

IN THE MATTER OF

the Resource Management Act
1991

AND

IN THE MATTER OF

Resource consent applications by
various applicants from the
Hakataramea Irrigation Water
Quality Group

STATEMENT OF EVIDENCE OF LYNN TORGERSON

BACKGROUND AND QUALIFICATIONS

- 1 My name is Lynn Torgerson and I am an Environmental Engineer with Pattle Delamore Partners Ltd. I have a Bachelor of Science in Civil and Environmental Engineering from the University of Wisconsin (Madison), USA (1988). From 1988 to 1998, I worked for the Wisconsin Department of Natural Resources as a Water Regulation Engineer. My duties involved the review, analysis and design of surface water resources projects. In 1999, I was an Investigating Officer for the Canterbury Regional Council. From 1999 to 2005, I was a Hydrology Lecturer for the Natural Resource Engineering Group at Lincoln University. My lecture topics included surface and groundwater behaviour and modelling. I have been employed with Pattle Delamore Partners (PDP) since 2006 working on surface and groundwater-related projects.
- 2 I have been involved in the preparation of numerous resource consent applications and assessment of environmental effects for groundwater and surface water projects in Canterbury.
- 3 The evidence I will present today is within my area of expertise, except where I state that I am relying on information provided by another party. I have not knowingly

omitted facts of information that might alter or detract from the opinions I express. I am familiar with the Code of Conduct for Expert Witnesses and I agree to comply with this code.

SCOPE OF EVIDENCE

- 4 The evidence I will present today considers the effects of the proposed irrigation of thirteen properties on the water quality of the Hakataramea River. Specifically, I will be discussing the expected nitrogen and phosphorus loadings into the Hakataramea River under the existing and proposed land uses as it relates to the growth of periphyton in the Hakataramea River. In my evidence, I will discuss the proposed management of the land in relation to its contribution to the risk of periphyton growth.

- 5 In my evidence, I will present information about
 - the environmental setting of the Hakataramea river;
 - the results of theoretical assessments of N & P losses carried out by ECan and by AgResearch;
 - the impact of irrigation on N & P loadings to waterways;
 - existing water quality of the Hakataramea River, with particular emphasis on nitrogen and phosphorus concentrations;
 - proposed mitigation measures and their values.

- 6 In preparing my evidence, I have reviewed the following documents:
 - Environment Canterbury, 2007. "Water quality impacts from irrigation development in the Hakataramea River catchment", ECan report No U05/13.
 - Institute of Geological and Nuclear Sciences Ltd (GNS), 2006. "Potential impacts of irrigation on groundwater nitrate in the Hakataramea River catchment." GNS

Science Consultancy Report 2006/106. Prepared for Environment Canterbury.

- McDowell, RW, 2006. "Estimation of phosphorus loads from dryland and irrigation areas in the Hakataramea catchment". Prepared for NIWA.
- National Institute for Water & Atmospheric Research (NIWA), 2007. "Assessment of effects of increased nutrient concentrations due to catchment land use changes in the Hakataramea River." NIWA Client Report: CHC2007-076. Prepared for Environment Canterbury.
- AgResearch Ltd, 2008. "Estimation of nitrogen and phosphorus loads from dryland and irrigation areas in the Hakataramea catchment" Prepared for the Hakataramea Irrigation water quality group.

CONSENT APPLICATIONS UNDER CONSIDERATION

- 7 My evidence considers the cumulative impact of consent applications listed in Table 1 below. This table shows the consent number, the applicant name, rate of take and annual volume and the area to be irrigated. Figure 1 (found in the appendix) shows the location of the properties involved in these applications. This group of applicants are known in this evidence as the Hakataramea Irrigation water quality group (HIWQG).

Resource Consent Number	Applicant	Rate of Take (L/s)	Annual Volume (m³/yr)	Area (ha)
CRC032177	Hakataramea Valley Irrigation Inc	1,000 (from Waitaki River)	11,142,000	1,797
CRC031592	R H & J Robertson Family Trust	26	354,250	65
CRC072756	Star Holdings Limited	434 (from a dam)	3,420,000	600
CRC032220.1	Foveran Station Limited	320 (from a dam)	3,657,000	690
CRC040999	Hakataramea Station 1990 Limited	75 (from a dam)	577,500	105
CRC050940	Mr & Mrs R G & Z L Pringle	14	612,000	120
CRC050957	Mr & Mrs R G & Z L Pringle	35	0	0
CRC051767	RPNZ Properties Limited	30	252,000	48
CRC051766	Mr N J Small	200 (from a dam)	1,540,000	275
CRC051768	RPNZ Properties Limited	26	212,000	40
CRC051769	RPNZ Properties Limited	20	216,000	40

CURRENT ENVIRONMENTAL SETTING

Geology and Soils

- 8 The geology and soils of the Hakataramea catchment have been described in the report prepared by the Institute of Geological & Nuclear Sciences (GNS) in June 2006.
- 9 The basement rock of the Hakataramea valley consists of Mesozoic-age greywacke with some fractures. Overlain on the greywacke are Tertiary sediments, consisting of quartz sandstones, greensands and limestone, with a total thickness of about several hundred metres. On top of the Tertiary sediments are Quaternary sediments. These sediments are

either river alluvial gravels deposited by the Hakataramea River or fan alluvial gravels deposited by tributary streams to the Hakataramea River.

- 10 GNS (2006) provided information on the classification of the soils in the Hakataramea River catchment which were either currently under irrigation or proposed for irrigation. Within the Hakataramea River catchment there were five soil group classifications based on soil characteristics, such as depth, profile available water capacity, drainage class and slope angle. These soils range from 'impeded' (4) and 'moderate slope' (5) on the upper and steeper valley slopes to 'deep to shallow' (1) and 'stony and rolling' (2) in the valley floor.
- 11 There are very few groundwater bores in the Hakataramea Valley. ECan's database records 29 bores which are used for irrigation and stockwater supply. As a result, there are no major water quality issues in regard to groundwater quality impacts in their own right. However, it is expected that groundwater will seep into the surface waterways and therefore the main issue in regard to water quality management relates to the effects on surface water quality – either via groundwater seepage or via surface migration pathways.

Flow Patterns in the Hakataramea River

- 12 The Hakataramea River is the largest tributary of the Waitaki River (Morland 1994), having its source in the Kirkliston Range and the Hunter Hills. GNS reports that it is "a shallow braided river with mid channel island and large open cobble and shingle areas." The flows in the Hakataramea River are linked hydrologically to the precipitation in the catchment, with river flows generally high in the later winter and spring and low flows in the summer and autumn (Mosely 1991). Reports of very low flow, or no flow, within the Hakataramea River occur during summer periods. Within this catchment,

perceptible flow responses to rainfall events occur only when the soil moisture is replenished (Mosely 1991). As a consequence, most notable flow responses to rainfall events occur during winter when a combination of winter rainfall and low rates of evapo-transpiration saturate the soil, and the excess rainfall becomes runoff to the river.

- 13 Figure 2 shows the location of the three river flow gauges located on the Hakataramea River Valley. These are shown as a blue dot. The gauges are labelled Main Highway Bridge (MHB), Mt Florence and Kirkliston. All gauges are maintained and monitored by ECan, and the flow data is recorded and housed in ECan's database.
- 14 Figure 3 is a plot of the daily mean flows at sites in the Hakataramea River catchment at these gauging sites from February 2006 through September 2007. This plot shows that during the year, there are many periods of low flow, particularly during the period from January to June. Within this low flow period, there are some higher flow events.
- 15 On 6 and 7 May 2008, flow measurements were taken at nine reaches along the Hakataramea River. Figure 4 shows the locations along the river in which flow readings were taken. The purpose of the flow measurements was to assess the stream flow at different reaches along the river in order to understand the losing and gaining characteristics of the stream.
- 16 Figure 5 is the long section of the flows measured at the reaches identified in the previous figure. On the x-axis is the distance in metres above the SH 82 Bridge. Looking at this figure, the pattern of surface flow along the river is quite variable with gaining and losing reaches, with a more significant again in the lower reaches.

- 17 The losses occur at Wrights Crossing, Rocky Point and The Hayes, with losses occurring to a lesser degree at Deadman Stream. These locations are similar in character in that the streambed consists of wide gravelly fans, which are more prone to loss through the gravels. The increases in stream flow are due to a combination of tributary inflows and locations where the channel is much more defined and the bed consists of mixed materials.

THEORETICAL ASSESSMENTS OF N & P LOSSES IN THE HAKATARAMEA VALLEY

The ECan Study

- 18 Environment Canterbury commissioned a study to consider the water quality impacts from irrigation development in the Hakataramea River catchment (ECan 2007). The purpose of the study was to assess the water quality in the catchment under the current irrigation status, and to estimate the potential impacts to water quality under proposed irrigation and no irrigation scenarios. This study estimated losses of nitrogen and phosphorus to the surface waters under the different scenarios, and then goes on to assess the effects of the nutrient concentrations in the Hakataramea River. The chief effect considered in that study is the effect that nutrient concentrations in the river have on the promotion of periphyton growth within the river.
- 19 Periphyton is composed of algae, diatom, bacteria and fungi. It appears as slimy material attached to the surfaces of rocks in waterways. Periphyton is an important component in the food chain, however excessive growth can reduce aesthetic and recreational qualities, block water intakes and impact on ecosystem values.
- 20 Controlling factors of periphyton biomass are described in Fresh Waters of New Zealand (Harding, et al 2004).

“Ultimate” controlling variables such as climate and catchment geology, along with land use, influence the wider landscape setting of a stream. On a more localised level, “reach-scale” variables directly influence the periphyton growth. These variables include light, flow regime, nutrients and temperature, which can be affected by land uses and management.

- 21 Given that land use and management can play a significant role in controlling some of the factors that affect periphyton production, guidelines have been developed to protect aesthetic, recreation and biodiversity values in rivers and stream. The New Zealand Periphyton Guidelines (MfE 2000) define thresholds for conditions that may promote excessive periphyton growth in an effort to ensure that these values in rivers and stream are protected.
- 22 However, the results of the ECan study calculated masses of N and P in the river that significantly exceeded measured concentrations. Dissolved Inorganic Nitrogen (DIN) and Dissolved Reactive Phosphorus (DRP) are the forms of N and P that contribute to periphyton growth. The measured concentrations of these parameters at the downstream end of the Hakataramea Catchment are summarised in Table 2.

	DIN (mg/L)	Total N (mg/L)	DRP (mg/L)
Minimum	0.001	0.035	0.001
Average	0.033	0.137	0.003
Maximum	0.659	0.891	0.013

- 23 Figures 6 and 7 show that the higher concentrations of nitrogen and DRP are associated with high flow events, most likely related to inundation of the riparian margins.
- 24 NIWA (2007) calculated that the ECan modelling study produced average concentrations in the river of 0.59 mg/L for DIN and 0.005 mg/L for DRP. This is significantly greater than what is measured, particularly in the case of nitrogen. The difference is even more significant when it is recognised that the modelling does not allow for the effects of stock in waterways and windblown soil losses.
- 25 Discussion among the applicants in the Hakataramea River Valley indicated that some of the farming types and locations of their properties described in the ECan study were not accurate. Given these inaccuracies, they were concerned that findings in the ECan study did not actually reflect what is happening in their catchments. Of particular concern was the broad brush approach to the assessment without regard to specific site conditions.

The AgResearch Study

- 26 In an effort to more accurately quantify these effects, AgResearch was commissioned by the HIWQG to look at the nitrogen and phosphorus loadings of the applicants' properties considering their site specific land uses. The purpose of the study was to gain an understanding of the nutrient loadings as they related to the specific properties rather than a general catchment assessment.
- 27 Subject landowners were surveyed as to their current land use and nutrient management practices and the proposed land uses. AgResearch also considered the soil types and slopes of the applicant properties. Using the OVERSEER version 5.3.0 nutrient budget model, AgResearch modelled the expected nitrogen and phosphorus loading in the runoff

under existing and proposed irrigation conditions. The modelling is limited to transport of nitrogen and phosphorus through water-based pathways and does not consider the transport of these nutrients through wind or the effects of stock in waterways.

- 28 The results of the AgResearch's modelling are shown in the table below. The table provides information as to the annual loading of nitrogen and phosphorus under the current conditions and under the proposed conditions for each of the HIWQG properties.

Property		Current Conditions			Proposed Conditions		
	Resource Consent #	Block Size (ha)	N (kg/ha)	P (kg/ha)	Block Size (ha)	N (kg/ha)	P (kg/ha)
Abelen ¹	CRC032177	3730	2.1	0.09	3730	2.2	0.12
Fovaran Park	CRC031592	3513	2.1	0.21	3513	2.1	0.21
Foveran-Winterburg	CRC032200.1	521	3.7	0.22	521	5.5	0.47
Laughton ^{1,2}	CRC032177	40	5.2	0.04	40	11.3	0.20
Hay ¹	CRC032177	280	6.8	0.17	280	10.1	0.93
Hakataramea Downs	Existing consent	1060	3.4	0.09	1060	3.4	0.12
Hakataramea Station	CRC040999	1260	4.0	0.05	1260	4.0	0.05
Normanvale ¹	CRC032177	860	4.1	0.20	860	4.9	0.23
Pringle	CRC050940 CRC050957	1366	5.9	0.06	1366	6.1	0.08
RPNZ	CRC051767 CRC051768 CRC051769	600	3.3	0.28	600	3.3	0.28
Small	CRC051766	4326	4.5	0.06	4326	5.4	0.12
Star Holdings ¹	CRC072756 CRC032177	6100	4.4	0.14	6100	4.6	0.20
Sutton ¹	CRC032177	626	2.9	0.25	626	8.4	0.86

¹Farms included in the Hakataramea Valley Irrigation Inc application CRC032177

²Listed in AgResearch Report as Haka Valley Irrigation Scheme

- 29 As with the previous modelling, the total concentrations of DIN and DRP from the model output correspond to in river concentrations of 0.48 g/m³ and 0.02 g/m³ respectively, which simply do not match the measured data. This inaccuracy is even more concerning given this latest survey does not cover the entire catchment, but is only for 13 properties. AgResearch comment on this and conclude that their study can perhaps best be used to quantify the percentage change in nutrient contributions that will arise from the change in land use. That percentage change is an 11 % increase in DIN and a 38 % increase in DRP.
- 30 The overall outcome of this theoretical modelling is disappointing in that both in the farmers' view and from the existing water quality information it appears to produce numbers that simply do not represent what is occurring in this catchment.
- 31 However, we are fortunate in the Hakataramea Valley to have a good database of measured water quality, which allows us to evaluate the effects of more irrigation based on the actual measured catchment. This provides a sound basis for determining the best management options for future land use.

Water Quality Observations in the Hakataramea

- 32 In an effort to understand the relationship between land use practices and periphyton growth in the Hakataramea River catchment, a review of water quality sampling results was undertaken. The purpose was to indicate the effects of land use on surface water quality.
- 33 PDP undertook an analysis of the existing surface water quality data in the Hakataramea catchment. The most regularly measured dataset comes from the Main Highway Bridge. At this site, NIWA have been recording observations of periphyton on a regular basis since 1989 [NIWA site TK5 –

Hakataramea above MH Bridge]. The long-term trend of this data is shown in Figure 8. It indicates that a significant reduction in the frequency and magnitude of periphyton has occurred at this site since the 1989-1994 period.

- 34 Flow is a significant variable in periphyton production. Harding, et al reports that for rivers, the time available for periphyton to grow without being severely disturbed by floods is an important factor in controlling periphyton. Greater time between flooding events allows for more periphyton production, while high flows (or floods) destroy the periphyton mass. More frequent flooding results in less periphyton mass production.
- 35 Figure 9 is an enlarged plot of the more recent period of record showing how periphyton build up has occurred during some, but not all, periods of low flow, and how it is cleaned out and reduced when freshes in river flow occur.
- 36 Figure 10 has been prepared to demonstrate how elevated nitrogen is sometimes, but not always, associated with E. coli in the water, indicating the effect of stock effluent.
- 37 Both Figure 6 and Figure 7 indicate how higher concentrations of both nitrogen and phosphorus occur on some occasions when river flows are higher. That is most likely due to the inundation of riparian areas of stock grazing during times of higher river flow.
- 38 The full water quality dataset includes some observations of water quality parameters at other sites in the valley, as collected by ECan at six stations. For five of the ECan stations, the record of data collected occurred from November 2004 to October 2007. The data collected at the sixth station was taken from July 2005 to October 2007.

- 39 Figure 2 shows the locations of the ECan and the NIWA water quality sampling stations. These water quality sampling stations are shown as a red dot. It should be noted that the location of flow measurements described in paragraphs 13 to 17 and shown on Figure 5 generally correspond to the water quality sampling stations. Figure 11 shows how this data indicates localised variability within the catchment, which is consistent with variable farm management practices throughout the valley.
- 40 In addition to these historical monitoring measurements, a sampling survey for nutrients was undertaken at the end of the 2007-2008 irrigation season to coincide with the flow measurements show in Figure 5. The results are summarised below:

Site	TP (mg/L)	DRP (mg/L)	NH₄-N (mg/L)	TN (mg/L)	TON (mg/L)	NO₂ + NO₃ (mg/L)
Hakataramea River at Round Hill	<0.008	0.002	0.024	<0.08	-	<0.005
Hakataramea River at The Hayes	<0.02	<0.005	<0.01	<0.10	<0.002	-
Hakataramea River at Cattle Creek	<0.02	<0.005	<0.01	<0.10	<0.002	-
Hakataramea River at Rocky Point	<0.02	<0.005	<0.01	<0.10	<0.002	-
Hakataramea River at Footbridge ¹	<0.02	<0.005	<0.01	<0.10	<0.002	-
Homestead Creek at Mount Menzies Road	<0.02	<0.005	<0.01	0.11	<0.002	-
Hakataramea River at Wrights Crossing	<0.02	<0.005	<0.01	<0.10	0.011	-
Hakataramea River at Milne Rock ²	<0.008	<0.001	0.015	<0.08	-	<0.005
Hakataramea River at Main Road Bridge	<0.02	<0.005	<0.01	<0.10	<0.002	-

Notes: ¹Footbridge site is on Hakataramea River below confluence with Deadmans Stream.
²Same site as Milne Road

- 41 The very low concentrations at a time of low summer flow towards the end of an irrigation season indicate that no significant nutrient concentrations via a groundwater seepage pathway were impacting on the river. Observations of periphyton at the time of these measurements indicate that some small accumulations were present at isolated locations, however the general state of the river had the appearance of an oligotrophic condition.
- 42 Nutrients will enter the river either via a surface or a subsurface (groundwater) pathway. It is generally to be expected that in the Hakatamea Valley the subsurface groundwater drainage pathway will contain concentrations of Dissolved Inorganic Nitrogen (DIN) whereas phosphorus which adsorbs well into soils when it infiltrates is more likely to enter the river via a surface migration pathway. An analysis of nitrogen species indicates that only around 20 – 40 % of the nitrogen is in DIN form, including measurements over a range of river conditions that are both favourable and unfavourable to periphyton growth (Figure 12).
- 43 Based on the existing water quality data, it appears that a major nutrient migration pathway is due to stock in or adjacent to the waterway.
- 44 The concentrations of N & P entering the groundwater via the subsurface and overland flow routes (i.e. the pathways described by theoretical modelling studies) appear to be a relatively minor component of nutrient effects in the river, due to the low concentrations of DIN concentrations.
- 45 Discussions with the applicants indicate that there is no fencing of the waterways and that stock regularly tracks through the waterways. That is consistent with the observations from the existing water quality.

- 46 In addition, during the summer, when the nor-west winds blow through the valley, there are dust storms. These dust storms carry nutrients attached to wind-borne sediments. These nutrients can then get transported into streams, either through direct deposition into the stream or indirectly by depositing the sediment on an upland area, where the sediment is later picked up in the overland flow. Figures 13 a, b and c show photographs of such a storm event. Whilst it is not possible to quantify the mass of nutrients that are transported by this mechanism, the photos indicate it creates significant movement of the surface soil mass.
- 47 This understanding is crucially important to managing land use impacts in the Hakataramea Valley. Whilst the focus of the theoretical studies by ECan and AgResearch has been on groundwater drainage and overland flow pathways and the increase in concentrations that might arise from that, it appears that change is of a relatively minor nature. If that small increase in those pathways is accompanied by measures that remove stock access to waterways and reduce windblown soil losses, then the available data suggests that those measures would lead to an overall decrease in nutrient loads entering the river.
- 48 This information and the necessary approach to land management has been discussed with the applicants. Whilst it imposes a cost on their farming operations, they are prepared to implement these measures if they can be funded by the revenue they gain from their irrigation developments.
- 49 Therefore, it appears to me that we have a choice, to either carry on with the status quo, or to allow agricultural development, which must be linked to improved catchment management. The applicants are strongly of the view that the second option is preferred. Furthermore, they have indicated a desire to extend the catchment management

initiatives beyond their property boundaries and implement those actions throughout the entire catchment of the Hakataramea Valley.

- 50 The measures to achieve improved water quality are set out in the final section of my evidence.

MITIGATION MEASURES TO REDUCE NITROGEN & PHOSPHORUS

- 51 The quality of the tributary streams is important to the quality of water in the main stem of the Hakataramea River.
- 52 While the amount of nitrogen and phosphorus transported into the waterways via stock access and wind transport processes cannot be accurately quantified, the existing water quality data and the experiences of the residents indicates that mitigation measures can be employed to reduce the amount of nutrients conveyed to the waterways through these processes.
- 53 It is expected that mitigation applied to these main sources of nitrogen and phosphorus will lead to reductions that more than offset the relatively small increase that arises from the granting of these consents.
- 54 Mitigation measures to minimise the transport of nitrogen and phosphorus to the streams have been proposed for farms in this catchment. The measures are: fencing to keep stock out of the waterways, promotion of riparian buffer strips within the fenced areas, the placement of shelter belts in key prevailing wind areas, promotion of vegetation on wind-blown susceptible areas, management of irrigation application, fertiliser management, and the formation of a local streamcare group to address catchment-wide issues.

Fencing and Buffer Strips

- 55 It is proposed that fencing will occur along waterways within the irrigated areas. It is proposed that the applicants will install fencing adjacent to waterways within the irrigated areas. Within this fenced area, riparian planting will be placed to provide soil stabilisation, additional trapping of nutrient transported by wind, and vegetative uptake of nutrient transported by overland flow or subsurface flow.
- 56 Minimum fencing and buffer strip distances have been recommended for the main stem of the Hakataramea River and the tributaries. Fencing shall be placed at a minimum of 12 m from the bank of the stream.
- 57 Most of the fencing will be permanent in nature, however it will be necessary to routinely inspect the fencing, and if necessary repair fencing that is in disrepair to ensure that stock does not get into the buffer strip or the waterway.
- 58 In some areas, temporary fencing (hot wired) will be used to keep stock from grazing or trampling in the buffer areas or stream. For areas which only carry stock for a short period of time, this would provide an effective and affordable barrier.
- 59 Given the large areas on the properties requiring fencing, it is proposed that an installation hierarchy be established to determine the areas which get the fencing first. The hierarchy is to ensure that critical areas which would be more likely to be contributing higher loads will be addressed first.
- 60 It is envisaged that the installation of fencing will commence immediately, and it expected that waterways fencing can be completed in a year.
- 61 Environment Canterbury's Living Streams group has a list of suitable plantings for the riparian margins. Plantings in the

margins shall be selected from their plant list. These plantings will assist in the nutrient uptake, will trap sediments and nutrients, act as a soil stabiliser and provide some shading along the waterways.

Shelter Belts

- 62 Given the predominant winds experienced in this valley, it is also proposed that shelter belts will be constructed on the northern side of the irrigated areas in effort to reduce the transport of soil by wind. The shelter belts will be placed outside for the paths of the irrigators and will consist of climate and terrain suitable plants, such as Macrocarpa. As with the fencing, the shelter belts will require inspection and maintenance to ensure that they are performing as expected.
- 63 Promotion of vegetation on windblown susceptible areas will be achieved by grass, pasture or crop cover. During the growing season, the promotion of grass, pasture or crop cover will help to stabilise the susceptible areas. The vegetation will act as a cover which protects the soil surface from wind. Irrigation will be used to help establish cover and during dry period, ensure that the vegetative growth continues.

Irrigation Management

- 64 Irrigation will reduce windblown soil loss by keeping soils moist and by increasing the vegetation cover over the soil. A high standard of irrigation management will also mitigate the effects of nitrogen and phosphorus into the waterways, particularly with respect to the contributions through overland flow or subsurface drainage. Irrigation management refers to the application of irrigation water, the maintenance and operation of irrigation infrastructure and fertiliser application. This control measure ensures that transport of nitrogen and phosphorus via water is minimised but also assists in

reducing wind-blown losses. Specifically, the irrigation will promote vegetation which will act to stabilise the soil and prevent soil from being suspended by the wind. In the event that some sediment is picked up by the wind, and deposited on the upland areas, the establishment of vegetation will act as a trap/filter and reduce the opportunities for the nutrient-bound sediment to be transported to the waterway via overland runoff.

- 65 As part of the irrigation management strategy, the application rates of irrigation water will be based on soil moisture conditions and soil infiltration rates. Soil moisture levels will be monitored to ensure that enough moisture is available to support vegetation growth. In addition, the information will be used to ensure that water is applied at a rate which does not lead to runoff.

Fertiliser Management

- 66 While my analysis has shown that the contribution of nutrients to the Hakataramea River from overland and sub-surface flow is not as significant, it is still important to ensure that nutrients are managed properly on the farm. Fertiliser management practices can be used to reduce potential nitrate-nitrogen leaching and further minimise the impacts of irrigation on the groundwater quality.
- 67 Nitrogen losses from soils are most effectively managed on the pasture. The losses can be reduced considering the timing and rate of irrigation application. Soil properties should be considered when planning the rates of irrigation. In addition, the timing and rate of irrigation should be compatible with the soil moisture levels, so that the irrigation does not cause surface runoff or raise the water table too near the surface. The timing of the irrigation should be considered with respect to any proposed fertiliser application.

- 68 Application of nitrogen fertiliser should not occur when the water table is high (no closer than 2 m below ground level) or when heavy rainfall is expected. Application of nitrogen fertiliser should occur when grass growth is active, and ideally in split dressings to give plants more opportunity to use what is applied.
- 69 Nitrogen fertilisers should only be applied in quantities necessary to support the plants' needs. A nitrogen budget should be created to consider the likely available on-pasture nitrogen, including that derived from livestock, plant fixation and if applicable, any land-based effluent application. Nitrogen fertilisers shall only be applied to meet any nitrogen deficit determined by the budget.
- 70 While the measures described will reduce nitrogen losses to groundwater, it should be recognised that the actual fertiliser management practices will vary based on the characteristics of each farm. Therefore, it is recommended that specific fertiliser management practices be tailored for each farm, and form a component of an individual farm management programme (FMP).

Streamcare Group

- 71 To make reductions of nitrogen and phosphorus in the Hakataramea River, all stock access to the waterways should be restricted. A review of the property locations within the Hakataramea River catchment indicates that the area covered by this group of applicants does not include all tributaries to the Hakataramea River. While the fencing of waterways on the applicants' properties will certainly reduce the opportunities for nitrogen and phosphorus to be transported to the Hakataramea River, there are other contributing sources of nitrogen and phosphorus that do not originate on these applicants' property. For example, water quality monitoring of Deadman's Creek found that the levels

of nitrogen and phosphorus in the stream were extremely high, which was then delivered to the Hakataramea River. None of the applicants in this group have property draining to Deadman's Creek. As a result, this catchment will need to become a high priority focus for the streamcare group.

- 72 Given that some of the sources do not occur on the HIWQG properties, in order to reduce the levels of nitrogen and phosphorus into the Hakataramea River, local cooperation is necessary. It is proposed that a local streamcare group is formed with catchment farmers. The Living Streams programme (administered by ECan) builds partnerships within the local communities to enable and encourage the best environment possible for the streams. HIWQG will approach ECan to start the process.

CONCLUSIONS

- 73 Nitrogen and phosphorus loading into the Hakataramea River has contributed to the periphyton blooms in the river. Thirteen applicants have proposed irrigation in the catchment. In the interests of understanding these issues, the applicants have commissioned a theoretical assessment of N & P losses from drainage and overland flow under existing and future irrigated conditions. However, the results of that study has not produced results that match the field measurements of water quality.

The results of the theoretical study do however indicate that the change caused by the granting of consents to these applicants causes a relatively small increase in N & P losses via drainage and overland flow.

- 74 A review of water quality data indicates that a major source of N & P in surface waters is caused by the presence of stock in the waterway. Windblown dust is another potentially significant source. Mitigation measures that address these

major transport mechanisms, coupled with good irrigation management should allow these consents to be granted whilst at the same time achieving a net reduction in N & P entering surface water. The mitigation measures that should provide the biggest effect are preventing stock from entering waterways, riparian planting and use of irrigation to lessen windblown soil loss. With these measures in place, the impact to the surface water quality from the increase irrigation will not be adverse.

- 75 In order to ensure that the on-farm measures occur, I suggest that they be incorporated as part of an individual Farm Management Programme (FMP), and a requirement for the development and implementation of a FMP be attached as part of a consent condition.
- 76 I would also encourage the farmers to work together throughout the entire catchment to form a streamcare initiative with ECan for the Hakataramea Valley.

REFERENCES

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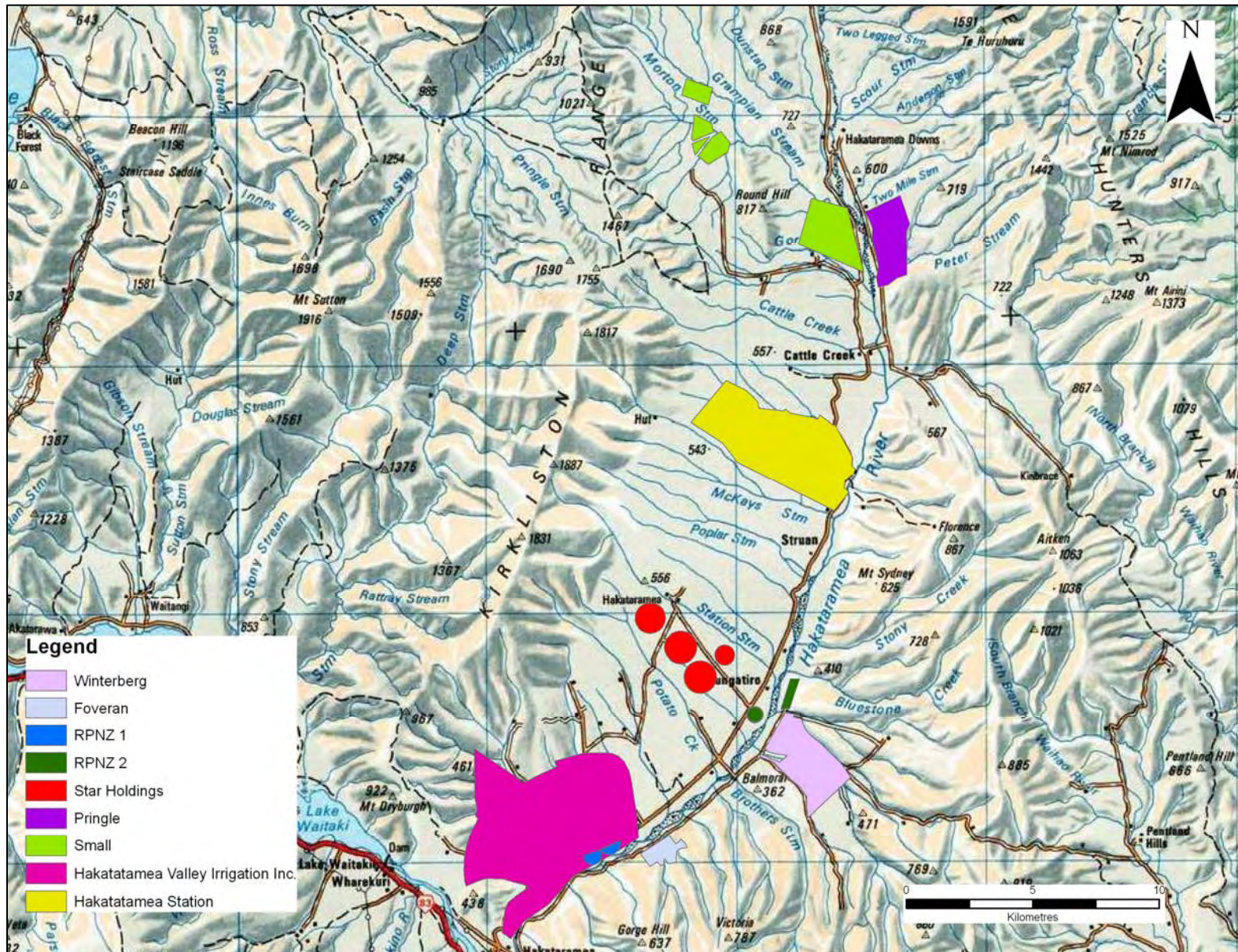


Figure 1: Locations of Properties in the Hakataramea Irrigation Water Quality Group (HIWQG)

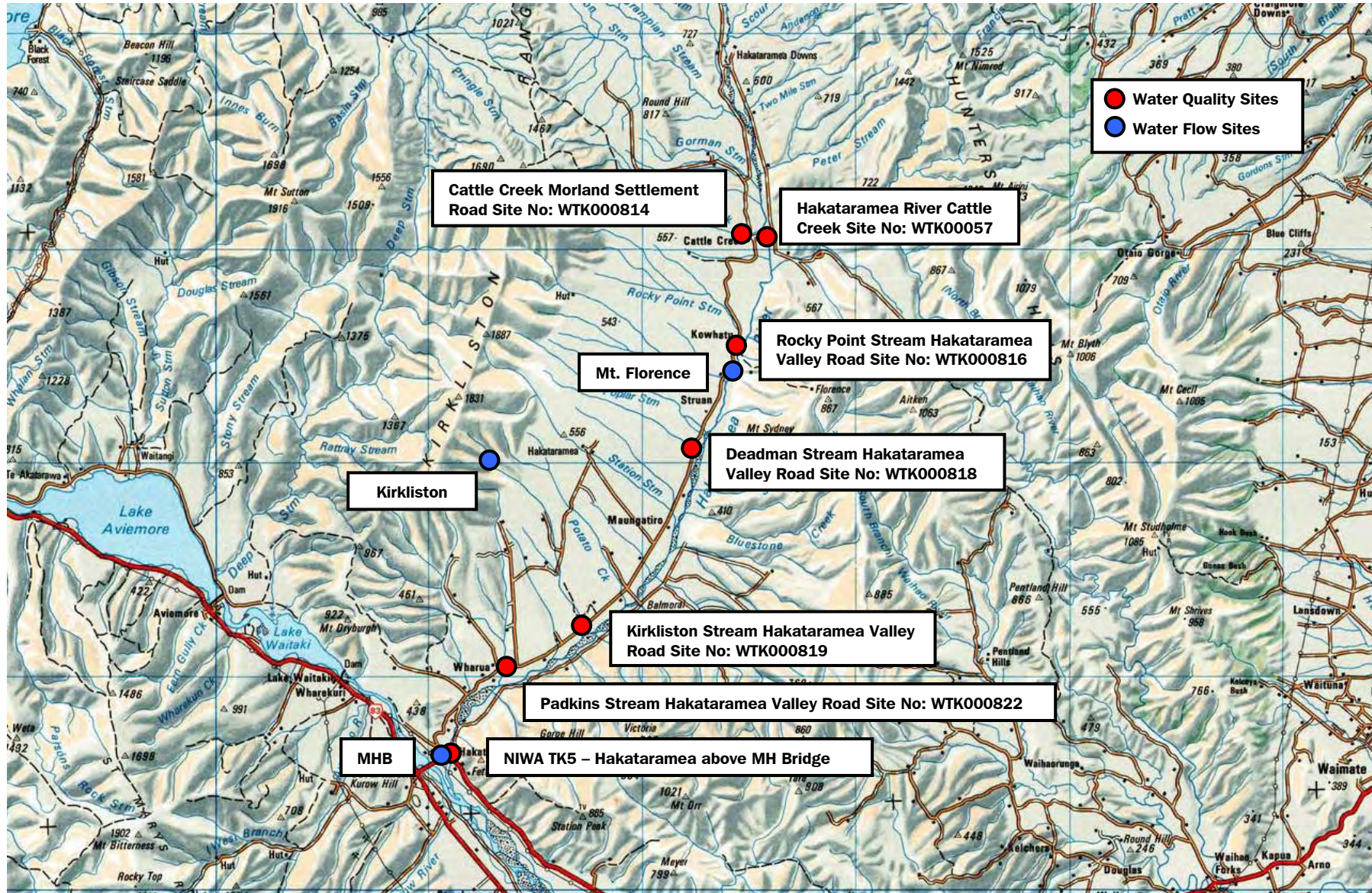
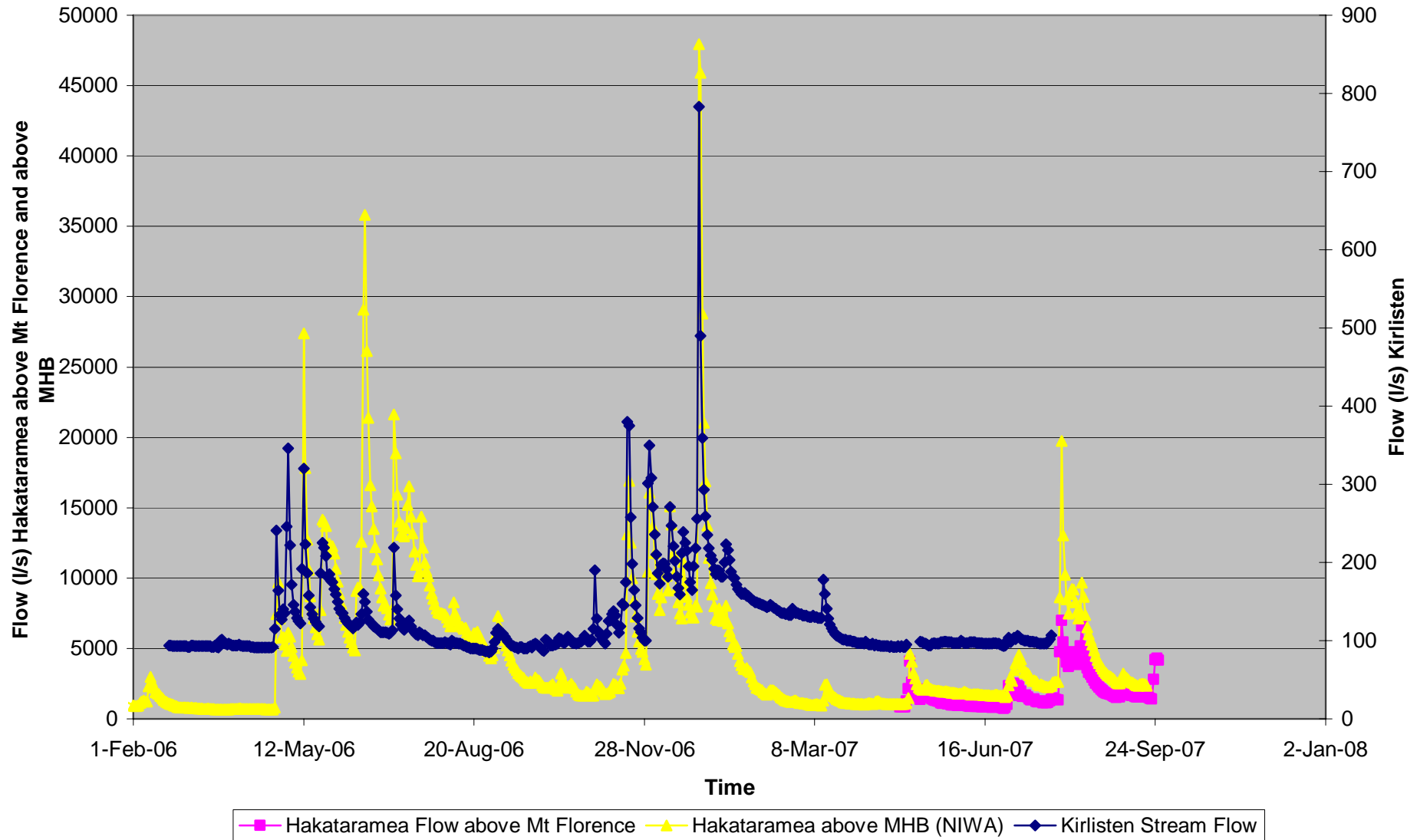


Figure 2: Water Quality and Flow Monitoring Sites in the Hakataramea Catchment (1:250000)



**Figure 3: Daily mean flow at sites in the Hakataramea Catchment
(Data provided by Environment Canterbury and NIWA)**

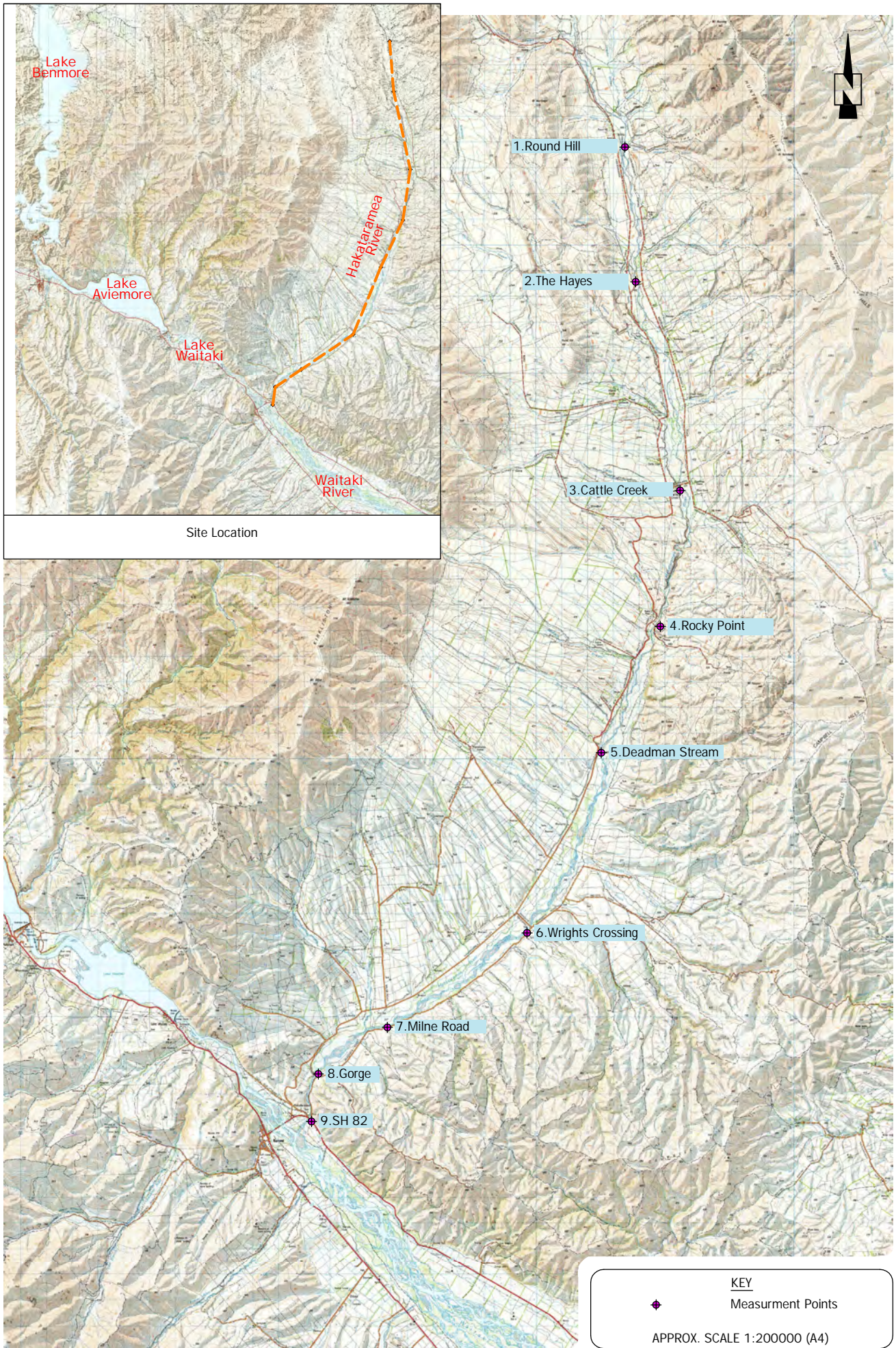


Figure 4 : Flow Measurement Location

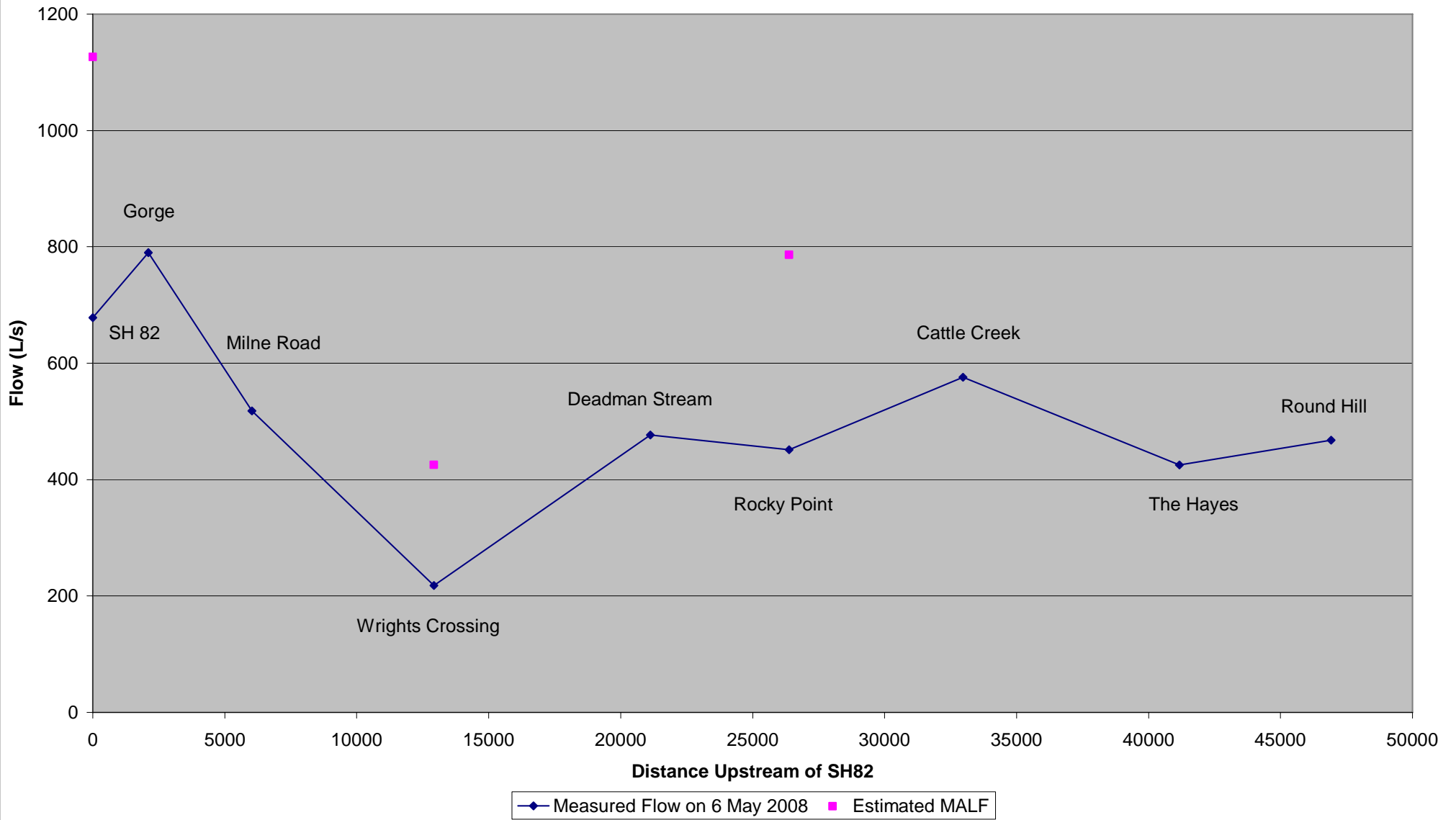
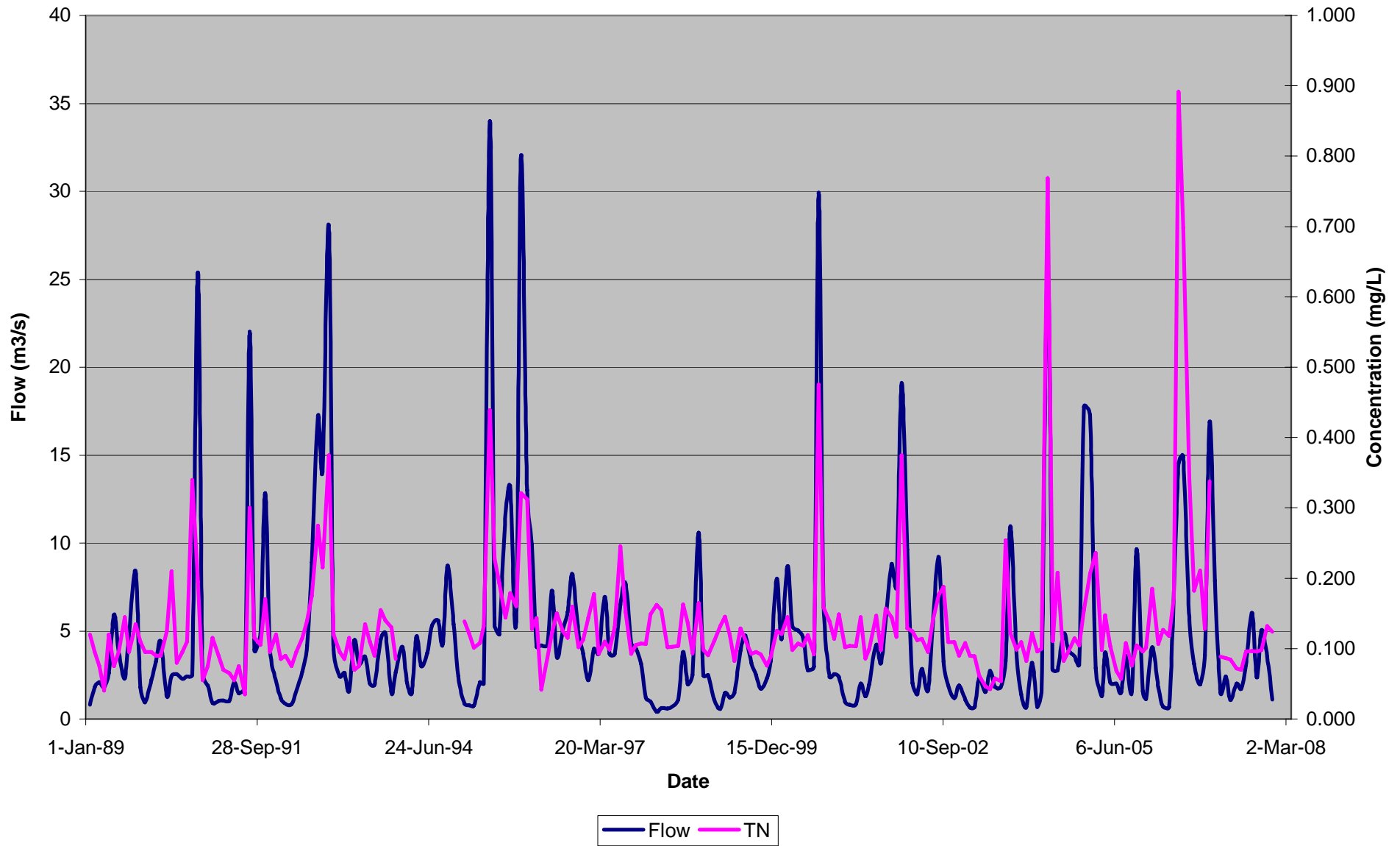
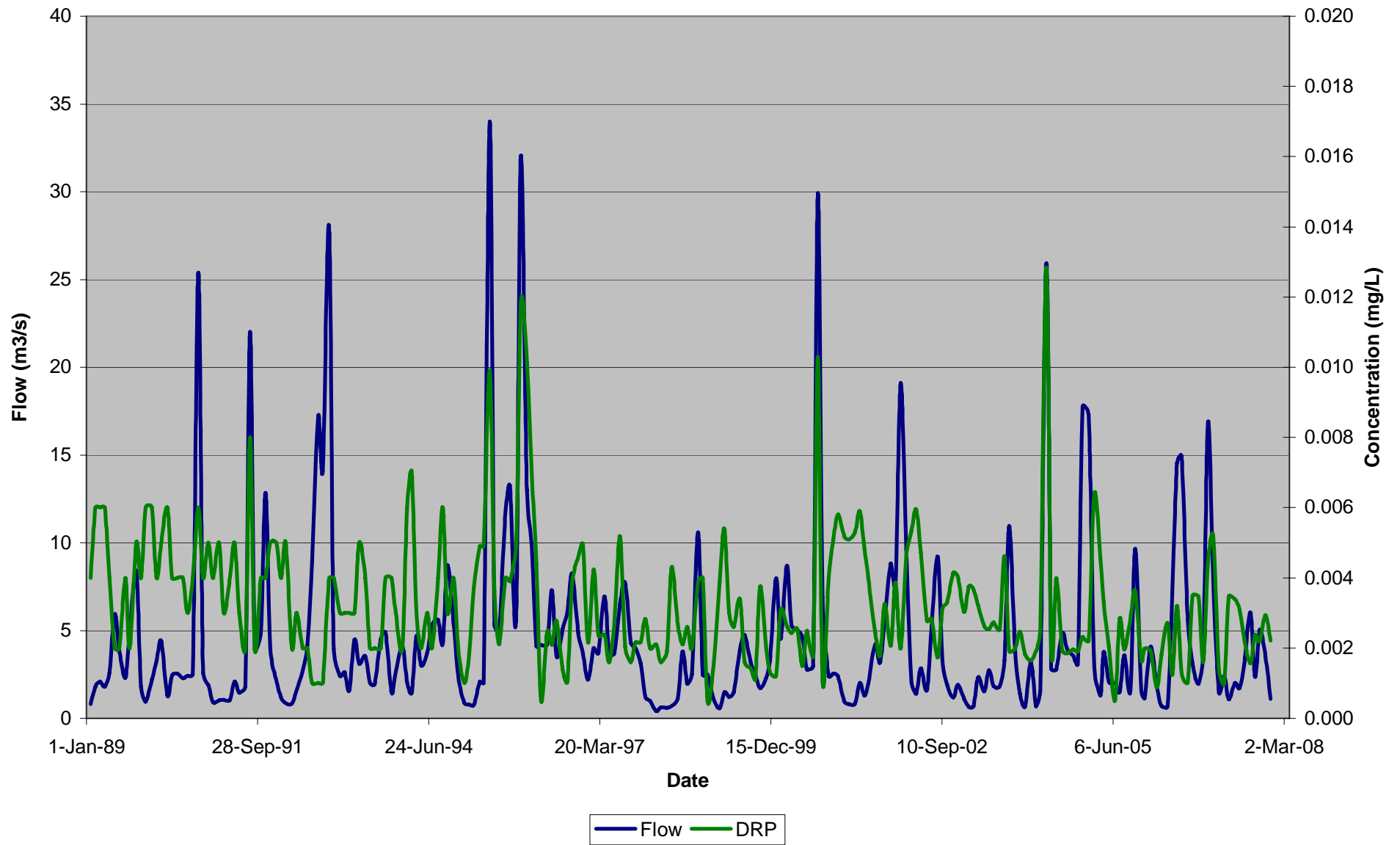


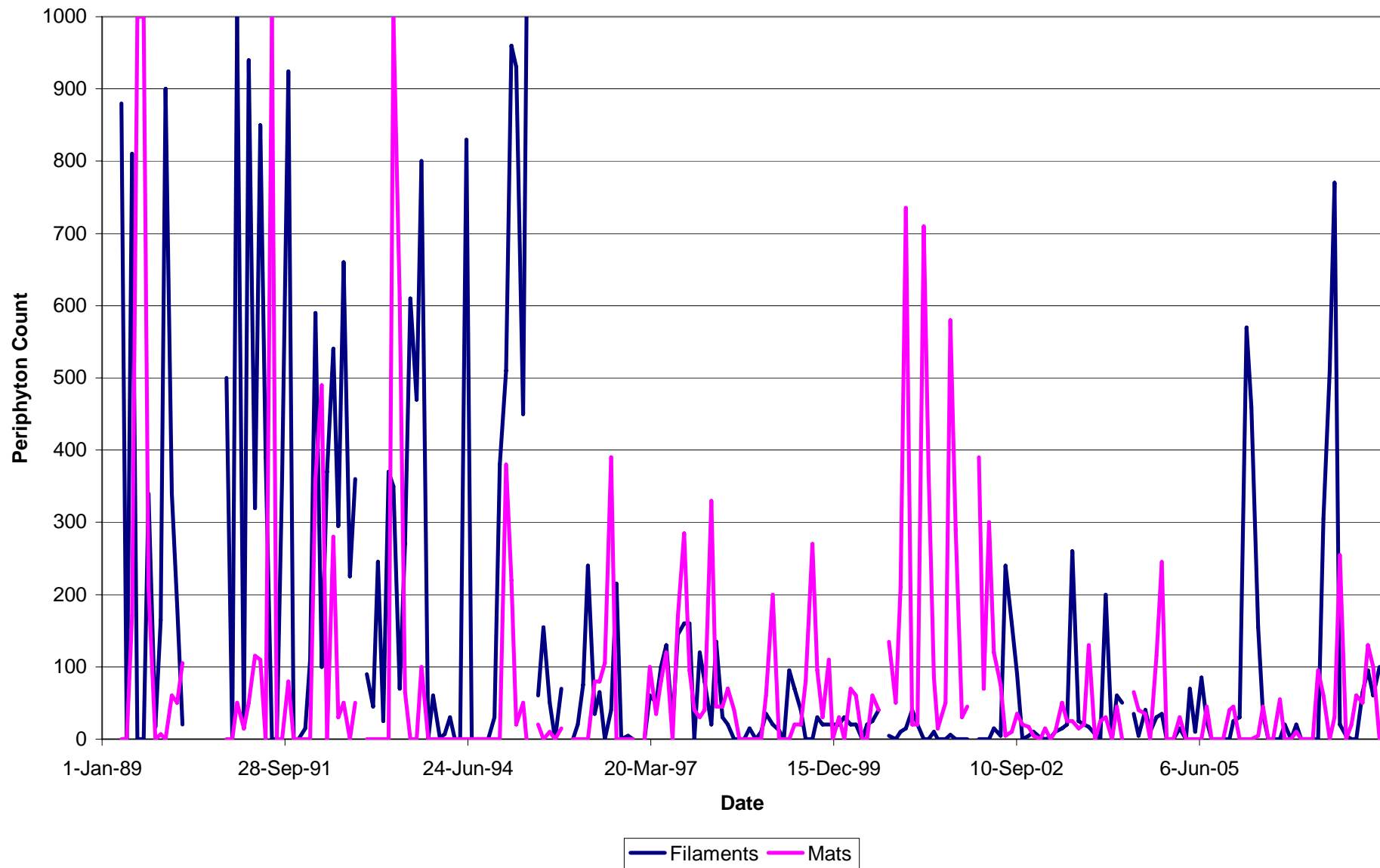
Figure 5: Long Section of Hakataramea River Flow



**Figure 6: Total Nitrogen and Flow in the Hakataramea River above MH Bridge
(Data provided by NIWA)**



**Figure 7: Dissolved Reactive Phosphorous and Flow in the Hakataramea River above MH Bridge
(Data supplied by NIWA)**



**Figure 8: Periphyton Occurrences Observed in the Hakataramea River above MH Bridge
(Data supplied by NIWA)**

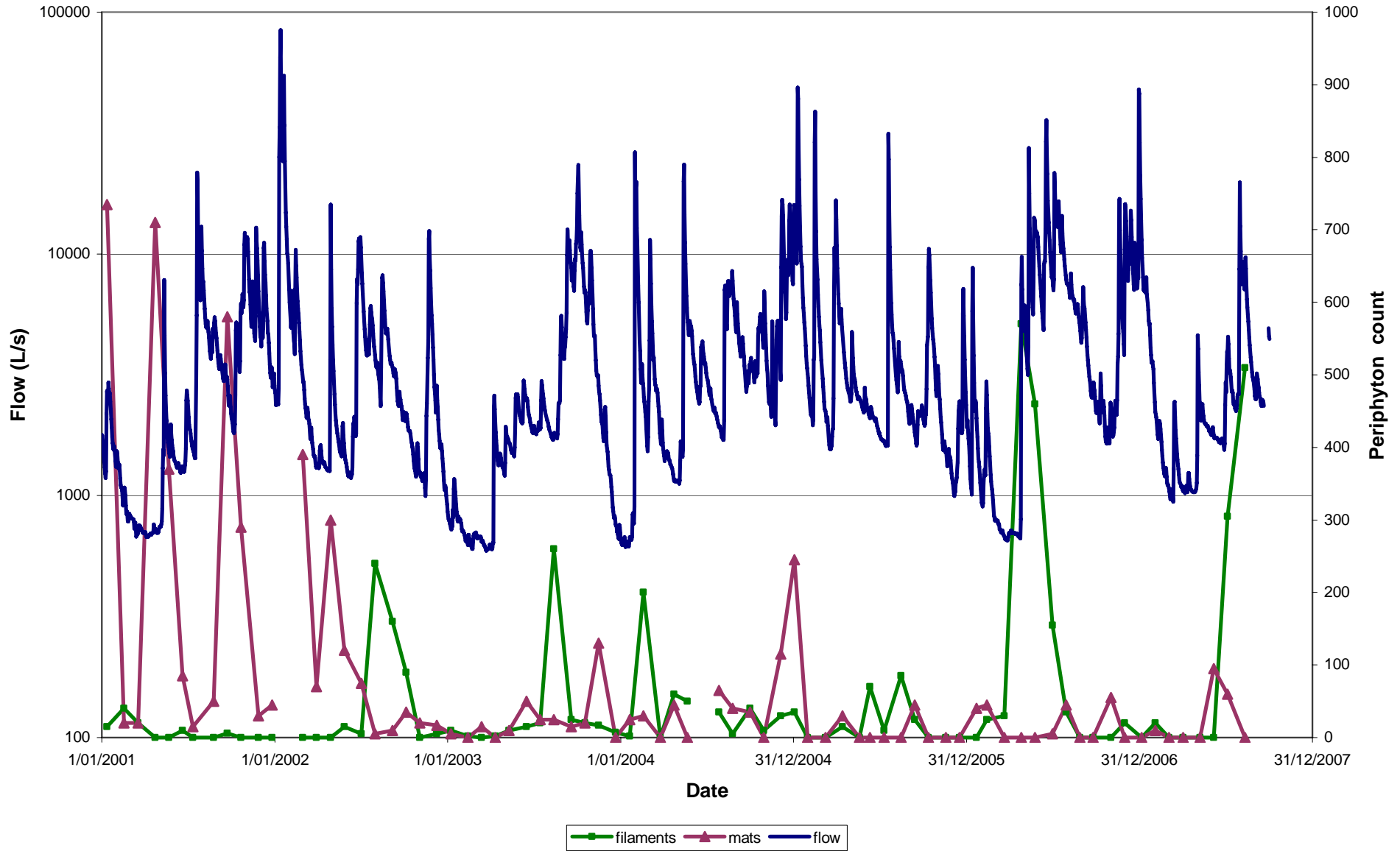


Figure 9: Recent Data showing relationship between Periphyton and Flow in the Hakataramea River above MH Bridge (Data supplied by NIWA)

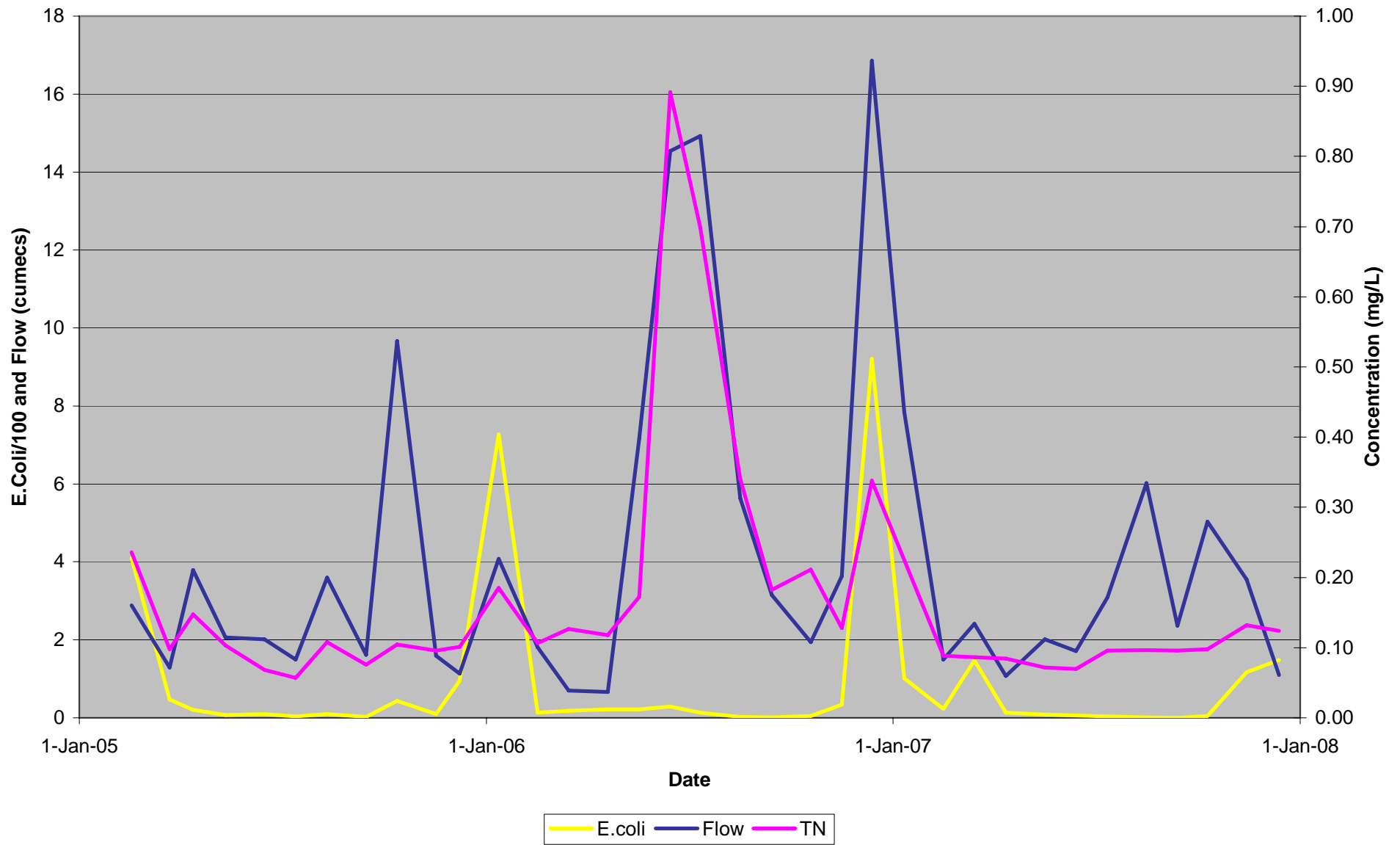
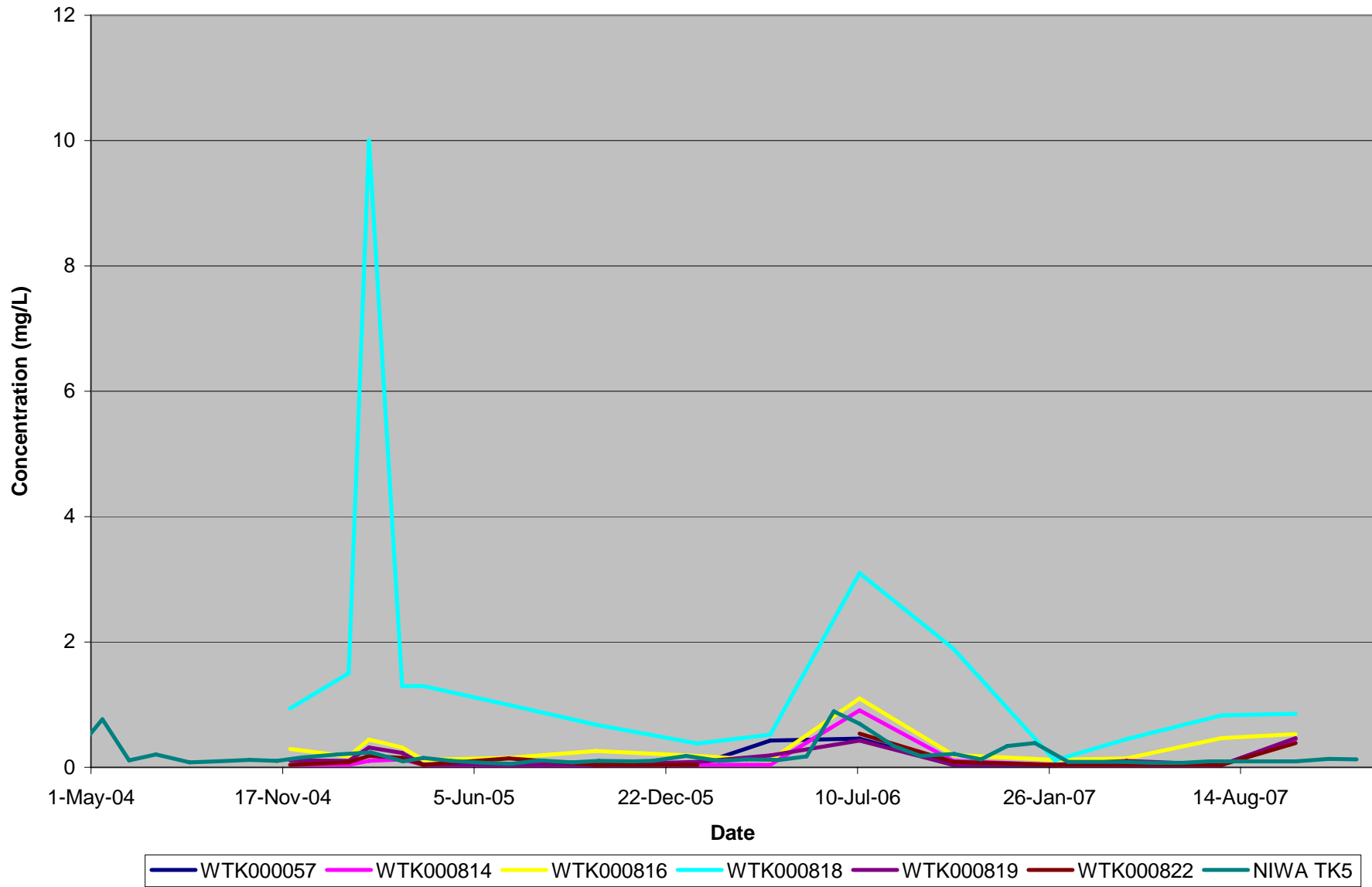


Figure 10: Total Nitrogen, E. coli and Flow in the Hakataramea River above MH Bridge (Data provided by NIWA)



**Figure 11: Total Nitrogen Concentrations at sites in the Hakataramea Catchment
(Data provided by Environment Canterbury and NIWA)**

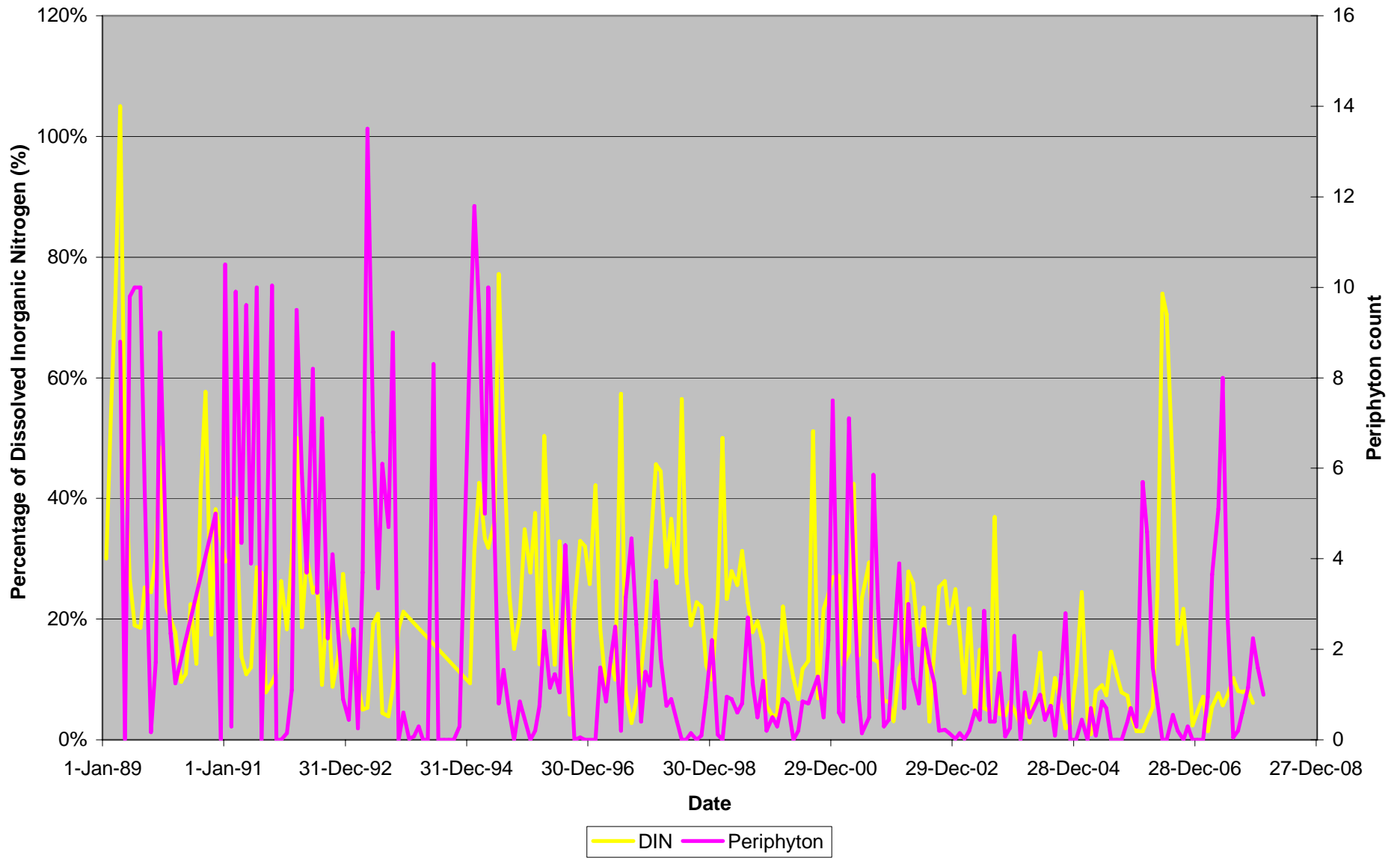


Figure 12: Dissolved Inorganic Nitrogen and Periphyton in the Hakataramea River above MH Bridge (Data provided by NIWA)



Figure 13a: Dust storm in the Hakataramea Valley (Source: Environment Canterbury)



Figure 13b: Wind blow dust in the Hakataramea Valley (Source: Environment Canterbury)



Figure 13c: Wind blown soil loss in the Hakataramea Valley (Source: Environment Canterbury)