BEFORE THE HEARINGS PANEL

IN THE MATTER of hearings on submissions concerning the Proposed One Plan notified by the Manawatu-Wanganui Regional Council

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SUPPLEMENTARY EVIDENCE OF MRS KATHRYN JANE MCARTHUR

FOR THE WATER HEARING

ON BEHALF OF HORIZONS REGIONAL COUNCIL

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1. PART ONE: INTRODUCTION AND EXECUTIVE SUMMARY

1. I have prepared this report as supplementary evidence to my Section 42A Report. It has been compiled in response to evidence received from experts on behalf of submitters. As a result of considering the expert evidence received and, where appropriate, after meeting and caucusing with those experts, I have revised some of my recommendations as they appeared in my Section 42A Report. These revised recommendations are presented here.

2. This evidence is in three parts:

   Part One: This introduction and Executive Summary;

   Part Two: Issues raised by submitters' experts and my response, including any revised recommendations as a result;

   Part Three: Corrections to my original evidence sections 4.5.2 and 4.5.3.

3. I have read, and comment here, on the technical evidence of the following experts:
   - Mr Keith Hamill on behalf of Palmerston North City Council
   - Mr Paul Kennedy on behalf of Winstone Pulp International and the Territorial Authority Collective
   - Dr Mike Scarsbrook on behalf of Fonterra Co-operative Group Ltd
   - Dr Russell Death on behalf of the Wellington Fish & Game Council and the Forest and Bird Society

4. I have also read, but do not provide comment on, the technical evidence of the following experts:
   - Mr Logan Brown on behalf of the Department of Conservation
   - Ms Corina Jordan on behalf of the Wellington Fish & Game Council
   - Dr Mike Joy on behalf of the Wellington Fish & Game Council and the Forest and Bird Society
   - Dr Ian Fuller on behalf of the Wellington Fish & Game Council
   - Mr Gary Williams on behalf of the Wellington Fish & Game Council
   - Mr David Cameron of the Territorial Authority Collective
   - Dr Jack McConchie on behalf of Palmerston North City Council
   - Ms Carmen Taylor on behalf of Winston Pulp International Limited

5. I have also been asked by Horizons Planning Officers to comment generally and clarify three issues raised in the evidence of a number of submitters. These are:

   (a) The importance of tributary habitats in relation to aquatic ecosystem health;

(b) The method for the definition of the SOS-A value;

(c) The method for the definition of the Natural State value.

6. I have met with the following experts and the meeting notes outline the outcomes of those meetings:

Table 1. Issues discussed at pre-hearing meetings and caucusing.

Issue discussed	With experts
Water quality standards in Schedule D and application of ANZECC guidelines	Keith Hamill Paul Kennedy John Quinn Bob Wilcock Jon Roygard Myself
Use of aquatic macroinvertebrate indices and significance of changes in Quantitative Macroinvertebrate Community Index (QMCI) upstream and downstream of discharges	Dr Russell Death Myself

2. EXECUTIVE SUMMARY OF SUPPLEMENTARY EVIDENCE AND REVISEDRECOMMENDATIONS

7. After consideration of the technical expert evidence, and subsequent discussions during, or in association with, caucusing meetings, I would like to clarify some matters raised by submitters' experts. I have revised some of my recommendations as presented in my Section 42A Report, particularly with regard to Schedules D and H.

8. The key issues on which I am providing supplementary evidence are:

(a) Recommended changes to Schedule D resulting from expert caucusing;

(b) Recommended changes to Schedule H resulting from supplementary evidence produced by Horizons' external expert;

(c) Further description of water quality trends;

(d) Reference site water quality and downstream change;

(e) Links between water quality standards and values;

(f) Control of periphyton;

(g) The importance of tributary habitats for aquatic ecosystem health;

(h) The method for the definition of the SOS-A and Natural State values.

3. PART TWO: RESPONSE TO ISSUES RAISED BY TECHNICAL EXPERTS

9. Table 2 below summarises the issues raised by submitters that I am responding to and outlines any resolution or explanation that is necessary.

10. I have focused on issues raised by submitters' experts that are not covered in my original evidence or that require further explanation. Where issues are raised by submitters' experts that I consider are already covered by material in my original evidence, or that of other S42A reports produced on behalf of Horizons, I have attempted to minimise repetition by referring directly to figures, sections or page numbers that are in my original evidence. I am happy to address those issues further in response to any questions the Panel may have.

Table 2. Summary table of matters raised by technical experts in evidence on the water provisions of the Proposed One Plan Recommendations in **bold**.

Matter raised by submitters' experts	Expert	Degree of agreement	Explanation/ outcome
Description of regional water quality	Dr Mike Scarsbrook Paragraph # 13	Disagree	The purpose of displaying water quality data using a regional scale map is described in the supplementary evidence of Dr Jon Roygard. However, I would add that regional displays of water quality data that are location- specific, provide transparent information on the distribution of water quality observations, and describe longitudinal water quality patterns have been reported in a number of technical reports, on numerous occasions. For example, I would direct the Panel to the following references that clearly display water quality observations using a range of methods (ie. via the use of box plots or scatter plots to represent the full range of data), for sites longitudinally in catchments or upstream and downstream of point-sources: a. McArthur (2009) S42A Report b. McArthur *et al.* (2009) c. Clark *et al.* (2009) d. Roygard and McArthur (2008) e. McArthur and Clark (2007) f. Clark *et al.* (2007) g. Roygard *et al.* (2006) h. Roygard and Carlyon (2004) i. WaterQuality Matters Website: http://www.horizons.govt.nz/default.aspx?pageid=376 I strongly disagree with the assertion by Dr Scarsbrook that Horizons Regional Council is exaggerating water quality issues and would refer the Panel to the Section 42A evidence on water quality state of myself (page 48) and Dr Rob Davies-Colley.
Control of periphyton	Dr M. Scarsbrook Paragraphs # 28, 31	Disagree	I do not agree that the recommendations of Wilcock *et al.* (2007) are broad generalisations. Paragraphs 28 to 32 below explain data collected in the early months of Horizons' periphyton monitoring programme for four sites which clearly validate, within the regional context, a number of the recommendations of Wilcock *et al.* (2007) and the nutrient standards approach taken in the POP. Paragraph 31 discusses the aspects of values that apply on a year-round basis, related to the periphyton standards. Dr Quinn has presented evidence linking periphyton cover and nutrient concentrations at six NRWQN sites in the Region.

Matter raised by submitters' experts	Expert	Degree of agreement	Explanation/ outcome
Links between values and water quality standards	Dr M. Scarsbrook Paragraph # 30	Disagree	In stating that "*the primary driver for the nutrient standards was life-supporting capacity*" Dr Scarsbrook appears to misunderstand the manner in which the values and standards are linked. Several values from the Ecosystem and Recreational and Cultural values groups are related to periphyton standards. To clarify, I have provided additional context around this subject below (paragraph 27) to be incorporated into the slide presentation at the hearing to address this point (see Figure 2, page 85, my Section 42A report).
Link between periphyton biomass and ecosystem health	Dr M. Scarsbrook Paragraph # 30	Disagree	According to Dr Scarsbrook, information linking periphyton biomass and ecosystem health is limited. This is addressed in the supplementary evidence of Dr Biggs. Associations between elevated nutrient concentrations and poor aquatic ecosystem health are well documented regionally in Appendix 2 of my Section 42A report and for several of the target catchments in Chapter 9 of that report. Observations of downstream decline in MCI, associated with nutrient increase (particularly increasing soluble nitrogen) are common where monitoring data is available for the target catchments (see Mangatainoka River, Figure 26, page 172; upper Manawatu River, Figure 34, page 192; Rangitikei River, Figure 42, page 238 and Mangawhero River, Figure 49, page 250 of my s42A report). Dr Russell Death has also documented regional associations between nutrient concentration and MCI/QMCI scores in paragraph 16 and Figure 5 of his evidence.
Nutrient limitation	Dr M. Scarsbrook Paragraph # 32, 68	Disagree	Dr Scarsbrook cites McDowell *et al.* (2009) to support his assertion that nitrogen loss is less important to manage because of wide-scale P-limitation. However, McDowell *et al.* (2009) also discuss nutrient limitation in the context of concentrations of the non-limiting nutrient. They state, "Furthermore, if the concentration of the non-limiting nutrient is sufficiently high, then nuisance or toxic algal blooms may occur regardless of N:P ratios". This statement is particularly relevant to the upper Manawatu catchment (among other target catchments) where periphyton is often potentially unlimited by either nutrient due to extremely high concentrations of both N and P (McArthur Section 42A report section 5.9.1, page 88). McDowell *et al.* (2009) also conclude that, "Consequently, although strategies to decrease N losses should *always* be practiced, mitigating P losses will be increasingly important to prevent algal growth" (own emphasis added).

Matter raised by submitters' experts	Expert	Degree of agreement	Explanation/ outcome
			In summary, McDowell *et al.* (2009) do not advocate managing land use specifically of one or other nutrient, rather they are identifying a need for both nitrogen *and* phosphorus to be managed to improve water quality outcomes, an approach that is certainly consistent with the POP.
Effects-based standards versus reference-based standards	Dr M. Scarsbrook Paragraph # 34,40	Disagree	Dr Biggs addresses the use of both reference-based and effects-based standards in the POP in his supplementary evidence. The application of standards downstream of references sites that naturally exceed The dissolved reactive phosphorus (DRP) levels, is a matter addressed in the objectives and policies in Chapter 6 of the POP. My understanding of this is that the relevant policies allow for a case-by-case assessment of the degree to which an activity will adversely affect the values if a water quality standard is exceeded. Additionally, as Dr Biggs alludes, nitrogen control will be more imperative in catchments where DRP levels are naturally elevated, to reduce the risk and frequency of nuisance periphyton growths. In the Mangawhero catchment DRP concentrations are naturally elevated because of the influence of volcanic geology (see Figure 51, page 252 of my S42A report). However, large inputs of DRP, such as those from point-sources, are likely to cause adverse periphyton effects at the reach scale and in some instances the catchment scale, particularly if nitrogen inputs (from any source) are also elevated.
Environmental imperative to control non-point source pollution: water quality trends	Dr M. Scarsbrook Paragraph # 46, 53, 54	Disagree	Graham McBride has produced S42A evidence on the use and interpretation of water quality trends, in which he disagrees with the conclusions of Dr Scarsbrook, although the trend data presented has been correctly analysed. It is fundamentally flawed to suggest relationships between decreasing nutrient trends at the site scale and land use change at the regional scale, particularly in the absence of a robust analysis to determine the causes of improving trends. Paragraphs 15 to 21 below detail a summary of the long-term and short-term trend regional analyses carried out by Ballantine and Davies-Colley (2009) in relation to the location of the FARM strategy catchments.
pH range: wording of the standard should provide for natural variation	Paul Kennedy Paragraph # 54	Agree	Natural pH ranges can vary in different water bodies as a result of the source of flow (ie. from the crater lake of Mt Ruapehu or from a large wetland area with naturally

Matter raised by submitters' experts	Expert	Degree of agreement	Explanation/ outcome
outside the range	(WPI evidence)		elevated pH). In many cases (such as the Whangaehu and Wahianoa) these variations are well documented. However, the natural ranges (unimpacted by human activities) for pH are not known in all cases and allowance for variation in unimpacted catchment areas is a pragmatic solution to this issue. This means that any reference to existing exemptions for low pH (ie. the Whangaehu mainstem) in Schedule D can be removed in favour of the recommended approach. **I recommend that the wording of the pH standard in the Schedule D standards key is amended to read "The pH of the water shall be within the range […] to […] unless natural levels are already outside this range".**
Temperature change: the standards for temperature change should be no more than 3 degrees throughout the Region	Paul Kennedy Paragraph # 56 (WPI evidence)	Disagree	The temperature change standard varies depending on Water Management Sub-zone because of the temperature change standards set according to the Life-Supporting Capacity (LSC) class in each zone. Sites in Upland Hard Sedimentary, Upland Volcanic Acidic and Upland Volcanic Mixed LSC geology classes were recommended to have a 2 degree temperature change standard to accommodate the temperature sensitive aquatic mayfly and stonefly species that are expected to dominate macroinvertebrate communities in these LSC classes. No evidence has been provided to justify departing from the values-based temperature change standards set within Schedule D. **No change recommended.**
Particulate Organic Matter (POM): the average POM concentration should apply	Keith Hamill Paragraph #5.4 & 5.42(b)	Agree	The average concentration of POM is the most appropriate statistic to measure effects on benthic organisms. **I recommend the wording of the POM standard in the Schedule D standards key is amended to read, "The average concentration of particulate organic matter when the river flow is at or below the 50^{th} percentile of flow shall not exceed […] grams per cubic metre".**
Particulate Organic Matter (POM) and Volatile Suspended Solids (VSS) are the same parameter	Keith Hamill / Paul Kennedy (raised during caucus)	Agree	The addition of a reference to VSS to the standards key for the POM standard is appropriate as the two measures are one and the same. **I recommend a footnote is added to POM which states, "Standard can also be applied to volatile suspended solids (VSS)".**

Matter raised by submitters' experts	Expert	Degree of agreement	Explanation/ outcome
Algal (periphyton) biomass standards should apply only to filamentous growths	Keith Hamill Paragraph # 5.28	Disagree	The term 'filamentous' is consistent with the NZ Periphyton Guidelines in relation to the algal biomass standards for aesthetics/recreation (see Table 14 Biggs, 2000). However, the guidelines were not directly applied to determine standards for periphyton biomass in the Region's Water Management Sub-zone (WMSZs). The relationship between Life-Supporting Capacity (LSC) and periphyton biomass standards was determined by the LSC classes, based on catchment geology, not on the benthic biodiversity figures in the NZ Periphyton Guidelines (Biggs, 2000). This is clearly described in Table 21 of the technical report on water quality standards by Ausseil & Clark (2007a). Furthermore, the most stringent periphyton biomass, which ultimately became the standard for each depended on the set of values within that zone. Desired outcomes in terms of periphyton biomass and cover were the primary drivers for the nutrient standards. The periphyton standards in turn were derived according to the desired outcomes in relation to the management objectives associated with the values in each WMSZ. Given that the approach taken to set periphyton biomass standards was a values-based approach consistent with the intent of the NZ Periphyton Guidelines but not totally consistent with the methods, Horizons prefers to retain the more localised values-based approach, developed in conjunction with the guideline's author (Dr Biggs). **No change recommended.**
Application of an advice note to DRP and SIN standards in the Schedule D standards key	Keith Hamill Paragraph # 5.41, 5.42 (h)	Disagree	The dissolved reactive phosphorus (DRP) and soluble inorganic nitrogen (SIN) standards are effects-based and were determined after considerable science advice and technical work. The manner in which the standards are applied to any particular situation should not be determined within the standards key and is a matter for the policies and objectives of the Plan. **No change recommended.**
Use of a reference-based approach to determine natural reference conditions for Macroinvertebrate Community Index (MCI)	Keith Hamill Paragraph # 5.9	Disagree	Horizons has invested considerable resources into investigating the use of a reference-based approach to invertebrate biomonitoring. Currently there is no robustly tested method accepted in New Zealand other than the MCI and variants (QMCI and SQMCI). Until a reference-based approach is developed that is robustly tested, the MCI will be used in preference. Additionally, reference conditions for

Matter raised by submitters' experts	Expert	Degree of agreement	Explanation/ outcome
			lowland water bodies are difficult to determine, as most are impacted by point-source or diffuse inputs of contaminants to a greater or lesser degree. **No change recommended.**
Clarity on appropriate use of the MCI	Paul Kennedy Paragraph # 75 (WPI evidence)	Agree	Footnote 4 referring to MCI in Table D2a makes it clear that this standard is only applied for State of the Environment reporting in appropriate situations. For clarity, this explanation should be placed as a footnote to MCI in the standards key. **I recommend Footnote 4 referring to MCI in Table D2a be shifted to refer to MCI in the standards key.**
QMCI should be compared between appropriately matched upstream and downstream habitats	Determined during caucus	Agree	Use of best practice methods for determining impact between upstream and downstream macroinvertebrate measurements would mean sampled habitats were appropriately matched (eg. both stony riffles with no tributary inflows or other discharges in between) to enable robust tests between upstream and downstream results. **I recommend the wording of the QMCI standard in the Schedule D standards key is amended to read "No more than a 20% reduction in Quantitative Macroinvertebrate Community Index (QMCI) between appropriately matched habitats upstream and downstream of discharges to water."** **I recommend Footnote 3 from Table D1a be amended to read, "This standard is only relevant for measuring the degree of change in Quantitative Macroinvertebrate Community Index (QMCI) between appropriately matched habitats upstream and downstream of activities such as discharges to water, for the purposes of measuring the effects of discharges on aquatic macroinvertebrate communities; it is not an appropriate standard for the measurement of the general state of macroinvertebrate communities in each Water Management Sub-Zone.** ***Note: But see further recommendation on QMCI below in relation to the evidence of Dr Russell Death***
Wording recommended by Palmerston North City Council including the term "cause"	Keith Hamill Paragraph # 3.5	Disagree	The Schedule D standards key wording is already appropriate. If "cause" were added it may create opportunity for arguments about causality that would be difficult to resolve in some circumstances. Recommended wording regarding appropriately matched habitats (see above) clarifies this matter.

Matter raised by submitters' experts	Expert	Degree of agreement	Explanation/ outcome
			No change recommended.
Ammoniacal-N as an average	Keith Hamill Paragraph # 5.12 – 5.23	Agree in part	Use of the average ammoniacal-N concentration can only be justified if a maximum value is also added to avoid acute toxicity as a result of large ammoniacal-N spikes from discharges. Dr Wilcock provides supplementary evidence on this matter and recommends maximum values that could be applied in conjunction with averages in Schedule D. **I recommend the wording of the ammoniacal-N standard in the Schedule D standards key be amended to read, "The average concentration of ammoniacal-N shall not exceed […] grams per cubic metre."**
Ammoniacal-N maximum	Determined following caucus	Agree in part	The addition of a maximum ammoniacal-N concentration is needed if the ammoniacal-N standard currently in Schedule D is changed to an average concentration (see above). Maximum standards to match the current standards have been devised using an agreed method by Dr Wilcock. **I recommend that maximum ammoniacal-N values are added to the Schedule D2a table as follows: "Water Management Sub-zones with current ammoniacal-N standards of 0.400 shall have a maximum concentration not to be exceeded of 2.1 grams per cubic metre; those with the current ammoniacal-N concentration of 0.320 shall have a maximum concentration not to be exceeded of 1.7 grams per cubic metre."** **I recommend the addition of wording of the maximum ammoniacal-N standard in the Schedule D standards key be amended to read, "The maximum concentration of ammoniacal-N shall not exceed […] grams per cubic metre."**
Relationship between SIN and ammoniacal-N	Determined following caucus	Agree	It should be clear to users of Schedule D that ammoniacal-N is a component of soluble inorganic nitrogen (SIN) and that standards apply for both contaminants to avoid nuisance periphyton growths (SIN and ammoniacal-N) and toxicity to aquatic ecosystems (ammoniacal-N only). Users should be directed to the SIN standards from the ammoniacal-N standard to ensure both are accounted for in any assessment. **I recommend the addition of a footnote to ammoniacal-N in the Schedule D standards key which reads, "Ammoniacal-N is a component of SIN. SIN standards should also be considered when assessing ammoniacal-N**

Matter raised by submitters' experts	Expert	Degree of agreement	Explanation/ outcome
			concentrations against the standards."
Toxicants	Keith Hamill Paragraph #5.25	Agree	The adjustment for hardness and use of soluble/dissolved fractions of metals in the ANZECC (2000) toxicants table is implied. However, for the sake of clarity these aspects should be added to the wording for toxicants in the Schedule D standards key. **I recommend the wording of the toxicants standards in the Schedule D standards key be amended to read, "For toxicants not otherwise defined in these standards, the concentration of toxicants in the water shall not exceed the trigger values defined in the 2000 ANZECC guidelines Table 3.4.1. for the protection of […] % of species. For metals the trigger value shall be adjusted for hardness and apply to the dissolved fraction as directed in the table."**
Clarity percent change and minimum standards	Keith Hamill Paragraph # 5.26	Agree	All reference to a 200 mm black disc size should be removed from the Schedule D standards key relating to clarity in rivers as it is appropriate when measuring horizontal visibility to use different disc sizes depending on the clarity of the water being measured. **I recommend the wording of the percent change clarity (rivers) standard in the Schedule D standards key be amended to read, "The clarity of the water measured as the horizontal sighting range of a black disc shall not be reduced by more than […] %."** **I recommend the wording of the minimum clarity (rivers) standard in the Schedule D standards key be amended to read, "The clarity of the water measured as the horizontal sighting range of a black disc shall equal or exceed […] metres when the river is at or below the 50^{th} percentile of flow."**
Statistically significant change in QMCI	Dr Russell Death Paragraph # 34	Agree	The 20% change in QMCI in Table D1a is a somewhat arbitrary figure for change between upstream and downstream of discharges to water. This percentage change was determined as appropriate because it is twice the percentage for error on QMCI, calculated using best practices (Dr John Stark *pers comm*.). However, determining changes between upstream and downstream QMCI scores using robust statistical methods is a preferable approach that is likely to be more defensible and provide added certainty around degree of effect on aquatic macroinvertebrate communities.

Matter raised by submitters' experts	Expert	Degree of agreement	Explanation/ outcome
			Futhermore, a "User Guide" for best practice for biomonitoring and assessing water quality and biological indices against Schedule D standards would be a useful stand-alone document. This could be produced in consultation with technical experts involved in the development of Schedule D (both within and outside of Horizons) once the final standards are decided. **I recommend the QMCI % change standard in Table D1a be changed to have a heading of "QMCI D" and that the "20" applied to all Water Management Sub-zones be amended to read "statistically significant reduction".** **I recommend the wording of the QMCI standard in the Schedule D standards key is amended to read, "No statistically significant reduction in Quantitative Macroinvertebrate Community Index (QMCI) between appropriately matched habitats upstream and downstream of discharges to water".** ***Note: This recommended change had not been circulated to other submitters' experts who have commented on QMCI at the time of writing this report.***

Recommended change to Schedule H

11. Dr Zeldis has provided a correction to his original s42A report via supplementary evidence, regarding the Schedule H standard in estuaries for macro-algal cover and for algal biomass in the Seawater Management Zone. He has recommended the percentage cover standard for macro-algae in recommended Table H5a should be reduced from 20 to 5 and that the algal biomass standard in recommended Table H7a should be raised from 1 mg/m^3 chlorophyll ^{a} to 3 mg/m^3 chlorophyll ^{a}.

12. Accordingly, on Dr Zeldis' advice, **I recommend that the figures in Table H 5a under the column heading Macro-algae % cover be changed from "20" to "5" for all estuaries.**

13. **I also recommend that the value in Table H7a under the column labeled "Periphyton" (see paragraph below) be changed from "1" mg/m^3 to "3" mg/m^3.**

14. I note a recommendation from my original s42A evidence has been omitted in error from the recommended Schedule H, Table H7a. Consequently, to correct this error, **I recommend that the column heading in Table H7a labeled "Periphyton" be changed to read "Algal biomass".**

Further description of water quality trends

15. Water quality trends have been identified by Dr Scarsbrook in relation to various periods of record at the NRWQN sites within Horizons' Region. Ballantine and Davies-Colley (2009) examined both long and short-term water quality trends for NRWQN and Horizons State of the Environment (SoE) monitoring sites. A summary of Ballantine and Davies-Colley's (2009) findings is presented in Tables 3 and 4 below.

16. The long-term and short-term trends for dissolved reactive phosphorus (DRP) (Map 1 and Map 2) are also shown below to display where the trends are in association with the target catchments for FARM strategy management. It is of note that Ballantine and Davies-Colley (2009) found no short-term improving trend for the Manawatu River at the Palmerston North Teachers College site, contrasting with the evidence of Dr Scarsbrook. The timeframe of analysis by Ballantine and Davies-Colley was 2001 to 2008, whereas Dr Scarsbrook examined a shorter-term trend from 1999 to 2008. This shows the influence that only two years of data can have on trend analysis and supports

the greater level of certainty associated with longer-term trend analysis. In general terms the more data collected the greater the confidence in the result.

17. Soluble inorganic nitrogen (SIN) trends show long-term increases (Map 3) at a number of sites, contrasting with short-term decreasing trends (Map 4). As discussed in the S42A report of Graham McBride, it would be incorrect to extrapolate beyond the period of measurement and assume that these short-term trends will continue into the future. However, the decreasing nitrogen trends, regardless of cause, are a positive sign for water quality in the Manawatu catchment, although they should be viewed with caution.

18. The Manawatu at Hopelands site shows no long-term or short-term trends for nutrients over the 1989 to 2008 period. Nutrient concentrations during this time appear to have been stable in the upper Manawatu, albeit at high levels.

19. Maps of long-term and short-term water quality trends for *Escherichia coli (E. coli),* clarity and turbidity are displayed in Appendix 1 below.

Table 3. Summary of the tend analysis results for DRP and SIN at Horizon's SoE monitoring sites and NRWQN sites (NIWA client report by Ballantine and Davies-Colley, June 2009).

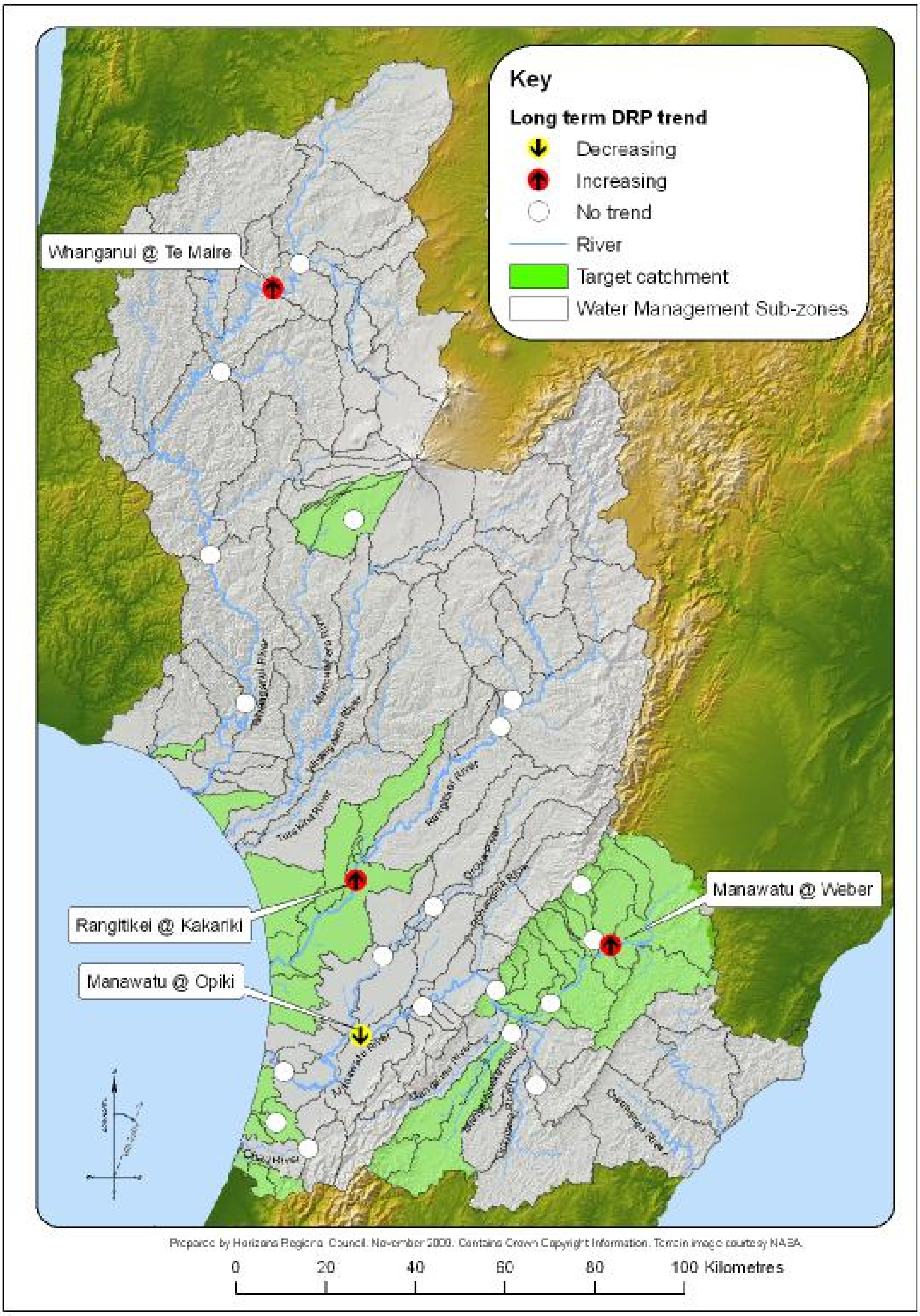
Site Name	Easting	Northing	Long term trend		Short term trend		Catchment	Rule 13.1 Target catchment
			DRP	SIN	DRP	SIN		
Whanganui @ Cherry Grove	2705700	6254500	No trend	No trend	No trend	↓	Cherry Grove	No
Whanganui @ Te Maire	2699812	6248985	↑	No trend	No trend	No trend	Te Maire	No
Whanganui d/s Retaruke	2688300	6230500	No trend	No trend	No trend	No trend	Middle Whanganui	No
Whanganui @ Pipiriki	2685800	6189600	No trend	↓	No trend	No trend	Pipiriki	No
Whanganui @ Paetawa	2693722	6156603	No trend	No trend	No trend	No trend	Paetawa	No
Mangawhero @ DOC HQ	2717762	6197545	No trend	↓	No trend	↓	Upper Mangawhero	Yes
Hautapu u/s Rangitikei	2753000	6157400	No trend	↓	No trend	↓	Lower Hautapu	No
Rangitikei @ Mangaweka	2750370	6151340	No trend	No trend	No trend	No trend	Pukeokahu-Mangaweka	No
Rangitikei @ Kakariki	2718305	6117218	↑	No trend	↓	↓	Coastal Rangitikei	Yes
Tamaki @ Reserve	2768300	6116200	No trend	No trend	No trend	No trend	Upper Tamaki	Yes
Tamaki @ SH2	2771200	6104000	No trend	No trend	No trend	No trend	Lower Tamaki	Yes
Manawatu @ Weber	2775061	6102713	↑	↑	No trend	No trend	Upper Manawatu	Yes
Manawatu @ Hopelands	2761500	6089800	No trend	No trend	No trend	No trend	Tamaki-Hopelands	Yes
Makuri @ Tuscan Hills	2758300	6071600	No trend	No trend	No trend	No trend	Makuri	No
Mangatainoka @ SH2	2752800	6083100	No trend	No trend	No trend	↓	Lower Mangatainoka	Yes
Manawatu @ Upper Gorge	2749400	6092700	No trend	No trend	No trend	↓	Upper Gorge	Yes
Manawatu @ Teachers College	2733100	6089200	No trend	↑	No trend	↓	Middle Manawatu	No
Manawatu @ Opiki	2719420	6082710	↓	↑	↓	↓	Lower Manawatu	No
Oroua @ Almadale	2735600	6111300	No trend	No trend	No trend	No trend	Upper Oroua	No
Oroua @ Awahuri	2724300	6100300	No trend	↓	No trend	No trend	Middle Oroua	No
Manawatu @ Whirokino	2702200	6074700	No trend	No trend	No trend	↓	Coastal Manawatu	No
Lake Horowhenua	2700500	6063500	No trend	No trend	No trend	No trend	Lake Horowhenua	Yes
Ohau @ Rongomatane	2707600	6057700	No trend	No trend	No trend	No trend	Rongomatane	No

Note: Sites in bold are NRWQN sites

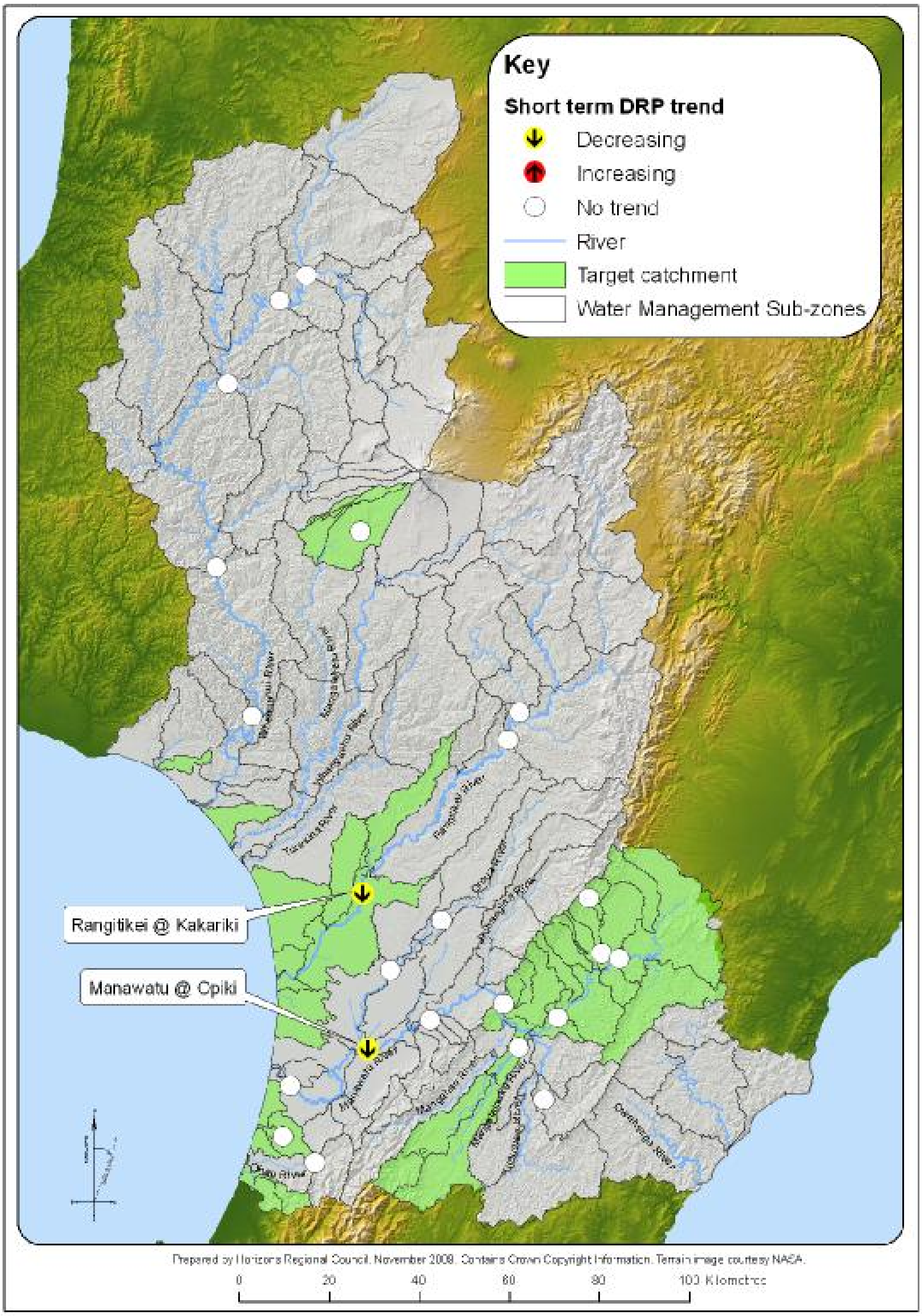
Table 4. Summary of the trend analysis results for clarity and turbidity at Horizon's SoE monitoring sites and NRWQN sites (NIWA client report by Ballantine and Davies-Colley, June 2009).

Site Name	Easting	Northing	Long term trend		Short term trend		Catchment	SLUI Priority catchment
			Clarity	Turbidity	Clarity	Turbidity		
Whanganui @ Cherry Grove	2705700	6254500	No trend	No trend	No trend	No trend	Cherry Grove	Yes
Whanganui @ Te Maire	2699812	6248985	No trend	↓	No trend	No trend	Te Maire	Yes
Whanganui d/s Retaruke	2688300	6230500	No trend	No trend	No trend	No trend	Middle Whanganui	Yes
Whanganui @ Pipiriki	2685800	6189600	No trend	↓	No trend	No trend	Pipiriki	Yes
Whanganui @ Paetawa	2693722	6156603	No trend	No trend	No trend	No trend	Paetawa	Yes
Mangawhero @ DOC HQ	2717762	6197545	No trend	↓	No trend	No trend	Upper Mangawhero	No
Hautapu u/s Rangitikei	2753000	6157400	↓	↓	No trend	↓	Lower Hautapu	No
Rangitikei @ Mangaweka	2750370	6151340	↑	No trend	No trend	No trend	Pukeokahu-Mangaweka	Yes
Rangitikei @ Kakariki	2718305	6117218	No trend	↑	No trend	No trend	Coastal Rangitikei	No
Tamaki @ Reserve	2768300	6116200	No trend	No trend	No trend	No trend	Upper Tamaki	No
Tamaki @ SH2	2771200	6104000	No trend	No trend	No trend	No trend	Lower Tamaki	No
Manawatu @ Weber	2775061	6102713	No trend	No trend	No trend	No trend	Upper Manawatu	No
Manawatu @ Hopelands	2761500	6089800	↑	No trend	↑	↓	Tamaki-Hopelands	No
Makuri @ Tuscan Hills	2758300	6071600	No trend	No trend	No trend	No trend	Makuri	Yes
Mangatainoka @ SH2	2752800	6083100	No trend	↓	No trend	↓	Lower Mangatainoka	No
Manawatu @ Upper Gorge	2749400	6092700	No trend	No trend	No trend	No trend	Upper Gorge	No
Manawatu @ Teachers College	2733100	6089200	↑	No trend	No trend	No trend	Middle Manawatu	No
Manawatu @ Opiki	2719420	6082710	No trend	No trend	No trend	No trend	Lower Manawatu	No
Oroua @ Almadale	2735600	6111300	No trend	No trend	No trend	No trend	Upper Oroua	Yes
Oroua @ Awahuri	2724300	6100300	No trend	No trend	↓	No trend	Middle Oroua	No
Manawatu @ Whirokino	2702200	6074700	↓	↑	No trend	No trend	Coastal Manawatu	No
Lake Horowhenua	2700500	6063500	No trend	No trend	No trend	No trend	Lake Horowhenua	No
Ohau @ Rongomatane	2707600	6057700	No trend	No trend	No trend	No trend	Rongomatane	No

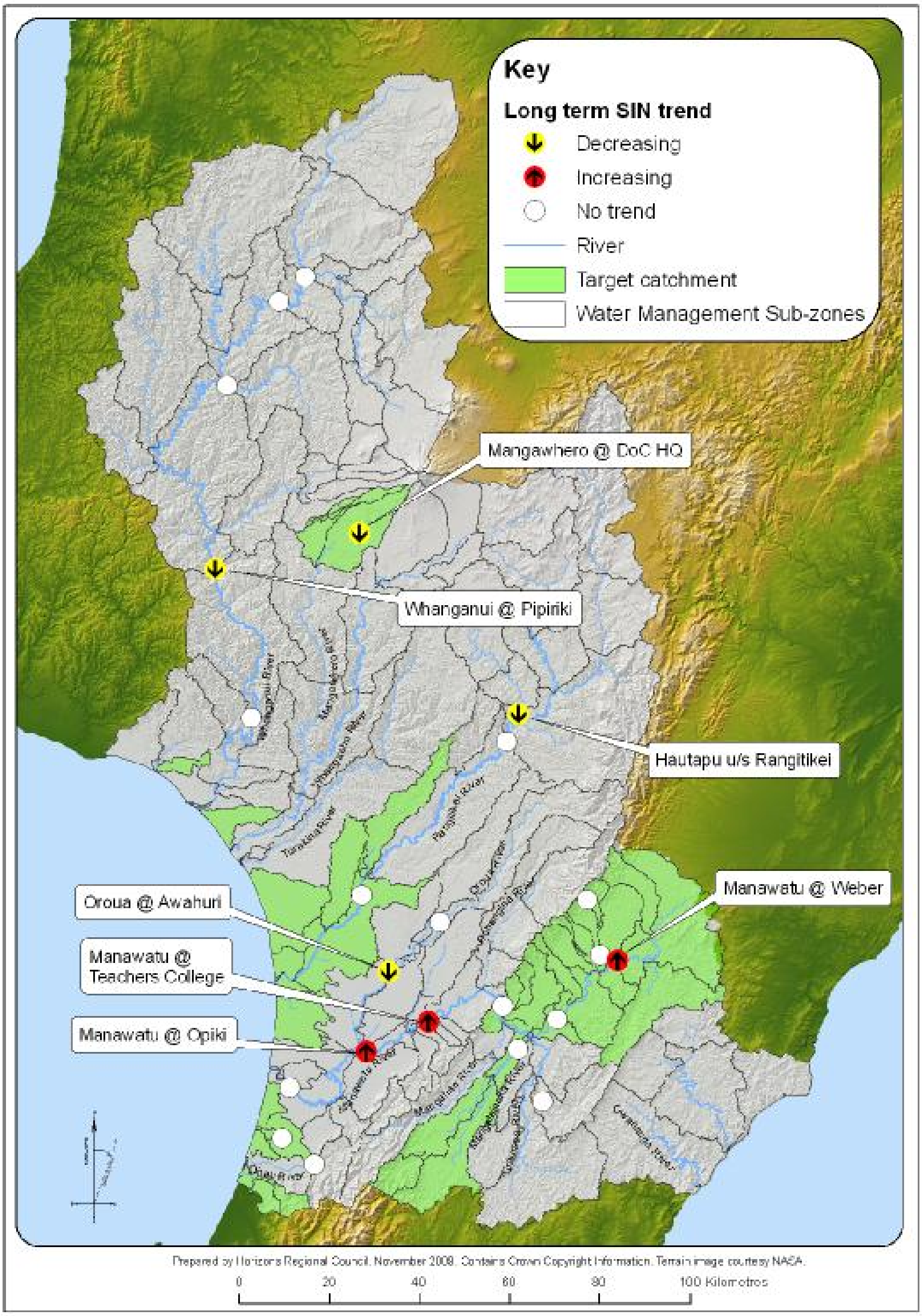
Note: Sites in bold are NRWQN sites



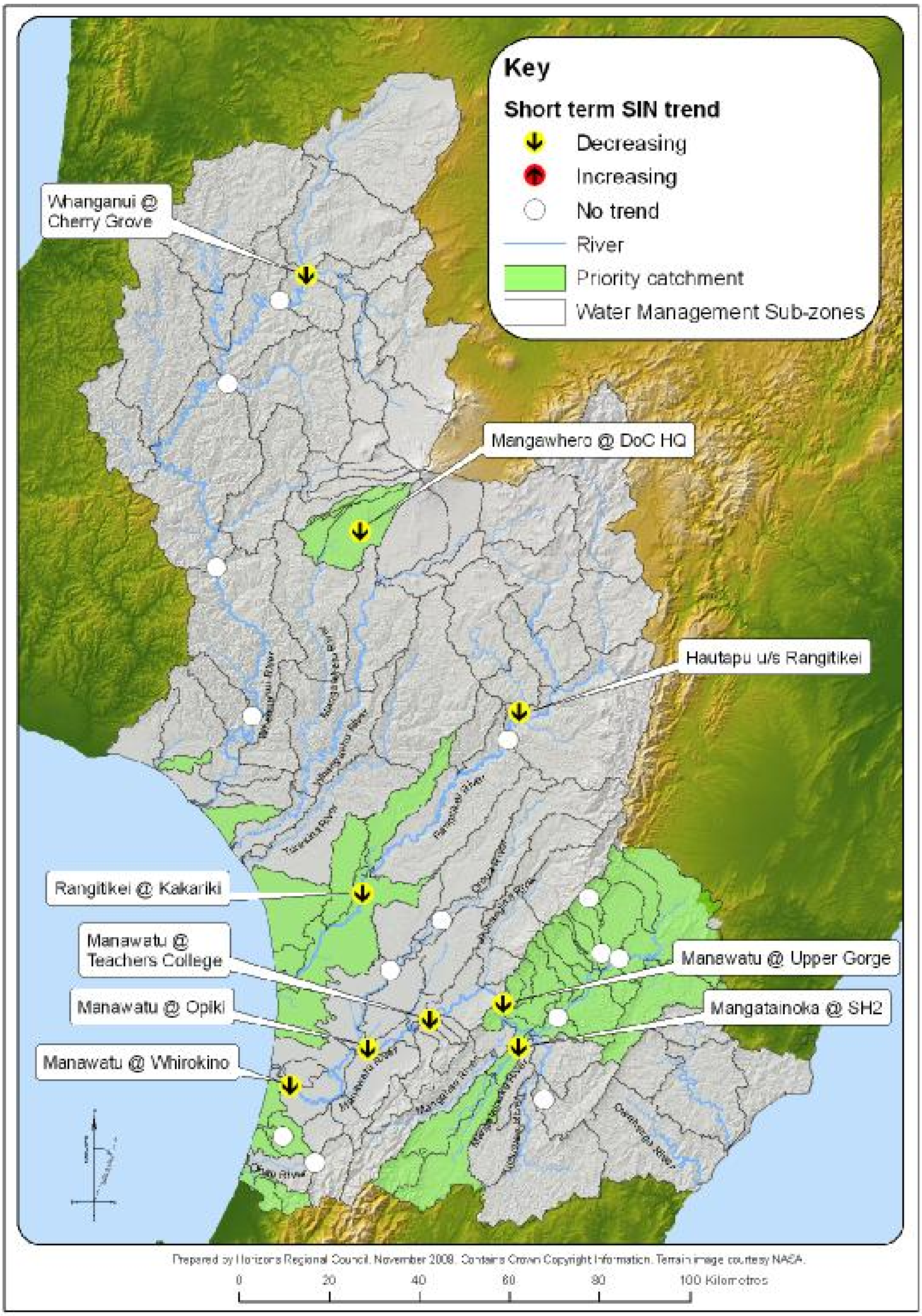
Map 1. Long-term dissolved reactive phosphorus (DRP) trends for SoE and NRWQN sites in Horizons' Region in relation to the location of target catchments.



Map 2. Short-term dissolved reactive phosphorus (DRP) trends for SoE and NRWQN sites in Horizons' Region in relation to the location of target catchments.



Map 3. Long-term soluble inorganic nitrogen (SIN) trends for SoE and NRWQN sites in Horizons' Region in relation to the location of target catchments.



Map 4. Short-term soluble inorganic nitrogen (SIN) trends for SoE and NRWQN sites in Horizons' Region in relation to the location of target catchments.

20. It is important to note that although some sites within target catchments show improving trends in the short term, soluble nutrient concentrations are still very high with regards to water quality state (see Section 42A report of Dr Davies-Colley) at many sites

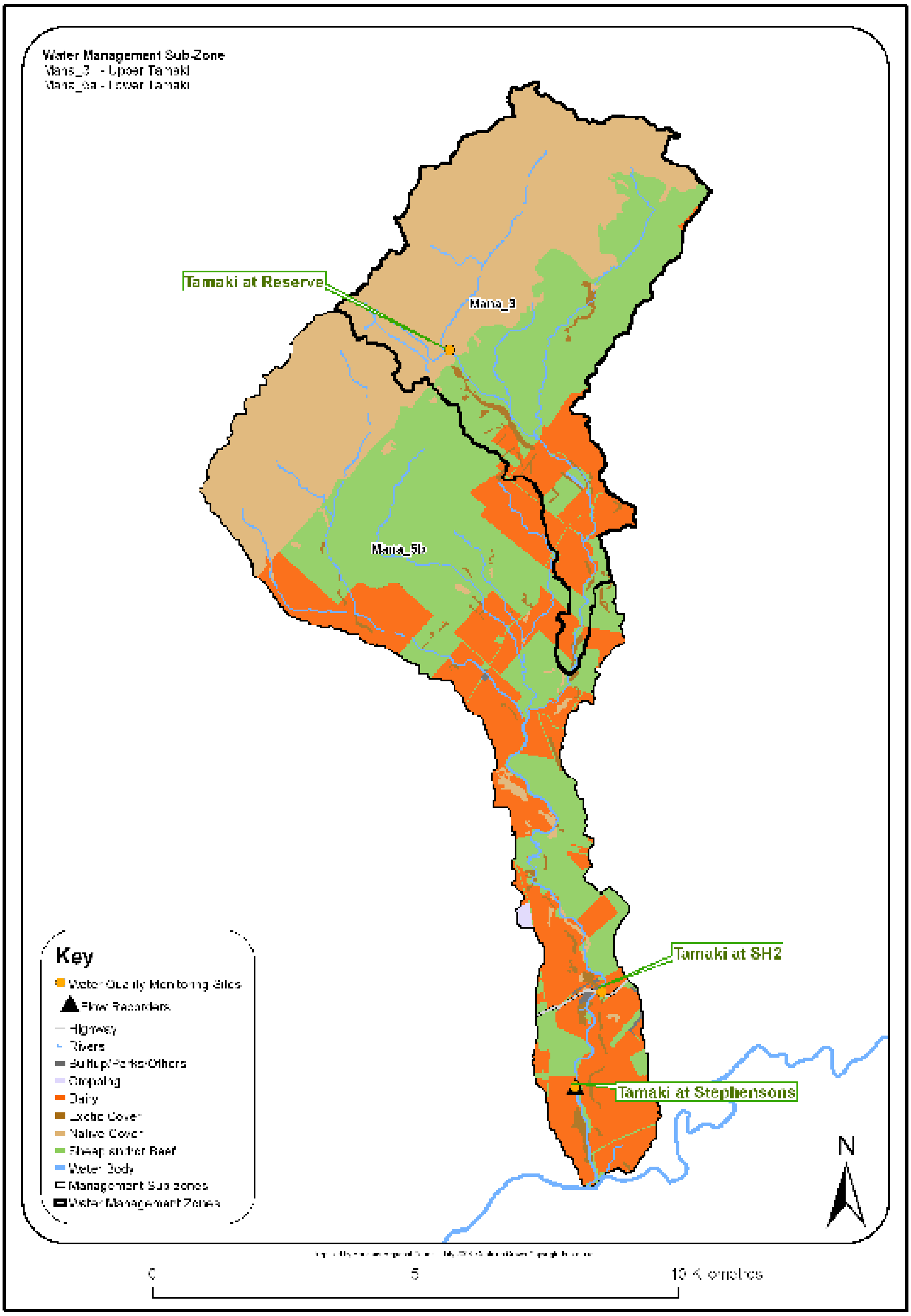
associated with a high percentage of pastoral land use. Because the improving trends are from a shorter period of record, certainty in the results is reduced and, as asserted by Graham McBride, we cannot infer that these trends will continue without collecting the data into the future to validate this inference.

21. I would also recommend that because there are also improving trends at sites with very little human impact (eg. Mangawhero at DoC HQ), it is imperative that further analyses are undertaken to better determine whether the causes of improving trends are due to changes in land use, farm dairy effluent management, point-source discharge treatment or natural climate variation (see Scarsbrook *et al.*, 2003), prior to making any assumptions of cause.

Reference site water quality and downstream change

22. Water quality naturally declines downstream as a function of increased contributing catchment area. However, in many cases the increase between reference sites and downstream SoE sites is several orders of magnitude as a result of contaminant loads from either point sources or non-point sources. Accounting for reference contaminants loads, particularly of *E. coli* or SIN that are naturally very low at references sites, is often unimportant in catchments with poor downstream water quality simply due to the magnitude of increase in a downstream direction.

23. For example, the Tamaki at Reserve reference site (Map 5) has naturally elevated DRP, which continues to remain elevated throughout the catchment (Figure 1). But the SIN (Figure 2) and *E. coli* (Figure 3) increases, which are attributable to non-point source contamination, are considerable at the downstream monitoring sites. Statistics and period of record for the water quality data displayed below are contained in Appendix 2 of this report.



Map 5. Land use in the Tamaki River catchment and State of the Environment monitoring sites on the Tamaki River mainstem.

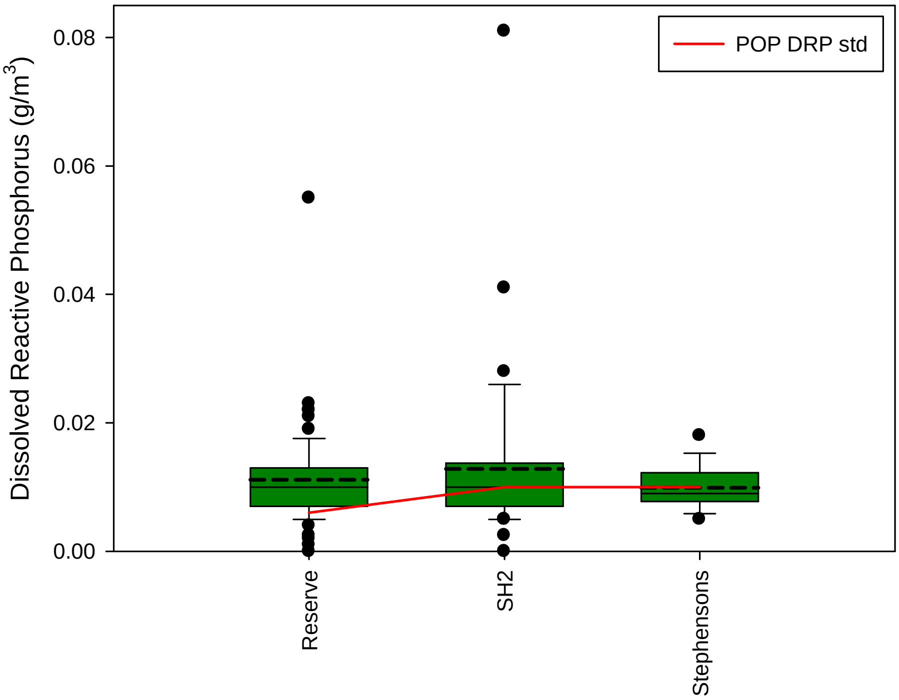


Figure 1. Dissolved reactive phosphorus (DRP) concentration at State of the Environment monitoring sites within the Upper and Lower Tamaki Water Management Sub-zones collected over various timeframes since 1999.

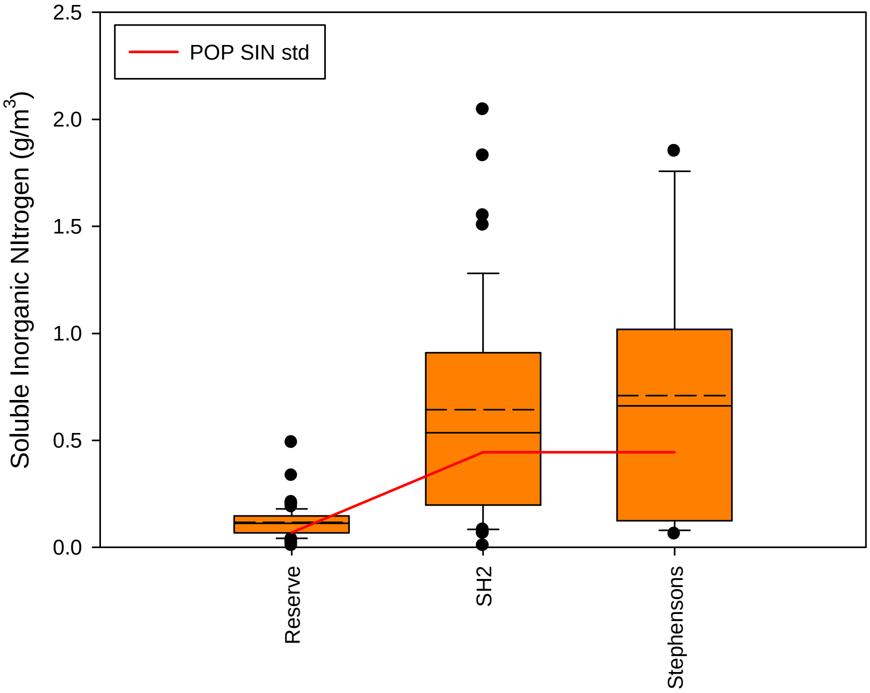


Figure 2. Soluble inorganic nitrogen (SIN) concentration at State of the Environment monitoring sites within the Upper and Lower Tamaki Water Management Sub-zones collected over various timeframes since 1999.

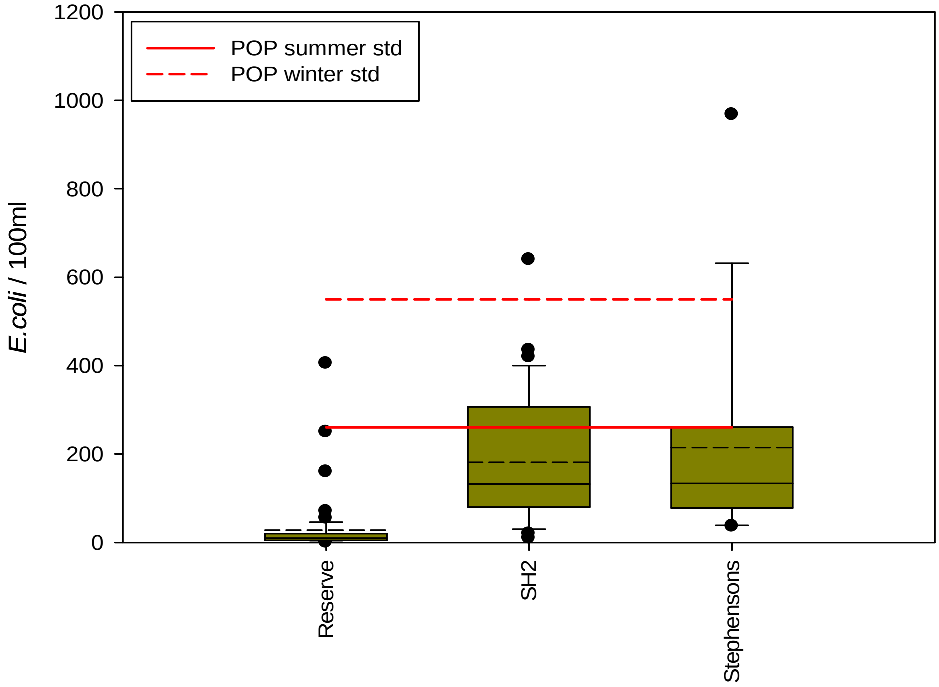
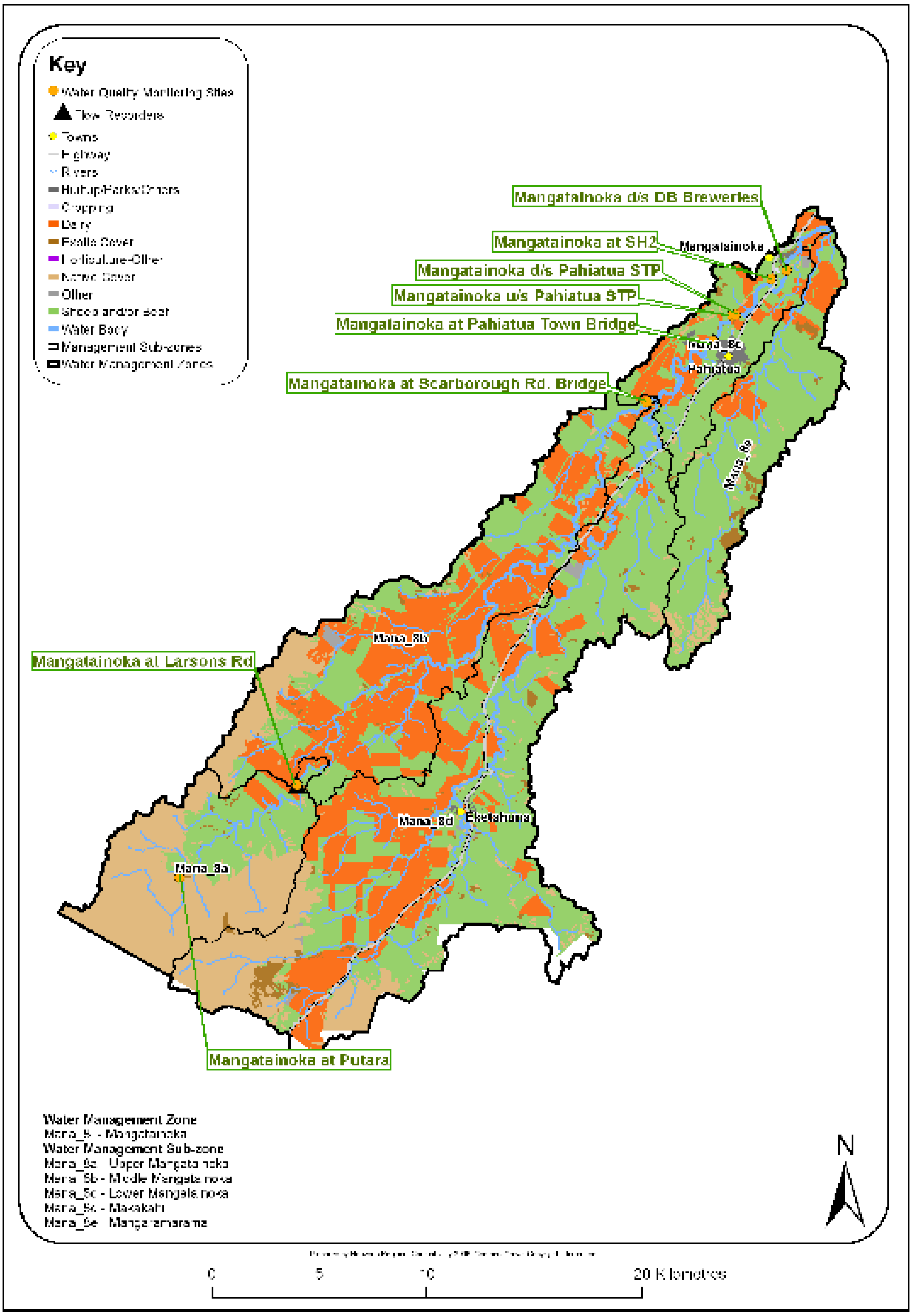


Figure 3. *Escherichia coli* (*E. coli*) concentration at State of the Environment monitoring sites within the Upper and Lower Tamaki Water Management Sub-zones collected over various timeframes since 1999. Outliers have been removed from the Tamaki at SH2 (17300 on 13/12/2005 and 4800 on 07/04/2003).

24. There are a number of other cases in target catchments where the downstream increases in contaminant concentrations are considerable, as described in my Section 42A report. In particular the Waikawa Stream and Rangitikei River, which have increasing downstream SIN, DRP and *E. coli* (see Figures 35, 36 and 37, page 208: Waikawa; and Figures 46, 47 and 48, page 241: Rangitikei).

25. The Mangatainoka River is another example where the magnitude of contaminant increases (SIN in particular, Figure 4) from upstream to downstream (Map 6) is substantial, and reference values make an almost negligible contribution to catchment loads.

26. In non-target catchments, with generally better water quality, the magnitude of increase is often less than in catchments that are adversely impacted by intensive land use. However, in some cases point sources cause contaminant increases of similar magnitude. For example, in the Oroua catchment (Map 7) the Feilding sewage treatment plant (STP) discharge has a notable effect on both DRP (Figure 5) and SIN (Figure 6).



Map 6. Land use in the Mangatainoka River catchment and water quality monitoring sites on the Mangatainoka River mainstem.

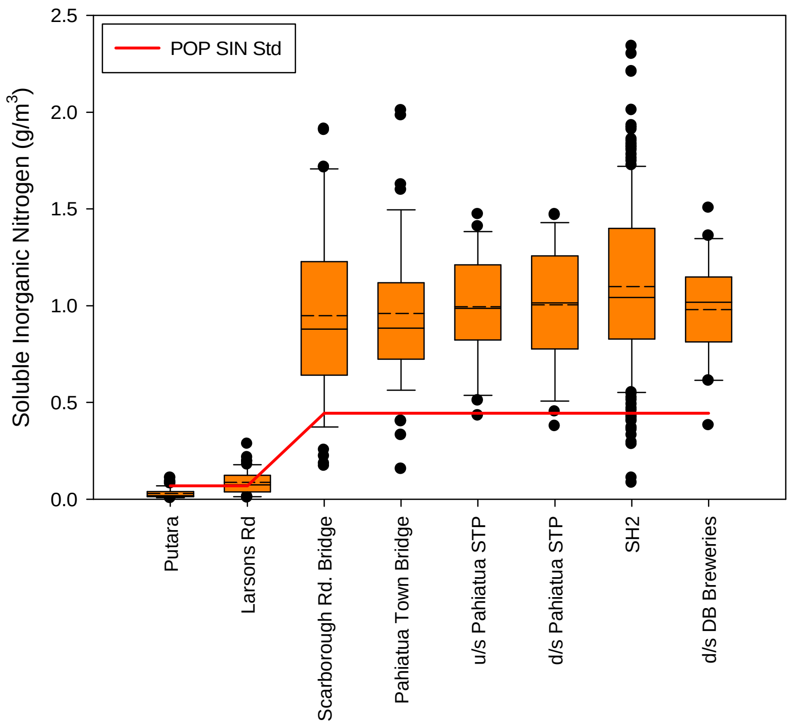


Figure 4. Soluble inorganic nitrogen (SIN) concentration at State of the Environment monitoring sites within the Upper, Middle and Lower Mangatainoka Water Management Sub-zones collected over various timeframes since 1989.

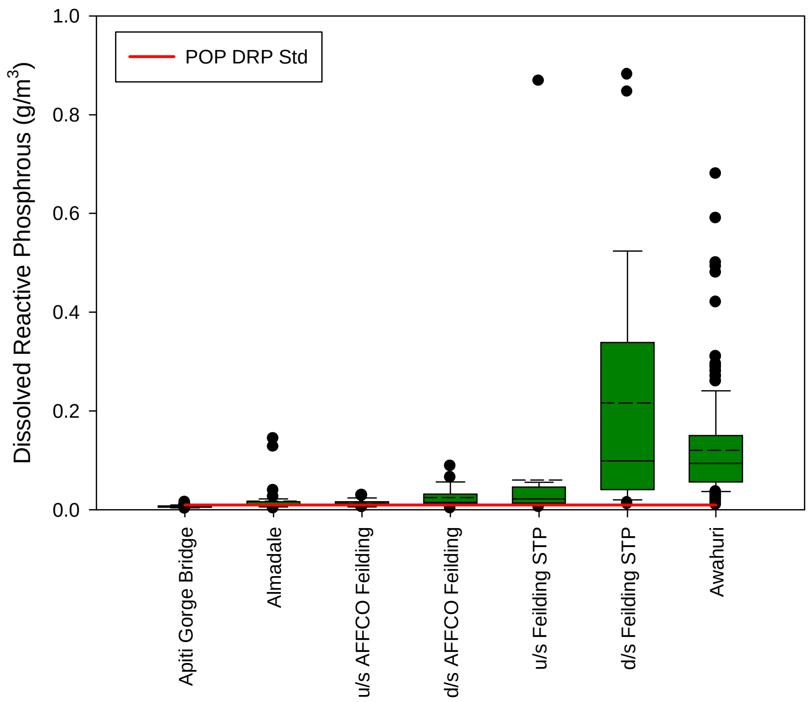


Figure 5. Dissolved reactive phosphorus (DRP) concentration at State of the Environment monitoring sites within the Upper and Middle Oroua Water Management Sub-zones collected over various timeframes since 1993.

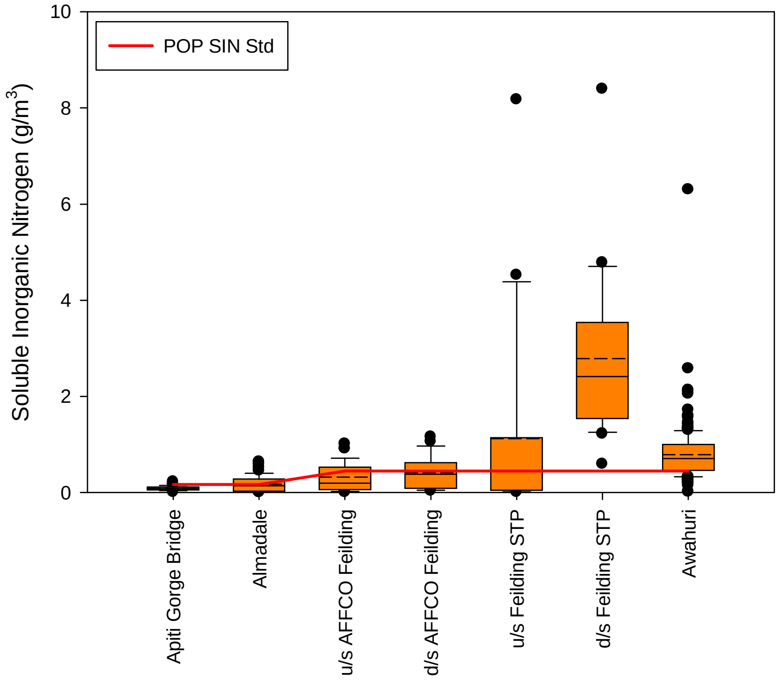
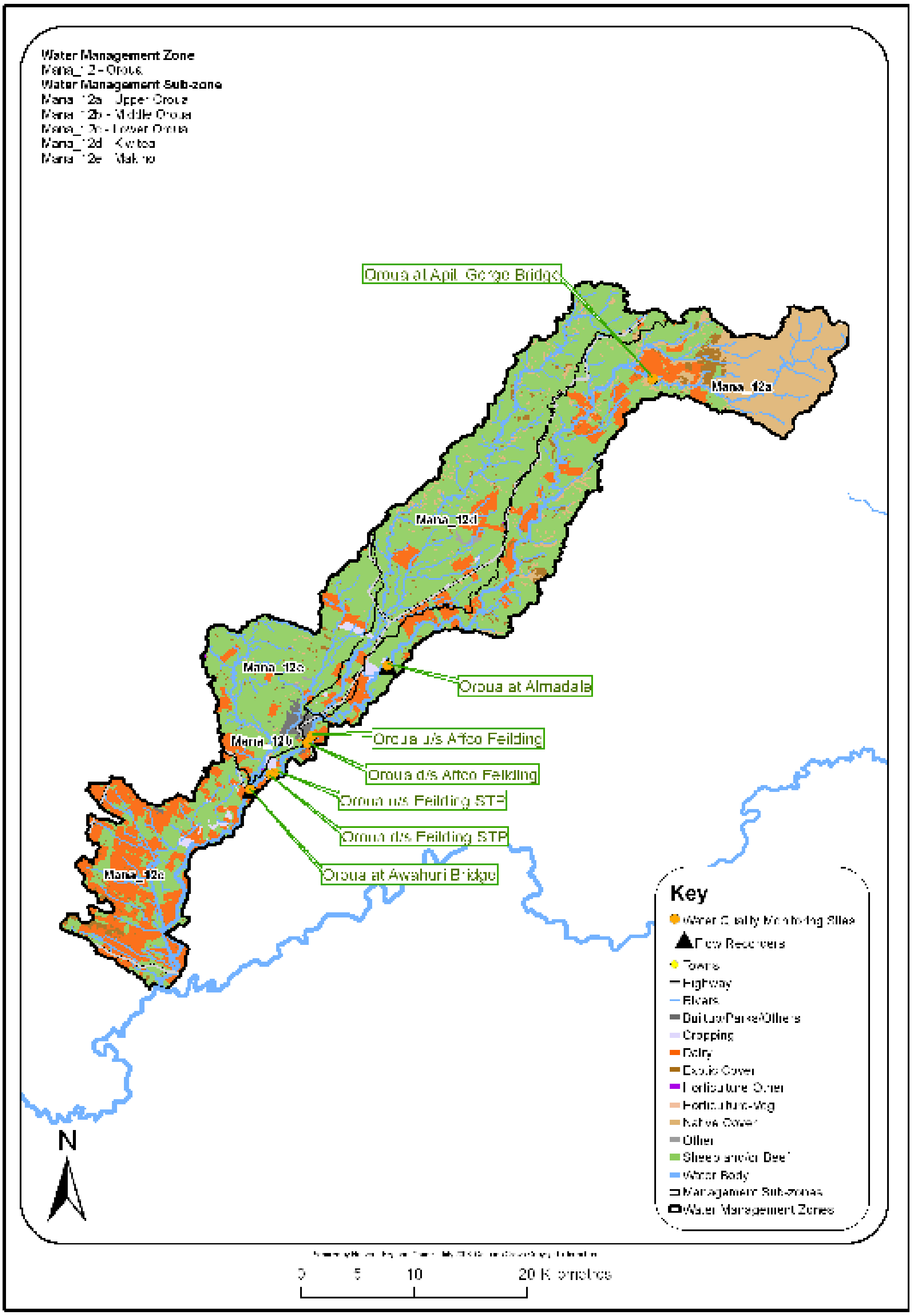


Figure 6. Soluble inorganic nitrogen (SIN) concentration at State of the Environment monitoring sites within the Upper and Middle Oroua Water Management Sub-zones collected over various timeframes since 1993.



Map 7. Land use in the Oroua River catchment and State of the Environment monitoring sites on the Oroua River mainstem.

Links between water quality standards and values

27. Figure 2 of my Section 42A report (page 85) shows an example of the complex inter-related nature of key values that correspond with water quality standards. To put the process for determining nutrient standards succinctly, the following points outline the steps linking the values of a Water Management Sub-zone to the determination of the nutrient (DRP and SIN) standards for that sub-zone:

(a) Some values from both the Ecosystem Group and Recreational and Cultural Group are affected by nuisance periphyton proliferation.

(b) Periphyton biomass standards (chlorophyll *a*) for the maintenance of Life-Supporting Capacity among the different classes (which incorporate catchment geology) should provide adequately for other Ecosystem values such as SOS-A or Inanga Spawning and for Contact Recreation (see Ausseil and Clark 2007a, section 4.1.3.2 page 76).

(c) Periphyton cover (percent cover) and biomass (chlorophyll *a*) standards for the maintenance of the Recreational and Cultural values group relate primarily to Trout Fishery (chlorophyll *a*) and Aesthetics and Contact Recreation (percent cover) values.

(d) The periphyton percent cover standard for Contact Recreation and Aesthetics was determined from the NZ Periphyton Guidelines (Biggs, 2000) to provide adequately for the protection of all other values from extensive nuisance periphyton cover.

(e) Chlorophyll *a* standards for each Life-Supporting Capacity class were determined depending on the ecosystem type within each geology class (between 50 and 200 mg/m^2).

(f) Chlorophyll *a* standards for the Trout Fishery value were determined from the NZ Periphyton Guidelines (120 mg/m^2).

(g) For each sub-zone the periphyton percent cover and the more stringent of the two possible (LSC or Trout Fishery) chlorophyll *a* standards were applied in

Schedule D to ensure all values likely to be affected by nuisance periphyton growths were provided for.

(h) Nutrient standards (DRP and SIN) were then determined using the approach, detailed in paragraph 255 (page 285) of my Section 42A report, to achieve the periphyton percent cover and chlorophyll *a* standards.

Control of periphyton

28. The recommendations of Wilcock *et al.* (2007) in relation to the need for year-round control of periphyton growth are supported by the periphyton cover data in Figures 7 to 11 and by the lack of seasonality of most of the values affected by nuisance periphyton growth.

29. From the initial months of periphyton cover data, results for total cover for four sites influenced by elevated nutrient concentrations indicate that periphyton growth and vigour is significant during May and June in the Manawatu and Mangatainoka sites (Figures 8, 9 and 10) but highly influenced by flow events during these months in the lower Rangitikei (Figure 11). Out of all sites monitored, April had the highest number of sites which exceeded the percent cover standards, however June also had a high number of exceedences and some sites were still elevated in July and August (Figure 7). These results support the recommendation of Wilcock *et al.* (2007) that periphyton (and thereby nutrient concentrations) should be controlled year-round, with the exception of high flow events.

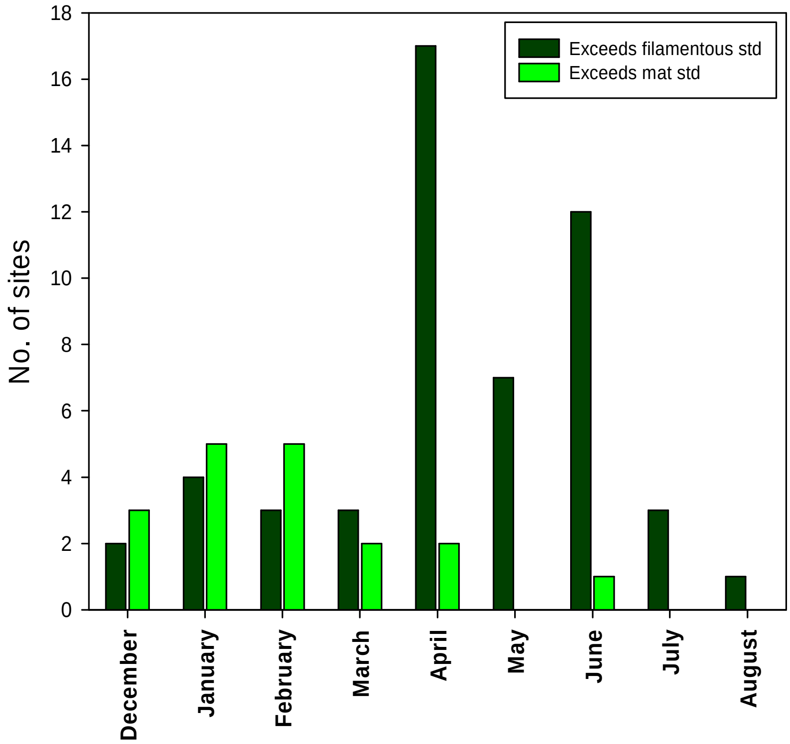


Figure 7. Number of monitored sites (out of a total of 48) that exceed percent cover standards for filamentous and mat algae between December 2008 and August 2009.

30. Figures 8 to 11 show that periphyton recovers quickly when cover in the preceding months has been high, even after freshes exceeding the 20^{th} percentile of flow. These results provide some regional validation of the advice from Wilcock *et al.* (2007) that upstream residual colony-forming material contributes to rapid recovery in the presence of elevated nutrients.

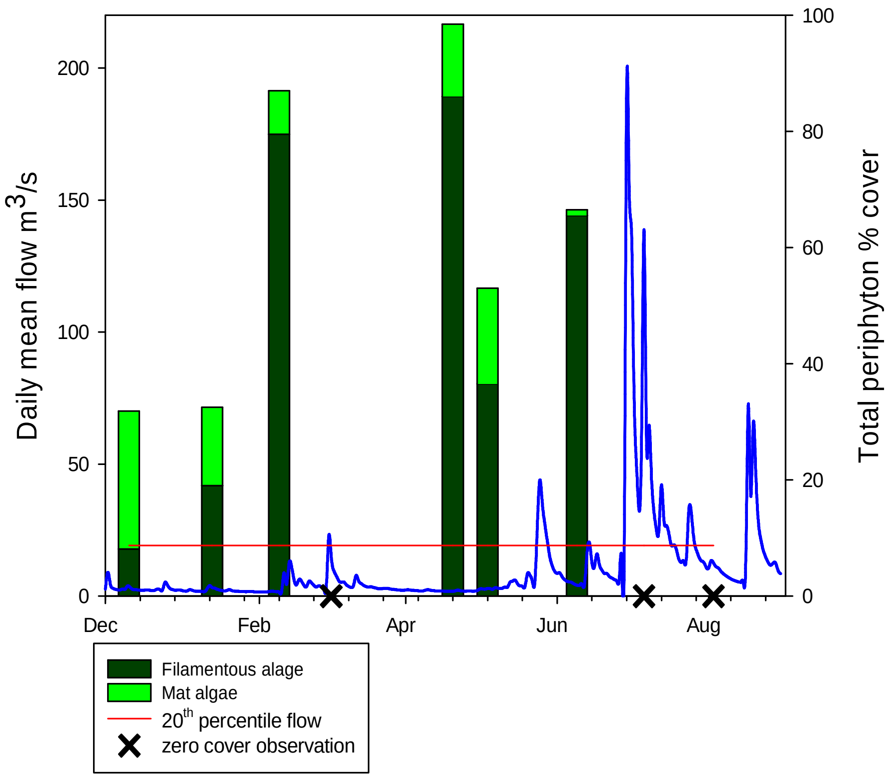


Figure 8. Manawatu at Weber Road daily mean river flow and total periphyton percent cover (filamentous and mats) between December 2008 and August 2009.

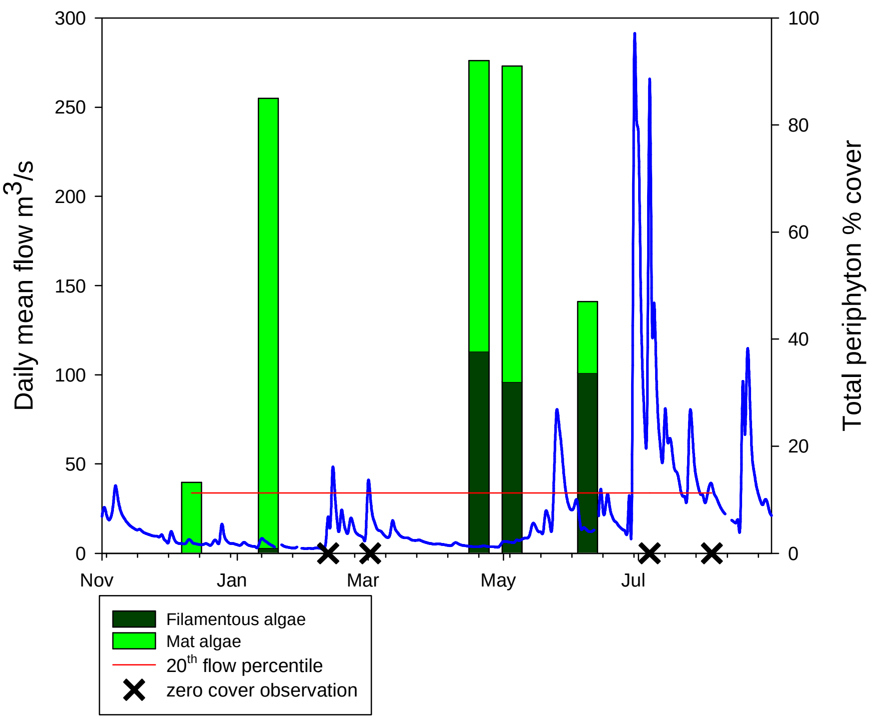


Figure 9. Manawatu at Hopelands daily mean river flow and total periphyton percent cover (filamentous and mats) between November 2008 and August 2009.

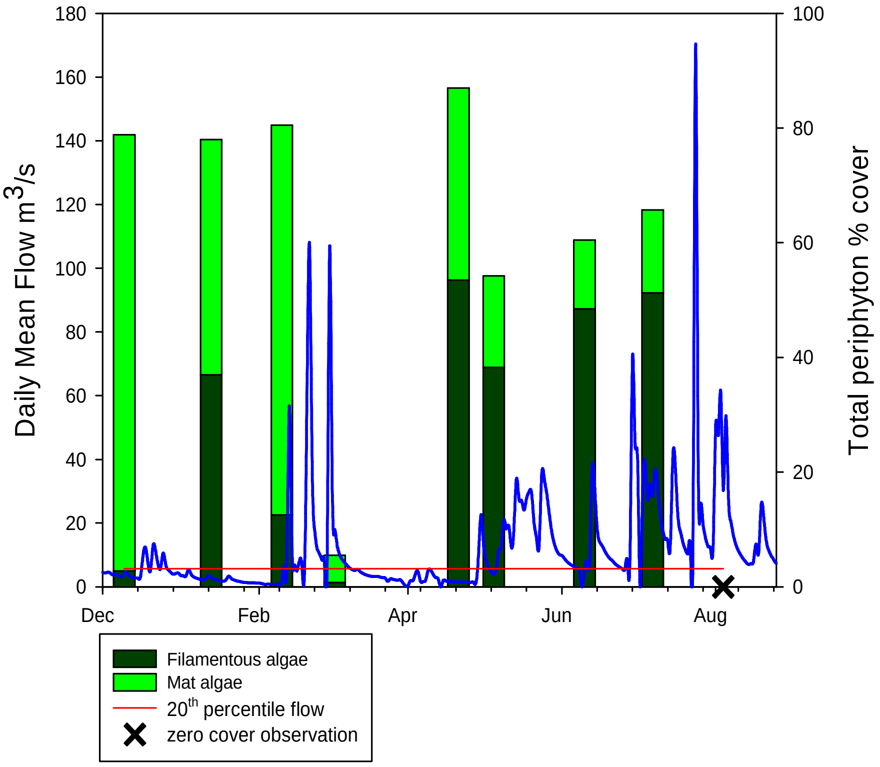


Figure 10. Mangatainoka downstream of Pahiatua STP discharge daily mean river flow and total periphyton percent cover (filamentous and mats) between December 2008 and August 2009.

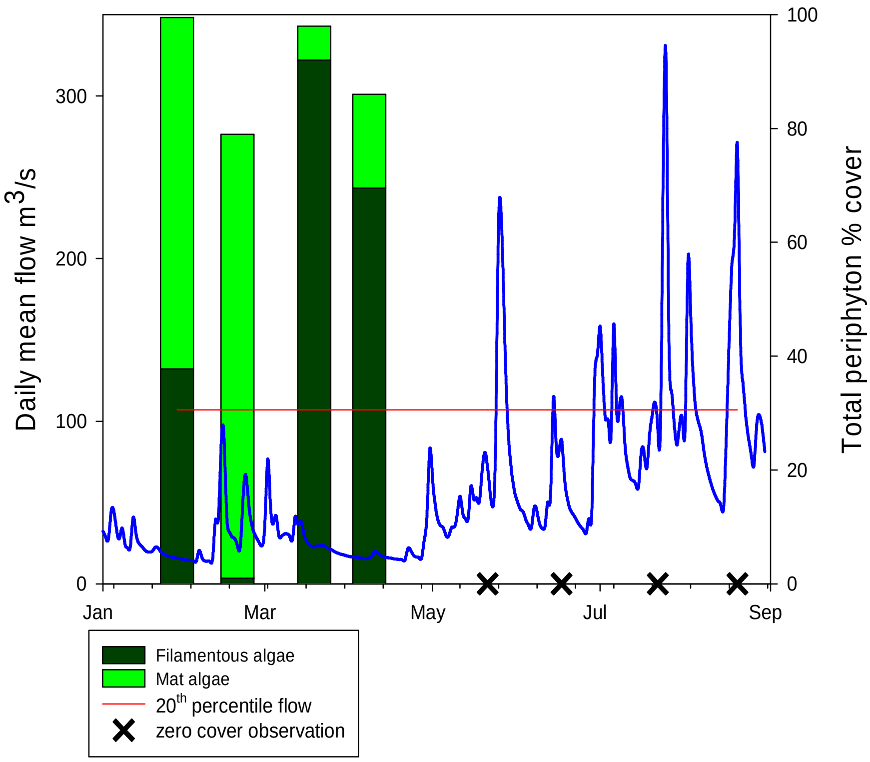


Figure 11. Rangitikei at McKelvies daily mean river flow and total periphyton percent cover (filamentous and mats) between December 2008 and August 2009.

31. Water Management Sub-zones are managed to control periphyton for a range of values as described above. The Life-Supporting Capacity value applies year-round and there are several aspects of Recreational and Cultural values (ie. Trout Fishery and Aesthetics) that occur throughout the year. For example, passive appreciation of rivers for their aesthetic appeal is not limited by season and Fish & Game sells 'winter fishing licences' to provide anglers the opportunity to use rivers exclusively between 1 April and 30 September.

Photo 1. Periphyton and macrophyte growth during June in Town Creek, a tributary of the Mangatainoka River downstream of the discharge from the Pahiatua STP (photo: Kate McArthur, 2005).

32. Timing of periphyton proliferation will be overridingly controlled by flow. The initial periphyton data shows periphyton growth over the early winter months is still substantial at some sites, particularly those with highly elevated nutrient concentrations, such as the upper Manawatu catchment or below point-source discharges (ie. downstream of Pahiatua STP; see Photo 1). This data provides further validation for the POP approach to control nitrogen and phosphorus year-round, for the purposes of managing periphyton growth and reducing adverse effects on water body values.

The importance of tributary habitats for aquatic ecosystem health

33. A small number of submitters have commented on the appropriateness of setting values and standards for tributary streams throughout the Region, as these smaller water bodies are deemed by some to be less valued. In ecological terms, tributaries are extremely important habitats as they are often the areas of catchments that have riparian vegetation and shade over the wetted channel, which provides for microhabitats, food and inputs of woody debris and terrestrial invertebrates, reduced temperatures, refuge and cover.

34. Tributaries also tend to have higher habitat variability as their meander patterns are small and (with the exclusion of some urban streams) the channel tends to be less modified. This variability provides more riffle habitat which in turn provides a greater biomass of macroinvertebrates. During floods and periods of low flow and high temperature, fish and aquatic macroinvertebrates find refuge in tributary streams.

35. From a water quality perspective, contaminant loads from tributaries contribute to cumulative loads in the mainstems of river systems. The tributaries of the upper Manawatu River are a good example of the cumulative impact of poor water quality in tributaries affecting downstream water quality and values (Clark *et al*., 2009). Tributaries are also more likely to suffer adverse effects from contaminants as there is less capacity for dilution. Because these sites are significant from an aquatic biodiversity perspective, degradation of habitat and/or water quality in tributary streams can cumulatively influence the aquatic biodiversity in the wider catchment, as fewer individuals and species are recruited into the catchment from affected tributary streams.

36. As such it is entirely appropriate in my opinion to assign values and standards to tributary streams; they should not be disregarded simply due to their size and/or their supposed reduced capacity for use for purposes such as contact recreation.

The method for the definition of the SOS-A and Natural State values

37. Sites of Significance – Aquatic and Natural State are defined in my Section 42A report (pages 19 and 20) and in the technical reports by McArthur *et al.* (2007) and Ausseil and Clark (2007b). Maree Clark also details the GIS method used to physically delineate the river reaches to which these values apply in paragraphs 119 to 124 of her Section 42A report.

38. Questions of uncertainty have been raised by experts on behalf of Meridian Energy with regard to the use of the River Environment Classification (REC) to determine river reaches defined for Natural State and Sites of Significance – Aquatic values. Although the REC was used to determine the maps of values (which it is noted in the POP are indicative only), New Zealand topographic map series references were used to determine the legal description of the values within the Schedule Ba tables, which describe each value.

39. The limitations of the REC method are well defined in the S42A report of Maree Clark (paragraphs 36 to 42, 51 to 55 and 139 to 140) and are not repeated here. Although limitations exist in the use of the REC, limitations also exist in all other spatially determined data and the REC is still one of the best tools available to define values for Schedule D of the POP.

40. Most of the uncertainties surrounding the REC exist in lower elevation areas near the coast as accuracy of REC river lines generally increases with elevation. Information on the extent of the DOC estate and map references from the New Zealand Freshwater Fish database were the key geographic markers used to locate the where the Natural State and SOS-A values should apply spatially.

41. I believe the use of the REC to indicate (on maps) where the values apply was totally appropriate, with a reasonably high degree of certainty at the scale the values were applied. Also, the use of information from other established databases to locate areas in the Conservation Estate (for Natural State) or where indicator native fish species have been referenced (for SOS-A) are accurately maintained by the organisations that provided this data and are also fit for purpose.

4. PART THREE: CORRECTIONS TO ORIGINAL S42A REPORT

42. As a result of corrections by NIWA staff to the report of Ballantine and Davies-Colley (2009) on regional water quality trends I wish to make some corrections to the sections of my original S42A report that summarises the results of that report. The sections below should be considered to replace sections 4.5.2 and 4.5.3 (paragraphs 151 to 158) of my original report and I have track changed the corrections for the purposes of clarity. Underlined text is an addition and strike-through text is a deletion from the original.

4.5.2 NRWQN trends

~~151.~~ Long-term trend analysis of the seven national network sites in the Horizons' Region (1989–2007) showed increasing trends in total oxidised nitrogen (N0x-N) at a number of sites, particularly in the Manawatū catchment, and increasing dissolved reactive phosphorus for the Whanganui at Te Maire (TU1), Rangitīkei at Kakariki (WA6) and the Manawatū at Weber Road (NIWA site WA7). A significant decreasing DRP trend was found in the Manawatū at Opiki (WA9). However, the shorter term analysis of 2001–2008 data showed decreasing trends at some sites for N0x-N (WA6, WA8 and WA9) in addition to decreasing DRP at WA6 and WA9. *Escherichia coli* and turbidity parameters also decreased at some sites, suggesting some water quality improvement in recent years. ~~No trends were detected for dissolved reactive phosphorus over any of the time periods analysed.~~

4.5.3 SoE trends

152. Long-term State of the Environment trends for soluble inorganic nitrogen showed four meaningful decreasing trends for the Oroua at Awahuri Bridge, Hautapu u/s Rangitīkei, Mangawhero at DOC and Whanganui at Pipiriki.

153. Black disc (clarity) decreased at the Manawatū at Whirokino and Hautapu u/s Rangitīkei. Turbidity increased at the Manawatū at Whirokino and decreased at Mangatainoka at SH2, Hautapu u/s Rangitīkei, Mangawhero at DOC and Whanganui at Pipiriki.

154. *Escherichia coli* decreased at the Manawatū at Upper Gorge and Hautapu u/s Rangitīkei and increased for the Ohau at Rongomātāne.

155. SoE short-term trend analysis (2001–2008) found no trends in dissolved reactive phosphorus. However, decreasing trends in soluble inorganic nitrogen were found at six sites: Mangatainoka at SH2, Manawatū at upper Gorge, Manawatū at Whirokino, Hautapu u/s Rangitīkei, Mangawhero at Doc and Whanganui at Cherry Grove.

156. Black disc clarity increased in the Manawatū at Hopelands and decreased in the Oroua at Awahuri. ~~Tamaki at Reserve increased for turbidity and t~~ Three

turbidity decreases were found at Mangatainoka at SH2, Manawatū at Hopelands and Hautapu u/s Rangitīkei.

157. *Escherichia coli* decreased at Tamaki at Reserve, Manawatū at Hopelands, Manawatū at Upper Gorge and Hautapu u/s Rangitīkei and increased in the Ohau at Rongomatane.

158. No trends were detected for dissolved reactive phosphorus over any of the time periods analysed for the Horizons' State of the Environment data. No trends were found at the seven historical sites monitored between 1979 and 1988 apart from a decrease in nitrate ($N0_3$) for the Tiraumea at Kohinui Bridge site.

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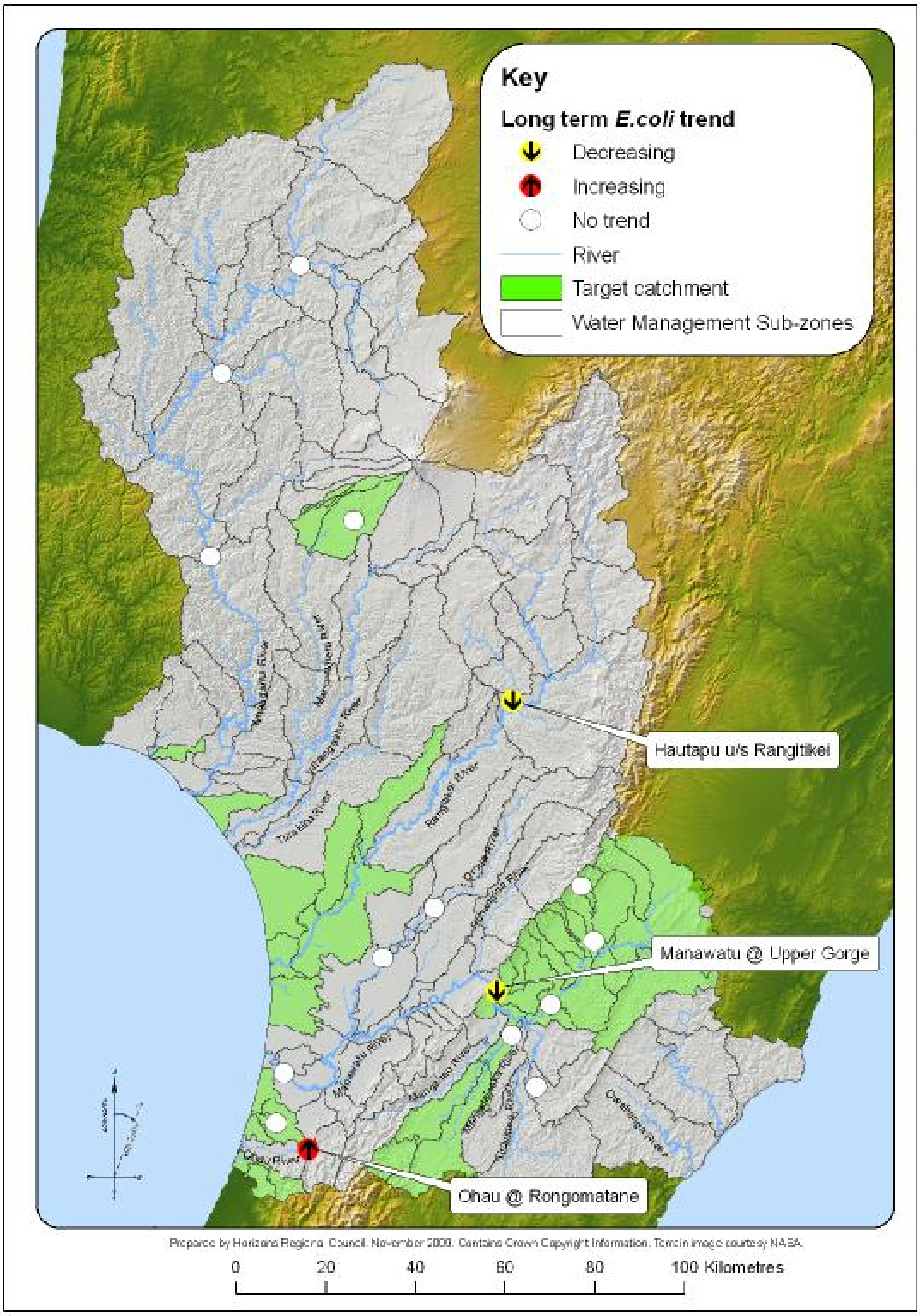
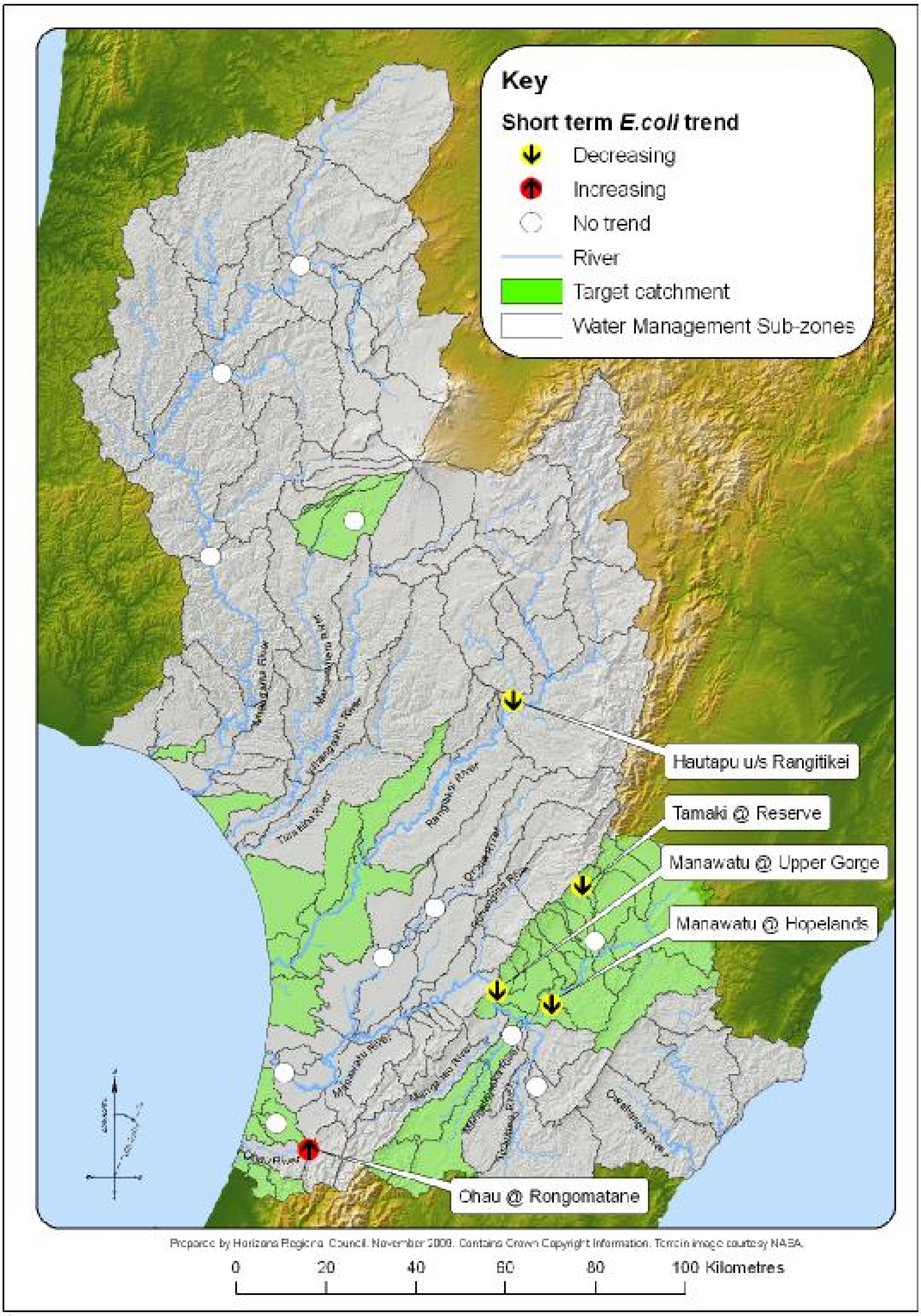
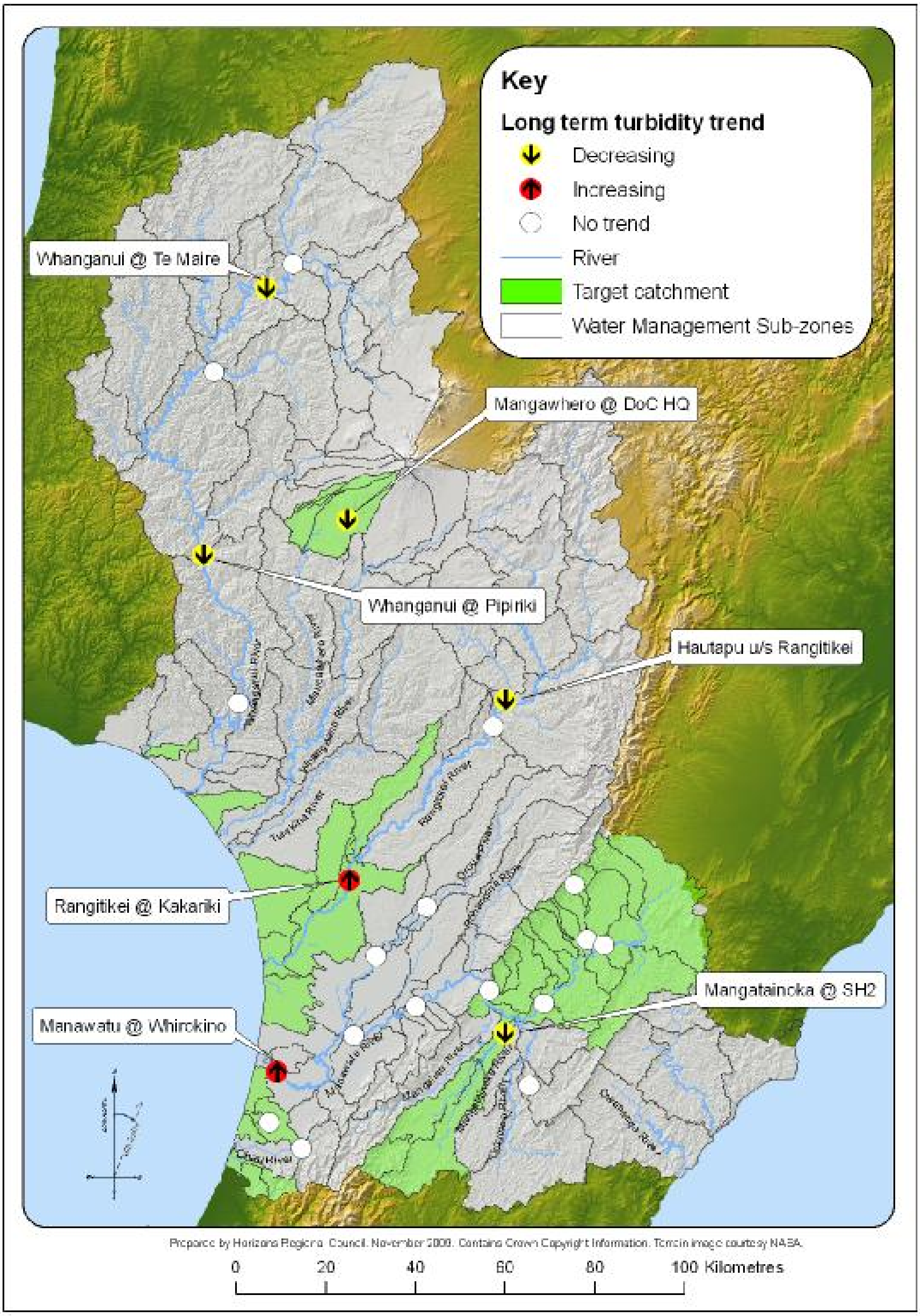
6. APPENDIX 1



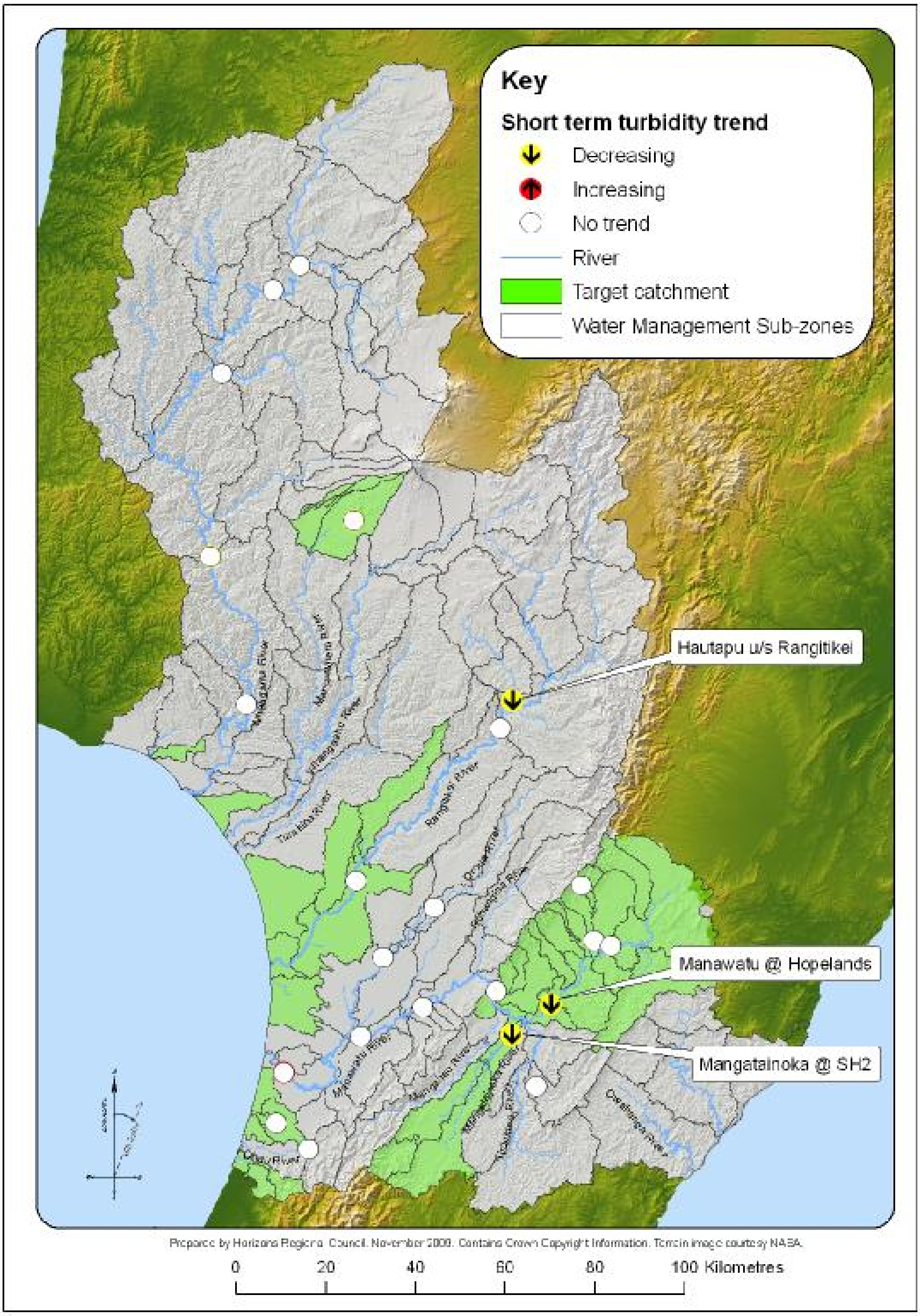
Map 8. Long-term *Escherichia coli* (*E. coli*) trends for SoE and NRWQN sites in Horizons' Region in relation to the location of target catchments.



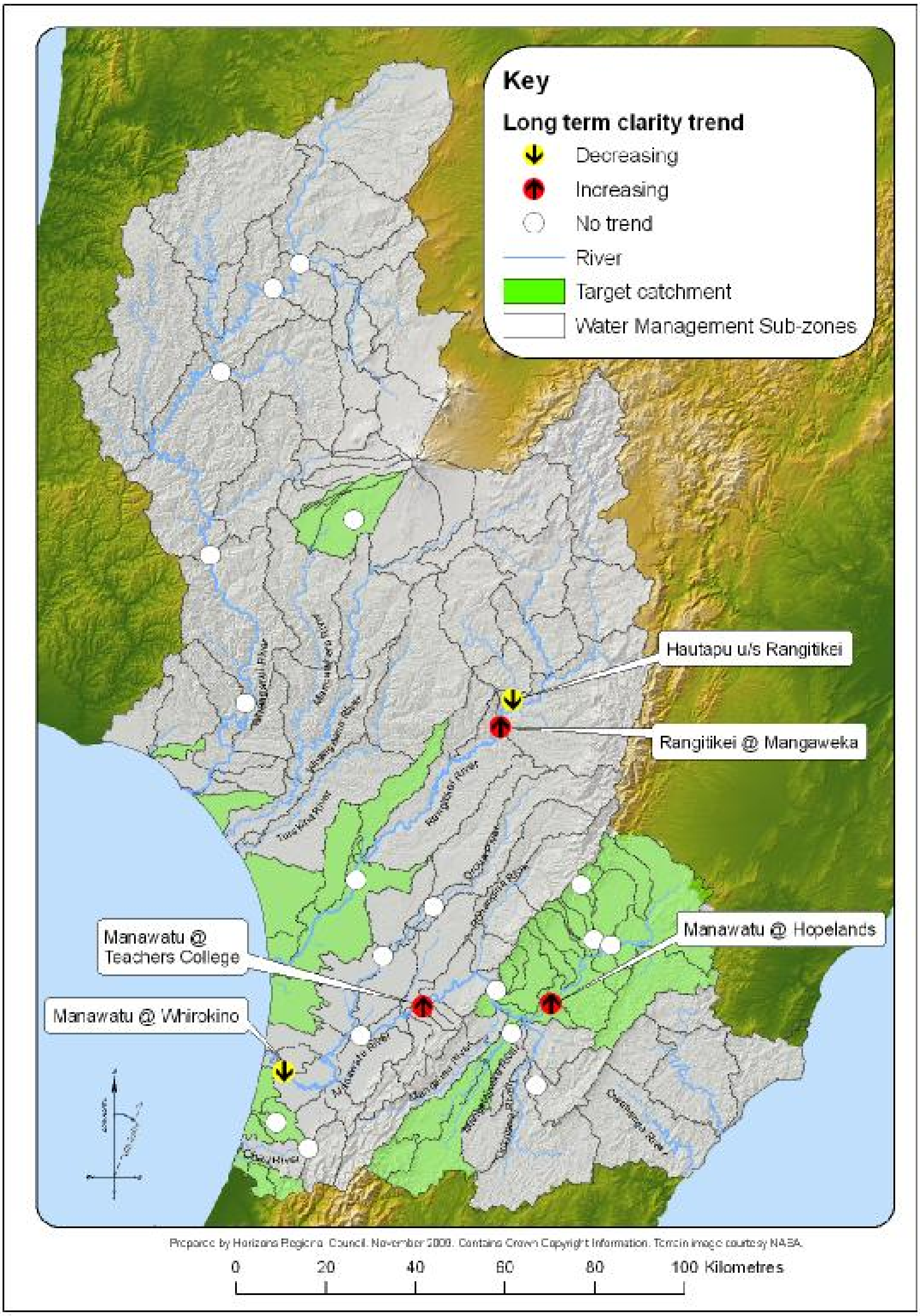
Map 9. Short-term *Escherichia coli* (*E. coli*) trends for SoE and NRWQN sites in Horizons' Region in relation to the location of target catchments.



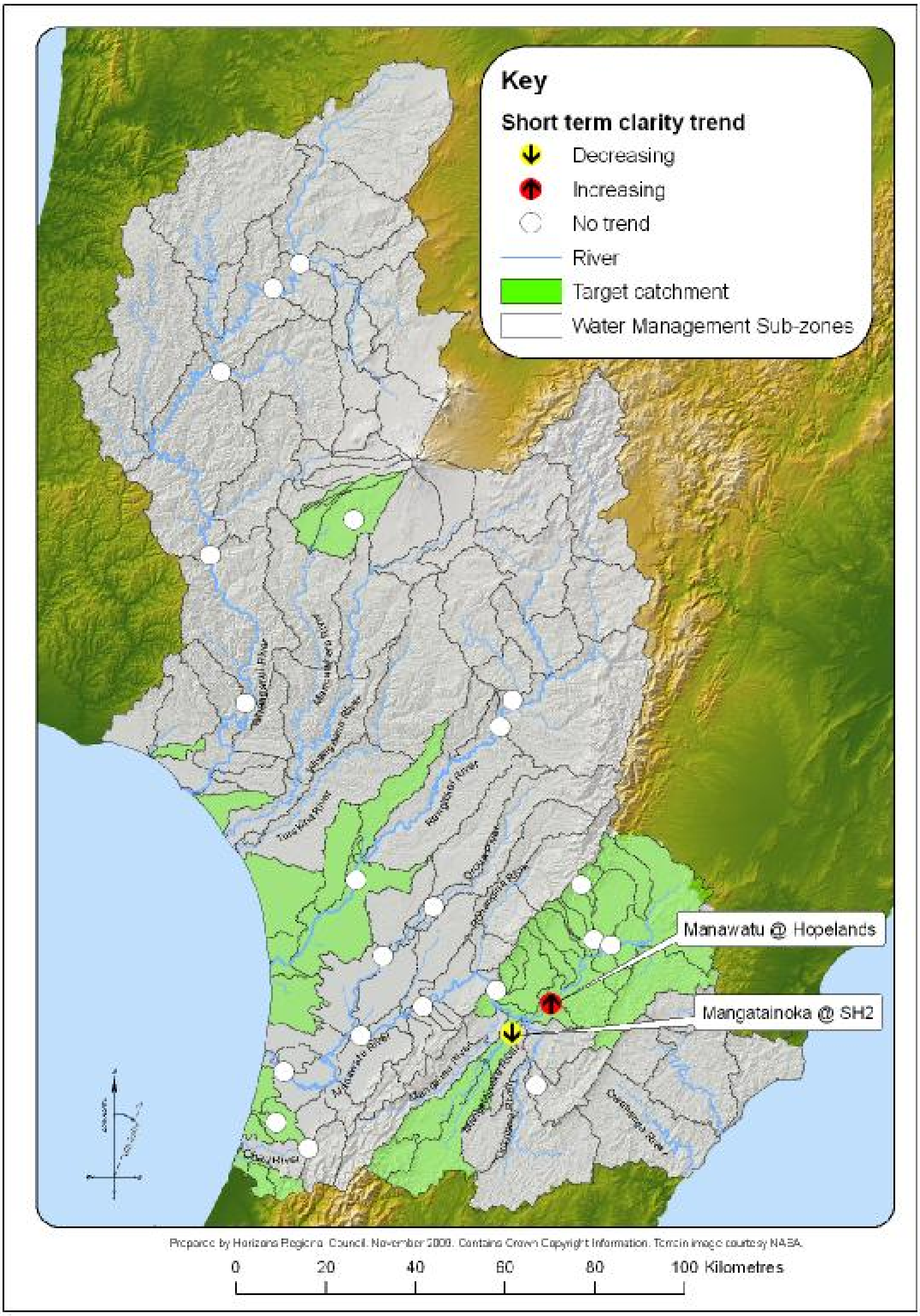
Map 10. Long-term turbidity trends for SoE and NRWQN sites in Horizons' Region in relation to the location of target catchments.



Map 11. Short-term turbidity trends for SoE and NRWQN sites in Horizons' Region in relation to the location of target catchments.



Map 12. Long-term visual clarity trends for SoE and NRWQN sites in Horizons' Region in relation to the location of target catchments.



Map 13. Short-term visual clarity trends for SoE and NRWQN sites in Horizons' Region in relation to the location of target catchments.

7. APPENDIX 2

Table 5. Water quality statistics in the Tamaki, Oroua, and Mangatainoka mainstem monitoring sites. The outliers removed from the graphs are included in this analysis.

Site	DRP					SIN					*E. coli*					Period of Record
	Std	Median	Upper Quartile	Lower Quartile	n	Std	Median	Upper Quartile	Lower Quartile	n	Std	Median	Upper Quartile	Lower Quartile	n	
Tamaki at Reserve	0.006	0.01	0.013	0.007	66	0.07	0.1125	0.143375	0.069125	66	260/550	10	20	5	36	July 1999 - ongoing
Tamaki at SH2	0.01	0.01	0.01325	0.007	48	0.444	0.5363	0.89	0.2085	48	260/550	140	310	85	55	July 1999 - Jan 2008
Tamaki at Stephensons	0.01	0.009	0.01175	0.008	18	0.444	0.6615	0.996625	0.137125	18	260/550	133.6	260.5	85.3	19	Jan 2007 - ongoing
Oroua at Apiti Gorge Bridge	0.01	0.006	0.008	0.005	76	0.167	0.08	0.115	0.058625	76	260/550	11.95	17.7625	4.775	25	Jul 1993 - Ongoing
Oroua at Almadale	0.01	0.011	0.01525	0.009	48	0.167	0.1427	0.275875	0.03	48	260/550	110	275	50	50	Jul 2005 - Ongoing
Oroua u/s AFFCO Feilding	0.01	0.012	0.0155	0.009	27	0.444	0.1931	0.515	0.0765	27	260/550	201.7	384.35	110	29	Jul 2007 - Ongoing
Oroua d/s AFFCO Feilding	0.01	0.015	0.0315	0.012	27	0.444	0.3775	0.6125	0.1275	27	260/550	197.95	815	134.95	29	Jul 2007 - Ongoing
Oroua u/s Feilding STP	0.01	0.022	0.043	0.014	25	0.444	0.458	1.063	0.0535	25	260/550	220.65	640	103.425	27	Jul 2007 - Ongoing
Oroua d/s Feilding STP	0.01	0.099	0.299	0.041	29	0.444	2.413	3.472	1.576	29	260/550	374	659.5	140	31	Jul 2007 - Ongoing
Oroua at Awahuri	0.01	0.094	0.15	0.05675	196	0.444	0.71	0.99725	0.46225	196	260/550	358.05	880	160.25	102	Jul 1993 - Ongoing
Mangatainoka at Putara	0.006	0.003	0.005	0.0025	40	0.07	0.0185	0.04	0.0125	40	260/550	3.1	15	2	29	Jul 1999 - Ongoing
Mangatainoka at Larsons Rd	0.006	0.005	0.008	0.0025	53	0.07	0.075	0.1225	0.04	53	260/550	41.3	77.1	20	51	Jul 2005 - Ongoing
Mangatainoka at Scarborough Rd. Bridge	0.01	0.004	0.007	0.003	49	0.444	0.879	1.223	0.662	49	260/550	ND	ND	ND	0	Jul 1993 - Feb 08
Mangatainoka at Pahiatua Town Bridge	0.01	0.005	0.008	0.003	48	0.444	0.8843	1.11375	0.728375	48	260/550	ND	ND	ND	2	Sept 1989- ongoing
Mangatainoka u/s Pahiatua STP	0.01	0.007	0.014	0.0025	21	0.444	0.986	1.189	0.841	21	260/550	90	188.075	58.625	22	Jul 2007 - Ongoing
Mangatainoka d/s Pahiatua STP	0.01	0.0185	0.039	0.01625	22	0.444	1.014	1.24375	0.789875	22	260/550	95	179.45	67.55	23	Jul 2007 - Ongoing
Mangatainoka at SH2	0.01	0.01	0.014	0.007	212	0.444	1.0425	1.39625	0.829	212	260/550	120	232	64.55	158	Jul 1993 - Ongoing
Mangatainoka d/s DB Breweries	0.01	0.01	0.012	0.006	20	0.444	1.017	1.142125	0.836125	20	260/550	173	314.175	74.875	20	Jul 2007 - Ongoing