WATER QUALITY IN THE POWELL CREEK CATCHMENT, MOTUPIPI

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The purpose of this report is to provide preliminary information about baseline water quality in the Powell Creek catchment, a sub-catchment of the Motupipi River, near Takaka. This monitoring was carried out prior to full implementation of best management practices on dairy farms, particularly stream fencing, bridging waterways and nutrient budgeting. It is intended that a repeat survey be carried out starting in July 2011 to determine any changes in water quality as a result of improved best management practice. This monitoring was carried as Part of the Tier 2 Catchment Monitoring Programme under the Dairying & Clean Streams Accord.

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EXECUTIVE SUMMARY

This report has been prepared for the Ministry for the Environment (MfE) as part of a Dairying and Clean Streams Accord (CSA)'Tier Two Catchment Baseline Monitoring Project". The report presents data collected within the Powell Creek catchment, near Takaka in Golden Bay. The investigation was undertaken over 12 months ending in June 2007 with the aim of determining baseline water quality conditions prior to full implementation of the best management practices, defined under the Dairying and Clean Streams Accord. Some data from Tasman District Council's 'State of the Environment' surface water quality monitoring programme is provided for completeness.

Powell Creek is a small rain-fed tributary of the Motupipi River located to the east of Takaka in Golden Bay. The three dairy farms in the catchment make up approximately 317 ha of the 560 ha total area (56.6% total in dairy farming). The remainder of the catchment is in sheep and beef farming or cropping (mostly maize). There are approximately 525 dairy cows in the Powell Creek catchment.

The Powell Creek catchment was initially selected for the Teir Two (CSA) monitoring because data collected by Tasman District Council showed degraded water quality with respect to disease-causing-organisms, nutrients, dissolved oxygen, fine sediment and water temperature. MfE set criteria that the catchment landuse had to be dominated by dairy farming, the catchment was relatively small (in the order of 2000 cows maximum) and with relatively few of the CSA targets met. In the case of the Powell Creek catchment, the downstream widest sections of stream were mostly fenced at the start of the investigation, but there are many other smaller streams that are unfenced. All farmers have nutrient budgets but it has yet to be determined if the nutrient management plans meet best practice. All stock crossings were already bridged at the start of the study.

E.coli loadings were relatively high (87,000-160,000 *E.coli*/sec) with median loadings similar across the whole Powell Creek catchment.

Median total nitrogen concentrations were over double the ANZECC guideline except for one site (McConnon Creek). Highest nitrogen loadings originated in the upper Motupipi River.

It is intended that this monitoring be repeated beginning July 2011.

ACKNOWLEDGEMENTS

Thanks to the farmers in the Motupipi catchment for providing access to undertake this monitoring, particularly Tony and Kathy Riley where most of the sites were located.

We are grateful to Tony Hewitt and Corina Kemp from Envirolink for collecting many of the samples.

Thanks also to Ministry for the Environment for providing funding for sample analysis.

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1 INTRODUCTION

1.1 Aim

The objective of this monitoring programme was to determine the baseline water quality prior to full implementation of best management practices (BMPs) on dairy farms, particularly stream fencing, bridging waterways and nutrient budgeting. The ultimate aim of this project is to determine whether the employment of these BMPs lead to an improvement in water quality.

1.2 Background

Location:
Powell Creek is a small rain-fed tributary of the Motupipi River, located to the east of Takaka in Golden Bay. Rainfall in the catchment is typically 1500 mm/year.

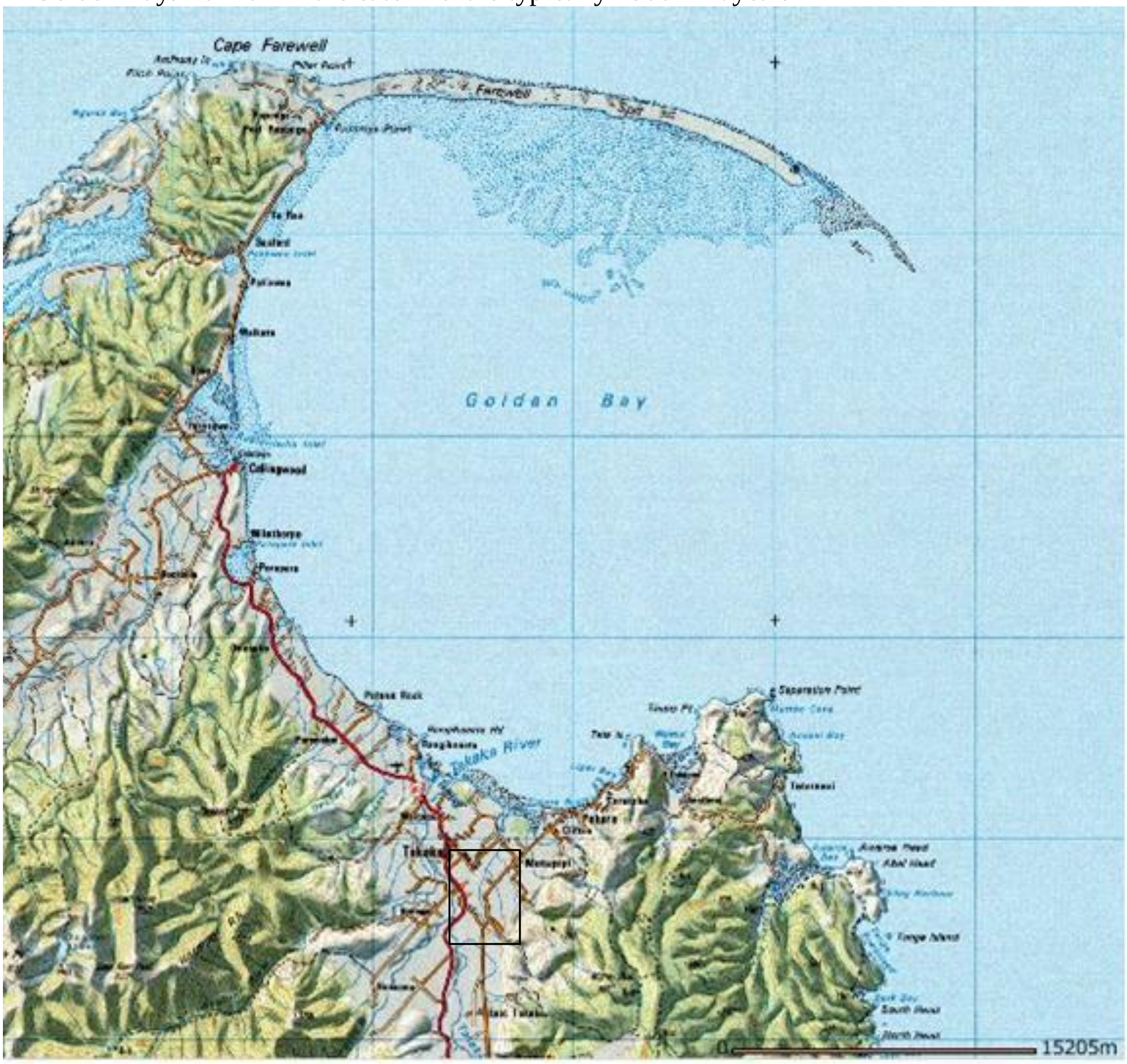


Figure 1.1 Map of Golden Bay, Tasman District. The Powell Creek catchment lies to the east of Takaka (within inset box). See Figures 1.2-1.7 for close-up maps.

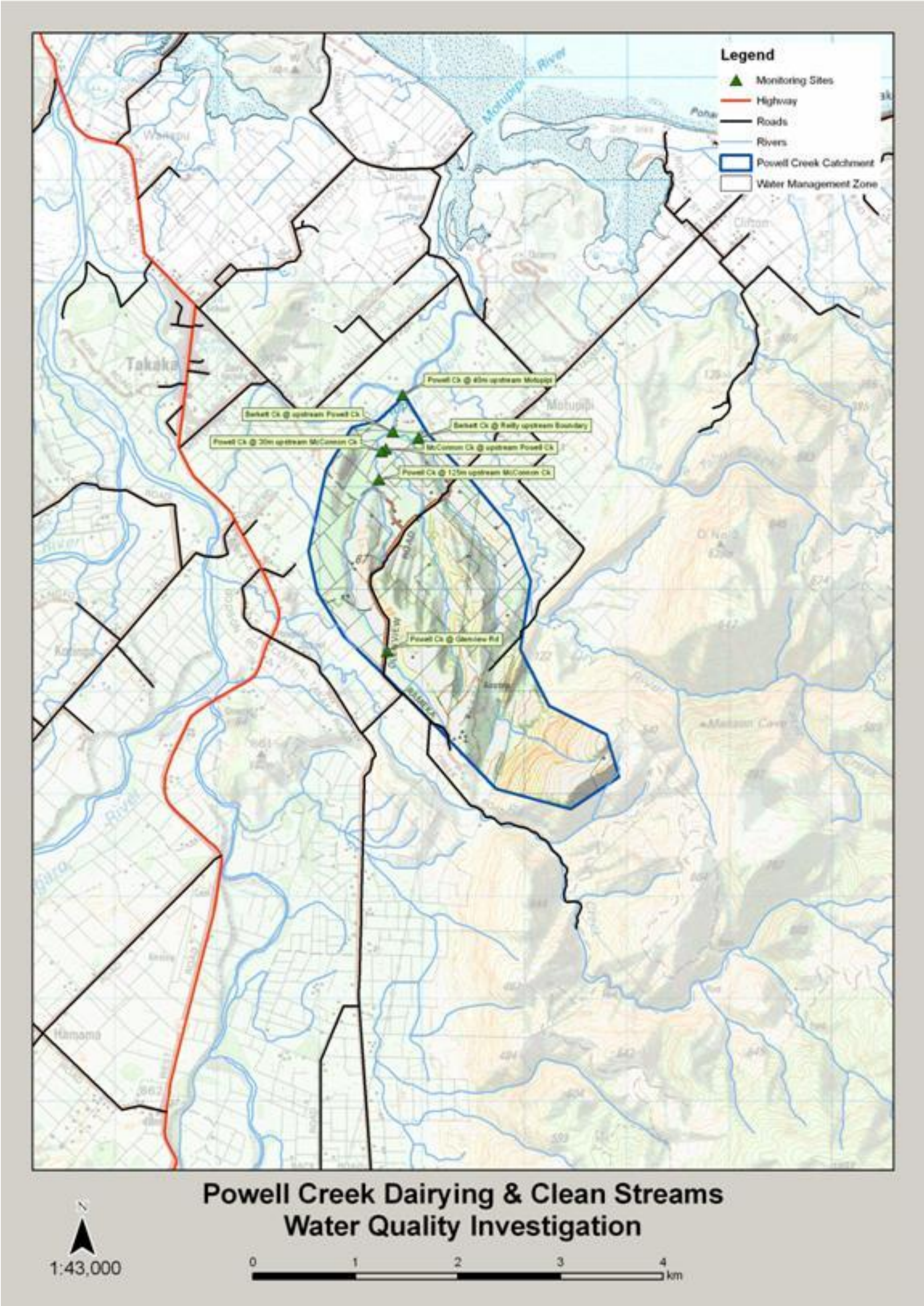
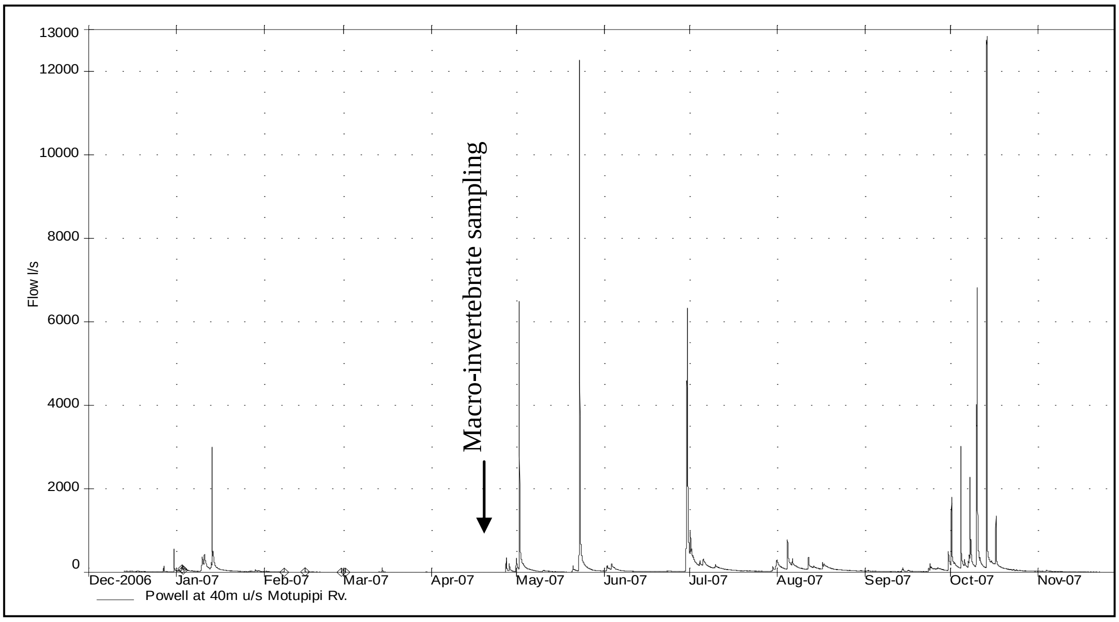


Figure 1.2 Monitoring Sites used in this investigation in the catchment

1.3 Character of the Waterway

Powell Creek and its main tributaries, Berkett and McConnon Creeks, make up a total length of 10.25km of flowing waterway. The dominance of tight silt-loam soils in the catchment means that runoff from storm events is high and base-flows are relatively low. Flow ceases for about 30-40% of the upper reaches in a typical summer dry period. A flow recorder was installed in Powell Creek at the bottom of the catchment 40m upstream of the confluence of the Motupipi River in December 2006. Minimum flow recorded in the year from December 2006 to December 2007 was 0.0 L/s (the creek dried up for a few days in April 2007). The mean flow was 86 L/s, with median flow of 29 L/s. The median is the better statistic to use as the flow is heavily skewed by the flood events. The maximum flow was 12,800 L/s. During



these summer dry periods aquatic plants, such as Swamp Willow Weed, can cover 90% or more of the bed in unshaded reaches.

Figure 1.3: Flow in Powell Creek at 40m upstream Motupipi River (milliliters per second) over the period December 2006 to December 2007. Only one macro-invertebrate sampling is shown on this plot as the flow record did not cover the period in which the earlier sample was taken.

Berkett Creek, McConnon Creek and Powell Creek upstream of Reilly's boundary are generally more narrow than the 'Dairying and Clean Streams Accord' (deeper than a 'Red Band', wider than a stride) threshold during summer low flows. However, where there is riparian forest they are larger than the threshold. Waterways are typically narrower in grassy farmland streams due to the grassy banks trapping sediment and the slumping of soil toward the stream. The definition does not distinguish between streams with forest or pasture on the margins.

The Motupipi River, into which Powell Creek flows, is a medium-sized spring-fed stream, with relatively consistent flow (average flow is approximately 500 L/s). Regular monitoring at several sites in the Motupipi has been carried out since 2000 and several other investigations into water quality and aquatic ecology have been undertaken to understand the causes of poor water quality in this parent catchment.

1.4 Soils and Geology

Soils

Soils in the Powell Creek catchment are dominated by heavy silt loam soils. This has resulted in much of the creek being soft-bottomed and, with the low permeability characteristics, subject to high flow variability. A complex pattern of soils exists in the catchment (see Fig 1.3) with Pisgah soils on the ridge tops, down-slope of which are Tadmore Soils. The more well-drained Glenview silt-loam soils are present on the western side of the catchment. On the outer edge of each side of the catchment there are Rameka heavy silt loam soils. In the valley floors to the bottom of the catchment there are Clifton heavy silt loam soils. Pikikiruna soils exist on the steeper hill-country at the top of the catchment.

Pisgah soils occur on the flattish hilltop surfaces of ancient alluvial terraces. These soils are well drained with good structure and have a moderately deep dark brown to dark yellowish brown silt loam topsoil and a deep clay loam to clay subsoil that is yellowish brown that becomes a little redder with increasing depth. Weathered stones may occur throughout but compact weathered bouldery gravel is generally present at an average depth of 50cm. Iron concretions, derived from weathering of iron rich rocks are common in the lower subsoil.

Tadmore soils are formed on predominantly hilly land and on the aged siltstone and silty sandstone sedimentary rocks of the Tarakohe Formation. Tadmore soils are predominantly deep (>90cm to underlying bedrock) well drained soils with a moderately deep to deep (average 25cm) very dark grayish brown to dark brown friable A horizon. The subsoil is firm yellowish brown well structured silt loam to clay loam, becoming paler near the base. The transition to underlying sedimentary rock is usually abrupt with the rock typically being firm to very firm and partly fragmented, rather than very hard and massive.

Glenview soils are formed from granite, diorite and limestone rocks from the Pikikiruna Range. The topsoil is well drained moderately deep silt loam (average 23cm). The upper B horizon is also predominantly well drained and overlies a paler coloured and mottled clay loam textured lower B horizon that often has a perched water table present during spring months. An iron pan is commonly present in the underlying gravel at around 70cm and iron concretions associated with weathering rock fragments are common. Some stones may be present throughout the soil and the stone content increases with depth

Rameka soils are common near Berkett Creek and upper Powell Creek. The top horizon of these soils are well drained with a dark brown to brown moderately deep silt loam to heavy silt loam topsoil (average 23cm). This overlies a B horizon that is at first yellowish brown heavy silt loam or clay loam, then passes into yellowish brown or strong brown clay loam to clay. A few weathered or partly-weathered stones may occur throughout the subsoil with weathered stones or gravel occurring at an average depth of 55cm (range 20-110cm). This has resulted in cobbly and gravely substrate being common in Berkett Creek.

Clifton soils occupy the valley floors, having been derived from erosion of adjacent hills. The soils are moderately deep (45-90cm above gravel or sedimentary rock) and the topsoil (average depth 23cm) is brown to dark brown heavy silt loam and overlies a yellowish brown clay loam B horizon.

Motupipi soils occupy small areas of the terraces near Dry Creek and lower Powell Creek. These soils are well drained, predominantly deep soils (>90cm to underlying gravel) but moderately deep and shallow soils also occur. The topsoil is moderately deep (average 21cm) and the colour is variable and ranges from brown to dark brown or dark yellowish brown to very dark greyish brown. The B horizons are friable or very friable yellowish brown silt loam to heavy silt loam and average approximately 60cm in thickness.

A very small amount of Karamea and Waingaro silt-loam soils exists in the very bottom of the catchment.

Soil Quality

Soils in parts of the upper and mid Motupipi catchment have historically had very high Olsen P levels (150-160 mg/kg on one farm and up to 300 mg/kg on another) where irrigation of whey occurred in the past. These concentrations have reduced considerably over time and are now 40-60 mg/kg (the guideline for Olsen P is 30 mg/kg) over much of the catchment. This high Olsen P concentration is a legacy from discharges of dairy factory wastewater.

Geology

As shown in figure 1.4 the parent material underlying the soils in the catchment are mostly alluvial gravels and siltstone with some limestone and siltstone at the top of the catchment. No outcrops of limestone are known to exist in the mid and lower catchment.

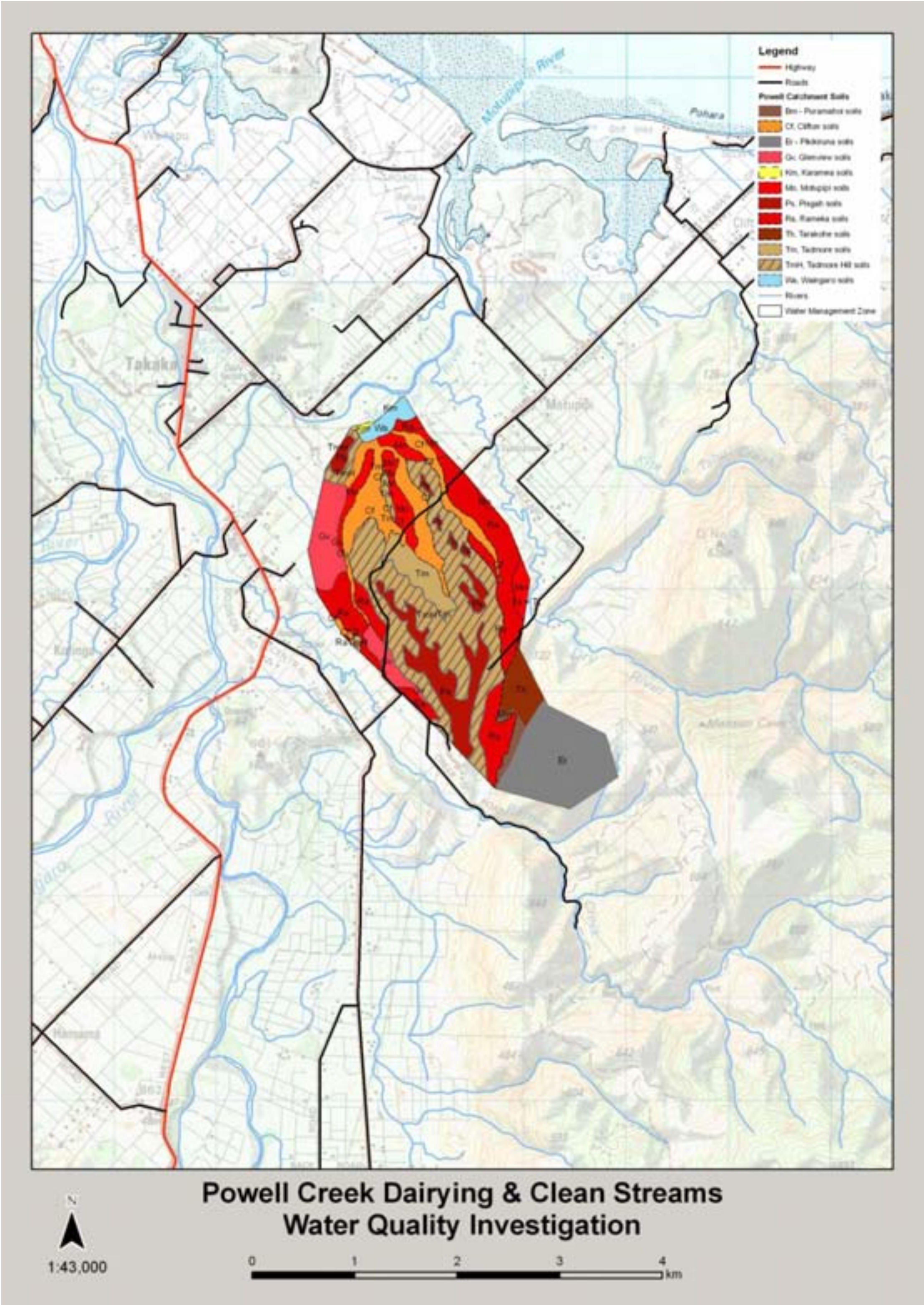
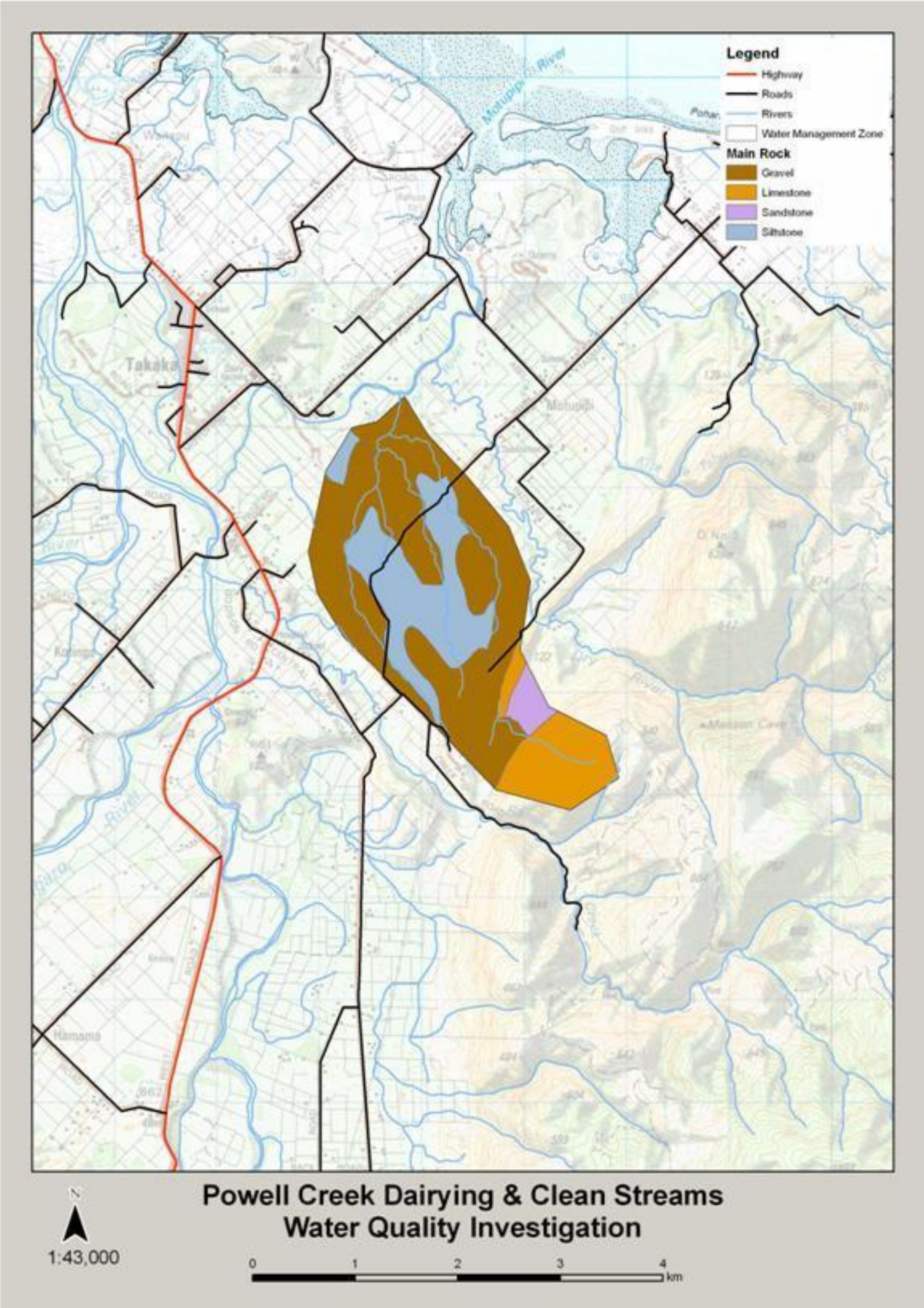


Figure 1.3 Soils of the Powell Creek Catchment

Figure 1.4 Geology of Powell Creek Catchment



1.5 Land Use

The three dairy farms in the Powell Creek catchment make up approximately 317 ha of the 560 ha total (56.6% total in dairy farming, see Fig 1.5). A total of approximately 525 milking cows are farmed in the catchment. Most of the remainder of the catchment is in sheep and beef farming or cropping (mostly maize). Some small patches of riparian scrub forest exist on Berkett and McConnon Creeks (~1.9km of stream length) but 89.3% of waterways in the catchment have pasture grasses to the stream margin. Fencing for stock exclusion is only present in the lower 12% of the catchment (1.2km) (see Fig 1.7).

Just over one third (1040 ha) of the whole Motupipi catchment's land use is intensive pastoral farming (out of a total catchment area of 2856 ha). Of the pastoral farming landuse, about 70% is in dairy farming. There are eight dairy farms in the entire Motupipi catchment with a total of approximately 2000 milking cows. About 60% of the streams in the catchment have stock exclusion (fencing in most cases) and less than 30% of the stream has riparian woody vegetation present.

The productivity of the land is high as can be seen from the Land Use Capability mostly at level 3 (see Figure 1.6).

1.6 Values of the Waterway

There are no specific water quality standards in any part of Tasman District other than those imposed by water conservation orders or directly from the Resource Management Act (eg section 107). The main values of the waterway are ecological. The waterway has reasonable ecological value and holds reasonable numbers of inanga, common bully and short-finned eel. Banded kokopu, long-finned eel and koura have also been found in the catchment but in low numbers.

There is only one potential swimming hole on the Powell Creek located near the confluence of Motupipi River. However, it is unlikely that this hole would be used for swimming given that public access is not available and in summer there is significant weed and algae growth around the pool.

Surface water from the Powell Creek catchment is not used for irrigation, stock water or any other supply. Irrigation water is either from groundwater, from the lower Motupipi River or from dairy factory wastewater.

Contaminants discharged from Powell Creek have an influence on the water quality of the Motupipi River. Therefore it is appropriate to consider the wider values of the Motupipi catchment. These values for the Motupipi catchment have been developed with full public participation and include:

- Aesthetics and amenity – water and surrounds
- Fishing – whitebaiting & mulleting
- Habitat for birds
- Water quality good for farm animals to drink

The Motupipi River appears not to be highly valued for swimming, as the water is regarded by many as too cold. However, water from the Motupipi is likely to affect beach water quality at Rototai, and potentially Pohara Beach during, and the days following, rain. Therefore management of water quality is likely to have to regard water for swimming or other contact recreation.

The Motupipi Estuary is recognised as nationally important for natural ecosystem values (Schedule 25.1F in Tasman Resource Management Plan).

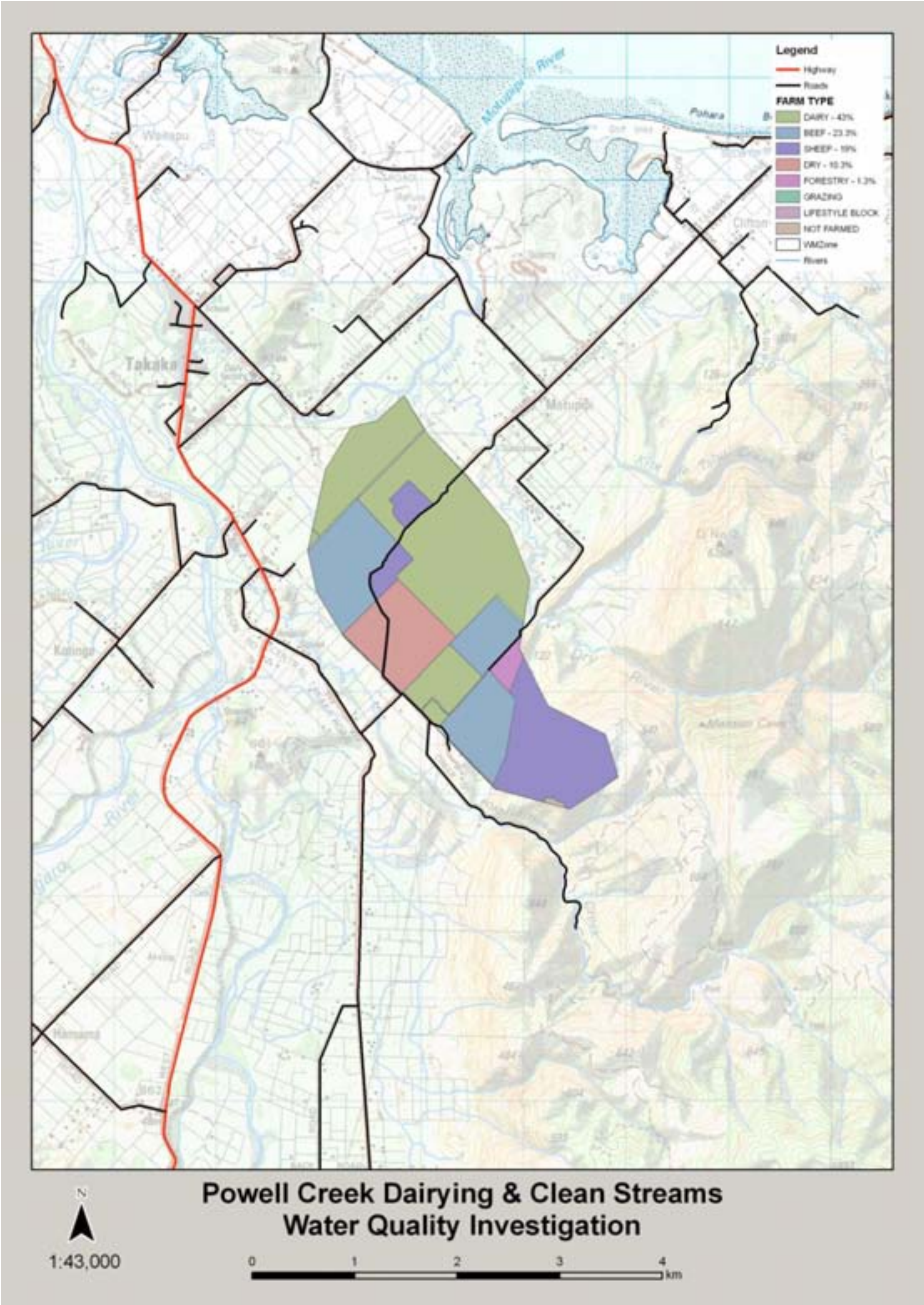


Figure 1.5 Land Use Patterns in Powell Creek Catchment (based on Agribase GIS database with some adjustment based on local knowledge). “Dry” refers to dairy dry stock. Much of the area marked as ‘dry’ is cropped for maize silage.

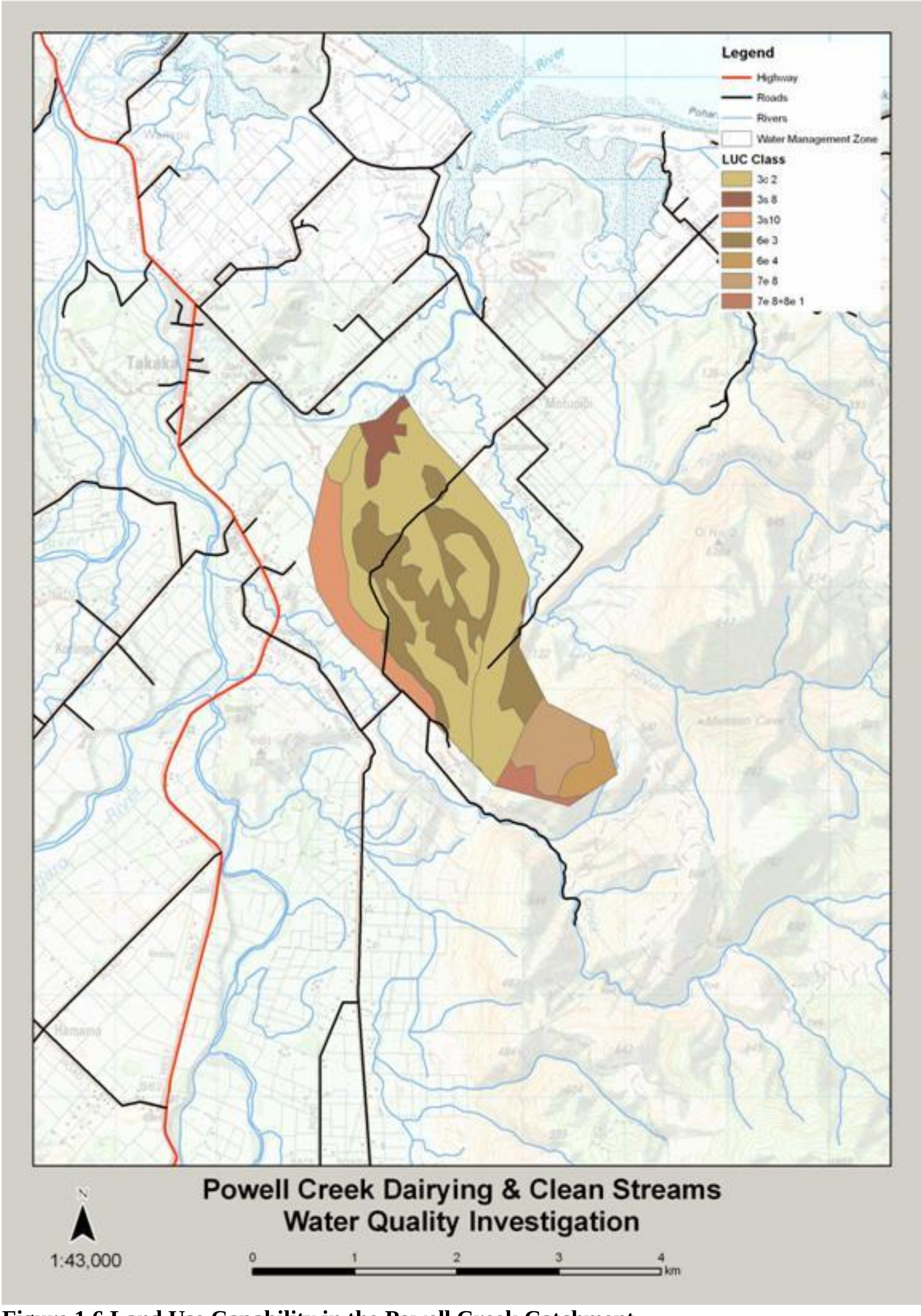


Figure 1.6 Land Use Capability in the Powell Creek Catchment

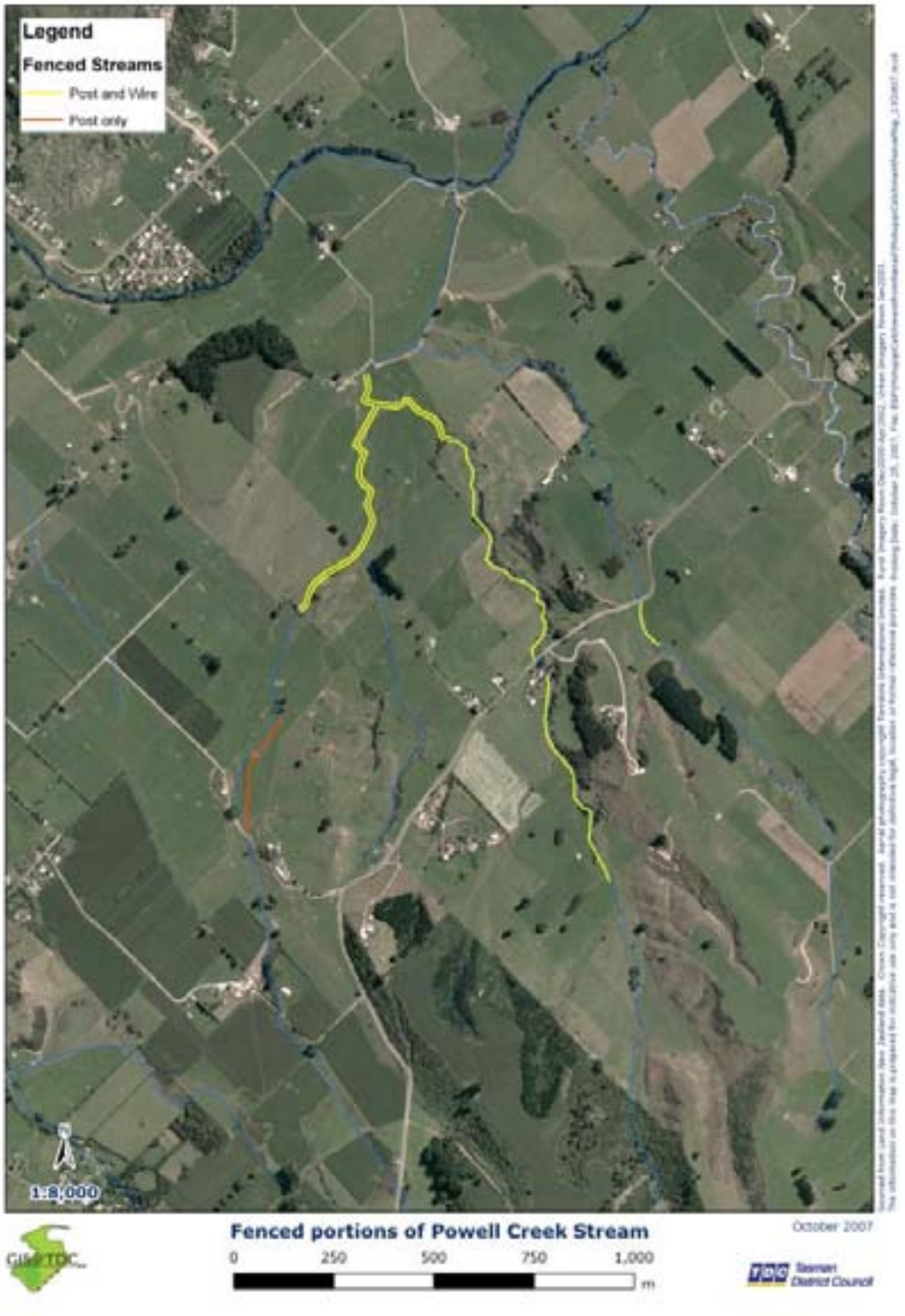


Figure 1.7 Extent of Riparian Fencing in Powell Creek Catchment

1.7 Resource Consented Activities in the Catchment

There are no resource consents for water takes, discharge to water, daming, or diverting from the Powell Creek catchment. There is one consent for discharge of wastewater from the Takaka dairy factory to land in the catchment.

Water supply to the farms in the catchment is either from surface or groundwater located out of the Powell Creek catchment (consent numbers 030163 and 030044) or from town supply. There are seven properties that take surface water from Rameka Creek, a neighbouring catchment, for the purposes of stock drinking water and domestic water supply.

1.8 Extent of employment of BMPs on dairy farms in the catchment at the outset of the monitoring programme

Fencing: A map with fencing locations is shown on Figure 1.7. Several months prior to the monitoring commencing fencing was installed on the Reilly farm in the mid reaches of Powell Creek (~150m downstream of McConnon Creek to ~600m upstream of McConnon Creek) and all of McConnon Creek within the Riley boundary. No other fencing initiatives have been undertaken to fully exclude stock from waterways. TDC requested of the landowners that Berkett Creek not be fenced until after the monitoring was complete.

Nutrient Budgets: All farms had nutrient budgets, have used 'Overseer' and followed nutrient management plans.

Bridging: All major races over Berkett, Powell and McConnon are bridged or culverted. Some minor crossings (used less than 4 times per month) are not bridged in the upper parts of the catchment.

Wetlands: No significant wetlands have been identified in the Powell Creek catchment.

Effluent: No effluent is discharged to land or water in the part of the catchment monitored as part of this investigation.

2 METHODS

2.1 Field sampling methods:

Sampling was carried out monthly for 12 months for water quality samples over the period from July 2006 to June 2007. A description of the sites is listed in Table 2.1 below. Water samples were collected from six sites and analysed for the following parameters: Faecal coliforms, *E.coli*, nutrients, suspended solids. Measurements of water clarity, conductivity, Dissolved Oxygen, pH and stream temperature were taken using a YSI600QS datasonde. Two sets of macro-invertebrate samples were collected, one in spring and the other in autumn.

Sample collection was carried out by Tasman District Council (4 of 12 times) and by a consultant company Envirolink Ltd, (8 of 12 times). Sample analysis was carried out at Cawthron Laboratories, Nelson, according to standard tests (APHA 1998).

Table 2.1: Location Details of Water Quality and Macro-invertebrate Sample Sites

SITE NAME	EASTING	NORTHING	REASON FOR CHOOSING SITE
Powell Ck @ 40m upstream Motupipi	2495805	6038900	To calculate loadings exported from the catchment to Motupipi River. Also a site of a water quality sonde with Dissolved Oxygen (Jan-Feb 2006) and a temperature logger (summer 2006-07).
Berkett Ck @ Reilly upstream Boundary	2495960	6038480	Major tributary of Powell Creek with dairy farm landuse dominating. Upstream reference for *Berkett Ck @ upstream Powell Ck* which may be impacted by an unfenced swampy pasture.
Berkett Ck @ upstream Powell Ck	2495710	6038540	Major tributary of Powell Creek with dairy farm landuse dominating. Downstream impact site for *Berkett Ck @ Reilly upstream boundary* which may be impacted by an unfenced swampy pasture.
McConnon Ck @ upstream Powell Ck	2495640	6038375	Major tributary of Powell Creek with dairy farm landuse dominating. Also a site of a water quality sonde with Dissolved Oxygen (Jan-Feb 2006).
Powell Ck @ upstream McConnon Ck	2495600	6038350	Major tributary of Powell Creek with dairy farm landuse dominating. Temperature logger installed about 100m upstream of this site (summer 2006-07, E2495575 N6038075).
Powell Ck @ Glenview Rd	2495655	6036400	Upstream reference site – although it is influenced by a considerable amount of pastoral land use. Also a site of a water quality sonde with Dissolved Oxygen (Jan-Feb 2006)

Although the Powell Creek site at Glenview is as close as we can get to a reference site it is still affected by farming upstream and the stream is unfenced for the uppermost reaches with riparian vegetation dominated by gorse in the ~500m upstream of Glenview Road .

Stream flow was measured monthly at each site using metered wading gaugings or, in the case of culverts velocity and depth readings were used to calculate flow. A hydrometric station to measure continuous water quality and flow was set up in December 2006.

Three Hobo temperature loggers were installed in the catchment at three sites recording at 30min intervals from Dec 2006 to Mar 2007. These sites were Powell Ck @ 40m upstream Motupipi, Powell Ck @ 500m upstream McConnon and Berkett Ck @ upstream Powell (unfortunately this logger broke free from its mount and was lost).

Periphyton sampling was carried out using Rapid Assessment Method 2 as covered in page 42 of Biggs & Kilroy, 2000.

Macro-invertebrate sampling was carried out according to Protocol C1 – Hard-bottomed, semi-quantitative (Stark et al, 2001) and samples processed according to Protocol P1 – Coded Abundance (Stark et al, 2001). Samples were collected on 11 October 2006 and 16 April 2007 after relatively stable weather over the preceding two weeks. There was no flow data associated with the Oct 2006 sampling. Rainfall data from the nearest rainfall gauge (only

2.4km away) showed 40mm in the two weeks prior to sampling with a maximum daily rainfall of 13mm 10 days prior to sampling (see Appendix 2). Sampling in April 2007 was after 3 months of very stable base flows (see Figure 1.3).

A fish survey was undertaken at three sites in the catchment Powell Creek upstream McConnon, McConnon Creek upstream Powell and Berkett Creek from Powell Creek to about 150m beyond the Reilly upstream boundary.

2.2 Data analysis methods

Water quality data was compared against the guidelines listed in Table 2.2.

Table 2.2 Guideline water quality values for protection of river ecosystem and human health

Parameter	Guideline Value	Reference
Dissolved oxygen	>80% Saturation or >6.5 mg/L	ANZECC (1992)
pH	5 - 9	CCREM (1987)
Clarity	>1.6 m	ANZECC & ARMCANZ(2000)
Turbidity	<5.6	ANZECC & ARMCANZ(2000)
Total nitrogen	<0.614 mg/L	ANZECC & ARMCANZ(2000)
Dissolved inorganic nitrogen periphyton growth in natural waters	<0.444 mg/L	ANZECC & ARMCANZ(2000)
Nitrate-N toxicity in natural waters	<7.2 mg/L-N for 95% level of protection	Hickey, C. (Recalculated from ANZECC & ARMCANZ(2000))
Dissolved reactive phosphorus	<0.01 mg/L	ANZECC & ARMCANZ(2000)
Total phosphorus	<0.033 mg/L	ANZECC & ARMCANZ(2000)
E. coli	<260 cfu/100 mL Acceptable 260-550 cfu/100 mL Alert >550 cfu/100 mL Action	MfE & MoH (2003)

Macro-invertebrate data was compared against the guidelines listed in Table 2.3.

Table 2.3: Criteria for water quality based on macro-invertebrate indices

Macro-invertebrate Index	Poor	Average	Good	Excellent
MCI	< 100	100 – 110	110 – 120	> 120
SQMCI	< 4.2	4.2 – 5.0	5.0 – 6.0	> 6.0
Mean number of species	<9	9 – 15	15 – 24	> 24
Total species	< 10	15 – 20	20 – 30	>30
Total EPT species	< 5	9 – 15	15 – 20	> 20

3 RESULTS

3.1 Disease-Causing Organisms - *E.Coli*

Faecal contamination is a major issue in the Powell creek catchment. 44% of the faecal coliform samples were above the guideline for stock drinking water (1000 cfu/100ml, ANZECC 1992). Having water that is suitable for drinking by farm animals is an environmental bottom line under the Resource Management Act (1991).

While it is acknowledged that waterways in the Powell Creek catchment are not likely to be used for contact recreation, it does flow down into an estuary and coast that is used for this purpose. *E.coli* concentrations indicated suitability for human contact for 20% of samples (below the national guideline Alert level of 240 *E.coli*/100ml), and 30% within the 'alarm level' of the national guidelines for microbiological water quality (MfE & MoH 2003) (see in Figure 3.1).

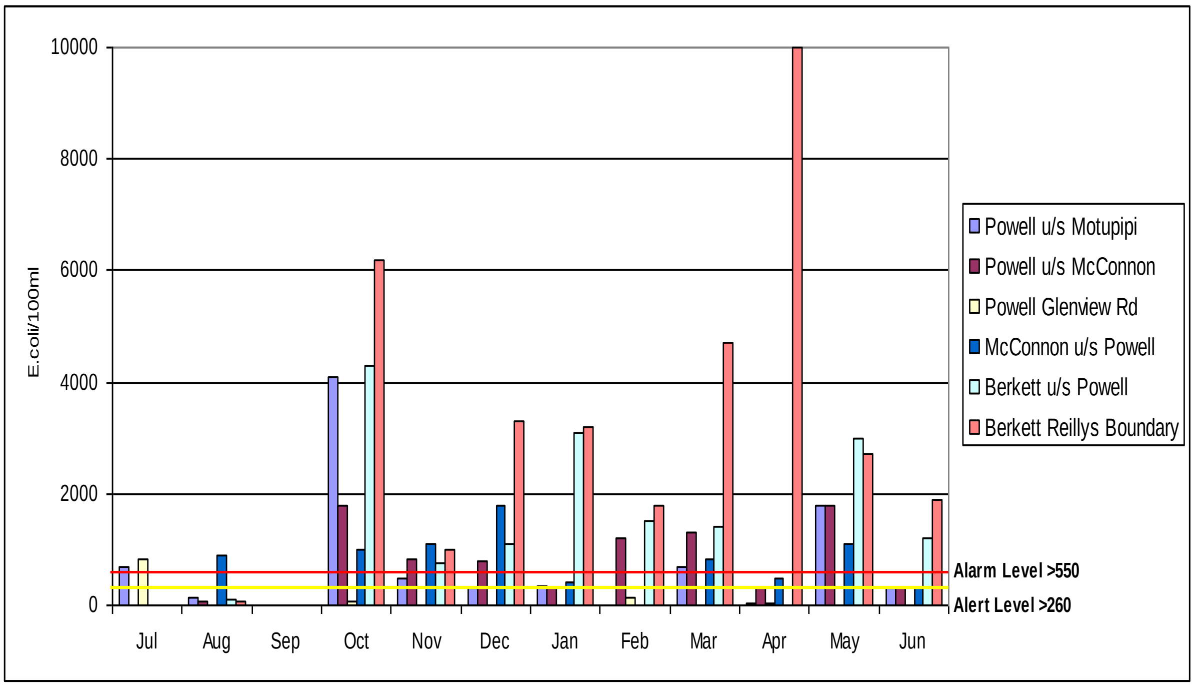
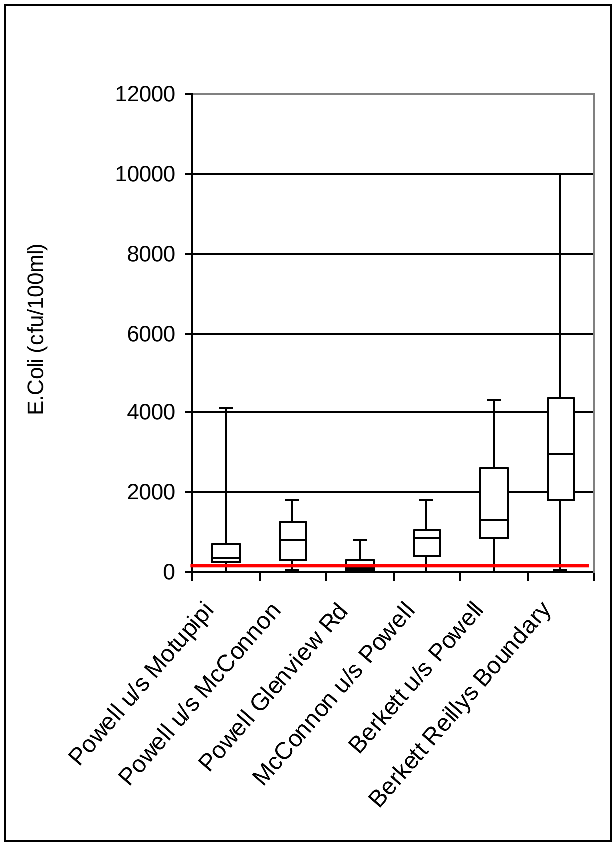


Figure 3.1 *E.coli* concentrations in sites in the Powell Creek Catchment July 2006 – June 2007

Consistently high readings were recorded from the two sample locations in Berkett Creek. Of the 24 samples that exceeded stock drinking water guidelines, 15 came from the 2 sites monitored in Berkett Creek.

Figures 3.2 and 3.3 show a series of box and whisker plots showing the distribution of data for each site (see Appendix 3 for the key to assist with interpretation of box-whisker plots) note the two Berkett Creek sites show higher median (average) results. The contact recreation guideline for *E.coli* medians (150 cfu/100ml ANZECC 2000) is also exceeded throughout the catchment, apart from at the upstream reference site at Glenview Rd.



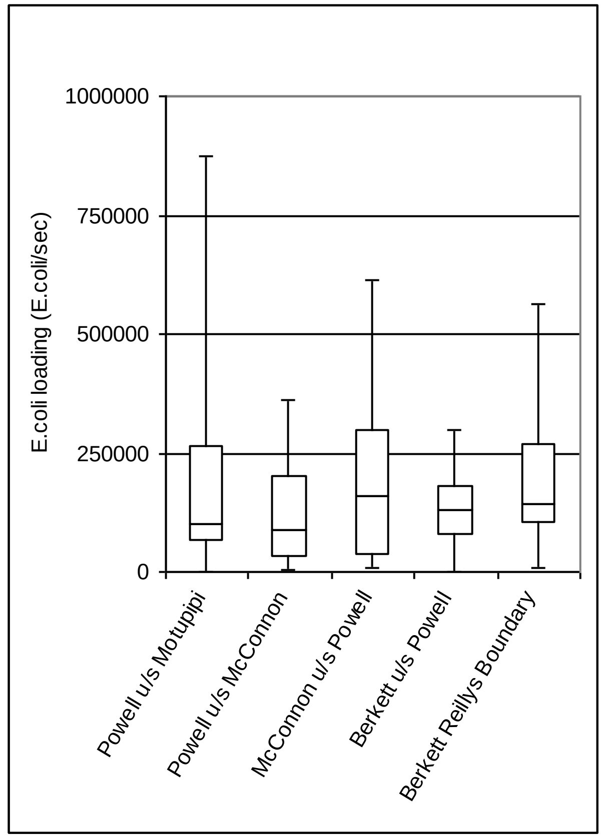


Figure 3.2 *E.coli* concentrations at Sites in Powell Creek catchment (2006-07). Contact Recreation guidelines shown by the red line.

Figure 3.3: *E.coli* loading at sites in Powell Creek catchment 2006-07 in low-flow conditions.

Although absolute concentration of faecal indicators at the two Berkett Creek sites is high, the loading (overall quantity; concentration multiplied by flow) compared to other sites is similar to the other sites. This is because of the relatively small quantity of water flowing in the waterway at base flows (see Figure 3.3). Data for the Glenview Road site was insufficient for robust analysis, but indications show average loadings of about 11,500, which is about 5-10% of the loadings from other sites. The median *E. coli loadings* in Powell Creek range from 87,000 to 160,000 *E.coli*/sec, with Berkett creek sites being at 130,000 and 140,000 *E.coli/*sec. The comparison between *E.coli* concentration and *E.coli* loading can be seen by comparing the two maps of Figures 3.4 and 3.5. These maps also present the results in the wider Motupipi catchment to show the comparatively high *E.coli* present in the Powell catchment and in the Motupipi River downstream of the Powell Creek confluence.

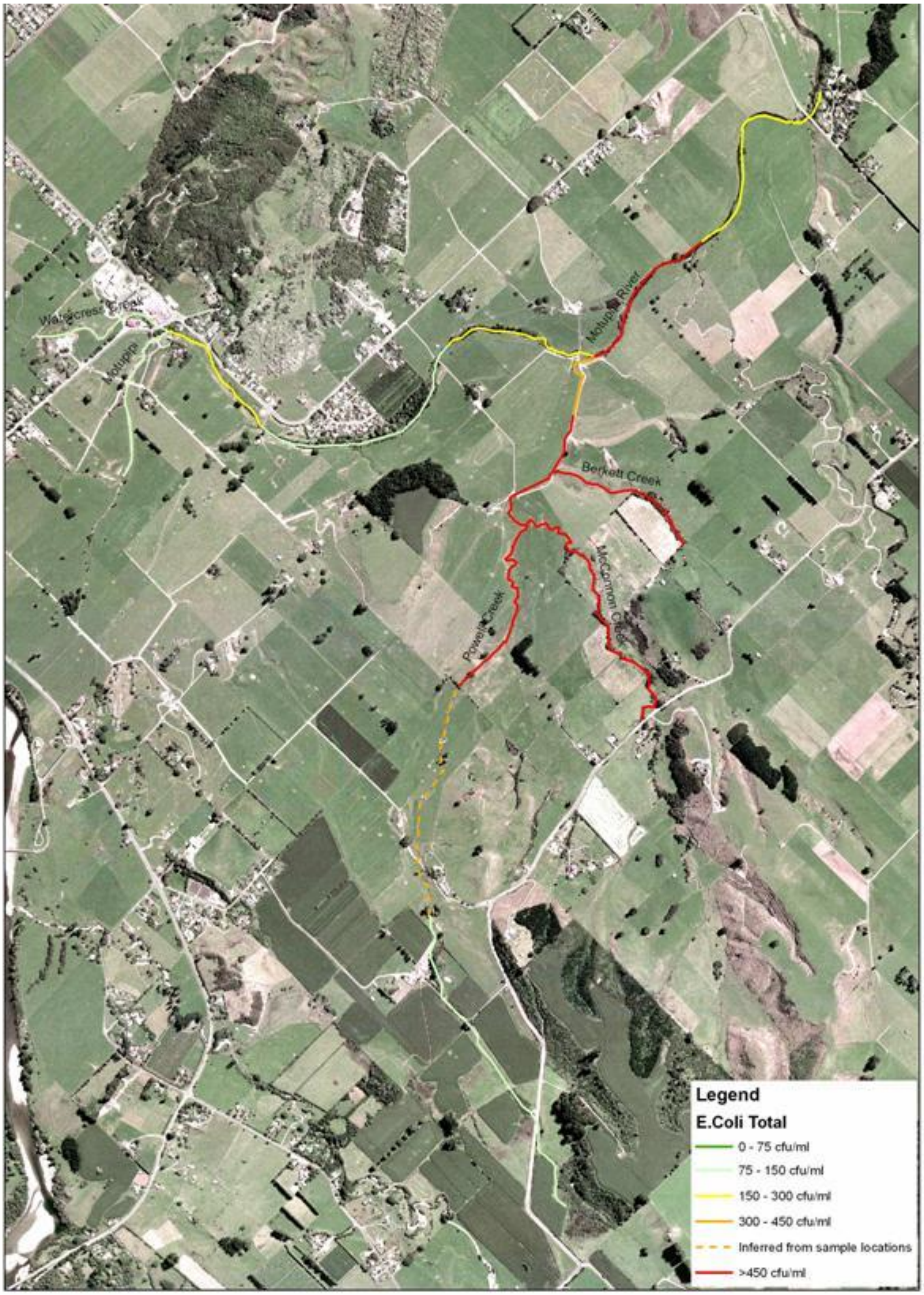


Figure 3.4 Median *E.coli* Concentrations (cfu/100ml) in the Motupipi catchment (2006-07)

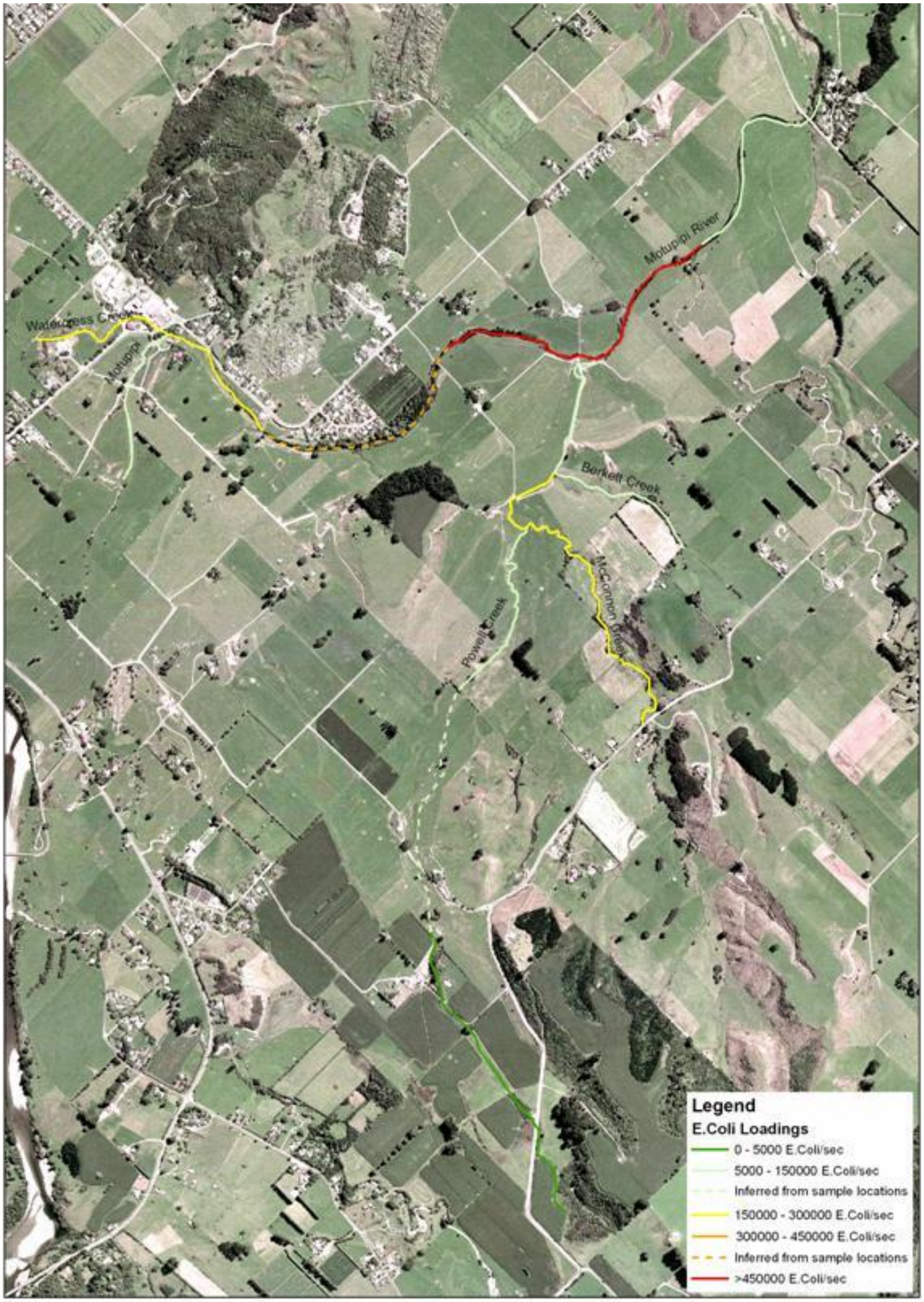


Figure 3.5 Median *E.coli* Loadings (cells/second) in the Motupipi catchment (2006-07)

3.1.1 Disease-causing Organisms – Concentrations During and After Storm Events

All of the monitoring results shown in Figure 3.3 are from samples taken at low flow levels. However, it is well know that in intensely farmed catchments when stream levels rise, faecal indictor concentrations also rise dramatically. In several intensively-monitored catchments throughout New Zealand it has been calculated that 99% of the *E.coli* load occurs during rainfall run-off events (Davies-Colley, *pers comm.*). The peak concentration of feacal indicators is usually within an hour or two prior to the peak flow in a waterway with higher concentrations occurring when little or no rainfall fell over the weeks prior to the high flow event. From the limited storm event sampling undertaken by TDC in the catchment, the typical concentration range is 5,000 to greater than 10,000. For the storm event shown in Figure 4 the sample taken had *E.coli* concentrations of 7,000 cfu/100ml. The calculated loading of 7,700,000 *E.coli*/sec is greater than 10 times (one order of magnitude) higher than the levels associated with base flows. This sampling event was well after the peak flow and *E.coli* loadings would be expected to be higher still.

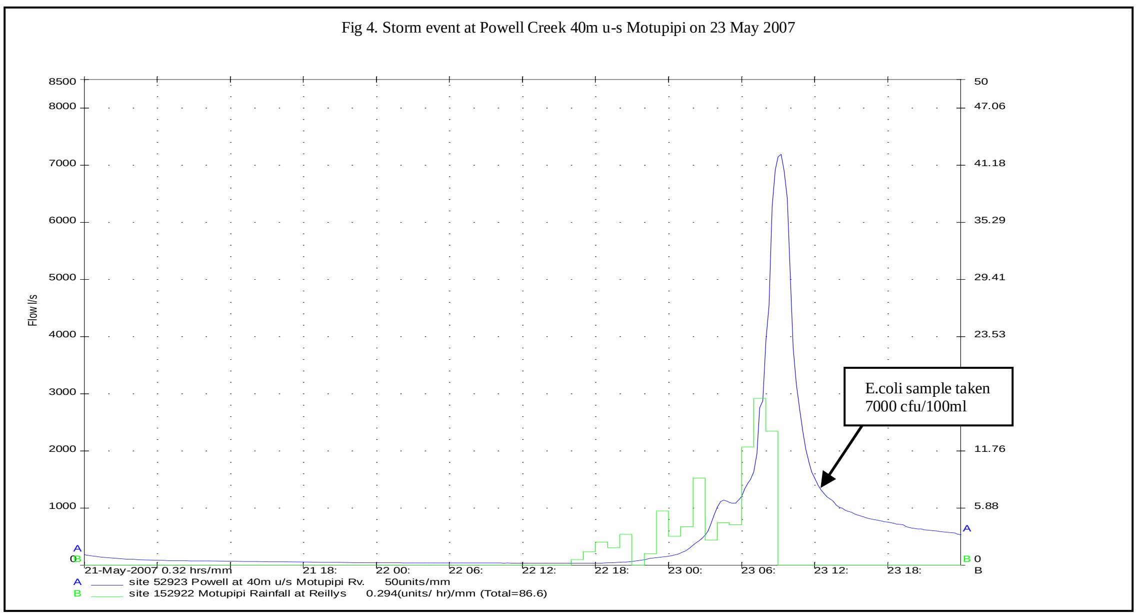


Figure 3.6 River Flow and Rainfall for a Storm Event on 23 May, 2007. The arrow shows when the *E.coli* sample was taken.

3.2 Nitrogen

3.2.1 Total Nitrogen

Total nitrogen concentrations measured in the Powell Creek catchment were high with 90% of samples exceeding the ANZECC (2000) guidelines of 0.614 g/m^3. All of the individual sites in the Powell catchment had median Total Nitrogen results above this guideline (Fig 3.7). McConnon Creek had the lowest levels with a median of 0.7 g/m^3. At these concentrations growth of aquatic plants and algae is enhanced. This, in turn, usually leads to increased fluctuations in oxygen concentration in the waterways which has been found to be a major issue in lower Powell Creek and Motupipi River.

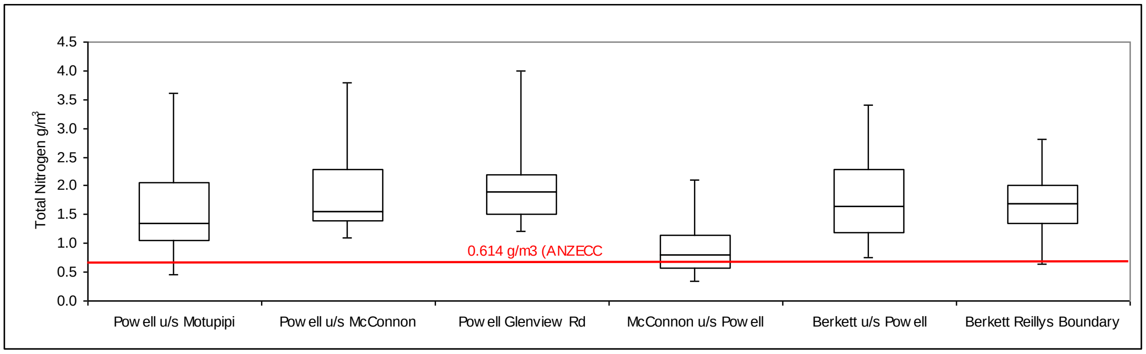


Figure 3.7: Total Nitrogen Concentrations and Powell Creek Monitoring Sites (2006-2007)

Although the Total Nitrogen concentrations measured at each site are high, the base flow of these streams is quite small and therefore the loading levels of Nitrogen in the waterways of Powell creek is relatively low compared to the Motupipi River. The maps (Fig 3.8 and 3.9) of Total Nitrogen concentration show high levels throughout the whole Motupipi catchment, but significantly higher loadings coming from the main Motupipi River rather than from the Powell creek catchment. These high nitrogen concentrations are not atypical for a catchment with over 75% of the land use in intensive farming.

3.2.2 Nitrate-N

Nitrate-N concentrations follow a similar patter to total nitrogen. In fact Nitrate-N makes up on average about 70-80% of the total nitrogen species. This is a fairly consistent pattern. Nitrate-N concentrations regularly exceed the guideline levels with over 90% of samples being above the ANZECC 2000 threshold level of 0.2 g/m^3. The median value for each site was well above this threshold also (Fig 3.10). However Nitrate-N levels in the main stem of Powell creek were higher than the smaller tributaries and decreased moving downstream through the catchment. The normal pattern for diffuse inputs of pollutants in a catchment is for the concentration to rise further downstream as the area of land drained increases. Therefore as we have the opposite occurring for nitrates it could indicate a more significant source, or sources, of nitrate in the upper catchment. Median values ranged from 1.65 g/m^3 at Glenview Rd down to 1.06 g/m^3 at Powell u-s Motupipi. McConnon creek had the lowest absolute value (0.07 $g/m^{3)}$ and median value (0.46 g/m^3).

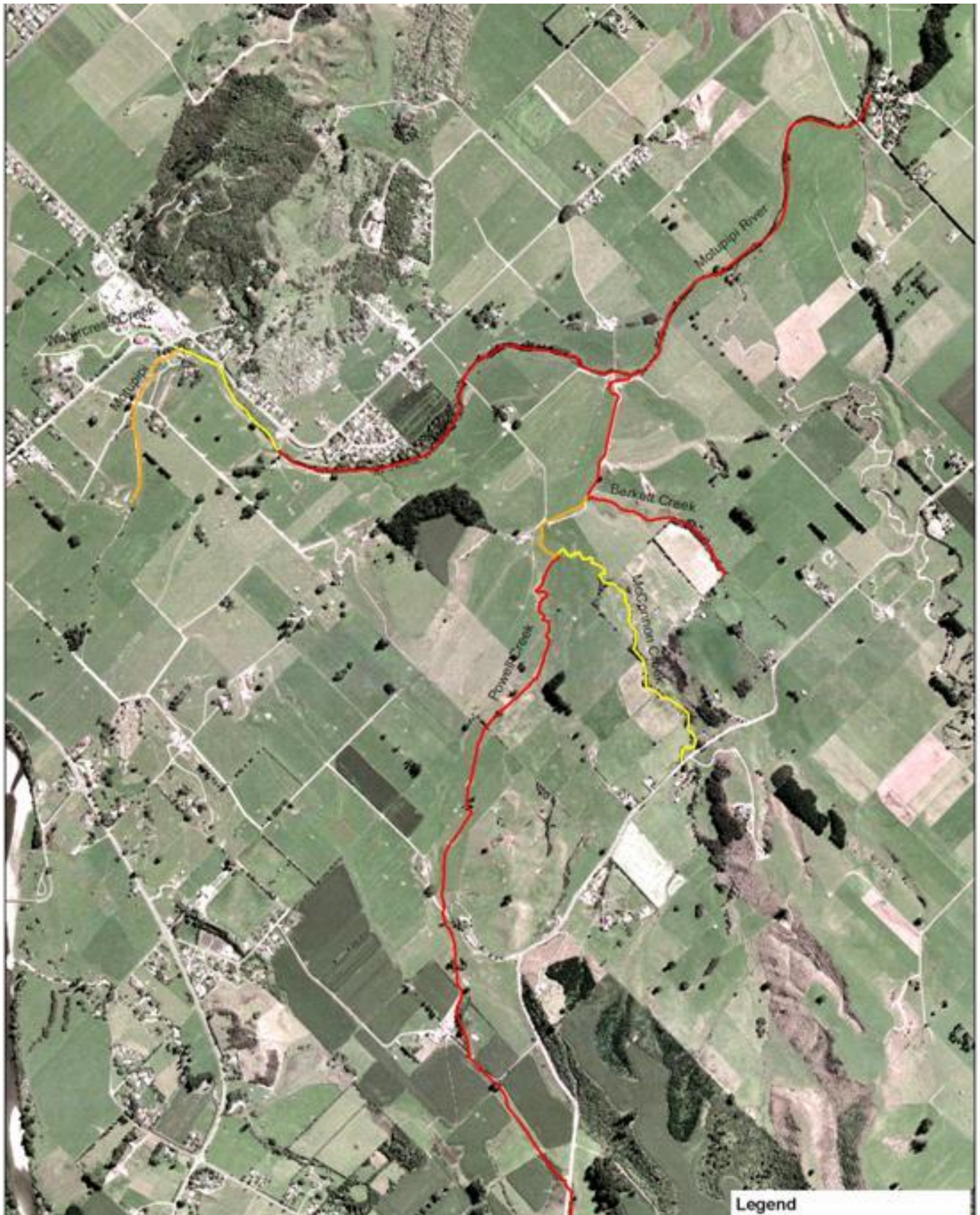


Figure 3.8: Median Total Nitrogen Concentrations in the Motupipi catchment (2006-07)

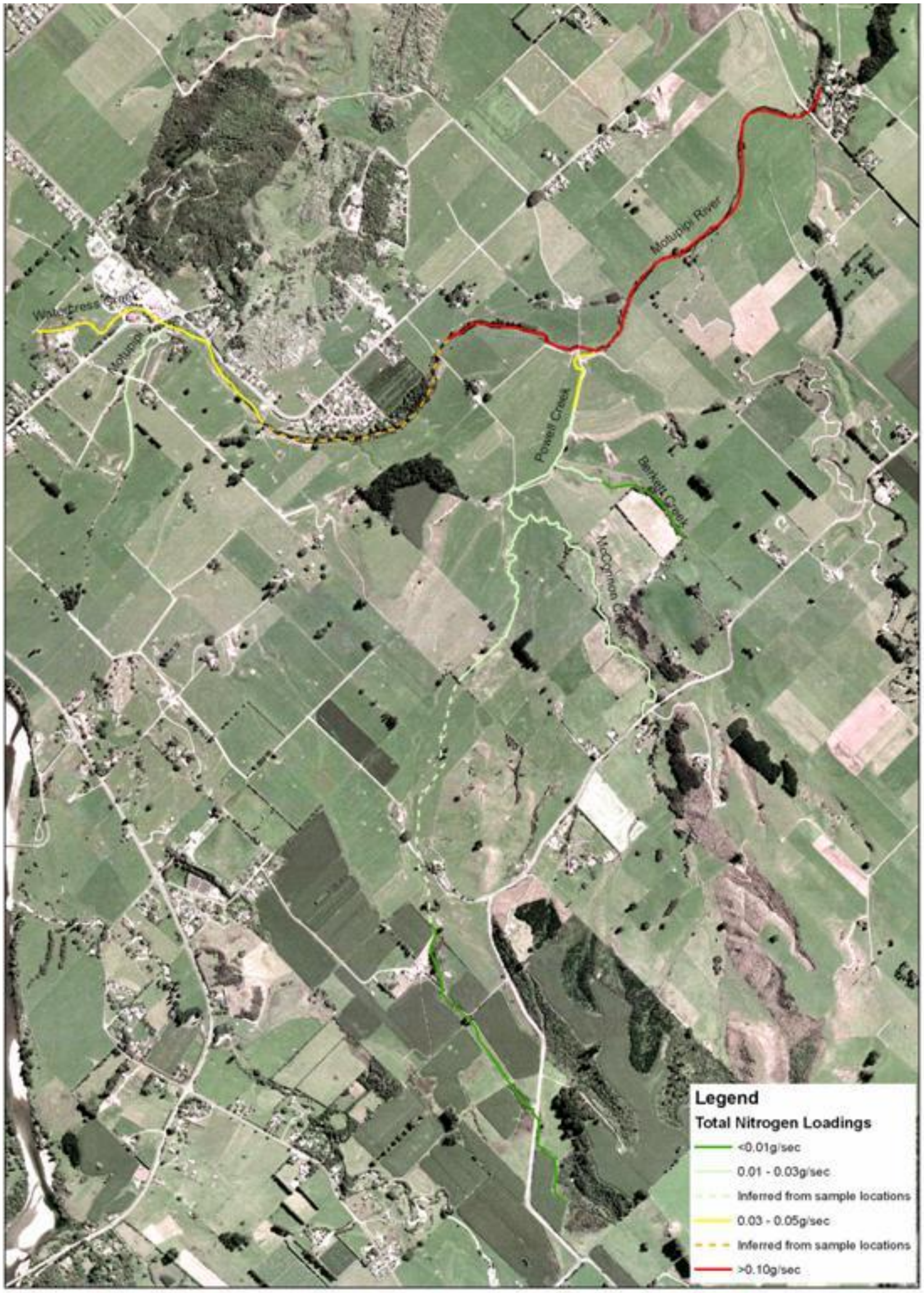


Figure 3.9: Median Total Nitrogen Loadings in the Motupipi catchment (2006-07)

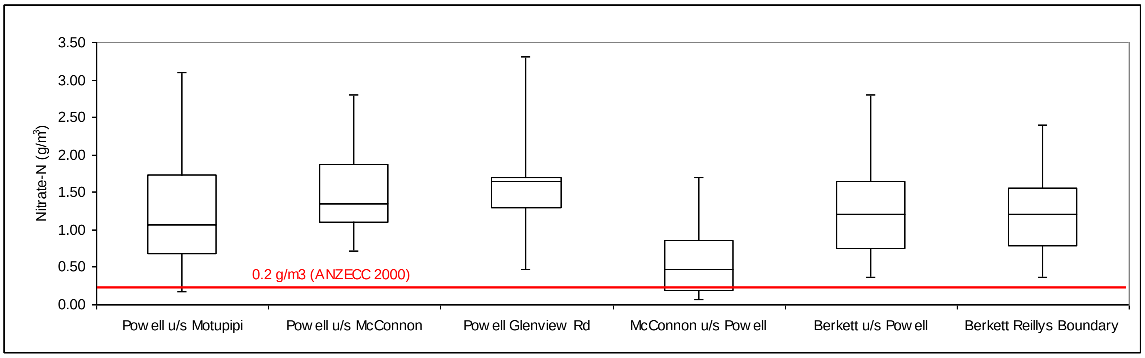


Figure 3.10: Nitrate-N Concentrations at Powell Creek Monitoring Sites (2006-07)

3.2.3 Ammonia-N

The highest total ammonia results across the sites ranged from 0.10 – 0.17 g/m^3. The guideline for Total Ammonia (using worst-case temperature and pH for the catchment) is 0.19 g/m^3. This suggests that ammonia toxicity is not likely to be a big issue. The toxic fraction of ammonia is the unionized form. The extent to which the ionization occurs is related to temperature and pH. High temperatures and high pH will drive the equilibrium of this reaction towards the unionized form. Worst case temperature and pH found in the catchment are 26^{0}C and 8.5 pH units.

Total ammonia results were quite consistent throughout the sampling sites as shown by the limited height of the boxes in Fig 3.11 with 50% of all the samples falling within the boundaries of the box. Yet all sites display a long 'whisker' at the upper end, with one or two readings being significantly higher than the average. Interestingly the dates at which these high readings occur is not consistent amongst the sites (Fig 3.11), so it does not automatically follow that if an upstream site is high in ammonia the corresponding downstream site will be high also. Therefore it would appear the localized site conditions such as stocking levels of adjacent paddocks influences the levels of ammonia sampled more than catchment wide conditions such as antecedent weather. As for nitrate, urine patches and fertilizer are known to be major sources of ammonia.

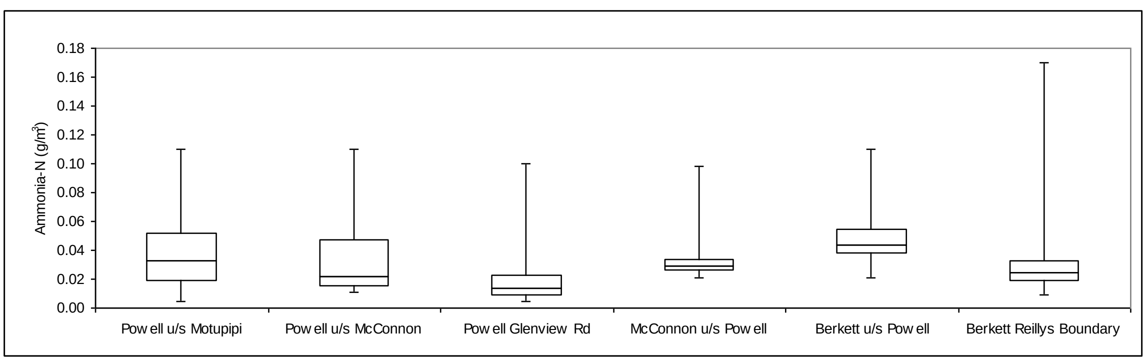


Figure 3.11: Total Ammonia concentrations at Powell Creek Monitoring Sites (2006-07)

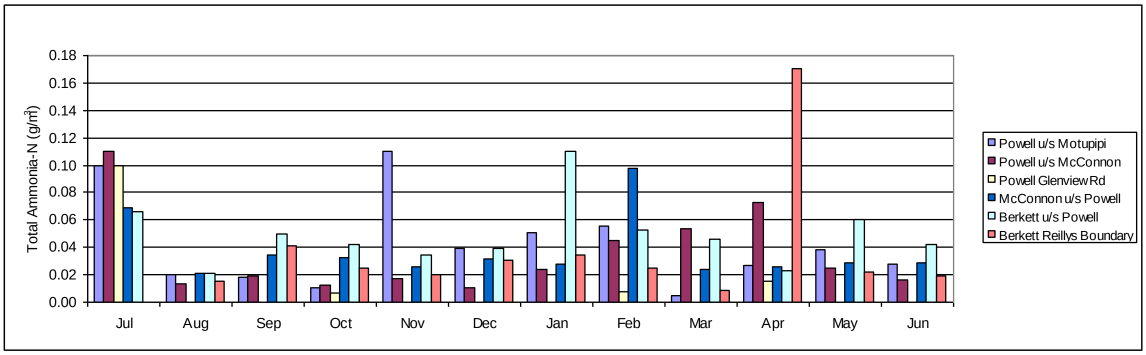


Figure 3.12: Total Ammonia concentrations at Powell Creek Monitoring Sites over the 2006-07 year

3.3 Phosphorus

Dissolved Reactive Phosphorus results are mostly below the ANZECC 2000 guidelines (Fig 3.13), with only 8% of all samples exceeding the 0.01 g/m^3 threshold. The median values ranged from 0.002 g/m^3 at the top of the catchment (Glenview Rd) to 0.007 g/m^3 at the bottom of the catchment (Powell at u-s Motupipi). In general the concentration of phosphorus from the main stem of Powell creek was lower than the smaller tributaries of Berkett and McConnon creeks.

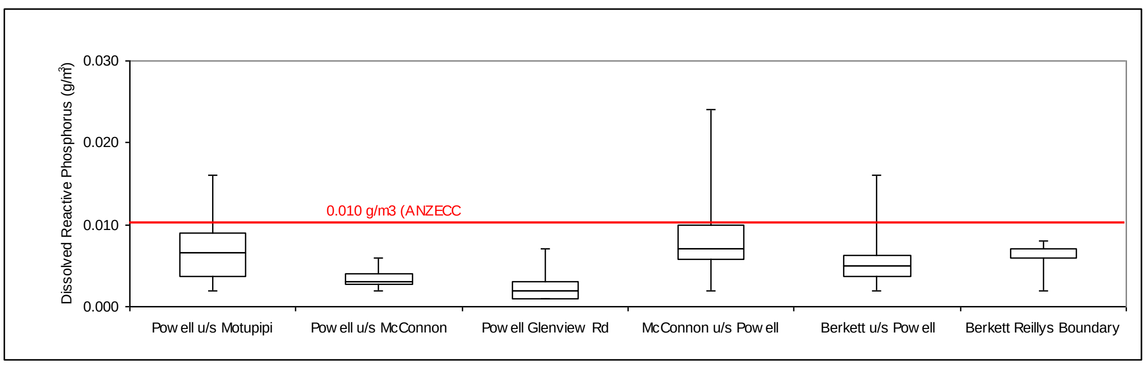


Figure 3.13: Dissolved Reactive Phosphorus concentrations at Powell Creek Monitoring Sites (2006-07)

A similar pattern is seen in the Total Phosphorus results (Fig 3.14). Median values at each site fell below the ANZECC 2000 guidelines. 46% of results were above the threshold level of 0.033 g/m^3, mainly coming from samples in Berkett and McConnon creeks, which had higher results overall. The levels of Total Phosphorus increased from the upper to lower sections of the catchment.

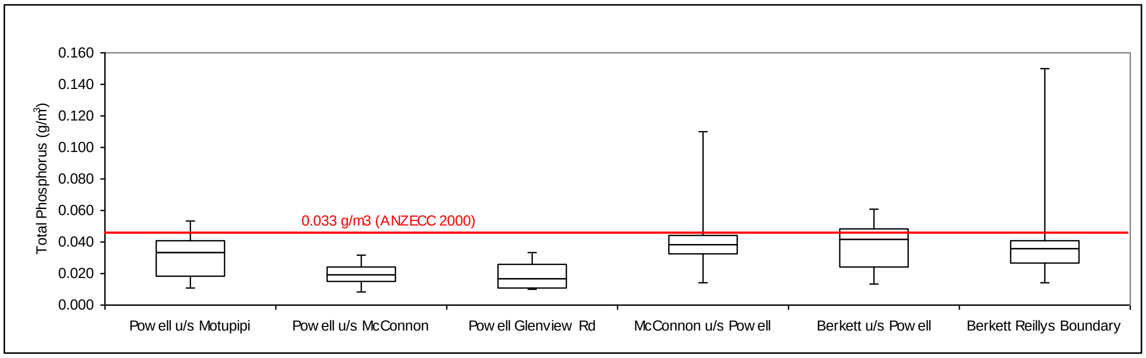


Figure 3.14: Total Phosphorus concentrations at Powell Creek Monitoring Sites (2006-07)

As expected the concentration of phosphorus was positively correlated to suspended solids concentrations. This is due to the capacity of phosphorus to bind tightly to sediment particles. Two major sources of fine sediment in the catchment over the last two years include the following: A farm track cutting in the McConnon Creek catchment, intense pugging in the McConnon Creek and to a lesser extent in the Powell Creek catchment, and stock trampling on the banks of Berkett Creek upstream of the Reilly Boundary.

3.4 Total Suspended Solids and Water Clarity

For base flow conditions the Total Suspended Solids results for all sites are typically in the range from 1 to 6 g/m^3. Occasional higher readings occur from time to time and are likely due to small individual stream disturbances on a site by site basis. However results obtained from base flow conditions does not give a full picture of the levels of sediments transported in the catchment as most is transported at high flow. Due to the low permeability of the silt-loam soils and rolling hilly topography, the Powell catchment has a very quick response to rainfall giving short sharp flood events. This causes higher rates of erosion and concentrations of suspended sediment in the waterway.

Total suspended solids sampled from Powell Creek at Reilly's Bridge during a flood event on the 10 October 2007 gave a result of 96.5 g/m^3 and was collected 2 hours after the flow peak. When combined with the flow this calculates at a sediment loading of 29,000 g/sec compared with the highest loadings taken at base flows of 2.5g/sec (Fig 3.15).

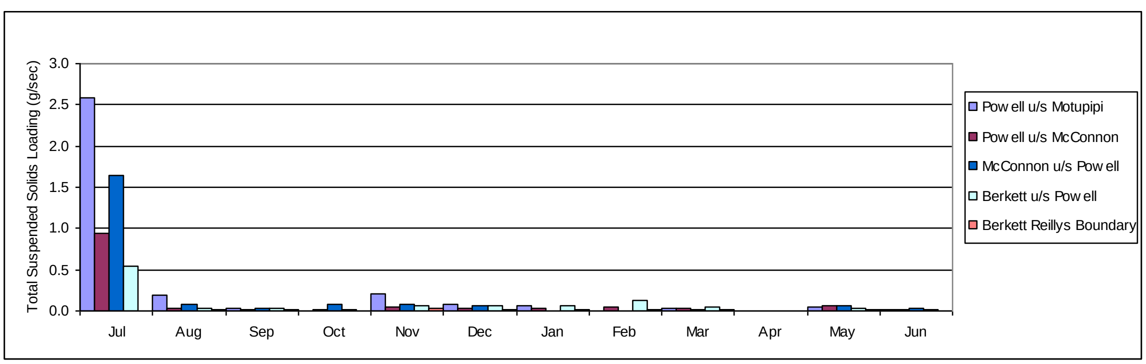


Figure 3.15 Total Suspended Solids Concentration at Powell Creek Monitoring Sites over the 2006-07 year

Water clarity is determined by visual sighting through the water column to the maximum distance that a standard size black disk can be seen. In the Powell catchment the results ranged from 0.3m up to 5.1m with medians in the range between 1 to 2 meters (Fig 3.16). Water clarity is effected even more than suspended solids by the heavy silt soils in the catchment due to particle size and shape (small plate-shaped particles). Various land uses can also cause increased input of sediment to the water course, such as stock access to streams, land cultivation and earthworks. Significant erosion caused by below-standard road building caused a significant discharge of fine sediment in McConnon Creek in 2005-06.

Figure 3.16: Water Clarity in metres at Powell Creek Monitoring Sites (2006-07)

There is also a strong correlation between faecal indicators and fine sediment in the water (as measured by suspended solids and water clarity). The more sediment that is mobilized into the water column, the greater the *E.coli* concentration.

3.5 Water Temperature

Two temperature loggers were installed in the main stem of Powell creek during the summer of 2006-2007, one at the downstream end of the catchment (Powell u/s of Motupipi) and the other in the mid reaches upstream of monitored tributaries (Powell u/s of McConnon). Water temperature is recorded every 30 minutes and then a daily value is derived for the midpoint between the daily maximum and mean. This value has been shown to be an appropriate description for temperature tolerance of freshwater invertebrates (Cox and Rutherford 2000). A value of 20^0C is attributed to the most sensitive species factoring in a 3 degree safety margin. Between December 2006 and March 2007 the upstream site exceeded this 20^0C value on 52 days while the downstream site exceeded it on 38 days. The greater number of high temperatures recorded at the upstream site come mainly in the early part of the summer as the temperature here rises faster. It is not until late January before the both sites begin to show a similar temperature pattern (Fig 3.17). Factors such as stream morphology, flow and the level of riparian shading will significantly influence the river temperatures. The water at neither of these sites (shown in Figure 3.17) is shaded, so it is likely that the lower fluctuations in water temperature are due to the higher water flow at the downstream site which is buffered to the temperature increases. The upstream site has less catchment area and hence lower base flow levels which results in the high water temperatures early on in the summer.

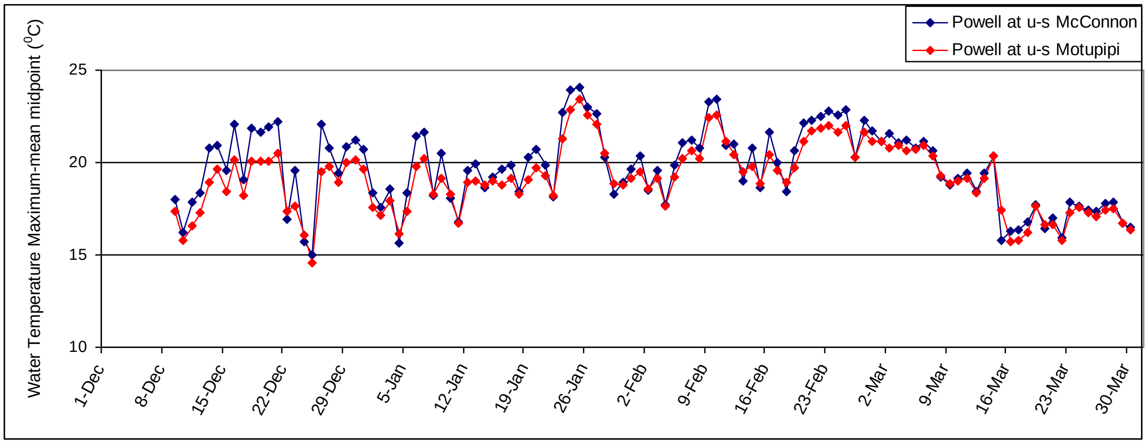


Figure 3.17: Water Temperature Expressed as the Midpoint of Daily Maximum and Daily Mean in Degrees Celsius over the 2007-08 summer.

3.6 Dissolved Oxygen and pH

Daily changes in dissolved oxygen saturation at Powell Creek sites had characteristic patterns with some very large daily fluctuations (Figure 3.18). Powell @ Glenview was the only site where oxygen saturation was consistently high enough to ensure that sensitive biota would not be detrimentally affected. Dissolved oxygen concentrations in Powell Creek upstream of Motupipi River have been recorded as regularly going below 20% in summer in the hours around day break (see the blue line in Figure 3.18). This is well below the ANZECC Guideline of 80% and likely to limit the diversity of species in the waterway.

Oxygen saturation was almost constant throughout the night at McConnell Ck @ u-s Powell Ck, and Powell Ck @ Glenview Rd, whereas oxygen saturation continued to drop steadily throughout the night at Powell Ck @ Reilly's. This is related to the amount of oxygen that is able to diffuse through the river surface. At most of the sites diffusion of oxygen into the river eventually matches oxygen uptake via respiration. However, oxygen changes at Powell Ck @ Reilly's during the night are almost entirely controlled by respiratory uptake with only a tiny influence of diffusion through the river surface.

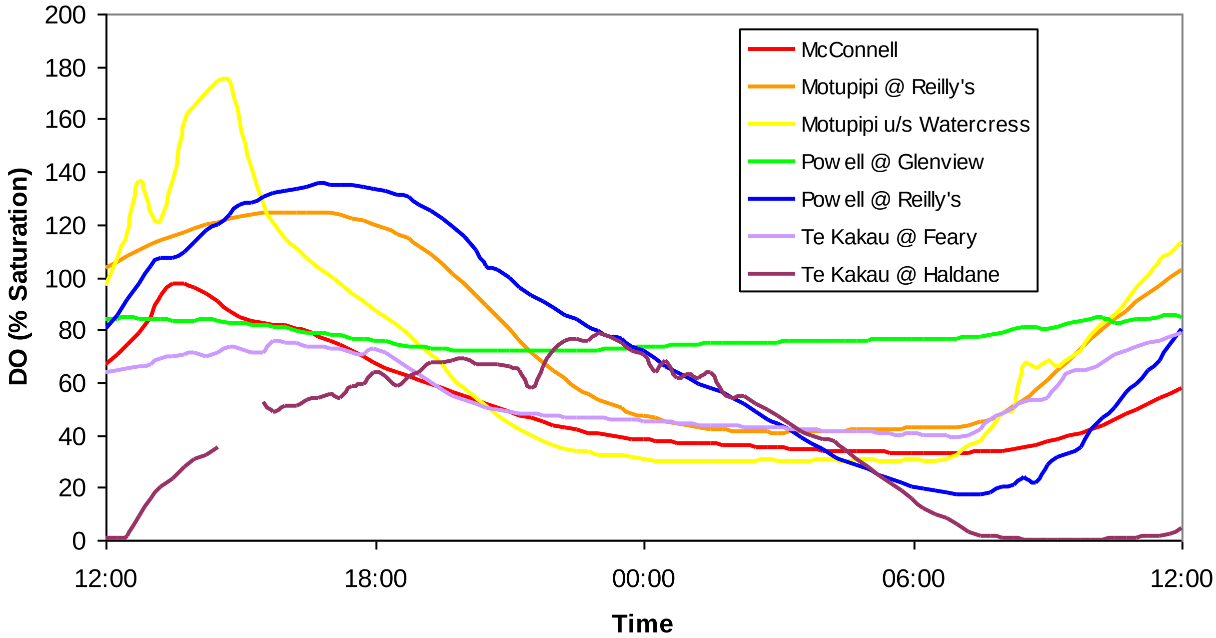


Figure 3.18a Examples of the daily changes in dissolved oxygen saturation at sites near Takaka. Blue and green lines show data for the furthest downstream and further upstream sites (respectively) on Powell Creek.

Gross Primary Productivity (GPP), a functional indicator of stream health was low at McConnell Ck and Powell Ck @ Glenview and indicative of healthy conditions according to the criteria suggested by Young et al. (2006). Rates of oxygen uptake (ER) at McConnell, Powell @ Glenview and Powell @ Reilly's were indicative of healthy or satisfactory ecosystem health.

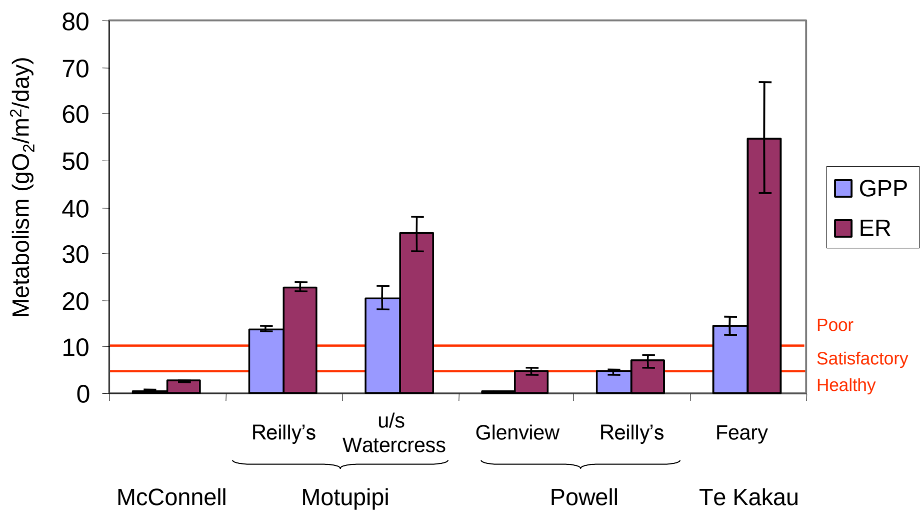


Figure 3.18b Average rates of plant production (GPP) and oxygen uptake (ER) at each of the sites. Thresholds for 'healthy', 'satisfactory' and 'poor' ecosystem health are shown with red lines.

The balance between GPP and ER is a useful measure of the sources of energy driving a stream ecosystem. If GPP equals or exceeds ER then organic matter produced within the system is probably supporting the food chain, whereas if ER greatly exceeds GPP then organic matter from upstream or the surrounding catchment is being used to maintain the ecosystem. The ratio of GPP:ER (or P/R) ranged from 0.05 (Powell @ Glenview) to 0.8 (Powell @ Reilly's). The P/R ratios indicated that these sites were generally relying on organic matter from upstream or the surrounding catchment to support the food chain. No particularly high values of P/R were observed and all sites had P/R ratios that were indicative of healthy ecosystems.

pH was consistently neutral (6.5-7.5 pH units) at all sites indicating no significant issue with regard to the parameter.

3.7 Periphyton

There were two occasions when periphyton scores (based on rapid cover assessments) where below 5. A score of 1 indicates very poor condition and high cover of filamentous green algae and 10 indicates good condition with thin films of diatoms. However these patterns were not consistent across both sampling occasions (see Figure 3.18). Earlier sampling at the lowest site (just upstream of the Motupipi) have shown very inconsistent scores ranging from 1 to 9. The lowest scores typically occur in summer when filamentous green algae can cover a large percentage of the bed.

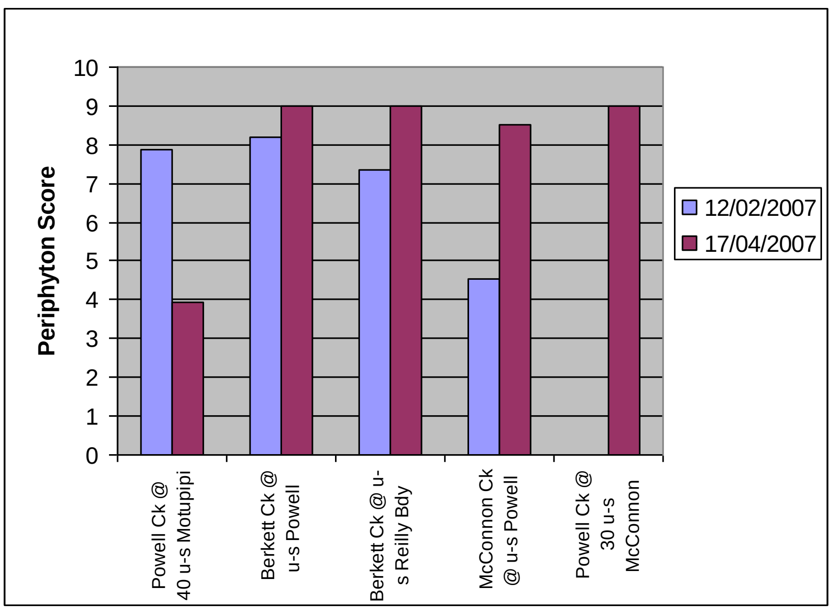


Figure 3.19: Periphyton Scores for Two Sampling Events in Powell Creek Catchment A score of 1 indicates very poor condition and high cover of filamentous green algae and 10 indicates good condition with thin films of diatoms

3.8 Macro-invertebrates

All sites had macro-invertebrate indices indicating poor or very poor water quality, except the upstream site on Powell Ck at Glenview Rd (see Appendix 1). The macro-invertebrate community index across the sites ranged from 56 to 95 whereas the site at Powell Ck at Glenview Rd site ranged from 106 to 108. About half the taxa in the samples at this upstream site were mayflies, stoneflies or caddisflies compared to 15-40% (mean at 30%) at the other sites in the Powell Creek catchment (see Fig 3.20a & 3.20b). There were no stoneflies in any samples and very few mayflies or caddisflies, except Powell Ck at Glenview Rd. At this upstream site the sensitive mayflies *Deliatidium spp*, *Austroclima sepia*, *Neozephlebia scita* and *Zephlebia* spp. were present in reasonable numbers (very abundant, common, abundant or common respectively).

At each site the indices were relatively consistent across the two sampling events.

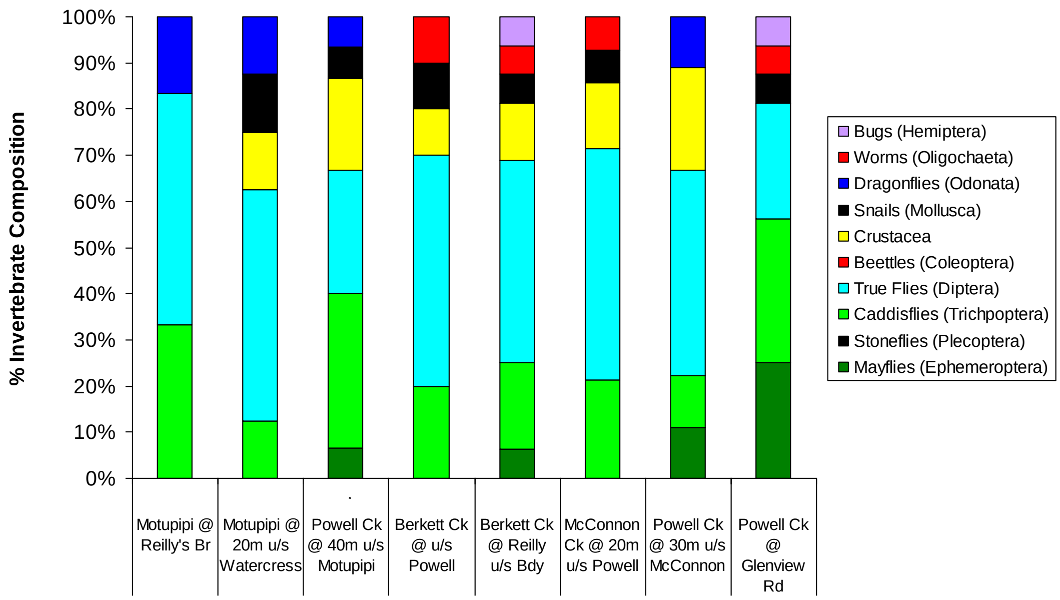


Figure 3.20a: Macro-invertebrate Taxa Composition Across Sampling Sites in Powell Creek catchment 10 October, 2006

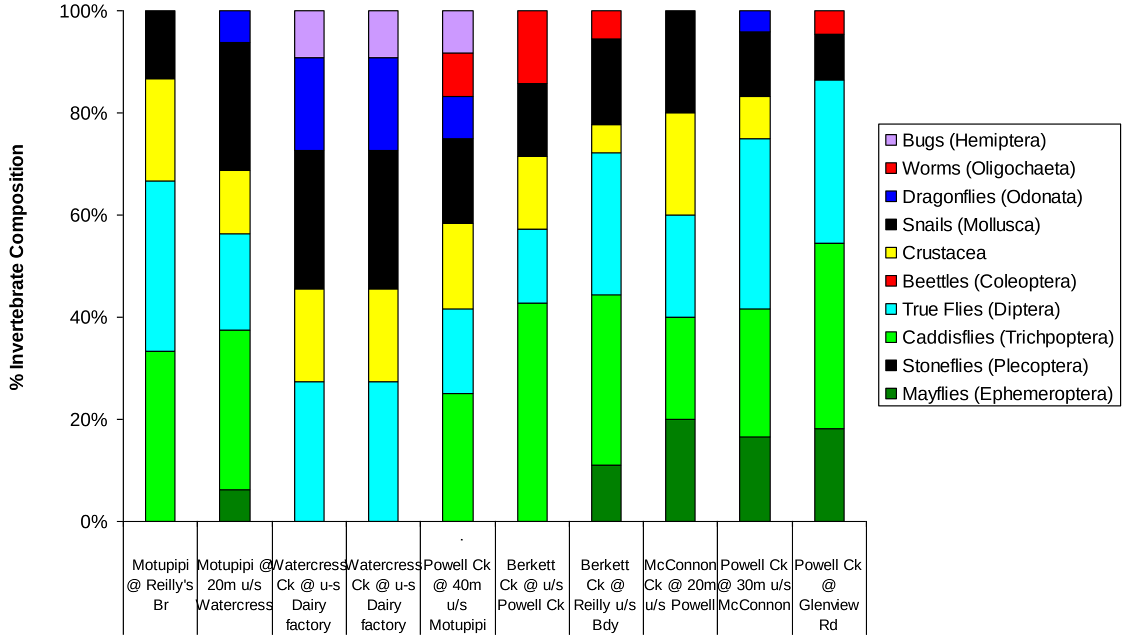


Figure 3.20a: Macro-invertebrate Taxa Composition Across Sampling Sites in Powell Creek catchment 16 April, 2007

3.9 Fish and Large Crustacea Communities

The Powell Creek catchment supports reasonably large numbers of tuna (short-fin eel) and inanga (see Fig 2.22). Long-fin eel were found occasionally in the deeper and wider parts of Powell Creek and McConnon Creek. Common Bully were common in much of the catchment, particularly those areas were there are recent silt deposits on the bed. Several large Common and Giant Bullies are regularly observed sunning themselves on rock protection work about 80m upstream of Motupipi River. One juvenile Banded Kokopu was found in Berkett Creek and Powell Creek immediately downstream and upstream of Glenview Road where there is good bank cover. It is expected that with fencing and planting woody vegetation along that waterway that more of the sensitive galaxids would return to the catchment. Koura are common on Powell Creek around Glenview Road where there is a considerable amount of overhanging gorse and are found very occasionally near overhanging woody vegetation in other parts of the catchment. *Paratya* shrimp are found in reasonable numbers in the lower end of the catchment. Shrimp are not typically found much more than 1-2km inland from the top of the tidal influence so they are not expected at the upstream sites.

Berkett Creek, a small hill-fed stream in the eastern part of the Motupipi catchment, harbours about 200m of very good stream habitat for fish in the mid section. In this section there is over 80% shade by woody vegetation, large and deep residual pools and good in-stream cover provided by woody debris and undercut roots (see Fig 3.21b). The average width in the mid-section was over twice that of the lower section. Adjacent sections of this waterway were heavily trampled by cattle and flowed through grazed pasture in the lower and upper sections of the waterway (see Fig 3.21a). Unexpectedly there were no sensitive native fish found in the mid section (Figure 3.21b). This could have been due to a potential fish barrier downstream of the site or poor water quality arising from upstream. Further survey would be necessary to understand the reason for this.

Figure 3.21a: Berkett Ck downstream of the wooded section

Figure 3.21b: Berkett Ck within the wooded section

The pest plant, *Glyceria maxima*, has been recently found in Powell Creek upstream and downstream of the confluence of Berkett Creek. This is a serious threat to inanga (and sensitive native fish if they were present) due to the plant's ability to extensively choke up the waterway and limiting the available 'space' in the stream. Eels are unlikely to be too affected by this situation as they are happy to 'burrow' into these weedy areas. The plant has been sprayed several times but continues to re-grow. Other spray strategies are being trialled.

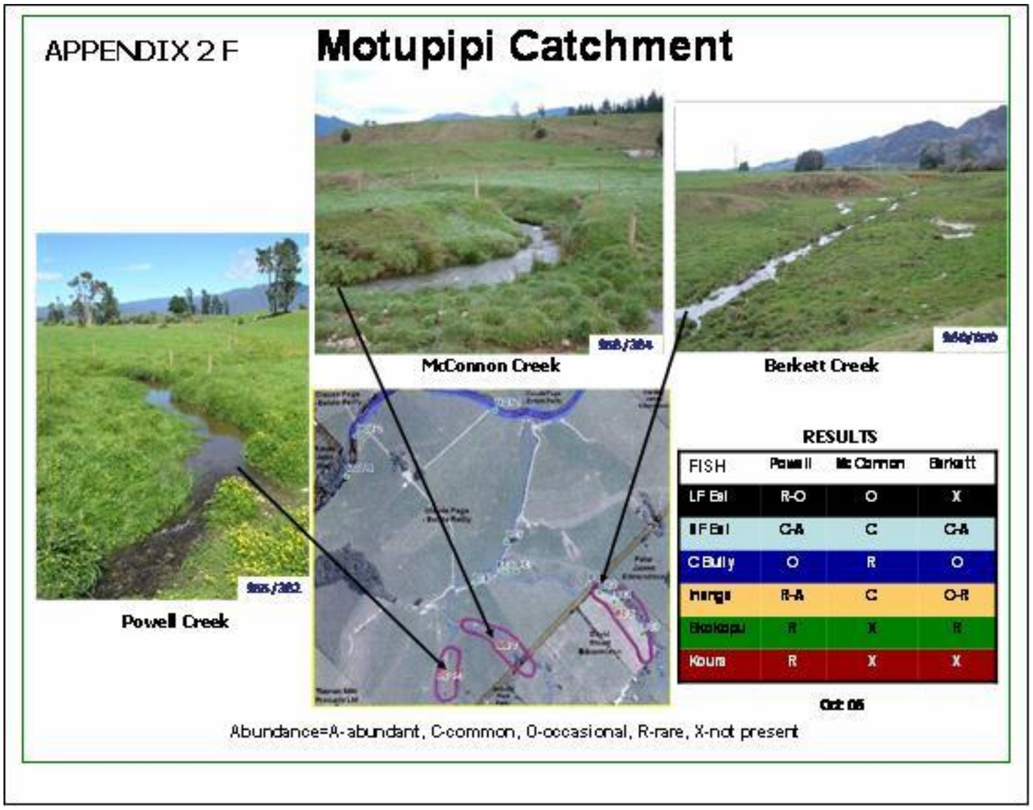


Figure 3.22 Freshwater fish survey results in Powell Creek 2006

3.10 Stream habitat

Streams in the Powell Creek catchment are generally soft-banked with considerable silt and mud in the bed matrix. The stream bed in some parts of the catchment is dominated by silt and mud substrate, while gravels and cobbles dominate in others (see Table 3.1). The representation of woody debris in the waterways of the catchment is very low as a result of very little woody riparian vegetation.

1-2cm of fine sediment deposits were regularly found in McConnon Creek. This was found to be associated with a road cutting that had caused significant erosion in the middle reaches of this waterway.

Not represented at these sites was bedrock and boulders. While mudstone bedrock has been found in the catchment, it is likely to make up less than 1%. The only boulders found in the catchment are those placed for erosion protection around culverts and one erosion scarp in lower Powell Creek.

SITE	LARGE COBBLES 120-250MM	SMALL COBBLES 60-120MM	GRAVELS 20-60MM	SAND 1-20MM	SILT/ MUD <1MM	WOODY DEBRIS
Powell Creek @ 40m upstream Motupipi	**1.5** (3+0)	**22** (44+0)	**54.25** (52+56.5)	**7.75** (1+14.5)	**14.5** (0+29)	**0** (0+0+0)
Berkett Creek @ Reilly upstream Boundary	**2** (2+0+4)	**31.8** (29+0+66.5)	**26.3** (8+55.5+11)	**5.5** (0+16.5+0)	**10.5** (59.5+27+18.5)	**0.83** (1.5+1)
Berkett Creek @ u-s Powell Creek	**10.5** (11+0)	**4.5** (9+0)	**12.5** (0+25)	**14** (0+28)	**62.75** (80+45.5)	**0.75** (0+1.5)
McConnon Ck @ upstream Powell Ck	**18.3** (12+0+43)	**15.7** (20+4+23)	**35** (22+77+15)	**0** (0+0+0)	**28** (46+19+19)	**0** (0+0+0)
Powell Ck @ upstream McConnon Ck	**0** (0+0+0)	**7.3** (14+0+8)	**11.8** (2+12.5+21)	**4.5** (0+13.5+0)	**70** (81.5+57.5+71)	**6.3** (2.5+16.5+0)
Powell Ck @ Glenview Rd	**2.5**	**15**	**56.25**	**1.25**	**25**	**0**

Table 3.1: Stream substrate % cover as assessed at the sampling sites in this programme (bracketed values represent the range of actual data).

Plants rooted in the bed were not included in this assessment but made up 50-100% cover at times. These plants included the introduced species Reed Sweet Grass (*Glyceria maxima)* and Swamp Willow Weed (*Persicaria decipiens*). Reed Sweet Grass is common in Powell Creek for about 200m upstream of the McConnon Creek confluence and Swamp Willow Weed is common in the lower reaches of Powell Creek. Pasture grasses invade the channel in Berkett Creek in summer when flows are low.

4 DISCUSSION

The very high *E.coli* readings in this sub-catchment could be attributed to the high degree of stock access to the creek, particularly in the headwaters where numerous small seeps combine to form surface flow. There is a lot of pugging from stock evident adjacent to the creek throughout much of its length, particularly in winter and spring. Effluent from diary sheds is not applied to land in this catchment.

It would be very useful to know if there is a best management practice system that has contributed to the low faecal indicator concentrations found at the Powell Creek at Glenview Road site. Even though not all the catchment upstream of this site is fenced there is a question about whether the intensity or type of farming is lower or different (respectively) in this area. Information from the farmer about farm practice in this area would be useful.

The reason for relatively low nitrogen concentrations in the McConnon Creek catchment would be interesting to determine in order to understand how to further develop best practice. McConnon Creek had a median total nitrogen about 50% of that in Berkett Creek and Powell Creek upstream of McConnon Creek and 40% of Powell Creek at Glenview Road. One potential reason for could be the greater dominance of Tadmore soils or the existence of more scrub in the catchment than other tributaries. It may also be because not so much wastewater was applied to this sub-catchment compared to other sub-catchments.

Plant growth in the waterways at all sites, except McConnon Creek, was strongly phosphorus-limited on every sample event. Mean NO3:DRP ratios across all sites ranged from 110 (McConnon Creek) to 658 (Powell Creek at Glenview Rd). On average McConnon Creek was phosphorus-limited (although much less so than the other sites) but a third of all samples at this site were nitrogen-limited. It is widely accepted that ratios of less than 20:1 (Dissolved Inorganic Nitrogen: Dissolved Reactive Phosphorus) are nitrogen limited and greater than 40:1 are phosphorus limited. This means that nitrogen is the most important nutrient to reduce in the catchment.

5 RECOMMENDATIONS

1. As recommended by Ministry for the Environment and other Regional Councils this sampling should be repeated in 2011-12 following further improvement in dairy farming best practice.

2. Implementation of further best management practice in the catchment should be encouraged. One example of best practice to be promoted is excluding stock from streams down to 0.4m in width. Seasonally wet areas should also be fenced but in this case the fencing could be temporary to allow summer grazing and restrict it in the wetter spring period. Best practice for farm tracking needs to be communicated.

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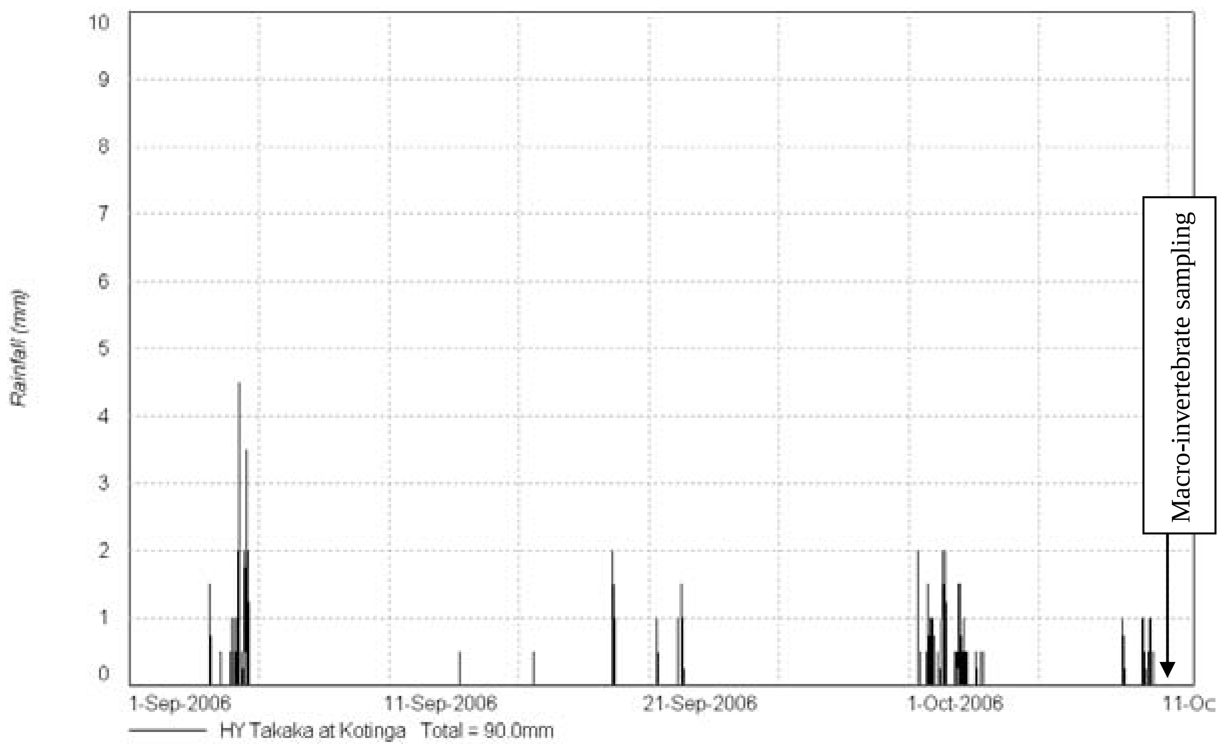
APPENDICES

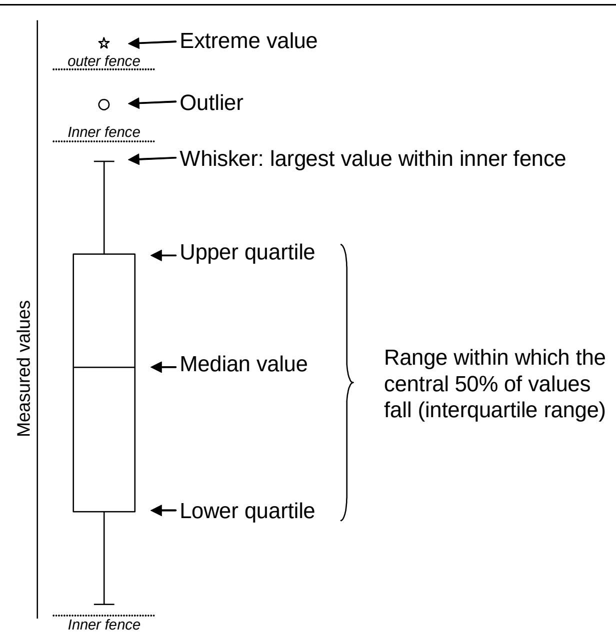
Appendix 1: Macro-invertebrate Metrics

	Powell Ck @ Glenview Rd		Powell Ck @ 40m u/s Motupipi R		McConnon Ck @ 20m u/s Powell Ck		Berkett Ck @ u/s Powell Ck		Berkett Ck @ Reilly u/s Bdy		Powell Ck @ 30m u/s McConnon Ck	
	11-Oct-06	16-Apr-07	11-Oct-06	16-Apr-07	11-Oct-06	16-Apr-07	11-Oct-06	16-Apr-07	11-Oct-06	16-Apr-07	11-Oct-06	16-Apr-07
MCI	106	108	85	75	82	94	56	78	71	84	89	95
sqMCI	7.75	6.50	4.13	4.00	2.75	4.31	3.84	4.04	2.95	4.49	3.53	3.97
Number of taxa	17	23	15	13	14	29	10	8	14	18	9	13
Number of EPT taxa (ex. Hydroptilidae caddis)	8	13	5	2	3	9	2	3	3	7	2	4
%EPT (ex. Hydroptilidae caddis)	47	57	33	15	21	31	20	38	21	39	22	31

Appendix 2: Rainfall at Kotinga over almost 6 weeks prior to macro-invertebrate sampling on 11 October 2007.



Appendix 3: Interpretation of box plots



Box and whisker plots illustrate how data are distributed around the central, or median, value. The 'box' represents the range of the central 50% of values around the median, which is shown as the line through the box. Values that are further from the median are illustrated by whiskers, outliers or extreme values, depending on how far the value is from the median and on the size of the interquartile range. The 'inner fence' is located 1.5 x the interquartile range from the median, and the 'outer fence' is at 3 x the interquartile range.

If only one data value has been collected, then the value appears as a single line (i.e. as the median value).

Appendix 4: Monitoring Site Photos

A4.1a McConnon Ck at 30m u-s Powell Ck view upstream.

A4.2b McConnon Ck at 30m u-s Powell Ck view downstream

A4.2a Powell Ck at Glenview Rd (view downstream) (view

A4.2b Powell Ck at Glenview Rd downstream)

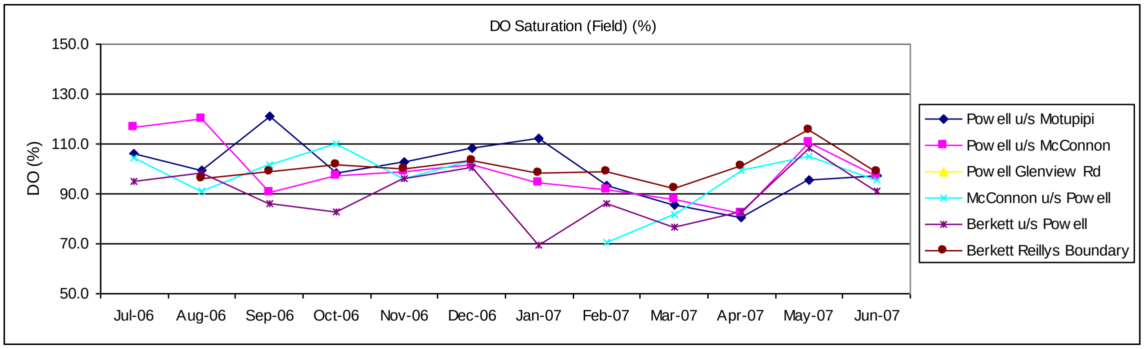
A4.3a Powell Ck at 40m u-s Motupipi River view upstream

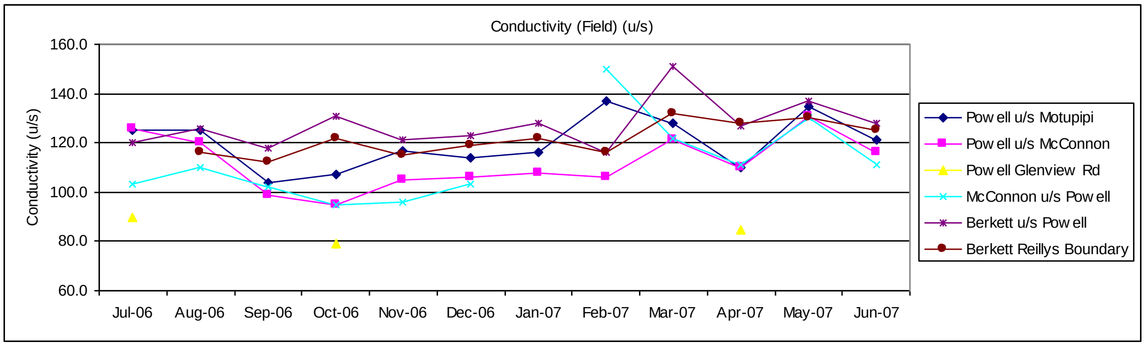
A4.3b Powell Ck at 40m u-s Motupipi River – view downstream

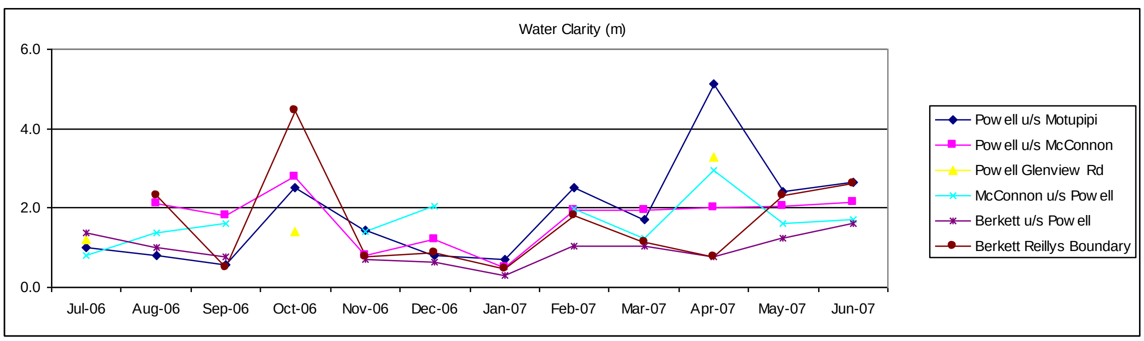
A3.5a Powell Creek 10m upstream McConnon Creek view upstream in winter (July 2006)

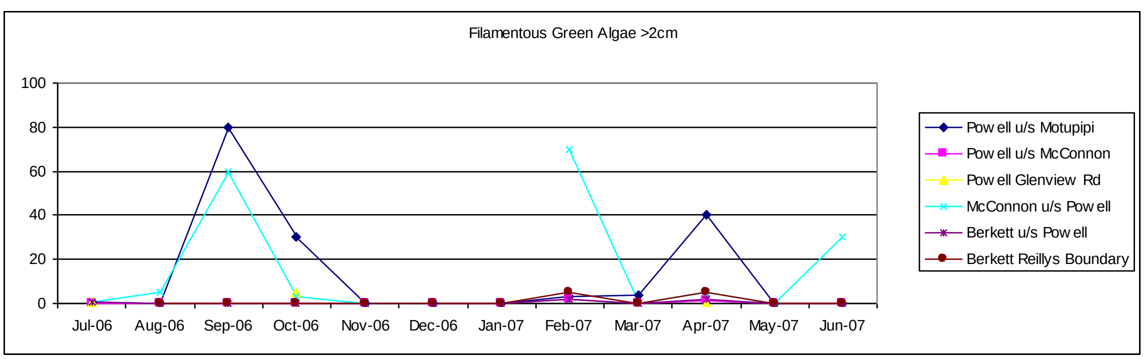
A3.5b Powell Creek 150m upstream McConnon view upstream in summer showing *Glyceria* growth in the creek.

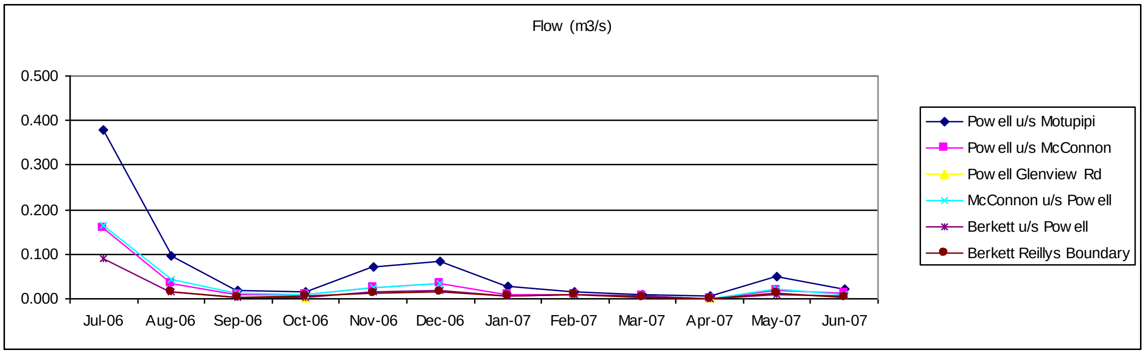
Appendix 5: Graphs of field measurements over the monitoring period










Flow (m3/s)
0.500
0.400
0.300
0.200
0.100
0.000
Jul-06
Aug-06
Sep-06
Oct-06
Nov-06
Dec-06
Jan-07
Feb-07
Mar-07
Apr-07
May-07
Jun-07
Pow ell u/s Motupipi
Pow ell u/s McConnon
Pow ell Glenview Rd
McConnon u/s Pow ell
Berkett u/s Pow ell
Berkett Reillys Boundary

Appendix 7: Summary of Catchment Features

Name	**MOTUPIPI**				
Region	**TASMAN**				
Area (km^2)	560				
Geology	Gravel and Siltstone				
Slope	60% rolling, 30% flat and 10% steep				
Rainfall (mm/yr)	1500				
Flow	25L/s (mean)				
Land Use					
Current	Dairy	Sheep	Beef	Native	Cropping
%	56.6	19	9.7	<2	10.3
Historical/changes	Reasonably static				
Farm Info					
Number of dairy Farms	3				
Number of cows	525				
Cow density (cows/ha)	3.5				
Accord Info					
Fencing of waterways					
Total length of Accord streams	1.0 km				
% Fenced	100				
Stream crossings					
Number	4				
Number unbridged	0				
Nutrient management					
Plans in place	100%				
Compliance					
Significant non-compliance	None				
Other catchment features to note					
e.g. drainage					

Appendix 8 Water Quality Statistics from Upstream and Downstream Sites in the Powell Creek Catchment and Comparisons with Other Dairying and Clean Streams Accord Catchments. Upstream site data used in this table was Powell Creek upstream McConnon Creek rather than Glenview Road as there was more data available and the difference between the two sites was not significant.

Total nitrogen

		TIER 1 CATCHMENTS					TIER 2 CATCHMENTS							
		Toenepi	*Waiokura*	*Waikakahi*	*Bog Burn*	*Pigeon*	*Puwera*	*Taharua*	*Mangapapa*	*Enaki*	*Powell*	*Canterbury*		*Washpool*
		Waikato	*Taranaki*	*Canterbury*	*Southland*	*West Coast*	*Northland*	*Hawke's Bay*	*Manawatu*	*Wairarapa*	*Tasman*	*Rhodes*	*Petrie*	*Otago*
Sample period		2001-2006	2001-2006	2001-2006	2001-2006		2006-2007			2002-2006	2006-07			
Sample number		~60	~60	~60	~60		26			~48	12			
Downstream site	Min	0.41	2.05	1.16	0.26	0.30	0.40				0.45			
	Max	5.80	4.50	5.20	4.30	2.70	1.30				3.1			
	Median	1.76	3.29	2.30	1.10	0.71	0.65			0.30	1.2			
Upstream site	Min										1.1			
	Max										3.2			
	Median										1.5			
Guideline														
Reference														

All units are mg/L unless otherwise stated

Nitrates

		TIER 1 CATCHMENTS					TIER 2 CATCHMENTS							
		Toenepi	*Waiokura*	*Waikakahi*	*Bog Burn*	*Pigeon*	*Puwera*	*Taharua*	*Mangapapa*	*Enaki*	*Powell*	*Canterbury*		*Washpool*
		Waikato	*Taranaki*	*Canterbury*	*Southland*	*West Coast*	*Northland*	*Hawke's Bay*	*Manawatu*	*Wairarapa*	*Tasman*	*Rhodes*	*Petrie*	*Otago*
Sample period		2001-2006	2001-2006	2001-2006	2001-2006		2006-2007			2002-2006	2006-07	2006-2007	2006-2007	2002-2006
Sample number		~60	~60	~60	~60		26			~48	12	12	12	
Downstream site	Min	0.032	1.62	0.79	0.036	0.049	0.008				0.17	7.6	3.7	
	Max	4.1	4.26	3.5	3.6	0.60	0.6				1.065	13.0	6.0	
	Median	1.19	2.82	1.76	0.755	0.284	0.236			1.18	3.1	9.35	4.6	0.734
Upstream site	Min										0.7	5.7	4.3	
	Max										2.8	9.7	6.1	
	Median										1.35	7.3	5.3	0.059
Guideline														
Reference														

All units are mg/L unless otherwise stated

Total phosphorus

		TIER 1 CATCHMENTS					TIER 2 CATCHMENTS							
		Toenepi	*Waiokura*	*Waikakahi*	*Bog Burn*	*Pigeon*	*Puwera*	*Taharua*	*Mangapapa*	*Enaki*	*Powell*	*Canterbury*		*Washpool*
		Waikato	*Taranaki*	*Canterbury*	*Southland*	*West Coast*	*Northland*	*Hawke's Bay*	*Manawatu*	*Wairarapa*	*Tasman*	*Rhodes*	*Petrie*	*Otago*
Sample period		2001-2006	2001-2006	2001-2006	2001-2006		2006-2007			2002-2006	2006-07	2006-2007	2006-2007	2002-2006
Sample number		~60	~60	~60	~60		26			~48	12	12	12	
Downstream site	Min	0.068	0.064	0.031	0.024	0.033	0.038				0.011	0.008	0.018	
	Max	0.251	0.392	0.699	0.22	0.251	0.251				0.053	0.029	0.045	
	Median	0.174	0.111	0.120	0.05	0.108	0.108			0.045	0.034	0.019	0.025	0.281
Upstream site	Min										0.01	0.009	0.004	
	Max										0.033	13.0	0.028	
	Median										0.017	0.029	0.013	0.061
Guideline														
Reference														

All units are mg/L unless otherwise stated

Dissolved reactive phosphorus

		TIER 1 CATCHMENTS					TIER 2 CATCHMENTS							
		Toenepi *Waikato*	*Waiokura* *Taranaki*	*Waikakahi* *Canterbury*	*Bog Burn* *Southland*	*Pigeon* *West Coast*	*Puwera* *Northland*	*Taharua* *Hawke's Bay*	*Mangapapa* *Manawatu*	*Enaki* *Wairarapa*	*Powell* *Tasman*	*Canterbury*		*Washpool* *Otago*
												Rhodes	*Petrie*	
Sample period		2001-2006	2001-2006	2001-2006	2001-2006		2006-2007			2002-2006	2006-07	2006-2007	2006-2007	
Sample number		~60	~60	~60	~60		26			~48	12	12	12	
Downstream site	Min	0.010	0.016	0.001	0.010	0.016	0.007				0.002	0.001	0.003	
	Max	0.177	0.107	0.560	0.130	0.336	0.149				0.016	0.019	0.027	
	Median	0.089	0.032	0.075	0.023	0.059	0.048			0.025	0.007	0.008	0.015	
Upstream site	Min										0.002	0.001	0.002	
	Max										0.006	0.029	0.019	
	Median										0.003	0.013	0.008	
Guideline														
Reference														

All units are mg/L unless otherwise stated

Ammoniacal nitrogen

		TIER 1 CATCHMENTS					TIER 2 CATCHMENTS							
		Toenepi *Waikato*	*Waiokura* *Taranaki*	*Waikakahi* *Canterbury*	*Bog Burn* *Southland*	*Pigeon* *West Coast*	*Puwera* *Northland*	*Taharua* *Hawke's Bay*	*Mangapapa* *Manawatu*	*Enaki* *Wairarapa*	*Powell* *Tasman*	*Canterbury* *Rhodes*	*Canterbury* *Petrie*	*Washpool* *Otago*
Sample period		2001-2006	2001-2006	2001-2006	2001-2006		2006-2007				2006-07			2002-2006
Sample number		~60	~60	~60	~60		26				12			
Downstream site	Min	0.009	0.001	0.001	0.015	0.015	0.010				0.005			
	Max	2.800	0.159	0.315	0.498	0.498	0.380				0.11			
	Median	0.022	0.026	0.022	0.104	0.104	0.040				0.033			0.960
Upstream site	Min										0.011			
	Max										0.11			
	Median										0.022			0.02
Guideline														
Reference														

All units are mg/L unless otherwise stated

Electrical conductivity

		TIER 1 CATCHMENTS					TIER 2 CATCHMENTS							
		Toenepi	*Waiokura*	*Waikakahi*	*Bog Burn*	*Pigeon*	*Puwera*	*Taharua*	*Mangapapa*	*Enaki*	*Powell*	*Canterbury*		*Washpool*
		Waikato	*Taranaki*	*Canterbury*	*Southland*	*West Coast*	*Northland*	*Hawke's Bay*	*Manawatu*	*Wairarapa*	*Tasman*	*Rhodes*	*Petrie*	*Otago*
Sample period		2001-2006	2001-2006	2001-2006	2001-2006		2006-2007			2002-2006	2006-07	2006-2007	2006-2007	2002-2006
Sample number		~60	~60	~60	~60		26				12			
Downstream site	Min	11.9	23.3	13.2	10.3	3.7	11.1				104	25.0	21.0	
	Max	38.7	31.1	33.8	21.5	8.1	50.0				137	33.0	28.0	
	Median	18.8	27.1	19.0	16.1	1.7	28.4			11.7	119	28.0	23.0	
Upstream site	Min										95	20	20	
	Max										131	27	26	
	Median										109	22.5	21.5	
Guideline														
Reference														

All units are micro-seimens / cm

Water temperature

		TIER 1 CATCHMENTS					TIER 2 CATCHMENTS							
		Toenepi	*Waiokura*	*Waikakahi*	*Bog Burn*	*Pigeon*	*Puwera*	*Taharua*	*Mangapapa*	*Enaki*	*Powell*	*Canterbury*		*Washpool*
		Waikato	*Taranaki*	*Canterbury*	*Southland*	*West Coast*	*Northland*	*Hawke's Bay*	*Manawatu*	*Wairarapa*	*Tasman*	*Rhodes*	*Petrie*	*Otago*
Sample period		2001-2006	2001-2006	2001-2006	2001-2006					2002-2006	2006-07	2006-2007	2006-2007	2002-2006
Sample number		~60	~60	~60	~60						4368*			
Downstream site	Min	8.5	5.6	4.1	3.3	2.4					12.94	7.4	8.3	
	Max	22.5	17.8	18.5	19.2	22.2					24.94	17.2	18.1	
	Median	16.0	12.6	10.9	9.8	10.9				13.8	18.46	12.5	13.4	9.5
Upstream site	Min										11.05	7.9	8.3	
	Max										26.35	18.7	14.6	
	Median										18.2	12.35	12	11.52
Guideline														
Reference														

All units are degrees celcius
* 30min data from 10 Dec to 10 Mar

Dissolved oxygen

		TIER 1 CATCHMENTS					TIER 2 CATCHMENTS							
		Toenepi	*Waiokura*	*Waikakahi*	*Bog Burn*	*Pigeon*	*Puwera*	*Taharua*	*Mangapapa*	*Enaki*	*Powell*	*Canterbury*		*Washpool*
		Waikato	*Taranaki*	*Canterbury*	*Southland*	*West Coast*	*Northland*	*Hawke's Bay*	*Manawatu*	*Wairarapa*	*Tasman*	*Rhodes*	*Petrie*	*Otago*
Sample period		2001-2006	2001-2006	2001-2006	2001-2006		2006-2007			2002-2006	2006-07	2006-2007	2006-2007	2002-2006
Sample number		~60	~60	~60	~60		~26				789*			
Downstream site	Min	25.5	83.9	49.7	70.7	73.5	3.1				0.67	7.24	8.24	
	Max	166	109	121	127	110	10.7				12.44	12.41	11.59	
	Median	80.7	96.5	87.4	92.5	90.6	7.8			10.2	6.26	9.3	10.62	11.2
Upstream site	Min										6.56	5.43	5.66	
	Max										10.22	12.06	9.98	
	Median										8.83	9.51	8.14	9.8
Guideline														
Reference														

Units are per cent saturation for the Tier 1 catchments and mg/L for the Tier 2 catchments
* 15min interval data from 26/01/2006 to 3/02/2006

pH

		TIER 1 CATCHMENTS					TIER 2 CATCHMENTS							
		Toenepi *Waikato*	*Waiokura* *Taranaki*	*Waikakahi* *Canterbury*	*Bog Burn* *Southland*	*Pigeon* *West Coast*	*Puwera* *Northland*	*Taharua* *Hawke's Bay*	*Mangapapa* *Manawatu*	*Enaki* *Wairarapa*	*Powell* *Tasman*	*Canterbury*		*Washpool* *Otago*
												Rhodes	*Petrie*	
Sample period		2001-2006	2001-2006	2001-2006	2001-2006					2002-2006	2006-07	2006-2007	2006-2007	
Sample number		~60	~60	~60	~60						12			
Downstream site	Min		7.27	7.1	6.6						6.96	6.4	6.8	
	Max		7.85	8.9	9						7.84	7.2	8.0	
	Median		7.68	7.91	7.3					7.00	7.37	7.05	7.5	
Upstream site	Min										7.12	6.5	6.2	
	Max										7.68	7.3	7	
	Median										7.4	7.05	6.9	
Guideline														
Reference														

Suspended sediments

		TIER 1 CATCHMENTS					TIER 2 CATCHMENTS							
		Toenepi *Waikato*	*Waiokura* *Taranaki*	*Waikakahi* *Canterbury*	*Bog Burn* *Southland*	*Pigeon* *West Coast*	*Puwera* *Northland*	*Taharua* *Hawke's Bay*	*Mangapapa* *Manawatu*	*Enaki* *Wairarapa*	*Powell* *Tasman*	*Canterbury* *Rhodes*	*Canterbury* *Petrie*	*Washpool* *Otago*
Sample period		2001-2006	2001-2006	2001-2006	2001-2006		2006-2007			2002-2006	2006-07	2006-2007	2006-2007	
Sample number		~60	~60	~60	~60		~26				12			
Downstream site	Min	0.3	6.0	1.4	1.5	0.3	1				1.0	1.1	2.5	
	Max	12.0	98.0	175.0	36.0	110	71				6.8	5.8	12.0	
	Median	3.0	20.5	7.2	4.2	4.6	4			3.0	2.0	2.6	4.75	
Upstream site	Min										1.0	1.0	0.25	
	Max										6.0	4.9	3.7	
	Median										2.0	1.4	0.95	
Guideline														
Reference														

All units are mg/L unless otherwise stated

Turbidity

		TIER 1 CATCHMENTS					TIER 2 CATCHMENTS							
		Toenepi *Waikato*	*Waiokura* *Taranaki*	*Waikakahi* *Canterbury*	*Bog Burn* *Southland*	*Pigeon* *West Coast*	*Puwera* *Northland*	*Taharua* *Hawke's Bay*	*Mangapapa* *Manawatu*	*Enaki* *Wairarapa*	*Powell* *Tasman*	*Canterbury* *Rhodes*	 *Petrie*	*Washpool* *Otago*
Sample period		2001-2006	2001-2006	2001-2006	2001-2006					2002-2006	2006-07	2006-2007	2006-2007	2002-2006
Sample number		~60	~60	~60	~60						0			
Downstream site	Min	1.1	4.5	1.2	2.6	1.5					-	0.4	0.4	
	Max	48	35	3.0	34	101					-	1.5	2.5	
	Median	2.6	11	4.6	6.2	4				2.6	-	0.6	1.15	14.5
Upstream site	Min										-	0.3	0.2	
	Max										-	1.8	0.8	
	Median										-	0.5	0.4	5.6
Guideline														
Reference														

All units are NTU

E.coli

		TIER 1 CATCHMENTS					TIER 2 CATCHMENTS							
		Toenepi	*Waiokura*	*Waikakahi*	*Bog Burn*	*Pigeon*	*Puwera*	*Taharua*	*Mangapapa*	*Enaki*	*Powell*	*Canterbury*		*Washpool*
		Waikato	*Taranaki*	*Canterbury*	*Southland*	*West Coast*	*Northland*	*Hawke's Bay*	*Manawatu*	*Wairarapa*	*Tasman*	*Rhodes*	*Petrie*	*Otago*
Sample period		2001-2006	2001-2006	2001-2006	2001-2006		2006-2007			2002-2006	2006-07	2006-2007	2006-2007	2002-2006
Sample number		~60	~60	~60	~60						12			
Downstream site	Min	40	70	4	270	20	54				2	29	66	
	Max	46000	54800	21800	11000	24300	2098				4100	17000	2400	
	Median	367	1250	290	530	640	422			207	336	140	205	580
Upstream site	Min										64	7	32	
	Max										1800	2400	920	
	Median										820	425	107	760
Guideline														
Reference														

All units are mg/L unless otherwise stated