Annual Freshwater Quality Report 2000-2001

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Executive Summary

Introduction

This report presents the results of the baseline freshwater quality monitoring programme for the period March 2000 to June 2001. The Wellington Regional Council monitors water quality at 51 sites in rivers and streams throughout the Region. Water samples are analysed for various physical, chemical and microbiological variables on a monthly basis while macroinvertebrate communities are sampled during summer at 42 sites.

This report provides an assessment of the overall state of the freshwater quality in the Wellington Region and helps to identify trends in water quality and water quality issues. The information contained in the report provides a basis for assessing the effectiveness of the objectives, policies, rules and methods included in the Regional Policy Statement and the Regional Freshwater Plan.

Results

The monitoring results for 2000/2001 show little change from those reported in previous years. The Ngarara, Pauatahanui, Waitohu, Ngauranga, Waiwhetu, Karori and Porirua Streams and the Mangaroa and Wainuiomata Rivers still have the poorest water quality in the Region. These waterbodies are affected by runoff from urban and/or rural areas and generally experience lower flows than other waterbodies.

Sites within or near to forested catchments showed good water quality.

At some sites there are discrepancies between the results of water quality monitoring and the level of pollution implied by the macroinvertebrate community present. These discrepancies may be due to diurnal variation in physical and chemical variables not detected by monthly sampling. In the case of urban streams water quality may be affected by contaminants such as heavy metals not currently measured as part of the freshwater quality monitoring programme.

The Wellington Regional Council has recently deployed continuous monitoring equipment at some of these sites to investigate diurnal changes in water quality. An investigation of Wellington City stormwater discharges is also underway and aims to increase our understanding of the effects of urban runoff on water bodies in this area.

The Regional Freshwater Plan identifies a number of rivers and streams as requiring enhancement in order to be suitable for sustaining aquatic ecosystems. These are the Ngarara, Waiwhetu, Ngauranga and Makara Streams and the Wainuiomata River. None of these rivers have shown any significant improvement in water quality in recent years.

The Wellington Regional Council has implemented a number of initiatives with the aim of enhancing water quality in these and other streams in the region. These include riparian restoration trials, the *Take Charge* industrial pollution prevention programme and a Region wide investigation of stormwater discharge impacts on surface water quality. As the lessons learnt from these projects are implemented we anticipate that water quality in the rivers identified in the Regional Plan and in rivers throughout the Region will improve.

Recommendations

The report includes some general recommendations which will assist the freshwater quality monitoring programme in providing a greater standard of water quality information, improve our understanding of the causes of poor water quality and aid us in identifying appropriate solutions. These are:

- Review of the rivers currently monitored by the programme to ensure the diversity of stream and river types found in the Wellington Region is represented.

- Further deployment of continuous water quality monitoring equipment so that diurnal changes in water quality can be identified.

- Integration of NIWA developed methods for assessing urban stream health into the monitoring regime at urban sites.

- Targeted study of stormwater contaminant concentrations in selected urban streams to assess their impact on water quality

- Review of the way in which results from the freshwater quality monitoring programme are reported to ensure that data are presented in the most efficient and useful manner.

A more specific recommendation is that specific steps be identified and implemented to enhance the water quality in the five sites identified in the Regional Freshwater Plan and the five other sites identified by the baseline monitoring programme.

1. Introduction

1.1 Background

Rivers in the Wellington Region have a number of values ranging from:

- For public water supply,
- Receiving waters for discharges, and
- Recreational activities such as swimming, fishing and rafting.

The rivers also have significant ecological value and have particular spiritual significance to Tangata Whenua.

The Regional Council undertakes its baseline freshwater quality monitoring programmes to fulfil its responsibilities under the Resource Management Act 1991.

The Resource Management Act 1991 gives regional councils the responsibility of managing (section 30) and monitoring (section 35) waters in its region. The Regional Council monitors freshwater quality at 51 sites around the Region. These sites have been chosen to represent water bodies that receive input from a wide range of surrounding land uses. In this way results from the freshwater monitoring programme can be considered to be representative of freshwater quality throughout the Region.

Monitoring and reporting of freshwater quality in the Region provides information about the degree to which the environmental outcomes sought in the Regional Policy Statement and Regional Freshwater Plan are being achieved.

Freshwater quality has been routinely monitored in the Western Wellington Region since 1987 and in the Wairarapa since 1991. Over the years the monitoring programme has been revised to provide a more accurate picture of freshwater quality in the Region. These adjustments have resulted in some sites having different periods of record and sampling frequencies.

This report will use data for the period March 1995 to June 2001 to assess spatial trends in water quality in the Region. In using data from this time scale short-term variability in the parameters used to indicate water quality will be accounted for.

This report also assesses the monitoring results for the period March 2000 to June 2001 for compliance with current water quality guidelines.

1.2 Objectives

The objectives of this report are to:

- Provide an assessment of the overall state of freshwater quality in the Wellington Region.

- Identify areas of poor water quality and the related issues

- Provide baseline information to Council to assist in improving catchment management and water quality at deteriorated sites.

- To provide information, which can be used to assess the effectiveness of the objectives, policies, rules and methods included in the Regional Policy Statement, Regional Plans and resource consents.

The design of the baseline freshwater quality monitoring programme does not allow for the assessment of the river's suitability for swimming. A separate contact recreation bacteriological monitoring programme is undertaken for this purpose in the Wairarapa. For further details see Wairarapa technical reports 97/2,98/1,99/10, 00/16 and 01/02.

The baseline freshwater quality monitoring programme does not specifically identify the factors causing impaired water quality. However, it does highlight areas where more detailed investigation should be carried out. Targeted studies are used to address these more specific water quality issues. This report includes recommendations for future targeted investigations and documents progress from existing studies.

1.3 Approach to Analysis

The first section of this report addresses spatial variation in water quality on a region wide basis. In making this comparison only sites with at least a five-year monitoring record are compared. Over this temporal scale seasonal and inter-annual variations in water quality can be accounted for.

Rivers within the Wellington Region are diverse. Some rivers may have differing water quality simply due to their size, climate and underlying geology rather than due to human induced impacts. To avoid this bias, the regional chapter (chapter 2) has grouped the sites according to their geology and predominant land use. Sites have been grouped into the following categories:

- Forest park sites (the catchment is >70% forested).
- Large rural sites (mean annual flow >4 m^3/s, the catchment is >30% in agriculture).
- Small rural sites (mean annual flow <4 m^3/s, the catchment is >30% in agriculture).
- Large urban sites (mean annual flow >2 m^3/s, the catchment is > 20 % urban)
- Small urban sites (mean annual flow <2 m^3/s, the catchment is > 20% urban)
- Eastern sites (miocene sandstone and mudstone geology)

The freshwater monitoring programme is to be reviewed and will in part use the River Ecosystem Classification (REC) methodology recently developed by MfE. This review will change how our monitoring sites are classified in the future.

Caution should be exercised when making comparisons between results from the Western Wellington Region and those from the Wairarapa as different laboratories are used for the analysis of water quality variables. The laboratories use different methods for analysing some water quality variables which may also have differing powers of detection.

The second portion of this report assesses monitoring data from March 2000 to June 2001 from all sites for compliance with water quality guidelines. The guidelines used and there management purpose are shown in Appendix 2.

However, comparisons of water quality monitoring data with current water quality guidelines should be treated cautiously as:

- Taxonomic identifications of the algal assemblages found in the rivers of the western side of the Wellington Region have never been undertaken. This makes it difficult to assess compliance with the current periphyton guidelines.

- Compliance with guidelines for dissolved oxygen, temperature and pH is based on a single monthly measurement taken at around the same time on each occasion. These parameters can show considerable diurnal fluctuation and breaches of the guideline levels may occur at certain times of the day not monitored under the current monitoring regime.

- Many of the 1992 ANZECC guidelines are based on overseas studies and may not be accurate when applied to rivers and streams in the Wellington Region.

A revised version of the ANZECC guidelines released just prior to publishing of this report is based on a stronger foundation of New Zealand data making them a more useful tool in indicating freshwater quality in the Wellington Region. These revised ANZECC guidelines will be used in future reports.

1.4 Report Layout

This report contains six chapters. The first chapter reports on median concentrations of key water quality variables and macroinvertebrate community index scores throughout the Region. The subsequent chapters focus on compliance with water quality guidelines for each site. The report is structured as follows:

- The Wellington Region as a whole
- Wairarapa sites
- Western sites
- Conclusions & Recommendations
- Problem urban streams

The appendices to this report contain the following information:

Appendix 1: Methods of the baseline water quality monitoring programme and an explanation of the water quality variables used in the programme.

Appendix 2: Water Quality Guidelines

Appendix 3: A list of the water quality sites within the Wellington Region and why these sites are monitored.

Appendix 4: A list of the water chemistry methods and the respective detection limits from each laboratory.

2. Results for the Wellington Region

At each of the freshwater quality sites a range of physical, chemical and biological indicators of water quality are measured. Physical, chemical and microbiological measurements provide a snapshot of environmental conditions and water quality at the time of sampling. Environmental conditions and water quality in turn effect the biological communities that inhabit streams and rivers in the region. Assessment of biological communities such as macroinvertebrates can provide an integrated view of water quality at a particular site.

2.1 Physical, Chemical and Microbiological Trends

Medians of physical, chemical and microbiological variables were calculated for all sites monitored in the Wellington Region that have records for the period March 1995 to June 2001 (Fig. 2.1).

2.1.1 Turbidity

The Ngarara, lower Waitohu, Waiwhetu and Ngauranga Stream sites showed the highest levels of turbidity in the Region (Fig. 2.2). The lowest turbidity readings were recorded at the uppermost Hutt, Wainuiomata, Waiohine, Waikanae, Ruamahanga sites as well as in the Pakuratahi and Horokiri Streams.

2.1.2 Phosphorus

The Ngarara Stream had considerably higher levels of dissolved reactive phosphorus than other streams in the Wellington Region (Fig. 2.3). The Ngauranga, Kaiwharawhara, Karori, Ohariu and lower Mangaroa, Ruamahanga and Waiohine sites also showed elevated levels of dissolved reactive phosphorus. However, a large proportion of sites in the Wellington Region had median dissolved reactive phosphorus levels below laboratory detection limit levels of 5 mg/m^3.

2.1.3 Nitrogen

The Ngarara, Waiwhetu, Ngauranga and lower Mangaroa, Waitohu and Makara Stream sites showed highest median levels of total ammonia (Fig. 2.4). Ammonia levels in the Ngarara Stream were considerably higher than those measured at other sites in the Wellington Region. Low median levels of total ammonia were recorded at the remainder of baseline monitoring sites in the Wellington Region.

2.1.4 Biological Oxygen Demand

Highest levels of biological oxygen demand were recorded in the Ngarara, lower Waitohu, Waiwhetu and Ngauranga Stream sites (Fig. 2.5). Lowest median levels of biological oxygen demand were recorded at the Wairarapa sites. However, this may have been due to the lower detection limits provided by the Wairarapa laboratory.

2.1.5 Faecal Coliforms

Highest median levels of faecal coliforms were recorded at the small urban sites including the Karori, Waiwhetu, Ngauranga and Porirua Stream sites (Fig. 2.6). Small rural sites such as those on the Makara and Ngarara Streams also recorded high levels of faecal coliforms. Lowest levels of faecal coliforms were recorded at forest park sites such as the upper Waiohine, Ruamahanga, Hutt, Wainuiomata, and Otaki River sites.

Physical, chemical and microbiological trends recorded at baseline sites over the 2000-2001 period are similar to those presented in last year's annual report.

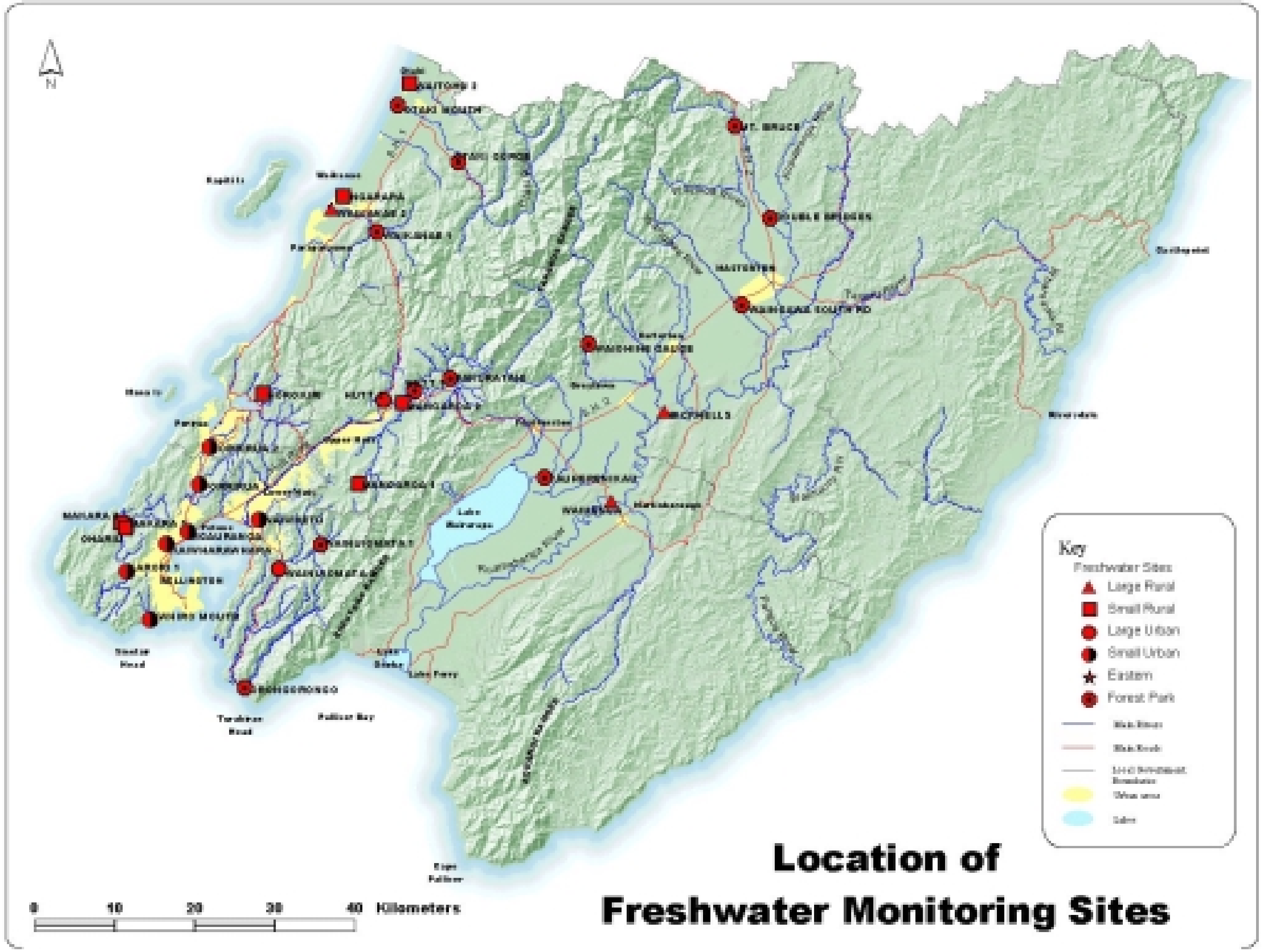


Figure 2.1. Map showing the location of freshwater monitoring sites throughout the Region.

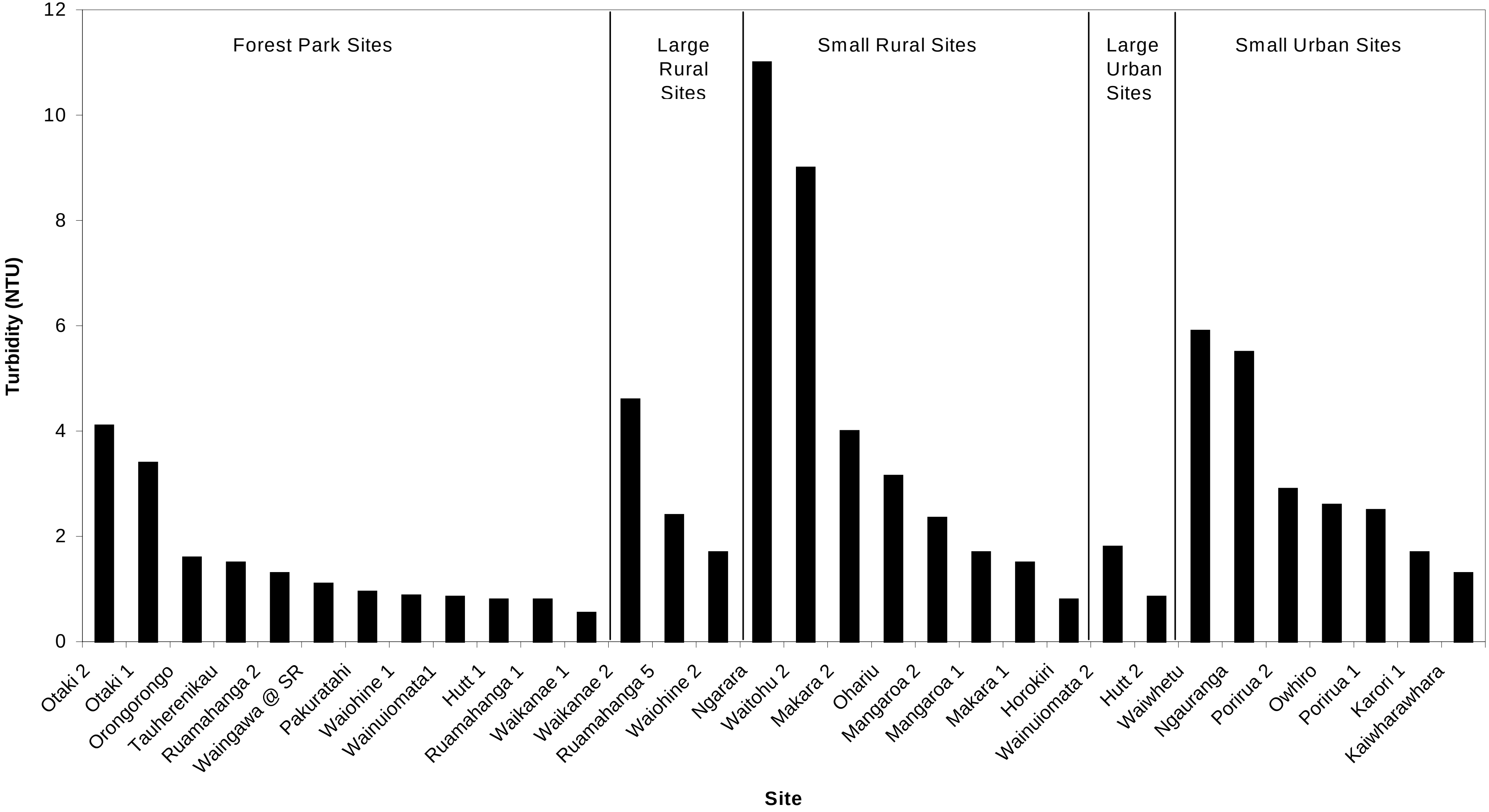


Figure 2.2 Median turbidity (NTU) levels for the period 1995-2001.

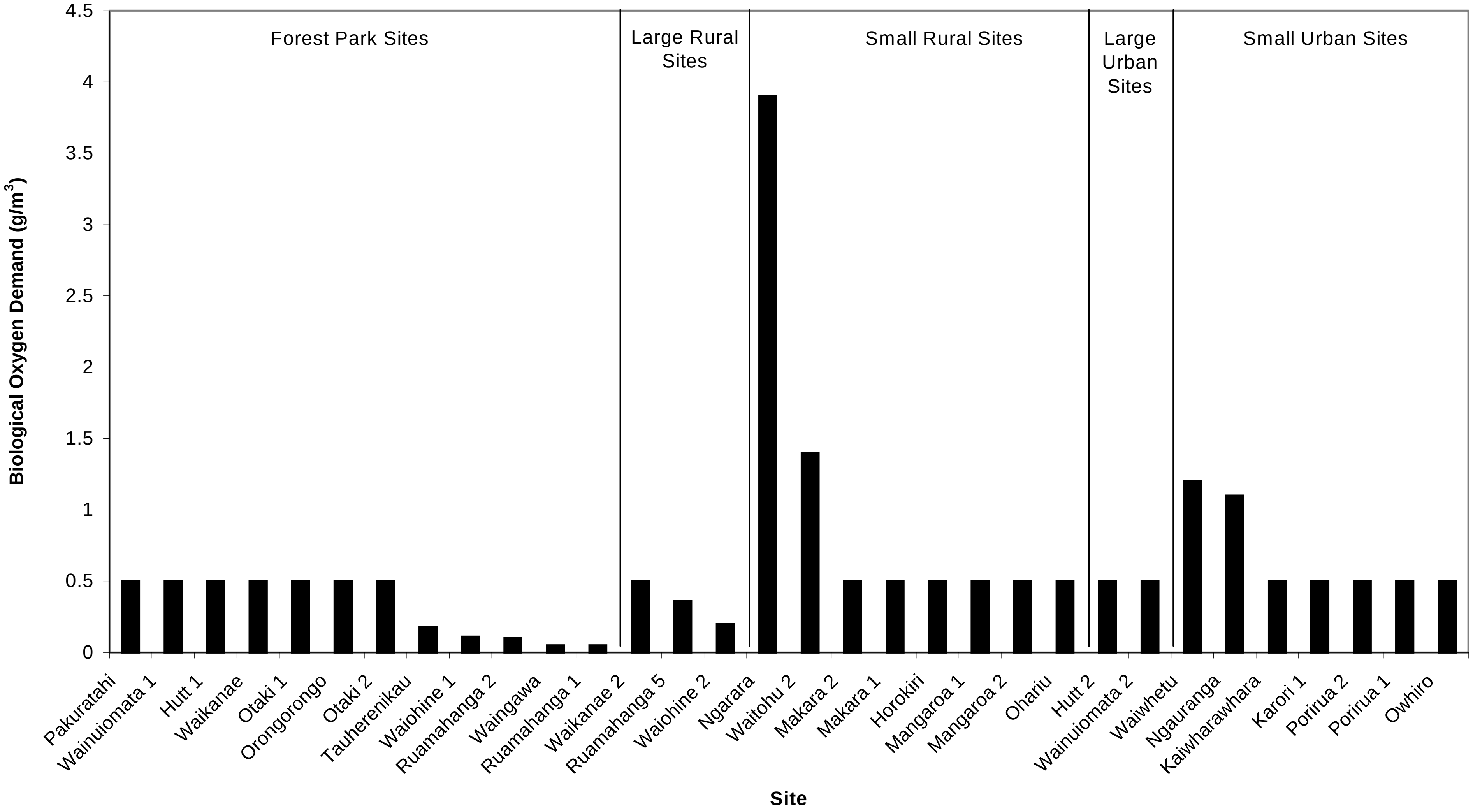


Figure 2.3 Median Biological Oxygen Demand (g/m^3) results for the period 1995-2001.

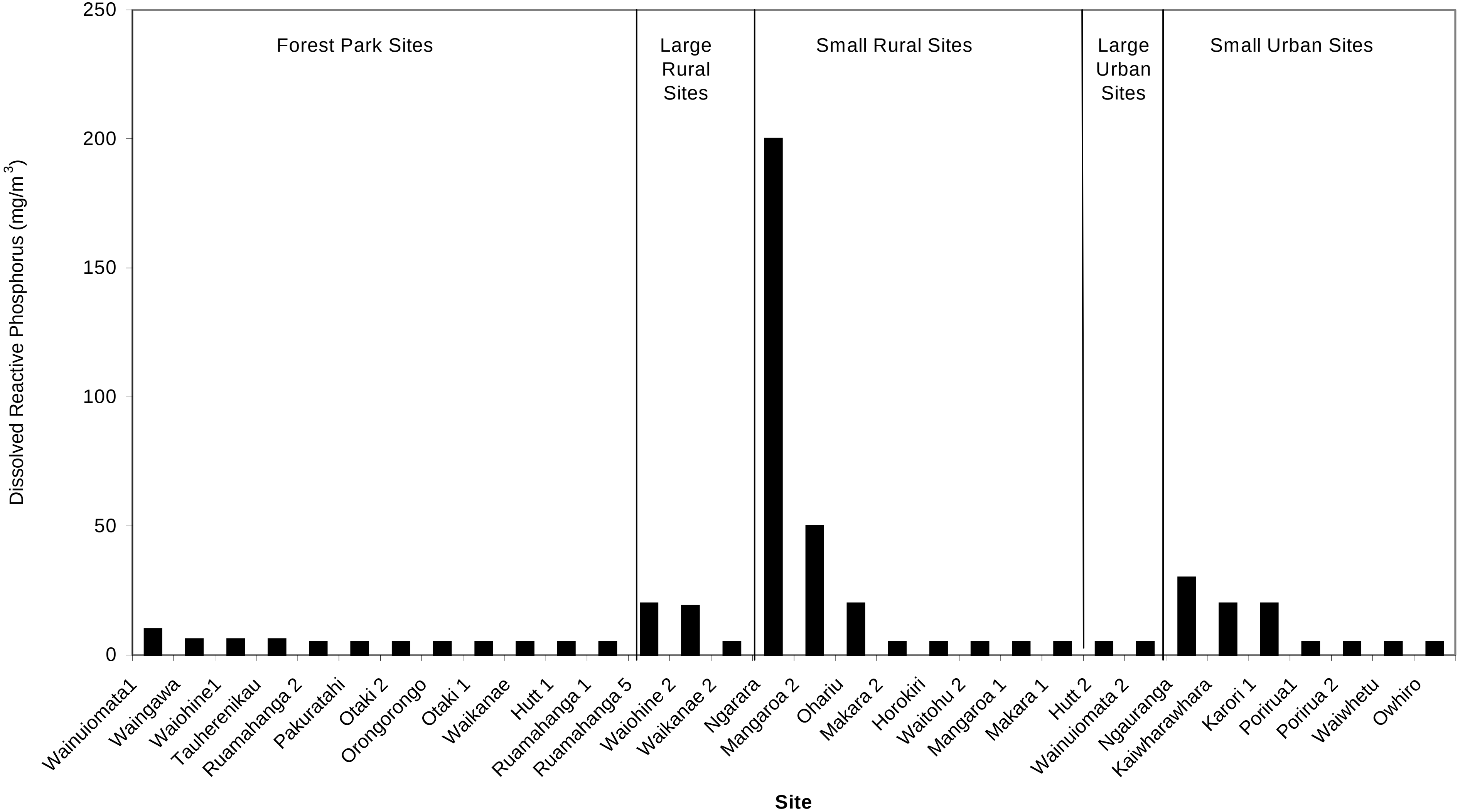


Figure 2.4 Median concentrations of Dissolved Reactive Phosphorus (mg/m3) for the period 1995-2001

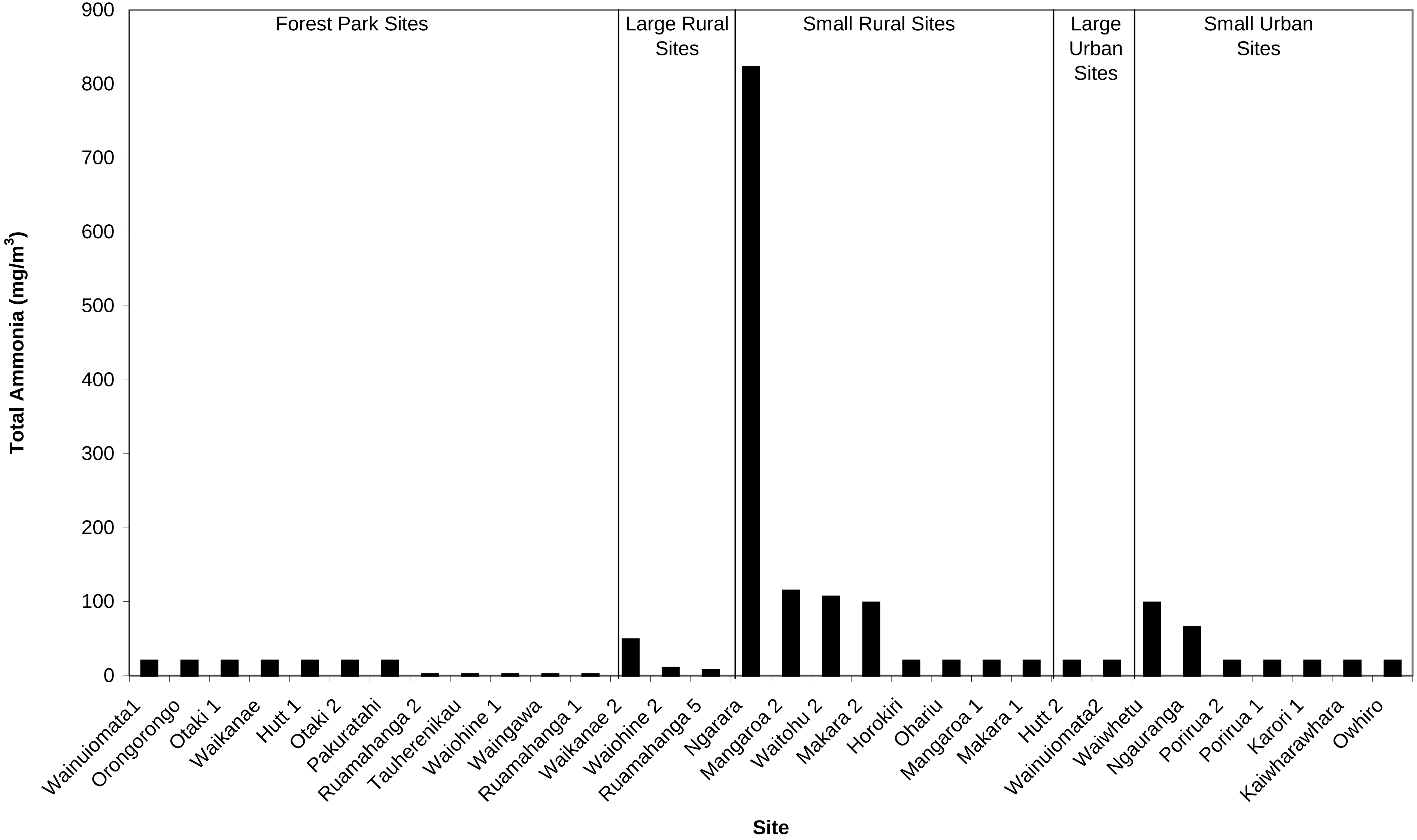


Figure 2.5 Median concentrations of Total Ammonia (mg/m3) for the period 1995-2001.

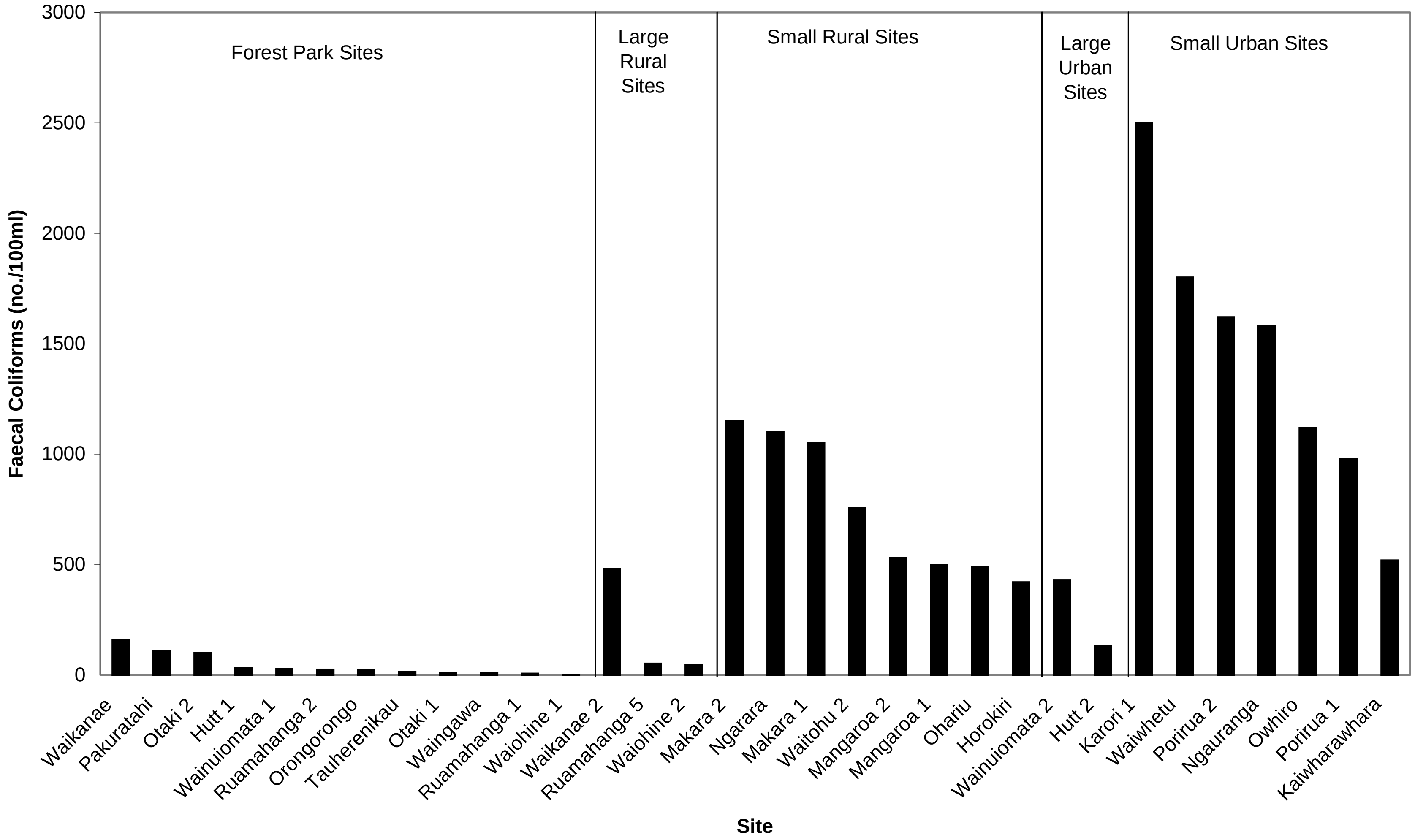


Figure 2.6 Median concentrations of faecal coliforms (per 100ml) for the period 1995-2001.

2.2 Macroinvertebrate Community Index Values

The macroinvertebrate results are presented separately from the water chemistry and microbiology results for the following reasons:

- Not all of the sites that are monitored for water chemistry and microbiology are also monitored for macroinvertebrates. Macroinvertebrate communities in rivers or streams with silty substrates are not currently monitored due to difficulties in relating macroinvertebrate assemblages from this type of habitat to water quality.

- Macroinvertebrate communities sampled may be affected by chemicals not measured in the baseline water quality monitoring programme.

- Chemistry and microbiological sampling assess a small fraction of the water flowing past a site whereas macroinvertebrate communities are influenced by the quality of water over several months. This is reflected in the sampling frequency required with yearly sampling being adequate to assess macroinvertebrate communities as an indicator of water quality.

Macroinvertebrate Community Index (MCI) and Semi Quantitative Macroinvertebrate Community Index (SQMCI) results are shown in Figures 2.8 and 2.9 respectively. Sites with the poorest water quality (low MCI and SQMCI values) were those on the Wainuiomata, Porirua, Tauherenikau, Waipoua, Mangaroa, Pauatahanui, Kaiwharawhara, Owhiro, Ngauranga and Kopuaranga Rivers. Highest MCI and SQMCI values were recorded at forest park sites such as the Akatarawa, Orongorongo and Otaki Rivers and upper Waitohu, Waikanae, Waiohine, and Ruamahanga sites. High MCI values were also recorded in the lower Karori, Waiohine and Ruamahanga sites as well as in the Hutt River.

The biological monitoring results were generally consistent with those presented in the 1999/2000 annual freshwater report.

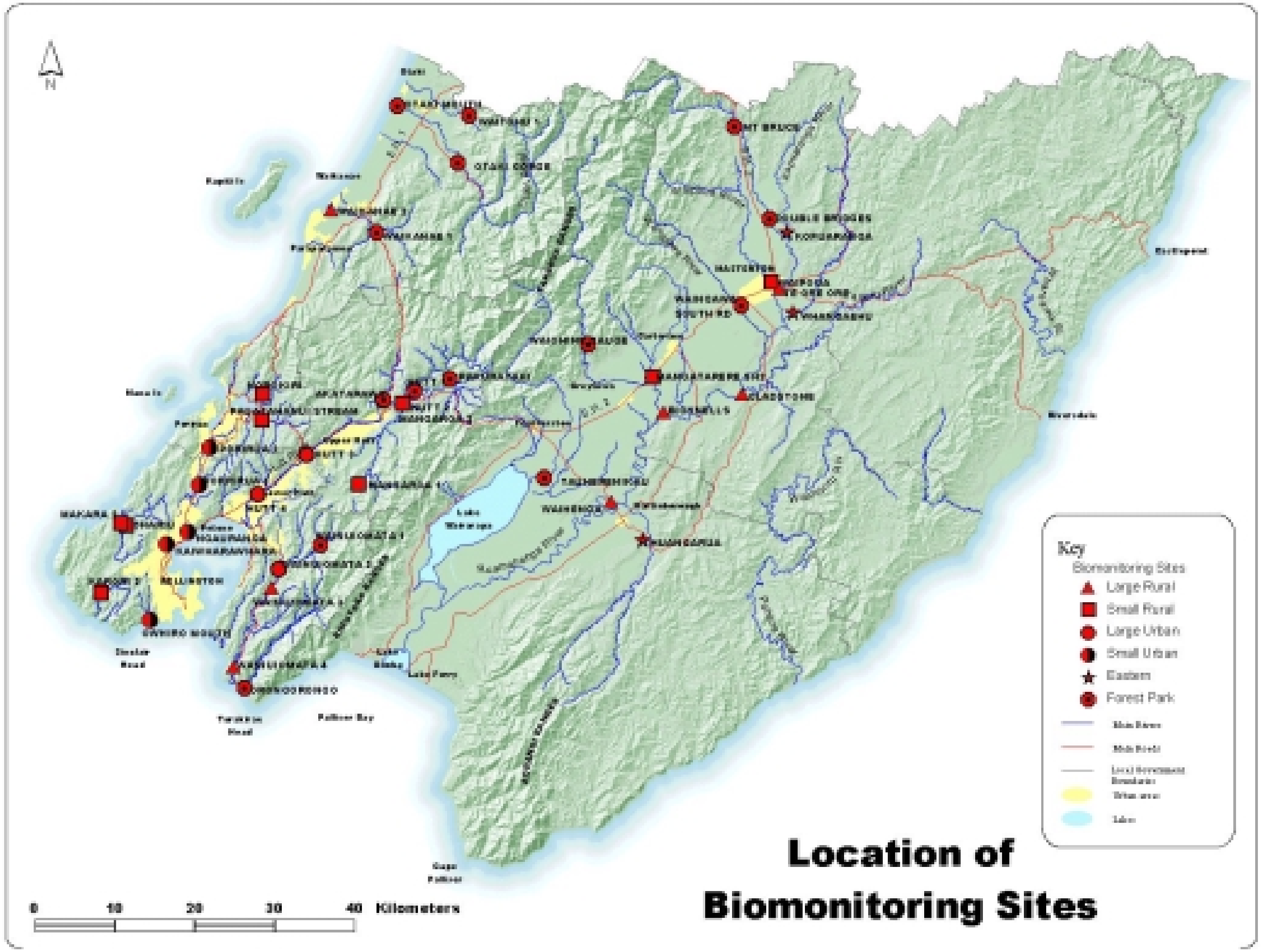


Figure 2.7 Locations of macroinvertebrate monitoring sites throughout the Region.

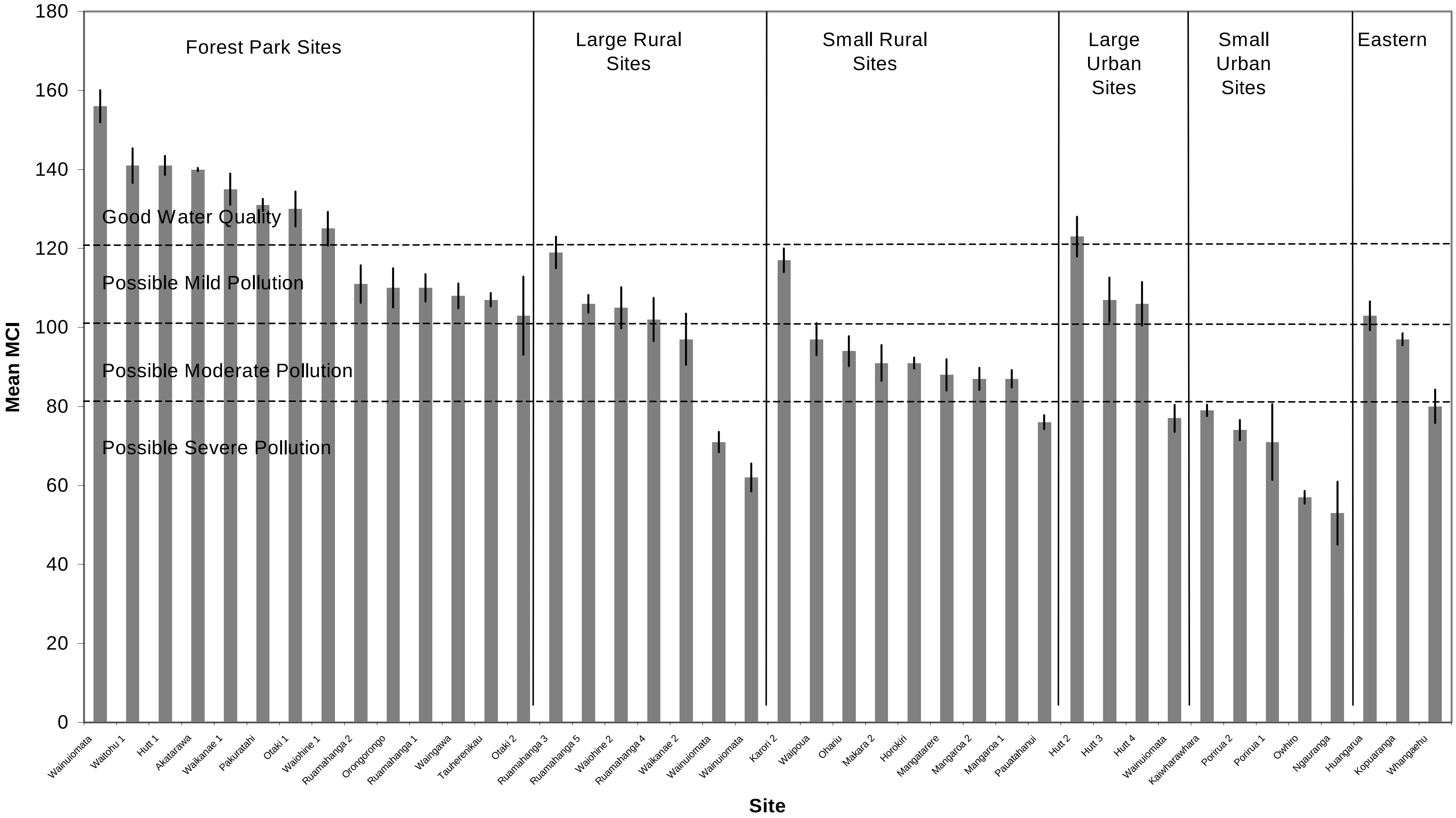


Figure 2.8. Mean Macroinvertebrate Community Index (MCI) scores for current biomonitoring sites.

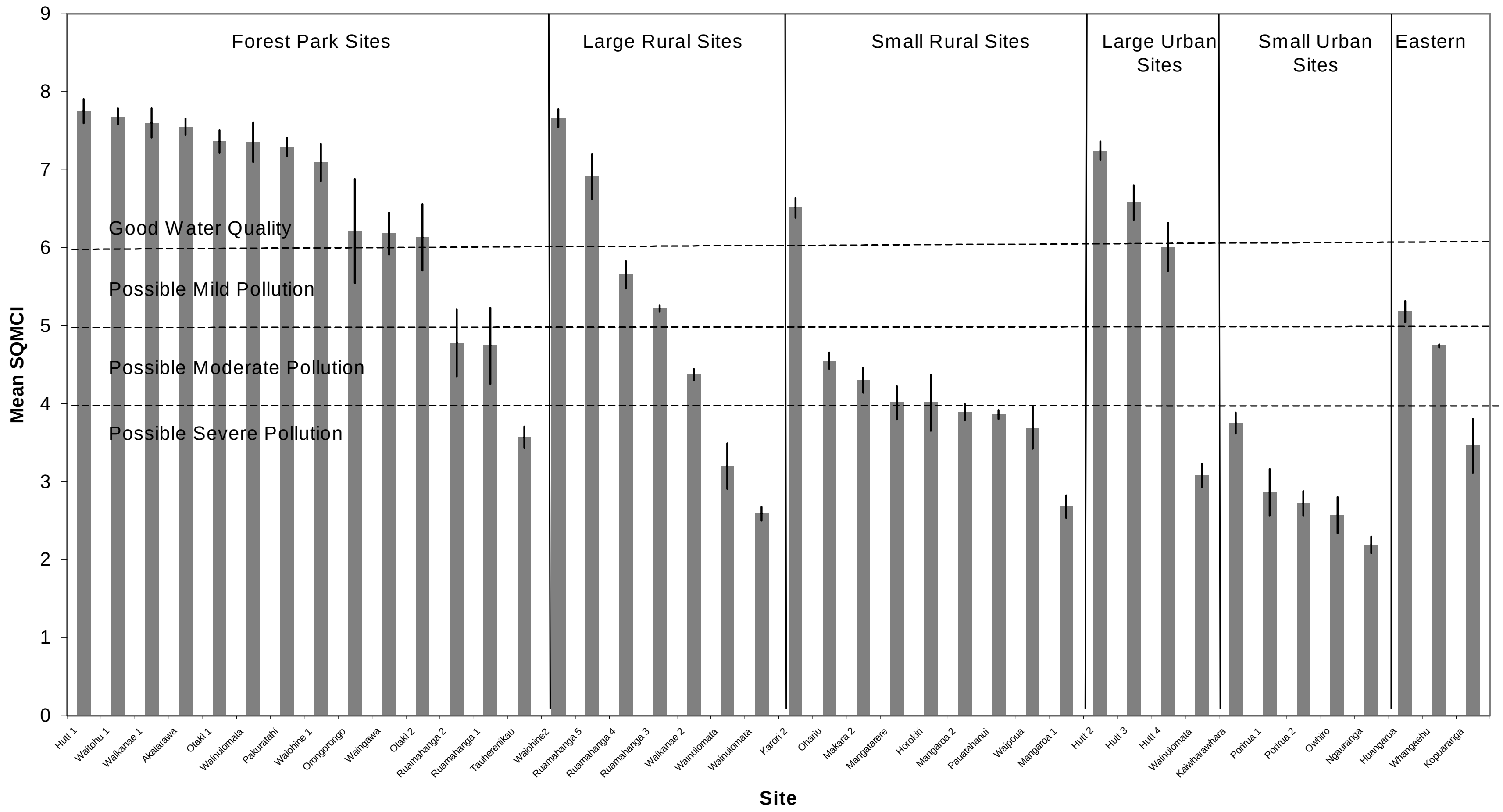


Figure 2.9 Mean Semi Quantitative Macroinvertebrate Community Index (SQMCI) scores for current biomonitoring sites in the Region.

2.3 Discussion and Conclusions

Trends in water quality throughout the Wellington Region shown by physical, chemical, microbiological variables are similar to those indicated by macroinvertebrate community index results. Sites within or near forest park sites such as the upper Waikanae, Hutt, Wainuiomata, Otaki, Ruamahanga, Waiohine Rivers and Pakuratahi, Orongorongo, Akatarawa River sites showed good water quality.

Small rural and small urban sites were consistently shown to have the poorest water quality in the region. Small rural sites with poorest water quality include:

- Ngarara Stream
- Pauatahanui Stream
- lower Mangaroa River
- Waitohu Stream

Small urban sites with poor water quality include:

- Ngauranga Stream
- Waiwhetu Stream
- upper Karori Stream

Rural runoff and urban stormwater pollution accompanied by low flows providing insufficient dilution are likely to be the primary factors behind the poor water quality found in these streams. In addition, poor water quality found at the Ngarara Stream site is likely to be the effect of upstream discharges from the Waikanae Wastewater Treatment Plant.

Wairarapa sites generally exhibited better water quality than other sites in the Wellington Region. This is likely to be a reflection of less intensive land use in this part of the Region combined with generally higher flows of the rivers monitored. In addition, the Wairarapa laboratory has lower detection limits for parameters such as ammonia and biological oxygen demand than the Lower Hutt lab. This can be misleading when interpreting the monitoring data as it can give the impression of better water quality at the Wairarapa sites by virtue of lower detection limits. Standardisation of laboratory detection limits is recommended to allow meaningful comparisons of all water quality results obtained by our monitoring programme.

The Regional Freshwater Plan specifically identifies the following waterbodies as needing enhancement:

- Ngarara Stream
- Waiwhetu Stream
- Wainuiomata River
- Ngauranga Stream
- Makara Stream

Previous reports have shown no improvement of water quality in any of these rivers or streams. The Ngarara Stream has shown increasing turbidity concentrations, the

Waiwhetu Stream has shown increasing biochemical oxygen demand concentrations, while the Wainuiomata River and Ngauranga Stream showed no change (Stansfield 1999; Stansfield 2000).

Based on the monitoring results obtained by the Wellington Regional Council the following five streams could be added to the list of water bodies needing enhancement. These are:

- Lower Waitohu Stream
- Lower Porirua Stream
- Upper Karori Stream
- Lower Mangaroa River
- Pauatahanui Stream

The Wellington Regional Council has implemented a number of initiatives with the aim of enhancing water quality in these streams. These initiatives include:

- Riparian restoration trials on the Karori, Kakariki (the Kakariki Stream is a major tributary to the Ngarara Stream) and Enaki Streams
- The *Take Charge* pollution prevention programme aimed at improving industrial discharge practises
- A comprehensive investigation of the effects of stormwater discharges to surface water in the Wellington Region.

2.4 Recommendations

Our monitoring has identified a number of water quality trends within the Wellington Region. In addition, a number of issues have been identified which require further action. These actions will assist the programme in providing a greater standard of water quality information and include:

- Ensuring standardisation of laboratory methods and detection limits between the Wairarapa and Wellington laboratories (see Stansfield 1999).
- Identify and implement specific actions to enhance the water quality in the five streams specifically identified in the Regional Freshwater Plan as needing enhancement and in the five other poor quality streams identified by the baseline monitoring programme.
- That a River Environment Classification based review of the baseline monitoring programme is carried out to ensure the diversity of stream and river types found in the Wellington region is represented.
- That baseline freshwater monitoring reporting procedures be reviewed to ensure water quality data is presented in the most efficient and useful way.

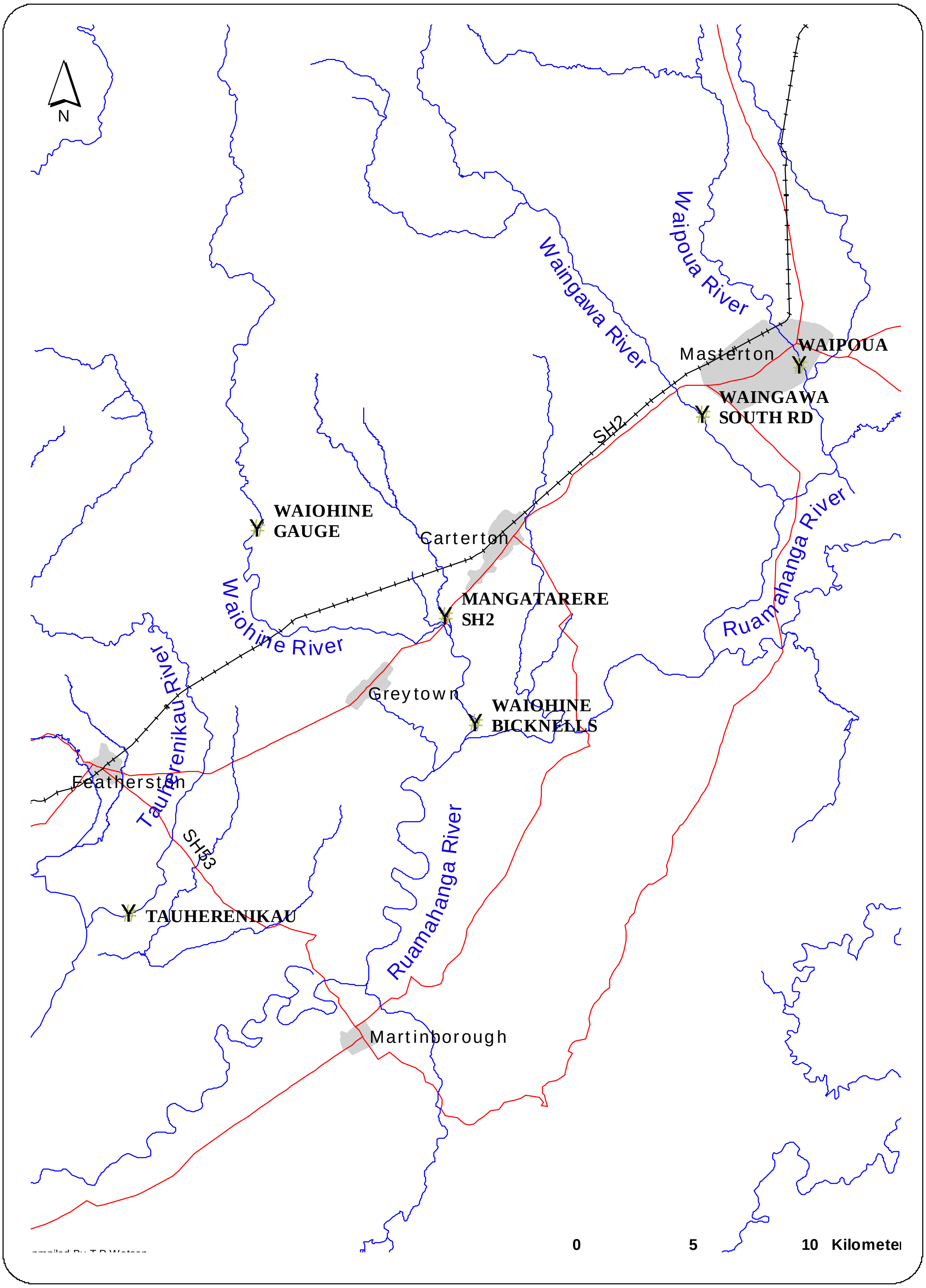
3. Wairarapa

3.1 Western Wairarapa

3.1.1 Background

The western tributaries of the Ruamahanga River are the Waipoua River, Waingawa River, Waiohine River, Mangatarere River and the Tauherenikau River. These rivers have been grouped together due to their similar topography, geology and climate.

The western tributaries have headwater reaches in the Tararua Forest Park. The surrounding geology of these catchments comprises folded mesozoic greywackes and argillites. The topography within the headwater catchment is very steep hills, which receive high rainfall. Flood events are far more frequent in the western tributaries than in the eastern tributaries and the riverbeds are comprised of a mixture of boulders, cobbles and gravels with a small amount of fine sands and silts. Periphyton or macrophytes seldom proliferate in these rivers due to the frequency of flooding.



Western Wairarapa Sites

Figure 3.1 Map of Western Wairarapa sites

3.1.2 Results

Water quality at sites in the western Wairarapa generally complied with aquatic ecosystem guidelines over the 2000-2001 period (Table 3.1). However, periphyton cover reached undesirable levels at Waipoua, Mangatarere and Tauherenikau River sites on two occasions. Dissolved nutrient levels were found to be high enough to stimulate these periphyton proliferations on both occasions in the Mangatarere and Waipoua Rivers and on one occasion on the Tauherenikau River.

Table 3.1 The number of occasions water quality variables at Western Wairarapa sites were outside of guideline limits of the 15 sampling occasions from March 2000 to June 2001.

Site	Dissolved Oxygen	pH	Total Ammonia	Temperature	Periphyton	Dissolved Nutrients
Waipoua	0/15	0/15	0/15	0/15	2/15	2/2
Waingawa	0/15	0/15	0/15	0/15	0/15	N/a
Waiohine 1	0/15	0/15	0/15	0/15	0/15	N/a
Mangatarere	0/15	0/15	0/15	0/15	2/15	2/2
Waiohine 2	0/15	0/15	0/15	0/15	0/15	N/a
Tauherenikau	0/15	0/15	0/15	0/15	2/15	1/2
Total	**0**	**0**	**0**	**0**	**6**	**5**

These results differ from 1999-2000 when periphyton cover was below guideline levels on all but one occasion (Stansfield 2000). This difference is likely to be related to different hydrological conditions experienced during the two years.

Algal samples taken from the macroinvertebrate sampling in 1999 indicated that the dominant taxa were mostly diatom species that are commonly found in oligotrophic or mesotrophic waters (Biggs 1999). Further targeted studies will be required to determine the true limiting variable (nutrients, light, temperature or water velocity) for the periphyton blooms in these rivers.

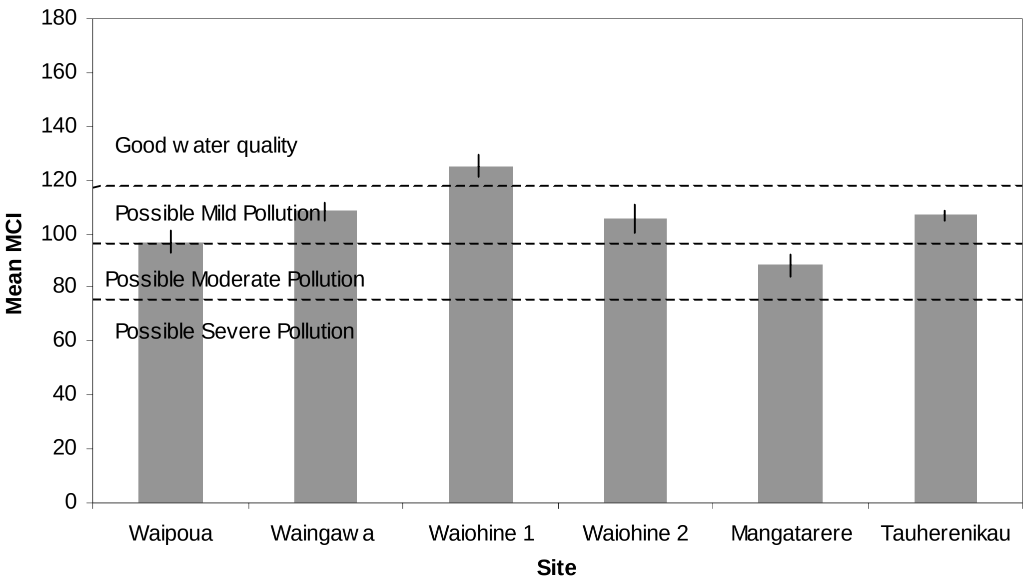


Figure 3.2. MCI scores for Western Wairarapa sites.

Macroinvertebrate community index (MCI) values recorded at the upper Waiohine River site indicated good water quality (MCI >120) (Fig. 3.2). MCI scores from the

Waingawa, Tauherenikau and lower Waiohine River sites indicate possible mild pollution (MCI 100-120). Scores for the Waipoua and Mangatarere sites suggested possible moderate pollution in these rivers (MCI 80-100).

3.2 Central Wairarapa

3.2.1 Background

The Ruamahanga River is the largest river in the Wellington Region and it acts as the main conduit for pollutants in the Wairarapa Region. The water quality sampling sites on the Ruamahanga River (in a down stream sequence) comprise Mt. Bruce, Double Bridges, Te Ore Ore, Gladstone and Waihenga (Fig. 3.3).

The underlying geology of the Ruamahanga River catchment is a mixture of folded mesozoic greywackes and argillites to the west and limestone and soft sedimentary rock, stretching to the east. The alluvial plains of the Ruamahanga River valley lie in between these two geological formations. Topography is steep in the upper reaches with a corresponding high rainfall while further down the system the topography is flat and experiences less rainfall. The bed of the Ruamahanga River consists of boulders, cobbles and gravels with small amounts of sand and silt. The scouring effect of the frequent flooding in the Ruamahanga River ensures that periphyton blooms are infrequent.

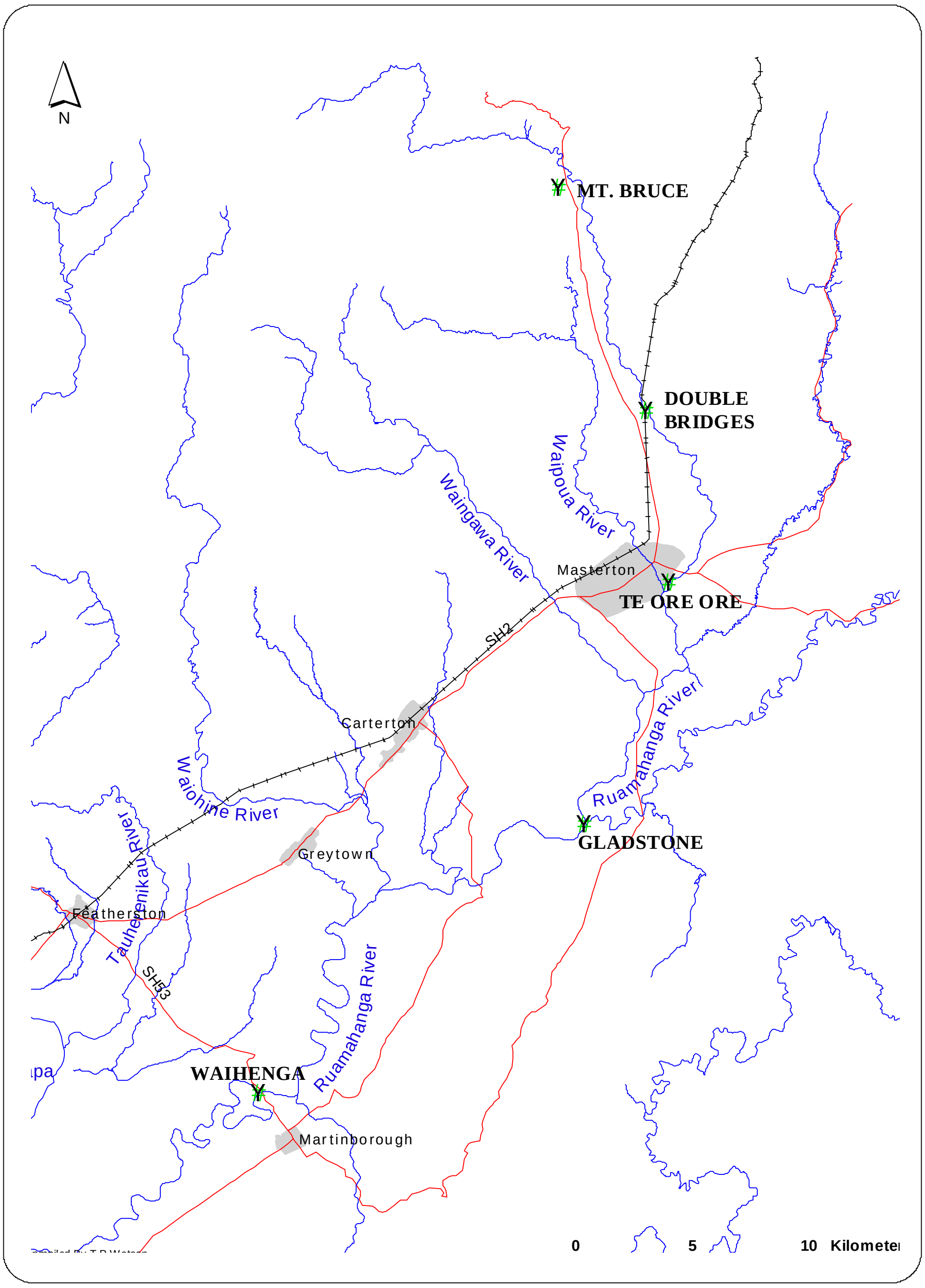


Figure 3.3 Map of Central Wairarapa sites.

3.2.2 Results

Water quality at the central Wairarapa sites generally complied with the aquatic ecosystem guidelines (Table 3.2). However, undesirable levels of periphyton cover were recorded at each site in March of 2001. Dissolved nutrient concentrations were found to be high enough to stimulate these undesirable levels of periphyton growth at each site.

Table 3.2 The number of occasions water quality variables at central Wairarapa sites were outside of guideline limits of the 15 sampling occasions from March 2000 to June 2001.

Site	Dissolved Oxygen	pH	Total Ammonia	Temperature	Periphyton	Dissolved Nutrients
Mt. Bruce	0/15	0/15	0/15	0/15	1/15	1/1
Double Bridges	0/15	0/15	0/15	0/15	1/15	1/1
Te Ore Ore	0/15	0/15	0/15	0/15	1/15	1/1
Gladstone	0/15	2/15	0/15	0/15	1/15	1/1
Waihenga	0/15	0/15	0/15	0/15	1/15	1/1
Total	**0**	**2**	**0**	**0**	**5**	**5**

Similar results were recorded at these sites in the 1999-2000 report however, periphyton cover only exceeded guidelines at Te Ore Ore and Gladstone sites.

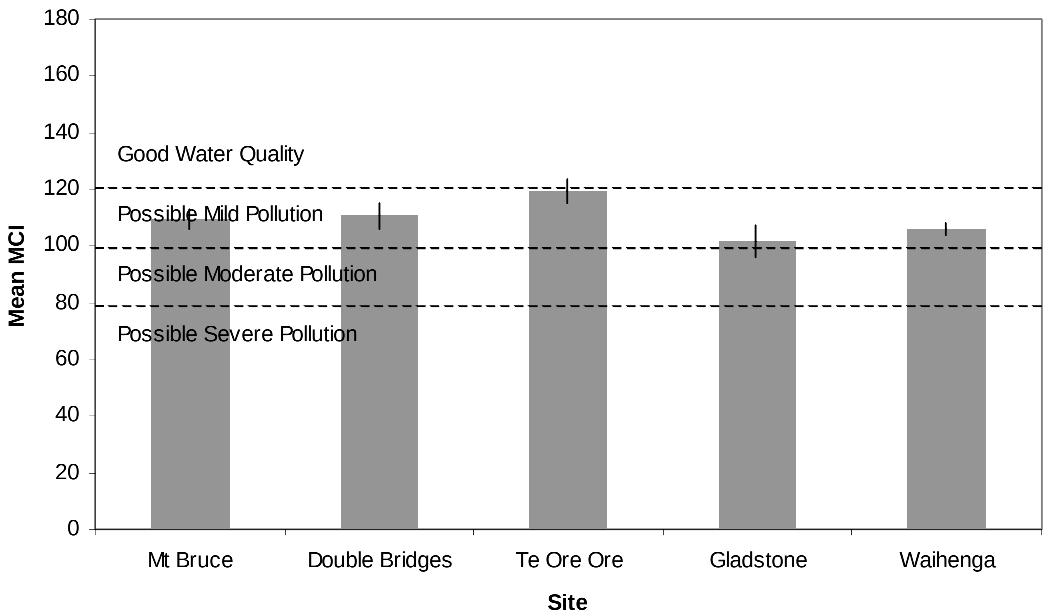


Figure 3.4. Mean MCI scores from Central Wairarapa sites.

All monitoring sites on the Ruamahanga River had macroinvertebrate communities characteristic of a possibly mildly polluted habitat (Fig 3.4). This differs from the 1999-2000 results, which indicated good water quality at these sites. Decreased water quality at these sites as indicated by MCI scores is likely to be the effect of low flows experienced in most of the Wairarapa Rivers during the 2000-2001 summer.

3.3 Eastern Wairarapa

3.3.1 Background

The eastern tributaries of the Ruamahanga River are the Kopuaranga River, Whangaehu River, Taueru River and the Huangarua River (Fig. 3.5). The eastern rivers have been grouped together due to their similar topography, geology and climate.

The eastern tributaries drain low hills composed of limestone and soft sedimentary rock, stretching to the east coast. Rainfall is generally lower in the eastern Wairarapa than in the west and low flows are therefore more common. The streambeds of the eastern tributaries are also characteristically covered in a matrix of algal mats and macrophytes.

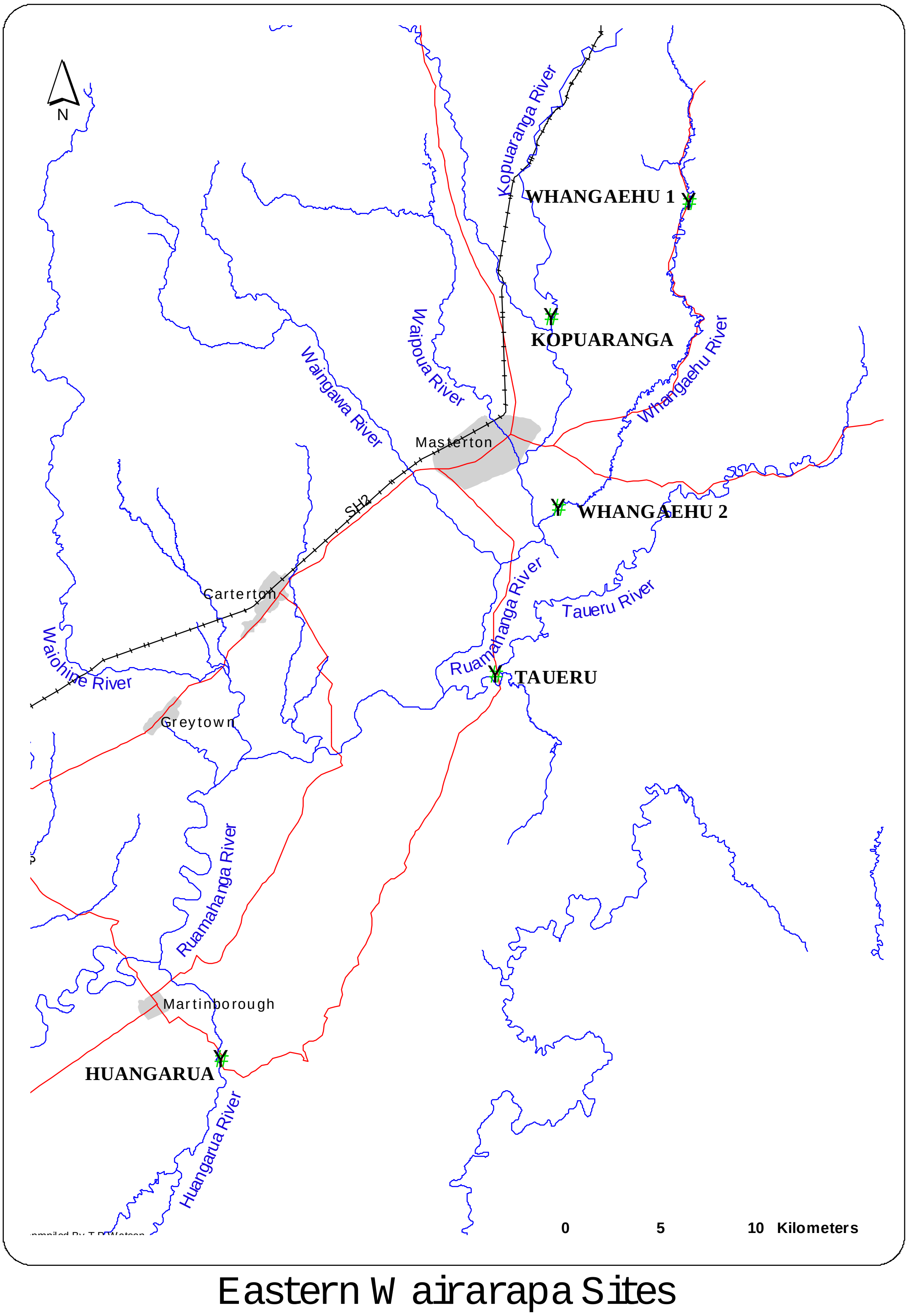


Figure 3.5 Map of Eastern Wairarapa sites

3.3.2 Results

Levels of dissolved oxygen below the guidelines for aquatic ecosystems (<80% saturation) were recorded on a number of occasions at the two sites on the Whangaehu River (Table 3.3). These decreased levels of dissolved oxygen generally occurred during summer and autumn months.

Table 3.3 The number of occasions water quality variables at Eastern Wairarapa sites were outside of guideline limits of the 15 sampling occasions from March 2000 to June 2001. *Flow data for the Huangarua River was not available at the time of publishing.

Site	Dissolved Oxygen	pH	Total Ammonia	Temperature	Periphyton	Dissolved Nutrients
Kopuaranga	0/15	0/15	0/15	0/15	6/15	6/6
Whangaehu	4/15	0/15	0/15	0/15	1/15	1/1
Taueru	0/15	0/15	0/15	0/15	0/15	N/a
Huangarua	0/15	0/15	0/15	0/15	5/15	*
Whangaehu @ Waihi	5/15	0/15	0/15	0/15	N/a	N/a
Total	**9**	**0**	**0**	**0**	**12**	**7**

A total of 12 periphyton blooms were recorded in the eastern tributaries during the monitoring period. These blooms occurred in the Kopuaranga, Whangaehu and Huangarua Rivers. Levels of dissolved nutrients were over guideline limits during all six blooms in the Kopuaranga River and once in the Whangaehu River. The unavailability of flow data for the Huangarua River meant that periphyton accrual periods could not be calculated.

The Whangaehu River at Waihi was often dominated by macrophytes. However, the current periphyton guidelines are not designed to assess macrophyte assemblages and are therefore not applicable at the Waihi site.

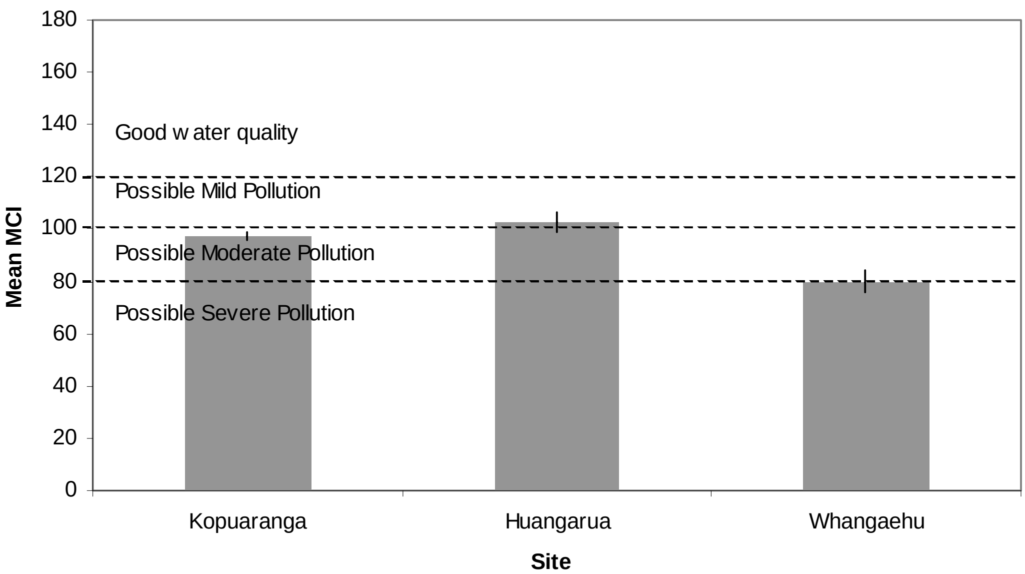


Figure 3.6. MCI scores from Eastern Wairarapa sites.

Macroinvertebrate communities sampled in the Huangarua River indicated possible mild pollution while those in the Kopuaranga and Whangaehu Rivers suggested possible moderate pollution (Fig. 3.6). These results are similar to those found in previous years.

3.4 Discussion

Monitoring of water quality at the Wairarapa sites suggests that the Ruamahanga River has the best water quality in the Region while its eastern tributaries exhibit the poorest water quality. With the exception of the Mangatarere and Waipoua Rivers the western tributaries to the Ruamahanga also exhibit good water quality.

These differences in water quality throughout the Wairarapa are likely to be the effect of variations in river size and catchment based differences such as climate, topography and geology. Western and central sites are generally associated with larger rivers, and greater rainfall while eastern sites have considerably lower flows and experience lower rainfall. These low flows, the limestone and soft sedimentary geology combined with intensive agricultural landuse are likely to be the main factors causing poor water quality in eastern Wairarapa rivers and streams.

The slight decreases in water quality observed at many sites over the past year, compared to the previous years results, can be largely attributed to the severe drought experienced in the Wairarapa during the summer of 2000-2001 and the associated low flow conditions.

4. Western Region

4.1 Hutt/Wainuiomata/Orongorongo Catchments

4.1.1 Background

The Hutt catchment extends from the Tararua Ranges in the north-east and drains into Wellington Harbour to the south-west (Fig. 4.1). It is bounded to the south-east by the Rimutaka Range and to the north west by the Hutt hills and foothills of the Tararua ranges (Wellington Regional Council, 1995). There are four main tributaries of the Hutt River. These are:

- Pakuratahi River;
- Mangaroa River;
- Akatarawa River; and
- Waiwhetu Stream

The Pakuratahi, Akatarawa, and the Hutt (above Kaitoke) Rivers drain predominantly Pinus radiata or native beech/podocarp forested catchments. These areas are also designated water supply catchments. In the lower reaches, (below the designated water supply areas) these catchments are largely pastoral. The Hutt River flows through the urban areas of Upper Hutt and Lower Hutt cities (DOSLI, 1995). The Waiwhetu Stream flows through the urban areas of Naenae and Waiwhetu.

The upper reaches of the Wainuiomata River are used for water supply and drain a native bush catchment. In the middle reaches of the Wainuiomata catchment, the river flows through high producing pasture and the urban Wainuiomata area. The lower reaches of the Wainuiomata catchment are in low producing pasture (DOSLI 1995).

The upper reaches of the Orongorongo catchment are also used for water supply. Most of the catchment is covered in indigenous forest with only a small proportion near the river mouth in pasture.

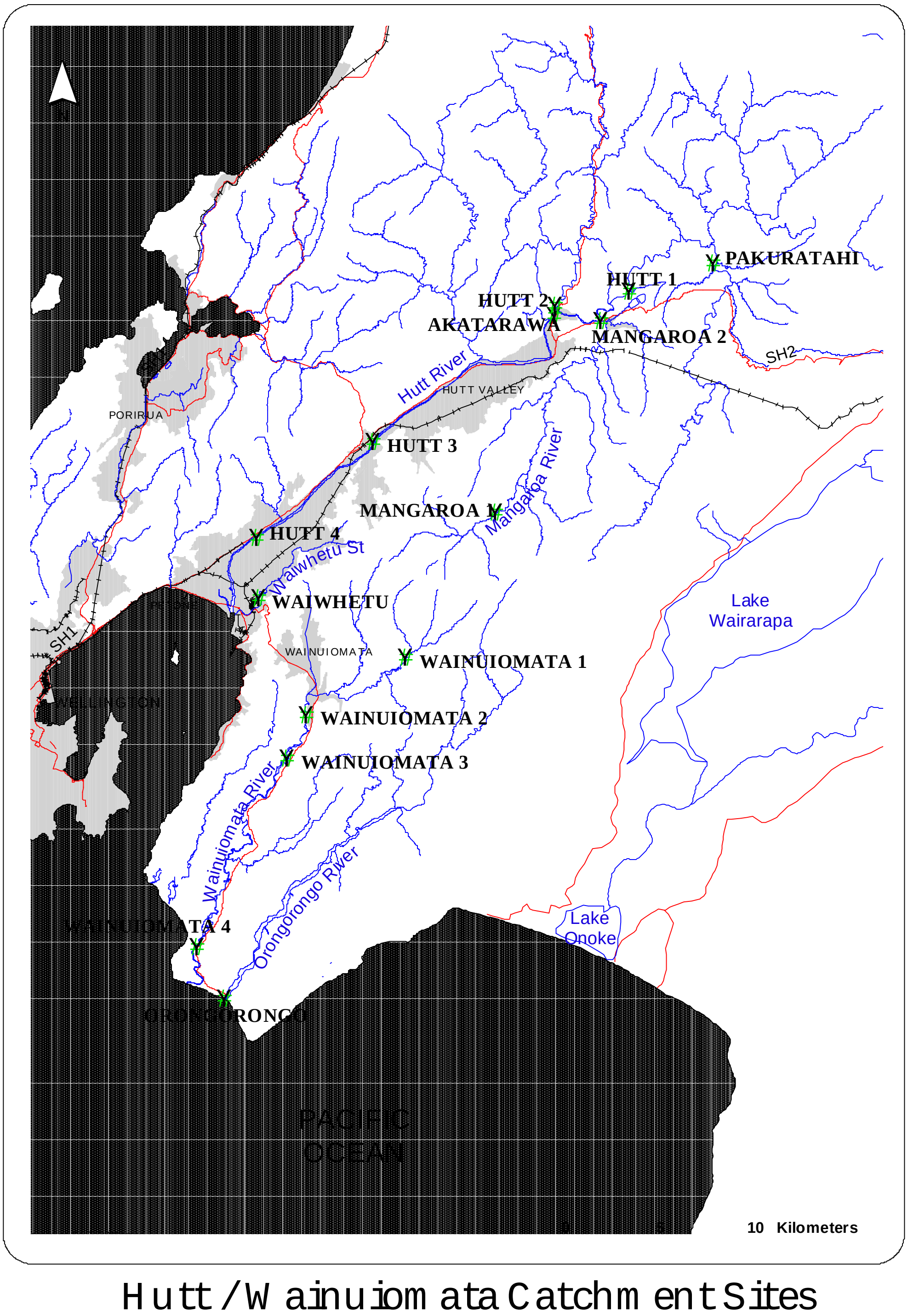


Figure 4.1. Map of the Wainuiomata, Hutt and Orongorongo River catchments.

4.1.2 Results

Hutt River Catchment

Generally all streams in the Hutt catchment showed good compliance with aquatic ecosystem guidelines (Table 4.1). The exception was the Waiwhetu Stream in which dissolved oxygen levels were below 80% (Schedule 3, Resource Management Act 1991) on 13 occasions. Periphyton blooms were also recorded in this stream as well as the lower Mangaroa site and the Hutt 3 site. Dissolved nutrient levels were not high enough to promote periphyton growth at the Waiwhetu site. However, dissolved nutrient concentrations were sufficiently elevated at the Mangaroa and Hutt sites to have encouraged periphyton proliferation on all but one occasion.

Table 4.1 The number of occasions water quality variables at each monitoring site were outside of guideline limits of the 15 sampling occasions from March 2000 to June 2001.

Site	Dissolved Oxygen	pH	Total Ammonia	Temperature	Periphyton	Dissolved Nutrients
Waiwhetu	13/15	0/15	0/15	0/15	1/15	0/1
Mangaroa 1	0/15	0/15	0/15	0/15	0/15	N/a
Mangaroa 2	0/15	0/15	0/15	0/15	4/15	3/4
Akatarawa	0/15	0/15	0/15	0/15	0/15	N/a
Pakuratahi	0/15	0/15	0/15	0/15	0/15	N/a
Hutt 1	0/15	0/15	0/15	0/15	0/15	N/a
Hutt 2	0/15	0/15	0/15	0/15	0/15	N/a
Hutt 3	0/15	0/15	0/15	0/15	4/15	3/4
Hutt 4	0/15	0/15	0/15	0/15	0/15	N/a
Total	**13**	**0**	**0**	**0**	**9**	**6**

Sites on the Akatarawa, Pakuratahi and upper Hutt Rivers had macroinvertebrate communities characteristic of good water quality (Fig. 4.2). MCI values at sites in the lower Hutt River suggested possible mild pollution while MCI scores at both Mangaroa River sites indicated possible moderate pollution. The silty substrate of the Waiwhetu Stream makes it unsuitable for water quality assessment using the MCI.

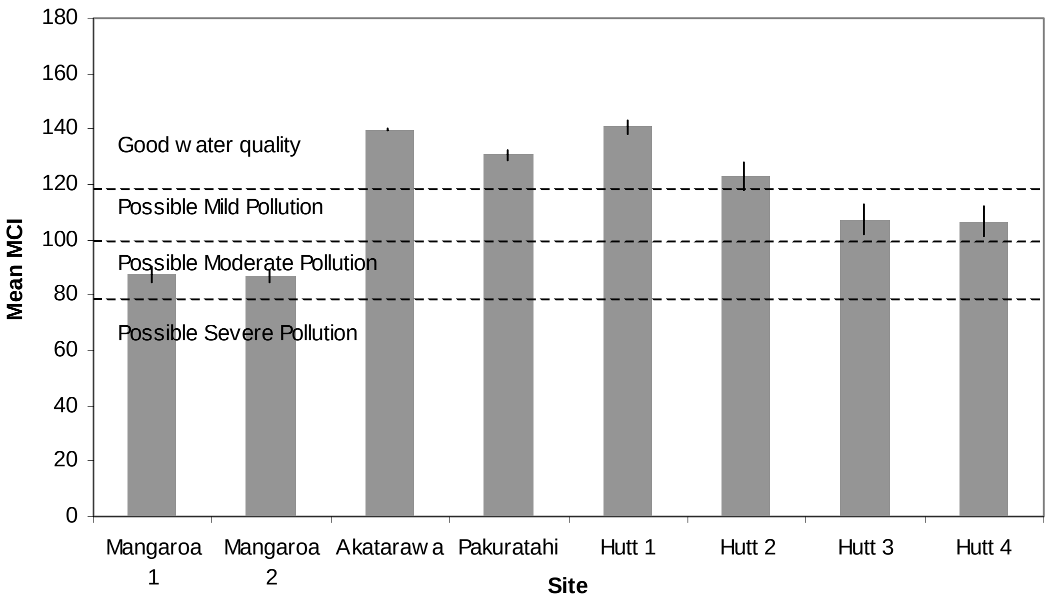


Figure 4.2. MCI scores from the Hutt River Catchment

Similar results were reported for these rivers in last year's report though dissolved oxygen levels and periphyton cover exceeded guidelines on a greater number of occasions during 2000-2001 than during 1999-2000.

Wainuiomata and Orongorongo Catchments

Water quality parameters measured within the Wainuiomata and Orongorongo catchments were generally within aquatic ecosystem guidelines (Table 4.2). However, periphyton cover outside the recommended guideline of 30% was recorded on six occasions. This periphyton proliferation was limited to the two lower Wainuiomata sites and on each occasion dissolved nutrient levels were found to be sufficient to have promoted these growths.

Table 4.2 The number of occasions water quality variables in the Wainuiomata and Orongorongo Rivers were outside of guideline limits of the 15 sampling occasions from March 2000 to June 2001.

Site	Dissolved Oxygen	pH	Total Ammonia	Temperature	Periphyton	Dissolved Nutrients
Wainuiomata 1	0/15	0/15	0/15	0/15	0/15	N/a
Wainuiomata 2	0/15	0/15	0/15	0/15	0/15	N/a
Wainuiomata 3	0/15	0/15	0/15	0/15	2/15	2/2
Wainuiomata 4	0/15	0/15	0/15	0/15	4/15	4/4
Orongorongo	0/15	0/15	0/15	0/15	0/15	N/a
Total	**0**	**0**	**0**	**0**	**6**	**6**

MCI results suggest that the uppermost Wainuiomata site had good water quality, while the MCI score for the Orongorongo River site indicated possible mild pollution (Fig. 4.3). However, in contrast to physical and chemical parameters measured at Wainuiomata River sites 2,3 and 4, MCI values indicated possible severe pollution. These results are consistent with those from 1999-2000.

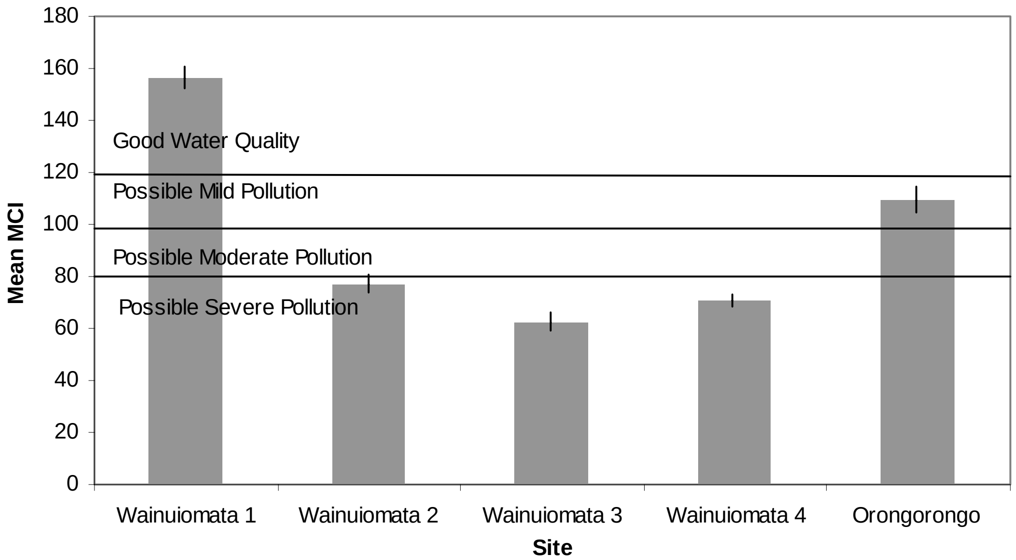


Figure 4.3. MCI scores from the Wainuiomata and Orongorongo River catchments.

4.1.4 Discussion

The Waiwhetu Stream, Mangaroa River and the lower reaches of the Wainuiomata River are recognised as having some of the poorest quality waters in the Wellington Region (see chapter 2). The Waiwhetu Stream and lower Wainuiomata River are strongly impacted by urban stormwater discharges while the Mangaroa River is primarily impacted by agricultural runoff.

Past studies have revealed high levels of heavy metals such as lead and zinc in the water column and sediments of the Waiwhetu Stream (Deely et al 1992; Ward 1997). These contaminants arose from historical discharges from the surrounding industrial area.

The Wellington Regional Council has implemented several initiatives to improve water quality in the Waiwhetu Stream. These include:

- The establishment of the Waiwhetu Stream working group comprising iwi, local residents, Hutt City Council and Wellington Regional Council staff. This group has produced an action plan to improve the water quality and habitat of the Waiwhetu Stream.

- The implementation of the *Take Charge* pollution prevention programme in the Seaview area. The aim of this programme is to improve industry awareness of the effects of their discharge on streams and improve discharge practises.

The marked downstream decrease in water quality in the Wainuiomata Stream as indicated by the MCI scores is likely to be attributable to a number of urban related stressors. These include water abstraction for water supply (of up to 84% of river flow), the discharge from the Wainuiomata Sewage Treatment Works, leachate from the Wainuiomata Landfill and stormwater discharges from Wainuiomata township (Stansfield 2000).

Conflicting indications of water quality from physical and chemical variables and MCI scores suggests that water quality in the Wainuiomata Stream is being impacted by one or more factors not detected in the current monitoring programme. This may include diurnal changes in dissolved oxygen, temperature or pH levels as well as chemical contaminants such as heavy metals and hydrocarbons from urban runoff.

Temporal analysis of water quality parameters in the Mangaroa River has shown that total ammonia concentrations have been decreasing in recent years (Stansfield 1999). This improved water quality is likely to be attributed to improved agricultural waste management practises in the catchment (Stansfield 2000). However, levels of dissolved reactive phosphorus in the Mangaroa River remain high. Wellington City Sites

4.2 Wellington City Sites

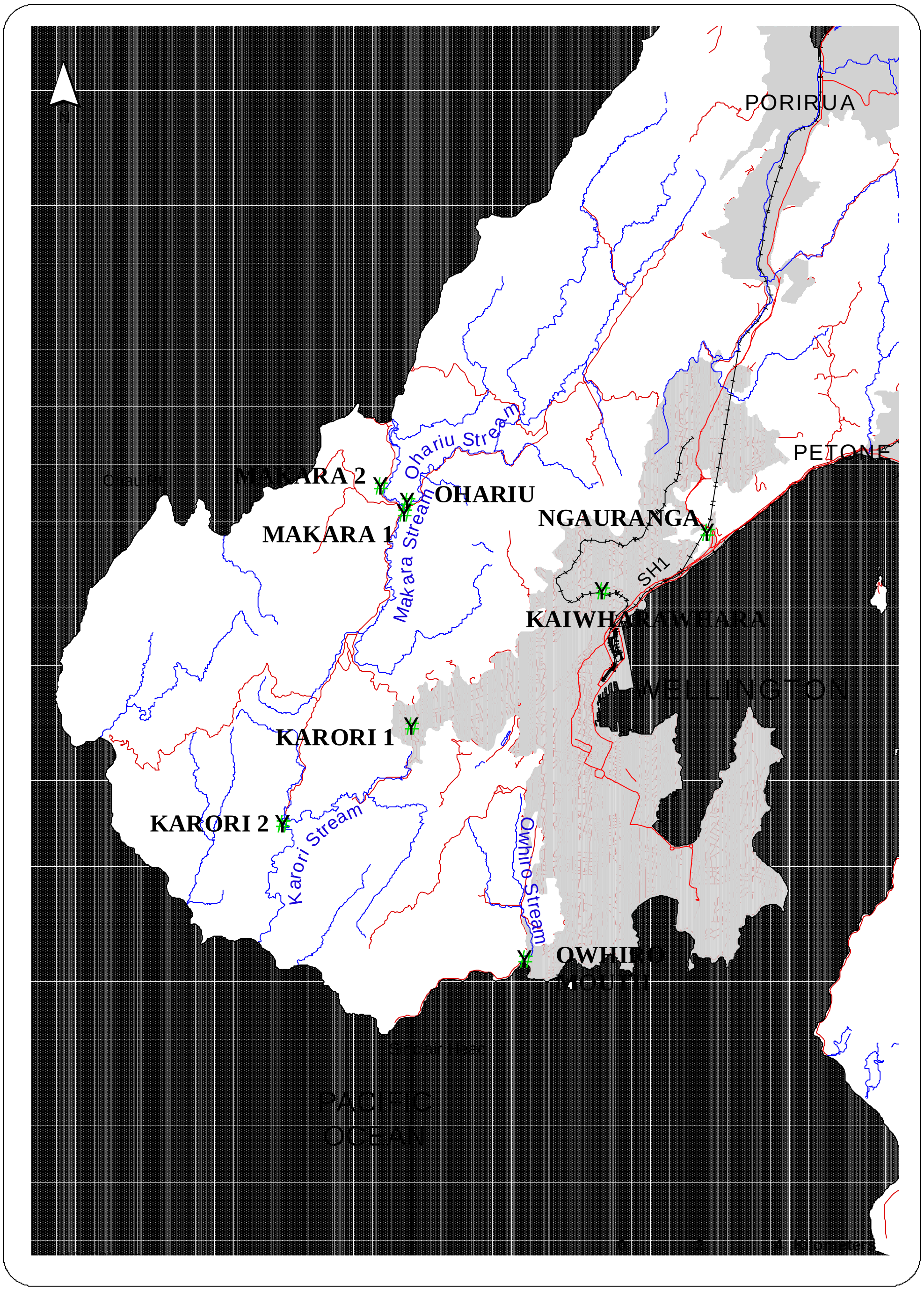
4.2.1 Background

The main streams in Wellington City are:

- Makara Stream
- Ohariu Stream
- Karori Stream

- Owhiro Stream
- Kaiwharawhara Stream
- Ngauranga Stream (Fig. 4.5)

The Makara and Ohariu Streams flow through a combination of high and low producing pasture country, while Owhiro, Ngauranga and Kaiwharawhara Streams drain urban areas. The Karori Stream flows through urban areas in the upper half of its catchment and pasture in the lower reaches (DOSLI, 1995).



Wellington City Sites

Figure 4.5. Map of the Wellington City sites.

4.2.2 Results

Though Wellington City streams generally complied with dissolved oxygen, pH, ammonia and temperature guidelines, periphyton cover exceeded guidelines on 11 occasions (Table 4.3). Periphyton blooms were observed at least once at all but the lower Karori Stream site and generally occurred during the 2000-2001 summer period.

Table 4.3 The number of occasions water quality variables at Wellington City sites were outside of guideline limits of the 15 sampling occasions from March 2000 to June 2001.

Site	Dissolved Oxygen	pH	Total Ammonia	Temperature	Periphyton	Dissolved Nutrients
Makara 1	0/15	0/15	0/15	0/15	1/15	1/1
Makara 2	0/15	0/15	0/15	0/15	1/15	0/1
Ohariu	0/15	0/15	0/15	0/15	1/15	0/1
Karori 1	0/15	0/15	0/15	0/15	2/15	2/2
Karori 2	0/15	0/15	0/15	0/15	0/15	N/a
Owhiro	0/15	1/15	0/15	0/15	4/15	1/4
Kaiwharawhara	0/15	0/15	0/15	0/15	1/15	1/1
Ngauranga	0/15	0/15	0/15	0/15	1/15	0/1
Total	**0**	**1**	**0**	**0**	**11**	**5**

In the Makara, Karori and Kaiwharawhara streams dissolved nutrient levels were high enough to stimulate the periphyton proliferation for that accrual period on each occasion. In the Owhiro Stream blooms were observed on four occasions but dissolved nutrients were only high enough to be the main factor stimulating periphyton growth on one of these occasions.

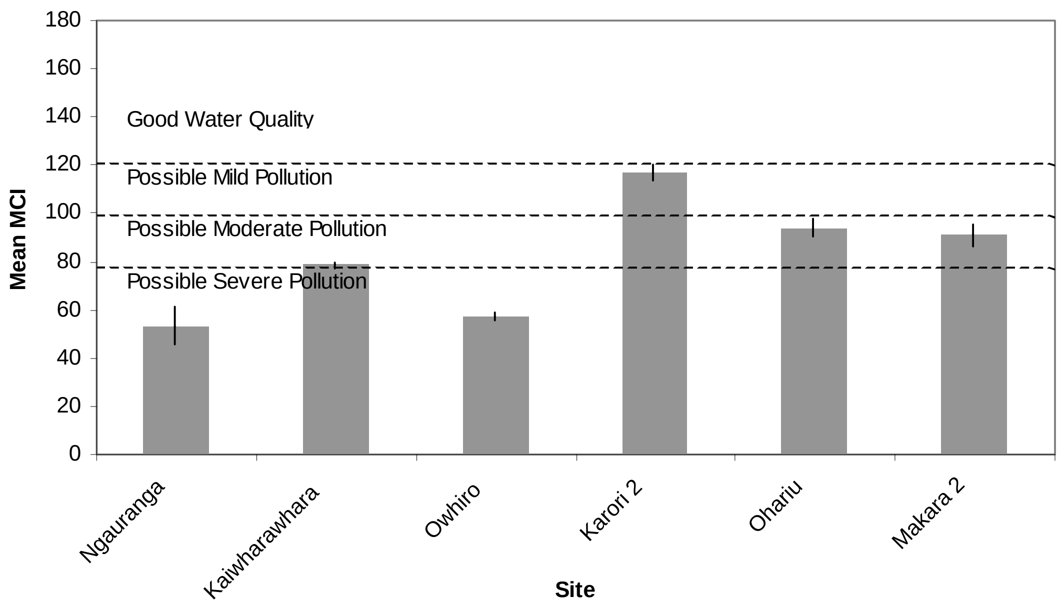


Figure 4.6 MCI scores from the Wellington City sites.

MCI scores in the lower Karori Stream indicated possible mild pollution while the Ohariu and lower Makara Stream sites indicated possible moderate pollution (Fig. 4.6). MCI scores recorded from the Ngauranga, Kaiwharawhara and Owhiro

Streams suggest possible severe pollution at these sites. MCI scores from the Ngauranga River were the lowest of all of the Wellington City sites.

4.2.3 Discussion

Poor water quality in the Kaiwharawhara, Ngauranga and Owhiro Streams are affected by a range of urban impacts including: stormwater discharges, channelisation, and pollution incidents. Levels of heavy metals (i.e., zinc, copper and cadmium) in the water column and sediments in the Ngauranga and Kaiwharawhara Streams often exceed water quality guidelines (Ward 1997). Very high numbers of faecal coliforms are consistently recorded in the upper reaches of the Karori Stream. This faecal contamination is likely to be due to sewage/stormwater system cross connections, and is probably also associated with elevated levels of dissolved reactive phosphorus measured at this site.

Discrepancies between the water quality indicated by monitoring of physical and chemical parameters and that suggested by assessment of macroinvertebrate communities indicates that the current monitoring programme is not adequately detecting impacts on these Wellington City Streams. Additional factors affecting the water quality of these streams may be diurnal variation in dissolved oxygen, temperature and pH levels as well as heavy metal and hydrocarbon contamination in stormwater discharges.

Continuous monitoring of dissolved oxygen, pH and temperature during summer low flow periods should be carried out to assess diurnal variation in these factors as this can have considerable effect on stream biota. In addition, study of heavy metals and polycyclic aromatic hydrocarbons (PAHs) in the water column and sediments of these urban streams during high flow events as well as during normal conditions should be carried out to improve our understanding of factors affecting water quality in Wellington City Streams.

Recently an urban community index (UCI) and an urban stream habitat assessment method (USHA) have been developed by NIWA to more adequately assess the biological health of urban streams (Suren et al 1998). Integration of these methods into the baseline monitoring of urban streams such as those found in Wellington City may provide a more accurate assessment of the water quality of these streams.

Wellington Regional Council initiatives to improve water quality in Wellington City streams include:

- The implementation of riparian planting trials on the Karori Stream to improve stream habitat values
- A detailed study of urban stormwater characteristics and impacts on streams in the Wellington Region

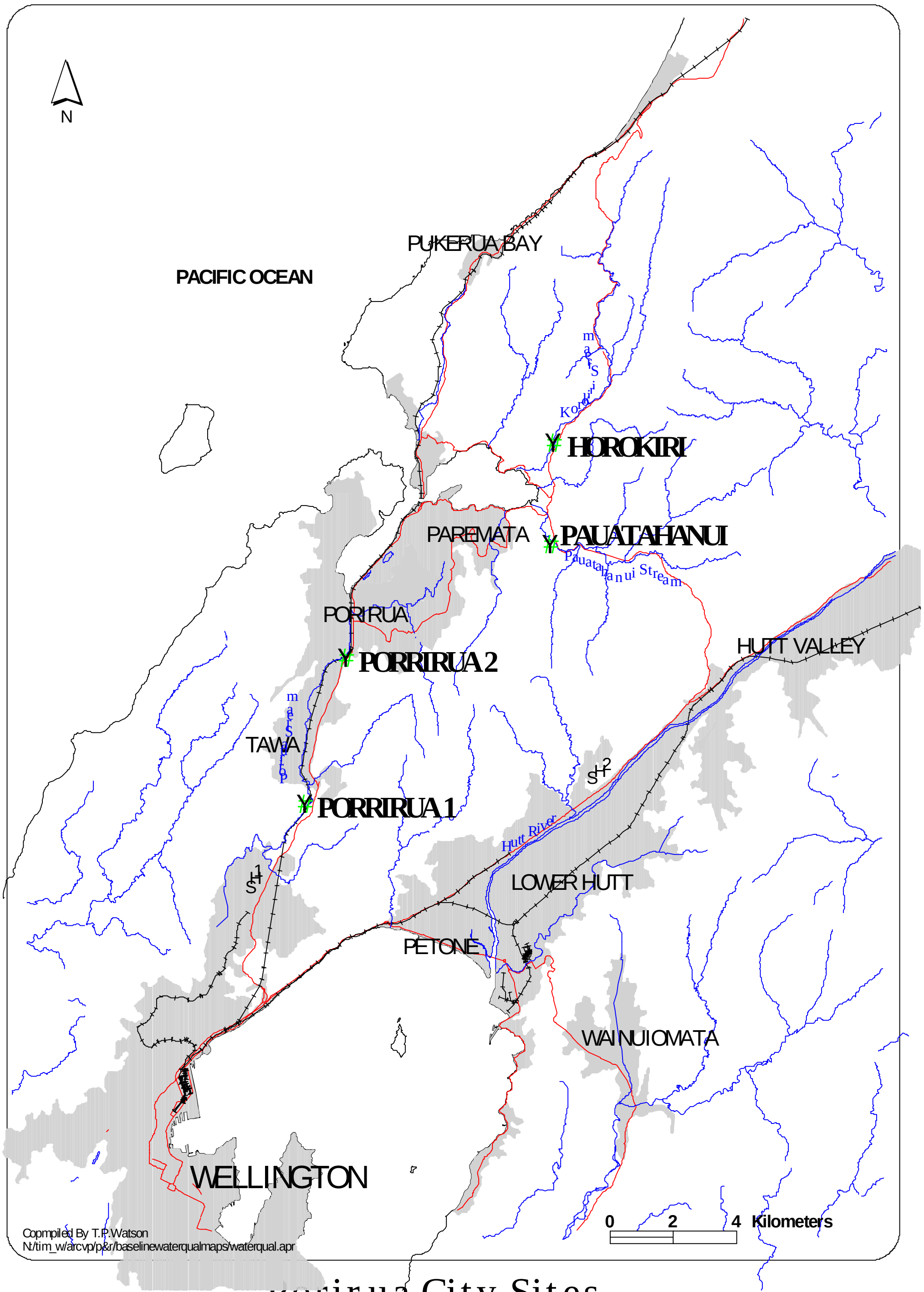
It is hoped that as information from these initiatives comes to hand and practises are improved an improvement in the water quality of Wellington City Streams will be observed.

4.3 Porirua City Sites

4.3.1 Background

The major streams in the Porirua area are the Horokiri Stream, Pauatahanui Stream and the Porirua Stream (Fig. 4.7).

Land surrounding the upper and middle reaches of the Pauatahanui and Horokiri Streams is predominantly used for high and low producing pasture while the Porirua Stream has a catchment, which is predominantly urban. (DOSLI, 1995). In recent years major subdivision works have been carried out in the Pauatahanui catchment.



Porirua City Sites

Figure 4.7. Map of Porirua City sites.

4.3.2 Results

Periphyton cover exceeded the guideline levels on numerous occasions in waterbodies in the Porirua area (Table 4.4). These blooms were particularly pronounced in the Horokiri and Pauatahanui Steams where elevated levels of dissolved nutrients were often likely to be the primary cause of the periphyton proliferations.

Table 4.4 The number of occasions water quality variables at Porirua sites were outside of guideline limits of the 15 sampling occasions from March 2000 to June 2001.

Site	Dissolved Oxygen	pH	Total Ammonia	Temperature	Periphyton	Dissolved Nutrients
Porirua 1	0/15	0/15	0/15	0/15	1/15	0/1
Porirua 2	0/15	0/15	0/15	0/15	0/15	N/a
Horokiri	0/15	0/15	0/15	0/15	5/15	2/5
Pauatahanui	0/15	0/15	0/15	0/15	13/15	7/13
Total	**0**	**0**	**0**	**0**	**19**	**9**

Assessment of macroinvertebrate communities at these sites suggested generally low water quality at all baseline sites in the Porirua area (Fig. 4.8). MCI scores in Horokiri Stream indicated possible moderate pollution while scores from Pauatahanui, and both upper and lower Porirua Stream sites suggested possible severe pollution.

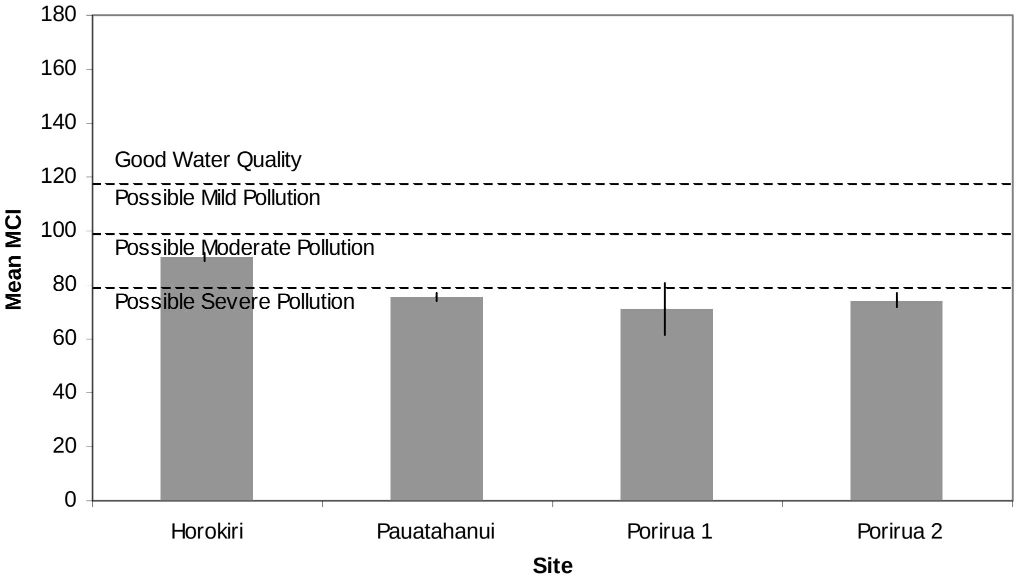


Figure 4.8. MCI scores from streams in the Porirua Area.

4.3.3 Discussion

The Pauatahanui and Horokiri Streams have predominately rural catchments and their poor water quality is likely to be attributable to impacts from diffuse agricultural runoff. In contrast, possible severe pollution indicated by macroinvertebrate communities in the Porirua Stream is likely to be due to stormwater discharges from urban areas. As is the case in other urban streams in the

Region the current monitoring of physical and chemical parameters does not appear to provide an accurate indication of water quality in the Porirua Stream. However, a targeted study of the Porirua Stream completed in the last year has helped identify the contaminants of concern and to identify major problem areas.

To improve understanding of the impacts on water quality in urban streams such as the Porirua it is recommended that:

- studies of diurnal changes in factors such as dissolved oxygen, pH and temperature be carried out
- stream waters be analysed for heavy metals and PAHs
- NIWA developed methods for assessment of urban stream biological communities and habitat be incorporated into the current freshwater monitoring programme.

The Porirua Stream catchment is one of the areas to be targeted by the *Take Charge* pollution prevention programme.

4.4 Kapiti Coast Sites

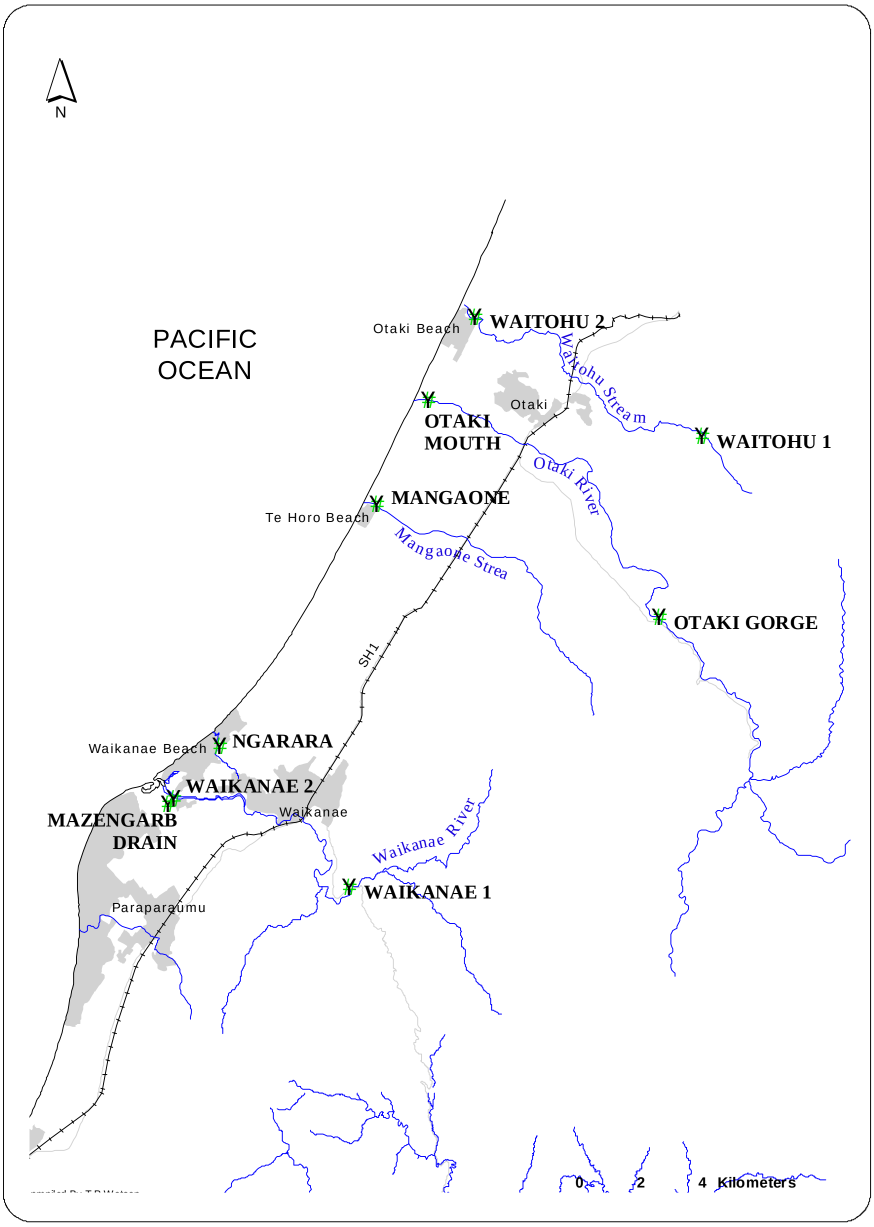
4.4.1 Background

Two rivers, three streams and one drain are monitored on the Kapiti Coast as part of the baseline freshwater monitoring programme, they are:

- Waitohu Stream
- Otaki River
- Mangaone Stream
- Waikanae River
- Ngarara Stream
- The Mazengarb Drain (Fig. 4.9)

With the exception of the Ngarara Stream and the Mazengarb Drain, these water bodies have their headwaters in the Tararua Ranges. Native beech and exotic forest in the foothills cover the upper reaches of these catchments. The middle and lower reaches of the catchments are characterised by several agricultural land uses including dairying, pastoral farming, horticulture and a small number of orchards (DOSLI, 1995).

The Ngarara Stream and Mazengarb Drain originate in swampy low-lying areas in the coastal area of Waikanae.



Kapiti Coast Sites

Figure 4.9 Map of Kapiti Coast Sites.

4.4.2 Results

Guidelines for dissolved oxygen levels were frequently exceeded in the Mangaone, Ngarara, Mazengarb drain, and lower Waitohu and Waikanae River/Stream sites (Table 4.5). Dissolved oxygen levels were particularly low in the Ngarara Stream, which was outside of aquatic ecosystem guidelines on every sampling occasion. Total ammonia levels were also extremely high in this stream, exceeding guideline levels on 12 out of 15 sampling occasions. Ammonia levels in the Mazengarb drain exceeded guideline levels on two occasions. Due to the soft substrate found at many of the Kapiti Coast sites excessive periphyton growth was uncommon.

Table 4.5 The number of occasions water quality variables at Kapiti Coast sites were outside of guideline limits of the 15 sampling occasions from March 2000 to June 2001.

Site	Dissolved Oxygen	PH	Total Ammonia	Temperature	Periphyton	Dissolved Nutrients
Waitohu 1	0/15	0/15	0/15	0/15	0/15	N/a
Waitohu 2	7/15	0/15	0/15	0/15	0/15	N/a
Otaki 1	0/15	0/15	0/15	0/15	0/15	N/a
Otaki 2	0/15	0/15	0/15	0/15	1/15	0/1
Mangaone	13/15	0/15	0/15	0/15	0/15	N/a
Waikanae 1	0/15	0/15	0/15	0/15	0/15	N/a
Waikanae 2	5/15	0/15	0/15	0/15	N/a	N/a
Ngarara	15/15	0/15	12/15	0/15	N/a	N/a
Mazengarb drain	11/15	0/15	2/15	0/15	N/a	N/a
Total	**52**	**0**	**14**	**0**	**1**	**0**

Both the physical, chemical and algal assessment monitoring and MCI scores indicated good water quality at sites in the upper Waitohu, Otaki and Waikanae Rivers. MCI scores from the lower Otaki River indicated possible mild pollution while those from the lower Waikanae River suggested possible moderate pollution (Fig. 4.11).

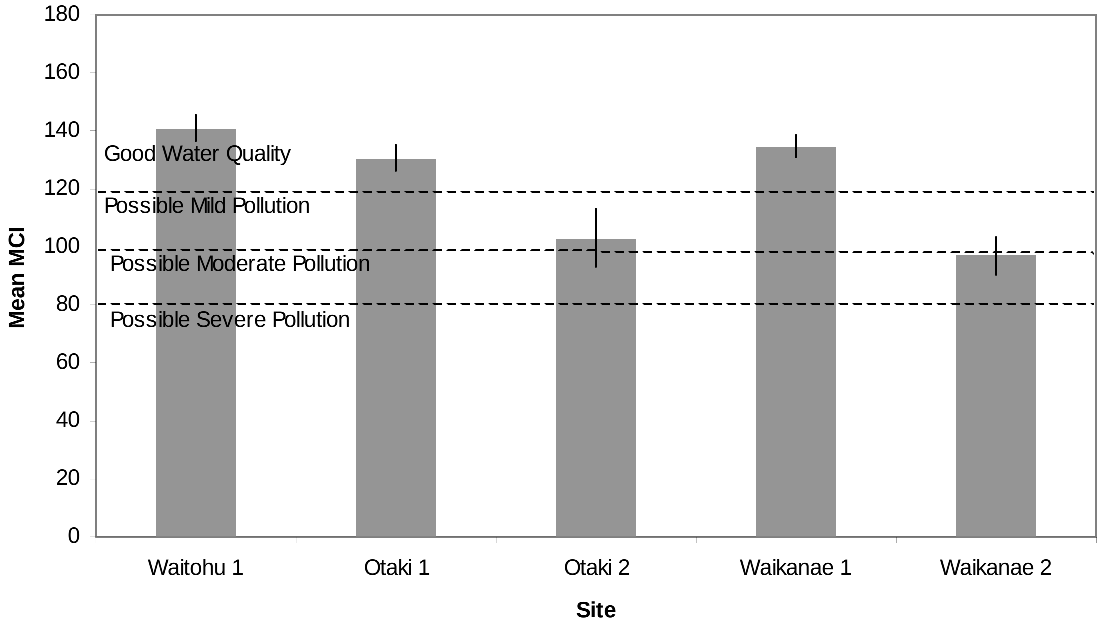


Figure 4.11. MCI scores from sites in the Kapiti Coast Area.

Unfortunately the sites suggested by physical and chemical parameters to have the poorest water quality such as the Ngarara, Mangaone, lower Waitohu and the Mazengarb drain are not currently assessed using macroinvertebrate communities as their soft substrates make them unsuitable for MCI assessment.

4.4.3 Discussion

Water quality in the low-lying Kapiti Coast streams is amongst the worst in the Wellington Region. The Mangaone, lower Waitohu, lower Waikanae, Ngarara and Mazengarb Drain all frequently had extremely low levels of dissolved oxygen. The

Ngarara Stream and Mazengarb drain have very high ammonia levels and were the only sites in the Wellington Region where levels exceeded aquatic ecosystem guidelines.

Poor water quality in these water bodies is likely to be related to the low lying nature of their catchments and the effects of intensive agricultural land use. In addition, the low flows experienced by these streams allows for little dilution of the pollutants they receive, further compounding their poor water quality.

In addition to diffuse agricultural inputs the extremely poor water quality found in the Ngarara Stream is likely to be related to upstream point discharge from the Waikanae Wastewater Treatment Plant. An assessment of the environmental effects of the wastewater treatment plant showed levels of ammoniacal nitrogen and dissolved reactive phosphorus were considerably higher downstream of the WTP discharge to the Ngarara than upstream on many occasions (Kingett Mitchell & Associates Ltd 1998). Ammonia levels in the Ngarara Stream have increased markedly in the last five years.

In contrast to urban streams, impacts on rural streams arise primarily from diffuse runoff. The water quality of rural streams in the Wellington Region is affected by diffuse inputs of suspended solids, nutrients and pathogens from agricultural land use. The presence of a margin of riparian vegetation between rivers/streams and surrounding land use is known to considerably reduce the impacts of diffuse pollutants on water bodies (Collier et al. 1995). The Wellington Regional Council is currently undertaking riparian restoration trials on the Kakariki Stream. The Kakariki Stream is a major tributary to the Ngarara Stream and improvements in water quality in the Kakariki Stream due to riparian restoration are also expected to improve water quality in the Ngarara Stream. However, management of point source pollution from the wastewater treatment plant will also need to be addressed to optimise improvements in water quality in the Ngarara Stream.

As results from the riparian restoration trials become available and riparian protection practises are promoted it is hoped that improvements in water quality in streams affected by diffuse pollution particularly rural streams such as those found on the Kapiti Coast will become evident.

5. Conclusions & Recommendations

5.1 Conclusions

Water quality is most degraded in small urban and small rural streams.

Results from this and previous reports indicate that water quality is generally better in Wairarapa streams and rivers than those in the western part of the Region. This is likely to be a reflection of less intensive land use in this part of the Region combined with generally higher flows of the rivers monitored.

The Waiwhetu, Ngauranga, Kaiwharawhara, Porirua, Wainuiomata, and Owhiro Streams are the most degraded urban streams in the Region. However, discrepancies between monitoring of physical and chemical characteristics of these streams and assessment of their macroinvertebrate communities indicates that the current monitoring programme is not accurately reflecting the water quality in these streams. It is likely that diurnal variation in parameters such as dissolved oxygen, pH and temperature as well as contamination by heavy metals and hydrocarbons are affecting water quality in these streams.

Current WRC Initiatives

The Council is currently in the middle of a major investigation to quantify the effects of stormwater discharges in the Wellington Region. The outcome of this study will be used as the basis for reviewing the current rules, which govern stormwater discharges.

The *Take Charge* pollution prevention programme has been established and aims to improve industrial discharge practises. The Waiwhetu and Porirua Stream catchments are the first to be targeted by this programme, however, the council aims for this programme to eventually be implemented region wide. It is anticipated that these actions to improve understanding and management of urban stormwater will in turn result in increases in water quality in urban streams in the region.

The Kopuaranga, Huangarua, Mangaroa, Mangaone, Pauatahanui, Waitohu, Horokiri and Ngarara Stream/River were the most degraded of the rural sites. Though the current monitoring programme appears to accurately assess water quality of streams in rural areas, assessment of diurnal variation in levels of dissolved oxygen, temperature and pH should also be carried out at the sites with poorest water quality.

Degradation of water quality in rural areas is caused largely by pollution from diffuse agricultural runoff. The presence of vegetated riparian margins is known to markedly reduce impacts of diffuse pollution on stream ecosystems. Trials currently underway on the Karori, Enaki and Kakariki Streams aim to document the benefits of riparian restoration on stream health and promote its practise on streams throughout the region.

Such restoration of stream riparian margins in conjunction with improved agricultural waste management practises currently being enforced by the Wellington Regional Council can bring about an improvement in water quality in the region particularly within small rural streams.

5.2 Recommendations

Freshwater quality monitoring results have highlighted a number of ways in which freshwater quality monitoring in the region, particularly in urban streams, can be improved. Recommendations for future action include:

- Studies of diurnal variation in levels of dissolved oxygen, pH and temperature at the Wainuiomata, Kaiwharawhara, Ngauranga, Owhiro, Karori, Porirua and lower Otaki sites. These waterways are likely to have considerable diurnal fluctuation in dissolved oxygen, pH and temperature and diurnal studies will better assess compliance of these variables with water quality guidelines.

- Measurement of levels of heavy metals and hydrocarbons in the water column of Wainuiomata, Kaiwharawhara, Ngauranga, Waiwhetu, Porirua and Karori Streams during normal and high flow events. These measurements will provide a more complete picture of factors affecting water quality in these streams.

- Urban community index and urban stream habitat assessment methods developed by NIWA be integrated into the current monitoring programme at selected urban sites throughout the region.

- Further investigation into the contents and impacts of stormwater in the Waiwhetu, Ngauranga, Kaiwharawhara, Porirua, Hutt and Wainuiomata catchments.

In a WRC commissioned report summarising knowledge of effects of urban stormwater in the Wellington Region, Williamson et al (2001) also recommended improved understanding of impacts on urban streams by:

- a survey of fish populations in selected urban streams (this work is already underway with surveys of native fish spawning sites being carried our throughout the region)
- development of a database of stormwater information available in the Wellington Region
- Investigation of the relationship between the degree of urbanisation in a catchment and biological impacts in urban streams

6. Problem Urban Streams

6.1 Background

This report has identified that the smaller urban streams of the Wellington Region have extremely poor water quality. Their poor invertebrate communities and poor compliance with current water quality guidelines identify this. This chapter discusses the pressures placed on these streams and the necessary responses to improve their water quality.

6.2 Pressures

The main pressures that have contributed to poor water quality in Wellington's urban streams include habitat modifications, contaminated stormwater inputs and pollution incidents.

Habitat Modifications

Urban streams of the Wellington Region are highly modified ecosystems. Often streams have been realigned, culverted and surrounding riparian vegetation has been removed to allow for urban development. This development causes extreme changes to instream habitat.

The catchments of urban streams have been altered through clearing vegetation and increasing the impervious surface area (concrete and tarseal surfaces). This alters the hydrology and habitat of the stream. Surface runoff is increased, and flood peaks become greater.

Clearing of riparian vegetation allows for increased sunlight to the stream, which may result in increased periphyton growths and water temperatures. Water temperatures become more variable because the riparian margins that normally provide a stable microclimate have disappeared. The clearance of a riparian margin takes away any capacity the stream may have had to filter contaminants from non point source pollutants entering the stream.

Realignment of the streams results in less diversity of riffle, pool and run habitat for instream fauna. Poorly designed culverts may impede fish passage, preventing fish from reaching important spawning areas.

Stormwater Runoff

Stormwater runoff is the water that runs off roads, roofs, footpaths, pasture and industrial yards, when it rains. In urban areas it is usually collected in pipes and discharged untreated to the nearest receiving water. Analysis of complaints received by council over the last three years has revealed that a lot of pollution is entering urban streams via the stormwater system (Hooper 2000).

Contaminated stormwater can comprise a cocktail of toxic substances depending on what has entered the drain. Common pollutants of contaminated stormwater include, faecal matter, nutrients, polycyclic aromatic hydrocarbons, heavy metals, silt, sewage, oil, grease, pesticides, inks dyes and detergent.

The impacts of stormwater pollution on small urban streams is not well researched as the main focus of research in New Zealand has been on the effects of land uses such as agriculture and forestry. Contaminated stormwater may contain thousands of pollutants and identifying which pollutant is primarily responsible for an impact to receiving water may be difficult to determine. The effects of pollutants may also be masked by the altered hydrological regime of the stream. Regular freshes in urban catchments often flush invertebrate fauna away leaving hardy taxa, which are aggressive colonisers.

Pollution Incidents

Records from the council's 24-hr pollution response service reveals that pollution incidents are frequent in the urban areas of the Wellington Region (Fig. 6.1). Of the small urban streams monitored as part of the baseline water quality programme the highest number of pollution incidents was measured in the Waiwhetu Stream. A total of 114 pollution incidents have been recorded in this stream since 1990. The Owhiro Stream recorded the lowest number of pollution incidents with a total of 23 since 1990. Liquid waste, silt and sewage spills were the most common types of pollution incident recorded in these streams.

However, care should be taken in comparing the number of incidents at sites as the numbers recorded may be highly correlated to the surrounding population of people who are able to observe the incidents (Bledsloe pers comm).

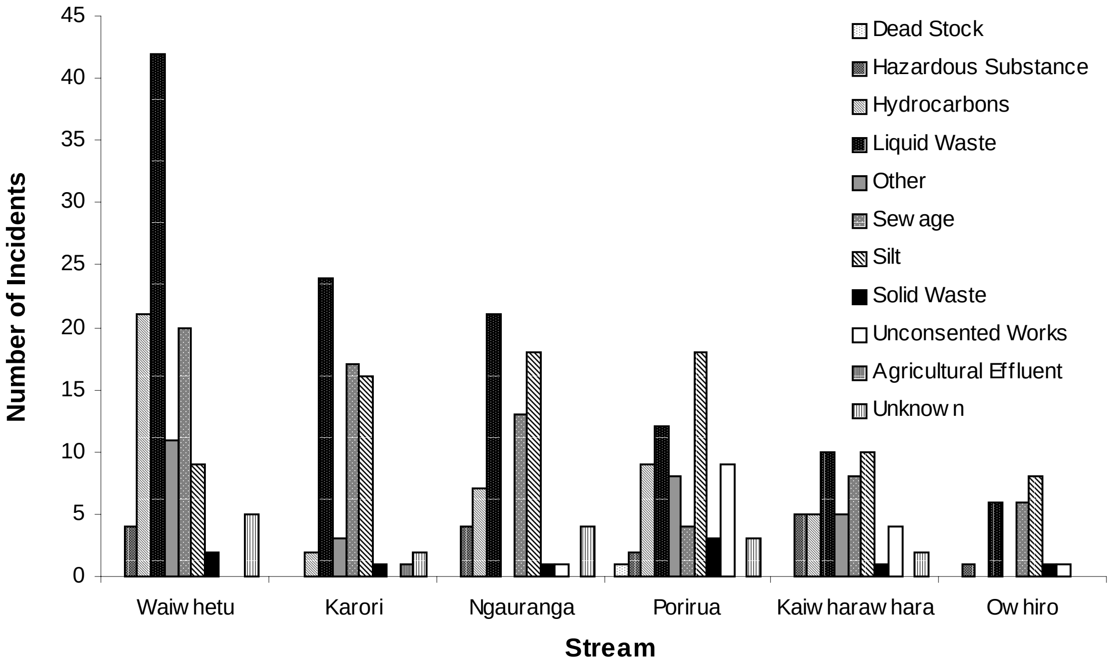


Figure 6.1. The number of pollution incidents recorded by the council's pollution response unit in the small urban streams monitored by the baseline freshwater quality monitoring programme. The totals shown are for the period from 1990 till June 2001

6.3 Current Response

More information is needed to adequately assess the health of Wellington's urban streams. An investigation of contaminated stormwater and receiving waters of the urban areas in the region is currently underway. The results of this study will identify what impacts contaminated stormwater is having on these receiving waters.

The council has also established an urban pollution prevention programme called *Take Charge*. The aim of this programme is to improve industry awareness of the effects of their discharges to stormwater on streams and improve industrial discharge practises. This programme is currently being trialed in the Waiwhetu Stream catchment and will soon be extended to the Porirua Stream catchment.

Care groups have been set up for the Waitohu, Kaiwharawhara and Waiwhetu streams of Wellington. The purpose of the care groups are to

- Promote restoration of streams
- Educate the public on the benefits of stream restoration
- Promote kaitiakitanga of our streams

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Appendix 1:

Water Sampling Methods

Chemical/Microbiological Methodology

Sampling and Analyses

During the 1998/99 sampling year, water samples were collected monthly from 50 monitoring sites across the Wellington Region. Sampling sites are listed in Appendix 4. The sampling year ran from March 1998 to February 1999.

Samples were analysed for the 12 variables listed below. The significance of each variable is described in this appendix also.

- Dissolved Oxygen
- Percentage Saturation
- Biochemical Oxygen Demand
- Turbidity
- Faecal Coliforms
- pH
- Temperature
- Dissolved Reactive Phosphorus
- Nitrate-N
- Dissolved Inorganic Nitrogen
- Ammonia-N
- Water Clarity

To ensure that samples were representative of the water body being monitored, wherever possible, grab samples were collected in mid stream. Field measurements of water clarity, dissolved oxygen and temperature were also taken. Care was taken to ensure that sites were sampled at approximately the same time each month to minimise possible changes in dissolved oxygen concentrations arising from diurnal fluctuations.

All variables, except water clarity, oxygen saturation and temperature, were analysed in the Wellington Regional Council laboratory or Wairarapa Laboratory Services Ltd laboratory using methods outlined in Appendix 5. Grab samples were transported to the laboratories in chilli bins containing ice. Samples were processed at the Wellington Regional Council laboratory in accordance with Telarc quality assurance procedures. The significance of the water quality variables monitored in the baseline water quality monitoring programme is outlined below.

Variable (units)	**Use**
pH	pH (acidity and alkalinity) will impact upon freshwater ecosystems and may change through the course of a day. Particularly high (alkaline) or low (acidic) pH levels may have an adverse impact on aquatic biota directly. Alkaline conditions may also increase the toxicity of other pollutants such as ammonia-N, which in turn may adversely impact upon the aquatic fauna (ANZECC, 1992). pH in most waters is controlled by the carbonate-bicarbonate buffer system. High degrees of undesirable periphyton growths and phytoplankton will alter the acidity and alkalinity of waterways. As aquatic vegetation respires overnight to produce carbon dioxide (a weak acid), the resulting dissolved carbon dioxide in the surrounding water is then converted to carbonic acid. The outcome is a small increase in acidity. During the course of a day, aquatic vegetation undergoes photosynthesis which requires the uptake of carbon dioxide. The result is a large increase in alkalinity (Sorrell, pers. comm., October, 1996).

Variable (units)	**Use**
Dissolved Oxygen (g/m^3)/Percentage Saturation	Dissolved oxygen levels are most often reduced in aquatic ecosystems directly by the addition of organic material or indirectly through the addition of plant nutrients. The addition of organic material stimulates the activity of aerobic heterotrophs, primarily bacteria, which utilise dissolved oxygen from the water as they mineralise the organic material. The addition of plant nutrients may influence dissolved oxygen, either through enhancing plant growth and therefore respiration at night, when they cease to photosynthesise, or through the decomposition of the plant material that has grown due to the nutrients. The concentrations of dissolved oxygen in a waterbody may vary enormously in the course of 24 hours, particularly in streams where there is significant nutrient enrichment (ANZECC, 1992). The solubility of oxygen in water is dependent on termperature, atmospheric pressure, and dissolved solids. The concentration of dissolved oxygen in water determines whether waste material is degraded by aerobic or anaerobic processes. The critical conditions for dissolved oxygen deficiency typically occur during the late summer months when temperatures are high, saturation concentrations are low, biological processes are enhanced and stream flow is low (McCutcheon,1992).
Biochemical Oxygen Demand (g/m^3)	Biochemical oxygen demand gives a measure of the oxygen required by bacteria, under standard conditions, to oxidise carbonaceous organic material into carbon dioxide and water. The biochemical oxygen demand indicates the amount of biodegradable organics present (Smith et. al, 1993).
Turbidity (NTU)	Turbidity may be defined as the relative tendency of water to scatter light. Informally turbidity is synonymous with “cloudiness’ (lack of visual clarity). Changes in water clarity may be used to interpret the aesthetic value of waterways. Differences in water clarity also affect the ability of sight feeding predators, such as fish and birds, to locate prey and the ability of algae to photosynthesise and hence provide food for animals further up the food chain (Ministry for the Environment, 1994).
Faecal Coliforms (/100 mL)	Faecal coliforms are useful for determining the suitability of waters for contact recreation and stock drinking. The most common diseases associated with swimming areas are eye, ear, nose and throat infections, skin diseases and gastrointestinal disorders. A number of pathogens and parasites can be transmitted by contaminated water to livestock which may result in reduced growth, morbidity or mortality. Faecal coliforms are "indicator organisms". This means their presence in water is indicative of harmful

Variable (units)	Use
	pathogens. Measurement of harmful pathogens themselves is difficult or impossible (ANZECC, 1992).
Temperature (°C)	Water temperature has a substantial effect on the functioning of aquatic ecosystems and the physiology of the biota. Physiological processes have thermal optima, and alterations to ambient temperatures may affect the species exposed in a variety of ways. Growth and metabolism, timing and success of reproduction, mobility and migration patterns and production may all be altered by the changes in ambient temperature regimes. Effects may be direct through changes to the metabolism, or indirect through the influence on the solubility of oxygen in water and changes to the toxicity of ammonia-N (ANZECC, 1992).
Dissolved Reactive Phosphorus (g/m^3)	Dissolved reactive phosphorous is a form of phosphate that is available for plant growth and will assist in interpretation of undesirable periphyton growths results (ANZECC, 1992). Dissolved reactive phosphorus concentrations in water samples are often inversely related to undesirable periphyton cover due to uptake of the nutrient by periphyton (Smith et. al, 1993).
Nitrate-N (g/m^3)	Nitrate-N is mainly derived from land and subsoil drainage. If most of nitrogen in the water is in the nitrate form, the waters may be considered stabilised and indicate previous pollution. Nitrate is an important nutrient for the growth of algae and other plants and may be harmful to stock in sufficient concentrations (ANZECC, 1992).
Dissolved Inorganic Nitrogen (g/m^3)	Dissolved Inorganic Nitrogen is a measure of the nitrogen available to plants. Dissolved Inorganic Nitrogen = (ammonia-N + nitrate-N) (ANZECC, 1992).
Ammonia-N (g/m^3)	The presence of toxic unionised ammonia indicates some contamination due to wastes or anaerobic waters. Of the wide range of aquatic organisms tested, invertebrates have proven to be most sensitive to ammonia-N. The toxicity of ammonia is dependent on the concentration of the undissociated form (NH_3), which is controlled by the pH and temperature of the solution (ANZECC, 1992).
Water Clarity (m)	Refers to the transmission of light through water. Poor water clarity may reduce the ability of light to reach aquatic plant life, the ability for predators to see their prey, and reduce the aesthetic value of streams and rivers (MfE, 1994).
Periphyton Cover (%)	Periphyton are the plants (usually algae) which grow on objects such as stones, logs and other plants. Undesirable periphyton growths may block intake screens for water supply, and reduce the aesthetic, recreational and ecosystem

Variable (units)	Use
	values of rivers and streams (MfE, 1992).
Semi-quantitative Macroinvertebrate Community Index	Macroinvertebrates are aquatic insects, crustaceans, worms and snails living in the beds of rivers and streams. These macroinvertebrates are collected from cobble beds and are used to calculate what is known as the Semi Quantitative Macroinvertebrate Community Index (SQMCI) (Stark, 1985). The SQMCI is based on the pollution tolerances of aquatic invertebrates where each taxon is assigned a score from 1 to 10. The more sensitive taxa are allocated higher scores while highly tolerant forms are allocated low scores. A Macroinvertebrate Community Index score is estimated by averaging the taxa scores and multiplying the result by a scaling factor of 20. Macroinvertebrates are susceptible to changes in sedimentation, undesirable periphyton growths, warm water temperatures, pH, low dissolved oxygen concentrations and toxins. The advantages of using the Semi-quantitative Macroinvertebrate Community Index are as follows: Macroinvertebrates indicate long-term water quality conditions compared with spot chemical samples which only represent water quality at time of sampling. Macroinvertebrates have advantages over other types of biological analyses. Macroinvertebrates are useful indicators of water quality because of long life spans (3 months-2 years) and their relatively sedentary nature and ease of sampling compared to fish. The Macroinvertebrate Community Index reduces complex information on community structure into a single number. Macroinvertebrate analyses are a useful means of assessing the life supporting capacity of waters.

Data Management, Preparation and Processing

Chemical and microbiological results were stored on Hill Top (Briffault and Zurr, 1991) or Excel. Prior to statistical analysis and other calculations, samples with variable concentrations reported as less than and greater than detection limits (i.e. non-detects) were replaced by values one half of the method detection limit, and the method detection limit respectively i.e.

$<x=1/2x$ and $>x=x$.

This procedure is in accordance with Ward et al (1990).
Summary statistics of annual results were calculated using Excel and are presented in Appendix 6. The median was employed as a measure of central tendency due to the skewness of the water quality data sets.

Flow Adjustment

Flow adjustment allows the user to relate 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, 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.

Flow adjustment was performed using the WQSTAT PLUS for Windows programme. For simplicity, the following log – log relationship between water quality and flow is assumed.

Log Concentration = b(log flow) +a

WQSTAT PLUS uses linear regression to estimate the slope and intercept of the line above. Then from each water quality observation (log concentration), the corresponding prediction based on flow, b(log flow)+ a is subtracted, producing a series of residuals with a mean of zero. To each residual , the mean of the original log concentrations series is added, producing series of residuals with a mean of zero. To each residual, the mean of the original log concentrations series is added, producing a flow – adjusted series of log concentrations which has the same mean as the original. Next, the antilogs of the log concentrations are found, and a final correction is made so that the resulting series in original concentration units will have the same mean as the original series of observations.

Trend Analysis

Trend analysis was conducted using a statistical method called the Seasonal Kendall Sen slope estimator. For monthly samples the seasonal Kendall Sen slope estimator is the median of all possible combinations of slopes for each of the months of the year. For example, in a 4 year record there will be 4 observations for January. There will thus be 10 (4+3+2+1) possible combinations of all pairs of January observations resulting in 10 January slopes. This will also be the case for each of the other 11 months. The seasonal Kendall Sen slope estimator is computed as the median of all 120 (=10*12) individual slopes. This means that seasonality is accounted for, because the results for all Januarys are compared one with another, but they are not compared with those from the other months. The Seasonal Kendall trend test assesses whether the trend slope is significant or not (i.e the probability of the observed trend being due to chance). This is often called a p value. It is calculated by comparing the total number of increasing monthly slopes with the total number of decreasing slopes. If the net result is close to zero the p value will be large, so the slope can be regarded as being due to chance; conversely, a large difference between the numbers of increasing and decreasing slopes produces a low p value, meaning the slope is unlikely to be due to chance. (Vant 1998) P values of 5% or less are conventionally regarded as indicating that a trend is statistically significant (i.e unlikely to be due to chance). In this analysis a p value of less than 5 % was adopted to determine statistical significance.

Semi-Quantitative Macroinvertebrate Community Index

Macroinvertebrates are the insects, snails, worms and crustaceans living in the bed of rivers and streams and can be used as indicators of water quality. Biological monitoring is undertaken using the Macroinvertebrate Community Index method (Stark 1997). The data is first coded according to abundance and tolerance scores are given to each taxa contained in the sample. The SQMCI is calculated as follows:

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

Where S = the total number of taxa in the sample, n_i is the coded abundance for the ith scoring taxon (i.e R=1, C=5, A=20, VA=100, VVA=500). a_i is the score for the ith taxon and N is the total of the coded abundances for the entire sample

Sampling and Analyses

Four macroinvertebrate samples were gathered at 42 of the 50 sample sites. These sites are listed in Appendix 4. Macroinvertebrates are usually most abundant in cobbly riffle areas and were collected from cobble substrates nearest to a chemical/microbiological sampling point.

Macroinvertebrates were collected once at each site during the summer period (November-February). The timing of sampling was determined at random, although no macroinvertebrate sampling occurred within a week of any flood event. Flooding may cause large drifts of macroinvertebrates, carrying pollution intolerant taxa from clean upper catchment habitats to less favourable lower catchment habitats (Taranaki Regional Council, 1994). Macroinvertebrate abundance is also greatly after a flood event.

Macroinvertebrate community structure is a product of the physical environment and water quality. Sites with similar physical characteristics were selected so that the macroinvertebrate community structure would predominantly reflect water quality influences. Before taking a sample, depth and velocity were measured using a ruler and velocity rod (Drost, 1963). Water depths were within 0.2-0.4m and velocities between 0.6 and 1.0m/s. If these conditions were unobtainable, a site with depth of <0.7m and flow velocity of 0.2-1.0m/s was selected (Smith et. al, 1991). Substrate size was also recorded.

Periphyton cover of the stream bed was measured using a $1m^2$ hoop.

Once sites were selected according to the above criteria, invertebrate animals were collected in a kick net with 250um mesh size. Four macroinvertebrate samples were taken at each site. Sample substrate was kicked for 30 seconds.

In the laboratory, macroinvertebrates were extracted from the sample under an Olympus dissecting microscope (x40). Specimens were identified to taxonomic levels specified by Stark (1985). Identifications were made according to Winterbourn (1973) for molluscs (snails) and Winterbourn et. al (1985) for insects.

Data Management: Preparation and Processing

Macroinvertebrate Community Index results were calculated for all 42 sites and interpreted in accordance with Table A1. Interpretation of results was based upon the methodology of Stark (1998). Physical, chemical and biological assessments were also made at the time of macroinvertebrate sampling to assist in the interpretation of results.

Table A1 Interpretation of Macroinvertebrate Community Index Scores

Macroinvertebrate Community Index Score	Water Quality Habitat
>6	Good Water Quality
5-6	Possible Mild Pollution
4-5	Possible Moderate Pollution
<4	Possible Severe Pollution

All results were entered into QUALARC or Excel.

Periphyton Cover

Sampling and Analyses

Periphyton cover was estimated by the percentage of visible mats and filaments on the stream or river bed within a $1m^2$ hoop. The assessment was made ten times across the width of the stream or river using a transect. If the stream or river width was not sufficiently long for ten samples, five samples were placed across the width of the waterway in two locations at the site. If the stream was too small for five samples an overall assessment of periphyton cover was made.

Data Management: Preparation and Processing

The total periphyton cover from each sampling occasion was stored in QUALARC or Excel.

Assessment of Results

The freshwater quality results were assessed by district or geological region. The Upper Hutt and Hutt Districts were combined to simplify analysis of the Hutt River system.

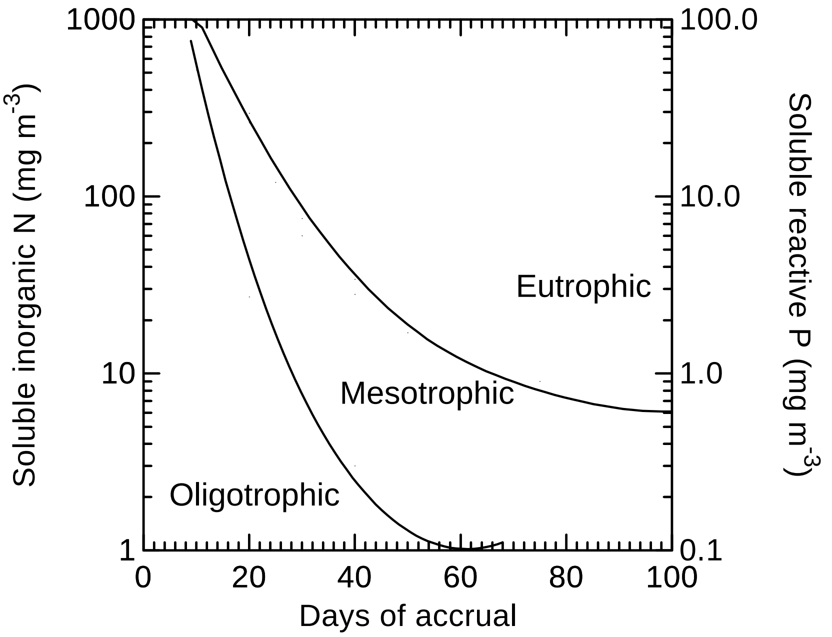
Water Quality Guidelines

The results of all 50 sites were assessed against guidelines relevant to their purposes of management under the Proposed Regional Freshwater Plan. Water quality guidelines are summarised in Appendix 2.

Appendix 2:

Water Quality Guidelines

Variable	Guideline	Management Purpose	Reference
Temperature	The natural temperature of the water shall not exceed 25 °C	Fishery	Resource Management Act 1991
% Saturation Dissolved Oxygen	The concentration of dissolved oxygen shall exceed 80% of saturation concentration	Aquatic Ecosystem Protection & Fishery	Resource Management Act 1991
Dissolved Oxygen Concentration	The dissolved oxygen shall exceed 6 mg/l measured over at least one but preferably several diurnal cycles.	Aquatic Ecosystem Protection	ANZECC Guidelines 1992
pH	6.5 - 9	Aquatic Ecosystem Protection	ANZECC Guidelines 1992
Total Ammonia	Dependent on pH and temperature	Aquatic Ecosystem Protection	ANZECC Guidelines 1992
Periphyton Cover	The % periphyton cover should not exceed: 30% filamentous green or 60% diatoms	Aquatic Ecosystem Protection	Ministry for the Environment 2001
Dissolved Nutrients	Dependent on the accrual period for the periphyton bloom (see nomograph next page)	Aquatic Ecosystem Protection	Ministry for the Environment 2001



The days of accrual is calculated as the number of days since the last fresh occurred. In this instance a fresh equates to 3* the median flow for the site concerned.

Appendix 3:

Water Quality Sites

WATER QUALITY SITES	POTENTIAL IMPACTS	MAP REFERENCE	MEAN ANNUAL FLOW (m^3/s)
Otaki gorge	Forest Park	S25 : 955-405	24.39
Waikanae 1	Forestry and Rural land	R26 : 854-317	2.67
Horokiri	Sheep farming	R26 : 712-116	0.44*
Pakuratahi	Rural runoff, forest park nearby	S26 : 945-134	2.64*
Wainuiomata 1	Forest Park	R27 : 784-927	0.65
Mt Bruce	Rural runoff, forest park nearby	T25 : 299-450	10.13
Tauherenikau	Dairying, forest park nearby	S27 : 063-011	9.37
Waingawa South Rd	Rural runoff, forest park nearby	T26 : 308-226	14.05*
Waiohine Gauge	Forest Park	S26 : 118-177	25.04
Waitohu 2	Dairying, horticulture	R25 : 895-503	0.75*
Ngarara	Rural runoff + sewage treatment plant	R26 : 812-363	0.05*
Porirua 2	Sheep farming + stormwater	R27 : 646-048	0.17*
Makara 2	Sheep farming + septic tanks	R27 : 535-955	0.29*
Karori 1	Stormwater	R27 : 543-893	0.10*
Ngauranga	Landfill, stormwater + industry	R27 : 619-943	0.17*
Waiwhetu	Stormwater	R27 : 707-958	0.26
Mangaroa 2	Dairying + pastoral farming	R26 : 886-104	2.11
Otaki mouth	Gravel extraction	R25 : 880-476	23.4*
Waikanae 2	Stormwater and rural runoff	R26 : 797-346	2.34*
Porirua 1	Stormwater runoff	R27 : 633-002	0.44
Ohariu	Rural runoff, septic tanks	R27 : 542-951	0.18*
Makara 1	Rural runoff, septic tanks	R27 : 541-948	0.12*
Owhiro mouth	Stormwater, landfill, cement works	R27 : 572-833	0.04*
Kaiwharawhara	Stormwater, landfill, sewer lines	R27 : 592-928	0.09*
Hutt 1	Forest Park	R26 : 901-119	8.46
Hutt 2	Stormwater	R26 : 862-108	15.21
Mangaroa 1	Dairy shed discharges, septic tanks	R27 : 831-003	0.44*
Wainuiomata 2	Stormwater	R27 : 732-897	1.6
Orongorongo	Rural runoff	R28 : 689-748	0.47*
Bicknells	Rural runoff + sewage treatment plant	S27 : 212-093	25.04*
Double Bridges	Rural runoff	T26 : 345-335	10.13*
Waihenga	Rural runoff + sewage treatment plants	S27 : 145-982	86.27

Good water quality	Poor Water Quality	Average Water Quality

Values followed by* indicate that the value has been calculated by correlation with another site.

Appendix 5:

Laboratory Detection Limits

Wairarapa Laboratory Services			Mabey Rd Laboratory	
Variable	Method	Detection Limit	Method	Detection Limit
Ammonium Nitrogen	Indophenol Blue (APHA, 17 Ed.)	5 mg/m^3	Phenate Method 4500/NH3F(APHA, 20 Ed.)	50mg/m^3
Biochemical Oxygen Demand	5 days, 20°C, oxygen Meter, APHA (14 Ed.) Method 507	0.1 g/m^3	5 days, 20°C, oxygen Meter, APHA (20 Ed.) Method 5210B	1.0 g/m^3
Conductivity	Radiometer	0.1 uS/cm	Orion Meter APHA (20 Ed.) Method 2510A	1.0 uS/cm
Dissolved Oxygen	YSI 59 Meter, O_2 Probe, NWSCA Method No. 38	0.1 g/m^3	YSI 55 Meter, O_2 Probe, APHA (20 Ed.) Method 4500/0G	0.1 g/m^3
Dissolved Reactive Phosphorus	Ascorbic Acid Colorimetry APHA Method 425F	3 mg/m^3	Ion Chromatography APHA (20 Ed.) Method 4110BA	10 mg/m^3
Nitrate Nitrogen	Pearson Cadmium Reduction	2 mg/m^3	Ion Chromatography APHA (20 Ed.) Method 4110B	10 mg/m^3
Turbidity	Hach 2100A	0.1 NTU	Hach 2100A	0.1 NTU