State of the environment:
Surface water quality in Otago

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Foreword

The high quality of Otago’s natural lakes and waterways has come to be expected from our rural and urban communities, and visitors. Maintaining water quality standards is a vital part of ensuring the regions future prosperity.

Parts of Otago are coming under increasing pressure, as seen in many other areas of the country, from intensive agricultural practices, urbanisation and water discharge practices, which all have the potential to negatively affect the quality of water in the regions rivers, streams and lakes. This is even more noticeable where the existing quality is so high.

The Otago Regional Council’s Regional Policy Statement and Regional Plan: Water demonstrate the Councils determination to maintain high water quality standards throughout Otago. In addition the Council continues to work closely with farmers, industries and community groups to ensure water quality does not deteriorate.

The Council carries out regular and extensive long-term water quality monitoring as part of its State of the Environment programme. This assists regional planning and helps everyone understand the need to protect water quality.

This report summarises the water quality monitoring data recorded throughout the region over several years. It looks at the major lakes and headwaters of our rivers, down to the lowland reaches and urban rivers. The analysis also tracks changes over past years to demonstrate whether patterns are emerging which can be attributed to changes in farming and other land use practices.

Good water quality is paramount for our wellbeing. This report provides a valuable resource on the state of Otago’s water quality. Many organisations, and people including farmers, anglers, recreationists, scientists, researchers and others who value good water quality will find much of interest in it.

Executive summary

This report summarises the state of river and stream water quality at 62 sites across the Otago region for the period July 2006 to June 2011. Bi-monthly water quality and annual macroinvertebrate records collected under Otago Regional Council's State of the Environment (SOE) monitoring programme are presented. Data analysis involved both an assessment of spatial variation on a region-wide basis, using a water quality index (WQI), an assessment of compliance with national water quality guidelines and an assessment of water quality trends.

SOE water quality reporting helps to identify areas in Otago where land-use change and change in land management is putting pressure on water quality.

As has been previously reported, water quality in rivers across the Otago region shows a clear spatial pattern related to land cover. Water quality is best at river and stream reaches located at high or mountainous elevation under predominantly tussock cover. These sites tend to be associated with the upper catchments of larger rivers (e.g. Clutha River/Matau-Au, Taieri River and Lindis River) and the outlets from large lakes (e.g. Hawea, Wakatipu and Wanaka).

Water quality is poorer at sites located on smaller, low-elevation stream reaches that drain pastoral or urban catchments, particularly those characterised by soft sedimentary substrates. The sites with the poorest water quality over the reporting period either drain intensively farmed catchments (e.g. Wairuna Stream, upper Waipahi) or catchments dominated by urban land cover (e.g. the Dunedin urban streams).

All the sites monitored in the 2006 to 2011 SOE programme (except the Wairuna Stream) were also assigned WQI grades, based on data collected between July 2001 and June 2006. Of the 61 sites, 38 retained the same WQI grade. Of the 23 sites that recorded a different WQI grade between the two reporting periods, 13 showed an improvement, and 10 recorded degradation. The WQI at Lake Tuakitoto and Waipahi at the Cairn dropped two WQI grades.

Trend analysis was undertaken on ammoniacal nitrogen (NH_4), total nitrogen (TN), nitrite-nitrate nitrogen (NNN), total phosphorus (TP), *Esherichia coli* (*E.coli*) and turbidity from each of the 62 core water quality monitoring sites. As most water quality variables are correlated with flow, either positively or negatively, data were flow adjusted before analysis.

Of the 372 trends analysed during the reporting period (2001 to 2011), 15% were degrading and 9% were improving. Over the shorter time period, 6% had degrading trends and 2% improving trends.

The sites with fewer trends and generally excellent water quality were the outlets of the large lakes in Central Otago (e.g. lakes Wakatipu, Wanaka and Hawea) and sites located in the upper catchments of rivers (e.g. Taieri at Stonehenge and Lindis at Lindis Peak).

The WQI identified many rivers as having 'very good' water quality. However, many of these catchments have undergone recent change to more intensive farming. As land use intensifies, particularly with the introduction of dairy farming, there tends to be a significant increase of NNN in waterways. The longer-term trend analysis (2001-2011) identified that once again the tributaries of the Pomahaka stand out as some of the worst sites, but also that some of the rapidly intensifying catchments have increasing nutrient levels, particularly the Kakanui River catchment (NNN, TP, DRP), Shag River (TN, NNN, TP, DRP), Catlins River (TN, NNN, TP, DRP, turbidity) and mid-Taieri River (NNN, TP). These catchments also show increasing recent trends (2006-2011): TN is increasing in the Shag River and the Catlins River, and NNN is increasing in the Taieri River at Sutton.

Between 2006 and 2011, improving water quality occurred at only a few sites, usually in one analyte only. Overall, TP improved at two sites, and DRP and turbidity improved at one site each. During this period, the sites with a trend of declining water quality tended to be the smaller streams in agriculturally intensive catchments (e.g. tributaries of the Pomahaka River) and also some of the larger rivers (e.g. NNN in the Taieri River, Clutha River/Mata-Au and Hawea River and TN in the Catlins River, Lindis River, Shag River and Waipori River).

Macroinvertebrate community health exhibited discrepancies between water quality and macroinvertebrate health at many SOE sites, with the macroinvertebrate monitoring results often suggesting better water quality than the WQI grade. This indicates that other factors (such as habitat quality) are more strongly influencing the instream macroinvertebrate community than water quality.

Following the 2007 SOE report, targeted catchments were identified for ORC studies with the aim of gaining a better understanding of land-use activity and stream health. Completed projects include the Pomahaka catchment, the Catlins area and the Manuherikia catchment. The upper Taieri will also be completed in 2012. Work planned for 2012/13 includes the Kakanui, Shag and Lake Tuakitoto catchments.

SOE monitoring has re-confirmed the areas within Otago where land use and land-use management activities are putting pressure on waterway health. Additional targeted catchment monitoring has assisted in providing evidence to help identify why there are rivers with degraded and degrading water quality.

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1. Introduction

1.1 Otago's rivers

The Otago region covers a land area of 32,000 km^2: from the Waitaki River in the north to Brothers Point in the south, and inland to Lake Wakatipu, Queenstown, Hawea, Haast Pass and Lindis Pass.

The distinctive and characteristic landscape of Otago includes the Southern Alps and alpine lakes; large high country stations; dry central areas, with tussock grassland and tors; and dramatic coastlines around the Otago Peninsula and the Catlins. Lowland pasture country is common in the west. The character of the region's water bodies is diverse, reflecting the variation in environmental conditions throughout the region.

The Clutha River/Mata-Au drains much of the Otago region. Its catchment area totals 21,000 km^2, and 75% of the total flow of the river at Balclutha comes from the outflows of Lakes Hawea, Wanaka and Wakatipu. Larger rivers feeding into the Clutha catchment include the Cardrona, Lindis, Shotover, Nevis, Fraser, Manuherikia, Teviot, Pomahaka, Waitahuna and Waiwera.

The Clutha and its principal tributary, the Kawarau River, pass through gorges, two of which are dammed for hydro-electricity generation. One of the larger tributaries of the Clutha, in its lower reaches, is the Pomahaka River, which rises in the mountains above Tapanui.

The second largest catchment in Otago is the Taieri River (5060 km^2). It rises in the uplands of Central Otago and meanders among the block mountain ranges before passing through an incised gorge and crossing the Taieri Plain, where it joins the waters of the Lake Waipori and Waihola catchments and becomes tidal before making its way through another gorge to the sea at Taieri Mouth.

Other significant Otago rivers drain the coastal hills in catchments of varying character. In the north, the Kakanui, Waianakarua, Shag and Waikouaiti rivers rise in high country and pass through mainly dry downlands. The Tokomairiro River, which flows through Milton, south of Dunedin, drains rolling country between the Taieri and Clutha catchments. Rivers to the south of Otago, particularly the Catlins area, emerge from wetter, often forested hills.

The environmental context in which Otago's water bodies exist is characterised by high rainfall in the Southern Alps and occasional very low rainfall in the semi-arid central Otago valleys. Despite the large water volumes in the region, parts of Otago are among the driest areas in New Zealand. Several rivers are characterised as 'water-short', including the Lindis, Manuherikia, Taieri, Shag and Kakanui rivers and their tributaries (Regional Plan: Water 2004).

1.2 Otago Regional Council SOE monitoring and reporting framework

Otago Regional Council (ORC) operates a long-term state of the environment (SOE) water quality monitoring network in rivers and streams throughout the region. Its objectives include providing information that underpins SOE reporting according to obligations under s35 of the Resource Management Act (1991). This monitoring is important as it improves the efficiency of council policy initiatives and strategies, as well as helping to identify the large-scale and/or cumulative impact of contaminants associated with varying land uses and disturbance regimes.

To meet these objectives, ORC produces annual summaries of the dataset, with five-yearly analysis of trends. ORC conducted the last analysis of spatial patterns (for the period 2000 to 2005) and trends (for the period 1995 to 2005) in 2007. The primary aim of this report is to present results of a trend-analysis of water quality indicators at 62 long-term monitoring sites in Otago between 2001 and 2011. Spatial patterns (i.e. state) are also summarised for the five-year period 2006 to 2011.

2 Monitoring objectives sites and variables

This section gives an overview of the monitoring objectives, sites monitored and variables measured.

2.1 Monitoring objectives

The aims of this report are to

- assess the state of water quality in Otago's rivers spatially, by comparing results to national water quality guidelines, using the WQI
- use the River Environment Classification system (REC) to compare water quality at source-of-flow and land cover level
- assess the state of water quality, by looking at individual analytes and linking results to WQI and REC
- identify any significant trends in water quality, and detect reasons for these trends
- assess the results of macroinvertebrate monitoring (both spatial and temporal).

The reporting period for the study was between July 2006 and June 2011, which was compared with the period July 2001 to June 2011.

2.2 Study sites

The ORC SOE water quality programme had 54 core sites) spread throughout the Otago Region. NIWA monitor another eight sites in the Otago region as part of the National River Water Quality Network (NRWQN). These 62 sites span a range of land uses.

2.3 Variables: Water quality

ORC directly measures, or collects water samples for, the analysis of up to 12 water quality parameters (Table 1). Measurements of water temperature, dissolved oxygen and conductivity are taken in the field, with all other variables being measured using standard laboratory protocols. Appendix 1 gives more details on how each parameter may affect stream health.

Table 1 Water quality parameters and guideline values summarised in this report. DO%, Turb, NH_4, DRP and *E. coli* are used to calculate the WQI.

Identifier (+ unit)	Parameter	Reference	Guideline value
DO (% saturation)	Dissolved oxygen	RMA 1991 Third Schedule	≥80
Turb (NTU)	Turbidity	ANZECC (2000)	≤5.6
NH_4 (mg/l)	Ammoniacal nitrogen	ANZECC (2000)	≤0.1
NNN (mg/l)	Nitrite-nitrate nitrogen	ANZECC (2000)	≤0.444
DRP (mg/l)	Dissolved reactive phosphorus	ANZECC (2000)	≤0.010
E.coli	*Escherichia coli*	ANZECC (1992)	≤126
		Acceptable MfE/MoH (2003)	<260
		Alert MfE/MoH (2003)	260-550
		Action MfE/MoH (2003	>550
TEMP (°C)	Temperature	-	≤20
Cond (mSm)	Conductivity	-	
pH	pH	ANZECC (1992)	6.5-9.0
SS (mg/l)	Suspended solids	-	
TN (mg/l)	Total nitrogen	ANZECC (2000)	≤0.614
TP (mg/l)	Total phosphorus	ANZECC (2000)	≤0.033

2.4 Biological monitoring

Water quality in the region's rivers and streams is also assessed through annual biological monitoring, which incorporates semi-quantitative assessments of the macroinvertebrate communities during the summer/autumn period when river levels are stable or low.

The record and scope of monitoring differ between sites. Details on current biological monitoring methods are provided in Appendix 2.

2.5 Analysis: Water quality

Water quality data for each of the 62 SOE sites monitored between July 2006 and June 2011 were used to assess the state of surface water quality in the Otago region.

Water quality at each site was assessed against national water quality guidelines and median values for selected variables, which were incorporated into a water quality index to compare water quality between sites. Analysis also included an assessment of compliance with national water quality guidelines at each site.

Table 1 contains the water quality guidelines considered in the assessment of water quality; guidelines used include the Australia and New Zealand Environment and Conservation Council guidelines for fresh water quality (ANZECC, 2000). It is important to note that the ANZECC guideline values are default 'trigger values' intended to assess the risk of adverse effects to aquatic ecosystems, rather than to provide thresholds against which to report. They should, therefore, be interpreted as indicative, rather than as absolute, thresholds. More information about specific guidelines is included in the text for each water-quality variable.

3 Water Quality Index (WQI)

The WQI was used to allow inter-site comparisons about the state of water quality in Otago's rivers and streams. The WQI for each site was derived from the median values for the following six variables: DRP, NNN NH_4, *E. coli*, TURB and DO. These values were then assessed against national water quality guidelines (Table 1). This approach has been used elsewhere at both a regional level (e.g. Perrie 2007) and a national level (e.g. Larned *et al*., 2005). Water quality statistics, including the median values, are presented in appendices 3 and 4.

Table 2. WQI classification

WQI Classification	Definition
Very good	Median values for all six variables comply with guideline values.
Good	Median values for five of the six variables comply with guideline values.
Fair	Median values for three or four of the six variables comply with guideline values.
Poor	Median values for two or less of the six variables comply with guideline values.

The WQI was calculated for 62 water quality sites. These include the 54 core water quality sites and the eight NIWA sites.

The application of the WQI enables water quality at each site to be classified into one of four categories (Table 2) to provide a snapshot of water quality in Otago over two time periods:

- 2006 to 2011
- 2001 to 2011.

The categories indicate how many variables meet their respective guideline values. Appendix 5 indicates which guidelines were exceeded and ranks the sites in order of percentage compliance[1] with guideline values.

Of the 62 sites (including eight sites monitored by NIWA):

- 36 sites were classified as very good (blue dots in Figure 1)
- 10 sites were classified as good (green dots in Figure 1)
- 12 sites were classified as fair (yellow dots in Figure 1)
- 4 sites were classified as poor (red dots in Figure 1)

[1] 'Percentage compliance' is calculated by assessing individual results against guideline values. 'Compliance' is then calculated by assessing the percentage exceedence of the relevant guideline value (for each analyte at each site).

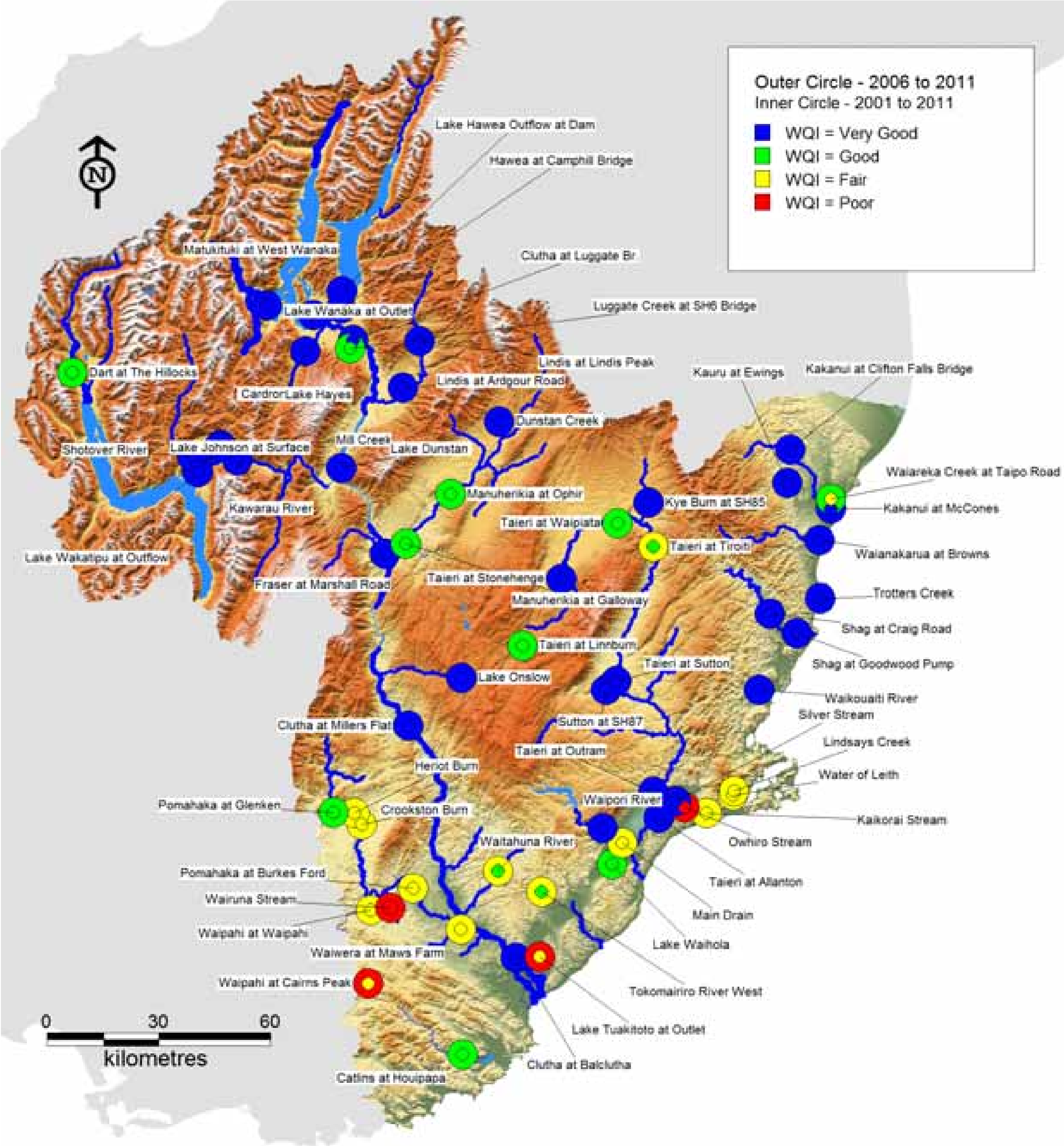


Figure 1 WQI: 62 core water quality monitoring sites in Otago

Figure 2 provides a breakdown of the categories fair and poor (2006 to 2011) and shows the sites that exceeded guidelines for bacteria (*E.coli* >126 cfu/ml) or had high nutrient concentrations DRP (>0.01 mg/l) and NNN (>0.444 mg/l). These variables are often elevated due to poor land management.

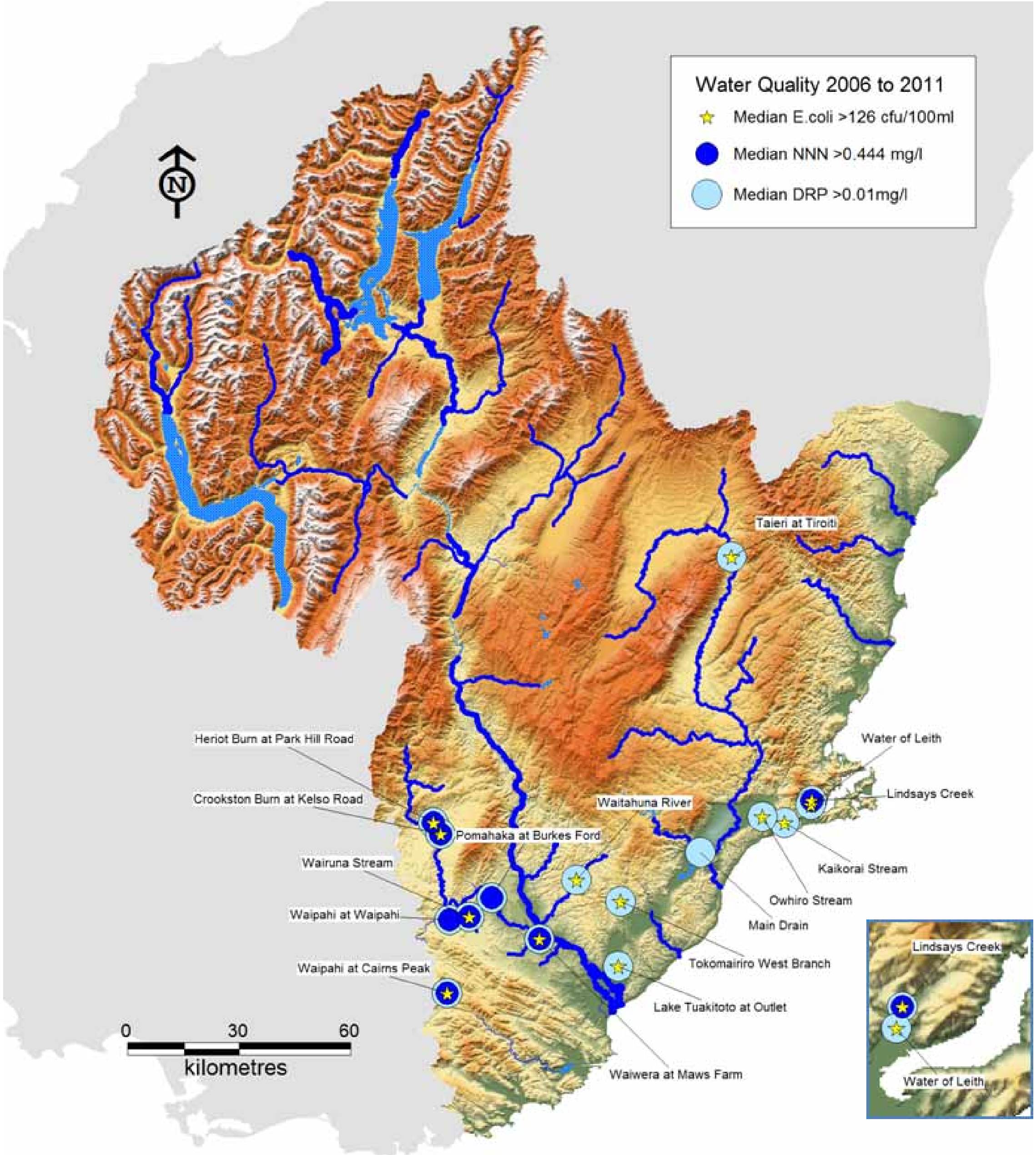


Figure 2 Sites with a fair or poor water quality classification (from the WQI) that have associated high NNN, DRP or *E.coli* concentrations

The other WQI variables were not shown because:

- low-dissolved oxygen values (less than 80%) were only found at four sites. The two lowest DO% levels were found in the Main Drain (48%), which is prone to large fluctuations in DO due to algae, and Lake Tutakitoto (61.1%), which has slow-moving water-reducing natural aeration. The Taieri at Linnburn and the Owhiro Stream recorded reasonably high DO (79.3% and 74%, respectively).
- ammoniacal nitrogen results were within guideline values at all sites.
- high turbidity levels were only found at six sites:
    - the Dart River (which has high natural erosion)
    - Lake Waihola and Lake Tutakitoto (shallow lakes prone to sediment resuspension)
    - the Owhiro Stream (a shallow stream with high numbers of resident fowl disturbing the sediment)
    - the Wairuna Stream, which has stock access (contributes to bank erosion), and high nutrient concentrations (encourages algae growth)

- the Waipahi at Cairns Peak (a naturally tannin-stained stream).

The WQI spatial analysis clearly shows that the rivers draining the higher altitude and less developed areas of Otago have excellent water quality. The main areas of concern are south-west Otago and around Dunedin, where small streams drain developed land (agriculture and urban). These sites generally showed elevated bacteria and/or nutrient levels.

Each WQI classification is discussed more fully below.

3.1 Very good water quality

Very good water quality was found at 36 sites throughout the region. Table 2 defines these sites as complying with all six guideline values.

Of these 36 sites, 23 are at high or mountainous elevation, five originated from lakes, and eight are at low-elevation. Four sites are on the main stem of the Taieri River; three sites are on the main stem of the Clutha River, and 11 other sites have mainly tussock in their upstream catchment. Seventeen sites have a cool dry climate, with pastoral land cover, and the other site has a cool dry climate, with mainly scrub.

The sites with very good water quality were ranked from 1 to 36. Of these 36 sites, compliance with guideline values for each analyte for every sampling occasion ranged from 100% (Lake Hawea, Lake Hawea outflow and Lake Wakatipu) to 80.3% (Taieri at Allanton). Sites that achieved >97% compliance were Lake Wanaka, Dunstan Creek and the Lindis River at Lindis Peak.

Figure 3 Very good water-quality site: Lindis River upper catchment

Table 3 below shows the breakdown of compliance. Three of the main-stem Taieri sites, the lower Shag River, Mill Creek, Silver Stream and lakes Onslow, Johnson and Hayes are the only sites that have two or more parameters exceeding 30% non-compliance.

Table 3 Percentage of non-compliance for each parameter. *E.coli* is assessed against the MfE/MoH green/surveillance (260 *E. coli*/100ml per single sample). Figures in bold show that non-compliance is >30%.

	Rank	WQI	NNN	NH_4	DRP	*E. coli*	Turbidity	DO
Cardrona at Mt Barker	18	Very good	0.0	0.0	3.4	6.9	10.3	0.0
Clutha at Balclutha	12	Very good	5.0	0.0	5.0	**23.5**	18.3	0.0
Clutha at Luggate Br.	8	Very good	0.0	0.0	0.0	0.0	**23.3**	0.0
Clutha at Millers Flat	3	Very good	0.0	0.0	0.0	4.5	15.0	0.0
Dunstan Creek at Beattie Road	27	Very good	0.0	0.0	2.9	9.1	0.0	0.0
Fraser at Marshall Road	15	Very good	0.0	0.0	10.3	6.9	3.4	0.0
Hawea at Camphill Bridge	2	Very good	0.0	0.0	0.0	0.0	0.0	0.0
Kakanui at Clifton Falls Bridge	11	Very good	0.0	0.0	3.3	**30.0**	0.0	0.0
Kakanui at McCones	29	Very good	7.7	0.0	5.1	12.8	0.0	**36.8**
Kauru at Ewings	14	Very good	0.0	0.0	6.9	27.6	0.0	6.9
Kawarau at Chards	10	Very good	0.0	0.0	0.0	15.0	23.3	0.0
Kye Burn at SH85 Bridge	25	Very good	0.0	0.0	18.5	11.1	25.0	0.0
Lake Dunstan	6	Very good	0.0	0.0	16.7	3.3	0.0	0.0
Lake Hawea Outflow at dam	1	Very good	0.0	0.0	0.0	0.0	0.0	0.0
Lake Hayes at surface	4	Very good	0.0	0.0	**37.0**	0.0	7.7	11.1
Lake Johnson at surface	16	Very good	0.0	0.0	**44.0**	4.0	8.3	**24.0**
Lake Onslow at boat ramp	24	Very good	0.0	0.0	10.7	0.0	**46.4**	**37.5**
Lake Wakatipu at outflow	5	Very good	0.0	0.0	0.0	0.0	0.0	0.0
Lake Wanaka at outlet	7	Very good	0.0	0.0	6.3	0.0	0.0	0.0
Lindis at Ardgour Road	26	Very good	0.0	0.0	0.0	10.0	13.3	0.0
Lindis at Lindis Peak	20	Very good	0.0	0.0	0.0	3.3	10.0	0.0
Matukituki at west Wanaka	13	Very good	0.0	0.0	6.7	3.3	13.3	0.0
Mill Creek at Fish Trap	33	Very good	**23.3**	0.0	10.0	**30.0**	13.8	0.0
Shag at Craig Road	23	Very good	2.5	0.0	7.5	17.5	2.6	17.1
Shag at Goodwood Pump	32	Very good	**32.1**	0.0	**21.4**	14.3	3.6	14.3
Shotover at Bowens Peak	9	Very good	0.0	0.0	0.0	13.3	25.0	0.0
Silverstream at Taieri Depot	31	Very good	**22.6**	0.0	19.4	**35.5**	16.7	6.9
Sutton at SH87	17	Very good	1.7	0.0	3.3	10.5	21.7	0.0
Taieri at Allanton Bridge	36	Very good	3.3	0.0	**26.7**	16.7	**30.0**	**41.4**
Taieri at Outram	30	Very good	1.7	0.0	**23.3**	**38.5**	21.7	0.0
Taieri at Stonehenge	21	Very good	0.0	0.0	4.3	4.5	0.0	25.0
Taieri at Sutton	34	Very good	0.0	0.0	**48.9**	17.8	**38.5**	6.7
Trotters Creek at Mathesons	35	Very good	17.9	0.0	7.1	14.3	0.0	39.3
Waianakarua at Browns	19	Very good	6.7	0.0	10.0	3.3	0.0	11.1
Waikouaiti at Orbells Crossing	22	Very good	0.0	0.0	6.1	11.8	0.0	**25.8**
Waipori at Waipori Falls Reserve	28	Very good	0.0	0.0	0.0	10.0	6.7	6.9

3.2 Good water quality

Good water quality was seen at 10 sites, which means that the median values for five of the six variables complied with guideline values. Of these sites, seven were located in high or mountainous elevation reaches and three in low-elevation reaches (including one lake).

Figure 4. Good water quality site: Catlins at Houipapa

Table 4 shows the breakdown of compliance. When the MfE/MoH green/acceptable mode level is applied (based on a limit of 260 *E. coli*/100ml per single sample), three of the 10 sites in the good water quality category exceed this limit for 15% or more of the time. These sites were the Manuherikia at Galloway (17.4%), Manuherikia at Ophir (19.6%) and Pomahaka at Glenken (18.9%). Median *E. coli* concentrations at one site (Pomahaka at Glenken) failed to meet the ANZECC 1992 guideline of 126 *E. coli*/100ml.

Six sites exceeded the DRP-guideline level (Manuherikia at Ophir and Galloway, Taieri at Waipiata, Catlins at Houipapa, Waiareka Creek and Luggate Creek) and two sites exceeded the turbidity-guideline level (Dart River and Lake Waihola).

The sites with good water quality were ranked from 37 to 46; of these 10 sites, compliance across all parameters ranged from 92.9% (Luggate Creek) to 66.1% (Waiareka Creek).

Table 4. Percentage of non-compliance for each parameter. *E. coli* is assessed against the MfE/MoH green/surveillance (260 *E. coli*/100ml per single sample). Figures in bold show that non-compliance is >30%.

	Rank	WQI	NNN	NH_4	DRP	*E. coli*	Turbidity	DO
Catlins at Houipapa	45	Good	28.6	0.0	**97.6**	**38.1**	**30.4**	0.0
Dart at The Hillocks	39	Good	0.0	0.0	0.0	7.4	**70.4**	3.7
Lake Waihola at end of jetty	41	Good	6.5	0.0	6.5	3.2	**72.4**	**37.9**
Luggate Creek at SH6 Bridge	37	Good	0.0	0.0	**56.7**	3.3	0.0	0.0
Manuherikia at Galloway	40	Good	0.0	0.0	**72.3**	26.1	23.3	0.0
Manuherikia at Ophir	43	Good	0.0	0.0	**74.5**	**37.0**	26.7	0.0
Pomahaka at Glenken	42	Good	1.9	0.0	25.9	**50.9**	24.1	**33.3***[2]
Taieri at Linnburn Runs Road	38	Good	0.0	2.2	2.2	11.4	0.0	**51.9**
Taieri at Waipiata	44	Good	0.0	0.0	**82.6**	13.3	11.5	17.2
Waiareka Creek at Taipo Road	46	Good	17.2	0.0	**100.0**	27.6	10.3	**48.3**

[2] Based on a limited data set (12 samples, of which 4 were <80%). See Appendix 2.

3.3 Fair water quality

Fair water quality was seen at 12 sites, of which 11 were in low-elevation and one was in hill country.

Figure 5 Fair water quality site: Waipahi at Waipahi

Nine of the sites had a median *E. coli* concentration that failed to meet the ANZECC 1992 guideline of 126 *E. coli*/100ml. Table 5 below shows that two sites exceeded the MfE/MoH green/surveillance (260 *E. coli*/100ml per single sample) on more than 90% of occasions.

The DRP-guideline level was exceeded at all the sites, with non-compliance levels ranging from 53.6% (Tokomairiro) to 100% (Water of Leith, Lindsays Creek, Crookston Burn, Waiwera, and Heriot Burn); no sites exceeded the turbidity guideline.

Of these 10 sites, the Taieri at Tiroiti had the highest water quality, with 75% compliance, and the Heriot Burn had the poorest water quality, with 39.9% compliance.

Table 5. Percentage of non-compliance for each parameter. *E. coli* is assessed against the MfE/MoH green/surveillance (260 *E. coli*/100ml per single sample). Figures in bold show that non-compliance is >30%.

	Rank	WQI	NNN	NH_4	DRP	*E. coli*	Turbidity	DO
Crookston Burn at Kelso Road	58	Fair	**100.0**	0.0	**100.0**	**91.7**	25.0	**33.3**
Heriot Burn at Park Hill Road	57	Fair	**100.0**	0.0	**100.0**	**93.1**	**36.7**	**30.8**
Kaikorai Stream at Brighton Road	50	Fair	**38.2**	0.0	**67.6**	**73.5**	23.5	9.1
Leith at Dundas Street Bridge	48	Fair	**42.9**	0.0	**100.0**	**74.3**	5.7	17.6
Lindsays Creek	52	Fair	**70.8**	0.0	**100.0**	**66.7**	17.4	4.3
Main Drain at Waipori Pump	56	Fair	**42.9**	27.9	**81.4**	**18.6**	**50.0**	**84.6**
Pomahaka at Burkes Ford	51	Fair	**53.8**	0.0	**76.9**	**30.0**	**37.0**	26.7
Taieri at Tiroiti	47	Fair	0.0	0.0	**70.0**	**53.3***[3]	26.7	0.0
Tokomairiro west branch	49	Fair	17.9	0.0	**53.6**	**58.6**	11.5	22.2
Waipahi at Waipahi	54	Fair	72.2	0.0	**85.2**	**48.1**	24.1	**33.3**
Waitahuna at Tweeds Bridge	53	Fair	9.7	0.0	**61.3**	**54.8**	19.4	**40.0**
Waiwera at Maws Farm	55	Fair	**74.2**	0.0	**100.0**	**70.0**	**35.5**	**35.3**

[3] Based on only 15 samples (of which 7 exceeded 126 cfu/100ml). See Appendix 2.

3.4 Poor water quality

Four sites were classified as having poor water quality, all of which were at low-elevation. The Owhiro Stream is in an urban environment; the Waipahi at Cairns peak has a cool wet climate and pastoral landcover; the Wairuna River is pastoral in a cool dry climate, and the other site is the outlet of Lake Tuakitoto.

All four sites exceed guideline values for DRP, *E. coli* and turbidity. The Wairuna and Waipahi exceeded the NNN guideline and the Owhiro and Lake Tuakitoto failed to meet the DO% guideline. Table 6 gives the percentage of non-compliance for each parameter.

Figure 6 Poor water-quality site: Wairuna River at Waipahi/Clydevale Road

Table 6 Percentage of non-compliance for each parameter. *E. coli* is assessed against the MfE/MoH green/surveillance (260 *E. coli*/100ml per single sample). Figures in bold show that non-compliance is >30%.

	Rank	WQI	NNN	NH_4	DRP	*E. coli*	Turbidity	DO
Lake Tuakitoto at outlet	59	Poor	24.2	0.0	**81.8**	27	**51.5**	**71.4**
Owhiro Stream at Burns Street	61	Poor	**33.3**	0.0	**100.0**	**40**	**86.7**	**58.6**
Waipahi at Cairns Peak	60	Poor	**75.6**	0.0	**100.0**	**47.7**	**77.8**	16.7
Wairuna Stream	62	Poor	**84.8**	0.0	**100.0**	**59.4**	**100.0**	**40.0**

3.5 WQI grades for 2006-2011, compared with 2001-2006

All the sites (except Wairuna Stream) monitored in the 2006 to 2011 programme were also assigned WQI grades, based on data collected between July 2001 and June 2006, inclusive. Of the 61 sites, 38 retained the same WQI grade. Of the 24 sites that recorded a different WQI grade between the two reporting periods, 13 showed an improvement, and 10 recorded degradation.

These sites typically dropped by one WQI grade (e.g. from good to fair), with the exception of Lake Tuakitoto at the outlet, which dropped three grades (from very good to poor). These sites were allocated lower WQI grades for the 2006-2011 reporting period because they exceeded the guidelines for turbidity (four sites), DRP (six sites), *E. coli* (two sites) or DO (two sites).

3.6 WQI, using alternative guidelines

The following section compares the traditional WQI with an alternative WQI measure for each site. The alternative WQI uses the same raw data, but compares the median values with the guideline values outlined in Table 7. The values in Table 7 are also used in the proposed Water Plan (ORC plan change 6A).

Table 7 Analytes, their effects and guideline values

Analyte	Effects	Guideline value	Reference
NNN	Periphyton	Short accrual 0.444 mg/l	ANZECC (2000)
		Long accrual 0.075 mg/l	Biggs (2000)
DRP	Periphyton	Short accrual 0.026 mg/l	Biggs (2000)
		Long accrual 0.006 mg/l	Biggs (2000)
NH_4	Indicates effluent contamination	0.1 mg/l	ORC
E. coli	Contact recreation	126 cfu/ 100 ml	ANZECC (1992)
Turb	Clarity	5 NTU	Young and Hayes (1999)
DO%	Life supporting capacity	6mg/l or 80% saturation	RMA 1991

3.6.1 Nutrients and accrual days

Streams that receive more rainfall tend to have more hydrological disturbance events that remove periphyton. Biggs (2000) found that the number of days without disturbance (accrual days) is important for periphyton proliferation, and he asserted that accrual days are at least as important as nutrient levels when determining risk of periphyton proliferations.

NNN and DRP are the key chemical analytes for determining the probability of nuisance algal growths, particularly periphyton. The growth of periphyton is often limited by the availability of one or the other of the two nutrients, NNN or DRP.

For catchments with long accrual periods (greater than 30 days) and therefore a higher risk of periphyton growth, the upper guidelines suggested by Biggs have been used (0.075mg/l NNN and 0.006mg/l DRP (Biggs, 2000).

In the wetter catchments of Otago, NNN is generally elevated relative to drier catchments, because it is very soluble and easily leached from saturated soils, more so than phosphorus, which readily binds to soils. Therefore, in wetter catchments, DRP tends to limit periphyton growth. As Biggs (2000) noted, DRP should be the focus nutrient in wetter catchments, because, in general, it is easier to control phosphorus than it is to control nitrogen.

These wetter catchments also have regular flushing flows that reduce the number of accrual days for periphyton, thereby reducing the risk of periphyton proliferation. In wetter catchments, the NZ periphyton guideline of 0.026mg/l for short accrual periods (less than 30 days) has been used, while the ANZECC guideline of 0.444mg/l has been used for NNN (as opposed to the more stringent NZ periphyton guideline of 0.295mg/l).

The ammonia component of ammoniacal nitrogen (NH_4) is toxic to aquatic organisms. NH_4 is also indicative of effluent contamination. As effluent should never enter a waterway, an alternative guideline value of 0.1mg/l for NH_4 has been used.

3.6.2 Bacteria (*E. coli*), turbidity and dissolved oxygen

E. coli is the commonly used indicator for bacterial contamination. As well as the ANZECC 1992 contact recreation median value guideline of 126cfu/100ml, a guideline of 10cfu/100ml has been used for the Lakes region to reflect the current excellent water quality.

The turbidity guideline of 5NTU (Young and Hayes (1999)) has been used; turbidity is essentially a measure of clarity and clear streams are desirable for angling and contact recreation. Generally, low turbidity also indicates low-suspended solids, which can smother aquatic habitat and reduce the feeding ability of visual predatory fish, such as trout and native fish, and there is also a good correlation between turbidity and suitability for contact recreation, as reported in Nagels *et al.* (2001).

The DO guideline remains at 80% because DO is essential for the respiration of fish, aquatic animals and plants. (For details of sites and accrual areas, including median values for each site, see Appendix 6.)

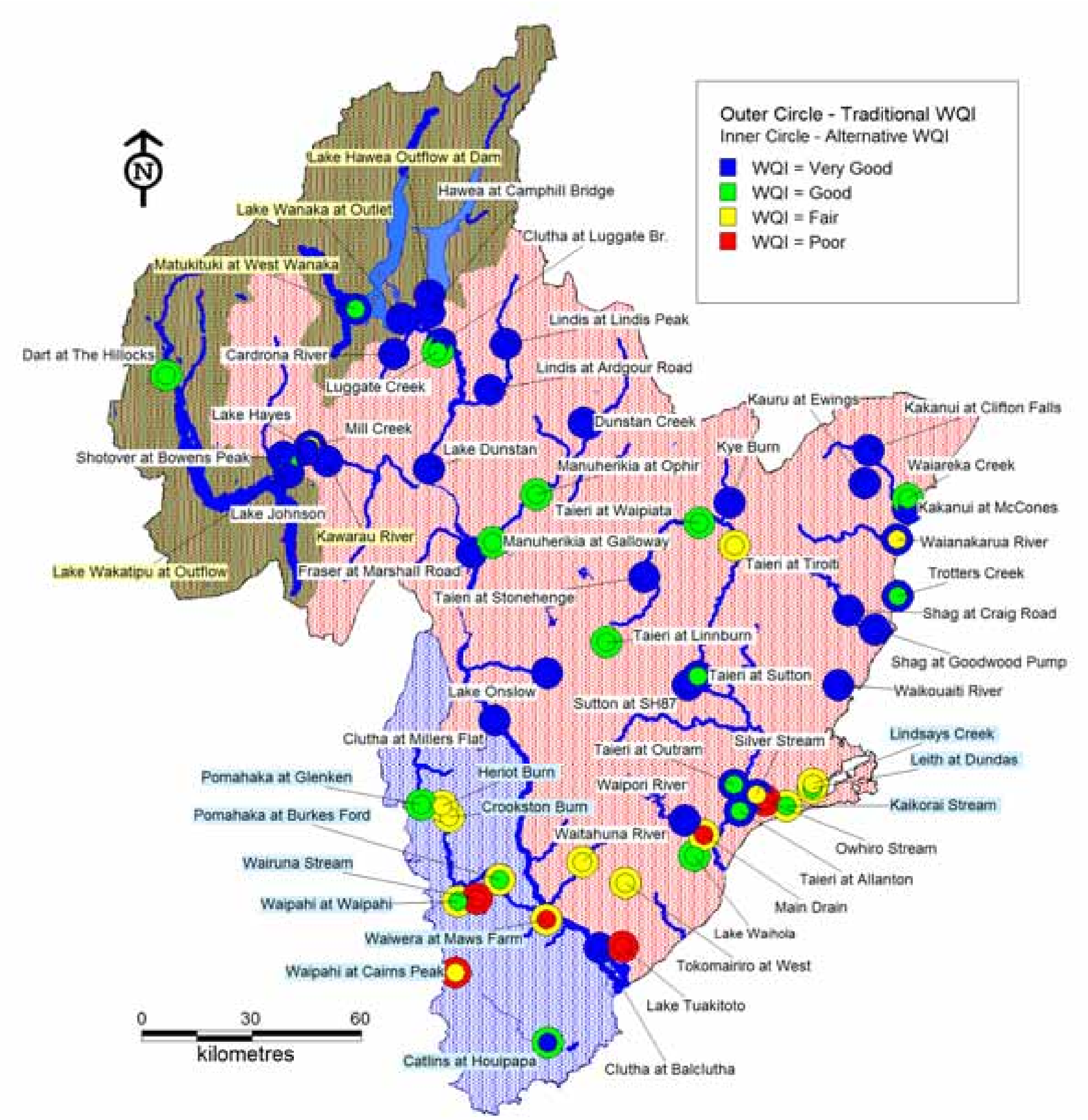


Figure 7 WQI of the 62 core water quality monitoring sites in Otago, using the alternative guidelines

Figure 7 shows the lakes area (shaded in brown) and the two accrual areas (long accrual shaded in pink and short accrual shaded in blue). Some sites have been allocated short-accrual status, although they are not obvious in the area shaded pink (the Dunedin urban streams). The 2006 to 2011 water quality data are shown in Figure 7 as the traditional WQI (larger outer circle) and the alternative WQI (smaller inner circle).

Of the 62 sites, 46 retained their traditional WQI score. Eight sites dropped by one WQI grade (Lake Johnson, Main Drain, Taieri River at Allanton, Outram and Sutton, Trotters Creek, Matukituki River and the Waiwera River); three dropped by two WQI grades (Mill Creek, Silver Stream and Waianakarua River), and five increased by one WQI grade (Catlins River, Kaikorai Stream, Water of Leith and both Waipahi River sites).

3.7 Mann-Whitney tests

Mann-Whitney tests were performed on raw data to highlight any significant differences (p<0.05) in median values between the two reporting periods (2001 to 2006 and 2006 to 2011). Appendix 7 presents the full results. Table 8 shows how many of the 53 sites showed significant differences between the two reporting periods for the eight analytes tested. (Nine sites were excluded as there was not enough data for the 2001 to 2006 period).

Table 8 Mann-Whitney results, showing the number of significant differences (52 sites) between the two reporting periods

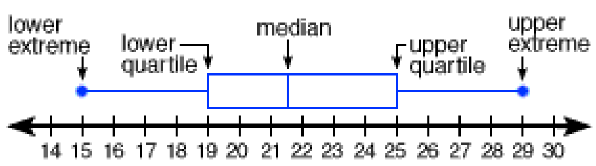
	NH_4	DRP	Ecoli	NNN	SS	TN	TP	Turb
Degrading	0	28	1	9	4	7	16	10
Improving	0	3	10	8	8	5	4	1

4 River Environment Classification System (REC)

This section uses the River Environment Classification (REC) system to interpret spatial patterns in water quality.

The Ministry for the Environment, in conjunction with NIWA, developed the New Zealand River Environment Classification (REC) system (Snelder *et al*., 2004). The REC system characterises river environments on six hierarchical levels, according to climate (1), source-of-flow (2), geology (3), land cover (4), network position (5) and valley landform (6), and within each level are a series of categories used to describe reaches of rivers throughout New Zealand (Table 9).

In this report, box-and-whisker plots ('box plots') are used; an overview of a box plot is shown in Figure 8. The box plots are used to compare water quality and macroinvertebrate health between different REC variables. Only two REC variables - source-of-flow and land cover - form the basis of most comparisons.



- The lower and upper boundaries of the box represent the lower (25%) and upper (75%) quartiles of the data, respectively.
- The horizontal line inside the box represents the median value.
- The 'whiskers' extending below and above the box represent the 5th and 95th percentile values, respectively.
- The black dots represent outliers.

Figure 8 Overview of box plot

4.1 Approach to analysis

The REC system allows sections of rivers that are similar with respect to these variables to be grouped together for management purposes.

Some REC categories are naturally linked (e.g. pastoral landcover is much more likely to be found in low-elevation areas, and tussock is much more likely to be found in hill country). The effect of land cover has the greatest bearing on water quality.

Sites in Otago were not classified according to climate, as nearly all the sites have a cool-dry climate. Five sites had cool wet climates (Catlins at Houipapa, Shotover at Bowens, Waipahi at Cairns Peak, Luggate Creek and Water of Leith at Dundas Street). Five sites also had 'cool extremely wet' climates (Dart River, Matukituki River, Hawea River at Camphill Road, Lake Hawea and Lake Wakatipu at outflow).

It is well known that the effects of source-of-flow, land cover and stream order (network position) have a significant effect on water quality. Median values for each water quality parameter in each REC class were calculated, and the results are presented in Table 10 to Table 12 and in Figure 9.

Table 9 REC classification levels, classes and criteria used to assign river segments to REC classes (from Snelder, 2004)

Factor	Climate	Code	Criteria
1. Climate	Warm extremely wet	WX	*Mean annual temperature:*
	Warm wet	WW	Warm: ≥12ºC
	Warm dry	WD	Cool: ≥12ºC
	Cool extremely wet	CX	*Mean annual effective precipitation:*
	Cool wet	CW	Extremely wet: ≥1500mm
	Cool dry	CD	Wet: 500 to 1500 mm, Dry: ≤ 500mm
2. Source-of-flow	Glacial mountain	GM	*% permanent ice:*
	Mountain	M	Glacial mountain: >1.5%
	Hill	H	*Rainfall volume in elevation categories:*
	Low-elevation	L	Mountain: >50% above 1000 m
	Lake	Lk	Hill: 50% between 400 to 1000 m
	Spring	Sp	Low-elevation: 50% below 400 m
	Regulated	R	*Lake influence index*
	Wetland	W	*Others manually assigned*
3. Geology	Alluvium	Al	*Spatially dominant geology category, unless:*
	Hard sedimentary	HS	
	Soft sedimentary	SS	Soft sedimentary >25%, then classified as sedimentary
	Volcanic basic	VB	
	Volcanic acidic	VA	
	Plutonic	Pl	
	Miscellaneous	M	
4. Land cover	Bare	B	*Spatially dominant land cover class, unless:*
	Native forest	IF	Pasture: >25%, then classified as pasture
	Pastoral	P	Urban: >15% then classified as urban
	Tussock	T	
	Scrub	S	
	Exotic forest	EF	
	Wetland	W	
	Urban	U	
5. Network position	Low order	L	*Stream order:*
	Middle order	M	Low: 1 and 2
	High order	H	Medium: 3 and 4
			High: >5
6. Valley landform	High gradient	H	Valley slope:
	Medium gradient	M	High: >0.04
	Low gradient	L	Medium: 0.02 to 0.04
			Low: <0.02

4.2 Results: Source-of-flow

Otago has four classes of source-of-flow, as shown in Table 10 and Figure 9. The low-elevation country consistently has the highest median values in all parameters. The maximum values are also found in the low-elevation country. Except for SS and turbidity, these values arise from the Dart River, which is classified as 'hill country' and is naturally high in turbidity/suspended solids.

Table 10 Comparison of results between the Otago REC source-of-flow classes

Source of flow		TN mg/l	NNN mg/l	NH_4 mg/l	TP mg/l	DRP mg/l	*E. coli* Ec/100ml	SS mg/l	Turb NTU
Glacial mountain	No. samples	30	30	30	30	30	30	30	30
	Maximum	0.27	0.08	0.04	0.63	0.057	2000	525	124
	median	0.08	0.05	0.01	0.01	0.005	8.5	5	2.04
Mountain	No. samples	153	153	153	153	153	107	92	133
	Maximum	0.51	0.28	0.03	2.31	0.048	686.7	41	135
	median	0.07	0.02	0.01	0.02	0.005	18	0.9	1.2
Hill	No. samples	1027	1030	1027	1027	1030	851	786	868
	Maximum	1.47	1.09	0.95	4.17	0.137	4880	10100	4000
	median	0.23	0.02	0.01	0.02	0.007	34	0.9	1.6
Low-elevation	No. samples	912	914	912	912	915	787	730	784
	Maximum	6.94	5.86	1.9	3	0.36	29000	228	460
	median	0.6	0.24	0.01	0.04	0.013	100	4	2.75

4.3 Results: Land cover

The Otago SOE monitoring network covers three classes of land cover (Table 11 and Figure 9). The largest number of sites is located in pastoral land. The number of samples taken from pastoral land was ten times that taken from sites in urban environments, which reflects the land use throughout Otago.

Tussock-dominated catchments have low nutrient, bacteria concentrations and the lowest turbidity/suspended solid concentrations. Urban land cover consistently has the highest median values in all parameters. However, the maximum values are found in the 'pastoral land cover' class, reflecting the large range in water quality in this class. Examples of this are shown in Figure 9.

Table 11 Comparison of results between the Otago REC land cover classes

Land cover		TN mg/l	NNN mg/l	NH_4 mg/l	TP mg/l	DRP mg/l	*E. coli* cfu/100ml	SS mg/l	Turb NTU
Tussock	No.samples	484	485	485	485	485	433	424	422
	Maximum	0.63	0.283	0.95	3	0.137	2660	525	135
	median	0.09	0.016	0.01	0.01	0.005	9	0.9	1.05
Urban	No.samples	122	123	122	122	123	123	121	122
	Maximum	2.77	2.21	0.24	0.86	0.061	6900	35	36.4
	median	0.78	0.395	0.02	0.05	0.02	250	4	3.62
Pastoral	No.samples	1666	1671	1666	1666	1672	1369	1244	1419
	Maximum	6.94	5.86	1.9	4.17	0.36	29000	10100	4000
	median	0.3	0.045	0.01	0.03	0.008	60	3	2.1

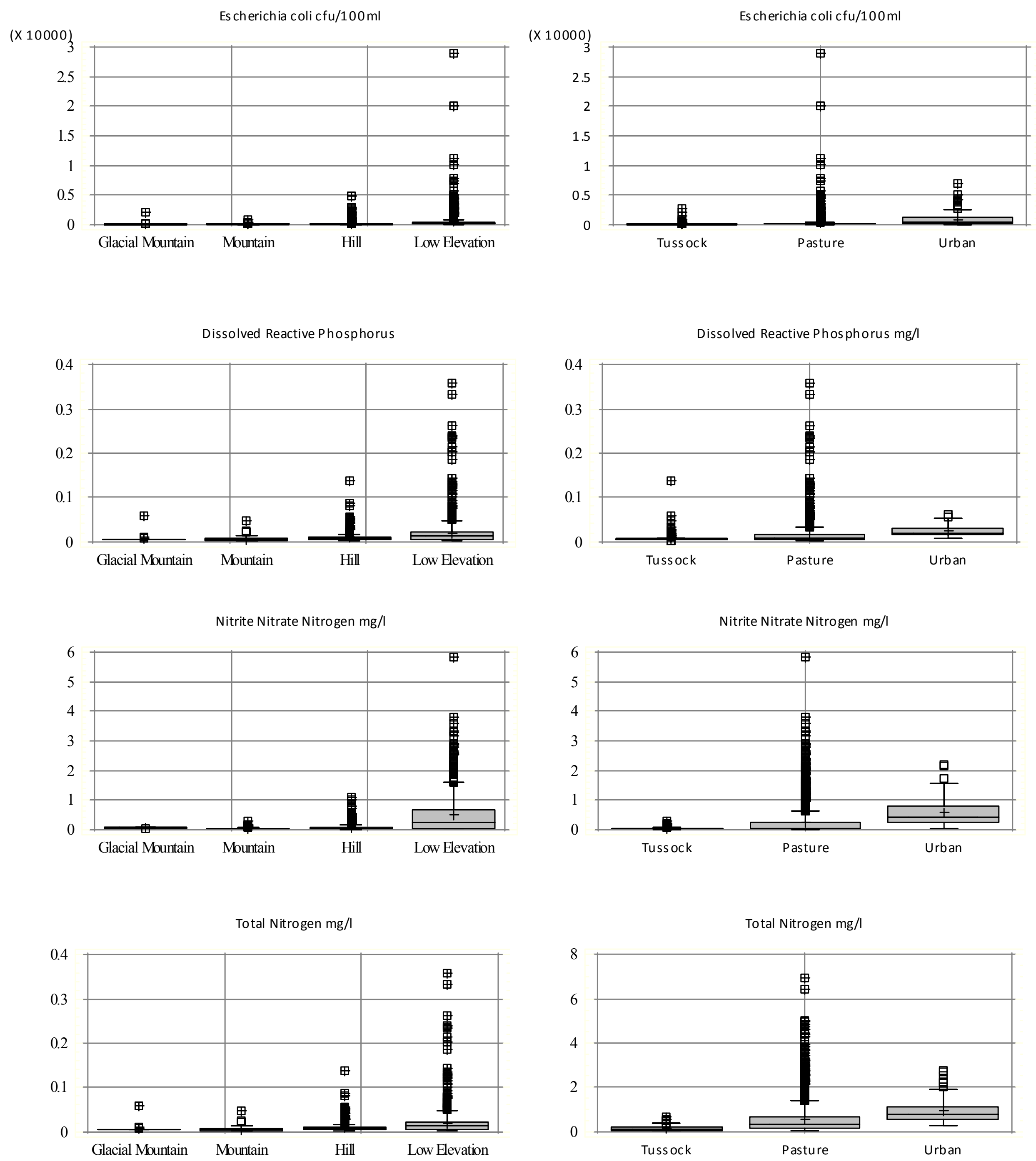


Figure 9 *E.coli*, DRP, NNN, TN box plots for selected REC landuse and source of flow classes, based samples taken between July 2006 and June 2011.

4.4 Results: Stream order

There are eight categories of 'stream order', with stream order 1 (SO1) being the smallest and stream order 8 (SO8) being the largest. The results are presented in Table 12 and Figure 10.

Due to a limited range of sampling sites for SOE monitoring (particularly on SO1 and SO2 streams), a true stream-order analysis was difficult. SO1 has only one site (Waipahi at Cairns Peak), and SO2 has only two sites (Dart River and Lake Johnson). Results are shown in Table 12

Table 12 shows that stream orders four and five generally have higher median concentrations of nutrients and bacteria than the other stream orders. The maximum values are also found in these stream orders. An example of the difference between stream orders is shown in Figure 10, which depicts DRP, TN, NNN and *E. coli* across all the stream orders in the form of box plots. Figure 10 shows that the largest variability in water quality also occurs in these classes.

Table 12 Comparison of results between the Otago REC stream-order classes

Stream order		TN mg/l	NNN mg/l	NH_4 mg/l	TP mg/l	DRP mg/l	*E. coli* cfu/100ml	SS mg/l	Turb NTU
1	No.samples	45	45	45	45	45	44	45	18
	Maximum	3.7	1.87	0.07	0.394	0.05	10200	206	106
	Median	1.08	0.616	0.02	0.066	0.021	250	7	8.805
2	No.samples	53	53	53	53	53	52	52	51
	Maximum	0.93	0.056	0.24	4.17	0.064	500	10100	4000
	Median	0.12	0.011	0.009	0.055	0.0045	2	7.5	3.68
3	No.samples	115	116	115	115	116	116	115	115
	Maximum	2.77	2.21	0.24	0.859	0.061	6900	35	36.4
	Median	0.73	0.3245	0.02	0.037	0.017	132	3	3.24
4	No.samples	357	358	357	357	359	320	295	334
	Maximum	6.94	2.84	1.9	0.76	0.202	29000	101	81
	Median	0.465	0.1395	0.009	0.031	0.01	67.5	3	2.47
5	No.samples	660	663	660	660	663	657	659	548
	Maximum	6.43	5.86	0.95	0.438	0.36	20000	338	182
	Median	0.26	0.054	0.009	0.02	0.008	44	0.9	1.49
6	No.samples	670	672	671	671	672	529	491	561
	Maximum	3.52	2.87	0.06	2.311	0.088	4880	621	135
	Median	0.233	0.024	0.009	0.024	0.007	42	0.9	1.75
7	No.samples	277	277	277	277	277	193	157	240
	Maximum	1	0.397	0.034	3	0.056	2100	263	68.3
	Median	0.085	0.025	0.009	0.009	0.0045	12.2	0.9	1.6
8	No.samples	120	120	120	120	120	39		120
	Maximum	0.93	0.515	0.029	0.114	0.02	410.6		460
	Median	0.095	0.0345	0.002	0.007	0.001	3.1		1.485

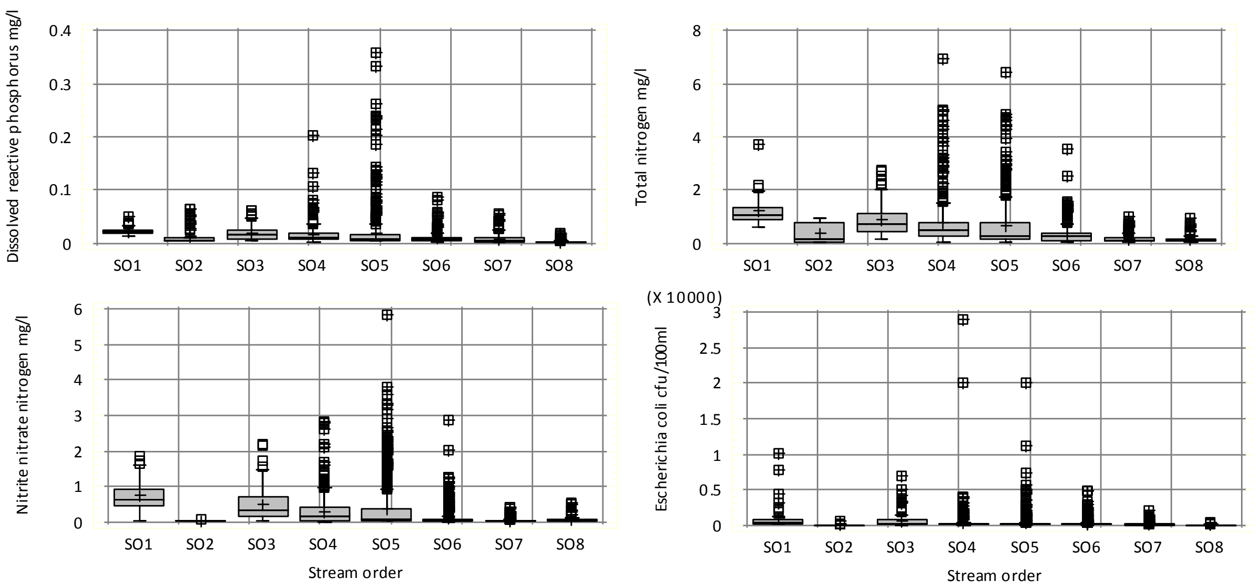


Figure 10 *E. coli*, DRP, NNN, TN box plots for stream-order classes, based on samples taken between July 2006 and June 2011

5 Discussion: Water quality

This section discusses the results of the water-quality analysis which the ORC and NIWA undertook between July 2006 and June 2011 (62 sites). Analytes were compared against guideline values (Table 1), and the percentage of samples that exceeded guideline levels were reported for selected sites.

The results are linked to both their REC class (Table 9) and their WQI grade (Appendix 5).

A description of the water-quality variables is given in Appendix 1; however, a brief summary is also given at the start of each of the following sections.

5.1 Faecal contaminants

Faecal contamination of waterways poses a public health risk. Illness may be contracted as a direct result of ingesting (including eating fish and shellfish) water containing bacterial, viral and protozoal pathogens that occur in faecal material. Faecal material reaches streams in numerous ways, including run-off from the land, effluent-pond discharges (e.g. Smith et al, 1993), stock and water fowl defecating directly into the water (e.g. Davies-Colley *et al*., 2004), overland run-off after rain and septic-tank discharges.

The indicator commonly used to assess this risk is *E. coli*, a faecal coliform bacterium that originates in the gut of warm-blooded animals and indicates the presence of other potentially harmful microbes. Pathogens are typically present in such small amounts that it is impractical to monitor them directly (MfE, 2009).

There are several reference values and guidelines used for interpreting *E. coli* data (Table 1). ANZECC 1992 guidelines recommend a season median of 126 *E. coli*/100 ml. Of the 54 sites with regular *E. coli* monitoring (i.e. not the NIWA sites), 14 had a median concentrations exceeding this value.

Table 13 shows that the highest median *E. coli* result came from Crookston Burn and Heriot Burn in the Pomahaka catchment. The Water of Leith and Kaikorai Stream also recorded elevated levels of *E. coli*. These streams drain urban catchments in Dunedin; the other urban stream (Lindsay's Creek) recorded 66.7% non-compliance.

Table 13 Sites with *E. coli* exceedences of >70%

Site	Median	% samples above guideline value	REC category (Table 9)	WQI grade
Crookston Burn	1040	91.7	CD/L/Al/P	Fair
Heriot Burn Park Hill Road	440	93.1	CD/L/HS/P	Fair
Kaikorai Stream	355	73.5	CD/L/SS/U	Fair
Waipahi at Cairns Peak	250	75	CD/L/SS/P	Poor
Wairuna Stream	345	81.2	CD/L/HS/P	Poor
Waiwera River	210	70	CD/L/SS/P	Fair
Water of Leith	210	74.3	CD/L/VB/U	Fair

Figure 9 shows that urban sites have much higher median concentrations than pastoral or tussock areas. The other three sites were low-elevation sites located in south west Otago, which are dominated by dairy farming (ORC, 2011).

At the other end of the scale, lakes Hawea, Wakatipu, Wanaka, Hayes, Johnson, Onslow and Dunstan recorded median *E. coli* results of <5cfu/100ml, as did the Hawea River, the Clutha River/Mata-Au (Luggate and Millers Flat) and the Dart River. Section 3 (REC source-of-flow) shows that bacteria levels are lower in sites sourced from mountain, hill and lakes than those from low-elevation sites.

5.1.1 Contact recreation

The Crookston Burn had median concentrations of *E. coli* that exceeded 550 per 100 mL. While this level poses an unacceptable health risk, activities such as swimming are not known to occur in the stream.

5.1.2 Stock drinking water quality

The microbiological quality of stream water is also important as a stock drinking supply. The ANZECC (2000) guideline ‘trigger value’ for stock drinking water quality is 100 faecal coliforms per 100ml. The guideline also recommends taking action once 20% of samples taken over an extended period exceed four times this value (i.e. 400 per 100 mL). Both the Heriot Burn and Crookston Burn had median *E. coli* concentrations exceeding 400 per 100 mL. These steams probably provide water for stock.

5.2 Nutrients (nitrogen and phosphorus)

Nitrogen and phosphorus are essential nutrients for the growth of aquatic plants and algae, which are an important part of any healthy stream ecosystem. However, excessive concentrations of these nutrients can lead to proliferations of algae and macrophtyes, which may compromise a range of instream values such as amenity, native fish conservation and recreation (Biggs, 2000).

The concentrations at which nitrogen or phosphorus start to have an adverse effect on ecosystem health or amenity values vary from site to site and catchment to catchment. For example, a stream with primarily muddy substrate may be more resistant to nuisance blooms than a rock or cobble-bottomed stream (given similar concentrations of nutrients) (MfE, 2009).

In New Zealand, two national guidelines are commonly used to assess nutrient concentrations:

1. *Periphyton guidelines (Biggs, 2000).* These guidelines provide suggested thresholds for the dissolved nitrogen and phosphorus concentrations required to control periphyton growth. A range of thresholds are provided that are related to flow conditions (high flow events tend to scour out periphyton growth). The upper guideline values, suggested by Biggs (2000), are 0.295 mg/L soluble inorganic nitrogen and 0.026 mg/L DRP; these relate to ‘20 mean days of accrual’.

2. *ANZECC guidelines (ANZECC, 2000).* These guidelines provide default trigger values for total and dissolved nitrogen and phosphorus for assessing the risk of adverse effects in slightly disturbed ecosystems. These trigger values are based on the 80th percentile of a distribution of reference data and have the following

values for lowland rivers: 0.614 mg/L for total nitrogen, 0.444 mg/L for oxides of nitrogen (nitrate-nitrite nitrogen), 0.033 mg/L for total phosphorus and 0.01 mg/L for DRP.

5.2.1 Total nitrogen (TN)

All organisms need nitrogen for the basic processes of life: to make proteins, grow and reproduce. Nitrogen is very common and found in many forms. Inorganic forms include nitrate (NO_3), nitrite (NO_2), ammonia (NH_3) and nitrogen gas (N_2). Organic nitrogen is found in the cells of all living things and is a component of proteins, peptides and amino acids. TN is affected by wastewater effluent, agricultural run-off, animal waste, fossil fuels and industrial discharges (MfE, 2009).

Table 10 shows that low-elevation sites produce the highest median concentrations of TN, and Figure 9 indicates that pastoral and urban catchments are likely to have higher concentrations of TN than scrub and tussock catchments.

The ANZECC 2000 trigger value for TN is 0.614 mg/l. At 15 sites, the median concentration of NNN was above this trigger value. The sites with a median concentrations >1.0 mg/l are listed in Table 14. Most of these sites have been mentioned in the NNN section. They are all of low-elevation, with pastoral land cover.

Table 14 Sites with median concentrations of TN greater than 1.0 mg/l

Site	Median	% samples above guideline value	REC category (Table 9)	WQI grade
Crookston Burn	1040	91.7	CD/L/Al/P	Fair
Heriot Burn Park Hill Road	440	93.1	CD/L/HS/P	Fair
Kaikorai Stream	355	73.5	CD/L/SS/U	Fair
Waipahi at Cairns Peak	250	75	CD/L/SS/P	Poor
Wairuna Stream	345	81.2	CD/L/HS/P	Poor
Waiwera River	210	70	CD/L/SS/P	Fair
Water of Leith	210	74.3	CD/L/VB/U	Fair

5.2.2 Total phosphorus (TP)

TP is a measure of all the forms of phosphorus, dissolved or particulate, found in a sample. Phosphorus is a natural element found in rocks, soils and organic material as it clings tightly to soil particles. TP is affected by wastewater effluent, fertilisers, animal waste, urban development and industrial discharges (MfE, 2009).

The ANZECC (2000) trigger value for TP is 0.033 mg/l. Twenty-one of the sites had median concentrations of TP exceeding this trigger value. Of these sites, 16 also exceeded the ANZECC (2000) trigger value for DRP. Included in the sites that did not exceed the DRP trigger level were Lake Hayes, Lake Johnson, Lake Waihola and the Taieri at Sutton. These lakes are generally shallow and sediment is therefore prone to resuspension by wind or waterfowl. The sediment has a high TP load, which is not reflected in DRP concentrations. The Taieri at Sutton had a median DRP of 0.01 mg/l, which is just on the guideline.

It can be seen that most of the sites with a high percentage exceedence had a pastoral land cover, except for the Owhiro Stream.

Table 15 shows the sites with the highest percentage exceedences of the ANZECC trigger value for TP (>80%).

Table 15 Sites recording the TP exceedences of >80%

Site	Median	% samples above guideline value	REC category (Table 9)	WQI grade
Crookston Burn	0.06	91.66	CD/L/Al/P	Fair
Heriot Burn	0.065	100	CD/L/HS/P	Fair
Lake Johnson	0.057	84	CD/Lk/HS/P	Very good
Lake Tuakitoto	0.1	87.8	CD/L/HS/P	Poor
Main Drain	0.111	100	CD/L/Al/P	Fair
Owhiro Stream	0.129	100	CD/L/Al/U	Poor
Taieri at Waipiata	0.055	82.6	CD/H/HS/P	Good
Waiareka Creek	0.018	100	CD/L/SS/P	Good
Waipahi at Cairns Pk	0.066	100	CW/L/SS/P	Poor
Waipahi at Waipahi	0.052	81.48	CD/L/SS/P	Fair
Wairuna	0.101	100	CD/L/HS/P	Poor
Waiwera	0.061	96.77	CD/L/SS/P	Fair

5.2.3 Nitrite-nitrate nitrogen (NNN)

NNN is the nitrogen available for plant growth and is beneficial up to a point, but may easily become a nuisance. NNN better reflects bioavailability than TN. NNN is affected by wastewater effluent, agricultural run-off, animal waste, fossil fuels and industrial discharges. Figure 9 shows that even though pastoral land cover does not produce the highest average dissolved nutrients, it produces many outliers. Table 10 and Table 12 show that low-elevation sites have elevated NNN levels compared to other sources and the lower order streams monitored in Otago generally have higher concentrations of NNN.

The ANZECC (2000) trigger value for NNN is 0.444 mg/l. Six of the sites had median values above this trigger level (Table 16). Five of the sites were in intensive pastoral catchments in south-west Otago, and one in an urban environment. All the streams with a high concentration of NNN have a WQI classification of 'fair' or 'poor'.

Table 16 Sites with a median level of NNN greater than 0.444 mg/l

Site	Median	% samples above guideline value	REC category (Table 9)	WQI grade
Pomahaka at Burkes Ford	0.4895	53.85	CD/L/HS/P	Fair
Waipahi at Cairns Peak	0.616	75.56	CW/L/SS/P	Poor
Lindsays Creek	0.705	70.03	CD/L/VB/U	Fair
Heriot Burn	1.19	100	CD/L/Al/P	Fair
Crookston Burn	1.1	100	CD/L/HS/P	Fair
Waiwera at Maws Farm	0.781	74.19	CD/L/SS/P	Fair
Waipahi at Waipahi	0.87	72.22	CD/L/SS/P	Fair
Wairuna Stream	1.09	84.85	CD/L/HS/P	Poor

The sites with very low median NNN levels (<0.01 mg/l) have a WQI classification of very good as they are sourced from hill country or lakes, have a hard sedimentary geology and the land cover tends to be tussock.

5.2.4 Dissolved reactive phosphorus (DRP)

DRP is a measure of orthophosphate, the filterable (soluble, inorganic) fraction of phosphorus, which is directly taken up by plant cells. Phosphorus is often found to be the growth-limiting nutrient, because it occurs in the least amount relative to the needs of plants. DRP is affected by wastewater effluent, fertilisers, animal waste, urban development and industrial discharges (MfE, 2009).

The ANZECC (2000) trigger value for DRP is 0.01 mg/l. At 22 sites, the median concentration was above this trigger value. Table 17 lists the sites with a median value of >0.02mg/l. All these sites drain pastoral or urban catchments and are at low-elevation.

Table 17 Sites with median concentrations of DRP greater than or equal to 0.02 mg/l

Site	Median	% samples above guideline value	REC category (Table 9)	WQI grade
Crookston Burn	0.031	100	CD/L/Al/P	Fair
Heriot Burn	0.024	100	CD/L/HS/P	Fair
Lindsays Creek	0.02	100	CD/L/VB/U	Fair
Main Drain	0.02	81.4	CD/L/Al/P	Fair
Owhiro Stream	0.032	100	CD/L/Al/U	Poor
Waiareka Creek	0.124	100	CD/L/SS/P	Good
Waipahi at Cairns Peak	0.021	100	CW/L/SS/P	Poor
Wairuna Stream	0.032	100	CD/L/HS/P	Poor
Waiwera at Maws Farm	0.027	100	CD/L/SS/P	Fair
Water of Leith	0.026	100	CW/L/VB/U	Fair

Table 18 shows the eight sites that had no exceedences. The table includes the rivers that drain into or out of lakes Wakatipu, Hawea and Wanaka (including the Shotover River). The Lindis River was also low in DRP, largely due to the upper tussock catchment.

The number of exceedences was extremely high at many of these sites, with nine sites recording a 100% exceedence of the ANZECC (2000) trigger level.

Table 18 Sites with no exceedences of the DRP guideline

Site	Median	% samples above guideline value	REC category (Table 9)	WQI grade
Clutha at Luggate Bridge	0.001	0	CD/L/Al/P	Very good
Clutha at Millers Flat	0.001	0	CD/L/Al/P	Very good
Dart at The Hillocks	0.005	0	CX/H/HS/P	Good
Hawea at Camphill Bridge	0.005	0	CX/Lk/HS/T	Very good
Kawarau at Chards	0.001	0	CD/H/Al/P	Very good
Lake Hawea outflow	0.005	0	CX/Lk/HS/T	Very good
Lake Wakatipu outlet	0.005	0	CX/Lk/HS/T	Very good
Lindis at Ardgour Road	0.005	0	CD/L/Al/P	Very good
Lindis at Lindis Peak	0.006	0	CD/H/HS/T	Very good
Shotover at Bowens Pk	0.001	0	CW/M/HS/T	Very good

5.2.5 Nitrogen:phosphorus ratio

Exceedances of guidelines for either nitrogen or phosphorus do not necessarily lead to algal proliferation. Given sufficient light, suitable water temperatures and substrate conditions, the extent to which nutrient concentrations will lead to nuisance plant growth is controlled largely by the relative abundance of dissolved nitrogen to phosphorus (i.e. the soluble inorganic nitrogen (SIN):DRP ratio (MfE, 2007)).

Wilcock, Biggs *et al*. (2007) suggest that SIN:DRP ratios of greater than 50:1 and less than 3:1 probably indicate phosphorus limitation and nitrogen limitation of algae growth, respectively, unless concentrations of SIN and DRP are well above those expected to saturate growth (in which case neither nutrient is limiting).

Table 19 shows the SIN:DRP ratios for each site, derived from medians for each of the variables between 2006 and 2011. Twelve sites had SIN:DRP ratios indicating nitrogen limitation (shaded dark grey in Table 19) and three sites had SIN:DRP ratios indicating phosphorus limitation (shaded light grey in Table 19).

Table 19 SIN:DRP ratios for each site derived from medians for each of the variables between 2006 and 2011. The sites shaded in dark grey are nitrogen limited; the sites shaded in light grey are phosphorus limited.

Site	SIN	DRP	Ratio	Site	SIN	DRP	Ratio
Waiareka Creek	0.082	0.124	0.66	Lake Wanaka at outlet	0.036	0.020	7.89
Luggate Creek	0.014	0.011	1.23	Waitahuna River	0.116	0.014	9.67
Taieri at Waipiata	0.027	0.019	1.39	Owhiro Stream	0.316	0.016	9.86
Lake Johnson	0.014	0.009	1.50	Matukituki River	0.056	0.005	12.44
Manuherikia at Gall	0.030	0.014	2.14	Cardrona at Mt Barker	0.064	0.007	12.80
Manuherikia at Ophir	0.035	0.016	2.19	Waipori River	0.063	0.032	13.40
Lake Hayes	0.014	0.006	2.25	Tokomairiro West Branch	0.164	0.013	14.86
Taieri at Stonehenge	0.014	0.006	2.25	Leith at Dundas Street	0.404	0.009	15.54
Taieri at Tiroiti	0.031	0.014	2.26	Lindis at Ardgour Road	0.081	0.006	16.20
Sutton at SH87	0.013	0.005	2.60	Shotover at Bowens Peak	0.019	0.008	18.50
Lake Waihola	0.014	0.005	2.70	Waianakarua at Browns	0.158	0.001	22.50
Taieri at Sutton	0.028	0.010	2.80	Catlins at Houipapa	0.387	0.007	23.42
Lake Onslow	0.014	0.005	3.00	Clutha at Balclutha	0.052	0.005	26.00
Taieri at Linnburn	0.014	0.005	3.00	Kaikorai at Brighton Road	0.355	0.008	26.30
Lake Hawea	0.017	0.005	3.67	Trotters Creek	0.135	0.005	26.90
Hawea at Camphill Br.	0.019	0.005	4.11	Clutha at Millers Flat	0.028	0.008	28.00
Lake Tuakitoto	0.080	0.018	4.44	Clutha at Luggate Bridge	0.030	0.006	29.50
Kauru at Ewings	0.028	0.006	4.67	Waiwera at Maws Farm	0.801	0.010	29.67
Taieri at Outram	0.041	0.008	5.06	Main Drain	0.597	0.014	29.83
Shag at Craig Road	0.031	0.006	5.08	Waipahi at Cairns Peak	0.636	0.019	30.29
Lindis at Lindis Peak	0.031	0.006	5.17	Kakanui at McCones	0.154	0.011	30.80
Kakanui at Clifton	0.026	0.005	5.20	Kawarau at Chards	0.033	0.005	33.00
Kye Burn at SH85	0.042	0.008	5.25	Lindsays Creek	0.715	0.007	35.75
Pomahaka at Glenken	0.048	0.009	5.28	Wairuna Stream	1.150	0.124	35.94
Dunstan Creek	0.040	0.007	5.64	Shag at Goodwood Pump	0.288	0.005	36.00
Dart at The Hillocks	0.027	0.005	6.00	Crookston Burn at Kelso	1.125	0.021	36.29
Taieri at Allanton Br.	0.050	0.008	6.25	Silverstream at Taieri	0.268	0.018	38.29
Lake Dunstan	0.029	0.005	6.44	Pomahaka at Burkes Ford	0.500	0.005	38.42
Waikouaiti at Orbells	0.035	0.005	7.00	Waipahi at Waipahi	0.880	0.012	50.29
Lake Wakatipu	0.032	0.005	7.11	Heriot Burn at Park Hill Rd	1.220	0.027	50.83
Fraser at Marshall Rd	0.037	0.005	7.40	Mill Creek at Fish Trap	0.358	0.032	55.00

5.3 Stressors and toxicants

5.3.1 Ammoniacal nitrogen (NH4)

Ammoniacal nitrogen can, at sufficiently high concentrations, be toxic to fish and other aquatic life. In farmed catchments, elevated concentrations are generally due to direct discharges of effluent, paddock run-off or stock access to streams. High concentrations are most likely to occur when stream flows are low, and when cattle use streams for drinking water.

The toxicity of NH_4 depends on stream-water temperature and pH (ANZECC, 2000). ANZECC recommends adopting a trigger value of 0.9 mg/L NH_4 for pH 8 and 20DegC to adequately protect 95% of species. No sites exceeded this concentration. The sites with median NH_4 concentrations >0.05mg/l are listed in Table 20.

Table 20 Sites with a median ammoniacal nitrogen concentrations > 0.05 mg/l

Site	Median	REC category (Table 9)	WQI grade
Wairuna Stream	0.06	CD/L/HS/P	Poor
Main Drain	0.26	CD/L/Al/P	Fair

The Main Drain has little flow, and the area drained is predominantly intensive pastoral, as is the catchment for the Wairuna Stream. The WQI classifies these sites with higher NH_4 concentrations as either 'fair' or 'poor'.

5.3.2 Dissolved oxygen (DO)

The concentration of oxygen that is dissolved in water and available for respiration by aquatic animals is a crucial indicator of the life-supporting capacity of a stream. DO concentrations usually increase during the daytime, due to photosynthesis, and reduce at night, due to plant respiration and the decay of organic matter. As a result, streams with organic-waste discharges or nuisance algal and weed growth often exhibit large fluctuations in DO, leading to DO depletion at night (MfE, 2009). DO is affected by the volume and velocity of water flowing in the water body, climate and season, altitude, the amount of dissolved nutrients and suspended solids present and the number and type of organisms/plants in the water body (MfE, 2009).

The Third Schedule of the RMA 1991 states that DO levels should not fall below 6 mg/l or 80% saturation. Only the Main Drain dropped below the 6 mg/l concentration; however, four sites recorded levels below 80% saturation, and these are detailed in Table 21.

Table 21 Sites with median dissolved oxygen levels below 80%

Site	Median	% samples above guideline value	REC category (Table 9)	WQI grade
Main Drain	48	84.6	CD/L/Al/P	Fair
Lake Tuakitoto	61.05	71.5	CD/L/HS/P	Poor
Owhiro Stream	74	58.6	CD/L/Al/U	Poor
Taieri at Linnburn Runs Road	79.3	51.8	CD/H/HS/T	Good

The Main Drain is often static, with excessive algal growth occurring during the summer months. Lake Tuakitoto outlet is a low-gradient water course, again with plenty of weed growth. The Owhiro Stream is very shallow with resuspension of sediment by fowl, and the Taieri at Linnburn is also a very slow-flowing segment of the river, with little opportunity for aeration.

The highest median oxygen levels were found at Lake Hawea, Hawea River and the Clutha River/Mata-Au at Luggate.

5.3.3 Water temperature

Large fluctuations instream-water temperature can be detrimental to aquatic life. For example, temperatures exceeding 22°C begin to have lethal effects on some mayfly insects (Quinn *et al.*, 1994), while temperatures over about 30°C may be lethal to some fish, such as inanga/whitebait (e.g. Richardson *et al.*, 1994). Generally, pastoral streams are susceptible to spikes in temperature, due to a lack of shade or channel disturbance reducing natural flows (MfE, 2009).

Water temperature exceeded 20°C at 17 of the 62 sites on at least one occasion during the reporting period. The only sites to exceed 20°C for more than 5% of the time are listed in Table 22.

Table 22 Sites that exceeded 20ºC for more than 5% of the time

Site	Median	% samples above guideline value	REC category (Table 9)	WQI grade
Lake Tuakitoto	12.7	6.06	CD/L/HS/P	Poor
Waikouaiti at Orbells Crossing	11.65	6.25	CD/H/HS/P	Good
Taieri at Sutton	10.05	6.25	CD/H/HS/P	Very good
Lake Hayes	13.7	7.40	CD/H/HS/P	Very good
Lake Waihola	11.55	10	CD/Lk/HS/P	Good
Silver Stream at Taieri Depot	11.6	10	CD/L/HS/P	Very good

Most of the sites are located in lowland areas near the coast; however, three sites originated from hill country (Waikouaiti, Sutton and Lake Hayes). Three of the sites are lake sites with shallow beaches. The water at these sites heats up relatively quickly compared to a flowing river; Lake Hayes stratifies during the summer. The Taieri River at Sutton and the Waikouaiti at Orbells are both low-gradient rivers, with low summer flows. All the sites are mainly pastoral.

The lowest median was recorded at the Taieri at Linnburn Runs Road in Central Otago (6.75DegC). The highest temperature recorded was 25.3°C, taken in the Silver Stream on the Taieri plain. This site has low flows and a shallow uniform channel, with little riparian cover.

5.3.4 Conductivity

Electrical conductivity is a measure of the total dissolved salts or ions in the water. Elevated concentrations may indicate the presence of point-source discharges (e.g. effluent) or diffuse nutrient inputs, but can also be a naturally occurring result of catchment geology (MfE, 2009).

There is no guideline level for conductivity. Those sites with a median conductivity of >0.2mS/cm are shown in Table 23. Two of the sites with the highest conductivity correspond to sites with high median turbidity (Lake Waihola and the Owhiro Stream). Most of the sites have pastoral catchments. It should be noted that Lake Waihola can be tidally influenced.

Table 23 Sites with a median conductivity greater than 0.2mS/cm. The shaded cells represent sites with a tidal influence.

Site	Median	REC category (Table 9)	WQI grade
Shag at Craig Road	0.205	CD/H/HS/P	Very good
Shag at Goodwood	0.21	CD/L/Al/P	Very good
Owhiro Stream	0.222	CD/L/Al/U	Poor
Lake Waihola	0.512	CD/Lk/HS/P	Good
Waiareka Creek	0.845	CD/L/SS/P	Good
Main Drain	2.13	CD/L/Al/P	Fair

The sites with low conductivity (<0.05 mS/cm) were all hill country sites (Lake Onslow, Taieri River at Stonehenge and Linnburn, Luggate Creek, Waipori River, Dunstan Creek, Lake Hawea and Sutton Stream). All the sites had hard sedimentary geology, five had tussock land cover, and one was pastoral.

5.3.5 pH

Changes in the pH value of water affect the organisms that live there. Most aquatic organisms have adapted to a specific pH and may die if even slight pH changes occur. Serious problems occur when pH drops below 5 or increases above 9.5. pH is affected by carbon dioxide, the geology and soils in the catchment, mine drainage, algal blooms and air pollution.

The median value of all 62 sites fell between pH 6.8 and pH 8.65.

The minimum pH fell below 6.5 at 13 sites, and the maximum pH rose above pH 9.0 at 10 sites, four of which recorded more than pH 9.5 (Taieri at Sutton, Lake Johnson and Lake Hayes and the Kye Burn). Of the 13 sites that recorded pH below 6.5, there was a fairly even split between hill and low-elevation sites, although most of the sites were pastoral.

5.4 Sediments and visual quality

Suspended solids and turbidity are important indicators of aquatic habitat and visual quality and affect human values such as fishing, swimming and amenity. If concentrations of suspended solids are too high for prolonged periods, there may not be sufficient light for species to navigate and feed effectively, and juvenile recruitment or passage of fish into catchments may be limited (Richardson and Jowett, 2001). As fine sediments settle out of the water column, benthic habitats may be smothered (MfE, 2009).

High suspended solids concentrations are commonly associated with higher flows and are also naturally elevated in catchments with soft (erosion-prone) geology or sandy-bottomed streams. However, high suspended solids and turbidity (which generally result in low visual clarity (ANZECC, 2000)) may also indicate stream bank and paddock erosion associated with poor land management (MfE, 2009).

The ANZECC (2000) trigger value for turbidity is 5.6NTU. Of the 62 sites, six have median values above the trigger value, two of which are shallow lakes (Waihola and Tuakitoto), one is tidal (Lake Waihola), one is naturally high in sediment (Dart) and the other three (Waipahi, Wairuna and Owhiro) have low flows and drain low-lying intensive pastoral or urban catchments. The sites where >50% of turbidity results were >5.6NTU are listed inTable 24.

Table 24 Sites with a median turbidity greater than 5.6 NTU for more than 50% of results. The shaded cells represent tidal sites.

Site	Median	% samples above guideline value	REC category (Table 9)	WQI grade
Lake Tuakitoto	6.48	51.5	CD/L/HS/P	Poor
Dart at the Hillocks	19	70.4	CX/H/HS/P	Good
Lake Waihola	7.78	72.4	CD/Lk/HS/P	Good
Waipahi at Cairns Peak	8.81	77.8	CW/L/SS/P	Poor
Owhiro Stream	11.6	86.7	CD/L/AI/U	Poor
Wairuna Stream	10.7	100	CD/L/HS/P	Poor

Fourteen sites had very good median turbidity levels of less than 1 NTU. The source of nine of these sites originated from either hill country, lakes or mountainous areas, and included all the large Otago lakes (Wakatipu, Wanaka, Hawea), as well as Lake Dunstan.

6 Trends in water quality

This section looks at the trends in surface water quality at 62 SOE monitoring sites in the Otago region.

6.1 Approach to analysis

To determine whether water quality has improved or degraded, trend analyses was undertaken on water-quality data from each of the 62 core water-quality monitoring sites.

Trends are reported for two time periods:

- the 10-year-period July 2001 until June 2011
- the five-year-period from July 2006 to June 2011. (This shorter time frame is used to highlight recent change, which could be of greater significance to river management.)

6.2 Influence of flow on trends in water quality

Most of the variables affecting water quality are correlated with flow, either positively or negatively.

- In catchments dominated by diffuse source pollution, pollutants (like total phosphorus or *E. coli*) are generally positively correlated with flow, and concentrations increase in high flows because of run-off from land during wet weather or mobilisation from in-channel stores.
- In point-source dominated catchments, the loading of pollutants is relatively constant, so an increase in flow will generally result in reduced concentrations due to dilution.
- Flow adjustment should be done if there is concern over the amount of pollution coming from a catchment because this allows investigation of whether associated loads are increasing or decreasing.
- Flow adjustment should not be done before trend analysis if the main question concerns the actual concentrations in the water body. Non-flow adjusted trends are used extensively to quantify changes in water-quality conditions affecting a particular environmental resource and are appropriate for determining changes in water quality at the monitoring site and examining the overall response of the ecosystem to changing water quality.

Flow-adjusted trends are reported in the main report (section 6), raw trends are reported in Appendix 8.

6.3 Actual and standardised flow data

Some of the water quality sampling sites did not have flow measurements. Therefore, for these sites a standardised flow measurement was used (Ballantine, 2010). For all sites without flow measurement, the flow measurement from the geographically closest (straight-line distance) station that shared the same REC climate and source-of-flow class was used, which also had a record of flow on the date of interest.

The flow (mean flow on the day) recorded on the date of interest at the closest gauging station was standardised by dividing by the mean flow for the entire flow-monitoring period. The standardised flow (i.e. recorded flow divided by mean flow) was sufficient for the purpose of flow adjustment because the interest is the relative change in flow on different water-quality measurement occasions, rather than absolute flow magnitudes (Ballantine, 2010).

The flow-adjustment procedure is built into the Time Trends software and was performed using LOWESS (LOcally WEighted Scatterplot Smoothing) with a 30% span. Every data point in the record was adjusted, depending on the value of flow, as outlined by Smith *et al.* (1996): adjusted value = raw value – smoothed value + median value (where the 'smoothed value' is that predicted from the flow using LOWESS).

For all sites with flow data, actual flow data were used to adjust the data for each analyte.

The non-parametric Seasonal Kendall Sen Slope Estimator (SKSE, Sen, 1968) was used to represent the magnitude and direction of trends in flow-adjusted data that were often subject to appreciable seasonality. Values of the SKSE were normalised by dividing by the raw data median to give the *relative* SKSE (RSKSE), allowing for direct comparison between sites measured as percent change per year. The RSKSE may be thought of as an index of the relative rate of change. A positive RSKSE value indicates an overall increasing trend, while a negative RSKSE value indicates an overall decreasing trend. The SKSE calculations were accompanied by a Seasonal Kendall test with the null hypothesis that there is no monotonic trend. If the associated P-value is 'small' (i.e. $P < 0.05$), the null hypothesis can be rejected (i.e. the observed trend or any larger trend, either upwards or downwards, is most unlikely to have arisen by chance (Ballantine, 2010)).

Note that negative values shown on the y axis in Figure 11 to Figure 19 are a function of flow adjustment, where higher than average values of one variable are paired with lower than average values of the other variable.

6.4 Categorisation of trends

Scarsbrook (2006) recognised that statistical significance of a trend does not necessarily imply a 'meaningful' trend (i.e. one that is likely to be relevant in a management context). Scarsbrook (2006) denotes a 'meaningful' trend as one for which the RSKSE is statistically significant and has an absolute magnitude >1 percent year^{-1} (Ballantine, 2010).

Trends were categorised into four groups as shown in Table 25.

Table 25 Trend categorisation

	Trend categorisation
	Stable trend: A trend (RSKSE value) with a value of exactly zero
	No significant trend: The null hypothesis for the Seasonal Kendall test was **not** rejected (i.e., $P > 0.05$).
🡅🡅 or ⇩⇩	**Significant trend**: The null hypothesis for the Seasonal Kendall test was rejected (i.e., $P < 0.05$), **but** the magnitude of the trend (SKSE) was less than one percent per annum of the raw data median (i.e. the RSKSE value was less than 1 percent year^{-1}). Note that the trend at some sites may be 'significant but not meaningful'. The trend may be up (🡅🡅) or down (⇩⇩).
🡅🡅 **or** ⇩⇩	**Meaningful trend**: The null hypothesis for the Seasonal Kendall test was rejected (i.e., $P < 0.05$), **and** the magnitude of the trend (SKSE) was greater than one percent per annum of the raw data median (i.e. the RSKSE value was greater than 1 percent year-^{1}). The trend may be up (🡅🡅) or down (⇩⇩).

6.5 Clutha catchment

Trends in the Clutha catchment between 2006 and 2011 are shown in Table 26. Nine sites had meaningful trends in at least one of the water-quality analytes monitored between 2006 and 2011. These are shown in Table 26.

Table 26 Clutha catchment: Trends in water quality 2006 to 2011

Site name	Flow data	WQI	NH_4	TN	NNN	TP	DRP	*E.coli*	Turb	SS
Main-stem Clutha										
Clutha at Balclutha	Actual	VG								
Clutha at Luggate Br.	Actual	VG			↑↑					
Clutha at Millers Flat	Actual	VG								
Clutha tributaries										
Cardrona at Mt Barker	Actual	VG								
Dart at The Hillocks	Actual	G								
Fraser at Marshall Road	Standardised	VG								
Hawea at Camphill Br.	Actual	VG			↑↑					
Kawarau at Chards	Actual	VG								
Lindis at Ardgour Road	Actual	VG		↑↑		⇩⇩				
Lindis at Lindis Peak	Actual	VG								
Luggate Creek at SH6	Standardised	G								
Manuherikia at Gallwy	Actual	G							↑↑	
Manuherikia at Ophir	Actual	G		↑↑					↑↑	
Mill Creek at Fish Trap	Actual	VG								
Shotover at Bowens PK	Actual	VG	↑↑							
Matukituki River	Actual	VG								
Waitahuna River	Actual	F					↑↑			
Waiwera River	Standardised	F								
Pomahaka catchment										
Crookston Burn	Standardised	F								
Heriot Burn	Standardised	F		↑↑	↑↑					
Pomahaka at Burkes Fd	Actual	F								
Pomahaka at Glenken	Actual	G								
Waipahi at Cairns Peak	Standardised	P								
Waipahi at Waipahi	Actual	F		↑↑						
Wairuna River	Actual	P								

Water quality in the main stem of the Clutha River/Mata-Au is generally very good The Clutha at Luggate is located just downstream of Lakes Wanaka and Hawea, and although it shows an increasing trend in NNN (Table 26), the longer-term (2001 to 2011) trend (Table 27) shows a decrease in most nutrients.

The Clutha tributaries also have good or very good water quality. Table 26 shows that increasing trends in more than one analyte only occur in the Manuherikia at Ophir (increasing TN and turbidity) and Heriot Burn (increasing TN and NNN). These are shown in Figure 11.

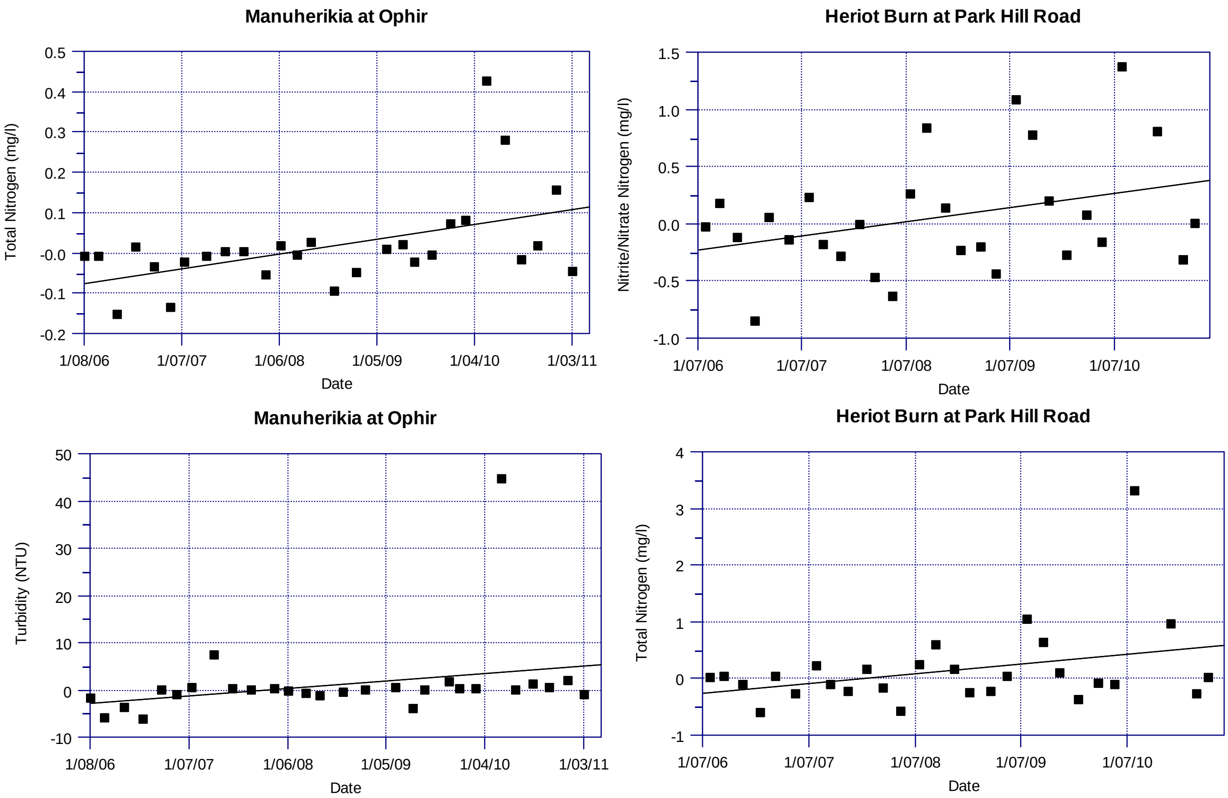


Figure 11 Increasing trends between 2006 and 2011: Manuherikia at Ophir (TN and turbidity) and Heriot Burn (TN and NNN)

The other increasing trends include NH_4 in the Shotover, TN in the upper Lindis River and lower Waipahi River, NNN in the Hawea River, DRP in the Waitahuna River and turbidity in the Manuherikia. There was only one decreasing trend: TP in the lower Lindis River.

Table 27 Core river sites, Clutha catchment: Trends in water quality 2001 to 2011

Site name	WQI	NH_4	TN	NNN	TP	DRP	*E.coli*	Turb	SS
Main-stem Clutha									
Clutha at Balclutha	VG		⇩⇩						
Clutha at Luggate Br.	VG	⇩⇩	⇩⇩	⇩⇩	⇩⇩				
Clutha at Millers Flat	VG				⇩⇩		⇩⇩		
Clutha tributaries									
Cardrona at Mt Barker	VG						⇩⇩		⇩⇩
Dart at The Hillocks	G								
Fraser at Marshall Road	VG								
Hawea at Camphill Bridge	VG			↑↑					
Kawarau at Chards	VG								
Lindis at Ardgour Road	VG				⇩⇩				
Lindis at Lindis Peak	VG								
Luggate Creek at SH6	G								
Manuherikia at Galloway	G								
Manuherikia at Ophir	G		↑↑				↑↑	↑↑	
Mill Creek at Fish Trap	VG		⇩⇩	⇩⇩		↑↑	⇩⇩		⇩⇩
Shotover at Bowens Peak	VG		⇩⇩						
Matukituki River	VG						⇩⇩		
Waitahuna River	F				↑↑	↑↑			
Waiwera at Maws Farm	F								
Pomahaka catchment									
Crookston Burn	F								
Heriot Burn	F								
Pomahaka at Burkes Ford	F				↑↑	↑↑			
Pomahaka at Glenken	G				↑↑	↑↑			
Waipahi at Cairns Peak	P								
Waipahi at Waipahi	F	⇩⇩			↑↑	↑↑			
Wairuna Stream	P								

Table 27 shows that the main stem and tributaries of the Clutha River/Mata-Au have mainly decreasing trends. Mill Creek, which is Lake Hayes' main source of water, shows a decreasing trend in four analytes (TN, NNN, *E. coli*, SS) and one increasing trend in DRP.

The Manuherikia at Ophir shows increasing trends for TN, *E. coli* and turbidity, which is consistent with the 2006 to 2011 trend at this site; and the Hawea River shows an increasing trend for turbidity. The Waitahuna River shows increasing trends for TP and DRP.

Water quality in the Pomahaka catchment ranges from poor to good (WQI). Water in these streams was characterised by high nutrient and *E. coli* bacteria concentrations. Between 2001 and 2011, DRP and TP had an increasing trend at the two main-stem Pomahaka sites and the Waipahi River at Waipahi.

A decreasing trend for NH_4 was found in the Waipahi at Waipahi.

6.6 Lakes

Only two lakes showed any trends during the 2006 to 2011 period (Table 28)

Table 28 Core lake sites: Trends in water quality 2006 to 2011

Site name	WQI	NH_4	TN	NNN	TP	DRP	*E. coli*	Turb	SS
Lake Dunstan	VG								
Lake Hawea	VG								
Lake Hayes	VG								
Lake Johnson	VG								
Lake Onslow	VG					⇩⇩			
Lake Tuakitoto	P								
Lake Waihola	G								
Lake Wakatipu	VG								
Lake Wanaka	VG		⇩⇩						

Of the nine lakes that exhibited a trend in the longer-term dataset (Table 29), seven had a WQI of very good, showing that concentrations of analytes are extremely low. Therefore, a trend (either up or down) has a baseline from a very low concentration. The larger high country lakes (Hawea, Wakatipu and Wanaka) all have increasing turbidity trends. However, Figure 12 shows that the maximum turbidity for these lakes remained very low.

Table 29 Core lake sites: Trends in water quality 2001 to 2011

Site name	WQI	NH_4	TN	NNN	TP	DRP	*E. coli*	Turb	SS
Lake Dunstan	VG				↑↑				
Lake Hawea	VG			⇩⇩				↑↑	
Lake Hayes	VG	⇩⇩			↑↑			↑↑	
Lake Johnson	VG		↑↑		↑↑	↑↑		↑↑	
Lake Onslow	VG	⇩⇩		⇩⇩					
Lake Tuakitoto	P				↑↑	↑↑			
Lake Waihola	G	⇩⇩			↑↑			↑↑	
Lake Wakatipu	VG						⇩⇩	↑↑	
Lake Wanaka	VG			⇩⇩				↑↑	

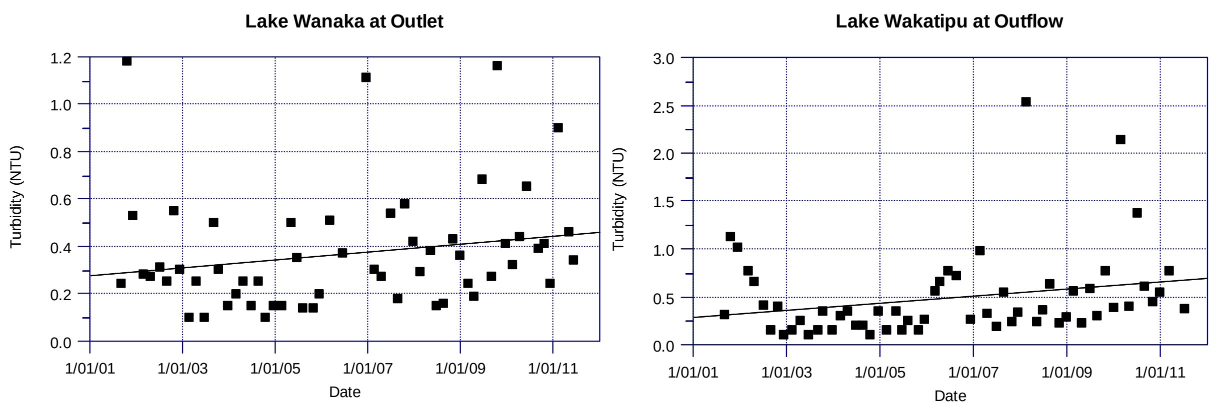


Figure 12 Increasing trends in turbidity between 2001 and 2011: Lake Wanaka and Lake Wakatipu

Turbidity was the most common analyte, with an increasing trend in seven of the nine lakes, and TP also exhibited increasing trends in most of the smaller lakes.

Of the lakes monitored, Waihola and Tuakitoto are shallow, and sediment is prone to wind suspension increasing TP (
Figure 13). Hayes and Johnson also have increasing TP concentrations, probably due to recent algal blooms. Lake Tuakitoto also had an increasing trend for DRP.

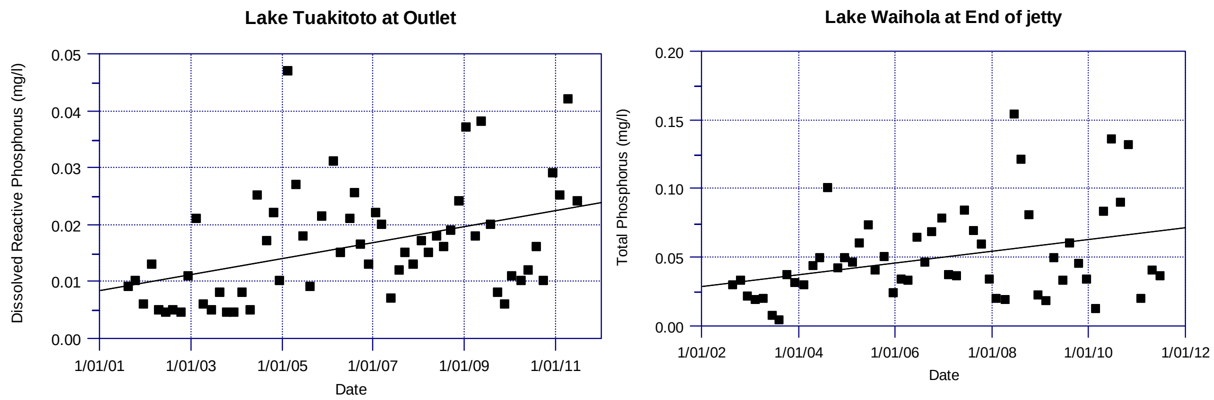


Figure 13 Increasing trends between 2001 and 2011: Lake Tuakitoto (DRP) and Lake Waihola (TP)

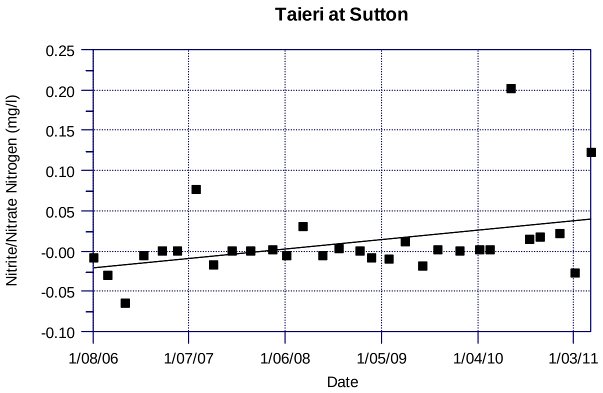
6.7 Taieri River

The Taieri main stem has five sites, which ORC monitors, and two sites monitored by NIWA. Of the seven sites, Linnburn is in the upper catchment, then moving downstream, the sites are Stonehenge, Waipiata, Tiroiti (NIWA), Sutton, Outram (NIWA) and Allanton.

Table 30 shows the trends in the Taieri River. The only sites with increasing trends between 2006 and 2011 were The Taieri at Sutton (NNN), the Taieri at Outram (NNN), the Waipori River (TN, *E. coli*) and the Silver Stream (NNN, DRP). NNN at Outram and Sutton are shown in Figure 14.

Table 30 Core river sites, Taieri catchment: Trends in water quality 2006 to 2011

Site name	Flow data	WQI	NH_4	TN	NNN	TP	DRP	*E. coli*	Turb	SS
Taieri main-stem										
Taieri at Allanton	Actual	VG								
Taieri at Linnburn	Standarised	G								
Taieri at Outram	Actual	VG			↑↑					
Taieri at Stonehenge	Standarised	VG								
Taieri at Sutton	Actual	VG			↑↑					
Taieri at Tiroiti	Actual	F								
Taieri at Waipiata	Actual	G								
Taieri tributaries										
Dunstan Creek	Actual	VG								
Kye Burn at SH85	Standarised	VG								
Main Drain	Standarised	F								
Owhiro Stream	Standarised	P								
Silver Stream	Actual	VG		↑↑			↑↑			
Sutton at SH87	Actual	VG								
Waipori River	Actual	VG		↑↑		⇩⇩		↑↑	⇩⇩	



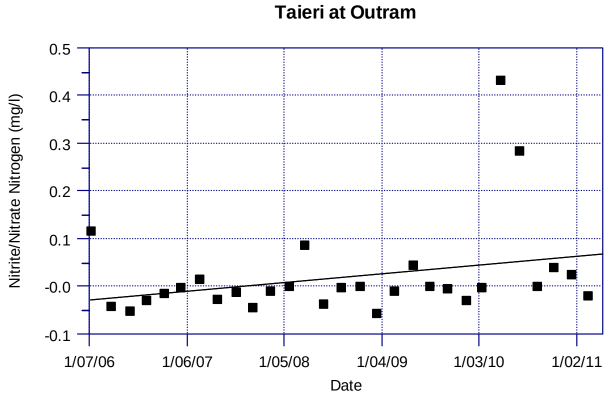


Figure 14 Increasing trends between 2006 and 2011: Taieri at Sutton (NNN) and Taieri at Outram (NNN)

The long-term trends in water quality (2001 to 2011) in the main-stem Taieri River are shown in Table 31.

Table 31 Core river sites, Taieri catchment: Trends in water quality 2001 to 2011

Site name	Flow data	WQI	NH_4	TN	NNN	TP	DRP	*E. coli*	Turb	SS
Taieri main stem										
Taieri at Allanton	Standarised	VG					↑↑		↑↑	
Taieri at Linnburn	Standarised	G								
Taieri at Outram	Actual	VG		↑↑	↑↑					
Taieri Stonehenge	Actual	VG								
Taieri at Sutton	Actual	VG			↑↑					
Taieri at Tiroiti	Actual	G			↑↑					
Taieri at Waipiata	Actual	G	⇩⇩					⇩⇩		⇩⇩
Taieri tributaries										
Dunstan Creek	Actual	VG			↑↑					
Kye Burn at SH85	Standarised	VG								
Main Drain	Standarised	F								
Owhiro Stream	Standarised	P								
Silver Stream	Actual	VG					↑↑			
Sutton at SH87	Actual	VG								
Waipori River	Actual	VG		↑↑		⇩⇩			⇩⇩	

In the Taieri main stem, NNN increases at Tiroiti (Figure 15), Sutton (Figure 15) and Outram. Allanton has increasing DRP and turbidity trends. Decreasing trends were only found at Waipiata (NH_4, *E. coli* and SS).

The increase in NNN was likely to be from the large tracts of land under dairy platform, which are often associated with rising N concentrations. There was no associated increase in TN.

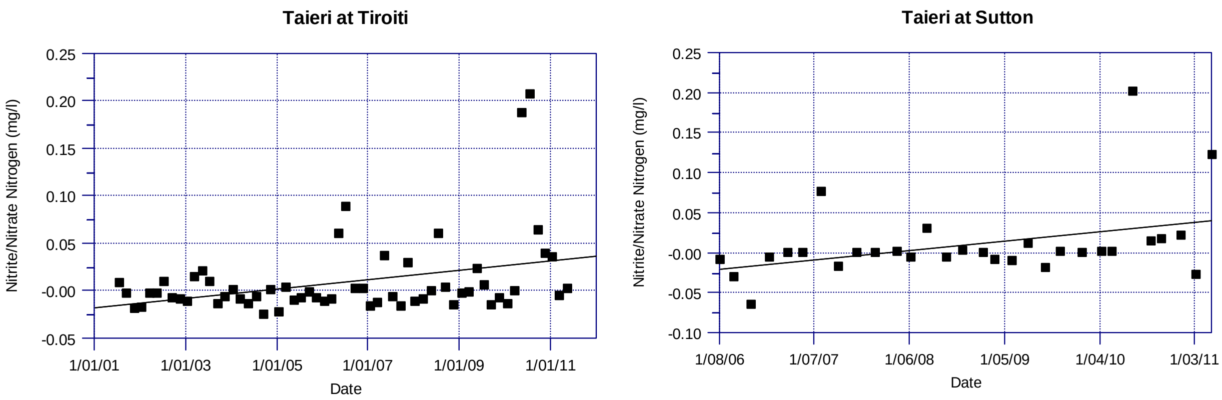


Figure 15 Increasing trends between 2001 and 2011: Taieri at Tiroiti (NNN) and Taieri at Sutton (NNN)

The Taieri tributaries show increasing DRP at Silver Stream, increasing TN in the Waipori River and increasing NNN in Dunstan Creek. Decreasing trends only occur in the Waipori River (TP and turbidity) for both time periods.

6.8 Coastal catchment

Trends in the coastal catchments between 2006 and 2011 are shown in Table 32.

Increasing trends were seen at three sites: TN in the Catlins and Shag rivers, and turbidity in the Tokomairiro River.

Decreasing trends were seen at two sites: Waiareka Creek (a tributary of the Kakanui River) had a decreasing trend in DRP (Figure 16), and *E. coli* had a decreasing trend at the Shag River (Craig Road) site.

Table 32 Core river sites, coastal catchments: Trends in water quality 2006 to 2011

Site name	Flow data	WQI	NH_4	TN	NNN	TP	DRP	*E. coli*	Turb	SS
Southern coastal										
Catlins at Houipapa	Actual	G		↑↑						
Tokomairiro West Br.	Actual	F							↑↑	
Urban										
Kaikorai Stream	Standarised	F								
Leith at Dundas	Actual	F								
Lindsays Creek	Actual	F								
Northen coastal										
Kakanui at Clifton	Actual	VG								
Kakanui at McCones	Actual	VG								
Kauru at Ewings	Actual	VG								
Shag at Craig Road	Actual	VG						⇩⇩		
Shag at Goodwood	Actual	VG		↑↑						
Trotters	Actual	VG								
Waiareka Creek	Actual	G					⇩⇩			
Waikouaiti River	Standarised	VG								
Waianakarua River	Actual	VG								

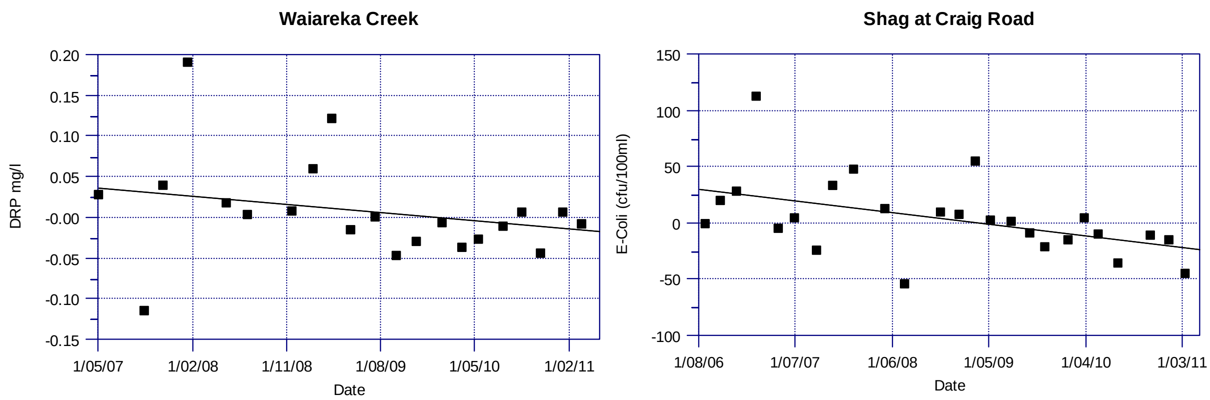


Figure 16 Decreasing trends between 2006 and 2011: DRP in Waiareka Creek and *E. coli* in the Shag River at Craig Road

Water quality in Waiareka Creek remained good despite rapidly changing land use, which is probably due to the introduction of the North Otago Irrigation (NOIC) scheme in 2006. Before the irrigation scheme, land use in the catchment was a mixture of sheep, beef, deer, cropping and some dairy. The land used for dairying has expanded over the last five years, with both conversions and dairy stock being grazed on run-off blocks during winter. The water quality in the Waiareka has a WQI of good.

The long-term water-quality trends (2001 to 2011) are shown in Table 33.

Table 33 Core river sites, coastal catchments: Trends in water quality 2001 to 2011

Site name	Flow data	WQI	NH_4	TN	NNN	TP	DRP	*E. coli*	Turb	SS
Southern coastal										
Catlins at Houipapa	Actual	G		↑↑	↑↑	↑↑	↑↑		↑↑	
Tokomairiro West Br	Actual	G					↑↑			
Urban										□
Kaikorai Stream	Standardised	F								
Leith at Dundas	Actual	F			↑↑		↑↑			⇩⇩
Lindsays Creek	Actual	F	⇩⇩					⇩⇩	⇩⇩	⇩⇩
Northen coastal										
Kakanui at Clifton	Actual	VG					↑↑			
Kakanui at McCones	Actual	VG			↑↑	↑↑				
Kauru at Ewings	Actual	VG						⇩⇩		
Waiareka Creek	Actual	VG					⇩⇩			
Shag at Craig Road	Actual	VG		↑↑	↑↑		↑↑	⇩⇩		
Shag at Goodwood	Standardised	VG		↑↑	↑↑	↑↑	↑↑	⇩⇩		
Trotters Creek	Actual	VG								
Waianakarua River	Actual	F			↑↑					
Waikouaiti River	Standardised	VG								

The five increasing trends in the Catlins River indicate that this area has been subject to considerable development in its upper catchment: the landscape has changed to more intensive farming, with areas of indigenous forest being cleared. Trends in NNN, DRP, Turb and TN are shown in Figure 17.

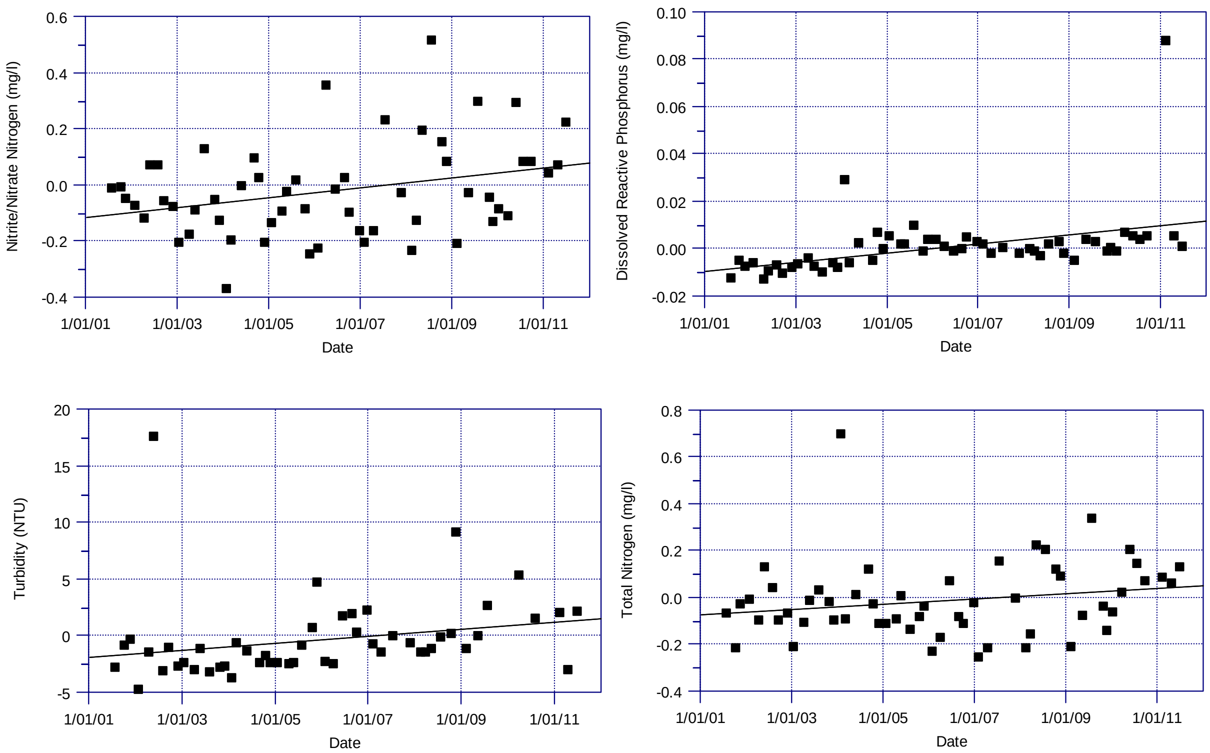


Figure 17 Catlins at Houipapa: NNN, DRP, turbidity and TN show increasing trends between 2001 and 2011

There are three rivers in the Dunedin urban area: the Kaikorai Stream, Water of Leith and its tributary Lindsay's Creek. The Water of Leith had increasing trends in DRP and NNN (Figure 18). Lindsay's Creek had decreasing trends in NH_4, *E. coli*, Turb and SS. The Water of Leith had a decreasing trend with SS.

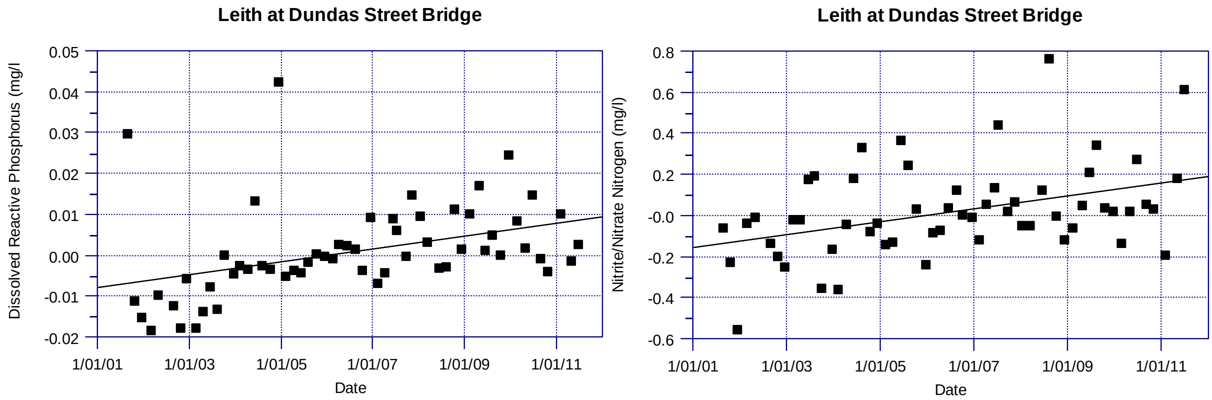


Figure 18 Increasing trends between 2001 and 2011: Water of Leith (DRP and NNN)

The northern coastal area had seven sites with meaningful trends. The Kakanui catchment has long-term monitoring at two sites: Clifton Falls (upper site) and McCones (lower site) both have a WQI of very good. Clifton Falls, which is on the boundary of intensive land use, showed a significant increase in DRP. Dairying has increased over the last ten years in the Kakanui Valley, with an increase in properties either being used for dairy grazing or as milking platforms. Most dairy farms are upstream of the McCones site, which showed an increasing trend in NNN and TP (Figure 19).

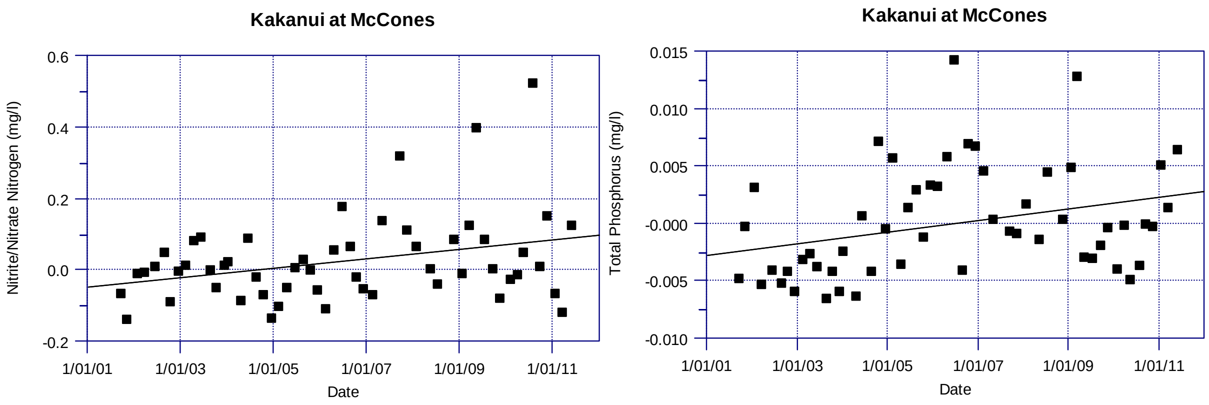


Figure 19 Increasing trends between 2001 and 2011: Kakanui at McCones (NNN and TP)

The Shag River has two long-term monitoring sites. Craig Road is in the mid-catchment and Goodwood is located in the lower catchment. At both sites, there was a decreasing trend in *E. coli* and an increasing trend in TN, DRP and NNN (

Figure 20). At Goodwood, there was also a statistically significant increase in TP.

The Waianakarua River showed an increase in NNN.

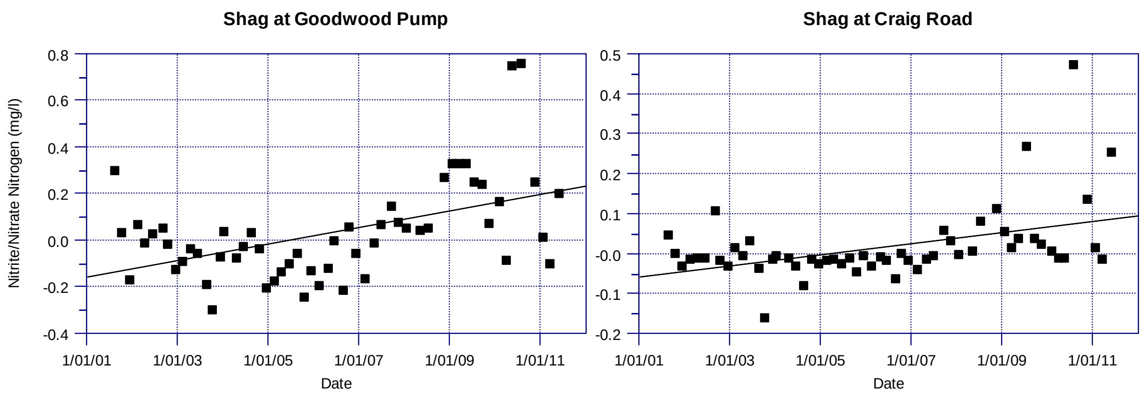


Figure 20 Increasing NNN trends between 2001 and 2011: Shag River at Goodwood and Craig Road

7 Macroinvertebrates

This section summarises macroinvertebrate data collected annually from each of the 27 SOE sites between 2006 and 2011.

7.1 Approach to analysis

As recommended for the reporting of SOE macroinvertebrate data (Stark and Maxted, 2007), the summary presented here focuses on the Macroinvertebrate Community Index (MCI), an index of sensitivity to organic pollution, based on the presence/absence of macroinvertebrate taxa. Additional indices (SQMCI, % EPT taxa and taxa richness) are described in Appendix 2 and presented in Appendix 9. The quality thresholds for interpretation of the MCI scores are outlined in Table 35. Note that there is some flexibility in interpreting the divisions between MCI quality classes, and boundaries should be regarded as 'fuzzy' (Stark and Maxted, 2007). For example, while an MCI score of 98 results in a site classed as fair, it should be considered as 98 ± 5 MCI units and could, therefore, fall within the good class (Perrie 2007). In this report, inter-site comparisons are based on the *mean* MCI score between 2006 and-2011.

7.2 Results

The MCI scores for each SOE site are presented in Table 34, along with the overall mean score for 2006-2011. Based on the mean scores, no sites scored a quality class of excellent 13 sites were graded as good, 11 were graded as fair and three were graded as poor(Figure 21).

Table 34 MCI values for SOE sites sampled between 2006 and 2011

Site name	MCI	2011	2010	2009	2008	2006	Mean	Std dev
Cardrona at Mt Barker	Good	107	99	101	101	100	102	3
Catlins at Houipapa	Good	117	119	109	123	108	115	6
Fraser at Marshall Road	Good	n/a	99	97	106	113	104	6
Heriot Burn at Park Hill Road	Good	95	113	111	100	n/a	105	7
Kaikorai Stream at Brighton Rd	Poor	75	64	63	73	62	67	5
Kakanui at Clifton Falls Bridge	Good	110	101	94	106	n/a	103	6
Kakanui at McCones	Fair	78	90	82	88	n/a	84	5
Kauru at Ewings	Good	109	108	109	99	112	107	4
Leith at Dundas Street Bridge	Fair	92	98	89	n/a	112	97	9
Lindis at Ardgour Road	Good	113	104	96	104	104	104	5
Lindsays Creek at North Road	Fair	97	90	91	83	89	90	4
Luggate Creek at SH6 Bridge	Good	103	104	105	94	107	102	5
Mill Creek at Fish Trap	Fair	78	87	86	89	91	86	4
Shag at Craig Road	Fair	93	95	99	94	n/a	95	2
Shag at Goodwood Pump	Fair	87	91	81	90	n/a	87	4
Silverstream at Taieri Depot	Fair	105	104	97	87	n/a	98	7
Tokomairiro West Branch	Good	113	105	111	119	114	112	5
Trotters Creek at Mathesons	Poor	76	82	75	81	n/a	79	3
Waianakarua at Browns	Good	109	104	123	113	n/a	112	7
Waiareka Creek at Taipo Road	Poor	69	60	64	n/a	n/a	64	4
Waikouaiti at Orbells Crossing	Fair	102	88	84	n/a	n/a	92	8
Waipahi at Cairns Peak	Good	113	114	98	n/a	103	107	7
Waipahi at Waipahi	Fair	101	91	87	n/a	89	92	5
Waipori at Waipori Falls Reserve	Good	109	95	105	n/a	n/a	103	6
Wairuna Stream	Fair	82	103		n/a	n/a	92	11
Waitahuna at Tweeds Bridge	Good	133	102	111	n/a	n/a	115	13
Waiwera at Maws Farm	Fair	97	n/a	82	n/a	n/a	90	8

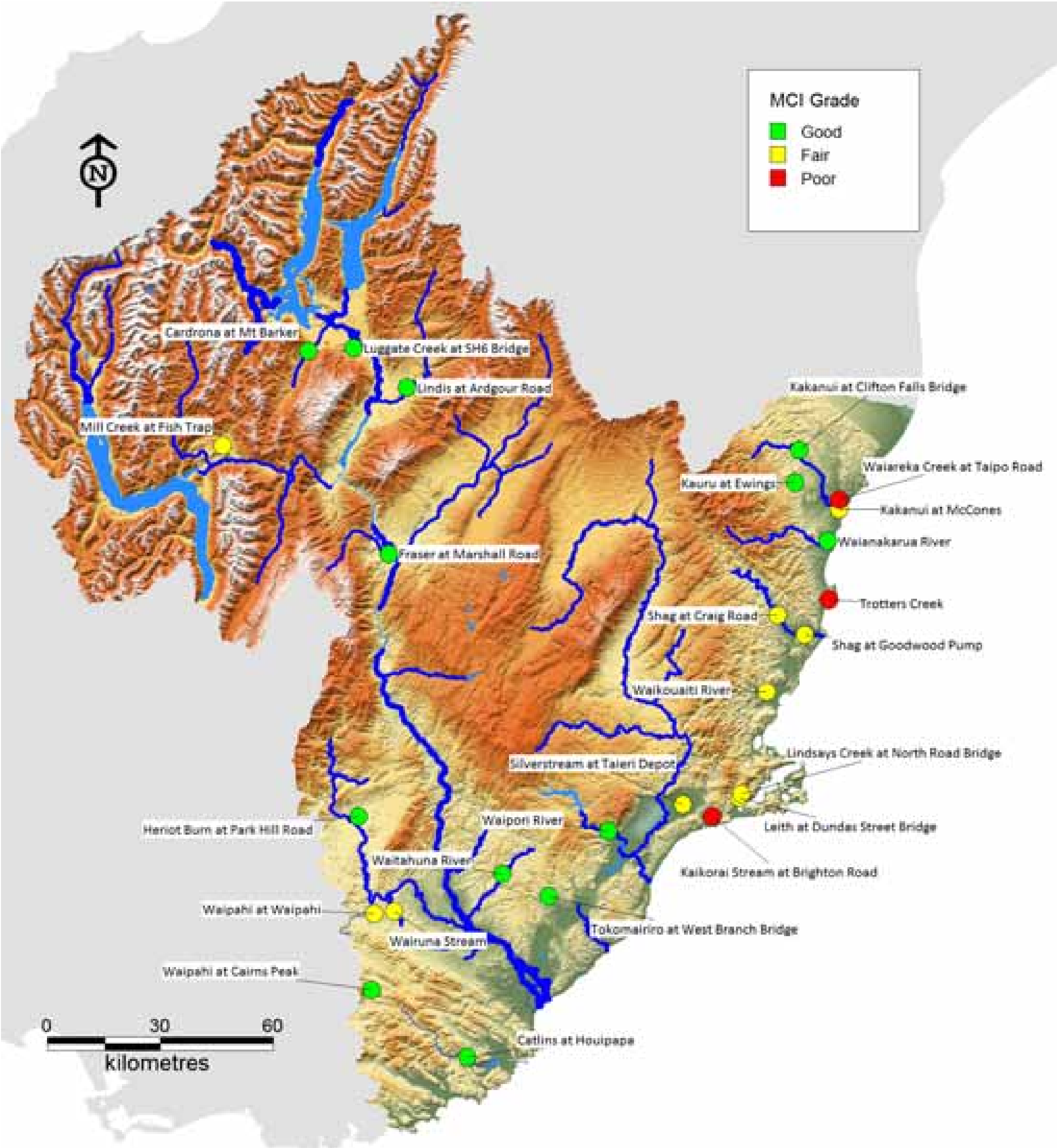


Figure 21 Mean MCI 'grades' for the 27 SOE sites, determined from annual monitoring between 2006 and 2011

Table 35 Interpretation of MCI-type scores (Stark and Maxted, 2007)

Grade	Macroinvertebrate Community Index (MCI)
Excellent	>119
Good	100 to 119
Fair	80 to 99
Poor	<80

7.3 Sites with good MCI scores

Thirteen sites were assigned an MCI grading of good. Most of the sites within this class have low-elevation source-of-flows (six sites) and are mainly drain catchments, dominated by pastoral land cover (10 sites). The other three sites are tussock dominated (Cardrona River, Luggate Creek and Waipori River); two have mountain source-of-flow (Fraser River and Luggate Creek), and the other five sites are fed from hill country. Figure 22 shows the Waitahuna River, the site with the highest MCI score.

Figure 22 The Waitahuna River at Tweeds Bridge had the highest mean MCI score (2006-2011). The substrate is coarse, with little fine sediment, which is ideal for invertebrates.

7.4 Sites with fair MCI scores

Eleven sites had mean MCI scores of fair. Most of these were low-elevation sites, draining pastoral (five sites) or urban catchments (two sites), or hill country sites, draining pastoral catchments (four sites). MCI scores within this class ranged from 84, for the lower Kakanui site at McCones, to 98, for the Silver Stream site on the lower Taieri plain (Table 34).

7.5 Sites with poor MCI scores

Three sites had a mean MCI score of 'poor'. These were all low-elevation sites draining pastoral catchments (two sites) or urban catchments (one site). The site with the lowest mean MCI score was Waiareka Creek at Taipo Road (Figure 23).

Figure 23 Waiareka Creek at Taipo Road had the lowest mean MCI score between 2006 and 2011.

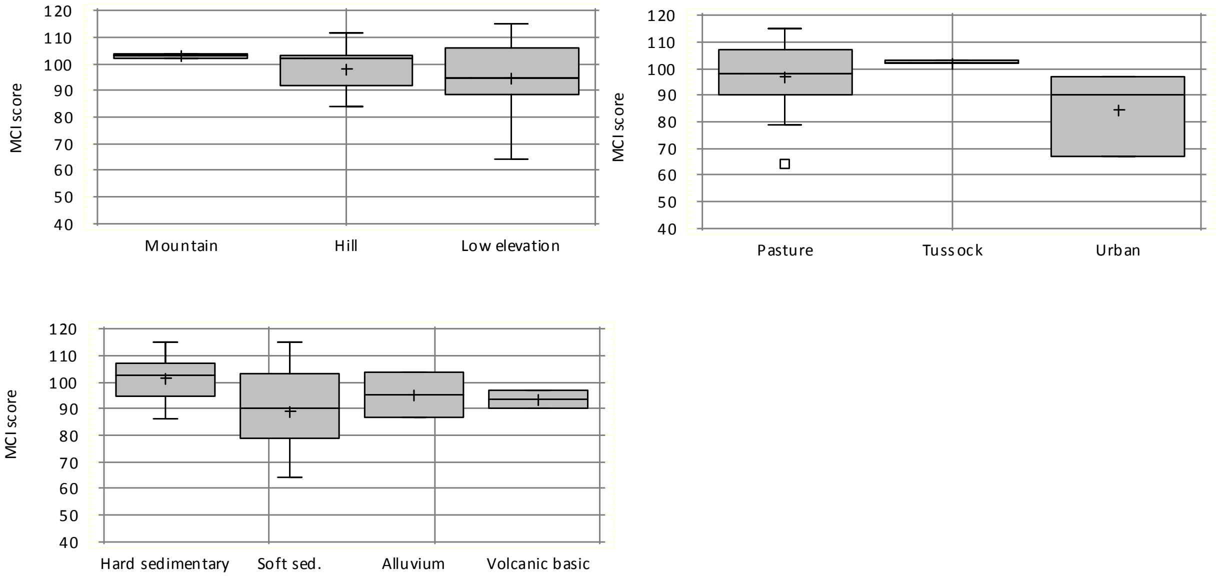


Figure 24 Mean MCI scores across the three main sources of flow classes, the three main land cover classes and the four main geology classes represented in the macroinvertebrate monitoring 2006-2011 data.

Overall, hill sources of flow tended to have higher MCI scores than those at lower elevation, and hard sedimentary geology tended to generate higher MCI scores than sites with soft sedimentary geology. The sites with the lowest MCI scores were all found at low-elevation, on soft sediments in either pastoral or urban settings.

Water quality was poorer in the lowland reaches of small streams draining pastoral catchments, and was particularly poor at some sites draining dairy catchments (e.g. Tokomairiro River). The distance between the headwaters and the estuary is relatively short in this catchment, compared to the Clutha or Taieri catchments, which have more assimilation capacity. Catchments dominated by urban land cover tend to have the poorest water quality in the region. Soft sedimentary geology was common to all the sites with poor water quality (Trotters Creek, Waiareka Creek and Kaikorai Stream). The spatial patterns reported here are consistent with previously reported results at a national scale (e.g. Larned *et al*., 2005); land cover is responsible for most of the observed spatial patterns in water quality and ecosystem health. Other factors, such as climate, source-of-flow and geology, are also known to influence water quality in the region (Perrie, 2007), but these are often inextricably linked with land cover (e.g. most development has occurred at low-elevations, so now catchments dominated by indigenous forest land cover are mostly restricted to higher elevations), or are not easily quantified by the monitoring network (i.e. the majority of sites are in the same climate class under the REC system (Appendix 10)).

7.6 Correlations between water quality and biological data

There was not a good correlation (R^2 = 0.03) (between water quality and biological data) when the sites were ranked by WQI grades and mean MCI scores. The sites with the highest WQI rankings were expected to have the highest mean MCI scores; while sites with the lowest WQI rankings were expected to have the lowest MCI scores (Figure 25).

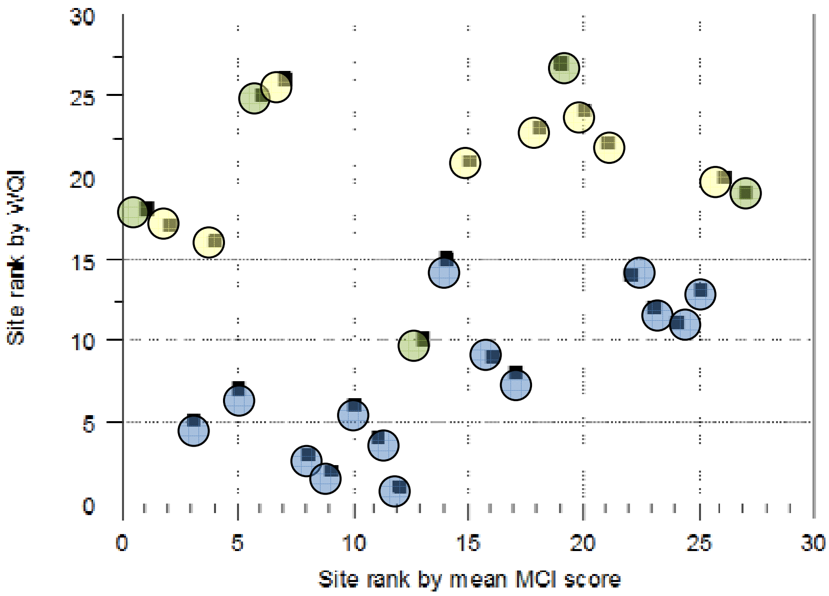


Figure 25 Correlation between water quality ranking (WQI) and MCI ranking. The sites in blue have a WQI of very good green are good and yellow fair

Figure 25 demonstrates a lack of agreement between water quality and macroinvertebrate grades at many sites. For example, of the top seven MCI sites, two had a WQI of good and three had a WQI of fair of the seven sites at the bottom of the MCI scale, four had a WQI of very good (Table 36).

Overall, WQI grades tend to portray SOE sites more favourably than MCI grades. Around 48% of all sites scored a good MCI grade (there were no sites with an excellent MCI grade), compared with 63% of sites, with very good and good WQI grades (Table 36).

Only six of the 27 sites had the same MCI and WQI grade. Most of the rest (8 of 14) had a WQI grade one higher than their respective MCI grade, which suggests that other factors such as habitat quality are more strongly influencing the instream macroinvertebrate community than water quality.

Table 36 Allocation of grades for SOE sites by mean MCI and WQI

Grade	Macroinvertebrate Community Index (MCI)	Water Quality Index (WQI)
Excellent	0	14
Good	13	3
Fair	11	8
Poor	3	2

7.7 MCI grades for 2006-2011 compared with 2001-2005

When the 2006-2011 MCI grades were compared to the 2001-2005 MCI scores, 23 sites were shown to have scored the same MCI grade/quality classification; two sites received higher grades and two sites received lower grades. Both of the sites that showed an improvement in their grading (Kakanui at Clifton and Waipori River) did so by one grade (i.e. from fair to good). As both of these sites had MCI values just below the good threshold in the 2001 to 2006 data, which means that they fall within the ‘fuzzy’ error region for interpreting grades (Stark and Maxted, 2007), these results may not indicate any improvement in macroinvertebrate health.

The two sites with lower MCI grades than for the 2006 to 2011 reporting period were Trotters Creek and the Waiwera River; again the changes in grade fell within the error region for MCI grade threshold interpretation, and so are unlikely to represent an actual decline in the macroinvertebrate community.

8 Discussion

This section focuses on the results of the spatial and temporal analysis discussed in sections 3 and 5, with reference to agricultural intensification and its impact on stream values.

8.1 Approach to analysis

Although the current state of water quality in lowland catchments is well understood, recent trends highlighted in this report show deteriorations in some aspects of water quality, particularly in the Manuherikia, Catlins, mid-Taieri, Kakanui and Shag catchments (Section 6.0). The following discusses the general implications of intensive farming, as well as the results from the temporal and spatial analysis undertaken in this report. Reference is also made to findings from previous ORC reports (e.g. the Manuherikia (ORC, 2011[1]), the Catlins (ORC, 2011[2]), the Pomahaka (ORC, 2011[3]) and the Upper Taieri (ORC, 2012).

8.2 Degrading and improving trends

This study found 30 sites (including lake sites) with meaningful degrading trends over the longer time period (2001 to 2011) (Table 37): 13 sites in the Clutha catchment, two in the Taieri catchment and three in coastal catchments. Two lakes also had meaningful trends. Of these sites, nine also had the same meaningful degrading trends over the shorter time period (2006 to 2011). These are shown as pink cells in Table 37.

Table 37 Sites with degrading water quality between 2001 and 2011. The parameters in red also degrade significantly between 2006 and 2011. The sites in grey refer to those listed in Table 40.

Site name	WQI	TN	NNN	TP	DRP	*E. coli*	Turb
Catlins at Houipapa	G	↑↑	↑↑	↑↑	↑↑		↑↑
Dunstan Creek	VG		↑↑				
Hawea at Camphill Br.	VG		↑↑				
Kakanui at Clifton Falls	VG				↑↑		
Kakanui at McCones	VG		↑↑	↑↑			
Lake Dunstan	VG			↑↑			
Lake Hawea	VG						↑↑
Lake Hayes	VG			↑↑			↑↑
Lake Johnson	VG	↑↑		↑↑	↑↑		↑↑
Lake Tuakitoto	P			↑↑	↑↑		
Lake Waihola	G			↑↑			↑↑
Lake Wakatipu	VG						↑↑
Lake Wanaka	VG						↑↑
Leith at Dundas Street	F		↑↑		↑↑		
Manuherikia at Ophir	VG	↑↑				↑↑	↑↑
Mill Creek at Fish Trap	VG				↑↑		
Pomahaka at Burkes Fd	G			↑↑	↑↑		
Pomahaka at Glenken	F			↑↑	↑↑		
Shag at Craig Road	VG	↑↑	↑↑		↑↑		
Shag at Goodwood	VG	↑↑	↑↑	↑↑	↑↑		
Silver Stream at Taieri	VG				↑↑		
Taieri at Allanton Br.	VG				↑↑		↑↑
Taieri at Outram	VG	↑↑	↑↑				
Taieri at Sutton	VG		↑↑				
Taieri at Tiroiti	G		↑↑				
Tokomairiro West Br.	G				↑↑		
Waianakarua River	VG		↑↑				
Waipahi at Waipahi	F			↑↑	↑↑		
Waipori River	VG	↑↑					
Waitahuna River	G			↑↑	↑↑		

The sites of concern in Table 37 include the Catlins River/Mata-Au (five increasing trends), Shag River (four increasing trends), Manuherikia River (three increasing trends) and increasing NNN in the main-stem Taieri (Sutton and Tiroiti). These are shown in Table 37.

Table 38 shows the 23 sites (including lake sites) with meaningful improving trends over the longer time period (2001 to 2011), including nine sites in the Clutha catchment, two in the Taieri catchment and six in the coastal catchments. Six lakes also had meaningful trends. Of these sites, three also had the same meaningful degrading trends over the shorter time period (2006 to 2011). These are shown as blue cells in Table 38.

Table 38 Sites with improving water quality between 2001 and 2011. The parameters in blue also improve significantly between 2006 and 2011.

Site name	WQI 06 to 11	NH_4	TN	NNN	TP	DRP	*E. coli*	Turb	SS
Cardrona at Mt Barker	VG						⇩⇩		⇩⇩
Clutha at Balclutha	VG		⇩⇩						
Clutha at Luggate Br.	VG	⇩⇩	⇩⇩	⇩⇩	⇩⇩				
Clutha at Millers Flat	VG				⇩⇩		⇩⇩		
Kauru at Ewings	VG						⇩⇩		
Lake Hawea	VG			⇩⇩					
Lake Hayes	VG	⇩⇩							
Lake Onslow	VG	⇩⇩		⇩⇩					
Lake Waihola	VG	⇩⇩							
Lake Wakatipu	VG						⇩⇩		
Lake Wanaka	VG			⇩⇩					
Leith at Dundas	F								⇩⇩
Lindis at Ardgour Road	VG				⇩⇩				
Lindsays Creek	F	⇩⇩					⇩⇩	⇩⇩	⇩⇩
Matukituki River	VG						⇩⇩		
Mill Creek at Fish Trap	VG		⇩⇩	⇩⇩			⇩⇩		⇩⇩
Shag at Craig Road	VG						⇩⇩		
Shag at Goodwood Pump	VG						⇩⇩		
Shotover at Bowens Peak	VG		⇩⇩						
Taieri at Waipiata	G	⇩⇩					⇩⇩		⇩⇩
Waiareka Creek	G					⇩⇩			
Waipahi at Waipahi	F	⇩⇩							
Waipori at Waipori Falls	VG				⇩⇩			⇩⇩	

8.3 Intensive farming and water quality

Intensive farming has an impact on the natural environment, especially on our waterways (Davies-Colley *et al.,* 2004) and the public also concur with this view (Hughey *et al.,* 2008). ORC monitoring has shown that compared to sheep/beef farming, dairying is responsible for some of the poorest water quality outside of our urban centres (ORC, 2011[3]).

The contaminant losses from intensive dairying are often greater per hectare than from other land uses (MfE, 2009), and the contaminants reach waterways from a combination of point and non-point (diffuse) sources. Point-source discharges in dairy catchments are mainly due to the disposal of stock effluent from farm oxidation ponds (MfE, 2009). The diffuse pollutants of primary concern are nutrients from livestock wastes (including urine patches) and fertiliser run-off (Monaghan *et al*., 2007), microbial contaminants from livestock faeces (Collins *et al*., 2007), and sediment from eroded banks and paddocks (Niyogi *et al*., 2007).

8.4 Nutrients

As land use intensifies, particularly with the introduction of intensive dairy farming, there may be a corresponding increase in the amount of NNN in waterways. ORC monitoring (2010 to 2011) of the Taieri catchment highlighted increasing concentrations of NNN from Linnburn to Sutton (ORC, 2012). This present report shows a trend of increasing NNN concentrations in the main-stem Taieri River at Tiroiti and Sutton. The increase in NNN is probably due to the large tracts of land under dairy platform, which is often associated with rising N concentrations. There was no associated increase in TN.

TN showed an increasing trend (2001 to 11) at six sites, including the Manuherikia at Ophir and the Catlins at Houipapa. The Manuherikia report (ORC, 2011[1]) highlighted degradation in water quality from the top of the catchment (compared to Galloway, downstream of Ophir), which is probably due to tributaries with degraded water quality during low flows, caused by irrigation run-off. The Catlins report (ORC, 2011[2]) noted that 'until recently, farming in the area has traditionally been sheep and beef grazing; however, land-use is changing and more intensive farming is now prevalent'. The increase in TN probably reflects these land-use changes.

Phosphorus is generally lost to pastoral waterways from paddock run-off of eroded soil and fertiliser, as well as from effluent-pond discharges (either directly or through a land application) (McDowell *et al*., 2008). This present report has found increasing trends of DRP in four of the seven Pomahaka River catchment sites. The Pomahaka report (ORC, 2011[3]) noted an increase in nutrients at the lower main-stem site (Burkes Ford), compared to that at the upstream main-stem site (Glenken), due to tributaries with poor water quality discharging into the Pomahaka between the two sites.

The Taieri report (ORC, 2012) noted that DRP increased between Linnburn and Waipiata, probably as a result of irrigation run-off that flows directly into the Taieri River. There is anecdotal evidence suggesting that there are a few channels that pick up irrigation run-off and flow directly into the Taieri River. Irrigation run-off has been proven to contain elevated levels of phosphorus (McDowell and Rowley, 2008; Monaghan *et al*., 2009). Furthermore, cattle have often been seen in the Styx wetland and on the banks on the Taieri River (ORC, 2012). This report did not show significant trends in DRP in the Taieri other than at Allanton (main stem) and the Silver Stream (Taieri Plain).

There were also increasing trends in DRP at six of 14 coastal catchment sites. The rivers of most concern are the Kakanui and Shag, as these catchments are under increasing agricultural intensification, and flows are low during the summer months. The Catlins River is also of concern, as previously mentioned. Increasing trends in TP tended to be found at the same sites as those with increasing trends of DRP, as well as at the Shag River at McCones.

At the moment, only three sites are N limited (Table 19); however, if more intensive land use becomes widespread, there is the potential for NNN concentrations to increase, and waterways will no longer be N limited. However, this has not yet happened; even the Washpool Stream (in the Pomahaka River catchment, south-west Otago) was N limited, although dairy farming consisted of about 79% of the catchment area. While there are fewer tile and mole drains outside south-west Otago, there is the risk (albeit, low) that NNN concentrations may increase as more intensive farming moves into catchments, which may reduce the NNN: DRP ratios and lead to more algal and macrophyte growth.

8.5 Bacteria

Faecal material reaches streams in various ways, including run-off from the land, effluent-pond discharges, stock defecating directly into the water, sewage discharges from municipal works and storm-water discharges. Table 39 shows sites where the more than 40% of samples taken at a site exceed the MfE/MoH green surveillance level of 260 *E. coli* per 100ml.

Table 39 Sites where more than 40% of *E. coli* results exceeded 260 *E. coli/100ml*

Site name	WQI grade	WQI rank	% samples >260 cfu/100ml	REC (Table 9)
Crookston Burn	Fair	58	75	CD/L/AI/P
Heriot Burn	Fair	57	62	CD/L/HS/P
Kaikorai Stream	Fair	50	56	CD/L/SS/U
Lindsay's Creek	Fair	52	50	CD/L/VB/U
Owhiro Stream	Poor	61	40	CD/L/Al/U
Taieri at Tiroiti	Fair	47	40	CD/H/HS/P
Tokomairiro River (west branch)	Fair	49	41	CD/L/HS/P
Waipahi at Cairns Peak	Poor	60	48	CW/L/SS/P
Wairuna Stream	Poor	62	59	CD/L/HS/P
Waitahuna River	Fair	53	42	CD/L/HS/P
Water of Leith	Fair	48	46	CW/L/VB/U

Five of the sites had >50% non-compliance with the MfE target value (260 *E.coli* per 100ml). Of these sites, Lindsay's Creek and the Kaikorai Stream are urban streams in Dunedin, while the other streams all drain low-elevation country, whose agricultural activities are intensive and heavily biased towards dairy farming. Microbiological contamination in low-elevation, pastoral and urban catchments is common. The sites with some of the highest percentage non-compliance are found in south west Otago, particularly in the area south of the Clutha (Crookston Burn, Heriot Burn, Waipahi and Wairuna). This area has intensive land use, high rainfall, saturated soils and is located where drainage is enhanced by tile and mole drains (ORC, 2011[3]).

Tile drainage systems are found in areas prone to saturated soils throughout much of south-west Otago. Streams drained by catchments with tile drains are likely to have elevated *E. coli* and nutrient levels, which can be partly attributed to these drains carrying contaminated surface water run-off to the nearest watercourse. The Pomahaka Report (ORC, 2011[3]*)* details that (*E. coli*) levels were high from both dairy and sheep tile-drained land after rainfall, with the two highest concentrations recorded from sheep farm drains.

Lindsay's Creek in Dunedin had a high non-compliance of *E. coli* concentrations (50%), but this was much less than the 94% non-compliance obtained between 2001 and 2006. Although the urban streams are not commonly used for full immersion recreational activities, they are often used as a focus for family activities (i.e. picnics, paddling etc.). The high levels of faecal bacteria indicate a higher health risk arising from these activities. The Dunedin City Council is aware of the high faecal bacteria levels in Dunedin's streams; however, they do not know of any regular sewage overflow or cross connection that may be causing these elevated levels.

8.6 Macroinvertebrates

A key component of the MCI is the availability of suitable habitat. The MCI is designed specifically for stony riffle substrates in flowing water. Deep and very slow flowing habitat, providing only muddy and weedy substrate, is not suitable for most aquatic insect taxa, particularly the sensitive members of the mayflies, stoneflies or caddisflies; in these habitats lower MCI values can be expected.

Only six of the 27 sites had the same MCI and WQI grade. Most of the others (8 of 14) had a WQI grade one higher than their respective MCI grade, which suggests that habitat quality is more strongly influencing the instream macroinvertebrate community than water quality.

Physical habitat plays an important role in the ecological health of a river system, as it not only provides refuge for macroinvertebrates and fish, but also provides breeding grounds for a number of fish species (McDowall, 2000). When habitat is degraded, mainly through the input of fine sediment, instream habitat can be smothered, reducing the amount of available habitat for macroinvertebrates (Death, 2000).

Sources of sediment include unstable banks, due to the loss of riparian vegetation, and bank collapse, due to stock access and natural erosion. The primary cause of ecological degradation in the Pomahaka catchment is the introduction of fine sediment, which smothers the larger substrate that provides habitat and refuge for fish and macroinvertebrates (ORC, 2011[3]). The relationship between bank instability and loss of riparian vegetation was pronounced in some south-west Otago streams, including the Wairuna and Heriot Burn (ORC, 2011[3]). In the Catlins (ORC, 2011[2]), riverbank collapse, caused by stock grazing in riparian zones, is a major source of sediment, as is pugging (due to stock access).

8.7 Actions to reduce the impact of intensive agriculture

Actions to reduce the impacts of intensive agriculture include fencing to keep stock from waterways, riparian planting, provision of stock drinking water (ORC, 2011[2]), improved control of effluent discharges, bridging and culverting of streams, wintering off stock, and adopting fertiliser management plans and nitrification inhibitors (MfE, 2009)

Most fine sediment sources could probably be eliminated by fencing streams. The fences would exclude stock from creating tracks to the stream, which become sediment sources during higher flows. Fences also allow riparian buffers to form, which filter out pollutants entering waterways through overland flow of excess water.

Appropriate riparian management is vital to maintaining the quality and ecological values of rivers and streams. Healthy riparian zones reduce the impact of land-based processes by reducing erosion (i.e. by slowing down the speed of overland water flow before it reaches the river) and filtering inputs of sediment, nutrients and bacteria in overland flow. Riparian zones also protect banks from erosion and buffer the impact of floods. Riparian zones are also instrumental in preventing nuisance aquatic plant growths, primarily by maintaining lower summer maximum water temperatures and reducing light levels.

Some contaminant sources and pathways, particularly diffuse ones, are notoriously difficult to manage. For example, small headwater streams can make substantial contributions to the overall pollutant loading of a stream, but can also be hard to isolate from farm activities (by fencing and planting) because of their number and the extent of the drainage area (MfE, 2009).

9 Conclusions

Water quality in rivers and streams across the Otago region shows a clear spatial pattern related to land cover. Water quality is highest at SOE sites, where catchments are dominated by tussock. These sites tend to be associated with the upper catchments of large rivers and the outlets from large lakes (Wakatipu, Hawea and Wanaka).

Water quality is poorer at sites located on smaller, low-elevation stream reaches draining pastoral or urban catchments, particularly those that are prone to saturated soils and/or characterised by soft sedimentary substrates. The sites with the poorest water quality between 2006 and 2011 drain:

- intensive-farming catchments, such as those located in south and south west Otago. The main problems with water quality in this area are either high nutrient levels and/or high bacteria levels
- catchments dominated by urban land cover, in particular, the Dunedin urban streams.

Thirteen SOE sites were assigned higher WQI grade in 2006 to 2011, compared with 2001 to 2006. Ten sites were assigned a lower WQI grade during the same reporting period. This decline in water quality is largely related to three variables: DRP (seven sites), *E. coli* (four sites) and turbidity (three sites), as shown in Table 40.

Table 40 Analytes ticked are those that met guidelines in 2001-06, but exceeded guidelines in 2006-11. The sites shown have dropped at least one WQI grade.

Site name	WQI 2001 - 06	WQI 2006 - 11	NNN	NH_4	DRP	*E. coli*	Turbidity	DO
Kaikorai Stream	Good	Fair			✓			
Lake Tuakitoto at outlet	Very good	Poor			✓	✓	✓	✓
Lake Waihola	Very good	Good					✓	
Main Drain	Good	Fair			✓			
Owhiro Stream	Fair	Poor						✓
Pomahaka at Burkes Ford	Good	Fair	✓					
Taieri at Tiroiti	Good	Fair			✓	✓		
Tokomairiro West Branch	Good	Fair			✓			
Waipahi at Cairns Peak	Fair	Poor			✓	✓	✓	✓
Waitahuna River	Good	Fair			✓	✓		

There were discrepancies between water quality and macroinvertebrate health: WQI results often indicated better water quality than the MCI grades suggested. It is likely that another factor, such as habitat quality, was more strongly influencing the instream macroinvertebrate community than water quality.

To determine whether water quality had improved or declined, 372 trend analyses, for the period 2001 to 2011, were undertaken for NH_4, TN, NNN, TP, DRP, *E.coli* and turbidity from each of the 62 core water-quality monitoring sites. The results are shown in Table 41.

The trend analyses (2001-2011) showed that 9% were improving and 15% were degrading trends. Ten sites showed an improving trend for *E. coli* (indicating improved effluent disposal); whereas 11 sites degraded in NNN, 12 in TP and 15 in DRP. Over the shorter time period, 6% showed degrading trends and 2% improving trends.

Table 41 Improving or degrading trends in water-quality analytes over two time periods

	2001 to 2011		2006 to 2011	
	Improving WQ	**Degrading WQ**	**Improving WQ**	**Degrading WQ**
NH4 (of 62 sites)	7	0		1
TN(of 62 sites)	4	7	1	8
NNN (of 62 sites)	5	11		5
TP (of 62 sites)	4	12	2	
DRP (of 62 sites)	1	15	2	2
Ecoli (of 62 sites)	10	1	1	1
Turb (of 62 sites)	2	9	1	3
TOTAL (of 372 analytes)	33	55	7	20
%	8.87	14.78	1.88	5.38

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Appendix 1 Water quality: Parameters (MfE 2009)

Parameters	What do they measure and/or tell us?
Nutrients	
Dissolved reactive phosphorus (DRP) and nitrite/nitrate nitrogen (NNN)	• Dissolved inorganic nutrient concentrations (ammoniacal nitrogen, nitrite-nitrate nitrogen and dissolved reactive phosphorus) are most relevant for predicting the potential for nuisance plant growth because they are the principal forms available to plants (i.e. soluble). When concentrations are too high, problems such as algal blooms, excessive weed growth and the loss of species occur. • Abundant plant growth, such as algal blooms, leads to increased pH and turbidity and sometimes to the production of toxins and odour. • Nitrate may be harmful to livestock in sufficient concentrations.
Total nitrogen (TN) and total phosphorus (TP)	• Total nutrient concentrations are also relevant in surface waters, because particulate matter can settle out in quiescent areas and become biologically available to plants via mineralisation.
Bacteria	
Escherichia coli (*E. coli*)	• Measure of faecal matter (effluent) in the water • Affects recreational (e.g. swimming, fishing) values and stock drinking water quality
Stressors and toxicants	
Ammoniacal nitrogen (NH_4)	• Ammonia is very soluble in water and can be toxic to aquatic life, especially fish. Toxicity is a function of both temperature and pH. • Ammonia is rarely found in any significant amounts in natural waters, and its presence most commonly indicates the presence of domestic, agricultural or industrial effluent
Dissolved oxygen (DO)	• Dissolved oxygen (DO) is the amount of available oxygen in the water and is essential for the respiration of fish, aquatic animals and plants. To have a healthy system, DO must remain at high levels, so water polluted with organic matter or nutrients such as nitrates, or overpopulated with bacteria, will reduce the amount of DO available to other organisms.
Temperature (Temp)	• Temperature changes can promote nuisance weed growth and have undesirable effects on aquatic species.
Measures of clarity	
Suspended solids (SS) and turbidity (Turb)	• Measures of fine solids in the water (sediment from erosion, soil loss and organic matter from direct discharges) • Suspended particles decrease the ability of light to pass through water and so limit plant and fish growth and food sources. Poor clarity can also affect the ability of sight-feeding predators, such as fish and birds, to locate food. It can also disrupt respiration, causing fish death. Prolonged poor clarity will change the stream habitat and cause a severe reduction in aquatic life. Poor clarity also reduces the suitability for bathing and angling.
Biological	
Stream macroinvertebrates	• Important indicators of general stream health and condition and aquatic biodiversity. Their advantage over spot measurements of chemical and physical properties is that communities of macroinvertebrates reflect long-term conditions.
Stream flow	
	• Natural hydrological flow regime of a catchment, which is required to interpret natural perturbations and influences on any information collected. Non-point source contamination often peaks during high-flow events because contaminants are washed in from the catchment.

Appendix 2 Macroinvertebrate monitoring methods

Macroinvertebrates include insect larvae (e.g. caddisflies, mayflies and stoneflies), aquatic worms (oligochaetes), aquatic snails and crustaceans (e.g. amphipods, isopods and freshwater crayfish). Macroinvertebrates can serve as good indicators of ecological change in freshwater environments. For example, different macroinvertebrate species have different tolerances to environmental factors, such as dissolved oxygen, chemical pollutants and fine sediment. The presence or absence of different species can also indicate changes in water quality.

Samples were collected according to the 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 were processed for macroinvertebrate species identification and their relative abundance using the semi-quantitative protocols outlined in Protocol 'P1: Coded abundance'.

10.1.1 Macroinvertebrate indices

Species richness is the total number of species (or taxa) collected at a sampling site. In general terms, high species richness may be considered good, though often mildly impacted or polluted rivers with slight nutrient enrichment can have higher species richness than naturally healthy streams and rivers.

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

The MCI, developed by Stark (1985, 1993, 1998), is used for assessing organic enrichment of stony or hard-bottomed streams, by sampling macroinvertebrates from riffle habitats. The index is based on adding the pollution-tolerance scores of all species found at a site. Species that are very sensitive to pollution score highly, whereas more pollution tolerant species receive a low score.

MCI values are calculated as follows:

$$MCI = \frac{\sum_{i=1}^{i=S} a_i}{S} \times 20$$

where S = the total number of taxa in the sample, and a_i = the score for the ith taxon.

Taxa are scored between 1 and 10, with low scores indicating high tolerance to organic pollution and high scores indicating taxa that will only be found in pristine rivers (Stark, 1985). A site score is obtained by summing the scores of individual taxa and dividing this total by the number of taxa present at the site, then multiplying by 20. Scores can range from 0 (no species present) to 200, with different scores indicating different pollution status.

The Semi-quantitative Macroinvertebrate Community Index (SQMCI) is a variation of the MCI that accounts for the abundance of pollution sensitive and tolerant species. The SQMCI is calculated from coded count data (individual taxa counts are assigned to one of Rare (R), Common (C), Abundant (A), Very Abundant (VA) or Very Very Abundant (VVA) abundance classes) as follows:

$$SQMCI = \sum_{i=1}^{i=S} \frac{(n_i \times a_i)}{N}$$

where S = the total number of taxa in the sample, n_i = the coded abundance for the ith scoring taxon (i.e. R=1, C=5, A=20, VA=100, VVA=500), a_i = the score for the ith taxon and N = the total of the coded abundances for the entire sample. The QMCI and SQMCI indices range from 0 to 10.

The table below categorises the results for each index into poor, fair, good and excellent. However, it needs to be noted that MCI and QMCI scores may be affected by a number of factors other than pollution (e.g. bed stability, recent flow conditions and regimes, water temperature and habitat type). Consequently, a useful approach is to compare MCI and QMCI scores upstream and downstream of an impact. In such a situation, the differences between scores for the index are much more important than the actual scores.

A key component of the MCI is the availability of suitable habitat. The MCI is designed specifically for stony riffle substrates in flowing water. MCI values can vary due to the availability of suitable habitat and are not necessarily due to water quality. As substrate type can vary greatly between riffles, it is often more appropriate to compare changes in MCI values at the same site over a period of time rather than between sites throughout the catchment. However, by understanding the limitation of the MCI, it still can be useful for picking up improvements or deterioration in water quality at individual sites over time.

Criteria for macroinvertebrate health according to different macroinvertebrate indices

Macroinvertebrate Index	Poor	Fair	Good	Excellent
MCI	<80	80 - 99	100 – 119	>120
SQMCI	<4	4 – 4.99	5 – 5.99	>6
Total species	<10	15 – 20	20 – 30	>30
Total EPT species	<5	9 - 15	15 – 20	>20

Appendix 3 Water quality statistics 2001 to 2011

Cardrona River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
22/08/02-9/06/11	56	62	62	62	62	62	62.0	61.0	59	61.0	43.0	62.0	62.0
Minimum	0.045	0.004	0.009	0.005	0.001	1	0.9	0.2	0.0472	6.3	83.0	7.0	0.7
Maximum	0.31	0.175	0.05	0.259	0.137	920	112.0	45.8	0.15	15.4	125.0	9.2	20.2
Mean	0.128	0.056	0.011	0.015	0.007	81	9.9	3.5	0.0883	11.5	100.3	7.7	9.0
Median	0.115	0.043	0.009	0.008	0.005	40	2.0	1.3	0.086	11.6	99.1	7.7	9.2
Catlins River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
24/07/01-20/06/11	82	82	82	82	82	82	81.0	63.0	59	58.0	43.0	63.0	63.0
Minimum	0.2	0.048	0.009	0.006	0.002	6	0.9	1.3	0.005	8.4	88.0	6.6	3.8
Maximum	1.28	0.963	0.07	0.504	0.106	3920	43.0	43.8	0.131	14.9	132.0	9.1	16.5
sMean	0.533	0.353	0.012	0.037	0.016	227	5.9	4.7	0.0982	11.6	100.8	7.4	9.0
Median	0.51	0.333	0.01	0.032	0.015	110	4.0	3.0	0.103	11.4	101.0	7.4	8.6
Clutha Balclutha	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
18/07/01-15/06/11	120	120	120	120	120	34		120.0	120	118.0	118.0	120.0	120.0
Minimum	0.052	0.005	0.001	0.003	0.001	1		0.3	0.0656	9.1	94.4	7.4	5.8
Maximum	0.93	0.515	0.029	0.114	0.02	411		460.0	0.1183	12.8	110.6	8.4	20.5
Mean	0.195	0.097	0.004	0.014	0.003	50		9.1	0.0739	10.9	100.8	7.8	12.2
Median	0.144	0.061	0.003	0.009	0.001	10		1.7	0.0726	10.8	100.8	7.8	12.0
Clutha Luggate	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
18/07/01-14/06/11	120	120	120	119	120	42		120.0	120	120.0	120.0	120.0	120.0
Minimum	0.028	0.009	0.001	0.001	0.001	1		0.2	0.0607	9.3	99.7	7.7	8.7
Maximum	0.347	0.066	0.01	0.248	0.008	86		45.0	0.0761	12.8	123.1	9.1	19.1
Mean	0.079	0.032	0.003	0.006	0.001	8		5.2	0.0685	11.0	107.0	8.2	12.7
Median	0.077	0.03	0.002	0.003	0.001	3		2.2	0.0692	11.0	106.1	8.2	12.3
Clutha Millers Flat	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
17/07/02-14/06/11	106	108	108	107	108	38		108.0	108	108.0	108.0	108.0	108.0
Minimum	0.043	0.013	0.001	0.002	0.001	1		0.2	0.0648	9.3	96.3	7.6	5.5
Maximum	0.193	0.086	0.008	0.029	0.004	127		48.0	0.0838	12.7	109.0	8.2	18.5
Mean	0.091	0.033	0.002	0.008	0.001	11		3.8	0.071	10.9	101.3	7.8	11.8
Median	0.087	0.03	0.002	0.006	0.001	4		1.8	0.0705	11.0	101.2	7.8	11.3
Crookston Burn	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
18/09/01-18/05/10	46	46	46	46	46	46	38.0	46.0	42	44.0	7.0	45.0	44.0
Minimum	0.4	0.181	0.009	0.018	0.005	49	0.9	1.6	0.08	7.8	71.7	6.4	3.6
Maximum	4.46	3.81	0.21	0.174	0.082	9700	31.0	18.2	0.94	12.9	100.0	8.7	18.2
Mean	1.87	1.429	0.046	0.06	0.026	1461	8.8	5.2	0.1453	10.8	87.9	7.3	10.0
Median	1.71	1.255	0.035	0.049	0.022	925	6.5	3.7	0.12	10.9	89.5	7.3	10.3
Dart River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
6/09/06-30/06/11	28	28	28	28	28	27	27.0	27.0	28	27.0	27.0	27.0	28.0
Minimum	0.045	0.01	0.009	0.005	0.005	1	0.9	0.3	0.0328	10.5	13.1	6.8	2.4
Maximum	0.25	0.056	0.01	4.17	0.009	200	10100	4000	0.0932	14.2	113.0	8.8	11.5
Mean	0.059	0.021	0.009	0.227	0.005	20	489.5	193.6	0.0592	11.9	93.8	7.7	6.6
Median	0.045	0.018	0.009	0.033	0.005	4	43.0	19.0	0.0588	11.8	97.0	7.7	6.9
Dunstan Ck	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
18/07/01-19/05/11	60	60	60	60	60	59	61.0	41.0	40	39.0	32.0	41.0	41.0
Minimum	0.045	0.005	0.009	0.005	0.001	1	0.9	0.4	0.018	8.9	79.9	6.3	1.0
Maximum	0.46	0.283	0.09	0.438	0.015	770	41.0	4.5	0.042	13.8	111.0	7.7	16.6
Mean	0.127	0.041	0.011	0.019	0.007	52	3.7	1.2	0.0333	10.9	94.6	7.1	9.4
Median	0.11	0.026	0.009	0.01	0.007	24	0.9	0.8	0.0348	10.7	95.6	7.2	9.3
Fraser River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
7/08/02-19/05/11	53	53	53	53	53	53	53.0	53.0	51	52.0	44.0	52.0	52.0
Minimum	0.06	0.006	0.009	0.005	0.005	1	0.9	0.4	0.02	6.3	81.4	6.7	3.3
Maximum	0.31	0.114	0.03	0.066	0.022	580	30.0	20.0	0.123	13.7	116.0	8.5	19.1
Mean	0.128	0.039	0.01	0.014	0.006	78	2.6	1.8	0.0662	10.8	98.8	7.4	11.1
Median	0.12	0.035	0.009	0.012	0.005	20	0.9	1.0	0.0636	10.9	97.7	7.4	10.6
Hawea River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
16/08/06-9/06/11	30	30	30	30	30	30	30.0	30.0	30	29.0	25.0	30.0	30.0
Minimum	0.045	0.005	0.009	0.005	0.005	1	0.1	0.1	0.0298	6.7	83.0	7.5	8.5
Maximum	0.09	0.021	0.009	0.014	0.006	32	0.9	1.2	0.058	13.4	122.0	9.0	18.2
Mean	0.049	0.01	0.009	0.006	0.005	4	0.9	0.4	0.047	11.0	106.7	8.1	12.3
Median	0.045	0.01	0.009	0.005	0.005	1	0.9	0.3	0.0513	11.0	107.0	8.0	11.5

Heriot Burn	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
18/09/01-21/06/11	63	66	66	63	63	65	59.0	66.0	58	61.0	17.0	63.0	64.0
Minimum	0.46	0.145	0.009	0.012	0.002	27	0.9	0.6	0.0712	0.1	69.4	6.4	3.1
Maximum	4.83	2.67	0.38	0.379	0.054	11200	126.0	111.0	0.868	15.5	119.0	7.8	17.0
Mean	1.675	1.167	0.046	0.08	0.022	1369	11.9	8.1	0.1265	10.9	91.8	7.2	9.7
Median	1.56	1.08	0.03	0.065	0.021	500	7.0	4.6	0.112	11.3	92.3	7.2	10.1
Kaikorai Stm	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
22/08/01-22/06/11	65	65	65	65	65	65	62.0	65.0	65	63.0	52.0	64.0	64.0
Minimum	0.24	0.011	0.009	0.005	0.003	24	0.9	1.2	0.08	6.8	58.2	6.5	3.9
Maximum	2.51	2.21	0.24	0.25	0.055	8000	140.0	38.0	0.332	16.0	133.0	9.5	19.5
Mean	0.783	0.426	0.033	0.042	0.013	1095	10.7	5.9	0.153	11.5	102.4	8.0	10.6
Median	0.6	0.326	0.02	0.032	0.011	500	4.0	3.5	0.128	11.5	101.5	8.0	10.4
Kakanui Clifton Falls	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
12/09/01-25/05/11	63	64	63	63	64	64	54.0	62.0	61	61.0	42.0	61.0	61.0
Minimum	0.045	0.003	0.009	0.005	0.001	1	0.9	0.1	0.028	7.5	80.2	6.4	1.4
Maximum	1.06	0.22	0.04	0.926	0.017	24200	30.0	27.0	0.709	17.2	117.0	8.5	20.7
Mean	0.152	0.022	0.011	0.03	0.006	543	1.5	1.0	0.0856	11.4	99.1	7.6	10.5
Median	0.12	0.013	0.009	0.008	0.005	82	0.9	0.4	0.0715	11.4	101.5	7.6	9.9
Kakanui at McCones	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
15/08/01-25/05/11	74	74	74	74	74	74	70.0	74.0	72	72.0	50.0	73.0	72.0
Minimum	0.06	0.005	0.009	0.005	0.001	1	0.9	0.2	0.01	2.7	28.4	6.8	3.6
Maximum	0.77	0.691	0.03	0.049	0.013	980	10.0	5.8	0.21	14.2	117.0	8.4	21.3
Mean	0.279	0.151	0.011	0.011	0.006	82	1.2	0.8	0.1116	9.7	84.1	7.4	12.0
Median	0.245	0.118	0.009	0.01	0.005	32	0.9	0.6	0.1065	10.0	86.8	7.4	12.0
Kauru at Ewings	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
12/09/01-25/05/11	37	37	37	37	37	37	29.0	37.0	37	37.0	29.0	37.0	37.0
Minimum	0.045	0.004	0.009	0.005	0.001	1	0.1	0.1	0.026	4.2	46.3	6.7	1.0
Maximum	0.29	0.115	0.06	0.016	0.026	730	0.9	3.1	0.536	16.2	114.0	8.3	20.1
Mean	0.142	0.023	0.011	0.009	0.007	152	0.9	0.5	0.068	11.0	96.5	7.5	10.5
Median	0.13	0.016	0.009	0.009	0.006	49	0.9	0.3	0.0555	11.0	99.0	7.6	9.8
Kawarau at Chards	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
18/07/01-14/06/11	118	120	120	119	120	44		120.0	120	120.0	120.0	120.0	120.0
Minimum	0.047	0.014	0.001	0.004	0.001	1		0.3	0.0584	9.5	96.9	7.7	5.8
Maximum	0.406	0.046	0.034	1.369	0.006	866		66.0	0.0836	12.3	107.9	8.3	18.3
Mean	0.087	0.025	0.009	0.041	0.001	73		4.5	0.0661	10.7	102.1	7.9	11.7
Median	0.081	0.025	0.008	0.012	0.001	19		2.0	0.0659	10.7	102.1	7.9	11.8
Kye Burn at SH85	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
30/07/03-27/06/11	45	45	45	45	45	45	45.0	26.0	30	29.0	24.0	27.0	31.0
Minimum	0.07	0.005	0.009	0.005	0.005	2	0.9	0.3	0.007	7.9	79.5	5.3	2.0
Maximum	0.8	0.236	0.02	0.228	0.021	2200	338.0	182.0	0.652	14.1	106.0	9.9	20.4
Mean	0.181	0.048	0.009	0.021	0.008	134	18.0	10.4	0.0867	11.1	94.8	7.2	9.0
Median	0.14	0.021	0.009	0.01	0.008	31	0.9	1.5	0.0551	11.5	97.4	7.1	7.1
Leith at Dundas St	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
22/08/01-22/06/11	64	64	64	64	64	64	61.0	64.0	62	61.0	54.0	63.0	63.0
Minimum	0.23	0.063	0.009	0.007	0.005	19	0.9	1.0	0.0844	5.2	55.2	6.5	4.8
Maximum	1.54	1.37	0.14	0.24	0.066	10500	91.0	21.0	0.64	15.8	137.0	9.2	17.9
Mean	0.692	0.438	0.02	0.047	0.022	1050	6.0	3.6	0.1449	11.3	98.3	8.0	10.1
Median	0.625	0.354	0.01	0.04	0.02	385	3.0	2.7	0.14	11.5	98.9	8.0	9.3
Lindis Ardgour Rd	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
20/09/05-9/06/11	38	38	38	38	38	38	38.0	38.0	37	37.0	33.0	38.0	37.0
Minimum	0.06	0.005	0.009	0.005	0.005	2	0.9	0.1	0.0332	4.7	64.2	6.6	3.4
Maximum	0.27	0.235	0.01	0.103	0.01	180	167.0	17.3	0.098	14.2	118.0	8.6	17.8
Mean	0.142	0.074	0.009	0.014	0.006	48	11.6	2.7	0.0677	10.6	96.4	7.6	10.3
Median	0.135	0.07	0.009	0.01	0.006	27	0.9	0.9	0.0697	10.6	95.7	7.6	10.5
Lindis Lindis Pk	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
27/08/03-9/06/11	51	51	51	51	51	50	51.0	51.0	47	49.0	42.0	49.0	50.0
Minimum	0.045	0.005	0.009	0.005	0.005	2	0.9	0.3	0.0276	7.3	87.0	6.6	0.9
Maximum	0.47	0.085	0.02	0.069	0.011	320	81.0	17.8	0.0782	16.7	117.0	9.0	17.0
Mean	0.095	0.023	0.01	0.017	0.006	45	9.9	2.7	0.0559	12.0	100.0	7.7	7.6
Median	0.07	0.015	0.009	0.01	0.006	28	3.0	1.2	0.0564	12.1	99.0	7.7	7.3

Lindsays Ck	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
17/10/01-22/06/11	53	54	53	53	54	54	52.0	53.0	53	50.0	43.0	53.0	42.0
Minimum	0.4	0.14	0.009	0.008	0.005	8	0.9	1.5	0.1014	6.7	61.7	6.7	5.0
Maximum	2.33	2.14	0.42	0.441	0.794	60000	50.0	303.0	0.217	15.9	143.7	9.2	21.3
Mean	1.066	0.742	0.032	0.057	0.036	2351	6.7	10.4	0.1671	11.7	103.6	7.9	10.2
Median	0.98	0.645	0.02	0.044	0.021	755	4.0	3.3	0.17	11.8	98.9	7.8	9.8
Luggate Creek	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
16/08/06-9/06/11													
Minimum	0.045	0.005	0.009	0.005	0.007	1	0.9	0.3	0.0114	7.2	86.2	6.8	1.3
Maximum	0.22	0.017	0.01	0.027	0.048	220	12.0	4.7	0.0527	14.4	116.0	8.4	16.6
Mean	0.068	0.005	0.009	0.018	0.013	40	2.1	0.8	0.0322	11.9	101.5	7.7	8.3
Median	0.06	0.005	0.009	0.019	0.011	19	0.9	0.6	0.0309	12.2	103.0	7.6	7.8
Main Drain	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
22/08/01-21/06/11													
Minimum	0.7	0.005	0.009	0.005	0.001	2	1.0	0.8	0.15	0.0	0.3	5.8	2.7
Maximum	6.94	2.84	2.9	0.551	0.202	4800	80.0	28.0	6.11	13.0	117.0	9.0	22.5
Mean	2.418	0.532	0.62	0.112	0.021	238	9.5	7.0	2.9889	5.9	58.6	7.4	12.0
Median	1.815	0.242	0.375	0.076	0.012	50	7.0	5.5	2.525	6.0	56.5	7.4	12.3
Manuherikia Gallwy	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
18/07/01-19/05/11	77	77	77	77	77	77	78.0	61.0	59	58.0	43.0	59.0	59.0
Minimum	0.09	0.005	0.009	0.005	0.005	1	0.9	0.8	0.034	7.5	78.1	6.6	1.7
Maximum	0.89	0.386	0.04	0.311	0.067	2900	263.0	68.3	0.441	15.4	125.0	8.7	22.4
Mean	0.287	0.056	0.011	0.042	0.015	216	17.6	6.0	0.0993	11.1	100.4	7.5	11.4
Median	0.24	0.024	0.009	0.03	0.013	62	4.0	1.9	0.0844	11.1	101.0	7.5	10.5
Manuherikia Ophir	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
2/08/06-19/05/11	47	47	47	47	47	46	47.0	30.0	30	30.0	25.0	29.0	30.0
Minimum	0.11	0.008	0.009	0.01	0.005	1	0.9	0.7	0.033	7.7	83.2	5.6	0.8
Maximum	1	0.397	0.02	0.265	0.056	1500	155.0	51.6	0.385	13.8	114.0	7.8	20.7
Mean	0.312	0.07	0.012	0.049	0.02	202	20.2	6.4	0.0734	10.6	96.0	7.3	10.6
Median	0.24	0.026	0.009	0.034	0.016	80	4.0	2.8	0.0675	10.5	96.0	7.4	9.9
Matukituki River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
16/08/06-9/06/11	30	30	30	30	30	30	30.0	30.0	29	29.0	25.0	30.0	29.0
Minimum	0.045	0.005	0.009	0.005	0.005	1	0.9	0.4	0.046	6.7	81.0	7.0	2.8
Maximum	0.27	0.082	0.04	0.634	0.057	2000	525.0	124.0	0.118	13.9	113.0	8.4	16.0
Mean	0.087	0.048	0.011	0.046	0.007	85	42.6	10.1	0.0862	11.5	100.2	7.9	8.8
Median	0.08	0.047	0.009	0.01	0.005	9	5.0	2.0	0.0906	11.7	102.0	7.9	9.0
Mill Creek	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
29/08/01-30/06/11	60	60	60	60	60	60	59.0	59.0	58	61.0	45.0	61.0	61.0
Minimum	0.19	0.005	0.009	0.007	0.001	2	0.9	1.1	0.0852	8.8	85.6	7.2	1.7
Maximum	0.9	0.72	0.05	0.076	0.021	4800	28.0	9.7	0.212	17.4	139.0	9.0	15.0
Mean	0.548	0.366	0.013	0.026	0.007	292	8.5	3.1	0.1268	11.9	102.3	8.0	8.6
Median	0.545	0.367	0.009	0.023	0.006	86	7.0	2.5	0.126	11.7	102.0	8.0	8.4
Owhiro Stream	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
16/10/01-21/06/11	65	65	65	65	65	65	53.0	65.0	64	61.0	48.0	64.0	65.0
Minimum	0.24	0.005	0.009	0.04	0.005	5	0.9	1.0	0.075	1.3	11.3	6.0	2.2
Maximum	2.77	1.47	0.15	0.859	0.061	5700	27.0	40.0	0.395	16.1	158.0	9.0	22.1
Mean	1.078	0.391	0.047	0.125	0.026	681	9.2	12.4	0.213	9.1	80.2	7.3	11.1
Median	0.93	0.207	0.03	0.1	0.023	180	7.0	9.8	0.2	9.4	80.0	7.3	10.9
Pomahaka Glenken	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
19/09/01-22/06/11	81	82	82	81	82	80	82.0	57.0	52	50.0	20.0	57.0	55.0
Minimum	0.09	0.005	0.009	0.006	0.004	2	0.9	1.3	0.0374	4.5	50.7	6.6	3.0
Maximum	3.52	2.87	0.07	0.149	0.039	8700	66.0	26.0	0.817	14.6	116.0	8.1	18.6
Mean	0.9	0.589	0.017	0.042	0.013	449	8.6	5.9	0.1237	10.9	90.8	7.4	10.9
Median	0.74	0.49	0.01	0.035	0.012	99	5.0	4.0	0.091	10.9	93.8	7.5	11.4
Pomahaka Burkes Fd	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
18/09/01-21/06/11	87	87	87	87	87	88	83.0	62.0	57	58.0	17.0	62.0	61.0
Minimum	0.045	0.003	0.009	0.005	0.001	18	0.9	0.5	0.017	0.7	70.4	6.2	1.0
Maximum	1.05	1.09	0.04	0.113	0.027	4800	85.0	43.5	0.334	15.9	119.0	8.0	17.9
Mean	0.267	0.079	0.012	0.027	0.009	441	6.7	4.3	0.0599	11.2	94.0	7.3	9.2
Median	0.22	0.034	0.009	0.02	0.009	140	2.0	1.8	0.051	11.5	94.6	7.4	9.2

Shag at Craig Rd	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
16/08/01-26/05/11	70	71	70	70	71	70	70.0	70.0	66	66.0	50.0	70.0	65.0
Minimum	0.045	0.005	0.008	0.005	0.001	1	0.9	0.1	0.076	4.1	42.9	6.8	0.6
Maximum	1.3	0.517	0.02	0.038	0.012	1100	7.0	6.1	0.293	14.4	113.0	8.7	20.5
Mean	0.246	0.054	0.01	0.012	0.006	104	1.2	0.7	0.1788	10.4	91.0	7.7	10.8
Median	0.18	0.015	0.009	0.01	0.006	53	0.9	0.5	0.179	10.6	93.7	7.7	10.2
Shag at Goodwd Pp	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
9/10/01-26/05/11	58	59	59	59	59	59	59.0	59.0	59	57.0	42.0	59.0	59.0
Minimum	0.13	0.005	0.009	0.005	0.001	1	0.9	0.2	0.087	4.6	45.1	6.7	2.8
Maximum	1.28	1.02	0.11	0.039	0.014	2000	10.0	6.6	0.328	13.8	130.0	8.4	18.0
Mean	0.407	0.233	0.014	0.012	0.006	140	1.1	0.8	0.1947	10.0	89.3	7.4	11.3
Median	0.33	0.188	0.01	0.012	0.006	66	0.9	0.6	0.196	9.9	90.0	7.4	11.5
Shotover River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
18/07/01-14/06/11	120	120	120	120	120	29		119.0	120	120.0	120.0	120.0	120.0
Minimum	0.012	0.004	0.001	0.002	0.001	1		0.3	0.0579	9.3	99.0	7.7	0.1
Maximum	0.874	0.059	0.025	3.26	0.005	687		205.0	0.129	14.3	107.6	8.2	18.3
Mean	0.079	0.018	0.003	0.14	0.001	91		9.2	0.0997	11.6	102.9	7.9	8.8
Median	0.058	0.017	0.003	0.032	0.001	16		2.4	0.1013	11.4	103.1	7.9	8.9
Silver Stream	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
21/10/02-21/06/11	54	55	54	54	55	55	54.0	54.0	54	52.0	51.0	54.0	54.0
Minimum	0.14	0.007	0.009	0.005	0.005	4	0.9	0.4	0	3.5	43.5	6.5	3.5
Maximum	0.97	0.72	0.1	0.044	0.025	1920	24.0	7.5	0.215	15.9	140.0	9.5	25.3
Mean	0.434	0.254	0.014	0.017	0.008	254	3.1	2.2	0.1534	11.2	103.6	8.0	12.4
Median	0.36	0.222	0.009	0.015	0.007	86	1.5	1.4	0.1615	11.5	100.0	7.9	12.3
Sutton at SH87	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
19/07/01-21/06/11	120	120	120	120	120	36		120.0	120	117.0	117.0	120.0	120.0
Minimum	0.12	0.001	0.001	0.008	0.001	1		0.4	0.0278	7.4	86.2	6.8	0.0
Maximum	1.117	0.787	0.015	0.221	0.015	1553		114.0	0.0718	14.3	102.8	7.6	21.8
Mean	0.268	0.024	0.006	0.021	0.005	131		7.0	0.0466	11.1	96.9	7.2	8.8
Median	0.245	0.01	0.006	0.018	0.004	25		2.0	0.0449	11.0	97.7	7.2	9.4
Taieri at Allanton	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
16/10/01-21/06/11	65	65	65	65	65	65	55.0	65.0	65	64.0	50.0	65.0	64.0
Minimum	0.16	0.003	0.009	0.005	0.001	15	0.9	0.8	0.05	3.3	37.5	6.0	2.6
Maximum	1.12	0.768	0.09	0.106	0.026	1700	33.0	26.0	0.945	15.4	118.0	8.1	21.9
Mean	0.36	0.078	0.017	0.033	0.009	167	5.8	4.2	0.0961	10.0	88.1	7.3	11.1
Median	0.3	0.039	0.01	0.031	0.008	99	4.0	2.5	0.0814	10.1	88.9	7.3	11.2
Taieri at Linnburn	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
29/07/03-27/06/11	63	63	63	63	63	62	63.0	44.0	46	47.0	38.0	42.0	47.0
Minimum	0.07	0.002	0.009	0.005	0.005	1	0.9	0.6	0.011	2.9	23.1	5.1	0.2
Maximum	0.53	0.025	0.95	0.045	0.014	2660	11.0	3.9	0.0534	14.2	107.0	8.2	17.6
Mean	0.17	0.006	0.026	0.014	0.005	104	2.1	1.3	0.0243	9.6	78.7	6.8	8.0
Median	0.16	0.005	0.009	0.014	0.005	36	0.9	1.2	0.0258	9.5	79.0	6.9	6.6
Taieri at Outram	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
19/07/01-21/06/11	120	120	120	120	120	21		120.0	120	116.0	116.0	119.0	120.0
Minimum	0.124	0.001	0.001	0.009	0.003	15		0.4	0	8.6	90.2	6.9	1.3
Maximum	1.467	1.021	0.019	0.302	0.052	727		110.0	0.1091	14.8	113.0	8.1	22.9
Mean	0.346	0.057	0.006	0.038	0.009	193		5.5	0.0785	11.5	102.3	7.6	10.7
Median	0.302	0.029	0.005	0.03	0.008	84		2.3	0.0781	11.2	101.7	7.5	11.2
Taieri at Stonehenge	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
26/09/01-27/06/11	86	86	86	86	86	84	85.0	66.0	67	67.0	40.0	64.0	70.0
Minimum	0.045	0.002	0.009	0.005	0.001	2	0.9	0.7	0.014	5.2	70.6	5.4	0.1
Maximum	0.8	0.038	0.22	0.118	0.016	1340	26.0	13.6	0.242	15.4	117.0	7.6	18.0
Mean	0.252	0.009	0.014	0.022	0.006	83	2.1	1.7	0.0376	10.7	90.2	6.9	9.3
Median	0.23	0.007	0.009	0.018	0.005	37	0.9	1.3	0.035	10.6	92.5	6.9	9.5
Taieri at Sutton	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
1/08/06-27/06/11	45	45	45	45	45	45	45.0	26.0	31	30.0	30.0	27.0	32.0
Minimum	0.08	0.005	0.009	0.021	0.005	1	0.9	0.7	0.02	7.8	70.7	6.1	3.5
Maximum	0.92	0.231	0.02	0.317	0.032	4880	621.0	81.2	0.91	13.5	122.0	9.6	23.1
Mean	0.349	0.049	0.01	0.049	0.013	340	27.7	10.0	0.1283	10.5	95.1	7.7	11.0
Median	0.3	0.019	0.009	0.034	0.01	66	6.0	3.6	0.0843	10.2	95.1	7.6	10.0

Taieri at Tiroiti	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
19/07/01-21/06/11	120	120	120	120	120	35		120.0	120	117.0	117.0	120.0	120.0
Minimum	0.17	0.001	0.001	0.018	0.002	6		0.7	0.0479	7.7	83.7	7.0	0.0
Maximum	0.818	0.373	0.016	0.154	0.076	1414		400.0	0.134	14.2	101.8	8.3	21.2
Mean	0.325	0.032	0.006	0.049	0.017	211		9.1	0.0894	10.9	97.2	7.5	9.2
Median	0.302	0.017	0.005	0.044	0.014	86		3.0	0.0911	10.8	97.4	7.5	9.7
Taieri at Waipiata	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
7/11/01-27/06/11	84	84	84	84	84	83	84.0	64.0	66	65.0	42.0	65.0	68.0
Minimum	0.12	0.003	0.009	0.011	0.005	1	0.9	1.6	0.031	4.1	66.8	6.2	0.7
Maximum	0.85	0.071	0.04	0.183	0.088	10100	31.0	17.2	0.918	15.6	118.0	7.9	21.1
Mean	0.346	0.021	0.012	0.056	0.02	288	5.7	3.7	0.1155	10.1	90.7	7.2	11.1
Median	0.32	0.015	0.01	0.052	0.017	76	4.0	3.1	0.0917	10.0	90.2	7.2	11.8
Tokomairiro W Branch	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
7/08/02-22/06/11	54	55	54	54	55	56	53.0	53.0	52	53.0	14.0	53.0	53.0
Minimum	0.06	0.005	0.009	0.005	0.005	6	0.9	1.1	0.0381	6.3	62.4	6.5	0.1
Maximum	2.26	1.21	0.05	0.76	0.039	29000	101.0	22.5	0.54	15.5	108.0	8.0	17.6
Mean	0.529	0.233	0.015	0.051	0.01	1039	4.9	3.6	0.0817	11.1	88.9	7.1	9.7
Median	0.395	0.14	0.01	0.032	0.01	205	1.0	2.5	0.067	10.8	90.0	7.1	10.4
Trotters Ck	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
23/08/06-26/05/11	28	28	28	28	28	28	28.0	28.0	27	28.0	28.0	28.0	28.0
Minimum	0.12	0.005	0.009	0.005	0.005	2	0.1	1.0	0.0131	2.1	23.0	6.9	2.7
Maximum	1.55	1.14	0.03	0.045	0.019	1200	0.9	3.1	0.245	16.0	155.0	8.4	18.9
Mean	0.438	0.234	0.012	0.015	0.006	106	0.9	1.6	0.167	9.6	84.1	7.4	10.9
Median	0.35	0.125	0.01	0.013	0.005	43	0.9	1.6	0.174	9.8	86.7	7.4	9.9
Waianakarua River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
15/08/01-25/05/11	59	60	59	59	60	60	59.0	59.0	56	56.0	40.0	58.0	57.0
Minimum	0.08	0.005	0.009	0.005	0.001	1	0.9	0.1	0.037	4.7	50.3	6.9	3.5
Maximum	0.97	0.543	0.03	0.017	0.016	620	4.0	2.4	0.91	15.1	119.0	8.6	21.9
Mean	0.261	0.156	0.011	0.008	0.007	37	1.0	0.4	0.0966	10.9	97.0	7.5	11.5
Median	0.22	0.14	0.009	0.007	0.007	15	0.9	0.3	0.081	10.8	99.5	7.5	11.5
Waiareka Ck	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
15/08/01-25/05/11	67	67	67	67	67	67	63.0	67.0	65	67.0	46.0	67.0	66.0
Minimum	0.39	0.005	0.009	0.031	0.01	2	0.9	0.3	0.0577	0.4	3.6	6.3	3.4
Maximum	4.65	1.92	0.85	1.8	1.68	2900	41.0	41.0	7.45	20.0	153.0	8.4	19.3
Mean	1.045	0.194	0.056	0.266	0.202	255	4.6	2.8	1.231	7.6	72.0	7.6	11.8
Median	0.84	0.041	0.03	0.184	0.124	77	2.0	1.0	1.07	7.7	70.9	7.6	12.3
Waikouaiti at Orbells	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
16/08/01-16/05/11	64	64	64	64	64	65	64.0	64.0	61	61.0	46.0	64.0	63.0
Minimum	0.06	0.005	0.009	0.005	0.001	1	0.9	0.4	0.0147	4.5	50.1	6.7	1.5
Maximum	0.56	0.4	0.1	0.033	0.04	4900	5.0	4.2	0.903	14.1	112.0	8.5	21.8
Mean	0.221	0.06	0.012	0.012	0.006	172	1.1	1.0	0.1719	9.7	86.9	7.5	11.6
Median	0.18	0.031	0.009	0.01	0.005	36	0.9	0.8	0.15	9.7	90.3	7.5	11.3
Waipahi Cairns Pk	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
21/10/02-21/06/11	75	75	75	75	75	75	74.0	48.0	46	44.0	12.0	48.0	46.0
Minimum	0.44	0.02	0.009	0.012	0.005	10	0.9	2.4	0.056	0.5	74.2	6.2	2.4
Maximum	3.7	1.87	0.07	0.394	0.05	37000	206.0	106.0	0.967	14.4	107.0	7.9	16.0
Mean	1.127	0.716	0.02	0.072	0.018	1374	16.1	11.6	0.1376	10.6	94.2	7.1	9.1
Median	0.98	0.616	0.02	0.057	0.018	280	7.0	5.4	0.093	11.3	92.8	7.0	9.1
Waipahi at Waipahi	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
19/09/01-21/06/11	91	91	91	91	91	89	90.0	66.0	63	62.0	18.0	66.0	65.0
Minimum	0.3	0.003	0.009	0.005	0.003	1	0.9	0.2	0.0734	4.9	51.2	6.5	3.7
Maximum	3.46	2.92	0.07	0.155	0.044	10800	72.0	30.3	0.235	14.0	119.0	9.3	20.6
Mean	1.332	0.958	0.019	0.048	0.015	534	8.8	5.1	0.1239	10.5	91.7	7.6	11.0
Median	1.34	0.926	0.01	0.042	0.015	146	4.0	3.0	0.124	11.1	97.3	7.5	10.9
Waipori River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
10/08/06-21/06/11	30	30	30	30	30	30	30.0	30.0	30	29.0	29.0	29.0	30.0
Minimum	0.09	0.033	0.009	0.01	0.005	1	0.9	1.1	0.0229	3.4	35.9	6.1	4.0
Maximum	0.46	0.142	0.02	0.042	0.01	700	20.0	8.4	0.326	12.7	114.0	7.9	18.3
Mean	0.249	0.061	0.011	0.021	0.006	47	2.3	3.1	0.0481	10.2	91.8	7.1	10.8
Median	0.24	0.054	0.009	0.02	0.005	6	0.9	2.5	0.035	10.2	93.2	7.2	10.6

Wairuna Stream	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
10/07/02-24/11/09	56	57	57	56	57	56	57.0	29.0	26	26.0	10.0	30.0	28.0
Minimum	0.79	0.029	0.01	0.053	0.007	21	0.9	6.2	0.1	3.2	26.5	6.5	2.9
Maximum	6.43	5.86	0.21	0.4	0.137	20000	214.0	104.0	0.24	14.1	98.6	7.8	18.0
Mean	1.986	1.309	0.067	0.133	0.04	1273	14.3	13.9	0.1693	10.5	80.4	7.2	9.8
Median	1.735	1.08	0.06	0.109	0.032	495	8.0	9.9	0.1645	10.5	84.5	7.2	9.9
Waitahuna River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
19/09/01-22/06/11	59	60	60	59	60	60	60.0	60.0	57	57.0	20.0	60.0	59.0
Minimum	0.06	0.006	0.009	0.005	0.003	23	0.9	1.2	0.0189	0.6	41.1	6.6	1.6
Maximum	2.95	1.57	0.06	0.375	0.037	4960	228.0	116.0	0.142	16.6	126.0	7.9	18.8
Mean	0.517	0.212	0.016	0.045	0.011	482	11.1	6.1	0.0753	10.6	87.0	7.2	10.6
Median	0.38	0.094	0.01	0.035	0.01	180	5.0	3.5	0.072	10.6	92.8	7.2	11.4
Waiwera River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
25/07/06-25/05/11	31	31	31	31	31	30	31.0	31.0	31	31.0	17.0	30.0	31.0
Minimum	0.41	0.008	0.009	0.033	0.012	14	0.9	0.9	0.0769	3.8	39.8	7.1	5.3
Maximum	4.4	3.33	0.08	0.282	0.053	2700	91.0	79.8	0.174	16.7	131.0	9.0	22.4
Mean	1.279	0.968	0.022	0.073	0.028	500	9.5	7.5	0.1305	10.4	90.0	7.9	12.0
Median	1.08	0.781	0.02	0.061	0.027	210	4.0	3.6	0.135	10.0	93.5	7.8	12.1

Lake Dunstan	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp	Chla
28/08/01-9/06/11	60	60	60	60	60	63	60.0	60.0	55	54.0	39.0	59.0	55.0	56
Minimum	0.045	0.005	0.009	0.005	0.001	1	0.9	0.3	0.0399	6.0	85.4	7.3	6.5	0.9
Maximum	0.2	0.058	0.05	0.03	0.044	600	9.0	5.3	0.109	16.1	126.0	8.8	21.5	3.42
Mean	0.082	0.025	0.011	0.008	0.006	12	1.5	1.0	0.0627	10.6	101.3	8.0	13.4	1.754
Median	0.08	0.024	0.009	0.005	0.005	1	0.9	0.6	0.065	10.6	101.0	7.9	13.1	1.71
Lake Hawea	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp	Chla
28/08/01-9/06/11	58	59	59	59	59	59	59.0	58.0	56	57.0	39.0	59.0	58.0	58
Minimum	0.045	0.003	0.009	0.005	0.001	1	0.9	0.1	0.0285	6.5	87.0	7.0	8.0	0.9
Maximum	0.19	0.029	0.11	0.05	0.01	40	11.0	4.2	0.511	14.2	131.0	8.8	18.1	2.34
Mean	0.054	0.012	0.013	0.006	0.005	2	1.3	0.5	0.0549	11.1	106.1	7.7	12.2	1.715
Median	0.045	0.01	0.009	0.005	0.005	1	0.9	0.3	0.0494	11.1	104.0	7.7	11.5	1.71
Lake Hayes	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp	Chla
29/08/01-30/06/11	53	53	53	53	53	56	52.0	52.0	53	53.0	43.0	54.0	54.0	52
Minimum	0.19	0.003	0.009	0.005	0.001	1	0.9	0.3	0.06	7.7	65.8	7.3	5.1	1.71
Maximum	0.65	0.256	0.29	0.1	0.041	58	23.0	14.7	1.61	15.0	163.0	10.3	21.1	53.1
Mean	0.335	0.02	0.032	0.037	0.011	3	2.7	1.5	0.1786	10.6	100.4	8.5	13.0	11.09
Median	0.33	0.005	0.009	0.032	0.005	1	1.0	0.7	0.15	10.4	99.4	8.4	12.4	5.13
Lake Johnson	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp	Chla
29/08/01-30/06/11	54	54	54	54	54	53	53.0	53.0	53	54.0	41.0	53.0	54.0	52
Minimum	0.12	0.003	0.009	0.005	0.001	1	0.9	0.4	0.0465	6.3	50.4	7.0	4.6	1.71
Maximum	1.2	0.682	0.24	0.102	0.064	500	22.0	13.4	0.293	13.9	145.0	9.8	20.8	53.1
Mean	0.723	0.02	0.046	0.049	0.019	17	2.8	1.7	0.1736	9.9	94.3	8.3	12.3	9.063
Median	0.72	0.005	0.01	0.045	0.007	1	1.0	0.9	0.174	9.8	96.3	8.3	12.7	4.455
Lake Onslow	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp	Chla
19/11/03-19/05/11	43	43	43	43	43	42	43.0	43.0	41	43.0	39.0	43.0	42.0	25
Minimum	0.13	0.005	0.009	0.016	0.005	1	0.9	1.4	0.013	5.5	50.6	5.8	1.5	1.71
Maximum	0.63	0.155	0.03	0.158	0.034	90	114.0	19.7	0.0363	12.0	107.0	7.7	23.2	4.95
Mean	0.294	0.013	0.013	0.039	0.006	5	14.2	5.5	0.0232	9.0	80.5	6.8	10.7	2.74
Median	0.26	0.005	0.009	0.03	0.005	1	6.0	4.5	0.025	9.1	80.6	6.9	11.0	2.61
Lake Tuakitoto	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp	Chla
16/08/01-22/06/11	63	63	63	63	63	63	63.0	63.0	60	62.0	19.0	63.0	63.0	49
Minimum	0.045	0.005	0.009	0.005	0.005	13	0.9	0.9	0.0002	2.4	27.8	6.5	2.5	1.71
Maximum	2.21	1.36	0.55	0.247	0.047	20000	73.0	73.8	0.3	12.6	104.0	9.3	22.2	25.2
Mean	1.007	0.232	0.053	0.091	0.016	526	12.3	10.3	0.1581	8.5	67.5	7.4	11.9	6.44
Median	0.97	0.039	0.03	0.086	0.015	91	6.0	5.0	0.1735	8.8	67.0	7.3	12.3	4.32
Lake Waihola	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp	Chla
22/08/02-21/06/11	54	52	54	54	55	59	54.0	53.0	54	53.0	51.0	55.0	55.0	51
Minimum	0.19	0.005	0.009	0.005	0.005	1	0.9	2.0	0.006	3.2	36.5	6.0	4.6	1.71
Maximum	1.42	0.592	0.05	0.154	0.027	790	135.0	79.4	12.9	13.4	114.0	9.1	23.0	23.4
Mean	0.504	0.046	0.015	0.05	0.006	64	21.9	12.1	1.5651	9.2	85.7	7.5	12.2	6.601
Median	0.455	0.007	0.01	0.04	0.005	30	11.5	6.9	0.581	9.3	87.4	7.4	11.1	4.77
Lake Wakatipu	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp	Chla
29/08/01-30/06/11	60	61	61	61	61	59	60.0	60.0	59	59.0	43.0	60.0	60.0	57
Minimum	0.045	0.011	0.009	0.005	0.001	1	0.9	0.1	0.0295	8.3	84.0	7.0	7.6	0.531
Maximum	0.21	0.037	0.03	0.02	0.009	1400	118.0	2.5	0.0855	13.5	131.0	8.4	16.8	2.16
Mean	0.071	0.024	0.01	0.006	0.005	30	3.4	0.5	0.0503	10.7	100.2	7.8	11.6	1.681
Median	0.06	0.024	0.009	0.005	0.005	1	0.9	0.4	0.0524	10.8	99.9	7.8	11.6	1.71
Lake Wanaka	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp	Chla
28/08/01-9/06/11	62	62	62	62	62	61	62.0	60.0	59	58.0	40.0	62.0	60.0	57
Minimum	0.045	0.008	0.009	0.005	0.001	1	0.9	0.1	0.0507	6.1	83.0	7.0	8.4	0.522
Maximum	0.18	0.055	0.04	3	0.028	30	10.0	1.2	0.109	13.5	131.0	8.7	19.4	20.7
Mean	0.068	0.03	0.01	0.053	0.005	2	1.3	0.4	0.0667	10.5	100.6	7.9	12.3	2.04
Median	0.06	0.031	0.009	0.005	0.005	1	0.9	0.3	0.0667	10.6	99.0	7.8	11.9	1.71

Appendix 4 Water quality statistics 2006 to 2011

Cardrona River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
16/08/06-9/06/11	29	29	29	29	29	29	29.0	29.0	28	28.0	25.0	29.0	29.0
Minimum	0.045	0.019	0.009	0.0045	0.0045	1	0.9	0.2	0.0472	6.3	83.0	7.0	0.9
Maximum	0.24	0.175	0.01	0.042	0.137	280	95.0	31.5	0.113	14.6	125.0	9.2	20.2
Mean	0.1222	0.0603	0.009	0.0113	0.0099	47	7.4	2.8	0.0842	11.2	100.2	7.9	9.7
Median	0.12	0.055	0.009	0.009	0.005	20	0.9	1.1	0.0856	11.2	99.1	7.8	9.3
Catlins River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
23/08/06-20/06/11	42	42	42	42	42	42	42.0	23.0	23	21.0	20.0	23.0	23.0
Minimum	0.2	0.055	0.009	0.019	0.01	6	0.9	1.3	0.063	9.7	89.7	6.7	4.7
Maximum	1.12	0.963	0.07	0.084	0.106	3920	28.0	12.0	0.131	14.5	113.0	9.1	16.5
Mean	0.5269	0.36	0.0126	0.0346	0.0184	254	5.5	4.8	0.1	11.4	99.6	7.5	9.4
Median	0.5	0.377	0.0095	0.033	0.0165	110	3.0	3.1	0.107	11.2	100.0	7.5	9.9
Clutha Balclutha	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
5/07/06-15/06/11	60	60	60	60	60	17		60.0	60	58.0	58.0	60.0	60.0
Minimum	0.052	0.005	0.001	0.003	0.001	1		0.3	0.0684	9.3	94.6	7.4	6.3
Maximum	0.93	0.515	0.029	0.114	0.02	411		460.0	0.1183	12.8	110.6	8.4	20.5
Mean	0.1964	0.0998	0.004	0.0141	0.0027	72		14.2	0.0745	10.9	101.5	7.8	12.3
Median	0.1385	0.049	0.003	0.0085	0.002	7		1.7	0.0723	10.8	101.2	7.8	12.3
Clutha Luggate	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
12/07/06-14/06/11	60	60	60	60	60	21		60.0	60	60.0	60.0	60.0	60.0
Minimum	0.028	0.009	0.001	0.001	0.001	1		0.2	0.0607	9.3	99.7	7.8	8.7
Maximum	0.125	0.048	0.007	0.01	0.002	86		28.0	0.0761	12.8	117.4	9.0	19.1
Mean	0.0668	0.0283	0.0023	0.003	0.0011	11		5.1	0.069	11.1	107.9	8.3	12.7
Median	0.0645	0.0275	0.002	0.0025	0.001	4		2.4	0.0705	11.2	107.2	8.3	12.4
Clutha Millers Flat	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
12/07/06-14/06/11	60	60	60	60	60	22		60.0	60	60.0	60.0	60.0	60.0
Minimum	0.043	0.013	0.001	0.002	0.001	1		0.3	0.0662	9.3	96.3	7.6	5.5
Maximum	0.193	0.086	0.008	0.025	0.004	127		48.0	0.0838	12.7	109.0	8.2	18.5
Mean	0.0874	0.0322	0.0025	0.0066	0.0012	10		4.0	0.0716	11.0	101.7	7.8	11.8
Median	0.079	0.026	0.002	0.006	0.001	3		1.3	0.0708	11.0	102.2	7.8	11.7
Crookston Burn	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
25/07/06-18/05/10	12	12	12	12	12	12	12.0	12.0	12	12.0	3.0	12.0	12.0
Minimum	0.87	0.707	0.01	0.028	0.016	52	0.9	1.6	0.08	7.8	71.7	6.9	4.6
Maximum	4.46	3.81	0.21	0.136	0.082	5000	16.0	15.9	0.171	11.9	89.5	7.7	14.8
Mean	1.7267	1.4255	0.0467	0.0739	0.0415	1749	7.0	5.0	0.1139	9.8	81.5	7.3	10.1
Median	1.46	1.1	0.025	0.06	0.031	1040	5.0	3.8	0.112	9.4	83.4	7.4	10.3
Dart River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
6/09/06-30/06/11	28	28	28	28	28	27	27.0	27.0	28	27.0	27.0	27.0	28.0
Minimum	0.045	0.01	0.009	0.0045	0.0045	1	0.9	0.3	0.0328	10.5	13.1	6.8	2.4
Maximum	0.25	0.056	0.01	4.17	0.009	200	10100.0	4000.0	0.0932	14.2	113.0	8.8	11.5
Mean	0.0587	0.0206	0.0091	0.2269	0.0048	20	489.5	193.6	0.0592	11.9	93.8	7.7	6.6
Median	0.045	0.018	0.009	0.0325	0.0045	4	43.0	19.0	0.0588	11.8	97.0	7.7	6.9
Dunstan Ck	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
2/08/06-19/05/11	34	34	34	34	34	33	34.0	14.0	15	14.0	13.0	14.0	15.0
Minimum	0.045	0.01	0.009	0.005	0.0045	1	0.9	0.4	0.02	8.9	86.0	6.5	3.2
Maximum	0.46	0.283	0.01	0.438	0.014	160	41.0	4.4	0.042	13.2	103.0	7.7	16.6
Mean	0.1399	0.052	0.0091	0.024	0.0071	34	4.4	1.2	0.0344	10.6	92.9	7.4	9.6
Median	0.12	0.0305	0.009	0.009	0.007	16	0.9	1.0	0.036	10.5	91.2	7.4	8.4
Fraser River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
3/08/06-19/05/11	29	29	29	29	29	29	29.0	29.0	27	28.0	23.0	28.0	28.0
Minimum	0.06	0.006	0.009	0.0045	0.0045	1	0.9	0.4	0.02	6.3	84.2	6.9	3.3
Maximum	0.31	0.114	0.03	0.066	0.022	260	17.0	9.8	0.123	13.4	116.0	8.5	19.1
Mean	0.1362	0.0369	0.0098	0.0155	0.0063	36	2.4	1.7	0.0634	10.7	99.7	7.5	11.4
Median	0.13	0.028	0.009	0.013	0.005	19	0.9	1.2	0.061	10.7	101.0	7.5	11.0
Hawea River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
16/08/06-9/06/11	30	30	30	30	30	30	30.0	30.0	30	29.0	25.0	30.0	30.0
Minimum	0.045	0.0045	0.0085	0.0045	0.0045	1	0.1	0.1	0.0298	6.7	83.0	7.5	8.5
Maximum	0.09	0.021	0.009	0.014	0.006	32	0.9	1.2	0.058	13.4	122.0	9.0	18.2
Mean	0.0485	0.0101	0.009	0.0055	0.0046	4	0.9	0.4	0.047	11.0	106.7	8.1	12.3
Median	0.045	0.0095	0.009	0.0045	0.0045	1	0.9	0.3	0.0513	11.0	107.0	8.0	11.5

Heriot Burn	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
25/07/06-21/06/11	30	30	30	30	30	29	30.0	30.0	29	28.0	13.0	30.0	30.0
Minimum	0.9	0.546	0.02	0.036	0.011	27	0.9	1.3	0.0712	0.1	69.4	6.8	3.7
Maximum	4.83	2.67	0.38	0.379	0.054	11200	126.0	111.0	0.868	15.5	119.0	7.8	16.2
Mean	1.78	1.312	0.044	0.083	0.0241	1286	13.6	10.8	0.1364	10.7	91.3	7.3	9.8
Median	1.605	1.19	0.03	0.065	0.024	440	7.0	4.6	0.114	11.2	92.3	7.3	9.8
Kaikorai Stm	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
9/08/06-22/06/11	34	34	34	34	34	34	34.0	34.0	34	33.0	33.0	33.0	34.0
Minimum	0.24	0.011	0.009	0.015	0.007	24	0.9	1.5	0.0858	6.8	58.2	6.5	4.4
Maximum	2.51	2.21	0.24	0.1	0.037	5040	35.0	31.8	0.32	15.2	122.0	9.5	18.6
Mean	0.8456	0.5296	0.0364	0.0386	0.0154	968	5.6	5.1	0.1698	11.2	99.3	8.1	10.7
Median	0.62	0.34	0.015	0.033	0.0135	355	3.0	3.4	0.1295	11.3	99.5	8.0	10.1
Kakanui Clifton Falls	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
22/08/06-25/05/11	29	30	29	29	30	30	29.0	29.0	28	28.0	28.0	29.0	28.0
Minimum	0.05	0.005	0.009	0.005	0.0045	1	0.1	0.1	0.028	8.3	80.2	7.1	1.9
Maximum	0.22	0.22	0.01	0.926	0.011	600	0.9	1.5	0.709	14.9	117.0	8.5	19.9
Mean	0.1221	0.0305	0.0091	0.051	0.006	108	0.9	0.5	0.0966	11.3	99.8	7.7	10.5
Median	0.12	0.017	0.009	0.009	0.005	72	0.9	0.3	0.0741	11.4	101.5	7.7	9.7
Kakanui at McCones	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
22/08/06-25/05/11	39	39	39	39	39	39	39.0	39.0	38	38.0	38.0	39.0	38.0
Minimum	0.06	0.0045	0.009	0.0045	0.0045	1	0.9	0.3	0.044	3.5	43.5	6.9	4.3
Maximum	0.77	0.691	0.03	0.025	0.013	800	4.0	2.7	0.184	14.2	117.0	8.4	20.4
Mean	0.3236	0.1876	0.0115	0.0118	0.0063	67	1.1	0.7	0.1164	9.2	84.9	7.5	11.8
Median	0.26	0.145	0.009	0.011	0.005	30	0.9	0.5	0.111	9.6	86.8	7.4	11.8
Kauru at Ewings	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
22/08/06-25/05/11	29	29	29	29	29	29	29.0	29.0	29	29.0	29.0	29.0	29.0
Minimum	0.045	0.0045	0.009	0.0045	0.0045	1	0.1	0.1	0.026	4.2	46.3	6.7	1.0
Maximum	0.23	0.102	0.06	0.016	0.026	620	0.9	1.4	0.536	16.2	114.0	8.3	20.1
Mean	0.1333	0.0222	0.0109	0.0092	0.0074	105	0.9	0.4	0.0722	11.0	96.5	7.6	10.3
Median	0.13	0.019	0.009	0.009	0.006	36	0.9	0.3	0.058	11.0	99.0	7.7	9.7
Kawarau at Chards	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
12/07/06-14/06/11	60	60	60	60	60	20		60.0	60	60.0	60.0	60.0	60.0
Minimum	0.047	0.014	0.001	0.004	0.001	1		0.3	0.0584	9.5	96.9	7.7	5.8
Maximum	0.179	0.037	0.034	0.309	0.004	866		66.0	0.0836	12.1	107.9	8.3	18.3
Mean	0.0829	0.0244	0.01	0.0276	0.0015	111		6.3	0.0667	10.7	102.5	7.9	11.6
Median	0.079	0.0245	0.0085	0.012	0.001	15		2.5	0.0663	10.7	102.5	7.9	11.8
Kye Burn at SH85	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
31/07/08-27/06/11	27	27	27	27	27	27	27.0	8.0	12	11.0	11.0	9.0	13.0
Minimum	0.07	0.0045	0.009	0.006	0.0045	2	0.9	0.5	0.007	8.5	87.1	5.3	2.2
Maximum	0.8	0.236	0.02	0.228	0.021	480	338.0	182.0	0.652	14.1	103.0	9.9	20.4
Mean	0.2048	0.0646	0.0095	0.0253	0.0086	74	25.0	26.4	0.1334	10.8	95.5	7.4	9.1
Median	0.16	0.033	0.009	0.011	0.008	26	0.9	1.4	0.0611	10.5	98.8	7.3	6.9
Leith at Dundas St	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
9/08/06-22/06/11	35	35	35	35	35	35	34.0	35.0	34	34.0	34.0	35.0	34.0
Minimum	0.23	0.089	0.009	0.019	0.012	19	0.9	1.0	0.0844	5.2	55.2	6.8	4.8
Maximum	1.54	1.37	0.08	0.076	0.042	3840	14.0	7.8	0.181	15.6	123.0	9.2	17.9
Mean	0.7014	0.5116	0.0188	0.0419	0.0262	922	3.2	2.9	0.1381	10.9	95.9	8.1	10.0
Median	0.62	0.394	0.01	0.042	0.026	210	3.0	2.4	0.139	11.1	98.8	8.0	9.2
Lindis Ardgour Rd	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
16/08/06-9/06/11	30	30	30	30	30	30	30.0	30.0	29	29.0	25.0	30.0	29.0
Minimum	0.06	0.005	0.009	0.0045	0.0045	2	0.9	0.2	0.0332	4.7	80.9	7.0	3.4
Maximum	0.24	0.162	0.01	0.103	0.01	140	167.0	17.3	0.098	14.2	118.0	8.6	16.1
Mean	0.1437	0.0716	0.0091	0.0149	0.0058	50	13.9	3.1	0.0669	11.1	99.4	7.7	9.3
Median	0.14	0.072	0.009	0.01	0.005	34	2.0	1.3	0.0684	11.4	97.5	7.6	9.9
Lindis Lindis Pk	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
16/08/06-9/06/11	30	30	30	30	30	30	30.0	30.0	29	29.0	26.0	29.0	30.0
Minimum	0.045	0.0045	0.009	0.0045	0.0045	2	0.9	0.3	0.0276	7.3	87.0	6.9	1.1
Maximum	0.16	0.07	0.02	0.069	0.01	160	81.0	17.8	0.0782	14.7	113.0	9.0	17.0
Mean	0.0837	0.0256	0.0094	0.0153	0.006	36	9.7	2.9	0.0568	11.7	99.4	7.9	7.7
Median	0.08	0.022	0.009	0.01	0.006	28	3.0	1.3	0.0564	12.0	98.7	7.7	7.5

Lindsays Ck	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
9/08/06-22/06/11	23	24	23	23	24	24	23.0	23.0	23	23.0	23.0	23.0	23.0
Minimum	0.4	0.177	0.009	0.022	0.013	8	0.9	1.9	0.128	6.7	61.7	7.0	5.0
Maximum	2.33	2.14	0.04	0.093	0.037	6900	16.0	10.9	0.217	14.3	118.0	8.3	15.1
Mean	0.9922	0.7891	0.0154	0.0407	0.0216	822	4.4	3.7	0.1723	11.3	99.0	7.8	9.4
Median	0.93	0.705	0.01	0.039	0.02	305	0.9	2.9	0.173	11.6	98.4	7.8	9.0
Luggate Creek	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
16/08/06-9/06/11	30	30	30	30	30	30	29.0	30.0	29	29.0	25.0	29.0	30.0
Minimum	0.045	0.0045	0.009	0.0045	0.007	1	0.9	0.3	0.0114	7.2	86.2	6.8	1.3
Maximum	0.22	0.017	0.01	0.027	0.048	220	12.0	4.7	0.0527	14.4	116.0	8.4	16.6
Mean	0.0678	0.0051	0.009	0.0184	0.0127	40	2.1	0.8	0.0322	11.9	101.5	7.7	8.3
Median	0.06	0.0045	0.009	0.019	0.011	19	0.9	0.6	0.0309	12.2	103.0	7.6	7.8
Main Drain	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
17/07/06-21/06/11	43	42	43	43	43	43	43.0	42.0	41	39.0	39.0	41.0	40.0
Minimum	0.7	0.0045	0.009	0.038	0.0045	2	3.0	1.2	0.25	0.0	0.3	5.8	4.4
Maximum	6.94	2.84	1.9	0.551	0.202	4000	29.0	19.9	5.82	12.1	117.0	9.0	20.1
Mean	2.5856	0.6817	0.536	0.1364	0.0327	201	8.0	7.2	2.3929	5.6	52.0	7.5	12.2
Median	2.62	0.3365	0.26	0.111	0.02	46	6.0	5.5	2.13	5.7	48.0	7.4	12.7
Manuherikia Gallwy	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
2/08/06-19/05/11	47	47	47	47	47	46	47.0	30.0	30	29.0	24.0	29.0	30.0
Minimum	0.12	0.0045	0.009	0.014	0.006	1	0.9	0.9	0.043	7.5	85.1	6.6	1.7
Maximum	0.75	0.386	0.02	0.173	0.044	2100	263.0	68.3	0.358	14.1	116.0	8.7	22.4
Mean	0.287	0.0634	0.0096	0.0416	0.0152	174	21.2	7.1	0.0924	10.8	99.8	7.5	11.8
Median	0.24	0.021	0.009	0.03	0.014	42	4.0	2.1	0.0769	10.8	101.0	7.5	10.4
Manuherikia Ophir	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
2/08/06-19/05/11	47	47	47	47	47	46	47.0	30.0	30	30.0	25.0	29.0	30.0
Minimum	0.11	0.008	0.009	0.01	0.005	1	0.9	0.7	0.033	7.7	83.2	5.6	0.8
Maximum	1	0.397	0.02	0.265	0.056	1500	155.0	51.6	0.385	13.8	114.0	7.8	20.7
Mean	0.3121	0.0695	0.0118	0.0486	0.02	202	20.2	6.4	0.0734	10.6	96.0	7.3	10.6
Median	0.24	0.026	0.009	0.034	0.016	80	4.0	2.8	0.0675	10.5	96.0	7.4	9.9
Matukituki River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
16/08/06-9/06/11	30	30	30	30	30	30	30.0	30.0	29	29.0	25.0	30.0	29.0
Minimum	0.045	0.0045	0.009	0.0045	0.0045	1	0.9	0.4	0.046	6.7	81.0	7.0	2.8
Maximum	0.27	0.082	0.04	0.634	0.057	2000	525.0	124.0	0.118	13.9	113.0	8.4	16.0
Mean	0.0865	0.0482	0.0106	0.0462	0.0066	85	42.6	10.1	0.0862	11.5	100.2	7.9	8.8
Median	0.08	0.047	0.009	0.01	0.0045	9	5.0	2.0	0.0906	11.7	102.0	7.9	9.0
Mill Creek	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
15/08/06-30/06/11	30	30	30	30	30	30	30.0	29.0	30	31.0	31.0	31.0	31.0
Minimum	0.28	0.0045	0.009	0.012	0.0045	2	0.9	1.2	0.0852	9.3	85.6	7.5	2.8
Maximum	0.69	0.493	0.04	0.059	0.021	1600	19.0	6.1	0.142	17.4	139.0	9.0	15.0
Mean	0.504	0.3292	0.0106	0.0258	0.0074	190	6.6	3.2	0.1229	11.9	101.7	8.2	8.9
Median	0.53	0.3485	0.009	0.0235	0.0065	79	5.5	3.1	0.124	11.6	102.0	8.1	8.5
Owhiro Stream	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
9/08/06-21/06/11	30	30	30	30	30	30	30.0	30.0	30	29.0	29.0	29.0	30.0
Minimum	0.42	0.0045	0.009	0.055	0.015	6	0.9	3.2	0.075	1.3	11.3	6.7	4.9
Maximum	2.77	1.47	0.15	0.859	0.061	3100	27.0	36.4	0.395	16.1	158.0	8.9	18.3
Mean	1.1853	0.4661	0.045	0.1506	0.0332	563	10.6	14.1	0.2269	8.3	74.4	7.4	11.2
Median	0.98	0.2855	0.03	0.1285	0.032	135	8.5	11.6	0.222	8.3	74.0	7.3	10.2
Pomahaka Burkes Fd	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
25/07/06-22/06/11	52	52	52	52	52	50	52.0	27.0	25	23.0	15.0	27.0	26.0
Minimum	0.26	0.037	0.009	0.021	0.005	13	0.9	1.3	0.0374	4.5	50.7	6.8	4.3
Maximum	3.52	2.87	0.05	0.133	0.029	3400	66.0	21.4	0.817	14.6	116.0	8.1	18.6
Mean	0.906	0.6155	0.0143	0.045	0.014	344	8.7	6.4	0.1457	10.5	89.2	7.5	11.2
Median	0.74	0.4895	0.01	0.035	0.013	88	4.5	3.3	0.094	10.6	92.8	7.5	11.7
Pomahaka Glenken	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
25/07/06-21/06/11	54	54	54	54	54	53	54.0	29.0	28	28.0	12.0	29.0	29.0
Minimum	0.045	0.0045	0.009	0.013	0.0045	24	0.9	0.7	0.017	0.7	70.4	6.9	1.9
Maximum	1.05	1.09	0.02	0.113	0.02	4800	85.0	43.5	0.077	15.9	119.0	8.0	17.9
Mean	0.2721	0.0792	0.0095	0.0302	0.0095	438	7.3	6.1	0.0497	10.9	91.6	7.4	9.2
Median	0.22	0.0385	0.009	0.0215	0.009	130	0.9	2.1	0.0508	11.5	93.2	7.5	7.7

Shag at Craig Rd	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
23/08/06-26/05/11	39	40	39	39	40	40	39.0	39.0	35	35.0	35.0	39.0	35.0
Minimum	0.045	0.0045	0.009	0.0045	0.0045	1	0.9	0.2	0.076	4.1	42.9	7.0	3.2
Maximum	0.74	0.517	0.02	0.038	0.012	220	7.0	6.1	0.268	14.4	109.0	8.7	17.8
Mean	0.2391	0.0701	0.0094	0.0117	0.0065	62	1.2	0.8	0.1937	10.1	90.7	7.7	11.1
Median	0.2	0.0215	0.009	0.01	0.006	38	0.9	0.6	0.205	9.6	93.2	7.7	10.2
Shag at Goodwd Pp	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
23/08/06-26/05/11	28	28	28	28	28	28	28.0	28.0	28	28.0	28.0	28.0	28.0
Minimum	0.16	0.0045	0.009	0.0045	0.0045	1	0.9	0.2	0.087	4.6	45.1	7.1	4.2
Maximum	1.28	1.02	0.03	0.039	0.014	180	10.0	6.6	0.26	13.6	108.0	8.4	16.9
Mean	0.5179	0.3343	0.0112	0.0144	0.0082	59	1.2	1.0	0.2029	9.8	89.2	7.5	11.5
Median	0.46	0.279	0.009	0.0145	0.008	43	0.9	0.6	0.21	9.8	90.9	7.5	11.4
Shotover River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
12/07/06-14/06/11	60	60	60	60	60	15		60.0	60	60.0	60.0	60.0	60.0
Minimum	0.012	0.005	0.001	0.002	0.001	1		0.3	0.0579	9.3	99.0	7.7	0.1
Maximum	0.509	0.036	0.025	2.311	0.005	687		135.0	0.129	14.3	107.2	8.2	18.3
Mean	0.0639	0.0156	0.0036	0.1052	0.0013	84		9.3	0.1012	11.5	102.9	7.9	8.9
Median	0.0495	0.0155	0.003	0.028	0.001	11		2.6	0.102	11.4	102.8	7.9	8.9
Silver Stream	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
9/08/06-21/06/11	30	31	30	30	31	31	30.0	30.0	30	29.0	29.0	30.0	30.0
Minimum	0.2	0.053	0.009	0.005	0.005	4	0.9	0.5	0	3.5	43.5	6.5	4.6
Maximum	0.97	0.72	0.1	0.044	0.016	1920	24.0	7.5	0.215	15.9	136.0	9.5	25.3
Mean	0.492	0.3034	0.0151	0.0177	0.0082	273	3.5	2.6	0.1536	10.9	100.5	7.9	12.4
Median	0.47	0.259	0.009	0.0155	0.007	77	0.9	1.6	0.162	11.3	99.0	7.8	11.6
Sutton at SH87	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
6/07/06-21/06/11	60	60	60	60	60	19		60.0	60	57.0	57.0	60.0	60.0
Minimum	0.126	0.001	0.001	0.008	0.002	2		0.4	0.0286	8.2	86.2	6.8	0.0
Maximum	1.117	0.787	0.015	0.059	0.015	727		81.0	0.0718	14.3	102.1	7.6	18.7
Mean	0.2813	0.0311	0.0066	0.0204	0.0054	75		6.5	0.0496	11.0	95.6	7.2	8.7
Median	0.252	0.007	0.006	0.017	0.005	23		2.2	0.0498	10.9	97.3	7.2	9.3
Taieri at Allanton	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
10/08/06-21/06/11	30	30	30	30	30	30	30.0	30.0	30	29.0	29.0	30.0	30.0
Minimum	0.2	0.0045	0.009	0.015	0.005	18	0.9	1.0	0.058	3.3	37.5	6.0	3.0
Maximum	1.12	0.768	0.06	0.096	0.026	510	30.0	26.0	0.945	12.8	101.0	8.1	21.9
Mean	0.3947	0.0976	0.0147	0.0355	0.0101	113	5.7	5.3	0.1183	9.1	82.5	7.4	11.3
Median	0.31	0.04	0.01	0.0315	0.008	72	3.5	2.5	0.092	9.3	85.8	7.4	10.6
Taieri at Linnburn	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
1/08/06-27/06/11	45	45	45	45	45	44	45.0	26.0	28	30.0	27.0	25.0	30.0
Minimum	0.07	0.0045	0.009	0.0045	0.0045	1	0.9	0.6	0.012	2.9	23.1	5.1	0.2
Maximum	0.53	0.009	0.95	0.045	0.014	2660	7.0	3.9	0.035	13.0	107.0	8.2	17.6
Mean	0.1676	0.0048	0.0308	0.0147	0.0053	111	1.7	1.3	0.0235	9.1	77.6	6.7	7.9
Median	0.16	0.0045	0.009	0.014	0.0045	36	0.9	1.2	0.0261	9.3	79.3	6.8	6.8
Taieri at Outram	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
6/07/06-21/06/11	60	60	60	60	60	13		60.0	60	56.0	56.0	59.0	60.0
Minimum	0.219	0.001	0.002	0.016	0.004	15		0.5	0	8.6	90.2	7.1	1.7
Maximum	1.467	1.021	0.019	0.167	0.052	579		110.0	0.1091	14.4	107.1	7.9	20.2
Mean	0.3813	0.0784	0.0066	0.0376	0.0098	150		5.9	0.0815	11.3	100.9	7.5	10.4
Median	0.316	0.035	0.0055	0.0285	0.008	58		2.4	0.0818	11.2	100.9	7.5	11.1
Taieri at Stonehenge	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
1/08/06-27/06/11	46	46	46	46	46	44	46.0	26.0	29	30.0	28.0	25.0	30.0
Minimum	0.045	0.002	0.009	0.01	0.0045	2	0.9	0.8	0.014	7.6	70.6	5.4	0.1
Maximum	0.55	0.038	0.06	0.069	0.016	1340	21.0	5.1	0.242	13.6	107.0	7.4	17.8
Mean	0.2301	0.0093	0.0109	0.0243	0.0068	80	2.1	1.7	0.0408	10.4	89.1	6.9	8.9
Median	0.225	0.0045	0.009	0.022	0.006	33	0.9	1.5	0.0363	10.1	92.5	7.0	8.2
Taieri at Sutton	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
1/08/06-27/06/11	45	45	45	45	45	45	45.0	26.0	31	30.0	30.0	27.0	32.0
Minimum	0.08	0.0045	0.009	0.021	0.0045	1	0.9	0.7	0.02	7.8	70.7	6.1	3.5
Maximum	0.92	0.231	0.02	0.317	0.032	4880	621.0	81.2	0.91	13.5	122.0	9.6	23.1
Mean	0.3489	0.0492	0.0104	0.0492	0.0128	340	27.7	10.0	0.1283	10.5	95.1	7.7	11.0
Median	0.3	0.019	0.009	0.034	0.01	66	6.0	3.6	0.0843	10.2	95.1	7.6	10.0

Taieri at Tiroiti	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
6/07/06-21/06/11	60	60	60	60	60	15		60.0	60	57.0	57.0	60.0	60.0
Minimum	0.188	0.001	0.002	0.018	0.005	6		0.8	0.0479	8.5	84.9	7.0	0.4
Maximum	0.818	0.373	0.013	0.154	0.056	1414		25.0	0.134	13.9	101.6	8.3	17.5
Mean	0.3417	0.0444	0.0054	0.0461	0.0153	295		4.5	0.0928	10.9	96.9	7.6	9.0
Median	0.321	0.0255	0.005	0.0395	0.0135	142		2.6	0.093	10.8	97.2	7.6	9.7
Taieri at Waipiata	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
1/08/06-27/06/11	46	46	46	46	46	45	46.0	26.0	31	29.0	29.0	27.0	30.0
Minimum	0.12	0.0045	0.009	0.027	0.007	1	0.9	1.6	0.031	7.9	66.8	6.2	2.8
Maximum	0.85	0.071	0.03	0.183	0.088	2060	15.0	6.7	0.918	13.0	115.0	7.8	21.1
Mean	0.3367	0.0237	0.01	0.0594	0.0221	125	4.1	3.5	0.1501	9.9	89.8	7.2	10.7
Median	0.31	0.0175	0.009	0.055	0.019	58	4.0	3.0	0.1	9.9	89.8	7.3	10.2
Tokomairiro W Branch	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
27/07/06-22/06/11	27	28	27	27	28	29	26.0	26.0	26	26.0	9.0	26.0	26.0
Minimum	0.17	0.0045	0.009	0.019	0.006	6	0.9	1.1	0.0381	6.3	62.4	6.7	0.1
Maximum	2.26	1.21	0.05	0.76	0.039	29000	101.0	22.5	0.453	15.5	107.0	8.0	17.4
Mean	0.583	0.2597	0.0146	0.0667	0.012	1371	6.6	4.1	0.0822	10.9	87.0	7.2	9.5
Median	0.39	0.1535	0.01	0.028	0.011	178	0.9	2.6	0.0679	10.6	89.9	7.2	10.5
Trotters Ck	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
23/08/06-26/05/11	28	28	28	28	28	28	28.0	28.0	27	28.0	28.0	28.0	28.0
Minimum	0.12	0.0045	0.009	0.0045	0.0045	2	0.1	1.0	0.0131	2.1	23.0	6.9	2.7
Maximum	1.55	1.14	0.03	0.045	0.019	1200	0.9	3.1	0.245	16.0	155.0	8.4	18.9
Mean	0.4382	0.2337	0.0124	0.015	0.0064	106	0.9	1.6	0.167	9.6	84.1	7.4	10.9
Median	0.35	0.1245	0.01	0.013	0.005	43	0.9	1.6	0.174	9.8	86.7	7.4	9.9
Waianakarua River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
23/08/06-25/05/11	29	30	29	29	30	30	29.0	29.0	26	27.0	27.0	28.0	27.0
Minimum	0.08	0.019	0.009	0.0045	0.0045	1	0.9	0.1	0.037	4.7	50.3	6.9	3.5
Maximum	0.67	0.543	0.02	0.017	0.016	620	4.0	2.4	0.112	15.1	117.0	8.4	19.0
Mean	0.2572	0.1818	0.0099	0.0087	0.0077	41	1.0	0.5	0.0822	10.7	95.6	7.5	11.1
Median	0.21	0.1485	0.009	0.008	0.007	14	0.9	0.3	0.0855	10.4	99.4	7.6	9.9
Waiareka Ck	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
22/08/06-25/05/11	29	29	29	29	29	29	29.0	29.0	28	29.0	29.0	29.0	29.0
Minimum	0.39	0.0045	0.009	0.089	0.026	3	0.9	0.3	0.0577	2.3	20.2	7.4	3.4
Maximum	4.65	1.92	0.85	0.402	0.36	2900	41.0	41.0	7.45	20.0	153.0	8.4	18.7
Mean	1.2248	0.3361	0.0491	0.2029	0.1437	234	5.0	4.3	1.2587	8.8	80.1	7.8	11.7
Median	0.87	0.062	0.02	0.18	0.124	87	0.9	1.1	0.8455	8.5	80.7	7.8	12.5
Waikouaiti at Orbells	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
11/10/06-16/05/11	33	33	33	33	33	34	33.0	33.0	30	31.0	31.0	33.0	32.0
Minimum	0.06	0.005	0.009	0.0045	0.0045	1	0.9	0.4	0.0147	4.5	50.1	7.3	3.2
Maximum	0.56	0.4	0.02	0.033	0.04	1320	5.0	4.2	0.903	14.1	112.0	8.5	21.8
Mean	0.2436	0.0713	0.0095	0.0134	0.0068	81	1.1	1.1	0.1876	9.7	89.0	7.7	12.2
Median	0.21	0.026	0.009	0.011	0.005	24	0.9	0.8	0.15	9.6	92.2	7.6	11.7
Waipahi Cairns Pk	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
25/07/06-21/06/11	45	45	45	45	45	44	45.0	18.0	17	16.0	6.0	18.0	17.0
Minimum	0.62	0.02	0.009	0.034	0.013	35	0.9	3.2	0.0594	0.5	74.2	6.7	4.8
Maximum	3.7	1.87	0.07	0.394	0.05	10200	206.0	106.0	0.967	12.8	102.0	7.9	16.0
Mean	1.224	0.7633	0.0202	0.0834	0.0226	979	17.4	19.8	0.1478	9.3	91.4	7.3	9.8
Median	1.08	0.616	0.02	0.066	0.021	250	7.0	8.8	0.102	10.3	91.5	7.3	10.0
Waipahi at Waipahi	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
25/07/06-21/06/11	54	54	54	54	54	52	54.0	29.0	29	28.0	12.0	29.0	29.0
Minimum	0.41	0.0045	0.009	0.027	0.007	1	0.9	1.1	0.0734	4.9	51.2	7.0	5.2
Maximum	3.46	2.92	0.06	0.155	0.044	3600	72.0	30.3	0.175	14.0	110.0	8.7	20.6
Mean	1.3631	0.9853	0.017	0.0556	0.0179	353	10.4	6.3	0.1223	9.8	86.5	7.6	11.2
Median	1.205	0.87	0.01	0.052	0.0175	120	3.5	3.1	0.125	10.5	86.6	7.6	11.6
Waipori River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
10/08/06-21/06/11	30	30	30	30	30	30	30.0	30.0	30	29.0	29.0	29.0	30.0
Minimum	0.09	0.033	0.009	0.01	0.0045	1	0.9	1.1	0.0229	3.4	35.9	6.1	4.0
Maximum	0.46	0.142	0.02	0.042	0.01	700	20.0	8.4	0.326	12.7	114.0	7.9	18.3
Mean	0.249	0.0608	0.0114	0.0207	0.0057	47	2.3	3.1	0.0481	10.2	91.8	7.1	10.8
Median	0.24	0.054	0.009	0.02	0.0047	6	0.9	2.5	0.035	10.2	93.2	7.2	10.6

Waitahuna River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
27/07/06-22/06/11	31	31	31	31	31	31	31.0	31.0	31	30.0	15.0	31.0	31.0
Minimum	0.15	0.009	0.009	0.022	0.007	24	0.9	1.8	0.0189	0.6	41.1	6.6	3.7
Maximum	2.95	1.57	0.06	0.375	0.037	4960	228.0	116.0	0.142	16.6	126.0	7.8	18.8
Mean	0.5803	0.2485	0.0156	0.0572	0.0133	609	16.8	8.6	0.0757	10.0	83.2	7.2	10.5
Median	0.39	0.106	0.01	0.038	0.012	138	5.0	3.7	0.075	10.0	84.8	7.2	11.1
Waiwera River	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
25/07/06-25/05/11	31	31	31	31	31	30	31.0	31.0	31	31.0	17.0	30.0	31.0
Minimum	0.41	0.008	0.009	0.033	0.012	14	0.9	0.9	0.0769	3.8	39.8	7.1	5.3
Maximum	4.4	3.33	0.08	0.282	0.053	2700	91.0	79.8	0.174	16.7	131.0	9.0	22.4
Mean	1.2794	0.9675	0.0215	0.0731	0.0275	500	9.5	7.5	0.1305	10.4	90.0	7.9	12.0
Median	1.08	0.781	0.02	0.061	0.027	210	4.0	3.6	0.135	10.0	93.5	7.8	12.1
Wairuna Stream	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp
7/07/08-24/11/09	33	33	33	33	33	32	33.0	5.0	5	5.0	5.0	5.0	5.0
Minimum	0.79	0.067	0.02	0.059	0.015	21	0.9	7.0	0.122	3.2	26.5	6.6	5.3
Maximum	6.43	5.86	0.21	0.4	0.116	20000	214.0	104.0	0.233	14.0	98.6	7.5	18.0
Mean	2.1224	1.4658	0.0621	0.1398	0.0435	1507	17.3	29.7	0.1808	8.5	71.8	7.0	10.1
Median	1.69	1.09	0.06	0.101	0.032	345	8.0	10.7	0.192	8.3	82.1	7.0	7.0

Lake Dunstan	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp	Chla
16/08/06-9/06/11	30	30	30	30	30	30	30.0	30.0	28	27.0	23.0	29.0	28.0	
Minimum	0.045	0.005	0.009	0.0045	0.0045	1	0.9	0.4	0.0399	6.0	86.0	7.5	8.0	
Maximum	0.18	0.04	0.01	0.03	0.044	600	9.0	5.3	0.0735	16.1	112.0	8.8	21.5	
Mean	0.0765	0.0205	0.0091	0.0098	0.0079	23	1.6	1.2	0.0599	10.5	100.3	8.0	13.6	
Median	0.07	0.02	0.009	0.007	0.0045	1	0.9	0.7	0.0667	10.4	100.0	8.0	13.2	
Lake Hawea	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp	Chla
16/08/06-9/06/11	29	30	30	30	30	30	30.0	29.0	29	29.0	25.0	30.0	30.0	29.0
Minimum	0.045	0.0045	0.009	0.0045	0.0045	1	0.9	0.2	0.0285	6.5	87.0	7.1	8.6	1.7
Maximum	0.05	0.021	0.01	0.05	0.01	1	11.0	4.2	0.053	14.2	131.0	8.8	18.1	2.3
Mean	0.0455	0.0099	0.009	0.0065	0.0047	1	1.4	0.6	0.0449	11.0	105.5	7.9	12.3	1.8
Median	0.045	0.0075	0.009	0.0045	0.0045	1	0.9	0.4	0.0497	11.1	104.0	7.8	11.3	1.8
Lake Hayes	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp	Chla
14/08/06-30/06/11	27	27	27	27	27	28	27.0	26.0	27	27.0	27.0	27.0	27.0	27.0
Minimum	0.19	0.0045	0.009	0.009	0.0045	1	0.9	0.3	0.128	7.7	65.8	7.4	5.6	1.7
Maximum	0.65	0.022	0.07	0.1	0.035	58	23.0	14.7	1.61	15.0	163.0	10.3	20.4	53.1
Mean	0.3622	0.0069	0.017	0.0431	0.0111	4	3.8	2.4	0.2039	10.6	102.5	8.8	13.2	17.3
Median	0.38	0.0045	0.009	0.046	0.006	1	0.9	1.3	0.152	10.1	102.0	8.7	13.7	9.9
Lake Johnson	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp	Chla
14/08/06-30/06/11	25	25	25	25	25	25	25.0	24.0	25	25.0	25.0	24.0	25.0	24.0
Minimum	0.59	0.0045	0.009	0.022	0.0045	1	0.9	0.5	0.137	6.3	50.4	7.0	4.6	1.7
Maximum	0.93	0.028	0.24	0.102	0.064	500	22.0	13.4	0.186	13.4	145.0	9.8	20.4	45.0
Mean	0.778	0.0058	0.0454	0.0583	0.0226	22	3.7	2.5	0.1699	9.8	94.5	8.5	12.9	12.3
Median	0.78	0.0045	0.009	0.057	0.009	1	0.9	1.6	0.174	9.6	97.1	8.5	13.1	8.3
Lake Onslow	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp	Chla
3/08/06-19/05/11	28	28	28	28	28	28	28.0	28.0	28	28.0	24.0	28.0	28.0	24.0
Minimum	0.19	0.0045	0.009	0.016	0.0045	1	0.9	1.4	0.013	5.5	57.6	5.8	2.7	1.7
Maximum	0.63	0.008	0.02	0.158	0.034	90	114.0	19.7	0.029	12.0	107.0	7.7	23.2	5.0
Mean	0.2846	0.0048	0.0095	0.0407	0.0071	5	17.2	6.0	0.0228	9.3	84.1	6.8	11.1	2.7
Median	0.25	0.0045	0.009	0.0325	0.0045	1	6.5	4.8	0.0245	9.1	82.0	6.9	11.1	2.6
Lake Tuakitoto	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp	Chla
27/07/06-22/06/11	33	33	33	33	33	33	33.0	33.0	32	33.0	14.0	33.0	33.0	28.0
Minimum	0.045	0.0045	0.009	0.013	0.006	13	0.9	0.9	0.0002	2.5	27.8	6.8	4.4	1.7
Maximum	2.11	1.03	0.55	0.247	0.042	20000	73.0	73.8	0.3	12.6	101.0	8.8	20.6	25.2
Mean	1.0062	0.2309	0.0474	0.1063	0.0186	855	15.2	12.8	0.1564	7.8	62.8	7.3	12.2	7.3
Median	1	0.06	0.02	0.1	0.018	130	8.0	6.5	0.176	8.0	61.1	7.3	12.7	6.6
Lake Waihola	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp	Chla
10/08/06-21/06/11	30	31	30	30	31	31	30.0	29.0	29	29.0	29.0	30.0	30.0	27.0
Minimum	0.19	0.0045	0.009	0.012	0.0045	1	0.9	2.0	0.006	3.2	36.5	6.0	4.9	1.7
Maximum	1.42	0.592	0.04	0.154	0.027	180	135.0	79.4	6.65	12.9	105.0	9.1	21.5	23.4
Mean	0.5627	0.059	0.0126	0.0579	0.0066	42	24.0	15.4	1.2997	8.6	80.4	7.4	12.5	7.6
Median	0.49	0.0045	0.009	0.0455	0.005	30	11.0	7.8	0.512	8.4	82.7	7.4	11.6	4.8
Lake Wakatipu	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp	Chla
14/08/06-30/06/11	31	31	31	31	31	29	31.0	30.0	31	31.0	30.0	31.0	31.0	28.0
Minimum	0.045	0.011	0.009	0.0045	0.0045	1	0.9	0.2	0.0295	9.2	84.0	7.0	8.0	1.7
Maximum	0.21	0.035	0.009	0.02	0.009	21	118.0	2.5	0.055	12.3	111.0	8.4	16.8	2.0
Mean	0.0805	0.023	0.009	0.0059	0.0046	4	5.1	0.6	0.0486	10.7	99.1	7.9	11.6	1.8
Median	0.08	0.023	0.009	0.0045	0.0045	1	0.9	0.4	0.0526	10.7	99.0	7.9	11.1	1.8
Lake Wanaka	TN	NNN	NH4	TP	DRP	*E. coli*	SS	Turb	Cond	DO	DO %	pH	Temp	Chla
15/08/06-9/06/11	32	32	32	32	32	31	32.0	30.0	30	29.0	25.0	32.0	30.0	29.0
Minimum	0.045	0.008	0.009	0.0045	0.0045	1	0.9	0.2	0.0507	6.1	83.0	7.5	8.8	1.7
Maximum	0.18	0.039	0.01	3	0.028	30	10.0	1.2	0.073	11.9	113.0	8.7	19.4	20.7
Mean	0.0691	0.0258	0.009	0.0989	0.0058	2	1.5	0.4	0.0653	10.3	98.7	8.0	12.7	2.4
Median	0.06	0.0265	0.009	0.0045	0.0045	1	0.9	0.4	0.0675	10.4	98.7	7.9	12.0	1.8

Appendix 5 WQI grades (2006 to 2011)

Site name	Compliance %	Rank	NNN >0.444 mg/l	NH4 >0.9 mg/l	DRP >0.01 mg/l	*E. coli* >126cfu /100ml	Turb >5.6 NTU	DO % <80%	WQI
Cardrona River	96.55	18	✓	✓	✓	✓	✓	✓	Very good
Catlins River	67.55	45	✓	✓	✗	✓	✓	✓	Good
Clutha at Balclutha	91.36	12	✓	✓	✓	✓	✓	✓	Very good
Clutha at Luggate Br.	96.11	8	✓	✓	✓	✓	✓	✓	Very good
Clutha at Millers Flat	96.74	3	✓	✓	✓	✓	✓	✓	Very good
Crookston Burn	41.67	58	✗	✓	✗	✗	✓	✓	Fair
Dart at The Hillocks	86.42	39	✓	✓	✓	✓	✗	✓	Good
Dunstan Creek	97.99	27	✓	✓	✓	✓	✓	✓	Very good
Fraser at Marshall Rd	96.55	15	✓	✓	✓	✓	✓	✓	Very good
Hawea at Camphill Br.	100.00	2	✓	✓	✓	✓	✓	✓	Very good
Heriot Burn	39.91	57	✗	✓	✗	✗	✓	✓	Fair
Kaikorai Stream	64.66	50	✓	✓	✗	✗	✓	✓	Fair
Kakanui at Clifton	94.44	11	✓	✓	✓	✓	✓	✓	Very good
Kakanui at McCones	89.59	29	✓	✓	✓	✓	✓	✓	Very good
Kauru at Ewings	93.10	14	✓	✓	✓	✓	✓	✓	Very good
Kawarau at Chards	93.61	10	✓	✓	✓	✓	✓	✓	Very good
Kye Burn at SH85	90.90	25	✓	✓	✓	✓	✓	✓	Very good
Leith at Dundas	96.67	6	✓	✓	✓	✓	✓	✓	Very good
Lindis at Ardgour Road	100.00	1	✓	✓	✓	✓	✓	✓	Very good
Lindis at Lindis Peak	90.69	4	✓	✓	✓	✓	✓	✓	Very good
Lindsays Creek	86.61	16	✓	✓	✓	✓	✓	✓	Very good
Luggate Creek at SH6	84.23	24	✓	✓	✓	✓	✓	✓	Very good
Main Drain at Pump	53.25	59	✓	✓	✗	✗	✗	✗	Poor
Manuherikia – G'way	78.92	41	✓	✓	✓	✓	✗	✓	Good
Manuherikia at Ophir	76.98	43	✓	✓	✗	✓	✓	✓	Good
Matukituki River	96.11	13	✓	✓	✓	✓	✓	✓	Very good
Mill Creek at Fish Trap	87.15	33	✓	✓	✓	✓	✓	✓	Very good
Owhiro Stream	45.23	61	✓	✓	✗	✗	✗	✗	Poor
Pomahaka at Ford	62.59	51	✗	✓	✗	✓	✓	✓	Fair
Pomahaka at Glenken	77.30	42	✓	✓	✓	✗	✓	✓	Good
Shag at Craig Road	92.13	23	✓	✓	✓	✓	✓	✓	Very good
Shag at Goodwood	85.71	32	✓	✓	✓	✓	✓	✓	Very good
Shotover River	93.61	9	✓	✓	✓	✓	✓	✓	Very good
Silver Stream	83.17	31	✓	✓	✓	✓	✓	✓	Very good
Sutton at SH87	93.80	17	✓	✓	✓	✓	✓	✓	Very good
Taieri at Allanton	80.33	36	✓	✓	✓	✓	✓	✓	Very good
Taieri at Linnburn	88.72	38	✓	✓	✓	✓	✓	✗	Good
Taieri at Outram	85.81	30	✓	✓	✓	✓	✓	✓	Very good
Taieri at Stonehenge	94.35	21	✓	✓	✓	✓	✓	✓	Very good
Taieri at Sutton	81.37	34	✓	✓	✓	✓	✓	✓	Very good
Taieri at Tiroiti	75.00	47	✓	✓	✗	✗	✓	✓	Fair
Taieri at Waipiata	79.21	44	✓	✓	✗	✓	✓	✓	Good
Tokomairiro West	72.70	49	✓	✓	✗	✗	✓	✓	Fair
Trotters Creek	86.90	35	✓	✓	✓	✓	✓	✓	Very good
Waianakarua River	94.81	19	✓	✓	✓	✓	✓	✓	Very good
Waiareka Creek	66.09	46	✓	✓	✗	✓	✓	✓	Good
Waikouaiti River	92.73	22	✓	✓	✓	✓	✓	✓	Very good
Waipahi at Cairns Peak	42.50	60	✗	✓	✗	✗	✗	✓	Poor
Waipahi at Waipahi	56.17	54	✗	✓	✗	✓	✓	✓	Fair
Waipori River	96.07	28	✓	✓	✓	✓	✓	✓	Very good
Wairuna Stream	32.32	62	✗	✓	✗	✗	✗	✓	Poor
Waitahuna River	69.14	53	✓	✓	✗	✗	✓	✓	Fair
Waiwera River	47.50	55	✗	✓	✗	✗	✓	✓	Fair

Appendix 6 Monitoring sites and their accrual status

Site name – Sites with short accrual times	Accrual days	NNN	NH4	DRP	*E. coli*	TURB
	<30	**0.444**	**0.1**	**0.026**	**126**	**5**
Catlins at Houipapa	27	0.377	0.0095	0.0165	110	3.11
Heriot Burn at Park Hill Road		1.19	0.03	0.024	440	4.585
Kaikorai Stream at Brighton Road		0.34	0.015	0.0135	355	3.41
Leith at Dundas Street Bridge	26	0.394	0.01	0.026	210	2.41
Pomahaka at Burkes Ford	27	0.4895	0.01	0.013	88	3.32
Pomahaka at Glenken	25	0.0385	0.009	0.009	130	2.11
Waipahi at Cairns Peak	27	0.616	0.02	0.021	250	8.805
Waipahi at Waipahi	27	0.814	0.01	0.018	120	2.95
Waiwera at Maws Farm	27	0.781	0.02	0.027	210	3.55

Site name – Sites with long accrual times	Accrual days	NNN	NH4	DRP	*E. coli*	TURB
	>30	**0.075**	**0.1**	**0.006**	**126**	**5**
Cardrona at Mt Barker	48	0.055	0.009	0.005	20	1.05
Clutha at Balclutha	1793	0.049	0.003	0.002	7.4	1.66
Clutha at Millers Flat	1090	0.025	0.002	0.001	2	1.275
Dunstan Creek at Beattie Road	66	0.0305	0.009	0.007	16	0.98
Fraser at Marshall Road	34	0.028	0.009	0.005	19	1.2
Kakanui at Clifton Falls Bridge	29	0.017	0.009	0.005	71.5	0.3
Kakanui at McCones	28	0.145	0.009	0.005	30	0.52
Kauru at Ewings	24	0.019	0.009	0.006	36	0.27
Kye Burn at SH85 Bridge	35	0.033	0.009	0.008	26	1.445
Lindis at Ardgour Road	48	0.072	0.009	0.005	34	1.34
Lindis at Lindis Peak	49	0.022	0.009	0.006	27.5	1.28
Luggate Creek at SH6 Bridge	48	0.0045	0.009	0.011	19	0.63
Manuherikia at Galloway	51	0.021	0.009	0.014	42	2.1
Manuherikia at Ophir	45	0.026	0.009	0.016	80	2.75
Mill Creek at Fish Trap	157	0.3485	0.009	0.0065	79	3.08
Owhiro Stream at Burns Street		0.2855	0.03	0.032	135	11.55
Shag at Craig Road	45	0.0215	0.009	0.006	37.5	0.56
Shag at Goodwood Pump	45	0.279	0.009	0.008	43	0.62
Shotover at Bowens Peak		0.015	0.003	0.001	15.6	2.775
Silverstream at Taieri Depot	23	0.259	0.009	0.007	77	1.645
Sutton at SH87	34	0.007	0.006	0.005	24.6	2.2
Taieri at Allanton Bridge	48	0.04	0.01	0.008	72	2.495
Taieri at Linnburn	23	0.0045	0.009	0.0045	35.5	1.195
Taieri at Outram	48	0.035	0.006	0.008	70.95	2.175
Taieri at Stonehenge (Waipiata recorder)	65	0.0045	0.009	0.006	33	1.48
Taieri at Sutton	51	0.019	0.009	0.01	66	3.595
Taieri at Tiroiti	57	0.0255	0.005	0.0135	142	2.6
Taieri at Waipiata	65	0.0175	0.009	0.019	58	3.005
Tokomairiro at West Branch Bridge	33	0.1535	0.01	0.011	178	2.575
Trotters Creek at Mathesons	45	0.1245	0.01	0.005	42.5	1.585
Waianakarua at Browns	30	0.1485	0.009	0.007	13.5	0.32
Waiareka Creek at Taipo Road	52	0.062	0.02	0.124	87	1.13
Waikouaiti at Orbells Crossing	41	0.026	0.009	0.005	30	0.76
Waipori at Waipori Falls Reserve		0.054	0.009	0.0047	6	2.54
Waitahuna at Tweeds Bridge	35	0.106	0.01	0.012	138	3.72

Site name – Lakes region	NNN	NH4	DRP	*E. coli*	TURB
	0.03	**0.01**	**0.005**	***10***	**3**
Clutha at Luggate Br.	0.027	0.002	0.001	3.1	2.425
Dart at The Hillocks	0.018	0.009	0.0045	4	19
Kawarau at Chards	0.022	0.009	0.001	15.35	2.45
Lake Hawea Outflow at Dam	0.0075	0.009	0.0045	0.9	0.41
Lake Wakatipu at Outflow	0.023	0.009	0.0045	0.9	0.43
Lake Wanaka at Outlet	0.0265	0.009	0.0045	0.9	0.37
Matukituki at West Wanaka	0.047	0.009	0.0045	8.5	2.04

Site name – Lakes sites	Chlorophyll a	TN	NH4	TP	EC	TURB
(using trophic level guidelines)	**12**	**0.725**	**0.1**	**0.043**	**126**	**5**
Clutha at Luggate Br.		0.027	0.002	0.001	3.1	2.425
Dart at The Hillocks		0.018	0.009	0.0045	4	19
Kawarau at Chards		0.022	0.009	0.001	15.35	2.45
Lake Hawea outflow at dam		0.0075	0.009	0.0045	0.9	0.41
Lake Wakatipu at outflow		0.023	0.009	0.0045	0.9	0.43

Appendix 7 Mann-Whitney test results

The significant differences between two reporting periods (July 2001 - June 2006 and July 2006 - June 2011) are highlighted in yellow (degrading) and blue (improving).

Site name	NH4 Statistic	NH4 P (Chi2)	DRP Statistic	DRP P (Chi2)	*E. coli* Statistic	*E. coli* P (Chi2)	NNN Statistic	NNN P (Chi2)
Cardrona at Mt Barker	6.5453	0.0105	2.9	0.0886	9.4227	0.0021	1.2749	0.2588
Catlins at Houipapa	2.0359	0.1536	11.2707	0.0008	0.0517	0.8201	0.0194	0.8893
Clutha at Balclutha	1.477	0.2242	0.18	0.6713	0.2222	0.6374	1.2442	0.2647
Clutha at Luggate Br.	3.5158	0.0608	0.131	0.7174	1.3105	0.2523	13.3613	0.0003
Clutha at Millers Flat	1.7948	0.1803	1.5329	0.2157	3.8172	0.0507	4.3592	0.0368
Crookston Burn	0.7269	0.3939	9.7923	0.0018	0.3312	0.565	0.0006	0.98
Dunstan Creek	8.2598	0.0041	2.505	0.1135	2.6469	0.1038	7.5016	0.0062
Fraser River	5.175	0.0229	0.0074	0.9314	3.2925	0.0696	2.2282	0.1355
Heriot Burn	0.8114	0.3677	5.3574	0.0206	0.9289	0.3352	3.2276	0.0724
Kaikorai Stream	0.4104	0.5218	13.9972	0.0002	2.2228	0.136	3.0975	0.0784
Kakanui at Clifton Falls	7.0272	0.008	4.4147	0.0356	2.7839	0.0952	9.6037	0.0019
Kakanui at McCones	0.085	0.7707	5.1931	0.0227	1.2443	0.2646	6.1209	0.0134
Kauru at Ewings	1.2008	0.2732	13.758	0.0002	7.4573	0.0063	0.419	0.5174
Kawarau at Chards	0.6529	0.4191	3.4474	0.0634	0.1093	0.741	0.0001	0.9916
Kye Burn at SH85	0.3119	0.5765	3.09	0.0788	2.5572	0.1098	2.5231	0.1122
Lake Dunstan	4.5948	0.0321	11.4634	0.0007	0.0668	0.7961	4.9589	0.026
Lake Hawea Outflow	5.5591	0.0184	4.8978	0.0269	2.566	0.1092	3.3369	0.0677
Lake Hayes	9.9416	0.0016	0.0997	0.7522	1.8922	0.169	6.251	0.0124
Lake Johnson	1.889	0.1693	1.4788	0.224	4.5549	0.0328	1.7344	0.1878
Lake Onslow	13.9311	0.0002	3.7729	0.0521	5.2321	0.0222	15.9736	0.0001
Lake Tuakitoto	2.5953	0.1072	6.1477	0.0132	0.7401	0.3896	0.0002	0.989
Lake Waihola	15.1604	0.0001	0.7891	0.3744	0.122	0.7269	0.4533	0.5008
Lake Wakatipu	9.3232	0.0023	1.0174	0.3131	6.5	0.0108	0.9234	0.3366
Lake Wanaka	8.2687	0.004	4.8731	0.0273	0.7536	0.3853	10.7917	0.001
Leith at Dundas Street	1.5194	0.2177	19.3733	0	1.0233	0.3117	5.7632	0.0164
Lindis at Ardgour Road	22.2307	0	4.9554	0.026	0.5137	0.4736	0.4881	0.4848
Lindis at Lindis Peak	10.4935	0.0012	0.137	0.7113	0.3302	0.5656	4.6042	0.0319
Lindsays Creek	5.0452	0.0247	0.1215	0.7274	13.691	0.0002	0.1212	0.7277
Main Drain	2.1538	0.1422	31.872	0	0.9885	0.3201	0.1681	0.6818
Manuherikia -Galloway	5.4004	0.0201	2.6467	0.1038	3.6143	0.0573	0.7076	0.4002
Mill Creek	3.7089	0.0541	11.6409	0.0006	3.1486	0.076	4.2234	0.0399
Owhiro Stream	0.0511	0.8211	12.3571	0.0004	0.634	0.4259	1.6294	0.2018
Pomahaka -Burkes	5.6529	0.0174	9.6633	0.0019	0.2045	0.6511	0.2225	0.6371
Pomahaka at Glenken	8.9573	0.0028	12.3313	0.0004	0.3718	0.542	0.0001	0.993
Shag at Craig Road	7.341	0.0067	2.1306	0.1444	7.9509	0.0048	2.989	0.0838
Shag at Goodwood	1.7557	0.1852	24.8132	0	6.3527	0.0117	12.7815	0.0004
Shotover River	2.8495	0.0914	0.9297	0.335	0.3502	0.554	2.4283	0.1192
Silver Stream	0.0976	0.7547	5.6652	0.0173	1.3519	0.2449	5.5652	0.0183
Sutton at SH87	0.0542	0.816	5.5982	0.018	1.689	0.1937	2.0453	0.1527
Taieri at Allanton	0.8238	0.3641	6.1484	0.0132	7.3865	0.0066	0.0728	0.7873
Taieri at Linnburn	15.8427	0.0001	5.6982	0.017	0.0049	0.9443	18.1137	0
Taieri at Outram	0.8114	0.3677	0.5703	0.4501	1.3427	0.2466	4.9309	0.0264
Taieri at Stonehenge	3.6525	0.056	31.4339	0	4.7193	0.0298	5.8853	0.0153
Taieri at Tiroiti	1.0903	0.2964	0.5887	0.4429	2.7229	0.0989	2.2103	0.1371
Taieri at Waipiata	17.9324	0	4.4876	0.0341	11.5653	0.0007	0.953	0.329
Tokomairiro West Br.	2.6808	0.1016	8.721	0.0031	0.3018	0.5827	0.8114	0.3677
Waianakarua River	7.8144	0.0052	10.8023	0.001	0.2837	0.5943	2.3192	0.1278
Waiareka Creek	10.3696	0.0013	0.0048	0.9445	0.6157	0.4327	4.6946	0.0303
Waikouaiti River	9.9069	0.0016	10.782	0.001	2.9851	0.084	0.1572	0.6918
Waipahi at Cairns Peak	2.4657	0.1164	34.5935	0	0.1042	0.7468	0.0885	0.7662
Waipahi at Waipahi	4.2274	0.0398	20.0623	0	0.7284	0.3934	0.0894	0.765
Wairuna Stream	0.7841	0.3759	2.1185	0.1455	1.8215	0.1771	0.776	0.3784
Waitahuna River	0.0647	0.7993	10.3913	0.0013	0.3329	0.5639	1.5259	0.2167

The significant differences between two reporting periods (Jul 2001 - Jun 2006 and Jul 2006 - Jun 2011) are highlighted in yellow (degrading) and blue (improving).

Site	SS Statistic	SS P (Chi2)	TN Statistic	TN P (Chi2)	TP Statistic	TP P (Chi2)	TURB Statistic	TURB P (Chi2)
Cardrona at Mt Barker	3.3478	0.0673	0.0327	0.8565	0.897	0.3436	0.1304	0.718
Catlins at Houipapa	2.3121	0.1284	0.0676	0.7949	4.5221	0.0335	0.0025	0.9601
Clutha at Balclutha			1.913	0.1666	4.0899	0.0431	0.2207	0.6385
Clutha at Luggate Br.			26.4479	0	12.4995	0.0004	1.3038	0.2535
Clutha at Millers Flat			6.0572	0.0139	7.4941	0.0062	2.3803	0.1229
Crookston Burn	1.2196	0.2694	0.7452	0.388	3.4762	0.0623	0.0002	0.99
Dunstan Creek	1.3746	0.241	2.6116	0.1061	0.0297	0.8633	0.0546	0.8152
Fraser River	1.1414	0.2854	1.4693	0.2255	3.3465	0.0673	3.3664	0.0665
Heriot Burn	0.6483	0.4207	0.902	0.3422	0.032	0.858	0.2996	0.5841
Kaikorai Stream	9.1937	0.0024	0.4402	0.507	0.2238	0.6361	0.9705	0.3245
Kakanui at Clifton Falls	4.9102	0.0267	1.0344	0.3091	6.0984	0.0135	0.5391	0.4628
Kakanui at McCones	1.8562	0.1731	6.959	0.0083	5.0071	0.0252	0.3678	0.5442
Kauru at Ewings	0	1	2.7748	0.0958	1.5987	0.2061	4.8274	0.028
Kawarau at Chards			0.4937	0.4823	0.6544	0.4185	4.8261	0.028
Kye Burn at SH85	3.2161	0.0729	3.318	0.0685	0.3115	0.5767	0.2501	0.617
Lake Dunstan	0.2862	0.5927	3.5385	0.06	15.435	0.0001	4.6669	0.0307
Lake Hawea Outflow	1.2256	0.2683	11.8016	0.0006	2.2704	0.1319	9.6931	0.0018
Lake Hayes	0.1809	0.6706	3.3659	0.0666	4.1883	0.0407	15.5002	0.0001
Lake Johnson	0.0023	0.9621	11.1756	0.0008	7.2829	0.007	19.3398	0
Lake Onslow	0.6913	0.4057	1.9014	0.1679	0.0132	0.9086	2.7441	0.0976
Lake Tuakitoto	0.1732	0.6773	0.0398	0.8418	4.7901	0.0286	0.4926	0.4828
Lake Waihola	0.0194	0.8891	2.7379	0.098	2.5122	0.113	3.0357	0.0815
Lake Wakatipu	0.2288	0.6324	5.3147	0.0211	6.047	0.0139	7.0981	0.0077
Lake Wanaka	0.4919	0.4831	0.0013	0.9714	0.0053	0.9422	5.5689	0.0183
Leith at Dundas Street	9.7253	0.0018	0.1922	0.6611	0.0558	0.8133	2.1025	0.1471
Lindis at Ardgour Road	0.7605	0.3832	0.8703	0.3509	0.2358	0.6273	0.8339	0.3611
Lindis at Lindis Peak	0.0004	0.9841	0.0075	0.9309	0.2301	0.6314	0.0404	0.8407
Lindsays Creek	5.3101	0.0212	1.8365	0.1754	2.8793	0.0897	2.1408	0.1434
Main Drain	1.5217	0.2174	0.7144	0.398	14.7076	0.0001	0.0091	0.9239
Manuherikia -Galloway	0.4836	0.4868	0.0007	0.9791	0.9051	0.3414	0.0918	0.7619
Mill Creek	7.8504	0.0051	5.189	0.0227	0.5583	0.4549	0.1554	0.6934
Owhiro Stream	4.5106	0.0337	2.0204	0.1552	3.5914	0.0581	4.517	0.0336
Pomahaka -Burkes	1.0813	0.2984	0.0297	0.8631	4.8112	0.0283	0.0023	0.9618
Pomahaka at Glenken	1.7362	0.1876	0.105	0.746	7.7554	0.0054	4.4199	0.0355
Shag at Craig Road	6.4033	0.0114	0.7066	0.4006	0.0257	0.8726	1.9646	0.161
Shag at Goodwood	6.0948	0.0136	10.7398	0.001	5.7223	0.0168	0.0554	0.8139
Shotover River			7.1954	0.0073	2.0464	0.1526	0.9933	0.3189
Silver Stream	0.4948	0.4818	6.378	0.0116	0.1679	0.682	2.1392	0.1436
Sutton at SH87			0.9379	0.3328	0.1062	0.7445	0.5134	0.4736
Taieri at Allanton	0.6708	0.4128	0.7788	0.3775	0.544	0.4608	0.6131	0.4336
Taieri at Linnburn	11.5614	0.0007	0.9539	0.3287	0.1401	0.7082	0.0205	0.886
Taieri at Outram			4.8138	0.0282	0.2361	0.627	0.3676	0.5443
Taieri at Stonehenge	6.9268	0.0085	2.3665	0.124	11.1695	0.0008	1.3962	0.2374
Taieri at Tiroiti			1.9641	0.1611	1.3099	0.2524	1.4262	0.2324
Taieri at Waipiata	6.9698	0.0083	0.7773	0.378	1.6409	0.2002	0.3376	0.5612
Tokomairiro West Br.	3.5862	0.0583	0.0588	0.8084	0.0027	0.9586	0.1825	0.6692
Waianakarua River	0.8828	0.3474	0.0746	0.7847	5.551	0.0185	2.189	0.139
Waiareka Creek	6.8376	0.0089	0.6159	0.4326	0.0014	0.9697	0.8306	0.3621
Waikouaiti River	2.9676	0.0849	2.4838	0.115	5.7497	0.0165	0.1366	0.7117
Waipahi at Cairns Peak	1.0892	0.2966	3.9611	0.0466	19.287	0	10.8314	0.001
Waipahi at Waipahi	0.0293	0.8641	0.1125	0.7374	16.7639	0	0.5051	0.4773
Wairuna Stream	0.8164	0.3662	0.2414	0.6232	0.0667	0.7963	0.1881	0.6645
Waitahuna River	0.0027	0.9585	0.858	0.3543	5.3661	0.0205	1.5444	0.214

Not enough 2001 to 2006 data for: Dart River, Hawea River, Luggate Creek, Manuherikia at Ophir, Matukituki River, Taieri at Sutton, Trotters Creek, Waipori River and Waiwera River

Appendix 8 Water quality: Trends

Non-flow adjusted 2001 to 2011

Site name	NH4	TN	NNN	TP	DRP	*E. coli*	Turb	SS
Cardrona at Mt Barker					↑↑	⇩⇩		
Catlins at Houipapa					↑↑			
Clutha at Balclutha								
Clutha at Luggate Br.			⇩⇩	⇩⇩				
Clutha at Millers Flat						⇩⇩		
Crookston Burn					↑↑			
Dart at The Hillocks								
Dunstan Creek			↑↑					
Fraser at Marshall Rd			⇩⇩			⇩⇩	↑↑	
Hawea at Camphill Br				⇩⇩				
Heriot Burn		↑↑	↑↑		↑↑			
Kaikorai Stream					↑↑			⇩⇩
Kakanui at Clifton					↑↑			
Kakanui at McCones					↑↑			
Kauru at Ewings					↑↑	⇩⇩		
Kawarau at Chards								
Kye Burn at SH85 Bridge					↑↑			
Leith at Dundas			↑↑		↑↑			⇩⇩
Lindis at Ardgour Road								
Lindis at Lindis Peak								
Lindsays Creek						⇩⇩		⇩⇩
Luggate Creek at SH6								
Main Drain at Pump								
Manuherikia at Galloway					↑↑	⇩⇩		
Manuherikia at Ophir		↑↑	↑↑					
Matukituki River						⇩⇩		
Mill Creek at Fish Trap		⇩⇩	⇩⇩		↑↑	⇩⇩		⇩⇩
Owhiro Stream				↑↑	↑↑		↑↑	↑↑
Pomahaka at Ford	⇩⇩			↑↑	↑↑			
Pomahaka at Glenken				↑↑	↑↑			
Shag at Craig Road		↑↑	↑↑		↑↑	⇩⇩		
Shag at Goodwood		↑↑	↑↑	↑↑	↑↑	⇩⇩		
Shotover River		⇩⇩	⇩⇩					
Silver Stream		↑↑	↑↑		↑↑		↑↑	
Sutton at SH87								
Taieri at Allanton Bridge					↑↑			
Taieri at Linnburn	⇩⇩		⇩⇩					⇩⇩
Taieri at Outram		↑↑	↑↑					
Taieri at Stonehenge			⇩⇩	↑↑	↑↑	⇩⇩		
Taieri at Sutton			↑↑					
Taieri at Tiroiti								
Taieri at Waipiata	⇩⇩				↑↑	⇩⇩		⇩⇩
Tokomairiro West					↑↑			
Trotters Creek								
Waianakarua at Browns				↑↑	↑↑			
Waiareka Creek	⇩⇩							
Waikouaiti River				↑↑	↑↑	⇩⇩		
Waipahi at Cairns Peak		↑↑		↑↑	↑↑		↑↑	
Waipahi at Waipahi				↑↑	↑↑			
Waipori at Reserve			↑↑					
Wairuna Stream								
Waitahuna River		↑↑	↑↑	↑↑	↑↑			
Waiwera		↑↑						

Non-flow adjusted 2006 to 2011

Site name	NH4	TN	NNN	TP	DRP	*E. coli*	Turb	SS
Cardrona at Mt Barker								
Catlins at Houipapa		↑↑	↑↑		↑↑			↑↑
Clutha at Balclutha								
Clutha at Luggate Br.								
Clutha at Millers Flat								
Crookston Burn								
Dart at The Hillocks								
Dunstan Creek								
Fraser at Marshall Rd							↑↑	
Hawea at Camphill Br				⇩⇩				
Heriot Burn		↑↑	↑↑					
Kaikorai Stream								
Kakanui at Clifton								
Kakanui at McCones								
Kauru at Ewings						⇩⇩		
Kawarau at Chards								
Kye Burn at SH85 Bridge								
Leith at Dundas								⇩⇩
Lindis at Ardgour Road								
Lindis at Lindis Peak								
Lindsays Creek								
Luggate Creek at SH6					↑↑			
Main Drain at Pump								
Manuherikia at Galloway								
Manuherikia at Ophir		↑↑	↑↑				↑↑	↑↑
Matukituki River						⇩⇩		
Mill Creek at Fish Trap								
Owhiro Stream								
Pomahaka at Ford	⇩⇩					⇩⇩		
Pomahaka at Glenken								
Shag at Craig Road		↑↑	↑↑			⇩⇩		
Shag at Goodwood		↑↑	↑↑			⇩⇩		
Shotover River	↑↑						↑↑	
Silver Stream								
Sutton at SH87								
Taieri at Allanton Bridge								
Taieri at Linnburn								
Taieri at Outram								
Taieri at Stonehenge								
Taieri at Sutton			↑↑					
Taieri at Tiroiti							⇩⇩	
Taieri at Waipiata			↑↑					
Tokomairiro West								
Trotters Creek							⇩⇩	
Waianakarua at Browns								
Waiareka Creek				⇩⇩	⇩⇩		↑↑	
Waikouaiti River							↑↑	
Waipahi at Cairns Peak			↑↑					
Waipahi at Waipahi								
Waipori at Reserve			↑↑					
Wairuna Stream								
Waitahuna River		↑↑						
Waiwera River		↑↑						

Appendix 9 Macroinvertebrate scores

EPT Taxa

Site name	2011	2010	2009	2008	2006	2004	2003	2002	2001	Mean 2006 to 2011	Std dev. 2006 to 2011	Mean 2001 to 2011
Cardrona River	9	9	10	8	6	9		10	9	8	1.52	9
Catlins at Houipapa	15	14	15	16	13	12		15	11	15	1.14	14
Fraser Marshall Rd		8	13	10	10	13				10	2.06	11
Heriot Burn	7	8	10	10		8		10	7	9	1.50	9
Kaikorai Stream	2	1	1	1	2	0			1	1	0.55	1
Kakanui at Clifton	12	12	10	10		11		12	10	11	1.15	11
Kakanui at McCones	8	11	8	8		9		7	4	9	1.50	8
Kauru at Ewings	10	5	11	8	12					9	2.77	9
Leith at Dundas	9	6	7		11	8	9		8	8	2.22	8
Lindis at Ardgour Rd	7	10	11	10	6					9	2.17	9
Lindsays Creek	9	6	5	6	6	4			7	6	1.52	6
Luggate Creek SH6	9	5	11	9	12					9	2.68	9
Mill Creek	4	7	4	4	7	6		9	4	5	1.64	6
Shag at Craig Road	11	8	12	9		11	5	8	8	10	1.83	9
Shag at Goodwood	8	7	5	8		6	4	7	8	7	1.41	7
Silver Stream	7	7	5	7		1	4		6	7	1.00	5
Tokomairiro West	13	9	13	11	14	12		8		12	2.00	11
Trotters Creek	4	4	4	1			4			3	1.50	3
Waianakarua River	11	8	12	9		8	9			10	1.83	10
Waiareka Creek	4	1	4			1	0	2		3	1.73	2
Waikouaiti River	10	5	3			3	8		7	6	3.61	6
Waipahi Cairns Pk	13	11	11		9	7				11	1.63	10
Waipahi at Waipahi	9	6	9		9	7	7	11	8	8	1.50	8
Waipori at Reserve	6	2	14			10	15		2	7	6.11	8
Wairuna Stream	8	11				7		6	5	10	2.12	7
Waitahuna River	10	8	8				9			9	1.15	9
Waiwera River	12		7			8	7		9	10	3.54	9

SQMCI scores

Site name	2011	2010	2009	2008	2006	2004	2003	2002	2001	Mean 2006 to 2011	Std dev. 2006 to 2011	Mean 2001 to 2011
Cardrona River	7.4	5.5	6.8	5.7	5.1	6.9		6.52	6.46	6	0.94	6
Catlins at Houipapa	6.5	5.8	5.1	5.1	6.1	5.1		7.37	7.47	6	0.61	6
Fraser Marshall Rd	5.9	5.4	5.1	4.9		5.1		6.41	5.93	5	0.43	6
Heriot Burn		4.1	5.9	3.7	6.2	6.0				5	1.25	5
Kaikorai Stream	1.9	2.4	1.4	1.7	2.6	1.5			1.72	2	0.49	2
Kakanui at Clifton	6.6	4.5	4.7	5.0		4.3		6.42	3.83	5	0.98	5
Kakanui McCones	3.7	4.8	2.7	4.2		4.4		4.55	3.49	4	0.92	4
Kauru at Ewings	5.6	6.2	5.3	3.2	6.2					5	1.22	5
Leith at Dundas	3.5	4.0	2.4		6.7	2.9	5.1		2.06	4	1.80	4
Lindis at Ardgour	6.6	4.6	2.7	2.4	5.6					4	1.83	4
Lindsays Creek	3.3	3.0	3.0	3.0	3.2	2.7			3.76	3	0.17	3
Luggate Creek SH6	5.1	3.9	5.1	3.0	6.2					5	1.21	5
Mill Creek	5.0	1.7	4.2	5.9	4.4	6.8		6.39	6.98	4	1.58	5
Shag at Craig Road	4.0	5.2	6.4	5.5		3.6	6.4	4.38	5.41	5	1.02	5
Shag at Goodwood	4.5	6.0	5.2	4.8		2.6	4.2	5.30	5.92	5	0.63	5
Silver Stream	4.8	3.8	3.5	4.9		2.8	3.8		4.06	4	0.70	4
Tokomairiro West	4.8	5.1	6.3	4.2	5.1	5.1		5.69		5	0.76	5
Trotters Creek	3.4	3.4	2.4	3.7			3.7			3	0.59	3
Waianakarua River	6.2	5.2	6.1	4.9		5.2	6.7			6	0.64	6
Waiareka Creek	4.4	4.3	4.0			4.0	4.4	3.86		4	0.21	4
Waikouaiti River	5.0	4.2	1.5			4.0	4.5		5.95	4	1.87	4
Waipahi Cairns Pk	6.5	6.2	4.9		5.3	4.4				6	0.77	5
Waipahi at Waipahi	4.9	4.5	4.4		4.4	5.0	4.6	6.00	5.72	5	0.23	5
Waipori at Reserve	5.2	4.0	5.6			4.6	3.7		4.92	5	0.83	5
Wairuna Stream	4.0	4.6				2.4		3.89	4.42	4	0.38	4
Waitahuna River	6.0	6.6	5.7				5.5			6	0.43	6
Waiwera River	4.0		1.9			4.0	2.8		6.87	3	1.47	4

Taxa richness

Site name	2011	2010	2009	2008	2006	2004	2003	2002	2001	Mean 2006 to 2011	Std dev. 2006 to 2011	Mean 2001 to 2011
Cardrona River	19	21	18	16	14	14		19	15	18	2.70	17
Catlins at Houipapa	22	26	25	22	24	19		24	17	24	1.79	22
Fraser Marshall Rd	16	16	20	17		19		20	10	17	1.89	17
Heriot Burn		19	24	18	17	24				20	3.11	20
Kaikorai Stream	15	11	8	9	9	7			12	10	2.79	10
Kakanui at Clifton	21	24	21	19		22		24	23	21	2.06	22
Kakanui aMcCones	24	26	19	18		22		16	11	22	3.86	19
Kauru at Ewings	20	16	18	15	20					18	2.28	18
Leith at Dundas	24	16	16		19	17	18		23	19	3.77	19
Lindis Ardgour Rd	12	22	19	19	15					17	3.91	17
Lindsays Creek	19	21	14	16	14	12			19	17	3.11	16
Luggate Creek SH6	19	16	22	19	18					19	2.17	19
Mill Creek	13	17	16	9	15	13		18	9	14	3.16	14
Shag at Craig Road	27	19	27	20		25	9	22	14	23	4.35	20
Shag at Goodwood	17	20	16	18		18	7	16	16	18	1.71	16
Silver Stream	16	20	15	14		9	15		15	16	2.63	15
Tokomairiro West	25	21	21	15	22	25		19		21	3.63	21
Trotters Creek	15	17	11	14			14			14	2.50	14
Waianakarua River	22	21	20	18		14	17			20	1.71	19
Waiareka Creek	18	10	15			16	9	13		14	4.04	14
Waikouaiti River	19	19	10			9	18		15	16	5.20	15
Waipahi Cairns Pk	24	20	21		18	16				21	2.50	20
Waipahi at Waipahi	16	18	22		22	18	15	24	18	20	3.00	19
Waipori at Reserve	13	4	27			19	27		9	15	11.59	17
Wairuna Stream	21	21				14		24	14	21	0.00	19
Waitahuna River	14	20	16				14			17	3.06	16
Waiwera River	25		18			16	15		16	22	4.95	18

Appendix 10 REC details

Site name	Stream order	Climate	Source-of-flow	Geology	Land cover
Cardrona River	5	CD	H	HS	T
Catlins River	4	CW	L	SS	P
Clutha at Balclutha	8	CD	L	HS	P
Clutha at Luggate Br.	7	CD	L	Al	P
Clutha at Millers Flat	7	CD	L	Al	P
Crookston Burn	5	CD	L	Al	P
Dart at The Hillocks	2	CX	H	HS	P
Dunstan Creek	5	CD	M	HS	T
Fraser at Marshall Rd	5	CD	M	HS	P
Hawea at Camphill Br.	6	CX	Lk	HS	T
Heriot Burn	5	CD	L	HS	P
Kaikorai Stream	3	CD	L	SS	U
Kakanui at Clifton	6	CD	H	SS	P
Kakanui at McCones	6	CD	H	SS	P
Kauru at Ewings	5	CD	H	HS	P
Kawarau at Chards	7	CD	H	Al	P
Kye Burn at SH85	5	CD	H	HS	P
Leith at Dundas	4	CW	L	VB	U
Lindis Ardgour Road	6	CD	L	Al	P
Lindis at Lindis Peak	6	CD	H	HS	T
Lindsays Creek	3	CD	L	VB	U
Luggate Creek at SH6	5	CW	M	HS	T
Main Drain at Pump	4	CD	L	Al	P
Manuherikia – G'way	7	CD	H	HS	P
Manuherikia at Ophir	7	CD	H	HS	P
Matukituki River	6	CX	GM	HS	T
Mill Creek at Fish Trap	4	CD	H	HS	P
Owhiro Stream	3	CD	L	Al	U
Pomahaka at Ford	6	CD	L	HS	P
Pomahaka at Glenken	6	CD	H	HS	P
Shag at Craig Road	5	CD	H	HS	P
Shag at Goodwood	5	CD	L	Al	P
Shotover River	6	CW	M	HS	T
Silver Stream	4	CD	L	HS	P
Sutton at SH87	4	CD	H	HS	P
Taieri at Allanton	6	CD	H	HS	P
Taieri at Linnburn	5	CD	H	HS	T
Taieri at Outram	6	CD	H	HS	P
Taieri at Stonehenge	6	CD	H	HS	T
Taieri at Sutton	6	CD	H	HS	P
Taieri at Tiroiti	6	CD	H	HS	P
Taieri at Waipiata	6	CD	H	HS	P
Tokomairiro West	4	CD	L	HS	P
Trotters Creek	3	CD	L	SS	P
Waianakarua River	5	CD	H	HS	P
Waiareka Creek	5	CD	L	SS	P
Waikouaiti River	5	CD	H	HS	P
Waipahi at Cairns Pk	1	CW	L	SS	P
Waipahi at Waipahi	5	CD	L	SS	P
Waipori River	5	CD	Lk	HS	T
Wairuna Stream	5	CD	L	HS	P
Waitahuna River	5	CD	L	HS	P
Waiwera River	5	CD	L	SS	P