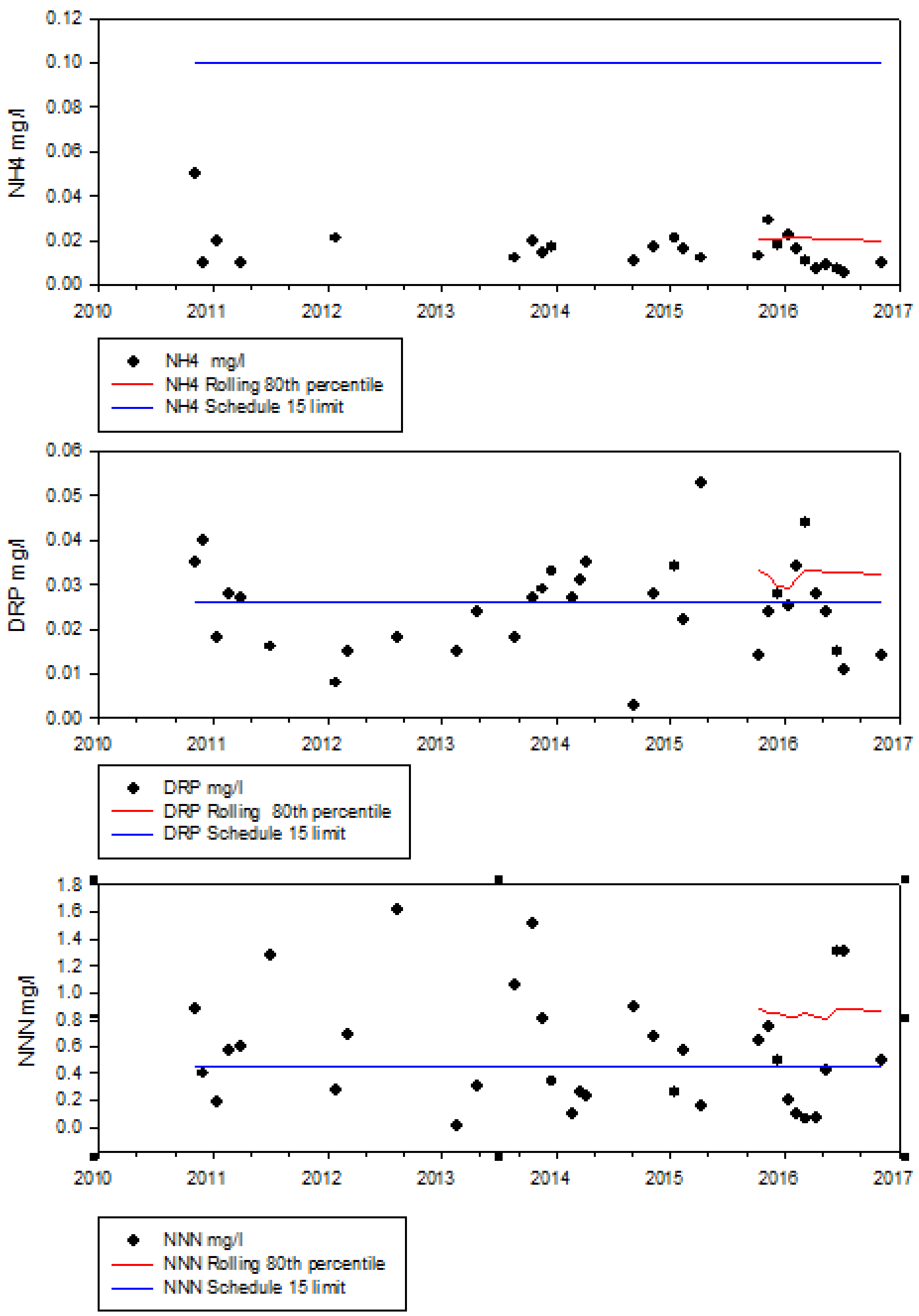


Figure 4.1 **Comparison of NH_4-N DRP and NNN at the Maw's Farm site when flows are below median flow with Schedule 15 limits (blue lines). Red lines represent five-year moving 80th percentiles**

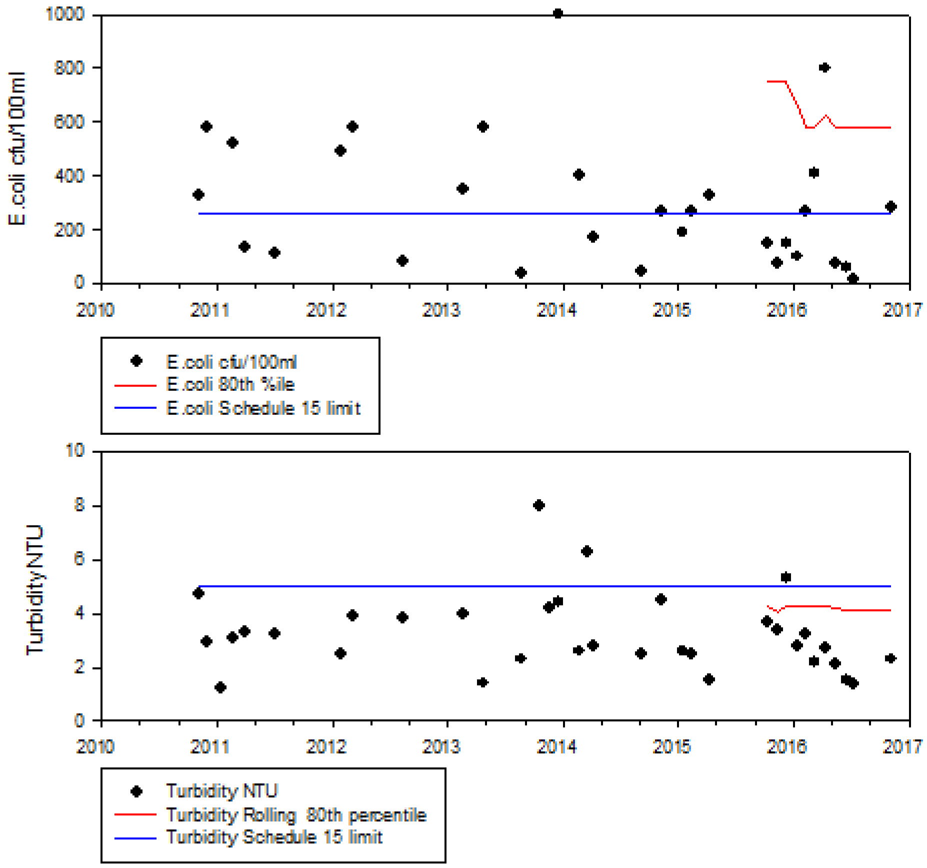


Figure 4.2 **Comparison of *E.coli* and Turbidity at the Maw's Farm site when flows are below median flow with Schedule 15 limits (blue lines). Red lines represent five-year moving 80th percentiles**

4.2 Water Quality Catchment survey

The 80th percentile concentration of water quality parameters in the Waiwera Catchment at or below median flow are shown in Table 4.2. The cells highlighted in grey indicate that the Schedule 15 limit has not been met. It can be seen that other than ammoniacal nitrogen, the catchment exceeds Schedule 15 limits at most sites for most variables.

Table 4.2 Comparison of 80th percentile water results (below median flow). Values that exceeded the limit are highlighted in grey

Site Name	Ammoniacal Nitrogen	Dissolved Reactive Phosphorus	E-Coli MPN	Nitrite/Nitrate Nitrogen	Turbidity
	0.1	0.026	260	0.444	5
Waiwera at Owaka Valley Rd	0.0174	0.0308	524	1.34	6.28
Waiwera River Hillfoot Rd	0.0170	0.0168	116	1.14	3.30
Waiwera at Kuriwao Siding Rd	0.0220	0.0172	318	1.16	3.04
Kuriwao Stream Old Coach Rd	0.0232	0.0318	940	1.42	7.54
Kuriwao Stream Hillfoot Rd	0.0184	0.0268	450	1.32	5.28
Awakia Stream at Hillfoot Road	0.1072	0.0370	1030	0.38	6.56
Kuriwao Stream u/s Kuriwao Siding Rd	0.0332	0.0804	648	1.22	4.60
Waiwera trib at Blaike Rd	0.0346	0.0372	564	3.04	19.60
Waiwera trib d/s quarry	0.0572	0.0506	1360	1.52	10.08
Waiwera at Robertson Rd	0.0318	0.0338	364	1.16	3.62
Waiwera at SH1 bridge	0.0310	0.0324	378	1.15	3.30
Waiwera near Clifton	0.0352	0.0366	464	1.08	3.60
Waiwera at Maw's Farm	0.0212	0.0280	246	1.30	3.36

4.2.1 Nitrogen

TN concentrations were similar throughout the catchment, with the highest concentrations observed in the tributary at Blaike Road (Figure 4.3). Generally, whether considering low flows or all flows, these patterns were similar, although TN concentrations were slightly lower during low flows at most sites

NNN showed similar patterns to TN; the highest concentrations observed in the tributaries at Blakie Road and downstream of the quarry (Figure 4.4). There was no obvious increase in NNN concentrations with distance downstream. Awakia Stream had the lowest concentration of NNN of all sites monitored. Figure 4.5 shows the seasonal variation in NNN concentrations over all sites, concentrations increase rapidly in late autumn and winter before dropping off sharply in spring. This typically is due to a mixture first flush of nitrates built up over the drier summer months being flushed through to the streams as well as reduced primary productivity and uptake of bioavailable nitrate due to lower stream temperatures, shorter days and reduced periphyton standing crop from winter high flow events.

Concentrations of NH_4-N were very low at all sites on all occasions (Figure 4.7 and Figure 4.8), although Awakia Stream had some elevated concentrations.

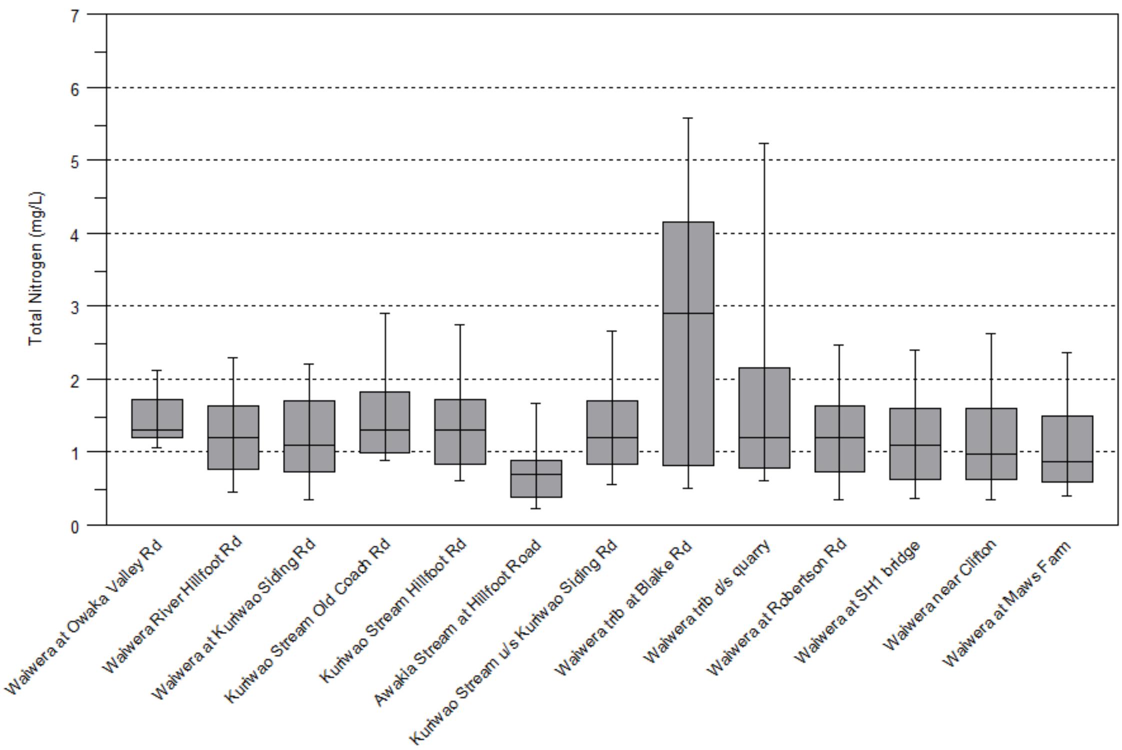


Figure 4.3 **TN concentrations in the Waiwera River and tributaries under all flows**

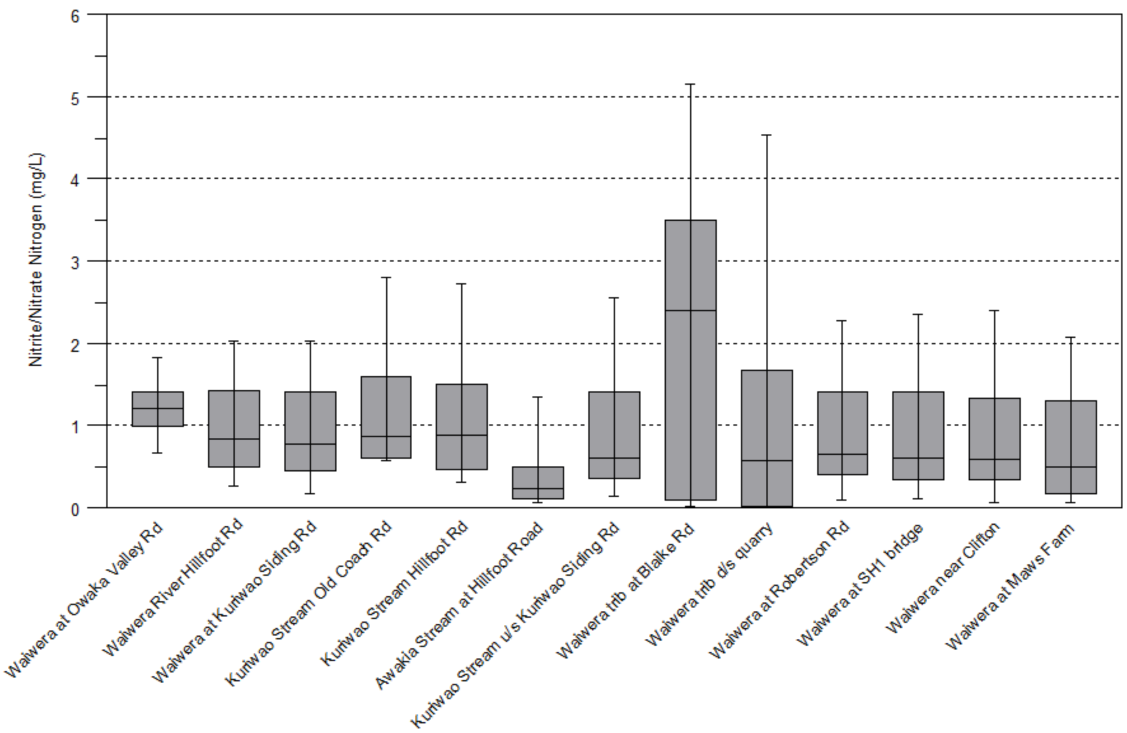


Figure 4.4 **NNN concentrations in the Waiwera River and tributaries under all flows. The blue line represents the Schedule 15 limit**

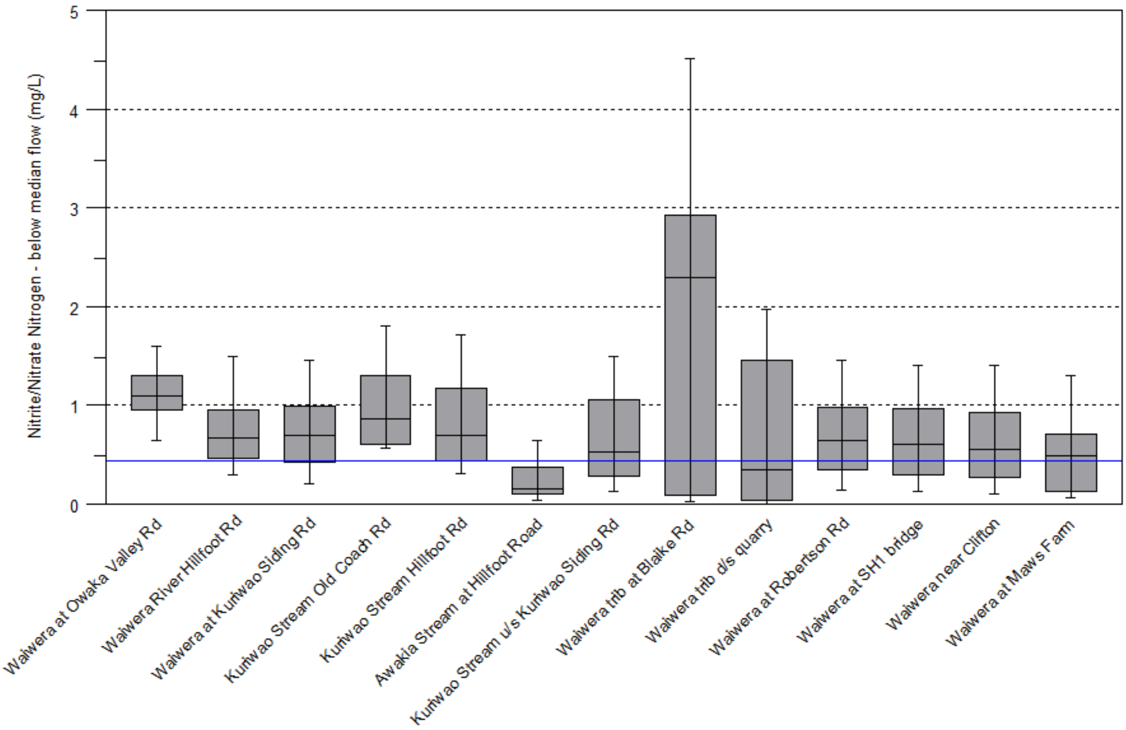


Figure 4.5 NNN concentrations in the Waiwera River and tributaries under low flows. The blue line represents the Schedule 15 limit.

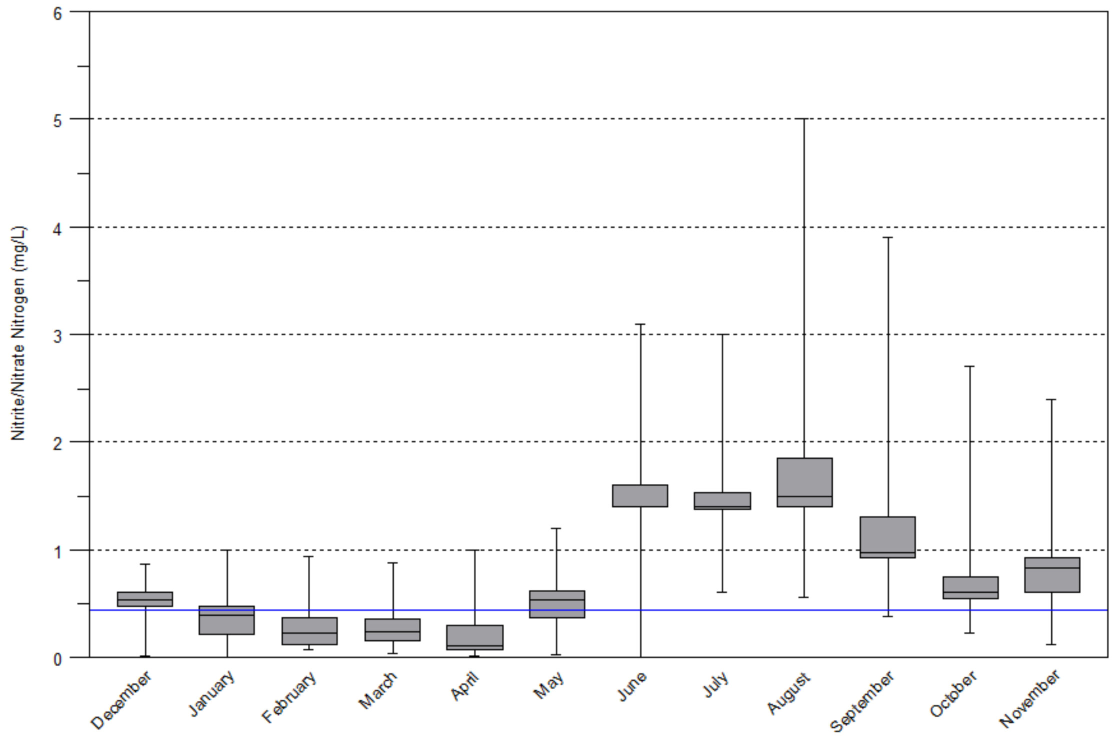


Figure 4.6 Seasonal concentrations of NNN in the Waiwera River and tributaries (below median flow). The blue line represents the Schedule 15 limit

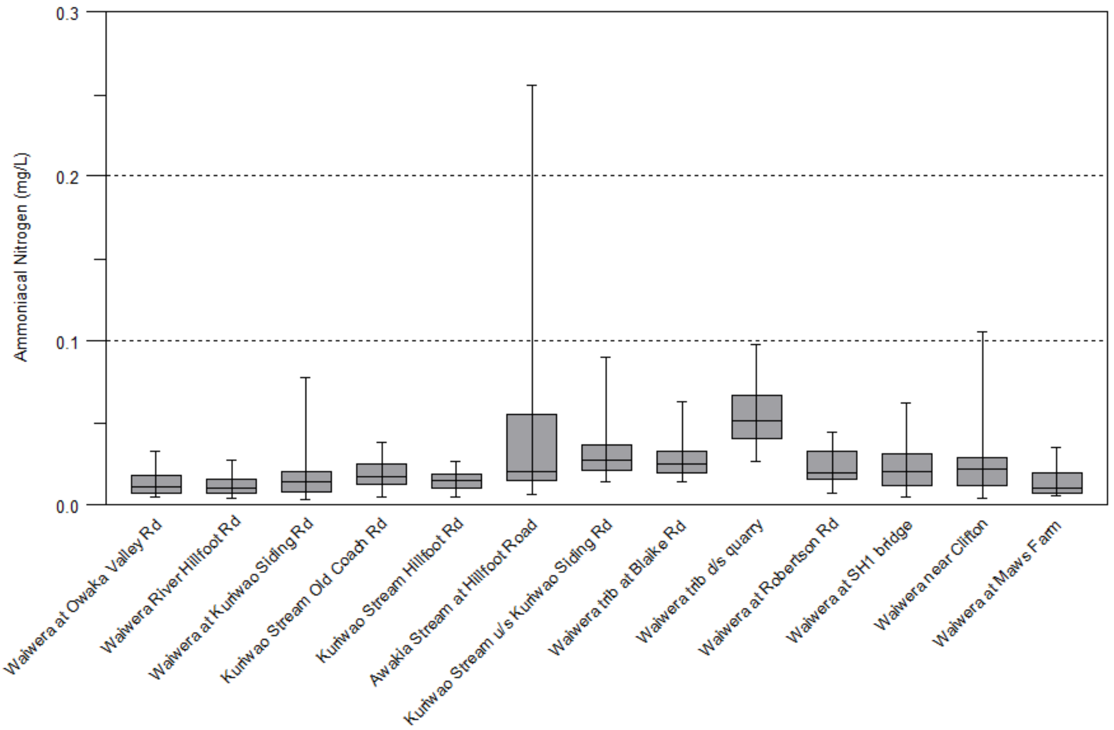


Figure 4.7 **NH_4-N concentrations in the Waiwera River and tributaries under all flows. The blue line represents the Schedule 15 limit**

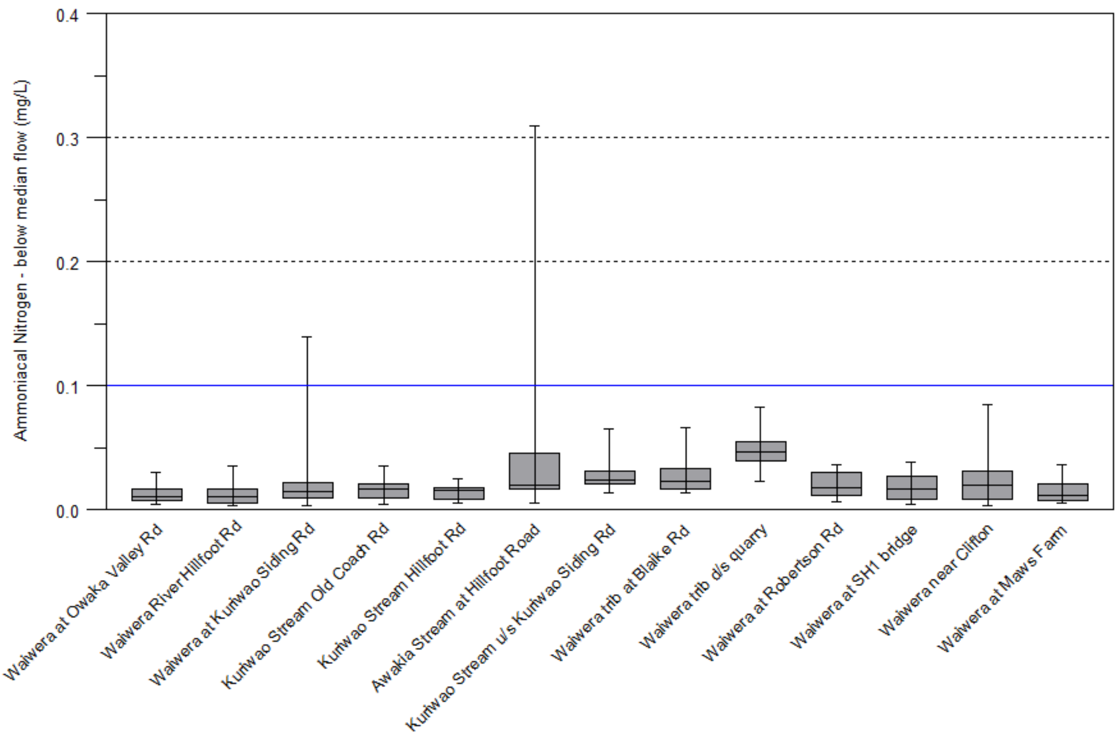


Figure 4.8 **NH_4-N concentrations in the Waiwera River and tributaries under low flows. The blue line represents the Schedule 15 limit**

4.2.2 Phosphorus

TP and DRP concentrations were consistently high at all the sites sampled throughout the Waiwera catchment, even at low flows (Figure 4.11). As a consequence, the 80th percentiles of DRP readings at all sites other than some main-stem Waiwera sites (Hillfoot Road, Kuriwao Siding Road, Clifton and Maw's Farm) exceeded the Schedule 15 limit (Figure 4.11).

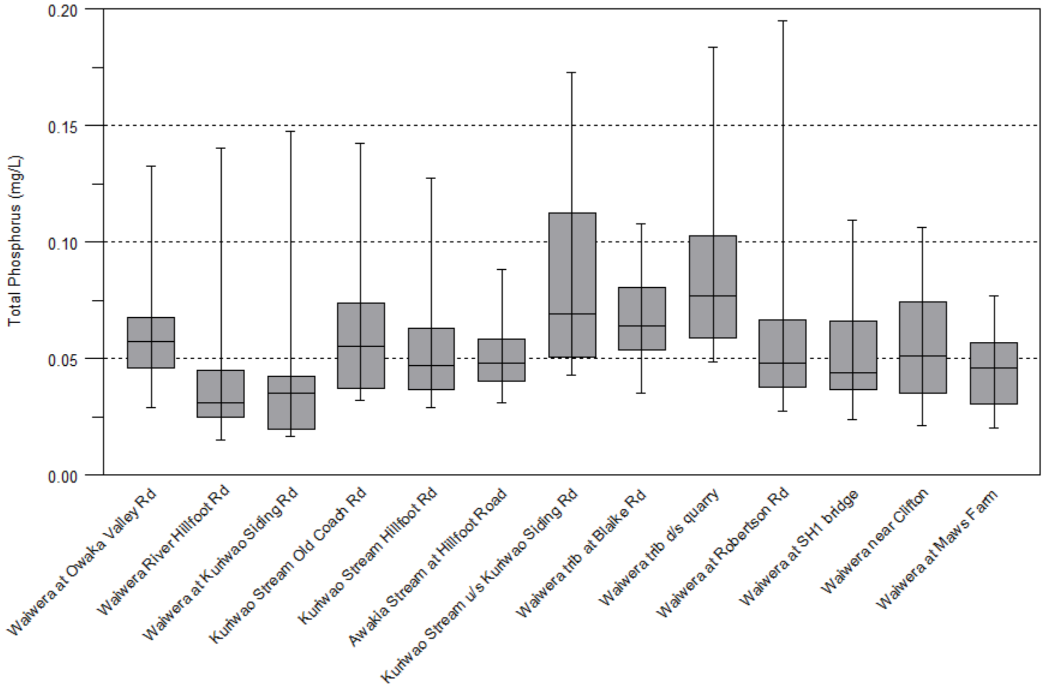


Figure 4.9 TP concentrations in the Waiwera River and tributaries under all flows

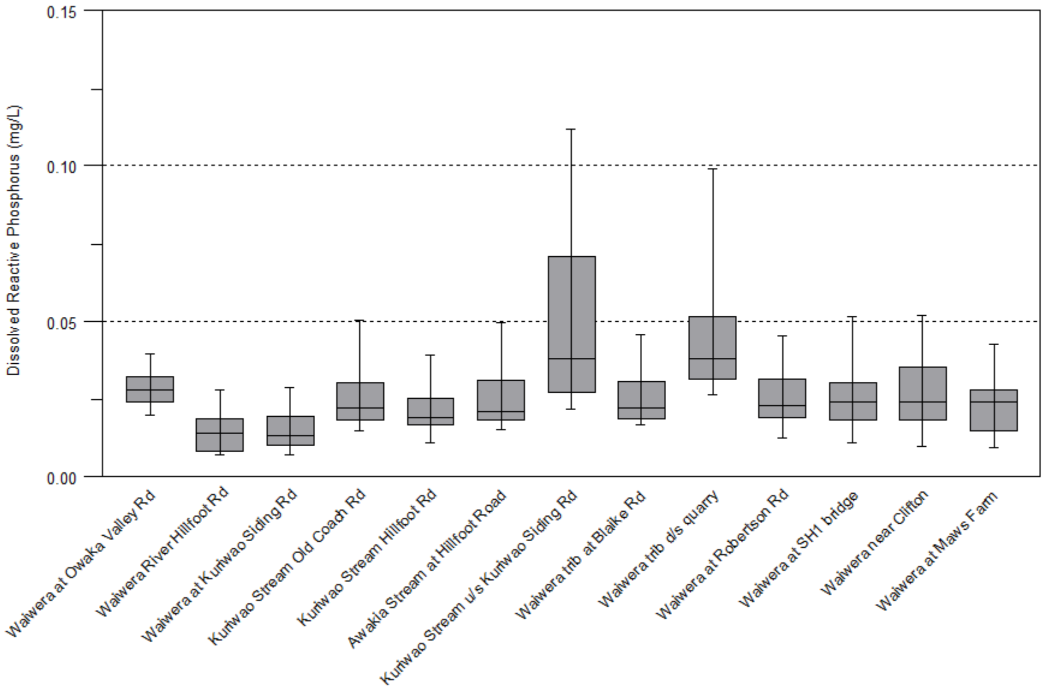


Figure 4.10 DRP concentrations in the Waiwera River and tributaries under all flows

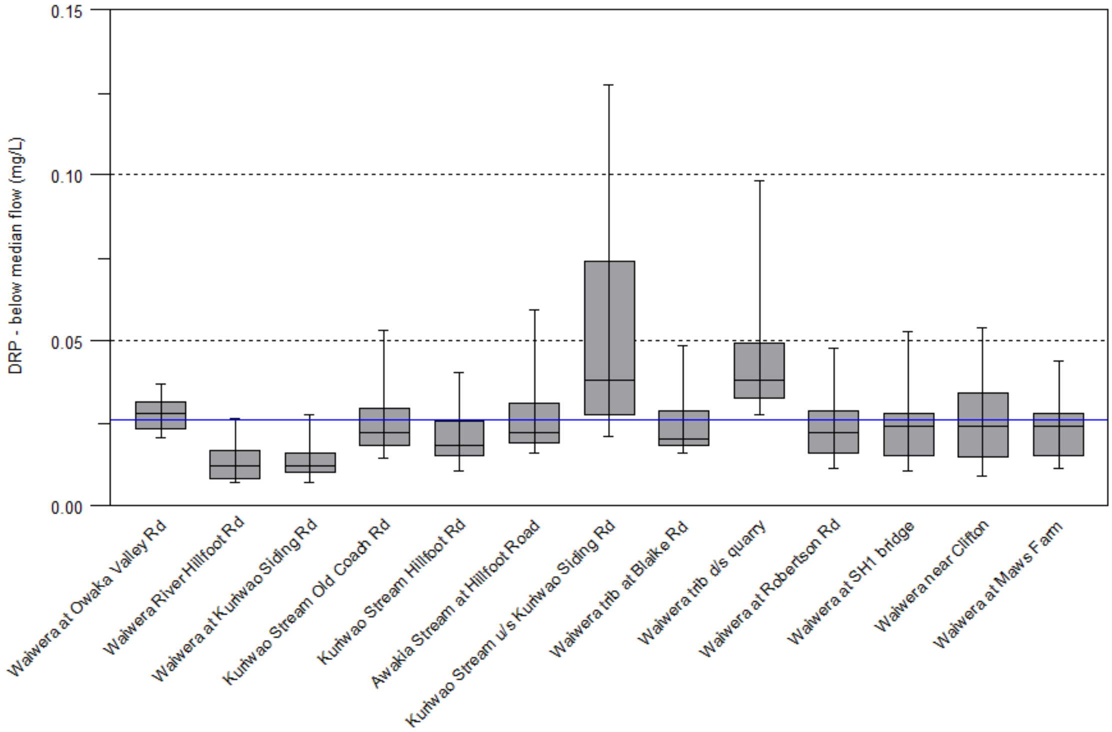


Figure 4.11 DRP concentrations in the Waiwera River and tributaries under all low flows. The blue line represents the Schedule 15 limit

4.2.3 Escherichia coli

Concentrations of *E. coli* were high across all sites in the Waiwera Catchment, with the 80th percentiles during low flows exceeding the Schedule 15 limits for *E. coli* at all sites other than the Waiwera at Hillfoot Road which returned an 80th percentile value of 128 cfu/100 ml (Figure 4.13).

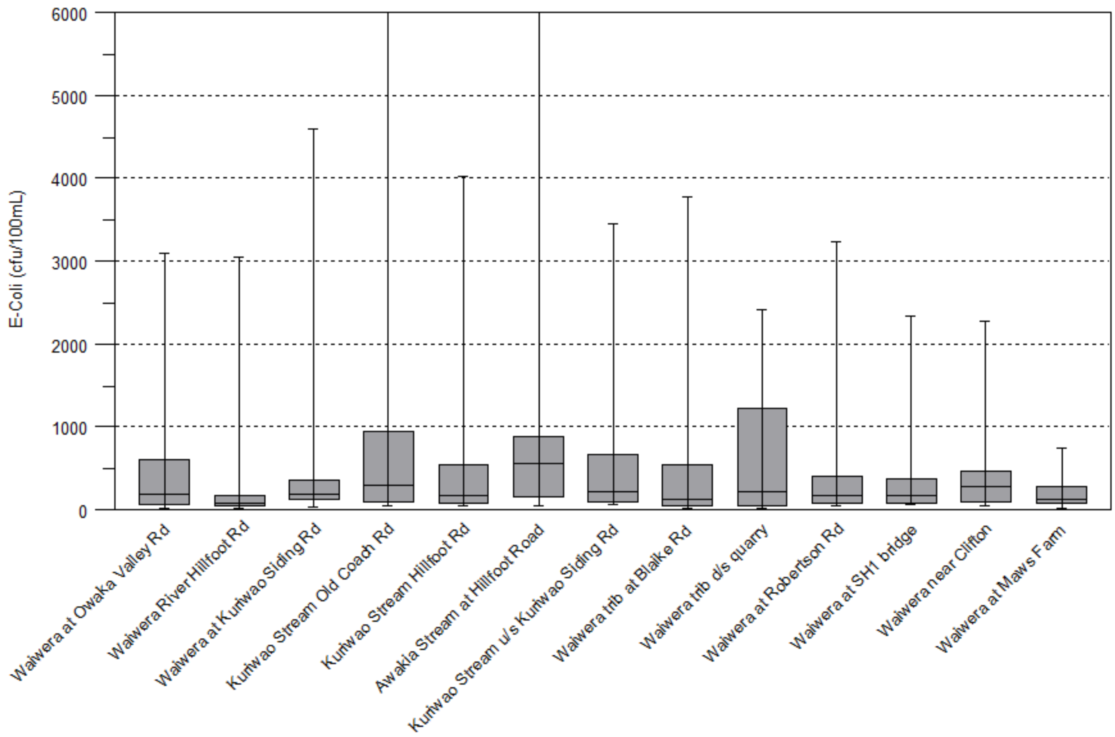


Figure 4.12 ***E.coli*** **concentrations in the Waiwera River and tributaries under all flows**

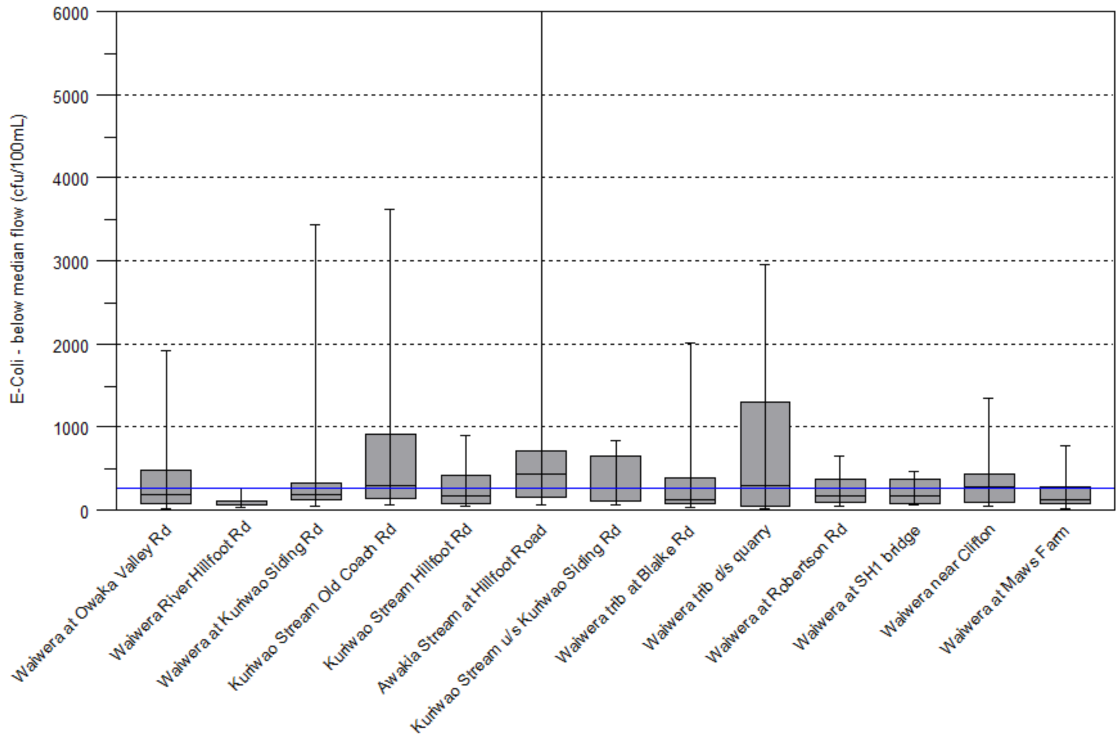


Figure 4.13 ***E.coli*** **concentrations in the Waiwera River and tributaries under low flows. The blue line represents the Schedule 15 limit**

4.2.4 Turbidity

The 80th percentile below median flow limit for turbidity is 5NTU. This was met at all sites in the catchment other than the Waiwera River at Owaka Valley Road, the Kuriwao Stream (at Old Coach Road, and Hillfoot Road), Awakia Stream at Hillfoot Road and the two smaller tributaries (where turbidity was especially high).

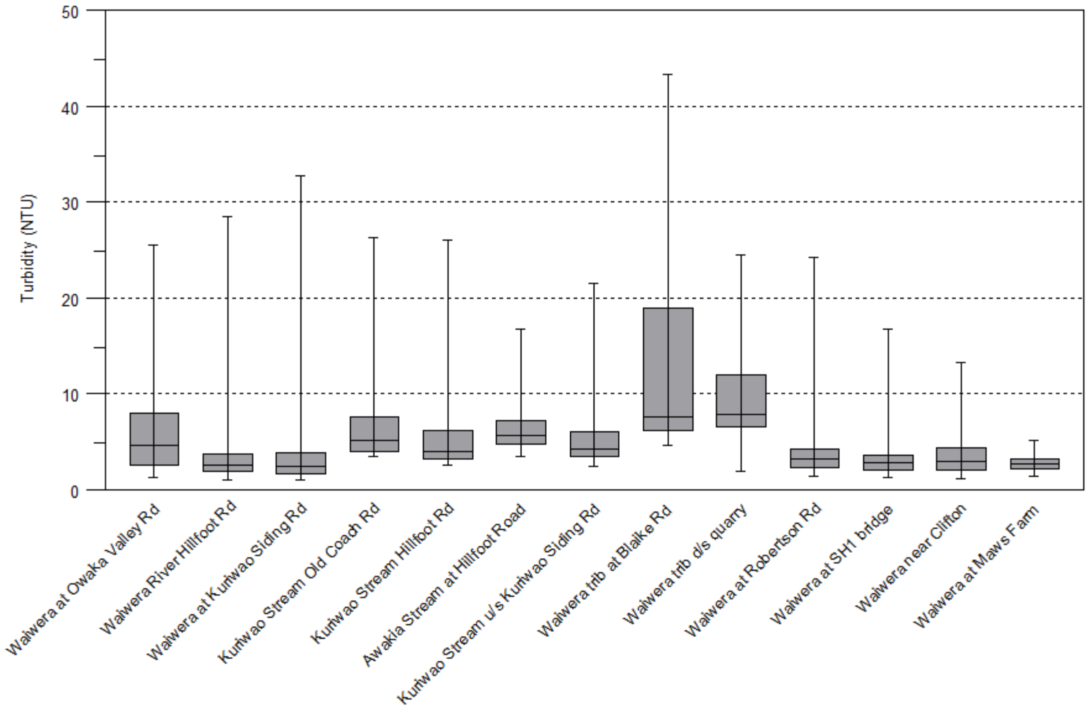


Figure 4.14 Turbidity in the Waiwera River and tributaries under all flows

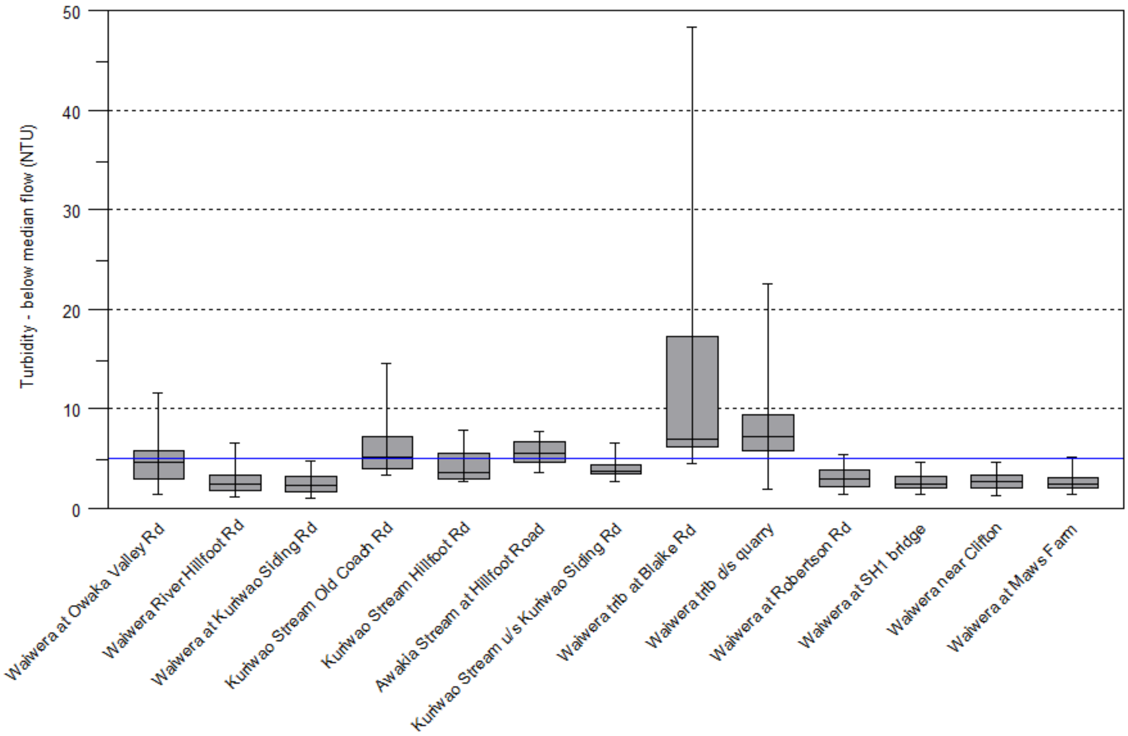


Figure 4.15 Turbidity in the Waiwera River and tributaries under low flows. The blue line represents the Schedule 15 limit

4.3 Habitat assessments

Habitat assessment scores for each site are summarised in Table 4.3. The sites with the highest total score are at the top of the table, sites with the lowest scores at the bottom of the table.

Table 4.3 Habitat assessment scores, Waiwera Catchment, March 2017

.	Deposited sediment	Invertebrate habitat diversity	Invertebrate habitat abundance	Fish cover diversity	Fish cover abundance	Hydraulic heterogeneity	Bank erosion	Bank vegetation	Riparian width	Riparian shade	TOTAL
Kuriwao Old Coach Rd	9.5	10	9	10	9.5	7	9	5.5	8	7.5	85
Waiwera at Kuriwao-Siding Rd	9	10	9.5	9.5	7.5	7	5.5	5.5	7.5	8	79
Awakia Hillfoot Rd	7.5	10	9.5	4.5	9.5	6.5	9	4	5	9	74.5
Waiwera at Robertson Rd	9.5	10	2	10	7	7	8.5	5	7.5	6	72.5
Waiwera at SH1	7	10	8	8	7	6.5	7	6	7	6	72.5
Waiwera at Hillfoot Rd	8	10	5	7	8	5	10	5	7.5	3	68.5
Waiwera at Owaka Valley Rd	7	10	2	10	9	5	10	6	7	2	68
Kuriwao Hillfoot Rd	7.5	7	10	6	8	7	5.5	3.5	5	6	65.5
Kuriwao u/s Kuriwao-Siding Rd	7	8	7	6	8	7	9	3.5	3.5	3	62
Waiwera at Maw's Farm	8	9	2	7	5.5	9	7.5	4	6.5	1	59.5
Waiwera near Clifton	8	9	3	6	5.5	7.5	6	4	6	4	59
Waiwera trib at Quarry Road	1.5	1	0	1	10	1	9	4	4	2	33.5
Waiwera at Blaike Rd	1	1	0	1	10	1	10	3	5	1	33

4.3.1 Vegetation and Riparian Margins

Vegetation and riparian scores are given in Table 4.3. Bank vegetation assessment scores ranged between three and six, generally mature shrubs and sparse tree cover was greater than young exotic, long rank grass. Only Owaka Valley Road had regenerating native or flaxes/sedges/tussock being more prevalent than dense exotic vegetation. The width of riparian vegetation was highest in the Kuriwao Stream at Old Coach Road with a width of eight metres, the lowest was Kuriwao at Kuriwao Siding Road, with 3.5m riparian width. Riparian shade really depended on river width, the Awakia Stream at Hillfoot Road is narrow and had over 80% riparian shade, this is compared to the Waiwera at Maw's Farm, a wide river with less than 5% riparian shade.

4.3.2 Invertebrate and fish: habitat diversity and cover diversity

Invertebrate/fish habitat diversity and habitat abundance scores for each site are given in Table 4.3. Invertebrate habitat diversity through different substrate types (such as boulders, cobbles, gravel, sand, wood, leaves, root mats, macrophytes and periphyton) was highest at the Waiwera River and Kuriwao Stream sites as well as Awakia Stream. It was lowest in the two tributaries. The invertebrate habitat abundance (percentage of substrate favourable for EPT colonisation) was highest in the Kuriwao at Hillfoot Road, although the Kuriwao at Old Coach Road, the Waiwera at Kuriwao Siding Road and the Awakia Stream also scored highly. Finally the fish cover abundance (the percentage of fish cover available) was highest in the two tributaries, as well as the Kuriwao Stream at Old Coach Road, the Waiwera at Owaka Valley Road and the Waiwera at Robertson Road, it was lowest in the Waiwera River at Maw's Farm and Clifton.

4.3.3 Hydraulic heterogeneity and bank erosion

Scores for hydraulic heterogeneity and bank erosion are given in Table 4.3. Hydraulic heterogeneity (number of hydraulic components such as pool, riffle, fast run, slow run, rapid cascade, waterfalls) scores were highest in the Waiwera River near Clifton and lowest in the two tributaries. The scores for bank erosion (percentage of the stream bank recently/actively eroding due to scouring at the waterline, slumping of the bank or stock pugging) was highest in the Waiwera at Hillfoot Road and the Waiwera Owaka Valley Road, as well as the tributary at Blaike Road (Table 4.3).

4.3.4 Substrate composition

Deposited sediment scores for each site are given in Table 4.3. The score relates to the percentage of stream bed covered by fine sediment. Sites with the least deposited sediment include the Kuriwao at Old Coach Road and the Waiwera at Robertson Road. The two tributaries had the highest percentage deposition of sediment.

4.4 Sediment

Results from the in-stream visual estimate of % sediment cover are outlined in Table 4.4 (Appendix 8.1.7 gives full details). The sites with the highest sediment cover are Blaike Road (100%) and Quarry Road (70%), all other sites had between 1.3% and 10.1% sediment cover. Clapcott (2011) recommended a 20% cover of sediment to protect stream biodiversity and fish. This was exceeded in both tributaries, but not in the Waiwera River or Kuriwao Stream.

Results from the Quorer are also detailed in Table 4.4 (Appendix 8.1.8 gives full details). Clapcott (2011) recommended an SIS of <450 g/m^2 to protect stream biodiversity and fish. The sites which exceeded this recommendation are the tributary at Quarry Road which had extremely elevated sediment concentrations and the Waiwera at Robertson Road. Sites with SIS >350 g/m^2 included the upper Waiwera at Owaka Valley Road. Note that Maw's Farm and Clifton were not sampled due to bedrock.

As the Quorer method provides a quantitative measure of sediment in the surface and subsurface layers and as such can also be used to indicate the 'embeddedness' of particles or the interstitial space, it was expected that the results would correlate with macroinvertebrate results (high sediment, low macroinvertebrate indices), however R^2 values between sediment and invertebrate metrics (Table 4.9) were low in all cases. However, the R^2 value between SIS and filamentous algae (Table 4.5) at the mainstem sites was >0.63, this may be due to the paucity of macroinvertebrates and associated low periphyton grazing.

Table 4.4 Sediment cover, suspended inorganic sediment and suspended organic sediment. Waiwera Catchment March 2017. The grey cells indicate where recommended guidelines have been exceeded

Location	Sediment cover (%)	SIS (g/m2)	SOS (g/m2)
	(SAM2)	Quorer (SAM 4)	Quorer (SAM 4)
Kuriwao Old Coach Rd	3.35	236.1	52.0
Waiwera at Kuriwao-Siding Rd	4.5	193.7	29.3
Awakia Hillfoot Rd	6.9	389.2	97.3
Waiwera at Robertson Rd	2	554.0	88.2
Waiwera at SH1	9.5	172.7	32.1
Waiwera at Hillfoot Rd	10.1	230.6	50.6
Waiwera at Owaka Valley Rd	13.25	384.9	65.1
Kuriwao Hillfoot Rd	6.4	208.2	33.1
Kuriwao u/s Kuriwao-Siding Rd	9.1	231.3	26.9
Waiwera at Maw's Farm	7.2	n/a	n/a
Waiwera near Clifton	5.4	n/a	n/a
Waiwera trib at Quarry Road	70	3875.1	526.0
Waiwera at Blaike Rd	100	435.6	147.9
Waiwera at Waiwera Gorge Rd	1.3	236.1	52.0

4.5 Periphyton

4.5.1 Long-term monitoring

Periphyton community composition has been monitored in the Waiwera River at Maw's Farm (1km upstream of the Clutha confluence) since 2007 (Appendix 8.1.2).

Cyanobacteria was only found in 2007 (*Oscillatoria)* and 2014 *(Phormidium).* The periphyton community is dominated by diatoms, particularly *Melosira* and *Gomphoneis*. There is little filamentous green algae, with *Microspora* being found most frequently but not in abundance.

The method used in long-term monitoring is based on scrapes of three stones at each site (total area 75 cm^2) and is unlikely to provide a reliable estimate of the community composition of periphyton across the entire stream bed at each site.

4.5.2 Catchment survey 2017

Long (>2 cm), filamentous algae cover was generally low at most sites. The highest cover by long, filamentous brown/reddish algae occurred at Maw's Farm at 36% this site exceeded guideline levels (30% cover), the Waiwera at Owaka Valley Road recorded 38% cover (green filamentous), and the Waiwera at Robertson Road 31% cover (green filamentous) (Table 4.5).

The percentage of the bed covered by other periphyton types (including unconsolidated algae, medium and thick mats, didymo and short, (<2 cm) filamentous algae) was well within guideline levels (60% total cover) at most sites, however guideline value were exceeded in the Waiwera at Kuriwao-Siding Road (84%), periphyton cover at this site was dominated by black/dark brown thin mats. The guideline was also exceeded at Waiwera at Hillfoot Road (77%), Waiwera at Waiwera Gorge Road (65%) and Waiwera at Clifton (63%).

Table 4.5 gives the overall average periphyton score for each site, the Waiwera at Kuriwao-Siding Road has the highest score, with the Kuriwao at Hillfoot Road having the lowest score.

Three sites were dominated by macrophytes (due to a soft substrate), cover is detailed in Table 4.6.

Table 4.5 Overall average periphyton score and percentage cover by algae

Site	Overall average periphyton score	% cover by long filamentous algae	% cover by other algae
Waiwera at Kuriwao-Siding Rd	9.8	0.3	84
Waiwera near Clifton	8.6	1.2	63
Waiwera at SH1	8.3	5.5	71
Kuriwao Old Coach Rd	7.5	0.7	17
Waiwera at Hillfoot Rd	7	3.4	77
Waiwera at Waiwera Gorge Road	6.9	22	65
Waiwera at Robertson Rd	6.1	31	53
Kuriwao u/s Kuriwao-Siding Rd	5.3	4.6	11
Waiwera at Maw's Farm	4.6	36	51
Waiwera at Owaka Valley Rd	4.3	38	40
Awakia Hillfoot Rd	4.1	0.5	9.3
Kuriwao Hillfoot Rd	1.9	0.6	3

Table 4.6 Macrophyte Cover

	Kuriwao Stream upstream of Kuriwao Siding Road	Tributary at Quarry Road	Waiwera River tributary at Blaikie Road
Macrophyte total cover (%)	0	91	100
Macrophyte channel clogginess (%)	0	91	100
Macrophyte native cover (%)	4.4	0	0

4.6 Macroinvertebrates

4.6.1 Long term monitoring

Macroinvertebrate samples have been collected annually from the Waiwera at Maw's Farm (100m upstream of the Clutha) since 2007 to the present.

The mollusc *Potamopyrgus* was 'abundant' to 'very very abundant' on all sampling occasions, with very high numbers recorded in 2007, 2010 and 2013. The Trichoptera *Pycnocentrodes* was also 'abundan't to 'very very abundant' on all sampling occasions, with very high numbers recorded in 2008 and 2010, (Table 4.7). The net-spinning caddisfly Aoteapsyche was also 'abundant' to 'very abundant' on all sampling occasions.

Other taxa that have occasionally been 'very abundant' are the oligochaete worm, the larvae of the *Chironomus* midges, larvae of the *Maoridiamesa* midges, larvae of the tanytarsus midges and the common amhipod *Paracalliope.*

Macroinvertebrate metrics provide a measure of long-term water and habitat quality. The %EPT taxa ranged from 6-12% over the 10 years of macroinvertebrate sampling at the Waiwera River site. There was no evidence of a trend in % EPT taxa at this site over this period (Figure 4.16 and Table 4.8).

Benthic macroinvertebates can be used as an indicator of water quality, the higher the MCI and SMCI the better the water quality (Table 3.5). MCI scores ranged from 80 to 102.9 at Maw's Farm, indicating that there is 'probable moderate pollution' (using the criteria in Table 3.5), and no trend in MCI scores was detected (Figure 4.16 and Table 4.8). SQMCI scores ranged from 1.8 to 4.1), and no trend in SQMCI scores was found (Figure 4.16 and Table 4.8).

Table 4.7 Macroinvertebrate taxa collected from the Waiwera River 100m u/s Maw's Farm SoE site (2007-2016). Relative abundance scores: R = rare (1-4 individuals), C = common (5-19 individuals), A = abundant (20-99 individuals), VA = very abundant (100-499 individuals), VVA = very, very abundant (500+ individuals)

TAXON	200	200	200	201	201	201	201	201	201	201
COLEOPTERA										
Elmidae		C			R					R
CRUSTACEA										
Ostracoda		A	R	R	C	R	C	R	R	R
Paracalliope fluviatilis	C	C	A	VA	A	A	A	A	A	VA
Paraleptamphopus species			R		R	R	C	R	C	R
DIPTERA										
Aphrophila species	R	C		A		R	C	R	R	R
Austrosimulium species							R	R	A	
Chironominae	VVA	VA	VA		C					
Empididae									R	
Maoridiamesa species	A	C	VA	A	C	A	R	A	VA	R
Muscidae	C	R				C	R		C	
Orthocladiinae	VVA	VVA	VA	A	C	C	R	A	A	C
Tanypodinae				A		C		R		R
Tanytarsini						C	A	A	VA	C
EPHEMEROPTERA										
Deleatidium species		A		A	R	A	C	R	A	A
HEMIPTERA										
Sigara				R						
HIRUDINA					C			R		R
MEGALOPTERA										
Archichauliodes diversus						R	C	R		R
MOLLUSCA										
Physella species		C	C	R		R	C	C		R
Potamopyrgus	VVA	A	VA	VVA		VA	VVA	VA	VA	VA
Sphaerium novaezelandiae		A	R				A	C	C	C
NEMATODA									R	
NEMERTEA							R		R	
OLIGOCHAETA	VA	VA	VVA			A	A	VA	A	VA
PLATYHELMINTHES		A	R			R	R	C	C	A
TRICHOPTERA										
Aoteapsyche species	A	C	R	VA	R	VA	VA	VA	VA	VA
Costachorema				R		R			R	
Helicopsyche species				C	A		C			
Hudsonema amabile	C	A	R	R	A		R	R		
Hydrobiosidae early instar	A	A					R			
Hydrobiosis umbripennis	R	R	R	C	A	C	A	C	C	C
Neurochorema species				A	R		C	A	C	
Olinga species	C				R	R				
Oxyethira albiceps		C		A	R		R	R		R
Polyplectropus species					R		R	R		
Psilochorema species	A	C	R	A	R	C	R	R		R
Pycnocentria species		A	R	R	A		C			
Pycnocentrodes species	VA	VVA	C	VVA	VA	C	A	VA	C	A
Number of taxa	15	22	18	21	25	2	28	25	22	22
EPT taxa	7	9	7	11	12	7	12	9	6	6
MCI score	89	85	82	103	97	93	93	88	80	85
SQMCI score	2.8	3.6	1.9	4.6	4	4.1	4.1	3.6	3.6	3.7

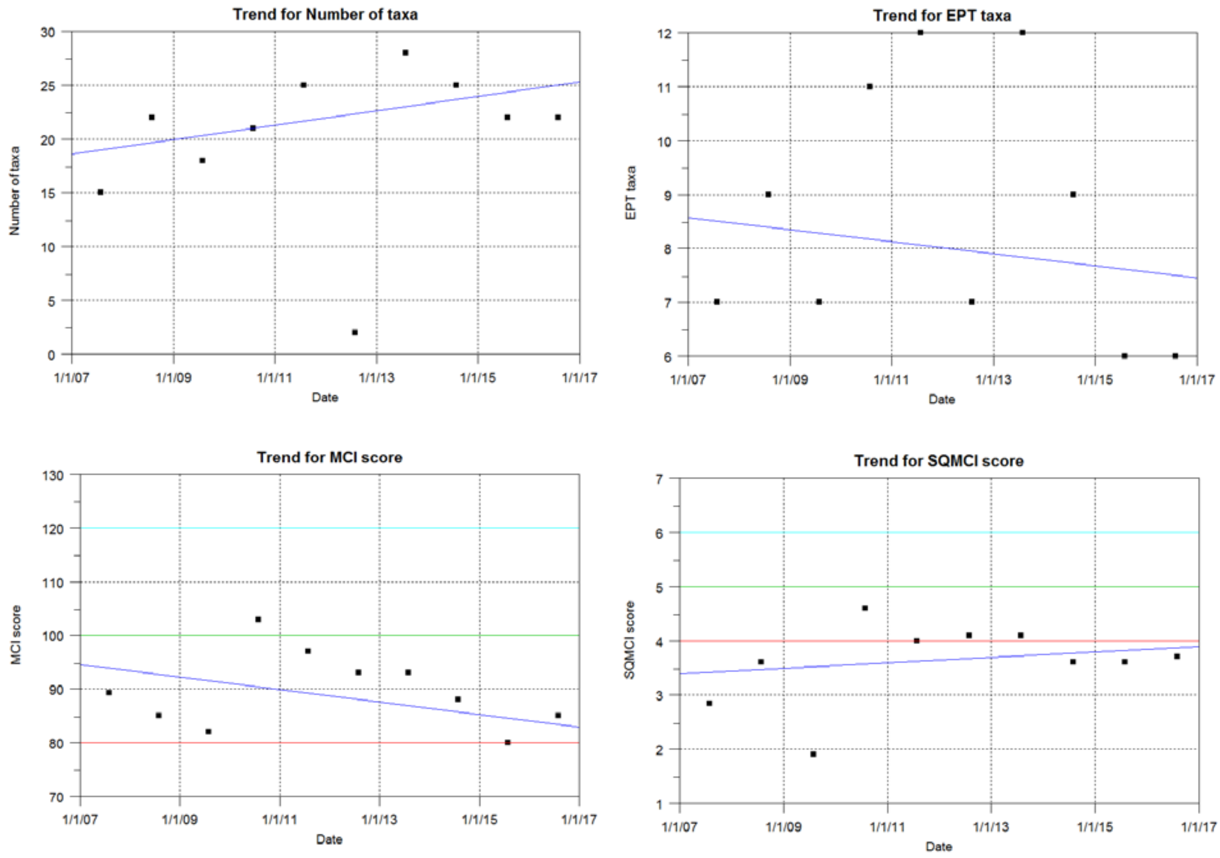


Figure 4.16 **Macroinvertebrate metrics in the Waiwera River 100m u/s Maw's Farm SoE site between 2007-2016 for Taxonomic richness , %EPT richness, MCI and SQMCI. The blue line is the median sen slope, water quality classes are represented by 'poor' below the red line, 'fair' below the green line, 'good' below the turquoise line and 'excellent' above the turquoise line**

Table 4.8 **Summary of trend analyses for macroinvertebrate metrics for the Waiwera River 100m u/s Maw's Farm SoE site between 2007-2016**

Variable	*Z*	*P*	PAC (% / yr)	Trend	Probability
Number of taxa	1.0939	0.2740	3.0310	Increasing	0.8067
% EPT	-0.5516	0.5812	-1.3886	Decreasing	0.6058
MCI	-0.9017	0.3672	-1.3158	Decreasing	0.7875
SQMCI	0.5470	0.5844	1.3689	Increasing	0.5981

4.6.2 2017 Catchment survey

Macroinvertebrate metrics for the catchment study are shown in Table 4.9. MCI scores for most sites in the Waiwera Catchment were consistent with having poor or fair water quality (Figure 4.17), however, MCI scores for Kuriwao Stream and Awakia Stream at Hillfoot Road indicated good water quality (Table 4.9 and Figure 4.17).

Table 4.9 Macroinvertebrate metrics in the Waiwera River Catchment, March 2017

Site	MCI score	SQMCI score	Number of EPT taxa	% EPT taxa	Number of taxa
Waiwera at Owaka Valley Rd	91	3.8	11	39	28
Waiwera at Hillfoot Rd	81	2.9	3	20	15
Waiwera at W-Gorge Rd	93	2.5	8	33	24
Waiwera at Kuriwao Siding Rd	90	3.6	10	42	24
Kuriwao Stm at Old Coach Rd	94	5.1	9	43	21
Kuriwao Stm at Hillfoot Rd	108	6.0	11	58	19
Awakia Stm at Hillfoot Rd	108	4.1	14	42	33
Kuriwao Stm u/s K-Siding Rd	98	5.5	11	44	25
Waiwera trib at Blaikie Rd	80	3.7	2	7	27
Trib at Quarry Rd	79	4.2	3	12	26
Waiwera d/s Robertson Rd	86	2.7	10	34	29
Waiwera at SH1	83	3.8	8	38	21
Waiwera nr Clifton	82	3.7	8	36	22
Waiwera at Maw's Farm	89	3.6	10	37	27

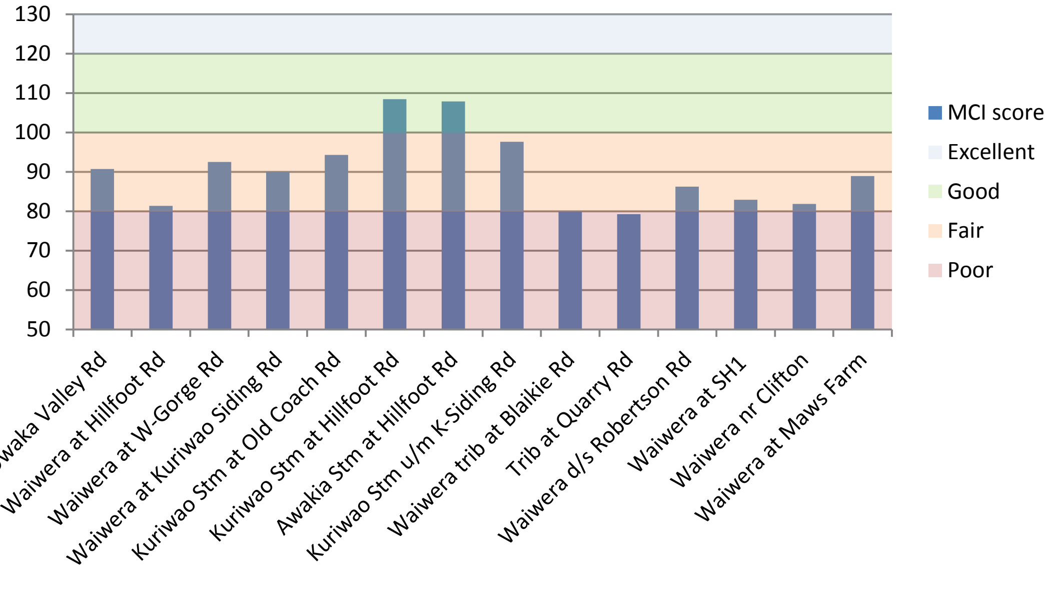


Figure 4.17 MCI scores, Waiwera Catchment March 2017

SQMCI scores followed the same pattern, with most sites being consistent with poor water quality (Figure 4.18), and the Kuriwao Stream, other than the Kuriwao Stream at Kuriwao Siding-Road, showing scores consistent with 'fair' to 'good' water quality (Table 3.5).

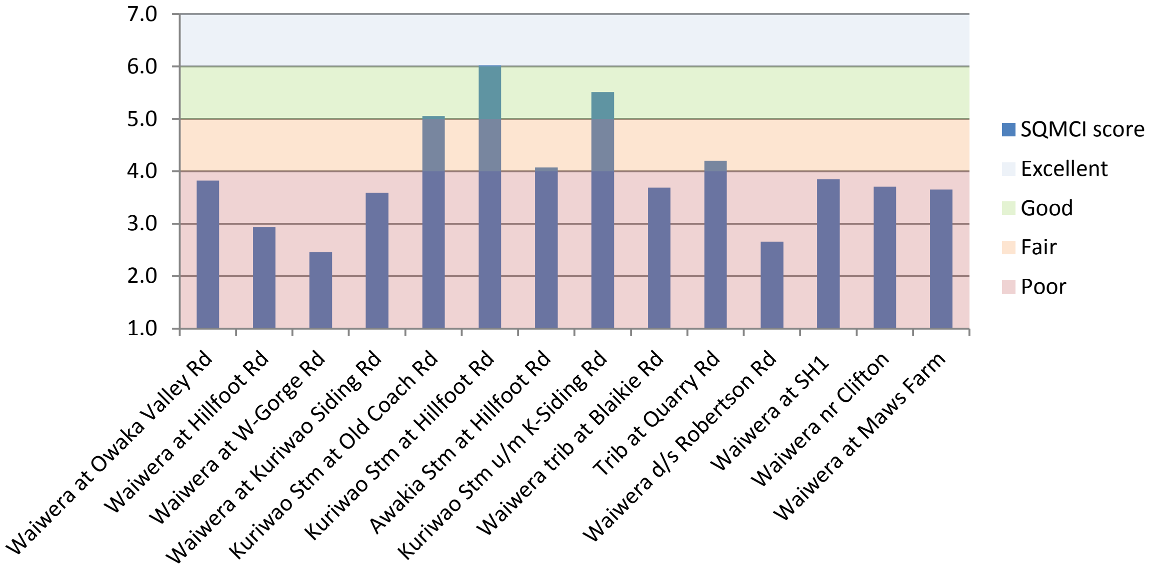


Figure 4.18 SQMCI scores, Waiwera Catchment March 2017

The number of taxa (Table 4.9) ranged from 16 (Waiwera at Hillfoot Road) to 33 (Awakia Stream at Hillfoot Road). The number of EPT taxa ranged from two at Blaike Road, to 11 in the Kuriwao Stream (Hillfoot Road, Kuriwao-Siding Road) and the Waiwera at Owaka Valley Road. The %EPT taxa was lowest at Blaike Road and highest in the Kuriwao Stream at Hillfoot Road.

Looking at the Waiwera Catchment as a whole, the mollusc, *Potamopyrgus antipodarum* and the orthoclad midge are the most abundant macroinvertebrates in the Waiwera River, closely followed by Oligochaetes and the axehead caddis *Oxyethira.* These invertebrates are tolerant of degraded waters. Looking at species recorded as Very Abundant and Very Very abundant the net-building caddis *Aoteapsyche* was found at most sites, although absent from the Waiwera River at Hillfoot Road, larvae of the common mayfly, *Deleatidium*, were abundant in the Awakia Stream and Kuriwao Stream, but numbers dropped off markedly in the Waiwera below Owaka Valley Road.

Chironomid midge larvae (*Maoridiamesa*, Orthocladiinae and Tanytarsini) were among the most abundant at many of the sites, probably because they are tolerant of poorer habitat conditions. A decline in macroinvertebrate fauna was noted between the Waiwera at Owaka Valley Road and the the Waiwera at Hillside Road, which had had approximately half the number of taxa and half the %EPT taxa found at the upstream site (Apendix 8.1.3).

4.7 SoE fish monitoring

Long-term monitoring of fish communities has been conducted at Maw's Farm since 2009, following the New Zealand Freshwater Fish Sampling Protocols (Section 3.7.4).

In total, four species have been found at the Maw's Farm site (Table 4.10). Densities of brown trout collected in this reach have been relatively high on most sampling occasions (0.12 to 14.81 fish/100 m^2), densities of longfin eel were between 0.25 and 2.01 fish/100 m^2 and densities of upland bully were between 0.33 and 12.38 fish/100 m^2 (Table 4.11).

Table 4.10 Fish numbers observed at at Maw's Farm in the Waiwera River

	2009	2010	2010	2011	2012	2013	2015
Upland Bully	8	117	50	53	43	24	4
Longfin Eel	6	19	12	6	4	3	3
Koura		present		present			
Brown Trout	3	113	206	52	136	151	89

Table 4.11 Fish densities (fish/100m^2) observed at at Maw's Farm in the Waiwera River

	4/02/2009	23/02/2010	14/12/2010	13/12/2011	18/12/2012	20/11/2013	25/11/2015
Bully	0.33	12.38	3.59	4.59	2.69	1.84	0.48
Eel Longfin	0.25	2.01	0.86	0.52	0.25	0.23	0.36
Trout	0.12	11.96	14.81	4.50	8.51	11.57	10.67

5. Discussion

5.1 Compliance with Schedule 15 limits

Schedule 15 outlines the water-quality limits for receiving waters. Receiving water limits are applied as five-year, 80th percentiles, when flows are at, or below, a reference flow. For the Waiwera Catchment the reference flow is 1580 l/s at the Maw's Farm flow-monitoring site. For most of the sites sampled (the exception being the SoE site at Maw's Farm), data is only available for one year. For these sites, 80th percentiles were calculated based on this limited data and should be interpreted with caution.

Water quality collected during the catchment survey is shown in Table 4.2. The Schedule 15 limit for NH_4-N was not breached, and turbidity was below the limit at seven of the 13 sites. The limits for DRP, *E.coli* and NNN were elevated above the Schedule 15 limit at most sites.

5.2 Nutrients

Nutrient concentrations affect the growth of algae and other periphyton, and high biomasses of periphyton can affect a wide range of instream values, including aesthetics, biodiversity, recreation and water quality (Biggs 2000). Periphyton biomass is regulated by the balance between two opposing processes: biomass accrual (growth) and biomass loss (Biggs 2000). Biomass accrual is driven by the availability of nutrients, light and water temperature, while biomass loss is driven by disturbance (substrate instability, increased or varying water velocity and suspended particles capable of scouring periphyton from the bed of the river) and grazing (mainly by invertebrates).

In most rivers, nitrogen and phosphorus are the main nutrients that potentially limit periphyton growth. Understanding the amount of these growth-limiting nutrients that are available to periphyton is important, particularly in rivers and streams where high periphyton biomass is a problem.

The concentrations of nitrogen (TN, NNN, NH_4-N) have not significantly changed at the long-term monitoring site in the lower Waiwera Catchment (Maw's Farm), however TP (and DRP) have decreased significantly (refer to Table 4.1). This is promising and shows possible improvements in these growth limiting nutrients, possibly relating to a decrease in sediment.

Results of nutrient sampling conducted during 2016-2017 is shown in Table 4.2, the 80th percentile (below median flow) shows that the concentrations of NNN and DRP in the Waiwera Catchment generally exceed the Schedule 15 limits, whereas NH_4-N is below the limit, this indicates that much of the NH_4-N is filtered by the soil, rather than a direct source from, for example, FDE application.

The main-stem Waiwera shows unusual N results, the 80th percentile NNN result at the upper Owaka Valley Road site showed little difference to the NNN concentration at the downstream site at Maw's Farm. Over the whole catchment NNN was only below the Schedule 15 limit (0.444mg/l) at the Awakia stream site. However this site showed elevated NH_4-N concentrations, which may indicate a localised source of effluent.

Although much of the lower catchment has artificial drainage, the monitoring results show little change in N concentrations between the upper and lower catchment. What is evident is the seasonal variation in N, which indicates indirect losses of nutrients associated with intensive farming (including application of FDE) due to nutrient enrichment of the soil during the summer-autumn period followed by leaching during the subsequent winter-spring drainage period. This is shown in Figure 4.6. Mitigation options are available to try to reduce nitrogen leaching from agricultural enterprises, these include reducing N fertiliser, grazing cows off in winter, using off paddock facilities, good management of effluent systems and good winter crop management.

Inorganic nitrogen or NNN concentrations observed in the Waiwera Catchment were at concentrations sufficient to stimulate the growth rate of algae, typically being well above the Biggs (2000) 30-day accrual threshold concentration of 0.075 mg/L. DRP concentrations were also high in the Waiwera, typically being 0.01 to 0.04 mg/L. These results are very high for Otago river and streams. There is no nutrient limitation for algal growth rate at these sites, based on the Biggs (2000) thresholds.

Clutha District Council (CDC) hold a consent to discharge up to 400 cubic metres per day of treated sewage into the Kuriwao Stream from the Clinton oxidation pond system. The effect of this is seen at Kuriwao Siding Road, the DRP results (Figure 4.11) at this site show significantly elevated results compared to other sites monitored, elevated concentrations of NH_4-N are also found at Kuriwao Siding Road (compared to the upstream site at Hillfoot Road).

The latest water quality monitoring results (8/2/17, CDC consent monitoring) show that upstream of the oxidation pond DRP is 0.013mg/L whereas downstream it DRP is 0.038mg/L and upstream NH_4-N is <0.01mg/L whereas downstream it is 0.06mg/L

5.3 Faecal contamination

Water contaminated with faecal matter poses a range of possible health risks to recreational users, including serious gastrointestinal and respiratory illnesses. Counts of the bacterium *E. coli* are commonly used as an indicator of faecal contamination and a measure of the probability of the presence of other disease-causing agents, such as the protozoa, *Giardia*, and *Cryptosporidium*, the bacterium, *Campylobacter*, and various other bacteria and viruses.

There was no measureable significant change (either increasing or decreasing) in the concentration of *E. coli* over the period July 2006 to February 2017, based on data collected and the long-term SoE monitoring site at Maw's Farm. Samples collected from the Maw's farm site at less than median flow are shown in Figure 4.13, there is a scatter of results both well below and well above the Schedule 15 limit of 260 cfu/100ml. The rolling 80th percentile tracks above the Schedule 15 limit of 260 cfu/100ml.

Catchment-wide sampling conducted during 2016-2017 shows the 80th percentile concentration of *E. coli* during low flows exceeded the Schedule 15 limits for *E. coli* at all sites other than the Waiwera at Hillfoot Road. Concentrations were generally similar across all sites, however sampling identified that *E. coli* counts in the Kuriwao Stream at Old Coach Road and Awakia Stream at Hillfoot Road were higher than average, further investigation would be required to be able to comment on the likely source of bacterial contamination at these sites. The tributary downstream of the quarry also had elevated *E.coli* counts, this may be due to open access for stock, the small volume of water in the tributary and the deep sediment within the channel.

5.4 Turbidity

Turbidity is a measure of the 'cloudiness' of water and is inversely related to how clear water appears (i.e. low turbidity is associated with good water clarity and very clear water, high turbidity with very low clarity and 'dirty' or cloudy water). Turbidity of natural waters tends to increase during runoff events as a result of increased overland flow, stream flow, and erosion.

Turbidity at Maw's Farm is generally low, and there is no evidence of a change in turbidity between July 2006 and February 2017. Catchment-wide sampling conducted during 2016-2017 shows the 80th percentile turbidity results during low flows exceeded the Schedule 15 limits at the upper Waiwera site (Owaka Valley Road), the two upper Kuriwao stream sites (Old Coach Road and Hillfoot Road) and the Awakia Stream, in addition turbidity was especially high in the two tributaries.

In an agricultural environment, a range of activities may contribute to elevated turbidity, including cultivation too close to the stream edge which may cause bank collapse. Particular care has to be taken when wintering cows, to limit pugging and to avoid the transport of sediment to rivers.

5.5 Substrate and riparian cover

The quantity and quality of habitat are important factors that can affect many instream values, among which composition of the streambed is particularly important because it provides the attachment substrate for periphyton and the habitat for macroinvertebrates and fish.

The riparian vegetation at most sites surveyed in the Waiwera Catchment was dominated by mature shrubs and sparse tree cover rather than long grass, there was also evidence of regenerating native plants. Most sites were not fenced from surrounding farmland, and stock generally had access to the stream channel.

The upper Waiwera sites had a thick layer of sediment and algae covering the cobbles, and a paucity of macoinvertebrates. There is no intensive grazing in this back country, rather extensive sheep and beef.

Although the substrate at most sites was varied with different substrate types providing ideal habitat for fish and invertebrates (i.e. a mixture of boulders, cobbles, gravels), the invertebrate abundance scores were low, due to the substrate having a coating of algae/sediment (Figure 5.1). This is particularly true of two of the mainstem Waiwera sites (Owaka Valley Road and Robertson Road).

Figure 5.1 Sediment/algae smothering substrate in upper Waiwera River despite dense riparian vegetation

The Waiwera generally had substrate which should have been favourable for macroinvertebrates to move around on and large enough to offer native fish large interstitial spaces as refuge from flows and predators. However this habitat was compromised by the large amount of deposited sediment which was smothering interstitial spaces and covering substrate. The Quorer analysis gives an indication of the amount of interstitial space, it measures the quantity of fine sediment on and within the upper layer of the streambed, rather than cover. The mainstem Waiwera (Owaka Valley Road and Robertson Road) had some of the highest levels of suspendible inorganic sediment (SIS) and suspendible organic sediment (SOS), these sites when compared to the lower Waiwera had approximately three times the sediment load.

Burdon et al. (2013) identified a change point at 20% sediment cover (estimated by in-stream visual assessment) in a regression with % EPT relative abundance. In this survey the highest % sediment cover recorded was 13% (Waiwera at Owaka Valley Road).

Referring to the Quorer method, Wagenhoff et al. (2011) found an inflection point was evident at around 200 mg SIS/m^2 in the response of the common benthic caddisfly Pycnocentrodes. In this catchment survey 200mg SIS/m^2 was found in the majority of sites monitored (other than Waiwera at Kuriwao-Siding Road and Waiwera at SH1). Clapcott (2011) recommended an SIS of <450 mg/m^2 to protect stream biodiversity and fish. The mainstem Waiwera at Robertson Road exceeded this guideline, in addition the upper Waiwera at Owaka Valley Road was close to the limit at 384 g/m^2.

It is likely that the heavy sediment deposition is linked to cattle accessing tributary streams for stockwater. AgFirst (2016) noted that stock in hill country preferred drinking from water troughs rather than tracking down to rivers (even when the streams were not fenced). Extensive sheep and beef farms usually have significant stream lengths and there may be minimal benefit in 10’s of kilometres of fencing for both the environment and the farm when the same benefit may be made through installing strategically placed stock water troughs (through water reticulation systems).

Currently there are no national guidelines for assessing the ecological impacts of fine sediment or for protecting the areas of river that may be degraded in the future.

5.6 Biological monitoring

5.6.1 Periphyton

The periphyton community forms the slimy coating on the surface of stones and other substrates in freshwaters. This community can include green (Chlorophyta), yellow-green (Xanthophyta), golden brown (Chrysophyta) and red (Rhodophyta) algae, blue-greens (Cyanobacteria), diatoms (Bacillariophyta), bacteria and fungi. Periphyton is an integral part of stream food webs; it captures energy from the sun and converts it, via photosynthesis, to energy sources available to macroinvertebrates, which feed on it. These, in turn, are fed on by other invertebrates and fish. However, periphyton can form nuisance blooms that can detrimentally affect other instream values, such as aesthetics, biodiversity, recreation (swimming and angling), water takes (irrigation, stock/drinking water and industrial) and water quality.

The most extreme case of periphyton affecting instream values is toxin-producing benthic cyanobacteria. Cyanobacteria has only been found at Maw’s Farm twice; in 2007 (*Oscillatoria)* and 2014 *(Phormidium).* These were not the dominant algae on either occasion. Cyanobacteria may produce toxins that pose a health risk to humans and animals.

Long-term monitoring of the composition of periphyton at Maw’s Farm shows that the periphyton community is dominated by diatoms, particularly *Melosira* and *Gomphoneis*. *Melosira* is common in freshwater habitats, especially eutrophic waters. In rivers it often forms fine brown filaments in marginal areas where the current is not so strong but these filaments are easily scoured away during freshes, on the other hand Gomphoneis is often found in rivers with good water quality.

The catchment survey identified that the guideline levels for long filamentous algae were exceeded at three sites, and the guideline for other periphyton types was exceeded at four other sites. This indicates a highly productive river. The SoE annual periphyton monitoring indicates that the most dominant species is *Melosira,* which is indicative of a mesotrophic-eutrophic environment (Biggs, 2000).

There was a good correlation between SIS (Table 4.4) and % cover of long filamentous algae (Table 4.5) producing an R^2 of 0.63, in addition where filamentous algae exceeded the recommended guideline (30%), SIS g/m^2 was recorded at either in exceedance, or close to the guideline (>450 SIS g/m^2). Nutrient enrichment of the sediment is likely as it is sourced from tributary streams frequented by livestock and the algae may be intercepting and utilising these inorganic nutrients.

5.6.2 Macroinvertebrates

Macroinvertebrates are a diverse group of animals and include insects, crustaceans, worms, molluscs and mites. They are an important part of stream-food webs, linking primary producers (periphyton and terrestrial leaf litter) to higher trophic levels (fish and birds). Because of the length of the aquatic part of their life-cycles, which generally range from a few months up to two years, macroinvertebrates provide a good indication of the medium- to long-term water quality of a waterway. For this reason, they are used as a biomonitoring tool around the world. In New Zealand, the MCI (Stark, 1985) and its derivatives (SQMCI, QMCI: Stark 1998) are used as a measure of organic enrichment and sedimentation in gravel-bed streams.

Long-term monitoring of the macroinvertebrate community in the Waiwera River at Maw's Farm indicates that the community is dominated by taxa that are tolerant of pollution and MCI scores indicate that water quality is fair (based on the criteria in Table 3.5), while SQMCI scores indicate that water quality is generally poor, with 6 out of the 10 sampling occasions having SQMCI scores of less than 4.

Analysis of macroinvertebrate indices over time suggests that water and habitat quality have not changed substantially since 2007. The pond snail *Potamopyrgus*, the common amphipod *Paracalliope* and the caddis *Aoteapsyche* have always been abundant at Maw's farm, these invertebrates can tolerate a wide range of water quality.

Biggs (2000) suggested that eutrophic streams tend to be dominated by filter-feeding caddisflies, snails, collector/browser beetles and oligochaete worms with fewer stoneflies and mayflies. This is reflected in the macroinvertebrate communities in the March 2017 catchment survey. Although nutrient concentrations in the catchment were elevated, water quality is unlikely to account for these poor invertebrate scores alone. It is more likely that sedimentation smothering interstitial spaces and covering substrate is to blame for a paucity of invertebrates, particularly the sensitive EPT taxa.

5.6.3 Fish

Three fish species (brown trout, longfin eel, upland bully) have been collected from the Maw's Farm site since 2007.

D. Linklater (pers. comm) recalled that the upper Waiwera used to be a first class trout fishery, but it is now 'dead', he recalled that the decline in the fishery has occurred over the last 30 years. The fishery has been affected by excessive sedimentation, which has reduced the macroinvertebrate community to a point where it is inadequate for fish requirement.

The most productive and available food for stream fish are the Ephemeroptera, Plecoptera and Trichoptera (EPT) species, unfortunately these species are particularly affected by sedimentation because sediment reduces the density of prey items, reduces available oxygen for respiration and reduces interstitial space for refuge(Waters, 1995).

6. Summary

- Nutrient concentrations (TN, NNN, TP, DRP) were high throughout the catchment. The mainstem Waiwera shows unusual results as the N results show little difference between the upper catchment and the lower site at Maw's Farm site.

- Inorganic nitrogen or NNN concentrations observed in the Waiwera Catchment were at concentrations sufficient to stimulate the growth rate of algae, typically being well above the Biggs (2000) 30-day accrual threshold concentration of 0.075 mg/L. DRP concentrations were also extremely high in the Waiwera, typically being 0.01 to 0.04 mg/L.

- The concentrations of nitrogen (TN, NNN, NH_4-N) have not significantly changed at the long-term monitoring site in the Waiwera Catchment (Maw's Farm), however total phosphorus and dissolved reactive phosphorus has decreased significantly (percent annual change 3.87%/yr).

- Sampling conducted during 2016-2017 shows the 80th percentile concentration of *E. coli (*during low flows) exceeded the Schedule 15 limits (260 cfu/100ml) at all sites other than the Waiwera at Hillfoot Road and the Waiwera at Maw's Farm.

- Sampling conducted during 2016-2017 shows the 80th percentile turbidity result during low flows exceeded the Schedule 15 limits at only the upper Waiwera site and the Kuriwao Stream (Old Coach Road, Hillfoot Road) and the three tributary sites.

- The Clinton oxidation pond discharge, downstream of Clinton increases concentrations of TP, DRP and NH4-N in the Kuriwao Stream. The effect of the discharge is noticeable at the Kuriwao Stream at Kuriwao Siding Road monitoring site.

- Habitat assessment scores indicated that the upper mainstem Waiwera scored poorly for invertebrate habitat abundance (percentage of substrate favourable for EPT colonisation, for example water flowing over substrate clear of algae) even though the habitat diversity (the number of different substrate types) scored highly (Table 4.3).

- Riparian buffers were generally present as mature shrubs, sparse tree cover (greater than young exotic) and long grass. This is typical of an extensive farming landscape. There was evidence of direct stock access at most sites surveyed.

- The results of the catchment periphyton survey showed that of the 12 sites monitored, seven exceeded guideline levels (30% long filamentous or 60% other algae). The Waiwera at Owaka Valley Road, Waiwera at Maw's Farm and the Waiwera at Robertson Road exceeded guideline levels for long filamentous algae and four other sites exceeded the guideline for % cover by other algae (Table 4.5).

- Macroinvertebrate communities collected from Maw’s Farm between 2007 and 2015 were consistent with ‘poor’ to ‘fair’ water quality, and trend analysis indicated that macroinvertebrate metrics at this site had been stable over this period (Table 4.7).

- Macroinvertebrate communities collected during the catchment survey of March 2017 indicated a poor SQMCI at all sites other than the Kuriwao Stream (Old Coach Road, Hillfoot Road and upstream of Kuriwao Siding Road) and Awakia Stream (Table 4.9).

- Sediment cover was highest at the Waiwera River at Owaka Valley Road site, but suspended inorganic sediment (Quorer) was greater than the recommended guideline (450 g/m^2) at the Waiwera at Robertson Road site (Table 4.4).

- Suspended inorganic sediment was greater than 200g/m^2 at most sites which is the inflection point for common benthic caddisfly *Pycnocentrodes* (Wagenhoff et al. 2011). This species was absent in the mainstem Waiwera River at Hillfoot Road and Gorge Road, ‘common’ at the Waiwera at Clifton site and ‘rare’ at the Waiwera at Owaka Valley Road site.

- Fine sediment accumulation seems to be the cause of catastrophic losses in abundance and diversity of macroinvertebrate communities and fish populations in the Waiwera catchment, particularly the mainstem Waiwera. Appropriate mitigation measures need to be implemented to protect the river from further degradation and to aid recovery.

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8. Appendices

8.1.1 Water Quality Results

Waiwera River Hillfoot Rd								
Date	Ammoniacal	Dissolved	E-Coli MPN	Nitrite Nitrate	Total	Total	Turbidity	pH
	(g/m³-N)	(g/m³-P)	(cfu/100mL)	(g/m³-N)	(g/m³)	(g/m³-P)	(NTU)	
12/11/2015	0.01	0.012	66	0.93	1.3	0.028	2.9	8.8
25/11/2015	0.017	0.014	58	0.83	1.1	0.038	3.3	8.4
9/12/2015	0.01	0.016	250	0.66	0.96	0.042	8.4	8.3
22/12/2015	0.014	0.03	6200	0.58	1.3	0.13	28	8
12/01/2016	0.013	0.018	60	0.45	0.69	0.039	2.1	8.5
28/01/2016	0.019	0.027	140	0.5	0.81	0.058	4	8.1
17/02/2016	0.021	0.024	230	0.4	0.67	0.051	2.9	8.1
8/03/2016	0.01	0.016	260	0.31	0.54	0.033	2.6	8
23/03/2016	0.017	0.025	100	0.36	0.61	0.047	2.5	8.2
7/04/2016	0.011	0.01	80	0.28	0.46	0.022	1.1	7.9
20/04/2016	0.011	0.007	94	0.24	0.42	0.015	1	8.1
4/05/2016	0.007	0.008	100	0.61	0.8	0.015	1.2	7.9
17/05/2016	0.02	0.017	2000	1.6	2.6	0.17	30	7.6
31/05/2016	0.015	0.02	260	1.8	2	0.044	8	7.5
15/06/2016	<0.005000	0.008	64	1.5	1.7	0.026	1.6	8.2
30/06/2016	<0.005000	0.014	40	1.4	1.6	0.026	2.5	7.9
13/07/2016	<0.005000	0.01	60	1.5	1.7	0.015	1.2	7.7
27/07/2016	0.009	0.025	21	2.1	2.2	0.034	3.7	7.5
9/08/2016	<0.005000	0.016	38	2	2.1	0.024	2.5	7.5
22/08/2016	<0.005000	0.008	54	1.4	1.6	0.019	1.8	8.2
6/09/2016	<0.005000	0.008	36	0.92	1.2	0.027	2.5	8.4
21/09/2016	0.046	0.007	23	0.97	1.3	0.025	2	8.6
4/10/2016	0.008	0.007	38	0.67	0.94	0.025	3.3	8.3
18/10/2016	0.009	0.008	86	0.61	0.85	0.031	3.5	8.1
3/11/2016	0.007	0.017	120	0.93	1.2	0.049	4.4	8.5
Waiwera at Kuriwao Siding Rd								
	Ammoniacal	Dissolved	E-Coli MPN	Nitrite/Nitrate	Total	Total	Turbidity	pH
	(g/m³-N)	(g/m³-P)	(cfu/100mL)	(g/m³-N)	(g/m³)	(g/m³-P)	(NTU)	
12/11/2015	0.018	0.013	410	1	1.2	0.024	2.4	7.8
25/11/2015	0.027	0.016	120	0.77	1.1	0.041	2.4	7.8
9/12/2015	0.018	0.015	190	0.63	0.91	0.04	5.5	7.9
22/12/2015	0.019	0.031	4200	0.65	1.4	0.17	35	7.6
12/01/2016	0.012	0.012	150	0.32	0.56	0.04	1.9	7.7
28/01/2016	0.023	0.028	450	0.46	0.77	0.056	4	7.7
17/02/2016	0.23	0.027	120	0.34	0.64	0.048	2.4	7.8
8/03/2016	0.016	0.019	260	0.24	0.46	0.035	2.3	7.7
23/03/2016	0.021	0.026	5800	0.42	0.67	0.048	1.9	7.7
7/04/2016	0.013	0.013	110	0.18	0.34	0.026	1	7.7
20/04/2016	0.02	0.009	100	0.12	0.34	0.02	0.9	7.8
4/05/2016	0.014	0.011	130	0.55	0.76	0.019	1.2	7.6
17/05/2016	0.02	0.016	2800	1.3	2.2	0.14	32	7.5
31/05/2016	0.008	0.02	210	1.8	2.1	0.043	5.8	7.4
15/06/2016	<0.005000	0.01	300	1.5	1.7	0.019	1.3	7.6
30/06/2016	0.006	0.012	330	1.4	1.7	0.021	2.8	7.8
13/07/2016	0.012	0.01	120	1.4	1.6	0.013	1.7	7.7
27/07/2016	0.005	0.02	42	2.1	2.2	0.037	3.6	7.4
9/08/2016	<0.005000	0.016	26	2	2	0.026	2.3	7.5
22/08/2016	<0.005000	0.008	78	1.4	1.9	0.018	1.7	7.8
6/09/2016	<0.005000	0.007	150	0.97	1.2	0.019	1.5	8.1
21/09/2016	0.008	0.007	21	0.93	1.1	0.019	1.6	8.6
4/10/2016	0.022	0.007	310	0.69	0.96	0.029	3.4	7.8
18/10/2016	0.022	0.011	210	0.59	0.9	0.038	3.8	7.7
3/11/2016	0.012	0.016	550	0.83	1.1	0.042	4	8

Water Quality Results continued

Waiwera at Owaka Valley Rd								
	Ammoniacal (g/m³-N)	Dissolved (g/m³-P)	E-Coli MPN (cfu/100mL)	Nitrite/Nitrate (g/m³-N)	Total (g/m³)	Total (g/m³-P)	Turbidity (NTU)	pH
12/11/2015	0.011	0.024	590	1.1	1.3	0.061	11	7.8
25/11/2015	0.017	0.02	200	1.2	1.3	0.042	4.7	7.9
9/12/2015	0.01	0.023	1200	0.86	1.2	0.065	5.8	8
22/12/2015	0.021	0.033	4900	0.72	1.3	0.11	18	7.6
12/01/2016	0.008	0.023	480	1	1.1	0.042	3.4	8
28/01/2016	0.013	0.026	2500	0.79	1.1	0.074	11	7.7
17/02/2016	0.022	0.028	290	0.94	1.1	0.046	1.8	7.8
8/03/2016	0.036	0.039	390	0.52	0.94	0.075	5.3	7.9
23/03/2016	0.01	0.027	450	0.88	1.1	0.055	1.8	8
7/04/2016	0.012	0.021	120	1	1.2	0.028	1.3	7.6
20/04/2016	0.014	0.019	58	1	1.2	0.029	1.3	7.7
4/05/2016	0.014	0.022	42	1.2	1.3	0.029	1.7	7.6
17/05/2016	0.028	0.032	1700	1.4	2.2	0.11	19	7.2
31/05/2016	0.031	0.041	2000	1.2	1.9	0.2	45	7.1
15/06/2016	0.007	0.032	98	1.4	1.6	0.058	7	7.6
30/06/2016	0.01	0.03	44	1.4	1.7	0.057	5.4	7.5
13/07/2016	0.007	0.03	15	1.6	1.8	0.045	4.4	7.5
27/07/2016	0.005	0.031	68	1.8	2.1	0.064	1.9	7.3
9/08/2016	0.005	0.029	140	1.9	1.9	0.052	4.1	7.3
22/08/2016	<0.005000	0.028	62	1.6	1.8	0.05	4.7	7.6
6/09/2016	0.007	0.034	170	1.3	1.6	0.064	5.8	7.5
21/09/2016	0.018	0.028	9.8	1.3	1.5	0.048	2.8	8.3
4/10/2016	0.005	0.027	96	1.2	1.3	0.052	4.6	8.3
18/10/2016	0.018	0.033	650	1.1	1.3	0.067	12	7.6
3/11/2016	0.01	0.032	190	1.1	1.3	0.068	4.3	7.8
Waiwera at Robertson Rd								
	Ammoniacal (g/m³-N)	Dissolved (g/m³-P)	E-Coli MPN (cfu/100mL)	Nitrite/Nitrate (g/m³-N)	Total (g/m³)	Total (g/m³-P)	Turbidity (NTU)	pH
12/11/2015	0.024	0.02	600	0.92	1.3	0.042	4.1	7.7
25/11/2015	0.036	0.022	210	0.65	1	0.055	3.1	7.7
9/12/2015	0.028	0.029	670	0.59	0.89	0.059	6.3	7.8
22/12/2015	0.032	0.043	6600	0.5	1.2	0.15	31	7.5
12/01/2016	0.018	0.023	260	0.29	0.61	0.057	2.3	7.6
28/01/2016	0.034	0.052	360	0.42	0.84	0.1	4.2	7.6
17/02/2016	0.031	0.042	98	0.24	0.58	0.066	2.2	7.6
8/03/2016	0.026	0.042	150	0.2	0.48	0.07	2.7	7.6
23/03/2016	0.023	0.041	170	0.33	0.7	0.067	3.3	7.6
7/04/2016	0.017	0.027	62	0.084	0.32	0.045	1.3	7.6
20/04/2016	0.019	0.02	70	0.099	0.35	0.041	1.7	7.7
4/05/2016	0.018	0.024	88	0.47	0.74	0.039	1.5	7.6
17/05/2016	0.046	0.038	2100	1.2	2	0.13	22	7.5
31/05/2016	0.043	0.027	320	2	2.3	0.051	4.9	7.4
15/06/2016	0.01	0.02	130	1.4	1.7	0.036	2.1	7.6
30/06/2016	0.008	0.019	200	1.4	1.7	0.03	3.2	7.6
13/07/2016	0.007	0.015	58	1.4	1.6	0.025	2.1	7.6
27/07/2016	0.019	0.023	70	2.5	2.7	0.042	6.9	7.2
9/08/2016	0.018	0.02	56	2.2	2.4	0.038	4.3	7.4
22/08/2016	<0.005000	0.013	42	1.5	1.6	0.03	3	7.7
6/09/2016	0.014	0.014	98	1	1.3	0.33	2.4	7.7
21/09/2016	0.011	0.01	120	0.93	1.2	0.028	2.4	7.9
4/10/2016	0.036	0.013	520	0.64	0.95	0.035	3.2	7.6
18/10/2016	0.033	0.019	370	0.56	0.93	0.051	4.3	7.6
3/11/2016	0.016	0.023	630	0.91	1.2	0.048	4	7.7

Water Quality Results continued

Waiwera at SH1 bridge								
	Ammoniacal (g/m³-N)	Dissolved (g/m³-P)	E-Coli MPN (cfu/100mL)	Nitrite/Nitrate (g/m³-N)	Total (g/m³)	Total (g/m³-P)	Turbidity (NTU)	pH
12/11/2015	0.031	0.021	390	0.84	1.1	0.044	3.3	7.7
25/11/2015	0.033	0.028	460	0.6	0.99	0.062	3.3	7.6
9/12/2015	0.028	0.028	460	0.54	0.86	0.064	5.5	7.8
22/12/2015	0.12	0.043	7100	0.48	1.2	0.14	28	7.6
12/01/2016	0.015	0.026	88	0.25	0.61	0.066	2.5	7.6
28/01/2016	0.022	0.055	370	0.39	0.78	0.082	3.7	7.6
17/02/2016	0.024	0.039	440	0.22	0.56	0.066	2.2	7.5
8/03/2016	0.013	0.043	290	0.14	0.48	0.07	2.4	7.6
23/03/2016	0.017	0.05	170	0.27	0.6	0.07	3	7.5
7/04/2016	0.015	0.028	120	0.11	0.32	0.043	1.7	7.5
20/04/2016	0.031	0.018	76	0.076	0.37	0.038	1.1	7.6
4/05/2016	0.017	0.021	68	0.37	0.63	0.038	1.3	7.5
17/05/2016	0.032	0.037	750	1.1	1.9	0.099	13	7.5
31/05/2016	0.023	0.027	230	2.1	2.3	0.05	3.5	7.4
15/06/2016	0.008	0.02	130	1.4	1.6	0.037	1.7	7.5
30/06/2016	0.008	0.018	60	1.4	1.7	0.029	2.9	7.7
13/07/2016	<0.005000	0.014	58	1.4	1.6	0.022	2.6	7.7
27/07/2016	0.02	0.023	46	2.5	2.7	0.044	6.2	7.2
9/08/2016	0.013	0.02	76	2.3	2.3	0.035	4.4	7.3
22/08/2016	<0.005000	0.012	58	1.4	1.6	0.024	1.8	7.8
6/09/2016	0.007	0.011	82	0.98	1.3	0.027	2	8
21/09/2016	0.007	0.01	60	0.91	1.2	0.025	2.1	7.9
4/10/2016	0.043	0.013	240	0.61	0.93	0.038	2.4	7.6
18/10/2016	0.032	0.024	240	0.51	0.83	0.053	3.3	7.5
3/11/2016	0.02	0.025	360	0.89	1.2	0.055	2.8	7.6
Waiwera near Clifton								
	Ammoniacal (g/m³-N)	Dissolved (g/m³-P)	E-Coli MPN (cfu/100mL)	Nitrite/Nitrate (g/m³-N)	Total (g/m³)	Total (g/m³-P)	Turbidity (NTU)	pH
12/11/2015	0.04	0.024	480	0.76	1.2	0.051	3.9	7.7
25/11/2015	0.041	0.026	260	0.55	0.94	0.067	3.1	7.7
9/12/2015	0.025	0.03	330	0.52	0.86	0.057	4.9	7.8
22/12/2015	0.15	0.047	2900	0.37	0.97	0.13	20	7.7
12/01/2016	0.017	0.026	220	0.23	0.63	0.077	3.1	7.7
28/01/2016	0.025	0.057	550	0.39	0.91	0.098	4.4	7.6
17/02/2016	0.077	0.045	370	0.16	0.5	0.074	2.9	7.5
8/03/2016	0.032	0.05	430	0.15	0.46	0.074	2.5	7.6
23/03/2016	0.02	0.047	440	0.2	0.5	0.076	2.4	7.6
7/04/2016	0.02	0.031	270	0.075	0.34	0.051	1.4	7.6
20/04/2016	0.026	0.02		0.046	0.34	0.043	1.1	7.7
4/05/2016	0.026	0.021	82	0.37	0.63	0.039	1.2	7.6
17/05/2016	0.021	0.036	640	1.1	1.7	0.093	11	7.5
31/05/2016	0.023	0.027	250	2.1	2.3	0.049	4.3	7.4
15/06/2016	0.008	0.02	280	1.4	1.6	0.032	1.7	7.6
30/06/2016	0.006	0.016	88	1.4	1.7	0.029	2.7	7.8
13/07/2016	<0.005000	0.013	42	1.3	1.6	0.023	2	7.7
27/07/2016	0.022	0.024	84	2.7	3	0.045	6.4	7.3
9/08/2016	0.013	0.019	58	2.3	2.5	0.036	4.7	7.4
22/08/2016	<0.005000	0.011	46	1.4	1.6	0.021	2	8.1
6/09/2016	0.006	0.01	44	0.94	1.3	0.024	2	8.5
21/09/2016	0.008	0.008	90	0.86	1.2	0.021	2.1	7.9
4/10/2016	0.027	0.014	2000	0.59	0.97	0.044	4.2	7.6
18/10/2016	0.09	0.024	480	0.51	0.93	0.064	3.4	7.7
3/11/2016	0.019	0.035	420	0.88	1.2	0.066	3	7.8

Water Quality Results continued

Waiwera trib at Blaike Rd								
	Ammoniacal (g/m³-N)	Dissolved (g/m³-P)	E-Coli MPN (cfu/100mL)	Nitrite/Nitrate (g/m³-N)	Total (g/m³)	Total (g/m³-P)	Turbidity (NTU)	pH
12/11/2015	0.021	0.022	810	2.3	2.9	0.064	23	7.7
25/11/2015	0.023	0.02	150	1.2	1.6	0.039	6.1	7.8
9/12/2015	0.046	0.017	100	0.53	0.93	0.036	5.2	7.9
22/12/2015	0.032	0.029	7300	0.88	1.6	0.068	12	7.7
12/01/2016	0.016	0.022	110	0.065	0.56	0.06	15	7.9
28/01/2016	0.016	0.027	310	0.098	0.64	0.054	6.2	7.8
17/02/2016	0.031	0.039	2600	0.07	0.64	0.077	5.2	7.8
8/03/2016	0.015	0.053	320	0.093	0.83	0.067	7	7.9
23/03/2016	0.032	0.043	400	0.039	0.79	0.064	6.8	7.8
7/04/2016	0.022	0.039	92	0.015	0.51	0.081	6.2	7.8
20/04/2016	0.015	0.036	28	0.024	0.5	0.063	5.9	7.9
4/05/2016	0.021	0.029	46	0.55	0.97	0.052	4.6	7.8
17/05/2016	0.037	0.026	490	3.8	5	0.13	36	7.4
31/05/2016	0.023	0.017	670	4.1	4.7	0.084	22	7.2
15/06/2016	0.06	0.018	52	2.7	3.2	0.069	18	7.5
30/06/2016	0.037	0.018	120	3.1	3.4	0.095	28	7.4
13/07/2016	0.071	0.019	9.8	3	3.5	0.1	22	7.5
27/07/2016	0.03	0.019	36	5.6	6.4	0.056	7.2	6.9
9/08/2016	0.025	0.036	18	4.7	5.2	0.055	12	7.1
22/08/2016	0.033	0.02	110	5	5.3	0.064	4.5	7.6
6/09/2016	0.028	0.026	72	3.9	4.3	0.053	10	7.5
21/09/2016	0.029	0.019	1000	3.4	4.1	0.08	65	7.7
4/10/2016	0.02	0.02	1300	2.7	3.1	0.092	13	7.8
18/10/2016	0.014	0.015	130	2.6	2.9	0.034	7.6	7.7
3/11/2016	0.013	0.017	44	2.4	2.8	0.035	6.3	7.8
Kuriwao Stream Hillfoot Rd								
	Ammoniacal (g/m³-N)	Dissolved (g/m³-P)	E-Coli MPN (cfu/100mL)	Nitrite/Nitrate (g/m³-N)	Total (g/m³)	Total (g/m³-P)	Turbidity (NTU)	pH
12/11/2015	0.017	0.017	660	0.88	1.4	0.044	7.2	7.8
25/11/2015	0.026	0.019	200	0.61	0.93	0.047	3.3	7.8
9/12/2015	0.015	0.019	770	0.47	0.85	0.047	5.9	7.9
22/12/2015	0.022	0.023	9800	0.88	1.7	0.12	25	7.7
12/01/2016	0.014	0.021	160	0.42	0.75	0.063	4	7.9
28/01/2016	0.017	0.038	290	0.48	1	0.071	5	7.8
17/02/2016	0.024	0.032	510	0.3	0.6	0.063	2.9	7.8
8/03/2016	0.015	0.028	200	0.31	0.66	0.056	3.5	7.7
23/03/2016	0.019	0.042	1000	0.34	0.76	0.073	3.5	7.8
7/04/2016	0.018	0.026	410	0.35	0.6	0.048	2.7	7.6
20/04/2016	0.017	0.023	100	0.38	0.66	0.04	2.2	7.7
4/05/2016	0.014	0.018	64	0.62	0.97	0.044	2.8	7.6
17/05/2016	0.026	0.029	2100	1.2	2	0.15	29	7.5
31/05/2016	0.017	0.019	820	2.1	2.4	0.056	12	7.4
15/06/2016	0.006	0.018	84	1.5	1.7	0.04	2.9	7.6
30/06/2016	0.007	0.016	120	1.6	1.8	0.032	3.6	7.6
13/07/2016	0.005	0.015	58	1.5	1.7	0.028	3.6	7.5
27/07/2016	0.012	0.018	100	2.8	3.2	0.042	7.9	7.3
9/08/2016	0.008	0.017	49	2.7	2.6	0.033	5	7.3
22/08/2016	<0.005000	0.018	62	1.8	2	0.032	4.3	7.5
6/09/2016	0.007	0.011	42	1.2	1.4	0.031	3.8	7.5
21/09/2016	0.011	0.01	84	1.1	1.3	0.029	2.9	8
4/10/2016	0.015	0.013	170	0.74	1	0.038	5.7	7.8
18/10/2016	0.019	0.015	170	0.69	1.1	0.049	5.9	7.7
3/11/2016	0.018	0.025	410	0.92	1.3	0.07	8.4	7.6

Water Quality Results continued

Kuriwao Stream Old Coach Rd								
	Ammoniacal	Dissolved	E-Coli MPN	Nitrite/Nitrate	Total	Total	Turbidity	pH
	(g/m³-N)	(g/m³-P)	(cfu/100mL)	(g/m³-N)	(g/m³)	(g/m³-P)	(NTU)	
12/11/2015	0.016	0.02	810	0.95	1.4	0.055	7.5	7.9
25/11/2015	0.025	0.022	290	0.81	1.1	0.053	4.9	8.1
9/12/2015	0.012	0.022	940	0.59	0.94	0.065	6.5	8.3
22/12/2015	0.031	0.03	####	0.78	1.6	0.15	26	7.8
12/01/2016	0.013	0.031	1100	0.56	1	0.091	15	8.1
28/01/2016	0.018	0.048	1200	0.6	0.95	0.094	7.6	7.8
17/02/2016	0.035	0.057	940	0.59	0.99	0.096	5.3	8
8/03/2016	0.012	0.025	5600	0.86	1.1	0.044	3.6	7.8
23/03/2016	0.025	0.047	410	0.61	0.97	0.091	5.2	7.9
7/04/2016	0.017	0.033	160	0.58	0.81	0.059	4.6	7.7
20/04/2016	0.016	0.027	260	0.61	0.9	0.06	4.2	7.8
4/05/2016	0.018	0.024	340	0.82	1.1	0.048	3.9	7.7
17/05/2016	0.042	0.03	84	1.3	2.1	0.14	27	7.6
31/05/2016	0.036	0.02	1300	2.2	2.5	0.068	19	7.5
15/06/2016	0.006	0.021	94	1.6	1.8	0.036	3.7	7.8
30/06/2016	0.008	0.018	290	1.7	1.9	0.037	4.1	7.7
13/07/2016	0.005	0.019	370	1.6	1.8	0.029	3.5	7.7
27/07/2016	0.016	0.018	28	2.8	2.9	0.042	3.9	7.3
9/08/2016	0.016	0.018	75	2.8	2.9	0.037	5.1	7.4
22/08/2016	<0.005000	0.018	92	1.9	2	0.033	14	7.4
6/09/2016	0.005	0.014	130	1.3	1.6	0.036	4.2	7.7
21/09/2016	0.036	0.015	54	1.3	1.5	0.034	3.2	8.3
4/10/2016	0.017	0.022	56	0.87	1.2	0.049	5.1	8.2
18/10/2016	0.022	0.021	250	0.75	1.1	0.063	7.6	7.8
3/11/2016	0.018	0.017	290	0.96	1.3	0.058	6	7.8
Kuriwao Stream u/s Kuriwao Siding Rd								
	Ammoniacal	Dissolved	E-Coli MPN	Nitrite/Nitrate	Total	Total	Turbidity	pH
	(g/m³-N)	(g/m³-P)	(cfu/100mL)	(g/m³-N)	(g/m³)	(g/m³-P)	(NTU)	
12/11/2015	0.028	0.036	810	0.71	1.2	0.069	6.7	7.8
25/11/2015	0.035	0.043	210	0.39	0.81	0.084	4.9	7.9
9/12/2015	0.083	0.057	480	0.48	0.95	0.091	6.5	8
22/12/2015	0.057	0.056	9600	0.6	1.5	0.16	32	7.5
12/01/2016	0.024	0.046	280	0.25	1.4	0.091	3.5	7.7
28/01/2016	0.032	0.092	640	0.41	0.84	0.13	5.9	7.7
17/02/2016	0.028	0.074	270	0.14	0.62	0.11	3.5	7.7
8/03/2016	0.02	0.09	450	0.17	0.61	0.12	3.6	7.8
23/03/2016	0.02	0.099	740	0.23	0.71	0.13	3.5	7.7
7/04/2016	0.018	0.073	100	0.12	0.44	0.091	2.5	7.6
20/04/2016	0.021	0.07	210	0.26	0.59	0.1	2.1	7.7
4/05/2016	0.043	0.15	76	0.53	0.93	0.18	3.3	7.6
17/05/2016	0.11	0.07	1400	1.1	1.9	0.17	18	7.5
31/05/2016	0.06	0.035	200	2.2	2.5	0.067	6.8	7.4
15/06/2016	0.027	0.036	150	1.4	1.7	0.057	3.1	7.6
30/06/2016	0.021	0.029	84	1.5	1.8	0.05	3.8	7.6
13/07/2016	0.023	0.027	62	1.4	1.6	0.04	3.5	7.5
27/07/2016	0.036	0.025	86	2.7	3.1	0.051	7.6	7.2
9/08/2016	0.035	0.023	100	2.5	2.5	0.046	5.7	7.2
22/08/2016	0.012	0.022	58	1.5	1.7	0.044	4.2	7.6
6/09/2016	0.039	0.025	140	1.1	1.5	0.05	4.3	8.2
21/09/2016	0.015	0.02	160	0.92	1.2	0.045	3.5	7.9
4/10/2016	0.022	0.027	700	0.61	0.93	0.058	3.9	7.8
18/10/2016	0.024	0.03	660	0.51	0.9	0.066	4.4	7.6
3/11/2016	0.023	0.038	850	0.93	1.3	0.066	4.2	7.7

Water Quality Results continued

Awakia Stream at Hillfoot Road								
	Ammoniacal	Dissolved	E-Coli MPN	Nitrite/Nitrate	Total	Total	Turbidity	pH
	(g/m³-N)	(g/m³-P)	(cfu/100mL)	(g/m³-N)	(g/m³)	(g/m³-P)	(NTU)	
12/11/2015	0.018	0.021	550	0.18	0.41	0.043	7.1	7.6
25/11/2015	0.21	0.04	850	0.12	0.5	0.072	4.8	7.5
9/12/2015	<0.005000	0.015	330	0.11	0.41	0.043	7.6	7.7
22/12/2015	0.014	0.016	4900	0.44	1.1	0.081	22	7.5
12/01/2016	0.009	0.018	88	0.11	0.23	0.043	4.5	7.6
28/01/2016	0.022	0.025	670	0.12	0.35	0.05	6.4	7.6
17/02/2016	0.021	0.031	700	0.1	0.31	0.053	5.5	7.5
8/03/2016	0.39	0.074	#####	0.15	0.74	0.11	5.5	7.5
23/03/2016	0.019	0.031	720	0.1	0.39	0.049	5.2	7.5
7/04/2016	0.02	0.03	560	0.071	0.23	0.047	3.7	7.5
20/04/2016	0.13	0.04	1300	0.097	0.39	0.057	3.2	7.5
4/05/2016	0.016	0.022	50	0.097	0.3	0.036	3.6	7.5
17/05/2016	0.015	0.018	770	0.47	0.94	0.066	13	7.4
31/05/2016	0.064	0.019	1000	1.3	1.6	0.058	15	7.3
15/06/2016	0.028	0.019	440	0.005	0.73	0.036	3.5	7.4
30/06/2016	0.013	0.017	140	0.68	0.89	0.032	4.9	7.4
13/07/2016	0.016	0.019	290	0.6	0.73	0.031	3.8	7.4
27/07/2016	0.052	0.019	150	1.5	1.9	0.045	6.6	7.2
9/08/2016	0.007	0.015	48	1.2	1.3	0.031	5.5	7.2
22/08/2016	0.011	0.018	100	0.56	0.88	0.038	5.7	7.3
6/09/2016	0.02	0.019	1500	0.38	0.77	0.041	6.2	7.3
21/09/2016	0.14	0.035	7100	0.38	0.7	0.064	6.3	7.5
4/10/2016	0.051	0.041	280	0.23	0.57	0.049	6.8	7.5
18/10/2016	0.092	0.028	180	0.36	0.65	0.06	7.7	7.6
3/11/2016	0.029	0.021	150	0.48	0.72	0.048	7.8	7.5
Waiwera trib d/s quarry								
	Ammoniacal	Dissolved	E-Coli MPN	Nitrite/Nitrate	Total	Total	Turbidity	pH
	(g/m³-N)	(g/m³-P)	(cfu/100mL)	(g/m³-N)	(g/m³)	(g/m³-P)	(NTU)	
12/11/2015	0.056	0.053	1600	0.35	1.1	0.11	15	7.6
25/11/2015	0.062	0.05	3400	0.12	0.99	0.13	25	7.5
9/12/2015	0.041	0.063	1300	0.012	0.55	0.11	12	7.8
22/12/2015	0.11	0.061	1100	0.014	0.79	0.1	8.9	7.4
12/01/2016								
28/01/2016	0.039	0.11	1600	0.005	0.78	0.17	7.8	7.4
17/02/2016								
8/03/2016								
23/03/2016								
7/04/2016	0.039	0.03	16	0.007	0.72	0.046	1.8	7.1
20/04/2016	0.053	0.029	33	0.006	0.64	0.052	2	7.3
4/05/2016	0.042	0.033	21	0.02	0.69	0.05	2.2	7.3
17/05/2016	0.076	0.09	780	0.94	2.1	0.2	24	7.3
31/05/2016	0.066	0.035	140	4.7	5.4	0.073	7.2	7
15/06/2016	0.052	0.035	9.8	1.6	2.1	0.064	5.4	7.3
30/06/2016	0.032	0.029	39	2	2.5	0.059	5.3	7.3
13/07/2016	0.069	0.032	300	1.5	2	0.055	7.2	7.3
27/07/2016	0.068	0.025	110	4.4	5.1	0.074	13	6.9
9/08/2016	0.048	0.051	52	3.1	3.6	0.059	12	7
22/08/2016	0.046	0.046	42	1.9	2.3	0.096	6.9	7.3
6/09/2016	0.032	0.038	160	1.3	1.7	0.077	9	7.5
21/09/2016	0.02	0.027	220	0.75	1.4	0.069	7	7.8
4/10/2016	0.051	0.038	680	0.35	1	0.1	8.4	7.5
18/10/2016	0.087	0.036	1300	0.57	1.2	0.095	9.6	7.4
3/11/2016	0.047	0.045	1200	0.2	0.88	0.083	6.9	7.5

Water Quality Results continued

Waiwera at Maw's Farm								
	Ammoniacal (g/m³-N)	Dissolved (g/m³-P)	E-Coli MPN (cfu/100mL)	Nitrite/Nitrate (g/m³-N)	Total (g/m³)	Total (g/m³-P)	Turbidity (NTU)	pH
12/11/2015	0.029	0.024	74	0.75	1.1	0.058	3.4	8.1
10/12/2015	0.018	0.028	150	0.49	0.81	0.056	5.3	7.9
12/01/2016	0.022	0.025	100	0.2	0.63	0.059	2.8	8.2
10/02/2016	0.016	0.034	270	0.098	0.44	0.054	3.2	8.2
8/03/2016	0.011	0.044	410	0.06	0.42	0.08	2.2	8.3
13/04/2016	0.007	0.028	800	0.07	0.39	0.051	2.7	8.1
12/05/2016	0.009	0.024	76	0.42	0.73	0.037	2.1	8.8
17/06/2016	0.007	0.015	58	1.3	1.5	0.025	1.5	7.8
12/07/2016	0.005	0.011	13	1.3	1.5	0.02	1.4	8.1
10/08/2016	0.009	0.016	40	2.2	2.5	0.032	4.1	7.5
13/09/2016	0.007	0.009	150	1.3	1.6	0.022	3	8.1
11/10/2016	0.036	0.016	130	0.58	0.95	0.046	2.4	7.8
9/11/2016	0.01	0.014	280	0.5	0.87	0.045	2.3	7.8

8.1.2 Periphyton results: Abundance codes are based on Biggs & Kilroy (2000): 1 = rare, 2 = rare-occasional, 3 = occasional, 4 = occasional-common, 5 = common, 6 = common-abundant, 7 = abundant, 8 = dominant

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Green filamentous										
Cladophora		4			3					
Microspora	7	6	4			2	2	3		
Oedogonium								2		
Rhizoclonium								2		
Stigeoclonium										3
Ulothrix					3		1			
Yellow green filamentous										
Tribonema										3
Green, non-filamentous										
Ankistrodesmus				1						
Closterium		1								
Scenedesmus				3						2
Diatoms										
Achnanthes									3	
Achnanthidium		5								3
Cocconeis	3	3	2	3			2		2	2
Cymbella		2	3						2	
Encyonema minutum				3						
Frustulia			3		3	3		2	3	3
Gomphoneis	4	3	4	4	5	3		3	6	2
Gomphonema	2	5	2	4		3	2	1		
Melosira	5	5	5	8	4	4	3	2	4	4
Naviculoid diatom	2		4	6	3	2		3	2	4
Nitzschia				4	2	1	1			3
Rhoicosphenia		3		4						
Synedra						1	1		3	3
Tabellaria spp.			2							
Cyanobacteria										
Oscillatoria	2									
Phormidium								1		

8.1.3 Macroinvertebrate results

TAXON	MCI score	Awakia Stream at Hillfoot Road	Kuriwao Stream at Hillfoot Road	Kuriwao Stream at Old Coach Road	Kuriwao Stream upstream of Kuriwao Siding Road	Tributary at Quarry Road	Waiwera River at Kuriwao Siding Road	Waiwera River at Maws Farm
ACARINA	5							
ARACHNIDA								
Dolomedes species	5							
CNIDARIA								
Hydra species	3					R		
COLEOPTERA								
Elmidae	6							
Hydraenidae	8	C		R		R		
Hydrophilidae	5							
Scirtidae	8							
COLLEMBOLA	6	C				C		R
CRUSTACEA								
Cladocera	5					VVA		
Copepoda	5					R		
Ostracoda	3	R	R		C	VA	C	A
Paracalliope fluviatilis	5	A			A	VA		R
Paraleptamphopus species	5	R			C	R		C
Paranephrops zealandicus	5	R						
Talitridae	5							
DIPTERA								
Aphrophila species	5	A	A	A	A		A	C
Austrosimulium species	3	A	R	C	C		C	R
Chironomus species	1			R		R		
Corynoneura scutellata	2					C		
Empididae	3							
Ephydridae	4							
Hexatomini	5							
Maoridiamesa species	3	VA	A	A	C		VA	A
Muscidae	3	R						
Orthocladiinae	2	VVA	C	A	C	C	A	VA
Paradixa species	4					C		
Polypedilum species	3	A						
Psychodidae	1							
Sciomyzidae	3							
Tanypodinae	5	R						
Tanytarsini	3				C		VA	VA
EPHEMEROPTERA								
Coloburiscus humeralis	9	C						
Deleatidium species	8	VA	wa	VA	VA		A	C
HEMIPTERA								
Microvelia macgregori	5					C		
Sigara species	5					A		
HIRUDINEA	3					R		
MEGALOPTERA								
Archichauliodes diversus	7	C	A	C	C		C	
MOLLUSCA								
Gyraulus species	3					R	R	R
Physa / Physella species	3			R	A	VVA	A	A
Potamopyrgus antipodarum	4	VVA	VA	VA	VA	VVA	VVA	VA
Sphaeriidae	3	A		C	A	A	A	C
NEMATODA	3	C						R
NEMERTEA	3						R	R
ODONATA								
Austrolestes colensonis	6					A		
Xanthocnemis zealandica	5					VVA		
OLIGOCHAETA	1	A	R	C	C	A	VA	A
PLATYHELMINTHES	3	A		R	C	A	A	A
PLECOPTERA								
Austroperla cyrene	9	C						
Megaleptoperla species	9	C						
Taraperla species	7							
Zelandoperla species	10			R			R	
TRICHOPTERA								
Aoteapsyche species	4	VVA	VVA	VA	VA		A	VVA
Beraeoptera roria	8				A			
Costachorema species	7		C				R	R
Helicopsyche species	10	VA	C		C			C
Hudsonema alienum	6	R				C		
Hudsonema amabile	6		A	R	VA			
Hydrobiosis species	5	A	C	C	C		A	C
Neurochorema species	6		R				C	A
Olinga species	9	A	VA	C	A			
Oxyethira albiceps	2	R		R	C	R	VA	A
Psilochorema species	8	C	R		R		R	R
Pycnocentria species	7	A	VA	A	VA		A	R
Pycnocentrodes species	5	C	VA	VA	VA		VA	A
Triplectides species	5					C		
Zelolessica species	10	C						
Number of taxa		33	19	21	25	26	24	27
Number of EPT taxa		14	11	9	11	3	10	10
% EPT taxa		42	58	43	44	12	42	37
MCI score		108	108	94	98	79	90	89
SQMCI score		4.1	6.0	5.1	5.5	4.2	3.6	3.6

Macroinvertebrate results continued

TAXON	MCI score	Waiwera River at Owaka Valley Road	Waiwera River downstream of Robertson Road Bridge	Waiwera River at Waiwera Gorge Road	Waiwera River near Clifton	Waiwera River at Hillfoot Road	Waiwera River at SH1 bridge	Waiwera River tributary at Blaikie Road
ACARINA	5		C	R				A
ARACHNIDA								
Dolomedes species	5							R
CNIDARIA								
Hydra species	3	C		C				
COLEOPTERA								
Elmidae	6	C						
Hydraenidae	8							
Hydrophilidae	5					C		
Scirtidae	8							R
COLLEMBOLA	6			R				A
CRUSTACEA								
Cladocera	5							
Copepoda	5							
Ostracoda	3	A	R			A	R	A
Paracalliope fluviatilis	5	A	VA					VA
Paraleptamphopus species	5				C			VA
Paranephrops zealandicus	5					R		
Talitridae	5							C
DIPTERA								
Aphrophila species	5	A	A		A	C	A	C
Austrosimulium species	3	C	A	A	R	A	R	R
Chironomus species	1		A					
Corynoneura scutellata	2			R				A
Empididae	3		R					
Ephydridae	4			R				R
Hexatomini	5							R
Maoridiamesa species	3	VVA	VVA	VA	VA	VVA	A	
Muscidae	3					R		
Orthocladiinae	2	VA	VVA	VA	A	VA	A	A
Paradixa species	4							A
Polypedilum species	3	C	VA		C		R	
Psychodidae	1				R			A
Sciomyzidae	3							R
Tanypodinae	5							R
Tanytarsini	3	C	VVA	C	VA	C	VA	
EPHEMEROPTERA								
Coloburiscus humeralis	9							
Deleatidium species	8	VA	A	R	C		C	
HEMIPTERA								
Microvelia macgregori	5							A
Sigara species	5							
HIRUDINEA	3							
MEGALOPTERA								
Archichauliodes diversus	7		C	R	C	R	C	
MOLLUSCA								
Gyraulus species	3	R						
Physa / Physella species	3	R	C	R	C		A	VA
Potamopyrgus antipodarum	4	VVA	VA	VVA	VA	VVA	VVA	VVA
Sphaeriidae	3	C	VA	R	A		VA	VVA
NEMATODA	3		R	C				
NEMERTEA	3	C	C					
ODONATA								
Austrolestes colensonis	6							
Xanthocnemis zealandica	5							A
OLIGOCHAETA	1	VA	VVA	VVA	A	A	A	C
PLATYHELMINTHES	3	A	C	C	R		A	A
PLECOPTERA								
Austroperla cyrene	9			R				
Megaleptoperla species	9			R				
Taraperla species	7	R						
Zelandoperla species	10			C		R		
TRICHOPTERA								
Aoteapsyche species	4	VA	A		VVA		VA	
Beraeoptera roria	8							
Costachorema species	7		A	R	R		R	
Helicopsyche species	10	R	R					
Hudsonema alienum	6							R
Hudsonema amabile	6	VA					C	
Hydrobiosis species	5	VA	C	R	A	R	c	
Neurochorema species	6		A	A	R			
Olinga species	9	R						
Oxyethira albiceps	2	A	VA	VVA	A	VVA	A	R
Psilochorema species	8	C	R					
Pycnocentria species	7	C	C		R		A	
Pycnocentrodes species	5	R	A		C		VA	
Triplectides species	5							
Zelolessica species	10							
Number of taxa		28	29	24	22	15	21	27
Number of EPT taxa		11	10	8	8	3	8	2
% EPT taxa		39	34	33	36	20	38	7
MCI score		91	86	93	82	81	83	80
SQMCI score		3.8	2.7	2.5	3.7	2.9	3.8	3.7

8.1.4 Habitat assessment data

Bank vegetation	*The maturity, diversity and naturalness of bank vegetation.*									
Left bank AND Right bank	*Mature native trees with diverse and intact understorey*		*Regenerating native or flaxes/sedges/tussock > dense exotic*			*Mature shrubs, sparse tree cover > young exotic, long grass*			*Heavily grazed or mown grass > bare/impervious ground.*	
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Riparian width	*The width (m) of the riparian buffer constrained by vegetation, fence or other structure(s).*									
Left bank	*≥ 30*	*15*	*10*	*7*	*5*	*4*	*3*	*2*	*1*	*0*
Right bank	*≥ 30*	*15*	*10*	*7*	*5*	*4*	*3*	*2*	*1*	*0*
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Riparian shade	*The percentage of shading of the stream bed throughout the day due to vegetation, banks or other structure(s).*									
	≥ 90	*80*	*70*	*60*	*50*	*40*	*25*	*15*	*10*	*≤ 5*
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
TOTAL								(Sum of parameters 1-10)		
Deposited sediment	*The percentage of the stream bed covered by fine sediment.*									
	0	*5*	*10*	*15*	*20*	*30*	*40*	*50*	*60*	*≥ 75*
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Invertebrate habitat diversity	*The number of different substrate types such as boulders, cobbles, gravel, sand, wood, leaves, root mats, macrophytes, periphyton. Presence of interstitial space score higher.*									
	≥ 5	*5*	*5*	*4*	*4*	*3*	*3*	*2*	*2*	*1*
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Invertebrate habitat abundance	*The percentage of substrate favourable for EPT colonisation, for example flowing water over gravel-cobbles clear of filamentous algae/macrophytes.*									
	95	*75*	*70*	*60*	*50*	*40*	*30*	*25*	*15*	*5*
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Fish cover diversity	*The number of different substrate types such as woody debris, root mats, undercut banks, overhanging/encroaching vegetation, macrophytes, boulders, cobbles. Presence of substrates providing spatial complexity score higher.*									
	≥ 5	*5*	*5*	*4*	*4*	*3*	*3*	*2*	*2*	*1*
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Fish cover abundance	*The percentage of fish cover available.*									
	95	*75*	*60*	*50*	*40*	*30*	*20*	*10*	*5*	*0*
Deposited sediment	*The percentage of the stream bed covered by fine sediment.*									
	0	*5*	*10*	*15*	*20*	*30*	*40*	*50*	*60*	*≥ 75*
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Hydraulic heterogeneity	*The number of of hydraulic components such as pool, riffle, fast run, slow run, rapid, cascade/waterfall, turbulance, backwater. Presence of deep pools score higher.*									
	≥ 5	*5*	*4*	*4*	*3*	*3*	*2*	*2*	*2*	*1*
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Bank erosion	*The percentage of the stream bank recently/actively eroding due to scouring at the water line, slumping of the bank or stock pugging.*									
Left bank	*0*	*≤ 5*	*5*	*15*	*25*	*35*	*50*	*65*	*75*	*> 75*
Right bank	*0*	*≤ 5*	*5*	*15*	*25*	*35*	*50*	*65*	*75*	*> 75*
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**

8.1.5 Periphyton data

Site:	Awakia Stream at Hillfoot Road	Periphyton Score	Transect 1					Transect 2					Transect 3					Transect 4				
Date:	9/03/2017		A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Thin mat/film	Green	7																				
	Light brown	10																				
	Black/dark brown	10	20	50	30	10																
Medium mat	Green	5																				
	Light brown	7																				
	Black/dark brown	9					15					15										
Thick mat	Green/light brown	4																				
	Black/dark brown	7																				
Short filamentous	Green	5		5	10	5		2					2			2		5			2	2
	Brown/reddish	5	5	5																		
Long filamentous	Green	1																				
	Brown/reddish	4		10																		
Notes:																						
A: Total % of stone surface covered by all types of periphyton			25	70	40	15	15	2	0	0	0	15	2	0	0	2	0	5	0	0	2	2
B: Periphyton Score x % Cover (sum for each stone)			225	590	350	125	135	10	0	0	0	135	10	0	0	10	0	25	0	0	10	10
C: Average Periphyton Score per stone (= B / A)			9	8.4	8.8	8.3	9	5	0	0	0	9	5	0	0	5	0	5	0	0	5	5
Overall average periphyton score		4.1																				

Site:	Kuriwao Stream at Hillfoot Road	Periphyton Score	Transect 1					Transect 2					Transect 3					Transect 4				
Date:	9/03/2017		A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Thin mat/film	Green	7																				
	Light brown	10																				
	Black/dark brown	10								20								5				
Medium mat	Green	5																				
	Light brown	7	10																			
	Black/dark brown	9																				
Thick mat	Green/light brown	4																				
	Black/dark brown	7																				
Short filamentous	Green	5																				
	Brown/reddish	5							5				20									
Long filamentous	Green	1						10														
	Brown/reddish	4											2									
Notes:																						
A: Total % of stone surface covered by all types of periphyton			10	0	0	0	0	10	5	20	0	0	22	0	0	0	0	5	0	0	0	0
B: Periphyton Score x % Cover (sum for each stone)			70	0	0	0	0	10	25	200	0	0	108	0	0	0	0	50	0	0	0	0
C: Average Periphyton Score per stone (= B / A)			7	0	0	0	0	1	5	10	0	0	4.9	0	0	0	0	10	0	0	0	0
Overall average periphyton score		1.9																				

Site:	Kuriwao Stream at Old Coach Road	Periphyton Score	Transect 1					Transect 2					Transect 3					Transect 4				
Date:	9/03/2017		A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Thin mat/film	Green	7																				
	Light brown	10																				
	Black/dark brown	10		10	30	40	10		10	20	20			15	5	20	10	10		10		10
Medium mat	Green	5																				
	Light brown	7																				
	Black/dark brown	9																				
Thick mat	Green/light brown	4																				
	Black/dark brown	7									10											
Short filamentous	Green	5	2																			
	Brown/reddish	5		10	10	5	10	15	2		2	10	2	5	5	20	5	2	2		2	2
Long filamentous	Green	1																				
	Brown/reddish	4		5				5	2								2					
Notes:																						
A: Total % of stone surface covered by all types of periphyton			2	25	40	45	20	20	14	20	32	10	2	20	10	40	17	12	2	10	2	12
B: Periphyton Score x % Cover (sum for each stone)			10	170	350	425	150	95	118	200	280	50	10	175	75	300	133	110	10	100	10	110
C: Average Periphyton Score per stone (= B / A)			5	6.8	8.8	9.4	7.5	4.8	8.4	10	8.8	5	5	8.8	7.5	7.5	7.8	9.2	5	10	5	9.2
Overall average periphyton score		7.5																				

Periphyton data continued

	Site:	Kuriwao Stream upstream of Kuriwao Siding R	Periphyton Score	Transect 1					Transect 2					Transect 3					Transect 4				
	Date:	9/03/2017		A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Thin mat/film		Green	7																				
		Light brown	10																				
		Black/dark brown	10	20																	5		
Medium mat		Green	5																				
		Light brown	7																				
		Black/dark brown	9	10		5	15	5						5	5	5		10					
Thick mat		Green/light brown	4																				
		Black/dark brown	7		10	10	5		15	5	10	10			2	10	20	10	5	5	2		
Short filamentous		Green	5		2			2						2	2	2							
		Brown/reddish	5																				
Long filamentous		Green	1			10	2	5	15	5	2	2	15	2		15	15			2	2		
		Brown/reddish	4																				
Notes:																							
A: Total % of stone surface covered by all types of periphyton				30	12	25	22	12	30	10	12	12	15	9	9	32	35	20	5	7	9	0	0
B: Periphyton Score x % Cover (sum for each stone)				290	80	125	172	60	120	40	72	72	15	57	69	140	155	160	35	37	66	0	0
C: Average Periphyton Score per stone (= B / A)				9.7	6.7	5	7.8	5	4	4	6	6	1	6.3	7.7	4.4	4.4	8	7	5.3	7.3	0	0
Overall average periphyton score			5.3																				

	Site:	Waiwera River at Kuriwao Siding Road	Periphyton Score	Transect 1					Transect 2					Transect 3					Transect 4				
	Date:	7/03/2017		A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Thin mat/film		Green	7																				
		Light brown	10											5									
		Black/dark brown	10	95	85	90	80	95	90	95	90	80	90	20	30	80	80	90	90	40	80	40	50
Medium mat		Green	5																				
		Light brown	7				5							15									
		Black/dark brown	9											30	15							50	40
Thick mat		Green/light brown	4																				
		Black/dark brown	7																				
Short filamentous		Green	5		2				5					5	5			2			2		5
		Brown/reddish	5																				
Long filamentous		Green	1						2					2		2							
		Brown/reddish	4																				
Notes:																							
A: Total % of stone surface covered by all types of periphyton				95	87	90	85	95	97	95	90	80	90	77	50	82	80	92	90	40	82	90	95
B: Periphyton Score x % Cover (sum for each stone)				950	860	900	835	950	927	950	900	800	900	652	460	802	800	910	900	400	810	850	885
C: Average Periphyton Score per stone (= B / A)				10	9.9	10	9.8	10	9.6	10	10	10	10	8.5	9.2	9.8	10	9.9	10	10	9.9	9.4	9.3
Overall average periphyton score			9.8																				

	Site:	Waiwera River at Maws Farm	Periphyton Score	Transect 1					Transect 2					Transect 3					Transect 4				
	Date:	8/03/2017		A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Thin mat/film		Green	7																				
		Light brown	10																				
		Black/dark brown	10																		10		
Medium mat		Green	5																				
		Light brown	7																				
		Black/dark brown	9			2	2																
Thick mat		Green/light brown	4																				
		Black/dark brown	7																				
Short filamentous		Green	5																				
		Brown/reddish	5	80	60	90	90	80	15	15	80	10	50	60	10	20	50		75	75	50	30	70
Long filamentous		Green	1																		5		
		Brown/reddish	4	20	30	5	5	5	85	85	20	60	20	30	50	70	40	90	20	15	20	20	15
Notes:																							
A: Total % of stone surface covered by all types of periphyton				100	90	97	97	85	100	100	100	70	70	90	60	90	90	90	95	90	85	50	85
B: Periphyton Score x % Cover (sum for each stone)				480	420	488	488	420	415	415	480	290	330	420	250	380	410	360	455	435	435	230	410
C: Average Periphyton Score per stone (= B / A)				4.8	4.7	5	5	4.9	4.2	4.2	4.8	4.1	4.7	4.7	4.2	4.2	4.6	4	4.8	4.8	5.1	4.6	4.8
Overall average periphyton score			4.6																				

Periphyton data continued

Site:	Waiwera River at Owaka Valley Road	Periphyton Score	Transect 1					Transect 2					Transect 3					Transect 4				
Date:	7/03/2017		A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Thin mat/film	Green	7																				
	Light brown	10																				
	Black/dark brown	10	50	20	10	30	10		20	20		20	20		15	10	10	5	5	10	10	5
Medium mat	Green	5																				
	Light brown	7		15	10		10	40	10	10		15	10	10		10	10		10	5	5	10
	Black/dark brown	9					10									10	5					
Thick mat	Green/light brown	4																				
	Black/dark brown	7																				
Short filamentous	Green	5						20	10	10			10		5			50	15	10	10	10
	Brown/reddish	5				10			15	10	15	10	30	25		10	15			15	10	15
Long filamentous	Green	1	15	25	50	50	20	15	30	30	70	40	20	40	60	30	50	20	25	60	50	60
	Brown/reddish	4																				
Notes:																						
A: Total % of stone surface covered by all types of periphyton			65	60	70	90	50	75	85	80	85	85	90	75	80	70	90	75	55	100	85	100
B: Periphyton Score x % Cover (sum for each stone)			515	330	220	400	280	395	425	400	145	395	490	235	235	340	340	320	220	320	285	305
C: Average Periphyton Score per stone (= B / A)			7.9	5.5	3.1	4.4	5.6	5.3	5	5	1.7	4.6	5.4	3.1	2.9	4.9	3.8	4.3	4	3.2	3.4	3.1
Overall average periphyton score		4.3																				

Site:	Waiwera River downstream of Robertson Ro	Periphyton Score	Transect 1					Transect 2					Transect 3					Transect 4				
Date:	7/03/2017		A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Thin mat/film	Green	7																				
	Light brown	10																				
	Black/dark brown	10	50	50	60	50	70	30	20	20	70	60	30	30	20			50	50	60	70	70
Medium mat	Green	5																				
	Light brown	7											10		10			10				5
	Black/dark brown	9																				
Thick mat	Green/light brown	4																				
	Black/dark brown	7																				
Short filamentous	Green	5	15	10	20	5		5	30	5			10					15	20	20	5	5
	Brown/reddish	5																				
Long filamentous	Green	1	10	35	10	20	30	40	20	40	15	20	30	50	40	90	100	15	30	5	15	5
	Brown/reddish	4																				
Notes:																						
A: Total % of stone surface covered by all types of periphyton			75	95	90	75	100	75	70	65	85	80	80	80	70	90	100	90	100	85	90	85
B: Periphyton Score x % Cover (sum for each stone)			585	585	710	545	730	365	370	265	715	620	450	350	310	90	100	660	630	705	740	765
C: Average Periphyton Score per stone (= B / A)			7.8	6.2	7.9	7.3	7.3	4.9	5.3	4.1	8.4	7.8	5.6	4.4	4.4	1	1	7.3	6.3	8.3	8.2	9
Overall average periphyton score		6.1																				

Site:	Waiwera River at Waiwera Gorge Road	Periphyton Score	Transect 1					Transect 2					Transect 3					Transect 4				
Date:	7/03/2017		A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Thin mat/film	Green	7																				
	Light brown	10				40	15		10													
	Black/dark brown	10																				
Medium mat	Green	5																				
	Light brown	7																				
	Black/dark brown	9				10	15			5												
Thick mat	Green/light brown	4																				
	Black/dark brown	7																				
Short filamentous	Green	5			5			15	15	5	5	2				5						
	Brown/reddish	5	60	90	55	40	50	50	60	70	80	60		80	80	65	60		75	90	50	30
Long filamentous	Green	1			5	2	10	10	10	15				5	10	5						
	Brown/reddish	4	10	5	15		10				10	10	100	15			20	100	15	10	10	40
Notes:																						
A: Total % of stone surface covered by all types of periphyton			70	95	80	92	100	75	95	95	95	72	100	100	90	75	80	100	90	100	60	70
B: Periphyton Score x % Cover (sum for each stone)			340	470	365	692	585	335	485	435	465	350	400	465	410	355	380	400	435	490	290	310
C: Average Periphyton Score per stone (= B / A)			4.9	4.9	4.6	7.5	5.9	4.5	5.1	4.6	4.9	4.9	4	4.7	4.6	4.7	4.8	4	4.8	4.9	4.8	4.4
Overall average periphyton score		4.9																				

Periphyton data continued

Site:	Waiwera River near Clifton	Periphyton Score	Transect 1					Transect 2					Transect 3					Transect 4				
Date:	8/03/2017		A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Thin mat/film	Green	7																				
	Light brown	10																				
	Black/dark brown	10	25	40	40	15	50	30	30	20	30	20	70	80	70	50	70	60	90	50	40	30
Medium mat	Green	5																				
	Light brown	7				5	5		10	15	5	5					5				5	
	Black/dark brown	9																				
Thick mat	Green/light brown	4																				
	Black/dark brown	7		2	2																	
Short filamentous	Green	5					2	2		2		2			2		2					
	Brown/reddish	5	40	20	40	30	20	10	15	20	5	20		5	5	20	5	20	5		5	
Long filamentous	Green	1				5		2														
	Brown/reddish	4			2	5				5	5											
Notes:																						
A: Total % of stone surface covered by all types of periphyton			65	62	84	60	77	44	55	62	45	47	70	85	77	70	82	80	95	50	50	30
B: Periphyton Score x % Cover (sum for each stone)			450	514	622	360	645	362	445	435	380	345	700	825	735	600	770	700	925	500	460	300
C: Average Periphyton Score per stone (= B / A)			6.9	8.3	7.4	6	8.4	8.2	8.1	7	8.4	7.3	10	9.7	9.5	8.6	9.4	8.8	9.7	10	9.2	10
Overall average periphyton score		8.6																				

Site:	Waiwera River at Hillfoot Road	Periphyton Score	Transect 1					Transect 2					Transect 3					Transect 4				
Date:	7/03/2017		A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Thin mat/film	Green	7																				
	Light brown	10	70	40		50	10	10		10	10	75	50	30	40	20	20	95	70	15	20	10
	Black/dark brown	10																				
Medium mat	Green	5																				
	Light brown	7	5			5	10		30	30	15		10		15					10		5
	Black/dark brown	9								15										5		
Thick mat	Green/light brown	4																				
	Black/dark brown	7																				
Short filamentous	Green	5	15	30	30	15	20	30	30	25	40	10	30	20	30	20	15	5	15	20	20	25
	Brown/reddish	5			30	20	50	15	15	10	20	10		10	10	30	20			20	10	15
Long filamentous	Green	1	5	10	5			5			5	5	5									5
	Brown/reddish	4				5	10										5		2			
Notes:																						
A: Total % of stone surface covered by all types of periphyton			95	80	65	95	100	60	75	90	90	100	95	60	95	70	60	100	87	70	50	60
B: Periphyton Score x % Cover (sum for each stone)			815	560	305	730	560	330	435	620	510	855	725	450	705	450	395	975	783	465	350	340
C: Average Periphyton Score per stone (= B / A)			8.6	7	4.7	7.7	5.6	5.5	5.8	6.9	5.7	8.6	7.6	7.5	7.4	6.4	6.6	9.8	9	6.6	7	5.7
Overall average periphyton score		7.0																				

Site:	Waiwera River at SH1 bridge	Periphyton Score	Transect 1					Transect 2					Transect 3					Transect 4				
Date:	8/03/2017		A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Thin mat/film	Green	7																				
	Light brown	10																				
	Black/dark brown	10	40	30	20	20	90	70	40	40	50	70	40	40	45	50	40	50	50	60	40	50
Medium mat	Green	5																				
	Light brown	7	20	5	15																	
	Black/dark brown	9	5	10	5	5		15		20	10	5	20	25	30	5	15		10	10		
Thick mat	Green/light brown	4			5																	
	Black/dark brown	7							25									5				
Short filamentous	Green	5	10	10	20	10	2	10	10	10	20	10	5	15	5	25	10	10	10	5	10	10
	Brown/reddish	5																				
Long filamentous	Green	1	2	10	10	25	5		5	5	2	2		2	2	10	5		2	2	10	10
	Brown/reddish	4																				
Notes:																						
A: Total % of stone surface covered by all types of periphyton			77	65	75	60	97	95	80	75	82	87	65	82	82	90	70	65	72	77	60	70
B: Periphyton Score x % Cover (sum for each stone)			637	485	480	320	915	885	630	635	692	797	605	702	747	680	590	585	642	717	460	560
C: Average Periphyton Score per stone (= B / A)			8.3	7.5	6.4	5.3	9.4	9.3	7.9	8.5	8.4	9.2	9.3	8.6	9.1	7.6	8.4	9	8.9	9.3	7.7	8
Overall average periphyton score		8.3																				

8.1.6 Macrophyte Data

Site: Kuriwao Stream upstream of Kuriwao Siding Road
Date: 9/03/2017

Transect	Wetted width (m)	Channe l width (m)	Vegetation cover (% wetted area) Total cover	Submerged plants Total submer ged	Surface-reaching ub-tota	Surface-reaching Taxa	Below surface ub-tota	Below surface Taxa	Emergent plants Total emerg	Emergent plants Taxa
1	4	4	34	32	0		32	*Elodea canadensis* 2% *otamogeton crispus* 30	2	*Glyceria fluitans* 2%
2	3.5	3.5	34	32	0		32	*Elodea canadensis* 2% *anunculus tricophyllus* 30	2	*Glyceria fluitans* 2%
3	4	4	44	42	0		42	identified Charophytes 1 *Elodea canadensis* 2% *anunculus tricophyllus* 30	2	*Glyceria fluitans* 2%
4	4	4	31	29	0		29	identified Charophytes 2 *Elodea canadensis* 10% *Potamogeton crispus* 2% *anunculus tricophyllus* 15	2	*Glyceria fluitans* 2%
5	4	4	25	25	0		25	*Elodea canadensis* 15% identified Charophytes 1	0	
			168	160	0		160		8	

Macrophyte total cover (%)	33.6
Macrophyte channel cloggines	17.6
Macrophyte native cover (%)	4.4

Native species underlined:

Unidentified Charophytes
Elodea canadensis (Canadian pondweed)
Glyceria fluitans (floating sweetgrass)
Potamogeton crispus (curly pondweed)
Ranunculus tricophyllus (water buttercup)

Site: Tributary at Quarry Road
Date: 8/03/2017

Transect	Wetted width (m)	Channe l width (m)	Vegetation cover (% wetted area) Total cover	Submerged plants Total submer ged	Surface-reaching ub-tota	Surface-reaching Taxa	Below surface ub-tota	Below surface Taxa	Emergent plants Total emerg	Emergent plants Taxa
1	1.5	1.5	95	0	0		0		95	*Elodea canadensis* 90% *Erythranthe guttata* 5%
2	1.5	1.5	100	0	0		0		100	*Elodea canadensis* 95% *Erythranthe guttata* 5%
3	1	1	60	0	0		0		60	*Erythranthe guttata* 60%
4	1.5	1.5	100	0	0		0		100	*rythranthe guttata* 100%
5	1.5	1.5	100	0	0		0		100	*Erythranthe guttata* 10% *Nasturtium officinale* 90%
			455	0	0		0		455	

Macrophyte total cover (%)	91
Macrophyte channel clogginess	91
Macrophyte native cover (%)	0

Native species underlined:

Elodea canadensis (Canadian pondweed)
Erythranthe guttata (monkey musk)
Nasturtium officinale (watercress)

Otago Regional Council

Macrophyte Data continued

Site: Waiwera River tributary at Blaikie Road
Date: 8/03/2017

Transect	Wetted width (m)	Channel width (m)	Vegetation cover (% wetted area)							
			Total cover	Submerged plants					Emergent plants	
				Total submerged	Surface-reaching		Below surface			
					Sub-total	Taxa	Sub-total	Taxa	Total emerg	Taxa
1	1	1	100	0	0		0		100	*Nasturtium officinale* 100%
2	1.5	1.5	100	0	0		0		100	*Nasturtium officinale* 100%
3	1	1	100	0	0		0		100	*Nasturtium officinale* 100%
4	1	1	100	0	0		0		100	*Nasturtium officinale* 100%
5	1	1	100	0	0		0		100	*Nasturtium officinale* 100%
			500	0	0		0		500	

Macrophyte total cover (%)	100
Macrophyte channel clogginess	100
Macrophyte native cover (%)	0

Native species underlined:

Nasturtium officinale (watercress)

Otago Regional Council

8.1.7 Sediment % cover

Awakia Stream at Hillfoot Road	Location 1	Location 2	Location 3	Location 4
Transect 1	5	2	15	20
Transect 2	15	20	2	5
Transect 3	10	5	5	5
Transect 4	15	2	0	0
Transect 5	10	2	0	0
				Average 9.5
Kuriwao Stream at Hillfoot Road	**Location 1**	**Location 2**	**Location 3**	**Location 4**
Transect 1	0	2	5	5
Transect 2	10	5	5	5
Transect 3	30	10	5	2
Transect 4	30	5	2	5
Transect 5	2	0	0	0
				Average = 6.4
Kuriwao Stream at Old Coach Road	**Location 1**	**Location 2**	**Location 3**	**Location 4**
Transect 1	15	5	2	10
Transect 2	5	0	0	0
Transect 3	0	2	0	2
Transect 4	0	5	2	5
Transect 5	2	10	0	2
				Average = 3.35
Kuriwao Stream upstream of Kuriwao Siding Road	**Location 1**	**Location 2**	**Location 3**	**Location 4**
Transect 1	15	10	15	2
Transect 2	10	5	2	15
Transect 3	10	5	20	2
Transect 4	2	2	10	25
Transect 5	2	5	5	20
				Average = 9.1
Tributary at Quarry Road	**Location 1**	**Location 2**	**Location 3**	**Location 4**
Transect 1	-	-	-	-
Transect 2	-	-	-	-
Transect 3	-	-	-	-
Transect 4	-	-	-	-
Transect 5	-	-	-	-
				Average = 70
Macrophytes across whole channel with little flow				
Waiwera River at Kuriwao Siding Road	**Location 1**	**Location 2**	**Location 3**	**Location 4**
Transect 1	5	2	5	5
Transect 2	2	2	0	2
Transect 3	0	0	0	2
Transect 4	10	5	5	20
Transect 5	15	10	0	0
				Average = 4.5
Waiwera River at Maws Farm	**Location 1**	**Location 2**	**Location 3**	**Location 4**
Transect 1	2	2	2	0
Transect 2	2	2	2	5
Transect 3	15	5	5	2
Transect 4	15	20	5	10
Transect 5	20	5	20	5
				Average = 7.2

Sediment % cover continued

Waiwera River at Owaka Valley Road	Location 1	Location 2	Location 3	Location 4
Transect 1	50	0	0	15
Transect 2	0	0	5	20
Transect 3	20	5	0	0
Transect 4	40	15	10	15
Transect 5	35	5	10	20
				Average = 13.25
Waiwera River downstream of Robertson Road Brid	**Location 1**	**Location 2**	**Location 3**	**Location 4**
Transect 1	5	0	0	10
Transect 2	0	0	0	0
Transect 3	5	0	0	0
Transect 4	0	0	0	10
Transect 5	0	0	5	5
				Average = 2
Waiwera River at Waiwera Gorge Road	**Location 1**	**Location 2**	**Location 3**	**Location 4**
Transect 1	0	5	10	0
Transect 2	2	0	0	0
Transect 3	0	0	5	0
Transect 4	0	0	0	2
Transect 5	0	0	2	0
				Average = 1.3
Waiwera River near Clifton	**Location 1**	**Location 2**	**Location 3**	**Location 4**
Transect 1	0	2	5	5
Transect 2	5	2	10	5
Transect 3	15	10	10	15
Transect 4	0	0	0	2
Transect 5	0	2	0	20
				Average = 5.4
Waiwera River at Hillfoot Road	**Location 1**	**Location 2**	**Location 3**	**Location 4**
Transect 1	30	15	10	0
Transect 2	15	50	2	0
Transect 3	5	20	5	10
Transect 4	10	5	10	10
Transect 5	0	5	0	0
				Average = 10.1
Waiwera River at SH1 bridge	**Location 1**	**Location 2**	**Location 3**	**Location 4**
Transect 1	2	2	2	2
Transect 2	10	20	15	5
Transect 3	10	15	10	2
Transect 4	15	5	10	10
Transect 5	15	10	10	20
				Average = 9.5
Waiwera River tributary at Blaikie Road	**Location 1**	**Location 2**	**Location 3**	**Location 4**
Transect 1	-	-	-	-
Transect 2	-	-	-	-
Transect 3	-	-	-	-
Transect 4	-	-	-	-
Transect 5	-	-	-	-
				Average = 100
Macrophytes across whole channel with little flow				

8.1.8 Quorer Results

			Depth											Stirred Depth						
Site Name	Suspended Solids	Volatile Solids	1	2	3	4	5	6	7	8	9	10	AVE	1	2	3	4	5	AVE	10cm
	(g/m^3)	(mg/L)																		
Awakia Stream at Hillfoot Road	5.3	5.3																		
Awakia Stream at Hillfoot Road	3600	700	70	67	70	73	67	75	73	73	72	73	71.3	68	71	74	65	68	69.2	171.3
Awakia Stream at Hillfoot Road	2600	490	80	82	82	77	79	79	82	75	78	81	79.5	79	79	79	78	82	79.4	179.5
Awakia Stream at Hillfoot Road	2500	470	110	110	110	105	107	109	111	112	111	110	109.5	109	111	111	109	105	109	209.5
Awakia Stream at Hillfoot Road	4300	920	100	97	99	99	102	95	98	102	102	96	99	96	96	101	102	98	98.6	199
Awakia Stream at Hillfoot Road	4300	840	200	201	195	202	202	203	202	202	202	200	200.9	198	203	198	194	197	198	300.9
Awakia Stream at Hillfoot Road	2300	480	240	238	236	234	234	243	236	240	240	241	238.2	234	235	236	242	240	237.4	338.2
Awakia Stream at Hillfoot Road	3800	780	230	232	225	229	223	223	222	223	230	230	226.7	230	229	223	229	222	226.6	326.7
Kuriwao Stream Hillfoot Rd	1.6	1.6																		
Kuriwao Stream Hillfoot Rd	2600	310	200	193	192	204	195	193	201	198	199	197	197.2	195	198	200	197	195	197	297.2
Kuriwao Stream Hillfoot Rd	710	110	170	166	166	172	171	166	166	169	165	167	167.8	165	165	168	166	171	167	267.8
Kuriwao Stream Hillfoot Rd	1200	170	210	210	210	205	206	209	212	205	205	207	207.9	211	208	205	205	208	207.4	307.9
Kuriwao Stream Hillfoot Rd	1100	150	250	256	255	251	254	258	249	256	249	253	253.1	256	253	254	254	248	253	353.1
Kuriwao Stream Hillfoot Rd	790	120	250	255	248	247	249	252	255	253	255	253	251.7	247	248	252	256	249	250.4	351.7
Kuriwao Stream Hillfoot Rd	580	93	230	233	236	225	229	238	231	240	230	239	233.1	231	231	233	236	232	232.6	333.1
Kuriwao Stream Hillfoot Rd	630	110	330	331	327	333	326	331	323	331	327	327	328.6	325	332	322	332	331	328.4	428.6
Kuriwao Stream Old Coach Rd	4.6	4.6																		
Kuriwao Stream Old Coach Rd	4600	910	130	136	140	140	133	126	126	126	136	140	133.3	120	124	134	129	133	128	233.3
Kuriwao Stream Old Coach Rd	1600	290	210	216	202	203	203	207	206	218	209	207	208.1	203	213	212	205	204	207.4	308.1
Kuriwao Stream Old Coach Rd	910	150	220	216	221	225	220	221	221	219	221	220	220.4	225	223	219	215	219	220.2	320.4
Kuriwao Stream Old Coach Rd	960	180	240	242	239	243	232	237	245	231	232	231	237.2	237	236	232	233	243	236.2	337.2
Kuriwao Stream Old Coach Rd	610	120	320	311	315	313	318	320	315	323	323	310	316.8	322	317	314	315	314	316.4	416.8
Kuriwao Stream Old Coach Rd	1900	320	230	229	239	237	231	225	224	223	239	240	231.7	224	225	225	234	224	226.4	331.7
Kuriwao Stream Old Coach Rd	210	38	260	250	246	248	265	261	262	260	252	259	256.3	262	246	258	254	260	256	356.3
Kuriwao Stream u/s Kuriwao Siding Rd	12.0	9.0																		
Kuriwao Stream u/s Kuriwao Siding Rd	880	100	210	208	207	207	207	206	208	207	212	205	207.7	210	206	206	208	208	207.6	307.7
Kuriwao Stream u/s Kuriwao Siding Rd	1100	130	200	201	202	201	205	205	202	201	204	199	202	203	199	202	202	198	200.8	302
Kuriwao Stream u/s Kuriwao Siding Rd	840	100	210	209	212	209	213	212	209	210	209	209	210.2	212	207	211	206	212	209.6	310.2
Kuriwao Stream u/s Kuriwao Siding Rd	2300	240	210	207	209	208	212	211	211	211	207	211	209.7	210	207	211	210	209	209.4	309.7
Kuriwao Stream u/s Kuriwao Siding Rd	500	53	360	311	295	367	282	330	314	364	351	310	328.4	327	302	331	316	347	324.6	428.4
Kuriwao Stream u/s Kuriwao Siding Rd	1800	190	200	205	201	200	203	197	205	198	197	197	200.3	196	195	199	196	198	196.8	300.3
Kuriwao Stream u/s Kuriwao Siding Rd	1500	150	160	165	163	155	157	158	165	155	157	165	160	158	156	157	165	157	158.6	260

Quorer Results continued

			Depth											Stirred Depth						
Site Name	Suspended Solids (g/m³)	Volatile Solids (mg/L)	1	2	3	4	5	6	7	8	9	10	AVE	1	2	3	4	5	AVE	10cm
Waiwera River Hillfoot Rd	2.8	2.8																		
Waiwera River Hillfoot Rd	1400	230	250	245	247	249	248	248	247	248	252	249	248.3	241	252	241	252	243	245.8	348.3
Waiwera River Hillfoot Rd	840	150	290	290	289	281	285	295	288	292	290	290	289	289	281	282	281	290	284.6	389
Waiwera River Hillfoot Rd	970	180	360	357	357	352	362	356	361	363	360	354	358.2	352	363	353	356	362	357.2	458.2
Waiwera River Hillfoot Rd	730	140	310	301	312	303	303	299	311	301	299	301	304	299	305	306	301	307	303.6	404
Waiwera River Hillfoot Rd	890	170	360	369	365	367	364	361	360	367	368	358	363.9	363	359	368	363	366	363.8	463.9
Waiwera River Hillfoot Rd	740	150	350	350	359	345	345	345	346	348	354	349	349.1	358	346	346	345	346	348.2	449.1
Waiwera River Hillfoot Rd	700	130	350	356	357	350	351	352	350	354	359	353	353.2	356	348	355	359	347	353	453.2
Waiwera at Kuriwao Siding Rd	2.8	2.8																		
Waiwera at Kuriwao Siding Rd	860	130	320	328	329	317	322	330	323	325	323	329	324.6	319	324	321	322	317	320.6	424.6
Waiwera at Kuriwao Siding Rd	2600	360	160	151	164	151	151	165	156	156	163	155	157.2	151	157	152	155	156	154.2	257.2
Waiwera at Kuriwao Siding Rd	560	73	360	363	364	365	361	364	364	358	361	365	362.5	358	358	365	360	359	360	462.5
Waiwera at Kuriwao Siding Rd	810	110	260	263	255	259	264	260	265	265	258	260	260.9	257	257	261	259	260	258.8	360.9
Waiwera at Kuriwao Siding Rd	880	120	230	226	229	233	226	225	228	229	229	226	228.1	231	228	226	229	225	227.8	328.1
Waiwera at Kuriwao Siding Rd	710	91	210	211	212	213	212	215	211	214	211	214	212.3	211	215	211	210	211	211.6	312.3
Waiwera at Kuriwao Siding Rd	1100	130	120	118	123	125	117	121	116	118	118	124	120	125	120	117	117	118	119.4	220
Waiwera at Owaka Valley Rd	4.2	3.0																		
Waiwera at Owaka Valley Rd	360	59	400	410	401	404	401	390	416	391	383	389	398.5	397	399	404	386	383	393.8	498.5
Waiwera at Owaka Valley Rd	3100	400	290	284	295	309	303	279	304	271	277	294	290.6	278	306	296	294	275	289.8	390.6
Waiwera at Owaka Valley Rd	570	110	380	375	387	391	371	388	381	392	371	383	381.9	381	373	380	383	392	381.8	481.9
Waiwera at Owaka Valley Rd	1400	190	310	306	316	316	309	296	317	294	300	294	305.8	312	313	298	302	298	304.6	405.8
Waiwera at Owaka Valley Rd	1400	190	280	277	278	284	277	280	280	275	277	282	279	277	279	279	283	276	278.8	379
Waiwera at Owaka Valley Rd	1500	220	380	380	371	371	378	381	384	373	388	375	378.1	387	381	375	372	373	377.6	478.1
Waiwera at Owaka Valley Rd	1800	320	290	288	294	285	296	294	290	293	290	290	291	286	293	286	291	292	289.6	391
Waiwera at Robertson Rd	4.0	4.0																		
Waiwera at Robertson Rd	1900	290	270	271	271	273	269	266	266	265	270	267	268.8	269	266	275	268	265	268.6	368.8
Waiwera at Robertson Rd	2200	330	180	182	181	185	179	184	178	183	181	182	181.5	179	180	183	180	184	181.2	281.5
Waiwera at Robertson Rd	2000	290	220	220	218	220	219	223	223	222	220	222	220.7	219	221	219	221	219	219.8	320.7
Waiwera at Robertson Rd	3400	450	310	305	308	311	312	315	306	313	312	308	310	310	310	307	312	306	309	410
Waiwera at Robertson Rd	2000	290	210	211	213	208	213	208	213	208	208	208	210	212	212	212	213	212	212.2	310
Waiwera at Robertson Rd	2000	260	340	345	341	335	343	339	339	336	338	336	339.2	339	338	343	340	335	339	439.2
Waiwera at Robertson Rd	3600	490	280	276	282	281	278	279	280	278	284	275	279.3	278	280	275	279	281	278.6	379.3

Quorer Results continued

			Depth											Stirred Depth						
Site Name	Suspended Solids	Volatile Solids	1	2	3	4	5	6	7	8	9	10	AVE	1	2	3	4	5	AVE	10cm
	(g/m^3)	(mg/L)																		
Waiwera at SH1 bridge	6.0	6.0																		
Waiwera at SH1 bridge	3100	500	150	150	145	151	148	150	150	150	149	150	149.3	149	149	150	148	149	149	249.3
Waiwera at SH1 bridge	210	32	148	147	148	150	150	145	150	150	148	149	148.5	148	148	147	149	150	148.4	248.5
Waiwera at SH1 bridge	960	140	149	150	150	150	145	150	145	148	148	146	148.1	148	147	149	145	150	147.8	248.1
Waiwera at SH1 bridge	1600	240	150	148	148	147	146	150	150	145	151	145	148	147	145	151	140	148	146.2	248
Waiwera at SH1 bridge	890	150	148	148	149	148	148	146	146	150	150	151	148.4	148	148	147	145	145	146.6	248.4
Waiwera at SH1 bridge	1600	250	148	147	147	146	145	150	151	150	148	148	148	150	146	145	146	145	146.4	248
Waiwera at SH1 bridge	1400	250	150	151	151	150	148	149	150	150	148	150	149.7	149	148	145	146	147	147	249.7
Waiwera trib at Blaike Rd	6.9	6.9																		
Waiwera trib at Blaike Rd	6900	1600	120	114	118	120	124	111	120	123	121	118	118.9	124	113	111	121	119	117.6	218.9
Waiwera trib at Blaike Rd	7000	1800	100	94	93	102	91	104	96	91	100	98	96.9	95	100	98	91	93	95.4	196.9
Waiwera trib at Blaike Rd	7500	1800	60	64	65	60	60	63	58	57	62	56	60.5	65	62	56	57	61	60.2	160.5
Waiwera trib at Blaike Rd	6600	1700	150	150	153	146	152	146	148	150	141	150	148.6	148	148	145	149	151	148.2	248.6
Waiwera trib at Blaike Rd	6100	1700	110	110	111	107	110	113	112	108	110	108	109.9	109	109	111	108	112	109.8	209.9
Waiwera trib at Blaike Rd	2600	680	150	151	150	149	148	147	148	146	152	147	148.8	148	150	148	150	147	148.6	248.8
Waiwera trib at Blaike Rd	1800	460	70	72	68	69	67	69	68	69	69	69	69	67	72	68	67	70	68.8	169
Waiwera trib d/s quarry	5.6	3.2																		
Waiwera trib d/s quarry	18000	2200	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	550
Waiwera trib d/s quarry	10000	1200	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	550
Waiwera trib d/s quarry	8000	980	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	550
Waiwera trib d/s quarry	13000	1500	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	550
Waiwera trib d/s quarry	7200	860	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	550
Waiwera trib d/s quarry	8100	980	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	550
Waiwera trib d/s quarry	4200	500	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	550