OURS.
THE MANAWATŪ RIVER
LEADERS' ACCORD

Joint statement of the Science and Mātauranga Māori Advisory Panel

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Executive Summary

The Manawatū River Leaders' Forum has reached a milestone in its work. Three years after launching an initial Action Plan in 2011 to restore the Manawatū River and Catchment, it is seeking to review the situation and produce a revised Action Plan for implementation over the next 2-3 years.

A Science and Mātauranga Māori panel was convened over the 5th and 6th of March 2015 to discuss the current state of the River, key issues and possible solutions to help inform development of a revised Plan.

The Panel agreed that it will take time for work carried out in the Manawatū Catchment to be reflected in the datasets. This is due to the time it takes for water to leave the root zone, move through groundwater and emerge in the river channel. Further, some of the works will take time to become effective, for example improvements in habitat as a result of riparian plantings will take time to reach their optimal level; planting to address hill country erosion will take time to mature; and ecological responses will also take time to show through as species recolonize and recover from their current state in response to habitat remediation. The panel expects some actions to produce more immediate results, for example fixing or removing point source discharges. It will also take time for statistical trends to be identified within the dataset.

It is important to remember, while a huge amount of work has been achieved under the current Action Plan, the Forum is just three years into its journey to restore the Manawatū River and Catchment. Perseverance, careful targeting of works and continuity of effort will be the key to achieving long-term success.

The Panel made some broad statements about the state and trends in water quality, aquatic biodiversity and cultural health of the catchment (summarised in the table below). The Panel agreed that variation in water quality data is high, which can complicate statements on water quality trends, and that emphasis should be placed on continuing comprehensive monitoring programmes for the long-term to enable more conclusive statements to be made around catchment trends.

The Panel was supportive of work currently underway to improve the state of the Manawatū River and Catchment. In many cases, they recommended that these actions be continued and/or enhanced through the next iteration of the Action Plan. A summary of the Panel's recommendations is outlined in the following table.

Issue	Effects	State	Trends	Current and future mitigation measures
High nutrient concentrations	• Excessive periphyton and phormidium blooms (also affects suitability for swimming) • Flow on effects to aquatic life including toxicity. • Dissolved oxygen fluctuations and habitat degradation	• Nitrate and ammonia toxicity is not generally a problem within the catchment • Ammoniacal nitrogen is generally a point source issue. • A large number of monitored sites do not meet One Plan targets for soluble inorganic nitrogen and dissolved reactive phosphorus – the key nutrients that promote algal growth • Excessive algal and phormidium blooms are a particular issue in the Mangatainoka, Makakahi, Tiraumea and mainstem of the Manawatū River downstream of the Palmerston North waste water treatment plant.	• Some short term (last 5 years) improvements; however, these could be related to the dry summer and subsequent algal growth at the end of the monitoring period. • 20 year trend analysis of total oxidised nitrogen shows an improving trend at four sites, a degrading trend at one site and no significant trend at three sites. • 20 year trend analysis of ammoniacal nitrogen shows an improving trend at four sites, a degrading trend at three sites and no significant trend at one site. • 20 year trend analysis of dissolved reactive phosphorus shows an improving trend at three sites and no significant trend at five sites.	• Focusing on both nitrogen and phosphorus • Implementing farm plan recommendations • Upgrading wastewater treatment plants • Removing wastewater treatment plant discharges to water particularly at low flows • Riparian fencing and planting.
Poor clarity/ High sediment yields	• Additional nutrients (phosphorus bound to sediment) • Smothering of habitat • Poor clarity affects recreational and aesthetic values and the ability of some fish and birds to see their prey.	• One Plan targets for clarity are not met within the catchment.	• 20 year trend analysis of visual clarity shows an improving trend at one site and no significant trend at seven sites. • Long-term continuous sediment monitoring at six sites in the catchment has shown patterns of reduced storm sediment yields at four sites, increasing yield at one site and no trend at one site.	• Riparian fencing and planting • Continue the erosion-prevention work under Sustainable Land Use Initiative • Carrying out best practice river engineering and drain maintenance
High bacteria counts (Pathogens)	• Suitability for swimming	• One Plan targets for bacteria are not met within the catchment.	• 20 year trend analysis of *Escherichia coli* counts show an improving trend at five sites and no significant trend at three sites.	• Riparian fencing and planting • Implementing farm plan recommendations • Upgrading wastewater treatment plants

Issue	Effects	State	Trends	Current and future mitigation measures
Impacts on Aquatic Life	• Macroinvertebrate communities • Native fish	• Macroinvertebrate Community Index (MCI) scores are good or excellent in most places. However, One Plan targets aspire for MCI scores to be better at the majority of sites. • Macroinvertebrate communities are particularly affected in the lower Manawatū, Mangatera and Mangatainoka • Within the Manawatū catchment there are 23 species of fish (both native and introduced) • Some of the panel stated that some of these native fish populations are present in particularly low numbers • The introduction of a structured monitoring programme by Horizons over the last five years has provided a better understanding of fish populations and barriers to fish migration in the Manawatū catchment.	• There are three improving trends in the Macroinvertebrate Community Index within the catchment. These improvements are at the Mangatainoka at SH2 and Putara monitoring sites, and the Manawatū at Teachers College monitoring site. • There is insufficient data to make statements on native fish trends at this point.	• Implementing the One Plan water allocation framework • Carrying out best practice river engineering and drain maintenance • Improving fish passage and habitat • One Plan sediment and nutrient controls
Scarcity of Cultural resources	• Reduced Mahinga Kai • Effects on baptismal rituals	• There is a paucity of customary resources within the catchment. • Through the Accord process there has been increased connection between Māori and the River, and other Accord partners and there is greater participation of Māori in the resource consent process. • The panel concluded that it would be good to have cultural values better identified and incorporated into the decision making process for the Action Plan.	• Monitoring of cultural values is starting to occur within the catchment using the developed method. There is on-going monitoring at four sites; however, there is currently insufficient data to report on trends.	• Riparian fencing and planting including culturally valued plants • Removing wastewater treatment plant discharges to water • Improving fish passage and habitat • Restoration of culturally significant sites

Specific recommendations

- Action in the catchment focuses on controlling both nitrogen and phosphorus.
- Work continues on the implementation of Environmental Farm Plans in target catchments. The Panel feels there is a need for greater monitoring and more transparent reporting on the uptake and outcomes of mitigation measures.
- There is continued promotion of the sealing and adequate sizing of effluent ponds on dairy farms to enable deferred irrigation.
- Erosion-prevention work is continued under the Sustainable Land Use Initiative (SLUI) and that the rate of protection is accelerated in critical sediment source areas, particularly considering the increased storminess predicted by climate change information.
- The current targeted approach to riparian fencing is continued. It is recommended that fencing be increased to include dairy run-offs and dairy support land. The rate and amount of fencing and planting should also be increased as only a small portion of potentially fenced and planted areas have been completed. Stream setback distances should also be considered to achieve the greatest improvements in water quality.
- Riparian planting is targeted to improve fish habitat restoration, iwi values and increase stream shading.
- Potential production values of riparian planting be promoted including harvesting for feed during droughts, timber products, manuka honey, traditional medicines, cut and carry or soil conditioner when mulched.
- Existing wetlands are further protected and enhanced through fencing, pest control and planting. The Panel also recommends increasing the connectivity of wetlands and their functionality in farm systems and creating new wetland habitats and sediment traps to reduce critical sources of nutrients and sediment.
- Faecal Source Tracking is carried out within the catchment where bacteria is identified as an issue to determine sources of bacteria to target future improvements. The Panel also recommends improving septic tank systems where these are identified as the source of bacteria; supporting an active programme for excluding all stock from rivers and streams; continuing bridging and culverting crossings and eliminating farm laneway runoff to streams.
- Wastewater discharges be applied to land, where feasible, for a range of cultural and water quality reasons. However, feasibility studies should take into account future use of the land where the effluent will be applied. The Panel identified that the hydraulics (managing the volumes of effluent applied) of any land treatment site is a key factor in the success of these discharges.
- Innovative solutions to improve discharge quality continue to be considered and work is continued to improve point source discharges including work to ensure UV treatment is more effective. The following discharges were identified as in need of improvement based on water quality information presented at the workshop: Woodville, Palmerston North, Eketahuna, Norsewood, Dannevirke, Pahiatua, Kimbolton and Feilding. However, it was noted that work is currently underway to improve discharge quality at all of these sites.
- Best practice river engineering and drain maintenance practices are undertaken to ensure sustainable management of rivers. Pool, run and riffle habitats should be maintained and any in-river works should maintain the river's natural character and geomorphology.

- Fish removed during drain cleaning should be returned immediately following this work. Riparian planting should be increased around drains to shade the water and this may reduce the frequency of cleaning required.
- Forum members take a coordinated approach to the management of fish populations and improvement of fish habitats.
- The targeted approach to identifying barriers to fish migration and prioritising fish passage improvements is continued. Monitoring should also be continued to determine the effectiveness of fish passage solutions. Chemical barriers to fish migration should also be considered when seeking to improve contaminant concentrations in the catchment.
- Monitoring of fish populations continues including key taonga species and trout populations. The Panel also recommends fish monitoring be carried out at all cultural monitoring sites.
- The restoration of trout spawning habitat should be a focus, particularly in the Mangatainoka. Identified trout spawning and juvenile recruitment areas should be resurveyed and trout populations should be monitored at a number of different life stages to provide quantitative information on the state and trends of trout populations in the catchment.
- Research to assess the effectiveness of water allocation policies and rules should be continued and includes assessment of minimum flows required to support cultural values.
- Surety of supply continues to be assessed to ensure allocation levels are sustainable and provide for the needs of users and values.

Monitoring and reporting

The Panel were supportive of the comprehensive monitoring and research programme currently in place across the catchment and noted its importance in Action Plan development and assessment of effectiveness. The Panel recognised that monitoring in the Manawatū catchment is amongst the best nationally and endorsed the continuation of work being undertaken to identify relationships between *E. coli* and flow for on-going reporting of suitability for swimming; and supported the addition of deposited sediment monitoring at all State of the Environment sites. However, the Panel also identified potential gaps in knowledge and monitoring that need to be addressed. Recommendations for addressing these gaps are:

- Including measures of river morphology and monitor habitat change (extent, condition, connectivity).
- Looking at ways to involve the community in monitoring to expand the monitoring network and achieve greater buy-in to the river restoration.
- Resurveying trout spawning habitat and juvenile recruitment areas.
- Collecting and analysing more data on trout populations.
- Including an expanded fish monitoring programme to monitor fish species and areas important to Accord partners e.g. eel populations.
- Increasing kakahi and koura monitoring and reporting.
- Increasing cultural monitoring in the catchment.
- Investigating options for continuous nutrient monitoring.

- Undertaking faecal source tracking/targeted investigations to inform implementation of mitigation measures.
- Measuring the effectiveness of implementing Environmental Farm Plans.
- Incorporating other monitoring measures to measure success of the Accord goals.

Research/analysis and reporting

The Panel recommends:

- Taking modelling of contaminant concentration with land use undertaken by Snelder et al. (2014) a step further to tease out point source effects.
- Looking at macroinvertebrate species data to see if there are trends at monitored sites.
- Investigating changes in invertebrates across the catchment using individual taxa/species.
- Researching visual clarity outcomes as a result of sediment reductions from SLUI.
- Reporting the results of SLUI more widely.
- Including review of chemical barriers to fish migration in work to reduce contaminant concentrations.
- Reporting habitat change identification in connection with river morphology using indices that have been developed.
- Carrying out a 10 year water quality trend analysis with increased sites.
- Reporting on deposited sediment data, collected as part of the periphyton programme, against One Plan targets.
- Continuing work on developing a suitability for swimming indicator.
- Undertaking analysis of periphyton data and including linkages to other ecosystem measures.
- Looking at the report card approach to dissemination of information.
- Looking into relationships between nutrients and sediment.
- Establishing monitor farms/study catchments to measure the effectiveness of mitigations.
- Continuing work in the Mangatainoka catchment to measure the effectiveness of Environmental Farm Plan implementation.

CONTENTS

1 Introduction

The Manawatū River Leaders' Forum has reached a milestone in its work. Three years after launching an initial Action Plan in 2011 to restore the Manawatū River and Catchment, it is seeking to review the situation and produce a revised Action Plan for implementation over the next 2-3 years.

A Science and Mātauranga Māori panel was convened over 5-6th March 2015. The following report documents the panel's agreed statements on state and trends in the Manawatū Catchment, recommended actions and monitoring gaps.

1.1 History of water quality management in the Manawatū

As water quality issues and community expectations evolve over time so has water quality management in the Manawatū catchment and wider Manawatū-Wanganui Region.

Early management of water quality in the Manawatū catchment focussed mainly on point source discharges to water. In the 1950s the focus was on implementing screening to remove gross solids from point source discharges; during the 1980s the focus shifted to increased treatment to reduce the biochemical oxygen demand in these discharges in order to control the growth of sewage fungus. In the late 1990s the Manawatū Catchment Water Quality Regional Plan became operative. The focus of this plan was shifting dairy shed effluent from being discharged to water to being discharged to land (this was fully implemented by 2011) and improved treatment of point source discharges to reduce bacteria and dissolved reactive phosphorus during low flows. In addition to the historical control on point source discharges, the catchment has had a long history of soil conservation, flood management and water allocation management.

Current water management is through the One Plan (Horizons' combined regional policy statement, Regional Plan and Coastal Plan). The catchment is divided into water management zones and sub-zones. Water body values have been derived for each of the sub-zones and numerical water quality targets established to provide for the values. Whilst the regulatory focus is still on improving point source discharges the One Plan also includes rules for managing the effects of intensive land use in the region and includes non-regulatory methods to improve water quality and aquatic biodiversity.

1.2 Accord History

In early 2010 the Manawatū River hit national headlines as "among the worst in the West". It has since become a beacon for all the challenges facing freshwater quality in New Zealand and the focus of the Manawatū River Leaders' Accord.

Media claims were not entirely accurate. However, they did provide an impetus for change at a time when freshwater management was already under intense litigation through the development of Horizons Regional Council's One Plan.

Horizons' Chairman took the opportunity to invite key leaders to meet and discuss the River's state. Over the next six months these leaders debated the issues with a view to achieving consensus. Often discussion was heated, but in August 2010 the leaders signed an Accord publicly pledging to work together to improve the health of

the Manawatū River and catchment. The Accord document set out a focus, vision, and goals for the River.

The Vision

Kei te ora te wai, kei te ora te whenua, kei te ora te tangata.

If the water is healthy, the land and the people are nourished.

The Goals

The main goal of the accord is to improve the Manawatū River, the mauri (life force) of the Manawatū River Catchment, such that it sustains fish species, and is suitable for contact recreation, in balance with the social, cultural and economic activities of the catchment community.

This goal represents a community opportunity to develop leadership in catchment improvement and capture the social and economic benefits of such leadership.

Specific goals set out in the Accord are:

- The Manawatū River becomes a source of regional pride and mana.
- Waterways in the Manawatū Catchment are safe, accessible, swimmable, and provide good recreation and food resources.
- The Manawatū Catchment and waterways are returned to a healthy condition.
- Sustainable use of the land and water resources of the Manawatū Catchment continues to underpin the economic prosperity of the Region.

The Action Plan

In June 2011 the Manawatū River Leaders' Forum launched their Action Plan which details the steps that will be taken to clean up the river. The plan identifies six key areas that need to be addressed for the river to improve: sediment; nutrients and bacteria from point source discharges; nutrients and pathogens from agricultural run-off; physical changes from flood control work; protection of native fish and birds; and management of water allocation. The six key priorities are backed up by over 130 specific actions to be taken by various members of the forum and will be added to over time.

During the few years since the Action Plan was signed considerable progress towards the 130 specific actions has been made. This was reported publicly by the leaders' forum in a progress report (April 2014).

Fresh Start for Fresh Water Clean-up Fund

Following the development of the Action Plan, Central Government sought applications for the Fresh Start for Freshwater Clean-up Fund (applications opened late 2011). The criteria for the funding included that the money had to be spent on physical works on the ground that show a measurable improvement in water quality, and at least half of the funding had to come from other parties within the region.

Horizons, on behalf of and in partnership with members of the Manawatū River Leaders' Forum, formulated an application for funding utilising the monitoring and

science information to date, including information from extensive monitoring upstream and downstream of major discharges and state of the environment network, to inform what interventions were necessary (see the attached Data summary 2007 – 2010). The application put forward included upgrades to six sewage treatment plants identified as contributing significantly toward the water quality issues in the catchment, stream fencing and habitat restoration projects to improve the biological health and water quality of the catchment and address some of the needs of the native fish populations, environmental farm plans for all dairy farms in the Mangatainoka catchment and funding towards community projects. Two other projects unsuccessfully put forward for funding were the investigation into a large-scale land treatment system for towns and cities in the Lower Manawatū and funding for a community monitoring programme.

Two and a half years on and many of the Clean-up Fund projects have now been completed. The achievements to date are summarised in Table 1 and shown in Figure 1.

Table 1: Clean-up Fund progress summary as at December 2014

	Wastewater Treatment Plant upgrades	Total metres Fenced	Total plants planted	Fish passage improvements	Farm plans completed	Community projects completed
Completed by 29th August 2014	3	208,487	66,420	12	98	14

On-going Work Programme

Work under the Clean-up Fund is on-going to complete the upgrades at Dannevirke, Pahiatua and Woodville wastewater treatment plants and with Iwi-led community projects. In the 2014/2015 financial year the targeted rate for the accord is aiming to achieve 57km of fencing and over 20,000 plants in the catchment.

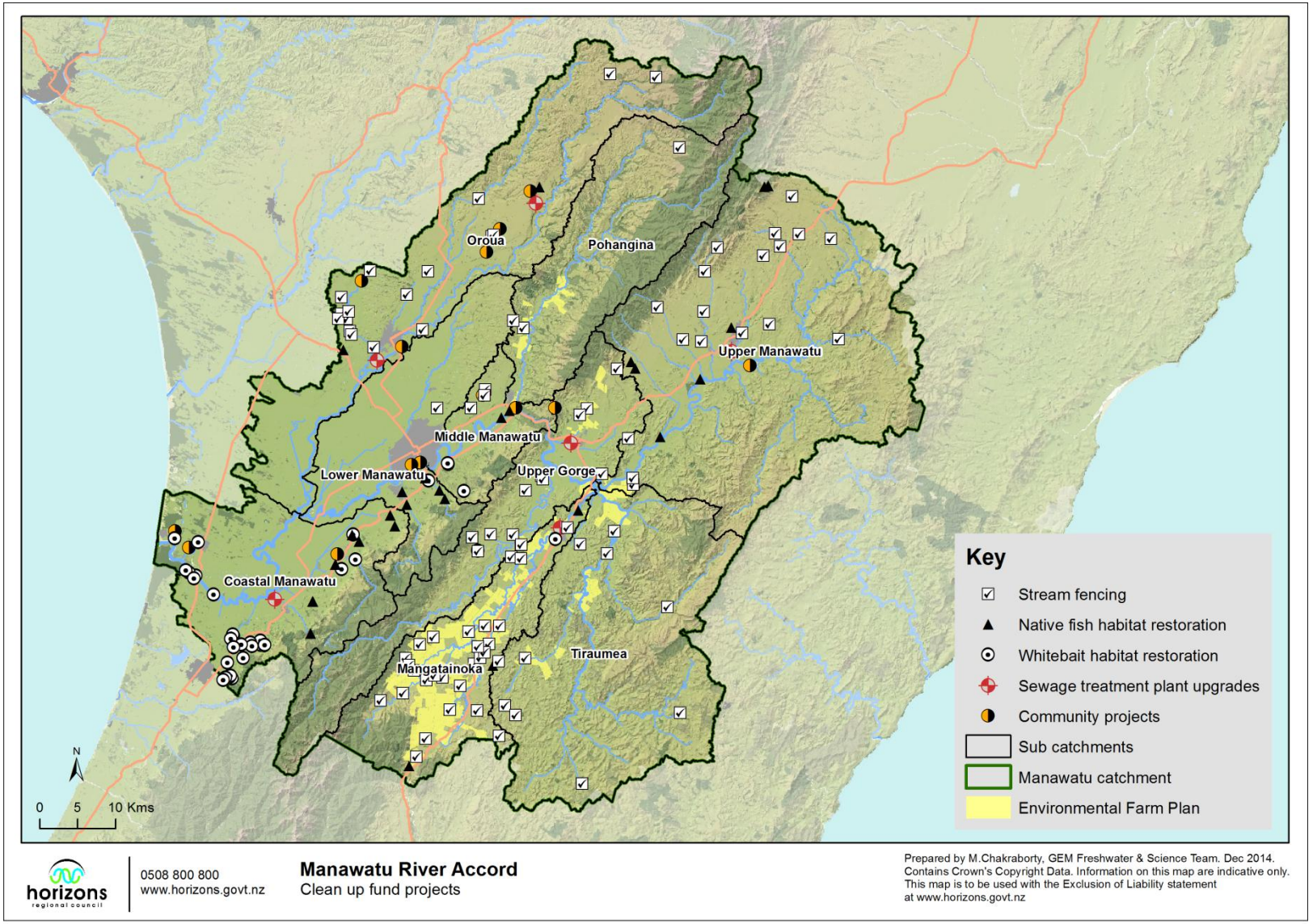

Figure 1: Manawatū Accord Clean-up Fund project summary

1.3 Science and Mātauranga Māori advisory panel

A Science and Mātauranga Māori panel was convened over the 5th and 6th March 2015 to discuss the current state of the River, key issues and possible solutions to help inform development of a revised Action Plan. This aligns with the approach taken during development of the original Action Plan. The following report documents the outcomes of the workshop to be considered by the leaders as they undertake a review of the Action Plan and commit to future actions.

The panel was comprised of experts in the fields of Mātauranga Māori, water quality, ecology, and geomorphology. Table 2 provides a list of attendees and their respective organisations.

Table 2: Advisory panel members

Attendee	Organisation
John Quinn	NIWA
Russell Death	Massey University
Mike Joy	Massey University
Ian Fuller	Massey University
Jon Procter	Massey University/Tanenuiarangi Manawatū Incorporated (TMI)
Garth Harmsworth	Landcare Research
Ton Snelder[1]	Land Water People
Mike Scarsbrook[2]	Dairy NZ
Roger Young	Cawthron Institute
Tene Tangatatai	Department of Conservation
Corina Jordan	Fish and Game New Zealand
Phil Teal[1]	Fish and Game Wellington Office
Jon Roygard	Horizons Regional Council
Logan Brown	Horizons Regional Council
Maree Clark	Horizons Regional Council
Lucy Ferguson[2]	Horizons Regional Council
Anna Regtien[2]	Horizons Regional Council

The panel received a pre-reading pack for consideration prior to the meeting and a number of presentations at the beginning of the workshop set the scene for the discussion.

The key questions put to the panel for consideration were:

- What is the state and trends of water quality (including biomonitoring) in the Manawatū Catchment?
- What progress has been made and when do we expect the outcomes of the interventions to be realised (and when will they show in monitoring data)?
- What further actions are recommended?
- What gaps are there in the science and monitoring to inform decision making?

The following sections document the panel's agreed statements on state and trends in the Manawatū Catchment, recommended actions and monitoring gaps.

[1] Attended day 1 only
[2] Attended day 2 only

2 Water Quality Statement

The panel made some broad statements about the state of the catchment before going through parameter by parameter discussing both state and trends. The experts' professional opinions, the April 2014 report on state and trends (Snelder et al., 2014), catchment summary graphs (Appendix One, Figure 6 to Figure 18), presentations at the workshop and the most recent macroinvertebrate report (Stark, 2014) informed the panel's statement on current state and trends in the Manawatū Catchment.

The panel agreed that:

- Nitrate and ammonia toxicity is not generally a problem within the catchment.
- Nutrients[3], bacteria and clarity do not meet One Plan targets for at least half of the monitored sites.
- Temporal and spatial variation in water chemistry data is high, which can complicate statements on water quality trends.
- Emphasis should be placed on continuing monitoring programmes over the long term. This will enable more conclusive trend analysis to be made as the length of the record and variability in the data can affect the trend result. The signal can only be separated from the noise with confidence if there are sufficient data points.

In 2007 the number of water quality monitoring sites in the catchment was more than doubled to include monitoring upstream, downstream and of the effluent of 20 major (municipal and industrial wastewater) point source discharges within the catchment. Further to this, in 2007 and 2008 the number of State of the Environment monitoring sites within the catchment was increased, from a small number of sites monitored on a monthly basis every year and a larger number monitored for one year in every three, to all sites being monitored permanently (on a continuous monthly basis). July 2017 will see the expanded water quality network (including upstream and downstream of the major point source discharges) reach its first decade enabling the analysis of 10-year trends.

2.1 How long will it take to see the results?

The panel felt it important to convey that it will take time for work carried out in the catchment to be reflected in the datasets. Recent research has shown the average time between water leaving the root zone and emerging in the river channel during low flows[4] is around 0 – 11 years (Morgenstern et al., 2014 and shown in Figure 2). This means there will be a lag in response to land use change and/or changes in management practices within the catchment. However, these lags are shorter than those within the Lake Taupo catchment, which are approximately 60 years.

In addition to lags in the transport of contaminants through the catchment there are also lag times in plant growth. Therefore, improvements in instream habitat as a result of shading and reduced run off due to riparian planting will take time as the plantings take time to reach their optimal level. Similarly, planting to address hill country erosion will take time to mature and produce benefits. Ecological responses

[3] Nutrients are managed for both toxicity effects and controlling plant and algal growth. One Plan nutrient targets not being met are those for controlling plant and algal growth.
[4] Groundwater residence time will be shorter for "average" conditions than measured during low flows

will also take time to show appreciable improvement as species recover from their current state to a new state in response to remediation of habitat and species are able to recolonize restored habitat.

There are some actions that the panel expects will produce immediate results, such as fixing or removing point source discharges. However, the frequency of water quality monitoring and the inherent variability of the data mean that it will take time before we can confidently detect improving trends.

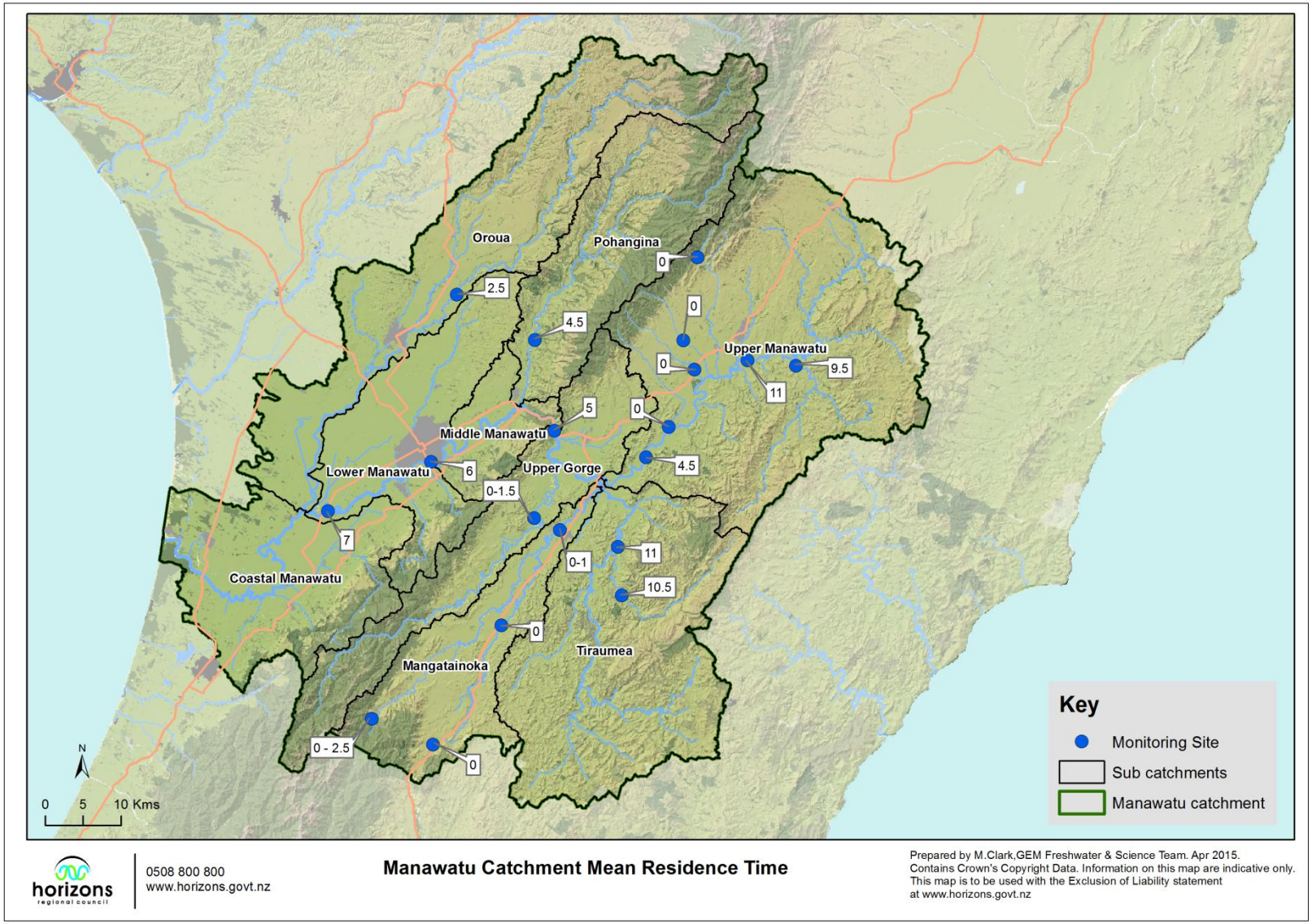

Figure 2: Mean Residence time (years) in surface water in the Manawatū Catchment during low flow conditions (March 2013) (Morgenstern et al., 2014)

2.2 Fish

Approximately 74% of New Zealand's native fish species are threatened or at risk. Within the Manawatū catchment there are 23 species of fish (both native and introduced) (Table 3); Some of the panel stated that some of these native fish populations are present in particularly low numbers

Factors influencing fish populations include harvesting (whitebait and tuna harvest), land use, barriers to migration, introduced species, river engineering, and riparian habitat removal (removing shading and spawning habitat).

When looking at migratory fish populations it is important to put the Manawatū in the national context as factors outside of the Manawatū (both nationally and internationally) may influence these populations. Conversely, non-migratory species (such as dwarf galaxias) will be influenced solely by activities taking place within the catchment.

Fish monitoring in the catchment has been carried out by a range of agencies including Fish and Game, the Department of Conservation, Massey University and Horizons Regional Council. The introduction of a structured monitoring programme by Horizons Regional Council over the last five years has provided a better understanding of fish populations and barriers to fish migration in the Manawatū catchment than we had five years ago. Horizons Regional Council also monitors Kakahi (freshwater mussel) and Koura (freshwater crayfish) populations; however, the panel concluded that there is insufficient data to make statements on state and trends of these species at this point and on-going collection of data was recommended.

Figure 3: Giant Kōkopu in the Mangaore Stream (April 2014).

Table 3: Fish species found in the Manawatū Catchment

Species	Common Name	Type
Galaxias maculatus	Inanga	Native
Galaxias postvectis	Shortjaw kōkopu	Endemic
Galaxias fasciatus	Banded kōkopu	Endemic
Galaxias argenteus	Giant kōkopu	Endemic
Galaxias brevipinnis	Kōaro	Native
Galaxias divergens	Dwarf Galaxias	Endemic
Gobiomorphus huttoni	Redfin bully	Endemic
Gobiomorphus gobioides	Giant bully	Endemic
Gobiomorphus cotidianus	Common bully	Endemic
Gobiomorphus basalis	Crans bully	Endemic
Gobiomorphus breviceps	Upland bully	Endemic
Anguilla australis	Shortfin eel	Native
Anguilla diffenbachii	Longfin eel	Endemic
Cheimarrichthys fosteri	Torrentfish	Endemic
Neochanna apoda	Brown mudfish	Endemic
Geotria australis	Lamprey	Native
Retropinna retropinna	Common smelt	Endemic
Salmo trutta	Brown trout	Sports Fish
Oncorhynchus mykiss	Rainbow trout	Sports Fish
Perca fluviatilis	Perch	Sports Fish
Crassius auratus	Goldfish	Pest
Gambusia affinis	Gambusia	Unwanted Organism
Scardinius erythrophthalmus	Rudd	Noxious Species

2.3 Macroinvertebrate communities

The catchment's waterways are home to numerous aquatic organisms including insects, worms and snails. These are collectively referred to as macroinvertebrates and are an important indicator of ecosystem health. Macroinvertebrate Community Index scores are 'good' or 'excellent' in most parts of the catchment but could do with improvement in the lower Manawatū, Mangatera and Mangatainoka (Appendix One, Figure 7) where ratings of 'fair' and 'poor' have occurred on some occasions, although the Manawatū at Opiki is the only monitored site in the years 2011 – 2013 (inclusive) that has been rated as 'poor' (this occurred in the 2011 monitoring year). However, One Plan targets aspire that MCI scores improve at the majority of sites (Snelder et al., 2014[5]).

There are three improving trends (assessed using the Mann Kendall test) in the Macroinvertebrate Community Index within the catchment (Stark, 2014). These are the Mangatainoka at Putara (8 years of data), the Mangatainoka at SH2 (15 years of data) and the Manawatū at Teachers College (15 years of data).

2.4 Periphyton

The panel felt it was important for the leaders to recognise that occasional blooms of periphyton should be expected to occur at times in any river system. There are three key measures of periphyton (percentage cover of individual groups[6], a weighted composite cover of filamentous and mat algae, and chlorophyll *a*[7]). All three monitoring methods show similar patterns within the catchment.

The periphyton weighted composite cover index was chosen as an indicator of state for the visual appearance of algal cover as this is how periphyton is most readily perceived by the public. Most monitored sites rate as good to excellent across the catchment but more frequent exceedances into the fair/poor categories are seen at monitoring sites in the Mangatainoka, Makakahi and Tiraumea catchment (Appendix One Figure 8).

Chlorophyll *a* is another important measure, which appears to be strongly related to the drivers of periphyton blooms and is less subjective than visual cover. Exceedances of the One Plan targets are more frequent in the Mangatainoka, Makakahi, Tiraumea and mainstem of the Manawatū downstream of the Palmerston North waste water treatment plant than other parts of the catchment (Appendix One, Figure 9).

Trends in chlorophyll *a* are difficult to identify due to the inability to remove the effects of flow (flow adjustment) on the chlorophyll *a* concentrations. The last five years have seen declining trends in chlorophyll *a* concentrations (Snelder et al., 2014[8]). The panel identified that there is uncertainty as to whether this is a true declining trend as there is no ability to remove the effect of a long dry summer at the end of the record[9].

[5] Pages 31 and 34
[6] Used in the One Plan as an indicator of recreational suitability
[7] Chlorophyll *a* is used in the National Objectives Framework and the One Plan as an indicator for ecosystem health.
[8] Page 48
[9] The last year of record included a long dry summer that would be expected to produce higher than normal biomass, even under natural conditions, due to the uncharacteristically stable and low flows. The panel identified that this means there is uncertainty as to whether this is a true declining trend in periphyton as there is currently no method for statistically accounting for the effect of flow on the periphyton biomass record

2.5 Phormidium

Phormidium is an important indicator of water quality as it impacts on amenity and recreation values and can be particularly toxic to dogs and horses. The presence of phormidium can be seasonally influenced (e.g. present one year and not the next). Nationally there are broad patterns in phormidium presence across gravel bed rivers related to flow and nitrogen/phosphorus concentrations.

Phormidium is found at times throughout the catchment, particularly in the Mangatainoka (Figure 4), Tiraumea and Makakahi catchments. Monitoring data has shown that phormidium toxicity is variable throughout the catchment. The data record is not long enough to report on trends (Appendix One Figure 10).

Figure 4: Phormidium mat with brown filamentous algae at Mangatainoka at Brewery State Highway 2, July 2010

2.6 Nutrients

The nutrients in waterways that are of interest for management are nitrogen and phosphorus, both of which can be present in water bodies in a number of forms (organic and inorganic, particulate and dissolved). Whilst nutrients occur naturally in low concentrations, they become an issue when they occur in higher concentrations as they stimulate plant and algal growth. When plant biomass becomes excessive it can clog waterways; affect the suitability of our rivers, lakes and streams for recreation; and cause daily fluctuations in oxygen and pH that are stressful for fish and other aquatic species. Some nutrients such as ammonia and nitrate can also be toxic to aquatic life at certain concentrations, but concentrations don't generally reach these levels in the Manawatū Catchment.

Soluble inorganic nitrogen

Soluble inorganic nitrogen (SIN) is the sum of nitrate + nitrite + ammoniacal nitrogen and is managed in the catchment and wider Horizons Region to reduce excessive algal growth.

A large number of monitored sites in the catchment do not meet the One Plan SIN targets (Snelder et al., 2014[10] and Appendix One Figure 11 and Figure 12).

Of the eight monitored sites with 20 years of monthly data (July 1993 – July 2013) for total oxidised nitrogen (nitrate + nitrite) four are showing improving trends, one is degrading and three are showing no significant trend (Snelder et al., 2014, reproduced in Table 4).

Table 4: 20 year trends in total oxidised nitrogen in the Manawatū Catchment

Improving	Degrading	No trend
Manawatū at Hopelands Manawatū at Whirokino Mangatainoka at Brewery S.H.2 Bridge Oroua at Awahuri Bridge	Manawatū at Weber Rd	Manawatū at Opiki Bridge Manawatū at Teachers College Mangatera u/s Manawatū Confluence

Five year trends are showing some total oxidised nitrogen improvements (Snelder et al., 2014[11]). The panel identified that these trends need to be interpreted cautiously because they could be related to low flows at the end of the five year period. The low flows resulted in high periphyton growth (Snelder et al., 2014), which may have caused high rates of nutrient uptake.

Ammoniacal nitrogen

Ammoniacal nitrogen is a component of SIN leading to algal growth but can be both acutely (when exposure to high concentrations occurs over short time frames) and chronically (when there is prolonged exposure to lower concentrations) toxic to aquatic life.

Within the Manawatū Catchment ammoniacal nitrogen is generally a point source issue with Feilding and Dannevirke wastewater treatment plants[12] being the key discharge sources (Snelder et al., 2014[13] and Appendix One Figure 13 and Figure 14).

Of the eight monitored sites with 20 years of data (July 1993 – July 2013) for ammoniacal nitrogen four are showing an improving trend, three are showing a degrading trend and one no significant trend (Snelder et al., 2014, reproduced in Table 5).

Table 5: 20 year trends in ammoniacal nitrogen in the Manawatū Catchment

Improving	Degrading	No trend
Manawatū at Hopelands Manawatū at Weber Road Manawatū At Whirokino Mangatainoka at Brewery S.H.2 Bridge	Manawatū at Opiki Bridge Mangatera u/s Manawatū Confluence Oroua at Awahuri Bridge	Manawatū at Teachers College

[10] Pages 30 - 33
[11] Pages 47 – 50.
[12] These treatment plants are undergoing upgrades as part of the Fresh Start for Freshwater Clean-up fund.
[13] Pages 30 - 33

Dissolved Reactive Phosphorus

Dissolved reactive phosphorus (DRP) is the most readily available form of phosphorus for algal and plant growth. Management of DRP in the Manawatū catchment and wider Horizons Region is therefore important to the avoidance of excessive algal growth.

Predominantly, the One Plan DRP targets are not being met across the catchment. However, the Mangatainoka and Tiraumea catchments generally meet targets. Dannevirke, Woodville and Kimbolton sewage treatment plants[12] are key contributors of phosphorus. At low flows these and other point source discharges are the predominant sources of DRP in the catchment's rivers and streams (Snelder et al., 2014[14] and Appendix One Figure 15 and Figure 16).

Of the eight monitored sites with 20 years of data (July 1993 – July 2013) for DRP three sites are showing an improving trend and five are showing no significant trend (Snelder et al., 2014, reproduced in

Table 6).

Table 6: 20 year trends in Dissolved Reactive Phosphorus in the Manawatū Catchment

Improving	Degrading	No trend
Manawatū at Opiki Bridge Manawatū At Whirokino Oroua at Awahuri Bridge		Manawatū at Hopelands Manawatū at Teachers College Manawatū at Weber Road Mangatera u/s Manawatū Confluence Mangatainoka at Brewery S.H.2 Bridge

Five year trends are showing some phosphorus improvements (Snelder et al., 2014[15]). The panel identified that these trends need to be interpreted cautiously because they could be related to low flows at the end of the five year period. The low flows resulted in high periphyton growth (Snelder et al., 2014), which may have caused high rates of nutrient uptake.

2.7 Clarity and Sediment

Clarity and sediment concentration are important measures for ecosystem health, amenity and recreational values. Sediment concentrations and visual clarity are influenced by erosion and sediment discharges.

Clarity targets are not met at any of the monitored sites in the catchment (Snelder et al., 2014[14]). The panel agreed that sediment and storm event erosion will be the main driver of the identified clarity issues.

Of the eight mon itored sites with 20 years of clarity data, one site was showing an improving trend and the remaining seven no significant trend (Snelder et al., 2014, reproduced in Table 7).

[14] Pages 30 - 33
[15] Pages 47 – 50.

Table 7: 20 year trends in visual clarity at monitored sites in the Manawatū Catchment

Improving	Degrading	No trend
Mangatera u/s Manawatū Confluence		Manawatū at Hopelands Manawatū at Opiki Bridge Manawatū at Teachers College Manawatū at Whirokino Mangatainoka at Brewery S.H.2 Bridge Oroua at Almadale

Modelling work that has assessed sediment and erosion control works carried out as part of the sustainable land use initiative (SLUI) to date indicates that 11% reduction in annual sediment load in the Manawatū catchment can be expected by 2043 (Dymond et al., 2014). Using predictions for on-going implementation of the SLUI initiative the reduction is modelled to be 27% across the catchment by 2043 and up to 45% in some catchments (Appendix Two, Figure 19).

Long-term continuous sediment monitoring at six sites in the catchment has shown patterns of reduced storm loads at four sites, increasing loads at one site and no trend at one site (Hicks and Hoyle, 2012 reproduced in

Table 8).

Table 8: Long-term trends in storm loads at continuous sediment sites

Reducing event yield (improving)	Increasing event sediment yield (degrading)	No trend
Makuri at Tuscan Hills Manawatū at Hopelands Mangatainoka at Pahiatua Town Bridge Pohangina at Mais Reach	Mangahao at Ballance	Manawatū at Teachers College

2.8 *Escherichia coli*

During the bathing season (November – April) when flows are low (below median) concentrations of *E. coli* exceed targets at monitored sites in the catchment; additionally, the year-round targets are not being met (Snelder et al., 2014[16] and Appendix One Figure 17 and Figure 18).

E. coli is very variable (Appendix One Figure 17 and Figure 18) which makes it difficult to detect statistically significant trends with short periods of record. However, of the eight sites with 20 years of data, five are improving and three are showing no trend (Snelder et al., 2014, reproduced in

Table 9).

Table 9: 20 year trends in Escherichia coli concentration at monitored sites in the Manawatū Catchment

Improving	Degrading	No trend
Manawatū at Hopelands Manawatū at Weber Rd Mangatainoka at Brewery S.H.2 Bridge Oroua at Almadale Mangatera u/s Manawatū Confluence		Manawatū at Opiki Bridge Manawatū at Teachers College Manawatū at Whirokino

[16] Pages 30 - 33

2.9 Is the catchment swimmable?

There are a range of factors influencing suitability for swimming including personal preference (for example access, look and feel of the location, physical safety, water temperature and state of flow).

The panel commented on suitability for swimming in the context of phormidium, *E. coli* and visual clarity. By these measures, suitability for swimming is very site and season specific. At monitored sites within the Manawatū catchment there are times when the phormidium, *E. coli* and clarity conditions are suitable for swimming and times when they are not. The Safe Swim Spots section of the Horizons Regional Council website is regularly updated during the bathing season for the public to evaluate risk. Figure 5 shows a screenshot of the website in early April 2015 following a period of significant rainfall in the region.

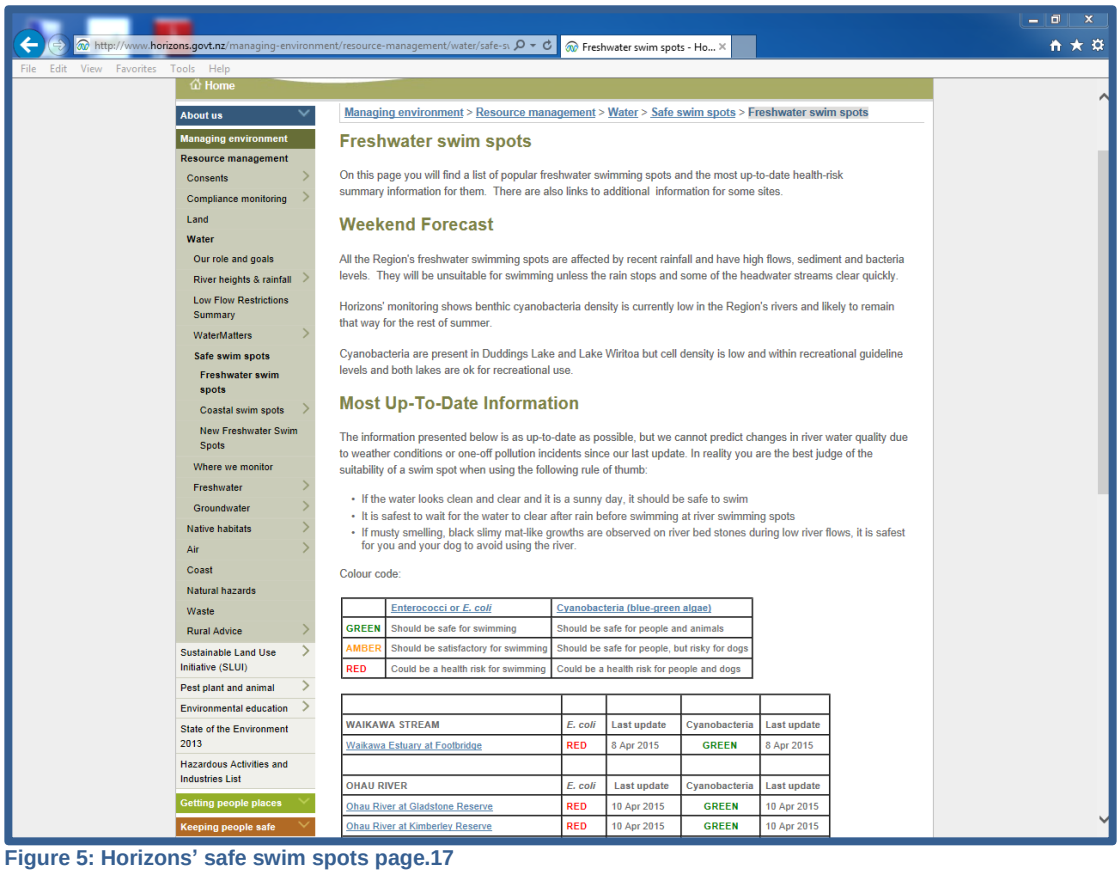

Figure 5: Horizons' safe swim spots page.17

2.10 Cultural Values

A method and indicators for cultural values monitoring is being developed through individual Iwi (undertaken in conjunction with Landcare Research and supported by Horizons Regional Council). Monitoring of cultural values is starting to occur within the catchment using the developed method. There is on-going monitoring at four sites; however, there is currently insufficient data to report on trends.

[17] http://www.horizons.govt.nz/managing-environment/resource-management/water/safe-swim-spots/freshwater-swim-spots/

The panel identified that there is a paucity of customary resources within the catchment. Through the Accord process there has been increased connection between Māori and the River, and other Accord partners and there is greater participation of Māori in the resource consent process.

The panel concluded that it would be good to have cultural values better identified and incorporated into the decision making process for the Action Plan.

3 Recommendations

The Panel was largely supportive of work currently underway to improve the state of the Manawatū River and Catchment. In many cases, they recommended that these actions be continued and/or enhanced through the next iteration of the Action Plan. More information regarding the Panel's recommendations is outlined below.

3.1 Actions

The Panel recommends that:

- Action in the catchment focuses on controlling both nitrogen and phosphorus.
- Work continues on the implementation of Environmental Farm Plans in target catchments. The Panel feels there is a need for greater monitoring and more transparent reporting on the uptake and outcomes of mitigation measures.
- There is continued promotion of the sealing and adequate sizing of effluent ponds on dairy farms to enable deferred irrigation.
- Erosion-prevention work is continued under the Sustainable Land Use Initiative (SLUI) and that the rate of protection is accelerated in critical sediment source areas, particularly considering the increased storminess predicted by climate change information.
- The current targeted approach to riparian fencing is continued. It is recommended that fencing be increased to include dairy run-offs and dairy support land. The rate and amount of fencing and planting should also be increased as only a small portion of potentially fenced and planted areas have been completed. Stream setback distances should also be considered to achieve the greatest improvements in water quality.
- Riparian planting is targeted to improve fish habitat restoration, iwi values and increase stream shading.
- Potential production values of riparian planting be promoted including harvesting for feed during droughts, timber products, manuka honey, traditional medicines, cut and carry or soil conditioner when mulched.
- Existing wetlands are further protected and enhanced through fencing, pest control and planting. The Panel also recommends increasing the connectivity of wetlands and their functionality in farm systems and creating new wetland habitats and sediment traps to reduce critical sources of nutrients and sediment.
- Faecal Source Tracking is carried out within the catchment where bacteria is identified as an issue to determine sources of bacteria to target future improvements. The Panel also recommends improving septic tank systems where these are identified as the source of bacteria; supporting an active programme for excluding all stock from rivers and streams; continuing bridging and culverting crossings and eliminating farm laneway runoff to streams.
- Wastewater discharges be applied to land, where feasible, for a range of cultural and water quality reasons. However, feasibility studies should take into account future use of the land where the effluent will be applied. The Panel identified that the hydraulics (managing the volumes of effluent applied) of any land treatment site is a key factor in the success of these discharges.
- Innovative solutions to improve discharge quality continue to be considered and work is continued to improve point source discharges including work to ensure UV treatment is more effective. The following discharges were identified as in

need of improvement based on water quality information presented at the workshop: Woodville, Palmerston North, Eketahuna, Norsewood, Dannevirke, Pahiatua, Kimbolton and Feilding. However, it was noted that work is currently underway to improve discharge quality at all of these sites.

- Best practice river engineering and drain maintenance practices are undertaken to ensure sustainable management of rivers. Pool, run and riffle habitats should be maintained and any in-river works should maintain the river's natural character and geomorphology.
- Fish removed during drain cleaning should be returned immediately following this work. Riparian planting should be increased around drains to shade the water and this may reduce the frequency of cleaning required.
- Forum members take a coordinated approach to the management of fish populations and improvement of fish habitats.
- The targeted approach to identifying barriers to fish migration and prioritising fish passage improvements is continued. Monitoring should also be continued to determine the effectiveness of fish passage solutions. Chemical barriers to fish migration should also be considered when seeking to improve contaminant concentrations in the catchment.
- Monitoring of fish populations continues including key taonga species and trout populations. The Panel also recommends fish monitoring be carried out at all cultural monitoring sites.
- The restoration of trout spawning habitat should be a focus, particularly in the Mangatainoka. Identified trout spawning and juvenile recruitment areas should be resurveyed and trout populations should be monitored at a number of different life stages to provide quantitative information on the state and trends of trout populations in the catchment.
- Research to assess the effectiveness of water allocation policies and rules should be continued and includes assessment of minimum flows required to support cultural values.
- Surety of supply continues to be assessed to ensure allocation levels are sustainable and provide for the needs of users and values.

3.2 Monitoring

The Panel were supportive of the comprehensive monitoring and research programme currently in place across the catchment and noted its importance in Action Plan development and assessment of effectiveness. The Panel recognised that monitoring in the Manawatū catchment is amongst the best nationally and endorsed the continuation of work being undertaken to identify relationships between *E. coli* and flow for on-going reporting of suitability for swimming; and supported the addition of deposited sediment monitoring at all State of the Environment sites. However, the Panel also identified potential gaps in knowledge and monitoring that need to be addressed. Recommendations for addressing these gaps are:

- Including measures of river morphology and monitor habitat change (extent, condition, connectivity).
- Looking at ways to involve the community in monitoring to expand the monitoring network and achieve greater buy-in to the river restoration.
- Resurveying trout spawning habitat and juvenile recruitment areas.
- Collecting and analysing more data on trout populations.

- Including an expanded fish monitoring programme to monitor fish species and areas important to Accord partners e.g. eel populations.
- Increasing kakahi and koura monitoring and reporting.
- Increasing cultural monitoring in the catchment.
- Investigating options for continuous nutrient monitoring.
- Undertaking faecal source tracking/targeted investigations to inform implementation of mitigation measures.
- Measuring the effectiveness of implementing Environmental Farm Plans.
- Incorporating other monitoring measures to measure success of the Accord goals.

3.3 Research/analysis and reporting

The Panel recommends:

- Taking modelling of contaminant concentration with land use undertaken by Snelder et al. (2014) a step further to tease out point source effects.
- Looking at macroinvertebrate species data to see if there are trends at monitored sites.
- Investigating changes in invertebrates across the catchment using individual taxa/species.
- Researching visual clarity outcomes as a result of sediment reductions from SLUI.
- Reporting the results of SLUI more widely.
- Including review of chemical barriers to fish migration in work to reduce contaminant concentrations.
- Reporting habitat change identification in connection with river morphology using indices that have been developed.
- Carrying out a 10 year water quality trend analysis with increased sites.
- Reporting on deposited sediment data, collected as part of the periphyton programme, against One Plan targets.
- Continuing work on developing a suitability for swimming indicator.
- Undertaking analysis of periphyton data and including linkages to other ecosystem measures.
- Looking at the report card approach to dissemination of information.
- Looking into relationships between nutrients and sediment.
- Establishing monitor farms/study catchments to measure the effectiveness of mitigations.
- Continuing work in the Mangatainoka catchment to measure the effectiveness of Environmental Farm Plan implementation.

4 References

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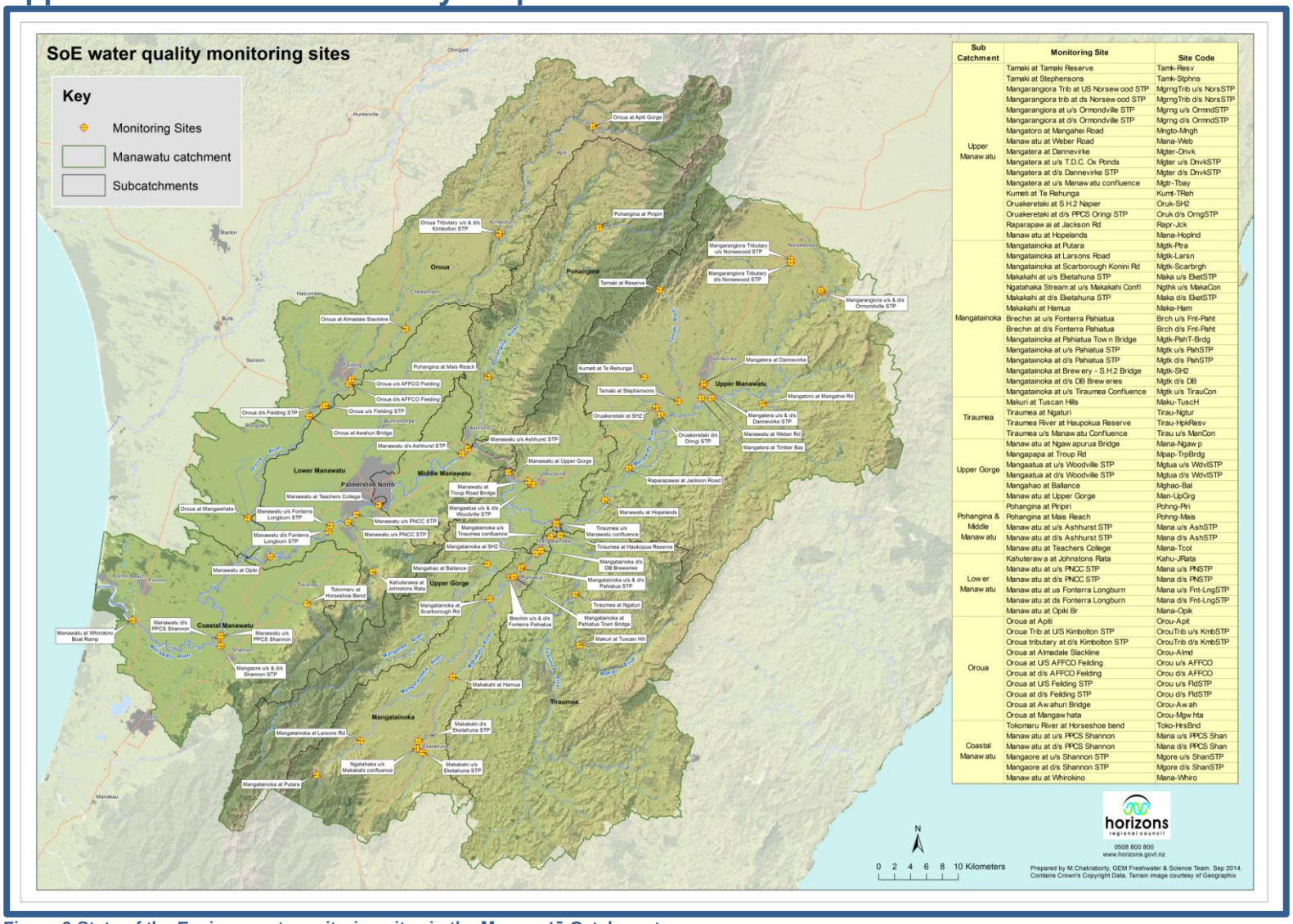
Appendix One – Data summary Graphs



Sub Catchment	Monitoring Site	Site Code
Upper Manaw atu	Tamaki at Tamaki Reserve	Tamk-Resv
	Tamaki at Stephensons	Tamk-Stphns
	Mangarangiora Trib at US Norsew ood STP	MgrngTrib u/s NorsSTP
	Mangarangiora trib at ds Norsew ood STP	MgrngTrib d/s NorsSTP
	Mangarangiora at u/s Ormondville STP	Mgrng u/s OrmndSTP
	Mangarangiora at d/s Ormondville STP	Mgrng d/s OrmndSTP
	Mangatoro at Mangahei Road	Mngto-Mngh
	Manaw atu at Weber Road	Mana-Web
	Mangatera at Dannevirke	Mgter-Dnvk
	Mangatera at u/s T.D.C. Ox Ponds	Mgter u/s DnvkSTP
	Mangatera at d/s Dannevirke STP	Mgter d/s DnvkSTP
	Mangatera at u/s Manaw atu confluence	Mgtr-Tbay
	Kumeti at Te Rehunga	Kumt-TReh
	Oruakeretaki at S.H.2 Napier	Oruk-SH2
	Oruakeretaki at d/s PPCS Oringi STP	Oruk d/s OrngSTP
	Raparapaw ai at Jackson Rd	Rapr-Jck
	Manaw atu at Hopelands	Mana-Hoplnd
Mangatainoka	Mangatainoka at Putara	Mgtk-Ptra
	Mangatainoka at Larsons Road	Mgtk-Larsn
	Mangatainoka at Scarborough Konini Rd	Mgtk-Scarbrgh
	Makakahi at u/s Eketahuna STP	Maka u/s EketSTP
	Ngatahaka Stream at u/s Makakahi Confl	Ngthk u/s MakaCon
	Makakahi at d/s Eketahuna STP	Maka d/s EketSTP
	Makakahi at Hamua	Maka-Ham
	Brechin at u/s Fonterra Pahiatua	Brch u/s Fnt-Paht
	Brechin at d/s Fonterra Pahiatua	Brch d/s Fnt-Paht
	Mangatainoka at Pahiatua Tow n Bridge	Mgtk-PahT-Brdg
	Mangatainoka at u/s Pahiatua STP	Mgtk u/s PahSTP
	Mangatainoka at d/s Pahiatua STP	Mgtk d/s PahSTP
	Mangatainoka at Brew ery - S.H.2 Bridge	Mgtk-SH2
	Mangatainoka at d/s DB Brew eries	Mgtk d/s DB
	Mangatainoka at u/s Tiraumea Confluence	Mgtk u/s TirauCon
Tiraumea	Makuri at Tuscan Hills	Maku-TuscH
	Tiraumea at Ngaturi	Trau-Ngtur
	Tiraumea River at Haupokua Reserve	Trau-HpkResv
	Tiraumea u/s Manaw atu Confluence	Trau u/s ManCon
Upper Gorge	Manaw atu at Ngaw apurua Bridge	Mana-Ngaw p
	Mangapapa at Troup Rd	Mpap-TrpBrdg
	Mangaatua at u/s Woodville STP	Mgtua u/s WdvlSTP
	Mangaatua at d/s Woodville STP	Mgtua d/s WdvlSTP
	Mangahao at Ballance	Mghao-Bal
	Manaw atu at Upper Gorge	Man-UpGrg
Pohangina & Middle Manaw atu	Pohangina at Piripiri	Pohng-Pri
	Pohangina at Mais Reach	Pohng-Mais
	Manaw atu at u/s Ashhurst STP	Mana u/s AshSTP
	Manaw atu at d/s Ashhurst STP	Mana d/s AshSTP
	Manaw atu at Teachers College	Mana-Tcol
Low er Manaw atu	Kahuteraw a at Johnstons Rata	Kahu-JRata
	Manaw atu at u/s PNCC STP	Mana u/s PNSTP
	Manaw atu at d/s PNCC STP	Mana d/s PNSTP
	Manaw atu at us Fonterra Longburn	Mana u/s Fnt-LngSTP
	Manaw atu at ds Fonterra Longburn	Mana d/s Fnt-LngSTP
	Manaw atu at Opiki Br	Mana-Opik
Oroua	Oroua at Apiti	Orou-Apit
	Oroua Trib at U/S Kimbolton STP	OrouTrib u/s KmbSTP
	Oroua tributary at d/s Kimbolton STP	OrouTrib d/s KmbSTP
	Oroua at Almdale Slackline	Orou-Almd
	Oroua at U/S AFFCO Feilding	Orou u/s AFFCO
	Oroua at d/s AFFCO Feilding	Orou d/s AFFCO
	Oroua at U/S Feilding STP	Orou u/s FldSTP
	Oroua at d/s Feilding STP	Orou d/s FldSTP
	Oroua at Aw ahuri Bridge	Orou-Aw ah
	Oroua at Mangaw hata	Orou-Mgw hta
Coastal Manaw atu	Tokomaru River at Horseshoe bend	Toko-HrsBnd
	Manaw atu at u/s PPCS Shannon	Mana u/s PPCS Shan
	Manaw atu at d/s PPCS Shannon	Mana d/s PPCS Shan
	Mangaore at u/s Shannon STP	Mgore u/s ShanSTP
	Mangaore at d/s Shannon STP	Mgore d/s ShanSTP
	Manaw atu at Whirokino	Mana-Whiro

Figure 6:State of the Environment monitoring sites in the Manawatū Catchment.

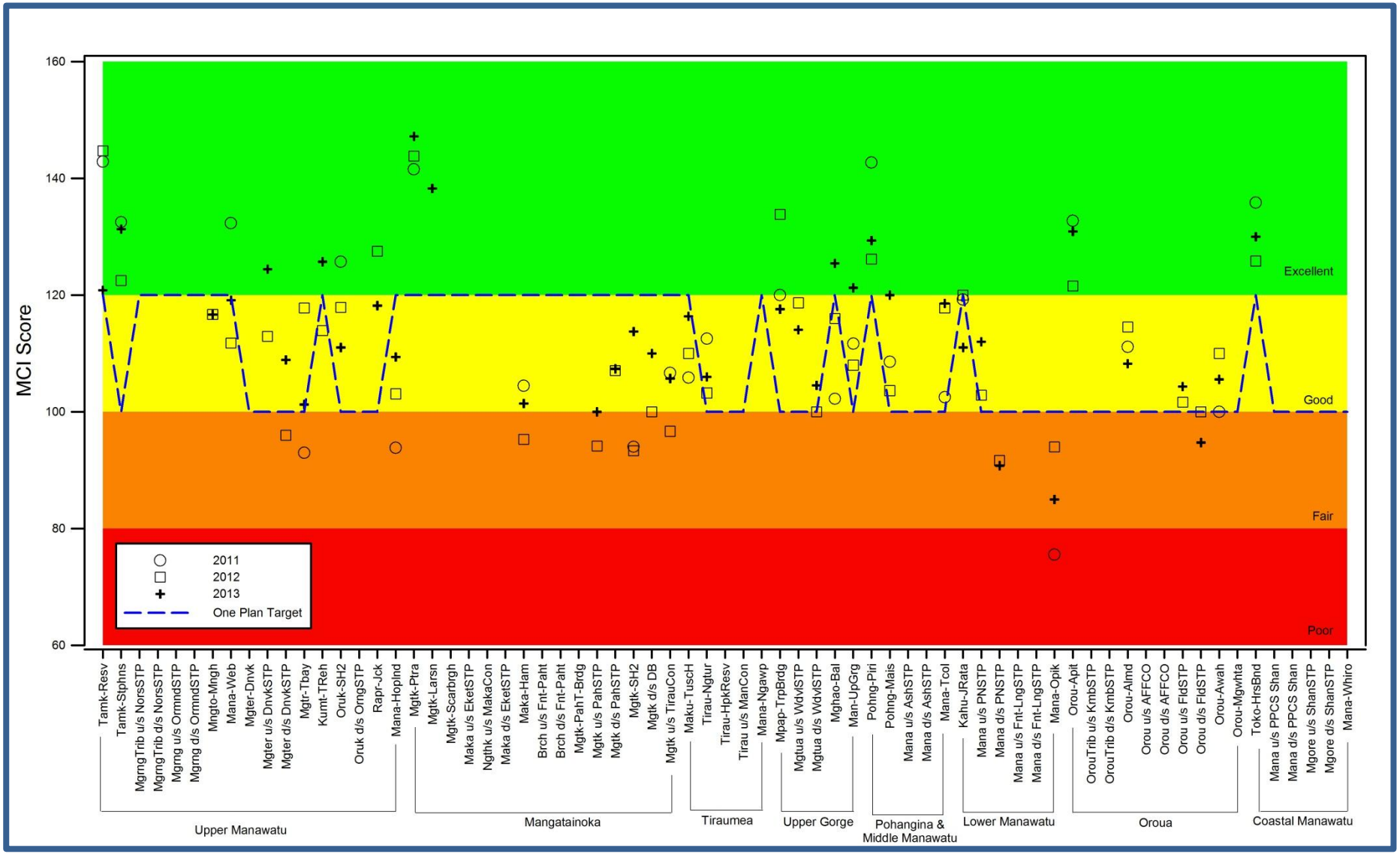


Figure 7: Macroinvertebrate Community Index scores for monitoring sites in the Manawatū catchment from 2011 - 2013.

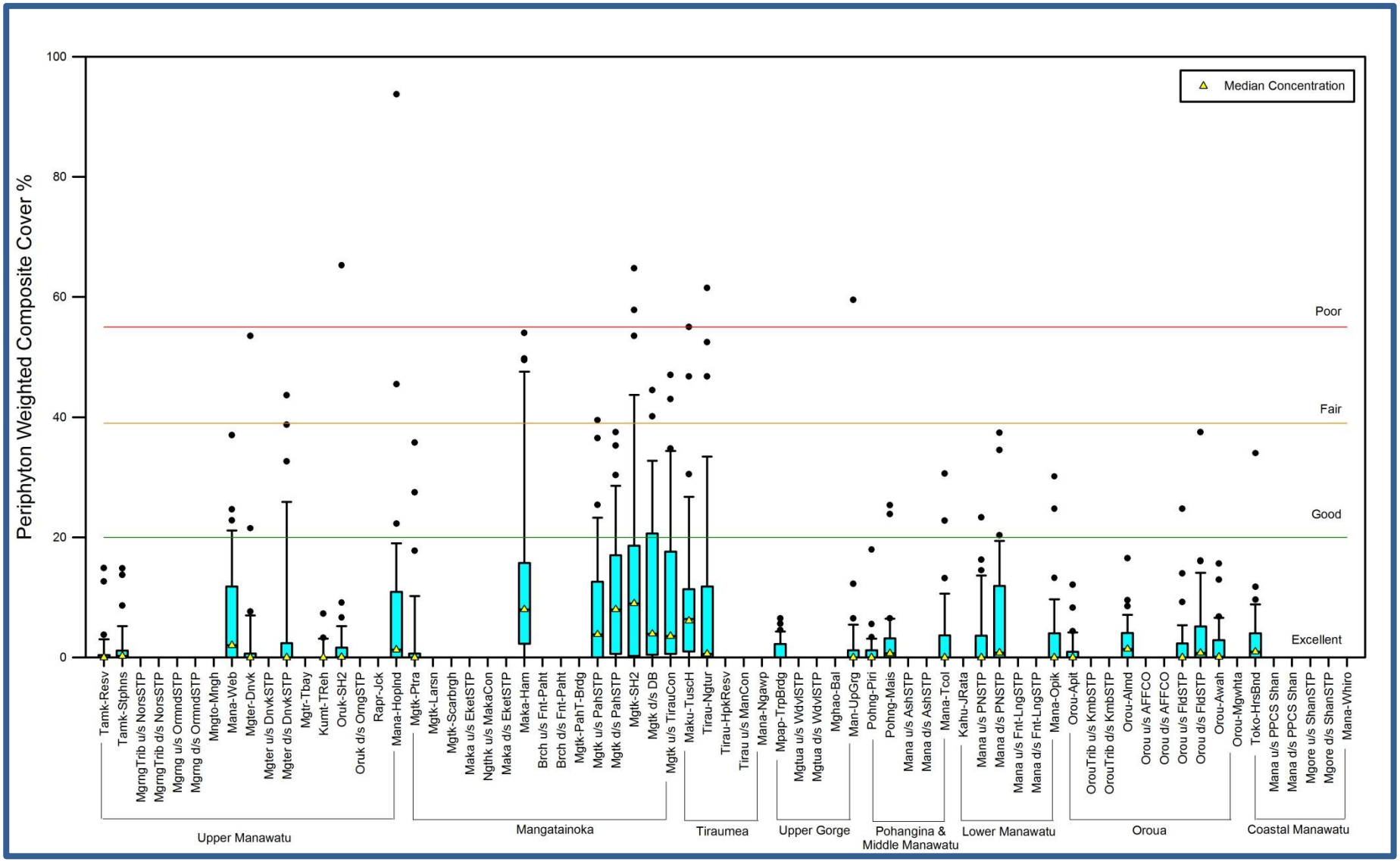


Figure 8: Periphyton Weighted Composite Cover index for monitoring sites in the Manawatū catchment from 2011 - 2013.

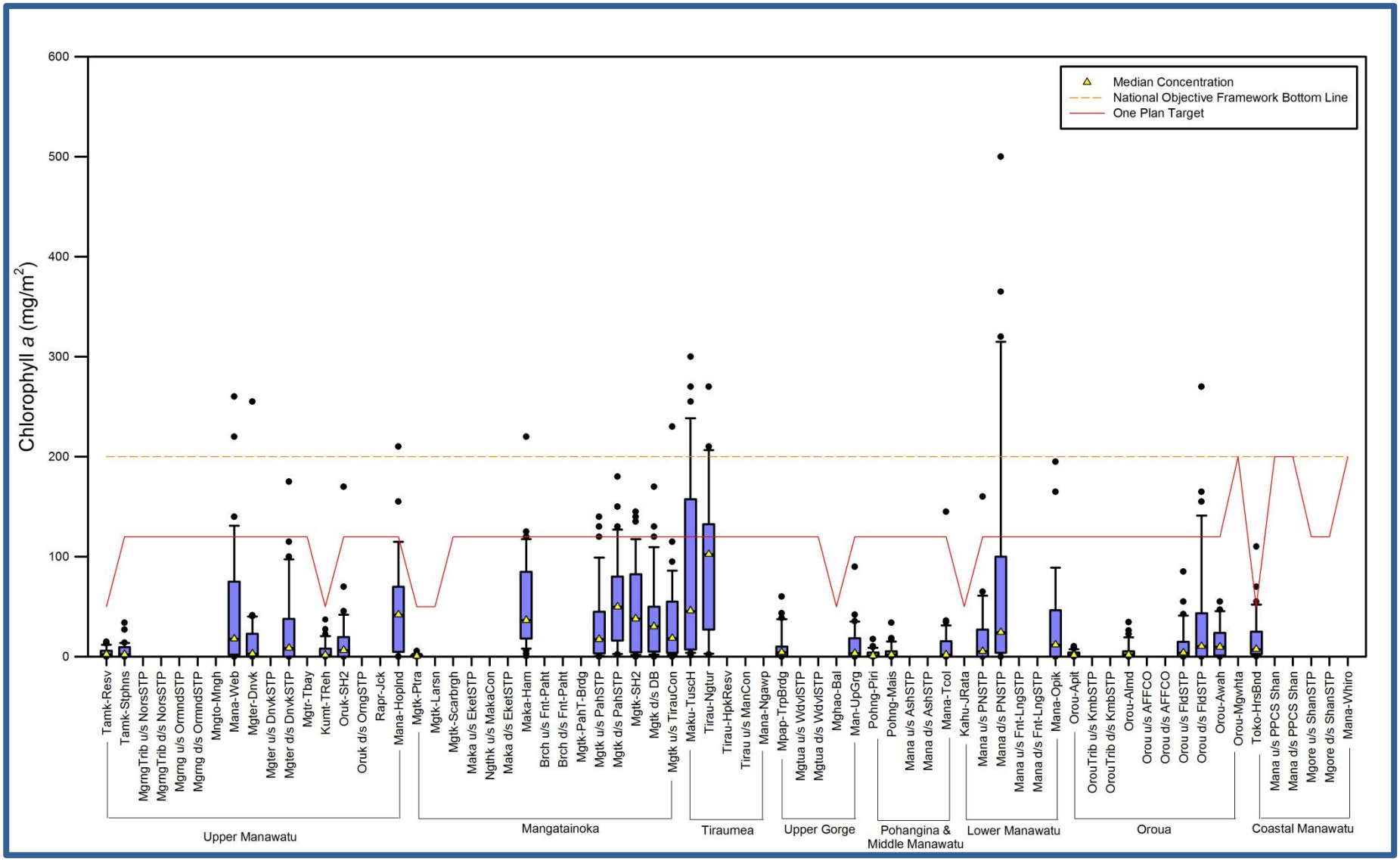


Figure 9: Chlorophyll a concentration for monitoring sites in the Manawatū catchment from 2011 - 2013.

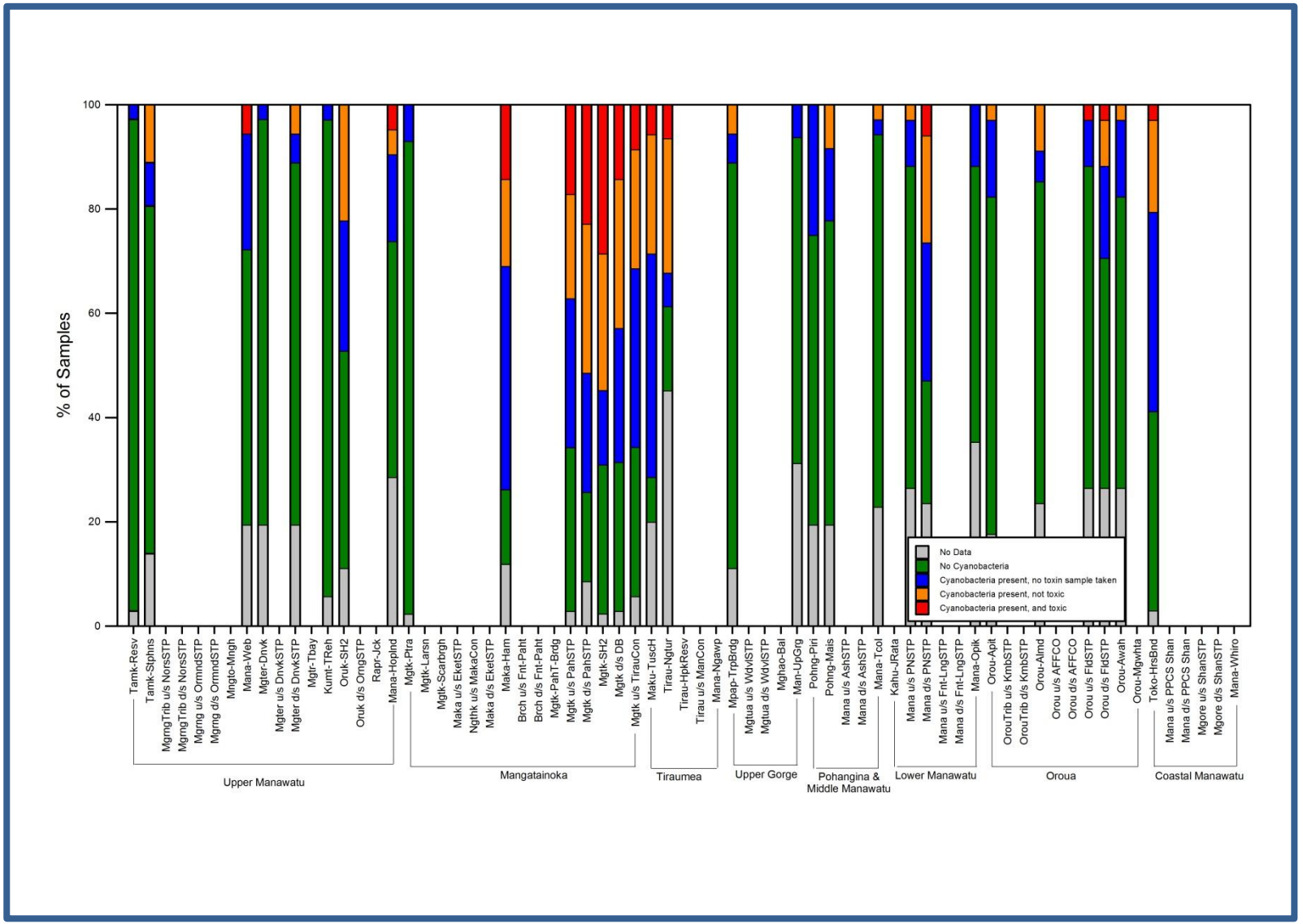


Figure 10: Phormidium prevalence and toxicity for monitoring sites in the Manawatū catchment from 2011 - 2013. Grey is no data, green is no phormidium present, blue is phormidium present but no toxin sample taken, orange is phormidium present but not toxic and red is phormidium present and toxic.

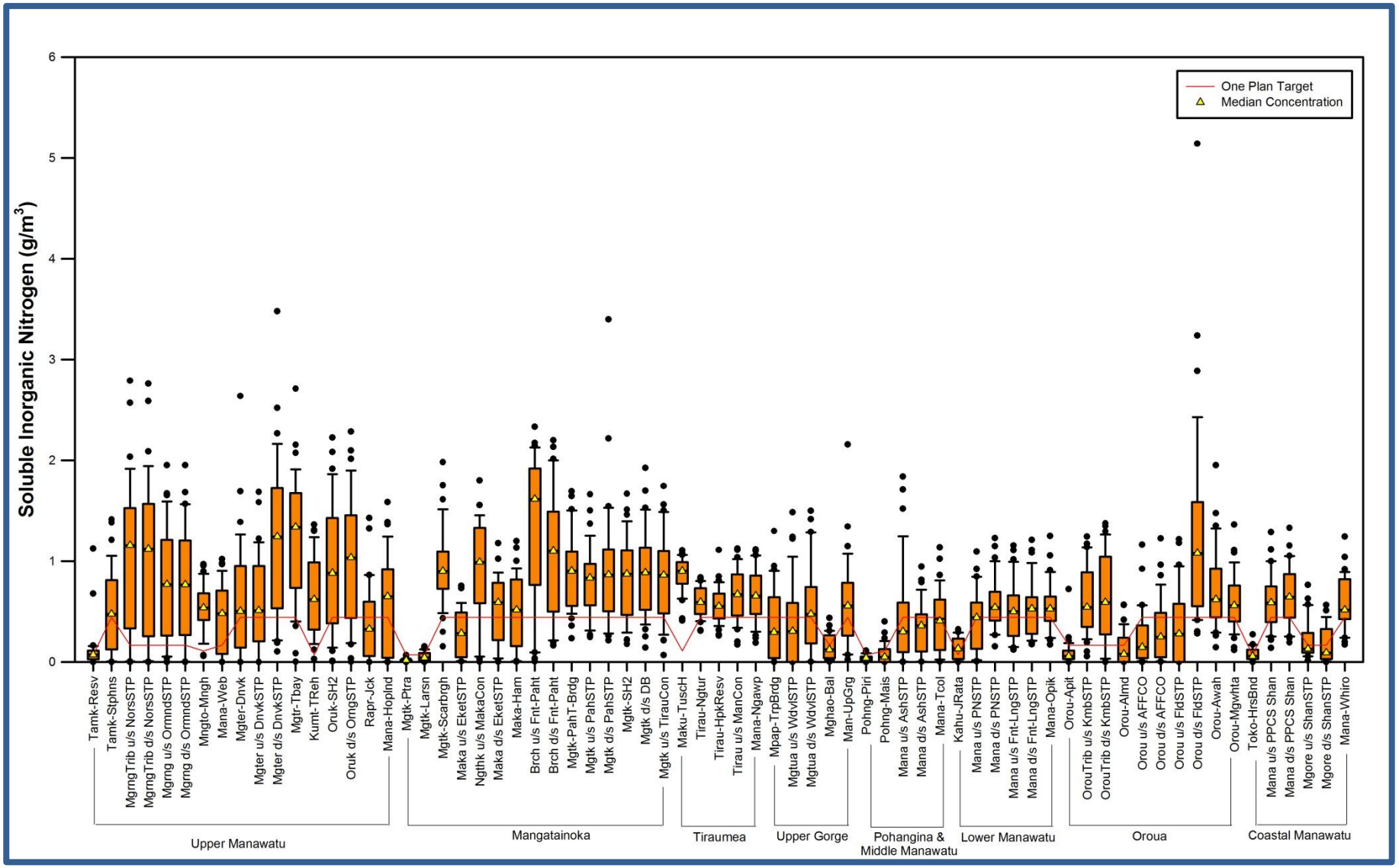


Figure 11: Soluble inorganic nitrogen concentrations at monitored sites in the Manawatū River catchment across all flows over the period July 2011 – July 2014.

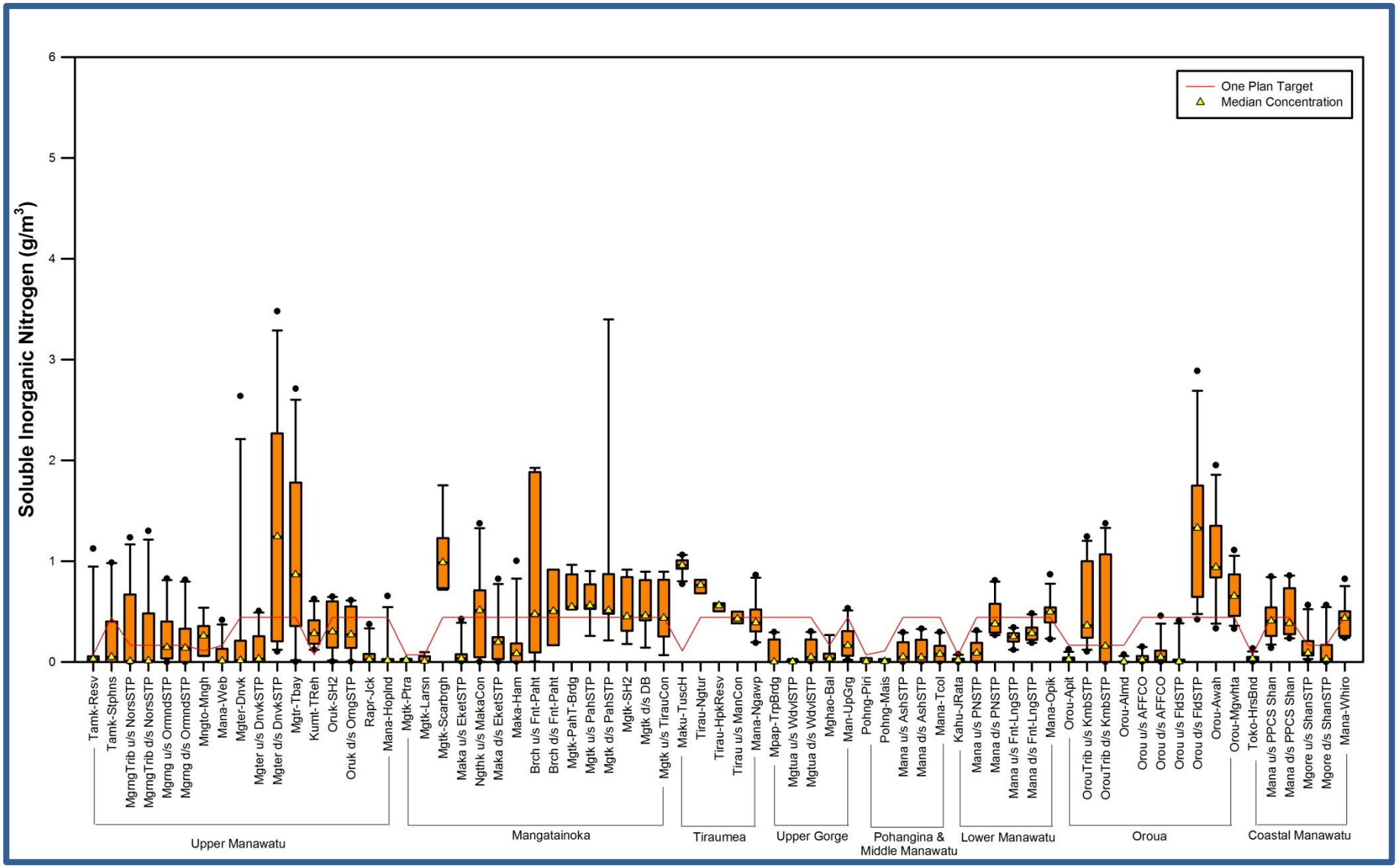


Figure 12: Soluble inorganic nitrogen concentrations at monitored sites in the Manawatū River catchment below half median flow over the period July 2011 – July 2014.

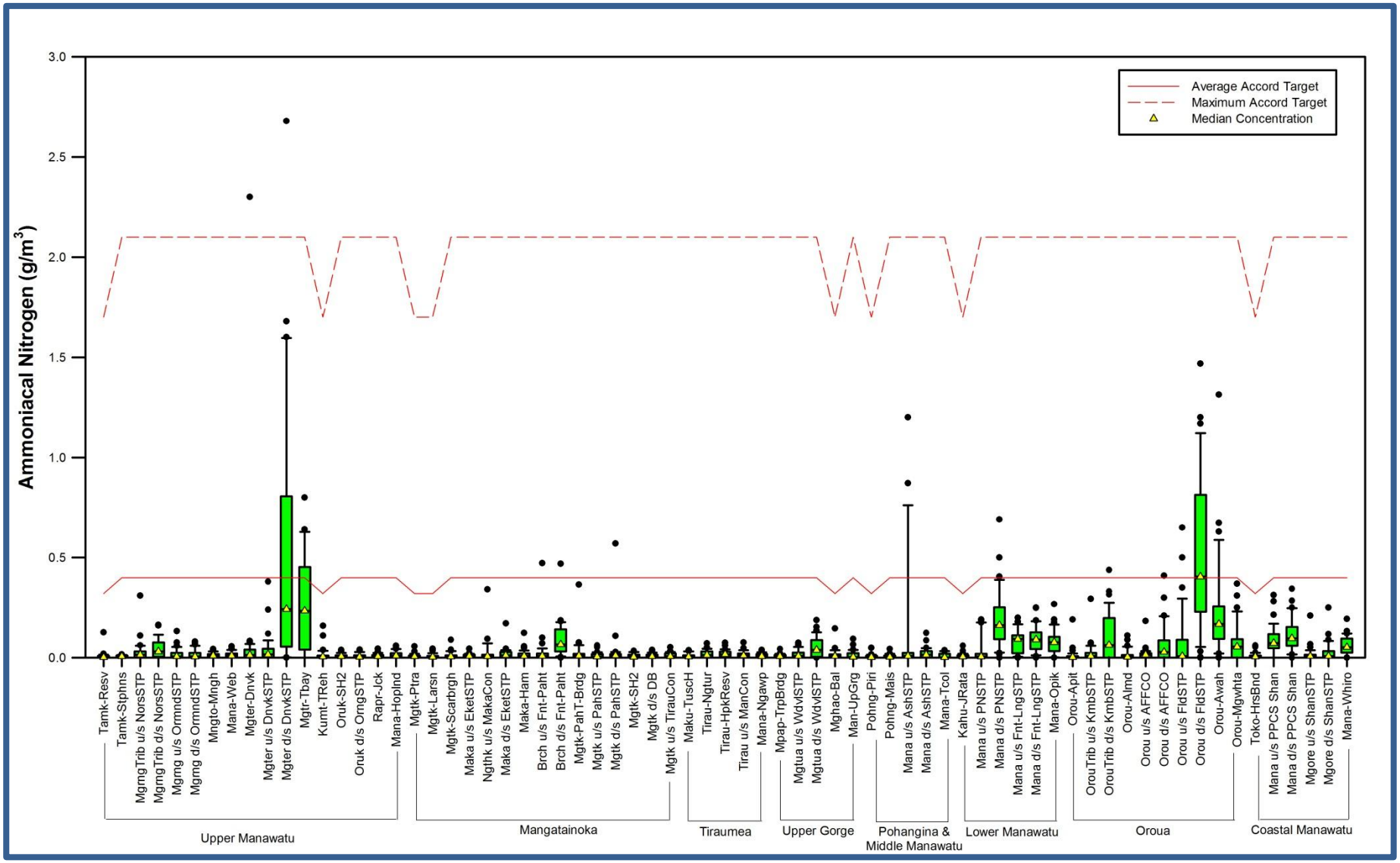


Figure 13: Ammoniacal nitrogen concentrations at monitored sites in the Manawatū River catchment across all flows over the period July 2011 – July 2014.

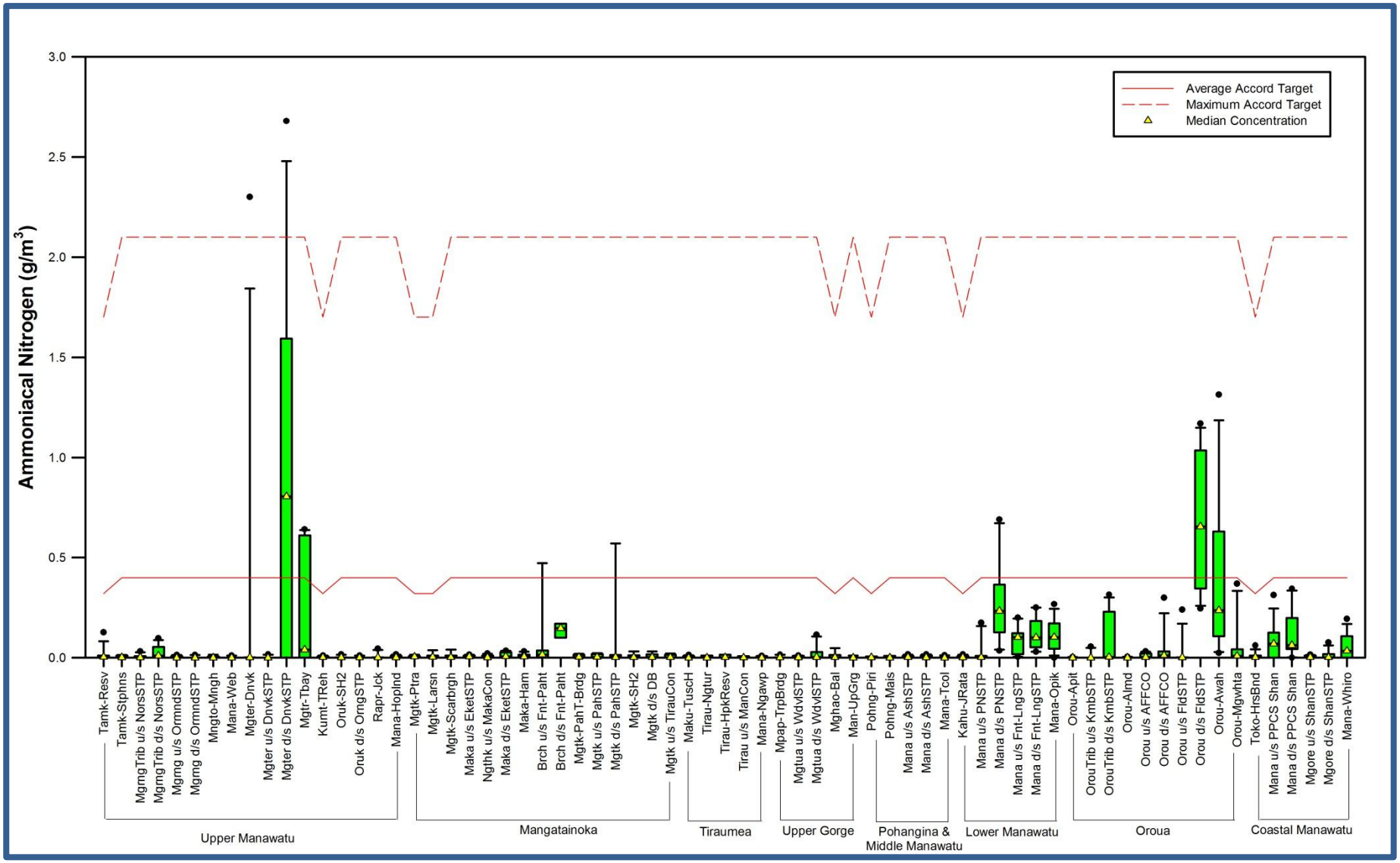


Figure 14: Ammoniacal nitrogen concentrations at monitored sites in the Manawatū River catchment below half median flow over the period July 2011 – July 2014.

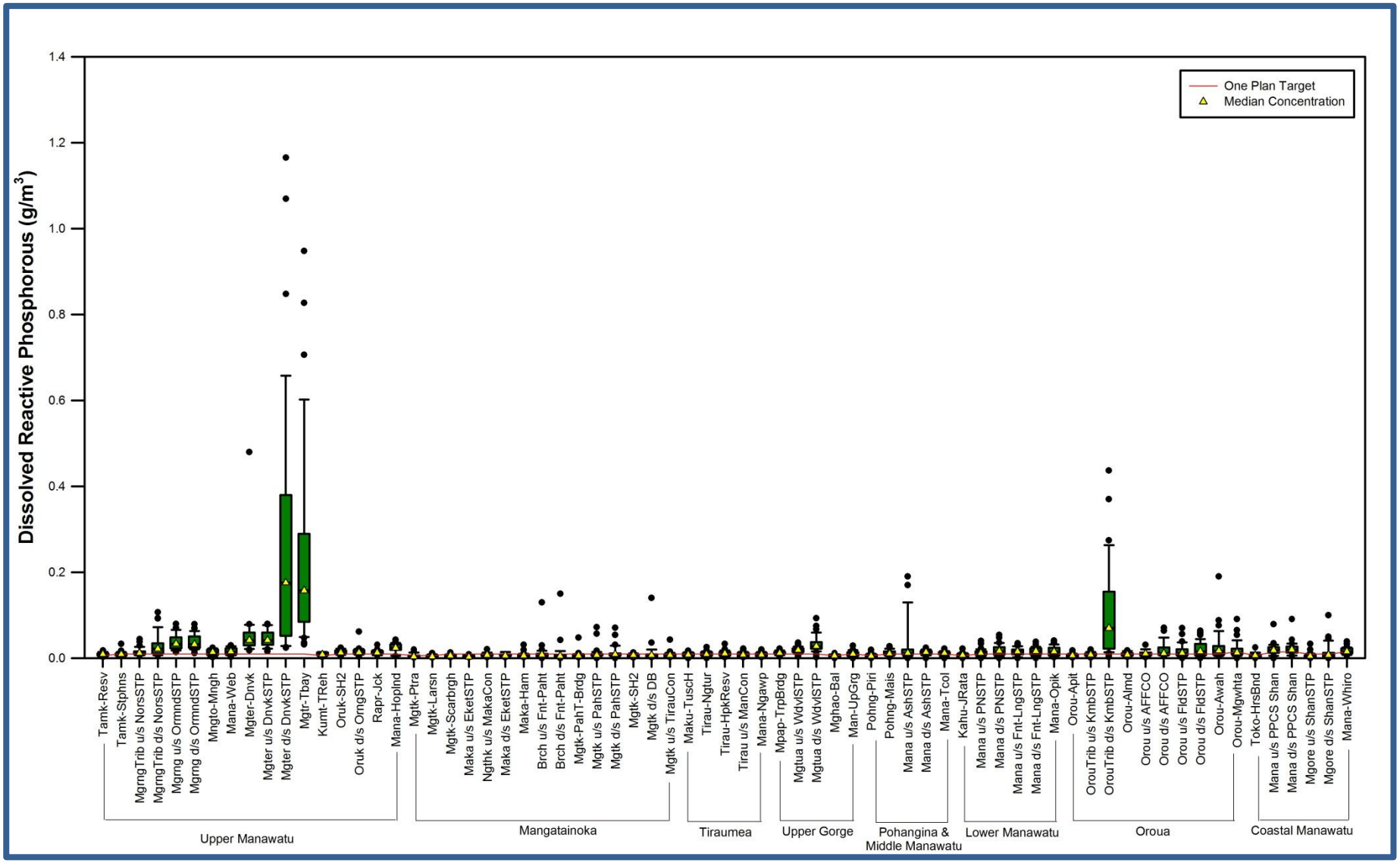


Figure 15: Dissolved reactive phosphorus concentrations at monitored sites in the Manawatū River catchment across all flows over the period July 2011 – July 2014.

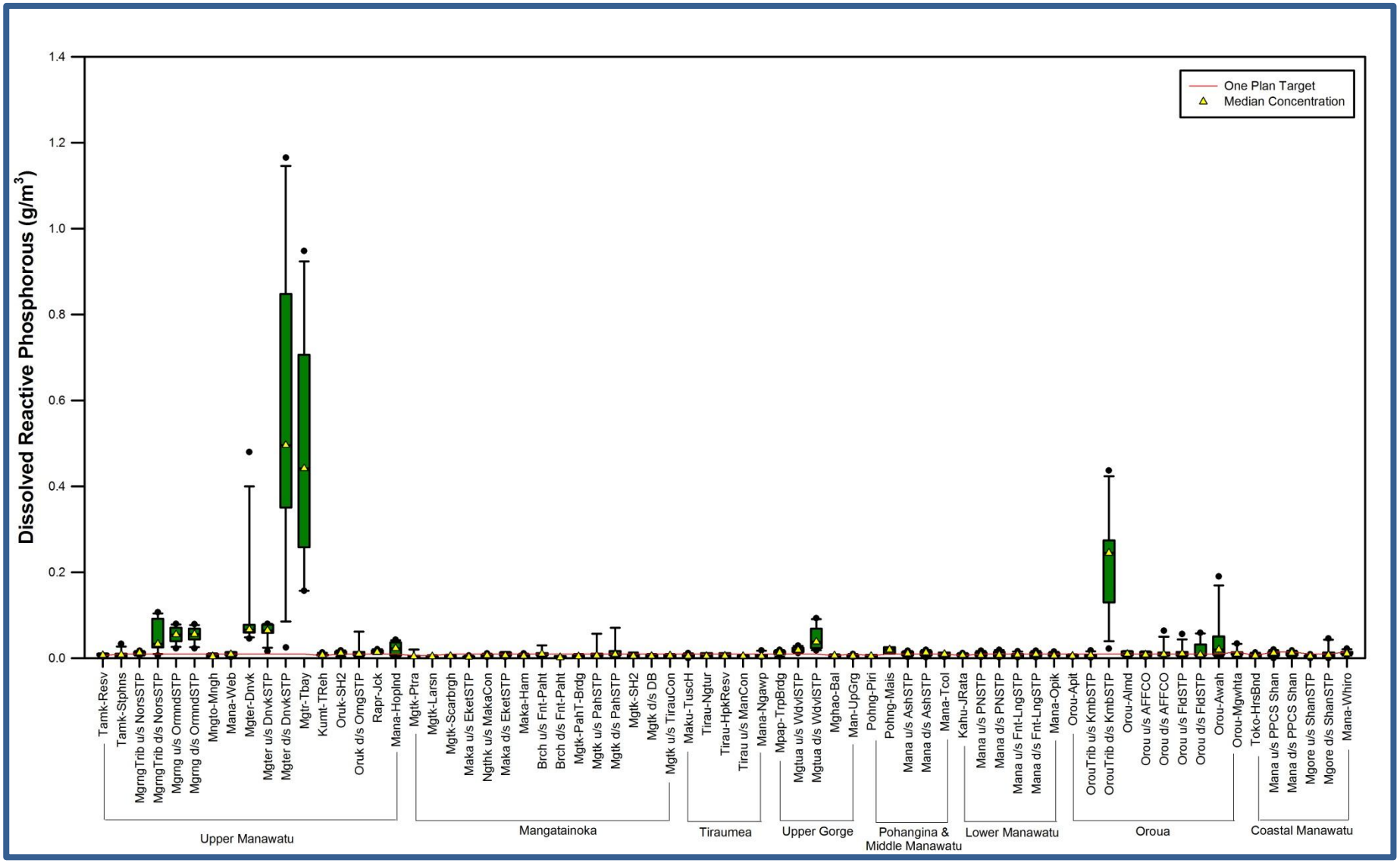


Figure 16: Dissolved reactive phosphorus concentrations at monitored sites in the Manawatū River catchment below half median flow over the period July 2011 – July 2014.

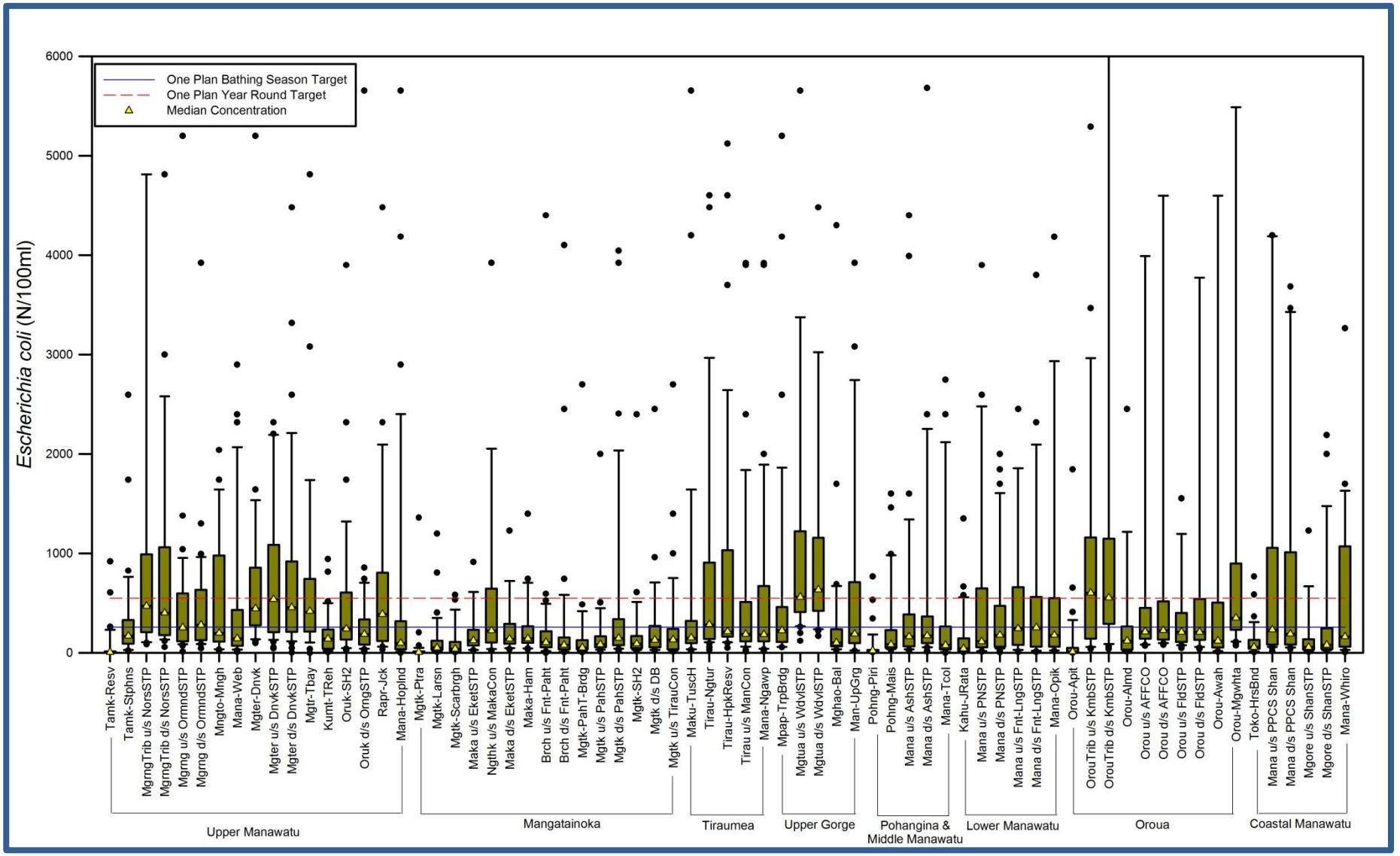


Figure 17: Escherichia coli counts at monitored sites in the Manawatū River catchment across all flows over the period July 2011 – July 2014.

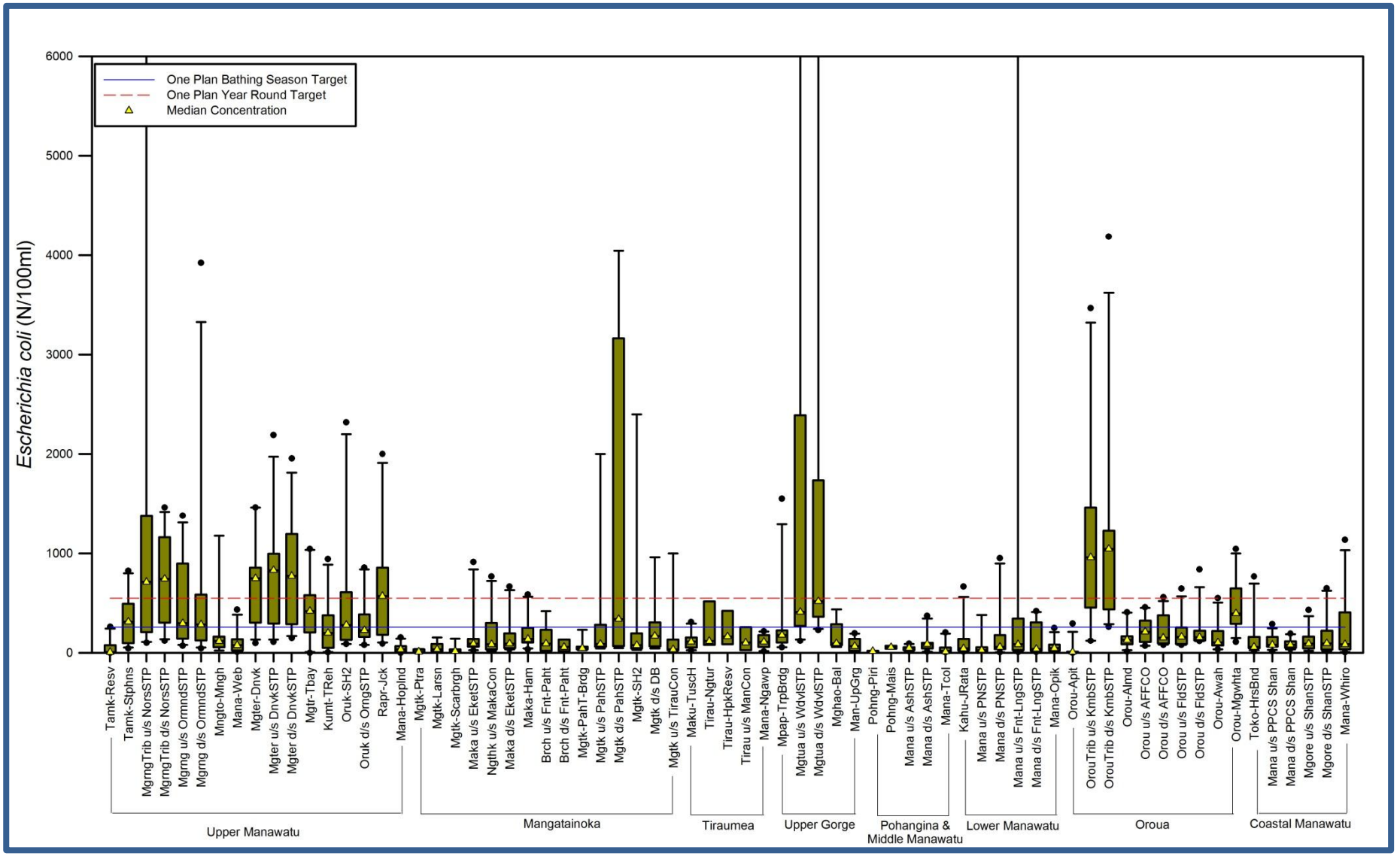


Figure 18: Escherichia coli counts at monitored sites in the Manawatū River catchment below half median flow over the period July 2011 – July 2014.

Appendix Two – SLUI Outcomes

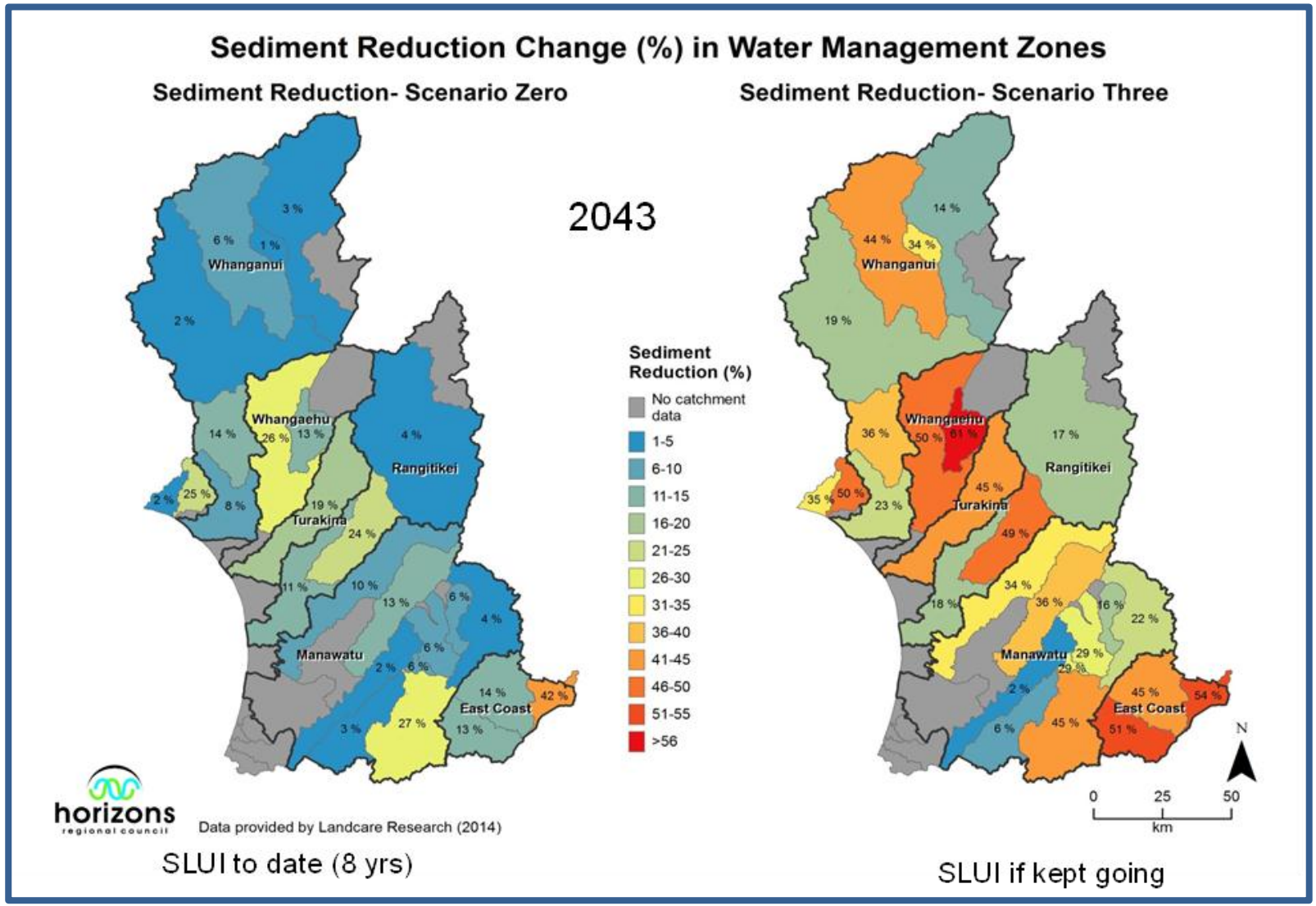


Figure 19: Modelled sediment load reduction from the Sustainable Landuse Initiative (Dymond et al, 2014)

OURS.

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