Updated Freshwater Classification for Nelson, 2013

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For Nelson 2013

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Prepared for

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EXECUTIVE SUMMARY

2013 Long Term Classification - Overall Changes in Water Quality

This report provides the revised Long Term Classification (2013), based on monitoring data gathered from 2000 to 2012 and can be compared with the 2007 Classification to show whether water quality at Nelson monitoring sites has improved or deteriorated. Overall there has been a slight improvement in the Long Term Classification, with eight sites classed as Degraded or Very Degraded in 2013, compared to nine sites in 2007 (Table i). Five of the sites have achieved an overall better long term classification than in the 2007 assessment. Two sites have been re-graded based on new information and one site was not graded in 2007 due to insufficient data. Four sites have been down-graded and sixteen sites remain unchanged (Table ii). The Council's target is to continue to reduce the number of rivers and streams that are Degraded or Very Degraded over the next three years and to maintain those that are Very Good and Excellent.

Table i. Summary table with overall changes in Class, and totals of each class in the Nelson Region.

Long Term Classification	A Excellent	B Very Good	C Moderate	D Degraded	E Very Degraded
2007	8	3	7	6	3
2013	6	7	7[1]	6	2
Change	-2	4	0	0	-1

[1] 2013 classifications include the Brook at Burn Pl, not graded in 2007 due to insufficient data.

The changes at each site are shown in Table ii.

The upgraded sites mostly showed a genuine improvement in one or more indicators. The four down-graded sites are all rural, showing water quality impacts to varying degrees from forest harvesting over the last decade, and livestock farming. The Whangamoa at Kokorua Bridge was down-graded to Very Good, whilst Sharland and Groom Creek at the Maitai confluence were downgraded to Degraded. These sites had lower overall grades due to elevated nitrates and phosphates and showed a decrease in the number of certain freshwater invertebrates that indicate good stream health.

Table ii. Comparison of changes in Class between the 2007 and updated 2013 Class.

Site	NCC No	2007 Class		2013 Class	Change
Saxton at Main Rd	1	E	↑	**D**	Upgrade
Orphanage at Saxton Rd East	2	D		D	
Poorman at Seaview Rd	4	D		D	
Poorman at Barnicoat Walkway	5	C	↑	**B**	Upgrade
Jenkins at Pascoe St	6	E		E	
York at Waimea Rd	9	E		E	
Todds at SH6	21	D		D	
Hillwood at Glen Rd	40	D	↑	**C**	Upgrade
Brook at Manuka St	10	D	↑	**C**	Upgrade
Brook at Burn Pl	11	-		C	
Brook at Motor Camp	12	A		A	
Maitai at Riverside	13	**D**	↑	C	Re-grade
Maitai at Groom Rd	15	C		C	
Maitai South Branch at Intake	16	A		A	
Sharland at Maitai Confluence	17	C	↓	**D**	Downgrade
Groom at Maitai Confluence	18	B	↓	**D**	Downgrade
Wakapuaka at Maori Pa Rd	25	C	↑	**B**	Upgrade
Wakapuaka at Hira	27	A	↓	**B**	Downgrade
Wakapuaka at Duckpond Rd	28	A		A	
Lud at SH6	29	C		C	
Lud at 4.7km	30	C		C	
Teal at 1.9km	32	**C**	↑	B	Re-grade
Pritchards at 890m	33	A		A	
Whangamoa at Kokorua Bridge	34	A	↓	**B**	Downgrade
Whangamoa at Hippolite Rd	36	A		A	
Graham at SH6	37	A		A	
Collins at SH6	38	B		B	
Dencker at Kokorua Rd	39	B		B	

The Wakapuaka at Hira was downgraded to Very Good due to elevated nitrate, phosphate and fine sediment (turbidity), mainly from the Lud tributary. The Maitai at Riverside was upgraded following a change in the paired sediment monitoring site. The sediment site that was previously used was for the most contaminated area downstream of Trafalgar Street Bridge. The newly paired sediment sampling site is located at Riverside and hence reflects conditions experienced by the biota at the water quality monitoring site. The Teal site was incorrectly classified in 2007; the actual overall score has remained the same.

Priorities

The Stoke Streams and York Valley Stream are the southern sub-group of the “Coastal and Urban” streams. These streams remain the most degraded waterbodies in the Nelson classification scheme, and as such have high priority for measures to improve their condition. The Stoke Streams are the subject of the Stoke Stream Rescue Project which runs to the end of 2012/13 financial year. A key aim of this project is to increase and target community advocacy work, raise awareness, and encourage community action.

The urban stormwater catchments in central Nelson are also a high priority, but are not explicitly included in the Freshwater Classification. In the Maitai catchment, stormwater and sewer management in the peri-urban areas adjacent to the lower Maitai and Brook remain a priority and focus of on-going work. Long term monitoring for the Maitai South Branch resource consent have shown a decline in health of invertebrate communities below the Maitai reservoir backfeed. Options to improve water quality within the reservoir and downstream are being investigated by Cawthron and Council staff.

Some of the nutrient related issues in the Maitai, Wakapuaka, and Whangamoa catchments, indicate the importance of prioritising actions higher up through their catchments. The identification and management of livestock, residential contamination, and other land-management related issues, will help improve conditions at the lowermost sites in these catchments. Elevated low flow nitrogen and E. coli (e.g. in the lower Lud) can be evidence of point source contamination, such as septic overflows, and drainage from over-intensive grazing (i.e. an overcrowded wet paddock).

Nutrient loads from point sources and non-point sources reach surface waters through different pathways, and therefore the management approach to each will need to be considered separately. Reducing nutrients and other contaminants from point-sources (e.g. livestock eroding banks and accessing waterways, reducing storm water contaminants through fixing damaged sewer and stormwater infrastructure, cleaning roads, regular checks and cleaning of sumps, developing waste management plans and enforcement of pollution controls) will provide greater improvements in water quality in the short term.

Forestry is the dominant productive land use activity in the upper Maitai catchment, timber harvesting results in nutrient pulses (exceedences), mainly in the form of dissolved nitrogen via surface run off lasting for several years. The cycles of nitrogen release in Sharland and Groom Creeks appear in the invertebrate diversity scores (SQMCI results) for each site. The average dissolved nitrate levels in harvested forestry areas (Groom Creek and Sharland) are double the Australia and New Zealand Environment and Conservation Council

(ANZECC) average values for lowland and upland rivers. These elevated nitrate levels are, however, comparable to national river network sites. Although exceeding the ANZECC trigger level does not imply that ecosystem damage is occurring, it provides a warning that a problem may be emerging (e.g. relative nitrate and phosphate nutrient loads can be one of a number of limiting factors for aquatic plant or cyanobacteria growth).

Considerably higher nitrate (and E. coli) loads can be found in waterways with intensive farming and inundation from nutrient enriched groundwater. Live stock are permitted access to waterways in some areas, and can erode river banks and stream beds, and can be a major point source of E. coli contamination (assessed by targeted investigations using microbial source tracking).

The contamination of waterways via diffuse surface run-off or sub-surface leaching from various land activities may show effects spanning several years and take decades to remediate. Management of cumulative inputs from diffuse non-point sources, thus, requires an integrated approach.

The Lud River and Paremata Flats in the Wakapuaka catchment have the highest priority for action. Freshwater conditions in the Wakapuaka are similar to the Maitai and dominated by the patterns of nutrient enrichment, namely nitrate-N, but faecal contamination and turbidity are also issues. The situation at the lowermost monitoring site is a reflection of the combined influence of pressures in the upper parts of the catchment.

The Lud upper site has shown a decline in E. coli levels. This improvement may be due to more sustainable land use (e.g. two land owners have moved cows to paddocks away from the stream) after collaboration with the NCC Sustainable Land Adviser. It is likely to be several years before the full benefits for water quality due to riparian planting in the Lud are seen. In the Wakapuaka River above Paremata Flats Reserve livestock access to the stream continues to be the main source of faecal contamination, where recreational bathing guideline levels are generally exceeded.

Forest harvest in the sub-catchments of the upper Wakapuaka and Whangamoa has yet to occur; here the nitrate-N concentrations are generally lower than those in the middle and lower sites of both the Maitai and Wakapuaka systems. In this context, forestry blocks harvested on a 30 year rotation are of a lower priority than land use (urban, farming) impacts that have cumulative impacts on waterways over time.

1. RECOMMENDATIONS

The report provides site by site specific recommendations including measures to help improve conditions at each site. However, some general recommendations are made below, as well as specific recommendations for the highly degraded urban streams.

Freshwater quality in urban and rural streams is a consequence of what is happening in the catchment, and unless land-use management in the middle and upper catchments is improved, localised downstream initiatives alone will not be so beneficial. This means managing land-disturbing activities in a manner which minimises their impact on freshwater quality. A key general recommendation is:

- The preparation of catchment management plans for all Nelson catchments. These are intended to be integrated land use strategies, starting with the Maitai Catchment Management Plan by 2015, and plans for all other catchments by 2022. Stoke Stream Rescue Project Catchment Plans have been completed for Saxton, Poorman, Jenkins and Orphanage Streams over 2011-2013. These have identified specific issues, such as potential areas for riparian planting, and improving fish passage and instream habitat. Council staff and contractors are working through the identified issues.

Recommendations relating to the Freshwater Classification System

- That the Total PAH classification approach of Simpson et al. (2008), highlighted by Sneddon and Elvines (2012), is adopted instead of the assessment based on all PAH values;
- That the pairing of sediment sampling sites and water quality sites is revised as recommended in Section 1.3.4, with this approach the sediment sites will better represent conditions at the stream health monitoring locations. This will require some “tuning” of the automated classification system to ensure continuity and comparability with previous results;
- That any changes to the automated classification system are carefully documented, and all efforts made to ensure that future assessments maintain consistency with earlier results, such that any changes in scores for individual parameters and overall classes are a result of real changes in the data and not an artefact of some change in the classification programme.

Recommendations for water quality monitoring in the urban catchments

- Target actions based-on stormwater contamination issues. The lower Maitai River is the gateway to Nelson and has high biodiversity, recreational and cultural values. High E. coli loads enter the lower Maitai River in the vicinity of Collingwood Street Bridge, and industrial contaminants enter the river via Saltwater Creek. These issues demand on-going improvements to infrastructure. More resources to work pro-actively with business and industry (e.g. developing pollution prevention plans, regular checks and maintenance of sumps and pipe work), and effective regulatory enforcement of polluters, are also required to reduce contaminants entering stormwater.

- Support for the work of any future Iwi Water Management Advisory board as set up through Treaty of Waitangi settlements for the Top of the South Island iwi.
- Target further investigations of York Valley Stream. Additional winter sampling above and downstream of both landfills, and the quarry site will be required to identify the source of the observed elevated E. coli, nitrate, and high conductivity. This will help to identify what action if any might be possible or beneficial.
- Build upon cross-council experience gained from flood restoration, Stoke Stream Rescue, and national guidance to develop best practice for restoring instream habitat and riparian margins with respect to land use and flood capacity.

Recommendations relating to nitrate and E. coli contamination from livestock farming

- Advocate sustainable land management through building relationships with land owners and providing advice and support to fencing and planting of riparian margins. Careful consideration should be given to the balance between habitat restoration and maintaining flood capacity, placement of fencing to minimise risk of flood damage to fencing, controlling soil erosion and provision of alternative drinking water supply to livestock (including storage of water for dry periods).
- The City Council should be proactive on storm water and soil erosion issues through the purchase of land with riparian margins, and planting areas prone to erosion and surface run off (e.g. hillsides), to create buffer zones and enhance biodiversity niches.
- Assess whether freshwater rules and enforcement are adequate in meeting water quality targets for regional and national freshwater reforms and seek advice on options available. Work closely with TDC to align freshwater rules and learn from other regional councils.
- Continue to target Sustainable Land Management advice to the Wakapuaka catchment and wider Nelson area.

- Work with land owners and interested groups to manage the Paremata Flats Reserve, this promotes restoration of the coastal flats ecosystem. Consider options for land purchase and future management.

Recommendations relating to the influence of Forestry activities

Given the dominance of plantation forestry land-cover in the Nelson area, the impact of this economic activity should be assessed more fully. The following recommendations are made:

- Work collaboratively with logging companies to share information and manage land in a sustainable manner. Buffer strips would help to limit some of the negative impacts of logging activities (see Wilkinson, 2007c). Phased felling of smaller coups could help to reduce nutrient impacts, and their size must be balanced against the economic impacts related to harvesting smaller areas. The carbon credit system may be helpful to encourage phased felling of smaller areas.
- A mapping investigation of felled areas in relation to total catchment areas would help to quantify the extent of forestry impacts on freshwater nitrogen levels, in terms of nitrogen output per hectare per year.
- To examine the relationships between nutrient concentrations and stream biotic indices, a combined desk data and literature review of nutrient N:P ratios and other factors relating to changes in MCI and SQMCI scores could be undertaken. Reviewing studies on the influence of elevated N for general stream health. This will help in determining how serious nutrient and logging impacts are, and whether improved management of forestry activities is required. If short-term impacts of forest felling are minimal, are higher trigger values for nitrogen acceptable? Improved land management to protect stream ecological values should be encouraged.
- Information about new, recent, or on-going forestry activity should be recorded in field journals or record sheets during sampling rounds.

TABLE OF CONTENTS

1. INTRODUCTION

This report provides a revision of rivers classifications for Nelson City Council (NCC) region reported by Wilkinson (2007a). The new classification is based on 11-12 years of water quality stream biota data, and 4 surveys of sediment quality (Sneddon and Elvines, 2012).

The report provides the updated summary tables and classification scores for each site in each major catchment group. The conditions in each catchment are discussed separately in greater detail giving evidence for changes and trends and their causes, as well as offering actions to investigate or improve certain problems highlighted. The overall findings for each catchment are summarised in a look-up table with a brief narrative on problems and actions, key water quality indicators are highlighted.

The report describes the methods used in the analysis and highlights any differences in approach or changes in trigger values made since the 2007 review.

1.1. Background

The last review of water quality classification was reported in the Updated Freshwater Classification for Nelson 2007, Cawthron Report No. 1349 (September 2007). This review introduced a more uniform water quality assessment process to ensure consistency of classification over the long term, incorporating all monitoring results from 2001 to 2006.

Subsequent surface water quality reports include the 2008 annual surface water quality, reported in the State of Environment Report 2010, and 2010 and 2011 annual monitoring summaries for River and Stream Health. A comprehensive review (Wilkinson, 2012) of freshwater related reports has identified gaps in knowledge, monitoring and reporting.

Plan Change 24 Freshwater (operative 12 March 2012) updated the Nelson Resource Management Plan water classifications for Nelson water bodies incorporating the 2007 Long Term Water Classification. Waterbodies with a classification lower than C are considered priority sites to target action for improvement.

Changes in water quality classification resulting from this review (2013) may need to be considered in a future Plan Change. The Ministry for Environment are expected to provide guidance (after April 2013) on the selection of monitoring sites, survey protocols and analysis to improve consistency in national State of the Environment (SoE) reporting.

The Nelson surface water quality review 2013 will be a stock take of our region's state of water quality and used principally for rationalising SoE monitoring programmes, strategic planning and Framing our Future, Nelson Development Strategy and Long Term Plan work programmes (Appendix 4).

1.1.1. Scope of Work

The review will include compiling data to determine the 2013 Long Term Water Classification, analysis and reporting that highlights key significant water quality trends and issues.

1.2. Site-by-site classifications with accompanying notes

The updated classifications for each river and stream monitoring site in the Nelson City Council Authority area are presented below. The classified monitoring sites are grouped by catchment or according to their general character, e.g., the small coastal and urban streams (Figure 1). The summary table for each site shows the updated statistics for each monitored parameter and the sub-class for each. The overall site classification is determined by an automatic procedure (Wilkinson, 2007a).

The overall classification includes an indication of whether the site has been up-, or, down-graded since the previous classification (2007). A brief narrative is provided for each site highlighting any changes in the parameters that are noteworthy or have influenced a change in class.

The individual parameter classes for 2007 are provided to show where improvements are apparent. It should be noted that some changes remain within a class, i.e., they do not cause the class to change, but may be noteworthy, and other smaller changes may tip the score into a higher or lower class, but may be insignificant. For this reason, it is advised to refer to the narrative for clarification and confirmation.

1.2.1. Freshwater Classifications: their uses and values in the Nelson region

For a full description of how the freshwater classification for Nelson was devised, and the parameters and trigger values used please refer to Robertson and Crowe (2002) and Wilkinson (2007a). A description of the five freshwater classes is provided below.

Class A: EXCELLENT - Natural State Ecosystems (High conservation/ecological value).

Effectively unmodified or other high value ecosystems, typically (but not always) occurring in conservation reserves or in remote, inaccessible, or restricted access locations. The ecological integrity of high conservation/ecological value systems is regarded as intact.

Uses and Values: Water uses which require, or water which is managed for, the highest possible natural water quality (pristine). Provides for flow and fauna, cultural and Tangata Whenua values.

Class B: VERY GOOD - Slightly disturbed ecosystems (generally healthy).

Ecosystems in which aquatic biological diversity may have been adversely affected by a relatively small but measurable degree of human activity. The biological communities remain in a healthy condition and ecosystem integrity is largely retained. Typically freshwater systems would have slightly to moderately cleared catchments and/or reasonably intact riparian vegetation. These systems could include rural streams where there is no significant contamination from grazing (restricted stock access) or forestry, or urban streams with intact or extensive riparian planting and/or esplanade reserves.

Uses and Values: This class includes water managed for values and uses requiring high quality water. Uses and values include aquatic ecosystems and fisheries, water bodies having significant cultural and spiritual values, aquaculture, shellfish and mahinga kai for human consumption, flow and fauna, Tangata Whenua values, human drinking water or contact recreation.

Class C: MODERATE - Moderately disturbed ecosystems (healthy but ailing).

Aquatic biological diversity has been moderately affected by human activity. The biological communities are under some stress from disturbance of their natural habitat. Typical Class C ecosystems would have cleared catchments with only sporadic riparian vegetation. These systems could include rural streams which receive some contamination from grazing (limited stock access) or forestry, or urban streams with limited building setbacks and only limited riparian vegetation.

Use and Values: Includes water managed for uses which require moderately high quality water, such as irrigation and stock water and general water use. Would also provide for limited contact, and noncontact recreation and aesthetic values where the visual characteristics of the water (clarity, colour and hue) are not compromised. May retain some spiritual and Tangata Whenua values.

Class D: DEGRADED – Highly disturbed ecosystems (unhealthy).

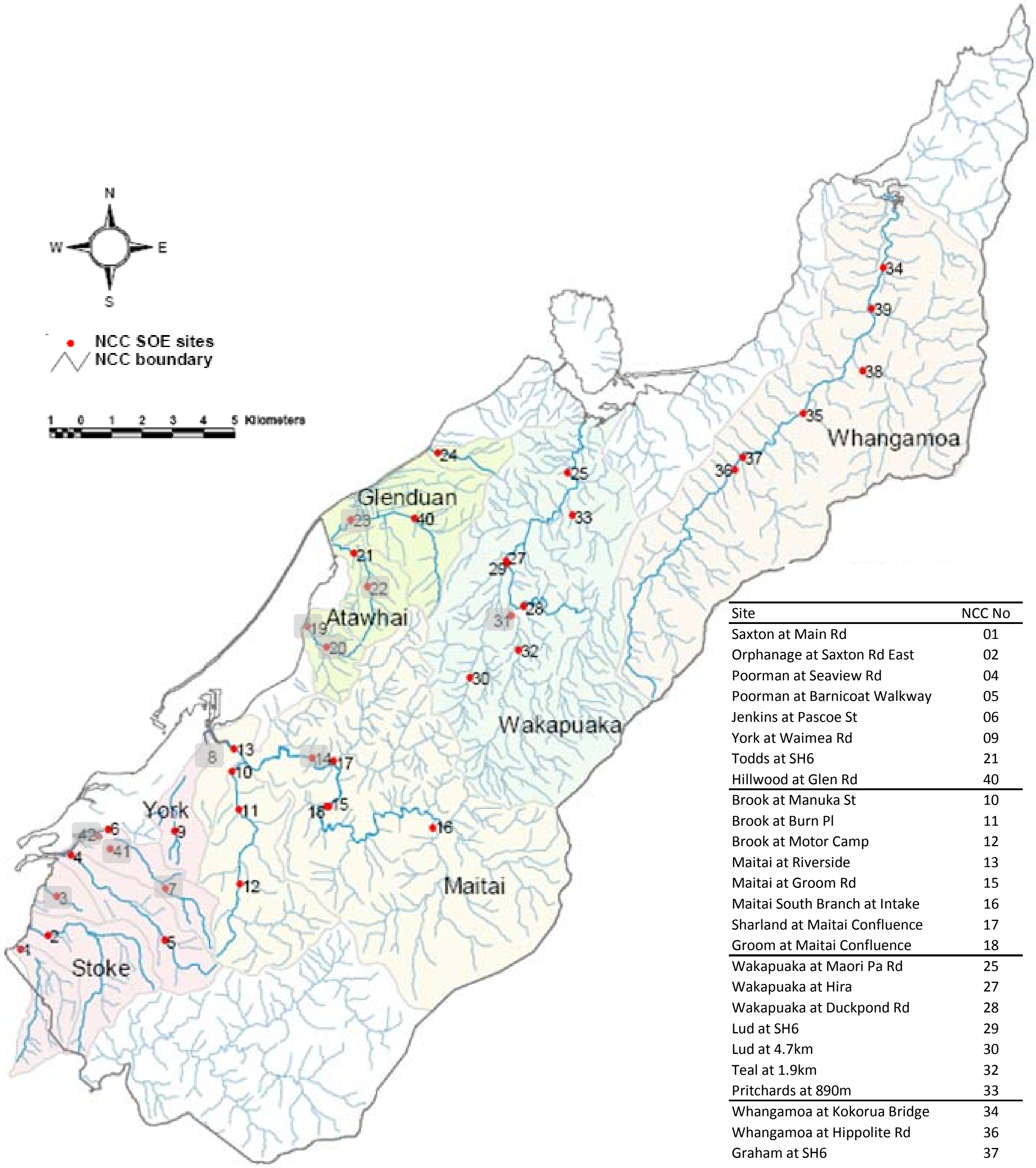
Highly degraded ecosystems of lower ecological value. Examples of highly disturbed systems would be urban streams receiving high volumes of road and stormwater contamination with no or little riparian protection, or rural streams which are contaminated by unrestricted stock access.

Uses and Values: Water quality which is suitable only for abstraction where quality is not an issue and contains few instream values, Tangata Whenua values or ecological values.

Class E: VERY DEGRADED - Severely degraded ecosystems.

Severely degraded ecosystems with few or no ecological values. Urban examples would include streams with historical industrial discharges and cumulative sediment contamination, or which have been highly modified or channelised to the extent that natural habitat is no longer retained. Rural streams might be subject to high intensity and frequent contamination from agriculture or land use activities, such as discharge of untreated effluent and uncontained large-scale sedimentation.

Uses and Values: Instream values are severely depleted and water is generally unsuitable for any use. Few values (e.g. Tangata Whenua values).



Site	NCC No
Saxton at Main Rd	01
Orphanage at Saxton Rd East	02
Poorman at Seaview Rd	04
Poorman at Barnicoat Walkway	05
Jenkins at Pascoe St	06
York at Waimea Rd	09
Todds at SH6	21
Hillwood at Glen Rd	40
Brook at Manuka St	10
Brook at Burn Pl	11
Brook at Motor Camp	12
Maitai at Riverside	13
Maitai at Groom Rd	15
Maitai South Branch at Intake	16
Sharland at Maitai Confluence	17
Groom at Maitai Confluence	18
Wakapuaka at Maori Pa Rd	25
Wakapuaka at Hira	27
Wakapuaka at Duckpond Rd	28
Lud at SH6	29
Lud at 4.7km	30
Teal at 1.9km	32
Pritchards at 890m	33
Whangamoa at Kokorua Bridge	34
Whangamoa at Hippolite Rd	36
Graham at SH6	37
Collins at SH6	38
Dencker at Kokorua Rd	39

Figure 1. Map of the Nelson area showing freshwater monitoring sites (other NCC sites not in the freshwater classification have been shaded-out).

1.3. Preparation and treatment of data

1.3.1. Statistical Reporting Periods

The 2007 updated classification (Wilkinson, 2007a) does not clearly specify the data duration used in the assessment. This was from January 2001 up to and including samples from December 2006 for water quality variables. For stream biological indicators the data period was from November 2001 to December 2006. There were some minor variations due to results not yet being available from the laboratory. For 2013, the assessment data duration has the same start dates as for 2007 and includes to November 2012.

1.3.2. Detection Limit Values

For the 2013 statistical assessment any values flagged as being less than the analytical detection limit (<ADL) were set to 0.5 ADL (as reported in the raw data). This approach helps to account for the uncertainty about whether values lie close to zero or near to the ADL.

1.3.3. Comparability with the 2007 assessment

Since 2007, the automated classification system underwent various modifications, which resulted in subtle changes in the scoring and statistical tests made to generate the final scores. To ensure continuity and consistency with the 2007 review, it has been necessary to painstakingly check the whole system and correct all changes that differ from the approach used in 2007.

The approach used in 2007 is set-out clearly in Sections 1 and 2 of the 2007 report (Wilkinson, 2007a). There are, however, a number of important details that are not clearly specified by Wilkinson (2007a). These include the following:

- the use of mean or median values;
  At low sample numbers certain parameters are better characterised by the mean than the median. Mean values were used for all parameters except water temperature and E. coli. Temperature is tested against the 95th percentile value. The E. coli scores rely on the median and 95th percentile values (Table 4, Wilkinson, 2007a). Nitrate-N and NH4-N are summed to give a measure of dissolved inorganic nitrogen, assuming nitrite-N is negligible under aerobic conditions. ***In Section 2 of this report, the values used to test each score are highlighted for clarity.***
- adjustments to the weighting values of individual parameters for the overall classes;
  All weightings except for periphyton are as specified by Wilkinson

(2007a). The periphyton weighting has been adjusted from 1 to 0.75 (see below).

- the scoring for periphyton is now based-on the “periphyton score” and not the percentage cover of long filaments (Section 1.3, Wilkinson, 2007a);
  The class thresholds for periphyton score have been adjusted to provide some consistency with the percentage long filaments measure, as follows: >7.5 – A, >6.5 – B, >5 – C, >3 – D, and <=3 – E. The reduced weighting for periphyton score is made to acknowledge the differences between the new and old scoring system. In the tables in Section 2 below, the class for the 2007 review period have been added for comparison with the current review period.
- change in paired sediment monitoring site for Maitai lower.
  For PAHs for NCC13-Maitai Lower@Riverside, the most recent three sediment samplings from Riverside LM3-Shakespeare (see Sneddon and Elvines 2012) were used in the current assessment. These data were unavailable prior to 2006, and the much more heavily contaminated L1-Trafalgar Bridge sediment data were used for the 2007 update (see site related notes below).

1.3.4. Comparability and appropriateness of Water Quality and Sediment Sampling sites

In the 2007 freshwater classification update water quality and biological survey sites were linked with the sediment samples according to the site linkages used in the initial classification (Figure 2a). Examination of the site locations and pairings has highlighted some large differences in location which raises questions about whether the pairings are appropriate.

The judgement of whether sites are paired appropriately depends on the objectives of the pairing. These potential objectives may include one or more of the following cases:

1. sites are chosen to represent an area of the river system and may therefore be distant (given considerations of consistent land use within that area)
   - if this applies, it may be acceptable to have sampling site pairings that are distant (but not too distant);

2. water quality and biological survey sites represent conditions at a specific location and represent the sum of influences at that location and flowing down from upstream influences
   - in this case, the sediment sampling site should at least be upstream of

the WQ monitoring site ensuring no major influences in the reach leading downstream to the WQ site;

3. sediment sites are paired as additional causative information to explain the condition of the biological indicators at a given site – *as for case 2.*

If we assume that objectives 2 and 3 apply to the Nelson freshwater monitoring network, then there are more than 5 sites where the paired sediment sampling location might be considered too far downstream of the WQ/biology survey site. It can also be argued that for some of these sites the expected differences in location are not too great based on the surroundings and pollution sources relating to those sites.

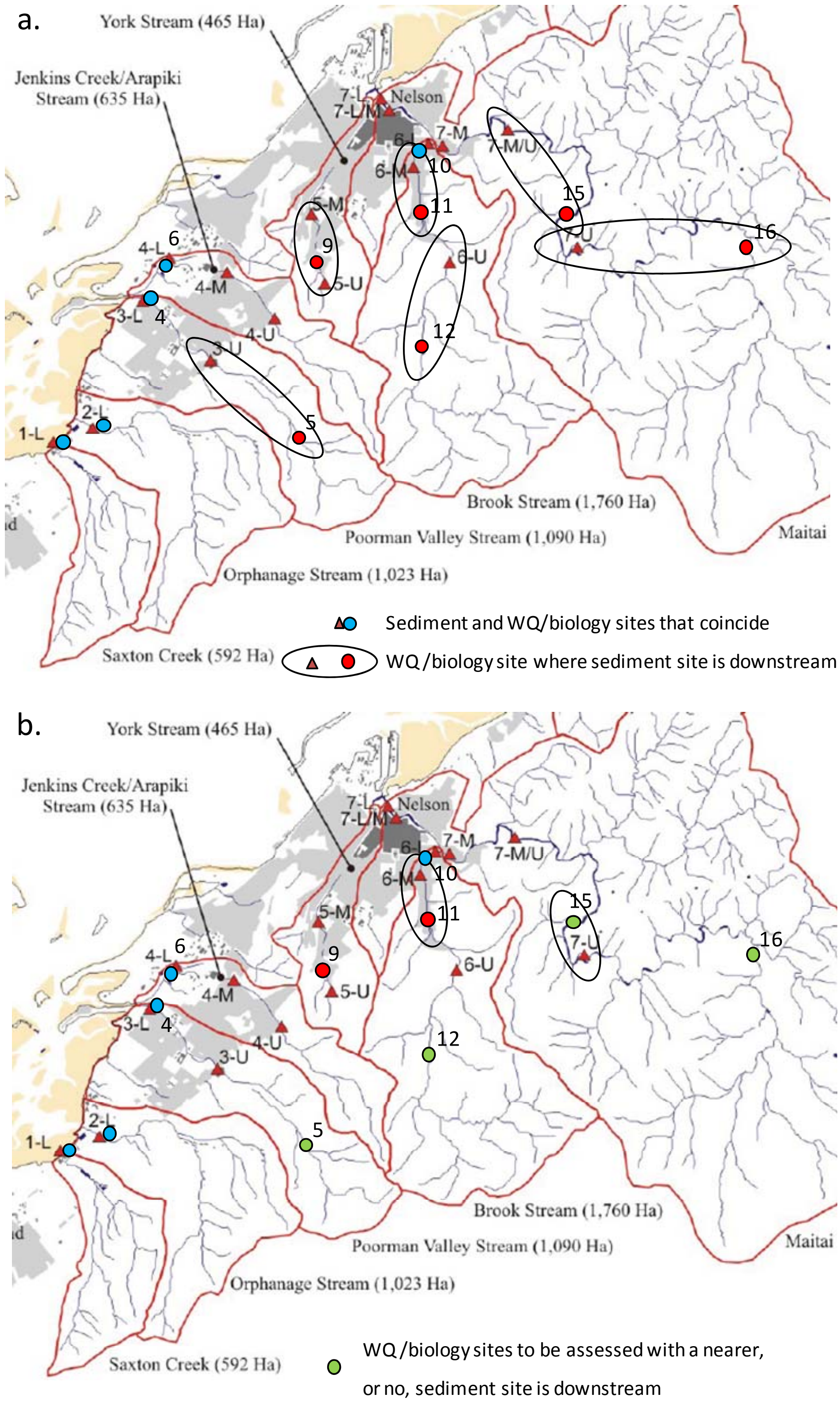


Figure 2. The locations of water quality and biology survey sites, and sediment sampling sites; a. showing sites that are co-located or distant from each other, b. possible reassignment of site pairings (base map after Sneddon and Elvines, 2012).

At 4 particular locations, NCC05 – Poorman at Barnicoat Walkway, NCC12 – Brook at Motor Camp, NCC15 – Maitai at Groom Rd, and NCC16 – Maitai at South Branch Intake, the sediment sampling sites are more than several kilometres downstream of the WQ/biology sites. Three of these sites NCC05, NCC12, and NCC16 have:

- no upstream sediment sampling sites;
- are in the upper uncontaminated parts of the catchments;
- have high biological scores and show minimal evidence of disturbance, and;
- are the reference sites for their catchment.

On the basis of these characteristics it is recommended that the paired sediment site be dropped from the classification at those sites (Figure 2b).

For NCC15, Maitai at Groom Rd, sediment sampling site Maitai 7-U is located around 5 km closer than 7-MU, and is upstream of WQ site 15. This site would be more appropriate to use for the freshwater classification here (Figure 2b). The changes to 5, 12, 15 and 16, do not change the overall scores at these sites.

In the case of NCC09 – York at Waimea Road, and NCC11 – Brook at Burn Place, both sites have biological scores that show evidence of disturbance. NCC09 – York at Waimea Road lies downstream of the York landfill, and the NCC11 – Brook at Burn Place lies within the peri-urban area. The upstream sediment sampling sites York 5-U and Brook 6-U show no or minimal evidence of contamination (Sneddon and Elvines, 2012), in this case it seems appropriate to maintain the use of the lower sediment sampling sites for the York at Waimea Road and Brook at Burn Place.

The other monitoring location where the pairing of sediment and WQ/biology sites deserves review is NCC13 – Maitai at Riverside. At the previous reporting period, the sediment data used for the freshwater classification at Riverside were values from sediment samples collected at the 7-L(1) Trafalgar Street (Figure 2) site. This site is located within the estuarine section of the river, and is 800 m downstream of the Riverside monitoring site. Consequently sediment data, which are highly contaminated by urban runoff cannot be considered as representative of conditions at Riverside, nor do they contribute to the ecological health there. Three other sediment sampling sites 7-LM1 to LM3 are located at or closer to Riverside (see Sneddon and Elvines, 2012). LM1-Ajax and LM2-Grove are located at Collingwood Bridge downstream on the true left bank, and upstream on the true right bank, respectively, and both monitor the outlets of storm drainage catchments. LM3-Shakespeare is located at Riverside and thus reflects the conditions contributing to the observed ecological condition at that site. The sediment quality characteristics LM3 have been applied in the 2013 updated classification. The total PAHs at Riverside are 30 times less than at Trafalgar Bridge, although the metals concentrations are only a third lower (Sneddon and Elvines, 2012).

Two further sediment sampling sites that deserve consideration are those in Saxton and Jenkins Creeks. Both sites show evidence of marine fauna such as burrowing crabs (Sneddon and Elvines, 2012), and as such the validity these locations to represent freshwater conditions relevant to the freshwater programme must be questioned. A series of duplicate samples from above the upper tidal limit might be of value to confirm whether these sites are suitable for inclusion in the freshwater classification programme.

Note that, other than for Maitai lower NCC13 at Riverside, **no** changes in site pairings have been applied in the current report.

1.3.5. PAH trigger values and weightings

In their review of the ANZECC (2000) sediment quality criteria Simpson et al. (2008) proposed the use of total PAHs to represent the overall PAH contamination situation. They proposed the use of 10 mg/kg and 50 mg/kg as the trigger values for SQG-Low and SQG-High, respectively. They also recommended dropping individual PAH trigger values, suggesting that no one PAH is likely to dominate the PAH distribution. This is not actually the case in Nelson, where the PAH compositional structure is relatively consistent from site to site (Figure A1). Fluoroanthrene and Pyrene are always the dominant PAHs in Nelson sediment samples. Benzo(a)pyrene is the single PAH which best represents the total PAH concentration (Figure A2). Only 13 Nelson PAHs are commonly greater than the ADL; Acenapthylene and Naphthalene are usually less than ADL (Appendix 1).

For the purposes of comparability, this modification has **not** been adopted in the revised freshwater classification for 2013.

1.3.6. Recreational MAC for Faecal Contamination of Bathing Waters

The 2007 updated classification added the recreation MAC for bathing water microbiological quality (Wilkinson, 2007a). In 2007, the MAC score was included in the overall site classification. For the current review, the recreational MAC score is provided for each site, but is not used to in the overall site rating. The rationale for this exclusion is that at many sites the MAC score is worse, when the general year round E. coli values are lower. The higher upper E. coli values are statistically likely given that year on year the chance of extreme rainfall and runoff events, or localised intense faecal contamination episodes is greater, and the probability of sampling such a high faecal load episode also increases. Thus, the increased high summer values may not indicate worse conditions per se, and should be considered in parallel with the year round E. coli results.

2. UPDATED CLASSIFICATION OF NELSON FRESHWATERS

2.1. Coastal and Urban Streams/Creeks

The coastal and urban streams and creeks are generally smaller water bodies that either drain the coastal margins of the hill ranges between Richmond in the south and Glenduan in the north. The more urbanised streams are centred around the Stoke and Tahunanui area, and include the York Stream which drains northwards into the Victory area of Nelson (see Map 1). The coastal streams show generally low impacts from the surrounding land uses, whereas the urban streams tend to be more impacted due to the density of residential, commercial and industrial land utilisation.

NCC01 – Saxton at Main Road

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95th %ile	2013	2007
Nutrients	Nitrate-Nitrogen	47	**1.21**	0.23	0.79	1.10	0.06	3.90	2.34	**E**	*E*
	Ammonia-Nitrogen	42	**0.051**	0.012	0.041	0.045	0.003	0.250	0.109		
	Dissolved Reactive Phosphorus	47	**0.018**	0.003	0.010	0.016	0.003	0.054	0.035	**C**	*D*
Physical	Acidity - pH	47	**7.0**	0.1	0.5	7.1	5.3	7.8	7.7	**C**	*C*
	Water Temperature °C	48	12.6	1.1	3.9	12.8	5.7	18.9	**18.5**	**A**	*A*
	Dissolved Oxygen %	47	**89.9**	4.8	16.9	92.2	19.7	128.8	107.4	**D**	*D*
	Dissolved Oxygen mg/L	46	9.7	0.6	2.1	9.7	2.0	13.0	12.2		
	Conductivity mS/cm	41	281	28	91	260	133	573	487		
Clarity	Turbidity NTU	47	**6.80**	1.51	5.28	5.05	1.04	21.40	18.51	**E**	*E*
	Black disc visible depth m	46	**1.2**	0.2	0.6	1.0	0.3	2.9	2.6	**D**	*D*
	Total suspended solids	45	8	4	14	4	1	91	20		
E. coli	CAW 774 - 2002	47	2354	714	2497	**1400**	3	10000	**7990**	**D/E**	*D/E*
cfu/100mL	2003 recreational MAC	23	2363			2000			**4690**	**D**	*D*
Macroinvertebrate Community Score	MCI	13	**85.3**	9.1	16.7	87.0	60.0	120.0	112.8	**C**	*D*
Semi-qualitative MCI	SQMCI	13	**4.2**	0.4	0.7	4.3	3.0	5.7	5.1	**C**	*D*
Periphyton	periphyton score	14	**6.3**	1.8	3.4	6.9	1.0	10.0	9.9	**C**	*B*
	% long filaments	2	8.0	6.4	4.6	8.0	4.8	11.3	10.9		*A*
Sediment	Cadmium - Cd	5	**0.21**				0.05	0.80		**A - D**	*A - D*
metals	Copper - Cu	5	**26.40**				25.00	28.00		**A - D**	*A - D*
mg/kg	Lead - Pb	5	**15.60**				13.00	19.00		**A - D**	*A - D*
	Zinc - Zn	5	**96.00**				84.00	100.00		**A - D**	*A - D*
OVERALL WATER QUALITY CLASSIFICATION:					**D**	Upgrade					E

Saxton Creek rises from Class E to Class D. Saxton Creek remains one of the more degraded water bodies in the Nelson area. The creek has serious faecal contamination, high turbidity, and high nitrate-nitrogen levels. Macroinvertebrate scores, DRP, and dissolved oxygen levels have all improved since 2007. The median MCI has risen 10 points, SQMCI is 0.3 points up. The median dissolved oxygen has increased by 4%. The Saxton Creek freshwater monitoring location was moved in June 2012.

NCC02 – Orphanage at Saxton Road East

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	2007
Nutrients	Nitrate-Nitrogen	47	**0.65**	0.20	0.70	0.38	0.01	3.00	1.91	**E**	*D*
	Ammonia-Nitrogen	42	**0.011**	0.002	0.007	0.010	0.003	0.035	0.022		
	Dissolved Reactive Phosphorus	47	**0.015**	0.001	0.005	0.015	0.005	0.025	0.024	**C**	*C*
Physical	Acidity - pH	47	**7.3**	0.2	0.5	7.3	5.4	8.2	7.9	**A**	*A*
	Water Temperature °C	48	13.0	1.2	4.2	13.3	6.2	23.4	**21.6**	**B**	*A*
	Dissolved Oxygen %	47	**107.0**	5.7	19.9	103.9	58.5	180.6	125.6	**C**	*B*
	Dissolved Oxygen mg/L	46	11.3	0.6	2.1	11.7	5.7	16.5	14.3		
	Conductivity mS/cm	47	194	15	53	189	93	375	302		
Clarity	Turbidity NTU	46	**4.59**	1.41	4.90	2.47	0.89	26.20	12.53	**D**	*D*
	Black disc visible depth m	43	**1.8**	0.3	0.9	1.7	0.3	4.4	3.1	**D**	*D*
	Total suspended solids	45	4	1	3	2	1	16	11		
E. coli	CAW 774 - 2002	47	692	256	895	**275**	5	3500	**2750**	**C**	*C*
cfu/100mL	2003 recreational MAC	23	874			360			**2850**	**D**	*D*
Macroinvertebrate Community Score	MCI	13	**75.1**	5.7	10.5	75.0	57.0	93.0	91.2	**D**	*D*
Semi-qualitative MCI	SQMCI	13	**3.4**	0.4	0.8	3.2	2.1	4.4	4.4	**D**	*D*
Periphyton	periphyton score	14	**5.9**	1.5	2.8	6.2	2.2	10.0	9.7	**C**	*B*
	% long filaments	5	31.1	31.0	35.4	8.0	0.8	73.8	72.1		*D*
Sediment	Cadmium - Cd	5	**0.19**				0.05	0.70		**A - D**	*A - D*
metals	Copper - Cu	5	**26.40**				23.00	30.00		**A - D**	*A - D*
mg/kg	Lead - Pb	5	**21.40**				14.00	43.00		**A - D**	*A - D*
	Zinc - Zn	5	**121.80**				89.00	140.00		**A - D**	*A - D*
OVERALL WATER QUALITY CLASSIFICATION:					**D**						D

In Orphanage stream there is little apparent change since the 2007 review. The median NO3-N concentration has risen from 0.26 for 2000-7 to 0.38 2000-13. Dissolved oxygen status and water temperature scores have also deteriorated. The site retains its overall classification of D – degraded.

NCC04 – Poorman at Seaview Road (Lower)

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	2007
Nutrients	Nitrate-Nitrogen	46	**0.35**	0.10	0.34	0.22	0.01	1.50	0.99	**D**	*C*
	Ammonia-Nitrogen	41	**0.006**	0.002	0.006	0.003	0.003	0.029	0.015		
	Dissolved Reactive Phosphorus	46	**0.012**	0.002	0.006	0.012	0.003	0.023	0.021	**C**	*C*
Physical	Acidity - pH	46	**7.7**	0.2	0.6	7.7	6.5	8.8	8.8	**A**	*A*
	Water Temperature °C	47	12.8	1.0	3.4	13.0	6.6	18.2	**18.2**	**A**	*A*
	Dissolved Oxygen %	46	**108.4**	3.8	13.1	105.9	86.2	163.0	127.8	**C**	*B*
	Dissolved Oxygen mg/L	46	11.5	0.4	1.5	11.2	8.3	15.9	13.8		
	Conductivity mS/cm	46	151	12	41	148	36	284	224		
Clarity	Turbidity NTU	46	**2.43**	0.96	3.31	1.55	0.55	22.00	5.13	**C**	*C*
	Black disc visible depth m	46	**3.1**	0.4	1.4	3.0	0.5	7.1	5.6	**C**	*C*
	Total suspended solids	44	1	0	1	1	0	8	3		
E. coli	CAW 774 - 2002	46	233	83	288	**107**	3	1400	**775**	**C**	*C*
cfu/100mL	2003 recreational MAC	22	204			157			**611**	**D**	*D*
Macroinvertebrate Community Score	MCI	13	**80.0**	7.6	14.0	78.0	58.0	106.0	102.4	**D**	*D*
Semi-qualitative MCI	SQMCI	13	**2.9**	0.2	0.4	2.8	2.2	3.6	3.5	**D**	*D*
Periphyton	periphyton score	14	**7.6**	0.9	1.7	7.4	4.1	10.0	10.0	**A**	*A*
	% long filaments	2	14.9	2.7	1.9	14.9	13.5	16.3	16.1		*D*
Sediment	Cadmium - Cd	5	**0.20**				0.05	0.60		**A - D**	*A - D*
metals	Copper - Cu	5	**30.50**				26.00	34.00		**A - D**	*A - D*
mg/kg	Lead - Pb	5	**20.75**				14.00	32.00		**A - D**	*A - D*
	Zinc - Zn	5	**190.00**				110.00	270.00		**A - D**	*E*
SVOCs - PAHs											
mg/kg	Fluorene	3	0.03				0.02	0.05		E	*E*
	Phenanthrene	3	0.05				0.02	0.08		A - D	*E*
	Anthracene	3	0.04				0.02	0.05		A - D	*E*
	Low Molecular Weight PAHs		0.11							A - D	*E*
	Fluoranthene	3	0.07				0.05	0.12		A - D	*A - D*
	Pyrene	3	0.07				0.05	0.10		A - D	*A - D*
	Benzo[a]anthracene	3	0.04				0.02	0.05		A - D	*A - D*
	Chrysene	3	0.03				0.02	0.05		A - D	*A - D*
	Benzo[b]fluoranthene	3	0.12				0.04	0.22		A - D	*A - D*
	Benzo[k]fluoranthene	3	0.05				0.02	0.10		A - D	*A - D*
	Benzo[a]pyrene	3	0.06				0.04	0.10		A - D	*A - D*
	Dibenzo[a,h]anthracene	3	0.05				0.02	0.10		A - D	*A - D*
	Benzo[g,h,i]perylene	3	0.05				0.02	0.10			
	Indeno(1,2,3-c,d)pyrene	3	0.05				0.02	0.10		A - D	*E*
	High Molecular Weight PAHs		0.58							A - D	*E*
	Total PAHs		0.69							A - D	*A - D*
	Bis(2-ethylhexyl)phthalate	3	0.63				0.15	1.30			
	OVERALL WATER QUALITY CLASSIFICATION:			**D**							D

Since 2007 there have been few obvious changes in the condition of Poorman at Seaview Road which retains its class D score. The median *E. coli* count has fallen slightly, and some PAH concentrations have dropped below the ISQG-Low trigger value. The macroinvertebrate fauna remains impoverished.

NCC05 – Poorman at Barnicoat Walkway (Upper)

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	2007
Nutrients	Nitrate-Nitrogen	47	**0.25**	0.06	0.22	0.17	0.00	1.10	0.61	**C**	*B*
	Ammonia-Nitrogen	42	**0.004**	0.001	0.003	0.003	0.003	0.012	0.009		
	Dissolved Reactive Phosphorus	47	**0.019**	0.002	0.008	0.019	0.002	0.063	0.025	**C**	*C*
Physical	Acidity - pH	47	**7.6**	0.1	0.4	7.6	6.9	8.6	8.1	**A**	*A*
	Water Temperature °C	48	11.3	0.7	2.4	11.1	7.3	15.6	**15.3**	**A**	*A*
	Dissolved Oxygen %	47	**101.2**	2.5	8.7	99.2	92.1	145.4	112.6	**A**	*A*
	Dissolved Oxygen mg/L	46	11.1	0.3	1.2	11.0	9.3	15.5	13.1		
	Conductivity mS/cm	47	137	10	34	133	72	249	184		
Clarity	Turbidity NTU	47	**2.38**	0.53	1.85	1.64	0.56	10.30	5.00	**C**	*C*
	Black disc visible depth m	43	**2.6**	0.3	0.9	2.6	0.8	5.6	4.0	**C**	*C*
	Total suspended solids	45	1	0	1	1	0	6	4		
E. coli	CAW 774 - 2002	45	20	8	28	**10**	3	145	**73**	**B**	*B*
cfu/100mL	2003 recreational MAC	23	29			20			**74**	**A**	*A*
Macroinvertebrate Community Score	MCI	13	**113.6**	6.0	11.0	117.0	87.0	128.0	126.2	**B**	*B*
Semi-qualitative MCI	SQMCI	13	**5.4**	0.8	1.5	5.4	2.4	7.3	7.2	**B**	*C*
Periphyton	periphyton score	14	**8.4**	0.6	1.2	8.4	6.1	10.0	10.0	**A**	*A*
	% long filaments	4	1.8	1.0	1.0	1.8	0.5	3.0	2.9		*A*
Sediment	Cadmium - Cd	5	**0.15**				0.05	0.60		**A - D**	*A - D*
metals	Copper - Cu	5	**30.17**				25.00	33.00		**A - D**	*A - D*
mg/kg	Lead - Pb	5	**15.92**				11.00	20.00		**A - D**	*A - D*
	Zinc - Zn	5	**122.00**				82.00	220.00		**A - D**	*A - D*
SVOCs - PAHs											
mg/kg	Fluorene	4	0.05				0.02	0.10		E	*E*
	Phenanthrene	4	0.19				0.03	0.59		A - D	*E*
	Anthracene	4	0.05				0.01	0.10		A - D	*E*
	Low Molecular Weight PAHs		**0.29**							A - D	*A - D*
	Fluoranthene	4	0.32				0.07	0.81		A - D	*A - D*
	Pyrene	4	0.29				0.07	0.68		A - D	*A - D*
	Benzo[a]anthracene	4	0.14				0.05	0.32		A - D	*A - D*
	Chrysene	4	0.11				0.05	0.24		A - D	*A - D*
	Benzo[b]fluoranthene	4	0.12				0.02	0.26		A - D	*A - D*
	Benzo[k]fluoranthene	4	0.10				0.04	0.15		A - D	*A - D*
	Benzo[a]pyrene	4	0.17				0.09	0.33		A - D	*A - D*
	Dibenzo[a,h]anthracene	4	0.06				0.02	0.10		E	*E*
	Benzo[g,h,i]perylene	4	0.13				0.10	0.21			*A - D*
	Indeno(1,2,3-c,d)pyrene	4	0.12				0.10	0.19		E	*E*
	High Molecular Weight PAHs		**1.56**							A - D	*E*
	Total PAHs		**1.85**							A - D	*A - D*
	Bis(2-ethylhexyl)phthalate	4	0.64				0.25	1.00			
OVERALL WATER QUALITY CLASSIFICATION:					**B**	Upgrade					C

Compared to the 2007 classification for Poorman at Barnicoat Walkway, SQMCI is up by 0.5 units rising into class B for this parameter. Dissolved oxygen closer to 100%, and the nitrate-N concentration has increased marginally. The overall classification for this site has risen to B.

NCC06 – Jenkins at Pascoe St

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	*2007*
Nutrients	Nitrate-Nitrogen	47	**0.48**	0.17	0.61	0.20	0.00	2.40	1.67	**E**	*D*
	Ammonia-Nitrogen	42	**0.011**	0.003	0.011	0.009	0.003	0.062	0.029		
	Dissolved Reactive Phosphorus	47	**0.016**	0.003	0.011	0.012	0.003	0.064	0.029	**C**	*C*
Physical	Acidity - pH	47	**7.9**	0.2	0.6	7.9	6.0	10.0	8.7	**A**	*A*
	Water Temperature °C	48	14.0	1.5	5.3	13.5	4.5	24.0	**23.9**	**B**	*C*
	Dissolved Oxygen %	47	**113.3**	5.1	17.7	111.0	82.5	187.0	144.9	**C**	*C*
	Dissolved Oxygen mg/L	46	11.8	0.5	1.9	11.7	7.3	17.7	14.9		
	Conductivity mS/cm	47	193	15	53	184	130	420	278		
Clarity	Turbidity NTU	47	**4.50**	1.79	6.26	2.96	0.86	42.20	10.30	**D**	*E*
	Black disc visible depth m	47	**2.2**	0.4	1.2	1.9	0.3	6.1	4.4	**D**	*D*
	Total suspended solids	45	4	2	5	2	0	28	10		
E. coli	CAW 774 - 2002	47	830	285	998	**365**	5	4300	**2840**	**C**	*C*
cfu/100mL	2003 recreational MAC	23	1354			1000			**2880**	**D**	*D*
Macroinvertebrate Community Score	MCI	13	**72.8**	6.4	11.7	76.0	51.0	91.0	89.2	**D**	*D*
Semi-qualitative MCI	SQMCI	13	**3.0**	0.3	0.6	2.9	1.7	4.0	3.8	**D**	*D*
Periphyton	periphyton score	14	**5.9**	1.6	3.1	7.2	1.2	10.0	9.3	**C**	*C*
	% long filaments	3	44.9	54.2	47.9	36.5	1.8	96.5	90.5		*D*
Sediment	Cadmium - Cd	4	**0.32**				0.05	0.90		**A - D**	*A - D*
metals	Copper - Cu	4	**64.25**				47.00	95.00		**A - D**	*E*
mg/kg	Lead - Pb	4	**58.25**				20.00	120.00		**E**	*E*
	Zinc - Zn	4	**1047.50**				280.00	2500.00		**E**	*E*
SVOCs - PAHs											
mg/kg	Fluorene	4	0.07				0.03	0.15		E	*E*
	Phenanthrene	4	0.07				0.03	0.10		A - D	*A - D*
	Anthracene	4	0.06				0.01	0.15		A - D	*A - D*
	Low Molecular Weight PAHs		**0.19**							A - D	*A - D*
	Fluoranthene	4	0.12				0.06	0.17		A - D	*A - D*
	Pyrene	4	0.12				0.06	0.16		A - D	*A - D*
	Benzo[a]anthracene	4	0.07				0.03	0.15		A - D	*A - D*
	Chrysene	4	0.07				0.03	0.15		A - D	*A - D*
	Benzo[b]fluoranthene	4	0.08				0.07	0.10		A - D	*A - D*
	Benzo[k]fluoranthene	4	0.09				0.04	0.15		A - D	*A - D*
	Benzo[a]pyrene	4	0.10				0.07	0.15		A - D	*A - D*
	Dibenzo[a,h]anthracene	4	0.09				0.04	0.15		E	*A - D*
	Benzo[g,h,i]perylene	4	0.10				0.06	0.15			*A - D*
	Indeno(1,2,3-c,d)pyrene	4	0.09				0.04	0.15		E	*E*
	High Molecular Weight PAHs		**0.93**							A - D	*A - D*
	Total PAHs		**1.12**							A - D	*A - D*
	Bis(2-ethylhexyl)phthalate	4	3.83				1.38	6.60			
OVERALL WATER QUALITY CLASSIFICATION:					**E**						E

The median nitrate-nitrogen concentration in Jenkins Creek has risen 7-fold since the 2007 classification. Sediment metal concentrations have declined. This site retains its 2007 score of class E.

NCC09 – York at Waimea Rd

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	2007
Nutrients	Nitrate-Nitrogen	47	**0.59**	0.12	0.41	0.49	0.02	1.80	1.34	**E**	*D*
	Ammonia-Nitrogen	42	**0.024**	0.017	0.057	0.009	0.003	0.330	0.085		
	Dissolved Reactive Phosphorus	47	**0.012**	0.003	0.010	0.010	0.001	0.053	0.027	**C**	*C*
Physical	Acidity - pH	47	**7.7**	0.1	0.5	7.7	6.2	9.8	8.1	**A**	*A*
	Water Temperature °C	48	13.9	0.9	3.2	14.3	6.1	18.8	**18.4**	**A**	*A*
	Dissolved Oxygen %	47	**100.1**	3.4	11.8	98.9	72.4	137.6	119.0	**A**	*B*
	Dissolved Oxygen mg/L	46	10.4	0.4	1.6	10.2	6.9	14.0	13.2		
	Conductivity mS/cm	46	488	35	121	524	219	874	581		
Clarity	Turbidity NTU	46	**6.69**	3.42	11.83	2.79	0.74	72.30	17.93	**E**	*E*
	Black disc visible depth m	43	**1.9**	0.4	1.2	1.8	0.2	5.6	3.7	**D**	*D*
	Total suspended solids	45	5	3	9	2	0	46	25		
E. coli	CAW 774 - 2002	47	1302	666	2329	**400**	5	13000	**5100**	**C**	*C*
cfu/100mL	2003 recreational MAC	23	1036			880			**3160**	**D**	*D*
Macroinvertebrate Community Score	MCI	13	**70.1**	7.5	13.7	68.0	40.0	95.0	89.6	**D**	*D*
Semi-qualitative MCI	SQMCI	13	**3.2**	0.3	0.5	3.3	2.0	4.0	3.9	**D**	*D*
Periphyton	periphyton score	13	**7.9**	1.3	2.4	9.0	2.5	10.0	10.0	**A**	*B*
	% long filaments	1	1.3			1.3	1.3	1.3	1.3		*B*
Sediment	Cadmium - Cd	5	**0.20**				0.05	0.70		**A - D**	*A - D*
metals	Copper - Cu	5	**45.00**				41.00	52.00		**A - D**	*A - D*
mg/kg	Lead - Pb	5	**114.00**				71.00	160.00		**E**	*E*
	Zinc - Zn	5	**228.00**				140.00	320.00		**E**	*E*
SVOCs - PAHs											
mg/kg	Fluorene	4	0.04				0.03	0.05		E	*E*
	Phenanthrene	4	0.32				0.03	0.50		E	*E*
	Anthracene	4	0.06				0.03	0.12		A - D	*A - D*
	Low Molecular Weight PAHs		**0.41**							A - D	*A - D*
	Fluoranthene	4	0.71				0.05	1.29		E	*A - D*
	Pyrene	4	0.67				0.06	1.16		E	*A - D*
	Benzo[a]anthracene	4	0.32				0.03	0.62		E	*A - D*
	Chrysene	4	0.29				0.02	0.56		A - D	*A - D*
	Benzo[b]fluoranthene	4	0.37				0.04	1.16		A - D	*A - D*
	Benzo[k]fluoranthene	4	0.18				0.03	0.44		A - D	*A - D*
	Benzo[a]pyrene	4	0.44				0.03	1.09		E	*A - D*
	Dibenzo[a,h]anthracene	4	0.07				0.03	0.11		E	*A - D*
	Benzo[g,h,i]perylene	4	0.25				0.03	0.38			*A - D*
	Indeno(1,2,3-c,d)pyrene	4	0.23				0.03	0.34		E	*E*
	High Molecular Weight PAHs		**3.54**							E	*E*
	Total PAHs		**3.95**							A - D	*A - D*
	Bis(2-ethylhexyl)phthalate	4	1.04				0.23	2.40			
	OVERALL WATER QUALITY CLASSIFICATION:					**E**					E

A marked increase in nitrate-nitrogen has occurred since the 2007 classification. The median value has risen from 0.37 to 0.49 mg/L resulting in a downgrade from D to E for this parameter. Some small increases in PAH concentrations have pushed some of these from class A-D into class E. Dissolved oxygen levels in the stream have risen by 2%, giving a class of A instead of B for DO. Overall this site remains classed at E.

NCC21 – Todds at SH6

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	*2007*
Nutrients	Nitrate-Nitrogen	47	**0.30**	0.10	0.34	0.13	0.00	1.10	0.96	**D**	*D*
	Ammonia-Nitrogen	42	**0.015**	0.006	0.019	0.009	0.003	0.092	0.054		
	Dissolved Reactive Phosphorus	47	**0.026**	0.008	0.027	0.020	0.003	0.190	0.051	**D**	*D*
Physical	Acidity - pH	47	**7.8**	0.1	0.4	7.9	6.9	8.6	8.3	**A**	*A*
	Water Temperature °C	48	13.8	1.1	3.7	13.6	6.2	21.6	**21.5**	**B**	*B*
	Dissolved Oxygen %	47	**101.2**	5.1	17.8	99.3	60.1	152.8	130.0	**A**	*B*
	Dissolved Oxygen mg/L	46	10.5	0.5	1.8	10.7	5.8	14.3	12.9		
	Conductivity mS/cm	46	360	23	81	354	244	705	461		
Clarity	Turbidity NTU	47	**5.48**	2.48	8.69	3.04	1.09	59.50	11.47	**E**	*D*
	Black disc visible depth m	43	**1.6**	0.2	0.8	1.6	0.2	3.4	2.7	**D**	*D*
	Total suspended solids	45	5	2	7	3	1	46	14		
E. coli	CAW 774 - 2002	47	813	479	1677	**210**	3	10000	**3140**	**C**	*C*
cfu/100mL	2003 recreational MAC	23	501			300			**1760**	**D**	*D*
Macroinvertebrate Community Score	MCI	13	**84.7**	6.8	12.4	89.0	53.0	103.0	97.6	**C**	*C*
Semi-qualitative MCI	SQMCI	13	**3.5**	0.5	0.8	3.3	2.2	5.2	4.9	**D**	*D*
Periphyton	periphyton score	12	**7.0**	1.6	2.7	7.4	0.4	10.0	9.8	**B**	*C*
	% long filaments	4	2.4	2.7	2.8	1.3	0.5	6.5	5.8		*A*
OVERALL WATER QUALITY CLASSIFICATION:				**D**							D

The Todd Valley Stream retains its overall D classification, mainly due to poor clarity, but also impoverished macroinvertebrate fauna and faecal contamination. The dissolved oxygen status has improved, with 5% reduction in the median value, suggesting a reduced tendency to excess oxygenation.

NCC40 – Hillwood at Glen Rd

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	*2007*
Nutrients	Nitrate-Nitrogen	47	**0.21**	0.08	0.27	0.05	0.00	0.87	0.81	**C**	*C*
	Ammonia-Nitrogen	42	**0.013**	0.003	0.009	0.011	0.003	0.044	0.034		
	Dissolved Reactive Phosphorus	47	**0.017**	0.002	0.007	0.017	0.001	0.042	0.028	**C**	*C*
Physical	Acidity - pH	47	**7.7**	0.1	0.3	7.6	7.1	9.1	8.2	**A**	*A*
	Water Temperature °C	48	14.4	1.2	4.4	14.2	5.9	22.7	**22.6**	**B**	*B*
	Dissolved Oxygen %	47	**102.1**	4.5	15.8	101.4	63.2	135.6	124.4	**A**	*B*
	Dissolved Oxygen mg/L	46	10.4	0.5	1.7	10.5	6.5	13.6	12.9		
	Conductivity mS/cm	47	266	19	67	251	105	484	411		
Clarity	Turbidity NTU	47	**3.37**	0.57	2.01	2.76	1.03	10.70	7.41	**D**	*D*
	Black disc visible depth m	41	**1.8**	0.3	0.8	1.8	0.4	5.7	2.8	**D**	*D*
	Total suspended solids	45	4	2	6	2	0	36	10		
E. coli	CAW 774 - 2002	47	643	334	1169	**305**	3	7600	**1600**	**C**	*C*
cfu/100mL	2003 recreational MAC	23	883			400			**1600**	**D**	*D*
Macroinvertebrate Community Score	MCI	13	**85.5**	6.3	11.5	83.0	64.0	103.0	101.8	**C**	*C*
Semi-qualitative MCI	SQMCI	13	**4.2**	0.5	1.0	4.5	2.3	6.3	5.4	**C**	*D*
Periphyton	periphyton score	12	**5.6**	2.2	3.8	7.0	0.2	10.0	10.0	**C**	*C*
	% long filaments	2	15.4	14.5	10.4	15.4	8.0	22.8	22.0		*A*
OVERALL WATER QUALITY CLASSIFICATION:				**C**	Upgrade						D

Hillwood Stream has had improvements in dissolved oxygen, periphyton score and SQMCI, resulting in an upgrade from D to C. SQMCI is up 0.5 compared to the 2007 update, and median dissolved oxygen has fallen by 4% showing a lower tendency to excess oxygenation. *E. coli* is down in the higher values (95th percentile value is down from 6600 to 1600), but up in lower values; the median value is up by one third on 2000-7. The cause of this increase is not clear, but may be due to changes in livestock numbers, practices, or access to the stream channel.

2.1.1. The Maitai River, The Brook, and Sharlands and Groom Creeks

The catchment of the Maitai River is one of the largest catchments in the Nelson area and is of great importance due its cultural, recreational and primary resources qualities. The catchment provides a large proportion of the Nelson potable water supply, it is a major timber growing and production area and provides many possibilities for recreation, both in and along the river itself and in the adjacent hills. The catchment also retains pockets of undisturbed or regenerating native vegetation and connects to the Richmond Ranges Forest Park. The conservation value of these undisturbed lands is growing in importance as evidenced by the drive to fence and reintroduce previously eradicated native bird species to the Brook Sanctuary.

Freshwater monitoring sites in the Maitai cover a wide range of habitats and locations, from the Upper Brook site which drains remnant native bush, the upper Maitai water supply zone, sub-catchments in varying stages of afforestation/logging, and highly modified river channels in the sub-urban reaches of Nelson City. Consequently, a wide range of water quality conditions exist. The upper most sites generally represent minimally or undisturbed conditions, and the lower sites and smaller sub-catchments show evidence of varying degrees of degradation due to human activity.

NCC10 – Brook at Manuka St. (Lower)

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	*2007*
Nutrients	Nitrate-Nitrogen	47	**0.27**	0.06	0.21	0.18	0.10	0.97	0.77	**C**	*C*
	Ammonia-Nitrogen	42	**0.006**	0.001	0.005	0.006	0.003	0.020	0.016		
	Dissolved Reactive Phosphorus	47	**0.011**	0.002	0.007	0.010	0.002	0.044	0.019	**C**	*C*
Physical	Acidity - pH	46	**8.0**	0.2	0.6	7.9	7.0	9.3	8.9	**A**	*A*
	Water Temperature °C	48	13.9	1.3	4.5	12.6	6.1	22.8	**22.6**	**B**	*B*
	Dissolved Oxygen %	47	**108.3**	3.7	13.1	106.1	91.1	177.6	124.1	**C**	*C*
	Dissolved Oxygen mg/L	46	11.3	0.5	1.7	11.2	8.4	16.9	14.3		
	Conductivity mS/cm	47	142	8	29	138	107	246	205		
Clarity	Turbidity NTU	47	**1.86**	0.44	1.55	1.52	0.59	10.20	3.73	**B**	*C*
	Black disc visible depth m	46	**3.2**	0.3	1.2	3.1	1.1	7.0	5.1	**C**	*C*
	Total suspended solids	45	2	1	2	1	0	7	5		
E. coli	CAW 774 - 2002	47	246	134	467	**139**	3	3000	**940**	**C**	*C*
cfu/100mL	2003 recreational MAC	23	244			175			**935**	**D**	*D*
Macroinvertebrate Community Score	MCI	13	**93.2**	6.3	11.6	91.0	72.0	112.0	109.6	**C**	*C*
Semi-qualitative MCI	SQMCI	13	**4.3**	0.4	0.8	4.3	2.8	5.7	5.6	**C**	*C*
Periphyton	periphyton score	14	**8.0**	0.5	0.9	8.2	6.2	9.6	9.2	**A**	*A*
	% long filaments	4	16.3	17.2	17.6	10.3	2.5	42.0	37.4		*A*
Sediment	Cadmium - Cd	5	**0.19**				0.05	0.60		**A - D**	*A - D*
metals	Copper - Cu	5	**41.40**				35.00	46.00		**A - D**	*A - D*
mg/kg	Lead - Pb	5	**31.40**				15.00	54.00		**A - D**	*A - D*
	Zinc - Zn	5	**172.00**				110.00	300.00		**A - D**	*A - D*
SVOCs - PAHs											
mg/kg	Fluorene	4	0.03	-	-	-	0.02	0.05		E	*E*
	Phenanthrene	4	0.16	-	-	-	0.06	0.41		A - D	*A - D*
	Anthracene	4	0.04	-	-	-	0.01	0.05		A - D	*A - D*
	Low Molecular Weight PAHs		0.23							A - D	*A - D*
	Fluoranthene	4	0.29	-	-	-	0.18	0.54		A - D	*E*
	Pyrene	4	0.28	-	-	-	0.18	0.54		A - D	*E*
	Benzo[a]anthracene	4	0.13	-	-	-	0.08	0.23		A - D	*A - D*
	Chrysene	4	0.12	-	-	-	0.09	0.20		A - D	*E*
	Benzo[b]fluoranthene	4	0.17	-	-	-	0.11	0.26		A - D	*A - D*
	Benzo[k]fluoranthene	4	0.08	-	-	-	0.05	0.12		A - D	*A - D*
	Benzo[a]pyrene	4	0.16	-	-	-	0.13	0.20		A - D	*E*
	Dibenzo[a,h]anthracene	4	0.04	-	-	-	0.02	0.08		A - D	*A - D*
	Benzo[g,h,i]perylene	4	0.11	-	-	-	0.09	0.15			*A - D*
	Indeno(1,2,3-c,d)pyrene	4	0.08	-	-	-	0.05	0.13		E	*E*
	High Molecular Weight PAHs		1.47							A - D	*E*
	Total PAHs		1.69							A - D	*E*
	Bis(2-ethylhexyl)phthalate	4	0.45	-	-	-	0.15	0.72			
OVERALL WATER QUALITY CLASSIFICATION:						**C**	Upgrade				D

The NCC10 - Brook at Manuka St monitoring site shows only minor changes in general. Dissolved oxygen has increased by 2.5% showing a greater tendency to excess oxygen. The main improvement at this site is a reduction in sediment PAH concentrations, the median total PAHs have fallen by almost a half since 2007. This improvement results in an overall upgrade in classification from D to C.

NCC11 –Brook at Burn Place (Middle)

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	2000-1
Nutrients	Nitrate-Nitrogen	26	**0.24**	0.10	0.26	0.12	0.01	0.92	0.75	**C**	B
	Ammonia-Nitrogen	21	**0.005**	0.001	0.003	0.005	0.003	0.012	0.009		
	Dissolved Reactive Phosphorus	26	**0.011**	0.002	0.004	0.012	0.001	0.018	0.018	**C**	C
Physical	Acidity - pH	25	**8.1**	0.2	0.6	8.1	7.0	9.4	9.2	**A**	A
	Water Temperature °C	27	13.1	1.4	3.8	12.3	5.9	23.0	**22.1**	**B**	A
	Dissolved Oxygen %	26	**108.1**	6.3	16.3	105.5	93.8	180.0	120.2	**C**	C
	Dissolved Oxygen mg/L	25	11.4	0.6	1.6	11.0	8.9	16.9	13.9		
	Conductivity mS/cm	26	134	14	36	128	74	239	214		
Clarity	Turbidity NTU	26	**1.80**	0.45	1.17	1.33	0.49	4.56	3.84	**B**	B
	Black disc visible depth m	25	**3.3**	0.5	1.2	2.9	2.0	5.7	5.6	**C**	C
	Total suspended solids	24	2	1	1	2	1	6	5		
E. coli	CAW 774 - 2002	26	90	27	71	**75**	3	320	**185**	**B**	B
cfu/100mL	2003 recreational MAC	13	134			129			**242**	**B**	-
Macroinvertebrate Community Score	MCI	8	**110.8**	9.4	13.6	108.5	96.0	134.0	129.8	**B**	B
Semi-qualitative MCI	SQMCI	8	**5.2**	1.2	1.7	5.5	2.5	7.0	7.0	**B**	D
Periphyton	periphyton score	9	**7.8**	1.4	2.1	7.9	3.2	10.0	10.0	**A**	B
	% long filaments	1	74.0			74.0	74.0	74.0	74.0		
Sediment	Cadmium - Cd	5	**0.19**				0.05	0.60		**A - D**	
metals	Copper - Cu	5	**41.20**				34.00	46.00		**A - D**	
mg/kg	Lead - Pb	5	**29.40**				12.00	54.00		**A - D**	
	Zinc - Zn	5	**167.00**				95.00	300.00		**A - D**	
SVOCs - PAHs											
mg/kg	Fluorene	4	0.04	-	-	-	0.02	0.06		E	
	Phenanthrene	4	0.23	-	-	-	0.07	0.55		A - D	
	Anthracene	4	0.07	-	-	-	0.02	0.16		A - D	
	Low Molecular Weight PAHs		0.34							A - D	
	Fluoranthene	4	0.65	-	-	-	0.15	1.50		E	
	Pyrene	4	0.74	-	-	-	0.14	1.91		E	
	Benzo[a]anthracene	4	0.36	-	-	-	0.06	0.89		E	
	Chrysene	4	0.32	-	-	-	0.07	0.77		A - D	
	Benzo[b]fluoranthene	4	0.38	-	-	-	0.02	0.75		A - D	
	Benzo[k]fluoranthene	4	0.17	-	-	-	0.04	0.32		A - D	
	Benzo[a]pyrene	4	0.39	-	-	-	0.09	0.74		A - D	
	Dibenzo[a,h]anthracene	4	0.11	-	-	-	0.02	0.21		E	
	Benzo[g,h,i]perylene	4	0.23	-	-	-	0.08	0.37		A - D	
	Indeno(1,2,3-c,d)pyrene	4	0.21	-	-	-	0.06	0.33		E	
	High Molecular Weight PAHs		3.55							E	
	Total PAHs		3.89							A - D	
	Bis(2-ethylhexyl)phthalate	3	0.33	-	-	-	0.02	0.81			
OVERALL WATER QUALITY CLASSIFICATION:					**C**						

The NCC11 - Brook at Burn Place monitoring site was re-established in September 2007 following the recommendation in Wilkinson (2007b) to monitor any potential impacts of the residential development in the upper Brook valley downstream of the Motor Camp. Preliminary monitoring was carried-out in 2000-1. The differences in median for the main water quality and river health parameters between 2000-1 and 2007-13 are very small, although, MCI is 1.8 points higher for the latter period, but the earlier statistic is based on a sample of only 2 surveys. Comparison with NCC12 - Brook at Motor Camp, shows that Nitrate-N is greater at the downstream site, as are turbidity and *E. coli*. PAH sediment concentrations (measured significantly further into the peri-urban area; Figure 2) are also markedly higher than at the upper site, and this may be a consequence of winter wood smoke being trapped in the valley and washing into the stream. The raw statistics do not indicate that the residential development in the upper middle reaches of the Brook has caused a deterioration in stream health, although a clear decline in condition is evident compared to NCC12 – Brook at Motor Camp. NCC11 has an overall class of C.

NCC12 –Brook at Motor Camp (Upper)

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	*2007*
Nutrients	Nitrate-Nitrogen	47	**0.06**	0.01	0.03	0.05	0.02	0.14	0.13	**A**	*A*
	Ammonia-Nitrogen	42	**0.004**	0.001	0.003	0.003	0.003	0.012	0.010		
	Dissolved Reactive Phosphorus	47	**0.017**	0.001	0.003	0.017	0.010	0.023	0.022	**C**	*C*
Physical	Acidity - pH	46	**7.7**	0.1	0.5	7.7	6.9	9.6	8.4	**A**	*A*
	Water Temperature °C	48	11.3	0.8	2.7	11.4	6.8	16.6	**16.5**	**A**	*A*
	Dissolved Oxygen %	47	**101.5**	2.5	8.8	100.3	84.4	147.4	110.1	**A**	*A*
	Dissolved Oxygen mg/L	46	11.2	0.4	1.2	11.0	8.7	15.2	13.2		
	Conductivity mS/cm	47	111	9	30	107	70	215	180		
Clarity	Turbidity NTU	47	**0.82**	0.15	0.52	0.73	0.18	3.20	1.62	**A**	*A*
	Black disc visible depth m	42	**5.2**	0.6	2.0	4.7	2.8	12.6	8.5	**B**	*B*
	Total suspended solids	45	1	0	1	0	0	6	2		
E. coli	CAW 774 - 2002	46	44	32	112	**10**	3	700	**149**	**B**	*B*
cfu/100mL	2003 recreational MAC	23	71			20			**270**	**C**	*A*
Macroinvertebrate Community Score	MCI	13	**127.2**	5.5	10.2	123.0	115.0	144.0	141.0	**A**	*A*
Semi-qualitative MCI	SQMCI	13	**7.0**	0.4	0.7	7.0	5.5	7.8	7.7	**A**	*A*
Periphyton	periphyton score	14	**8.7**	0.5	1.0	8.7	7.1	9.9	9.9	**A**	*A*
	% long filaments	1	1.3			1.3	1.3	1.3	1.3		*A*
Sediment	Cadmium - Cd	5	**0.19**				0.05	0.60		**A - D**	*A - D*
metals	Copper - Cu	5	**37.25**				34.00	41.00		**A - D**	*A - D*
mg/kg	Lead - Pb	5	**13.50**				11.00	17.00		**A - D**	*A - D*
	Zinc - Zn	5	**80.00**				64.00	95.00		**A - D**	*A - D*
SVOCs - PAHs											
mg/kg	Fluorene	4	0.03				0.02	0.05		E	*A - D*
	Phenanthrene	4	0.06				0.02	0.11		A - D	*A - D*
	Anthracene	4	0.05				0.02	0.09		A - D	*A - D*
	Low Molecular Weight PAHs		**0.13**							A - D	*A - D*
	Fluoranthene	4	0.12				0.02	0.28		A - D	*A - D*
	Pyrene	4	0.14				0.02	0.34		A - D	*A - D*
	Benzo[a]anthracene	4	0.07				0.02	0.15		A - D	*A - D*
	Chrysene	4	0.06				0.02	0.13		A - D	*A - D*
	Benzo[b]fluoranthene	4	0.28				0.06	0.80		A - D	*A - D*
	Benzo[k]fluoranthene	4	0.06				0.02	0.08		A - D	*A - D*
	Benzo[a]pyrene	4	0.09				0.02	0.18		A - D	*A - D*
	Dibenzo[a,h]anthracene	4	0.05				0.02	0.08		A - D	*A - D*
	Benzo[g,h,i]perylene	4	0.06				0.02	0.08			
	Indeno(1,2,3-c,d)pyrene	4	0.06				0.02	0.08		A - D	*A - D*
	High Molecular Weight PAHs		**0.98**							A - D	*A - D*
	Total PAHs		**1.12**							A - D	*A - D*
	Bis(2-ethylhexyl)phthalate	4	0.18				0.02	0.31			
OVERALL WATER QUALITY CLASSIFICATION:				**A**							A

NCC12 - Brook at Motor Camp is considered to be one of the "reference" sites for the programme. The catchment draining to this site is largely undisturbed and regenerating native forest and is therefore subject to minimal disturbance. The data show negligible change compared to the previous classification update. Minor increases in sediment PAHs are evident at the sampling site some kilometres downstream where the recent residential expansion may be having a greater impact, with wood burning and driving vehicles. The paired sediment site is not representative of conditions at the freshwater monitoring site (see Section 1.3.4). Further examination of trends and time-series plots may provide further evidence to support such a supposition.

The site retains its overall classification of A.

NCC013 – Maitai at Riverside (Lower)

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	2007
Nutrients	Nitrate-Nitrogen	47	**0.20**	0.05	0.18	0.11	0.04	0.77	0.62	**C**	*C*
	Ammonia-Nitrogen	42	**0.005**	0.001	0.003	0.003	0.003	0.016	0.012		
	Dissolved Reactive Phosphorus	47	**0.005**	0.001	0.003	0.005	0.001	0.017	0.010	**A**	*A*
Physical	Acidity - pH	47	**8.0**	0.1	0.5	7.9	6.7	9.1	8.8	**A**	*A*
	Water Temperature °C	48	13.7	1.2	4.2	13.2	6.8	22.8	**22.6**	**B**	*B*
	Dissolved Oxygen %	47	**110.1**	4.2	14.8	106.4	84.7	184.0	128.8	**C**	*C*
	Dissolved Oxygen mg/L	46	11.5	0.5	1.6	11.3	7.1	16.6	13.5		
	Conductivity mS/cm	43	160	12	42	150	111	316	245		
Clarity	Turbidity NTU	47	**1.68**	0.47	1.65	1.01	0.49	8.00	5.04	**B**	*B*
	Black disc visible depth m	44	**3.6**	0.4	1.4	3.6	0.9	6.8	5.9	**C**	*C*
	Total suspended solids	45	1	0	2	1	0	8	5		
E. coli	CAW 774 - 2002	47	218	90	316	**115**	3	1600	**916**	**C**	*C*
cfu/100mL	2003 recreational MAC	23	338			140			**1090**	**D**	*D*
Macroinvertebrate Community Score	MCI	13	**95.1**	6.4	11.7	95.0	75.0	116.0	111.2	**C**	*C*
Semi-qualitative MCI	SQMCI	13	**4.3**	0.3	0.5	4.4	3.5	5.4	5.0	**C**	*C*
Periphyton	periphyton score	13	**7.0**	0.8	1.4	7.0	4.8	9.4	9.1	**B**	*B*
	% long filaments	4	2.6	2.0	2.0	2.4	0.5	5.3	4.9		*A*
Sediment	Cadmium - Cd	3	**< 0.1**				0.05	0.60		**A - D**	*A - D*
metals	Copper - Cu	3	**39.33**				36.00	41.00		**A - D**	*A - D*
mg/kg	Lead - Pb	3	**22.67**				15.00	28.00		**A - D**	*E*
	Zinc - Zn	3	**103.00**				69.00	130.00		**A - D**	*A - D*
SVOCs - PAHs											
mg/kg	Fluorene	3	0.06	-	-	-	0.02	0.10		E	*E*
	Phenanthrene	3	0.18	-	-	-	0.10	0.25		A - D	*E*
	Anthracene	3	0.08	-	-	-	0.05	0.10		A - D	*E*
	Low Molecular Weight PAHs		0.31							A - D	*E*
	Fluoranthene	3	0.30	-	-	-	0.10	0.55		A - D	*E*
	Pyrene	3	0.30	-	-	-	0.11	0.51		A - D	*E*
	Benzo[a]anthracene	3	0.20	-	-	-	0.14	0.26		A - D	*E*
	Chrysene	3	0.18	-	-	-	0.12	0.23		A - D	*E*
	Benzo[b]fluoranthene	3	0.29	-	-	-	0.21	0.37		A - D	*E*
	Benzo[k]fluoranthene	3	0.14	-	-	-	0.13	0.14		A - D	*E*
	Benzo[a]pyrene	3	0.24	-	-	-	0.17	0.31		A - D	*E*
	Dibenzo[a,h]anthracene	3	0.10	-	-	-	0.06	0.14		E	*E*
	Benzo[g,h,i]perylene	3	0.18	-	-	-	0.14	0.22			*A - D*
	Indeno(1,2,3-c,d)pyrene	3	0.17	-	-	-	0.14	0.20		E	*E*
	High Molecular Weight PAHs		2.09							E	*E*
	Total PAHs		2.40							A - D	*E*
	Bis(2-ethylhexyl)phthalate	3	0.40	-	-	-	0.19	0.60			
	OVERALL WATER QUALITY CLASSIFICATION:			C	Re-grade						D

NCC13 – Maitai at Riverside is the lowest freshwater health monitoring site on the Maitai River. Other monitoring is carried-out further towards the mouth of the river, however, NCC13 is the main downstream site. Compared with the data for 2000-7, the extended data to 2013 show little variation. This site is re-graded up to C from D, based on the change in sediment quality data associated with the site (see Section 1.3.4, above). With these more appropriate sediment quality values the Maitai at Riverside achieves class C, consistent with the physicochemical water quality and biological indicators, macroinvertebrate and periphyton scores, for the site.

NCC15 – Maitai at Groom Rd (Upper-middle)

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	2007
Nutrients	Nitrate-Nitrogen	47	**0.04**	0.02	0.07	0.01	0.00	0.33	0.21	**A**	*A*
	Ammonia-Nitrogen	42	**0.003**	0.001	0.003	0.003	0.003	0.015	0.009		
	Dissolved Reactive Phosphorus	47	**0.004**	0.001	0.003	0.003	0.001	0.014	0.008	**A**	*A*
Physical	Acidity - pH	47	**8.2**	0.1	0.5	8.3	7.0	9.0	8.9	**A**	*A*
	Water Temperature °C	48	13.5	1.2	4.2	12.8	6.2	22.1	**21.5**	**B**	*B*
	Dissolved Oxygen %	47	**110.2**	3.6	12.6	107.4	96.3	179.4	122.9	**C**	*C*
	Dissolved Oxygen mg/L	46	11.5	0.4	1.4	11.1	8.4	16.1	14.0		
	Conductivity mS/cm	47	143	9	31	137	103	258	201		
Clarity	Turbidity NTU	47	**1.16**	0.22	0.75	0.95	0.37	3.89	2.54	**B**	*B*
	Black disc visible depth m	46	**4.9**	0.4	1.4	5.1	2.1	7.5	7.0	**B**	*B*
	Total suspended solids	45	1	0	0	1	0	2	1		
E. coli	CAW 774 - 2002	47	45	28	99	**20**	3	660	**111**	**B**	*B*
cfu/100mL	2003 recreational MAC	23	62			30			**113**	**A**	*A*
Macroinvertebrate Community Score	MCI	13	**98.4**	5.9	10.9	101.0	76.0	117.0	112.2	**C**	*C*
Semi-qualitative MCI	SQMCI	13	**4.2**	0.5	1.0	3.8	3.3	6.6	6.0	**C**	*C*
Periphyton	periphyton score	13	**7.5**	1.1	2.1	8.0	4.0	9.9	9.8	**B**	*A*
	% long filaments	0					0.0	0.0			*A*
Sediment	Cadmium - Cd	5	**0.21**				0.05	0.70		**A - D**	*A - D*
metals	Copper - Cu	5	**39.75**				37.00	47.00		**A - D**	*A - D*
mg/kg	Lead - Pb	5	**7.10**				4.30	12.00		**A - D**	*A - D*
	Zinc - Zn	5	**65.25**				54.00	82.00		**A - D**	*A - D*
OVERALL WATER QUALITY CLASSIFICATION:					**C**						C

Maitai at Groom Road, NCC15, shows negligible change since the 2007 classification update. The overall grading remains C.

NCC16 – Maitai at South Branch Intake (Upper)

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	2007
Nutrients	Nitrate-Nitrogen	45	**0.02**	0.01	0.03	0.02	0.00	0.22	0.05	**A**	*A*
	Ammonia-Nitrogen	40	**0.004**	0.001	0.003	0.003	0.003	0.018	0.009		
	Dissolved Reactive Phosphorus	45	**0.005**	0.001	0.002	0.005	0.001	0.010	0.009	**A**	*A*
Physical	Acidity - pH	45	**8.1**	0.1	0.4	8.1	7.1	8.8	8.6	**A**	*A*
	Water Temperature °C	45	11.7	1.0	3.3	11.5	5.3	18.4	**18.1**	**A**	*A*
	Dissolved Oxygen %	45	**105.5**	2.9	9.9	103.3	97.4	161.8	115.4	**C**	*B*
	Dissolved Oxygen mg/L	44	11.5	0.3	1.1	11.4	9.7	16.0	12.9		
	Conductivity mS/cm	45	159	10	35	154	109	292	228		
Clarity	Turbidity NTU	45	**0.95**	0.32	1.09	0.65	0.22	5.78	2.60	**A**	*B*
	Black disc visible depth m	44	**7.3**	0.8	2.6	7.2	1.2	12.0	11.6	**A**	*A*
	Total suspended solids	44	0	0	0	0	0	2	1		
E. coli	CAW 774 - 2002	43	26	20	66	**10**	3	400	**55**	**B**	*B*
cfu/100mL	2003 recreational MAC	22	40			13			**187**	**B**	*C*
Macroinvertebrate Community Score	MCI	13	**137.8**	5.2	9.6	140.0	122.0	153.0	150.0	**A**	*A*
Semi-qualitative MCI	SQMCI	13	**7.4**	0.3	0.5	7.6	6.3	8.0	8.0	**A**	*A*
Periphyton	periphyton score	13	**7.7**	1.0	1.8	7.9	3.6	9.6	9.6	**A**	*A*
	% long filaments	4	5.9	7.2	7.3	3.4	0.3	16.5	14.7		*A*
Sediment	Cadmium - Cd	5	**0.24**				0.05	0.80		**A - D**	*A - D*
metals	Copper - Cu	5	**33.00**				23.00	40.00		**A - D**	*A - D*
mg/kg	Lead - Pb	5	**9.13**				4.50	17.00		**A - D**	*A - D*
	Zinc - Zn	5	**63.00**				49.00	80.00		**A - D**	*A - D*
OVERALL WATER QUALITY CLASSIFICATION:					**A**						A

Since 2007 the new statistics suggest minimal change for the NCC16 - Maitai at South Branch Intake. Excess dissolved oxygen concentrations have occurred more often. The E. coli remains very low, and the recreational MAC value has improved. The periphyton score has dropped 0.8 points.

NCC17 – Sharlands at Maitai confluence

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	*2007*
Nutrients	Nitrate-Nitrogen	47	**0.75**	0.21	0.72	0.60	0.00	3.30	1.97	**E**	*D*
	Ammonia-Nitrogen	42	**0.005**	0.001	0.004	0.003	0.003	0.026	0.012		
	Dissolved Reactive Phosphorus	47	**0.007**	0.001	0.004	0.007	0.001	0.017	0.016	**B**	*B*
Physical	Acidity - pH	47	**7.9**	0.1	0.4	7.9	6.9	8.7	8.4	**A**	*A*
	Water Temperature °C	48	13.0	1.0	3.7	12.7	5.5	18.9	**18.9**	**A**	*A*
	Dissolved Oxygen %	47	**107.0**	3.6	12.7	106.8	92.5	179.5	118.4	**C**	*B*
	Dissolved Oxygen mg/L	46	11.3	0.4	1.3	11.0	9.3	16.8	13.2		
	Conductivity mS/cm	47	189	13	46	183	125	333	255		
Clarity	Turbidity NTU	47	**2.51**	0.77	2.69	1.50	0.65	16.50	6.82	**C**	*C*
	Black disc visible depth m	44	**2.7**	0.3	1.1	2.7	0.6	5.5	4.7	**C**	*C*
	Total suspended solids	45	1	0	1	1	0	7	3		
E. coli	CAW 774 - 2002	47	111	41	142	**50**	10	720	**405**	**B**	*C*
cfu/100mL	2003 recreational MAC	23	143			115			**403**	**C**	*C*
Macroinvertebrate Community Score	MCI	13	**110.0**	6.0	11.0	112.0	89.0	126.0	123.6	**B**	*B*
Semi-qualitative MCI	SQMCI	13	**5.4**	0.7	1.3	5.4	2.9	7.3	7.0	**B**	*A*
Periphyton	periphyton score	13	**7.8**	0.9	1.7	8.2	5.0	10.0	9.8	**A**	*A*
	% long filaments	1	1.0			1.0	1.0	1.0	1.0		*A*
OVERALL WATER QUALITY CLASSIFICATION:					**D**	Downgrade					C

NCC17 - Sharlands at Maitai confluence is downgraded from class C to D. SQMCI is down 0.8 points to 5.4 which involves a downgrade from A to B. Dissolved oxygen has shown a greater tendency to excess values and the mean is up 2.6% to 107.0% resulting in a downgrade from B to C. Nitrate-N remains elevated, and this is likely to be due to N-loss from the catchment caused by wide-spread clear-cut logging. The change in dissolved reactive phosphorus (DRP) is negligible and at the class threshold.

NCC18 – Groom at Maitai confluence

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	*2007*
Nutrients	Nitrate-Nitrogen	44	**0.55**	0.29	0.97	0.15	0.00	4.10	2.98	**E**	*C*
	Ammonia-Nitrogen	41	**0.004**	0.001	0.004	0.003	0.003	0.024	0.010		
	Dissolved Reactive Phosphorus	44	**0.009**	0.001	0.004	0.009	0.001	0.019	0.012	**C**	*C*
Physical	Acidity - pH	44	**7.9**	0.1	0.4	7.9	7.1	8.9	8.5	**A**	*A*
	Water Temperature °C	45	12.3	0.9	3.1	12.2	6.3	17.9	**17.6**	**A**	*A*
	Dissolved Oxygen %	44	**104.6**	3.0	10.3	102.1	90.4	153.9	119.4	**B**	*A*
	Dissolved Oxygen mg/L	43	11.3	0.4	1.3	10.9	9.5	15.6	13.4		
	Conductivity mS/cm	44	150	13	44	147	72	293	216		
Clarity	Turbidity NTU	44	**2.92**	0.91	3.07	1.90	0.58	16.30	7.92	**C**	*C*
	Black disc visible depth m	42	**2.7**	0.4	1.3	2.5	0.4	7.2	4.8	**C**	*C*
	Total suspended solids	42	2	1	2	1	0	12	5		
E. coli	CAW 774 - 2002	43	169	120	402	**75**	3	2600	**423**	**C**	*B*
cfu/100mL	2003 recreational MAC	21	301			150			**780**	**D**	*B*
Macroinvertebrate Community Score	MCI	13	**105.8**	5.9	10.8	109.0	82.0	120.0	116.4	**B**	*B*
Semi-qualitative MCI	SQMCI	13	**5.1**	0.7	1.3	5.1	3.3	7.1	7.1	**B**	*B*
Periphyton	periphyton score	11	**7.4**	1.2	2.0	7.9	4.3	9.8	9.8	**B**	*A*
	% long filaments	0									*A*
OVERALL WATER QUALITY CLASSIFICATION:					**D**	Downgrade					B

NCC18 - Groom Creek falls from Class B two classes to D. A marked (3 fold) increase in nitrate-N has occurred. The maximum nitrate-N detected by sampling is 4.1 mg/L (0.75 mg/L for 2000-7), which would indicate that higher values will have occurred, but have not been detected by grab sampling. It is likely that the increase in nitrate in Groom Creek is related to extensive clear-felling. Other declines in condition include MCI (down 1.5 points), periphyton (down 1.7 points), and black disc (down 0.2 m).

2.1.2. The Wakapuaka River and sub-catchments

In the upper Wakapuaka catchment, the Lud, Teal, and Wakapuaka Rivers flow in a northerly direction to Hira, the three branches are of similar size and drain predominantly plantation forestry, although the mid and lower reaches of the Lud and Teal are more open paddock lands associated with small farms and lifestyle blocks. Downstream of Hira, the mainstem of the Wakapuaka flows through open farm land with mainly cleared or scrubland hill slopes.

NCC25 – Wakapuaka at Maori Pa Rd (Lower)

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	2007
Nutrients	Nitrate-Nitrogen	47	**0.20**	0.06	0.22	0.10	0.02	1.10	0.54	**C**	*C*
	Ammonia-Nitrogen	42	**0.004**	0.001	0.003	0.003	0.003	0.015	0.010		
	Dissolved Reactive Phosphorus	47	**0.006**	0.001	0.003	0.005	0.001	0.014	0.011	**B**	*B*
Physical	Acidity - pH	47	**8.1**	0.1	0.5	8.1	7.0	9.1	8.8	**A**	*A*
	Water Temperature °C	48	13.3	1.1	3.9	13.3	6.4	21.0	**21.0**	**B**	*B*
	Dissolved Oxygen %	47	**107.7**	4.2	14.8	105.9	77.6	143.7	130.1	**C**	*C*
	Dissolved Oxygen mg/L	46	11.3	0.5	1.7	11.1	7.4	16.0	14.0		
	Conductivity mS/cm	47	210	13	44	203	137	372	294		
Clarity	Turbidity NTU	47	**1.54**	0.47	1.65	0.90	0.41	9.57	4.01	**B**	*B*
	Black disc visible depth m	47	**4.5**	0.6	2.0	4.3	1.2	10.0	8.0	**B**	*B*
	Total suspended solids	45	1	0	1	1	0	5	2		
E. coli	CAW 774 - 2002	47	155	69	241	**73**	3	1300	**438**	**C**	*C*
cfu/100mL	2003 recreational MAC	23	166			80			**369**	**C**	*D*
Macroinvertebrate Community Score	MCI	13	**102.1**	4.4	8.0	100.0	89.0	118.0	114.4	**B**	*B*
Semi-qualitative MCI	SQMCI	13	**5.1**	0.6	1.1	5.2	3.1	6.7	6.6	**B**	*C*
Periphyton	periphyton score	13	**8.0**	1.0	1.9	9.0	3.7	9.9	9.9	**A**	*A*
	% long filaments	2	0.6	0.7	0.5	0.6	0.3	1.0	1.0		*A*
OVERALL WATER QUALITY CLASSIFICATION:					**B**	Upgrade					C

The biological indicators for NCC25 – Wakapuaka at Maori Pa Rd have improved since 2007, the periphyton median score is up 0.9 points, and SQMCI is up 0.6 points. These improvements push NCC25 up to class B. The site shows a tendency to excess oxygen, this usually implies strong algal activity driving-up the oxygen concentration, and is evidence of nutrient enrichment, although the nutrient levels are low (the nutrient available may be rapidly taken-up into algal cells).

NCC27 – Wakapuaka at Hira (Middle)

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	2007
Nutrients	Nitrate-Nitrogen	47	**0.15**	0.04	0.13	0.10	0.01	0.49	0.38	**C**	*B*
	Ammonia-Nitrogen	42	**0.004**	0.001	0.003	0.003	0.003	0.014	0.009		
	Dissolved Reactive Phosphorus	47	**0.006**	0.001	0.003	0.006	0.001	0.021	0.009	**B**	*B*
Physical	Acidity - pH	47	**8.2**	0.1	0.4	8.2	7.3	9.0	8.8	**A**	*A*
	Water Temperature °C	48	11.7	1.0	3.4	12.0	5.4	18.4	**17.6**	**A**	*A*
	Dissolved Oxygen %	47	**104.5**	2.2	7.9	103.6	92.0	135.2	116.3	**B**	*B*
	Dissolved Oxygen mg/L	46	11.4	0.4	1.2	11.2	9.2	13.5	13.3		
	Conductivity mS/cm	47	208	13	45	203	143	378	299		
Clarity	Turbidity NTU	47	**1.18**	0.23	0.80	0.97	0.38	4.40	2.40	**B**	*B*
	Black disc visible depth m	46	**4.6**	0.5	1.6	4.4	1.5	8.9	7.2	**B**	*B*
	Total suspended solids	45	1	0	0	1	0	2	2		
E. coli	CAW 774 - 2002	47	166	124	434	**72**	3	3000	**333**	**B**	*B*
cfu/100mL	2003 recreational MAC	23	250			104			**344**	**C**	*B*
Macroinvertebrate Community Score	MCI	13	**124.8**	3.5	6.5	124.0	112.0	135.0	133.8	**A**	*A*
Semi-qualitative MCI	SQMCI	13	**6.6**	0.5	0.9	6.7	5.0	7.7	7.7	**A**	*A*
Periphyton	periphyton score	14	**8.6**	1.1	2.0	9.0	2.0	10.0	10.0	**A**	*A*
	% long filaments	0									*A*
OVERALL WATER QUALITY CLASSIFICATION:					**B**	Downgrade					A

The Wakapuaka at Hira (NCC27) is downgraded to class B status, mainly on account of the increase in nitrate-N concentration, which has edged this parameter down to class C. The increase in nitrate-N at Hira may be a consequence of the increases in the Lud and Teal Rivers. NCC28 – Wakapuaka (upper) at Duckpond Rd shows no evidence of increased nutrient levels.

NCC28 – Wakapuaka at Duckpond Rd (Upper)

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	*2007*
Nutrients	Nitrate-Nitrogen	47	**0.09**	0.02	0.07	0.07	0.01	0.24	0.20	**B**	*B*
	Ammonia-Nitrogen	42	**0.004**	0.001	0.004	0.003	0.003	0.025	0.007		
	Dissolved Reactive Phosphorus	47	**0.006**	0.001	0.002	0.006	0.001	0.013	0.011	**B**	*A*
Physical	Acidity - pH	47	**8.2**	0.1	0.4	8.2	7.4	9.2	8.8	**A**	*A*
	Water Temperature °C	48	11.0	0.7	2.6	11.1	6.5	17.0	**16.2**	**A**	*A*
	Dissolved Oxygen %	47	**105.0**	2.2	7.6	103.7	91.7	126.3	117.4	**B**	*B*
	Dissolved Oxygen mg/L	46	11.6	0.3	1.1	11.5	9.4	13.8	13.3		
	Conductivity mS/cm	47	206	13	45	201	114	371	299		
Clarity	Turbidity NTU	46	**0.97**	0.16	0.55	0.79	0.34	2.52	2.01	**A**	*A*
	Black disc visible depth m	45	**5.2**	0.5	1.8	4.8	2.1	9.5	7.7	**B**	*B*
	Total suspended solids	45	1	0	0	1	0	2	2		
E. coli	CAW 774 - 2002	47	41	21	75	**10**	3	425	**152**	**B**	*B*
cfu/100mL	2003 recreational MAC	23	65			25			**237**	**B**	*B*
Macroinvertebrate Community Score	MCI	13	**130.8**	4.0	7.4	131.0	116.0	144.0	140.4	**A**	*A*
Semi-qualitative MCI	SQMCI	13	**7.1**	0.3	0.6	7.1	6.2	8.1	8.1	**A**	*A*
Periphyton	periphyton score	14	**8.7**	0.5	1.0	8.5	6.5	10.0	10.0	**A**	*A*
	% long filaments	1	5.0			5.0	5.0	5.0	5.0		*A*
OVERALL WATER QUALITY CLASSIFICATION:					**A**						A

The Wakapuaka at Duckpond Rd (NCC28) site currently serves as a reference site for the catchment, and shows little evidence of degradation. Changes in the river at Hira may be due to the influence of water from the more degraded Lud (NCC29/30) and Teal (NCC32). While the NCC28 retains is A classification, it is important to note that, given the dominance of plantation forestry, logging of this catchment will eventually take place, and stream health degradation should be anticipated, especially in nutrient levels and the associated knock-on effects.

NCC29 – Lud at SH6 (Lower)

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	*2007*
Nutrients	Nitrate-Nitrogen	47	**0.52**	0.12	0.40	0.34	0.03	1.60	1.17	**E**	*D*
	Ammonia-Nitrogen	42	**0.008**	0.002	0.006	0.006	0.003	0.030	0.018		
	Dissolved Reactive Phosphorus	47	**0.011**	0.001	0.004	0.010	0.003	0.024	0.017	**C**	*C*
Physical	Acidity - pH	47	**7.7**	0.1	0.3	7.7	7.0	8.5	8.2	**A**	*A*
	Water Temperature °C	48	13.1	1.0	3.7	13.4	6.5	20.4	**19.6**	**A**	*B*
	Dissolved Oxygen %	47	**99.7**	1.9	6.8	99.0	87.7	124.4	110.0	**A**	*B*
	Dissolved Oxygen mg/L	46	10.6	0.3	1.2	10.4	8.6	12.6	12.4		
	Conductivity mS/cm	47	146	9	31	138	106	259	208		
Clarity	Turbidity NTU	47	**1.97**	0.34	1.17	1.64	0.58	6.20	3.62	**B**	*B*
	Black disc visible depth m	46	**2.8**	0.4	1.3	2.7	0.9	6.8	5.7	**C**	*D*
	Total suspended solids	45	13	22	76	1	0	510	4		
E. coli	CAW 774 - 2002	47	4848	7509	26265	**365**	17	180000	**3170**	**C**	*C*
cfu/100mL	2003 recreational MAC	23	8670			860			**3590**	**D**	*D*
Macroinvertebrate Community Score	MCI	13	**112.7**	4.7	8.6	114.0	97.0	131.0	123.8	**B**	*B*
Semi-qualitative MCI	SQMCI	13	**6.2**	0.4	0.7	6.4	4.8	7.2	7.0	**A**	*A*
Periphyton	periphyton score	14	**8.7**	1.1	2.0	9.7	3.5	10.0	10.0	**A**	*A*
	% long filaments	0									*A*
OVERALL WATER QUALITY CLASSIFICATION:					**C**						C

Conditions in the lower Lud at SH6 are consistent with those in 2007. Minor improvements in oxygen status, water temperature, and black disc are indicated, which all fell at their class thresholds, respectively. The site retains its overall C classification, which is supported by the biological indicators - SQMCI and periphyton scores.

NCC30 – Lud at 4.7km (Upper)

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	*2007*
Nutrients	Nitrate-Nitrogen	47	**0.38**	0.10	0.36	0.32	0.01	1.40	1.09	**D**	*C*
	Ammonia-Nitrogen	42	**0.024**	0.035	0.116	0.005	0.003	0.760	0.017		
	Dissolved Reactive Phosphorus	47	**0.012**	0.001	0.005	0.012	0.003	0.024	0.021	**C**	*C*
Physical	Acidity - pH	47	**7.9**	0.1	0.4	7.8	7.2	8.7	8.5	**A**	*A*
	Water Temperature °C	48	14.7	1.2	4.1	14.0	8.0	24.6	**23.4**	**B**	*C*
	Dissolved Oxygen %	47	**107.3**	2.5	8.7	106.1	94.2	137.2	121.2	**C**	*C*
	Dissolved Oxygen mg/L	46	10.9	0.3	1.1	10.9	8.5	13.4	12.7		
	Conductivity mS/cm	46	130	8	29	122	103	243	194		
Clarity	Turbidity NTU	47	**2.63**	1.30	4.56	1.61	0.63	32.00	5.81	**C**	*C*
	Black disc visible depth m	45	**2.6**	0.3	1.1	2.5	0.5	5.2	5.0	**C**	*C*
	Total suspended solids	45	2	1	2	1	0	15	5		
E. coli	CAW 774 - 2002	47	699	530	1855	**200**	3	12000	**2620**	**C**	*C*
cfu/100mL	2003 recreational MAC	23	656			290			**2910**	**D**	*D*
Macroinvertebrate Community Score	MCI	13	**101.8**	10.9	20.0	109.0	53.0	119.0	118.4	**B**	*B*
Semi-qualitative MCI	SQMCI	13	**5.2**	0.7	1.3	5.4	2.7	7.2	6.7	**B**	*B*
Periphyton	periphyton score	14	**8.1**	1.0	1.9	8.8	4.0	10.0	9.7	**A**	*A*
	% long filaments	5	5.9	5.6	6.4	2.8	0.3	16.0	14.5		*A*
OVERALL WATER QUALITY CLASSIFICATION:				**C**							C

The upper Lud at 4.7 km retains its overall class C rating. There have, however, been various notable changes in certain indicator groups. The data suggest a decline in faecal contamination since 2007, the upper values have fallen and the mean has fallen by 450 cfu/100mL. There has been a doubling in the mean nitrate-N (change from C to D), and mean MCI has fallen by 10 points. There has been large scale clear-cut logging in the Upper Lud since the last reporting period. Nitrates could also be from urea, the upper valley has sheep that access the tributaries. Cows are also present but fenced away from the stream; cows and horses access the stream below the monitoring site. Livestock including wildfowl are also present on the Macs Rd and Frost Rd tributaries of the Lud.

NCC32 – Teal at 1.9km

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	*2007*
Nutrients	Nitrate-Nitrogen	47	**0.15**	0.05	0.19	0.10	0.00	1.10	0.40	**C**	*A*
	Ammonia-Nitrogen	42	**0.005**	0.002	0.006	0.003	0.003	0.037	0.010		
	Dissolved Reactive Phosphorus	47	**0.006**	0.001	0.003	0.005	0.002	0.015	0.010	**B**	*A*
Physical	Acidity - pH	47	**8.3**	0.1	0.4	8.3	7.5	9.3	8.9	**A**	*A*
	Water Temperature °C	48	12.1	1.0	3.4	12.0	6.4	19.4	**19.0**	**A**	*A*
	Dissolved Oxygen %	47	**105.2**	2.3	8.0	103.7	93.0	138.0	115.9	**C**	*C*
	Dissolved Oxygen mg/L	46	11.3	0.3	1.0	11.3	9.0	13.4	13.2		
	Conductivity mS/cm	47	238	15	51	232	161	430	336		
Clarity	Turbidity NTU	47	**0.91**	0.15	0.53	0.68	0.32	3.00	1.77	**A**	*A*
	Black disc visible depth m	47	**4.9**	0.6	2.0	4.5	0.8	10.0	8.0	**B**	*B*
	Total suspended solids	45	1	0	1	1	0	5	2		
E. coli	CAW 774 - 2002	46	102	106	366	**19**	3	2300	**345**	**B**	*C*
cfu/100mL	2003 recreational MAC	23	186			30			**942**	**D**	*D*
Macroinvertebrate Community Score	MCI	13	**120.7**	8.2	15.0	119.0	101.0	149.0	142.4	**A**	*B*
Semi-qualitative MCI	SQMCI	13	**6.5**	0.5	0.9	6.6	4.7	8.1	7.7	**A**	*A*
Periphyton	periphyton score	14	**8.3**	0.7	1.4	8.0	6.3	10.0	10.0	**A**	*A*
	% long filaments	2	13.5	22.5	16.3	13.5	2.0	25.0	23.9		*D*
OVERALL WATER QUALITY CLASSIFICATION:					**B**	Re-grade (see notes)					C

With the values and parameter scores recorded in 2007 (Wilkinson, 2007a) at this site cannot have been classed correctly at C, the 2007 values achieve a class B. The current values also achieve an overall B.

The Teal at 1.9 km has had a 3-fold increase in mean nitrate-N, reducing the class from A to C. At the same time there has been a noticeable increase in MCI (median up 13 points) which makes this site borderline A for MCI. There has been some clear-cut logging in the uppermost reaches of the Teal, and this may account for the increase in nitrate-N observed.

NCC33 – Pitchers at 890 m

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	*2007*
Nutrients	Nitrate-Nitrogen	47	**0.03**	0.01	0.04	0.02	0.00	0.26	0.08	**A**	*A*
	Ammonia-Nitrogen	42	**0.004**	0.001	0.003	0.003	0.003	0.016	0.007		
	Dissolved Reactive Phosphorus	47	**0.011**	0.001	0.005	0.010	0.003	0.036	0.018	**C**	*C*
Physical	Acidity - pH	47	**7.8**	0.1	0.3	7.9	7.1	8.6	8.2	**A**	*A*
	Water Temperature °C	48	11.0	0.9	3.2	10.8	0.6	17.6	**17.2**	**A**	*A*
	Dissolved Oxygen %	47	**102.0**	2.3	8.2	101.7	81.6	127.1	117.1	**A**	*A*
	Dissolved Oxygen mg/L	46	11.2	0.3	1.0	11.2	9.0	13.3	12.8		
	Conductivity mS/cm	47	125	8	27	122	72	224	167		
Clarity	Turbidity NTU	47	**0.96**	0.22	0.77	0.80	0.25	5.12	1.94	**A**	*B*
	Black disc visible depth m	46	**4.6**	0.3	1.1	4.4	1.4	6.4	6.2	**B**	*B*
	Total suspended solids	45	1	0	1	1	0	4	2		
E. coli	CAW 774 - 2002	47	66	51	180	**20**	3	1100	**191**	**B**	*B*
cfu/100mL	2003 recreational MAC	23	114			25			**560**	**D**	*A*
Macroinvertebrate Community Score	MCI	13	**135.7**	8.9	16.3	134.0	111.0	180.0	159.6	**A**	*A*
Semi-qualitative MCI	SQMCI	13	**7.3**	0.4	0.8	7.4	5.6	9.0	8.3	**A**	*A*
Periphyton	periphyton score	13	**8.2**	1.1	2.0	8.4	2.5	10.0	10.0	**A**	*A*
	% long filaments	3	10.3	12.9	11.4	5.3	2.3	23.3	21.5		*A*
OVERALL WATER QUALITY CLASSIFICATION:					**A**						A

Pitchers Stream which drains westwards into the lower reaches of the Wakapuaka shows negligible evidence of change since 2007. It holds its A classification, and remains as a potential reference quality site.

2.1.3. *The Whangamoa River and side streams*

The Whangamoa is the next major catchment north and east of the Wakapuaka, on the westward flank of the Bryant Ranges, and drains a long straight valley in a north-easterly direction parallel to State Highway 6. The catchment is predominantly plantation forestry with remnant native and regenerating bush, and areas of scrubland.

NCC34 – Whangamoa at Kokorua Bridge (Lower)

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	*2007*
Nutrients	Nitrate-Nitrogen	46	**0.08**	0.03	0.09	0.03	0.00	0.29	0.26	**B**	*B*
	Ammonia-Nitrogen	42	**0.006**	0.003	0.011	0.003	0.003	0.067	0.012		
	Dissolved Reactive Phosphorus	47	**0.005**	0.001	0.003	0.005	0.001	0.012	0.009	**A**	*A*
Physical	Acidity - pH	47	**7.9**	0.1	0.4	7.9	7.2	8.8	8.6	**A**	*A*
	Water Temperature °C	47	12.1	1.1	3.9	12.1	4.2	21.8	**20.3**	**B**	*B*
	Dissolved Oxygen %	47	**107.5**	2.7	9.5	105.9	84.3	131.8	123.8	**C**	*B*
	Dissolved Oxygen mg/L	46	11.6	0.3	1.1	11.6	9.3	13.9	13.3		
	Conductivity mS/cm	47	178	11	38	181	71	326	214		
Clarity	Turbidity NTU	47	**1.21**	0.50	1.74	0.74	0.24	9.40	2.53	**B**	*B*
	Black disc visible depth m	47	**5.0**	0.5	1.8	4.9	0.9	9.5	7.4	**B**	*B*
	Total suspended solids	45	2	2	8	1	0	53	5		
E. coli	CAW 774 - 2002	47	158	90	315	**65**	3	1600	**640**	**C**	*C*
cfu/100mL	2003 recreational MAC	23	217			85			**1284**	**D**	*B*
Macroinvertebrate Community Score	MCI	13	**120.9**	5.1	9.4	120.0	105.0	135.0	134.4	**A**	*A*
Semi-qualitative MCI	SQMCI	13	**6.3**	0.5	1.0	6.7	4.4	7.7	7.4	**A**	*A*
Periphyton	periphyton score	14	**7.9**	0.6	1.1	8.0	5.4	9.5	9.2	**A**	*A*
	% long filaments	5	9.0	8.0	9.2	8.0	0.8	23.5	21.0		*A*
OVERALL WATER QUALITY CLASSIFICATION:					**B**	Downgrade					A

The Whangamoa at Kokorua Bridge (NCC34) is downgraded from A to B, although the changes are marginal. There is an increased tendency to excess oxygen with the median up 4.5%. The overall median *E. coli* count has halved, however, the summer recreational E. coli level has risen significantly (refer Section 1.3.6). The reduced overall E. coli levels may indicate a reduced faecal load, and this may be due to changes in livestock densities; the lowland is mainly grazed by beef cattle.

NCC36 – Whangamoa at Hippolite Road (Upper)

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	*2007*
Nutrients	Nitrate-Nitrogen	47	**0.15**	0.02	0.09	0.11	0.03	0.34	0.29	**C**	*C*
	Ammonia-Nitrogen	42	**0.006**	0.003	0.010	0.003	0.003	0.057	0.027		
	Dissolved Reactive Phosphorus	47	**0.006**	0.002	0.006	0.006	0.001	0.046	0.009	**B**	*B*
Physical	Acidity - pH	47	**8.1**	0.1	0.3	8.1	7.3	8.7	8.6	**A**	*A*
	Water Temperature °C	48	11.6	0.9	3.1	11.5	6.1	19.2	**18.1**	**A**	*A*
	Dissolved Oxygen %	47	**104.0**	2.5	8.8	102.5	76.0	135.7	118.3	**B**	*A*
	Dissolved Oxygen mg/L	46	11.3	0.3	1.1	11.3	9.1	13.8	13.1		
	Conductivity mS/cm	47	205	11	38	204	136	372	234		
Clarity	Turbidity NTU	47	**0.80**	0.15	0.53	0.64	0.30	3.23	1.65	**A**	*A*
	Black disc visible depth m	44	**6.1**	0.6	2.1	6.0	1.6	10.4	9.9	**A**	*B*
	Total suspended solids	45	1	0	1	1	0	5	2		
E. coli	CAW 774 - 2002	47	27	11	39	**15**	3	216	**79**	**B**	*B*
cfu/100mL	2003 recreational MAC	23	43			30			**139**	**B**	*A*
Macroinvertebrate Community Score	MCI	13	**140.5**	4.2	7.8	141.0	129.0	151.0	151.0	**A**	*A*
Semi-qualitative MCI	SQMCI	13	**7.4**	0.2	0.4	7.3	6.7	8.0	7.9	**A**	*A*
Periphyton	periphyton score	14	**9.0**	0.7	1.3	9.3	5.8	10.0	10.0	**A**	*A*
	% long filaments	0									*A*
OVERALL WATER QUALITY CLASSIFICATION:					**A**						A

The Whangamoa at Hippolite Road (NCC36) shows excellent macroinvertebrate diversity and abundance, and has a good periphyton score. MCI has increased by 6 points since 2007, and nitrate-nitrogen has declined slightly. This site retains its class A rating, but may be susceptible to future logging operations.

NCC37 – Graham at SH6

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	2007
Nutrients	Nitrate-Nitrogen	47	**0.06**	0.01	0.04	0.05	0.01	0.20	0.12	**A**	*A*
	Ammonia-Nitrogen	42	**0.005**	0.002	0.007	0.003	0.003	0.038	0.014		
	Dissolved Reactive Phosphorus	47	**0.006**	0.001	0.003	0.005	0.001	0.017	0.009	**B**	*B*
Physical	Acidity - pH	47	**8.1**	0.1	0.4	8.1	7.3	8.8	8.6	**A**	*A*
	Water Temperature °C	48	10.8	0.8	2.7	11.0	5.8	18.0	**16.8**	**A**	*A*
	Dissolved Oxygen %	47	**103.2**	2.1	7.2	102.1	84.6	127.1	114.4	**B**	*A*
	Dissolved Oxygen mg/L	46	11.5	0.3	1.0	11.6	9.0	13.4	13.1		
	Conductivity mS/cm	47	208	12	43	208	112	382	245		
Clarity	Turbidity NTU	46	**1.15**	0.33	1.14	0.80	0.29	6.52	3.14	**B**	*B*
	Black disc visible depth m	45	**3.8**	0.4	1.3	3.8	0.9	6.6	6.0	**C**	*C*
	Total suspended solids	45	1	0	2	1	0	9	4		
E. coli	CAW 774 - 2002	46	16	9	31	**8**	3	165	**46**	**B**	*B*
cfu/100mL	2003 recreational MAC	23	25			10			**131**	**B**	*A*
Macroinvertebrate Community Score	MCI	13	**135.1**	4.6	8.4	137.0	126.0	153.0	148.8	**A**	*A*
Semi-qualitative MCI	SQMCI	13	**7.4**	0.3	0.5	7.5	6.5	8.0	8.0	**A**	*A*
Periphyton	periphyton score	14	**8.7**	0.4	0.8	8.7	7.1	9.9	9.8	**A**	*A*
	% long filaments	2	1.1	1.7	1.2	1.1	0.3	2.0	1.9		*A*
	OVERALL WATER QUALITY CLASSIFICATION:			**A**							A

The Graham at SH6 (NCC37) is located close to NCC36, the Whangamoa at Hippolite Rd, and drains a very similar catchment. The water quality and biological indicators have almost identical values to those in NCC36. The site classes as A – excellent. It could be argued that NCC37 and NCC36 could be merged with a single site below the confluence of the two branches. This would result in a loss of specific information for each channel, but supplementary samples could be collected if a particular activity was causing stress in one or other of the channels.

Note that the black disk depth class C is misleading, the physical water depth in the creek limits the observable optical depth. The DRP value for September 2009 was recorded as 0.082 mg/L, this value is inconsistent with all other values for this and similar sites and has been treated as a reporting decimal place error, and duly adjusted to 0.008 mg/L.

NCC38 – Collins at SH6

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	2007
Nutrients	Nitrate-Nitrogen	47	**0.12**	0.02	0.08	0.11	0.00	0.34	0.26	**C**	*C*
	Ammonia-Nitrogen	42	**0.007**	0.002	0.007	0.005	0.003	0.040	0.017		
	Dissolved Reactive Phosphorus	47	**0.007**	0.001	0.003	0.007	0.001	0.012	0.011	**B**	*B*
Physical	Acidity - pH	47	**8.0**	0.1	0.4	8.0	7.1	8.9	8.5	**A**	*A*
	Water Temperature °C	48	11.3	1.0	3.6	11.8	4.3	20.4	**19.3**	**A**	*B*
	Dissolved Oxygen %	47	**106.3**	2.7	9.6	106.0	76.3	138.2	118.4	**C**	*B*
	Dissolved Oxygen mg/L	46	11.7	0.3	1.2	11.8	9.6	14.8	13.6		
	Conductivity mS/cm	47	144	9	32	147	87	244	195		
Clarity	Turbidity NTU	47	**2.04**	0.76	2.64	1.20	0.58	14.60	4.12	**C**	*C*
	Black disc visible depth m	46	**3.3**	0.4	1.3	3.1	0.5	6.0	5.7	**C**	*C*
	Total suspended solids	45	1	0	1	1	0	9	4		
E. coli	CAW 774 - 2002	47	102	44	155	**45**	3	800	**371**	**B**	*C*
cfu/100mL	2003 recreational MAC	23	155			75			**599**	**D**	*A*
Macroinvertebrate Community Score	MCI	13	**129.2**	3.8	7.0	128.0	122.0	148.0	140.2	**A**	*A*
Semi-qualitative MCI	SQMCI	13	**7.4**	0.3	0.6	7.6	6.4	8.5	8.0	**A**	*A*
Periphyton	periphyton score	14	**8.8**	0.8	1.5	9.3	5.0	10.0	10.0	**A**	*A*
	% long filaments	0									*A*
OVERALL WATER QUALITY CLASSIFICATION:				**B**							B

The Collins at SH6 (NCC38) is a more extensive sub-catchment of the Whangamoa, in the same way that the Brook is to the Maitai River. This site shows negligible changes since the 2007 classification update. There has been an increase in dissolved oxygen by around 4% indicating a greater tendency to excess oxygenation. An area of around 20 Ha has been logged in the last few years, but this shows little evidence of impacting conditions at NCC38. The site retains its B classification.

NCC39 – Dencker at Kokorua Rd

Parameters	(mg/L unless specified)	n	Mean	± 95% CI	Std Dev	Median	Min	Max	95 %ile	2013	2007
Nutrients	Nitrate-Nitrogen	47	**0.07**	0.02	0.08	0.05	0.00	0.29	0.26	**A**	*A*
	Ammonia-Nitrogen	42	**0.005**	0.002	0.006	0.003	0.003	0.035	0.017		
	Dissolved Reactive Phosphorus	47	**0.008**	0.001	0.003	0.008	0.001	0.014	0.013	**C**	*B*
Physical	Acidity - pH	47	**7.9**	0.1	0.4	8.0	7.1	8.6	8.5	**A**	*A*
	Water Temperature °C	48	11.0	0.9	3.3	11.5	4.5	19.2	**17.9**	**A**	*A*
	Dissolved Oxygen %	47	**105.3**	2.2	7.5	104.5	87.6	132.4	117.3	**C**	*B*
	Dissolved Oxygen mg/L	46	11.6	0.3	1.1	11.7	9.6	13.7	13.6		
	Conductivity mS/cm	47	154	10	36	160	91	264	204		
Clarity	Turbidity NTU	47	**2.10**	0.85	2.99	1.19	0.50	14.20	8.66	**C**	*C*
	Black disc visible depth m	45	**3.3**	0.4	1.5	3.0	0.8	9.3	5.5	**C**	*C*
	Total suspended solids	45	1	0	1	1	0	7	2		
E. coli	CAW 774 - 2002	47	307	195	682	**95**	3	3400	**1980**	**C**	*C*
cfu/100mL	2003 recreational MAC	23	439			160			**2350**	**D**	*B*
Macroinvertebrate Community Score	MCI	13	**128.4**	5.2	9.6	130.0	108.0	140.0	139.4	**A**	*A*
Semi-qualitative MCI	SQMCI	13	**6.9**	0.4	0.7	7.0	5.9	7.9	7.9	**A**	*A*
Periphyton	periphyton score	14	**8.4**	0.8	1.5	8.7	4.1	10.0	10.0	**A**	*A*
	% long filaments	1	14.8			14.8	14.8	14.8	14.8		*A*
OVERALL WATER QUALITY CLASSIFICATION:				**B**							B

NCC39 the Dencker at Kokorua Road characterises plantation forestry in its regrowth phase, and lies on the south eastern flank of the Whangamoa in the lower reaches 2 km north of State Highway 6. Conditions at NCC39 show minimal evidence of change since 2007. DRP has deteriorated from B to C. There has been a small increase in excess dissolved oxygen. The site retains its overall B class.

3. CATCHMENT OVERVIEWS

3.1. Interpretation of data

Long-term means

The updated classification summarised in Section 2.1 provides an indication of the status of each site. It is based on the full period of monitoring undertaken. The longer the period of record the greater any recent change must be to influence the mean or median value, this is simple mathematics. The long-term classifications give an integrated measure of the condition, but provide little information about the nature of the variations in concentrations over time.

Visual analysis of time-series data

Time-series data provide a visual indication of the variations, but can be of limited value if the time between samples is longer than the natural variation of a given parameter. In this case monitoring may only detect an almost random selection of values, which will over time represent the “mean” condition, but may also show an unrepresentative pattern of variation. Where the natural variation is slow, infrequent samples can provide an indication of the general patterns of variation. This is important to remember when analysing or interpreting time-series data.

Time-series data for the Nelson monitoring stations include approximately quarterly values for water quality and annual biological surveys. Although this frequency for water quality parameters is low, it does show the seasonal and longer-term patterns (Appendix 2).

Trend analyses and equivalence tests

The analyses carried-out to confirm changes or trends in the Nelson data include equivalence testing of means (Table 1), and Seasonal Kendall trend analysis (Appendix 3). These tools can be used to check whether “apparent” trends are real, or simply a consequence of when samples were taken. Measures of the significance of a trend, or the difference between two means, are often favoured where a “robust” indication of a difference or change is required. They can be used to support a conclusion.

Here, we have used seasonal adjustment and flow correction to compensate for when samples were taken, this was done using correlated flows and Seasonal Kendall Trend analysis within the NIWA “Time Trends” statistical analysis tool.

For equivalence testing, the data were split into equal six year halves, 2001 to end 2006, and 2007 to end 2012, predefined upper and lower test bounds were set as a percentage of the initial mean. A second subset of the data was examined, two five year halves, 2003 to end 2007, and 2008 to end 2012, consistent with the Seasonal Kendall analyses. The results of this second subset were very similar to the longer dataset. Full numerical results are available, but for ease of interpretation the results are expressed as an indication of the statistical strength or weakness of the difference and the direction of the difference, i.e., is it an increase or decrease. The MCI and SQMCI values are too infrequent for equivalence testing, the choice of year to use as the split for before and after subsets heavily influences the results, which are thus erratic and inconsistent.

No conclusive differences were found between 2001-7 and 2007-12 for conductivity, water temperature, or pH which can be confirmed by an examination of the time-series data presented in Appendix 2. The majority of changes or differences were detected in the nutrients, turbidity and E. coli. A calculated parameter N:P ratio = NO3-N / DRP was also examined, the combination of the two parameters either accentuates or minimises the differences in nutrient supply. An N:P ratio of 16, the Redfield Ratio, is ideal for normal plant growth, values greater or much greater than this indicate excess nitrogen (or phosphorus limited) conditions, values less than 16 indicate nitrogen limitation.

3.1.1. Hydrological setting and influence on observed water quality

The need to examine the hydrological context of the water quality and biological sampling, as well as, the overall year to year conditions is clear (Figures 3 to 5). In general, since 2007 winter water quality samples tend to have been taken during periods of moderately elevated flows. This is reflected in the water quality data; the peaks in various parameters are associated with runoff (e.g. nitrate-nitrogen, Figure 6, see also Appendix 2).

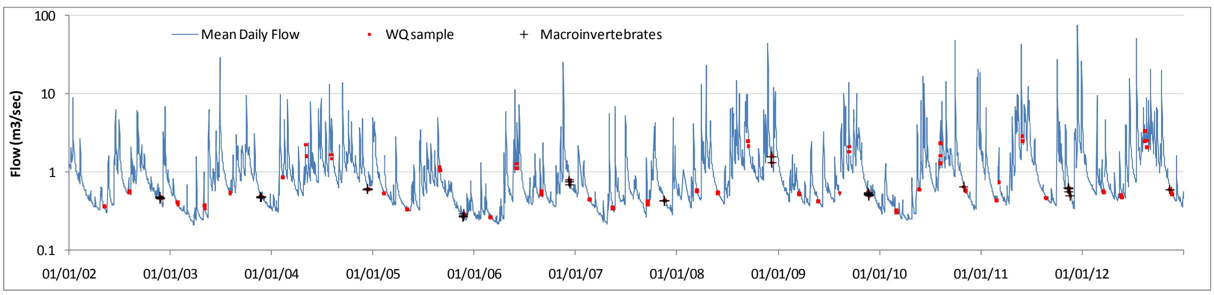


Figure 3. Water quality sampling and biological monitoring surveys in relation to river flow.

In addition to the Seasonal Kendall trend analysis, Lowess curves were also generated for some parameters and these highlight larger low frequency variations in the data, which also appear, in general, to be related to the wet weather winter samples from 2007 onwards.

Certain sites show clear trends over the monitoring period, but most sites show no trends, or the variation relates to more rapid processes occurring over several years, e.g., Sharlands Creek in the Maitai catchment showed elevated nitrate-N after logging in the early 2000s, this declined, only to be replaced by N released from extensive logging in Packer Creek from 2007 onwards (see Figure 14 below). The nitrate anion is highly mobile and responds to wet and dry weather, with strong wet weather peaks. The marked seasonal pattern is associated with its release from the break-down of vegetation in the winter months, and it's dilution and flushing into the stream network during the rainfall runoff (e.g. Figure 7 where the seasonal variation is very clear). The extent of winter nitrate leaching will depend on the volume of source material. While the seasonal pattern in variation is clear from site to site, when we compare the actual concentrations, the significance of the nitrogen source becomes apparent. Seasonal box-plots showing site by site data have been used to demonstrate this, the y-axis scales have been kept identical, so that those sites which are not loosing much nitrogen are clearly distinguished from those which are (e.g. Figure 15). In the Maitai catchment, the relatively undisturbed upper sites, Brook Upper (NCC 12) and Maitai Upper (NCC 16) are producing very little N, whereas Sharlands and Groom Creeks which have been extensively logged are delivering a high winter concentration of nitrate-N which contributes to the elevated N levels at the monitoring stations further downstream (discussed further in Section 3.3.1).

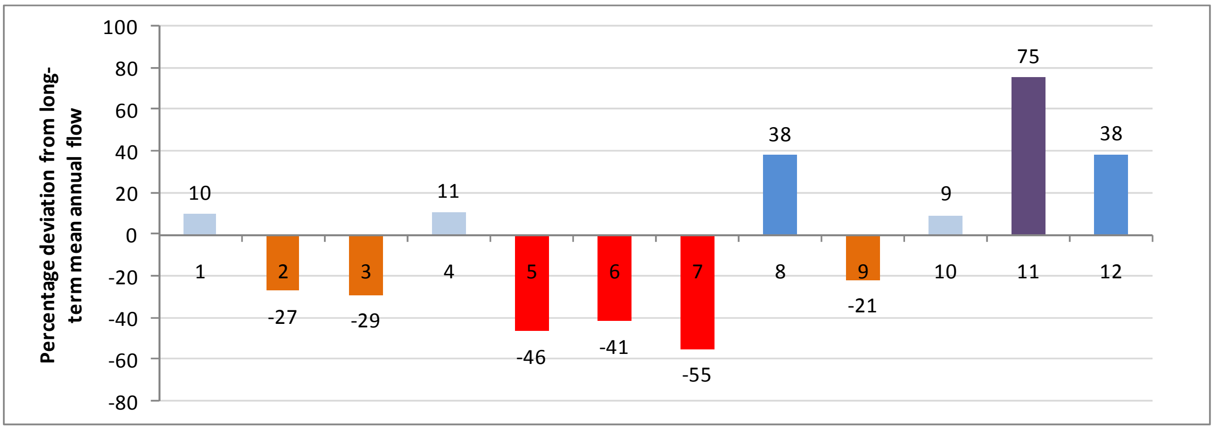


Figure 4. Wetter and drier years (2001 – 12 left to right) in the Nelson area; the percentage deviation of annual means from the long-term mean (1979 to 2012), based on data for the Wakapuaka at Hira.

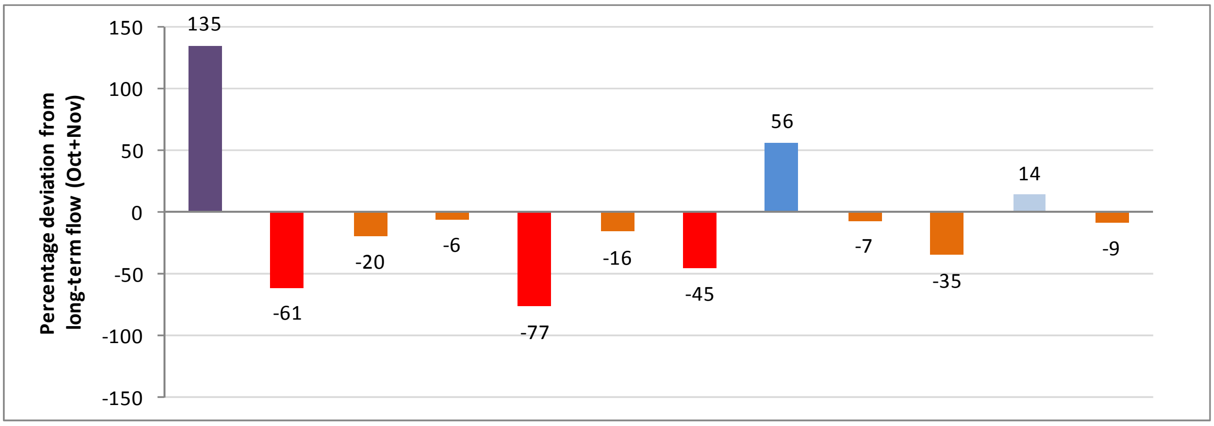


Figure 5. Hydrological setting of biological monitoring: dry or wet conditions in the October and November (2001 – 12 left to right) lead-up to surveys.

The influence of the broader year to year variation in flow is also apparent in the water quality data, and possibly to a more subtle extent in the biological data. The effect of the three years of relatively dry conditions (2005-7; Figures 4 and 5), compared to wetter years, can be seen in the nitrate-N and DRP observations, electrical conductivity, and MCI scores (Appendix 2). It is also possible, that there is a post-drought recovery period indicated by the data resulting in very low nutrient concentrations in 2008. Extended dry conditions halt the decomposition of organic matter and hence limit the supply of nitrogen for leaching (e.g., Goldberg and Gebauer, 2009). Subsequently, the initial drought-break flushes the available N out of the catchments, and the re-wetting of organic matter and the continuation of microbial decay mechanisms is slow such that the supply of N remains limited.

The specific conditions and pressures vary from catchment to catchment, and the following sections provide an overview for each of the four catchment groups.

3.2. Coastal and Urban Catchments

The sections of these streams that run through urban areas tend to be heavily impacted. The observations tend to differ from the more typical and consistent behaviours observed in the bigger catchments. Sneddon and Elvines (2012) summarises the contaminating impacts succinctly. Most of the creeks are impacted by runoff from residential/urban areas to some extent, many of the stream beds have been modified, straightened and have culverted sections. Certain of the catchments have specific pressures relating to industrial activities, livestock and solid waste disposal. Consequently, these sites have the lowest classification scores in the Nelson area (Table 1), and remain the focus of initiatives to reduce impacts and improve stream health (e.g., Stoke Streams Rescue Plan). Despite these low scores, various of the sites have been upgraded following the change scoring for PAH sediment contamination and or real improvements in condition (refer Section 2.1).

Table 1. Current and previous freshwater classifications

Site	NCC No	2007 Class		2013 Class	Change
Saxton at Main Rd	1	E	↑	**D**	Upgrade
Orphanage at Saxton Rd East	2	D		D	
Poorman at Seaview Rd	4	D		D	
Poorman at Barnicoat Walkway	5	C	↑	**B**	Upgrade
Jenkins at Pascoe St	6	E		E	
York at Waimea Rd	9	E		E	
Todds at SH6	21	D		D	
Hillwood at Glen Rd	40	D	↑	**C**	Upgrade

Because these sites are on generally self-contained small catchments with their own specific degradation issues, they are mostly described individually, whereas the patterns and characteristics of the larger catchments are discussed from the perspective of the whole catchment, or relevant zonation of the catchments. Appendix 5 provides a tabulated summary with brief interpretation of additional sampling along Saxton, Orphanage, Poormans, and Jenkins Creeks. These data clearly identify localised contamination sources, but interestingly conditions can improve in a downstream direction if no new pollution sources enter.

NCC01-Saxton at Main Rd and NCC02-Orphanage at Saxton Rd East

Elevated nitrogen levels all year round in (NCC01) Saxton at Main Road (Figures 6 and 7), suggest that beef and dairy livestock farming runoff in the upper catchment may still be impacting the stream. This may require further field investigation. Preliminary results from additional Stoke Stream Rescue water quality sampling indicates elevated faecal bacteria and moderate P and MCI scores in the upper catchments, and elevated N in upper tributaries of Saxton Creek.

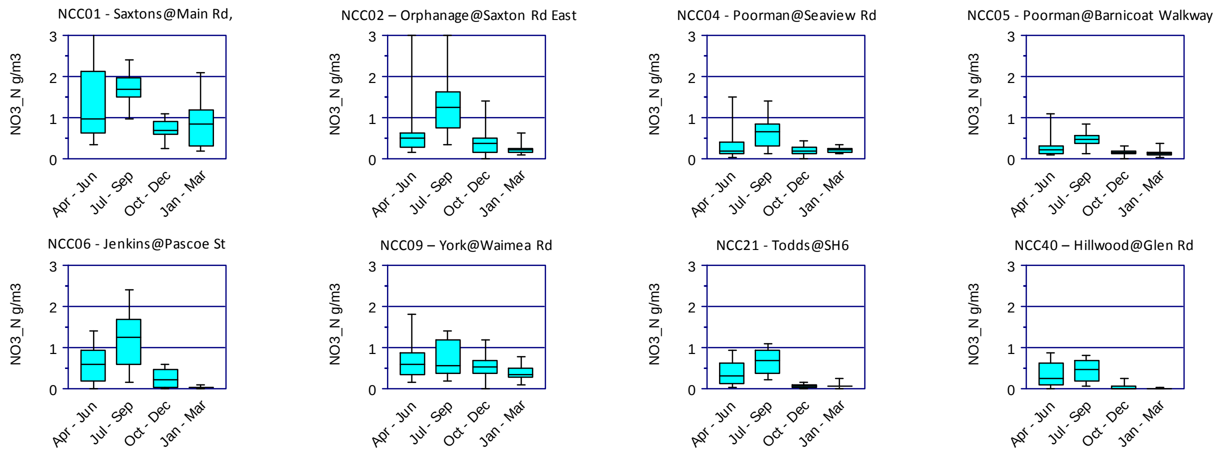


Figure 6. Box-plots of seasonal variation in nitrate-N for coastal and urban streams plotted with same y-axis extent for comparison of nitrate magnitude

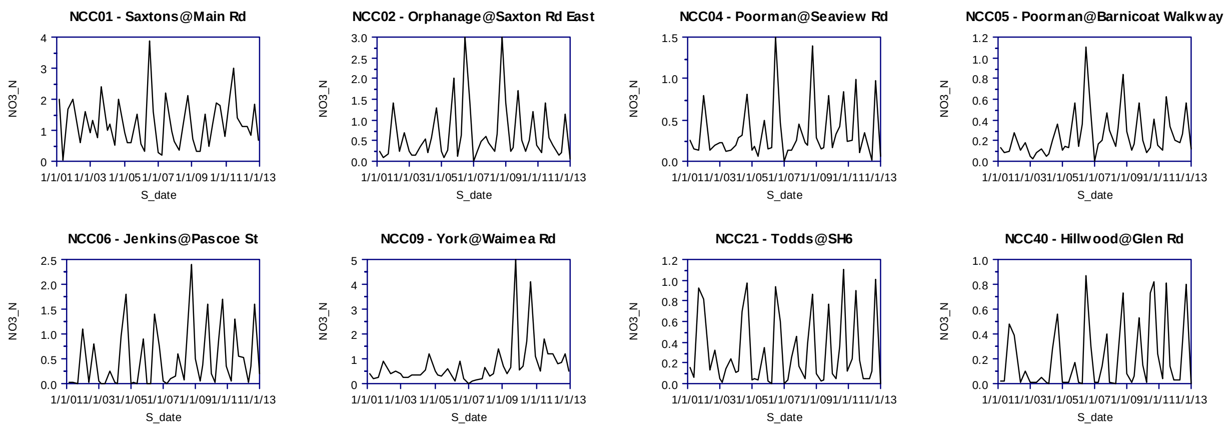


Figure 7. Time-series plots of raw nitrate-N data for the coastal and urban catchments

Saxton Creek (NCC01) showed a significant reduction in DRP (Tables 2 and 3, Figure 8), the cause for this is not immediately apparent. Recent MCI scores in Saxton Creek indicate better conditions than previously (Figure 9). The moderate improvement in biology may be in response to the declining DRP, or to other changes within the catchment; on-going efforts to clean-up the southern small streams may be showing some positive results.

Table 2. Equivalence testing results for selected water quality parameters

Site No. and Name	NO3_N 10%	Turb 5%	DRP 10%	DO% 10%	Log10_E. coli 5%	N:P_ratio
1-Saxton@Main Rd	inc	no diff	**strong -**	inc +	inc	**strong +**
2-Orphanage@Saxton Rd East	inc +	inc +	inc	no diff	inc	inc +
4-Poorman@Seaview Rd	inc +	inc -	inc	mod +	inc	inc
5-Poorman@Barnicoat Walkway	inc +	no diff	mod +	no diff	inc	inc +
6-Jenkins@Pascoe St	inc +	inc -	**strong +**	inc +	inc	inc +
9-York@Waimea Rd	**strong +**	inc --	inc +	no diff	inc	**strong ++**
21-Todds@SH6	inc	mod +	inc -	inc -	inc	inc +
40-Hillwood@Glen Rd	imp ++	inc	inc -	inc -	**strong +**	inc ++

Key:- no diff – means are the same; inc – inconclusive; mod – moderate evidence of a practically important difference; strong – strong evidence of a practically important difference; + increase; - decrease; ++/-- large increase/decrease.

Table 3. Seasonal Kendall significant or near significant trends in data for the coastal and urban streams

Monitoring Site	Parameter	Median value	Kendall statistic	Z	P	Median annual Sen slope	5% confidence limit	95% confidence limit
1 - Saxtons@Main Rd	DRP	0.0155	-47	-2.07	0.03868	-0.0008	-0.0020	-0.0002
	flow adjusted	0.0153	-62	-2.73	**0.00637**	-0.0008	-0.0020	-0.0004
9 -York@Waimea Rd	Nitrate-N	0.500	77	3.41	0.00065	0.0671	0.0347	0.1013
	flow adjusted	0.498	64	2.82	**0.00484**	0.0529	0.0188	0.0903
	N:P_ratio	49.9	100	4.43	0.00001	10.6123	5.7938	16.2932
	flow adjusted	61.7	68	3.00	**0.00273**	7.3013	2.9150	12.3712
21 - Todds@SH6	DRP	0.0195	-69	-3.05	0.00229	-0.0013	-0.0022	-0.0006
	flow adjusted	0.0193	-54	-2.37	**0.01778**	-0.0011	-0.0018	-0.0005

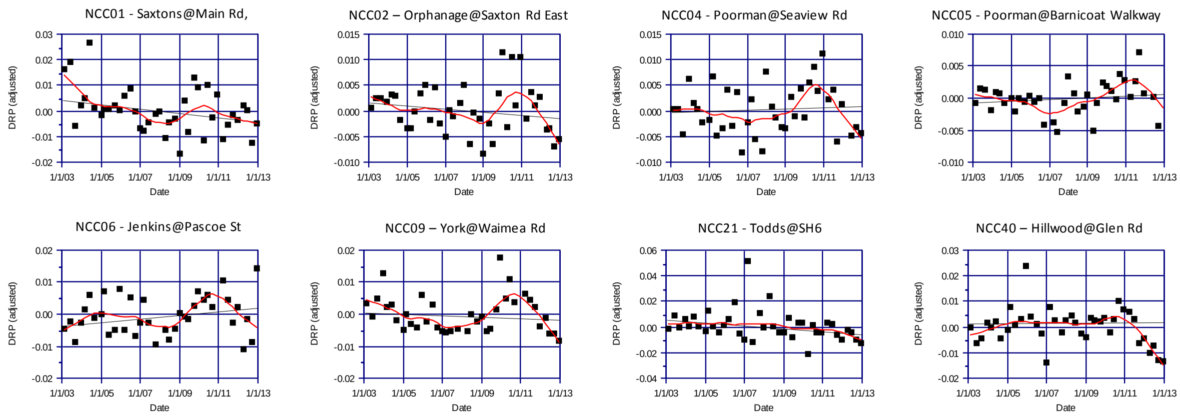


Figure 8. Time-series plots of flow adjusted dissolved reactive phosphorus with Seasonal Kendall trend and LOWESS curves

Table 4. Summarised findings of four sediment sampling surveys (after Sneddon and Elvines, 2012)

Catchment	Site	Trends (increase/decrease)	Levels and variability
Saxton	1-L	None	
Orphanage	2-L	Decreasing Zn since 2006	Elevated lead - 2006
Poorman	3-U	Marginally increasing Zn	Elevated LMW/HMW PAHs - 2006
	3-L	Possibly increasing Zn (no sample in 2012)	Elevated lead zinc - 2006
Jenkins	4-M	Decreasing Pb Zn, HMW PAH since 2006	
	4-L	Strongly decreasing Pb Zn, decreasing HMW PAH since 2006	High Cu, Pb, very high Zn – 2003, elevated Cu – all years
York	5-U	Marginally increasing Cu	
	5-M	Increasing Pb, increasing Zn until 2012	Elevated LMW/HMW PAHs – 2006 2010

Sneddon and Elvines (2012) summarises the trends in sediment contaminants for the urban catchments (Table 4), for which they have most importance. Zinc in Orphanage stream (NCC02) sediments is reported to have been declining since 2006 (Table 4). SQMCI in Orphanage Stream appears to have risen in recent years, but shows a pattern of variation similar to the changes in flow between wet and dry years (Figures 4 and 9). The differences between MCI and SQMCI may result from the relationships between the abundances of pollution sensitive and insensitive species, and the diversity of species, and how these are quantified in the score. Lower SQMCI values tended to coincide with dryer years, and may simply relate to the availability of suitable quality habitat and food supply (e.g. Lake, 2003).

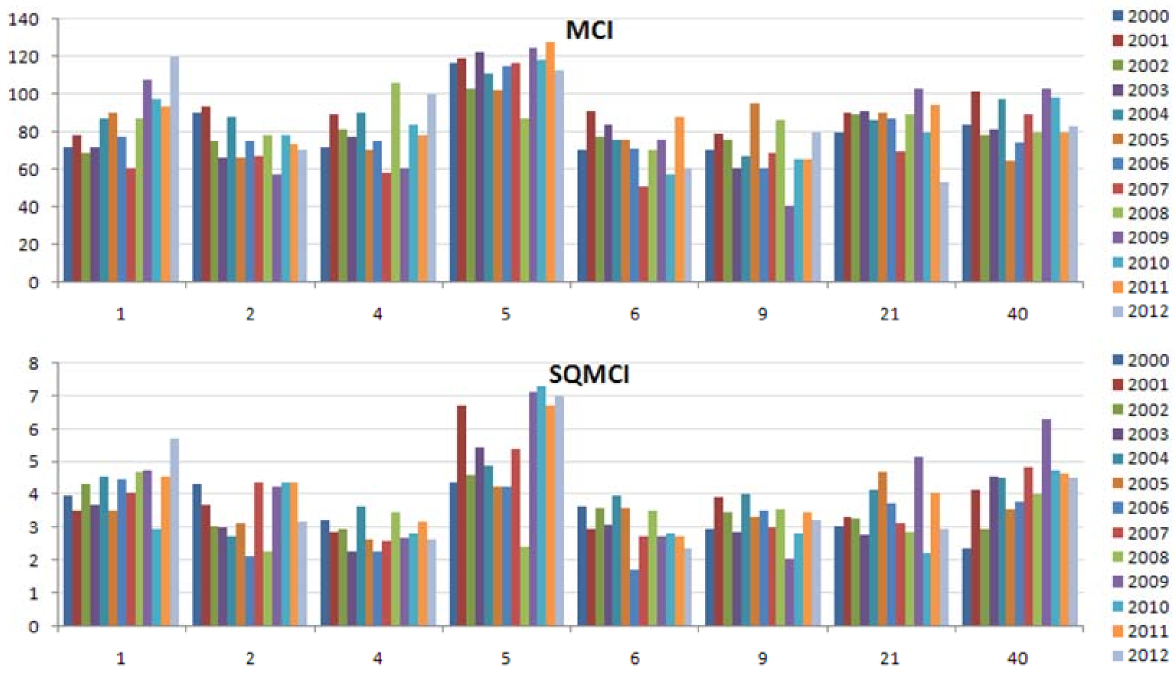


Figure 9. Annual MCI and SQMCI values in the Coastal and Urban Catchments

NCC04-Poorman at Seaview Road and NCC05-Poorman at Barnicoat Walkway

Recent fish salvage surveys prior to post-2001 gravel extraction/remediation work has shown Poorman Valley Stream to harbour a significant native fish community; making it a flagship for Stoke streams.

No significant trends were observed at either monitoring site in Poorman Valley Stream, although Sneddon and Elvines (2012) noted marginal increases in zinc (Table 4). Road runoff is a source of sediment contamination to Poorman at Seaview Rd (NCC04). Vehicle tyres are known to contain significant levels of zinc, roof run-off is also a well known source of zinc. The pattern in SQMCI variation in Poorman at Barnicoat Walkway (NCC05) was very similar to those in Orphanage Creek (Figure 9), and the changes in MCI were consistent with those for SQMCI.

Poorman at Barnicoat Walkway (NCC05) has been upgraded from C to B, due to improvements in SQMCI and PAH. The site should in any case be upgraded, because the sediment quality values used are not appropriate; the water quality site lies several kilometres upstream of sediment sampling site, and well above the urban area (see Section 1.3.4).

NCC06-Jenkins@Pascoe St

Jenkins Creek receives runoff from industrial sites, and has suffered elevated heavy metal and PAH contamination in its sediments (Table 4). These are now generally in decline (Sneddon and Elvines, 2012), however, the Jenkins lower site fell a class from D to E, on account of deteriorating MCI (Figure 9) and nitrate-N (Figure 10), although the nitrate trend is not significant. The equivalence tests (Table 2) suggest a slight increase in DRP, but this is not significant, and is not confirmed by Seasonal Kendall plots (Figure 8). Data on Jenkins Creek should be watched carefully to confirm whether there are trends in nitrate-N or DRP. In addition the catchment should be examined for evidence of possible changes that may lead to further deterioration. Preliminary results from additional sampling throughout the Jenkins catchment indicates elevated E. coli, poor clarity and moderate N, P and MCI in the upper tributaries.

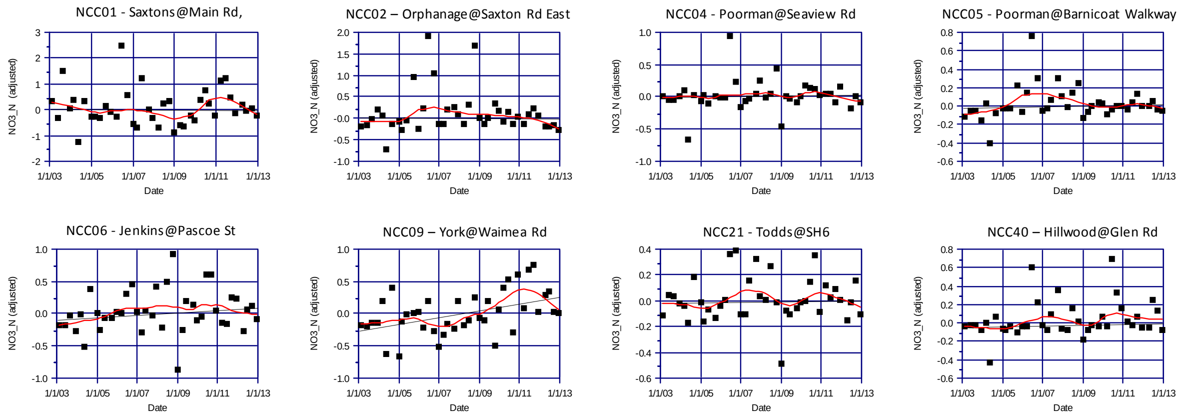


Figure 10. Time-series plots of flow adjusted nitrate-N with Seasonal Kendall trend and LOWESS curves

NCC09-York at Waimea Road

York Stream drains a valley containing two landfill sites and a quarry, and has shown a strong increase in nitrate-N concentrations (Tables 2 and 3, Figures 7 and 10). The difference in the pattern compared to the other streams is clearly apparent, the pattern and magnitude is also consistent with those observed in Sharlands (NCC17) and Groom Creeks (NCC18) (Figure 12). Potential causes of the elevated nitrate-N include logging, landfill leachate, and sewer cross-connections.

Several hectares of plantation forest have been cleared in the southern valley of the upper York catchment, and this N source may contribute to the strong wet weather (winter) nitrate peaks (Figure 7). The elevated dry-weather (summer, Figure 6) nitrate is more consistent with an undiluted point source, this suggests either a sewer cross connection with foul-water entering the creek, or elevated levels of leachate from the York Valley landfill. Electrical conductivity is typically elevated in York Valley, and this suggests a point source or geological/mineral origin, however, it has not risen with the nitrate. Elevated ammonium nitrogen might also be expected from landfill leachate; this has not been observed (see Appendix 2). Additional sampling downstream of the logged area and in the vicinity of the landfill might be beneficial for identifying the source of the elevated N. E. coli are elevated, and microbial source tracking indicated the presence of human faeces (March, 2011). However, more intensive bacteria sampling at several sites below the NCC managed York landfill and dye tests of the sewer network at Bishopdale to identify damaged pipes or cross-connections with storm water were inconclusive.

NCC21-Todds at SH6

The Todds Valley Stream is largely rural with scrub land cover with lifestyle blocks with small paddocks, the stream network has approximately 50% shading. No major trends in water quality or stream biota are apparent, although a moderate declining trend in DRP is noted (Table 3, Figure 8). Nitrate-N and turbidity are elevated and SQMCI is low. If the elevated N were due to leaking septic systems, then high values would be expected all year round (Figures 6 and 7), the high values appear to be associated with winter runoff episodes. It is not clear whether there is sufficient livestock to supply the nitrogen, or whether it is simply a consequence of the winter breakdown of organic matter. The extent of sheep and goat browsing in the catchment could be checked.

NCC40-Hillwood at Glen Rd

The Hillwood Stream catchment is dominated by scrubland in its headwaters, runs down past small-holdings and lifestyle blocks, and then alongside SH6 through cultivated farmland before crossing the Glen Road. The site is exhibiting a marked improving trend in SQMCI (Figure 9), a non-significant rising trend in N, and E. coli (Table 2). A possible weak association of elevated turbidity with low flow, may indicate that residential discharges are impacting the stream, however, both N and E. coli high values are associated with wet weather which indicates run-off. This site deserves further on foot investigation if the various causes of poor water quality are to be identified and acted upon.

3.3. Maitai and sub-catchments

As stated in Section 2.1.1 above, the Maitai catchment encloses a wide range of habitats, landuses, and stream channel types, ranging from remnant and regenerating native bush, to monoculture plantation forestry, lifestyle blocks, and peri-urban areas. Consequently, the freshwater monitoring sites in the catchment exhibit a range of conditions. The Maitai catchment upstream of Nelson CBD is not impacted by major industrial, commercial, or roading activities, and thus escapes the worst kinds of degradation observed in the Coastal and Urban streams. The freshwater classifications for the Maitai monitoring sites range from C to A (Table 5).

Table 5. Current and previous freshwater classifications for the Maitai

Site	NCC No	2007 Class		2013 Class	Change
Brook at Manuka St	10	D	↑	C	Upgrade
Brook at Burn Pl	11	-		C	
Brook at Motor Camp	12	A		A	
Maitai at Riverside	13	D	↑	C	Re-grade
Maitai at Groom Rd	15	C		C	
Maitai South Branch at Intake	16	A		A	
Sharland at Maitai Confluence	17	C	↓	D	Downgrade
Groom at Maitai Confluence	18	B	↓	D	Downgrade

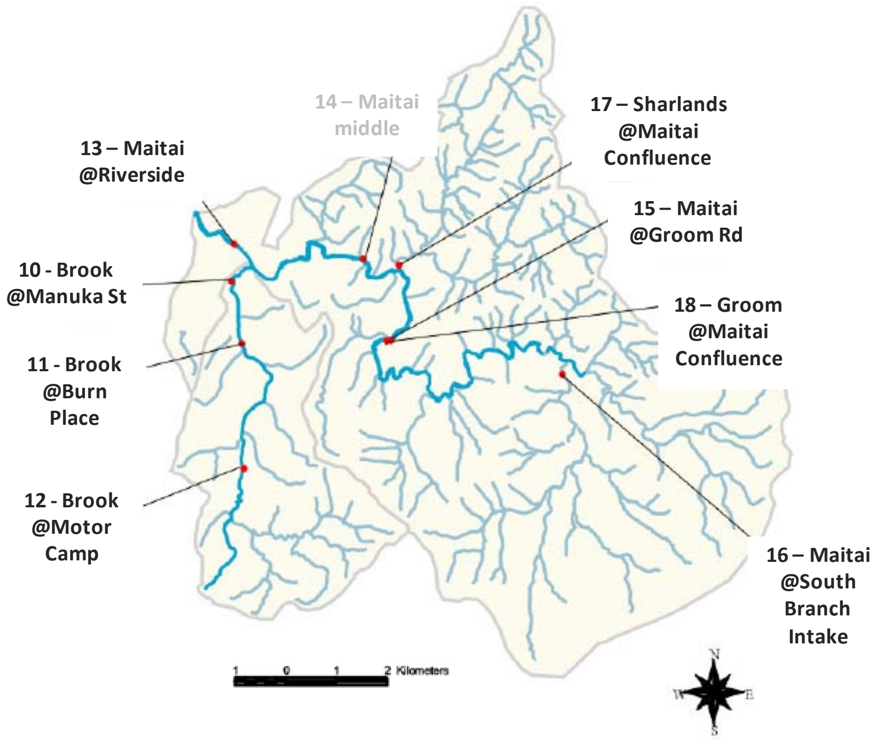


Figure 11. Map showing the relative locations of the freshwater monitoring sites in the Maitai catchment (after Wilkinson, 2007b).

Because of the great range of poor conditions in the Coastal and Urban Streams (Section 3.2), it was appropriate to describe each site individually. The Maitai catchment shows much more consistent freshwater quality characteristics and is described on the basis of broad catchment zones.

3.3.1. Maitai headwater to valley floor pattern

The Maitai freshwater monitoring sites show a consistent pattern of behaviours from the headwaters, and sub-catchments, on down into the valley floors and culminating next to Nelson City at the Riverside sampling location (Figure 11). One of the dominant water quality parameters is nitrate-nitrogen (NO_3-N) and this will be used to illustrate the changing stream and river quality with distance downstream.

The headwaters

The headwaters of the Brook (NCC 12 – Brook at Motor Camp) and main stem Maitai River (NCC 16 – Maitai at South Branch Intake) show excellent water quality and healthy stream biota assemblages (Figure 12). The nitrogen concentrations are very low (Figures 13), but DRP at NCC12 scores C. The clarity at both sites is generally excellent. There is some minor faecal contamination at both sites, and the Maitai South Branch below the backfeed suffers occasional oxygen depression due to anoxic compensation flows from the Maitai Dam (P Fisher *pers comm*.,). The upper Brook is showing a significant downward trend in E. coli (Table 6), and an increasing but minor trend in nitrate-N (Table 6 and Figures 14). These sites represent relatively undisturbed "reference" conditions in the catchment.

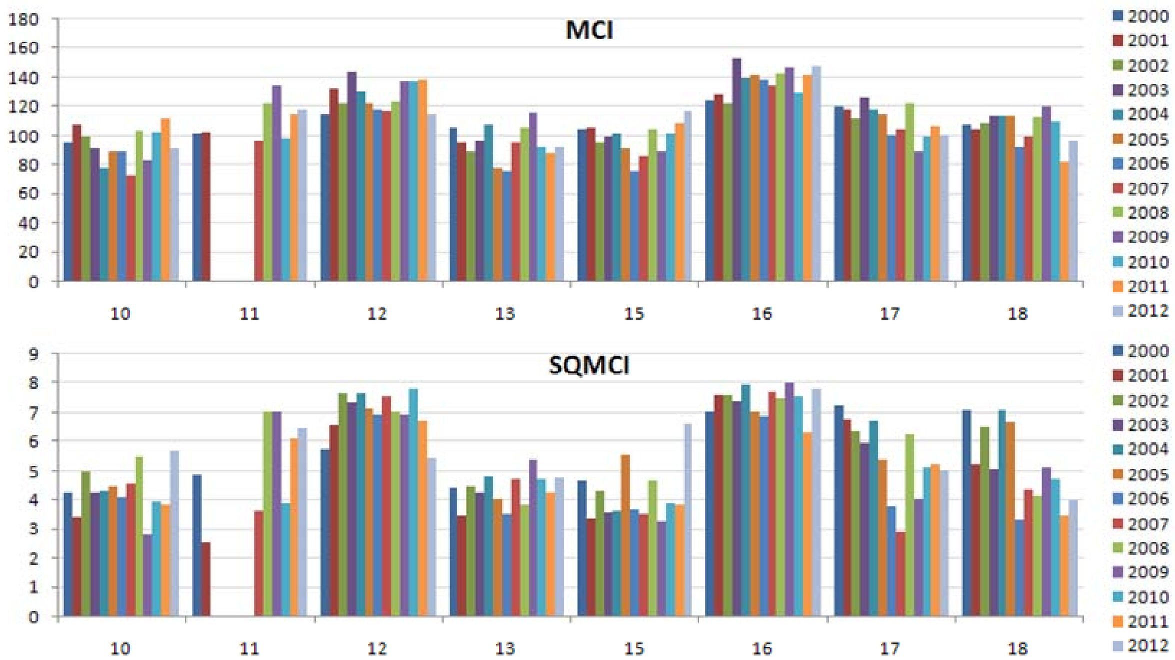


Figure 12. Annual MCI and SQMCI values at each site in the Maitai catchment (x-axis NCC No.).

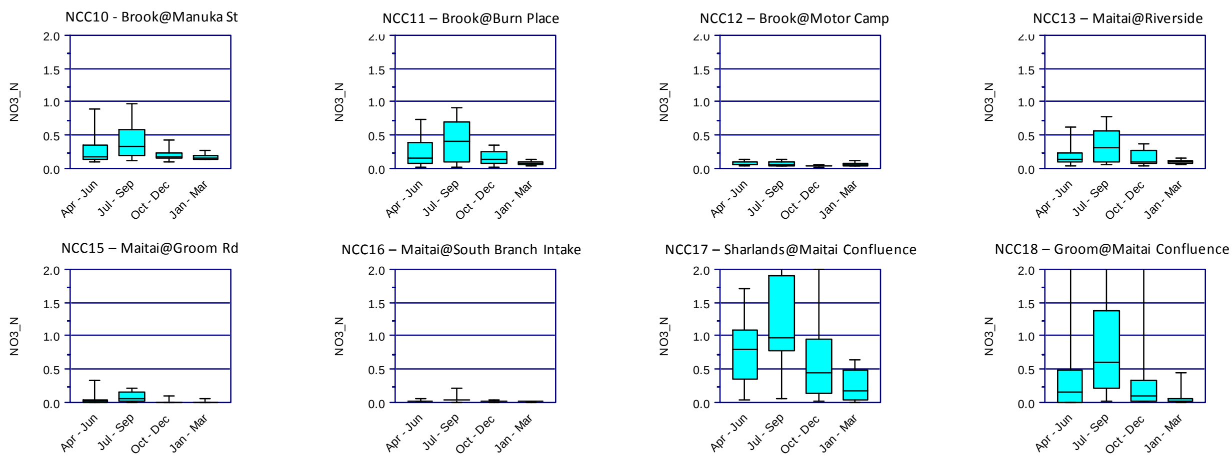


Figure 13. Box-plots of seasonal variation in nitrate-N for the Maitai catchment plotted with same y-axis extent for comparison of nitrate magnitude

Table 6. Seasonal Kendall significant or near significant trends

Monitoring Site	Parameter	Median value	Kendall statistic	Z	P	Median annual Sen slope	5% confidence limit	95% confidence limit
10 - Brook@Manuka St	Nitrate-N	0.175	57	2.52	0.01161	0.0182	0.0047	0.0304
	flow adjusted	0.145	68	3.00	**0.00273**	0.0186	0.0100	0.0316
	N:P_ratio	22.1	62	2.73	0.00627	2.0560	0.6633	3.1835
	flow adjusted	18.8	59	2.60	**0.00942**	2.2009	0.3244	3.7576
12 - Brook@Motorcamp	Nitrate-N	0.050	53	2.33	0.01992	0.0032	0.0007	0.0058
	flow adjusted	0.045	46	2.01	**0.04417**	0.0027	0.0002	0.0047
	N:P_ratio	2.94	57	2.59	0.00956	0.1848	0.0970	0.3169
	flow adjusted	2.76	55	2.50	**0.01246**	0.1730	0.0692	0.2749
	Log10 E. coli	1.00	-54	-2.78	0.00551	-0.0568	-0.1178	0.0000
	flow adjusted	0.86	-53	-2.41	**0.01612**	-0.0423	-0.0781	-0.0189
13 - Maitai@Riverside	Nitrate-N	0.105	60	2.64	0.00820	0.0107	0.0032	0.0218
	flow adjusted	0.080	64	2.82	**0.00484**	0.0141	0.0065	0.0260
	N:P_ratio	31.5	71	3.26	0.00113	2.4250	1.2522	4.9850
	flow adjusted	30.6	63	2.87	**0.00412**	2.8837	1.0807	4.3934
15 - Maitai@Groom Rd	Nitrate-N	0.0090	76	3.41	0.00066	0.0029	0.0017	0.0060
	flow adjusted	-0.0011	78	3.44	**0.00057**	0.0033	0.0015	0.0069
	N:P_ratio	3.000	80	3.73	0.00019	0.6579	0.2655	1.4316
	flow adjusted	1.035	61	2.78	**0.00550**	0.9457	0.3637	1.7911
18 - Groom@Maitai confluence	Nitrate-N	0.140	98	4.49	0.00001	0.0638	0.0243	0.1363
	flow adjusted	0.048	63	2.87	**0.00412**	0.0680	0.0236	0.1380
	N:P_ratio	17.8	102	4.85	0.00000	11.8753	6.3708	16.7112
	flow adjusted	10.8	72	3.41	**0.00065**	11.5047	4.9105	15.4571

Sharlands and Groom Creeks

These two side creek systems lie along the middle reaches of the Maitai and drain the northern and southern slopes of the main river (Figure 11). Sharlands Creek is a more extensive valley system and Groom Creek is a simple first order stream valley. Downstream of the protected headwaters, the middle hill land and valleys have long been used for monoculture plantation forestry; in fact a very large proportion of the Nelson administered area is under plantation forest. The freshwater quality at these sites is representative of the cycles of forest growth and harvesting.

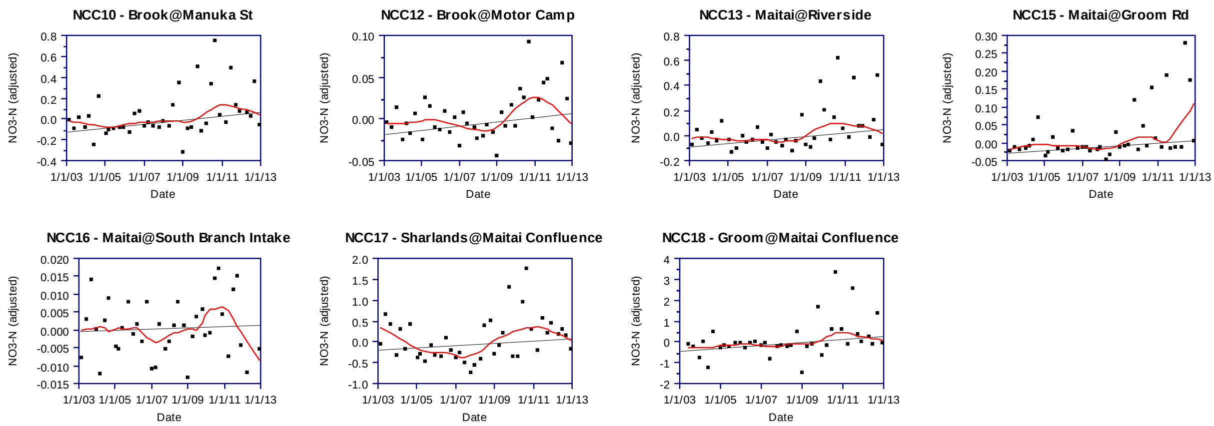


Figure 14. Time-series plots of flow adjusted nitrate-N with Seasonal Kendall trend and LOWESS curves

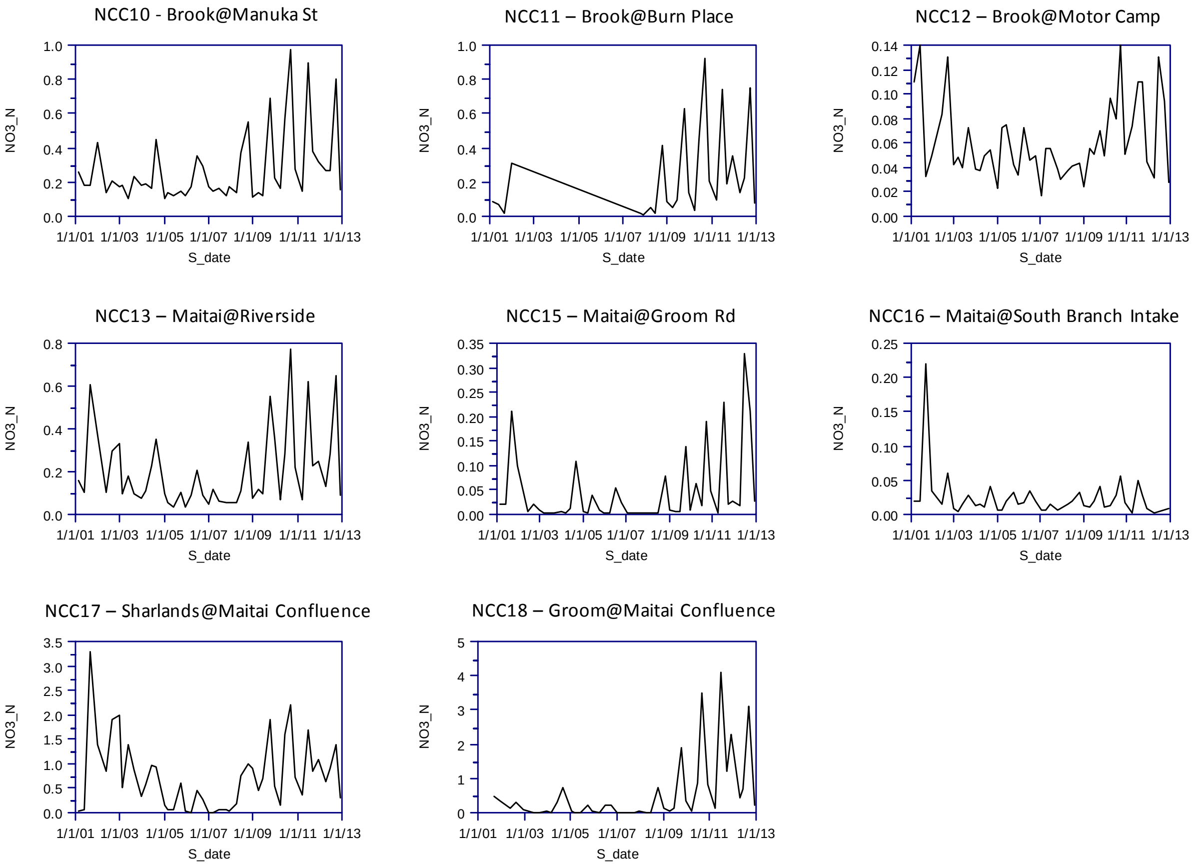


Figure 15. Time-series plots of raw nitrate-N data for the Maitai catchment

Sharlands Creek was reported upon in 2007 (Wilkinson 2007b, c) as being impacted by logging activities, this exhibited itself in elevated nitrate-N probably derived from the clear-fell logging of the upper north and western slopes of the catchment (Figure 16). By 2007 the impact of this cycle of logging had already declined to background levels (Figure 15). A second major cycle of logging commenced in 2008 in the Packer Creek sub-catchment (Figure 16) and disruption of the nitrogen cycle and breakdown of slash from the felled area would explain the large and extended pulse of leaching nitrogen observed from 2008 onwards (Figure 15). The Wakapuaka middle and Whangamoa upper sites serve as reference conditions against which to compare the behaviour in Sharlands Creek, the concentrations are much lower and still exhibit a clear wet/dry weather seasonal pattern, but without the rise and fall and further rise in concentration (Figures 23 and 30). Sharlands Creek shows a similar pattern for DRP (Figure 16), which is known to respond to clear-felling in a similar manner to nitrate-N (e.g. Neal et al. 1998, 1997). It should also be noted that forest felling has been found to release toxic aluminium species into solution (e.g. Neal et al. 1997).

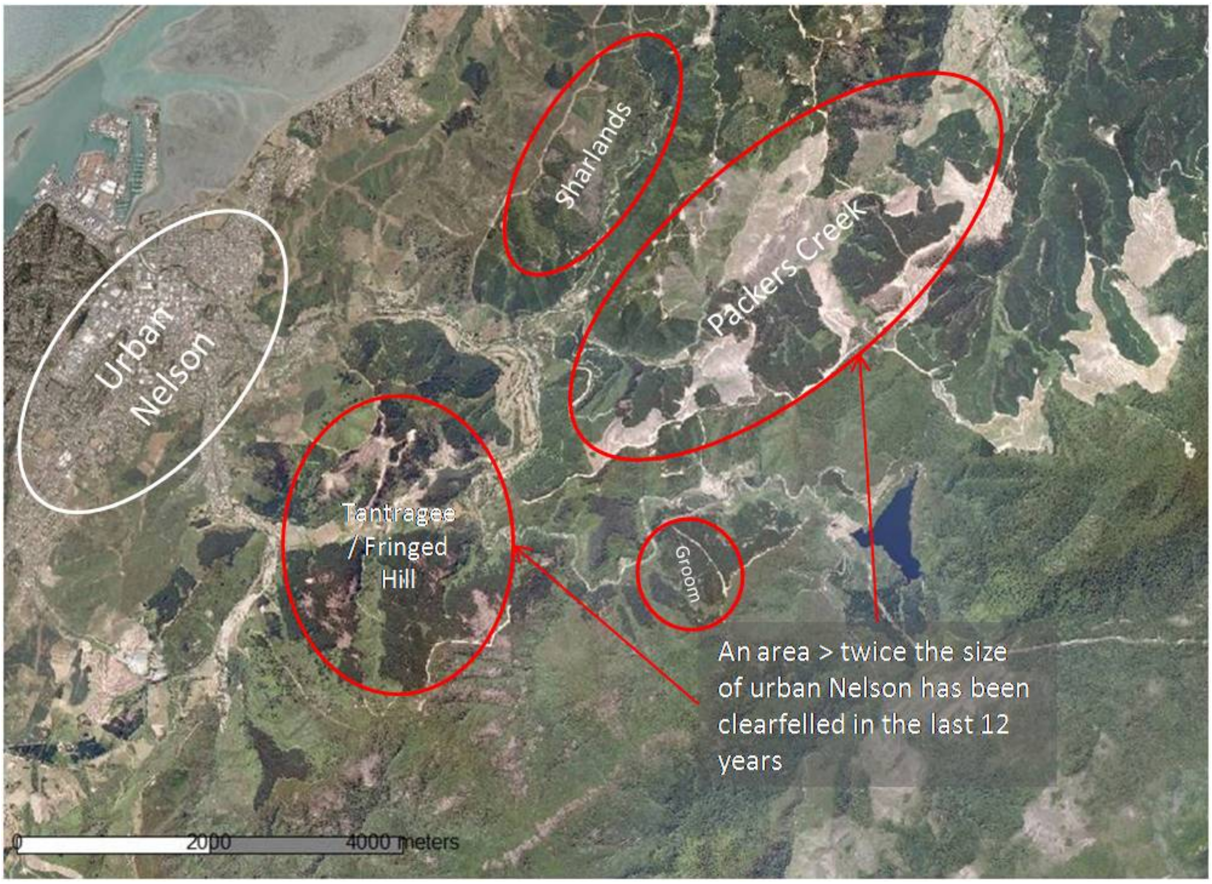


Figure 16. Aerial photograph showing areas felled in recent years (note: the photo pre-dates some of the actual felling, a more recent picture is needed).

Groom Creek shows a similar nitrogen concentration pattern to Sharlands Creek (Figure 15), although without the early nitrogen pulse, extensive logging of Groom Creek appears to have commenced around 2009 (not seen in Figure 16). The N concentration is higher than in Sharlands Creek, this can be explained by the relatively larger proportion of the catchment area felled compared to that in the Sharland/Packer system. The rise in nitrate-N in Groom Creek is highlighted as a significant positive trend (Table 6).

The cycles of nitrogen release in Sharlands and Groom Creeks appear in the SQMCI results for each site. Interestingly, the SQMCI in Sharlands has followed, i.e. declined with the nitrate-N and DRP concentrations, and risen with the second cycle of increased N and DRP (Figures 12, 15 and 17). This might be interpreted in terms of the elevated nutrient supply contributing to the food web of the stream invertebrates (e.g. Wyatt et al., 2005). The same pattern between nutrients and SQMCI was not seen in Groom Creek, where SQMCI has generally fallen during the period of elevated nitrate-N (Figures 12 and 15).

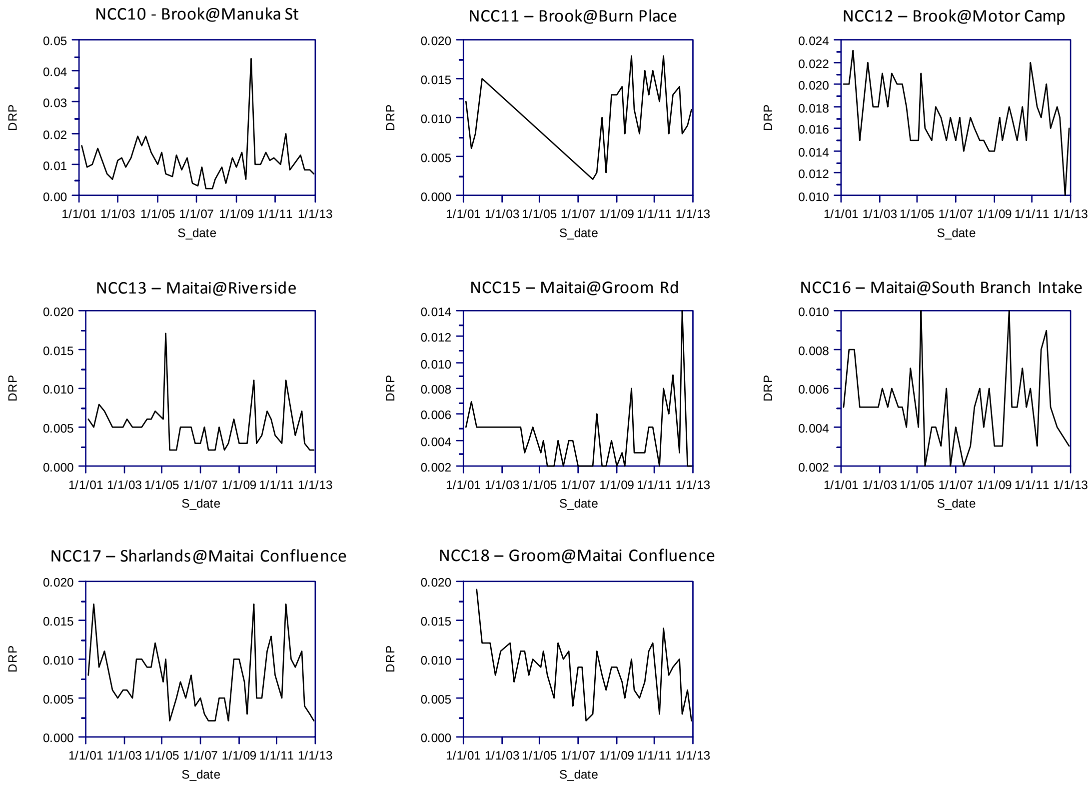


Figure 17. Time-series plots of raw dissolved reactive phosphorus data for the Maitai catchment

With regard to potential remedial action for the increased nutrients in Sharland and Groom Creeks, it is too late to make a significant improvement, given the magnitude of the logging and it´s impact on the streams, no wetland system or riparian planting will be large enough to uptake the nutrients being released (typically in the range 200-300 kg/Ha, around 200-300 times more than would normally be released in a year; see Wilkinson, 2007c and Wilkinson et al., 2005). With the completion of logging, with the break down of slash and growth of new vegetation it generally takes 2 to 3 years before the nutrient levels decline to background levels.

The best hope to prevent future logging impacts, if this is considered to be a priority, is to work with logging firms and/or regulate to limit the proportion of a catchment that can be felled at any time. Phased felling of smaller coups will help to reduce nutrient impacts, and their size must be balanced against the economic impacts related to harvesting smaller areas, but still bringing on-site the same set of equipment and machinery. In addition, larger buffer strips would help to limit some of the negative impacts of logging activities (see Wilkinson, 2007c).

Valley floors and catchment outlet

Continuing the narrative describing the nitrate-N patterns in the Maitai River, we can see the impact of the elevated nitrate sources at the downstream sites in the catchment (Figures 13 and 15). Groom Creek enters the Maitai upstream of monitoring site NCC15 – Maitai at Groom Road, but the Groom is very small compared to the Maitai and the nitrate it delivers to the Maitai is greatly diluted. The outflow from Sharland Creek is sufficiently large that it´s nutrient concentration is only diluted to around a quarter of it's initial value and hence has a clear impact on the nitrate concentrations of the main stem (Figures 13 and 15), this is also apparent at NCC13 - Maitai at Riverside. This was also confirmed by Crowe et al. 2002. The Brook is also impacted by logging (see Wilkinson 2012), and this is reflected in the nitrate-N concentrations at sites NCC10 and NCC11, Brook at Manuka St and Burn Place (Figures 13 and 15). The concentrations at NCC10 - Brook at Manuka St are also elevated at lower flow and this may imply some sewer leakage into the channel (Figure 15).

The flow from the Brook also contributes to the total nitrogen load at Maitai lower, and the concentrations observed there are a direct consequence of the nutrient loadings from upstream (Figure 15). Given that logging slash can deliver between 60 and 100 times more nitrogen per hectare a year than normal (assuming a three year decay period), it is not surprising that logging effects are clearly seen downstream. In other words, if 1 Ha in a 100 Ha catchment is clear-felled and the slash left to decay in-situ, the stream nitrate load and concentration (assuming minimal in-stream uptake) will be doubled. This highlights the need to ensure forestry operations are adequately supervised, if the objective of limiting stream nutrient levels is a priority.

Nutrients are not the whole story in the Maitai, at the valley floor sites, within the peri-urban area, Sneddon and Elvines (2012) highlight the trends in sediment metals and PAH concentrations (Table 8). In general the data show improving sediment metals concentrations at the sites relevant to the freshwater monitoring programme. Lead and zinc are declining in the Brook, and also at the Maitai sediment sampling sites that represent stormwater inflows adjacent to Collingwood Street bridge. The pattern for PAHs is mixed, but there is some suggestion that they are decreasing at Riverside – NCC13, the Maitai lower site (refer to Section 1.3.4 for location of freshwater and sediment sampling sites).

Table 8. Summarised findings of four sediment sampling surveys (after Sneddon and Elvines, 2012)

Catchment	Site	Trends (increase/decrease)	Levels and variability
Brook	6-M (11)	Decreasing Pb, Zn since 2006	Elevated PAHs - 2003, otherwise variable
	6-L (12)	Decreasing Cu, Pb, Zn since 2006	Elevated PAHs - 2003
Maitai (13)	7-LMshak	Possibly decreasing HMW PAHs	
	7-LMgrov	Marginally decreasing Zn, possibly decreasing PAHs	Elevated PAHs
	7-LMcoll	Decreasing Pb, Zn. Increasing PAHs	Elevated LMW PAHs, high HMW PAHs

Recreational Bacteriological Results

The Maitai provides various freshwater bathing locations commonly enjoyed during the summer months. The freshwater recreational standards apply to these locations and the City Council is obliged to monitor the water quality and warn the public if conditions are unsuitable for contact recreation (see Wilkinson 2007a). Additional summer sampling for E. coli carried out at various of the swimming holes has identified breaches of the freshwater guidelines (Figure 18).

The behaviour of faecal contaminant bacteria (E. coli, in this case) in catchments and rivers is influenced and complicated by many factors (see Wilkinson et al., 2011). The source of the contamination plays an important role in the observed variations in concentration over time. There are essentially two main types of source that behave in relatively predictable ways in relation to river flow. These are point sources and diffuse sources.

Point sources include any concentrated inputs at a specific location, whereas diffuse sources tend to be spread-out over an area and it is difficult to accurately define their source. Diffuse sources tend to be dominated by grazing animals, but can include spreading of animal waste to land, as well as, faecal contamination by wildlife. Point sources are typically pipe or channel outlets draining faecally contaminated water to the stream or river, they can include broken pipes crossing rivers. Animals accessing a stream channel can qualify as a point source due to direct deposition in the channel, similarly a favourite feeding place for ducks can qualify as a point source.

The behavioural characteristics of point and diffuse sources are simply defined. Point sources tend to result in elevated concentrations at low flow, and are diluted at higher river flows. Diffuse sources tend to respond to river flow, with elevated concentrations occurring on the rising-limb of the hydrograph as the organisms (E. coli bacteria) are both washed-in from the catchment and stirred-up from the river bed (e.g. Wilkinson et al., 1995), and concentrations a generally lower after the peak flow has passed, this is a kind of hysteresis.

Where there are both point and diffuse sources impacting a particular location the behaviour may be rather unpredictable, combining features of both source types. Faecal pollutant concentration dynamics in rivers is sometimes said to be non-stationary, this means that for a given set of conditions a fixed and repeatable E. coli concentration cannot be expected. It is for these reasons that modelling (e.g. Wilkinson et al. 2011) and advanced molecular tracking approaches (Kirs et al. 2009) have been employed in attempts to better predict concentrations and determine faecal sources.

With this background in mind we can attempt to interpret the data from the summer monitoring of the Nelson water holes. The data for Girlies Hole, Sunday Hole and Maitai Camp show a degree of consistency. The E. coli concentrations tend to rise through the season and decline again towards the end of the season, and there is a weak tendency for higher concentrations at elevated flow conditions. Because of the infrequent sampling it is difficult see the true relationship with flow. During dry-weather flow in strong sunlight there will tend to be a degree of natural purification. Some bathing water studies have shown that the bathers themselves can influence the water quality due to accidental faecal releases (e.g. Cromar et al. 2006), as well as, stirring-up faecally contaminated silt from the river bed. The time of day when samples are taking may also be significant in relation to solar purification.

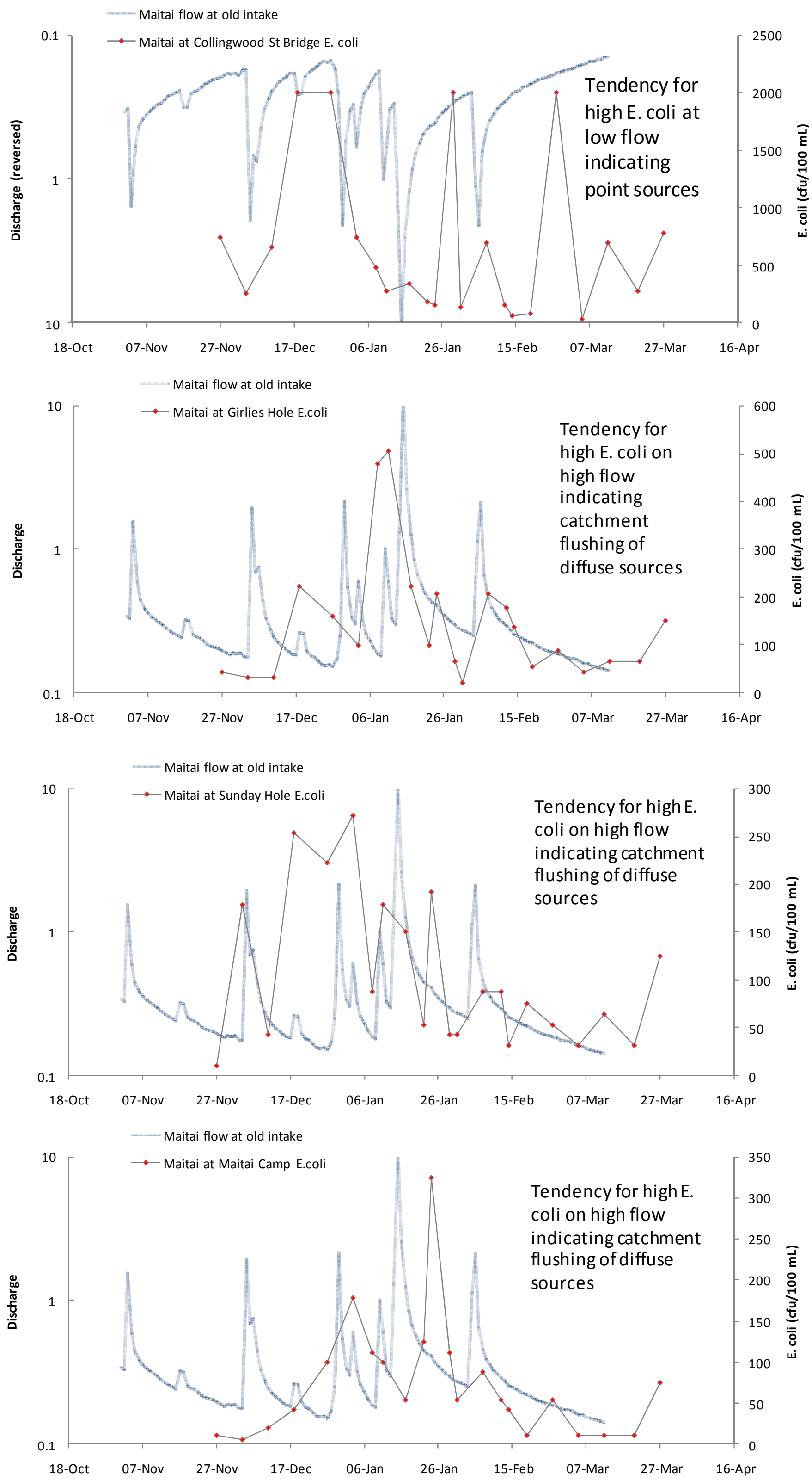


Figure 18. E. coli time-series for summer 2013 in Maitai River swimming holes, with flow and indicating the tendency towards flushing of diffuse sources, or dilution of point sources.

The pattern of E. coli behaviour at Collingwood Bridge is noticeably different to the other sites. For this reason the flow is plotted upside-down, this is done to indicate the tendency for the highest values to occur at low flow, suggesting a concentrated source which is diluted into the river.

As noted above, increases in the upper summer E. coli values, that are assessed for recreational bathing water quality, are statistically likely given that year on year the likelihood of extreme rainfall and runoff events increases, as does the probability of sampling during a high faecal load episode.

3.4. Wakapuaka and sub-catchments

In many ways the Wakapuaka system shows similar patterns of water quality to the Maitai system, although the pressures in the Lud, Teal and lower Wakapuaka valley are different. The headwater areas are dominated by plantation forestry, and the mid and lower reaches of the Lud and Teal are more open paddock lands associated with small farms and lifestyle blocks. Downstream of Hira, the main stem of the Wakapuaka flows through open farm land with mainly cleared or scrubland hill slopes. Pitchers stream flows out from native bush. Figure 19 shows the stream network and the relationship of the monitoring station locations, and Table 9 summarises the freshwater classifications for 2013. Note that the only change since 2007 is an upgrading of lower Wakapuaka at Maori Pa Road (NCC25) from C to B.

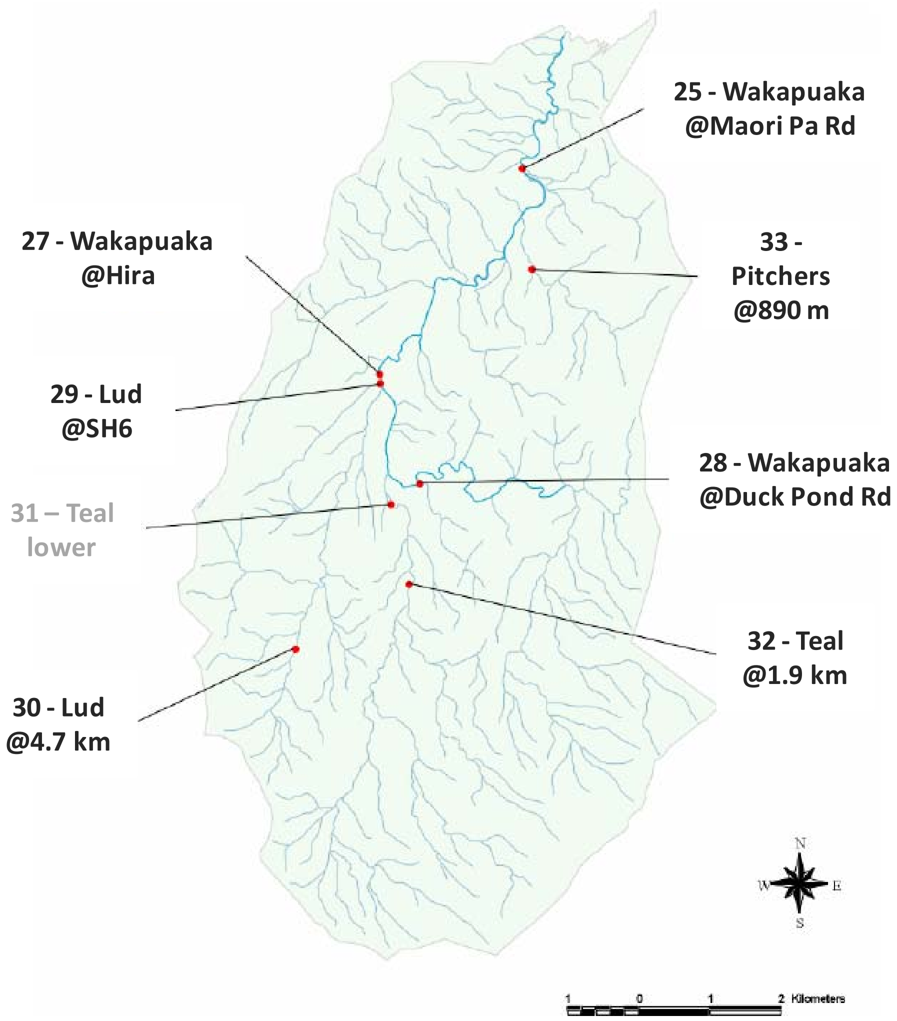


Figure 19. Map showing the Wakapuaka catchment and freshwater monitoring sites (after Wilkinson, 2007b)

Table 9. Current and previous freshwater classifications for the Wakapuaka

Site	NCC No	2007 Class		2013 Class	Change
Wakapuaka at Maori Pa Rd	25	C	↑	**B**	Upgrade
Wakapuaka at Hira	27	A	↓	**B**	Downgrade
Wakapuaka at Duckpond Rd	28	A		A	
Lud at SH6	29	C		C	
Lud at 4.7km	30	C		C	
Teal at 1.9km	32	C	↑	B	Re-grade
Pritchards at 890m	33	A		A	

Table 10. Equivalence testing results for selected water quality parameters

Site No. and Name	NO3_N 10%	Turb 5%	DRP 10%	DO% 10%	Log10_E. coli 5%	N:P_ratio
25-Wakapuaka@Maori Pa Rd	inc	**strong -**	inc -	no diff	inc	inc +
27-Wakapuaka@Hira	inc +	inc -	mod -	no diff	inc	**strong +**
28-Wakapuaka@Duckpond Rd	inc	inc	mod -	no diff	inc	inc +
29-Lud@SH6	inc	inc	inc -	no diff	inc	inc
30-Lud@4.7km	**strong +**	inc -	inc	no diff	**strong -**	**strong ++**
32-Teal@1.9km	imp ++	no diff	inc	no diff	inc	inc +
33-Pritchards@890m	**strong -**	**strong -**	mod -	no diff	inc	**strong +++**

Key:- no diff – means are the same; inc – inconclusive; mod – moderate evidence of a practically important difference; strong – strong evidence of a practically important difference; + increase; - decrease; ++/-- large increase/decrease.

Table 11. Seasonal Kendall significant or near significant trends

Monitoring Site	Parameter	Median value	Kendall statistic	Z	P	Median annual Sen slope	5% confidence limit	95% confidence limit
25 - Wakapuaka@Maori Pa Rd	N:P_ratio	21.111	44	1.992	0.04638	1.0424	0.2608	1.9696
	flow adjusted	20.2290	45	2.04	**0.04174**	0.9092	0.2889	1.5788
	Turbidity	0.9000	-39	-1.76	0.07800	-0.0570	-0.1100	-0.0040
	flow adjusted	0.8200	-41	-1.85	**0.06400**	-0.0370	-0.0880	-0.0060
27 - Wakapuaka@Hira	Turbidity	0.9700	-36	-1.62	0.10500	-0.0480	-0.1160	0.0000
	flow adjusted	0.8760	-57	-2.59	**0.00960**	-0.0620	-0.1040	-0.0230
29 - Lud@SH6	Nitrate-N	0.3400	-26	-1.12	0.26260	-0.0137	-0.0373	0.0055
	flow adjusted	0.3301	-40	-1.74	**0.08114**	-0.0197	-0.0344	-0.0003
30 - Lud@4.7km	Nitrate-N	0.3250	97	4.30	0.00002	0.0556	0.0384	0.0867
	flow adjusted	0.3182	84	3.71	**0.00021**	0.0444	0.0220	0.0618
	N:P_ratio	27.5000	78	3.57	0.00036	3.7739	2.3029	5.5481
	flow adjusted	28.0894	83	3.79	**0.00015**	3.2794	2.2615	4.8496
	Log10 E. coli	2.2900	-61	-2.79	0.00526	-0.0590	-0.1116	-0.0331
	flow adjusted	2.2466	-47	-2.13	**0.03329**	-0.0703	-0.1181	-0.0182
32 - Teal@1.9km	Nitrate-N	0.0920	84	3.74	0.00019	0.0207	0.0123	0.0301
	flow adjusted	0.0894	86	3.80	**0.00014**	0.0159	0.0111	0.0238
	N:P_ratio	15.6000	73	3.35	0.00081	3.0500	1.8333	4.0970
	flow adjusted	14.0543	67	3.05	**0.00226**	2.2657	1.3920	3.4003
33 - Pitchers@890m	Nitrate-N	0.0200	-49	-2.19	0.02851	-0.0005	-0.0011	0.0000
	flow adjusted	0.0201	-39	-1.70	**0.08892**	-0.0006	-0.0013	0.0000
	Turbidity	0.7200	-36	-1.62	0.10500	-0.0340	-0.0710	0.0010
	flow adjusted	0.690	-37	-1.666	**0.09600**	-0.0320	-0.0560	-0.0010

3.4.1. Wakapuaka headwater to valley floor pattern

Freshwater conditions in the Wakapuaka are similar to the Maitai and dominated by the patterns of nutrient enrichment, namely nitrate-N, but faecal contamination and turbidity are also issues. The situation at the lowermost monitoring site is a reflection of the combined influences of what is happening in the upper parts of the catchment.

Headwaters

The headwaters of the Wakapuaka include the Lud, Teal and Wakapuaka itself (Figure 19). The very upper margins, the watershed, of the Teal and the Lud have undergone a degree of clear-felling in recent years. The upper Wakapuaka at Duckpond Road (NCC28) remains undisturbed, and shows minimal evidence of negative impacts, there are no strong trends and the stream biota score highly (Figure 20).

The Lud and Teal show a different situation and are known to be the source of impacts in the Wakapuaka system (Wilkinson, 2007b). The upper Lud at 4.7 km (NCC30) and Teal at 1.9 km (NCC32) show rising trends in nitrate-N (Tables 10 and 11, Figure 21), and these catchments have the highest stream nitrate concentrations observed in the Wakapuaka (Figure 22). The upper Lud at 4.7 km (NCC30) upper shows a strong increasing trend in nitrate-N consistent with the logging impacts noted in Sharlands (NCC17) and Groom Creeks (NCC18) (Figures 21 and 23).

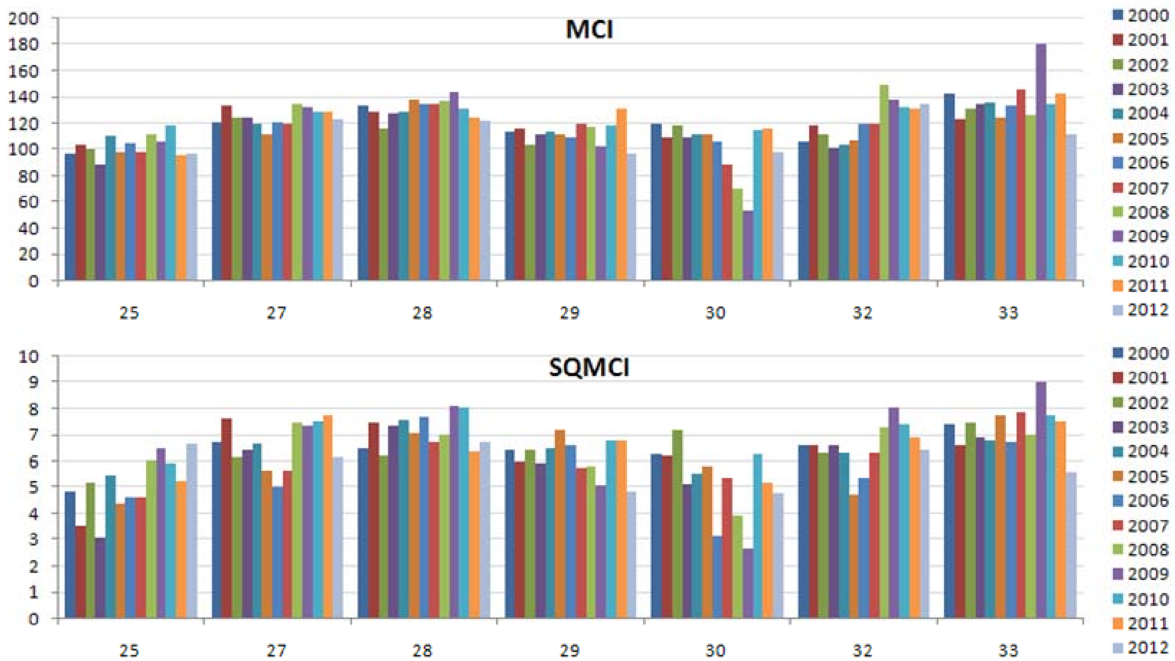
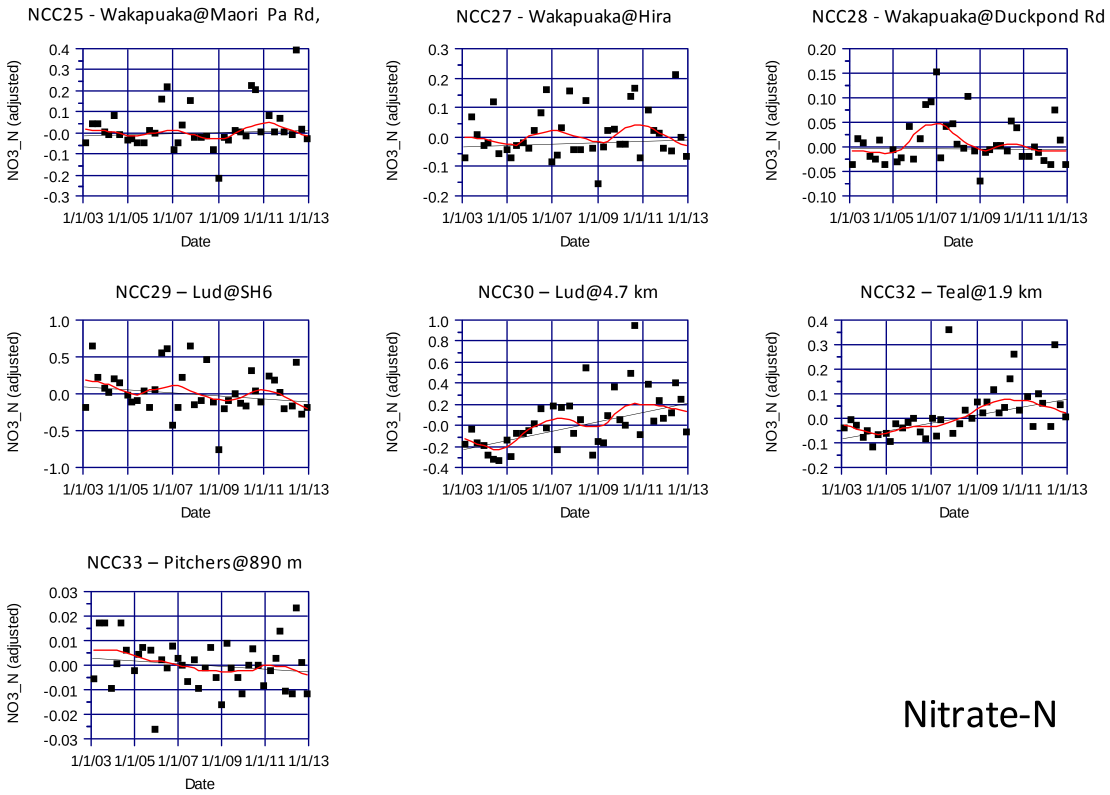
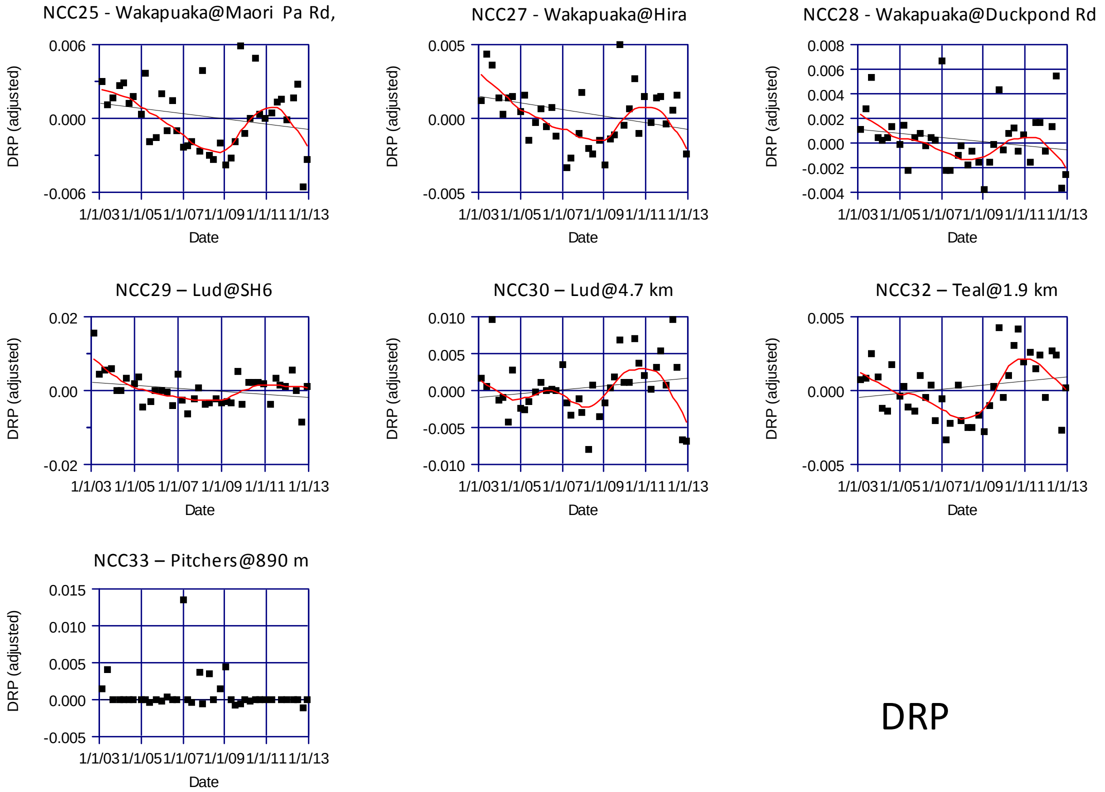


Figure 20. Annual MCI and SQMCI values at each site in the Wakapuaka catchment.



Nitrate-N



DRP

Figure 21. Time-series plots of flow adjusted nitrate-N with Seasonal Kendall trend and LOWESS curves

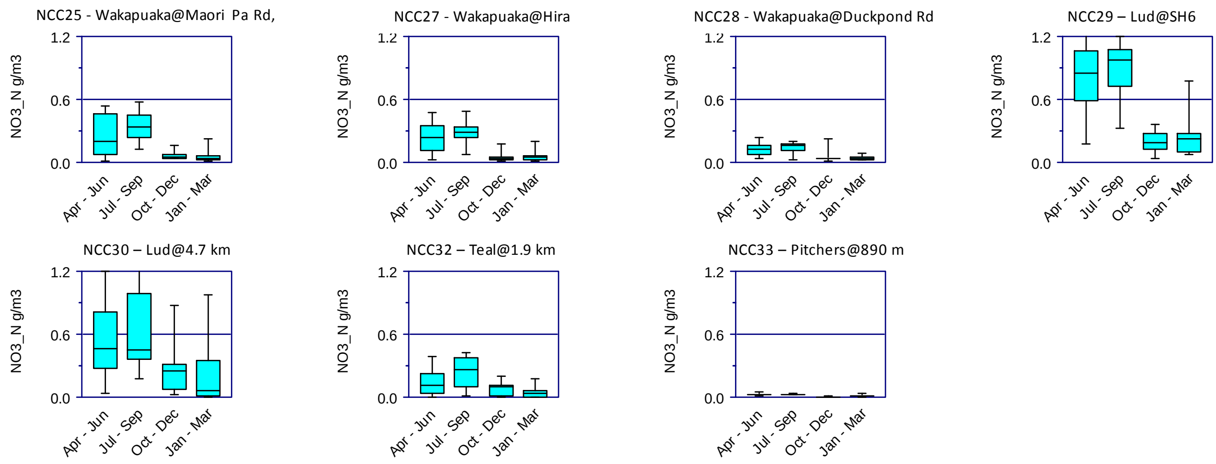


Figure 22. Box-plots of seasonal variation in nitrate-N for Wakapuaka catchment plotted with same y-axis extent for comparison of nitrate magnitude

The increasing N pattern in the upper Lud at 4.7 km (NCC30) is not seen in the lower Lud at SH6 (NCC29). This is because lower Lud at SH6 was already experiencing rising N from 2001 onwards due to logging in the lower catchment (Figure 24). The felled area in the lower Lud is already revegetating, and the elevated N from 2007 onwards at this site is the N coming downstream from the upper reaches of the Lud (Figure 25).

The stream biota in the upper Lud at 4.7 km (NCC30) are also showing evidence of a decline in condition, MCI and SQMCI are all showing a downward trend (Figure 19), consistent with the upward trend in nitrogen.

In the Teal at 1.9 km (NCC32) the increase in nitrate-N is not as great as in the Lud (Figure 23), and this may reflect the relative proportion of the catchment that has been felled. With regard to nitrogen levels in the Nelson rivers, a mapping investigation of felled areas in relation to total catchment areas would help to quantify the extent of forestry impacts on freshwaters, i.e. to relate the observed stream nitrogen concentrations to the felled area.

The increased N in the Teal (NCC32) has not had a clear negative impact on the biota; the MCI score in the Teal is generally higher than before the increase in nitrate occurred. The N:P ratio might help to explain this behaviour (Figure 23). Prior to the increase in N, the site appears to have been nitrogen limited – N:P less than 16 – since the rise in N, the N:P ratio has risen above 20, and perhaps the change in nutrient availability has affected the food supply of the macroinvertebrate fauna and hence their abundances.

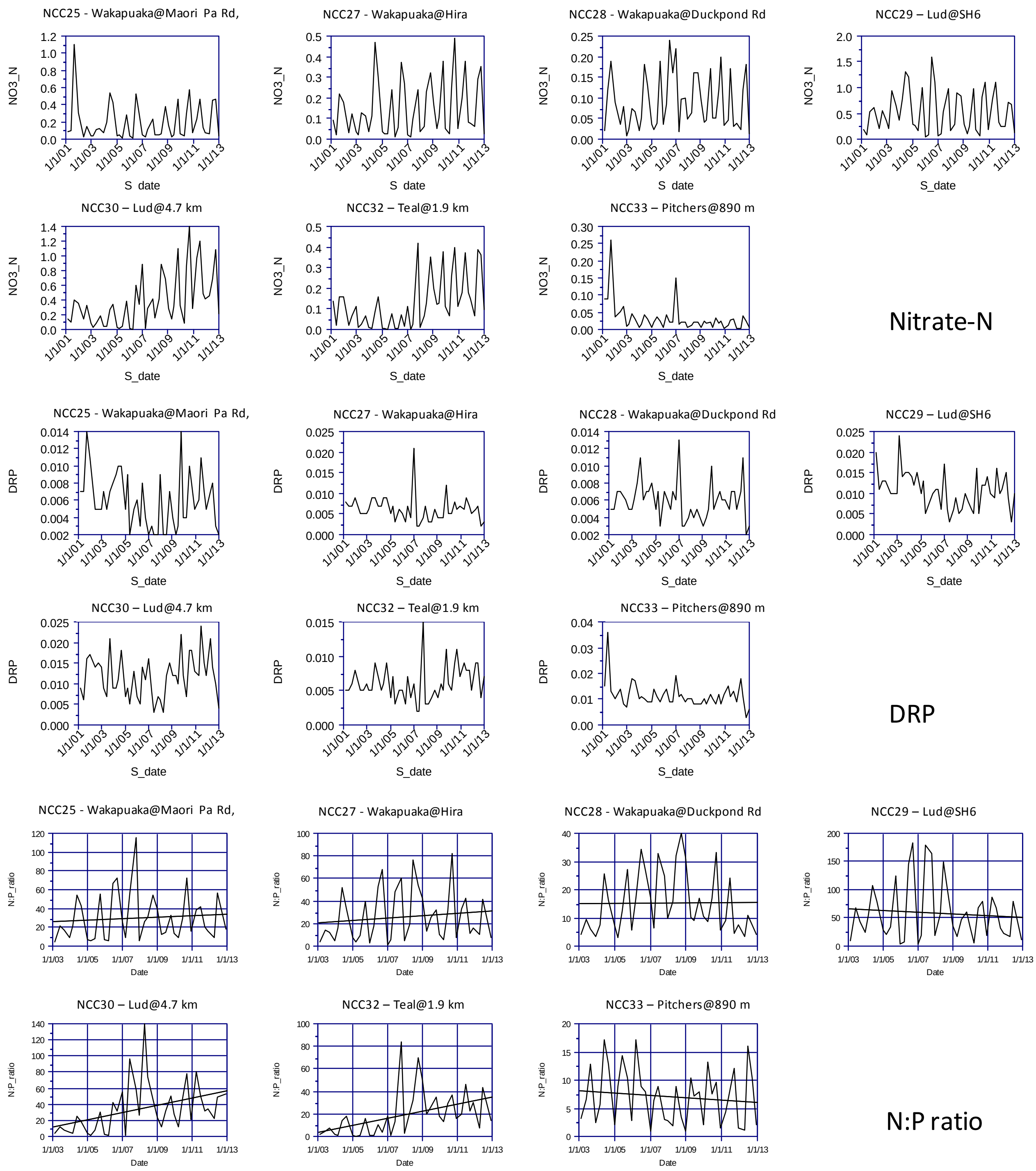


Figure 23. Time-series plots of raw nitrate-N, DRP and N:P ratio for the Wakapuaka catchment

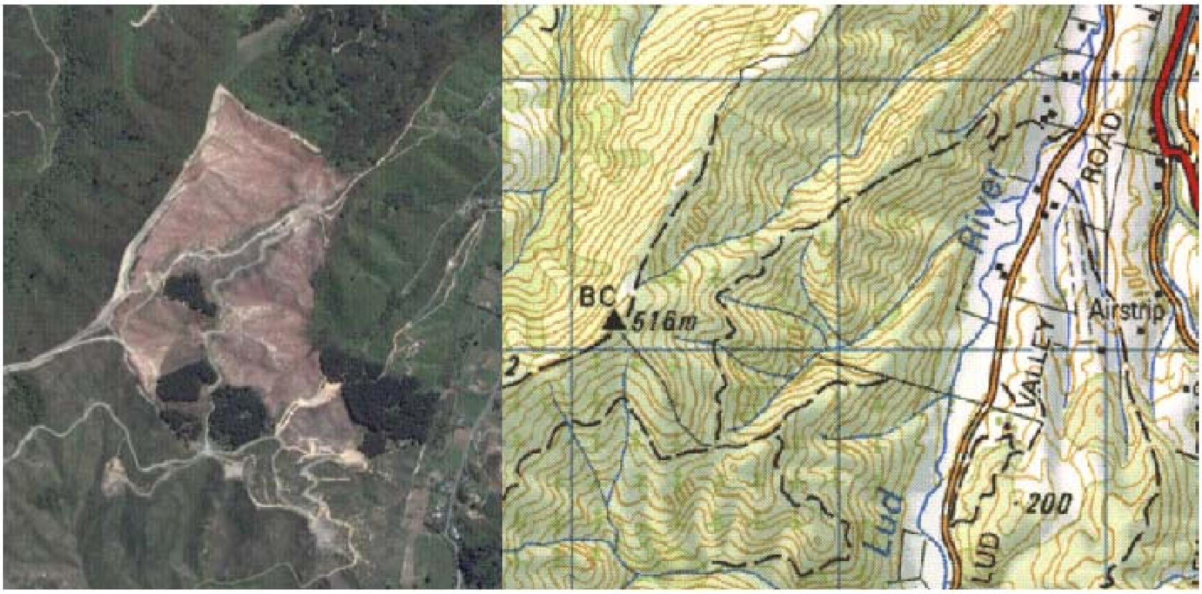


Figure 24. Areal imagery of logging activity in the lower Lud presented by Wilkinson (2007b), the cleared area is now revegetated

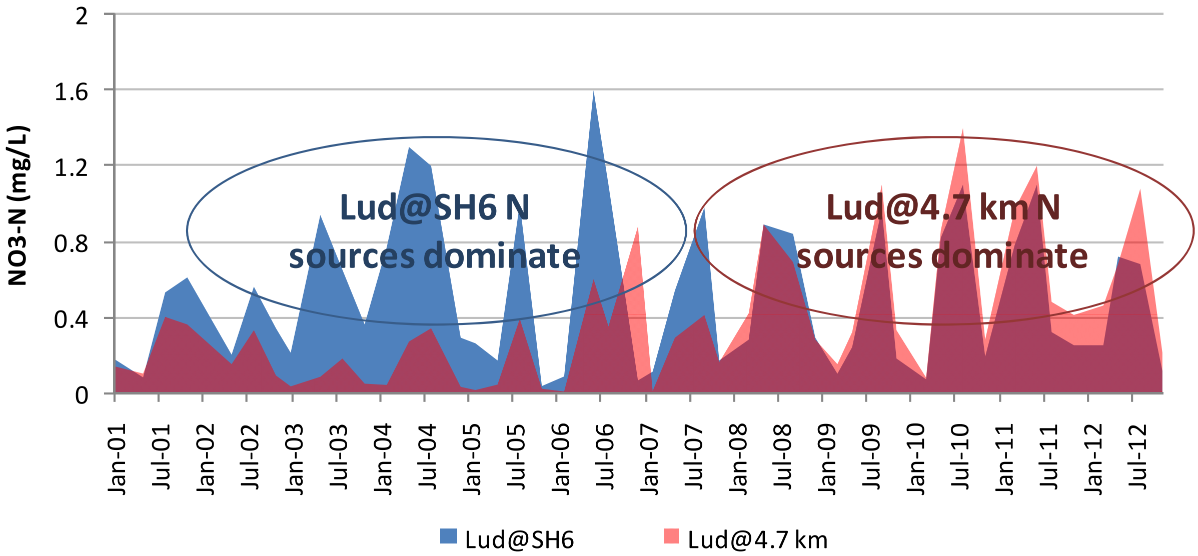


Figure 25. Changing sources of nitrate-N in the Lud River

Aside from nutrient variations, the Lud upper site has shown a decline in E. coli levels (Table 11). This improvement may be due to fencing of the paddock areas near this part of the stream. The NCC Sustainable Land Adviser has discussed water quality results with most land owners in the upper Lud and provided advice about fencing and planting options to improve riparian margins, as well as, maintenance of septic tanks to minimise point discharges. Several land owners have fenced and planted riparian strips since 2009.

Valley Floors

The pollutants from the upper sites in the Wakapuaka clearly impact the downstream sites (Figure 23). The nitrate concentrations from the Teal and Lud clearly combine as they mix into the Wakapuaka main stem, and their influence is reflected at the Hira monitoring site. The elevated E. coli in the Lud and to a lesser extent in the Teal certainly contribute to the elevated E. coli levels at in the Wakapuaka at Hira (NCC27).

The lower Lud at SH6 (NCC29) scores Class C for general faecal contamination, mean and median are around 5000 and 350 cfu/100mL, respectively. The data exhibit a distinct seasonal pattern with high summer values, and occasionally elevated ammonium-nitrate concentrations. This combination of high dry weather E. coli values and NH4-N pulses suggest a point-source of faecal contamination rather than catchment washoff. A number of lifestyle blocks have livestock accessing the Lud and tributaries, and some lifestyle properties have dogs, goats, pigs and chooks housed close to the tributaries that feed the Lud.

Turbidity appears to have declined slightly in the Wakapuaka at Hira (NCC27) and Maori Pa Road (NCC25) (Tables 10 and 11), however, only the trend at Hira is significant. SQMCI in the lower Wakapuaka at Maori Pa Road (NCC25) lower has improved (Figure 20), but MCI remains at class B. The improved SQMCI may relate to nutrient supply and turbidity and the dynamics determining the productivity and success of different species. Without examining the community compositional changes over time it is hard to interpret these observations.

Recreational Bacteriological Results

Microbial source tracking of a faecal samples from the Wakapuaka at Paremata Flats in the lower Wakapuaka indicated that stock and wildfowl were responsible for the observed faecal contamination. Other sources of bacteria may include leaking septic tanks, particulalry during wet weather conditions when.

Additional recreational bathing water sampling in the Wakapuaka at Hira and Paremata Flats in the summer 2012/13 season highlights the breaches of guideline E. coli values at both sites, and examination of the data in relation to river flow helps to confirm the nature of the contamination (Figure 26). The trends in the data and the smaller scale variation, confirm the suggestion that at Paremata the faecal source has a point source nature, with a tendency to dilution at elevated flow and increasing concentrations as discharge falls, suggesting less dilution. Further upstream at Hira the pattern is different, the concentrations are lower, and diffuse sources are weakly indicated by the data. A number of storm flow samples at Hira might help to strengthen this conclusion.

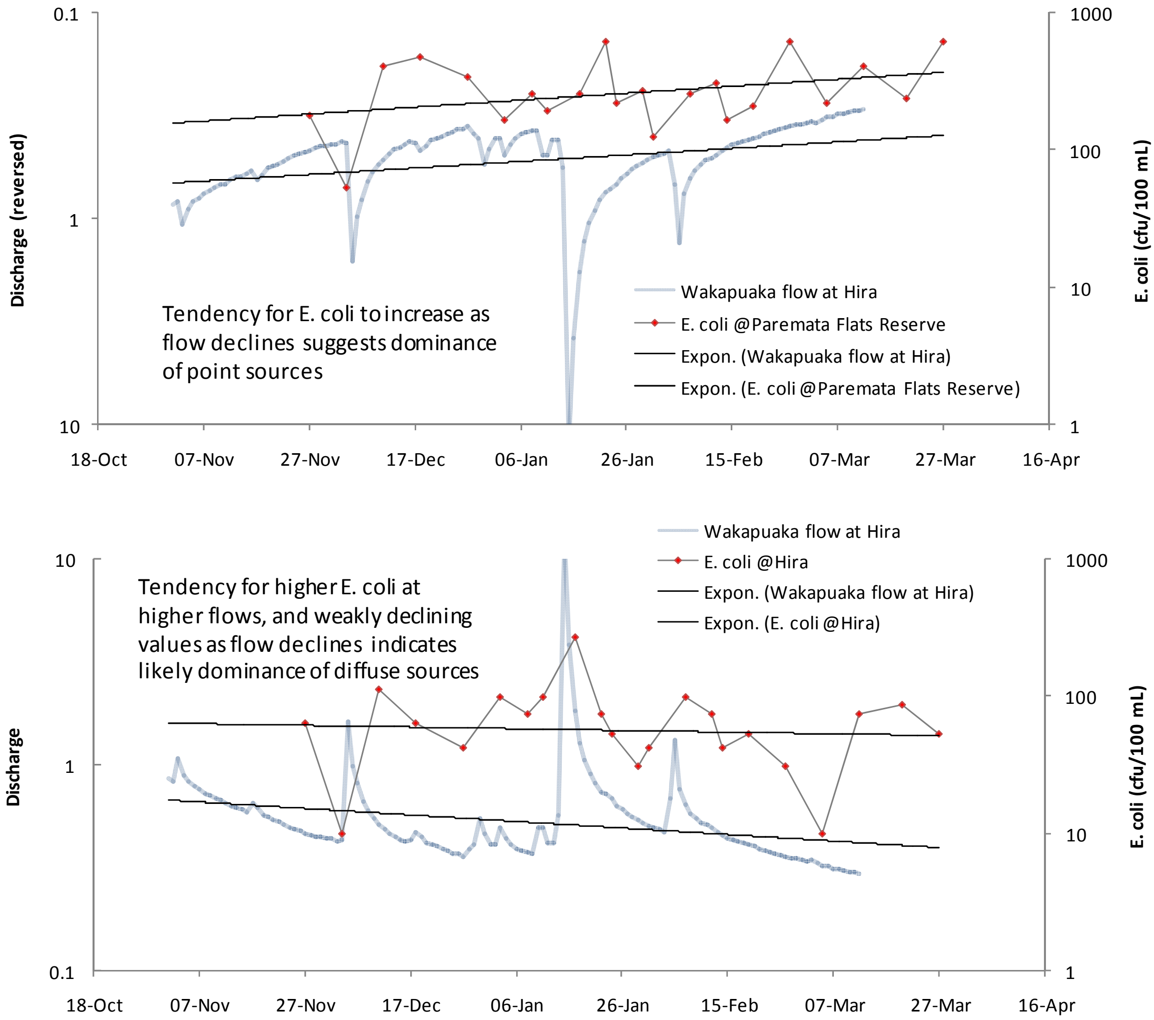


Figure 26. Summer recreational E. coli survey data with river flow, showing trends in E. coli in relation to flow.

3.5. Whangamoa and sub-catchments

As mentioned above, the Whangamoa is predominantly under plantation forestry with remnant native and regenerating bush, and areas of scrubland. Currently, it scores very highly for most water quality and biological parameters. Most sites are classed A to B, and the downgrade of Whangamoa from A to B, is a threshold change (Table 13).

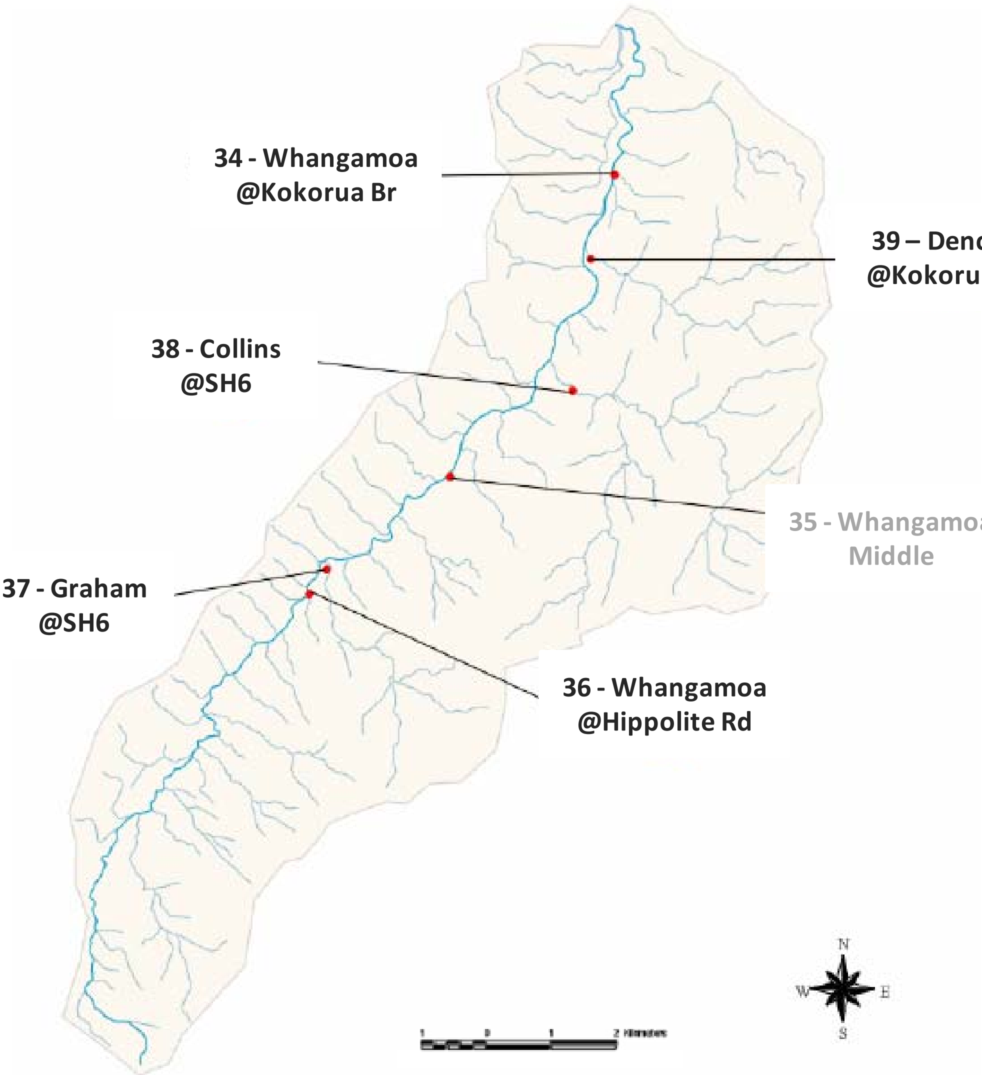


Figure 27. Map showing stream network and freshwater monitoring sites in the Whangamoa (after Wilkinson 2007b)

The Whangamoa has been subject to forestry activity in the last ten years with logging in the upper Whangamoa before 2007 (Figure 28), as well as in the middle of the catchment on the northern flanks upstream of the Collins River inflow (Figure 29). More recently, extensive clear-felling of the areas around the lower Whangamoa downstream of the Dencker confluence has taken place.

Table 13. Current and previous freshwater classifications for the Whangamoa

Site	NCC No	2007 Class		2013 Class	Change
Whangamoa at Kokorua Bridge	34	A	↓	**B**	Downgrade
Whangamoa at Hippolite Rd	36	A		A	
Graham at SH6	37	A		A	
Collins at SH6	38	B		B	
Dencker at Kokorua Rd	39	B		B	

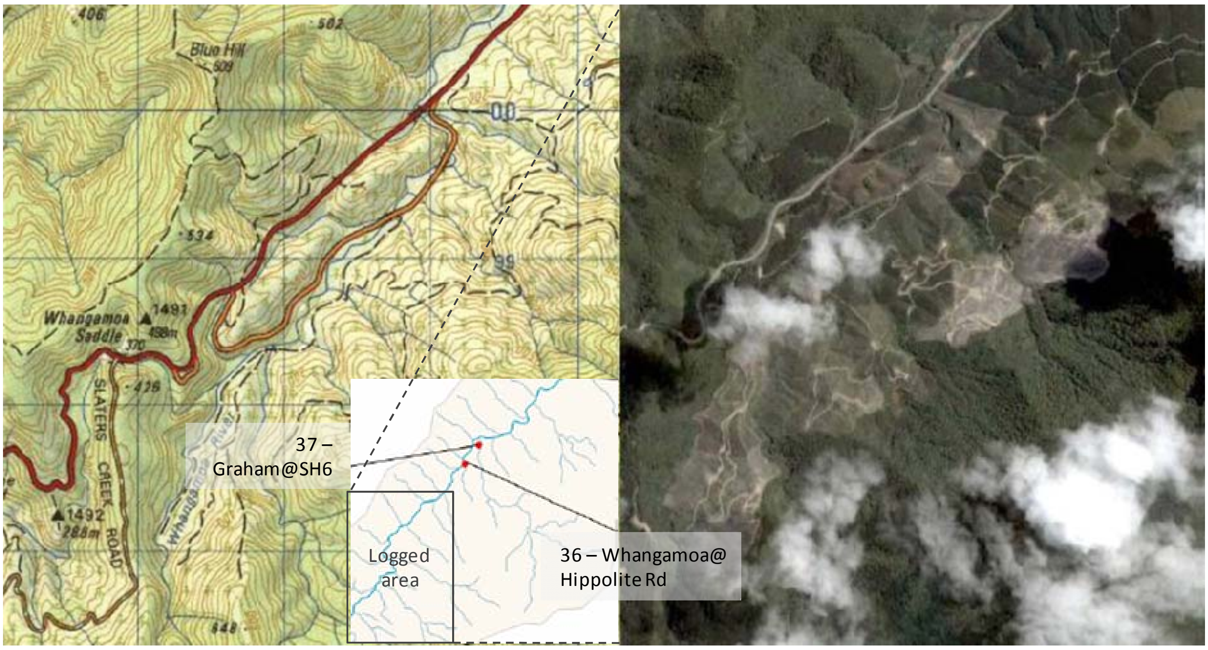


Figure 28. Logged area in the upper Whangamoa in the period leading up to 2007 (after Wilkinson, 2007b)

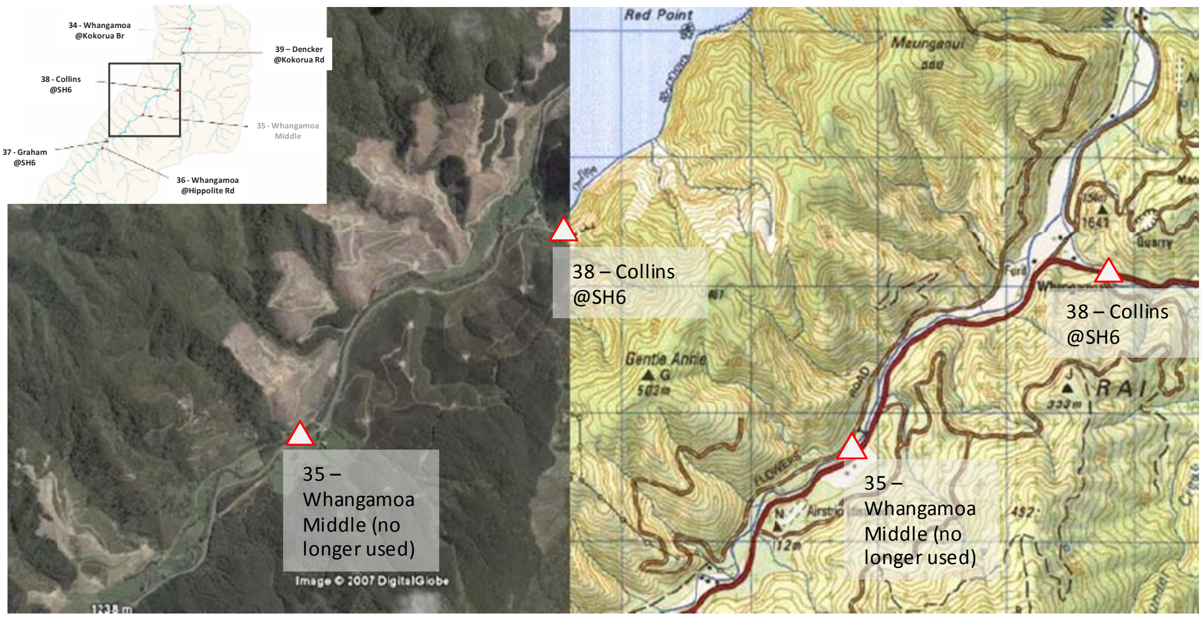


Figure 29. Logging in the middle Whangamoa in the period leading up to 2007.

Despite this logging activity the freshwater monitoring sites display relatively minimal impacts. Most sites have shown minimal changes (Figures 30 and 31) and only a few significant trends in water quality parameters have been observed (Tables 14 and 15).

Nitrate-N values are slightly elevated at all sites except in the Graham at SH6 (NCC37), and levels there offer a local reference value (Figures 30 and 32). The two main stem sites and the Collins at SH6 (NCC38) show strong seasonal variability with marked winter wet-weather spikes in N concentration, indicating winter respiration/decay and N washoff.

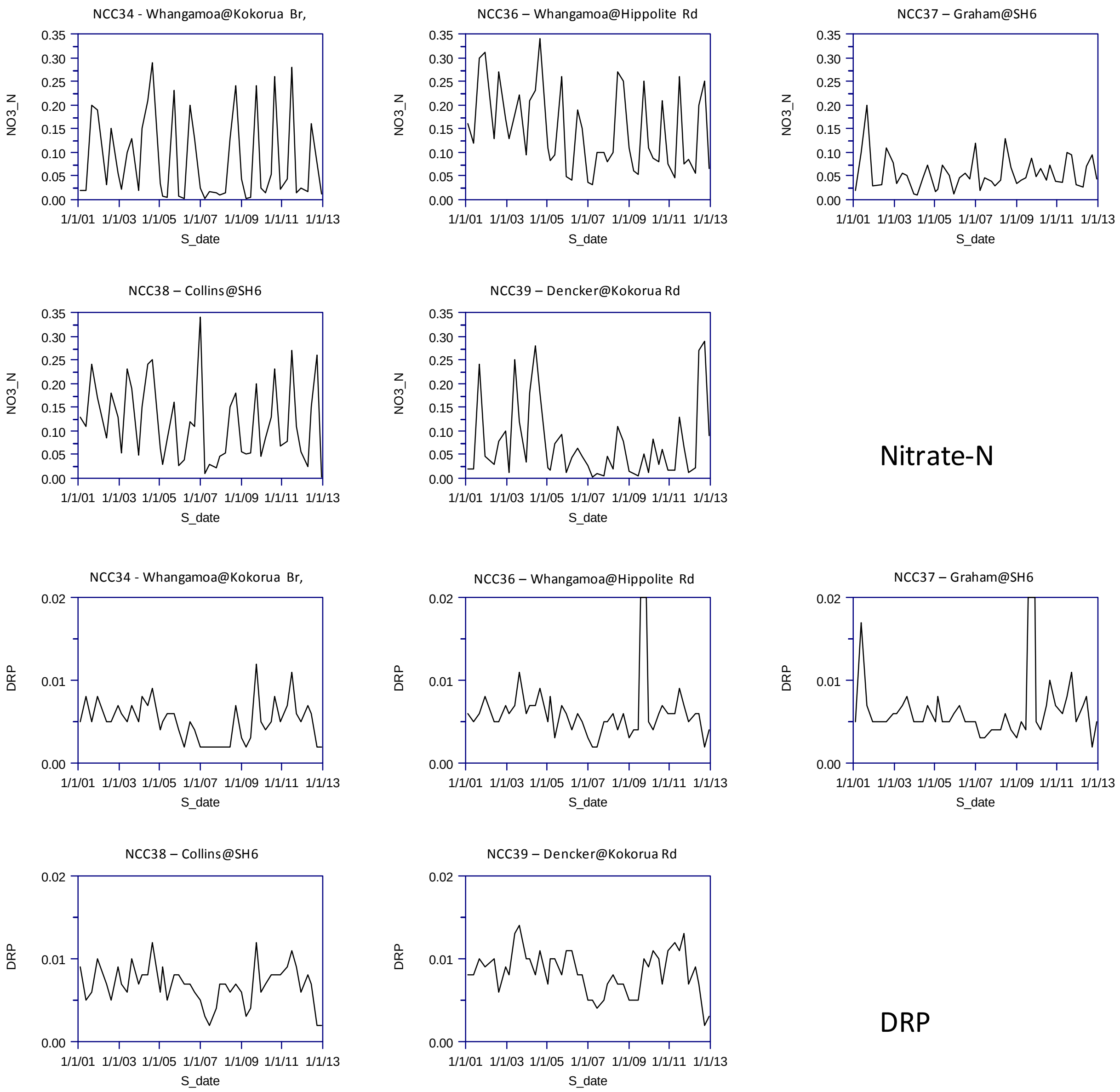


Figure 30. Time-series plots of raw nitrate-N and DRP data for the Whangamoa catchment

Table 14. Seasonal Kendall significant or near significant trends

Monitoring Site	Parameter	Median value	Kendall statistic	Z	P	Median annual Sen slope	5% confidence limit	95% confidence limit
34- Whangamoa@Kokoroa Br	Log10 E. coli	1.653	-63	-2.909	0.00363	-0.0853	-0.1208	-0.0428
	flow adjusted	1.6327	-67	-3.05	**0.00226**	-0.0737	-0.1038	-0.0412
36 - Whangamoa@Hippolite Rd	Nitrate-N	0.1000	-30	-1.31	0.19137	-0.0035	-0.0102	0.0009
	flow adjusted	0.1018	-42	-1.83	**0.06672**	-0.0044	-0.0101	-0.0003
37 - Graham@SH6	Nitrate-N	0.0450	50	2.20	0.02811	0.0031	0.0011	0.0044
	flow adjusted	0.044	42	1.834	**0.06672**	0.0024	0.0007	0.0037

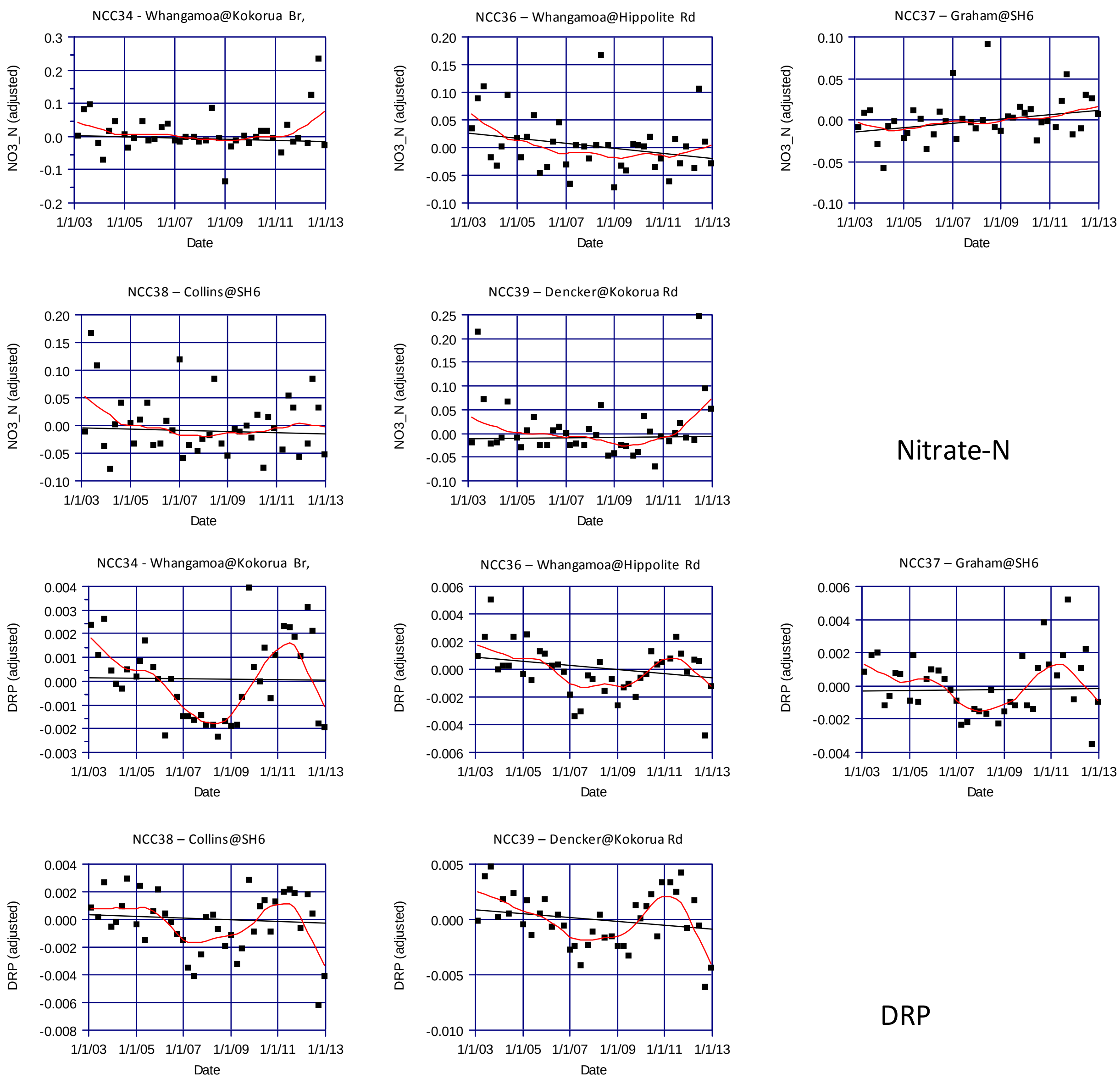


Figure 31. Time-series plots of flow adjusted NO_3-N and DRP with Seasonal Kendall trend and LOWESS curves

Table 15. Equivalence testing results for the biological and water quality indicators

Site No. and Name	NO3_N 10%	Turb 5%	DRP 10%	DO% 10%	Log10_E. coli 5%	N:P_ratio
34-Whangamoa@Kokorua Bridge	inc -	inc -	inc -	no diff	**strong -**	inc -
36-Whangamoa@Hippolite Rd	mod -	inc -	inc	no diff	inc	inc
37-Graham@SH6	inc	inc -	inc +	no diff	inc	inc
38-Collins@SH6	mod -	inc -	inc -	no diff	inc	inc
39-Dencker@Kokorua Rd	inc -	inc -	mod -	no diff	inc	inc +

Key:- no diff – means are the same; inc – inconclusive; mod – moderate evidence of a practically important difference; strong – strong evidence of a practically important difference; + increase; - decrease; ++/-- large increase/decrease.

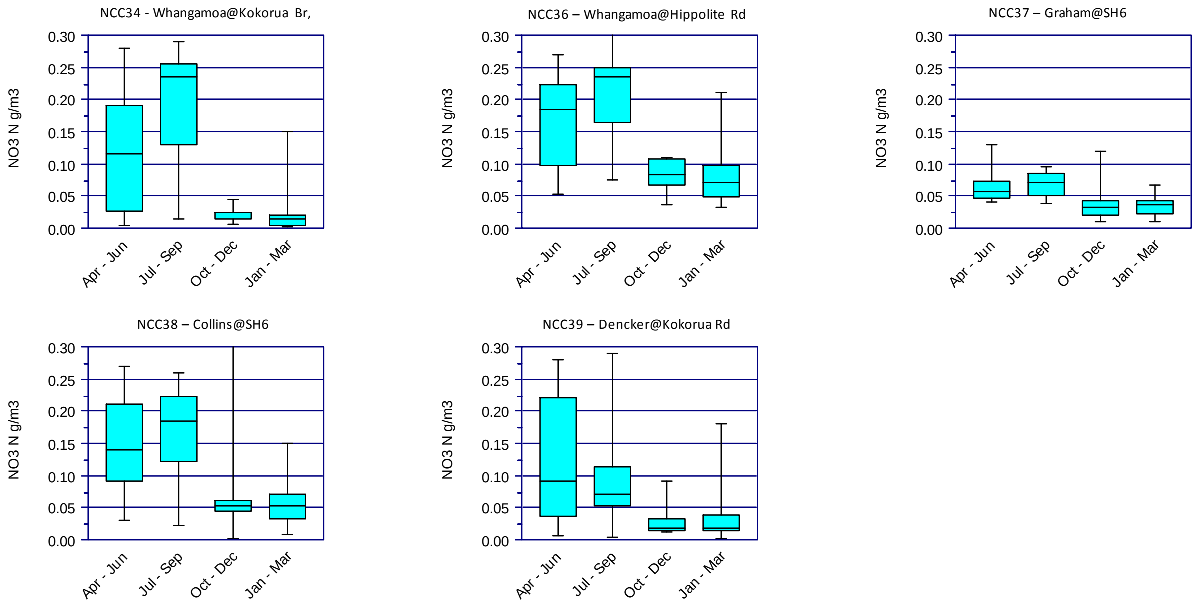


Figure 32. Box-plots of seasonal variation in nitrate-N for the Whangamoa catchment plotted with same y-axis extent for comparison of nitrate magnitude

The upper Whangamoa at Hippolite Road (NCC36) shows elevated dry-weather (summer/baseflow) nitrate-N concentrations (Figures 30 and 32), this may indicate continuous seepage of leached nitrate via the groundwater system to the river channel. If the underlying topography (less steep) in the upper Whangamoa is suitable for deeper percolation of leached winter nitrate from decaying woody debris, this may account for the elevated dry weather N concentrations, and would also increase the dispersion/dilution of released nitrate which would keep stream concentrations lower. The nitrate-N concentrations are generally lower than those in the middle and lower sites of both the Maitai and Wakapuaka systems.

The lower nitrate concentrations may also be due to the relative scale (intensity) and timing of logging activities, as well as, mixing and dilution in the river and soil/groundwater percolation effects, there may also be a degree of uptake within riparian margins. It should also be noted that, unlike in the Maitai where monitoring sites in sub-catchments with intensive forestry activity directly measure their impact, in the Whangamoa forest felling has not taken place in a monitored small sub-catchment. The impacts on those creeks which have had extensive clear-felling can be surmised from results elsewhere.

The pattern of elevated dry weather nitrate-N seen in the upper Whangamoa at Hippolite Road (NCC36) is observed to a lesser degree in the Collins River (NCC38), but is almost absent at (NCC34) Whangamoa at Kokorua Bridge, the lower monitoring site (Figures 30 and 32). The absence of elevated dry weather nitrate in the Whangamoa at Kokorua Bridge may be a consequence of dilution effects from untainted groundwater inflows, and perhaps due to uptake with the river channel (although periphyton scores indicate healthy (un-enriched) conditions. An examination of N:P ratios (Figure 33) shows that other than the upper Whangamoa at Hippolite Road (NCC36) site, the monitoring sites all exhibit nitrogen limited conditions, i.e. the available nitrate is low relative to the available phosphorus and that the ratio is less than 16 (the Redfield ratio). This situation would be expected to encourage the complete utilisation of available N and would hence lead to the low summer/dry-weather N concentrations observed.

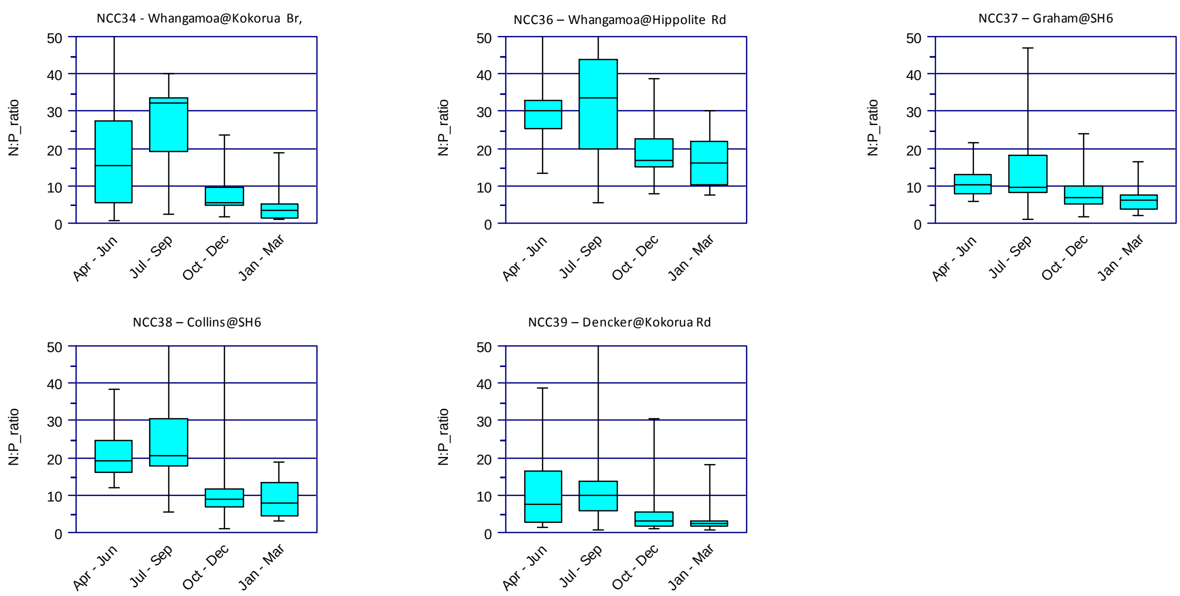


Figure 33. Seasonal extent of the nitrogen to phosphorus ratio at the freshwater monitoring sites in the Whangamoa

The stream biota in the Whangamoa system indicate healthy conditions (Figure 34). SQMCI appears to have increased in the lower Whangamoa at Kokorua Bridge (NCC34) after a period of lower scores from 2005 to 2007. These low scores may coincide with conditions in these dryer years (Figures 2 and 3). MCI is also lower at NCC34 - Whangamoa at Kokorua Bridge than elsewhere in the system. The lower site is wider, less shaded and has thinner riparian vegetation than the other sites (Crowe 2002) this exposure to brighter conditions may be the cause of elevated dissolved oxygen, which may in-turn impact the stream biota.

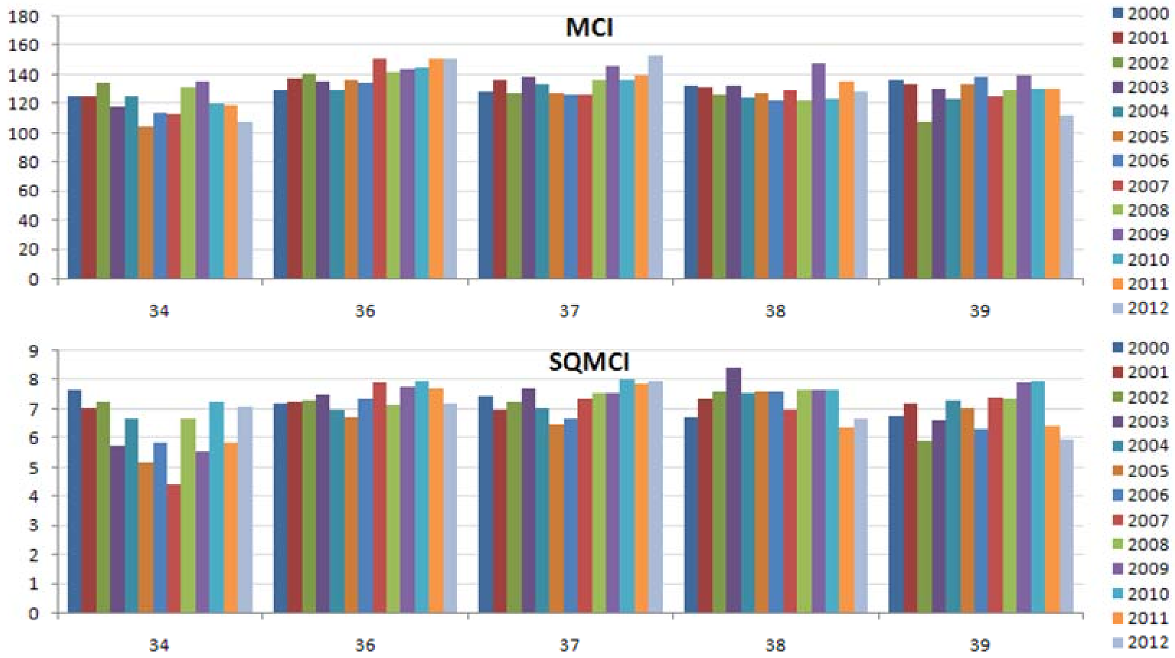


Figure 34. Annual MCI and SQMCI values at each site in the Whangamoa catchment.

NCC34 - Whangamoa at Kokorua Bridge exhibits a downward trend in E. coli, this may reflect the impact of a possum control operation, or the removal of stock in the lower reaches of the river. A marginal increasing trend in nitrate-N is indicated in the Graham (Table 14), however, the concentration is very low. Observations should be maintained for evidence of activities that may give rise to further N increases, e.g., evidence of new, recent or on-going forestry activity should be recorded in field journals or record sheets.

4. CATCHMENT SUMMARIES

The following catchment summary tables show site by site classes and scores, changes and trends. They highlight problems and issues, key indicators, and suggest possible remedial action and priority sites.

4.1. Coastal and Urban Catchments

Coastal and Urban	Saxton at Main Rd	Change / Trend	Orphanage at Saxton Rd East	Change / Trend	Poorman at Seaview Rd	Change / Trend	Poorman at Barnicoat Walkway	Change / Trend	Jenkins at Pascoe St	Change / Trend	York at Waimea Rd	Change / Trend	Todds at SH6	Change / Trend	Hillwood at Glen Rd	Change / Trend
NCC No.	1		2		4		5		6		9		21		40	
Final Class 2013	**D**	↑	**D**		**D**		**B**	↑	**E**		**E**		**D**		**C**	↑
Class 2007	E		D		D		C		E		E		D		D	
Rounded score	**4**		**4**		**4**		**2**		**5**		**5**		**4**		**3**	
Actual score	4.33		4.49		3.98		2.34		4.60		4.77		4.13		3.35	
Nitrate-N	5.0		5.0		4.0		3.0		5.0		5.0	↑	4.0		3.0	↑
DRP	3.0	↓	3.0		3.0		3.0		3.0	↑	3.0		4.0	↓	3.0	
pH (pH units)	3.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0	
Temperature (°C)	1.0		2.0		1.0		1.0		2.0		1.0		2.0		2.0	
DO (%)	4.0		3.0		3.0		1.0		3.0		1.0		1.0		1.0	
Turbidity (NTU)	5.0		4.0		3.0		3.0		4.0		5.0		5.0		4.0	
Black disc (m)	4.0		4.0		3.0		3.0		4.0		4.0		4.0		4.0	
General E. coli	4.5		3.0		3.0		2.0		3.0		3.0		3.0		3.0	↑
Recreation E. coli	4.0		4.0		4.0		1.0		4.0		4.0		4.0		4.0	
MCI	3.0	↑	4.0		4.0		2.0		4.0	↓	4.0		3.0		3.0	
SQMCI	3.0		4.0		4.0		2.0	↑	4.0		4.0		4.0		3.0	↑
Periphyton score	3.0		3.0		1.0		1.0		3.0		1.0		2.0		3.0	
Cd (mg/kg)	2.0		2.0		2.0		2.0		2.0		2.0					
Cu (mg/kg)	2.0		2.0		2.0		2.0		2.0		2.0	↑				
Pb (mg/kg)	2.0		2.0		2.0		2.0		5.0	↓	5.0	↑				
Zn (mg/kg	2.0		2.0	↓	2.0	↑	2.0		5.0	↓	5.0	↑				
Total PAHs					2.0		2.0		2.0	↓	2.0					

Catchment, Site	**Site summary of problems and remedial action**
Saxton at Main Rd - High priority	Improved MCI. On-going elevated N, E. coli and poor clarity. Impacted by pond at Daylands Fruit with wildfowl, nutrients and E. coli, also dairy farm and two reservoirs in upper catchment. Investigate measures to minimise dairy farm runoff, and possible reedbed or wetland sites.
Orphanage at Saxton Rd East - High priority	Elevated N, P, E. coli and poor clarity. Diminished stream insects. Examine all options to improve storm-runoff quality - buffer strips, detention bunds. Fencing to reduce erosion
Poorman at Seaview Rd - High priority	N, P elevated. DO and black disk poor. Heavily impacted stream insects. Take action to reduce road runoff impact - detention pond
Poorman at Barnicoat Walkway - Low priority	Improved SQMCI. N and P elevated, explore options for riparian planting, fencing and buffer strips
Jenkins at Pascoe St - HIGH PRIORITY	Deteriorating MCI. Elevated but improving zinc and PAH levels. Poor clarity and E. coli levels. Investigate options for stormwater detention bunds, fencing, buffer strips, roof-water harvesting systems etc.
York at Waimea Rd - HIGH PRIORITY	Elevated and increasing N, Zn, Pb. Elevated base-flow N, suggests point source. Poor clarity and E. coli. Take additional samples to highlight N source. Explore options for passive retention of roof and road runoff, and other forms of stormwater detention.
Todds at SH6 - High priority	Elevated N, P, E. coli and poor clarity. Diminished stream insects. Check condition of fencing, bank erosion, riparian planting etc.
Hillwood at Glen Rd - Moderate priority	Improved SQMCI. Increasing N, poor clarity and E. coli. Is this paddock runoff? Further on-foot investigation required. Has fencing been established and stock restricted from streamway?
Key indicators: N, DRP, E. coli, Turbidity/black disk, DO, PAH/metals, MCI/SQMCI	

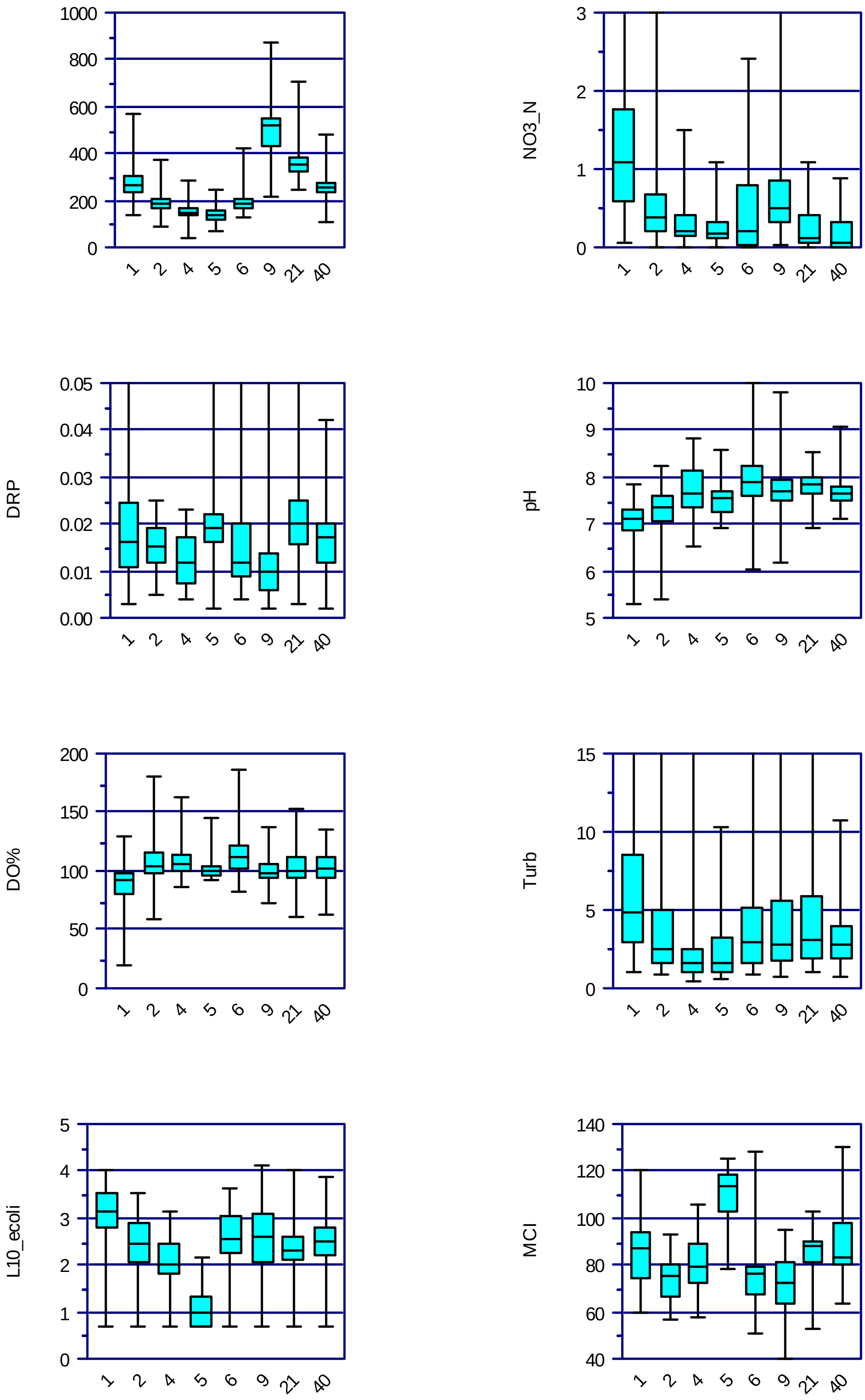


Figure 35. Comparative box plots of water quality parameters in the Coastal and Urban Streams.

4.2. Maitai River and sub-catchments

Maitai and Brook	Brook at Manuka St	Change / Trend	Brook at Burn Pl	Change / Trend	Brook at Motor Camp	Change / Trend	Maitai at Riverside	Change / Trend	Maitai at Groom Rd	Change / Trend	Maitai South Branch at Intake	Change / Trend	Sharland at Maitai Confluence	Change / Trend	Groom at Maitai Confluence	Change / Trend
NCC No.	10		11		12		13		15		16		17		18	
Final Class 2013	**C**	?	**C**		**A**		**C**	?	**C**		**A**		**D**	?	**D**	?
Class 2007	D		-		A		D		C		A		C		B	
Rounded score	**3**		**3**		**1**		**3**		**3**		**1**		**4**		**4**	
Actual score	2.96		2.89		1.35		3.22		2.67		1.10		3.52		3.57	
Nitrate-N	3.0	?	3.0		1.0	?	3.0	?	1.0	?	1.0		5.0		5.0	?
DRP	3.0		3.0		3.0		1.0		1.0		1.0		2.0		3.0	?
pH (pH units)	1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0	
Temperature (°C)	2.0		2.0		1.0		2.0		2.0		1.0		1.0		1.0	
DO (%)	3.0		3.0		1.0		3.0		3.0		3.0		3.0		2.0	
Turbidity (NTU)	2.0		2.0		1.0		2.0		2.0		1.0		3.0		3.0	
Black disc (m)	3.0		3.0		2.0		3.0		2.0		1.0		3.0		3.0	
General E. coli	3.0		2.0		2.0		3.0		2.0		2.0		2.0		3.0	
Recreation E. coli	4.0		2.0		3.0	?	4.0		1.0		2.0		3.0		4.0	
MCI	3.0		2.0		1.0		3.0		3.0		1.0		2.0	?	2.0	?
SQMCI	3.0		2.0		1.0		3.0		3.0		1.0		2.0	?	2.0	?
Periphyton score	1.0		1.0		1.0		2.0		2.0		1.0		1.0		2.0	
Cd (mg/kg)	2.0		2.0		2.0		2.0		2.0		2.0					
Cu (mg/kg)	2.0	?	2.0		2.0		2.0		2.0		2.0					
Pb (mg/kg)	2.0	?	2.0	?	2.0		2.0	?	2.0		2.0					
Zn (mg/kg	2.0	?	2.0	?	2.0		2.0	?	2.0		2.0					
Total PAHs	2.0		2.0		2.0		2.0	?								

Catchment, Site	**Site summary of problems and remedial action**
Brook at Manuka St - Higher priority	Local stormwater input and sediment metals/PAHS. Nutrients, turbidity, E. coli. Measures in upper catchment to reduce erosion, and nutrient release. Roof water harvesting initiatives for local runoff. Checking for storm/foul wastewater cross-connections. Other stormwater detention intiatives. Street-sweeping initiative.
Brook at Burn Pl	As above. Investigate runoff from Tantragee area - erosion and nitrate.
Brook at Motor Camp	Marginally increasing N. Moderately elevated DRP - probably natural signal. Continue to monitor.
Maitai at Riverside - Higher priority	As for Brook at Manuka. Upstream conditions responsible for increasing N. Target nitrogen leaching sub-catchments. Sediment PAH levels at downstream stormwater outlets remains priority for action
Maitai at Groom Rd - Moderate priority	Poor SQMCI might be related to local habitat. Minor E. coli, clarity and DO issues. Pursue options to improve buffering and reduce erosion
Maitai South Branch at Intake	Known issues relating to Dam management and operation. Remediation of these issues will benefit this site
Sharland at Maitai Confluence - Moderate priority	Strong downward trend in SQMCI, lesser decline in MCI. On going high N due to extensive logging. Only option is wetland in any workable configuration. Re-afforestation, completion of slash break-down, and natural revegetation will reduce N in 2-3 years
Groom at Maitai Confluence - Moderate priority	Strong downward trend in SQMCI, lesser decline in MCI. N, P and erosion issues. As per Sharlands Creek. Time will heal the damage. Consider limitations on total clear-fell area as % catchment area
Key indicators for the Maitai: N, DRP, Turbidity/black disk, PAH/metals, MCI/SQMCI	

*Lower Maitai at Collingwood Street Bridge has high faecal contamination from stormwater and sewer contamination identified at upper Collingwood and Manuka Street.

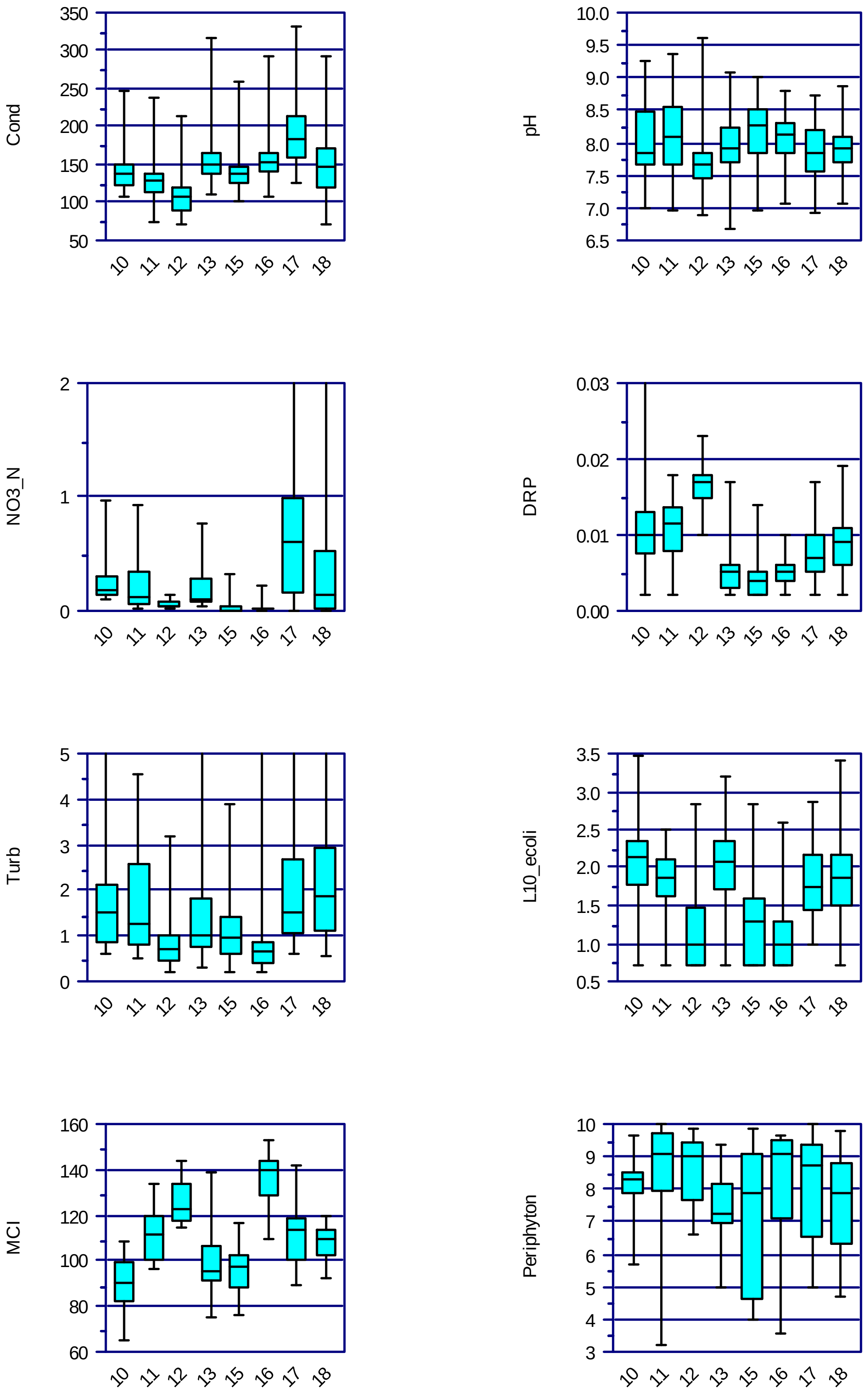


Figure 36. Comparative box plots of water quality parameters in the Maitai catchment.

4.3. Wakapuaka and sub-catchments

Wakapuaka	Wakapuaka at Maori Pa Rd	Change / Trend	Wakapuaka at Hira	Change / Trend	Wakapuaka at Duckpond Rd	Change / Trend	Lud at SH6	Change / Trend	Lud at 4.7km	Change / Trend	Teal at 1.9km	Change / Trend	Pritchards at 890m	Change / Trend
NCC No.	25		27		28		29		30		32		33	
Final Class 2013	**B**	↑	**B**	↓	**A**		**C**		**C**		**B**	↑	**A**	
Class 2007	C		A		A		C		C		C		A	
Rounded score	**2**		**2**		**1**		**3**		**3**		**2**		**1**	
Actual score	2.23		1.51		1.07		3.46		2.86		1.61		1.07	
Nitrate-N	3.0		3.0		2.0		5.0	↓	4.0	↑	3.0	↑	1.0	↓
DRP	2.0		2.0		2.0		3.0		3.0		2.0		3.0	
pH (pH units)	1.0		1.0		1.0		1.0		1.0		1.0		1.0	
Temperature (°C)	2.0		1.0		1.0		1.0		2.0		1.0		1.0	
DO (%)	3.0		2.0		2.0		1.0		3.0		3.0		1.0	
Turbidity (NTU)	2.0	↓	2.0	↓	1.0		2.0		3.0		1.0		1.0	↓
Black disc (m)	2.0		2.0		2.0		3.0		3.0		2.0		2.0	
General E. coli	3.0		2.0		2.0		3.0		3.0		2.0		2.0	
Recreation E. coli	3.0		3.0		2.0		4.0		4.0	↓	4.0		4.0	
MCI	2.0		1.0		1.0		2.0		2.0	↓	1.0		1.0	
SQMCI	2.0	↑	1.0		1.0		1.0		2.0	↓	1.0		1.0	
Periphyton score	1.0		1.0		1.0		1.0		1.0		1.0		1.0	

Catchment, Site	**Site summary of problems and remedial action**
Wakapuaka at Maori Pa Rd	Improved SQMCI. Decline in turbidity. Elevated N, P. Check fencing, riparian plantings. Upstream measures may reduce N input
Wakapuaka at Hira	Elevated N, P, turbidity and clarity caused by Lud and Teal. Efforts in these sub-catchments will benefit here
Wakapuaka at Duckpond Rd	Minor clarity, DO and E. coli issues. Examine possible sources and options.
Lud at SH6 - High priority	Point-source faecal contamination indicated with NH4-N pulses. Check for septic overflows, examine fencing, stocking densities, riparian buffer and vegetation options. Measures at Lud upper will help.
Lud at 4.7km - High priority	Decline in MCI/SQMCI. Increased N, reduced E. coli. Forestry and livestock related issues indicated. Examine fencing, riparian buffer and vegetation options. Check upper reaches for logging activity.
Teal at 1.9km	Increased N, reduced E. coli. Forestry and livestock related issues indicated. Examine fencing, riparian buffer and vegetation options. Check upper reaches for logging activity.
Pritchards at 890m	Elevated DRP. N, turbidity down. Slightly elevated E. coli. Continue to monitor.
Key indicators: N, DRP, DO, E. coli, clarity measures, MCI/SQMCI	

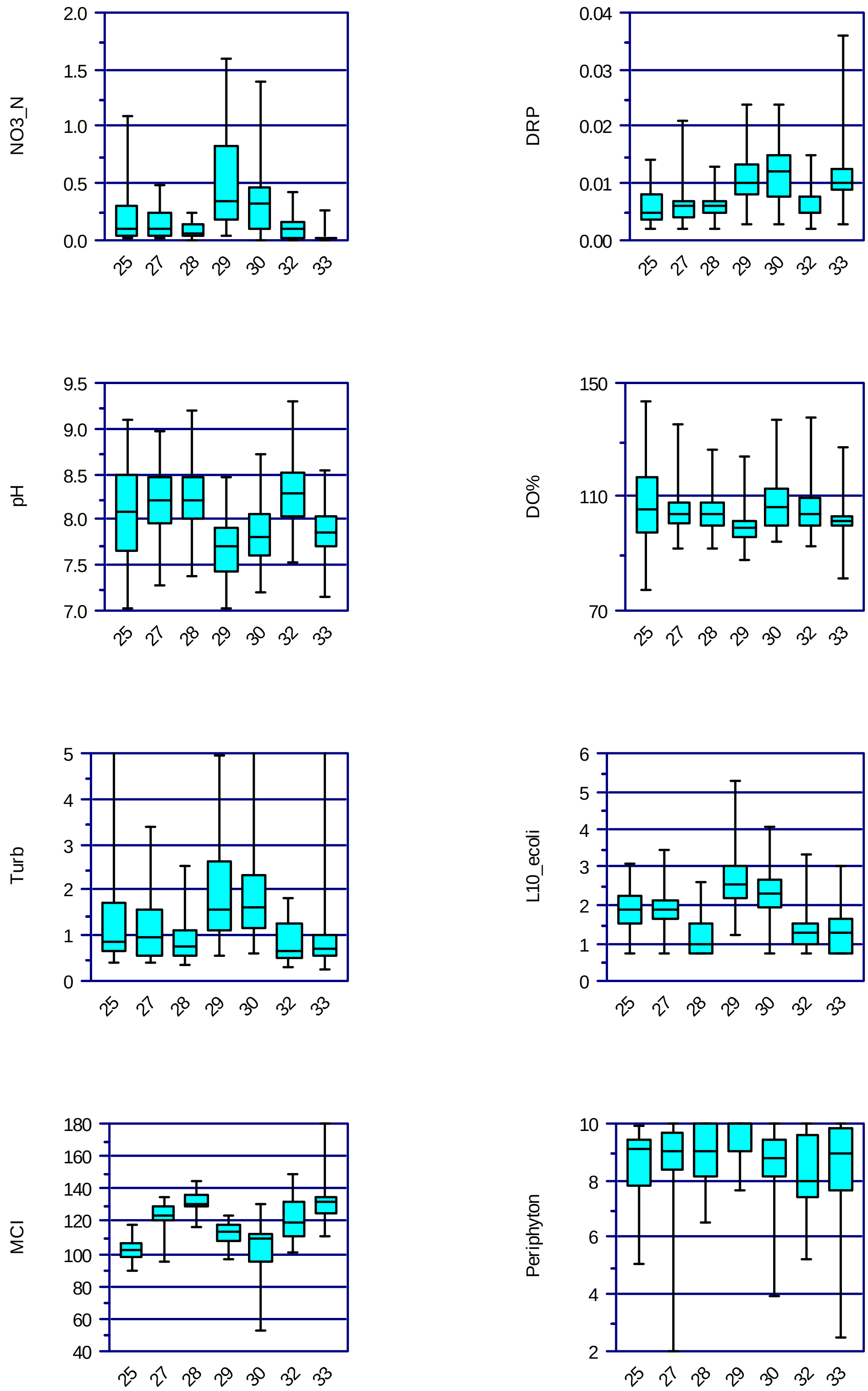


Figure 37. Comparative box plots of water quality parameters in the Wakapuaka catchment.

4.4. Whangamoa and sub-catchments

Whangamoa	Whangamoa at Kokorua Bridge	*Change / Trend*	Whangamoa at Hippolite Rd	*Change / Trend*	Graham at SH6	*Change / Trend*	Collins at SH6	*Change / Trend*	Dencker at Kokorua Rd	*Change / Trend*
NCC No.	34		36		37		38		39	
Final Class 2013	**B**	↓	**A**		**A**		**B**		**B**	
Class 2007	A		A		A		B		B	
Rounded score	**2**		**1**		**1**		**2**		**2**	
Actual score	1.56		1.40		1.21		1.92		1.84	
Nitrate-N	2.0		3.0	↓	1.0		3.0		1.0	↑
DRP	1.0		2.0		2.0		2.0		3.0	
pH (pH units)	1.0		1.0		1.0		1.0		1.0	
Temperature (°C)	2.0		1.0		1.0		1.0		1.0	
DO (%)	3.0		2.0		2.0		3.0		3.0	
Turbidity (NTU)	2.0		1.0		2.0		3.0		3.0	
Black disc (m)	2.0		1.0		3.0		3.0		3.0	
General E. coli	3.0		2.0		2.0		2.0		3.0	
Recreation E. coli	4.0	↓	2.0		2.0		4.0		4.0	
MCI	1.0		1.0	↑	1.0		1.0		1.0	
SQMCI	1.0	↓	1.0		1.0		1.0		1.0	
Periphyton score	1.0		1.0		1.0		1.0		1.0	

Catchment, Site	**Site summary of problems and remedial action**
Whangamoa at Kokorua Bridge	Elevated DRP, DO. E. coli improved. Slight decline in SQMCI. Continue to observe for futher deterioration.
Whangamoa at Hippolite Rd	Elevated N, P, E. coli. Check for future logging schedules.
Graham at SH6	Slightly elevated DRP. Check for future logging schedules.
Collins at SH6	Elevated N, DRP, DO, turbidity, E. coli. Check for future logging schedules.
Dencker at Kokorua Rd	Elevated DRP, DO, turbidity, E. coli. Check for future logging schedules.

Key indicators: N, P, DO, clarity measures, E. coli, MCI/SQMCI

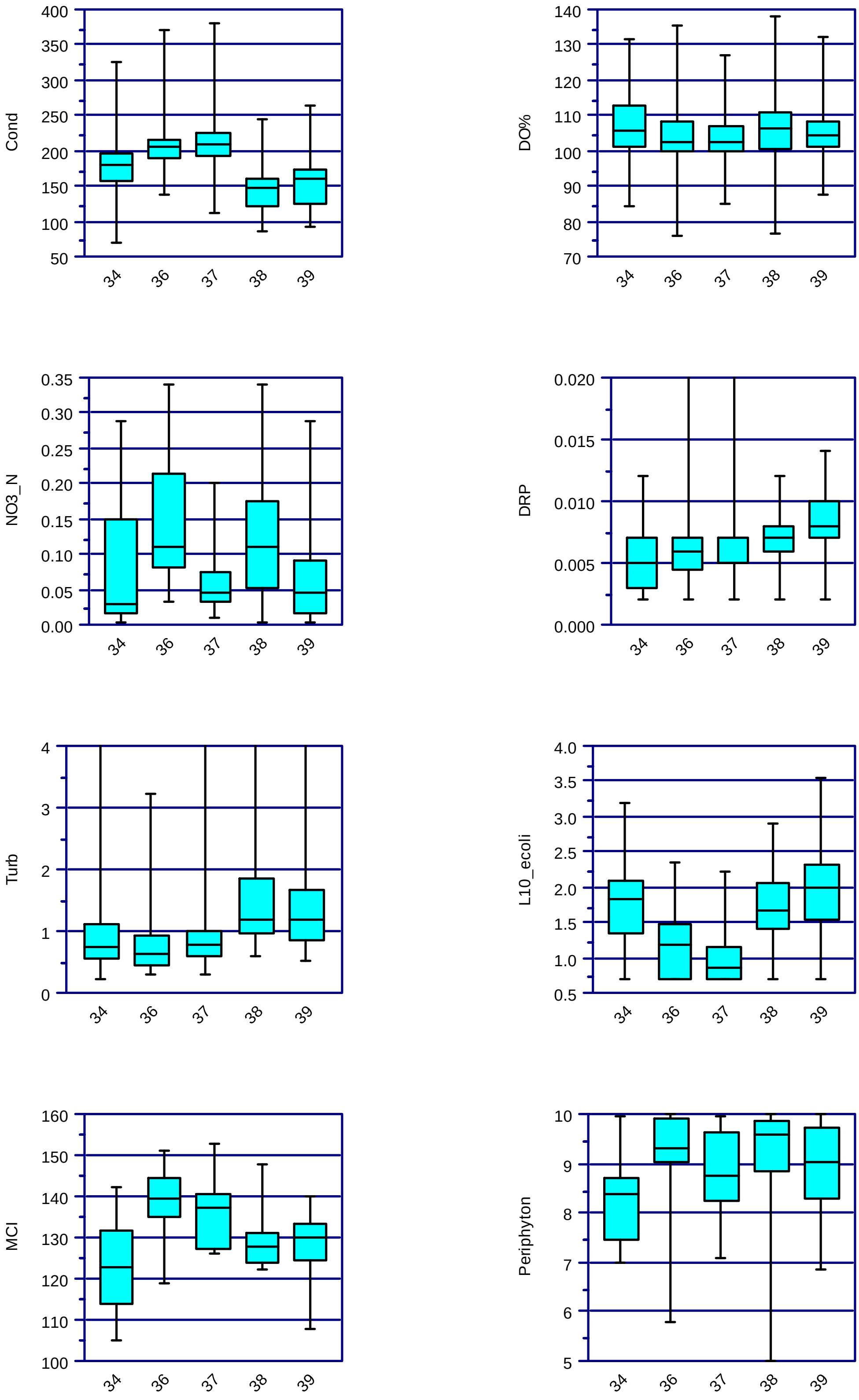


Figure 38. Comparative box plots of water quality parameters in the Whangamoa catchment.

5. REFERENCES

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Appendix 1: Plots of PAH compositional profiles for Nelson stream sediment samples

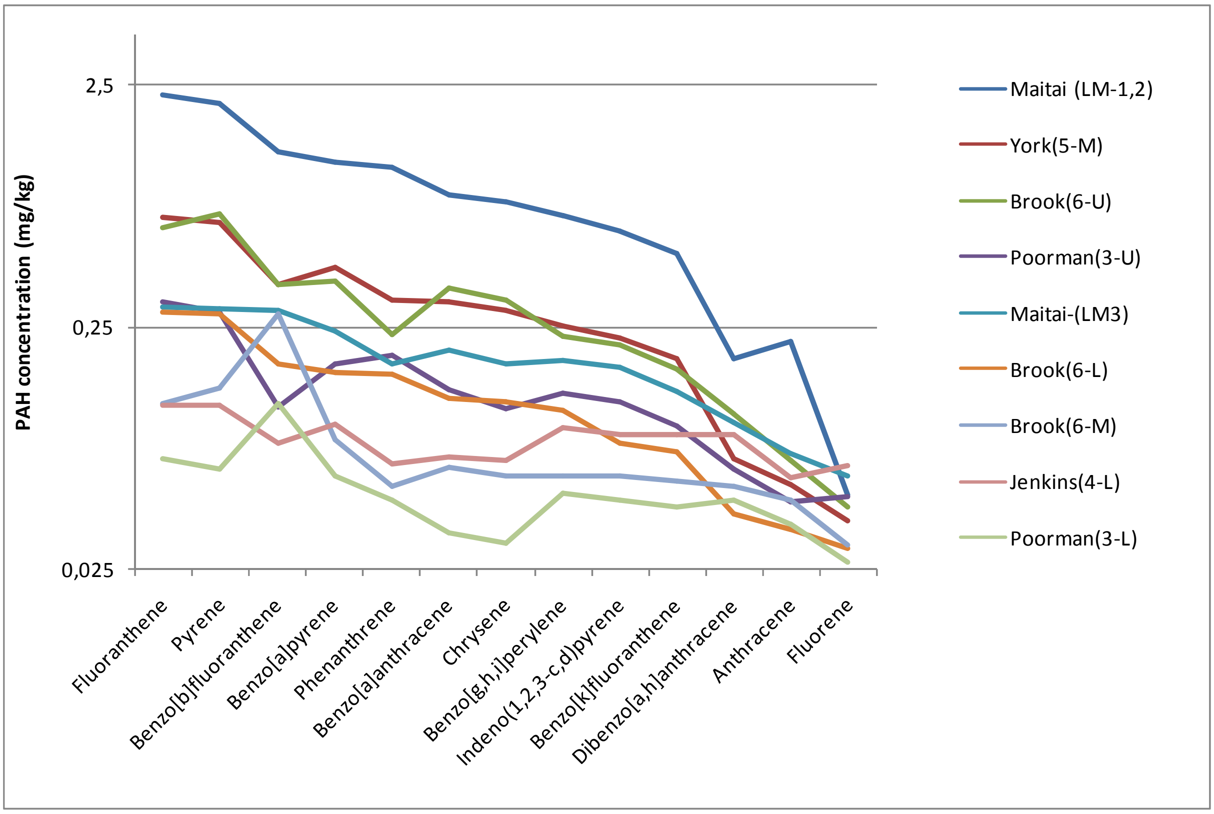


Figure A1. The mean compositional profiles of PAHs in Nelson sediments for 2000 to 2012 freshwater classification update.

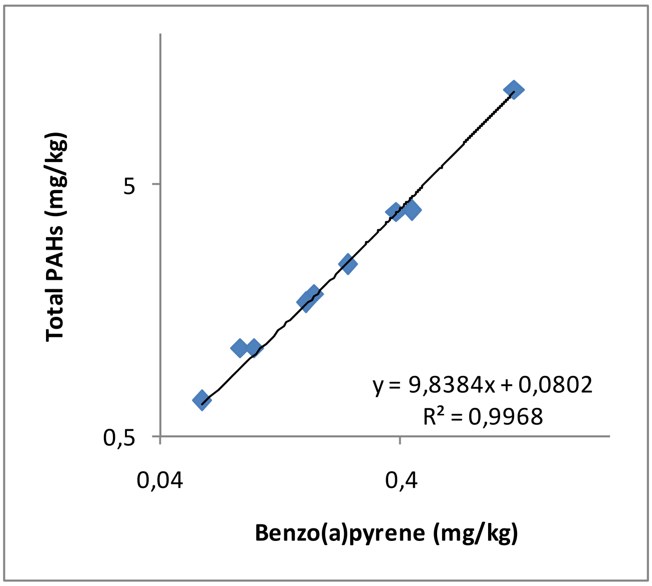
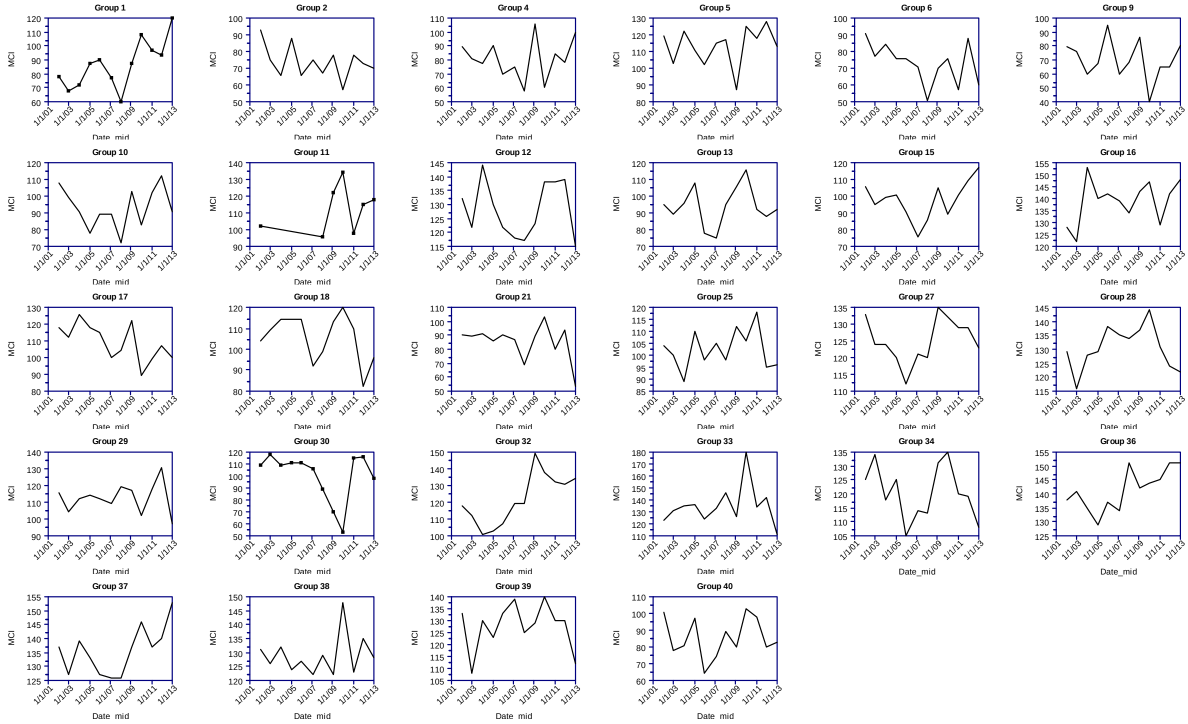
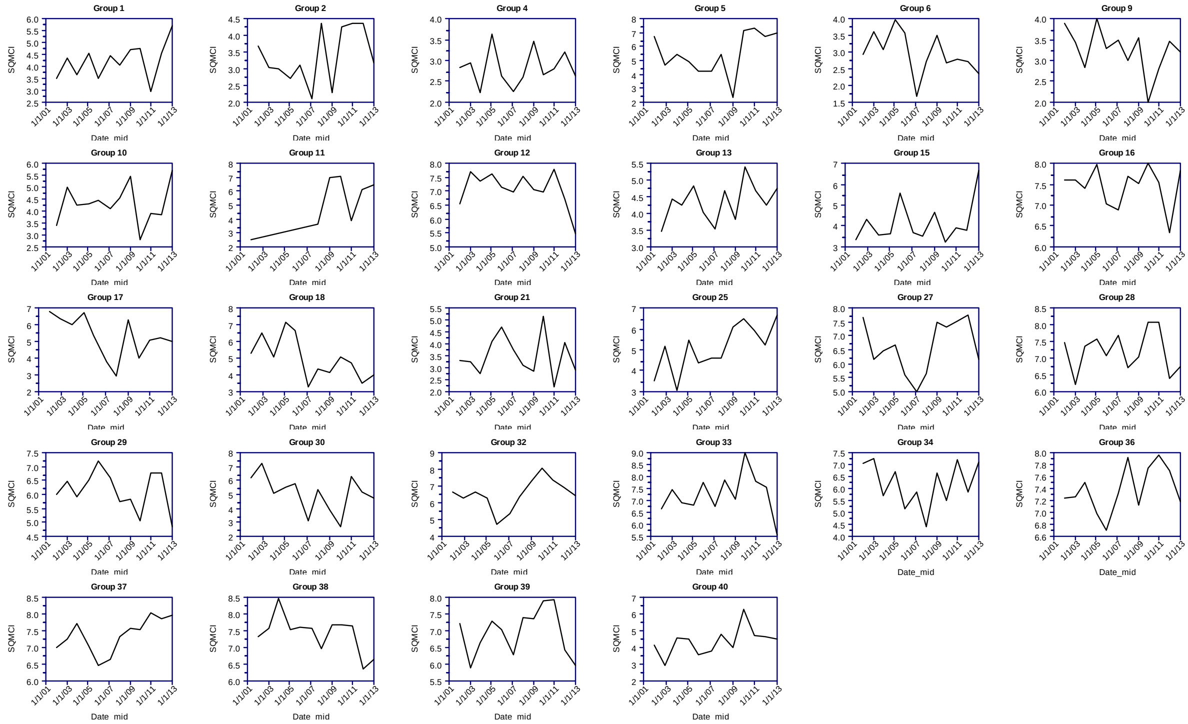


Figure A2. The relationship between site by site mean Benzo(a)pyrene and Total PAH concentrations (mg/kg) in Nelson (2000-12).

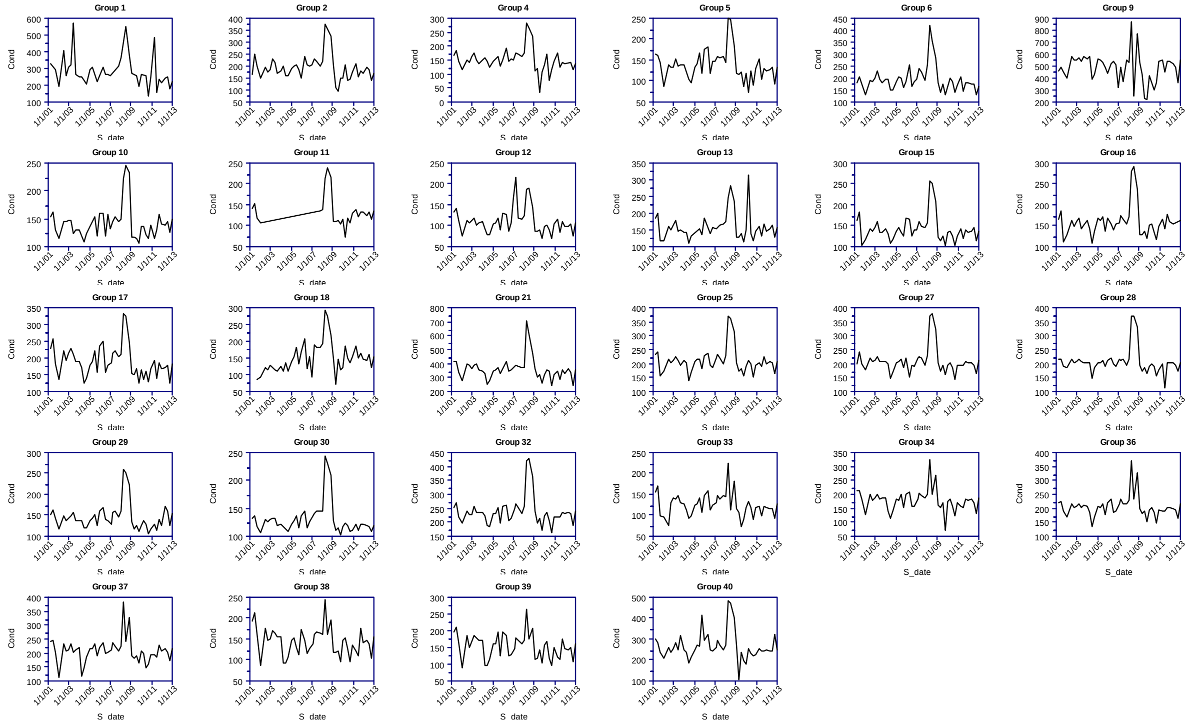
Appendix 2. Time-series plots of raw monitoring parameter values.



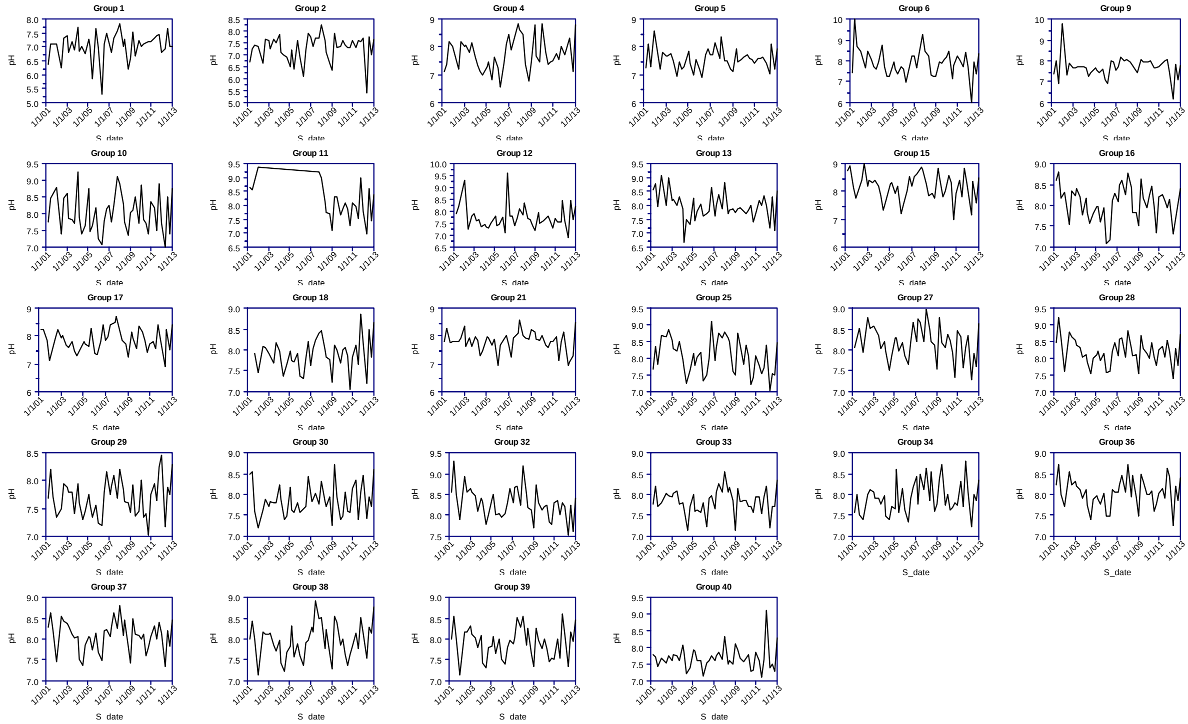
MCI



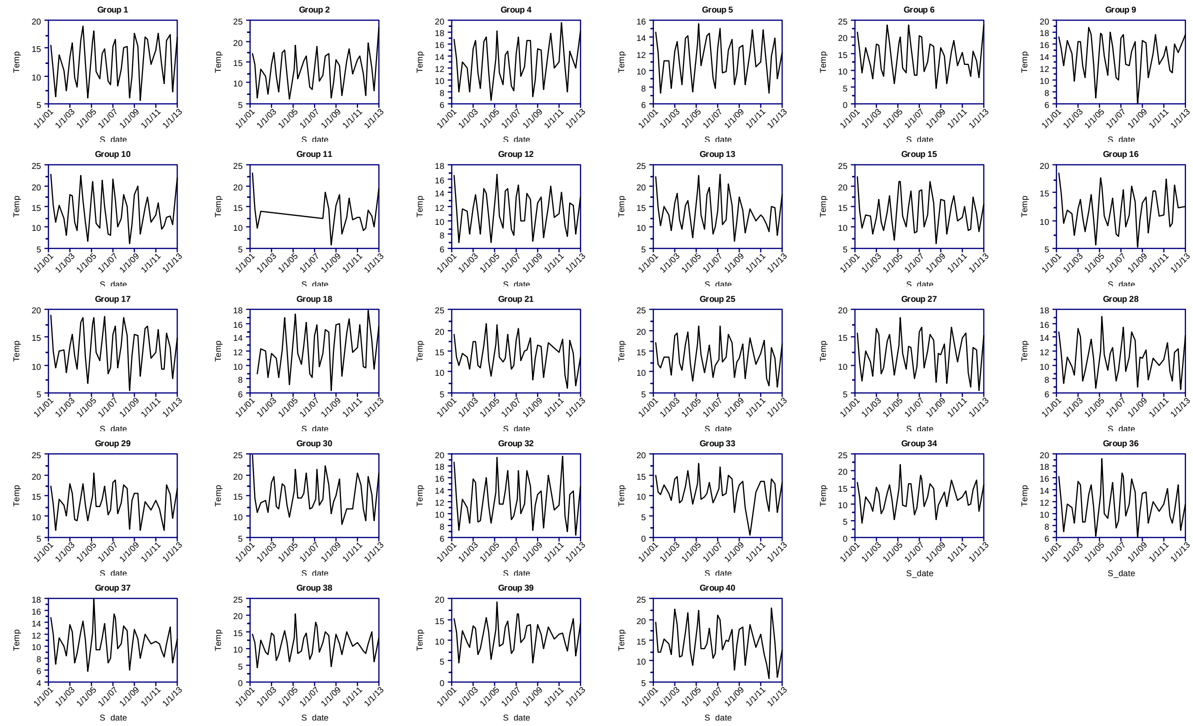
SQMCI



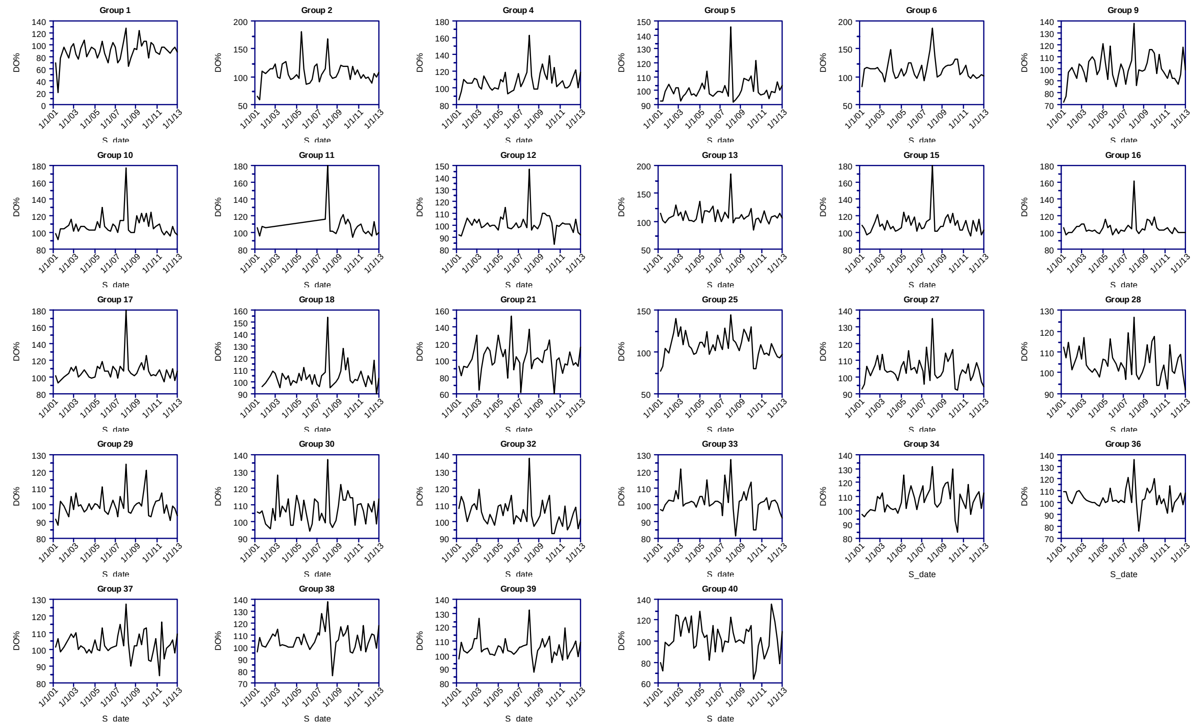
Electrical conductivity



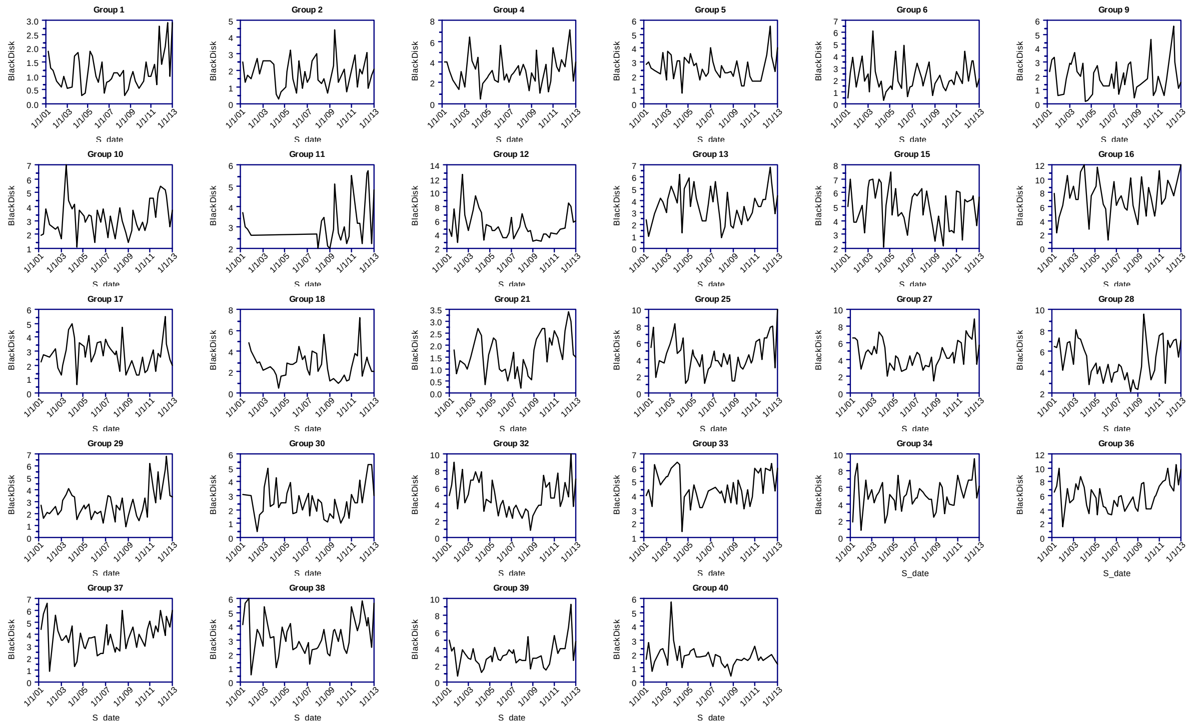
pH



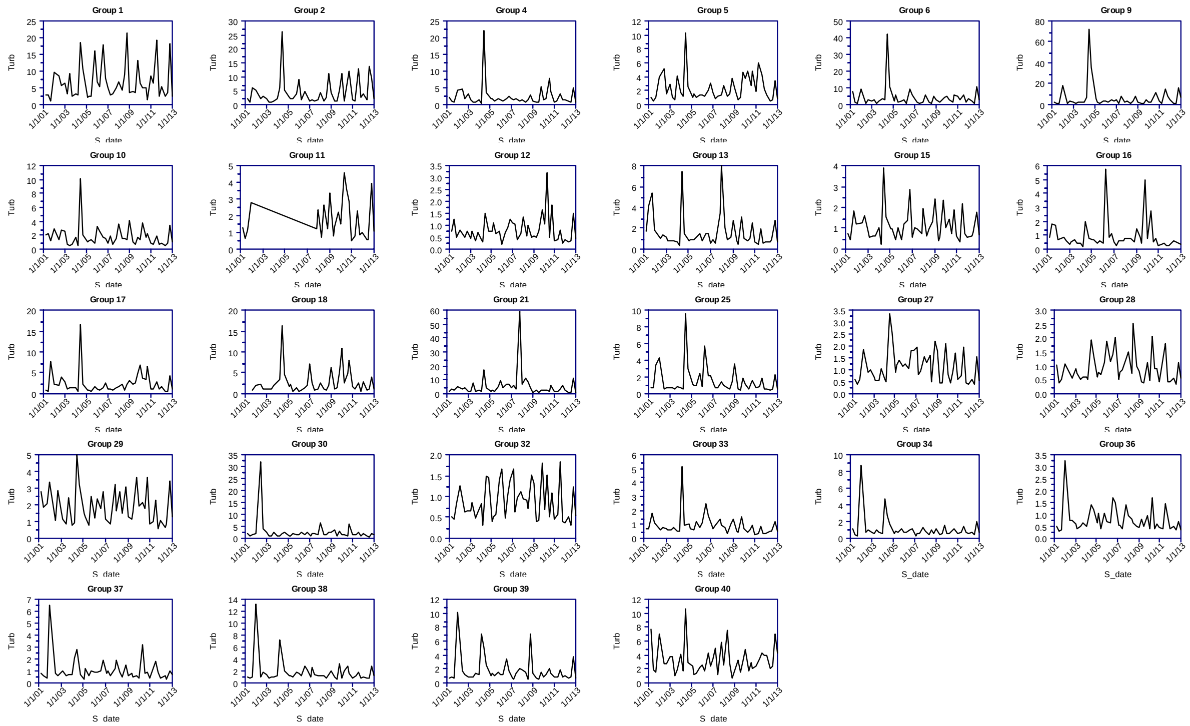
Water temperature °C



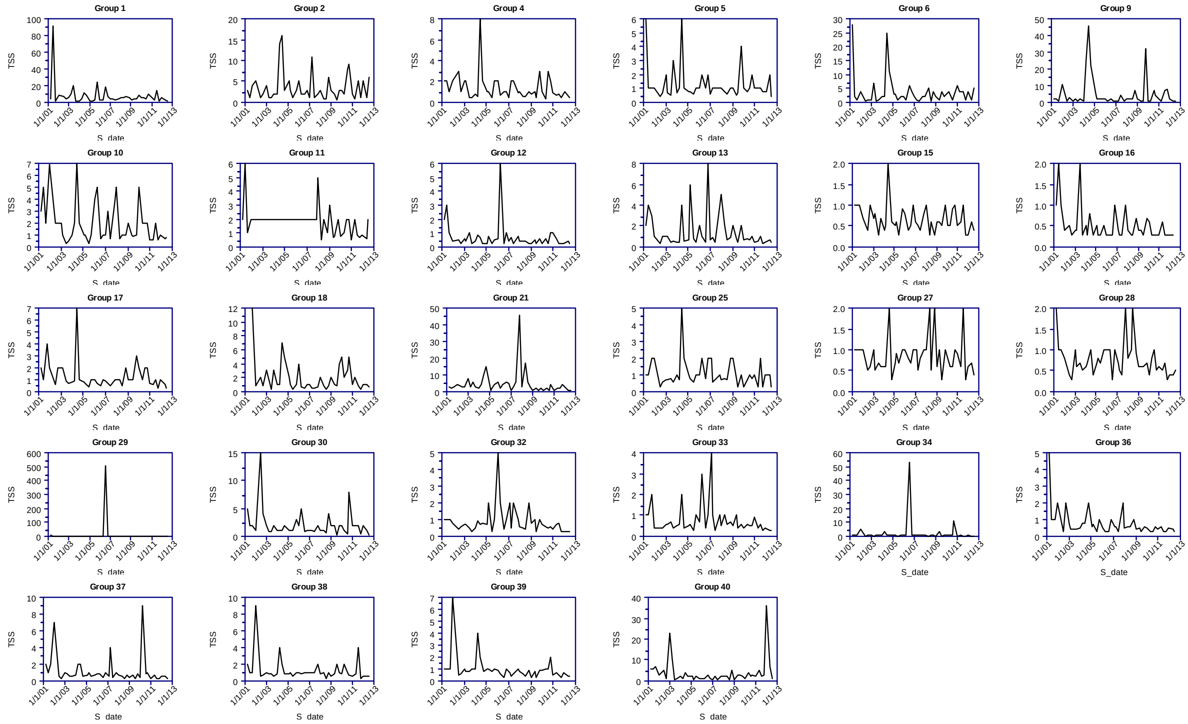
Dissolved Oxygen Percentage Saturation (DO%)



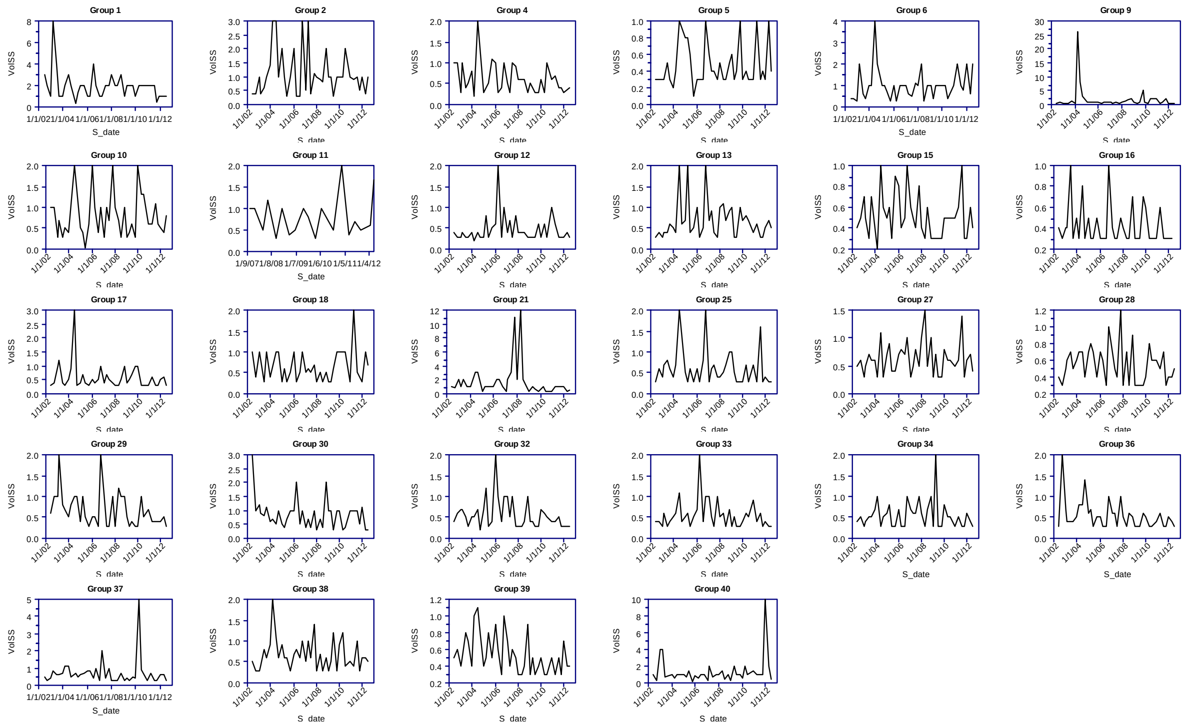
Black disk visible depth (m)



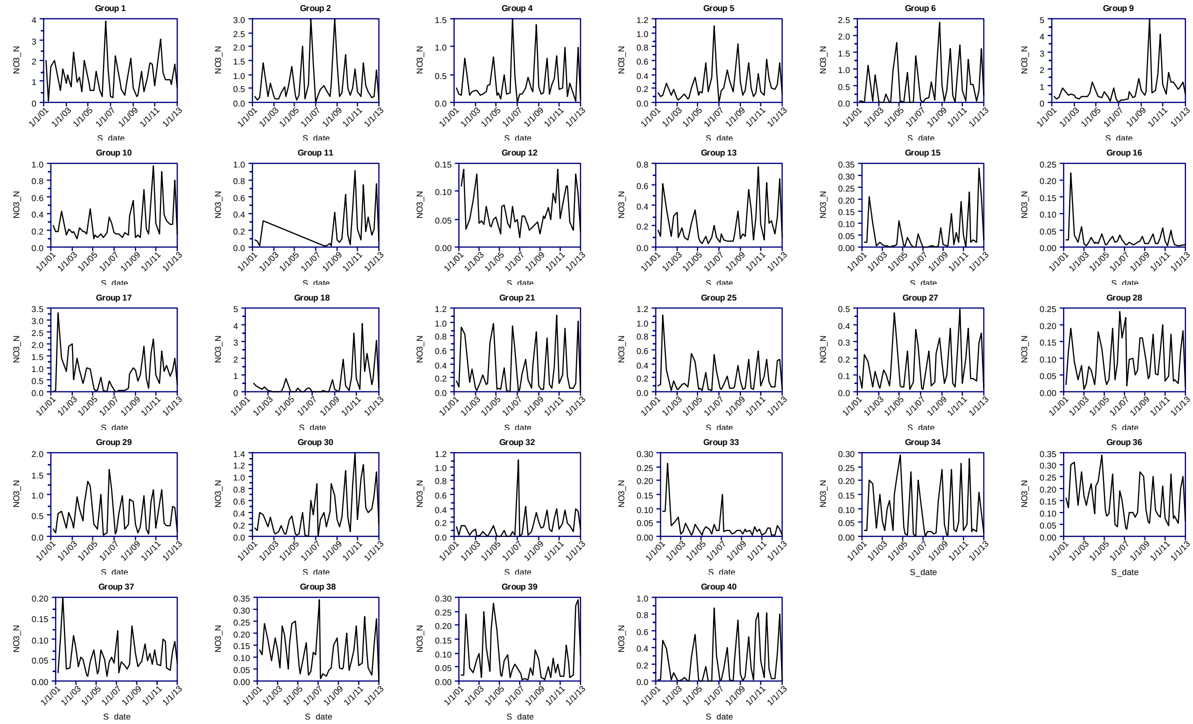
Turbidity (NTU)



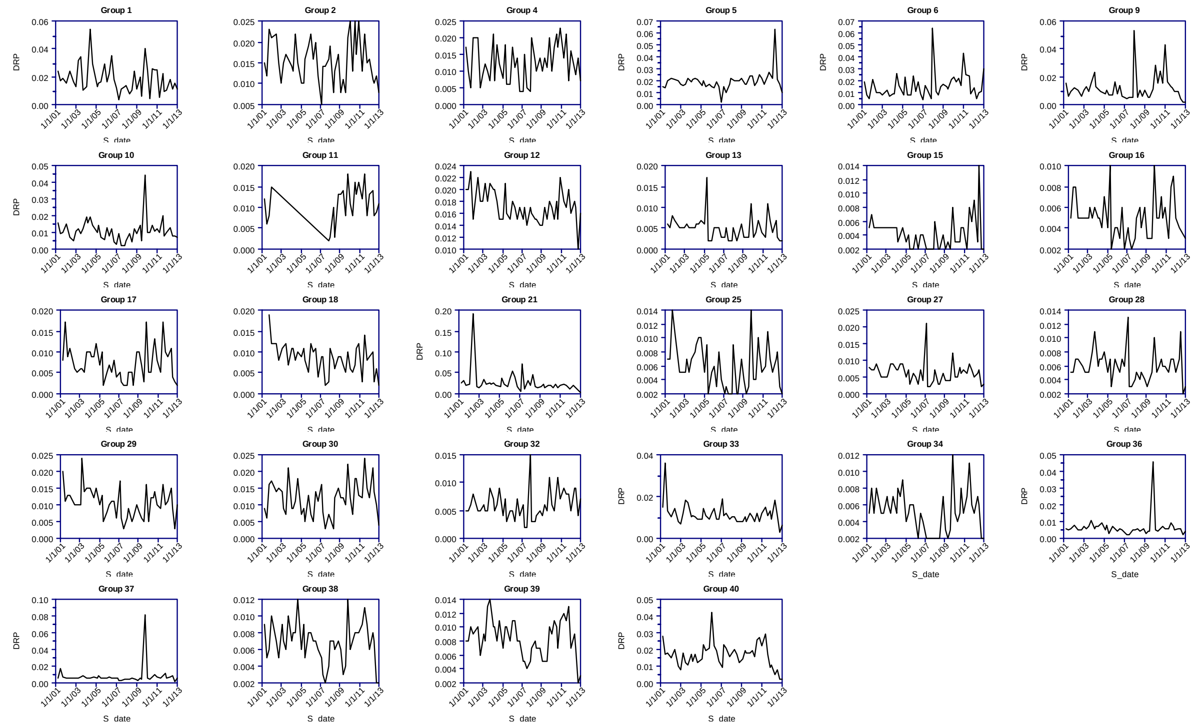
Total suspended solids (TSS)



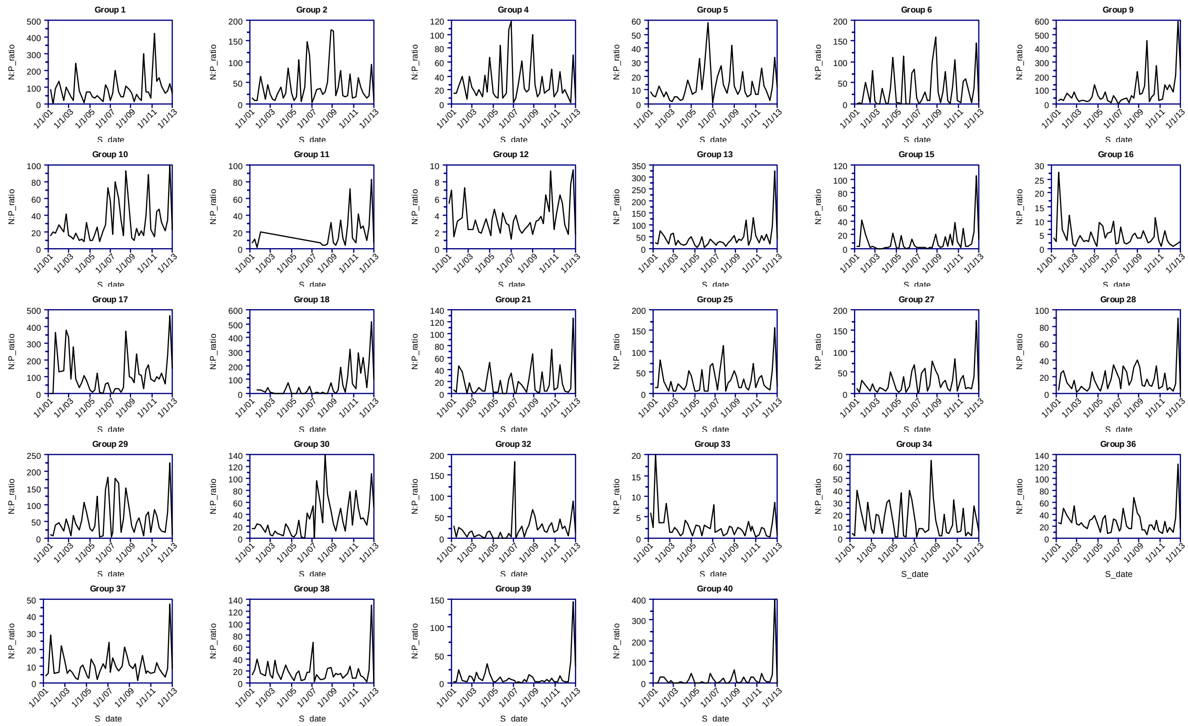
Volatile suspended solids (mg/L)



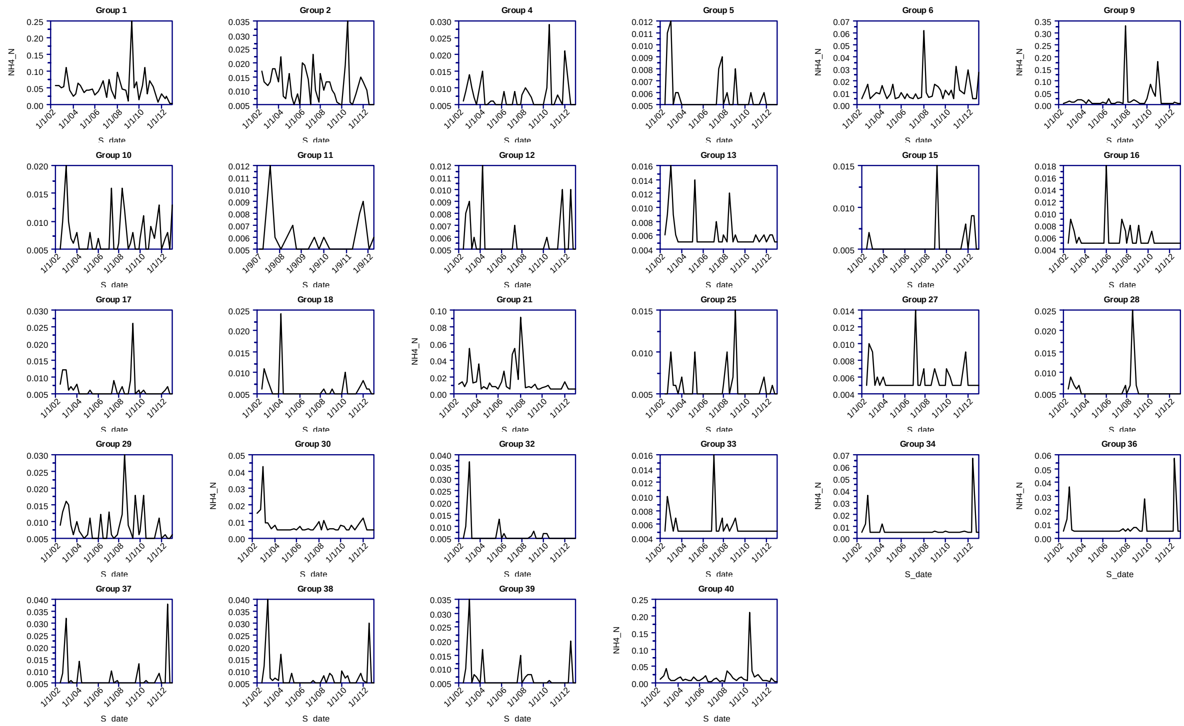
Nitrate-nitrogen (NO3-N)



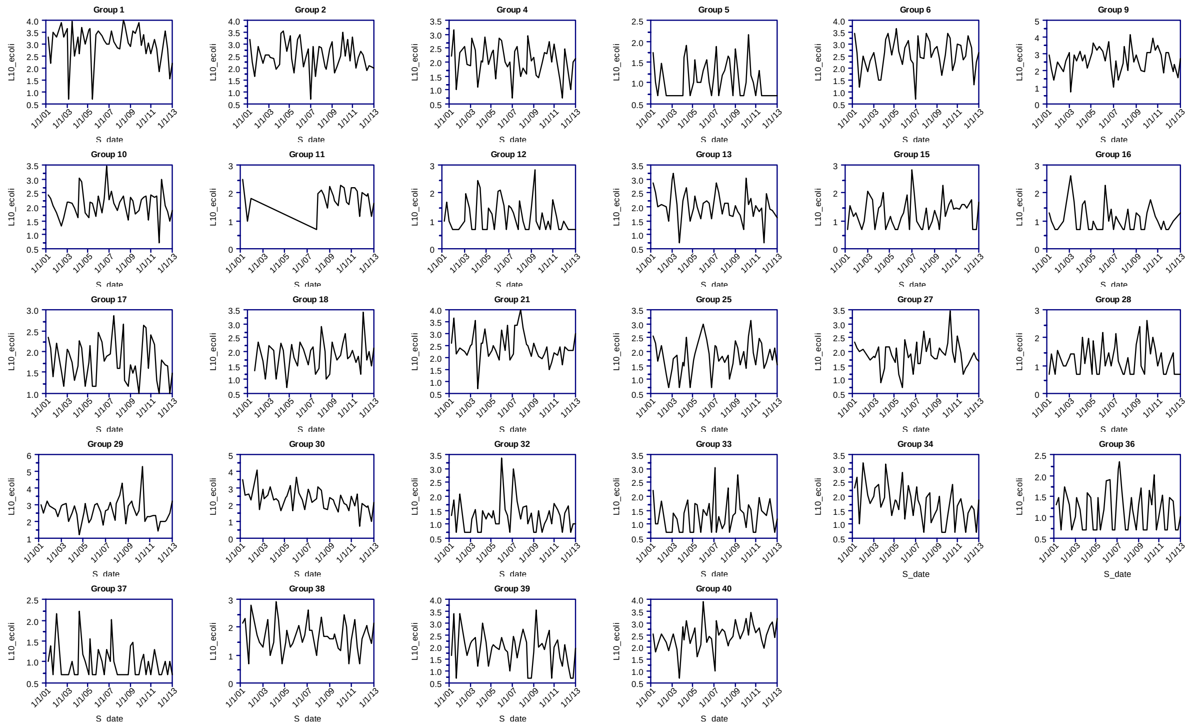
Dissolved reactive phosphorus (DRP, mg/L)



Nitrogen to phosphorus ratio (NO3-N / DRP)

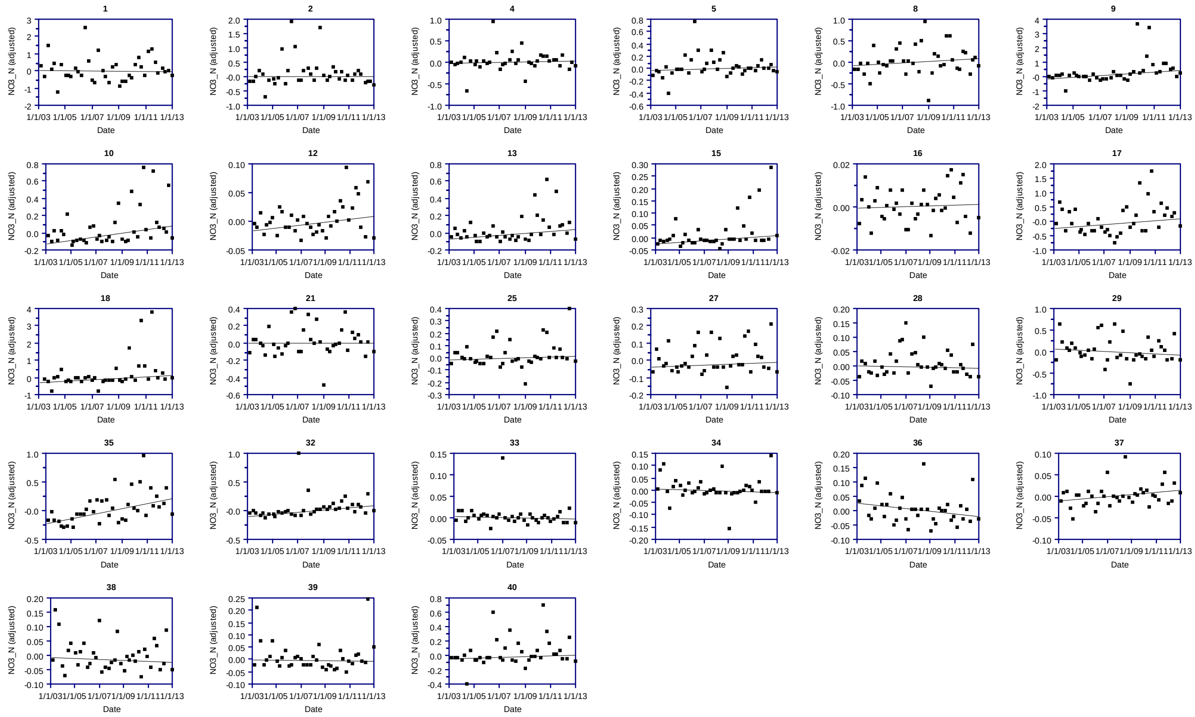


Ammonium-nitrogen (NH4-N, mg/L)

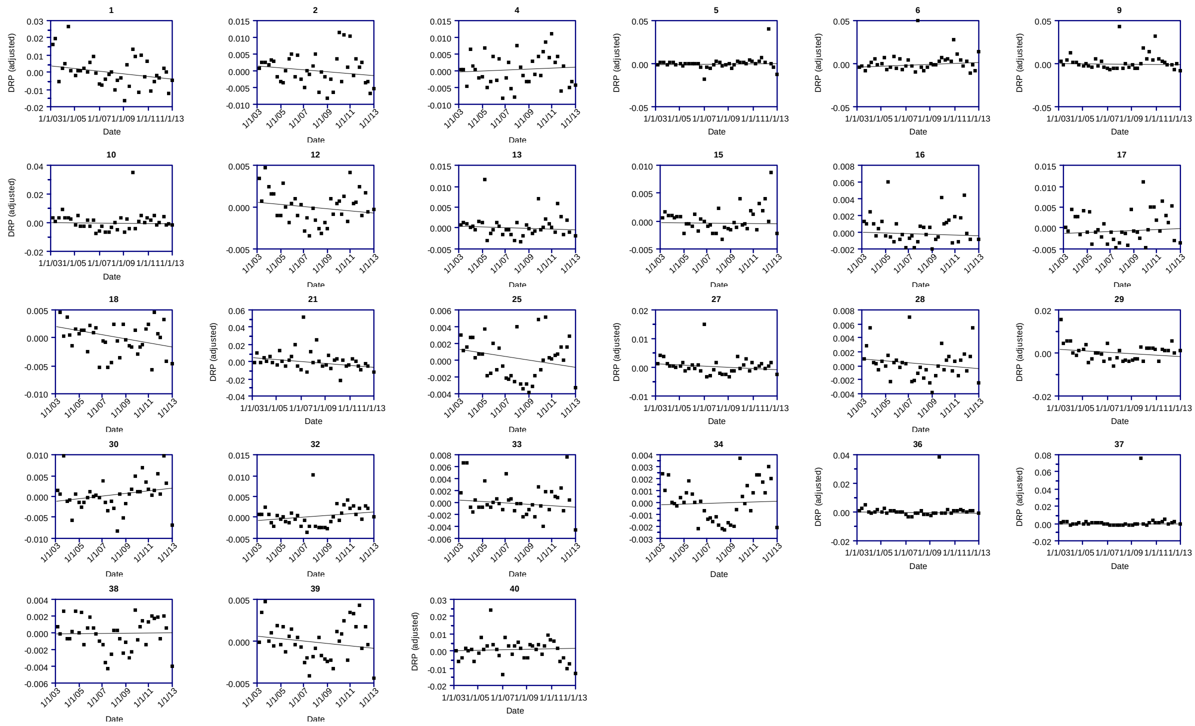


E. coli – $\log_{10}$ transformed to linearise the distribution

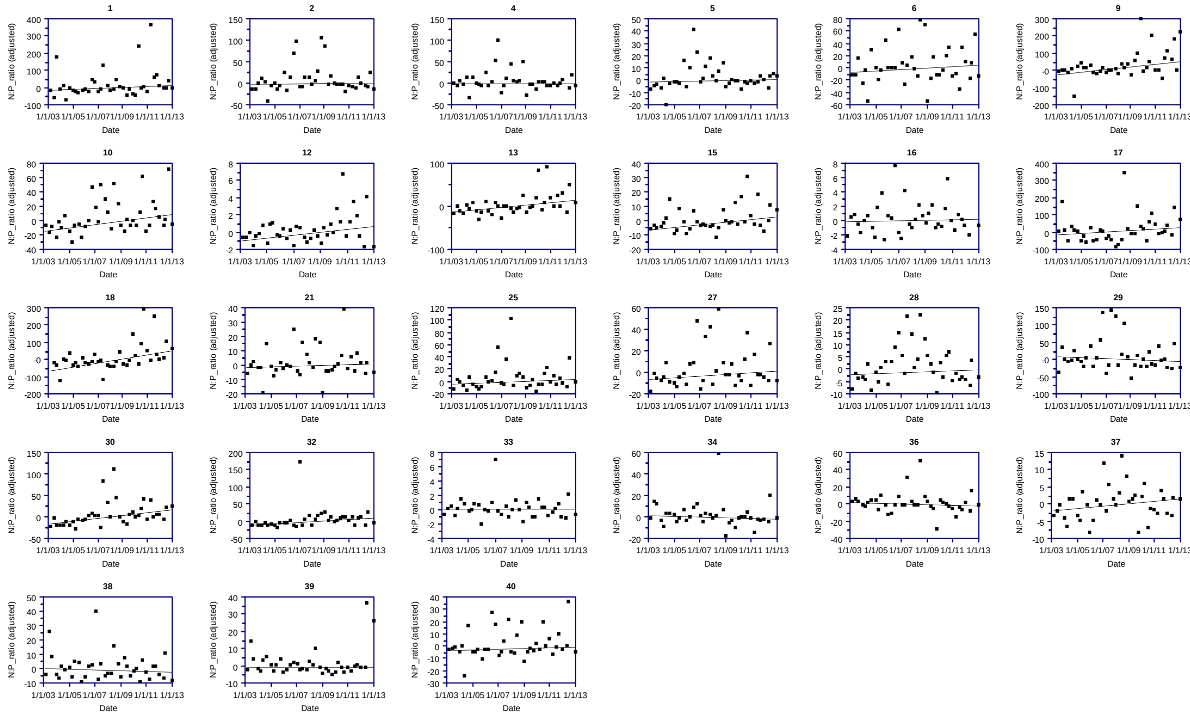
Appendix 3. Seasonal Kendall trend analysis plots and results.



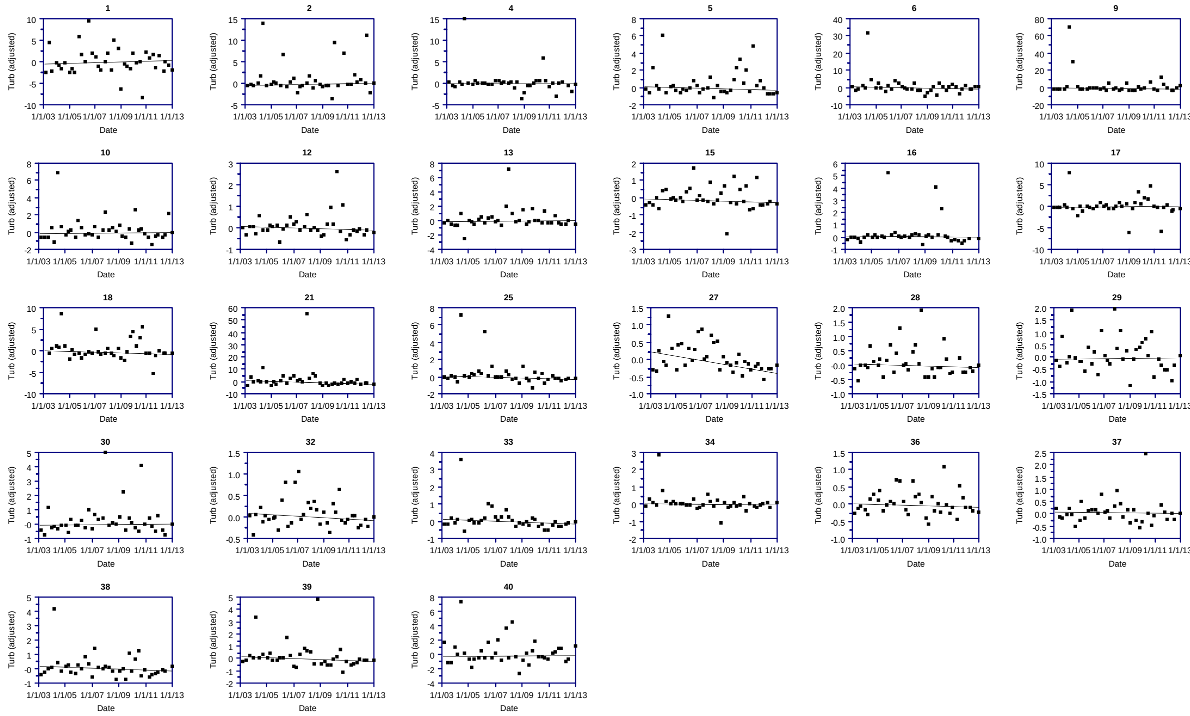
NO3_N



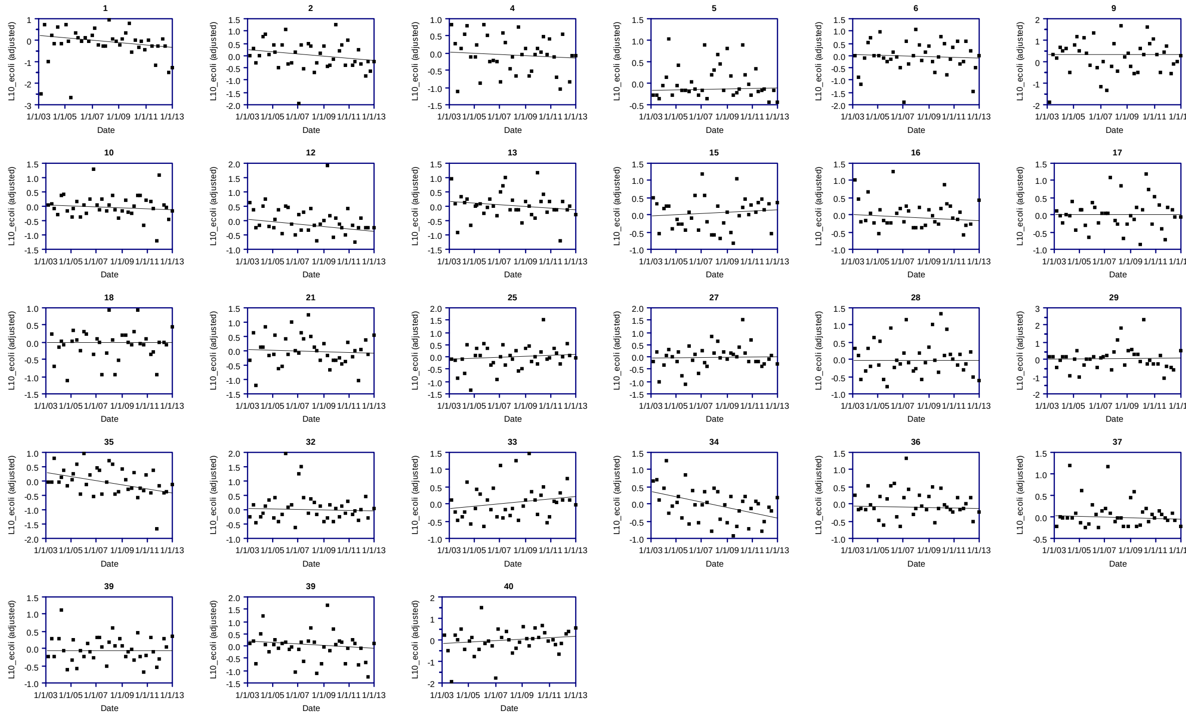
DRP



N:P ratio



Turbidity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L10_ecoli (adjusted)
Date

Log10 E. coli

Appendix 4. National Policy Direction and Local Initiatives

The National Policy Statement requires all regional councils to either fully implement the policy by 2014, or to implement it in stages so that it is fully implemented by 31 December 2030. A programme outlining the Council's process for implementing the National Policy Statement needs to be adopted by the Council by November 2012. Progress on that programme must be publicly reported annually.

The National Policy Statement has five sections related to:

- water quality,
- water quantity,
- integrated management,
- tangata whenua roles and interests, and
- a progressive implementation programme.

Section A (water quality) requires regional councils to specify objectives and limits and targets, establish improvement methods, and apply best practicable option to discharges to water, or to land where contaminants may enter fresh water.

Section B (water quantity) requires regional councils to set environmental flows for all water bodies, promote efficient water use, and state criteria for transfer of water permits. It also requires councils to avoid and phase out over-allocation.

Section C (integrated management) requires regional councils to take a catchment management planning approach to integrate freshwater, land use and development.

Section D (tangata whenua roles and interests) requires regional councils to involve iwi, and to identify and include iwi values and interests in freshwater management and decision-making.

Section E (progressive implementation programme) requires regional councils to either implement all the objectives and policies in the National Policy Statement by 2014 or to adopt a progressive implementation programme for more gradually implementing the National Policy Statement by 2030. Implementation means that the quality and quantity limits are set for all water bodies by 2030, and the direction for making improvements is in place. It does not mean that all quantity and quality targets are required to be met by 2030.

The National Policy Statement Implementation Guide states that councils' progressive implementation programmes can include the consultation strategy/programme, and the expected time for key milestones, such as notification of plan changes.

The Implementation Guide also states that engagement with communities and robust durable solutions can take time. It recognises the importance of quality rather than quick processes and frameworks, while seeking to ensure rapid progress where this is possible.

Part A. Existing Council actions

The Council has a range of plans and actions underway which will contribute to the meeting of the National Policy Statement requirements. These include:

- operative freshwater objectives, policies and rules related to water quality, water quantity and activities in the beds of rivers
- a water classification system, with quarterly monitoring of the state of Nelson's freshwater environments
- stormwater consent requirements, committing the Council to a stormwater monitoring and management programme
- the Stoke Streams Rescue Project
- esplanade reserve requirements at the time of subdivision
- programmes to encourage planting of urban and rural riparian margins (and the consent to take water from the Maitai for the urban water supply includes a condition to undertake riparian planting)
- investigations to identify and address water quality issues in specific catchments
- an ongoing programme of stormwater and wastewater pipe upgrades and renewals
- a stormwater asset management plan (2012-22) which includes commitments to: develop a strategy for diverting stormwater inflow and infiltration from the wastewater network; develop catchment management plans for all catchments in Nelson, beginning with the Maitai River over the next three years; and have wider interdepartmental and community involvement in enhancing the major natural waterways
- provision for low impact design through the Land Development Manual
- the Wakapuaka wetland project.

Nelson City Council's Freshwater-Related Work

Council staff involved in freshwater-related work have identified a number of actions which can be progressed alongside the development of the progressive implementation programme. These include:

- more emphasis on stormwater pollution prevention and enforcement of illegal discharges
- ongoing improvements to channel design to avoid adverse impacts on freshwater quality while retaining channel capacity for flood events
- more integration between the management of the wet areas and planting of the adjacent land
- earlier notification and follow up action on freshwater issues arising from pipe failures.

Part B – Council actions in the short to medium term

Actions	Timing
Monitor and enforce compliance with resource consent conditions	Ongoing
Increase investigation into water quality problems and solutions	Ongoing
Prepare catchment management plans for all Nelson catchments as integrated land use strategies, starting with the Maitai Catchment Management Plan over the first three years.	Maitai River plan by 2015 and for all other catchments by 2022.
Increase and target community advocacy work to raise awareness and encourage community action, such as through the Stoke Streams Rescue project. One area for improvement identified as part of this work is more integration between the management of the wet areas and planting of the adjacent land, to protect inanga spawning habitats.	Stoke Streams project is for three years, finishing in 2012/2013 year
Improve the stormwater and waste water systems through the development of a stormwater inflow and infiltration strategy, to reduce the effects of discharges to water courses. One area for improvement is earlier notification and follow up action on freshwater issues arising from pipe failures.	2012/13 (strategy development)
More emphasis on stormwater pollution prevention, through increased monitoring and enforcement of Nelson Resource Management Plan rules controlling discharges to the stormwater system or direct to freshwater water or the coastal marine area	Increased funding for this in 2012/13 year
Support the work of any future Iwi Water Management Advisory board as set up through Treaty of Waitangi settlements for the Top of the South Island iwi	As required
Improvements to channel design to avoid impacts on freshwater quality while retaining channel capacity for flood events. One example is the ongoing fish passage improvements for Brook Stream, scheduled to be completed by 2017/18.	Ongoing

Appendix 5. Preliminary Interpretation of Stoke Streams Rescue Programme Data

A preliminary interpretation of data from the Stoke Streams Rescue Programme shows some clear patterns (Tables A4.1 and A4.2).

In Saxton at 1.7 km there is clearly a source of nitrogen, poor turbidity and oxygen status, but with low E. coli, which indicates organic pollution without faecal contamination. At 1.25 km, the nitrate-N has declined, but there is high E. coli, the turbitidy is also less, here the impact of the nitrogen rich turbid pollution source has declined, but a faecal source has appeared. By 1.0 km, the influences from upstream have declined. This can be the case that dilution and natural purification at low flow can result in significant changes along a downstream profile in a small stream.

Table A4.1 Mean values for two sampling runs in Saxton Creek and Orphanage Stream

	NCC43 Saxton @ 1.0km C	**NCC44** Saxton @ 1.25km D	**NCC45** Saxton @ 1.7km D	**NCC46** Orphanage @ 1.7km C	**NCC47** Orphanage @ 2.3km D	**NCC48** Orphanage @ 2.4km B	**NCC49** Orphanage @ 3.8km C
Nitrate-N	0.1	0.2	0.58	0.02	0.04	0.02	0.1
Dissolved Reactive Phosphorus	0.009	0.016	0.015	0.015	0.019	0.015	0.033
pH	7.2	7.1	7	7.6	7.7	7.6	7.6
Temperature	11.05	8.9	10.6	15.85	17.6	11.05	12.3
Dissolved Oxygen (%)	88.75	88.75	81.2	111.5	104.6	103.25	102.3
Turbidity	0.98	10.61	17.8	19.4	5.04	2	2.14
Black Disk Distance	3.1	1.3	1.35	1.4	1.6	2.4	2.7
E.coli	139	1253	45	103.5	1250	201	132.5
MCI	100	90	92	87	83	104	93
SQMCI	6.48	5.03	4.79	5.09	4.9	6.25	6.71
Mean Periphyton Score	8.28	9.64	7	6.76	2.99	8.04	5.01

In Orphanage Creek at 2.3 km a faecal source appears to enter the stream, the temperature is also elevated, but the turbidity is not greatly elevated and there is negligible nitrate-N. The presence of high E. coli, high temperature, but low N and moderate turbidity is puzzling, unless this is a channel pool with wild-fowl. 600 m further downstream the faecal contamination is diminished, but the temperature remains elevated and the turbidity is high. Visual inspections of these sites with the data to hand should help to clarify the changing situation with distance downstream.

Table A4.2 Mean values for two sampling runs in Poorman Valley Stream and Jenkins Creek

	NCC50 Poorman @ 1.0km C	NCC51 Poorman @ 2.4km B		NCC52 Jenkins @ 2.0km D	NCC53 Jenkins @ 2.6km E	NCC07 Jenkins at Cattleyards B
Nitrate-N	0.07	0.05		0.25	0.13	0.17
Dissolved Reactive Phosphorus	0.013	0.013		0.014	0.017	0.012
pH	8.2	8.2		8	8	8.1
Temperature	13.1	12.65		13.1	14.1	13.3
Dissolved Oxygen (%)	102.6	110.25		96.8	96.85	104.3
Turbidity	0.6	0.89		18.92	20.96	2.28
Black Disk Distance	3.4	4.8		2.15	1.95	2.75
E.coli	35	19.5		830	2660	40
MCI	88	96		98	100	123
SQMCI	4.74	7.09		7.3	3	7.88
Mean Periphyton Score	9.25	7		10	2.5	10

In Poorman Valley Stream (Table A4.2) at 1.0 km and 2.4 km conditions appear to be consistent with NCC05 – Poorman at Barnicoat Walkway, and other than low MCI and SQMCI, the water quality data do not indicate a particular pollution source.

Jenkins Creek at Cattleyards shows relatively unimpacted conditions. At 2.6 km, the data indicate relatively severe faecal contamination, very poor SQMCI and periphyton score, although MCI is moderate. Turbidity is also elevated. At 2.0 km the data show an improvement in turbidity and E. coli, but the nitrate-N levels are slightly elevated all along the channel.

These additional samples clearly indicate the presence of various contaminant sources and should assist with locating these sources and taking appropriate action to improve the situation.