STATE OF THE ENVIRONMENT OF THE MANAWATU-WANGANUI REGION | 2005

TECHNICAL REPORT

FOUR | FRESHWATER QUALITY



horizons
REGIONAL COUNCIL

CONTENTS

1. ISSUES

Good water quality is a community priority: water is valued for the wildlife it supports, as a drinking and food source, for its spiritual and cultural values, for many recreational activities, and simply for its aesthetic values.

Water quality is influenced by a number of natural factors such as climate, topography, soils and land cover. Some human activities such as: waste disposal, urban and road network development, and unsustainable agricultural practices may also have marked detrimental effects on the water quality and compromise the values of a water body.

The main issues affecting water quality in the region are:

- Faecal contamination compromising the water's recreational quality and affecting its mauri.
- Nutrient enrichment causing accelerated eutrophication.
- Modified physicochemical characteristics of the water and/or presence of toxic substances compromising the life supporting capacity of the water.
- High turbidity, affecting aesthetic values, life supporting capacity (also an indicator of soil erosion).

2. WHAT'S HAPPENING?

2.1 WHAT WATER QUALITY DATA HAS BEEN COLLECTED?

Water quality in the rivers naturally varies with season, river flow and time of the day. To obtain a good summary of the water quality, data collected over several years is needed. However, water quality also changes with time, so the data used to described the current state of the water needs to be recent.

Using the last seven years of data is a good compromise between having sufficient data to provide a reliable result and using data recent enough to give an up to date picture.

During the past seven years (1997 to 2004), water quality variables have been analysed at 500 different sites across the region, representing more than 63,000 datapoints. This includes different sampling programmes:

- State of the Environment (SoE) monitoring programme – physical and chemical parameters. Different water quality parameters (Table 4- 1) have been monitored monthly at 53 sites across the region. 24 of these sites are monitored every year, while the others are monitored every three years.
- SoE monitoring programme – biomonitoring. This programme started in 1999 and is run by Massey University' s Institute of Natural Resources on behalf of Horizons Regional Council (Horizons). Macroinvertebrates and periphyton communities are monitored once every year at 21 sites and every 3 years at an additional 24 sites.
- Bathing beaches monitoring programme. Until 2004, 24 of the region's most popular swimming spots were monitored bimonthly during the bathing season (November to April). From the start of the 2004-05 bathing season, Horizons has increased his monitoring effort: 28 sites are now monitored every week and the results are made available on Horizons website . The appropriate bacterial indicators are monitored at each site to asses the potential health risk to recreational water users.
- Compliance monitoring. Discharge permits in the region are administered by Horizons Regional Council. These discharges are allowed to operate under specific conditions. Regular monitoring

is undertaken to ensure each discharge complies with its permit conditions.

- Incidents sampling. Water quality variables analysed in response to an incident (fish kills, suspected pollution, accidental discharge).
- Various research programmes run by Horizons aiming to improve our understanding of the causes of degraded water quality. These programmes account for a very large number of sites being monitored only for a certain period of time.

The first three programmes represent the core dataset this report is based on. Where appropriate, data from the other programmes has been incorporated.

PARAMETER	COMMENTS
Nitrates (NO_3)	An indicator of nutrient enrichment. High concentration of nitrates can also be toxic to aquatic life and animals (including humans) drinking the water.
Dissolved reactive phosphorus (DRP)	An indicator of nutrient enrichment in rivers.
Total Phosphorus (TP)	An indicator of nutrient enrichment in lakes and estuaries.
Water clarity - Black Disc (BDisc)	An indicator of contact recreation and visual aspect quality. Also an indicator of accelerated erosion in the catchment. Horizontal visibility in rivers is measured using the black disc method.
Turbidity (Turb)	An indicator of accelerated erosion in the catchment. Also an indicator of degraded life supporting capacity
Suspended solids (SS)	An indicator of accelerated erosion in the catchment.
Escherishia coli (Ecoli)	An indicator of faecal contamination (health risk) in freshwater.
Enterococci (Ent)	An indicator of faecal contamination (health risk) in seawater. Used to be the preferred indicator in freshwater.
Faecal coliforms (FC)	An indicator of faecal contamination (health risk) in seawater for shellfish gathering areas.
Ammonia (NH_4)	Toxic to aquatic life: an indicator of life-supporting capacity . Also an indicator of nutrient enrichment.
Cadmium (Cd)	Toxic to most life forms: an indicator of life-supporting capacity. Also an indicator of urban / industrial contamination.
PH	An indicator of life-supporting capacity.
Conductivity	An indicator of life-supporting capacity.
Temperature	An indicator of life-supporting capacity.

TABLE 4- 1: Parameters monitored as part of the State Of the Environment and swimming beaches monitoring programmes.

2.2 DATA ANALYSIS METHODS

In order to turn the large amount of data into valuable information, the data needs to be suitably analysed and presented.

A number of statistical and graphical methods have been applied to the water quality dataset, and are presented in this chapter. Each approach has advantages and limitations (described at the end of this chapter).

2.2.1 BASIC STATISTICS

For each parameter, at each site, the following have been calculated:

- number of samples
- date of first and last sampling
- median value
- minimum value
- maximum value
- lower quartile
- upper quartile

The results are presented in Appendix 4- 2. This approach presents the advantage of providing numerical values. However, the results can be hard to understand for a non-specialised audience (e.g. is a DRP concentration of 0.065 gP/m^3 good or bad?).

2.2.2 WATER QUALITY INDICATORS

One approach to summarise water quality data at a site is to define, for each parameter measured, how often the water quality falls into different qualitative categories. Two methods have been developed:

- The first method classifies the data into two categories: satisfactory and unsatisfactory (i.e. good and bad). For this, a threshold value between satisfactory and unsatisfactory water quality has been defined for each parameter (Table 4- 2). The result is given as percentages of satisfactory and unsatisfactory samples. This in turn can easily be turned into a 1 to 10 score (Table 4- 3). This approach gives a direct, easy–to–understand result, and is well suited for reporting at the catchment or region scale, and has been used to produce the water quality maps presented in this report.

% SATISFACTORY SAMPLES	SCORE
0 - 10	1
10 - 20	2
20 - 30	3
30 - 40	4
40 - 50	5
50 - 60	6
60 - 70	7
70 - 80	8
80 - 90	9
90 - 100	10

TABLE 4-3: definition to water quality scores in relation to the percentage of satisfactory samples

PARAMETER	SHORT NAME	UNIT	THRESHOLDS[3]		SOURCE/REFERENCE
Water Clarity	BDISC	m	E – G	4	Environment Waikato.
			G – F	2.8	Arbitrary.
			F – P	**1.6**	(1) p5-6. Guideline to protect the aesthetic quality of a waterbody.
			P – VP	0.6	Arbitrary.
Escherishia coli	ECOLI	MPN/ 100ml	E – G	65	Arbitrary (Half the grade A microbiological Assessment Category value).
			G – F	130	(2) pE7. Grade A microbiological Assessment Category value (95 percentile).
			F – P	**260**	(2) pE9. Alert / Amber Mode level for freshwater.
			P – VP	550	(2) pE9. Action / Red Mode level for freshwater.
Enterococci (freshwater)	ENT	MPN/ 100ml	E – G	35	(1)p5-4. Primary contact recreational waters, median value over bathing season.
			G – F	80	(1)p5-4. Primary contact recreational waters, maximum value in any one sample
			F – P	**107**	Manawatu Catchment Water Quality Regional Plan, p49. Rule 2.4.e.
			P – VP	280	Microbiological Water Quality guidelines (MfE, MHealth) 2003, pD9. Action / Red Mode level for marine waters.
Enterococci (Seawater)	ENT	MPN/ 100ml	E – G	35	(1)p5-4. Primary contact recreational waters, median value over bathing season.
			G – F	80	(1)p5-4. Primary contact recreational waters, maximum value in any one sample.
			F – P	**140**	Microbiological Water Quality guidelines (MfE, MHealth) 2003, pD9. Alert / Amber Mode level for marine waters.
			P – VP	280	Microbiological Water Quality guidelines (MfE, MHealth) 2003, pD9. Action / Red Mode level for marine waters.

3 In bold is the main threshold, between satisfactory and unsatisfactory categories

PARAMETER	SHORT NAME	UNIT	THRESHOLDS[3]		SOURCE/REFERENCE
Faecal coliforms	FC	MPN/ 100ml	E – G	14	Microbiological Water Quality guidelines (MfE, MHealth) 2003, p F2. Maximum
			G – F	**43**	median and 10-percentile values for shellfish gathering areas.
			F – P	150	(1)p5-3. Maximum median value for primary contact.
			P – VP	1000	(1)p5-3. Maximum median value for secondary contact.
Nitrate Nitrogen	NO_3	g/m^3 -N	E – G	0.075	p103. Maximum soluble inorganic nitrogen concentration for N-limited stream communities, 30 days accrual period
			G – F	0.167	(1) p3.3-17 for oxides of nitrogen in upland streams.
			F – P	**0.444**	(1) p3.3-17 for oxides of nitrogen in lowland streams.
			P – VP	0.767	(1) p3.4-5. Trigger value for level of protection of 90 % species.
Ammonia	NH_3	g/m^3 -N	E – G	0.1	Arbitrary value.
			G – F	0.25	(1) p3.4-5. Trigger value for protection of 99 % species.
			F – P	**0.7**	(1) p3.4-5. Trigger value for typical slightly - moderately disturbed systems (protection level of 95 % species).
			P – VP	1.1	(1) p3.4-5. Trigger value for protection of 90 % species.
Dissolved Reactive Phosphorus	DRP	g/m^3 -P	E – G	0.0028	(3) p103. Maximum soluble reactive phosphorus concentration for N-limited stream communities, 40 days accrual period.
			G – F	0.006	(3) p103. Maximum soluble reactive phosphorus concentration for N-limited stream communities, 30 days accrual period.
			F – P	**0.01**	(1) p3.3-17. Default trigger value for New Zealand slightly disturbed ecosystems.
			P – VP	0.026	(3) p103. Maximum soluble reactive phosphorus concentration for N-limited stream communities, 20 days accrual period.

PARAMETER	SHORT NAME	UNIT	THRESHOLDS[3]		SOURCE/REFERENCE
Turbidity	TURB	NTU	E – G	2	Arbitrary value.
			G – F	4.1	(1) p3.3-18. Default trigger value for New Zealand upland rivers.
			F – P	**5.6**	(1) p3.3-18. Default trigger value for New Zealand lowland rivers.
			P – VP	10	Arbitrary value.
Temperature summer (May-Sept)	TEMP	Celsius	E – G	15	Arbitrary value.
			G – F	17.5	Arbitrary value.
			F – P	**19**	Hayes, J. W. and Young R. G. 2001. Effects of low flow on trout and salmon in relation to the Regional Water Plan : Otago.
			P – VP	22.5	Arbitrary value.
Temperature winter (Oct – Apr)	TEMP	Celsius	E – G	10	Arbitrary value.
			G – F	11	Arbitrary value
			F – P	**12**	Environment Waikato
			P – VP	13	Arbitrary value
Dissolved Oxygen	DO	% Sat	E – G	95	Arbitrary value
			G – F	90	(1) p3.3-25.
			F – P	**80**	Manawatu Catchment Water Quality Regional Plan, p51. Rule 3.3b.
			P – VP	70	Arbitrary value
Cadmium	CDT	ppb	E – G	0.06	(1) p3.4-5. Trigger value for level of protection of 99 % species.
			G – F	**0.2**	(1) p3.4-5. Trigger value for level of protection of 95 % species.
			F – P	0.4	(1) p3.4-5. Trigger value for level of protection of 90 % species.
			P – VP	0.8	(1) p3.4-5. Trigger value for level of protection of 80 % species.
pH	PH	N/A	Satisfactory	7.2 to 8	(1) p3.3-17. Default trigger values for New Zealand rivers.
			Unsatisfactory	<7.2 or >8	

PARAMETER	SHORT NAME	UNIT	THRESHOLDS[3]		SOURCE/REFERENCE
Periphyton density (Chlorophyl a)	CHLOROA	g/m^2	E - G	15	(3) p102. Mean monthly value for benthic biodiversity protection.
			G - F	**50**	(3) p102. Maximum value for benthic biodiversity protection.
			F - P	120	p102. Maximum value for trout habitat and angling protection (filamentous algae).
			P - VP	200	(3) p102. Maximum value for trout habitat and angling protection (diatoms / cyanobacteria).
MCI		N/A	E - G	120	Boothroyd, I. K. G., and J. D. Stark. 2000. Use of invertebrates in monitoring. Pages 344-373 in K. C. Collier and M. J. Winterbourn, editors. New Zealand Stream Invertebrates: Ecology and Implications for Management. New Zealand Limnological Society, Hamilton.
			G - F	100	
			F - P	90	
			P - VP	**80**	
QMCI		N/A	E - G	6	Boothroyd, I. K. G., and J. D. Stark. 2000. Use of invertebrates in monitoring. Pages 344-373 in K. C. Collier and M. J. Winterbourn, editors. New Zealand Stream Invertebrates: Ecology and Implications for Management. New Zealand Limnological Society, Hamilton.
			G - F	5.5	
			F - P	**5**	
			P - VP	4	
Invertebrates Observed over Expected Ratio	OBS_EXP	N/A	E - G	1.25	Joy, M. K., and R. G. Death. 2003. Biological assessment of rivers in the Manawatu-Wanganui region of New Zealand using a predictive macroinvertebrate model. New Zealand Journal of Marine and Freshwater Research 37:367-379.
			G - F	1.00	
			F - P	**0.85**	
			P - VP	0.6	
Percentage of Ephemeroptera, Trichoptera and Plecoptera Taxa	ETP TAXA	%	E - G	60	R. G. Death (Pers. Communication).
			G - F	**40**	Arbitrary.
			F - P	30	Arbitrary.
			P - VP	10	R. G. Death (Pers. Communication).

Table 4-2: Water quality parameters routinely monitored during the State of the Environment monitoring programmes, and thresholds used for the water quality indicators. Key threshold boundaries are in bold.

References:

(1) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. 2000.

(2) Microbiological Water Quality guidelines (MfE, MHealth) 2003,

(3) New Zealand Periphyton Guidelines, Barry JF Biggs, 2000

2.2.3 ISSUE-BASED WATER QUALITY INDICES

The State of the Environment (SOE) report 2005 defines four main issues affecting water quality in the region:

- Faecal contamination
- Nutrient enrichment
- Compromised life supporting capacity
- High turbidity / sedimentation

To be able to report on these issues, four water quality indices have been developed by Horizons. Each of these indices integrates several indicators to summarise the state of the water quality in relation to one of the four issues. For each index, a 1 to 10 score has been calculated at each site where suitable data was available. These scores have been used to populate the maps presented in the SOE report. Details of the scores are given in Appendix 4-2.

a Microbiological water quality Index

Several bacterial indicators of faecal contamination of the water have been used and are still used, depending on the situation (e.g. freshwater, seawater) and the guidelines in force at the time of monitoring. For example, Enterococci used to be the favoured indicator in freshwater, but the latest microbiological water quality guidelines (MfE, MoH 2002) recommend E. coli as the preferred indicator in freshwater. This means some monitoring sites have inconsistent datasets, with Enterococci monitored for a time, then E. coli.

Another example is estuaries, where the water is alternatively fresh and salty. In these two examples, the use of only one microbiological indicator would give an incomplete or inaccurate picture.

A microbiological water quality index has been developed, which uses the following data:

- in freshwater, E. coli in priority, and Enterococci when E. coli data is not available,
- in estuaries, E.coli when the sample has been collected in freshwater
  (conductivity less than 200 µS/cm^2),
  and Enterococci when the sample has been collected in seawater
  (conductivity more than 200 µS/cm^2),
- in seawater, Enterococci in priority and E. coli when Enterococci data is not available

Each measurement is compared to the appropriate threshold (Table 4- 2), to determine if the microbiological quality of the water is satisfactory or unsatisfactory. The final score reflects the total percentage of satisfactory samples (Table 4- 3).

b Nutrient enrichment Index

At each site, the Nutrient Index is calculated as follow:

- Nitrates data is compared to the thresholds defined in Table 4- 2;
- Dissolved Reactive Phosphorus (DRP) levels in freshwater rivers and streams and Total Phosphorus (TP) levels in lakes and estuaries are compared to the thresholds defined in Table 4- 2;
- when both Phosphorus and Nitrates levels are satisfactory, the sample scores 3;
- when either Nitrates or Phosphorus level is unsatisfactory but the other is satisfactory, the sample scores 1;

- when both P and N levels are unsatisfactory, the sample scores 0;
- the index score is calculated using the formula:
  (total score for the site *10) / maximum possible score[4].

The result is a 1 to 10 score reflecting how often the nutrient status of the site may promote nuisance algal growth.

c Life-supporting capacity

This index compares pH, water temperature, dissolved oxygen, ammonia and cadmium concentration with the appropriate thresholds (Table 4- 2). The final index score reflects (as defined in Table 1) the percentage of time when all these parameters have been classified satisfactory. More development is planned to incorporate all relevant data, particularly biomonitoring data (Table 4- 4).

d Sediment Index

The Sediment Index currently uses turbidity data only. More development is planned to incorporate all relevant data (Table 4- 4).

2.2.4 WATER QUALITY MAPS

Maps are the preferred approach for showing region-wide water quality indicators' and indices' scores.

The water quality at a point in the river is the result of what is happening upstream. The catchment above each sampling site has been calculated, the water quality score associated with the sampling point has been allocated to this catchment and displayed on the maps. For these maps, each catchment is identified by a number, which corresponds to a catchment name given in Appendix 4-1.

This method has advantages, but also limitations. While it provides a regional perspective for any water quality indicator, it does not mean that water quality is homogenous across the whole catchment that has been assigned a particular score. For example, when a catchment scores "very poor" (dark brown), this only indicates that something, somewhere within that catchment is causing the degradation of water quality (and water quality could actually be better upstream of that source, but still within the same catchment).

This approach rapidly identifies good and bad water quality catchments, and any fine-scale analysis should use a more classical "monitoring site" display.

2.2.5 LIMITATIONS AND FORESEEABLE IMPROVEMENTS

Most indicators and indices presented in this report are a "first generation" development, and still require further development and improvements, as summarised in Table 4- 4.

[4] number of samples x 3

DATA PROCESSING APPROACH	ADVANTAGES	DISAVANTAGES	FUTURE IMPROVEMENTS
BASIC STATISTICS			
mean, median, minimum, maximum, percentiles	- undisputable, "hard" data - good indication of the data's distribution	- hard to understand for non-specialised audience (absence of qualitative - good /bad - references) - uses indiscriminately year round, all-flow data	Incorporates flow and season variables
INDICATORS			
Two-category indicators (% satisfactory / unsatisfactory and 1 to 10 score)	- very easy to understand - good tool to report water quality information at a wide (Region) scale - possible to incorporate in a region scale map	- uses indiscriminately year round, all-flow data - does not account for the different river types - does not describe well the data distribution	- Adapt the thresholds to different: - river types - seasons - flow conditions
Five-category indicators (% very poor / Poor / Fair / Good / Excellent)	- more precise information than the two categories approach (better description of the data distribution) - good tool to report information at the site / subcatchment scale	- Not as intuitive as the two categories approach - does not account for the different river types - uses indiscriminately year round, all-flow data	- Adapt the thresholds to different: - river types - seasons - flow conditions
INDICES			
Nutrients	- summarises nutrient status of the waterbody	- does not account for the different river types - uses indiscriminately year round, all-flow data	- Develop a "summer" and a "low flows" indices (when undesirable plant growth is most likely to occur) - Incorporate following data: - ammonia - macroinvertebrates - periphyton

Microbiological water quality	- summarises the microbiological water quality over the past five years - allows the use of different microbiological indicators	- uses indiscriminately year round, all flow data - Poor correlation between Enterococci and E.coli indicators results on some rivers:.	- Incorporate water clarity to obtain a complete Contact Recreation Index - Develop a "summer" and a "low flows" indices (when high recreational use of the rivers is likely to occur) -Refine Enterococci thresholds to align on E.coli indicator
Life supporting capacity (stressors Index)	Incorporates different physicochemical parameters to identify "problem areas"	Limited to physico-chemical parameters	- Refine temperature and pH thresholds - Incorporate the following data - macroinvertebrates - periphyton - fish communities - turbidity
Sedimentation / turbidity		Limited to turbidity data	- Incorporate the following data: - macroinvertebrates - embeddedness - Water clarity - Suspended sediments
WATER QUALITY MAPS			
	- Displays regionwide information on one page - Points out "good" and "bad" catchments	- may be misunderstood as water quality is in reality not homogenous inside the coloured catchments	Increase the number of sampling sites in some area to obtain finer scale maps.

3. RESULTS

3.1 SUITABILITY FOR CONTACT RECREATION

The term "Contact Recreation" encompasses all the activities involving some degree of contact with the water, like swimming or boating.

An ideal water body for recreational use would be clear and would not present a significant health risk to water users. Hence, two parameters are important to consider when defining the suitability of a water body for contact recreation: the bacteriological water quality (indicative of health risks) and water clarity.

Health safety was judged much more important than aesthetic aspects, hence only indicators of faecal contamination were reported in the SOE report. In this report, both indicators are presented to provide more complete information.

3.1.1 BACTERIOLOGICAL WATER QUALITY

Pathogens from human and animal faecal material can enter the freshwater environment. Elevated concentrations of these pathogens may pose a health risk to people in direct contact with the water. Sources of faecal contamination of the water include:

- Overland runoff of urban and farmed land.
- Discharge of untreated or poorly treated sewage, agricultural or industrial waste.
- Dysfunctioning septic tanks.

The Contact Recreation Index summarises the prevalence of unacceptable bacterial levels for the past five years (Map 4-1).

Excellent / Good (water is almost always safe for swimming):

Upper catchments of Whanganui, Mangawhero, Rangitikei (down to Mangaweka), Pohangina, Oroua, Ohau, Tokomaru and Mangahao Rivers. Some tributaries of the middle Whanganui River.

Fair:

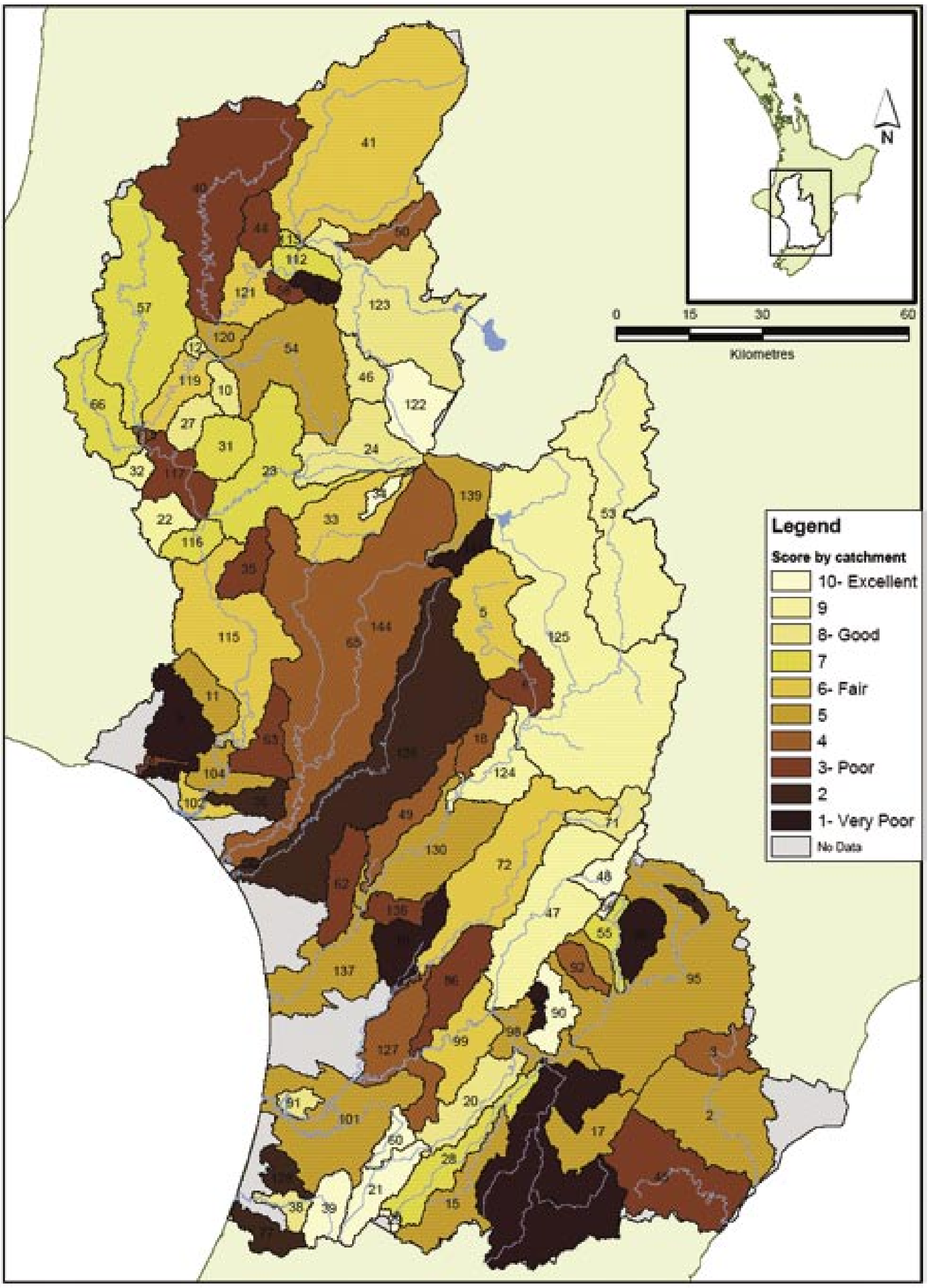
Middle and Lower Whanganui River and most of its tributaries, Middle Rangitikei (down to Vinegar Hill), Pohangina.

Poor:

Most of the Manawatu catchment, some tributaries of Whanganui (Ohura, Upokongaro) and Rangitikei (Porewa, Tutaenui, Hautapu, Rangitawa) Rivers, Turakina and Akitio Rivers.

Very Poor (water is almost always unsafe for swimming):

Some coastal streams (Mowhanau, Kai Iwi, Waikawa). Some tributaries of Manawatu (Tiraumea, Makino, Mangapapa, Mangatera), Whanganui (Hikumutu, Matarawa), and Whangaehu Rivers.



MAP 4- 1: Bacteriological water quality score by catchment. The catchment names can be identified with their number by referring to Appendix 4-1.

3.1.2 WATER CLARITY

Water clarity is a measure of how far we can see through the water. The 2000 ANZEEC Guidelines define a minimum clarity of 1.6m for waters used for swimming.

Degraded (low) water clarity is usually associated with high turbidity and suspended sediments. Sources of high turbidity are described in chapter 3.4.

The water clarity indicator summarises how often the water is clear enough for swimming (Map 4- 2).

Excellent / Good (water is almost always clear enough for swimming):

Mangahao, Mangatainoka and Tamaki Rivers. Upper parts of Mangawhero, Manganui O Te Ao, Whakapapa, Rangitikei (down to River Valley Lodge), Oroua and Tokomaru Rivers.

Fair:

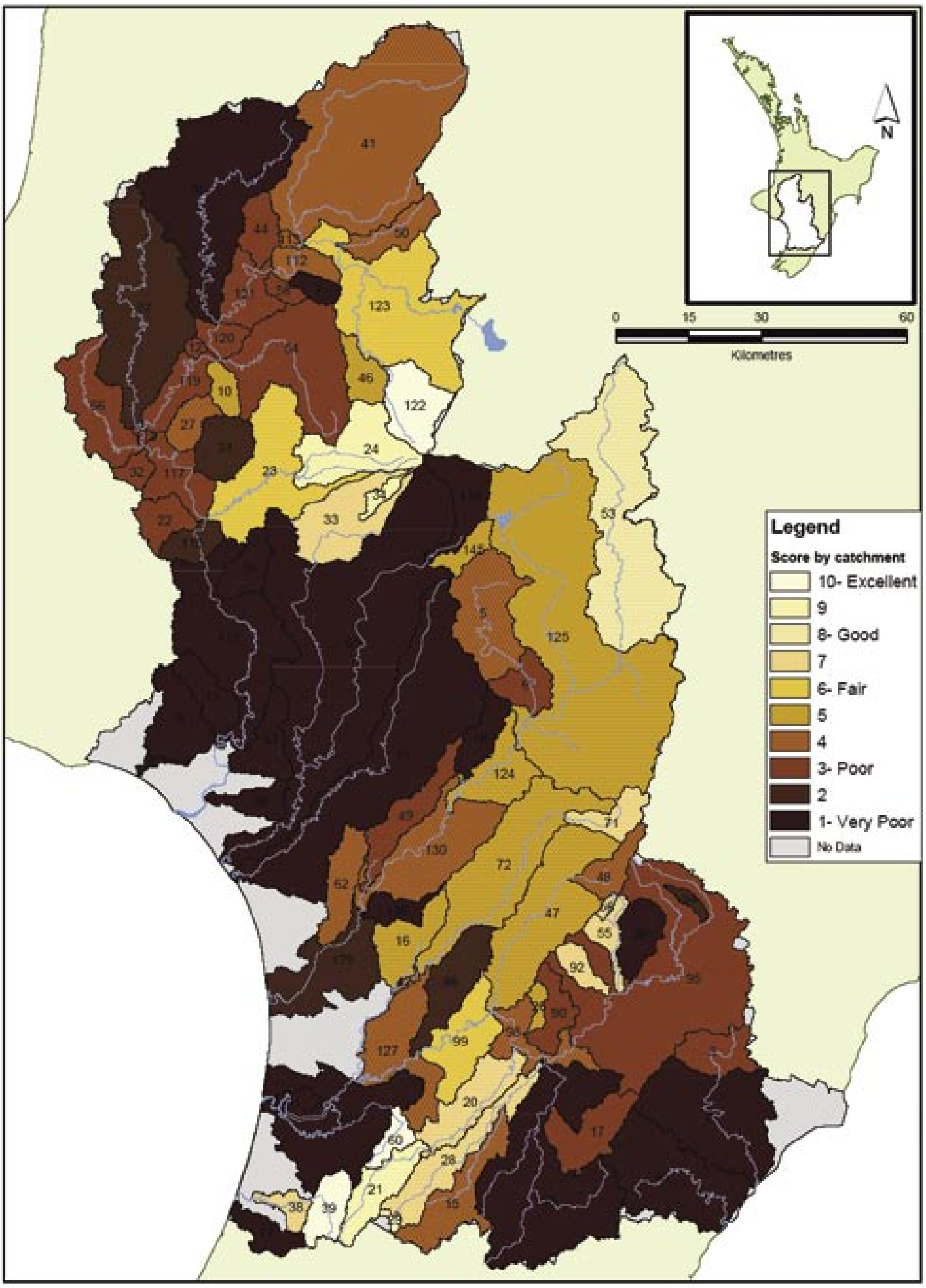
Upper Whanganui (upstream of Taumarunui), lower Manganui O Te Ao, middle Rangitikei down to Mangaweka, Oroua down to Fielding, Pohangina.

Poor:

Middle Whanganui and most tributaries, lower Hautapu, lower Rangitikei and tributaries (Tutaenui, Porewa), Upper and Middle Manawatu, Makuri.

Very Poor (water is almost never clear enough swimming):

Whanganui catchment downstream of Pipiriki (including tributaries), Ohura. Kai Iwi stream, Whangaehu and Turakina. Lower Manawatu, Tiraumea, East coast catchments (Owahanga, Akitio) and Waikawa.



MAP 4-2: Visual Clarity Indicator score by catchment. The catchment names can be identified with their number by referring to Appendix 4-1.

3.2 NUTRIENT ENRICHMENT

Nutrients such as nitrogen and phosphorus encourage the growth of aquatic plants and algae. These are a normal and necessary part of an aquatic ecosystem. However, excessive amounts of nutrients in rivers cause nuisance periphyton growth particularly during periods of extended stable/low flows in summer. In lakes, excess nitrogen and phosphorus is responsible for summer nuisance algae blooms.

Algae and macrophytes need both nitrogen and phosphorus for growth. When one of these nutrients is missing, it causes plant growth to slow down or stop, even if all other conditions are favourable. In this case, the nutrient in question is a limiting factor for plant growth. Some systems (rivers or lakes) are phosphorus-limited, while others are nitrogen-limited.

This has important implications for water quality management: in a phosphorus- limited system, it is very important to keep the phosphorus sources as low as possible. Conversely, in a nitrogen- limited system, nitrogen management becomes a priority.

The main sources of nutrients entering the freshwater environment are:

- Discharge of treated wastewater (sewage, industrial effluent, livestock operation effluent).
- Runoff and seepage from agricultural land (excessive or poorly timed application of fertilisers, poorly managed discharges to land).
- Seepage from dysfunctioning septic tanks.

The Nutrient Enrichment Index uses the concentration of nitrates, ammonia and phosphates in the water to summarise how often the nutrient concentration in the water will encourage weed and algae proliferation (Map 4- 3).

Excellent / Good (water is almost never too nutrient-rich):

Most of Whanganui catchment, Rangitikei down to Vinegar Hill, Mangahao and upper catchments of Pohangina, Oroua, Ohau Mangatainoka and Tokomaru Rivers.

Fair:

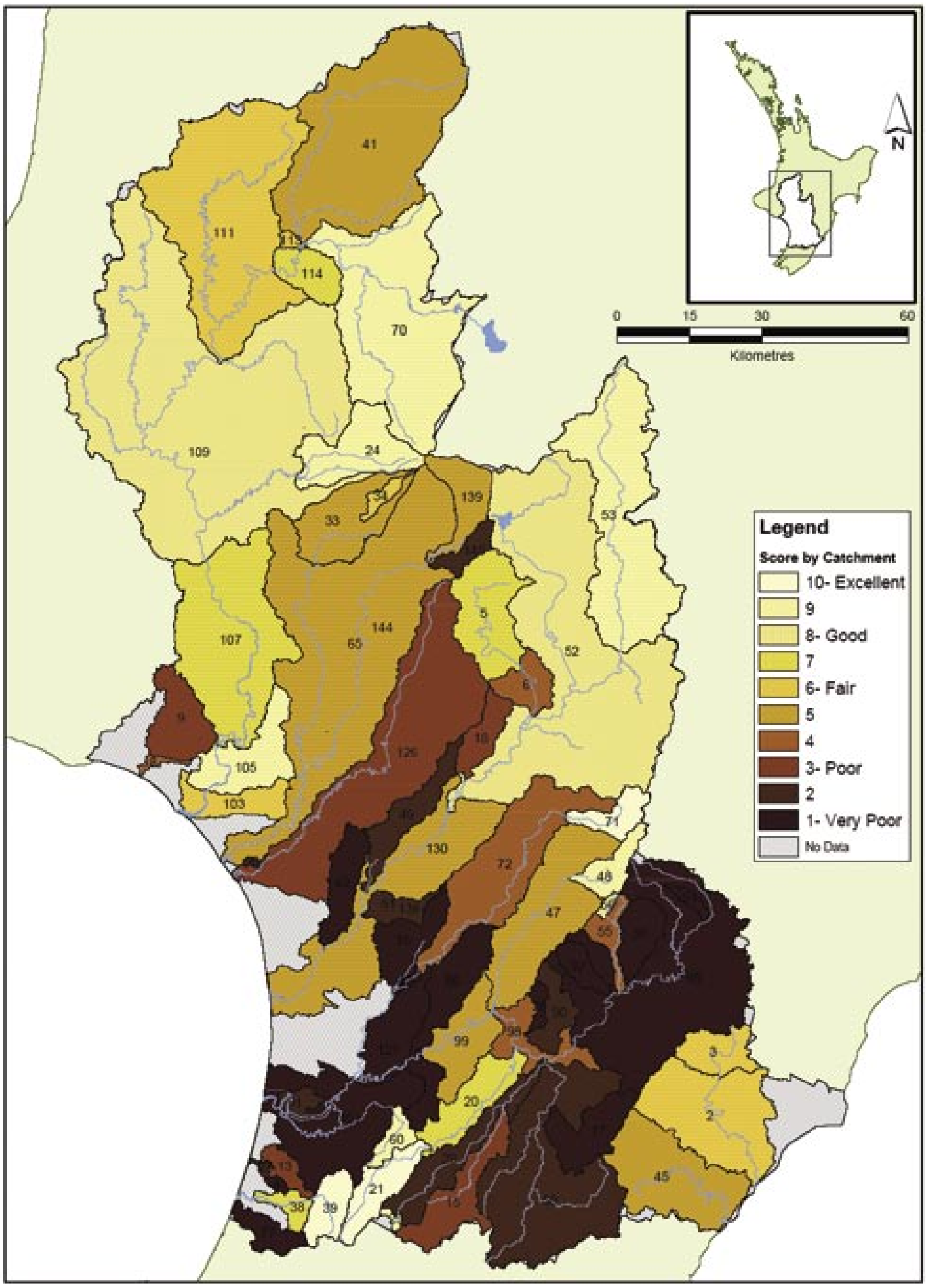
Lower Whanganui, Mangawhero, Whangaehu, Rangitikei, Mangahao and Pohangina, Akitio and Owahanga, Upper Hautapu.

Poor:

Turakina and Lower Hautapu Rivers, Kai Iwi and Makohine Streams.

Very poor (water is almost always too nutrient-rich):

Most of Manawatu catchment, some tributaries of lower Rangitikei River (Tutaenui, Porewa, Rangitawa), Hokio Stream (Lake Horowhenua), Waikawa Stream.



MAP 4- 3: Nutrient Index score by catchment. The catchment names can be identified with their number by referring to Appendix 4- 1.

3.2.1 NITRATE

Nitrate is usually the main nitrogen form available to plants in rivers. Too much nitrate in the water promotes undesirable plant growth and can be toxic to stock and people. Nitrates are very soluble in water and are easily leached to the waterways (via subsurface flows) and the groundwater.

Sources of nitrates entering the waterways are:

- leaching from agricultural land (fertilisers, stock urine, dairy, piggery or poultry sheds wastes application to land),
- discharges of treated wastewater
- leaching from dysfuctioning septic tanks.

The Nitrate Indicator summarises how often the nitrate concentration in the water is satisfactory (Map 4-4).

Excellent / Good (water is almost never too nitrate-rich):

Whanganui catchment, Rangitikei catchment (except some tributaries), Upper Mangawhero and Whangaehu, Pohangina, Upper Oroua, Tokomaru, Mangahao and Mangatainoka. Ohau and East Coast catchments (Akitio and Owahanga).

Fair:

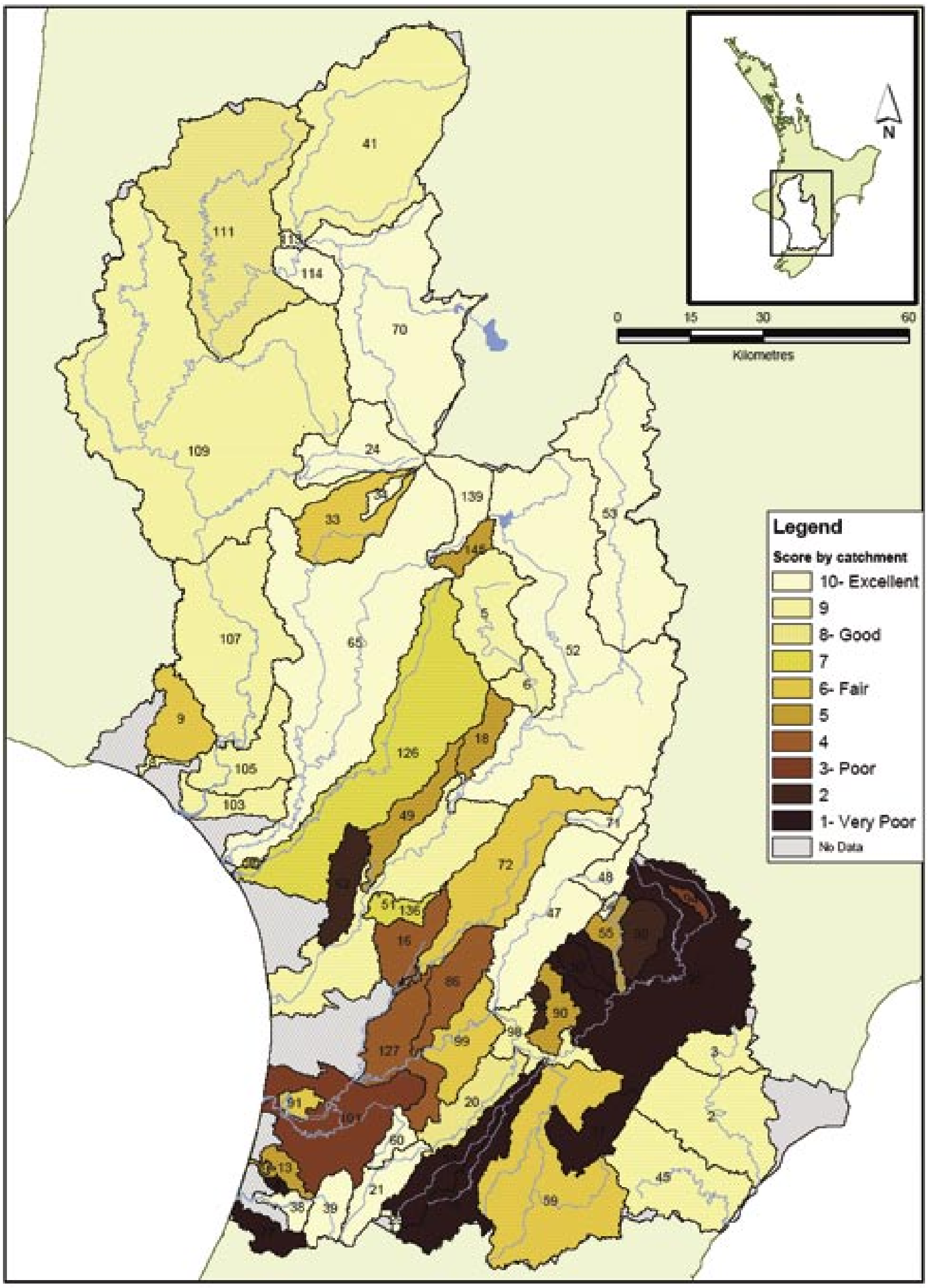
Kai Iwi, middle Mangawhero, Turakina River, Makohine and Porewa Streams, Middle Manawatu, Foxton Loop, Oroua down to Fielding, Tamaki, Tiraumea Rivers.

Poor:

Lower Manawatu, Mangaone and Makino Streams, Oroua River downstream of Fielding, Hokio Stream (Lake Horowhenua).

Very poor (water is almost always too nitrate-rich):

Tutaenui Stream, Upper Manawatu, lower Mangatainoka, Makuri Rivers, Arawhata and Waikawa Streams.



MAP 4- 4: Nitrate Indicator score by catchment. The catchment names can be identified with their number by referring to Appendix 4- 1.

3.2.2 PHOSPHORUS

Phosphorus is a nutrient that can encourage the growth of aquatic plants. Dissolved reactive phosphorus (DRP) is routinely measured in the rivers and gives a good idea of the phosphorus readily available to uptake by plants. In lakes, estuaries and seawater, total phosphorus (TP) is the preferred measurement. Unlike nitrates, phosphorus is not very soluble in water, and tends to be associated with particles (e.g. soil particles washed into a stream).

Sources of phosphorus in the waterways include:

- Poorly timed application of fertilisers e.g. before a heavy rain,
- Land erosion in areas of phosphorus-rich rock types,
- Insufficiently treated wastewater discharged into the rivers. In wastewater, phosphates are very hard and expensive to remove.

The Phosphorus Indicator uses the DRP and TP data to summarise how often phosphorus levels in the water are satisfactory (Map 4- 5).

Excellent / Good (Phosphorus levels are is almost always satisfactory):

Most of the Whanganui catchment, Rangitikei down to Vinegar Hill, Upper Oroua, Pohangina, Mangatainoka and Tokomaru Rivers, Mangahao River.

Fair:

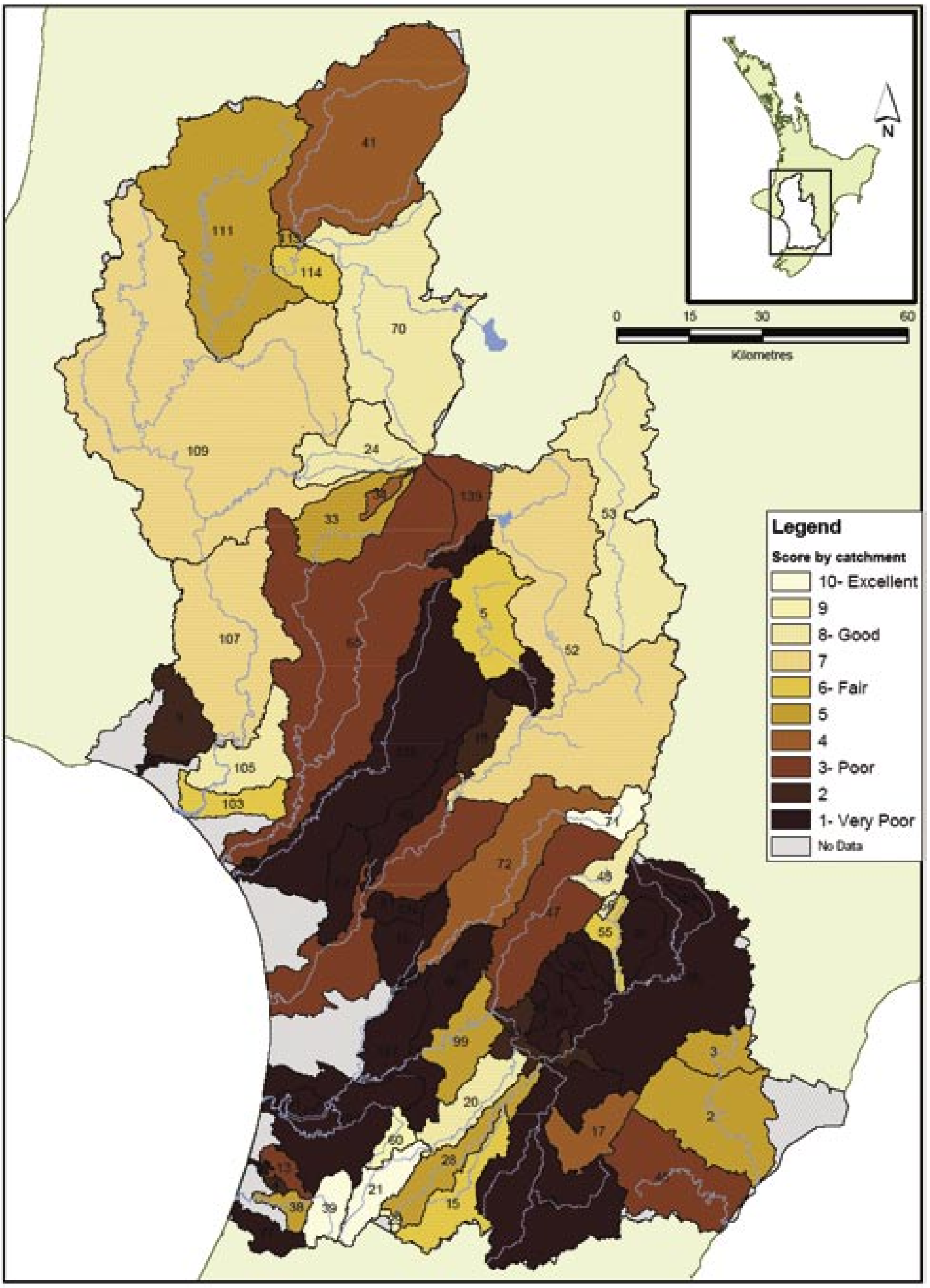
Middle Mangawhero, Upper Hautapu, Akitio, Mangatainoka and Makakahi, Tamaki, Ohau

Poor:

Ongarue River, Whangaehu River, Upper Mangawhero, Lower Rangitikei, Oroua down to Fielding, Lower Pohangina

Very Poor (Phosphorus levels are is almost never satisfactory):

Kai Iwi Stream, Whangaehu River, Lower Hautapu River, Makohine, Porewa and Tutaenui Streams, Upper and Lower Manawatu, Oroua downstream of Fielding, Makino and Magaone Streams, Tiraumea River, Hokio Stream (Lake Horowhenua), Waikawa Stream.



MAP 4- 5: Dissolved Reactive Phosphorus Indicator score by catchment. The catchment names can be identified with their number by referring to Appendix 4- 1

3.3 LIFE SUPPORTING CAPACITY

In a healthy water body, the main physicochemical characteristics, such as water temperature, pH, and dissolved oxygen, are kept within limits compatible with a healthy development of aquatic life. The water and sediment should also not contain any toxicants, such as ammonia or cadmium.

Sources of degraded water quality include:

- Discharge of poorly treated industrial, agricultural or domestic effluent.
- Stormwater from urban / industrial areas.
- Absence of riparian vegetation.
- Abstraction of water.
- Runoff and seepage from agricultural land

The Stressors Index incorporates all these variables and summarises how often any one of these parameters is outside the acceptable range (Map 4- 6)

Excellent / Good:

The large majority of the region's rivers.

Fair:

Lower Whanganui, Mangaone Stream, Tutaenui Stream

Poor:

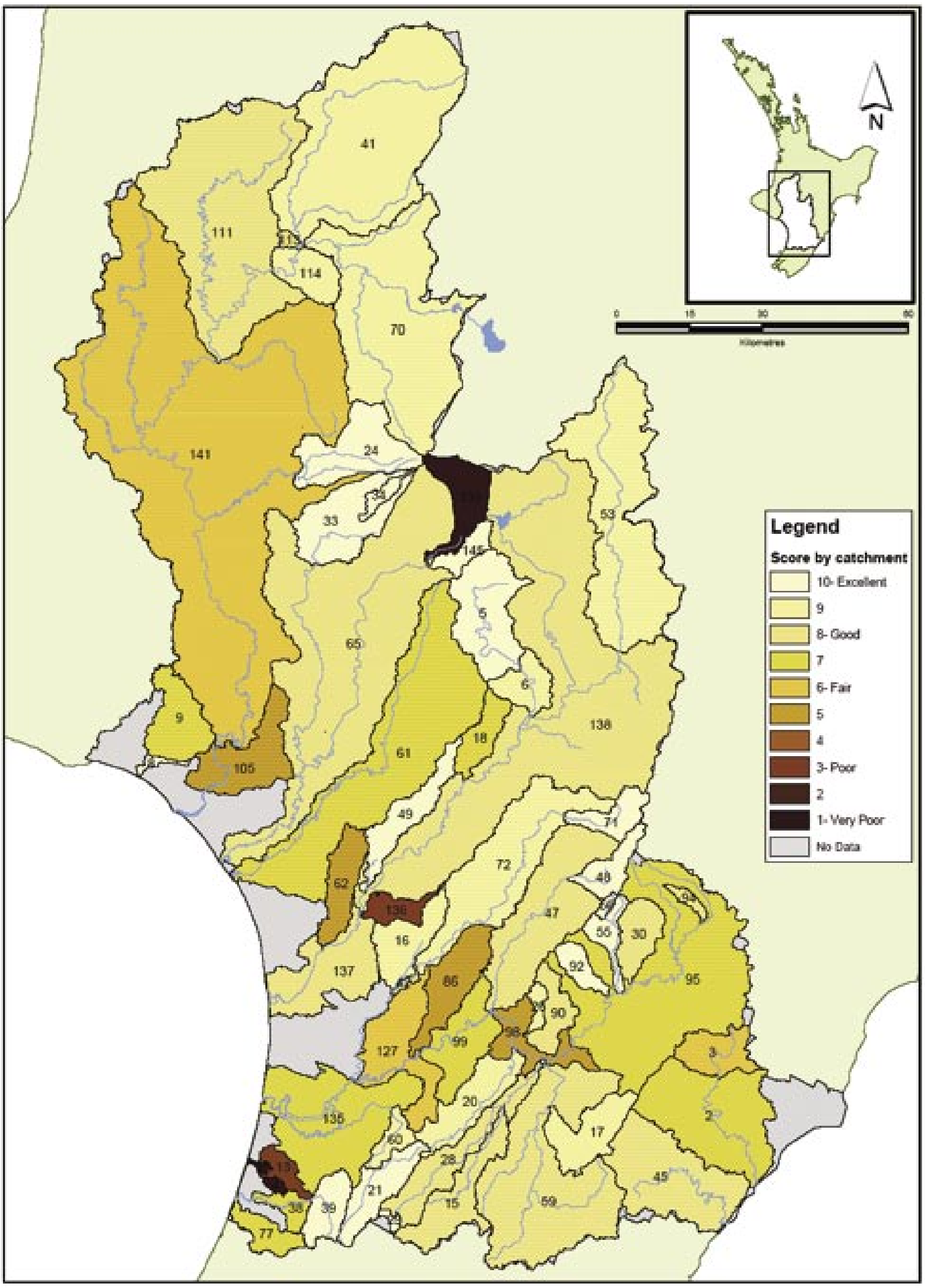
Rangitawa Stream

Very poor:

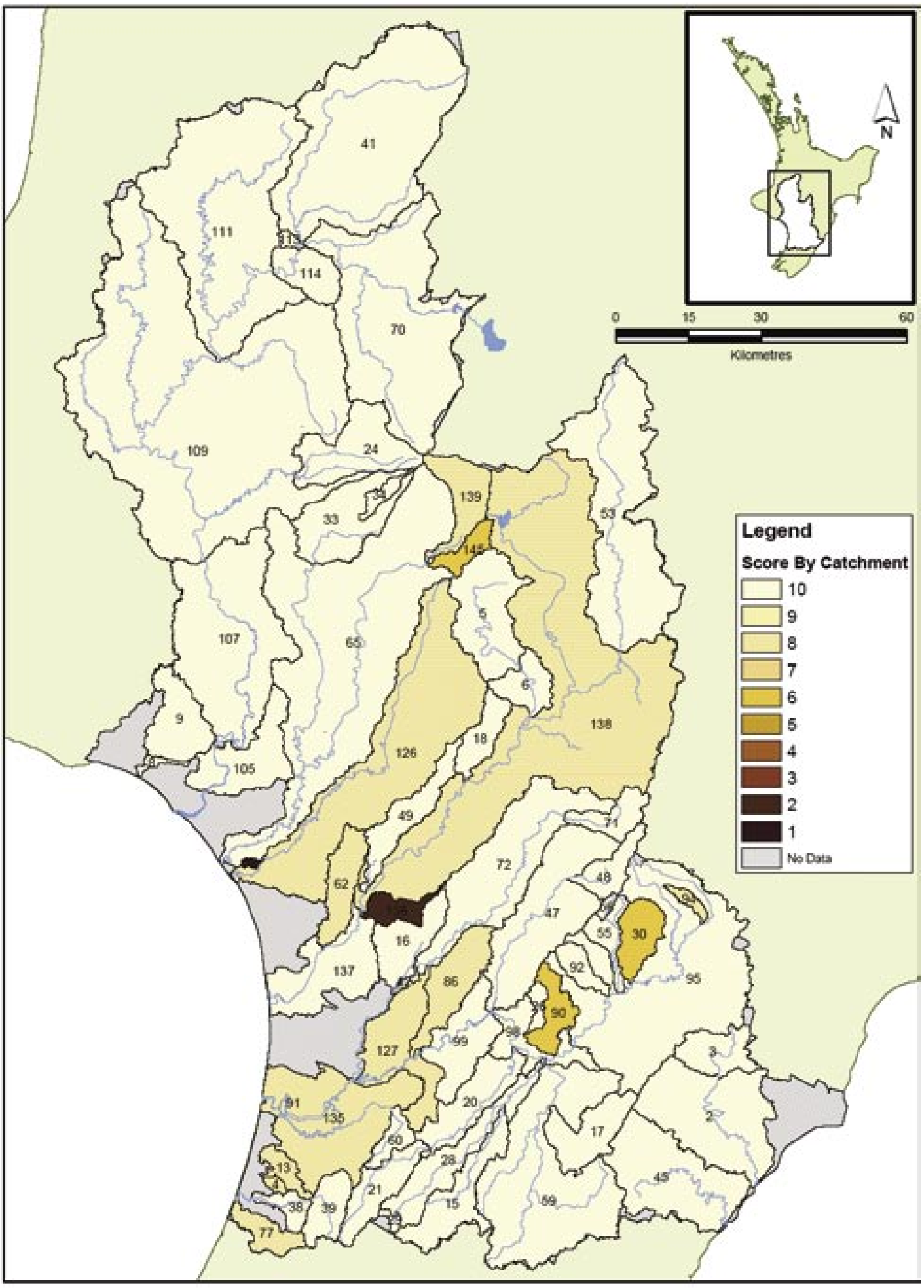
Hokio Stream (Lake Horowhenua) catchment, Whangaehu River

3.3.1 AMMONIA, PH, TEMPERATURE AND DISSOLVED OXYGEN INDICATORS

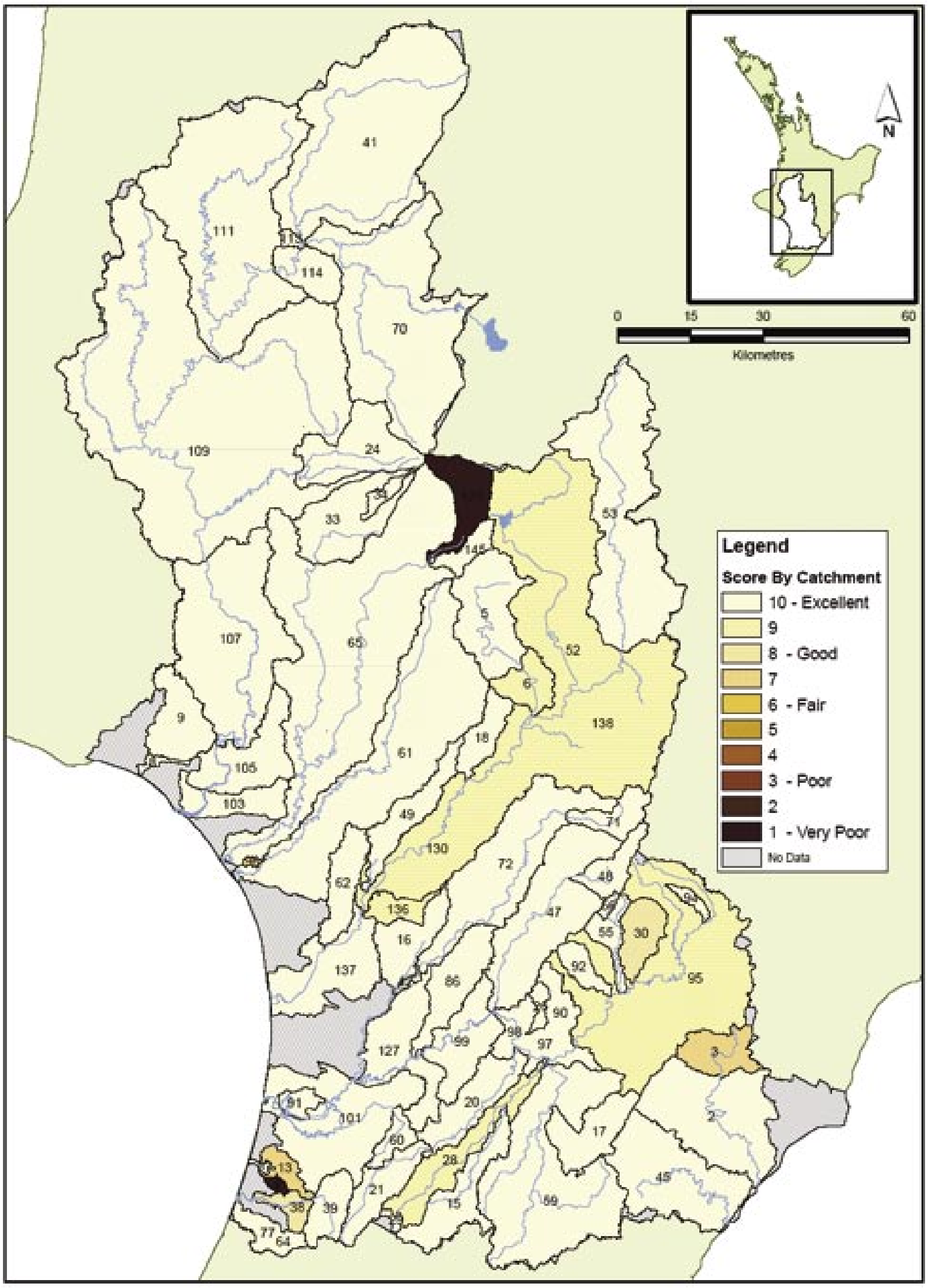
The Stressor Index indicates that the situation is mostly good in regards to ammonia, pH, temperature and dissolved oxygen levels in the region's waterways. To provide a complete picture, maps relating to these indicators are provided as follows, but are not commented in detail to avoid repetition (Maps 4- 7, 4- 8 and 4- 9).



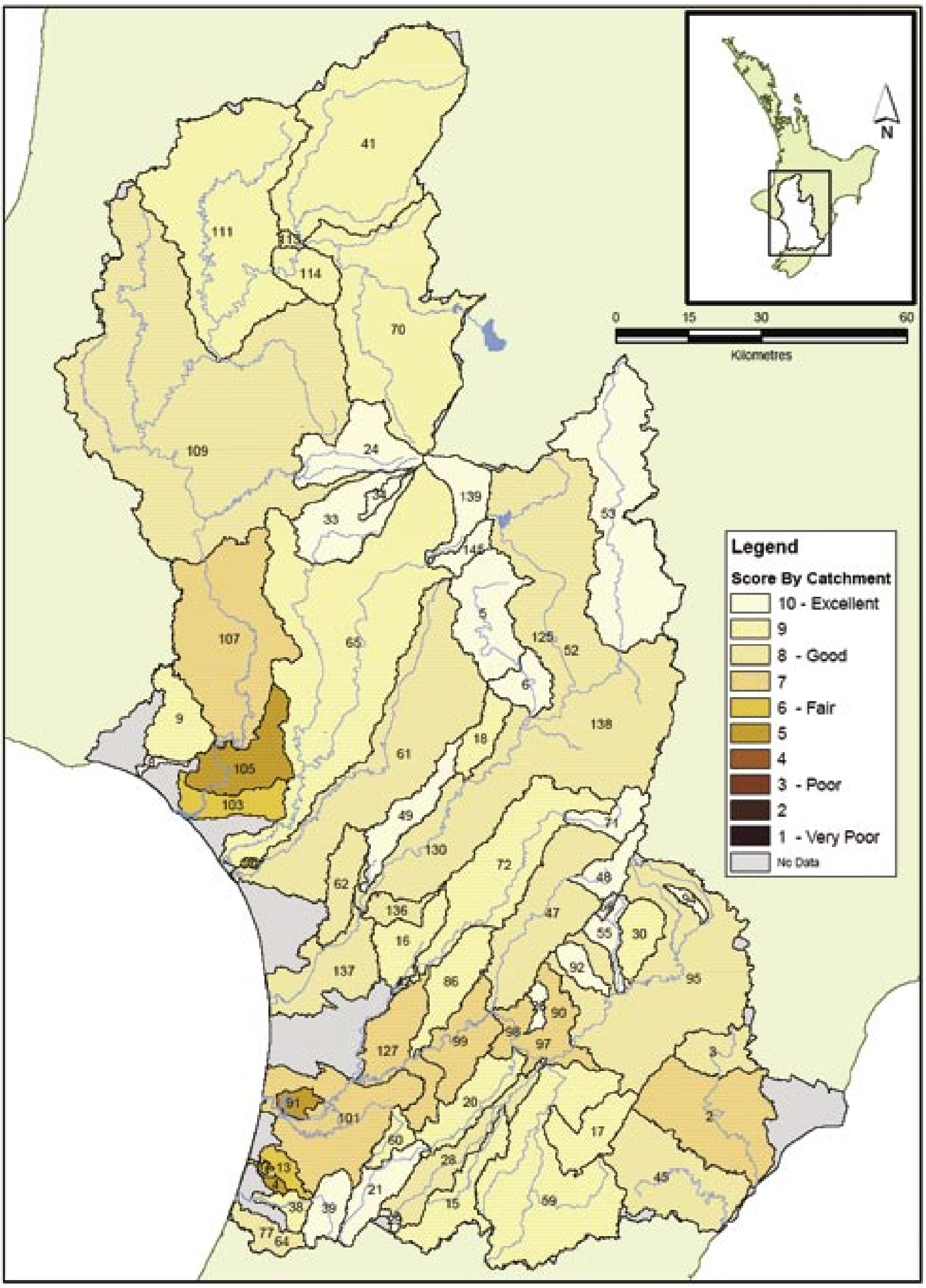
MAP 4- 6: Physicochemical Stressors Index score by catchment. The catchment names can be identified with their number by referring to Appendix 4-1



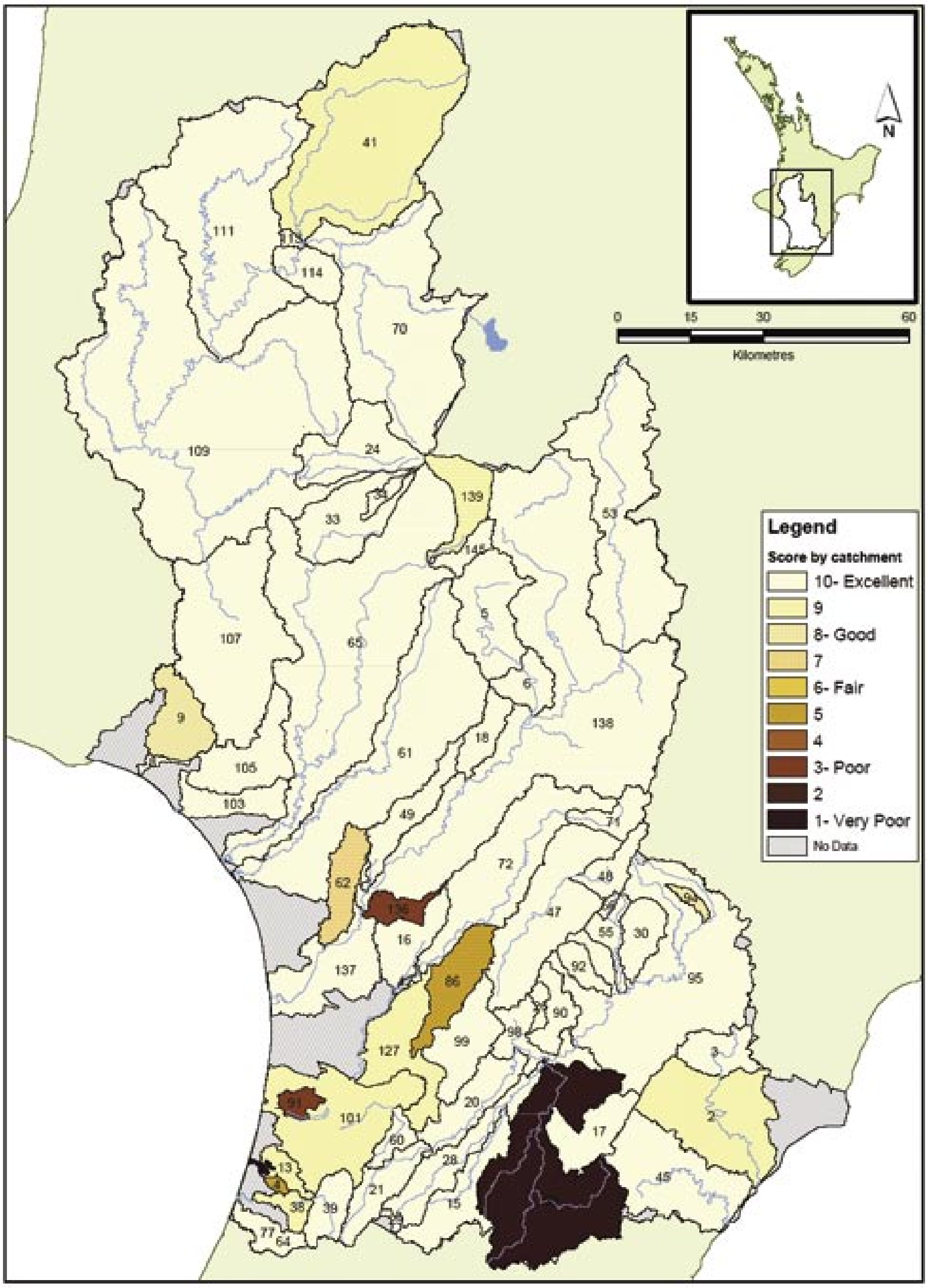
MAP 4- 7: Ammonia Indicator score by catchment. The catchment names can be identified with their number by referring to Appendix 4-1



MAP 4- 8: pH Indicator score by catchment. The catchment names can be identified with their number by referring to Appendix 4-1



MAP 4- 9: Temperature Indicator score by catchment. The catchment names can be identified with their number by referring to Appendix 4- 1



MAP 4- 10: Dissolved Oxygen Indicator score by catchment. The catchment names can be identified with their number by referring to Appendix 4- 1.

3.4 TURBIDITY

High turbidity is associated with low water clarity and large amounts of sediment suspended in the water. This is the "visible" part of water quality. Fairly high turbidity during floods and 'freshes' is a natural phenomenon, and some rivers will naturally be more turbid than others.

However, "muddy" water compromises the aesthetic values of the water. Further, large amounts of sediments in the water can also impact on aquatic life by clogging the gills of fish and invertebrates and smothering stony habitat. Frequent high turbidity is an indicator of accelerated land erosion.

Sources of sediments in the water can be:

- Land erosion (landslides, slips and gullies reaching the waterways).
- River channel erosion.
- Discharge of stormwater, industrial wastewater (e.g. vegetable washing operations).
- Runoff from agricultural land (ploughed land, farm tracks).

The Turbidity Indicator summarises how often water turbidity is unsatisfactory (Map 4- 11)

Excellent / Good:

Upper Rangitikei (down to River Valley Lodge), upper Mangawhero, Manganui O Te Ao, Whakapapa, Mangahao, Mangatainoka. Tamaki and Makino and upper Tokomaru

Fair:

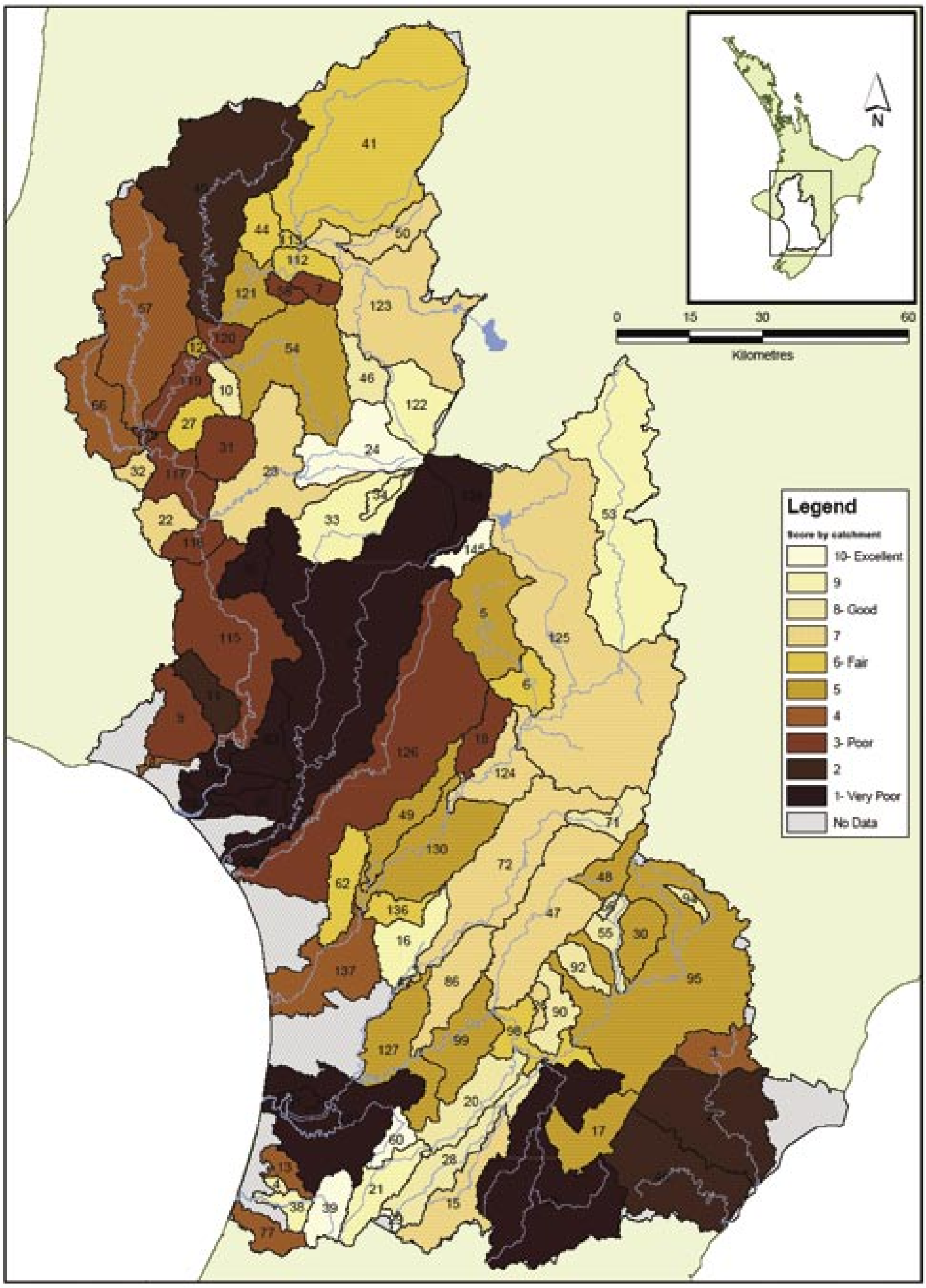
Upper Whanganui, Rangitikei down to Mangaweka, Oroua above Fielding.

Poor:

Lower Rangitikei, middle Whanganui and some tributaries (Tangarakau, Whangamomona)

Very poor:

Whanganui catchment downstream of Pipiriki (including tributaries), Ohura. Lower Manawatu, Tiraumea, East coast catchments (Owahanga, Akitio) and Whangaehu



MAP 4- 11: Turbidity water quality score by catchment. The catchment names are identified with their number by referring to Appendix 4- 1.

4. CONCLUSIONS

This Region faces some significant water quality issues. Most of these relate human activities (land use, discharges) and land types. It is not possible to have good water quality without appropriate land management practice.

This report aims to describe as accurately as possible the state of the region's water quality. It points out the nature of the problems and the areas where these problems occur, but does not indicate development of trends.

Horizons is currently analysing all historical water quality data to try and identify trends. The results of this water quality trends project will be made available as soon as it is completed (expected in September 2005).

This report does not identify the sources of contamination or stressors on water quality. Horizons is also starting a region wide project aiming at defining, for each catchment, the sources of water quality degradation and recommending solutions to improve water quality. These results will also be made available as soon as possible (expected in December 2005).

APPENDIX 4-1: CATCHMENT NUMBERS AND NAMES AS USED IN THE WATER QUALITY MAPS.

NUMBER	CATCHMENT
1	Ahuahu
2	Akitio
3	Akitio Above Weber Road Bridge
4	Arawhata Stream
5	Hautapu above Taihape
6	Hautapu River
7	Hikumutu
8	Lower Kai Iwi
9	Kai Iwi Above SH
10	Kaiwhakauka
11	Kauarapaoa
12	Kowhaiturua
13	Lake Horowhenua -Hokio Stream at outlet
14	Lake Horowhenua
15	Makakahi
16	Makino
17	Makuri
18	Makohine Stream
19	Manawatu above Hopelands
20	Mangahao
21	Mangahao above Kakariki
22	Mangaio
23	Lower Manganuiteao
24	Manganuiteao above Hoihenga Rd
25	Upper Mangaone u/s Milsons Line
26	Mangapapa Stream
27	Mangapurua
28	Mangatainoka
29	Mangatainoka above Putara
30	Mangatera Stream
31	Mangatiti
32	Mangawaiiti
33	Mangawhero
34	Mangawhero above DoC Headquarters
35	Mangoihe
36	Matarawa
37	Mowhanau
38	Ohau River above Haines Property
39	Ohau River above Gladstone Reserve
40	Ohura
41	Ongarue (including Taringamotu)
42	Oroua above awahuri
43	Oroua above MBP discharge
44	Otunui
45	Owahanga
46	Piopiotea Stream
47	Pohangina
48	Pohangina above Piripiri
49	Porewa Stream
50	Pungapunga
51	Lower Rangitikei (Estuary to Vinegar Hill)
52	Rangitikei River (Vinegar Hill)t
53	Rangitikei River above River Valley Lodge
54	Retaruke River
55	Tamaki
56	Tamaki above Reserve
57	Tangarakau
58	Te Maire Stream
59	Tiraumea
60	Tokomaru (at Horseshoe Bend)
61	Turakina
62	Tutaenui Stream
63	Upokongaro
64	Waikawa Stream
65	Whangaehu (incl. lower Mangawhero)
66	Whangamomona
67	Whanganui above Cherry Grove (excl 50)
68	Okahu Stream
69	Ototoka Stream
70	Upper Whanganui (u/s Cherry Grove)
71	Upper Oroua (u/s Apiti Rd Bridge)
72	Oroua above Fielding
73	Kahuterawa Stream
74	Mangaore Stream
75	Lower Mangaone Stream (d/s Milson Line)
76	Lower Waikawa Stream (d/s sampling point Manakau)

NUMBER	CATCHMENT
77	Waikawa Stream
78	Lower Ohau River
79	Waiwiri Stream
80	Motutara Stream
81	Forest Hill Stream
82	Wainui River
83	Papuka Stream
84	Waimata River
85	Lower Oroua River (d/s Awahuri Bridge)
86	Mangaone Stream
87	Hokio Stream d/s Lake outlet
88	Hokio Stream
89	Kai Iwi
90	Mangaatua Stream
91	Foxton Loop
92	Oruakeretaki Stream
93	Upper Manawatu excl 30 55 56 92
94	Mangarangiora Stream
95	Upper Manawatu excl 30 55 56 92 94
96	Lake Waipu
97	Manawatu u/s Ashhurst Domain excl 19 30
98	Manawatu u/s Ashhurst Domain excl 19 30 90
99	Manawatu u/sMaxwells Line to Ashhurst
100	Manawatu u/s Oroua confl to Maxwells Line (excl 73)
101	Lower Manawatu Estuary to Oroua confl.
102	Whanganui Estuary to Aramoho Bridge (excl Matarawa)
103	Whanganui Estuary to Aramoho Bridge
104	Whanganui Aramoho to Kaiwhaiki (excl Upokongaro)
105	Whanganui Aramoho to Kaiwhaiki
106	Whanganui Kaiwhaiki to Pipiriki (excl 35 11 1)
107	Whanganui Kaiwhaiki to Pipiriki
108	Whanganui Pipiriki to Retaruke confl. (excl 22 32 66 57 23 24 10 27 31 12)
109	Whanganui Pipiriki to Retaruke confl. (excl 24)
110	Whanganui Retaruke confl. to Te Maire (excl 40 44 58)
111	Whanganui Retaruke confl. to Te Maire

NUMBER	CATCHMENT
112	Whanganui Te Maire to Waymouths Crusher (excl 7)
113	Whanganui Waymouths Crusher to Cherry Grove (excl 41)
114	Whanganui Te Maire to Waymouths Crusher
115	Whanganui Kaiwhaiki to Pipiriki (excl 35 11)
116	Whanganui Pipiriki to d/s Manganuiteao (excl 22 23 24)
117	Whanganui Manganuiteao to Whangamomona
118	Whanganui Whangamomona to Tangarakau
119	Whanganui Tangarakau to Retaruke
120	Whanganui Retaruke to Ohura
121	Whanganui Ohura to Te Maire
122	Whakapapa
123	Upper Whanganui (u/s Cherry Grove) (excl 50 46 122)
124	Rangitikei Vinegar Hill to Mangaweka
125	Rangitikei Mangaweka to River Valley Lodge
126	Turakina without Lake Waipu
127	Manawatu u/s Oroua confl to Maxwells Line
128	Lake Horowhenua Catchment
129	Lower Rangitikei Estuary to Kakariki (excl 62)
130	Rangitikei Kakariki to Vinegar Hill
131	Manawatu Estuary to Oroua confl. (excl 74 91)
132	Mangamokio Stream
133	Mangatoro River
134	Mangatewainui River
135	Manawatu Estuary to Oroua confl.
136	Rangitawa Stream
137	Lower Rangitikei Estuary to Kakariki (excl 62 136)
138	Rangitikei Kakariki to River Valley Lodge (excl 5 6 18 49)
139	Upper Whangaehu u/s Tangiwai
140	Whangaehu River d/s Tangiwai
141	Whanganui Kaiwhiki to Retaruke (excl 24)
142	Mangawhero River d/s Ohakune
143	Whangaehu excl. Mangawhero
144	Whangaehu d/s Tangiwai
145	Waitangi Stream
146	Whangaehu incl. Mangawhero
147	Whangaehu excl. 145