Trends in the quality of the surface waters of Taranaki

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Executive summary

Section 35 of the Resource Management Act requires local authorities to undertake monitoring of the region's environment, including land, soil, air, and fresh and marine water quality. Monitoring is undertaken to identify pressures upon the regional resources, their state, changes in their state (trends), and the effectiveness of the policies and actions undertaken to maintain and enhance the environment. The Taranaki Regional Council initiated comprehensive state of the environment monitoring programmes (SEM) in 1995 to inform itself and the regional community on the state of the region. The results of the programmes describing Taranaki's environment have been reported twice to date.

This report examines trends in the physicochemical quality of the region's surface freshwater. With the accumulation of ten years' data, and the development and implementation of appropriate statistical analysis tools, the Council is now in a position to quantitatively assess trends in water quality, taking into account variations in flow conditions. While the SEM data is the primary record used in this review, use has also been made of data gathered 25 years ago in a survey of the Taranaki ring plain conducted by the Taranaki Catchment Commission.

The state of Taranaki's surface freshwater is reviewed in general terms, and is also compared to various national guidelines and to comparable rivers and streams elsewhere in New Zealand.

The findings of this work show that generally Taranaki has good to excellent freshwater quality, and water quality is generally not compromised for appropriate water uses. Levels of organic parameters are low and water is clear. While nutrient levels (particularly nitrate) are higher than desirable to avoid nuisance growths, this of itself does not mean such growths will occur. Ammonia levels are low, and bacteriological quality meets some stock and recreational water guidelines for most of the year.

Fresh water quality in Taranaki is as good as or better than in most other equivalent water ways in New Zealand.

An analysis of recent and longer term trends in water quality shows that levels of nitrates and ammonia are substantially better now than 25 years ago. This probably reflects the changes in farm effluent treatment and municipal and industrial wastewater systems that have occurred over this period. However, more recently nitrate levels have been deteriorating, and halting this decline is a challenge for the Council and the regional community. The increasing use of nitrogenous fertilisers (particularly urea) in the region in the last few years is likely to be a contributing cause of the deterioration.

Dissolved and total phosphorus levels have been stable over the last 25 years at some sites, and have declined at others. However, at almost all sites where declines have occurred, in more recent years the decline has been arrested. This pattern follows the pattern of use of superphosphate fertiliser in Taranaki, where heavy applications into the 1980s began to reduce in the mid 1990s before going into a sharper decline.

Bacteriological quality has been maintained or has improved throughout the region over the last ten years, and clarity and suspended solids levels have been maintained, while organic contamination has been reduced.

Overall, other than for nutrients, the picture is very positive. For phosphorus, the outlook is encouraging with a previous deterioration now being substantially halted. For nitrates, the region is still better off now than it was 25 years ago despite the deterioration in more recent years. The management of applications of nitrogenous fertiliser, riparian planting, and exclusion of stock from waterways when grazing or moving are key factors that will address this situation further.

A companion report (Volume 2 under the same title) presents the data, technical analysis, and methodology used in this study in more detail.

Acknowledgement: Graham McBride, Principal Scientist of NIWA, provided comment on a draft of this report. His comments are appreciated.

Table of contents

List of tables

List of figures

1. Monitoring the environment for surface water quality

1.1 Background

1.1.1 The structure of this report

This report has five sections. Section 1 provides a background to the purpose of state of the environment monitoring (SEM) and describes the physicochemical freshwater quality SEM programme. Section 2 contains information on the state of the rivers and streams of the Taranaki region, and Section 3 identifies and discusses trends- how the quality of our rivers is changing.

Section 4 discusses whether the trends themselves might be changing, and Section 5 provides a summary review of the current situation and the future outlook.

1.1.2 Sites and parameters for analysis

The Taranaki Regional Council's predecessor, the Taranaki Catchment Commission, carried out its first comprehensive study into the water quality of the region in 1980-1981. Some sites were repeatedly sampled over an eighteen month period during this time. More recently (since 1995), the Council has been gathering data on surface water quality on a continuing basis as one of its State of the Environment monitoring programmes. The design of the programme is considered to be scientifically rigorous. It is based on a NIWA national network water quality monitoring programme. The programme requires the monthly collection and analysis of samples from eleven sites, chosen to be representative of different land uses and intensity of use. The location of each site and the catchments in which they are located are shown in Figure 1.

The parameters for analysis have been chosen to help identify the extent to which land uses may be bringing pressure upon the quality of our waterways. The parameters and their environmental significance are:-

- **temperature** (higher temperatures may make water less suitable for aquatic organisms, and may promote weed and algal growth);
- **flow** (Higher flows may indicate rainfall washing contaminants from land, or may dilute in-stream concentrations);
- **dissolved oxygen** (well oxygenated water supports a greater diversity of aquatic life);
- **biochemical oxygen demand (BOD)** (a measure of degradable organic matter, which may lead to undesirable growths and reduction in dissolved oxygen);
- **pH** (indicates the acidity or alkalinity of a stream)
- **conductivity** (indicates the level of dissolved matter)
- **black disc clarity** (cleaner water is more aesthetically pleasing and a better environment for aquatic life)
- **turbidity** (as above)
- **absorbance** (indicates the level of dissolved organic matter)
- **ammonia (NH4)** (indicative of animal wastes and organic decomposition. A nutrient for weed growth and toxic to aquatic organisms)
- **nitrate (NO3)** (nutrient for weed growth, toxic at higher levels to mammals)

- **total nitrogen (TN)** (nutrient)
- **dissolved reactive phosphorus (DRP)** (nutrient for weed growth - readily available)
- **total phosphorus (TP)** (nutrient for weed growth- includes phosphorus associated with insoluble matter)
- **alkalinity** (buffering capacity of water against acidic disturbance)
- **suspended solids (SS)** (affects aesthetic value of water and may smother benthic organisms)
- **faecal coliform bacteria (FC)** (indicate presence of faecal matter such as animal wastes, and indicate the relative risk of disease-causing organisms being present)
- **enterococci bacteria (Ent)** (as for faecal coliforms)
- **percentage algal cover** (higher levels imply a degraded environment)

Information on the methods of sample collection and analysis within the SEM programme is available from the Council. In particular it should be noted that the BOD test reported here has no nitrification inhibition.

The SEM water quality data is reported annually by the Council, and these reports contribute to the Council's collated state of the environment reports (see bibliography). This report examines trends in some of the water quality parameters listed above, primarily the nutrients and bacteriological indicators. These are the parameters influenced most by changing land use practices, and those in which there is most interest nationally. Of the remaining parameters, flow is used to adjust raw data within the statistical analysis undertaken. Dissolved oxygen levels in surface water throughout Taranaki are consistently high, and this situation is not changing, while the pH of the region's streams is affected much more by photosynthesis by in-stream algae rather than land use and so is not examined further in this report.

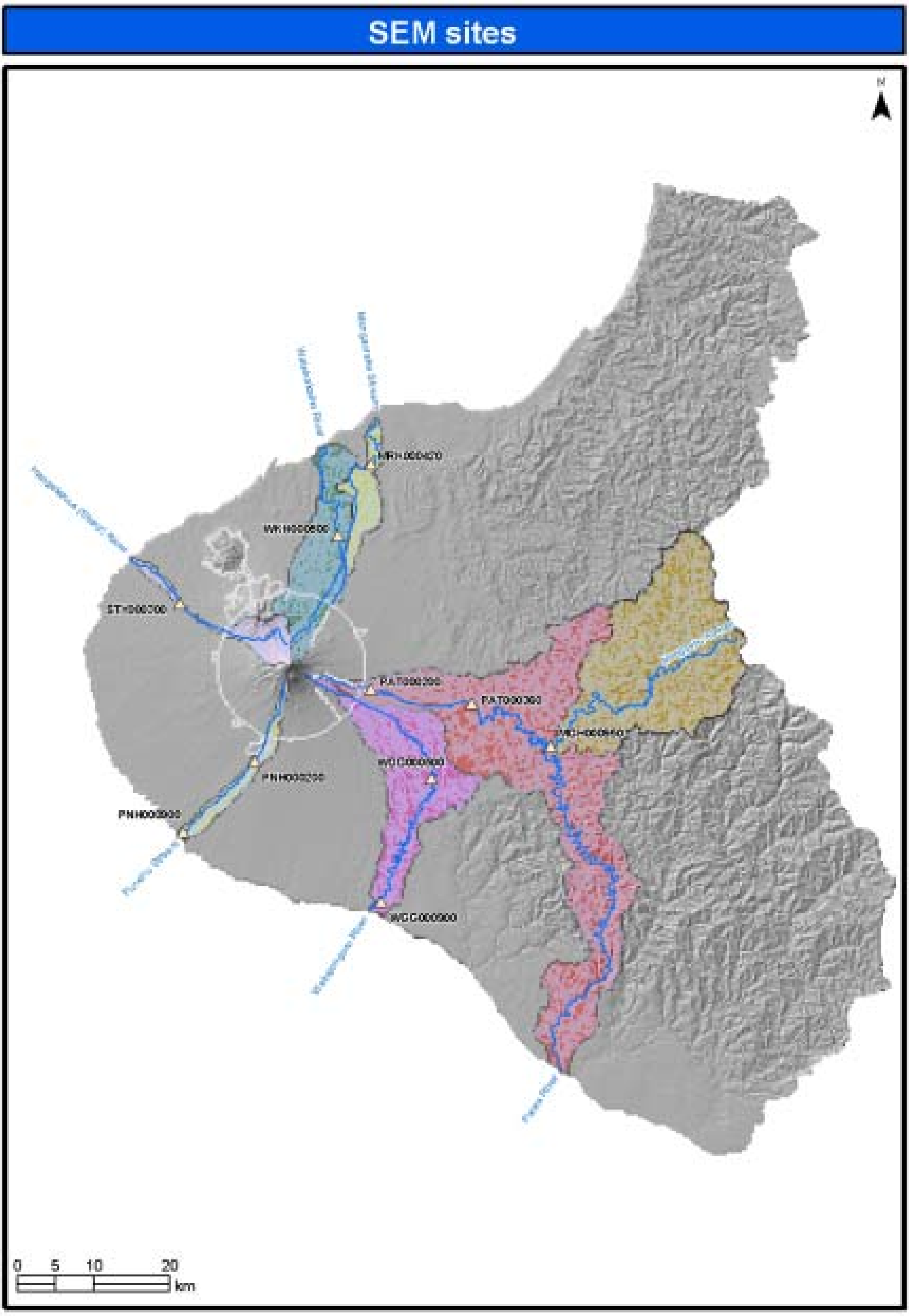

Figure 1 Freshwater SEM sites and catchments for Taranaki

1.1.3 State and trend analysis

Data can be interpreted in several ways, and care needs to be exercised when interpreting data before conclusions are drawn about the meaning and significance of data.

Trends: Data at each site can be analysed to see whether they reveal a trend**- increase, decrease, or no detectable change.** There are a range of statistical tools that can be used to identify whether there is a pattern within a scatter of data points. The basic question to be answered is: is there a change over time, and if so, how rapidly are things changing? In some cases, an increase may be desirable (clarity), in others it may be undesirable (nutrients) or make no difference (alkalinity).

The size of any change can be expressed in terms of the unit used to express the level of the parameter (e.g. g/m^3), which expresses the magnitude of the change in absolute terms, or in terms of a percentage change, which expresses change in relative terms. A doubling of a very small amount will be expressed as a small absolute change, but as a very big relative change. Depending on the information sought, either the rate of change, or the absolute level of the parameter, may be more important.

Statistical significance of trends: If there is a trend, then there are further tools that can be applied to see **how 'real'** that trend is. That is, it may look as though data are following a pattern, but the trend analysis may be influenced by (for example) a couple of points of extreme value occurring close together. A further test can be applied to examine how robust the trend is- whether it is statistically significant. The question is: how strongly can we believe that this change is a real change, or is it just a product of fluctuation and variability in 'normal' levels? On the other hand, a real change may be occurring, but the evidence to date for it might be so weak that justification for claiming there is a change might still be lacking.

Comparisons: the results from each site can be compared with **other sites**, to see whether there is a pattern common across the region or across all sites of a similar land use, or climate type, or source, or alternatively whether there might be site-specific factors at work. To focus solely on the effects of one land use while not examining what is happening at sites related to other land uses (including 'background' sites) can be misleading. For example, sites near the Mt Egmont National Park often show elevated phosphorus levels- not because of any land use practice such as fertiliser application, but because the phosphorus is naturally present within volcanic rock. The questions to be answered through comparisons are: is the water quality at this site better than or worse than at other sites; is the water quality at all sites of similar character different in some meaningful way to water quality at other types of sites?

Data can also be compared with **guideline values**, such as guidelines for water to be used for stock watering, maintaining aquatic ecosystems, or contact recreation. The question is: **how suitable** is this water for its appropriate use? Guideline comparisons may not always be appropriate e.g. streams in Taranaki close to the mountain are highly unlikely to be deep or warm enough to swim in, and so comparisons with contact recreation guidelines are inappropriate and misleading. Similarly, if most exceedances of contact recreation guidelines occur during high flows (rainfall events) or in winter, then this is not necessarily a real issue. Also, an exceedance of a guideline does not of itself mean that the water has become unsuitable for that stated purpose. For example, excessive weed growth in streams generally requires not only higher levels of nutrients, but also low and slow flows for extended periods, sunlight, and warmth. An occasional exceedance might not represent a real environmental problem, and median values (or percentile values, such as the 75%ile or 95%ile) may be more informative than maximum values.

1.1.4 Methods of analysis of data

The Taranaki Regional Council collects samples for the SEM freshwater physicochemical monitoring programme regularly throughout the year. Because many water quality variables are influenced by factors such as the season and prevailing flows, there is a growing tendency to use software to take these factors into account. In New Zealand, organisations such as NIWA and other regional councils are using a technique called LOWESS smoothing to take flow variations into account, and seasonal Kendall trend analysis to adjust for seasonality.

A summary of the methods of statistical analysis used by the Council in the preparation of this report is available upon request.

1.1.5 Adequacy of record for trend analysis

The accumulation of ten years' worth of appropriate data has provided the Council with the opportunity to undertake a rigorous statistical analysis for trend detection in its SEM data. Water quality data has been assessed previously, and reported in the Council's state of the environment reports. This earlier analysis has focused on the state of our surface water, and has considered trends only in qualitative terms.

Water quality varies with flow rates, rainfall, and seasonality. These variations can obscure any underlying trends. It is therefore important to accumulate enough data sampled across all conditions to provide opportunity to adjust for these factors. In particular, New Zealand passes through cycles of climatic drivers (El Nino and La Nina) which can last for several years. The longer the period over which data is gathered, the better the compensation for climatic influence that can be incorporated into the analysis. Now that the Council has a continual record of ten years for almost all its SEM sites, and the appropriate statistical tools have come into accepted use by other agencies, the Council has undertaken the analysis presented in this report. Water quality data at one site, in the Maketawa Stream, has been gathered only for the last three years and so is not analysed in this report.

1.1.6 National categorisation of water quality sites

Most sites used by the Council for SEM water quality were selected during the 1994-1995 period, when SEM was being established.

NIWA has subsequently (2001) developed a system of classifying surface waters according to various criteria. The development of the GIS-based River Environment Classification (REC) was supported by the Ministry of the Environment (MfE) with the involvement of a number of regional councils. The REC is an ecosystem-based spatial framework for river management purposes and provides a context for inventories of river resources, and a spatial framework for effects assessment, policy development, developing monitoring programmes and interpretation of monitoring data and state-of-environment reporting. The REC has been used to classify all the rivers of New Zealand at a 1:50,000 mapping scale.

REC uses six different classifications to define the characteristics of a river system. Each classification has a number of classes into which rivers are assigned. The six classifications are: climate, source of flow, geology, land cover, river order, and valley landform. For the purposes of trend analysis, it is considered that the two having the greatest significance are climate and land cover, while source of flow and geology are also used to classify rivers for comparative purposes in NIWA work.

In the REC system these four classes are sub-divided as follows:

Climate: warm extremely wet (WX), warm wet (WW), warm dry (WD), cool extremely wet (CX), cool wet (CW) and cool dry (CD)

Source of flow: low elevation (L), hill (H)

Geology: soft sedimentary (SS), volcanic ash (VA)

Land cover: urban (U), bare (B), indigenous forest (IF), exotic forest (EF), wetland (W), tussock (T), pastoral (P), and scrub (S).

As explained above, SEM sites in the region were chosen particularly for their usefulness at providing information in relation to particular pressures upon the water resources of the region and the state of our rivers in relation to those pressures. They were selected well before the development of the REC system, and were not chosen to reflect and proportionally represent REC classes found in the region. Despite this, examination of the Taranaki sites shows that they match the regional distribution of land cover classes very closely. The match to climatic classes found within the region is not as strong. For purposes of comparison with equivalent river systems elsewhere in New Zealand, it is useful to reference the REC classifications of the catchments for each of the Taranaki sites. These are as set out in Table 1.

Table 1 Freshwater SEM sites in Taranaki and their REC classifications

Site code	Stream/river	Location	REC
MRK000420	Mangaoraka Stream	Lower reach	WW/L/VA/P
STY000300	Stony River	Mid reach	CX/H/VA/S
PNH000200	Punehu Stream	Near National Park boundary	CX/H/VA/IF
PNH000900	Punehu Stream	Near coast	CW/L/VA/P
PAT000200	Patea River	National Park boundary	CX/H/VA/IF
PAT000360	Patea River	Mid reach	CW/L/VA/P
MGH000950	Mangaehu Stream	Lower reach	CW/L/SS/P
WGG000500	Waingongoro River	Mid reach	CW/L/VA/P
WGG000900	Waingongoro River	Near coast	CW/L/VA/P
WKH000500	Waiwhakaiho River	Mid reach	CX/H/VA/P

The sequence of the REC classification is:-
climate type /nature of source catchment /geology /land cover;
and the categories are:-

WW warm wet	L low elevation	SS soft sedimentary	IF indigenous forest
CW cool wet	H hill	VA volcanic ash	S scrub
CX cool extremely wet			P pastoral

There is a more detailed discussion of the relationship between Taranaki's SEM sites and the REC classification of the region's rivers in Appendix I of this report.

1.1.7 The Regional Freshwater Plan for Taranaki and monitoring

State of the environment monitoring involves on-going programmes that regularly monitor different parts of the environment and enable the Council and the community to ascertain how successful the Council has been in promoting the purpose of the Resource Management Act –namely, the sustainable management of our natural and physical resources. It involves the sampling of air, land, fresh water (including groundwater) and coastal water and may include chemical, physical, bacterial or viral analysis, soil analyses, flow gauges, electric fishing, biological surveys of freshwater or marine ecosystems, and the sampling and analysis of ambient air. It may also involve the review of operational monitoring data provided by other sections of the Council, consent holders and other organisations.

State of the environment monitoring puts in place systems and programmes that enable the Council to look back on environmental trends and changes over time. With this information, the Council can continuously assess its own performance in resource management as well as that of resource users.

The Council's objective in respect of point source discharges to land and water is set out in the Council's Regional Freshwater Plan for Taranaki (RFWP). It is 'to maintain and enhance the quality of the surface water resources of Taranaki by avoiding, remedying or mitigating the adverse effects of contaminants discharged to land and water from point sources' (Objective 6.2.1).

The Council's objective in respect of diffuse source discharges to land and water is 'to maintain and enhance the quality of the surface water resources of Taranaki by avoiding, remedying or mitigating the adverse effects of contaminants discharged to land and water from diffuse sources' (Objective 6.3.1).

In order to monitor the implementation and effectiveness of the Council's policies and methods that support and provide for the objectives set out above, the Council is committed to the following procedures (amongst others) :

1. use of State of the Environment monitoring;

2. continuation of the freshwater monitoring programme, including physicochemical, biological and bathing water quality programmes; and

3. use of monitoring and research programmes carried out by other agencies where appropriate (Section 10.3, *ibid*).

The RFWP came into effect in October 2001, and by statue has an effective life of no more than 10 years. In simple terms, this means that the current regulatory and management regime in place in the region for surface water quality has six years or less to run. The Council intends to conduct an interim review of the RFWP next years, half way though its statutory life. Either as a consequence of the review, or in any case at the end of the life of the RFWP, this management regime is subject to change. Therefore, when this study into trends looks at the possible consequences of current trends, this is referenced to a six year timeframe. Beyond this any projections become highly speculative, as pressures upon and measures implemented in response in the regional environment are subject to change beyond this milestone.

2. The state of our rivers

2.1 Water quality and guideline values

Data on the state of the region's rivers is presented in Figure 2 and Table 2.

In its State of the Environment Report released in 2003 (SER), the Council set out a scale and numerical values for classifying the quality (state) of the water in the region's rivers as 'excellent', 'good', 'moderate', or 'poor'. These categories were derived by staff of the Council, and took into account various standards and guidelines, knowledge of local rivers and conditions and effects, appropriate water uses, and categories used by other councils around the country. Further information on the categorisation is given in Section 4.2 of SER.

The same scale is used here (Figure 2) to indicate the state of our rivers, for the sake of consistency. The SER used five years' accumulated data, while date for ten years is presented here. This figure therefore supercedes that presented in Figure 29 of the SER.

Data can also be compared to various guidelines and standards issued by various agencies. Table 2 sets out some values commonly used or referenced in New Zealand, and indicates their purpose. Table 2 also includes a comparison of the water quality of the SEM sites against those guidelines.

When interpreting compliance with guidelines and the implications of exceedances, it is important to understand the basis of the guideline and how it is meant to be applied. Comments to assist in interpretation are set out below.

It must be noted that the Council's data represents a sampling programme that occurs on a strictly scheduled basis all year round, under all weather conditions. Therefore it includes samples collected during rainfall and when rivers are in flood or fresh conditions.

Given the previous comment, the result shown in Table 2, that the median water quality at most sites satisfies the transparency/clarity condition for **aesthetic quality** (black disc measurement), is a good result. Interestingly, the lowest transparency has been in the stream with the highest level of environmental protection- the Stony River, where continuing erosion events in the head of the catchment have released sediment loads into the stream.

It should be noted that whereas for most water quality parameters discussed in this report, an increase in value represents a deterioration in quality, for water clarity as measured by black disc method an increase in numerical value represents an improvement in quality i.e. greater clarity of the water.

For the majority of rivers, median (and in some cases maximum) values of BOD indicate minimal organic pollution, an encouraging result given the extent of pastoral farming in the region.

The E coli guideline for **protection of public health in contact recreation** is taken from the Ministry for the Environment (MfE)/ Ministry for Health's (MoH) guidelines (MfE

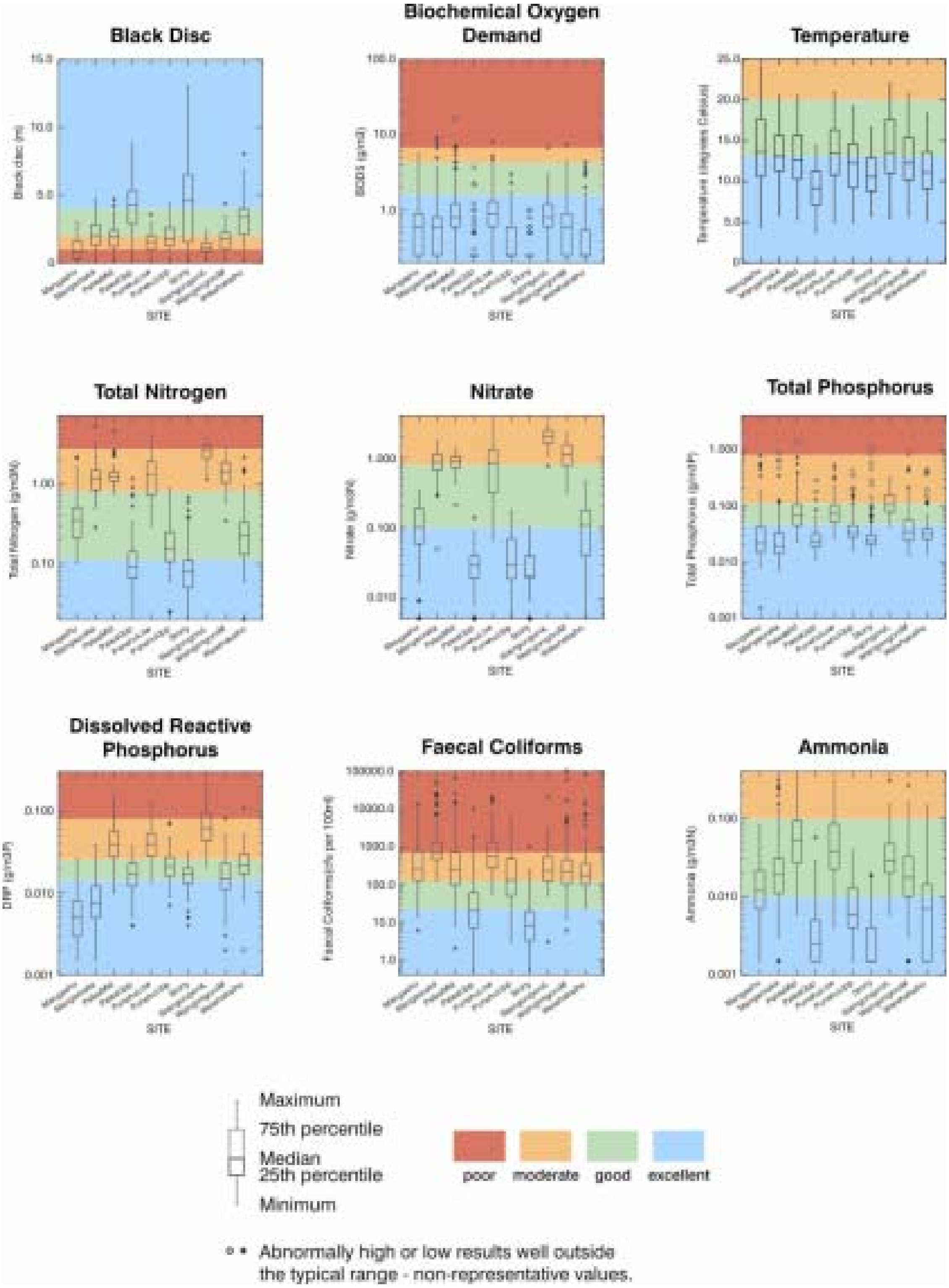

Figure 2 Surface water quality at SEM sites in Taranaki

Table 2 Surface water quality at SEM sites in Taranaki compared with guideline values

Guideline	Aesthetics		Contact recreation		Prevention of undesirable growths			Stock water			Aquatic ecosystems			Irrigation		Drinking water
	Black disc >1.6m A,SER	BOD <3 g/m^3 M,SER	E coli <550/ 100ml M,SER	BOD <3 g/m^3 SER	DRP <0.03 g/m^3 SER	TP <0.03 g/m^{3}* A*	TN <0.6 g/m3* A*	Faecal colif'm <1000/ 100 ml SER	Faecal colif'm median<100/ 100 ml A	NO3 <90 g/m^3 A	NO3 <0.7 g/m^3 A	NH4 <0.9 g/m^3 A	Temp <25 'C SER	TN <25 g/m^3 A	TP <0.8 g/m^3 A	NO3 <11.3 g/m^3 SER
PAT200 Patea Park boundary	😐	😐	😐	😐	😐	☺	☺	😐	☺	☺	☺	☺	☺	☺	☺	☺
PAT360 Patea below Stfd	😐	😐	😐	😐	☹	☹	☹	😐	☹	☺	☹	☺	☺	☺	😐	☺
WGG500 Waingongoro midreaches	😐	😐	😐	😐	😐	😐	☹	😐	☹	☺	☹	☺	☺	☺	☺	☺
WGG900 Waingongoro near coast	☹	😐	😐	😐	☹	☹	☹	😐	☹	☺	☹	☺	☺	☺	☺	☺
PNH200 Punehu Park boundary	😐	☺	😐	☺	😐	😐	☺	😐	☹	☺	☺	☺	☺	☺	☺	☺
PNH900 Punehu near coast	😐	😐	😐	😐	☹	☹	☹	😐	☹	☺	☹	☺	☺	☺	☺	☺
MRK420 Mangaoraka lower reaches	😐	😐	☹	😐	😐	☺	☹	😐	☹	☺	☹	☺	☺	☺	😐	☺
WKH500 Waiwhakaiho midreaches	😐	😐	😐	😐	😐	😐	☺	😐	☹	☺	☺	☺	☺	☺	☺	☺
STY300 Stony midreaches	😐	☺	😐	☺	☺	☺	☺	😐	☺	☺	☺	☺	☺	☺	😐	☺
MGH950 Mangaehu midreaches	☹	😐	😐	😐	☺	😐	☺	😐	☹	☺	☺	☺	☺	☺	☺	☺

Guidelines: A Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council 2000

SER As used in 'Taranaki-our place, our future', State of the Environment Report 2003

M Ministry for the Environment 'Microbiological guidelines for marine and freshwater recreational areas' 2003

* 80% of results to meet threshold

Key: ☺ maximum value (or minimum for black disc) recorded value meets suitability threshold

😐 median value meets suitability threshold

☹ median does not meet suitability threshold

2003). The Council's freshwater quality SEM programme does not necessarily collect samples representative of water quality typical of conditions at times when bathing is likely, as is stipulated in the MfE guidelines, and therefore care should be taken when comparing results against a bathing-based guideline. It should also be noted that most of the SEM sites in the Council's programme are not bathing sites- the streams are simply too shallow and small for contact recreation at these points. The Council's recreational water quality SEM programme is structured around the requirements of the MfE guidelines.

The guideline is based around the concept of a level of acceptable risk. Exceedance of the guideline does not mean that bathing is no longer safe; rather, that the risk of contracting a gastro-enteric disease under such water quality conditions is considered to have become unacceptably high.

The Council's recreational water quality SEM programme requires that eleven freshwater sites are regularly sampled during each bathing season, and compared with appropriate guidelines. The guidelines have changed frequently over the last twelve years. The latest (MfE 2003) require an assessment of the last five years' data. Of the eleven sites monitored in Taranaki, one has had a relatively poor compliance with the guideline over this period (Waimoku Stream, a coastal stream Oakura), while for the other sites, compliance rates range from 89% (Patea River in Stratford) to 100% (Waiwhakaiho River at the Merrilands domain in New Plymouth). Other sites are located at Lake Rotomanu, the mid and lower Waingongoro River, Kaupokonui River, Timaru Stream, Oakura River, Urenui estuary, and Manganui River. Exceedances are considered to be a feature common to mid and lower reaches of river and streams draining developed land throughout New Zealand. The Council follows up exceedances, and invariably bacteriological quality is found to rapidly return to typical levels.

For a more detailed and appropriate discussion of bathing water quality in the region, the Council's website and the bibliography to this report should be consulted.

Algal growth smothers habitat and food sources for more highly rated aquatic life and looks unattractive. Exceedance of guideline values at some sites is therefore of concern. However, the guidelines for the **prevention of undesirable nuisance growths** are 'necessary but not sufficient' guidelines. That is, the fact that they are exceeded will not of itself mean that nuisance growths occur in the region's streams. Rather, excessive algal growths are most likely to occur in mid to late summer, under conditions of warmth, low and slow flows, absence of recent rain events to scour the growths, and strong continuing sunlight. As noted earlier, the water quality data presented in Table 1 has been collected all year round under all meteorological conditions.

In the lower parts of most Taranaki catchments, nutrient levels are high enough to promote algal growth under summer conditions. This is true particularly of nitrate, which generally increases in concentration downstream. Phosphorus levels are more variable, with levels falling in some cases below the National Park boundary (phosphates are present from natural sources).

The Council has a separate SEM programme that focuses specifically on nuisance growths at various freshwater indicator locations in the region. In general, periphyton growths are more likely and more prolific in drier summers, when flows decrease and there is less scouring and disturbance of stream beds, more sunlight, less grazing by macroinvertebrates, higher temperatures, and less dilution of discharges containing nutrients. The lower reaches of ring plain streams in south Taranaki can be prone to nuisance growths in the late summer-early autumn period.

For a more detailed and appropriate discussion of the monitoring of nuisance growth occurrences in the region, the bibliography to this report should be consulted.

The Council also has a separate SEM programme that focuses specifically on the biological ecosystems at various freshwater indicator locations at some 51 sites reflecting a variety of water and landuse conditions and environments in the region. The region's waterways typically show that the proportion of sensitive taxa in macroinvertebrate communities reduces down the length of the waterway. This is not necessarily associated with a reduction in water quality, as changes in habitat (warmer temperatures, increased periphyton cover, more open streams, increased fine sediment on stream beds) also affect communities. The proportion of sensitive taxa are also generally lower in summer than in spring, due to rising temperatures, lower base flows, increased algal growth, and fewer freshes. However, a wet summer (such as in 2003-2004) can increase macroinvertebrate diversity and richness.

For a more detailed and appropriate discussion of the monitoring of freshwater ecology in the region, the bibliography to this report should be consulted. The Council is also beginning the preparation of a report into trends in biological quality equivalent to this report of trends in physicochemical quality, and this will be reported in due course.

The bacteriological guideline for stockwater was previously 1000 faecal coliforms per 100 mls. All median values at all sites comfortably meet this guideline. Given that higher faecal coliform levels in streams generally occur under conditions of heavy rainfall, when stream water is less likely to be utilized, maximum results above the guideline do not indicate a need for concern.

The 2000 ANZECC water quality guideline stipulates a limit of 100 thermo-tolerant coliforms (which includes faecal coliforms) per 100 mls, for median values. As noted above, with many Council samples gathered at times when stock would not need irrigation water, the guideline is not necessarily appropriate as a basis for evaluating the regional water quality data. It may be noted that at six of the sites shown in Table 2 as otherwise exceeding the bacteriological guideline, the 25^{th} percentile result satisfies the criterion. The implication is that when stock watering is necessary (drier periods with less runoff of wastes into streams), the water available at that time may well satisfy the criterion.

When data from a NIWA study prepared on behalf of and published by MfE collating water quality studies nationwide is reviewed (see next section), it can be noted that referencing the MfE bathing standard at the time of 126 *E coli* / 100 ml[1] for

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[1] (It should be noted that the standard referenced in the national report introduced above, of 126 *E coli* for the median of *E coli* measurements, was contained in the 2002 draft version of the microbiological guidelines. It does not appear in the 2003 final version. The 2003 final version requires that a site is classed into a Microbiological Assessment Category based on the 95%ile value for the site- category 'A' if the 95%ile is less than 130, category 'B' if the 95%ile lies between 130 and 260, and so on. Monitoring [not site classification] is elevated to 'alert' if a single *E coli* result exceeds 260 / 100 ml, and to 'action' if a single result exceeds 550 *E coli* / 100 ml.)

the median of *E coli* measurements (in fresh water in Taranaki, *E coli* counts are very similar to faecal coliform counts), 87% of all sites nationwide in pastoral land cover classes exceed the standard, as do 100% of all urban sites, 32% of all exotic forestry sites, and (interestingly) 42% of all indigenous forest/ scrub sites. That is, almost half of even 'pristine' sites nationwide fail the ANZECC water quality guideline for stockwater and the MfE guideline for recreational use of freshwater.

All sites satisfy the current guideline for nitrate levels in **drinking water** used for human supply.

2.2 National comparisons

Data for Taranaki's SEM sites can be compared with data from other equivalent sites (i.e. on the basis of REC categories) for New Zealand. To undertake this comparison, water quality data presented in a report prepared for the Ministry for the Environment by NIWA has been used (NIWA-MfE 2005). The report utilized data from close to 1000 sites across New Zealand. Appendix II of that report provides collated data from comparable REC sites across New Zealand.

The basis of comparison used here is of median values. Where the median value for a particular parameter for a Taranaki SEM site lies within the range of the 25^{th}-75^{th} percentile values of the NZ data for all REC equivalent sites, then the water quality of the Taranaki site is taken as being of similar quality for the purposes of this comparison. If the median value for the Taranaki site lies below the 25^{th} percentile value or above the 75% percentile value, then it is considered clearly better or worse, as is applicable (this is an indicative comparison only).

Because the data in Appendix II of the MfE report was presented in graphical form, it is difficult to interpolate precise numerical values in some cases. The information in Table 3 should therefore be treated as indicative only.

Table 3 Comparison of water quality at Taranaki SEM sites with a national database

	PAT 200	PAT 360	WGG 500	WGG 900	PNH 200	PNH 900	MRK 420	WKH 500	STY 300	MGH 950
	Patea near National Park boundary	Patea below Stratford	Waingongoro mid reaches	Waingongoro near coast	Punehu near National Park boundary	Punehu near coast	Mangaoraka lower reaches	Waiwhakaiho mid reaches	Stony mid reaches	Lower Mangaehu central Taranaki
REC	CX/H VA/IF	CW/L VA/P	CW/L VA/P	CW/L VA/P	CX/H VA/IF	CW/L VA/P	WW/L VA/P	CX/H VA/P	CX/H VA/S	CW/L SS/P
NH4	☺	😐	😐	😐	😐	😐	😐	😐	☺	☺
NO3	☺	😐	😐	☹	☺	😐	😐	😐	☺	☺
E coli	☺	☺	☺	☺	😐	😐	😐	☺	☺	☺
Clarity	☺	☺	😐	😐	☹	😐	😐	😐	☺	☹
DRP	😐	😐	☺	😐	😐	😐	☺	😐	😐	☺

NH4: ammonium NO3: nitrate DRP: dissolved reactive phosphorus

Key:
- ☺ median value is worse than the 25th percentile value of all comparable national sites
- 😐 median value lies within range 25-75th percentile values of all comparable national sites
- ☹ median value is better than the 75th percentile value of all comparable national sites

Coding:

Climate: warm wet (WW), cool extremely wet (CX), cool wet (CW) and cool dry (CD)

Source of flow: low elevation (L), hill (H)

Geology: soft sedimentary (SS), volcanic ash (VA)

Land cover: urban (U), bare (B), indigenous forest (IF), exotic forest (EF), wetland (W), tussock (T), pastoral (P), and scrub (S).

With only a few isolated exceptions, water quality in Taranaki appears as good as or better than water quality at comparable sites around New Zealand.

3. Trends in the state of our rivers

Table 4 presents the trends in water quality at the SEM sites in Taranaki in symbolic form. All results have been tested for statistical significance.

Alongside the question of whether there is a change occurring in our rivers, is the question of whether any such change has environmental implications, such as affecting the suitability of water for various purposes and uses and values. Therefore the discussion set out below also includes comments on how important for our environment any trend might be. Obviously time scale must be taken into account. The Council has an operative regional plan dealing with the quality of freshwater in the region, the 'Regional Freshwater Plan for Taranaki' (RFWP). This Plan became operative in October 2001, and has ten year lifespan (i.e. six years left to run). The discussion on the implications of trends revealed in this analysis has been placed in the context of that time frame.

Table 4 Trends in surface water quality at SEM sites in Taranaki- 1995-2005 (flow and seasonally adjusted)

	PAT 200	PAT 360	WGG 500	WGG 900	PNH 200	PNH 900	MRK 420	WKH 500	STY 300	MGH 950	Total ☺/😐/☹
	Patea near National Park boundary	Patea below Stratford	Waingongoro mid reaches	Waingongoro near coast	Punehu near National Park boundary	Punehu near coast	Mangaoraka lower reaches	Waiwhakaiho mid reaches	Stony mid reaches	Lower Mangaehu central Tara	
DRP	☹	😐	☹	😐	😐	☹	😐	😐	☹	☹	0 / 5 / 5
T P.	😐	😐	😐	😐	😐	😐	😐	😐	😐	😐	0 / 10 / 0
NO3	😐	☹	☹	☹	😐	☹	😐	☹	☹	😐	0 / 4 / 6
NH4	😐	😐	😐	😐	😐	😐	☺	☹	😐	😐	1/ 8 / 1
T N.	☺	☹	☹	😐	☺	☹	😐	☹	☺	😐	3 / 3 / 4
F. coli	😐	☺	☺	😐	😐	☺	😐	😐	☺	😐	4 / 6 / 0
Ent.	😐	😐	😐	☹	😐	😐	😐	😐	😐	😐	0 / 9 / 1
Alk	😐	😐	😐	😐	😐	😐	😐	😐	😐	😐	0 / 10 / 0
Black D.	😐	😐	😐	😐	😐	😐	😐	😐	😐	😐	0 / 10 / 0
S.S.	😐	😐	😐	☺	😐	😐	😐	😐	☹	😐	1 / 8 / 1
Temp.	😐	😐	😐	😐	😐	😐	😐	😐	😐	😐	0 / 10 / 0
BOD	😐	😐	☺	😐	☺	☺	☺	😐	😐	😐	4 / 6 / 0

DRP dissolved reactive phosphorus; TP total phosphorus; NO3 nitrate nitrogen; NH4 ammonium nitrogen
TN total nitrogen; F coli faecal coliforms; Ent enterococci; Alk alkalinity
Black D black disc; SS suspended solids; temp temperature; BOD biochemical oxygen demand

Key:
☺ statistically significant improvement
😐 no statistically significant change
☹ statistically significant deterioration

3.1.1 Patea River

At site PAT 000200, on the fringe of the Egmont National Park, there has been an increase in the level of dissolved reactive phosphate (degradation). This site is above the point of any influence from pastoral activity. The rate of change is relatively small, and even if it continues the trend is unlikely to have any environmental consequences within the remaining life of the RFWP (i.e. to 2011). Further down the catchment (PAT 000360), there has been no significant change in the level of DRP over the ten year record. This latter site lower in the catchment would have been influenced by any changes in farming activities and practices. It is also below the Stratford municipal oxidation pond system discharge, and the stability of DRP in the Patea River at this site indicates no deterioration in the performance of the municipal ponds treatment system.

Site PAT 000200 has shown a trend of a decrease (improvement) in the level of total nitrogen species (nitrate plus ammonia plus organic nitrogen). The nitrogen levels already satisfy the various water quality criteria referenced. Further down the catchment, there is no evidence of a change in the level of ammonia, but nitrate levels are increasing. Given the significant increase in the use of nitrogenous fertiliser (especially urea) within the last ten years and intensification in stocking rates, the stability of ammonia level at this site is pleasing to note. The deterioration in nitrate and total nitrogen levels at this site is not at a rate that will change the suitability of water for any purpose within the remaining life of the RFWP.

PAT 000360 shows improving faecal coliform numbers, a good outcome in terms of reduced inputs (such as farm runoff and municipal oxidation pond performance) and reduced environmental effects (increased suitability for recreational use).

Other than for these parameters, the two sites in the Patea River show stable water quality (ten and nine parameters respectively for the upper and mid-catchment sites).

3.1.2 Waingongoro River

At site WGG 000500 (upstream of the Eltham wastewater treatment system and the Riverlands meatworks discharges), DRP and nitrate levels are increasing (deteriorating), but faecal coliform levels and biochemical oxygen demand are improving, indicating less organic and animal wastes entering the river. Although the rate of deterioration of DRP is relatively high, in absolute terms the levels are low and the increase will not affect water suitability assessed against guidelines within the remaining life of the RFWP. Nitrate levels here are already above guideline values for maintaining aquatic ecosystems. Ammonia and total nitrogen levels have remained stable despite the increasing use regionally of urea.

Further down the catchment (site WGG 000900 at SH45), the decline in DRP found in mid-catchment is not evident. However, bacteriological quality declines- faecal coliform levels are not showing improvement as they are upstream but remain unchanged, while enterococci levels increase (deteriorate). However, on current trends the present state of the water will not be further compromised within the remaining life of the RFWP.

Site WGG 000900 has a longer record of data because it has been used as part of a national programme (NIWA's National River Water Quality Network). Therefore further analysis has been carried out on this record of results, and shows interesting changes. Over the last sixteen years, this site shows overall deterioration (increases) in ammonia, nitrate, and DRP. This could be associated with stocking intensification, increasing use of nitrogenous fertiliser, and discharges from the Riverlands meat works. However, when the data from the last ten years is examined, the increases in DRP and ammonia found when the sixteen year record is assessed are not apparent- that is, there has been no decline in these two parameters over the last ten years. All the changes were happening before the last decade. Even more interestingly, when the record for only the last six years is scrutinized, the increase in nitrates is also halted while DRP actually begins to improve.

That is, in the lower Waingongoro River earlier trends of deteriorating ammonia and nitrate levels have been arrested, while deteriorating DRP has not only ceased but reversed in recent years.

3.1.3 Punehu Stream

The higher site in the Punehu Stream (PNH 000200) is in pastoral land close to the Park boundary, with the catchment above this point predominantly within the Park, while the lower site (PNH 000900) is close to the coast, at the bottom of the catchment.

Over the last ten years, the higher site has shown decreases (improvements) in levels of total nitrogen and biochemical oxygen demand, and levels of other parameters have remained steady. Total nitrogen and BOD levels already satisfy relevant guidelines.

In the lower reaches of the catchment, there are trends of increases (deterioration) in DRP, nitrate (this trend is only just considered statistically significant), and total nitrogen (due in part to the change in nitrate), while there is a trend of an improvement in faecal coliform levels. The trend higher up in the catchment of an improvement in biochemical oxygen demand is also found in the lower reaches of the catchment, below farm pond and diffuse runoff discharges sources. Other parameters are unchanged.

DRP and nitrate at the lower site are already compromised, and the evidence of an ongoing deterioration in these parameters is of concern.

3.1.4 Mangaoraka Stream

This site is towards the bottom of a pastoral catchment, and has its source below the National Park.

None of the parameters monitored show evidence of deterioration over the last ten years. There are decreases (improvements) in two parameters, ammonia and biochemical oxygen demand. As at other sites previously discussed, this is consistent with improving management of nitrogenous fertiliser and animal wastes in spite of increasing fertiliser use and higher stocking rates in the region.

Only a small improvement in DRP and TP is needed at this site for it to fully satisfy (i.e. maximum rather than median values are compliant) guidelines for management of water for prevention of undesirable growths and for irrigation.

3.1.5 Waiwhakaiho River

This site is in mid-catchment, below the National Park within pastoral land upstream of the New Plymouth domestic water intake.

It is the only SEM site in the region to show increasing ammonia levels. Nitrate levels are also increasing at this site, and these two effects lead to increasing total nitrogen levels. On the other hand, DRP levels at this site have remained stable, as have all other parameters.

The changes in ammonia and total nitrogen / nitrate will not further compromise the state of water at this site within the remaining life of the RFWP.

3.1.6 Stony River

This site is in mid catchment. The river arises within the National Park and is fed by a large catchment within the Park. There is a considerable amount of riparian planting along its banks downstream of eh Park and upstream of the monitoring site. No discharges of farm wastes to surface water are allowed, due to the Local Conservation Order. The river is subject to ongoing heavy sedimentation and debris travel due to subsidence within its headwaters in the National Park. The most recent of these events occurred in February 2004.

Parameter trend analysis shows deteriorating levels of suspended solids, DRP, and nitrates in the river. This river, along with two other sites of the ten SEM sites analysed, has the highest number of parameters for which there is deterioration in quality. The headwater sedimentation releases into the river are consistent with these changes.

The rate of change of DRP is very small and the current levels are low, so even though there is a definite trend this is not of concern environmentally. Similarly, nitrate levels are far below levels of concern against guideline values.

3.1.7 Mangaehu River

This river drains the eastern hill country through pastoral land into the Patea River. The monitoring site is in the lower reaches near its confluence with the Patea River. Almost all water quality parameters have remained unchanged over the past ten years. DRP is deteriorating, but levels are far below concentrations of concern when compared to guideline values.

4. Changes in trends in nutrient concentrations

4.1 Changes over the last twenty-five years

As outlined earlier, the Council's first comprehensive study of water quality in the region was undertaken in 1980-1981, when 65 sites on the ring plain around the mountain were sampled up to eight times each. Details are given in the report 'Water quality Taranaki ring plain water resources survey', Taranaki Catchment Commission 1984 (TCC). The sampling protocol followed for the survey involved sampling under low flow or recessive (falling) river conditions at various times of the year, and excluded rainfall events and floods or rising river conditions. The full data set from the ring plain survey is therefore not strictly comparable with SEM data, which follows a 'systematically-random' protocol.

However, for the purposes of this report, a comparison has been made between the two sets of data, to identify in general terms changes in water quality in the region over the last twenty-five years. Six of the ring plain sites corresponding to sites now used for SEM purposes had flow data recorded at the time of each sampling, and SEM data for each site with corresponding flow conditions and time of year have been extracted from the SEM record to enable a comparison of equivalent data to be made. The comparison is based on median values. It should be noted that in some cases as few as 3 data points collected in the ring plain survey are being compared with in some cases more than 30 flow- and month-equivalent SEM data values. The comparison should therefore be considered semi-quantitative only.

Using this approach, the values for conductivity at each site were found to match extremely closely between the ring plain survey data and the filtered SEM data. This gives some confidence that the comparison is relatively robust.

The results are shown in Table 5.

Table 5 Semi-quantitative analysis of changes in water quality over twenty-five years

Parameter	STY300	PAT200	PAT360	WGG900	WKH500	PNH900
DRP	😐	😐	☹	☹	☹	☹
TP	😐	😐	☹	☹	☹	☹
NO3	☹	😐	☺	☹	☺	☺
NH4	😐	😐	☺	☺	😐	😐

Key:
☺ definite improvement
😐 no clear change
☹ definite deterioration

DRP: of the six sites in Table 5, four have declined in quality during the last twenty-five years. However, Table 4 shows that at three of these three sites (PAT360, WGG900, and WKH500) the decline has been arrested for the last ten years. That is, the decline happened between 1980 and 1995, and since then DRP has remained steady. This closely coincides with the end of the period of high application rates of superphosphate fertiliser in the region. The application rates began to decline in 1993 and have fallen more steadily and substantially since 1998.

Two of the sites shown in Table 4 as having increasing DRP (deterioration in water quality) over the last ten years, are shown in Table 5 as being stable overall during the last twenty-five years- that is, overall there has actually been no net change (sites STY000300 and PAT000200).

TP: of the six sites in Table 5, four have declined in quality during the last twenty-five years (the same sites showing decline in DRP). However, examination of Table 4 shows that at all four sites the deterioration in TP has been arrested and that TP levels have remained stable at these sites over more recent years.

NO3: of the six sites, there has been a significant improvement (reduction) in nitrate levels at three, and deterioration at two. At one of the two sites where there is deterioration (STY000300), the level twenty-five years ago was very low (less than detectable at the time) that a very small change in absolute terms is comparatively large in relative terms. Even the current nitrate level at this site represents excellent water quality.

Five of the six SEM sites shown in Table 4 as having deteriorated in nitrate quality over the past ten years are sites for which there is data from the ring plain survey on nitrate levels twenty-five years ago. At three of those five sites, notwithstanding the more recent deterioration in nitrate levels, there remains a substantial improvement in nitrate levels when viewed over twenty-five years. That is, some of the gains made over the last twenty-five years are now being eroded, but overall there has been and remains a clear improvement. The challenge for the Council and the regional community is that the gains that have been made should be protected.

At the time of the ring plain survey, the Taranaki Catchment Commission was putting a major emphasis into preventing the direct discharge of untreated farm wastes into streams, a thrust that had started some years previously. This is the most likely cause of the improvement achieved in nitrate and ammonia (see next paragraph) levels in the region over the last twenty-five years.

NH4: levels of ammonia at all sites used in this comparative study have been maintained or improved (decreased) over the last twenty-five years, despite the increased pressures upon water quality that have occurred during that time. While Table 4 shows that at one site (WKH000500) there has been an increase in the median ammonia concentration within the last ten years, this represents only a return towards the concentrations present at this site previously. There has been no net deterioration over a twenty-five year timeframe (Table 5).

4.2 Trends in recent years

Since 1997, there have been two significant changes in the use of fertiliser in Taranaki. The use of phosphate-based fertiliser has halved, while the use of nitrogenous fertiliser has increased considerably. There is also a trend towards land application of dairy shed effluent over discharge to rivers, while stocking rates on dairy pasture are increasing. Therefore while the statistical robustness of a trend, if any, from more recent data is less than if the full ten year data set is used (that is, we are less certain that any trend is ‘real’ longer term), applying this analysis may help identify early evidence of a changing pattern.

Table 6 Changes in trends in surface water quality at NIWA sites in Taranaki over the last 16, 10, and 6 years

	Waitara Bertrand Rd			Manganui SH3			Waingongoro SH45		
	16 years	10 years	6 years	16 years	10 years	6 years	16 years	10 years	6 years
Ammonia	☺	😐	😐	☺	😐	😐	☹	😐	😐
Nitrate	😐	☹	☹	☹	😐	☹	☹	☹	😐
DRP	😐	☺	😐	☺	☺	☺	☹	😐	☺
Total Nitrogen		☹			😐			☹	
Total Phosphorus		😐			😐			😐	
Clarity	😐		☹	☺		😐	😐		😐

Key:
☺ statistically significant improvement
😐 no clear change
☹ statistically significant deterioration

The data depicted in Table 6 shows that improvements in **ammonia** that have occurred over the past 16 years have flattened out at two sites. This is consistent with the information in Table 4, that over a ten year timeframe ammonia levels have remained steady at almost all sites in the region. Table 6 shows that a previous deterioration in ammonia levels in the Waingongoro River has been arrested. This is probably due at least in part to the improvements instituted by Riverlands Ltd at their meatworks in Eltham, to improve effluent treatment and management. The improvements include a higher standard of effluent treatment and discharge to land when conditions allow.

Nitrate levels have begun to deteriorate at one site, having previously been steady; remained steady at a second, and stabilised at the third of the three NIWA network sites, having previously been deteriorating. Again the improvements in the Waingongoro River may in part be due to the efforts of Riverlands.

Trends in the levels of **DRP** are unchanged at two NIWA network sites, but in the Waingongoro River have changed from a deterioration (if taken over the past twenty-five or sixteen years) to being steady (if measured over the last ten years) to now improving. This is a significant turnaround in the state of the river.

5. Regional summary

5.1.1 Introduction

This section provides a brief summary of current state and trends, and likely future influences upon trends and state. The first emoticon indicates the current situation, and the second the outlook.

5.1.2 Dissolved reactive phosphorus

😐 some sites are showing no change, but others are deteriorating. Some of the declining sites are not influenced by pastoral activity- i.e. natural influences are at work. There are already indications of an improvement in DRP levels at some sites in more recent data (e.g. Waingongoro and Manganui Rivers).

☺ rates of application of superphosphate fertiliser are reducing significantly-they are half of what they were ten years ago. This should become evident as an improvement in DRP in due course.

5.1.3 Total phosphorus

😐 all sites show stable levels of total phosphate.

☺ rates of application of superphosphate fertiliser are reducing significantly-they are half of what they were ten years ago. This should become evident as an improvement in TP in due course

5.1.4 Nitrate

☹ more sites in Taranaki are showing a deteriorating trend in nitrate than are remaining steady. Increasing applications of urea and other nitrogenous fertilisers have the potential to increase nitrate in rivers and streams.

☺ Overall over the last twenty-five years, Taranaki has enjoyed and still enjoys lower levels of nitrates than used to be present. Studies of levels of nitrates in Taranaki's groundwater by the Council are showing declining levels across the region. In due course this will reduce the levels of nitrates entering surface water from this source

5.1.5 Ammonia

☺ Despite the increasing use of urea in Taranaki within the last ten years, there is no evidence of increasing levels of ammonia in our rivers. Levels are actually the same as or lower overall than they were twenty-five years ago.

😐 If use of urea continues to climb or its use is poorly managed on farms, then there is potential for water quality to be affected. There are early signs at a couple of sites that a previous trend of decreasing ammonia levels may be flattening out.

5.1.6 Total nitrogen

- 😐 Despite the increasing use of urea in Taranaki within the last ten years and the recent increase in nitrates, there is no overall trend in the levels of total nitrogen in our rivers. Increases in nitrates are not necessarily associated with changes in total nitrogen. Reducing discharges of organic nitrogen may be off-setting the nitrate run-off.

- 😐 If use of urea continues to climb or its use is poorly managed on farms, or stocking rates increase without corresponding close pasture management, then there is potential for water quality as measured by TN to be adversely affected. Better-sized oxidation ponds and riparian management will reduce TN discharges to the region's streams

5.1.7 Faecal coliforms

- ☺ Levels are remaining stable or falling (improving)

- ☺ Exclusion of stock from waterways when grazing or moving, and increasing riparian management, should result in further declines in levels

5.1.8 Enterococci

- 😐 Levels are remaining stable

- ☺ Exclusion of stock from waterways when grazing or moving, and increasing riparian management, should result in further declines in levels

5.1.9 Clarity (black disc)

- 😐 Levels are remaining stable

- ☺ Exclusion of stock from banks when grazing and from watercourses when moving, and increasing riparian planting, should result in improvements in clarity.

5.1.10 Suspended solids

- 😐 Levels are remaining stable

- ☺ Exclusion of stock from banks when grazing and from watercourses when moving, and increasing riparian planting, should result in reduction (improvements) in levels.

5.1.11 Temperature

- 😐 Levels are remaining stable. This gives some confidence that the dataset analysed for this study is not biased by short-term climatic events

- ☺ In the long term (e.g. ten-twenty years or more), riparian planting will reduce temperatures in Taranaki's streams through shading.

5.1.12 Biochemical oxygen demand

- ☺ Levels are remaining stable or falling (improving).
- ☺ Exclusion of stock from waterways when grazing or moving, and increasing riparian management, should result in further declines in levels

Bibliography and references

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Appendix I

Taranaki's SEM sites and REC categories

The distribution of SEM water quality sites in Taranaki in relation to REC categories is analysed in Tables 7 and 8, and also shown in Figures 3 (land cover classes) and 4 (climate classes).

Table 7 Council SEM sites vs REC climate classes for Taranaki rivers

Climate class	WX	WW	WD	CX	CW	CD	
Taranaki rivers (km)	544	5239	1035	2143	4033	3	12,559
%	4	40	8	17	31	0.02	
% of SEM sites in class	0	18	0	36	45	0	

Table 8 Council SEM sites vs REC land cover classes for Taranaki rivers

Land cover class	B	EF	IF	P	S	U	
Taranaki rivers (km)	68	115	3448	8605	632	129	12,559
%	0.5	0.9	26	66	5	1	
% of SEM sites in class	0	0	27	64	9	0	

Examination of the Taranaki sites shows that they match the regional distribution of land cover classes very closely. The match to climatic classes found within the region is not as strong. However, two SEM sites lie very close to the interface between CX and WW classes (the change occurs on the lower northern slopes of Mt Egmont/Taranaki), and with this adjustment the SEM sites would be very closely aligned to REC climate classes.

There appears no good reason to change the locations currently used for SEM purposes.

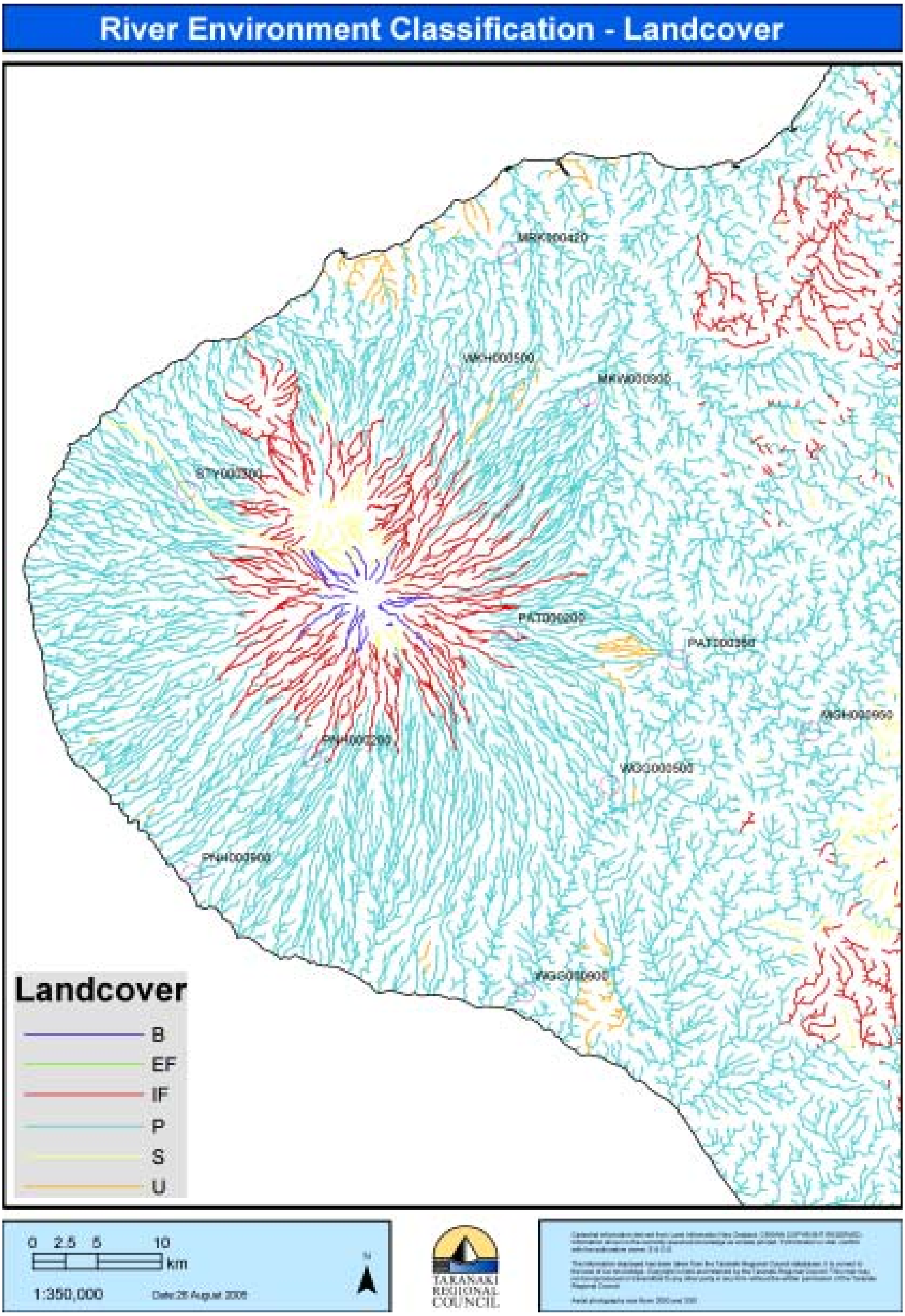

Figure 3 Council SEM sites and REC landcover classes

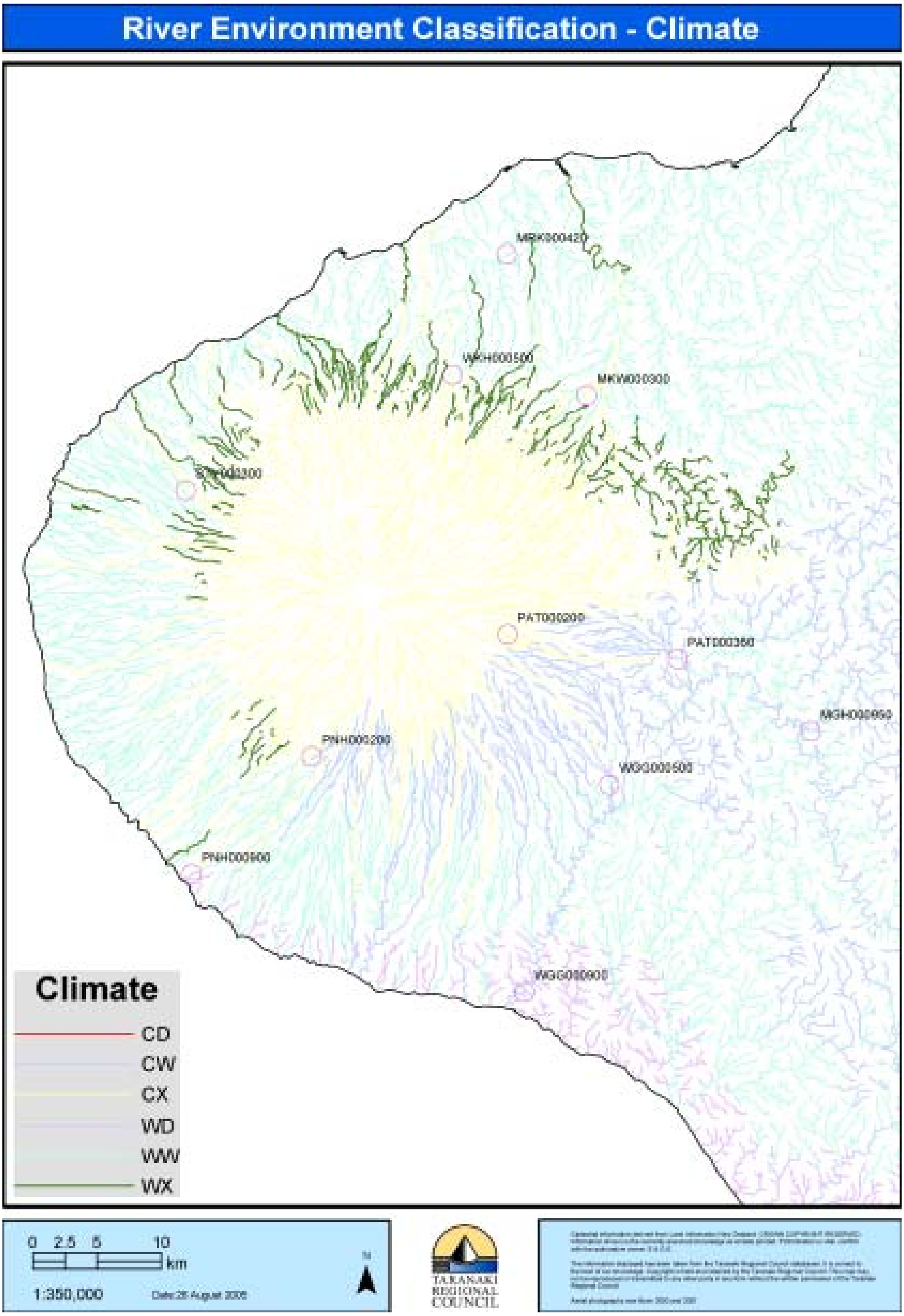

Figure 4 Council SEM sites and REC climate classes

Appendix II
Summary of SEM water quality data

Table 9 Comparison of median results from comparable SEM and ring plain survey data

SEM data in range of flow and months of Ring Plain survey data

	STY000300	PAT 000200	PAT000360	WGG000900	WKH000500	PNH000900
n=	15	23	35	25	37	31
DRP	0.02	0.015	0.044	0.059	0.027	0.032
Total P	0.024	0.018	0.063	0.089	0.033	0.058
Nitrate	0.019	0.02	0.909	1.816	0.069	0.472
Ammonia	0.0015	0.003	0.034	0.024	0.006	0.024
Conductivity	11.1	5.5	10.2	16.4	13.8	16.2
Alkalinity	46	17	30	39	56	37

Median early '80s Ring Plain survey data

	STY000300	Patea - Cardiff Rd [(1)]	PAT000360	WGG000900	WKH000500	PNH000900
n=	3	7	8	5	7	5
DRP	0.018	0.012	0.019	0.026	0.018	0.014
Total P	0.021	0.018*	0.036**	0.056	0.025*	0.032
Nitrate	<0.01	0.24	0.99	1.44	0.12	0.93
Ammonia	<0.005	<0.005	0.108	0.05	0.006	0.027
Conductivity	11	7	10	15.5	13.5	16
Alkalinity	41	20	22	32	50	26
Flow range	2.4 - 3.4	0.21 - 0.56#	0.49 - 4.78	1.0 - 10.6	2.2 - 5.4	0.3 - 1.3

[(1)] Cardiff Rd site lies close to and below PAT000200

* denotes 3 analysis for this parameter for this site

** denotes 5 analysis for this parameter for this site

# denotes 6 flow measurements out of 7 samples taken

Table 10 Summary of SEM programme water quality data

g/m³

DRP	MRK000420	STY000300	PNH000200	PAT000200	PAT000360	MGH000950	WGG000500	WGG000900	PNH000900	WKH000500
Max	0.039	0.032	0.389	0.038	0.151	0.026	0.081	0.223	0.120	0.108
Min	<0.003	0.004	0.007	0.004	0.010	<0.003	<0.003	0.021	0.013	<0.003
Med	0.008	0.017	0.022	0.017	0.039	0.005	0.015	0.061	0.039	0.022
25%	0.005	0.013	0.016	0.012	0.028	0.003	0.011	0.043	0.028	0.017
75%	0.012	0.020	0.027	0.023	0.056	0.008	0.023	0.094	0.052	0.030

Nitrate	MRK000420	STY000300	PNH000200	PAT000200	PAT000360	MGH000950	WGG000500	WGG000900	PNH000900	WKH000500
Max	1.733	0.100	0.179	0.140	1.361	0.334	2.309	2.981	3.134	0.468
Min	0.049	0.005	0.005	0.005	0.210	0.005	0.310	0.771	0.066	0.005
Med	0.859	0.020	0.029	0.029	0.872	0.100	1.092	2.057	0.834	0.109
25%	0.656	0.019	0.019	0.019	0.721	0.059	0.762	1.607	0.315	0.040
75%	1.117	0.039	0.068	0.039	1.051	0.188	1.519	2.422	1.299	0.178

Ammonia	MRK000420	STY000300	PNH000200	PAT000200	PAT000360	MGH000950	WGG000500	WGG000900	PNH000900	WKH000500
Max	0.308	0.019	0.039	0.057	0.329	0.081	0.265	0.305	0.308	0.148
Min	<0.003	<0.003	<0.003	<0.003	0.006	<0.003	<0.003	0.006	0.004	<0.003
Med	0.019	<0.003	0.006	<0.003	0.052	0.012	0.018	0.029	0.038	0.007
25%	0.011	<0.003	0.004	<0.003	0.028	0.007	0.010	0.020	0.023	<0.003
75%	0.031	0.004	0.013	0.005	0.093	0.021	0.033	0.047	0.085	0.014

F. coli	MRK000420	STY000300	PNH000200	PAT000200	PAT000360	MGH000950	WGG000500	WGG000900	PNH000900	WKH000500
Max	53000	1000	5700	10000	63000	13000	100000	20000	20000	83000
Min	120	<1	3	<1	2	6	6	3.000	51	23
Med	680	8	130	20	245	260	210	225	555	170
25%	450	3	52.5	7	99	128	100	120	278	100
75%	1300	19	455	59	700	740	443	530	1300	345

Black D.	MRK000420	STY000300	PNH000200	PAT000200	PAT000360	MGH000950	WGG000500	WGG000900	PNH000900	WKH000500
Max	4.730	13.120	4.390	8.870	4.680	3.030	4.390	2.390	3.570	8.050
Min	0.055	0.043	0.080	0.090	0.050	<0.01	0.100	0.140	0.055	0.130
Med	2.045	4.575	1.825	4.290	1.945	0.780	1.770	1.115	1.550	3.410
25%	1.305	1.685	1.278	2.875	1.255	0.340	1.063	0.825	1.028	2.105
75%	2.813	6.513	2.573	5.335	2.363	1.650	2.243	1.495	2.033	4.000

Alkalinity	MRK000420	STY000300	PNH000200	PAT000200	PAT000360	MGH000950	WGG000500	WGG000900	PNH000900	WKH000500
Max	95.0	54.0	26.0	31.0	57.0	69.0	45.0	58.0	46.0	72.0
Min	14.0	5.0	6.0	3.0	10.0	12.0	11.0	21.0	15.0	8.0
Med	40.0	39.0	22.0	22.0	27.0	38.0	30.0	39.0	34.0	49.0
25%	30.0	28.0	17.0	14.0	23.0	29.8	26.0	33.0	30.0	31.0
75%	52.0	45.0	24.0	25.0	30.3	47.3	33.0	42.0	38.0	59.3

Temp	MRK000420	STY000300	PNH000200	PAT000200	PAT000360	MGH000950	WGG000500	WGG000900	PNH000900	WKH000500
Max	20.5	16.6	19.2	14.4	20.5	24	20.8	22	21	18.3
Min	5.8	5.7	5	3.7	5.3	4.3	5.6	5.4	5	5.2
Med	13.05	10.6	12.25	9.15	12.6	13.6	12.25	13.55	13.45	11.1
25%	11.28	8.8	9.275	7.1	10.35	10.68	10.1	11	10.8	9.125
75%	15.63	12.9	14.6	11.23	15.63	17.55	15.4	17.6	16.25	13.55

BOD	MRK000420	STY000300	PNH000200	PAT000200	PAT000360	MGH000950	WGG000500	WGG000900	PNH000900	WKH000500
Max	9.2	1	3	3.7	16	5.6	7.3	6.7	8.1	4.3
Min	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Med	0.6	<0.5	<0.5	<0.5	0.8	0.6	0.6	0.8	0.9	<0.5
25%	0.25	<0.5	<0.5	<0.5	0.6	0.25	0.25	0.6	0.6	<0.5
75%	0.8	<0.5	0.6	<0.5	1.2	0.9	0.9	1.2	1.3	0.525

Total P	MRK000420	STY000300	PNH000200	PAT000200	PAT000360	MGH000950	WGG000500	WGG000900	PNH000900	WKH000500
Max	0.860	1.080	0.413	0.281	1.390	0.786	0.829	0.325	0.531	0.437
Min	0.007	0.013	0.016	0.011	0.022	<0.003	0.013	0.043	0.026	0.014
Med	0.019	0.024	0.034	0.023	0.068	0.022	0.034	0.104	0.072	0.032
25%	0.014	0.020	0.028	0.019	0.045	0.015	0.024	0.078	0.052	0.026
75%	0.032	0.029	0.044	0.031	0.104	0.041	0.054	0.156	0.101	0.039

Total N	MRK000420	STY000300	PNH000200	PAT000200	PAT000360	MGH000950	WGG000500	WGG000900	PNH000900	WKH000500
Max	5.180	0.671	0.870	1.130	4.500	2.100	2.910	3.590	3.960	2.100
Min	0.282	<0.05	<0.05	<0.05	0.740	0.101	0.342	1.120	0.290	<0.020
Med	1.125	0.080	0.150	0.090	1.210	0.340	1.390	2.555	1.280	0.220
25%	0.835	0.050	0.108	0.066	1.068	0.210	1.024	2.070	0.720	0.130
75%	1.460	0.110	0.243	0.141	1.380	0.493	1.823	2.945	1.846	0.324

S.S	MRK000420	STY000300	PNH000200	PAT000200	PAT000360	MGH000950	WGG000500	WGG000900	PNH000900	WKH000500
Max	310	1100	160	160	360	1300	180	120	220	89
Min	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Med	2	<2	<2	<2	2	5	2	5	3	<2
25%	<2	<2	<2	<2	<2	2	<2	3	2	<2
75%	5	7	3	<2	4	23	5	9	5	<2

Ent.	MRK000420	STY000300	PNH000200	PAT000200	PAT000360	MGH000950	WGG000500	WGG000900	PNH000900	WKH000500
Max	53000.0	360.0	980.0	2200.0	19000.0	6000.0	5100.0	4200.0	5100.0	6000.0
Min	31.0	<1	<1	<1	9.0	<1	4.0	17.0	15.0	<1
Med	270.0	5.0	40.0	7.0	105.0	61.5	110.0	120.0	250.0	79.0
25%	130.0	<1	13.0	3.0	47.5	25.8	45.5	65.0	120.0	34.8
75%	572.5	13.0	84.3	25.0	382.5	282.5	300.0	310.0	600.0	252.5