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REGIONAL COUNCIL

The state of water quality in selected rivers and streams in the Wellington region, 2003-2006

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Executive summary

This report summarises the state of river and stream water quality at 56 sites on rivers and streams across the Wellington region over September 2003 to August 2006. Monthly water quality records are presented, together with annual macroinvertebrate and periphyton records collected under Greater Wellington Regional Council's River State of Environment (RSoE) monitoring programme. Data analysis involved both an assessment of compliance with national water quality guidelines and an assessment of spatial variation on a region-wide basis using a water quality index (WQI).

Consistent with previously reported results, physico-chemical and microbiological water quality in rivers and streams across the Wellington region shows a clear spatial pattern related to land cover. Water quality is highest at RSoE sites located on hill-fed river and stream reaches under predominantly unmodified indigenous forest cover. These sites tend to be associated with the Tararua, Rimutaka and Aorangi Ranges and include the Hutt River at Te Marua, Waiohine River at the Gorge, and the Ruamahanga River at McLays.

Water quality is poorer at sites located on smaller, low elevation stream reaches draining pastoral or urban catchments, particularly those characterised by soft sedimentary substrates. The sites with the poorest water quality over the reporting period drain either dairy catchments (e.g., the lower reaches of the Mangaone and Mangatarere streams, and the Mangaroa, Kopuaranga and Whangaehu rivers) or catchments dominated by urban land cover – in particular, sites on the lower Ngarara, Mangapouri and Waiwhetu streams.

Macroinvertebrate community health exhibited a similar spatial pattern to physico-chemical and microbiological water quality. However, discrepancies between water quality and macroinvertebrate health exist at a number of RSoE sites, with the macroinvertebrate monitoring results often indicating better water quality than the WQI.

The influence of land cover on periphyton biomass and cover was less clear. However, sites located on low elevation river and stream reaches draining pastoral catchments tended to exceed periphyton guidelines more frequently.

The Regional Policy Statement and Regional Freshwater Plan require some reaches of rivers and streams to be managed for specific purposes such as natural state, fish spawning, or enhancement for aquatic ecosystem health or fish habitat and spawning. Analysis of monitoring data collected from the RSoE monitoring programme over the reporting period indicates that:

- RSoE sites located on river and stream reaches to be managed in their natural state typically have good water quality and excellent macroinvertebrate community health.

- Fourteen of the 20 RSoE sites on river or stream reaches that are managed for fisheries generally have good or excellent water quality and macroinvertebrate communities. The other six sites have considerably lower water quality: the Mangaroa River at Te Marua, Taueru River at Gladstone, Kopuaranga River at

Stewarts, Waiohine River at Bicknells, and the Mangatarere Stream at State Highway 2.

- Six of the seven RSoE sites on river or stream reaches in need of enhancement for aquatic ecosystems or trout fishery/spawning purposes showed no improvement in water quality state since the 1997-2003 reporting period. The Wainuiomata River upstream of White Bridge was the one exception, showing improvements in both water quality and macroinvertebrate health following the removal of a municipal wastewater discharge in late 2001.

Eleven RSoE sites were assigned lower WQI grades than those assigned by Milne and Perrie (2005) for the 1997-2003 reporting period. This apparent decline in water quality is largely related to two variables: visual clarity and dissolved reactive phosphorus. In the case of dissolved reactive phosphorus, the observed increases in measured concentrations reflect changes in analytical methods and do not represent an actual decline in water quality. The apparent decline in visual clarity is not as easily explained due to multiple changes in sampling personnel collecting water samples and field data, and a lack of data to investigate the influence of rainfall and river flow on water clarity. Although elevated river flows may explain the lower readings recorded at most sites, further investigation is warranted at a few sites, particularly those on the Porirua Stream (Glenside Overhead Cable and Wall Park).

Recommendations

1. Investigate the apparent decline in visual clarity observed at some RSoE sites, particularly sites on the Porirua Stream.

2. Implement the recommendations listed in Milne and Perrie (2005), in particular those relating to:
    - establishing a formal quality assurance programme;
    - establishing flow monitoring at priority sites;
    - broadening the scope of physico-chemical analytes;
    - developing a fish monitoring programme;
    - developing region (or catchment) specific water quality guidelines; and
    - undertaking targeted catchment water quality investigations where appropriate.

3. Manage the RSoE monitoring programme so that consistency in sampling personnel and analytical laboratories is maintained.

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1. Introduction

Greater Wellington Regional Council (Greater Wellington) manages water quality in lakes, rivers and streams of the Wellington region for natural state, public water supply, recreation and amenity, fish spawning, and aquatic ecosystem health. Regular monitoring of physico-chemical and microbiological water quality, together with assessments of ecosystem health, are integral in managing water for these purposes.

River water quality has been routinely monitored in the western half of the Wellington region since 1987 and in the Wairarapa since 1991. In August 2003 a single region-wide monitoring programme (the Rivers State of the Environment (RSoE) Monitoring Programme) was established, resulting in a number of changes to the location of monitoring sites (Figure 1.1), the range of water quality variables monitored, and the methods of water quality analysis.

Greater Wellington reports annually on the state of the region's rivers and streams based on the results of the RSoE monitoring programme. Formal analysis of spatial and temporal trends in water quality is undertaken every five to six years (e.g., see Milne and Perrie 2005). This interim technical report summarises the results of RSoE monitoring over the period September 2003 to August 2006 inclusive, and in doing so, provides the first comprehensive assessment of the state of river and stream water quality in the region since the introduction of a number of new monitoring sites in September 2003.

Figure 1.1: The Ruamahanga River at McLays, one of 24 new sites[1] added to the RSoE monitoring programme in September 2003

[1] Of these 24 sites, six were relocated a short distance upstream of existing long-term sites.

1.1 Report outline

This report has five sections. Section 2 provides a brief overview of the RSoE monitoring programme, including monitoring objectives, sites and variables. Section 3 summarises the results of water quality and biological monitoring undertaken over 2003-2006. These results are discussed in more detail in Section 4, focusing in particular on spatial patterns in water quality, comparisons with earlier monitoring results presented in Milne and Perrie (2005), and the management objectives in Greater Wellington's Regional Policy Statement (RPS) and Regional Freshwater Plan (RFP) relating to natural state, fisheries and fish spawning, and enhancement. Conclusions and recommendations are presented in Section 5.

2. Overview of the Rivers SoE water quality programme

2.1 Background

Surface water quality has been routinely monitored in the western half of the Wellington region since 1987 and in the Wairarapa since 1991. Up until a few years ago, this monitoring was effectively conducted under two separate monitoring programmes, with some differences present in the suite of water quality variables and the laboratory analytical methods employed. From around 2000 onwards, greater consistency was achieved between the two programmes and, in 2003, when the key recommendations of a comprehensive review of the surface water quality monitoring in the region were implemented (Warr 2002), water quality monitoring in the western and eastern parts of the region was merged into a single monitoring programme. At this time, a number of changes were made to the location of monitoring sites, the range of variables monitored and the methods of analysis to improve the representativeness and quality of the information collected. These changes, documented by Milne and Perrie (2005), took effect from September 2003.

2.2 Monitoring objectives

The aims of Greater Wellington's Rivers State of the Environment (RSoE) water quality monitoring programme are to:

1. Assist in the detection of spatial and temporal changes in fresh waters.

2. Contribute to our understanding of freshwater biodiversity in the region.

3. Determine the suitability of fresh waters for designated uses.

4. Provide information to assist in targeted investigations where remediation or mitigation of poor water quality is desired.

5. Provide a mechanism to determine the effectiveness of policies and plans.

2.3 Monitoring sites

There are 56 river and stream sites currently monitored under the RSoE programme (Figure 2.1, Appendix 1). These sites were chosen to represent the natural diversity of rivers and streams, and the major land uses and human activities in the region.

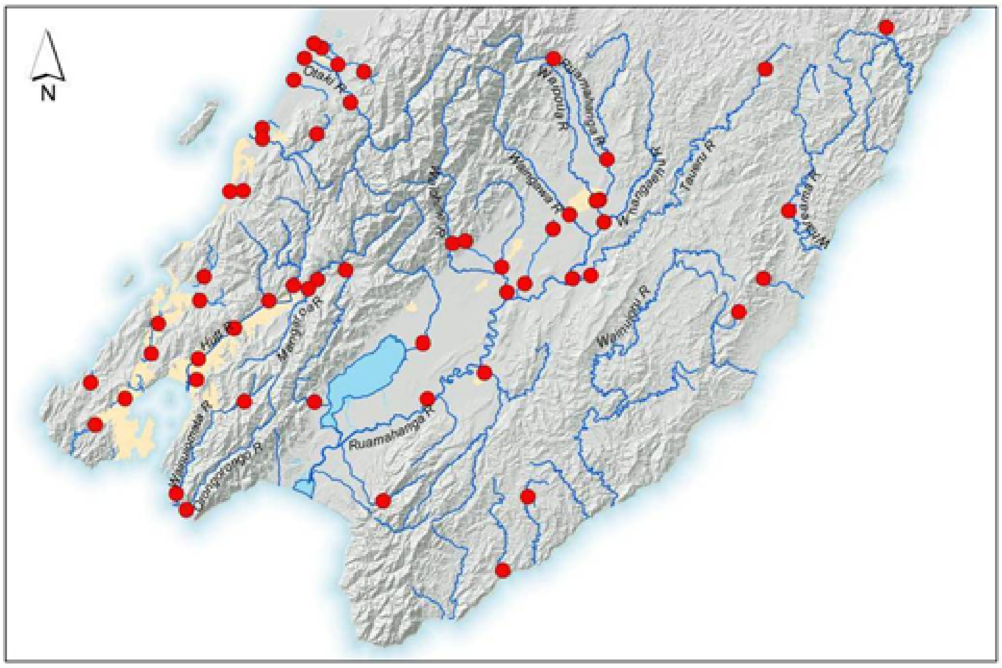

Figure 2.1: Current RSoE monitoring sites

2.4 Water quality variables

River and stream water quality is assessed at monthly intervals by measuring a range of physico-chemical and microbiological variables: dissolved oxygen, temperature, pH, conductivity, visual clarity, turbidity, faecal indicator bacteria, total organic carbon, and dissolved and total nutrients. Periphyton cover at each site is also assessed at monthly intervals. The full list of variables monitored, together with details of field and analytical methods is provided in Appendix 2.

2.5 Biological monitoring

Water quality in the region's rivers and streams is also assessed through annual biological monitoring, incorporating semi-quantitative assessments of the instream periphyton and macroinvertebrate communities during the summer-autumn period when river levels are stable or low. The record and scope of monitoring differs between sites (refer Milne and Perrie 2005); those sites with substrates comprised of soft sediment have only had macroinvertebrates assessed since 2003. The assessment of periphyton communities at sites with hard bottom substrates was also extended at this time to include quantitative measurements of chlorophyll *a* concentrations and ash free dry weight, and a semi-quantitative assessment of taxonomic richness.

Details on current biological monitoring methods are provided in Appendix 3.

3. Water quality and biological monitoring results

This section looks at the state of surface water quality at 56 RSoE monitoring sites in the Wellington region over 2003-2006. Physico-chemical and microbiological data collected monthly from each site are assessed against national water quality guidelines, and median values for selected variables are incorporated into a water quality index to compare water quality between sites. Semi-quantitative periphyton cover and biomass data are also presented and compared amongst sites, together with macroinvertebrate data collected from annual biological monitoring.

Where appropriate, the River Environment Classification (REC) system is used to interpret spatial patterns in water quality and biological data. The REC system characterises river environments at six hierarchical levels, corresponding to a controlling environmental factor (Snelder et al. 2003, Appendix 4). The factors, in order from the largest spatial scale to the smallest, are climate, source-of-flow, geology, land cover, network position and valley landform.

In this report, box and whisker plots (box plots) are used to compare water quality and macroinvertebrate health between different REC factors (Figure 3.1). Only two factors – source-of-flow and land cover[2] – form the basis of most comparisons. Other REC variables such as climate and geology are also known to influence water quality in the region (Milne and Perrie 2005) but the RSoE programme has a limited range of climate and geology classes, preventing meaningful summary statistics for box plots that incorporate these variables[3].

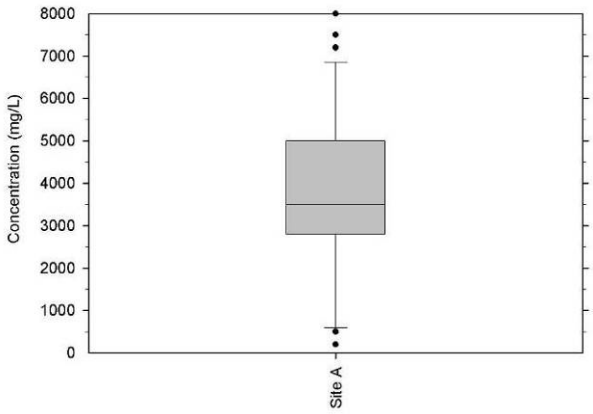

Figure 3.1: Overview of box-plot lay-out

- 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

[2] In this report RSoE sites with upstream catchments dominated by scrub cover were included in the indigenous forest land cover class.

[3] Box plots were prepared using Sigmaplot 2002. This programme requires a minimum of three data points to generate a median value, six data points to generate 25th and 75th percentile values, and 10 points to generate 5th and 95th percentile values.

3.1 Physico-chemical and microbiological water quality results

3.1.1 Assessment approach

Water quality data for each of the 56 RSoE sites monitored over the period September 2003 to August 2006 inclusive were used to assess the state of surface water quality in the Wellington region. Data analysis involved both an assessment of compliance with national water quality guidelines and an assessment of spatial variation on a region-wide basis using a water quality index.

The physico-chemical and microbiological water quality variables and guidelines (where applicable) considered in the assessment of water quality state are outlined in Table 3.1. Most of the guidelines used in this report are the Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) "default trigger values" for aquatic ecosystems (herewith denoted as ANZECC 2000). These trigger values are intended to be compared with the *median* value from independent samples at a site. They are not legal standards and exceedances do not necessarily mean an adverse environmental effect would result. Rather an exceedance is an 'early warning' mechanism to alert resource managers to a potential problem or emerging change that may warrant site-specific investigation or remedial action (ANZECC 2000).

Table 3.1: Physico-chemical and microbiological variables and guideline values

Variable	Guideline Value	Reference
Water Temperature (ºC)	≤20	-
Dissolved Oxygen (% saturation)	≥80	RMA 1991 Third Schedule (and WRC 1999)
pH	6.5-9.0	ANZECC (1992)
Conductivity (µS/cm)	-	-
Visual Clarity (m)	≥1.6	MfE (1994)
Turbidity (NTU)	≤5.6	ANZECC & ARMCANZ (2000)
Total Organic Carbon (mg/L)	-	-
Nitrite-Nitrate Nitrogen (mg/L)	≤0.444	ANZECC & ARMCANZ (2000)
Ammoniacal Nitrogen (mg/L)	≤0.021	ANZECC & ARMCANZ (2000)
Total Nitrogen (mg/L)	≤0.614	ANZECC & ARMCANZ (2000)
Dissolved Reactive Phosphorus (mg/L)	≤0.010	ANZECC & ARMCANZ (2000)
Total Phosphorus (mg/L)	≤0.033	ANZECC & ARMCANZ (2000)
E. coli (cfu/100 mL)	≤100	ANZECC & ARMCANZ (2000)

The ANZECC (2000) guidelines provide different trigger values for New Zealand upland (> 150 m altitude) and lowland ecosystems[4]. While Greater Wellington's RSoE monitoring programme encompasses both upland and *lowland* sites, for simplicity in comparing water quality between sites, only the lowland trigger values were used in the assessment of compliance with water quality guidelines.

[4] These trigger values are derived from water quality data collected by NIWA (from 77 sites across a range of New Zealand rivers and streams).

Key points to note in relation to the reported variables and guidelines:

- There are no formal guidelines for temperature, but it is accepted that prolonged water temperatures above 20 ^{o}C are detrimental to some aquatic biota (MfE 2001), including sensitive macroinvertebrate species such as mayflies and stoneflies (Quinn and Hickey 1990). The Regional Freshwater Plan (RFP) has a requirement that water temperatures at fresh water sites managed for trout fishery and spawning values should not exceed 25^{o}C.

- The dissolved oxygen guideline is the "bottom line" value in the Third Schedule of the RMA 1991; the ANZECC (2000) default trigger values (98 to 105% for lowland waters) are considered overly stringent.

- The guideline range for pH is from the ANZECC (1992) water quality guidelines because the default trigger values quoted in the 2000 guidelines (pH 7.2 to 7.8 for lowland waters) are considered overly stringent.

- The MfE (1994) guideline for visual clarity is used (bathing waters) in this report; the ANZECC (2000) lowland trigger value is considered erroneous (see Milne and Perrie 2005).

- The ammoniacal nitrogen guideline used here generally indicates potential for nutrient enrichment; it does not relate to the toxicity of ammonia to aquatic life (toxicity depends on water temperature and pH).

- The *E. coli* guideline relates to livestock drinking water, not contact recreation. Greater Wellington has a separate recreational water quality monitoring programme to assess the suitability of fresh waters for contact recreation (e.g., see Milne 2007).

(a) Water quality index

A water quality index (WQI) is used to facilitate inter-site comparisons of the state of water quality in the region's rivers and streams. The WQI was first presented in Milne and Perrie (2005), derived from the *median* values for the following six variables: visual clarity (black disc), dissolved oxygen (% saturation), dissolved reactive phosphorus, ammoniacal nitrogen, nitrate nitrogen and faecal coliforms. The WQI used in this report differs slightly in that nitrite-nitrate nitrogen and *E. coli* are used in place of nitrate nitrogen and faecal coliforms respectively. These changes relate to changes in RSoE analytes and should have little material effect on the WQI; nitrite nitrogen concentrations are usually below detection in surface waters while *E. coli* counts are generally similar to (or a little lower than) faecal coliform counts.

The application of the WQI enables water quality at each site to be classified into one of four categories as follows:

- Excellent[5]: median values for all 6 variables comply with guideline values

[5] This category was denoted as "Very Good" in Milne and Perrie (2005).

- Good: median values for 5 of the 6 variables comply with guideline values, of which dissolved oxygen is one variable that must comply

- Fair: median values for 3 or 4 of the 6 variables comply with guideline values, of which dissolved oxygen is one variable that must comply

- Poor: median values for <3 of the 6 variables comply with guideline values.

Sites with a grade of good, fair or poor represent *degraded* sites as the median value of at least one of the six key water quality variables does not comply with guideline values. The degree of degradation is relative, with good sites having the least degraded water quality and poor sites the most degraded water quality.

(b) Data adjustment

During data processing (Table 3.2), any water quality variables reported as less than or greater than detection limits were replaced by values one half of the detection limit or the detection limit respectively (e.g., a value of <2 became 1, a value of >400 became 400).

(c) Cautionary notes

- A formal quality assurance (QA) system is not currently in place for water quality data collected under the RSoE programme. The only changes made to raw data drawn from Greater Wellington's Water Quality Database were the removal of gross outliers, where detected.

- Compliance with guidelines for dissolved oxygen, temperature and pH is based on a single monthly measurement taken at around the same time on each sampling occasion. These variables can exhibit considerable diurnal fluctuation and may exceed guideline values at certain times of the day outside of the sampling period.

- The best reference conditions or guideline values are set by locally appropriate data. The ANZECC (2000) guidelines therefore recommend deriving *site-specific* trigger values for different catchments where possible, using a minimum of two years of water quality results from continuous monthly sampling (24 samples) at appropriate reference sites. The review of the RSoE monitoring programme by Warr (2002) identified an under-representation of reference sites in the monitoring network and accordingly recommended that a number of new sites be added. Changes were since made to the site network (in September 2003) and, with four years of monitoring information for these sites now available consideration should be given to using site-specific guidelines in future RSoE reporting.

Table 3.2: Summary of physico-chemical and microbiological water quality data and compliance with guideline values, for the 56 RSoE sites monitored at monthly intervals over September 2003 to August 2006 inclusive (median values that do not comply with a guideline value are shown in bold type)

Site No.	Site Name	Temperature (ºC)					Dissolved Oxygen (% saturation)					pH					Visual Clarity (m)					Turbidity (NTU)					Conductivity (uS/cm)				Total Organic Carbon (mg/L)			
		Median	Min	Max	*n*	% Results >20 ºC	Median	Min	Max	*n*	% Results <80%	Median	Min	Max	*n*	% Results <6.5 or >9	Median	Min	Max	*n*	% Results <1.6 m	Median	Min	Max	*n*	% Results >5.6 NTU	Median	Min	Max	*n*	Median	Min	Max	*n*
RS01	Mangapouri S at Rahui Rd	12.7	8.0	16.4	36	0	87.0	75.6	100.7	36	2.8	7.0	6.6	7.4	36	0	0.52	0.16	1.13	31	100	7.1	2.7	24	36	66.7	215	187	236	36	4.4	1.7	33.9	36
RS02	Mangapouri S at Bennetts Rd	13.8	8.7	20.3	36	2.8	74.8	57.1	97.7	36	63.9	6.9	6.5	7.5	36	2.8	0.95	0.20	1.55	36	100	7.3	3.2	59	36	61.1	219	159	249	36	6.0	2.8	14.6	36
RS03	Waitohu S at Forest Park	10.9	6.1	18.9	35	0	100.3	93.7	111.2	35	2.9	7.5	6.9	9.4	35	2.9	2.78	0.38	5.95	35	11.4	0.8	0.3	7	35	2.9	83	43	94	35	1.9	1.4	6.0	35
RS04	Waitohu S at Norfolk Cres.	13.0	7.5	20.3	36	2.8	84.2	60.3	105.8	36	33.3	6.9	6.2	7.3	36	2.8	0.90	0.24	1.69	36	97.2	4.4	1.8	18	36	25.0	146	24	209	36	3.6	2.7	6.1	36
RS05	Otaki R at Pukehinau	10.3	5.9	18.9	36	0	100.3	91.4	114.6	36	0	7.4	6.7	8.3	36	0	1.53	0.06	8.75	36	55.6	2.4	0.4	126	36	19.4	59	29	76	36	1.5	0.8	9.2	36
RS06	Otaki R at Mouth	11.6	7.6	20.8	36	2.8	102.9	79.8	115.3	36	2.8	7.5	6.8	8.2	36	0	1.40	0.05	4.32	36	58.3	2.4	0.6	261	36	27.8	62	30	85	36	1.4	0.7	11.2	36
RS07	Mangaone S at Sims Rd Br	13.7	8.3	19.8	35	0	85.3	22.1	110.6	36	27.8	7.0	6.4	7.4	36	5.6	0.79	0.07	1.64	36	97.2	5.3	1.8	113	36	44.4	208	125	798	36	4.3	0.7	10.0	36
RS08	Ngarara S at Field Way	14.7	7.0	21.9	36	8.3	60.9	14.9	83.9	36	97.2	7.0	6.0	7.4	36	2.8	0.42	0.17	2.38	36	94.4	14.2	3.4	31	36	83.3	343	200	768	36	14.2	3.4	28.4	36
RS09	Waikanae R at Mangaone Walkwy	11.3	5.9	15.8	36	0	98.0	85.8	107.3	36	0	7.5	6.8	7.9	36	0	3.12	0.34	6.10	36	13.9	0.7	0.2	3	36	0	85	60	264	36	1.3	0.8	4.5	36
RS10	Waikanae R at Greenaway Rd	13.4	7.1	19.0	36	0	103.3	90.3	133.5	36	0	7.3	6.5	7.9	36	2.8	2.11	0.08	7.84	36	33.3	1.0	0.2	30	36	19.4	102	74	162	36	1.2	0.8	5.3	36
RS11	Whareroa S at Waterfall Rd	11.2	6.6	15.7	27	0	97.2	93.2	111.3	27	0	7.6	7.3	8.0	27	0	0.65	0.02	1.33	27	100	5.9	1.9	513	27	51.9	235	173	265	27	2.6	1.7	9.4	27
RS12	Whareroa S at QE Park	14.7	8.0	20.1	36	2.8	76.8	35.0	115.7	36	61.1	6.8	6.1	7.3	36	16.7	0.42	0.17	1.70	36	97.2	11.2	2.6	147	36	86.1	281	179	592	36	11.5	6.7	28.4	36
RS13	Horokiri S at Snodgrass	15.3	6.8	21.3	36	5.6	98.7	91.4	134.5	36	2.8	7.4	6.8	7.9	36	0	2.30	0.18	4.12	36	27.8	1.3	0.3	50	36	13.9	182	146	344	36	2.0	1.2	4.4	36
RS14	Pauatahanui S at Elmwood Br	14.0	6.6	20.1	36	2.8	96.0	79.9	124.1	36	2.8	7.4	7.0	8.4	36	0	1.36	0.15	3.02	36	63.9	3.0	1.0	18	36	25.0	173	122	198	36	3.3	2.1	6.6	36
RS15	Porirua S at Glenside	13.1	7.5	22.0	36	8.3	103.9	94.6	129.5	36	0	7.7	7.0	9.2	36	5.6	1.38	0.05	3.64	36	61.1	2.9	0.8	608	36	27.8	250	120	286	36	3.0	0.1	13.5	36
RS16	Porirua S at Wall Park (Milk Depot)	13.0	8.1	23.1	36	8.3	105.0	95.5	143.6	36	0	7.5	6.7	9.1	36	2.8	1.09	0.06	2.63	36	80.6	4.0	1.1	204	36	33.3	254	149	286	36	2.8	0.1	18.1	36
RS17	Makara S at Kennels	13.8	7.5	21.4	36	11.1	106.9	91.0	137.4	36	0	7.6	7.0	9.0	36	2.8	1.13	0.05	2.95	36	80.6	3.6	1.2	57	36	27.8	269	214	331	36	3.7	2.2	13.0	36
RS18	Karori S at Makara Peak	14.0	10.2	18.4	36	0	101.2	93.8	120.0	36	0	7.3	6.7	7.9	36	0	1.89	0.15	3.29	36	41.7	1.9	0.8	101	36	30.6	228	143	278	36	2.0	1.2	5.9	36
RS19	Kaiwharawhara S at Ngaio Gorge	12.8	8.0	18.2	36	0	101.3	93.8	124.7	36	0	7.7	5.7	8.6	36	2.8	2.25	0.00	4.45	35	31.4	1.2	0.3	26	36	16.7	278	129	316	36	2.6	1.7	4.5	36
RS20	Hutt R at Te Marua Intake Site	10.9	6.1	17.0	36	0	101.1	84.0	119.3	35	0	7.4	6.3	8.3	36	5.6	2.81	0.06	5.90	36	16.7	0.8	0.3	75	36	11.1	69	34	96	36	2.0	1.2	12.3	36
RS21	Hutt R opp. Manor Park G.C.	13.1	8.8	20.4	36	8.3	103.0	95.1	113.7	35	0	7.3	6.6	8.6	36	0	2.18	0.04	4.00	36	36.1	1.4	0.3	218	36	25.0	93	59	110	36	2.2	1.2	12.3	36
RS22	Hutt R at Boulcott	12.9	8.2	21.2	36	8.3	103.2	89.0	120.4	35	0	7.3	6.3	8.5	36	2.8	2.00	0.04	4.15	36	41.7	1.9	0.3	216	36	22.2	92	43	125	36	2.0	1.0	12.6	36
RS23	Pakuratahi R 50m d/s Farm Ck	12.2	7.0	19.7	36	0	97.0	88.1	122.4	35	0	7.1	6.5	8.3	36	2.8	2.61	0.08	4.65	36	27.8	1.2	0.3	75	36	11.1	84	49	92	36	2.4	1.1	12.8	36
RS24	Mangaroa R at Te Marua	12.9	7.9	19.5	36	0	100.7	95.1	122.3	35	0	7.2	5.9	8.8	36	5.6	1.59	0.05	7.80	36	50.0	1.8	0.6	118	36	19.4	108	74	118	36	3.9	1.7	20.9	36
RS25	Akatarawa R at Hutt Confl.	11.7	6.5	17.5	36	0	99.8	87.1	118.3	35	0	7.5	6.7	8.2	36	0	2.95	0.07	6.98	36	19.4	0.7	0.2	99	36	13.9	82	45	91	36	1.7	1.2	15.0	36
RS26	Whakatikei R at Riverstone	11.3	6.2	16.5	36	0	101.5	76.3	123.5	35	2.9	7.6	6.9	8.5	36	0	3.26	0.12	5.75	36	13.9	0.7	0.2	39	36	2.8	111	78	123	36	1.6	1.2	4.3	36
RS27	Waiwhetu S at Wainui Hill Br	14.4	9.9	21.6	36	8.3	96.0	24.6	178.3	35	25.7	6.9	6.3	8.2	35	8.6	0.77	0.06	4.33	36	80.6	7.5	1.3	82	36	66.7	241	76	4,440	36	2.5	1.8	7.9	36
RS28	Wainuiomata R at Manuka Track	10.6	6.6	14.5	36	0	100.0	93.9	124.1	36	0	7.4	6.8	7.8	36	0	2.65	0.38	5.87	36	16.7	0.6	0.4	5	36	0	104	83	117	36	1.8	1.2	4.4	36
RS29	Wainuiomata R u/s White Br	13.3	7.4	20.0	35	0	96.7	82.3	122.3	36	0	7.3	6.6	8.6	36	0	1.13	0.13	2.73	36	83.3	2.7	1.2	29	36	22.2	144	107	159	36	1.7	1.0	4.5	36
RS30	Orongorongo R at Orongo. Stn	14.6	9.0	20.7	36	8.3	101.3	77.8	125.2	36	2.8	7.7	6.8	8.5	36	0	1.20	0.03	4.41	36	55.6	7.2	0.5	155	36	52.8	142	79	178	36	1.5	0.8	5.9	36
RS31	Ruamahanga R at McLays	9.4	4.4	18.5	36	0	100.0	88.9	124.8	36	0	7.4	7.1	7.8	36	0	2.65	0.20	8.35	36	30.6	1.0	0.2	24	36	16.7	47	27	65	36	1.2	0.7	3.2	36
RS32	Ruamahanga R at Te Ore Ore	13.8	8.3	26.0	36	8.3	102.5	93.6	121.9	35	0	7.7	6.9	8.7	36	0	1.10	0.04	3.64	36	58.3	3.2	0.3	350	36	36.1	129	56	193	36	2.1	1.3	11.4	36
RS33	Ruamahanga R at Gladstone Br	14.1	8.8	24.6	36	13.9	99.4	90.3	149.9	35	0	7.5	7.0	9.6	36	8.3	1.09	0.04	3.40	36	63.9	4.0	0.5	223	36	38.9	112	52	147	36	2.1	1.2	8.3	36
RS34	Ruamahanga R at Pukio	15.2	8.0	25.5	36	13.9	98.5	83.3	133.1	35	2.9	7.6	7.0	9.0	36	0	0.75	0.02	2.95	36	83.3	7.6	0.4	358	36	52.8	138	63	204	36	2.5	1.2	12.4	36
RS35	Mataikona Trib. at Sugar Loaf Rd	13.0	6.4	20.7	36	5.6	100.1	78.0	117.6	36	2.8	8.2	7.2	8.5	35	0	0.78	0.01	2.80	36	69.4	5.0	0.4	245	36	47.2	355	220	550	36	2.4	1.0	9.4	36
RS36	Taueru R at Castlehill	11.9	6.1	21.8	36	2.8	95.0	84.9	121.7	36	0	7.7	7.1	8.1	35	0	1.04	0.05	2.10	36	75.0	5.1	1.5	53	36	41.7	196	132	290	36	5.6	3.2	12.3	36
RS37	Taueru R at Gladstone	14.2	6.4	23.8	36	11.1	96.4	63.3	169.8	36	5.6	7.9	7.0	8.7	36	0	0.62	0.04	2.41	36	91.7	7.5	0.8	433	36	55.6	385	189	564	36	6.3	1.6	17.8	36
RS38	Kopuaranga R at Stewarts	12.7	7.2	19.5	36	0	95.6	84.8	114.3	35	0	7.7	6.7	8.1	36	2.8	0.90	0.02	1.92	36	94.4	4.3	0.9	466	36	44.4	237	98	373	36	3.4	1.9	18.1	36
RS39	Whangaehu R 250m from Confl.	14.8	7.9	24.7	36	5.6	96.9	33.9	147.8	35	14.3	7.4	6.6	8.3	36	0	0.75	0.02	2.52	35	91.4	6.3	0.7	481	36	55.6	286	179	411	36	6.2	1.6	16.2	36
RS40	Waipoua R at Colombo Rd Br	13.7	8.0	22.1	36	13.9	100.9	87.8	116.1	35	0	7.5	6.9	8.4	36	0	2.18	0.15	4.23	35	37.1	1.2	0.3	37	36	19.4	102	64	128	36	1.9	1.0	6.1	36
RS41	Waingawa R at South Rd	13.1	7.2	20.5	36	2.8	99.5	85.1	115.5	36	0	7.5	7.0	8.0	36	0	2.68	0.05	9.78	36	33.3	1.2	0.1	62	36	13.9	58	41	76	36	1.1	0.6	3.6	36
RS42	Whareama R at Gauge	12.7	6.8	22.9	36	13.9	94.4	76.2	125.5	36	2.8	7.9	7.1	8.4	36	0	0.31	0.03	2.06	36	91.7	23.9	1.3	410	36	75.0	507	290	708	36	6.4	4.1	14.3	36
RS43	Motuwaireka R at Headwaters	10.3	6.1	16.3	36	0	97.7	84.3	119.6	36	0	7.7	7.2	8.0	36	0	2.13	0.24	4.15	36	38.9	0.9	0.3	22	36	16.7	252	146	418	36	1.9	0.9	5.0	36
RS44	Totara S at Stronvar	12.2	6.2	23.5	36	5.6	102.7	81.1	122.7	36	0	7.7	7.0	8.9	36	0	2.03	0.10	4.96	35	37.1	1.6	0.2	38	36	22.2	316	182	442	36	2.8	1.5	4.8	36
RS45	Parkvale Trib. at Lowes Reserve	12.5	8.6	15.0	34	0	72.5	54.1	97.5	34	79.4	6.6	6.3	7.4	34	8.8	1.80	0.22	3.73	35	40.0	0.5	0.1	7	34	2.9	188	163	338	34	3.3	1.8	18.8	34
RS46	Parkvale S at Weir	13.3	6.9	21.9	36	5.6	105.8	74.8	133.0	36	2.8	7.4	6.1	8.9	36	5.6	0.82	0.20	4.27	36	91.7	4.7	1.2	31	36	38.9	158	115	225	36	5.5	2.7	13.5	36
RS47	Waiohine R at Gorge	10.5	5.3	16.2	36	0	100.9	95.4	140.5	36	0	7.6	6.7	8.2	36	0	2.84	0.20	7.23	36	36.1	1.2	0.3	30	36	22.2	52	33	66	36	1.3	0.6	5.3	36
RS48	Waiohine R at Bicknells	13.4	7.8	21.6	36	2.8	99.8	90.6	129.1	36	0	7.2	6.5	8.9	36	0	0.88	0.08	3.73	36	69.4	4.7	1.0	115	36	38.9	73	44	90	36	1.5	0.8	3.5	36
RS49	Beef S at Headwaters	10.3	7.4	14.9	35	0	100.3	90.5	130.2	35	0	7.6	7.2	8.0	35	0	2.54	0.32	5.36	34	17.6	0.8	0.3	10	35	2.9	89	60	107	35	1.4	0.9	4.3	35
RS50	Mangatarere S at SH 2	14.0	7.3	20.6	36	5.6	97.6	83.7	145.1	36	0	7.0	6.5	8.0	36	0	1.22	0.03	3.32	36	66.7	2.5	0.6	74	36	19.4	109	87	140	36	1.8	1.2	4.4	36
RS51	Huangarua R at Ponatahi Br	13.0	6.2	20.3	36	2.8	98.5	79.9	141.3	36	2.8	8.0	7.6	8.4	36	0	1.21	0.05	4.59	36	61.1	5.5	0.4	632	36	47.2	383	227	455	36	3.1	1.9	12.4	36
RS52	Tauanui S at Whakatomotomo Rd	11.3	7.5	19.4	35	0	99.0	82.8	124.0	35	0	7.7	7.0	8.1	35	0	2.11	0.02	7.47	35	34.3	1.5	0.3	65	35	22.9	147	99	199	35	1.9	1.3	4.5	35
RS53	Awhea R at Tora Rd	13.9	6.2	22.0	36	8.3	100.2	80.0	151.3	36	0	8.1	7.6	8.6	36	0	0.77	0.02	4.92	34	73.5	6.2	0.6	1480	36	50.0	450	259	615	36	3.7	2.5	11.9	36
RS54	Coles Trib. at Lagoon Hill Rd	11.1	6.0	19.1	33	0	97.4	64.0	114.3	33	6.1	8.0	7.8	8.3	33	0	0.71	0.10	3.28	35	88.6	5.5	1.1	84	33	45.5	470	253	1652	33	4.7	3.2	9.9	32
RS55	Tauherenikau R at Websters	14.8	7.5	23.8	36	13.9	99.0	85.5	131.9	36	0	7.4	6.8	8.9	36	0	1.98	0.08	3.98	36	47.2	2.1	0.3	108	36	22.2	70	46	99	36	1.4	0.7	5.0	36
RS56	Waiorongomai R at Forest Pk	12.7	8.4	22.0	36	2.8	96.5	86.3	114.7	36	0	7.5	7.0	7.9	36	0	2.91	0.17	6.95	34	29.4	1.2	0.3	61	36	11.1	123	87	156	36	1.8	1.2	8.6	35

Table 3.2 *cont.*: Summary of physico-chemical and microbiological water quality data and compliance with guideline values, for the 56 RSoE sites monitored at monthly intervals over September 2003 to August 2006 inclusive (median values that do not comply with a guideline value are shown in bold type)

Site No.	Site Name	Nitrite-Nitrate Nitrogen (mg/L)					Ammoniacal Nitrogen (mg/L)					Total Nitrogen (mg/L)					Dissolved Reactive Phosphorus (mg/L)					Total Phosphorus (mg/L)					*E. coli* (cfu/100 mL)				
		Median	Min	Max	*n*	% Results >0.444	Median	Min	Max	*n*	% Results >0.025	Median	Min	Max	*n*	% Results >0.614	Median	Min	Max	*n*	% Results >0.010	Median	Min	Max	*n*	% Results >0.033	Median	Min	Max	*n*	% Results >100
RS01	Mangapouri S at Rahui Rd	7.110	1.000	9.610	36	100	0.016	0.005	0.040	36	19.4	7.707	4.260	10.100	36	100	0.020	0.005	0.034	36	86.1	0.048	0.009	0.121	36	75.0	390	20	3,500	36	91.7
RS02	Mangapouri S at Bennetts Rd	2.475	0.020	4.500	36	94.4	0.070	0.020	0.250	36	91.7	2.765	0.690	5.170	36	100	0.022	0.005	0.063	36	91.7	0.077	0.023	0.195	36	97.2	1,050	160	19,000	36	100
RS03	Waitohu S at Forest Park	0.033	0.003	0.110	35	0	0.005	0.005	0.080	35	5.7	0.110	0.050	0.225	35	0	0.011	0.003	0.016	35	51.4	0.014	0.003	0.031	35	0	7	1	87	35	0
RS04	Waitohu S at Norfolk Cres.	0.559	0.198	1.380	36	69.4	0.046	0.020	0.220	36	86.1	0.883	0.409	1.700	36	75.0	0.014	0.003	0.022	36	80.6	0.049	0.003	0.082	36	83.3	530	40	2,500	36	83.3
RS05	Otaki R at Pukehinau	0.043	0.005	0.134	36	0	0.005	0.005	0.080	36	5.6	0.078	0.025	0.540	36	0	0.007	0.002	0.014	35	5.7	0.012	0.003	0.173	36	13.9	5	1	420	36	2.8
RS06	Otaki R at Mouth	0.043	0.003	0.132	36	0	0.005	0.005	0.040	36	2.8	0.100	0.025	0.500	36	0	0.006	0.002	0.015	35	5.7	0.013	0.003	0.233	36	19.4	25	1	900	36	11.1
RS07	Mangaone S at Sims Rd Br	2.276	0.364	4.380	36	97.2	0.080	0.005	0.180	36	88.9	2.730	1.180	5.250	36	100	0.020	0.003	0.069	36	88.9	0.062	0.008	0.385	36	83.3	520	80	26,000	36	94.4
RS08	Ngarara S at Field Way	0.448	0.008	1.380	36	52.8	0.132	0.020	0.470	36	97.2	1.435	0.430	10.900	36	91.7	0.033	0.012	0.068	36	100	0.143	0.025	0.641	36	97.2	350	34	11,000	36	77.8
RS09	Waikanae R at Mangaone Walkwy	0.107	0.043	0.261	36	0	0.005	0.005	0.050	36	5.6	0.179	0.087	0.592	36	0	0.016	0.003	0.025	36	88.9	0.019	0.003	0.037	36	2.8	21	4	1,200	36	11.1
RS10	Waikanae R at Greenaway Rd	0.244	0.039	0.423	36	0	0.005	0.005	0.080	36	2.8	0.322	0.087	3.010	36	5.6	0.010	0.003	0.176	36	44.4	0.016	0.003	0.311	36	16.7	38	11	4,200	36	25.0
RS11	Whareroa S at Waterfall Rd	0.477	0.135	0.761	27	51.9	0.005	0.005	0.060	27	7.4	0.620	0.240	3.690	27	51.9	0.034	0.016	0.056	27	100	0.050	0.033	0.625	27	96.3	400	9	66,000	27	66.7
RS12	Whareroa S at QE Park	0.400	0.030	1.440	36	38.9	0.135	0.030	0.330	36	100	1.090	0.350	2.500	36	86.1	0.033	0.009	0.054	36	97.2	0.100	0.032	0.250	36	97.2	300	53	7,700	36	94.4
RS13	Horokiri S at Snodgrass	0.473	0.020	1.060	36	58.3	0.008	0.005	0.110	36	8.3	0.670	0.140	1.370	36	55.6	0.016	0.008	0.028	36	88.9	0.027	0.010	0.098	36	19.4	365	38	3,200	36	86.1
RS14	Pauatahanui S at Elmwood Br	0.293	0.012	0.729	36	25.0	0.020	0.005	0.210	36	22.2	0.592	0.180	1.000	36	38.9	0.019	0.007	0.047	36	91.7	0.038	0.010	0.083	36	55.6	690	100	3,800	36	91.7
RS15	Porirua S at Glenside	1.190	0.343	2.650	36	97.2	0.014	0.005	0.220	36	33.3	1.443	0.620	3.150	36	100	0.023	0.003	0.093	36	91.7	0.040	0.003	0.346	36	63.9	680	180	31,000	36	100
RS16	Porirua S at Wall Park (Milk Depot)	1.020	0.003	1.780	36	91.7	0.020	0.005	0.295	36	44.4	1.400	0.580	3.920	36	94.4	0.024	0.007	0.059	36	97.2	0.045	0.003	0.337	36	77.8	790	140	25,000	36	100
RS17	Makara S at Kennels	0.410	0.003	1.490	36	47.2	0.020	0.005	0.090	36	25.0	0.679	0.224	1.600	36	52.8	0.029	0.011	0.046	36	100	0.054	0.017	0.222	36	88.9	500	9	12,000	36	94.4
RS18	Karori S at Makara Peak	1.385	0.307	1.670	36	97.2	0.015	0.005	0.080	36	25.0	1.525	0.829	1.970	36	100	0.039	0.011	0.064	36	100	0.055	0.010	0.168	36	86.1	1,250	100	11,000	36	97.2
RS19	Kaiwharawhara S at Ngaio Gorge	1.125	0.545	1.580	36	100	0.018	0.005	0.090	36	27.8	1.330	0.920	1.740	36	100	0.040	0.010	0.058	36	97.2	0.050	0.003	0.148	36	80.6	500	18	4,400	36	97.2
RS20	Hutt R at Te Marua Intake Site	0.117	0.027	0.224	36	0	0.005	0.005	0.020	36	0	0.200	0.050	0.446	36	0	0.007	0.003	0.012	36	8.3	0.011	0.003	0.086	36	5.6	18	6	2,900	36	5.6
RS21	Hutt R opp. Manor Park G.C.	0.258	0.071	0.468	36	11.1	0.005	0.005	0.030	36	2.8	0.359	0.090	0.761	36	5.6	0.008	0.003	0.016	36	16.7	0.014	0.003	0.298	36	11.1	100	13	4,300	36	47.2
RS22	Hutt R at Boulcott	0.215	0.070	0.797	36	2.8	0.005	0.005	0.040	36	2.8	0.336	0.139	1.120	36	8.3	0.008	0.003	0.021	36	19.4	0.015	0.003	0.268	36	13.9	57	11	5,200	36	44.4
RS23	Pakuratahi R 50m d/s Farm Ck	0.311	0.053	0.495	36	8.3	0.005	0.005	0.050	36	5.6	0.405	0.191	2.020	36	2.8	0.009	0.003	0.016	36	27.8	0.015	0.003	0.892	36	8.3	59	11	14,000	36	30.6
RS24	Mangaroa R at Te Marua	0.635	0.003	1.200	36	83.3	0.010	0.005	0.079	36	8.3	0.812	0.173	1.450	36	86.1	0.016	0.003	0.043	36	88.9	0.027	0.003	0.261	36	36.1	200	19	18,000	36	58.3
RS25	Akatarawa R at Hutt Confl.	0.090	0.011	0.175	36	0	0.005	0.005	0.012	36	0	0.193	0.025	0.760	36	2.8	0.007	0.002	0.016	35	5.7	0.011	0.003	0.157	36	8.3	45	4	2,700	36	19.4
RS26	Whakatikei R at Riverstone	0.089	0.003	0.229	36	0	0.005	0.005	0.130	36	5.6	0.200	0.050	0.420	36	0	0.010	0.003	0.020	36	47.2	0.015	0.003	0.050	36	2.8	25	3	840	36	11.1
RS27	Waiwhetu S at Wainui Hill Br	0.548	0.140	1.040	36	58.3	0.080	0.005	0.250	36	83.3	0.836	0.342	1.600	36	88.9	0.019	0.008	0.065	36	88.9	0.057	0.015	0.164	36	88.9	620	30	8,900	36	94.4
RS28	Wainuiomata R at Manuka Track	0.085	0.026	0.131	36	0	0.005	0.005	0.060	36	13.9	0.149	0.050	0.214	36	0	0.014	0.003	0.026	36	66.7	0.018	0.003	0.057	36	2.8	6	1	740	36	5.6
RS29	Wainuiomata R u/s White Br	0.205	0.003	0.636	36	13.9	0.020	0.005	0.100	36	30.6	0.362	0.109	0.839	36	13.9	0.014	0.003	0.026	36	72.2	0.029	0.017	0.087	36	36.1	80	7	2,600	36	38.9
RS30	Orongorongo R at Orongo. Stn	0.040	0.003	0.156	36	0	0.005	0.005	0.070	36	8.3	0.082	0.025	0.870	36	2.8	0.007	0.003	0.014	36	13.9	0.021	0.006	0.167	36	27.8	10	1	1,000	36	16.7
RS31	Ruamahanga R at McLays	0.025	0.005	0.304	36	0	0.005	0.005	0.100	36	11.1	0.055	0.025	0.420	36	0	0.005	0.003	0.019	36	2.8	0.008	0.002	0.047	36	5.6	4	1	700	36	8.3
RS32	Ruamahanga R at Te Ore Ore	0.449	0.003	1.390	36	55.6	0.005	0.005	0.060	36	8.3	0.551	0.230	1.850	36	41.7	0.010	0.003	0.182	36	44.4	0.020	0.003	0.198	36	25.0	100	15	4,500	36	47.2
RS33	Ruamahanga R at Gladstone Br	0.537	0.026	1.590	36	63.9	0.020	0.005	0.090	36	47.2	0.709	0.240	2.000	36	61.1	0.025	0.010	0.047	36	97.2	0.043	0.015	0.999	36	75.0	39	4	3,600	36	22.2
RS34	Ruamahanga R at Pukio	0.505	0.003	1.520	36	58.3	0.011	0.005	0.070	36	22.2	0.640	0.051	2.100	36	55.6	0.019	0.003	0.061	36	80.6	0.040	0.003	0.352	36	66.7	110	12	3,800	36	50.0
RS35	Mataikona Trib. at Sugar Loaf Rd	0.074	0.003	0.233	36	0	0.005	0.005	0.028	36	2.8	0.196	0.025	0.677	36	2.8	0.007	0.002	0.016	36	11.1	0.017	0.003	0.354	36	36.1	83	2	940	36	41.7
RS36	Taueru R at Castlehill	0.179	0.003	0.942	36	16.7	0.014	0.005	0.060	36	27.8	0.520	0.150	1.417	36	33.3	0.010	0.003	0.017	36	47.2	0.027	0.003	0.128	36	27.8	135	5	12,000	36	52.8
RS37	Taueru R at Gladstone	0.675	0.189	1.450	36	83.3	0.020	0.005	0.100	36	44.4	1.195	0.723	2.014	36	100	0.017	0.003	0.074	36	72.2	0.063	0.003	0.589	36	77.8	170	21	14,000	36	66.7
RS38	Kopuaranga R at Stewarts	0.880	0.402	1.870	36	97.2	0.011	0.005	0.090	36	19.4	1.210	0.610	2.600	36	97.2	0.015	0.005	0.231	36	69.4	0.042	0.003	0.284	36	66.7	300	48	4,600	36	86.1
RS39	Whangaehu R 250m from Confl.	1.255	0.114	5.770	36	91.7	0.020	0.005	0.140	36	27.8	1.935	0.397	5.500	36	94.4	0.035	0.012	0.095	36	100	0.075	0.013	0.459	36	88.9	320	27	45,000	36	91.7
RS40	Waipoua R at Colombo Rd Br	1.275	0.336	2.760	36	94.4	0.005	0.005	0.230	36	2.8	1.335	0.470	3.000	36	94.4	0.010	0.003	0.030	36	44.4	0.016	0.003	0.080	36	13.9	65	12	1,900	36	38.9
RS41	Waingawa R at South Rd	0.100	0.011	0.404	36	0	0.005	0.005	0.010	36	0	0.140	0.025	0.440	36	0	0.007	0.003	0.016	36	8.3	0.009	0.003	0.075	36	8.3	23	4	580	36	19.4
RS42	Whareama R at Gauge	0.167	0.003	0.667	36	8.3	0.014	0.005	0.110	36	22.2	0.657	0.282	1.360	36	52.8	0.008	0.002	0.122	36	38.9	0.061	0.006	0.253	36	63.9	190	6	26,000	36	58.3
RS43	Motuwaireka R at Headwaters	0.046	0.003	0.187	36	0	0.005	0.005	0.050	36	5.6	0.120	0.025	0.260	36	0	0.007	0.002	0.022	35	17.1	0.012	0.003	0.026	36	0	5	1	200	36	2.8
RS44	Totara S at Stronvar	0.380	0.003	1.410	36	38.9	0.005	0.005	0.014	36	0	0.473	0.120	1.570	36	33.3	0.006	0.002	0.012	35	8.6	0.011	0.003	0.044	36	2.8	2	1	100	36	0
RS45	Parkvale Trib. at Lowes Reserve	4.685	0.008	6.200	34	97.1	0.005	0.005	0.370	34	5.9	5.145	2.950	6.900	34	100	0.017	0.003	0.093	34	82.4	0.024	0.003	0.120	34	23.5	27	7	1,500	34	17.6
RS46	Parkvale S at Weir	2.745	0.003	5.350	36	88.9	0.020	0.005	0.250	36	47.2	3.195	0.547	6.100	36	97.2	0.040	0.016	0.159	36	100	0.089	0.039	0.284	36	100	1,000	120	9,000	36	100
RS47	Waiohine R at Gorge	0.028	0.009	0.106	36	0	0.005	0.005	0.050	36	2.8	0.070	0.025	0.290	36	0	0.006	0.003	0.020	35	8.6	0.010	0.003	0.054	36	8.3	5	1	320	36	5.6
RS48	Waiohine R at Bicknells	0.381	0.030	1.300	36	38.9	0.010	0.005	0.030	36	8.3	0.460	0.150	1.500	36	33.3	0.017	0.005	0.036	36	86.1	0.031	0.016	0.174	36	36.1	52	9	820	36	25.0
RS49	Beef S at Headwaters	0.029	0.003	0.096	35	0	0.005	0.005	0.040	35	2.9	0.080	0.025	0.243	35	0	0.013	0.003	0.036	35	74.3	0.016	0.003	0.041	35	2.9	2	1	1,100	35	8.6
RS50	Mangatarere S at SH 2	1.430	0.650	3.100	36	100	0.069	0.005	0.210	36	80.6	1.706	0.920	3.500	36	100	0.060	0.012	0.227	36	100	0.085	0.008	0.241	36	91.7	260	6	4,300	36	63.9
RS51	Huangarua R at Ponatahi Br	0.350	0.007	0.965	36	41.7	0.005	0.005	0.080	36	5.6	0.629	0.140	1.800	36	50.0	0.010	0.003	0.037	36	47.2	0.025	0.003	0.437	36	33.3	130	19	3,800	36	52.8
RS52	Tauanui S at Whakatomotomo Rd	0.014	0.003	0.047	35	0	0.005	0.005	0.040	35	2.9	0.080	0.025	1.200	35	5.7	0.012	0.003	0.031	35	65.7	0.017	0.003	0.075	35	5.7	3	1	15	35	0
RS53	Awhea R at Tora Rd	0.078	0.003	0.272	36	0	0.005	0.005	0.070	36	5.6	0.302	0.130	1.910	36	16.7	0.009	0.003	0.032	36	36.1	0.022	0.003	0.600	36	38.9	200	8	9,100	36	66.7
RS54	Coles Trib. at Lagoon Hill Rd	0.010	0.006	0.055	33	0	0.005	0.005	0.050	33	6.1	0.182	0.117	0.428	33	0	0.009	0.003	0.018	33	27.3	0.019	0.003	0.600	33	24.2	37	4	900	33	24.2
RS55	Tauherenikau R at Websters	0.054	0.003	0.456	36	2.8	0.005	0.005	0.153	36	13.9	0.136	0.025	0.600	36	0	0.007	0.003	0.020	36	5.6	0.012	0.003	0.152	36	16.7	20	5	840	36	13.9
RS56	Waiorongomai R at Forest Pk	0.029	0.003	0.057	36	0	0.010	0.005	0.430	36	8.3	0.084	0.025	0.497	36	0	0.008	0.005	0.024	35	11.4	0.011	0.005	0.072	36	8.3	5	1	35	36	0

3.1.2 Water temperature

Water temperature exceeded 20 ºC at 26 of the 56 RSoE sites on at least one routine sampling occasion during the reporting period (Table 3.2). However, exceedances were not common, with only seven sites exceeding 20 ºC more than 10 % of the time: the Makara Stream at Kennels, Ruamahanga River at Gladstone Bridge, Ruamahanga River at Pukio, Taueru River at Gladstone, Waipoua River at Colombo Road Bridge, Whareama River at Gauge, and Tauherenikau River at Websters. These are generally low elevation sites with predominantly pastoral catchments. The Tauherenikau River at Websters is the only exception, being high elevation and having a predominantly indigenous forest catchment.

Two sites on the Ruamahanga River (Te Ore Ore and Pukio) recorded temperatures above the RFP critical threshold of 25 ºC.

3.1.3 Dissolved oxygen

Four RSoE sites recorded a median dissolved oxygen level below the RMA 1991 critical threshold of 80 % saturation (Table 3.2): the Mangapouri Stream at Bennetts Road, Ngarara Stream at Field Way, Whareroa Stream at QE II Park, and the Parkvale tributary at Lowes Reserve. A further three sites were frequently below the 80 % threshold: the Waitohu Stream at Norfolk Crescent (33 % of sampling occasions), Mangaone Stream at Sims Road Bridge (28 %), and the Waiwhetu Stream at Wainuiomata Hill Bridge (26 %). All of these sites are low elevation with either pastoral or urban catchments.

3.1.4 pH

Median pH values at all 56 RSoE sites were within the expected range of pH 6.5 and pH 9 (Table 3.2). Fourteen sites recorded pH values below 6.5, and four sites recorded values above 9. However, values outside the expected range were generally rare. Only one site, the Whareroa Stream at Queen Elizabeth Park, recorded a pH of below 6.5 on more than 10 % of sampling occasions; the low pH results at this site are likely to reflect the peaty nature of the lower catchment.

3.1.5 Visual clarity

Thirty-one (55 %) of the 56 RSoE sites recorded median visual clarity values below the MfE (1994) guideline of 1.6 m (Table 3.2). Three sites were below the guideline on all sampling occasions: the Mangapouri Stream at Rahui Road (median 0.52 m), Mangapouri Stream at Bennetts Road (0.95 m), and the Whareroa Stream at Waterfall Road (0.65 m). These are all low elevation sites draining pastoral or urban catchments. Of the 31 sites that recorded medians below the guideline value, thirteen (including the two sites on the Mangapouri Stream mentioned above) recorded median values of less that half the guideline value: the Mangaone Stream at Sims Road Bridge (median 0.79 m), Ngarara Stream at Field Way (0.42 m), Whareroa Stream at Queen Elizabeth Park (0.42 m), Waiwhetu Stream at Wainuiomata Hill Bridge (0.77 m), Ruamahanga River at Pukio (0.75 m), Mataikona tributary at Sugar Loaf Road

(0.78 m), Taueru River at Gladstone (0.62 m), Whangaehu River 250 m from the Ruamahanga River confluence (0.75 m), Whareama River at Gauge (0.31 m), Awhea River at Tora Road (0.77 m), and Coles Creek tributary at Lagoon Hill Rd (0.71 m).

Median clarity measurements were greatest at RSoE sites with hill elevation sources of flow, and/or sites with indigenous forest cover (Figure 3.2); for example, the Wairongomai River at Forest Park (2.91 m).

Of the 16 sites with indigenous forest cover, only three had median values below the MfE (1994) guideline: the Otaki River at Pukehinau (1.53 m), Otaki River at Mouth (1.40 m), and the Orongorongo River at Orongorongo Station (1.20 m). These three sites have all previously complied with the MfE (1994) guideline for water clarity (Milne and Perrie 2005). This is discussed further in Section 4.3.

Water clarity was noticeably poorer at low elevation sites draining pastoral and or urban catchments (Figure 3.2).

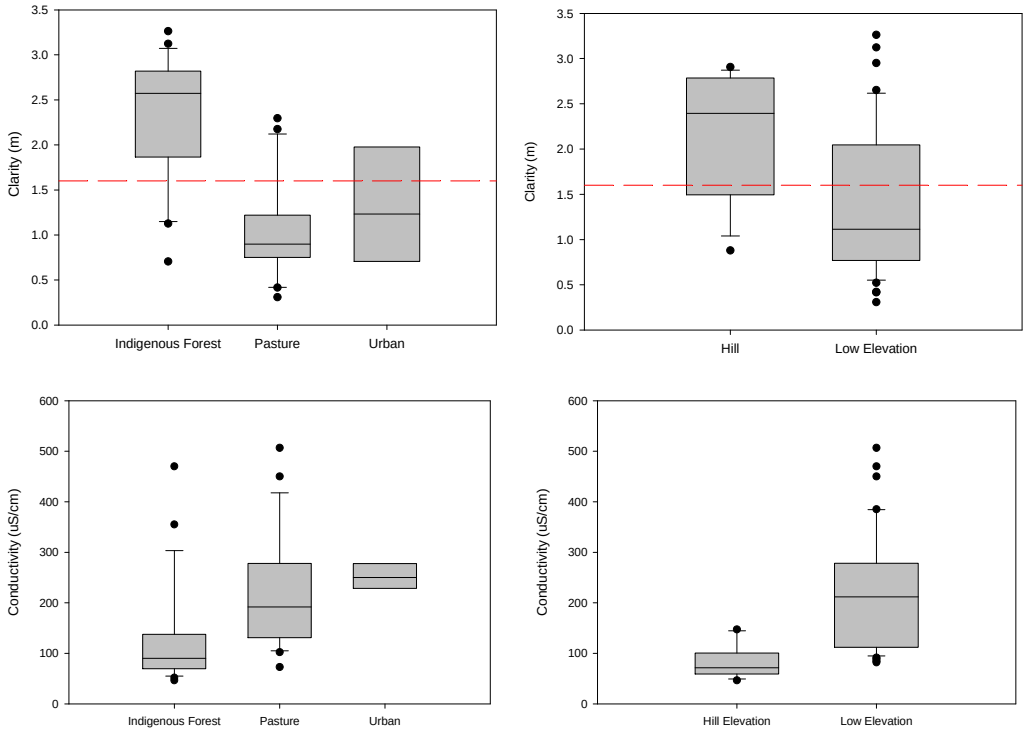

Figure 3.2: Visual clarity and conductivity box plots for selected REC land cover and source-of-flow classes, based on the median values from routine monthly monitoring at RSoE sites over September 2003 to August 2006 inclusive

- - - - - - - MfE (1994) guideline for bathing

3.1.6 Turbidity

Median turbidity measurements complied with the ANZECC (2000) trigger value at 44 of the 56 RSoE sites over the reporting period (Table 3.2). The 12 sites that did not comply also failed the water clarity MfE (1994) guideline.

These are all sites with low elevation sources of flow draining pastoral or urban catchments, the only exception being the Orongorongo River at Orongorongo Station (hill elevation and indigenous forest).

3.1.7 Conductivity

Median conductivity concentrations were typically lowest at sites with indigenous forest cover and hill sources of flow, and highest at sites draining urban catchments (Figure 3.2). The lowest median concentration recorded was in the Ruamahanga River at McLays (median 47 µS/cm) while the highest was in the Whareama River at Gauge (507 µS/cm).

Two sites recorded conductivity concentrations over 1000 µS/cm on several occasions: the Waiwhetu Stream at Wainuiomata Hill Bridge (maximum 4,400 µS/cm) and Coles Creek Tributary at Lagoon Hill Road (maximum 1,652 µS/cm). The Waiwhetu Stream site is in close proximity to the sea and the high conductivities recorded are the result of tidal influence. The Coles Creek tributary site is located inland and high conductivity concentrations are possibly a result of underlying geology.

3.1.8 Total organic carbon

Median total organic carbon concentrations typically ranged from around 1 to 4 mg/L (Table 3.2), with lower concentrations recorded at sites under indigenous forest cover than those located in catchments dominated by urban or pastoral cover. Two low elevation pastoral sites had median concentrations over 10 mg/L: the Ngarara Stream at Field Way (median 14.2 mg/L) and Whareroa Stream at Queen Elizabeth Park (11.5 mg/L). Both of these sites are slow flowing, tannin-rich, coastal streams.

3.1.9 Nitrite-nitrate nitrogen

Median nitrite-nitrate nitrogen concentrations exceeded the ANZECC (2000) trigger value of 0.444 mg/L at 23 (41 %) of the 56 RSoE sites over the reporting period. These sites were all low elevation sites draining urban or pastoral catchments. In addition, the five sites that recorded the highest median concentrations drain particularly low-lying dairy catchments with alluvial geology: the Mangapouri Stream at Rahui Road (median 7.110 mg/L), Mangapouri Stream at Bennetts Road (2.475 mg/L), Mangaone Stream at Sims Road Bridge (2.276 mg/L), Parkvale Tributary at Lowes Reserve (4.685 mg/L), and Parkvale Stream at Weir (2.745 mg/L). The number of exceedances was very high at some sites, with 12 sites exceeding the trigger value on 90 % of sampling occasions.

Overall, median nitrogen concentrations were lowest at hill elevation sites with indigenous forest cover, and highest in low elevation sites draining predominantly pastoral and urban catchments (Figure 3.3).

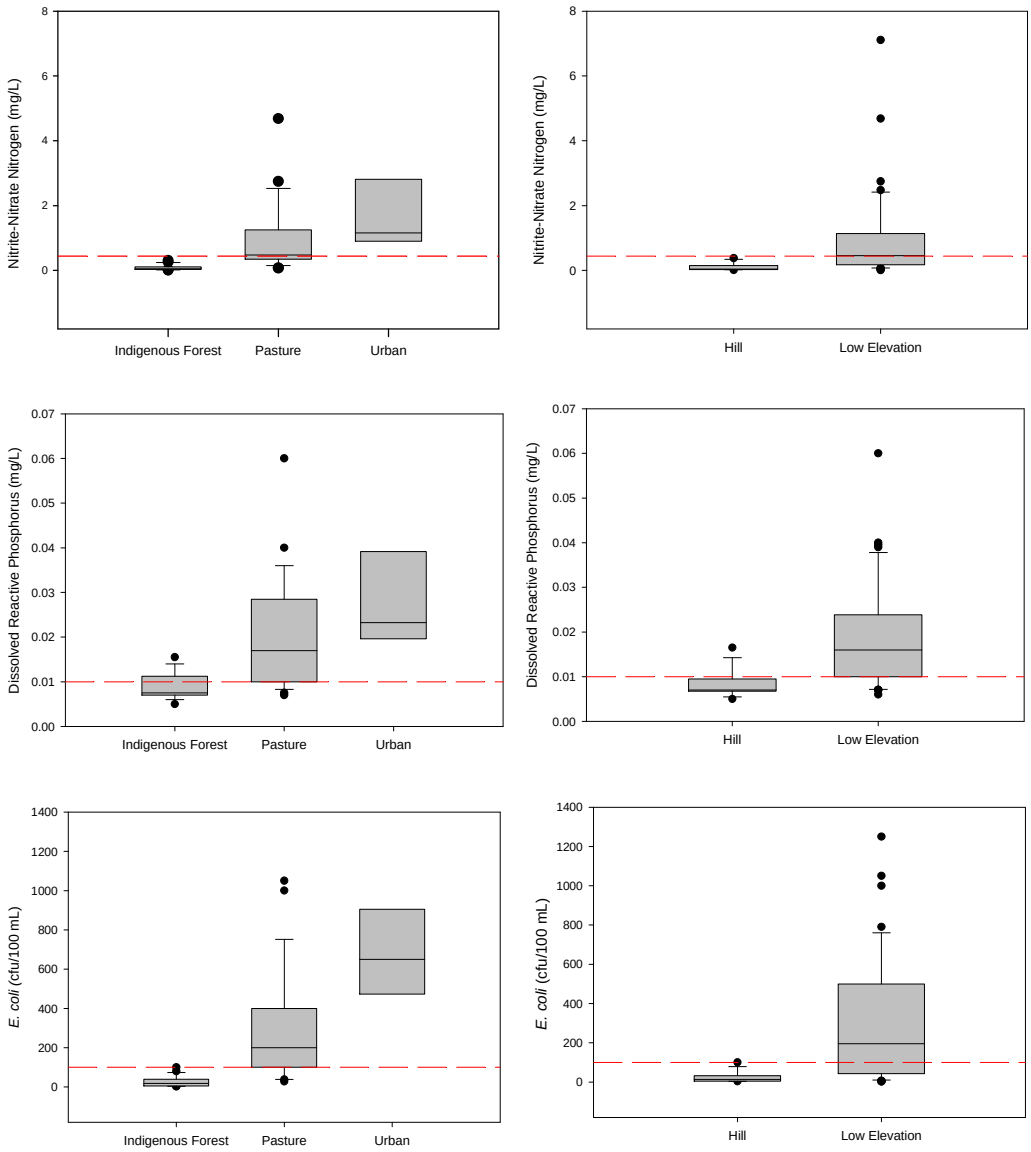

Figure 3.3: Nitrite-nitrate nitrogen, dissolved reactive phosphorus and E. coli box plots for selected REC land use and source of flow classes, based on the median values from routine monthly monitoring of RSoE sites over September 2003 to August 2006 inclusive

- - - - - - - guideline values (refer Table 3.1)

3.1.10 Ammoniacal nitrogen

Seven of the 56 sites recorded median concentrations above the ANZECC (2000) trigger value (Table 3.2), including the Ngarara Stream at Field Way (median 0.132 mg/L), Whareroa Stream at Queen Elizabeth Park (0.135 mg/L), Mangaone Stream at Sims Road Bridge (0.80 mg/L) and the Mangatarere Stream at State Highway 2 (0.069 mg/L). All seven sites are low elevation sites draining predominantly pastoral or urban catchments. The Mangatarere Stream at State Highway 2 is also located downstream of a municipal wastewater treatment plant discharge. Four sites did not exceed the trigger value on any occasion: the Hutt River at Te Marua, Akatarawa River at Hutt confluence, Orongorongo River at Orongorongo Station and Totara Stream at Stronvar.

These sites all drain catchments dominated by indigenous forest, except in the case of the Totara Stream catchment which is predominantly exotic forest.

3.1.11 Total nitrogen

Twenty-six (46 %) RSoE sites had a median total nitrogen concentration above the ANZECC (2000) trigger value of 0.614 mg/L (Table 3.2). The majority of these sites were the same as those that exceeded the nitrite-nitrate nitrogen guideline. The Mangapouri Stream at Rahui Road recorded the highest median concentration (7.707 mg/L) while the lowest median concentration was recorded at the Ruamahanga River at McLays (0.055 mg/L).

Higher total nitrogen concentrations were typically found in low elevation sites draining predominantly pastoral or urban catchments. The 15 sites that did not exceed the trigger value on any occasion over the reporting period all drain catchments dominated by indigenous forest.

3.1.12 Dissolved reactive phosphorus

Median dissolved reactive phosphorus concentrations exceeded the ANZECC (2000) trigger value of 0.01 mg/L at 30 (54 %) RSoE sites (Table 3.2). Twenty one of these 30 sites also exceeded the ANZECC (2000) trigger value for nitrite-nitrate nitrogen. The majority of sites that exceeded the dissolved reactive phosphorus trigger value were low elevation sites draining predominantly pastoral and urban catchments (Figure 3.3). However, five of these sites have upstream catchments dominated by indigenous forest land cover (100 % cover in some cases): the Waitohu Stream at Forest Park (median 0.011 mg/L), Waikanae Stream at Mangaone Walkway (0.016 mg/L), Wainuiomata River at Manuka Track (0.014 mg/L), Beef Creek at Headwaters (0.013 mg/L) and the Tauanui River at Whakatomotomo Road (0.012 mg/L). Exceedance of the ANZECC (2000) trigger value at these five sites is discussed further in Section 4.4.

3.1.13 Total phosphorus

Twenty-two (39 %) RSoE sites had a median total phosphorus concentration above the ANZECC (2000) trigger value of 0.033 mg/L. All but one of these sites also recorded a median dissolved reactive phosphorus concentration above the ANZECC (2000) trigger value. Only two sites did not exceed the trigger value on any occasion over the reporting period: the Waitohu Stream at Forest Park and the Motuwaireka Stream at Headwaters (Table 3.2).

In contrast with Section 3.1.12, all of the sites that exceeded the total phosphorus trigger value were low elevation sites draining predominantly pastoral or urban catchments (i.e., all five of the forested sites that exceeded the dissolved reactive phosphorus trigger value complied with the total phosphorus trigger value). The lowest median concentrations were recorded at sites under indigenous forest cover.

3.1.14 E. coli

Median *E. coli* counts exceeded the ANZECC (2000) stockwater trigger value of 100 cfu/100 mL at 26 (46 %) RSoE sites (Table 3.2). All of these were low elevation sites draining predominantly pastoral or urban catchments. Three sites had median counts equal to or greater than 1,000 cfu/100 mL: the Mangapouri Stream at Bennetts Road (1,050 cfu/100 mL), Karori Stream at Makara Mountain Bike Park (1,250 cfu/100 mL), and Parkvale Stream at Weir (1,000 cfu/100 mL).

E. coli counts were strongly influenced by catchment land cover, with the lowest median counts typically recorded at sites under indigenous forest cover and with hill elevation flow sources (Figure 3.3). Only four sites did not exceed the trigger value over the reporting period: the Waitohu Stream at Forest Park, Totara Stream at Stronvar, Tauanui River at Whakatomotomo Road, and the Wairongomai River at Forest Park.

3.1.15 Water Quality Index

Application of the WQI resulted in the following overall water quality grades for the 56 RSoE sites monitored in the Wellington region over the reporting period (Figure 3.3):

- Excellent: 14 sites (25 %)
- Good: 11 sites (20 %)
- Fair: 13 sites (23 %)
- Poor: 18 sites (32 %)

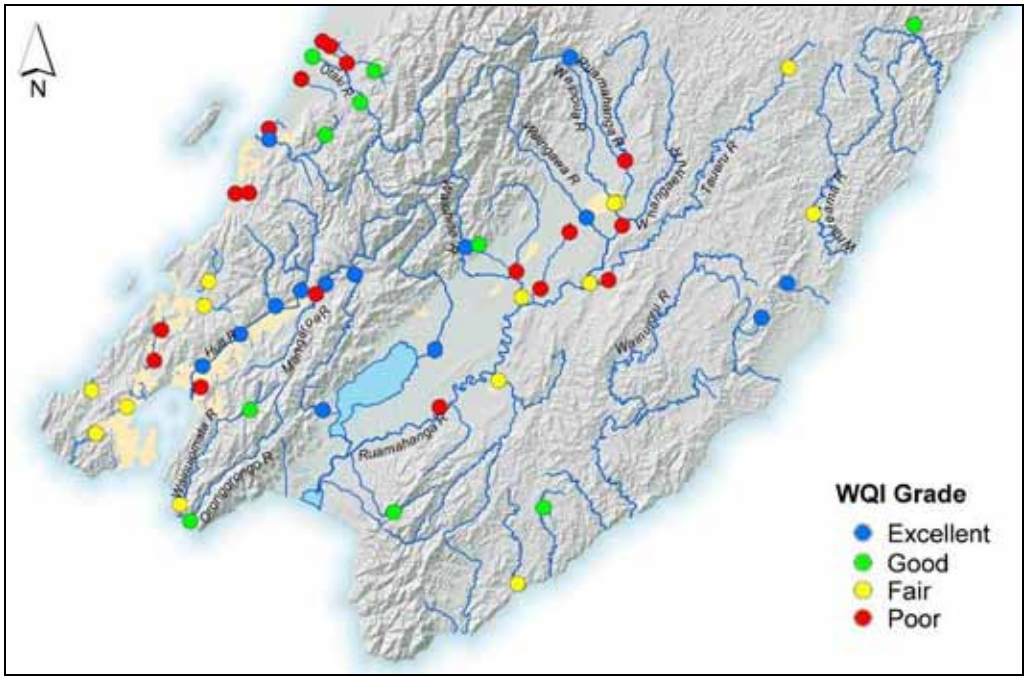

Figure 3.3: Water Quality Index grades for RSoE sites monitored at monthly intervals over September 2003 to August 2006 inclusive, based on compliance of median dissolved oxygen, visual clarity, nitrite-nitrate nitrogen, ammoniacal nitrogen, dissolved reactive phosphorus and *E. coli* values with guideline values

As outlined earlier in this section, the WQI is for comparative purposes rather than an absolute measure of water quality; sites with a grade of good, fair, or poor are all considered degraded because the median value of at least one of the six physico-chemical or microbiological variables in the WQI exceeded a guideline value (Table 3.3). In addition, because the WQI is based on median values (i.e., 50 % compliance), sites awarded the same water quality grade may exhibit varying degrees of compliance (from 51 to 100 %) with the guideline value. This means that while two sites may fall within the same WQI class, they may differ in actual water quality. Therefore to differentiate between "better" and "poorer" sites within a water quality grade, in Table 3.3 the sites within each WQI grade have been ranked based on the number of guideline exceedances for each of the six key variables (i.e., a site that exceeded a guideline on 40% of sampling occasions will be ranked lower than a site with the same WQI grade that exceeded the guideline on 10% of sampling occasions).

Sites with excellent water quality

The 14 sites that were assigned a WQI grade of "excellent" have either a cool and wet, or a cool and extremely wet climate, hard sedimentary geology, and drain catchments of predominantly indigenous forest cover (in one case exotic forest cover) (Table 3.3). These sites are typically river and stream reaches associated with the Tararua, Rimutaka and Aorangi Ranges.

The Hutt River at Te Marua had the highest water quality of the 14 sites (Figure 3.4), achieving 100 % compliance with the dissolved oxygen, nitrite-nitrate nitrogen, and ammoniacal nitrogen guidelines, and exceeding the clarity, *E. coli*, and dissolved reactive phosphorus guidelines on just 17 %, 6 %, and 8 % of sampling occasions over the reporting period respectively (refer Table 3.2).

Figure 3.4: The Hutt River at Te Marua complied with all six WQI criteria

Table 3.3: Water Quality Index grades for RSoE sites monitored at monthly intervals over September 2003 to August 2006 inclusive, based on compliance of median dissolved oxygen, visual clarity, nitrite-nitrate nitrogen, ammoniacal nitrogen, dissolved reactive phosphorus and *E. coli* values with guideline values

Rank	Site No.	Site Name	Guideline Compliance (median values)						REC
			DO	Clarity	*E. coli*	NNN	Amm. N	DRP	
Excellent water quality									
1	RS20	Hutt R at Te Marua Intake	✓	✓	✓	✓	✓	✓	CX/H/HS/IF
2	RS25	Akatarawa R at Hutt confl.	✓	✓	✓	✓	✓	✓	CW/L/HS/IF
3	RS56	Waiorongomai R at Forest Pk	✓	✓	✓	✓	✓	✓	CW/H/HS/IF
4	RS31	Ruamahanga R at McLays	✓	✓	✓	✓	✓	✓	CX/H/HS/S
5	RS47	Waiohine R at Gorge	✓	✓	✓	✓	✓	✓	CX/H/HS/IF
6	RS41	Waingawa R at South Rd	✓	✓	✓	✓	✓	✓	CX/H/HS/IF
7	RS43	Motuwaireka S at Headwaters	✓	✓	✓	✓	✓	✓	CW/L/HS/S
8	RS26	Whakatikei R at Riverstone	✓	✓	✓	✓	✓	✓	CW/L/HS/S
9	RS55	Tauherenikau R at Websters	✓	✓	✓	✓	✓	✓	CW/H/HS/IF
10	RS44	Totara S at Stronvar	✓	✓	✓	✓	✓	✓	CW/L/HS/EF
11	RS23	Pakuratahi R 50m d/s Farm Ck	✓	✓	✓	✓	✓	✓	CX/H/HS/IF
12	RS10	Waikanae R at Greenaway Rd	✓	✓	✓	✓	✓	✓	CW/L/HS/P
13	RS22	Hutt R at Boulcott	✓	✓	✓	✓	✓	✓	CW/L/HS/IF
14	RS21	Hutt R opp. Manor Park G. C.	✓	✓	✓	✓	✓	✓	CW/H/HS/IF
Good water quality									
15	RS05	Otaki R at Pukehinau	✓	x	✓	✓	✓	✓	CW/H/HS/IF
16	RS03	Waitohu S at Forest Pk	✓	✓	✓	✓	✓	x	CW/H/HS/IF
17	RS06	Otaki R at Mouth	✓	x	✓	✓	✓	✓	CW/H/HS/IF
18	RS30	Orongorongo R at Orongorongo Stn	✓	x	✓	✓	✓	✓	CW/H/HS/IF
19	RS28	Wainuiomata R at Manuka Trk	✓	✓	✓	✓	✓	x	CW/L/HS/IF
20	RS52	Tauanui R at Whakatomotomo Rd	✓	✓	✓	✓	✓	x	CW/H/HS/IF
21	RS49	Beef Ck at Headwaters	✓	✓	✓	✓	✓	x	CW/L/HS/S
22	RS09	Waikanae R at Mangaone Walkway	✓	✓	✓	✓	✓	x	CW/L/HS/IF
23	RS35	Mataikona Trib. at Sugar Loaf Rd	✓	x	✓	✓	✓	✓	CW/L/SS/P
24	RS54	Coles Ck Trib. at Lagoon Hill Rd	✓	x	✓	✓	✓	✓	WW/L/SS/S
25	RS40	Waipoua R at Colombo Rd Br	✓	✓	✓	x	✓	✓	CW/L/HS/P
Fair water quality									
26	RS53	Awhea R at Tora Rd	✓	x	x	✓	✓	✓	WW/L/SS/P
27	RS51	Huangarua R at Ponatahi Br	✓	x	x	✓	✓	✓	CD/L/SS/P
28	RS32	Ruamahanga R at Te Ore Ore	✓	x	✓	x	✓	✓	CW/L/SS/P
29	RS42	Whareama R at Gauge	✓	x	x	✓	✓	✓	WW/L/SS/P
30	RS48	Waiohine R at Bicknells	✓	x	✓	✓	✓	x	CW/H/HS/P
31	RS29	Wainuiomata R u/s of White Br	✓	x	✓	✓	✓	x	CW/L/HS/S
32	RS36	Taueru R at Castlehill	✓	x	x	✓	✓	x	CW/L/SS/P
33	RS13	Horokiri S at Snodgrass	✓	✓	x	x	✓	x	CW/L/HS/P
34	RS33	Ruamahanga R at Gladstone Br	✓	x	✓	x	✓	x	CW/L/SS/P
35	RS14	Pauatahanui S at Elmwood Br	✓	x	x	✓	✓	x	CW/L/HS/P
36	RS17	Makara S at Kennels	✓	x	x	✓	✓	x	CW/L/HS/P
37	RS19	Kaiwharawhara S at Ngaio Gorge	✓	✓	x	x	✓	x	CW/L/HS/U
38	RS18	Karori S at Makara Peak	✓	✓	x	x	✓	x	CW/L/HS/U
Poor water quality									
39	RS45	Parkvale Trib at Lowes Res.	x	✓	✓	x	✓	x	WD/L/Al/P
40	RS24	Mangaroa R at Te Marua	✓	x	x	x	✓	x	CW/L/HS/P
41	RS34	Ruamahanga R at Pukio	✓	x	x	x	✓	x	CW/L/SS/P
42	RS11	Whareroa S at Waterfall Rd	✓	x	x	x	✓	x	WW/L/HS/P
43	RS37	Taueru R at Gladstone	✓	x	x	x	✓	x	CD/L/SS/P
44	RS38	Kopuaranga R at Stewarts	✓	x	x	x	✓	x	CW/L/SS/P
45	RS15	Porirua S at Glenside	✓	x	x	x	✓	x	CW/L/HS/U
46	RS01	Mangapouri S at Rahui Rd	✓	x	x	x	✓	x	WD/L/Al/U
47	RS16	Porirua S at Wall Pk	✓	x	x	x	✓	x	WW/L/HS/U
48	RS39	Whangaehu R 250m u/s confl.	✓	x	x	x	✓	x	CD/L/SS/P
49	RS46	Parkvale S at Weir	✓	x	x	x	✓	x	WD/L/Al/P
50	RS50	Mangatarere S at SH 2	✓	x	x	x	x	x	CW/L/HS/P
51	RS27	Waiwhetu S at Wainui Hill Br	✓	x	x	x	x	x	WW/L/HS/U
52	RS04	Waitohu S at Norfolk Cres.	✓	x	x	x	x	x	CW/L/HS/P
53	RS12	Whareroa S at QE Park	x	x	x	✓	x	x	WW/L/HS/P
54	RS07	Mangaone S at Sims Rd Br	✓	x	x	x	x	x	WW/L/Al/P
55	RS08	Ngarara S at Field Way	x	x	x	x	x	x	WW/L/Al/P
56	RS02	Mangapouri S at Bennetts Rd	x	x	x	x	x	x	WD/L/Al/P

The Hutt River opposite Manor Park Golf Club was ranked the lowest of the RSoE sites in the excellent grade and only just complied with the *E. coli* guideline (median 100 cfu/100 mL). If faecal coliforms had been used as the bacteriological indicator, as in Milne and Perrie (2005), this site would have dropped a WQI grade to good (median 140 cfu/100 mL).

Sites with good water quality

Eleven sites received a WQI grade of "good", indicating that median values of five of the six water quality variables in the WQI complied with guideline values (Table 3.3). Five of these sites had a median dissolved reactive phosphorus value that exceeded the ANZECC (2000) trigger value. Five other sites had a median water clarity value that failed to meet the MfE (1994) guideline although for three sites (the Otaki River at Pukehinau, Otaki River at Mouth, and the Orongorongo River at Orongorongo Station), the percentage of exceedance was under 60 %.

Sites in this class were both hill and low elevation sites with a predominantly cool and wet climate and hard sedimentary geology. Eight of these sites drain catchments dominated by indigenous forest cover and their inclusion in this grade may potentially indicate a degradation of water quality; typically, catchments with large proportions of indigenous forest cover have near pristine water quality and should comply with the guidelines incorporated in the WQI. These eight sites are discussed further in Section 4.3.

The two remaining sites (the Mataikona Tributary at Sugar Loaf Road and Waipoua River at Colombo Road Bridge) drain pastoral catchments and ranked amongst the lower sites in this grade. However, despite being classed as pastoral, the Mataikona Tributary at Sugar Loaf Road still has a large proportion of its catchment in indigenous forest land cover (60 %).

Sites with fair water quality

Thirteen sites were assigned a water quality grade of "fair", because median values of only three or four of the six water quality variables in the WQI complied with guideline values. With the exception of the Waiohine River at Bicknells, all sites were low elevation and all but three sites (two urban and one indigenous forest) drain predominantly pastoral catchments. The Wainuiomata River upstream of White Bridge was the only RSoE site with a catchment dominated by indigenous forest cover (64 %) that did not receive a WQI grade of either "excellent" or "good"; having failed to comply with both the water clarity and the dissolved reactive phosphorus guidelines.

Six sites complied with four of the six guidelines and the other seven sites complied with just three. The water quality guidelines that were exceeded by sites within this grade were water clarity (ten sites), dissolved reactive phosphorus (ten sites), *E. coli* (nine sites), nitrite-nitrate nitrogen (seven sites), and dissolved oxygen (one site). All sites complied with the ammoniacal nitrogen guideline.

Two of the RSoE sites with soft sedimentary substrates were in this WQI grade: the Whareama River at Gauge and the Taueru River at Castlehill. These sites received the highest WQI grades of the ten RSoE sites characterised by a soft sedimentary substrate.

Sites with poor water quality

Eighteen RSoE sites received a grade of "poor", indicating that median values of less than three water quality variables in the WQI complied with guideline values (Table 3.3). The exception was the Parkvale tributary at Lowes Reserve; this site actually only exceeded three WQI criteria but as one of these was dissolved oxygen, the WQI grade was automatically downgraded from fair to poor.

Figure 3.5: Ngarara Stream at Field Way did not meet any of the six WQI criteria

With the exception of Parkvale tributary at Lowes Reserve, all sites within this grade failed to comply with clarity, *E. coli*, and dissolved reactive phosphorus guidelines. The nitrite-nitrate nitrogen guideline was exceeded at all but one site (Whareroa Stream at Waterfall Road) and ammoniacal nitrogen and dissolved oxygen guidelines were exceeded at seven and four sites, respectively. Median values at two sites, the Ngarara Stream at Field Way (Figure 3.5) and the Mangapouri Stream at Bennetts Road, exceeded all WQI guidelines.

All of the sites graded poor are located on low elevation reaches of small streams draining predominantly pastoral (14 sites) or urban (4 sites) catchments. In addition, of the ten RSoE sites with soft sedimentary substrates, the majority (eight) were in this WQI grade.

3.2 Periphyton results

3.2.1 Approach to analysis

As outlined in Section 2.5, assessment of periphyton data is limited to RSoE sites with hard bottomed substrates (46 of the 56 sites). Monthly observations of percent periphyton streambed cover, from September 2003 to August 2006 inclusive, and annual assessments of periphyton biomass (chlorophyll *a* and Ash Free Dry Mass (AFDM)) from the summer months for 2004, 2005 and 2006 are compared against various MfE (2000) guidelines (Table 3.4).

Table 3.4: Guidelines used to assess periphyton stream bed cover and biomass (MfE 2000)

Instream value/variable	Mat periphyton	Filamentous periphyton
Aesthetics/recreation		
Maximum cover of visible stream bed	60% >0.3 cm thick	30% > 2 cm long
Benthic biodiversity		
Maximum chlorophyll *a*	50 mg/m^2	50 mg/m^2
Trout habitat and angling		
Maximum AFDM (mg/m^2)	35 mg/m^2	35 mg/m^2
Maximum cover of visible stream bed	N/A	30% > 2 cm long

The guidelines presented in Table 3.4 are for a range of instream values and guidelines for biomass and visible stream bed cover are not necessarily comparable. Some of these instream values are not applicable to all of the RSoE sites monitored (i.e., not all rivers are managed for trout habitat and angling). Guidelines that relate to specific management requirements listed in the RFP or RPS are discussed in Section 4.4.

(a) Cautionary note

There is some variability in the quality of Greater Wellington's RSoE periphyton records. A comprehensive quality assurance audit of RSoE fieldsheets and database entries is to be undertaken in 2007/08. This audit is likely to result in some changes in the *stream bed cover* data presented in this report. These changes will be reflected in future RSoE reporting.

3.2.2 Visible stream bed cover

The number of observations of periphyton stream bed cover varied among the 46 RSoE sites assessed over the reporting period. Up to 40 % of the possible 36 observations were missed at some sites due to turbidity, high flows or, on occasion, field recording errors.

Twenty two RSoE sites exceeded guidelines for periphyton stream bed cover during the reporting period (Table 3.5). The majority (82 %) of these sites were low elevation sites located in catchments draining the full range of land cover classes. Guidelines for filamentous stream bed cover were more frequently exceeded than mat guidelines (20 sites and six sites respectively).

Sites that exceeded guidelines for mat periphyton cover typically exceeded the filamentous periphyton guideline at some time over the reporting period except in the cases of the Otaki River at Mouth and the Waipoua River at Colombo Road.

Eight sites exceeded the MfE (2000) filamentous periphyton stream bed cover guidelines on more than 10 % of sampling occasions during the reporting period. The poorest compliance was recorded in the Taueru River at Gladstone (Figure 3.6) and the Kopuaranga River at Stewarts; these sites exceeded the guidelines on 35% and 21% of sampling occasions respectively (Table 3.5). A number of the sites with poor compliance commonly experience periods of relatively stable low flows and are typically located in agricultural catchments showing signs of eutrophication.

Figure 3.6: Long green filamentous algae in the lower Taueru River, December 2004

Table 3.5: Summary of monthly observations at RSoE sites over September 2003 to August 2006 inclusive of visible stream bed cover for filamentous and mat periphyton in relation to exceedances of the MfE (2000) guidelines

Site No.	Site Name	Stream bed cover - filamentous periphyton (> 2 cm long)			Stream bed cover - mat periphyton (> 0.03 cm thick)		
		No. >30% cover	%n >30% cover	n	No. >60% cover	%n >60% cover	n
RS01	Mangapouri S at Rahui Rd	*	*	*	*	*	*
RS02	Mangapouri S at Bennetts Rd	*	*	*	*	*	*
RS03	Waitohu S at Forest Pk	0	0	34	0	0	34
RS04	Waitohu S at Norfolk Cres	*	*	*	*	*	*
RS05	Otaki R at Pukehinau	0	0	32	0	0	32
RS06	Otaki R at Mouth	0	0	30	1	3	29
RS07	Mangaone S at Sims Rd Br	*	*	*	*	*	*
RS08	Ngarara S at Field Way	*	*	*	*	*	*
RS09	Waikanae R at Mangaone Walkway	0	0	35	0	0	35
RS10	Waikanae R at Greenaway Rd	0	0	32	0	0	32
RS11	Whareroa S at Waterfall Rd	0	0	25	0	0	25
RS12	Whareroa S at QE Park	*	*	*	*	*	*
RS13	Horokiri S at Snodgrass	2	6	33	0	0	33
RS14	Pauatahanui S at Elmwood Br	0	0	21	0	0	21
RS15	Porirua S at Glenside	1	3	32	0	0	32
RS16	Porirua S at Wall Park (Milk Depot)	1	3	31	0	0	31
RS17	Makara S at Kennels	0	0	30	0	0	30
RS18	Karori S at Makara Peak	1	3	33	0	0	33
RS19	Kaiwharawhara S at Ngaio Gorge	0	0	35	0	0	35
RS20	Hutt R at Te Marua Intake Site	0	0	31	0	0	31
RS21	Hutt R opp. Manor Park G.C.	0	0	31	0	0	31
RS22	Hutt R at Boulcott	0	0	26	0	0	26
RS23	Pakuratahi R 50m d/s Farm Ck	1	3	33	0	0	33
RS24	Mangaroa R at Te Marua	4	13	32	0	0	31
RS25	Akatarawa R at Hutt confl.	0	0	30	0	0	30
RS26	Whakatikei R at Riverstone	2	6	34	0	0	34
RS27	Waiwhetu S at Wainui Hill Br	*	*	*	*	*	*
RS28	Wainuiomata R at Manuka Trk	0	0	35	0	0	35
RS29	Wainuiomata R u/s of White Br	5	16	31	1	3	31
RS30	Orongorongo R at Orong. Stn	0	0	25	0	0	25
RS31	Ruamahanga R at McLays	0	0	32	0	0	31
RS32	Ruamahanga R at Te Ore Ore	0	0	29	0	0	29
RS33	Ruamahanga R at Gladstone Br	0	0	28	0	0	28
RS34	Ruamahanga R at Pukio	1	4	25	0	0	25
RS35	Mataikona Trib at Sugar Loaf Rd	0	0	31	0	0	30
RS36	Taueru R at Castlehill	*	*	*	*	*	*
RS37	Taueru R at Gladstone	9	35	26	0	0	26
RS38	Kopuaranga R at Stewarts	6	21	29	0	0	28
RS39	Whangaehu R 250m u/s confl.	*	*	*	*	*	*
RS40	Waipoua R at Colombo Rd Br	0	0	32	1	3	32
RS41	Waingawa R at South Rd	0	0	31	0	0	31
RS42	Whareama R at Gauge	*	*	*	*	*	*
RS43	Motuwaireka S at Headwaters	3	9	34	0	0	34
RS44	Totara S at Stronvar	2	6	36	0	0	36
RS45	Parkvale Trib at Lowes Res.	0	0	32	0	0	32
RS46	Parkvale S at Weir	5	19	27	1	4	27
RS47	Waiohine R at Gorge	0	0	30	0	0	28
RS48	Waiohine R at Bicknells	0	0	29	0	0	29
RS49	Beef Ck at Headwaters	0	0	33	0	0	33
RS50	Mangatarere S at SH 2	3	9	32	0	0	32
RS51	Huangarua R at Ponatahi Br	5	19	27	0	0	27
RS52	Tauanui R at Whakatomotomo Rd	0	0	34	0	0	34
RS53	Awhea R at Tora Rd	5	18	28	2	7	28
RS54	Coles Ck trib at Lagoon Hill Rd	3	9	32	1	3	32
RS55	Tauherenikau R at Websters	1	3	29	0	0	29
RS56	Waiorongomai R at Forest Pk	6	17	35	0	0	35

* This site has a soft substrate and is not assessed for visible stream bed cover

3.2.3 Biomass

Chlorophyll *a* (and to a lesser extent, AFDM) concentrations varied greatly among RSoE sites during the reporting period (Table 3.6). The lowest chlorophyll *a* concentration was recorded in the Hutt River at Te Marua (0.01 mg/m^2 in 2005), while the highest was recorded in the Taueru River at Gladstone (345.5 mg/m^2 in 2004). Within site variation over the three years was also quite large with the Hutt River at Boulcott recording chlorophyll *a* concentrations of 0.2, 1.0, and 162 mg/m^2 in 2004, 2005 and 2006 respectively. River flow conditions prior to sampling vary from year to year, and so caution is needed when trying to interpret the observed within and between site variation in periphyton biomass.

Fourteen RSoE sites exceeded the chlorophyll *a* guidelines for benthic biodiversity on at least one occasion during the reporting period. Ten of these sites exceeded the guideline on just one occasion while three sites (the Kopuaranga Stream at Stewarts, Parkvale Stream at Weir (Figure 3.7), and the Huangarua River at Ponatahi Bridge) exceeded the guideline twice, and one site (the Taueru River at Gladstone) exceeded it on all three sampling occasions.

Figure 3.7: Parkvale Stream at Weir regularly exceeded MfE (2000) guidelines for periphyton stream bed cover and biomass (pictured: *Spirogyra* spp.)

Table 3.6: Summary of periphyton biomass (chlorophyll *a* and AFDM), measured annually at RSoE sites over 2004 to 2006 inclusive (including mean concentration ± 1 std deviation). Concentrations exceeding the MfE (2000) guidelines are indicated in bold type

Site No.	Site Name	Chlorophyll *a* (mg/m²)					Ash Free Dry Mass (g/m²)				
		2004	2005	2006	Mean	SD	2004	2005	2006	Mean	SD
RS01	Mangapouri S at Rahui Rd	*	*	*	*	*	*	*	*	*	*
RS02	Mangapouri S at Bennetts Rd	*	*	*	*	*	*	*	*	*	*
RS03	Waitohu S at Forest Pk	8.50	9.31	3.58	7.13	3.10	2.52	2.54	1.93	2.33	0.34
RS04	Waitohu S at Norfolk Cres	*	*	*	*	*	*	*	*	*	*
RS05	Otaki R at Pukehinau	0.41	4.66	1.71	2.26	2.18	0.29	1.75	1.00	1.01	0.73
RS06	Otaki R at Mouth	1.92	4.99	12.23	6.38	5.29	1.22	5.15	12.23	6.20	5.57
RS07	Mangaone S at Sims Rd Br	*	*	*	*	*	*	*	*	*	*
RS08	Ngarara S at Field Way	*	*	*	*	*	*	*	*	*	*
RS09	Waikanae R at Mangaone Walk.	2.85	3.05	10.33	5.41	4.26	0.66	1.34	3.24	1.75	1.33
RS10	Waikanae R at Greenaway Rd	27.15	12.12	70.68	36.65	30.41	4.07	2.73	17.35	8.05	8.08
RS11	Whareroa S at Waterfall Rd	0.73	0.41	4.67	1.94	2.37	1.88	1.63	5.98	3.16	2.44
RS12	Whareroa S at QE Park	*	*	*	*	*	*	*	*	*	*
RS13	Horokiri S at Snodgrass	6.25	14.90	43.18	21.44	19.31	1.12	4.36	9.95	5.14	4.47
RS14	Pauatahanui S at Elmwood Br	19.83	33.88	33.10	28.94	7.90	4.42	7.53	11.66	7.87	3.63
RS15	Porirua S at Glenside	6.67	37.40	11.51	18.53	16.53	2.19	3.56	9.02	4.92	3.61
RS16	Porirua S at Wall Park (Milk Depot)	11.67	23.58	9.86	15.04	7.45	2.48	4.20	5.42	4.04	1.48
RS17	Makara S at Kennels	1.50	1.25	2.92	1.89	0.90	1.55	4.63	4.51	3.56	1.74
RS18	Karori S at Makara Peak	15.89	36.58	33.46	28.65	11.15	4.32	4.01	9.20	5.84	2.91
RS19	Kaiwharawhara S at Ngaio Gorge	33.18	47.34	22.14	34.22	12.63	10.82	8.39	6.89	8.70	1.98
RS20	Hutt R at Te Marua Intake Site	0.56	0.01	5.06	1.87	2.77	0.57	0.09	2.61	1.09	1.34
RS21	Hutt R opp. Manor Park G.C.	0.48	3.71	18.95	7.72	9.87	0.53	0.74	10.97	4.08	5.97
RS22	Hutt R at Boulcott	0.23	0.97	162.75	54.65	93.62	0.25	1.38	8.68	3.44	4.58
RS23	Pakuratahi R 50m d/s Farm Ck	0.84	1.36	60.05	20.75	34.04	0.48	0.83	22.12	7.81	12.40
RS24	Mangaroa R at Te Marua	0.57	9.65	58.29	22.84	31.04	0.33	1.70	17.56	6.53	9.57
RS25	Akatarawa R at Hutt confl.	0.18	2.81	1.74	1.58	1.32	0.57	0.42	1.93	0.97	0.83
RS26	Whakatikei R at Riverstone	2.41	1.63	45.91	16.65	25.34	0.99	0.43	12.01	4.48	6.53
RS27	Waiwhetu S at Wainui Hill Br	*	*	*	*	*	*	*	*	*	*
RS28	Wainuiomata R at Manuka Trk	4.62	19.87	9.93	11.47	7.74	0.90	5.30	5.23	3.81	2.52
RS29	Wainuiomata R u/s of White Br	22.57	30.74	6.08	19.80	12.56	4.51	21.33	7.77	11.21	8.92
RS30	Orongorongo R at Orong. Stn	1.42	7.39	2.56	3.79	3.17	1.23	6.07	2.01	3.11	2.60
RS31	Ruamahanga R at McLays	2.46	5.59	0.46	2.84	2.59	0.65	1.07	0.29	0.67	0.39
RS32	Ruamahanga R at Te Ore Ore	27.28	66.53	11.27	35.03	28.44	3.30	7.86	3.00	4.72	2.72
RS33	Ruamahanga R at Gladstone Br	13.19	12.02	4.08	9.76	4.96	1.95	1.97	1.02	1.64	0.54
RS34	Ruamahanga R at Pukio	61.26	0.25	5.28	22.26	33.87	5.17	1.82	3.92	3.64	1.69
RS35	Mataikona Trib at Sugar Loaf Rd	3.94	1.67	2.40	2.67	1.16	2.02	2.37	2.28	2.22	0.18
RS36	Taueru R at Castlehill	*	*	*	*	*	*	*	*	*	*
RS37	Taueru R at Gladstone	345.53	86.96	84.78	172.4	149.9	29.62	36.76	48.45	38.27	9.51
RS38	Kopuaranga R at Stewarts	18.77	203.63	195.21	139.2	104.3	2.69	36.20	43.48	27.46	21.76
RS39	Whangaehu R 250m u/s confl.	*	*	*	*	*	*	*	*	*	*
RS40	Waipoua R at Colombo Rd Br	14.26	16.62	178.85	69.91	94.35	2.25	5.61	20.03	9.30	9.45
RS41	Waingawa R at South Rd	1.34	2.69	15.21	6.41	7.65	0.99	0.90	2.77	1.55	1.06
RS42	Whareama R at Gauge	*	*	*	*	*	*	*	*	*	*
RS43	Motuwaireka S at Headwaters	1.59	7.42	8.00	5.67	3.55	1.35	4.43	3.07	2.95	1.54
RS44	Totara S at Stronvar	3.28	27.89	27.76	19.65	14.17	1.73	5.96	24.49	10.73	12.11
RS45	Parkvale Trib at Lowes Res.	18.88	10.47	64.85	31.40	29.27	7.87	4.81	23.16	11.95	9.83
RS46	Parkvale S at Weir	92.04	87.33	16.59	65.32	42.26	18.41	18.88	16.59	17.96	1.21
RS47	Waiohine R at Gorge	0.75	1.59	0.40	0.91	0.61	0.51	1.13	0.77	0.80	0.31
RS48	Waiohine R at Bicknells	4.24	3.05	3.71	3.67	0.59	0.92	1.15	3.27	1.78	1.29
RS49	Beef Ck at Headwaters	3.26	4.04	10.27	5.85	3.84	1.39	1.41	5.88	2.89	2.59
RS50	Mangatarere S at SH 2	72.11	10.74	29.33	37.39	31.47	11.65	2.27	9.25	7.72	4.87
RS51	Huangarua R at Ponatahi Br	6.98	229.26	71.54	102.6	114.4	1.62	30.57	23.85	18.68	15.15
RS52	Tauanui R at Whakatomotomo Rd	3.18	6.55	8.78	6.17	2.82	0.68	3.60	12.30	5.53	6.04
RS53	Awhea R at Tora Rd	19.38	34.54	56.67	36.86	18.75	16.80	9.40	32.38	19.53	11.73
RS54	Coles Ck trib at Lagoon Hill Rd	5.62	11.71	8.11	8.48	3.06	2.26	4.76	4.50	3.84	1.37
RS55	Tauherenikau R at Websters	5.90	2.31	11.43	6.55	4.60	0.83	0.64	9.67	3.71	5.16
RS56	Waiorongomai R at Forest Pk	3.44	0.57	3.85	2.62	1.79	1.34	1.61	2.64	1.87	0.69

* This site has a soft substrate and is not assessed for visible stream bed cover

Just two sites exceeded the AFDM guideline for trout habitat and angling: the Taueru River at Gladstone and the Kopuaranga River at Stewarts, in both 2005 and 2006 (Table 3.6). Exceedances of AFDM guideline were matched with exceedances of the chlorophyll *a* guideline for benthic biodiversity at both sites. As discussed previously, these sites experience periods of prolonged low flows and are situated in agricultural catchments. Both these sites are also listed in the RFP to be managed for trout habitat and angling and are discussed further in Section 4.4.

Sites with low elevation source of flow draining catchments dominated by pastoral land use typically had higher periphyton biomass while hill elevation sites with upstream catchments dominated by indigenous forest recorded the lowest (Figure 3.8). This is to be expected given greater canopy (and therefore shade) cover, and the lower concentrations of dissolved nutrients in catchments dominated by indigenous forest land cover. Sites that exceeded chlorophyll *a* benthic biodiversity guidelines were all low elevation sites (except the Otaki River at Mouth), and most drain catchments dominated by pastoral land cover.

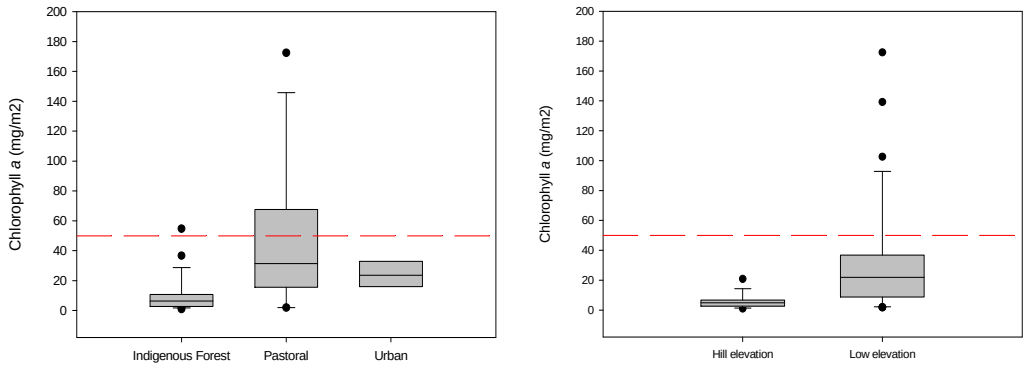

Figure 3.8: Mean chlorophyll a concentrations from samples collected annually during the summers of 2004, 2005 and 2006 across land cover classes, and source of flow classes represented in the RSoE monitoring network

- - - - - - - MfE (2000) chlorophyll *a* guideline for benthic biodiversity

3.3 Macroinvertebrates

3.3.1 Approach to analysis

This section summarises macroinvertebrate data collected annually from each of the 56 RSoE sites in 2004, 2005 and 2006. As recommended for the reporting of State of Environment 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 (QMCI, % EPT taxa, and taxa richness) are described in Appendix 3 and presented in Appendix 5.

The quality thresholds for interpretation of the MCI scores are outlined in Table 3.7. Soft bottomed MCI scores (MCI-sb) were calculated at sites deemed appropriate (i.e., those sites that were sampled using sampling protocol C2

(Stark et al. 2001). Quality thresholds for the MCI-sb are the same for the "traditional" hard bottomed MCI; this allows for inter-site comparison of MCI scores for soft and hard bottomed sites (Stark and Maxted 2007).

Table 3.7: Interpretation of MCI-type scores (Stark and Maxted 2007)

Quality Class	MCI and MCI-sb
Excellent	>119
Good	100-119
Fair	80-99
Poor	<80

It should be noted that there is some flexibility in interpreting the divisions between MCI quality classes, and boundaries should be should be regarded as 'fuzzy' (Stark and Maxted 2007). For example, while an MCI score of 98 results in a site has been classed as "fair", in actuality it should be considered as 98 ± 5 MCI units, and could therefore fall within the "good" class (MCI 103).

In this report, inter-site comparisons are based on the *mean* MCI score over 2004-2006.

3.4 Results

The MCI scores for each RSoE site are presented in Table 3.8, along with the overall mean score for 2004-2006. Based on the mean scores, 21 sites scored a 'quality class' of excellent, 18 sites a grade of good, eight sites a grade of fair and nine sites a grade of poor (Figure 3.9).

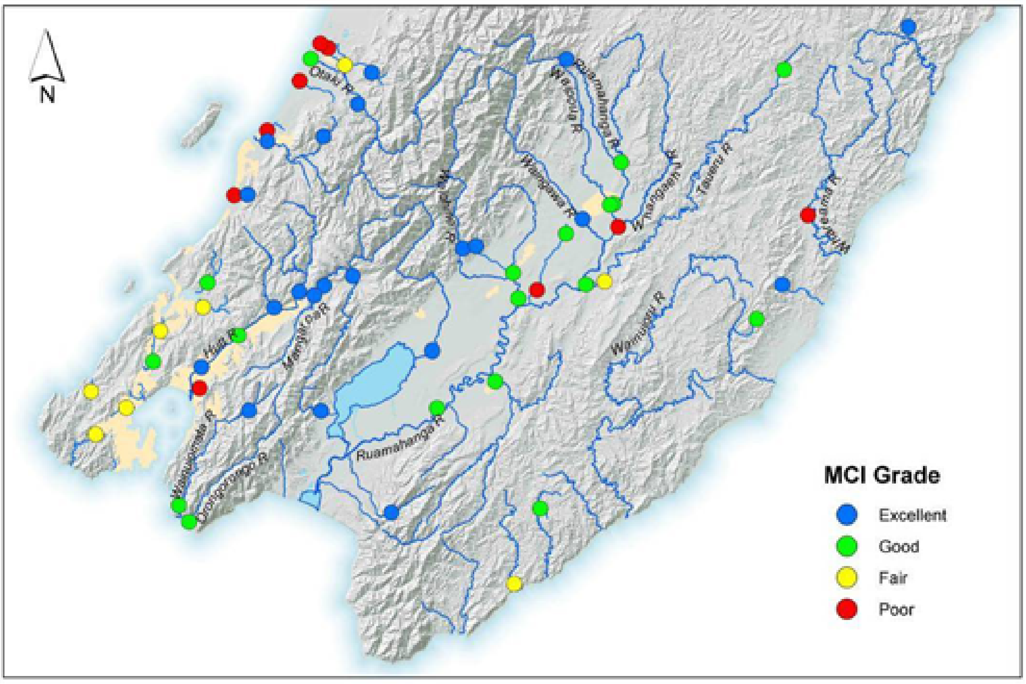

Figure 3.9: Mean MCI 'grades' for the 56 RSoE sites, determined from annual monitoring over 2004-2006 inclusive

Table 3.8: MCI values for RSoE sites sampled annually (three replicate samples per site) in the summers of 2004, 2005 and 2006

Site No.	Site Name	2004			2005			2006			Mean	SD
RS01*	Mangapouri S at Rahui Rd	78	84	92	103	113	100	74	82	90	91	12.8
RS02*	Mangapouri S at Bennetts Rd	60	61	81	73	60	84	73	54	81	70	11.0
RS03	Waitohu S at Forest Pk	149	147	140	148	135	144	144	147	144	144	4.4
RS04*	Waitohu S at Norfolk Cres	101	93	99	63	65	78	46	68	49	74	20.6
RS05	Otaki R at Pukehinau	131	147	151	143	131	131	141	147	134	140	7.9
RS06	Otaki R at Mouth	116	135	128	92	112	105	107	98	104	111	13.7
RS07*	Mangaone S at Sims Rd Br	43	81	60	68	81	63	65	65	69	66	11.4
RS08*	Ngarara S at Field Way	54	51	61	93	63	77	64	67	62	66	12.7
RS09	Waikanae R at Mangaone Walk.	151	143	150	150	151	152	145	145	137	147	5.2
RS10	Waikanae R at Greenaway Rd	138	146	128	114	124	112	113	97	116	121	14.9
RS11	Whareroa S at Waterfall Rd	127	129	116	137	126	124	127	118	124	125	6.0
RS12*	Whareroa S at QE Park	71	81	75	80	59	78	62	60	50	69	11.1
RS13	Horokiri S at Snodgrass	117	108	107	122	127	126	93	103	102	112	11.7
RS14	Pauatahanui S at Elmwood Br	90	105	94	97	104	113	79	93	89	96	10.0
RS15	Porirua S at Glenside	118	113	116	126	127	119	86	88	83	109	17.7
RS16	Porirua S at Wall Park (Milk Depot)	106	97	90	115	86	100	91	82	86	95	10.7
RS17	Makara S at Kennels	101	95	103	96	93	93	108	108	99	99	5.7
RS18	Karori S at Makara Peak	92	91	97	108	113	105	83	85	79	95	11.8
RS19	Kaiwharawhara S at Ngaio Gorge	90	88	94	86	88	90	81	89	82	88	4.0
RS20	Hutt R at Te Marua Intake Site	148	150	143	140	128	139	133	123	141	138	8.9
RS21	Hutt R opp. Manor Park G.C.	117	110	108	147	135	132	102	110	94	117	17.2
RS22	Hutt R at Boulcott	138	142	143	118	115	124	108	98	111	122	15.9
RS23	Pakuratahi R 50m d/s Farm Ck	150	138	151	154	137	135	128	134	121	139	11.1
RS24	Mangaroa R at Te Marua	125	132	119	129	135	136	103	106	106	121	13.4
RS25	Akatarawa R at Hutt confl.	144	146	152	140	146	147	134	136	139	143	5.8
RS26	Whakatikei R at Riverstone	116	129	144	140	127	151	118	112	118	128	14.1
RS27*	Waiwhetu S at Wainui Hill Br	66	58	54	86	74	84	75	67	52	68	12.5
RS28	Wainuiomata R at Manuka Track	135	148	140	141	140	139	145	139	145	141	3.9
RS29	Wainuiomata R u/s of White Br	102	98	100	104	117	115	95	93	97	102	8.2
RS30	Orongorongo R at Orongo. Stn	106	133	120	112	81	107	118	114	142	115	17.3
RS31	Ruamahanga R at McLays	146	150	142	148	146	145	149	165	148	149	6.4
RS32	Ruamahanga R at Te Ore Ore	123	116	100	96	107	100	114	118	113	110	9.4
RS33	Ruamahanga R at Gladstone Br	135	104	125	103	122	130	128	100	104	117	13.7
RS34	Ruamahanga R at Pukio	87	108	98	105	117	110	109	107	116	106	9.2
RS35	Mataikona trib at Sugar Loaf Rd	124	127	138	121	123	115	139	121	130	126	7.9
RS36*	Taueru R at Castlehill	118	122	133	94	85	98	118	121	111	111	15.5
RS37	Taueru R at Gladstone	109	101	104	110	99	90	92	97	86	99	8.5
RS38	Kopuaranga R at Stewarts	114	103	111	100	98	104	107	104	116	106	6.0
RS39*	Whangaehu R 250m u/s confl.	76	76	54	53	53	58	67	52	60	61	9.7
RS40	Waipoua R at Colombo Rd Br	124	106	98	110	112	104	106	113	107	109	7.3
RS41	Waingawa R at South Rd	133	140	112	138	150	137	119	122	126	131	12.0
RS42*	Whareama R at Gauge	65	77	76	82	69	78	65	60	56	70	9.0
RS43	Motuwaireka S at Headwaters	140	144	131	121	134	123	121	123	116	128	9.7
RS44	Totara S at Stronvar	129	131	118	115	112	123	103	97	98	114	12.7
RS45	Parkvale Trib at Lowes Res.	99	96	100	106	118	105	111	111	120	107	8.5
RS46	Parkvale S at Weir	65	68	69	89	78	82	68	72	62	73	8.8
RS47	Waiohine R at Gorge	145	145	135	142	134	124	140	163	153	142	11.3
RS48	Waiohine R at Bicknells	126	117	118	105	132	115	100	113	120	116	9.9
RS49	Beef Ck at Headwaters	145	141	152	151	145	152	141	147	143	146	4.4
RS50	Mangatarere S at SH 2	116	115	113	112	118	105	106	101	98	109	7.1
RS51	Huangarua R at Ponatahi Br	105	103	120	105	99	97	115	95	106	105	8.1
RS52	Tauanui R at Whakatomotomo Rd	144	130	136	126	118	124	124	116	125	127	8.7
RS53	Awhea R at Tora Rd	100	100	104	81	92	93	89	80	86	92	8.5
RS54	Coles Ck trib at Lagoon Hill Rd	122	114	113	Not sampled**			104	94	94	107	11.5
RS55	Tauherenikau R at Websters	121	127	124	140	137	143	119	120	127	129	9.0
RS56	Waiorongomai R at Forest Pk	118	124	119	146	128	147	138	144	133	133	11.5

*Denotes a soft sediment site and subsequent calculation of MCI-sb scores

** This site was not sampled for macroinvertebrates in 2005 due to insufficient flows

Sites with excellent MCI scores

Nineteen of the 21 RSoE sites that were classed as "excellent" drain catchments dominated by indigenous forest land cover. The remaining two sites were classed as pastoral catchments but still had greater than 60% of their upstream catchment in combined indigenous and exotic forest land cover. Scores from these sites did however fall within the lower range of MCI scores for this class. Ten of the 14 RSoE sites with hill elevation source of flow were in this class and all sites have a hard sedimentary substrate.

The RSoE site with the highest mean MCI score was the Ruamahanga River at McLays (MCI 149, Figure 3.10) while the sites with the lowest scores within this class were the Mangaroa River at Te Marua and the Waikanae River at Greenaway Road (121), (Table 3.8).

Figure 3.10: The Ruamahanga River at McLays had the highest mean MCI score over 2004-2006

Sites with good MCI scores

Eighteen RSoE sites were assigned an MCI grading of "good". Sites that drain catchments dominated by indigenous forest land cover (five sites) or have hill elevation source of flows (four sites) that didn't score an MCI grade of "excellent" were found in this class.

The remaining 11 sites within this class have low elevation source of flows and tend to predominantly drain catchments dominated by pastoral land cover. The only RSoE site with a catchment dominated by exotic forest was found within this class (Totara Stream at Stronvar, mean MCI 114).

The highest mean MCI score for RSoE sites draining urban catchments (seven sites) was found within this class; the Porirua Stream at Glenside Overhead Cable (109). Of the ten RSoE sites with soft sediment substrates (i.e., sampled using protocol C2; Stark et al, 2001), only the Taueru River at Castlehill had a high enough mean MCI to be in this class (111).

Sites with fair MCI scores

The eight sites with mean MCI scores of "fair" are all low elevation sites draining pastoral (5 sites) or urban catchments (3 sites). Scores within this class ranged from 88 for the Kaiwharawhara Stream at Ngaio Gorge to 99 for both the Taueru River at Gladstone and the Makara Stream at Kennels (Table 3.8).

Sites with poor MCI scores

Nine RSoE sites had a mean MCI score of "poor". These were all low elevation sites draining pastoral (six sites) or urban catchments (three sites). Eight of the 10 RSoE sites with a soft sediment substrate were in this grade; these sites typically had lower mean MCI scores than sites with hard sediment substrates (Figure 3.11). The only hard-bottomed site to score an MCI grade of poor was the Parkvale Stream at Weir (mean MCI 73). The site with the lowest mean MCI score was the Whangaehu River 250 m from its confluence with the Ruamahanga River (61, Figure 3.12).

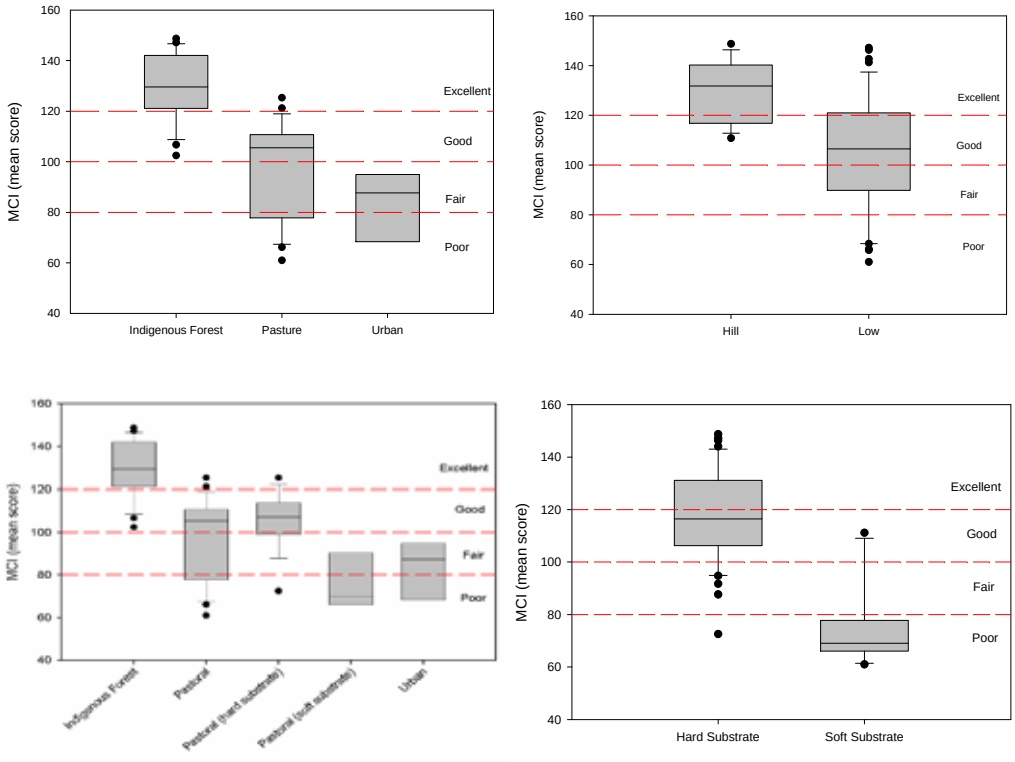

Figure 3.11: Mean MCI scores across the three main land cover classes and the two source of flow classes represented in the RSoE monitoring site network, 2004-2006 data

- - - - - MCI thresholds (Stark and Maxted 2007)

Overall, the highest MCI scores were clearly found at RSoE sites in catchments dominated by indigenous forest land cover, with the lowest MCI scores found in urban catchments and sites with soft substrates (Figure 3.11). Sites with hill sources of flow tended to also have higher MCI scores than those at low elevation.

Figure 3.12: The lower Whangaehu River recorded the lowest mean MCI score of all RSoE sites

4. Discussion

In this section the relationship between physico-chemical and microbiological water quality and biological data is examined, along with spatial patterns in water quality and biological indicators. The WQI and MCI grades presented in Section 3 are then compared against those determined by Milne and Perrie (2005) for the 1997-2003 period. Finally, the WQI and MCI grades are assessed against the management objectives of the RPS and RFP.

4.1 Correlations between water quality and biological data

Even with the inclusion of a microbiological variable in the WQI (i.e., unrelated to macroinvertebrate health), there was a reasonable correlation between RSoE sites ranked by WQI grades and sites ranked by mean MCI scores. The sites with the highest WQI rankings generally had the highest mean MCI scores while sites with the lowest WQI rankings generally had the lowest MCI scores (Figure 4.1).

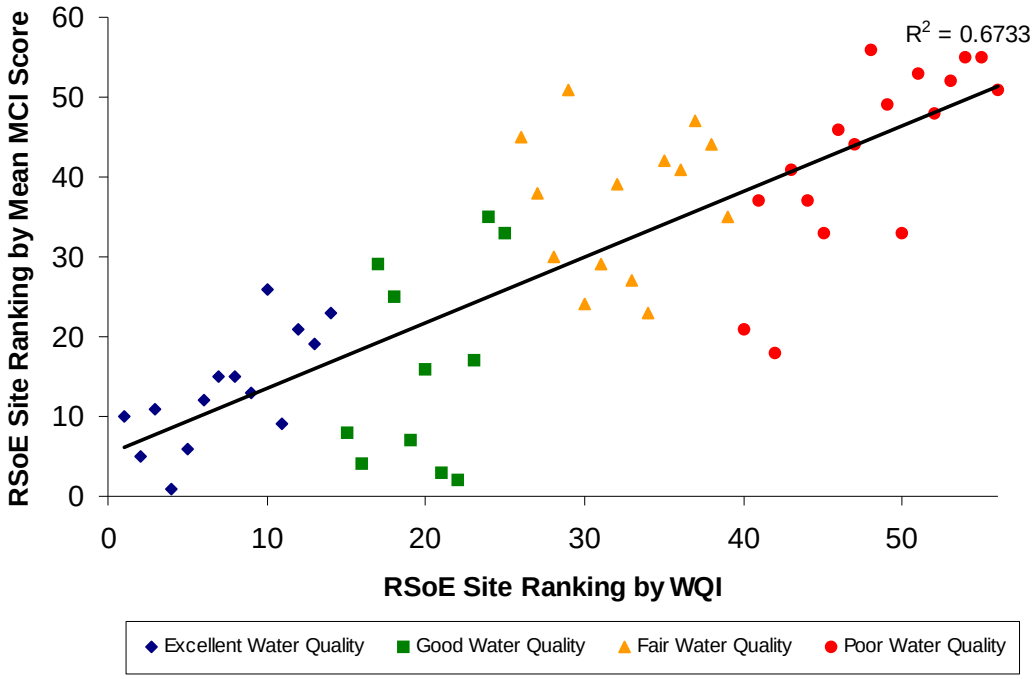

Figure 4.1: RSoE sites ranked from highest to lowest physico-chemical and microbiological water quality (based on the WQI) and mean MCI scores

There was a lack of agreement between water quality and macroinvertebrate grades at some sites. For example, two sites with poor WQI grades had excellent MCI grades (albeit only just within the excellent threshold) and three of the top five ranking sites by MCI grade only scored a WQI grade of good.

Overall, mean MCI grades tend to portray RSoE sites more favourably than WQI grades; around 70 % of all sites scored either good or excellent MCI grades, compared with only 45 % of sites based on WQI grades (Table 4.1). Half of the RSoE sites fell into the same MCI and WQI grade, while the majority of the remainder (25 of 28) had an MCI grade one higher than their

respective WQI grade. This suggests that the WQI may be overly stringent, or, more likely, that some other factor – probably habitat quality – is more strongly influencing the instream macroinvertebrate community.

Table 4.1: Allocation of grades for RSoE sites by mean MCI and WQI

Grade/quality classification	MCI	WQI
Excellent	21	14
Good	18	11
Fair	8	13
Poor	9	18

Links between water quality and periphyton were not overly clear. Exceedance of both periphyton biomass and stream bed cover guidelines were not limited to RSoE sites with poor or fair WQI grades; sites with good or very good WQI grades also exceeded periphyton guidelines at times. However, RSoE sites with fair or poor water quality tended to exceed guidelines more regularly over the reporting period (e.g., the Taueru River at Gladstone), and all but one of the nine hard-bottomed sites with a poor WQI grade exceeded guidelines for stream bed cover and/or biomass.

As with water quality, periphyton guidelines were exceeded at RSoE sites with varying MCI grades. However, the only hard-bottomed site to score an MCI grade of poor, the Parkvale Stream at Weir, regularly exceeded both stream bed cover and biomass guidelines over the reporting period.

4.2 Spatial patterns

Both WQI and MCI grades for the 2003 to 2006 reporting period show a strong pattern in relation to land cover (Figure 4.2). Water quality and MCI scores are highest at sites located on hill-fed river and stream reaches with hard sedimentary geology and unmodified indigenous forest cover in their upstream catchment. These sites tend to be associated with the Tararua, Rimutaka, and Aorangi Ranges. Water quality is poorer in lowland reaches of small streams draining pastoral catchments, and is particularly poor at some sites draining dairy catchments. Catchments dominated by urban land cover tend to have the poorest water quality in the region. Soft sedimentary geology is another common characteristic of RSoE sites with poor water quality.

The spatial patterns reported here are consistent with previously reported results at both a regional (e.g., Milne and Perrie 2005) and 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 (Milne and Perrie 2005) 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 RSoE network (i.e., the majority of RSoE sites are in the same climate class under the REC system, refer Appendix 4).

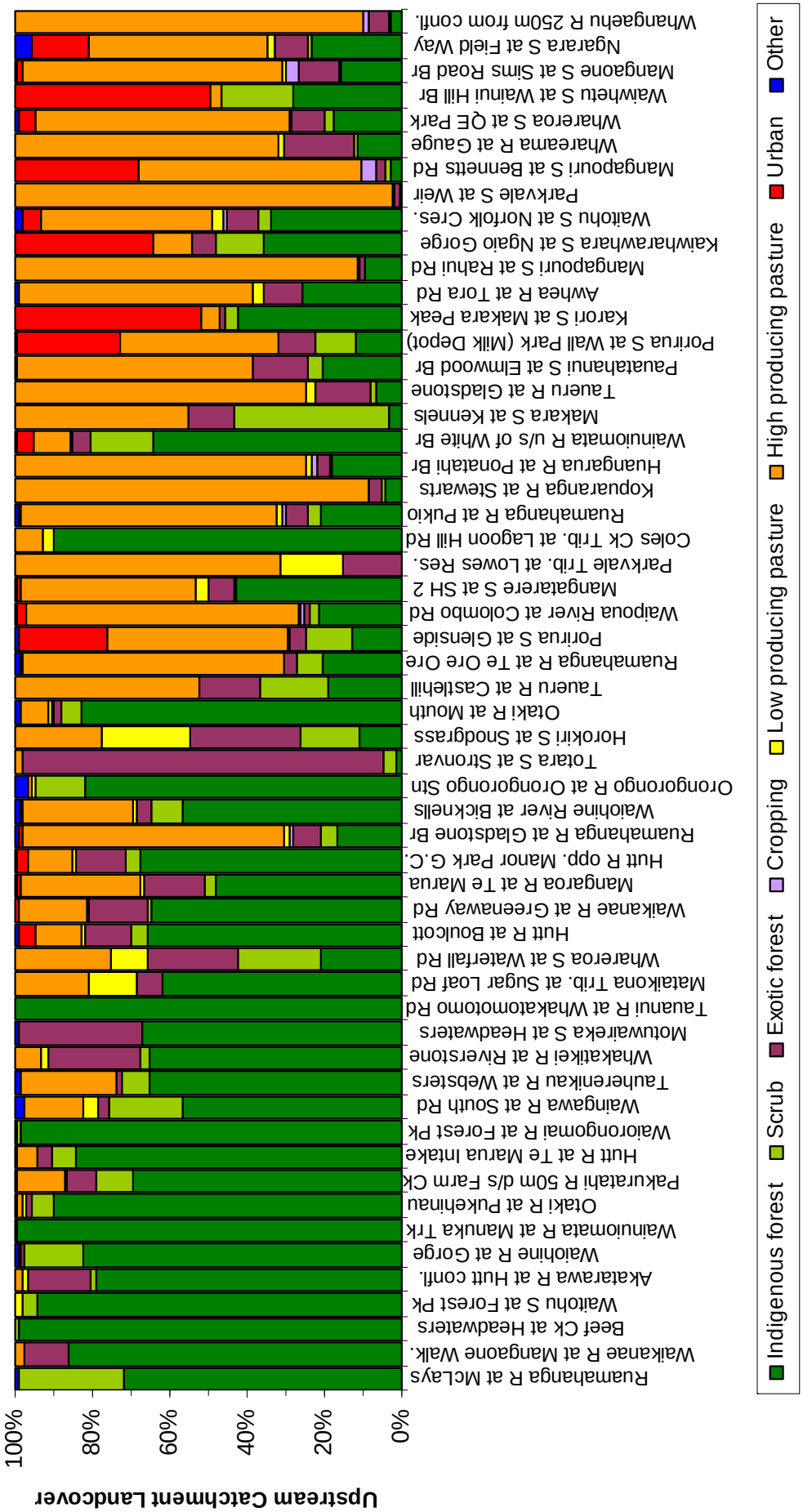

Figure 4.3: RSoE sites ranked from highest (left) to lowest, based on mean MCI scores and key land cover classes in the upstream catchment area, as derived from the Landcover Database (MfE 2001)

The link between land cover and both periphyton cover and biomass is less clear. However, RSoE sites on low elevation river or stream reaches draining pastoral land uses did tend to exceed guidelines more regularly.

4.3 WQI and MCI grades for 2003-2006 compared with 1997-2003

4.3.1 Water quality

Thirty-two of the 56 sites currently monitored in the RSoE programme were assigned WQI grades by Milne and Perrie (2005) based on data collected over the period July 1997 to July 2003 inclusive. Despite slight differences in the application of the WQI used by Milne and Perrie (2005) and the one used in this report (refer Section 3.1.1), 19 of these 32 sites retained the same WQI grade. Seven of these 19 sites had slight changes in the guideline variables that they did or did not comply with between the two reporting periods but this did not influence their overall WQI grade.

Of the 13 sites that recorded a different WQI grade between the two reporting periods, only two showed an improvement; the Hutt River opposite Manor Park (good to excellent) and the Wainuiomata River upstream of White Bridge (poor to fair). The change in grade for Manor Park does not represent a true improvement in water quality; it is a product of a change in the WQI bacteriological indicator from faecal coliforms to *E. coli*. Had the median faecal coliform value been used, Manor Park would have retained its grade of good (refer Table 3.2, Section 3.1). In contrast, the change in WQI grade for the Wainuiomata River upstream of White Bridge – reflecting a reduction in median *E. coli* and nitrite-nitrate nitrogen concentrations – probably does represent an improvement in water quality between the two reporting periods. This site was affected by the Wainuiomata Wastewater Treatment Plant (WWTP) discharge up until November 2001 (Milne and Perrie 2005).

Eleven RSoE sites were assigned lower WQI grades than those assigned by Milne and Perrie (2005). These sites typically dropped by one WQI grade (e.g., from good to fair), except the Huangarua River at Ponatahi Bridge which dropped two grades (from excellent to fair). The allocation of lower WQI grades for the 2003-2006 reporting period was mostly a result of sites exceeding guidelines for visual clarity (eight sites) or dissolved reactive phosphorus (five sites).

The number of RSoE sites that exceeded visual clarity and dissolved reactive phosphorus guidelines over 2003-2006 compared with the 1997-2003 reporting period is of some concern and may indicate a decline in water quality. However, it may also simply reflect changes in RSoE sampling and analysis. This is discussed further below.

(a) Visual clarity

Eight RSoE sites have lower WQI grades for the 2003-2006 reporting period due to their median visual clarity value failing to meet the MfE (1994) guideline of 1.6 m. Multiple changes in sampling personnel over the 2003-2006 reporting period may have had some influence on the consistency of

visual clarity measurements and so may be partly responsible for the observed decline in visual clarity between the two reporting periods[6]. To investigate this possibility further, the eight sites were examined for differences in median turbidity values between 1997-2003 and 2003-2006 (Table 4.2). Turbidity is closely related to visual clarity but is determined by laboratory measurement in the RSoE programme, meaning that it effectively provides an independent check on the visual clarity measurement recorded in the field.

Table 4.2: Median visual clarity and turbidity values for the eight RSoE sites that scored lower WQI grades over 2003-2006 compared with 1997-2003

Site No.	Site Name	Visual clarity (m)				Turbidity (NTU)			
		1997-2003	n	2003-2006	n	1997-2003	n	2003-2006	n
RS05	Otaki R at Pukehinau	2.47	72	1.53	36	1.9	72	2.4	36
RS06	Otaki R at Mouth	2.12	72	1.40	36	2.9	72	2.4	36
RS14	Pauatahanui S at Elmwood Br	1.94	70	1.36	36	2.7	73	3	36
RS15	Porirua S at Glenside	1.92	73	1.38	36	2.1	73	2.9	36
RS16	Porirua S at Wall Park	1.75	73	1.09	36	2.9	73	4	36
RS30	Orongorongo R at Orong.Stn	2.94	73	1.20	36	1.5	73	7.2	36
RS48	Waiohine R at Bicknells	1.64	74	0.88	36	1.6	74	4.7	36
RS51	Huangarua R at Ponatahi Br	2.48	74	1.21	36	0.7	74	5.5	36

Table 4.2 indicates that median turbidity increased between the two reporting periods at all of the sites except the Otaki River at Mouth. Statistical tests (Mann-Whitney) performed on the raw data showed significant differences ($p<0.05$) between median visual clarity values for the two reporting periods at all sites except the Otaki River at Pukehinau and the Otaki River at Mouth. Significant differences in median turbidity values were also evident for the Porirua Stream at Glenside Overhead Cable, Orongorongo River at Orongorongo Station, Waiohine River at Bicknells, and Huangarua River at Ponatahi Bridge (Appendix 6).

Visual clarity and turbidity are often closely correlated with river flow, meaning that 'raw' measurements should take flow into consideration to determine any true underlying trend[7]. Unfortunately, with river flow data only available for two of the eight sites listed in Table 4.2 (the Otaki River at Pukehinau[8] and Pauatahanui Stream at Elmwood Bridge[9]), it was not possible to thoroughly evaluate the effects of flow on visual clarity and turbidity measurements at all sites. However, as an indication of likely conditions at the time of sampling, flow and rainfall records from other locations within the catchments were examined for the other sites in Table 4.2.

[6] Declining visual clarity was not limited to just eight sites; around 70 % of the 32 RSoE sites monitored over both reporting periods recorded a median visual clarity value at least 10 % less than the median value reported by Milne and Perrie (2005).

[7] Flow adjustment is a statistical technique that allows the user to relate river or stream flow to various constituents and to remove flow effects prior to further statistical analysis. For water quality variables which are closely related to flow (such as turbidity), an apparent trend in quality could be caused by a change in flow. By flow adjusting before trend analysis, the user can remove flow effects and determine the magnitude and statistical significance of trends which are not explained by flow.

[8] River flow monitoring site operated by NIWA

[9] Stream flow monitoring site 'Pauatahanui Stream at Gorge' operated by NIWA

All of the sites listed in Table 4.2 show a positive correlation between (estimated) flow at time of sampling, or 24-hour rainfall total prior to sampling, and turbidity, and a negative correlation with visual clarity. The relationship is clearest for the two sites where stream flow is monitored at the sampling site (Otaki River at Pukehinau (Figure 4.4) and Pauatahanui Stream at Elmwood Bridge).

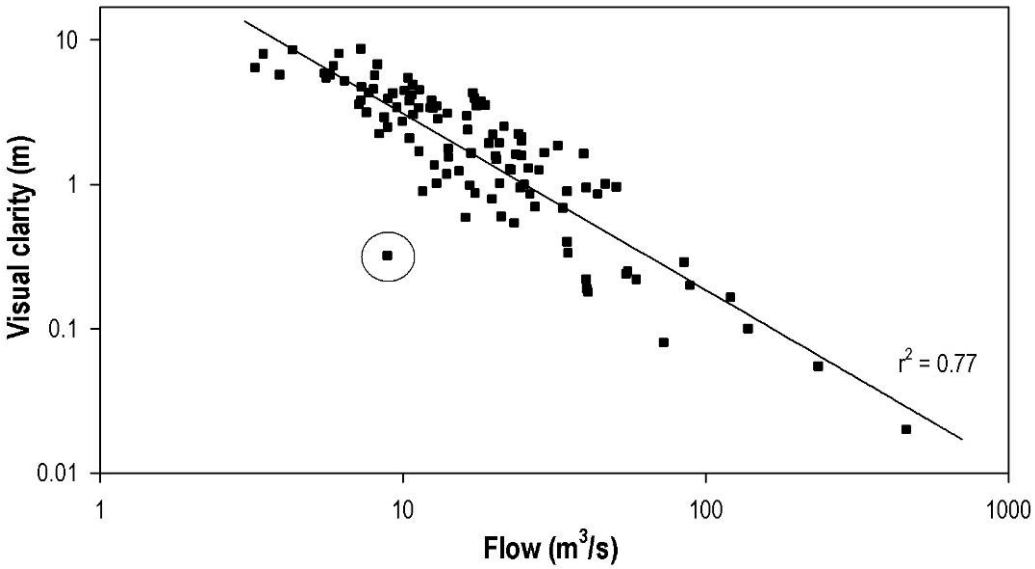

Figure 4.4: Correlation between river flow at time of sampling and visual clarity measured in the Otaki River at Pukehinau, 1997-2006. The outlier circled was when low clarity was observed shortly after a flood in the Otaki River. Note the logarithmic scale on both axes.

The relationships above suggest that the observed decline in visual clarity in the 2003-2006 sampling period, compared to the 1997-2003 sampling period, may be largely due to more sampling events in the latter period coinciding with rainfall and elevated stream flows. To further test this assumption, the 1997-2003 and 2003-2006 periods were compared in terms of the flow during each sampling occasion (at the nearest flow monitoring site) and rainfall in the 24 hours prior to sampling. For all sites in Table 4.2 the median of all flows recorded at the time of sampling was higher for 2003-2006 than 1997-2003 (Table 4.3). In addition, at all sites the proportion of samples that were taken following 'significant'[10] rainfall in the 24 hours before sampling increased between the two periods, and at most sites the proportion of 'dry weather'[11] samples decreased. The Waiohine River at Bicknells appears to be particularly significant, with 22% of samples in the 2003-2006 sampling period taken following significant rainfall compared to 7% of samples in 1997-2003. It also appears that, as well as median flow at time of sampling increasing between the two periods, the number of 'high-flow' samples increased (e.g., Figure 4.5). This, along with the finding that turbidity and clarity tend to correlate well with flow/rainfall, confirms that the observed decrease in clarity between the 1997-2003 and 2003-2006 sampling periods is likely to be a function of the latter period having a greater proportion of samples influenced by wet weather.

[10] Significant rainfall in 24 hours was arbitrarily assigned as 20 mm in the Otaki, Orongorongo and Waiohine catchments, and 15 mm in the Porirua, Pauatahanui and Huangarua catchments

[11] Defined for the purposes of this analysis as less than 1 mm of rainfall in the 24 hours prior to sampling

Table 4.3: Flow (median of all sampling occasions) and proportion of samples taken during dry weather and following significant rainfall, for the 1997-2003 and 2003-2006 sampling periods, at the eight sites from Table 4.2

Sampling site	Median flow at time of sampling (m^3/s)		% of dry weather samples		% of samples following significant rainfall	
	1997-2003	2003-2006	1997-2003	2003-2006	1997-2003	2003-2006
Otaki R at Pukehinau & Otaki R at Mouth*	14.7	19.2	53	41	7	11
Pauatahanui S at Elmwood Br^	0.32	0.44	73	67	4	11
Porirua S at Glenside OC & Porirua S at Wall Park#	0.30	0.53	73	76	6	8
Orongorongo R at Orongo. Station§	0.10	0.19	62	43	10	14
Waiohine R at Bicknells‡	10.4	13.7	53	33	7	22
Huangarua R at Ponatahi Br†	0.21	0.32	65	71	3	9

*Flow data from Otaki River at Pukehinau (NIWA), rainfall data from Taungata in Otaki catchment

^Flow data from Pauatahanui Stream at Gorge (NIWA), rainfall data from Seton Nossiter Park in Porirua catchment

#Flow data from downstream at Porirua Stream at Town Centre, rainfall data from Seton Nossiter Park in Porirua catchment

§Flow data from upstream at Orongorongo River at UDS, rainfall data from Orongo Swap in Orongorongo catchment

‡Flow data from upstream at Waiohine River at Gorge, rainfall data from Carkeek in Waiohine catchment

†Flow and rainfall data from upstream at Ruakokoputuna River at Iraia (NIWA)

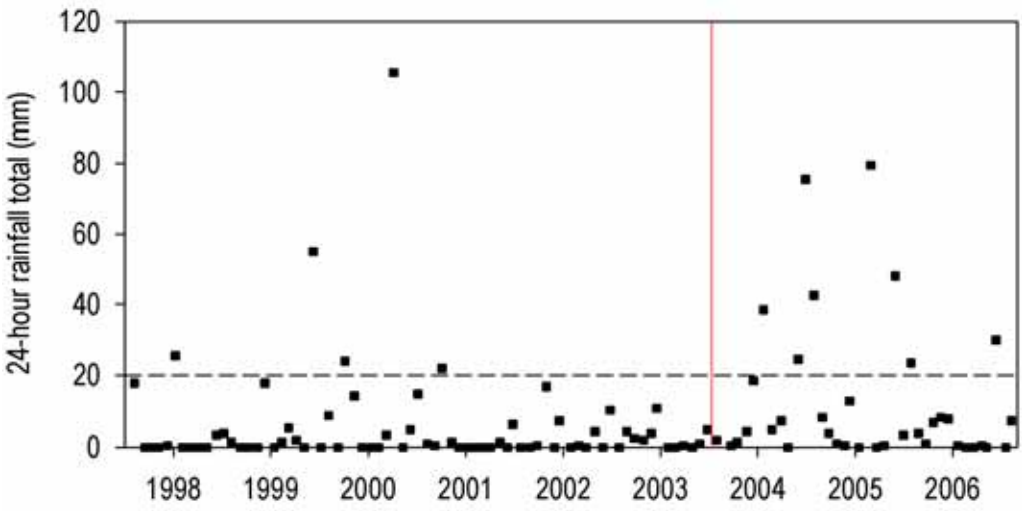

Figure 4.5: Rainfall in the Waiohine catchment (at "Carkeek") in the 24 hours prior to sampling the Waiohine River at Bicknells. The red line separates the 1997-2003 and 2003-2006 sampling periods. Note the higher number of samples with significant rainfall (e.g., greater than 20 mm) in the 2003-2006 sampling period.

Note that the relationship between visual clarity (or turbidity) and flow (or rainfall) is not so clear for the two Porirua Stream sampling sites. It is possible that factors other than rainfall and its resulting runoff are affecting visual clarity and turbidity in the Porirua Stream. This should be investigated further.

(b) Dissolved reactive phosphorus

Water quality index grades were lower at five sites for 2003-2006 compared with 1997-2003 because the median dissolved reactive phosphorus concentration exceeded the ANZECC (2000) trigger value. In addition, a number of other sites recorded higher median concentrations over the 2003-2006 reporting period. Although increasing phosphorus concentrations can not be ruled out without trend analysis (outside the scope of this report), the raw data clearly suggests that the observed increases in median concentrations are a result of changes in analytical methods that occurred during the two reporting periods (detailed in Appendix 2, illustrated in Figure 4.6).

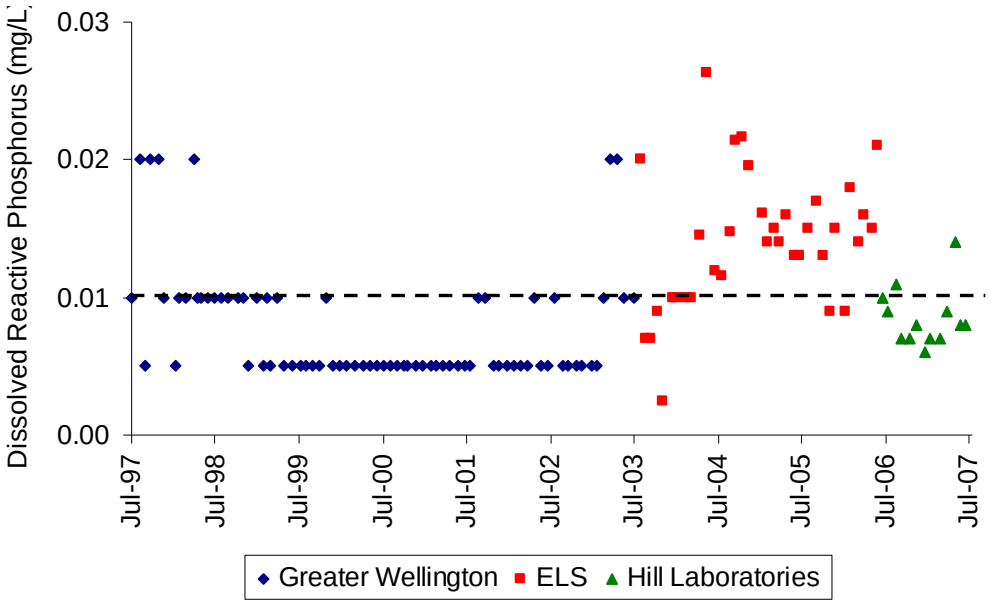

Figure 4.6: Dissolved reactive phosphorus concentrations recorded in the Wainuiomata River at Manuka Track over July 1997 to July 2007, along with the laboratories used for analysis (changes in analytical methods occurred in September 2003 and in July 2006)

---- ANZECC (2000) lowland trigger value

As noted in Section 3.1.12, five reference sites dominated by indigenous forest land cover (86% cover or greater) exceeded the dissolved reactive phosphorus trigger value of 0.01 mg/L (median concentration). This was a surprising result, but one with no real bearing on water quality; these sites all scored an MCI grade of excellent, confirming they are indeed pristine sites. Looking at Figure 4.6, it is clear that the observed changes in median concentrations are being influenced by the analytical method used; a check of the results in the last few months of the reporting period, following another change in analytical laboratory, shows that dissolved reactive phosphorus concentrations at "pristine" sites such as the upper Wainuiomata River now comply with the ANZECC (2000) trigger value. Clearly it is difficult to accurately assess both state and trends in the region's water quality when the analytical laboratories and/or methods are regularly changing.

4.3.2 Macroinvertebrates

Milne and Perrie (2005) reported on macroinvertebrate health at 27 of the current RSoE sites (using 1999-2003 data). Of these sites, 17 scored the same MCI grade/quality classification, while eight sites received higher grades and two sites received lower grades.

Six of the eight sites that improved did so by one grade (i.e., from fair to good) while two sites improved by two grades (i.e., from fair to excellent). The mean MCI values recorded at sites that improved by one grade were typically within the 'fuzzy' error region for interpreting grades (Stark and Maxted 2007) and so may not indicate actual improvements in macroinvertebrate health. However, the improvement by two grades for the Mangaroa River at Te Marua (from fair to excellent) and the Wainuiomata River upstream of White Bridge (from poor to good), more likely reflect actual improvements in the macroinvertebrate health. Both of these sites were affected by point source wastewater discharges during part of the 1997-2003 reporting period (Milne and Perrie 2005).

The two RSoE sites with lower MCI grades than for the 1997-2003 reporting period were the Orongorongo River at Orongorongo Station and the lower Whangaehu River. For the Orongorongo River site, the change of grade is within the error region for MCI grade threshold interpretation and so may not represent an actual decline in the macroinvertebrate community. Due to changes in both sampling and MCI calculation methodology[12], MCI results for the Whangaehu River site are not comparable between the two reporting periods.

4.4 RPS and RFP management requirements

Greater Wellington has set out how it will manage freshwater quality in its RPS (Wellington Regional Council 1995) and the RFP (Wellington Regional Council 1999). The purposes for which various water bodies are to be managed are set out in Policies 5.2.1-5.2.5 and 5.2.9 of RFP. This section looks at RSoE sites located on reaches of waterbodies managed for natural state, fisheries and fish spawning, or enhancement of aquatic ecosystem health or fish habitat and spawning (Figure 4.7). River or stream reaches that are to be enhanced for contact recreation purposes are not shown here. As noted in Section 3.1.1, Greater Wellington has a separate recreational water quality monitoring programme (refer Milne 2007).

[12] In Milne and Perrie (2005) macroinvertebrate data for the Whangaehu River 250 m upstream of confluence was collected using macroinvertebrate protocol C1, but from 2004 it was collected using protocol C2 (Stark et al. 2001). In addition, the MCI scores calculated in this report for this site used soft bottomed tolerance values, while Milne and Perrie (2005) used hard-bottomed values.

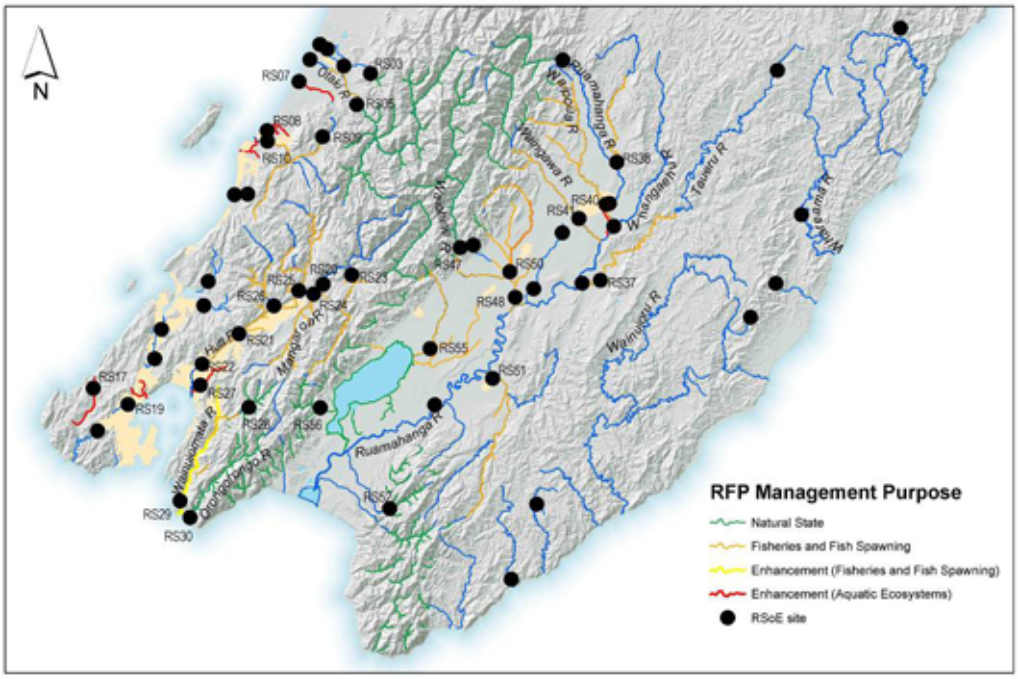

Figure 4.7: RSoE sites and river and stream reaches (or catchments) managed for natural state, fisheries or fish spawning, and enhancement, in accordance with the Regional Freshwater Plan

Note: Policy 5.2.6 of the RFP requires all rivers and streams – except those identified as requiring enhancement – to be managed for aquatic ecosystem health as a minimum

4.4.1 Natural state

Seven of the 56 RSoE sites monitored over 2003-2006 are located on river or stream reaches listed in Policy 5.2.1 of the RFP requiring water quality to be managed in its natural state. These monitoring sites and their associated WQI and macroinvertebrate grades are summarised in Table 4.3.

Table 4.3: WQI and MCI grades for RSoE sites located on river and stream reaches where water quality is to be managed in its natural state, based on selected data from Tables 3.3 and 3.8 in Section 3

Site No.	Site Name	WQI Grade (Rank)	MCI Grade (Rank)
RS03	Waitohu St at Forest Park	Good (16)	Excellent (4)
RS05	Otaki R at Pukehinau	Good (15)	Excellent (8)
RS28	Wainuiomata R at Manuka Track	Good (19)	Excellent (7)
RS30	Orongorongo R at Orongorongo Stn	Good (18)	Good (25)
RS47	Waiohine R at Gorge	Excellent (5)	Excellent (6)
RS52	Tauanui R at Whakatomotomo Rd	Good (20)	Excellent (16)
RS56	Waiorongomai R at Forest Park	Excellent (3)	Excellent (11)

Only two sites received an excellent WQI grade, with the other five sites being graded good as a result of either the median dissolved reactive phosphorous concentration (three sites) or visual clarity value (two sites) exceeding the WQI criteria. However, as discussed in Section 4.3.1, this does not appear to indicate water quality is degraded, particularly given that six of the seven sites scored an excellent MCI grade. In addition, none of the sites exceeded any of

the periphyton biomass guidelines (the Wairongomai River at Forest Park did exceed the stream bed cover guideline for filamentous periphyton on several occasions, probably a result of low flows observed at this site).

The good-excellent WQI and MCI grades for the seven sites reflects the fact that they are located in the Tararua, Rimutaka and Aorangi Ranges and therefore have their upstream catchments in unmodified indigenous forest cover.

4.4.2 Fisheries and fish spawning

Twenty RSoE sites monitored over the reporting period are located on river and stream reaches listed in Policy 5.2.3 of the RFP as areas where water quality is to be managed for trout fisheries and spawning. These monitoring sites are listed in Table 4.4, along with their associated WQI and MCI grades and summary details of selected variables considered to influence trout; ammoniacal nitrogen, water temperature and periphyton. There are many other variables that can influence trout populations (e.g., habitat quality) but they are not currently assessed under the RSoE monitoring programme.

The majority (14) of the 20 sites had good or excellent water quality, based on the WQI. Generally sites with good or excellent water quality also received similar MCI grades. Six sites had WQI grades of fair or poor: the Mangaroa River at Te Marua, Taueru River at Gladstone, Kopuaranga River at Stewarts, Waiohine River at Bicknells, Mangatarere Stream at State Highway 2, and the Huangarua River at Ponatahi Bridge. These six sites typically recorded a greater number of exceedances of guidelines, including guidelines for ammoniacal nitrogen and other dissolved nutrients. Generally the poor or fair water quality at these sites was not reflected in the MCI grades, with only the Taueru River at Gladstone receiving a grade of fair.

Five of the six sites with poor or fair water quality exceeded the guideline for filamentous periphyton stream bed cover on more than 10 % of sampling occasions. The highest frequency of exceedances occurred in the Taueru River at Gladstone (34.6 %), Kopuaranga River at Stewarts (20.7), and the Huangarua River at Ponatahi Bridge (18.5 %). In addition, the Taueru River and Kopuaranga River sites also exceeded periphyton biomass guidelines in 2005 and 2006.

Water temperature was not one of the six water quality variables encompassed within the WQI but it is very influential on trout populations. Temperatures above 20 ^{o}C were recorded at 10 sites, with three of these sites recording temperatures above this level on greater than 10 % of sampling occasions; the Taueru River at Gladstone, the Waipoua River at Colombo Road and the Tauherenikau River at Websters. On no occasion did the temperatures recorded at these sites exceed the RFP critical threshold of 25^{o}C.

Table 4.4: WQI and MCI grades for RSoE sites located on river and stream reaches where water quality is to be managed for trout fishery and spawning, based on selected data from Tables 3.2, 3.3, 3.5, 3.6 and 3.8 in Section 3

Site No.	Site Name	Water Temperature (˚C)		Ammoniacal Nitrogen (% Results >0.025 mg/L)	Dissolved Oxygen (% Results <80% saturation)	Filamentous Periphyton Cover (% Results >30%)	Periphyton Biomass (AFDM, g/m^2)			WQI Grade (Rank)	MCI Grade (Rank)
		Max	% Results >20 ºC				2004	2005	2006		
RS05	Otaki R at Pukehinau	18.9	0	5.6	0	0	0.29	1.75	1.00	Good (15)	Excellent (8)
RS09	Waikanae R at Mangaone Walk.	15.8	0	5.6	0	0	0.66	1.34	3.24	Good (22)	Excellent (2)
RS10	Waikanae R at Greenaway Rd	19.0	0	2.8	0	0	4.07	2.73	17.35	Excellent (12)	Excellent (21)
RS20	Hutt R at Te Marua Intake	17.0	0	0	0	0	0.57	0.09	2.61	Excellent (1)	Excellent (10)
RS21	Hutt R opp. Manor Park G.C.	20.4	8.3	2.8	0	0	0.53	0.74	10.97	Excellent (14)	Good (22)
RS22	Hutt R at Boulcott	21.2	8.3	2.8	0	0	0.25	1.38	8.68	Excellent (13)	Excellent (19)
RS23	Pakuratahi R 50m d/s Farm Ck	19.7	0	5.6	0	3.0	0.48	0.83	22.12	Excellent (11)	Excellent (9)
RS24	Mangaroa R at Te Marua	19.5	0	8.3	0	12.5	0.33	1.70	17.56	Poor (40)	Excellent (20)
RS25	Akatarawa R u/s Hutt confl.	17.5	0	0	0	0	0.57	0.42	1.93	Excellent (2)	Excellent (5)
RS26	Whakatikei R at Riverstone	16.5	0	5.6	2.9	5.9	0.99	0.43	12.01	Excellent (8)	Excellent (14)
RS37	Taueru R at Gladstone	23.8	11.1	44.4	5.6	34.6	29.62	36.76	48.45	Poor (43)	Fair (41)
RS38	Kopuaranga R at Stewarts	19.5	0	19.4	0	20.7	2.69	36.20	43.48	Poor (44)	Good (37)
RS40	Waipoua R at Colombo Rd Br	22.1	13.9	2.8	0	0	2.25	5.61	20.03	Good (25)	Good (32)
RS41	Waingawa R at South Rd	20.5	2.8	0	0	0	0.99	0.90	2.77	Excellent (6)	Excellent (12)
RS47	Waiohine R at Gorge	16.2	0	2.8	0	0	0.51	1.13	0.77	Excellent (5)	Excellent (6)
RS48	Waiohine R at Bicknells	21.6	2.8	8.3	0	0	0.92	1.15	3.27	Fair (30)	Good (24)
RS50	Mangatarere S at SH 2	20.6	5.6	80.6	0	9.4	11.65	2.27	9.25	Poor (50)	Good (31)
RS51	Huangarua R at Ponatahi Br	20.3	2.8	5.6	2.8	18.5	1.62	30.57	23.85	Fair (27)	Good (38)
RS55	Tauherenikau R at Websters	23.8	13.9	13.9	0	3.4	0.83	0.64	9.67	Excellent (9)	Excellent (13)
RS56	Waiorongomai R at Forest Pk	22.0	2.8	8.3	0	17.1	1.34	1.61	2.64	Excellent (3)	Excellent (11)

The monthly water temperature spot-measurements collected under the RSoE programme provide a conservative picture of the potential extreme elevated temperatures trout and other instream fauna may experience at some sites. Continuous temperature monitoring would be a better indicator of the likely impacts on instream fauna as temperature undergoes large diurnal fluctuations, with warmer and more harmful temperatures generally recorded in the afternoon. Continuous temperature monitoring is currently limited to just a few RSoE sites.

4.4.3 River reaches requiring enhancement

Seven of the 56 RSoE sites monitored over the reported period are located on river or stream reaches listed in the RPS or RFP as areas where water quality is to be enhanced to satisfy aquatic ecosystem or fishery/fish spawning purposes. The state of water quality and macroinvertebrate health at these sites is summarised in Table 4.5. Note that formal assessment of changes in water quality over time typically requires trend analysis on a minimum of five years of data; such analysis was beyond the scope of this report.

Table 4.5: WQI and MCI grades for RSoE sites located on river and stream reaches where water quality is to enhanced, based on selected data from Tables 3.3 and 3.8 in Section 3

Site No.	Site Name	WQI Grade (Rank)	Guideline Compliance (median values)						MCI Grade (Rank)
			DO	Clarity	*E. coli*	NNN	Amm. N	DRP	
Management Purpose: Enhancement for aquatic ecosystem health									
RS07	Mangaone S at Sims Rd Br	Poor (54)	✓	x	x	x	x	x	Poor (54)
RS08	Ngarara S at Field Way	Poor (55)	x	x	x	x	x	x	Poor (55)
RS17	Makara S at Kennels	Fair (36)	✓	x	x	✓	✓	x	Fair (40)
RS19	Kaiwharawhara S at Ngaio G	Fair (37)	✓	✓	x	x	✓	x	Fair (47)
RS27	Waiwhetu St at Wainui Hill Br	Poor (51)	✓	x	x	x	x	x	Poor (53)
RS50	Mangatarere S at SH 2	Poor (50)	✓	x	x	x	x	x	Good (31)
Management Purpose: Enhancement for trout fishery and spawning									
RS29	Wainuiomata R u/s White Br	Fair (31)	✓	x	✓	✓	✓	x	Good (39)

The Wainuiomata River upstream of White Bridge was the only site with an improved WQI grade (from poor to fair) when compared to the grades previously allocated by Milne and Perrie (2005) for the 1997-2003 reporting period. As discussed in Section 4.3.1, improvements in water quality at this site reflect the removal of the Wainuiomata WWTP discharge in November 2001 (Milne and Perrie 2005). Macroinvertebrate health also improved at this site (from poor to good).

Water quality index grades at the other five RSoE remain the same as previously reported by Milne and Perrie (2005), although there were some differences in the variables that sites complied or did not comply with for the two different reporting periods. The Mangatarere Stream at State Highway 2 showed an improvement in MCI grade (from fair to good), although the new grade is within the MCI error threshold and so may not indicate an actual improvement in macroinvertebrate health.

In addition to the river and stream reaches listed in the RPS and RFP as in need of enhancement, Milne and Perrie (2005) identified a further five RSoE sites with poor water quality that are also in need of enhancement. These include the Whangaehu River upstream of confluence, Mangaroa River at Te Marua, Waitohu Stream at Norfolk Crescent, Karori Stream at Makara Peak Mountain Bike Park, and the Porirua Stream at Wall Park. Water quality at these five remains similar to that reported by Milne and Perrie (2005); all sites scored a WQI grade of poor except for the Karori Stream at Makara Peak (fair).

4.5 Synthesis

Microbiological contamination and nutrient enrichment is evident at around half of the 56 RSoE sites monitored over September 2003 to August 2006 inclusive. The poorest water quality was recorded at sites located on small, low elevation stream reaches draining pastoral or urban catchments; sites with these characteristics typically have the lowest WQI and MCI grades of all sites. Sites with a soft sedimentary substrate are also heavily represented in the poorer WQI and MCI grades; however, these sites are also typically situated in low elevation pastoral or urban catchments.

The strong influence of land cover on water quality and ecosystem health is consistent with previous studies of water quality on a regional and national scale. With few point-source discharges remaining in the Wellington region, and a substantial proportion of the region used for agriculture, non-point source pollution is clearly a key contributor to poor water quality in many parts of the region.

Eleven RSoE sites were assigned lower WQI grades than those assigned by Milne and Perrie (2005) for the 1997-2003 reporting period. Analysis of the data suggests that these lower grades largely reflect changes in the RSoE monitoring programme, rather than actual changes in water quality. Multiple changes in sampling personnel are likely to have impacted on the quality of field measurements such as visual clarity (black disc), and varying analytical methods and detection limits have in particular affected compliance with the dissolved reactive phosphorus guideline used in this report. It is difficult to accurately assess spatial and temporal trends in the region's rivers and streams when sampling personnel and analytical methods are regularly changing.

To improve the RSoE programme, the recommendations outlined in Milne and Perrie (2005) should be implemented. These include:

1. Establishing a formal quality assurance programme for the collection, processing and storage of all surface water quality information collected under the RSoE programme;

2. Establishing flow monitoring at or near priority RSoE monitoring sites where flow information is lacking, with provision for continuous measurements of key water quality variables such as dissolved oxygen, pH and water temperature during the summer months;

3. Broadening the scope of physico-chemical water quality analytes to include selected stormwater contaminants (e.g., heavy metals) at RSoE sites draining urban catchments and, for a short fixed period at all RSoE sites, major anions and cations;

4. Developing a fish monitoring programme for implementation at selected RSoE monitoring sites;

5. Investigating the development of region-specific water quality guidelines, using long-term water quality records from appropriate reference sites; and

6. Undertaking targeted catchment water quality monitoring to investigate ongoing poor water quality at selected RSoE sites.

5. Conclusions and recommendations

Physico-chemical and microbiological water quality in rivers and streams across the Wellington region shows a clear spatial pattern related to land cover. Water quality is highest at RSoE sites with catchments dominated by unmodified indigenous forest cover. These sites tend to be associated with the Tararua, Rimutaka and Aorangi Ranges (i.e., have hill elevation source of flows) and include the Wainuiomata River at Manuka Track, Hutt River at Te Marua, Waiohine River at the Gorge, and the Ruamahanga River at McLays.

Water quality is poorer at sites located on smaller, low elevation stream reaches draining pastoral or urban catchments, particularly those characterised by soft sedimentary substrates. The sites with the poorest water quality over the September 2003 to August 2006 reporting period drain either:

- Dairy catchments, such as those on the lower reaches of the Mangaone, and Mangatarere streams, and the Mangaroa, Kopuaranga and Whangaehu rivers; or

- Catchments dominated by urban land cover – in particular, sites on the lower Ngarara, Mangapouri and Waiwhetu streams.

Macroinvertebrate community health exhibited a similar spatial pattern to physico-chemical and microbiological water quality. However, discrepancies between water quality and macroinvertebrate health exist at a number of RSoE sites, with the macroinvertebrate monitoring results often indicating better water quality than the WQI. This suggests that the WQI may be overly stringent, or, more likely, that some other factor such as habitat quality is more strongly influencing the instream macroinvertebrate community.

The influence of land cover on periphyton guideline compliance was less clear, although sites located on low elevation river and stream reaches draining pastoral catchments tended to exceed guidelines more frequently.

The RPS and RFP require some reaches of rivers and streams to be managed for specific purposes, including natural state, fish spawning, or enhancement for aquatic ecosystem health or fish habitat and spawning. Analysis of monitoring data collected from the RSoE monitoring programme over the 2003–2006 reporting period indicates that:

- RSoE sites located on river and stream reaches to be managed in their natural state typically have good water quality and excellent macroinvertebrate community health.

- Fourteen of the 20 RSoE sites on river or stream reaches that are managed for fisheries generally have good or excellent water quality and macroinvertebrate communities. The other six sites have considerably lower water quality: the Mangaroa River at Te Marua, Taueru River at Gladstone, Kopuaranga River at Stewarts, Waiohine at Bicknells, and the Mangatarere Stream at State Highway 2.

- Six of the seven RSoE sites on river or stream reaches in need of enhancement for aquatic ecosystems or trout fishery/spawning purposes showed no improvement in water quality state since the 1997-2003 reporting period. The Wainuiomata River upstream of White Bridge was the one exception, showing improvements in both water quality and macroinvertebrate health following the removal of a municipal wastewater discharge in late 2001.

Eleven RSoE sites were assigned lower WQI grades than those assigned by Milne and Perrie (2005) for the 1997-2003 reporting period. This apparent decline in water quality is largely related to two variables: visual clarity and dissolved reactive phosphorus. In the case of dissolved reactive phosphorus, the observed increases in measured concentrations reflect changes in analytical methods and do not represent an actual decline in water quality. The apparent decline in visual clarity is not as easily explained due to multiple changes in sampling personnel and a lack of data to investigate the influence of rainfall and river flow on water clarity. Although elevated river flows may explain the lower readings recorded at some sites, further investigation is warranted at a few sites, particularly those on the Porirua Stream (Glenside Overhead Cable and Wall Park).

The ability of the RSoE monitoring programme to reliably report on the health of the region's rivers and streams has been limited by a number of factors: multiple sampling personnel used to collect water samples and field data, changes in the analytical laboratories (and the resulting changes in analytical methods and detection limits), and a lack of flow data available for a large proportion of the monitoring sites.

5.1 Recommendations

1. Investigate the apparent decline in visual clarity observed at some RSoE sites, particularly sites on the Porirua Stream.

2. Implement the recommendations listed in Milne and Perrie (2005), in particular those relating to:

    - establishing a formal quality assurance programme;
    - establishing river flow monitoring at priority sites;
    - broadening the scope of physico-chemical analytes;
    - developing a fish monitoring programme;
    - developing region (or catchment) specific water quality guidelines; and
    - undertaking targeted catchment water quality investigations where appropriate.

3. Manage the RSoE monitoring programme so that consistency in sampling personnel and analytical laboratories is maintained.

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Appendix 1: RSoE site details

Site No.	Site Name	Site Coordinates		Substrate (hard or soft bottomed)	REC	Dominant Land Cover Classification	% Land Cover Classes (simplified) in Upstream Catchment (Source: MfE Land Cover Database, v2, 2001)							
		Easting	Northing				Indigenous Forest	Exotic Forest	Scrub	High Prod. Pasture	Low Prod. Pasture	Urban	Cropping	Other
RS01	Mangapouri S at Rahui Rd	2693390	6046615	soft	WD/L/Al/U	Pasture	9.5	1.5	0	88.8	0	0	0.2	0
RS02	Mangapouri S at Bennetts Rd	2690920	6049359	soft	WD/L/Al/P	Urban	2.6	2.5	1.4	58	0	31.7	3.7	0
RS03	Waitohu S at Forest Park	2697610	6045404	hard	CW/H/HS/IF	Indigenous forest	94.4	0	3.6	0	2	0	0	0
RS04	Waitohu S at Norfolk Cres	2689554	6050018	soft	CW/L/HS/P	Pasture	38.7	8.2	3.5	42.8	1.5	3.2	0.8	1.3
RS05	Otaki R at Pukehinau	2695443	6040464	hard	CW/H/HS/IF	Indigenous forest	90.1	1.4	5.6	1.2	1.1	0	0	0.6
RS06	Otaki R at Mouth	2688000	6047600	hard	CW/H/HS/IF	Indigenous forest	82.7	2.1	5.1	7.3	1.1	0.3	0.3	1.3
RS07	Mangaone S at Sims Rd Br	2686260	6044122	soft	WW/L/AL/P	Pasture	17.3	11.1	0.8	64.2	2.3	1.1	2.1	1.1
RS08	Ngarara S at Field Way	2681198	6036335	soft	WW/L/AL/P	Urban	19.6	9.8	1	52.6	2.1	10.3	0	4.6
RS09	Waikanae R at Mangaone Walkway	2689992	6035353	hard	CW/L/HS/IF	Indigenous forest	86.1	11.7	0	2.2	0	0	0	0
RS10	Waikanae R at Greenaway Rd	2681241	6034630	hard	CW/L/HS/P	Indigenous forest	65	15.2	0.9	17.6	0.5	0.8	0	0.1
RS11	Whareroa S at Waterfall Rd	2678093	6026247	hard	WW/L/HS/P	Pasture	20.7	23.4	21.6	24.7	9.6	0	0	0
RS12	Whareroa S at QE Park	2675995	6026115	soft	WW/L/HS/P	Pasture	17.6	8.6	2.3	65.7	0.8	4.2	0	0.9
RS13	Horokiri S at Snodgrass	2671824	6012367	hard	CW/L/HS/P	Pasture	11	28.2	15.5	22.3	22.8	0	0.2	0
RS14	Pauatahanui S at Elmwood Br	2671117	6008497	hard	CW/L/HS/P	Pasture	20.9	14.7	3.9	59.7	0.1	0.4	0	0.2
RS15	Porirua S at Glenside Overhead Cable	2663310	6000077	hard	CW/L/HS/U	Urban	12.2	3.2	12.1	45	0.4	26.5	0	0.7
RS16	Porirua S at Wall Pk (Milk Station)	2664386	6004745	hard	WW/L/HS/U	Urban	11.4	8.9	10.7	40	0.4	28.3	0	0.3
RS17	Makara S at Kennels	2653551	5995347	hard	CW/L/HS/P	Pasture	3.3	8.1	22.3	66	0.1	0.2	0	0
RS18	Karori S at Makara Peak	2654234	5988585	hard	CW/L/HS/U	Urban	42.7	1.7	3.4	5.5	0	46.8	0	0
RS19	Kaiwharawhara S at Ngaio Gorge	2659090	5992789	hard	CW/L/HS/U	Urban	34.5	6.1	12.5	11.1	0	35.6	0	0.2
RS20	Hutt R at Te Marua Water Intake	2690091	6011874	hard	CX/H/HS/IF	Indigenous forest	84.5	3.4	6.2	5.4	0.2	0.1	0	0.2
RS21	Hutt R opp. Manor Park Golf Course	2676700	6004000	hard	CW/H/HS/IF	Indigenous forest	67.6	12.8	3.8	11.3	1	2.9	0	0.6
RS22	Hutt R at Boulcott	2670879	5999200	hard	CW/L/HS/IF	Indigenous forest	65.7	11.9	4.2	12.2	1	4.3	0	0.7
RS23	Pakuratahi R 50m d/s Farm Ck	2694627	6013394	hard	CX/H/HS/IF	Indigenous forest	69.7	8.4	9.4	11.7	0.3	0.1	0	0.4
RS24	Mangaroa R at Te Marua	2688563	6010359	hard	CW/L/HS/P	Pasture	47.9	15.6	2.9	30.7	1.3	1.1	0	0.5
RS25	Akatarawa R u/s Hutt R confl.	2686203	6010900	hard	CW/L/HS/IF	Indigenous forest	79.1	16.1	1.4	1.8	1.6	0	0	0
RS26	Whakatikei R at Riverstone	2682276	6008463	hard	CW/L/HS/S	Indigenous forest	65.1	24	2.4	6.8	1.6	0	0	0
RS27	Waiwhetu S at Wainuiomata Hill Br	2670587	5995855	soft	WW/L/HS/U	Urban	26	0.5	17.8	3.5	0	52.2	0	0
RS28	Wainuiomata R at Manuka Track	2678265	5992349	hard	CW/L/HS/IF	Indigenous forest	98.9	0.7	0	0.3	0.2	0	0	0
RS29	Wainuiomata R u/s of White Br	2667340	5977436	hard	CW/L/HS/IF	Indigenous forest	64.7	4.6	15.8	9.7	0.5	4.4	0	0.3
RS30	Orongorongo R at Orongo. Stn	2668955	5974807	hard	CW/H/HS/IF	Indigenous forest	82.1	0.2	12.7	0.9	0.8	0	0	3.2
RS31	Ruamahanga R at McLays	2728161	6047524	hard	CX/H/HS/S	Indigenous forest	71.8	0	27	0.1	0	0	0	1.1
RS32	Ruamahanga R at Te Ore Ore	2735588	6024740	hard	CW/L/SS/P	Pasture	21.2	3.1	6.8	67.1	0.1	0.3	0.1	1.4
RS33	Ruamahanga R at Gladstone Br	2731225	6012049	hard	CW/L/SS/P	Pasture	16.6	7.4	4.4	67.8	1.6	0.8	0.6	0.9
RS34	Ruamahanga R at Pukio	2707855	5992730	hard	CW/L/SS/P	Pasture	20.7	5.7	3.7	66.2	1.2	0.6	1	0.9
RS35	Mataikona Trib. at Sugar Loaf Rd	2781839	6052625	hard	CW/L/SS/P	Pasture	61.9	6.8	0	19.2	12.1	0	0	0
RS36	Taueru R at Castlehill	2762304	6045917	soft	CW/L/SS/P	Pasture	18.9	15.7	17.8	47.5	0	0	0	0
RS37	Taueru R at Gladstone	2734164	6012538	hard	CD/L/SS/P	Pasture	6.8	14.3	1.2	75.1	2.5	0	0	0.1
RS38	Kopuaranga R at Stewarts	2736773	6031289	hard	CW/L/SS/P	Pasture	4.9	3.5	0.8	90.7	0	0	0	0.1
RS39	Whangaehu R 250 u/s confl.	2736281	6021129	soft	CD/L/SS/P	Pasture	3	5.4	0.2	90.5	0.1	0	0.8	0.1
RS40	Waipoua R at Colombo Rd Br	2735032	6024611	hard	CW/L/HS/P	Pasture	21.4	1.5	2.1	70.5	0.3	2.6	1.1	0.5
RS41	Waingawa R at South Rd	2730731	6022370	hard	CX/H/HS/IF	Indigenous forest	56.5	3	19.1	15.1	3.6	0.2	0.1	2.2
RS42	Whareama R at Gauge	2766097	6022956	soft	WW/L/SS/P	Pasture	11.2	18.3	1.1	68.1	1.2	0	0	0
RS43	Motuwaireka S at Headwaters	2762028	6012031	hard	CW/L/HS/S	Indigenous forest	67.4	31.8	0	0.1	0	0	0	0.8
RS44	Totara S at Stronvar	2758038	6006645	hard	CW/L/HS/EF	Exotic forest	1.5	93.5	3.2	1.8	0	0	0	0
RS45	Parkvale Trib. at Lowes Reserve	2728110	6020073	hard	WD/L/Al/P	Pasture	0	15.1	0	68.5	16.4	0	0	0
RS46	Parkvale S at Weir	2723533	6011190	hard	WD/L/Al/P	Pasture	0.5	1.5	0.2	97.5	0.3	0	0	0.1
RS47	Waiohine R at Gorge	2711907	6017714	hard	CX/H/HS/IF	Indigenous forest	82.4	0.9	15.3	0.2	0.1	0	0	0.9
RS48	Waiohine R at Bicknells	2720633	6009820	hard	CW/H/HS/P	Pasture	54.5	3.6	7.5	31.3	1	0.6	0.3	1.2
RS49	Beef Ck at Headwaters	2713981	6018117	hard	CW/L/HS/S	Indigenous forest	99.2	0.1	0.6	0	0	0	0	0
RS50	Mangatarere S at SH2	2719786	6013880	hard	CW/L/HS/P	Pasture	42.4	6.6	0.3	45.6	3.1	1.6	0	0.3
RS51	Huangarua R at Ponatahi Br	2717030	5996934	hard	CD/L/SS/P	Pasture	18	3.5	0.5	75	1.6	0	1.2	0.1
RS52	Tauanui R at Whakatomotomo Rd	2700674	5976234	hard	CW/H/HS/IF	Indigenous forest	99.8	0	0.2	0	0	0	0	0
RS53	Awhea R at Tora Rd	2719980	5965013	hard	WW/L/SS/P	Pasture	25.6	9.8	0.2	60.4	3.1	0	0	0.9
RS54	Coles Ck Trib. at Lagoon Hill Rd	2724046	5976941	hard	WW/L/SS/S	Indigenous forest	90.1	0	0	7	2.9	0	0	0
RS55	Tauherenikau R at Websters	2707103	6001661	hard	CW/H/HS/IF	Indigenous forest	72.2	1.4	7.5	17.3	0	0	0	1.6
RS56	Waiorongomai R at Forest Park	2689627	5992276	hard	CW/H/HS/IF	Indigenous forest	98.4	0	1.3	0	0.2	0	0	0.1

Appendix 2: Water quality variables and analytical methods

As far as practicable, individual RSoE monitoring sites are sampled at the same time of the month and at the same time of the day throughout the year, with all sites on an individual river or stream sampled on the same day. Water samples (spot samples) are collected in mid stream, on a representative stretch of the stream, usually a run[13]. Over the September 2003 to August 2006 reporting period, water temperature, dissolved oxygen, conductivity, pH, and visual clarity (black disc) measurements were taken in the field. Turbidity, faecal coliforms, *E. coli*, total organic carbon, and nutrients were analysed in the laboratory.

Table A2:1 outlines the key water quality variables monitored in the RSoE monitoring programme over the reporting period. Laboratory analyses were performed by ELS and Hill Laboratories. Table A2:2 lists the analytical methods and detection limits utilised by these two laboratories along with details on field meters. All water samples were transported to the laboratories in chilli bins containing ice. Table A2:3 shows the dissolved reactive phosphorus analytical methods used over the last ten years.

Table A2.1: Key water quality variables monitored in the RSoE monitoring programme over the reporting period (1997-2003)

Water Quality Variable	Explanation/Relevance
Water Temperature	- Indicator of biological activity – temperature affects the functioning of aquatic ecosystems and the physiology of biota, including cell function, enzyme activity, bacteriological reproduction rates, and plant growth rates. - Requirement for aquatic life (e.g., temperatures >20 ^{o}C can stress trout). - Influences dissolved oxygen concentrations (the higher the temperature, the lower the oxygen concentration) and can affect the toxicity of certain pollutants such as ammonia.
Dissolved Oxygen (DO)	- Essential for aquatic life - concentrations less than 5 mg/L adversely affect trout and concentrations of 2-3 mg/L may result in fish kills. - Indicator of organic pollution (e.g., sewage) - DO concentrations are reduced as bacteria require oxygen to break organic matter down. - Indicator of photosynthesis (plant growth).
pH	- Protection of aquatic life - particularly high (alkaline) or low (acidic) pH levels may adversely impact on aquatic biota. Alkaline conditions may also increase the toxicity of certain pollutants such as ammonia. - Indicator of industrial discharges.
Conductivity	- Indicator of total salts/mineral content - the lower the value, the purer the water is. Wastewater/effluents therefore have higher concentrations of minerals than natural water and a large increase in the conductivity in a water body can often be traced back to wastewater discharges.

[13] A run is defined as a place where the water velocity is uniformly moderately-low (e.g., 0.2-0.4 m/s) and the water depth is 0.2-0.6 m.

Table A2.1: *cont*. Key water quality variables monitored in the RSoE monitoring programme over the reporting period (1997-2003)

Water Quality Variable	Explanation/Relevance
Visual Clarity & Turbidity	- Aesthetic appearance. - Aquatic life protection - differences in water clarity affect the ability of sight-feeding predators (e.g., fish, birds) to locate prey and the ability of algae to photosynthesise and hence provide food for animals further up the food chain. - Light availability for excessive plant growth. - Indicator of catchment condition, land use.
Total Organic Carbon	- Indicator of organic carbon content of a water body – provides a quick and convenient way of determining the degree of organic contamination (e.g., as a result of wastewater discharges).
Nutrients - Nitrogen - Phosphorus	- Vital elements for aquatic plant and algal growth – may be limiting factors in plant growth when in short supply but in sufficient quantities they may also promote unsightly algal blooms and nuisance plant growth. Dissolved inorganic nutrient concentrations (ammoniacal nitrogen, nitrite-nitrate nitrogen and dissolved reactive phosphorus) are most relevant for predicting the potential for nuisance plant growth as they are the principal forms available to plants (i.e., soluble). 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. - Nitrate may be harmful to livestock in sufficient concentrations. - Ammoniacal nitrogen is comprised of ammonium (NH_{4+}) and unionised ammonia (NH_3). 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. Ammonia is very soluble in water and can be toxic to aquatic life, especially fish. Toxicity is a function of both temperature and pH, with toxicity increasing with increasing water temperature and alkalinity.
E. coli	- Indicator of pollution with faecal matter, useful for determining the suitability of waters for contact recreation and stock drinking – presence in water may indicate the presence of harmful pathogens that can cause eye, ear, nose and throat infections, skin diseases, and gastrointestinal disorders - a number of parasites and pathogens can also be transmitted by contaminated water to livestock and affect their health. - *E. coli* is the most specific indicator of faecal contamination and is nearly always found in high numbers in the gut of humans and warm blooded animals. *E. coli* is the preferred microbiological indicator for faecal contamination and health effects in fresh waters.

Table A2.2: Laboratory analytical methods and detection limits employed in the RSoE monitoring programme over the September 2003-August 2006 reporting period

Analytical methods September 2003 to June 2006			
Laboratory	Variable	Method	Det. Limit
N/A	Temperature	Field Meter (YSI and TPS WP81 types)	0.01 ºC
N/A	Dissolved Oxygen	Field Meter (YSI type)4500/0G	0.1 mg/L
N/A	Visual Clarity	Black disc	0.01 m
N/A	pH	Field Meter (YSI and TPS WP81 types)	0.01 units
N/A	Conductivity	Field Meter (YSI and TPS WP81 types)	1.0 uS/cm
ELS	Turbidity	APHA 20th ed. Method 2130 B. Las official test 4.1, 5.04	0.01 NTU
ELS	Total Organic Carbon	Total Non-Purgeable Organic Carbon. APHA 20th ed. 5310B,C, ASTM D2579, D4839. LAS official test 5.42	0.1 mg/L
ELS	Ammoniacal Nitrogen	APHA 21st ed. Method 4500 NH3-G. LAS official test 4.5, 5.10	0.01 mg/L
ELS	Nitrite	Flow Injection Autoanalyser following APHA 21 ed. 4500-NO2 B. LAS official test 5.14	0.01 mg/L
ELS	Nitrate	By Calculation - NNN minus Nitrite Nitrogen	0.01 mg/L
ELS	Nitrate + Nitrite Nitrogen	APHA 21st ed. Method 4500-NO3 F. LAS official test 4.4	0.005 mg/L
ELS	Total Kjeldahl Nitrogen	By Calculation -Total Nitrogen minus NNN	0.1 mg/L
ELS	Total Nitrogen	APHA 21st ed. Method 4500-NO3 F.Persulphate digestion follows APHA 20th ed. 4500-N C.	0.05 mg/L
ELS	Total Phosphorus	APHA 21st ed. Mehtod 4500-P F. Persulphate digestion follows APHA 20th ed. 4500-P B	0.005 mg/L
ELS	Dissolved Reactive Phosphorus	APHA 21st Edition Method 4500-P F	0.005 mg/L
Biostandards	Faecal Coliforms	APHA 21st Ed. Method 9222 D	1 cfu/100 mL
Biostandards	*E. coli*	APHA 21st Ed. Method 9222 G	1 cfu/100 mL
Analytical methods July 2006 to August 2006			
Laboratory	Variable	Method	Det. Limit
NA	Temperature	Field Meter - ExStik DO600 (Extech Instruments)	0.1 ºC
NA	Dissolved Oxygen	Field Meter - ExStik DO600 (Extech Instruments)	0.01 mg/L
NA	Visual Clarity	Black disc	0.01 m
NA	pH	Field Meter - ExStik EC500 (Extech Instruments)	0.01 units
NA	Conductivity	Field Meter - ExStik EC500 (Extech Instruments)	0.1 uS/cm
Hills	Turbidity	Analysis using a Hach 2100N, Turbidity meter. APHA 2130 B 20th ed. 1988	0.05 NTU
Hills	Total Organic Carbon	Catalytic oxidation, IR detection, for Total C. Acidification, purging for Total Inorganic C. TOC = TC - TIC. APHA5310 B 20th ed. 1998	0.5 mg/L
Hills	Ammoniacal Nitrogen	Filtered sample. Phenol/hyperclorite colorimetry. Discrete Analyser. (NH4-N = NH4+-N + NH3-N) APHA 4500-NH3 F (modified from manual analysis) 20th ed. 1998	0.001 mg/L
Hills	Nitrite	Automated Azo dye colorimetry, Flow indection analyser. APHA 4500-NO_3^- I (proposed) 20th ed. 1998	0.002 mg/L
Hills	Nitrate	Calculation: (Nitrate-N + Nitrite-N) - Nitrite-N	0.002 mg/L
Hills	Nitrate + Nitrite Nitrogen	Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO_3^- I (Proposed) 20th ed. 1998	0.002 mg/L
Hills	Total Kjeldahl Nitrogen	Kjeldahl digestion, phenol/hyperclorite colorimetry (Discrete Analysis). APHA 4500-Norg B. (modfied) 4500-NH3 F (modified) 20th ed. 1998	0.1 mg/L
Hills	Total Nitrogen	Calculation: TKN + Nitrate-N +Nitrite-N	0.1 mg/L
Hills	Total Phosphorus	Acid/Persulphate Digestion Ascorbic Acid Method APHA 20th Ed. 4500-P E (modified from manual analysis). 20th ed. 1998	0.004 mg/L
Hills	Dissolved Reactive Phosphorus	Filtered Sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 21st ed. 2005	0.004 mg/L
ELS	Faecal Coliforms	APHA 21st Ed. Method 9222 D	1 cfu/100 mL
ELS	*E. coli*	APHA 21st Ed. Method 9222 G	1 cfu/100 mL

Table A2.3: Historical and current laboratory analytical methods and detection limits employed in the RSoE monitoring programme for analysis of dissolved reactive phosphorus (1997-present)

Laboratory	Time Period	Method	Detection Limit (mg/L)
Greater Wellington	1997 - August 2003 (Western Region)	Ion Chromatography APHA 20th Ed. Mehtod 4111oBA	0.01
Wairarapa Laboratory Services	1997 - August 2003 (Eastern Region)	Ascorbic Acid Method, APHA 20th Ed. 4500-P E	0.003
ELS	September 2003 - June 2006	APHA 4500-P F, Wat.Res., 17 (1983)	0.005
Hills	July 2006 - present	Filtered Sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 21st ed. 2005	0.004

Appendix 3: Biological monitoring methods

Periphyton and macroinvertebrates can serve as good indicators of ecological change in freshwater environments. For example, changes in abundance (density) of macroinvertebrates can indicate changes in periphyton productivity, which may be indicative of increased nutrient inputs. Different macroinvertebrate species also have different tolerances to environmental factors such as dissolved oxygen, nutrients and fine sediment, such that the presence or absence of different species in an environment may indicate changes in water quality.

Periphyton

Periphyton assessments are limited to the 46 RSoE sites with hard bottomed substrates (refer Appendix 1).

Monthly assessment of visible stream bed cover

Periphyton cover is determined by estimating the percentage of visible mats (>0.3 cm thick) and filaments (>2 cm long) present on the stream or river bed within a 20 cm diameter metal ring. Ten observations are made across the width of the stream or river, along a transect. If the stream or river is not wide enough for 10 observations, five observations are made across the width of the waterway in two locations at the site. Two transects of five observations (usually to 0.6 m depth) were also used where it was not possible to wade across more than half of the river's width.

Annual assessment of biomass

Quantitative assessments of periphyton chlorophyll *a* concentrations and ash-free dry matter (AFDM) are undertaken annually during summer or early autumn to coincide with macroinvertebrate sampling. Sampling protocols follow quantitative method 1a (QM-1a), as outlined in the *Stream Periphyton Monitoring Manual* (Biggs and Kilroy 2000).

Macroinvertebrates

Three macroinvertebrate samples are collected annually in cobbly riffle areas at or adjacent to each RSoE water sampling site. Sampling is generally undertaken during the summer period or early autumn in water depths within 0.2-0.4 m and velocities between 0.6 and 1.0 m/s. The timing of sampling is determined at random, although no macroinvertebrate sampling is undertaken within two weeks of any flood event.

Samples are collected with the use of a kick-net (250 um mesh size) following Protocol C1 of the national macroinvertebrate sampling protocols (Stark et al. 2001) for the 46 RSoE sites with hard bottom substrate and Protocol C2 for the ten RSoE sites with a soft bottom substrate. Since 2004, all samples have been processed in accordance with protocol P2 (Stark et al. 2001).

Macroinvertebrate indices

Macroinvertebrate "guidelines" as an indicator of macroinvertebrate community health and water quality exist in the form of various biotic indices that have been developed over the last 10 to 20 years. These indices are based on the number, type and

abundance of macroinvertebrate taxa present at a monitoring site (Table A3.1). The most widely known index is the Macroinvertebrate Community Index (MCI).

Table A3.1: Macroinvertebrate indices

Index	Definition	Quality Class
Macroinvertebrate Community Index (MCI)	An index of sensitivity to organic pollution, based on the presence/ absence of macroinvertebrate taxa.	- Excellent: >119 - Good: 100-119 - Fair: 80-99 - Poor: <80 (Source: Stark and Maxted 2007)
Quantitative MCI (QMCI)	Similar to the MCI, but also incorporates the relative abundance of the macroinvertebrate taxa present.	- Excellent: >6 - Good: 5-6 - Fair: 4-5 - Poor: <4 (Source: Stark and Maxted 2007)
% Ephemeroptera, Plecoptera and Trichoptera (EPT) Taxa	The number of pollution-sensitive Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera* (caddisfly) taxa present, expressed as a percentage of total taxa richness. * excludes *Oxyethira* and *Paroxyethira* which are relatively insensitive to pollution	- Very Good: >60 % - Moderate: 10-60 % - Poor: <10 % (Source: Russell Death, Massey University, unpublished data)

MCI values were developed by Stark (1985, 1993, 1998) for assessing organic enrichment of stony or hard-bottomed streams based on sampling macroinvertebrates from riffle (preferably) or run habitats. The MCI relies on prior allocation of scores (between 1 and 10) to freshwater macroinvertebrate taxa (usually genera) based upon their relationship to the degree of organic enrichment. Taxa that are characteristic of un-enriched conditions score more highly than taxa that may be found predominantly in polluted conditions. The MCI is calculated as follows:-

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

where S = the total number of taxa in the sample, and ai is the score for the ith taxon. The MCI ranges from 0 (when no taxa are present) to 200 (when all taxa score 10 points each) although MCI scores < 40 or > 150 are rare.

Appendix 4: River Environment Classification (REC)

Rivers and streams within the Wellington region are diverse and some may have differing water quality simply due to their size, climate and underlying geology rather than due to human-induced impacts. To reduce this bias, comparisons between sites are undertaken with the assistance of the River Environment Classification (REC) system. The REC system characterises river environments at six hierarchical levels, corresponding to a controlling environmental factor (Snelder et al. 2003). The factors, in order from the largest spatial scale to the smallest, are climate, source-of-flow, geology, land cover, network position and valley landform.

The first four REC factors – climate, source-of-flow, geology and land cover – are explained in Table A2.1 a break down of RSoE sites in each REC factor are presented in Table A2.2. In this report analysis focused on land cover and source of flow.

Table A4.1: REC classification levels, classes, mapping characteristics, and criteria used to assign river segments to REC classes

Classification Level and Scale	Classes and Notation	Mapping Characteristics	Class Assignment Criteria
Climate (10^3 – 10^4 km^2)	Warm extremely wet (WX) Warm wet (WW) Warm dry (WD) Cool extremely wet (CX) Cool wet (CW) Cool dry (DC)	Mean annual precipitation, mean annual potential evapotranspiration, mean annual temperature.	*Warm:* mean annual temperature ≥ 12˚C *Cool:* mean annual temperature <12˚C *Extremely wet*: mean annual effective precipitation ≥ 1500 mm *Wet*: mean annual effective precipitation < 1500 mm *Dry:* mean annual effective precipitation ≤ 500 mm
Source of Flow (10^2 – 10^3 km^2)	Mountain (M) Hill (H) Low elevation (L) Lake (Lk)	Catchment rainfall volume in elevation categories, lake influence index.	*M:* >50% annual precipitation volume > 1000 m ASL *H:* 50% precipitation volume 400 to 1000 m ASL *L:* >50% rainfall < 400 m ASL *Lk:* Lake influence index > 0.033
Geology (10 – 10^2 km^2)	Alluvium (Al) Hard sedimentary (HS) Soft sedimentary (SS) Volcanic basic (VB) Volcanic acidic (VA) Plutonic (Pl) Miscellaneous (M)	Proportions of each geological category in section catchment.	Class = spatially dominant geology category unless combined soft sedimentary geological categories exceed 25% of catchment area, in which case class = SS.
Land Cover (10 km^2)	Bare (B) Indigenous forest (IF) Pastoral (P) Tussock (T) Scrub (S) Exotic forest (EF) Wetland (W) Urban (U)	Proportions of each land cover category in section catchment.	Class= spatially dominant land cover category unless pastoral exceeds 25% of catchment area, in which case class = P, or unless urban exceeds 15% of catchment area, in which case class = U.

Source: adapted from Larned et al. (2005).

Table A4.2: Break down of the number of RSoE sites in each REC variable class: geology, land cover, source of flow and climate

REC Variable	No. of RSoE sites
Geology	
AL	6
HS	38
SS	12
Land cover	
EF	1
IF	16
P	27
S	6
U	6
Source of flow	
H	14
L	42
Climate	
CD	3
CW	35
CX	5
WD	4
WW	9

Appendix 5: Macroinvertebrate index scores

Table A5.1: % EPT taxa

Site No.	Site Name	Year									Mean	SD
		2004			2005			2006				
RS01	Mangapouri S at Rahui Rd	0	14	33	7	14	10	0	0	7	9	10.6
RS02	Mangapouri S at Bennetts Rd	27	33	25	0	23	22	8	10	14	18	10.7
RS03	Waitohu S at Forest Pk	75	72	67	71	61	68	59	63	65	67	5.4
RS04	Waitohu S at Norfolk Cres	47	47	50	21	27	25	8	7	9	27	17.3
RS05	Otaki R at Pukehinau	71	78	82	68	56	59	60	67	62	67	8.8
RS06	Otaki R at Mouth	36	38	38	30	42	27	47	42	40	38	6.0
RS07	Mangaone S at Sims Rd Br	0	29	13	17	17	11	17	10	16	14	7.6
RS08	Ngarara S at Field Way	20	0	0	13	11	10	7	6	7	8	6.3
RS09	Waikanae R at Mangaone Walk.	80	63	72	64	71	78	65	59	59	68	7.9
RS10	Waikanae R at Greenaway Rd	44	62	50	37	56	44	47	45	56	49	7.6
RS11	Whareroa S at Waterfall Rd	60	65	45	54	43	46	52	50	52	52	6.9
RS12	Whareroa S at QE Park	11	22	20	14	0	11	8	8	9	12	6.7
RS13	Horokiri S at Snodgrass	62	57	57	55	53	71	38	48	50	55	9.3
RS14	Pauatahanui S at Elmwood Br	13	47	40	39	53	50	26	37	37	38	12.6
RS15	Porirua S at Glenside	56	47	44	56	58	58	32	39	22	46	12.8
RS16	Porirua S at Wall Park (Milk Depot)	45	35	25	54	23	36	38	29	26	35	10.1
RS17	Makara S at Kennels	40	47	44	30	40	33	46	39	40	40	5.5
RS18	Karori S at Makara Peak	18	20	27	46	47	41	26	32	29	32	10.6
RS19	Kaiwharawhara S at Ngaio Gorge	39	32	38	29	32	30	19	33	24	30	6.4
RS20	Hutt R at Te Marua Intake Site	69	79	63	79	53	73	59	55	68	67	9.5
RS21	Hutt R opp. Manor Park G.C.	67	50	54	89	67	60	46	50	38	58	14.9
RS22	Hutt R at Boulcott	44	56	63	36	54	67	53	50	46	52	9.2
RS23	Pakuratahi R 50m d/s Farm Ck	70	69	82	71	58	65	62	63	48	65	9.5
RS24	Mangaroa R at Te Marua	56	54	57	58	62	65	45	48	45	54	7.2
RS25	Akatarawa R at Hutt confl.	71	75	69	61	72	60	61	59	65	66	6.0
RS26	Whakatikei R at Riverstone	52	57	68	68	59	64	50	48	52	58	7.8
RS27	Waiwhetu S at Wainui Hill Br	20	13	17	17	11	0	17	0	0	10	8.2
RS28	Wainuiomata R at Manuka Track	63	72	68	67	58	64	73	62	67	66	4.9
RS29	Wainuiomata R u/s of White Br	35	46	38	50	46	55	41	40	33	43	7.0
RS30	Orongorongo R at Orongo. Stn	43	33	20	38	31	42	45	50	70	41	13.9
RS31	Ruamahanga R at McLays	60	63	64	71	80	67	64	69	69	67	5.9
RS32	Ruamahanga R at Te Ore Ore	42	50	33	33	36	33	36	50	44	40	6.9
RS33	Ruamahanga R at Gladstone Br	58	44	50	33	42	63	63	40	36	48	11.2
RS34	Ruamahanga R at Pukio	33	47	42	38	43	33	33	44	56	41	7.5
RS35	Mataikona Trib at Sugar Loaf Rd	52	60	56	50	52	52	52	48	57	53	3.7
RS36	Taueru R at Castlehill	44	55	57	36	19	17	33	33	29	36	14.2
RS37	Taueru R at Gladstone	53	50	44	50	53	45	47	43	36	47	5.6
RS38	Kopuaranga R at Stewarts	50	44	47	40	42	45	50	50	56	47	4.8
RS39	Whangaehu R 250m u/s confl.	22	25	11	13	8	27	17	17	16	17	6.4
RS40	Waipoua R at Colombo Rd Br	53	50	33	48	50	45	56	47	40	47	6.7
RS41	Waingawa R at South Rd	38	67	20	63	75	67	50	45	57	53	17.2
RS42	Whareama R at Gauge	22	22	25	33	22	13	20	0	25	20	9.3
RS43	Motuwaireka S at Headwaters	60	65	52	56	65	56	54	55	46	57	6.2
RS44	Totara S at Stronvar	53	54	47	59	54	55	41	22	38	47	11.5
RS45	Parkvale Trib at Lowes Res.	38	30	29	43	46	45	41	44	50	41	7.3
RS46	Parkvale S at Weir	8	0	0	45	31	33	25	10	18	19	15.8
RS47	Waiohine R at Gorge	73	76	64	73	80	67	71	86	75	74	6.6
RS48	Waiohine R at Bicknells	54	50	42	46	50	50	36	38	50	46	6.2
RS49	Beef Ck at Headwaters	60	55	68	70	65	75	62	62	61	64	6.1
RS50	Mangatarere S at SH 2	50	50	44	39	39	38	44	43	44	43	4.5
RS51	Huangarua R at Ponatahi Br	36	50	45	25	31	31	45	35	36	37	8.2
RS52	Tauanui R at Whakatomotomo Rd	63	58	62	45	50	57	58	55	59	56	5.7
RS53	Awhea R at Tora Rd	27	43	40	25	25	21	25	21	26	28	7.8
RS54	Coles Ck trib at Lagoon Hill Rd	57	58	46	NS	NS	NS	33	28	25	41	14.5
RS55	Tauherenikau R at Websters	53	60	60	73	57	63	56	50	64	60	6.7
RS56	Waiorongomai R at Forest Pk	55	47	47	69	65	67	68	67	55	60	9.0

Table A5.2: QMCI Scores

Site No.	Site Name	Year									Mean	SD
		2004			2005			2006				
RS01	Mangapouri S at Rahui Rd	4.80	4.46	4.19	4.70	4.83	4.77	4.90	4.85	4.71	4.69	0.23
RS02	Mangapouri S at Bennetts Rd	4.67	4.65	4.69	4.86	4.92	4.93	4.60	4.34	4.53	4.69	0.19
RS03	Waitohu S at Forest Pk	8.02	7.99	7.95	8.43	8.06	8.34	7.89	7.78	7.81	8.03	0.22
RS04	Waitohu S at Norfolk Cres	4.90	4.62	4.43	4.69	4.79	4.37	4.25	4.33	4.66	4.56	0.22
RS05	Otaki R at Pukehinau	6.60	7.44	7.46	7.53	7.52	7.17	7.91	7.87	7.73	7.47	0.40
RS06	Otaki R at Mouth	7.70	7.18	7.85	2.40	2.89	3.06	5.28	5.43	6.34	5.35	2.13
RS07	Mangaone S at Sims Rd Br	4.52	4.80	4.42	4.79	4.43	4.46	4.05	4.41	4.46	4.48	0.22
RS08	Ngarara S at Field Way	4.94	4.65	4.89	4.49	4.40	4.64	3.91	3.88	4.04	4.43	0.40
RS09	Waikanae R at Mangaone Walk.	7.92	8.35	7.53	8.11	7.96	7.98	8.04	7.84	8.00	7.97	0.22
RS10	Waikanae R at Greenaway Rd	7.48	7.19	6.96	7.33	7.12	7.13	3.44	3.61	4.25	6.06	1.73
RS11	Whareroa S at Waterfall Rd	7.96	8.01	8.16	7.52	7.50	7.50	6.87	5.63	7.05	7.36	0.77
RS12	Whareroa S at QE Park	4.48	4.36	4.33	4.17	4.29	4.37	4.38	4.67	4.51	4.39	0.14
RS13	Horokiri S at Snodgrass	6.78	7.01	6.81	6.66	5.52	6.09	5.61	5.04	6.40	6.21	0.69
RS14	Pauatahanui S at Elmwood Br	4.36	4.35	4.34	5.52	5.39	6.07	3.92	4.50	4.03	4.72	0.75
RS15	Porirua S at Glenside	3.56	3.07	3.49	7.21	7.24	7.32	4.48	3.85	3.69	4.88	1.82
RS16	Porirua S at Wall Park (Milk Depot)	3.50	3.03	3.17	7.33	6.30	6.89	3.21	3.29	2.90	4.40	1.85
RS17	Makara S at Kennels	4.51	4.33	4.43	4.36	4.52	4.76	4.73	4.38	4.57	4.51	0.15
RS18	Karori S at Makara Peak	2.89	3.22	3.20	5.22	5.49	5.41	2.65	2.91	2.63	3.74	1.25
RS19	Kaiwharawhara S at Ngaio Gorge	3.82	4.40	4.43	4.14	4.79	4.49	3.28	3.76	3.50	4.07	0.50
RS20	Hutt R at Te Marua Intake Site	7.94	8.30	8.18	7.78	7.16	7.93	7.04	7.47	7.72	7.72	0.43
RS21	Hutt R opp. Manor Park G.C.	7.57	7.58	7.64	8.01	7.73	7.68	5.02	3.50	4.92	6.63	1.67
RS22	Hutt R at Boulcott	7.71	7.67	7.82	6.58	6.73	7.58	5.00	3.93	4.45	6.39	1.53
RS23	Pakuratahi R 50m d/s Farm Ck	7.90	7.94	8.17	8.41	8.31	7.58	6.35	6.80	5.51	7.44	1.00
RS24	Mangaroa R at Te Marua	7.52	7.23	7.57	7.40	7.52	7.51	4.01	4.43	4.72	6.43	1.55
RS25	Akatarawa R at Hutt confl.	8.20	8.03	8.24	8.21	8.09	8.15	7.57	7.44	7.74	7.96	0.30
RS26	Whakatikei R at Riverstone	8.19	7.87	7.80	8.80	8.54	9.18	4.21	4.28	4.57	7.05	2.07
RS27	Waiwhetu S at Wainui Hill Br	4.01	4.24	3.96	4.12	4.25	4.19	3.98	3.92	3.92	4.07	0.14
RS28	Wainuiomata R at Manuka Track	7.81	7.92	7.81	7.35	7.46	7.77	6.84	7.31	7.69	7.55	0.35
RS29	Wainuiomata R u/s of White Br	3.89	4.09	2.92	4.69	5.21	4.60	4.47	4.45	4.34	4.30	0.64
RS30	Orongorongo R at Orongo. Stn	7.78	7.51	5.93	6.19	4.24	6.25	7.16	7.61	6.47	6.57	1.11
RS31	Ruamahanga R at McLays	6.74	6.72	7.01	8.03	7.94	7.92	8.18	8.14	8.00	7.63	0.62
RS32	Ruamahanga R at Te Ore Ore	7.35	7.56	6.43	6.62	5.95	5.75	6.90	6.68	6.99	6.69	0.59
RS33	Ruamahanga R at Gladstone Br	6.84	7.03	6.96	7.21	7.01	7.28	7.65	6.97	6.40	7.04	0.34
RS34	Ruamahanga R at Pukio	6.50	6.12	6.32	6.38	6.59	6.59	6.36	5.82	6.03	6.30	0.26
RS35	Mataikona Trib at Sugar Loaf Rd	7.26	7.62	7.71	6.09	6.91	6.28	6.23	6.51	6.43	6.78	0.62
RS36	Taueru R at Castlehill	6.50	6.21	6.30	4.63	4.65	4.57	5.28	4.93	4.65	5.30	0.81
RS37	Taueru R at Gladstone	5.02	4.97	4.78	4.99	4.78	5.17	4.71	4.77	4.61	4.87	0.18
RS38	Kopuaranga R at Stewarts	6.63	6.41	6.69	4.49	4.06	3.87	6.05	6.23	6.32	5.64	1.15
RS39	Whangaehu R 250m u/s confl.	4.96	4.87	4.64	4.65	4.03	4.18	4.26	3.88	4.18	4.41	0.38
RS40	Waipoua R at Colombo Rd Br	6.96	6.88	7.11	5.67	5.94	6.62	5.03	5.47	5.31	6.11	0.79
RS41	Waingawa R at South Rd	7.43	7.44	7.76	7.84	8.00	7.95	7.20	7.70	7.55	7.65	0.27
RS42	Whareama R at Gauge	4.42	4.48	4.18	4.03	4.01	3.99	4.06	4.04	3.79	4.11	0.22
RS43	Motuwaireka S at Headwaters	8.18	8.14	7.75	5.85	5.61	5.47	6.26	6.89	5.17	6.59	1.19
RS44	Totara S at Stronvar	6.60	6.85	7.07	4.73	4.49	4.65	5.07	4.76	4.74	5.44	1.07
RS45	Parkvale Trib at Lowes Res.	5.49	4.65	4.40	5.34	5.40	5.22	5.69	5.42	5.37	5.22	0.42
RS46	Parkvale S at Weir	3.99	3.91	4.01	4.44	4.84	4.49	3.73	4.01	3.85	4.14	0.36
RS47	Waiohine R at Gorge	7.93	7.80	7.62	7.49	7.53	7.55	7.87	7.65	7.90	7.70	0.17
RS48	Waiohine R at Bicknells	7.39	6.74	7.14	7.24	7.53	7.29	7.84	7.78	7.93	7.43	0.38
RS49	Beef Ck at Headwaters	7.75	8.13	8.17	7.97	7.93	8.16	7.20	7.75	7.14	7.80	0.39
RS50	Mangatarere S at SH 2	5.93	5.72	5.31	6.27	6.80	5.72	4.79	5.23	5.27	5.67	0.61
RS51	Huangarua R at Ponatahi Br	6.11	6.36	6.17	6.23	5.14	5.86	4.31	4.36	4.38	5.43	0.89
RS52	Tauanui R at Whakatomotomo Rd	7.56	7.18	7.49	5.55	4.82	4.52	6.31	5.38	6.18	6.11	1.13
RS53	Awhea R at Tora Rd	7.09	6.42	7.40	6.68	4.89	6.27	4.11	4.22	5.64	5.86	1.21
RS54	Coles Ck trib at Lagoon Hill Rd	6.69	6.79	6.82	NS	NS	NS	3.99	3.38	5.08	5.46	1.53
RS55	Tauherenikau River at Websters	7.53	7.62	6.94	7.76	7.93	7.88	6.48	5.77	6.38	7.14	0.78
RS56	Waiorongomai River at Forest Park	7.35	7.52	7.63	7.85	7.56	7.83	7.45	7.39	7.81	7.60	0.19

Table A5.3: Taxa Richness

Site No.	Site Name	Year									mean	SD
		2004			2005			2006				
RS01	Mangapouri S at Rahui Rd	7	7	6	14	14	21	17	15	15	13	5.1
RS02	Mangapouri S at Bennetts Rd	11	9	8	11	13	9	13	10	14	11	2.1
RS03	Waitohu S at Forest Pk	20	18	18	21	23	25	22	24	20	21	2.5
RS04	Waitohu S at Norfolk Cres	15	15	18	14	11	8	12	14	11	13	2.9
RS05	Otaki R at Pukehinau	7	9	11	19	16	17	15	12	13	13	3.9
RS06	Otaki R at Mouth	11	8	8	10	12	11	15	12	15	11	2.5
RS07	Mangaone S at Sims Rd Br	5	7	8	6	12	9	12	20	19	11	5.4
RS08	Ngarara S at Field Way	5	11	12	8	9	10	15	17	14	11	3.7
RS09	Waikanae R at Mangaone Walk.	20	19	18	22	21	23	26	22	29	22	3.5
RS10	Waikanae R at Greenaway Rd	9	13	12	19	18	25	17	20	18	17	4.8
RS11	Whareroa S at Waterfall Rd	15	17	11	24	23	28	21	30	27	22	6.4
RS12	Whareroa S at QE Park	9	9	10	7	7	9	13	12	11	10	2.1
RS13	Horokiri S at Snodgrass	13	21	14	11	15	14	21	23	18	17	4.2
RS14	Pauatahanui S at Elmwood Br	8	19	20	18	15	16	23	19	19	17	4.2
RS15	Porirua S at Glenside	9	17	16	16	19	19	19	18	18	17	3.2
RS16	Porirua S at Wall Park (Milk Depot)	20	23	16	13	13	11	13	17	19	16	4.0
RS17	Makara S at Kennels	15	15	16	10	15	12	13	18	15	14	2.3
RS18	Karori S at Makara Peak	17	20	22	24	15	17	19	19	14	19	3.2
RS19	Kaiwharawhara S at Ngaio Gorge	23	22	24	21	22	20	16	15	17	20	3.2
RS20	Hutt R at Te Marua Intake Site	13	14	19	14	15	15	22	20	19	17	3.2
RS21	Hutt R opp. Manor Park G.C.	12	12	13	9	15	15	13	16	13	13	2.1
RS22	Hutt R at Boulcott	9	9	8	11	13	9	15	12	13	11	2.4
RS23	Pakuratahi R 50m d/s Farm Ck	10	13	11	17	19	17	21	19	21	16	4.2
RS24	Mangaroa R at Te Marua	16	13	14	19	21	23	22	21	20	19	3.6
RS25	Akatarawa R at Hutt confl.	17	16	13	18	18	15	23	22	23	18	3.6
RS26	Whakatikei R at Riverstone	23	21	19	19	17	14	24	29	27	21	4.8
RS27	Waiwhetu S at Wainui Hill Br	15	16	12	6	9	9	6	7	7	10	3.8
RS28	Wainuiomata R at Manuka Track	27	18	19	21	24	22	26	26	24	23	3.2
RS29	Wainuiomata R u/s of White Br	17	13	13	16	13	11	17	15	15	14	2.1
RS30	Orongorongo R at Orongo. Stn	14	6	5	13	16	12	11	10	10	11	3.6
RS31	Ruamahanga R at McLays	10	8	11	17	10	15	14	13	13	12	2.8
RS32	Ruamahanga R at Te Ore Ore	12	14	12	9	11	12	14	16	16	13	2.3
RS33	Ruamahanga R at Gladstone Br	12	9	8	6	12	8	8	10	11	9	2.1
RS34	Ruamahanga R at Pukio	9	15	12	8	7	6	9	9	9	9	2.7
RS35	Mataikona Trib at Sugar Loaf Rd	23	20	25	24	21	21	21	21	23	22	1.7
RS36	Taueru R at Castlehill	18	20	21	14	16	12	21	15	17	17	3.2
RS37	Taueru R at Gladstone	15	16	18	14	15	20	17	14	14	16	2.1
RS38	Kopuaranga R at Stewarts	22	18	19	15	19	20	20	22	18	19	2.2
RS39	Whangaehu R 250m u/s confl.	9	12	9	8	12	11	23	18	19	13	5.3
RS40	Waipoua R at Colombo Rd Br	19	16	18	21	18	20	18	19	15	18	1.9
RS41	Waingawa R at South Rd	8	9	5	8	8	6	14	11	14	9	3.2
RS42	Whareama R at Gauge	9	9	8	6	9	8	5	8	8	8	1.4
RS43	Motuwaireka S at Headwaters	20	20	21	27	26	25	26	29	24	24	3.2
RS44	Totara S at Stronvar	19	13	17	22	26	20	22	18	21	20	3.7
RS45	Parkvale Trib at Lowes Res.	16	20	14	23	13	11	17	16	16	16	3.6
RS46	Parkvale S at Weir	12	10	7	11	13	12	12	10	11	11	1.8
RS47	Waiohine R at Gorge	15	17	11	11	10	9	14	7	12	12	3.1
RS48	Waiohine R at Bicknells	13	14	12	13	10	8	11	8	8	11	2.4
RS49	Beef Ck at Headwaters	25	22	22	20	20	20	26	21	23	22	2.2
RS50	Mangatarere S at SH 2	18	16	18	18	18	16	16	21	16	17	1.7
RS51	Huangarua R at Ponatahi Br	11	8	11	12	16	13	11	17	14	13	2.8
RS52	Tauanui R at Whakatomotomo Rd	19	26	21	20	20	21	24	22	22	22	2.2
RS53	Awhea R at Tora Rd	15	7	10	16	20	14	16	19	19	15	4.3
RS54	Coles Ck trib at Lagoon Hill Rd	21	19	24	NS	NS	NS	21	25	20	22	2.3
RS55	Tauherenikau River at Websters	17	15	15	11	14	8	16	16	14	14	2.8
RS56	Waiorongomai River at Forest Park	11	17	15	16	17	15	22	18	20	17	3.2

Appendix 6: Mann-Whitney test results

Table A6.1: Tests for difference in median turbidity and visual clarity at eight RSoE sites over two reporting periods – Jul 1997-Jul 2003 vs Sept 2003-Aug 2006

Site No.	Site Name	Visual Clarity			Turbidity		
		U	*p*	Chi-square	U	*p*	Chi-square
RS05	Otaki R at Pukehinau	1560.0	0.085	2.958	1214.5	0.601	0.273
RS05	Otaki R at Pukehinau (flow adjusted)	1833.0	0.000	14.612	2109.0	0.000	32.078
RS06	Otaki R at Mouth	1447.0	0.391	0.734	1368.0	0.728	0.121
RS14	Pauatahanui S at Elmwood Br	1719.5	0.004	8.474	1299.0	0.833	0.044
RS15	Porirua S at Glenside	1804.5	0.003	9.061	992.5	0.031	4.679
RS16	Porirua S at Wall Park (Milk Depot)	1788.0	0.006	7.662	1240.0	0.484	0.489
RS30	Orongorongo R at Orongorongo Stn	1949.0	0.000	14.339	883.5	0.003	8.732
RS48	Waiohine R at Bicknells	1946.5	0.000	15.325	506.0	0.000	27.710
RS51	Huangarua R at Ponatahi Br	1845.0	0.001	10.680	656.5	0.000	18.521