Presented to Natural Resources Committee 9/6/11
Decision: That the report be noted.

REPORT

Document Id: A345900

Report No: 2011/0847
Prepared For: Natural Resources Committee
Prepared By: Justin Kitto, Environmental Resource Scientist
Date: 26 May 2011

Subject: Manuherikia Catchment Water Quality Study

Otago Regional Council

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1. Précis

The Manuherikia River is located in Central Otago and extends for approximately 64 km having a catchment area of approximately 3085 km^2. The river headwaters are in the Hawkdun Range and the catchment is surrounded by mountainous terrain on all sides, except to the south-west where it joins the Clutha River/Mata-Au at Alexandra. Water quality in the Manuherikia catchment is generally very good with landuse currently dominated by low intensity farming. However, there is a range of envisaged water harvesting and distribution schemes that may potentially lead to changes in land use and intensity that may potentially drive changes in water quality and ecological values.

The main objectives of this study were to determine the current state of water quality in the catchment and quantify the current state of the catchments instream biological health. The work expands on a previous ORC study (2004) which identified irrigation runoff as a cause of poor water quality within some tributaries to the Manuherikia River.

A 12-month water sampling program was started at the end of 2009, with fortnightly samples collected from 17 streams. During the summer of 2010/2011 physical habitat surveys and ecological surveys (macroinvertebrates and fish) were also undertaken.

The following conclusions have been made:

- Water quality was generally excellent or good in the upper catchment and main stem of the Manuherika.
- Some tributaries (Ida Burn, Pool Burn, Lauder Creek and Thomsons Creek) have degraded water quality during low flows, caused by flood irrigation runoff.
- Water quality and physical habitat could be easily be improved in the degraded tributaries by improving flood irrigation methods and better riparian management.
- It is suspected that in some tributaries low flows induced by natural conditions and irrigation are excluding trout, allowing native fish populations to thrive.

Results from this study will be used to provide baseline data which will help direct Council policy in line with the Rural Water Quality Strategy. The results are currently being used by the Land Resources team at local field days to advise farmers how to better use and maintain local water sources.

This paper acts as a summary to the full technical report which has been supplied separately.

2. Introduction

A review of State of Environment (SOE) water quality monitoring showed that water quality in the Manuherikia catchment is generally good, with three of the four sites monitored in this catchment having very good water quality, and none having poor water quality (ORC, 2007).

Land use intensification has been observed to adversely affect water quality in a number of catchments around New Zealand. Often these changes occur relatively quickly as farming technology and changing markets allow intensive farming practices in new areas to become viable. This good water quality could be put under pressure as intensive farming enters the area. A single dairy farm exists in the Manuherikia catchment as of June 2009 and a big increase in wintering dairy cows in the catchment has been observed in recent times. It is envisaged that there will also be a dramatic change in irrigation methods, water distribution and sources of irrigation water. These changes may result in a move from flood/border dyke irrigation to spray irrigation in the near future, with an associated risk of an intensification of landuse and diffuse discharges of agricultural pollution.

A previous water quality study (ORC 2004) investigated the effects of flood irrigation on the surface water quality in tributaries of the Manuherikia River (Chatto Creek, Thomson's Creek and Ida Burn). The study clearly showed that water quality was degraded between upstream and downstream sites after irrigation runoff re-entered the streams. The study showed that Thomsons Creek experienced the worst degradation.

This study builds on previous work and provides an assessment of the current state of water quality and ecological values in the catchment, and a robust baseline to compare land-use changes. The aims of this study are to identify changes in water quality along the Manuherikia River and what tributaries have degraded water quality. Water quality monitoring sites referred to in this report are shown in Figure 1.

The Regional Plan: Water (Water Plan) identifies significant ecosystem values and significant habitat values for the conservation of indigenous fauna. For the Manuherikia River mainstem, significant ecosystem values include trout spawning habitat, juvenile habitat, adult trout and Longfin eels. Chatto Creek has significant trout spawning habitat and juvenile habitat as does the Pool Burn downstream of Cobb Cottage. Chatto Creek and Dovedale Creek also provide significant habitat for the Roundhead galaxid which is considered to be in gradual decline. The Manuherikia River supports a diverse fishery with 11 species of fish (summarised in Table 1) and one species of freshwater crayfish (*Paranephrops zealandicus*) listed as being in the catchment (NIWA freshwater fish database, Otago Regional Council records).

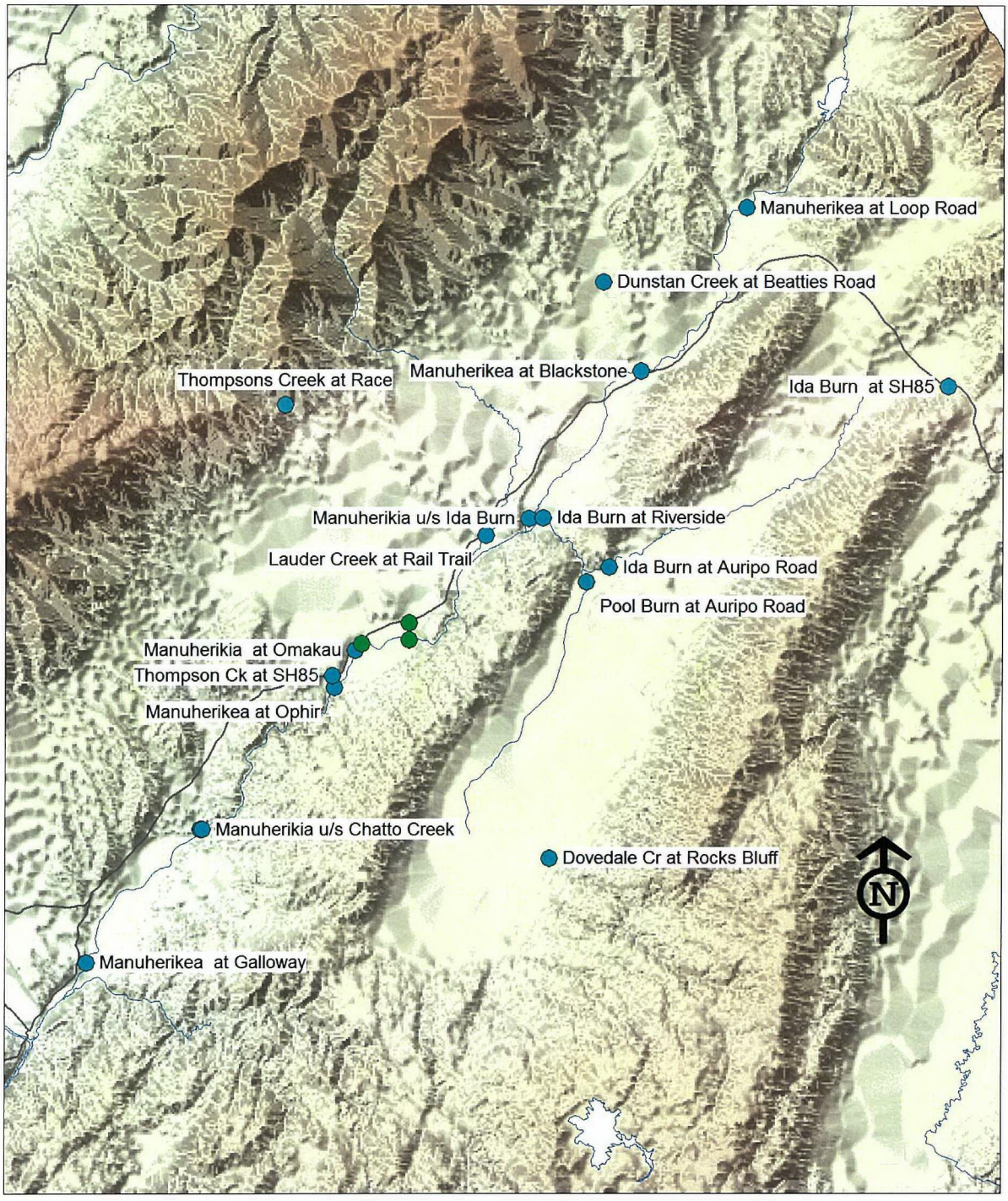

Figure 1. The Manuherikia catchment with study monitoring locations.

Table 1. Fish species present within the Manuherikia catchment (Sources: New Zealand Freshwater Fish Database, ORC records and Fish and Game Otago records).

Common name	Species name	Conservation status
Chinook salmon	*Oncorhynchus tshawytscha*	Introduced
Brown trout	*Salmo Trutta*	Introduced
Rainbow trout	*Oncorhymchus mykiss*	Introduced
Brook trout	*Salvelinus fontialis*	Introduced
Perch	*Perca fluvialtilis*	Introduced
Longfin eel	*Angullia dieffenbachia*	Gradual decline
Central Otago roundhead galaxiids	*Galaxias anomalus*	Gradual decline
Flathead galaxiids	*Galaxias* Sp. D	Gradual decline
Alpine galaxiid	*Galaxias paucispondylus*	
Koaro	*Galaxias brevipinnis*	
Common bully	*Gobiomorphus cotidianus*	
Upland bully	*Gobiomorphus breviceps*	

3. Water quality results

3.1 Water quality guidelines

Water quality results are frequently reported as being above or below ANZECC guidelines. However, these guidelines do not neccessarily represent a threshold for detecting an ecological effect. They have limitations because they are broadly based on studies from New Zealand and Australia and do not always take into account regional differences. For this study, effects based guideline values were chosen to reflect the nature of the Manuherikia catchment and where possible, reflecting discernable effects on ecology, angling and contact recreation.

The ANZECC (2000) guidelines are referenced for ammoniacal nitrogen (NH_4), total nitrogen (TN) and total phosphorus (TP), while the biologically available nutrients, dissolved reactive phosphorus (DRP) and nitrite-nitrate nitrogen (NNN) are referenced against the New Zealand Periphyton Guidelines (2000). These biologically available nutrients are important because excessive growth of algae or macrophytes is only possible if they are available. If one of these nutrients is in low supply, then plant growth is restricted.

The suitability of water for recreational activities (such as swimming) and stock drinking is typically assessed by the level of *E.coli* bacteria in a water sample. For safe swimming a median *E.coli* level of less than 126 cfu/100ml is recommended while for stock drinking water a threshold of 1000 faecal coliforms per 100ml water is described by ANZECC (1992).

There are no NZ suspended solids guidelines available. However, 10.3 mg/ L has been calculated using a method devised by the Cawthron Institute. For this study, water

quality data have been divided into two categories. The first category is "all flows" which is all of the water quality samples regardless of flow. The other category is below median flows (low flows) which are all the samples collected when flows were less than the median flow for the project period. These flows are used to represent low flows which are more likely to occur during the summer period.

3.2 Nutrients

NNN concentrations were above the guideline value at the majority of sites with Ida Burn lower having the highest concentration (Figure 2). Chatto Creek lower was the only site where NNN concentrations were slightly higher during lower flow conditions. Dovedale Creek and Ida Burn upper were the two sites with the lowest NNN concentrations.

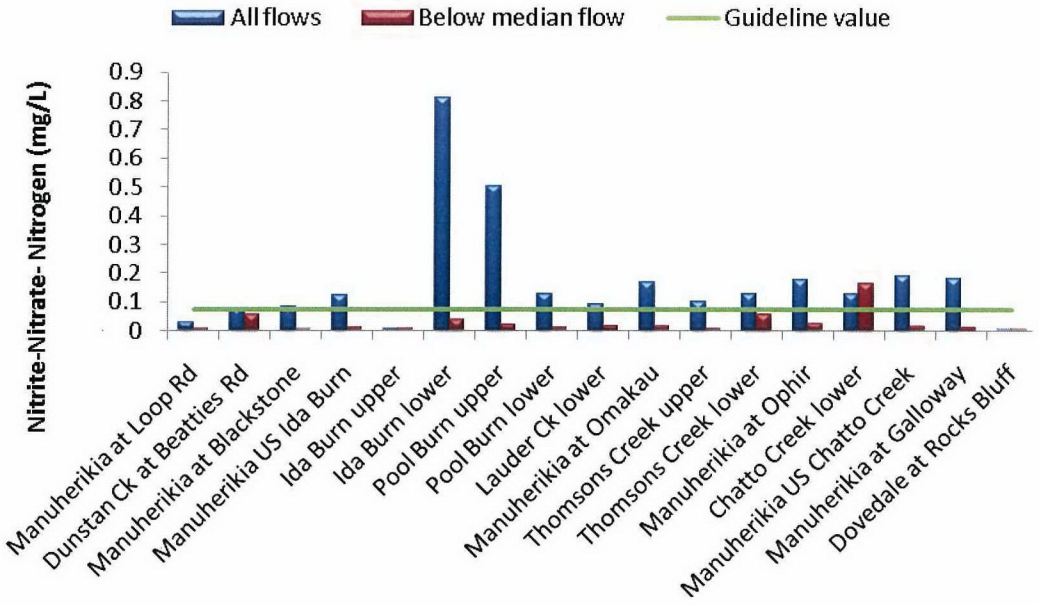

Figure 2. Flow weighted median concentrations of NNN for all flows (blue column) and below median flows (lower flows) (red column).

The lowest DRP concentrations were found in the upper catchment with the Manuherikia upstream of the Ida Burn confluence marginally above the guideline during lower flows (Figure 3). Lower flow concentrations of DRP were very high at Ida Burn lower, both Pool Burn sites and Thomson's Creek lower. There was also a distinct increase in DRP concentrations between Manuherikia at Omakau and Manuherikia at Ophir. There was a general increase in DRP concentrations longitudinally down the Manuherikia River as different tributaries entered.

Ratios between NNN and DRP have suggested that all streams are nitrogen limited. Therefore, despite high DRP availability algal growth is limited by the amount of available nitrogen.

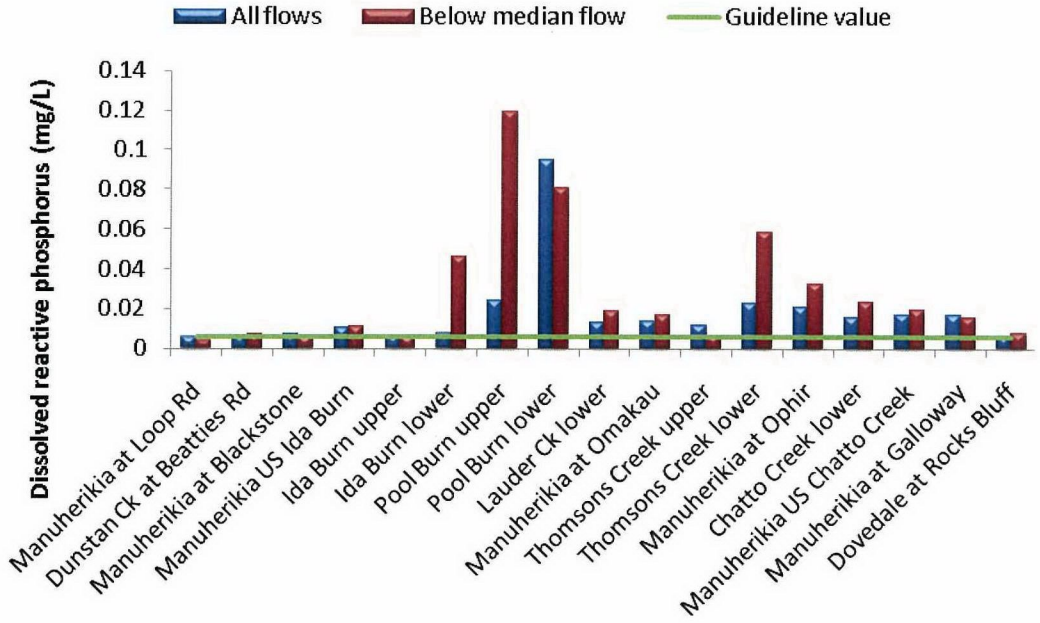

Figure 3. Flow weighted median concentrations of DRP for all flows (blue column) and below median flows (red column).

3.3 Bacteria

Concentrations of *E.coli* were below the contact recreation guideline for the upstream sites for all samples (Figure 4). The concentration of *E.coli* was high at Ida Burn lower, both the Pool Burn sites, Lauder Creek lower, Thomson's Creek lower and Dovedale Creek for lower flows. Manuherikia at Ophir had the highest concentrations for all the Manuherikia River mainstem sites.

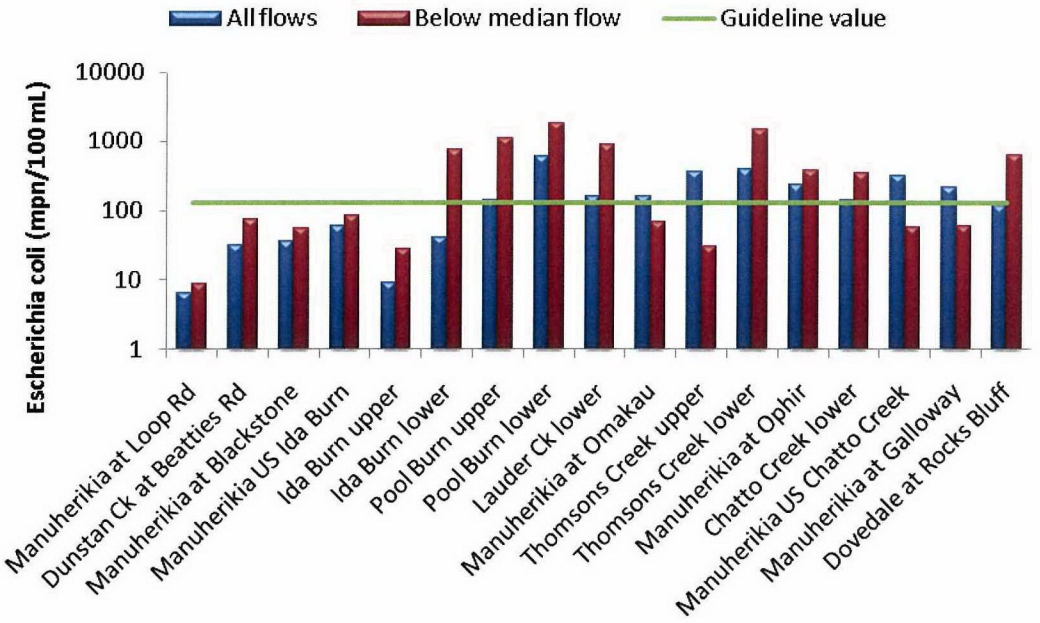

Figure 4. Flow weighted median concentrations of *E. coli* for all flows (blue column) and below median flows (red column).

3.4 Sediment

SS concentrations often exceed the guideline value when all flows were considered, and were below the guideline for all sites during lower flows with the exception of Thomson's Creek lower and Lauder Creek lower (Figure 5).

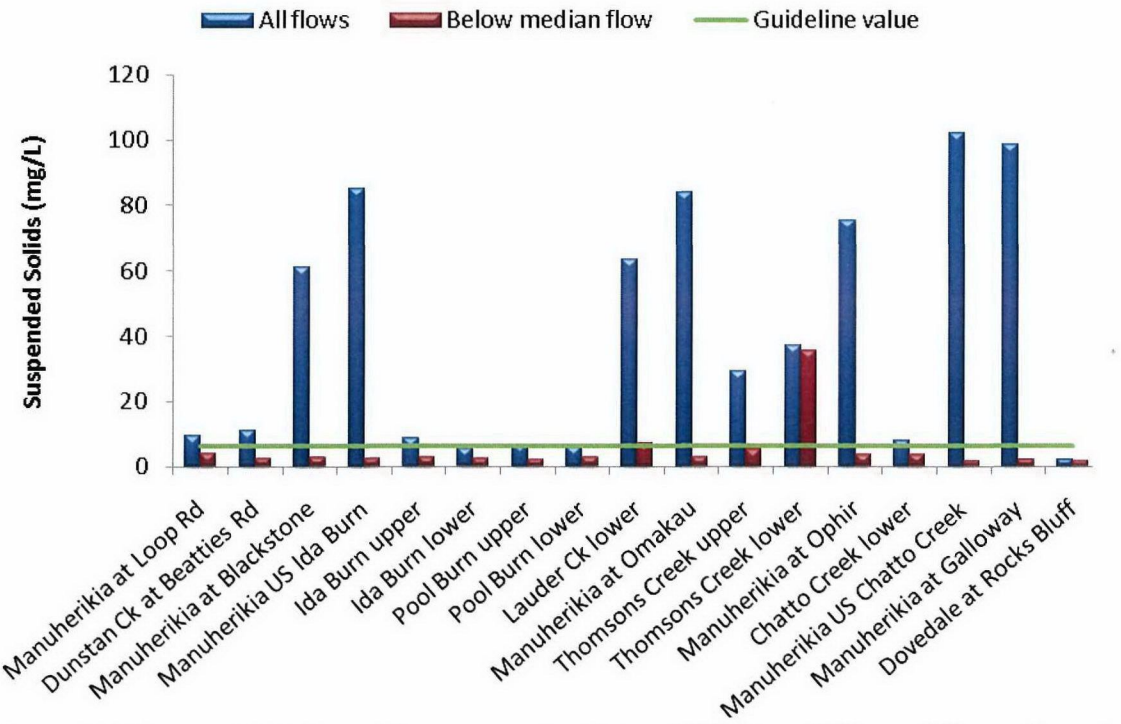

Figure 5. Flow weighted median concentrations of SS for all flows (blue column) and below median flows (red column).

Ratios between NNN and DRP have suggested that all streams are Nitrogen limited.

3.5 Comparison of long term SOE water quality data and project data

There are five long term SOE monitoring sites in the Manuherikia catchment: Dunstan Creek at Beatties Road (since 2001); Manuherikia at Galloway (since 2000); Manuherikia River at Ophir (since 2006); Pool Burn upper (since 2003); and Ida Burn lower (since 2003). Trend analysis was carried out to detect significant changes between the long term SOE data and the data from this monitoring program. The results of significant increases or decreases between the two periods are summarised in Table 2.

Table 2. Long term trends in SOE monitoring. Blanks indicate no significant changes.

Analyte	Dunstan Creek at Beatties Road	Manuherikia River at Ophir	Manuherikia at Galloway	Pool Burn upper	Ida Burn lower
DRP		Increase	Increase		
TP		Increase	Increase		
NNN	Increase				
TN					
NH_4	Decrease	Increase	Decrease	Decrease	Decrease
E. coli		Increase			
SS				Increase	

3.6 Physical habitat

Substrate or particle size of the river bed is an important driver in determining the biological communities inhabiting a river. Cobble and gravel streambeds provide a different habitat from sand or silt laden streams in that gaps between the particles of the former are much larger and provide greater flow through and oxygenation when compared to the silt laden streams.

The majority of streams had very little fine sediment build up on the stream bed. The exception to this was the Pool Burn lower which was completely covered with fine sediment less than 2 mm in diameter and Lauder Creek lower which was dominated by small sediment (5-10 mm diameter). The mainstem of the Manuherikia River had the highest median substrate size (80-135 mm).

3.7 Biological results

Macroinvertebrates and fish are useful tools to assess the biological health of a river. Macroinvertebrates are found everywhere and they have different tolerances to temperature, dissolved oxygen, sediment and chemical pollution. Thus, the presence or absence of taxa can provide significant insight into long term changes in water quality. The location, quantity and quality of native and exotic fish are useful indicators of the ecological functionality of each river. For this report the Macroinvertebrate Community Index (MCI) was used. The MCI uses the occurrence of specific macroinvertebrate taxa to determine the level of organic enrichment in a stream. Taxon are scored between one and 10. One represents taxa highly tolerant of organic pollution while 10 represents taxa sensitive to organic pollution. The MCI score is obtained by adding the scores of individual taxa and dividing this total by the number of taxa present at the site.

MCI scores were the highest in Dunstan Creek at Beatties Road, which was the only site to have an excellent MCI score (Figure 6). Pool Burn upper was the only site that fell into the poor category. The majority of the remaining sites fell into the fair category.

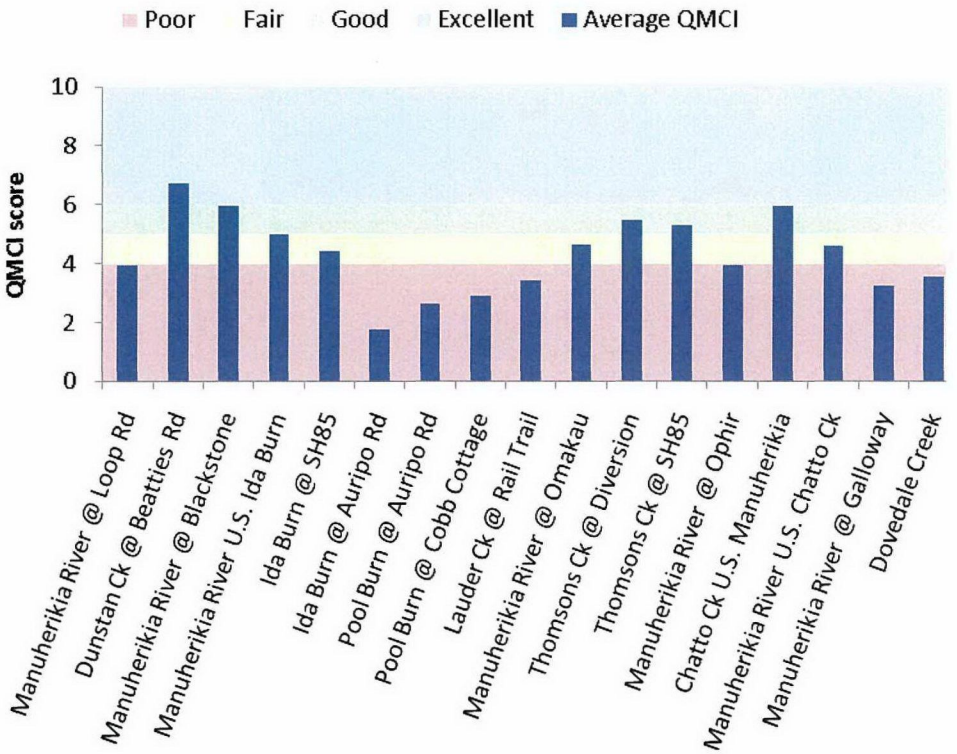

Figure 6. Average MCI scores for all sample sites.

Brown Trout densities were excellent in the Ida Burn upper (Figure 7). Both the Pool Burn lower and Chatto Creek lower had fair Brown Trout populations. No trout were caught at either Dovedale Creek or Pool Burn upper.

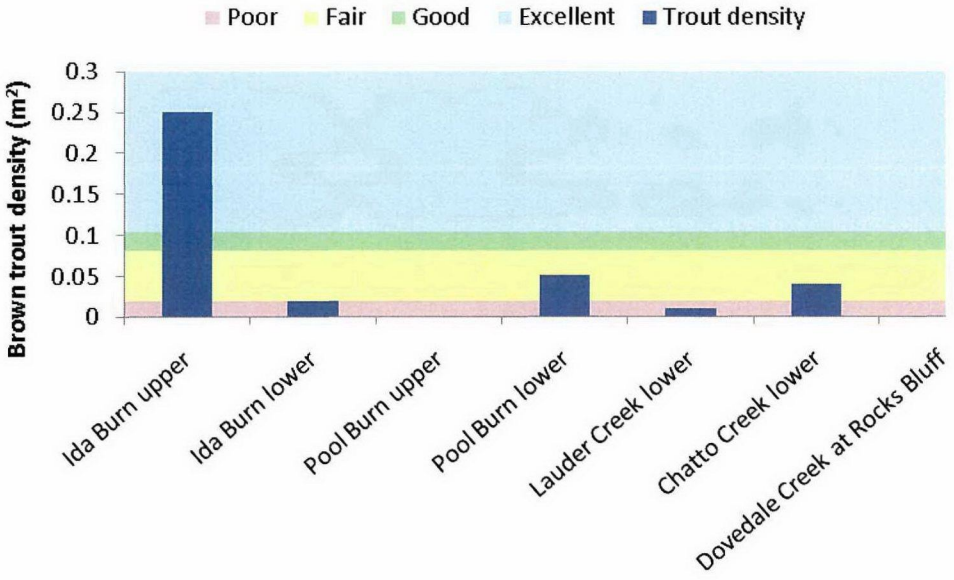

Figure 7. Brown trout density in sites that were able to be fished with density categories.

Native fish densities are classified as excellent when compared to the rest of the Clutha catchment in Dovedale Creek followed by Ida Burn lower (Figures 8). The Pool Burn lower and Lauder Creek lower just fall into the good category.

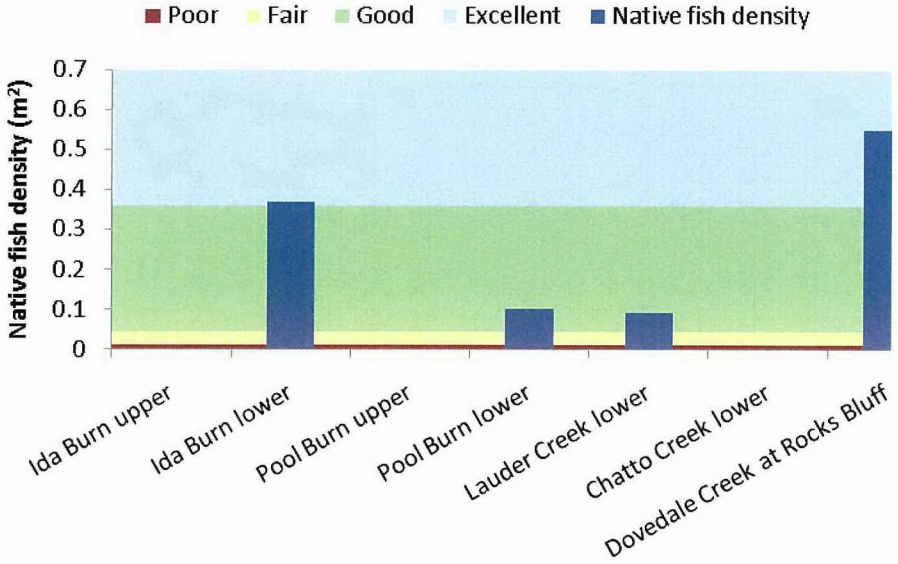

Figure 8. Native fish density in sites that were able to be wished. Density classes have also been presented.

4. Discussion

4.1 Nutrients

The main nutrients of concern are NNN and DRP as these are the two nutrients that are biologically active. NNN concentrations were generally low compared to intensive catchments (e.g. the Pomahaka catchment). The only two sites above the guideline were Ida Burn lower and Pool Burn upper. However, both of these exceedances were for the all flows category. This is most likely the result of NNN being exported out of the catchment when the catchment is saturated. NNN is readily exported out of the catchment as it is highly soluble and mobile in soil when wet, thus easily exported from the soil. NNN concentrations are likely to be low due to the comparative under-developed nature of the Manuherikia catchment, the fact that where agricultural activity does exist, it is comparatively low intensity, and that soils are dry which limits NNN movement out of the catchment.

DRP concentrations are above the guideline value at all sites including the control sites of Ida Burn upper and Dovedale Creek at Rocks Bluff. The highest concentrations, especially those during lower flow conditions (high risk for nuisance algal growth) are found in Ida Burn lower, both Pool Burn sites and Thomson's Creek lower. These sites are followed by the tributaries of Lauder Creek lower and Chatto Creek lower. All these tributaries are likely to increase the DRP load at the mainstem Manuherikia sites such as Omakau, Ophir upstream of the Chatto Creek confluence, and Galloway. While this study has not investigated the effects of irrigation runoff, the consistent pattern between the tributaries streams is that they all receive significant inputs of irrigation runoff likely to be contributing agricultural pollutants. A number of research papers from New

Zealand have demonstrated how irrigation runoff from flood irrigation can adversely affect water quality.

This can potentially be resolved by:

- Allowing riparian buffers to be established along the stream edge to filter out agricultural pollutants;
- Collecting water in ponds at the bottom of the property and then using this water for spray irrigation at the bottom of the property;
- Converting to spray irrigation.

There is a notable increase in DRP and TP concentrations between Omakau and Ophir which is leading to degradation in water quality. Omakau has 'good' water quality, but degrades to 'fair' water quality at Ophir. This is likely to be the combined result of contributions from Thomson's Creek and the Omakau wastewater plant discharging treated human effluent.

4.2 Bacteria

E. coli concentrations were below the guideline value in the upper part of the catchment. Sites with high *E. coli* were the Ida Burn lower, both the Pool Burn sites, Lauder Creek, Dovedale Creek and Thomsons Creek lower. These results are concerning because they are occurring during lower flow conditions, when there has been no rain and when people are more likely to be using the rivers and streams for recreation. The high *E. coli* at lower flows when the catchment is dry indicates direct inputs of bacteria. Ida Burn, Pool Burn, Lauder Creek and Thomson's lower all have flood irrigation inputs which wash agricultural pollutants (in this case animal effluent) into the waterways. Dovedale Creek had *E. coli* concentrations that exceeded the guideline value during lower flows. This sampling site was located within a deer farm and the tendency of deer to wallow in water could be the explanation of this contamination by animals during low flow conditions. Most streams that were sampled had little stream fencing to prevent animal access.

E. coli concentrations also increase between Omakau and Ophir which results in water degrading from "good" at Omakau to "fair" at Ophir.

4.3 Suspended Solids

SS concentrations were elevated above guideline values at a number of sites when all flows were considered. However, this was expected as high flows and significant rainfall events wash land surfaces through overland flow. When SS concentrations were considered for only lower flows, concentrations never exceeded the guideline value except at Thomson's Creek lower. This could possibly be the result of sediment contributions from flood irrigation techniques.

4.4 Physical habitat

The main measure of habitat degradation used in this study is the proportion of fine sediment (less than 2 mm) on the stream bed. The majority of the sample sites had almost no fine sediment build-up. This was particularly so for the mainstem of the Manuherikia River and the sampling sites in the upper part of the catchment (such as Dunstan Creek) or upper sites in the river network (such as Ida Burn upper and

Thomsons Creek upper). The site with the highest proportion of fine sediment was in the Pool Burn lower and Lauder Creek lower. Most of these fine sediment sources can be eliminated by fencing off streams on the Ida Valley floor. These fences would exclude stock from creating tracks to the stream which then become sediment sources during higher flows. They would also allow riparian buffers to form which would filter out pollutants running off following flood irrigation.

4.5 Instream ecological values

This investigation approach looks at multiple stressors (chemical, physical and community structure) in tandem and therefore provides a more relevant ecological impact assesment. Each site has been graded as 'excellent', 'good', 'fair' or 'poor', for chemical, physical habitat, macroinvertebrate, trout and native fish populations (Table 3).

Table 3. Summary of categories for chemical, physical, macroinvertebrate, sports fish (trout) and native fish for all 17 sites in this investigation. N/A denotes sites that were unable to be fished as flows were too high.

Site	Water quality	Habitat	Macroinvertebrates	Trout	Native Fish
Manuherikia at Loop Road	Excellent	Excellent	Poor	N/A	N/A
Dunstan Ck at Beatties	Good	Excellent	Excellent	N/A	N/A
Manuherikia at Blackstone	Excellent	Excellent	Good	N/A	N/A
Manuherikia US Ida Burn	Good	Excellent	Fair	N/A	N/A
Ida Burn upper	Excellent	Excellent	Fair	Excellent	Poor
Ida Burn lower	Fair	Good	Poor	Fair	Excellent
Pool Burn upper	Fair	Poor	Poor	Poor	Poor
Pool Burn lower	Fair	Good	Poor	Good	Excellent
Lauder Creek lower	Fair	Fair	Poor	Poor	Excellent
Manuherikia at Omakau	Good	Excellent	Fair	N/A	N/A
Thomsons Creek upper	Good	Excellent	Good	Excellent	Poor
Thomsons Creek lower	Poor	Good	Good	N/A	N/A
Manuherikia at Ophir	Fair	Excellent	Poor	N/A	N/A
Chatto Creek lower	Fair	Good	Good	N/A	N/A
Manuherikia US Chatto Creek	Good	Excellent	Fair	N/A	N/A
Manuherikia at Galloway	Good	Excellent	Poor	N/A	N/A
Dovedale at Rocks Bluff	Good	Fair	Poor	Poor	Excellent

The relationships observed between water quality, physical habitat, trout and fish values in this study were more complicated than in other areas where similar studies have been undertaken (for example, the Pomahaka catchment and Catlins region). Confounding factors such as the hydro electric dams on the Clutha River/Mata-Au which impede Longfin Eel migration, sport fish competition mainly from brown trout which predate on rare non-migratory native fish, and natural low flows which are often exacerbated by water abstraction for irrigation.

In the upper part of the catchment there were excellent water quality, excellent habitat, and excellent macroinvertebrate communities, but no fish data due to the abnormally high river flows. Mauherikia River at Loop Road had a poor macroinvertebarte community which is most likely to be the result of a didymo invasion smoothering substrate and excluding the healthy invertebrate taxa that generate good and excellent scores. In one site (Ida Burn upper) there was good water quality, excellent habitat and fair macroinvertebrates and an excellent trout population. The poor native fish ranking at this site is likely due to the historic invasion of brown trout and their predation on native fish.

Conversely, Pool Burn upper had fair water quality, poor physical habitat, poor macoroinvertebrate communities and poor fish populations (no fish were found at this site). At this site, the stream bed was covered in fine silt which is possibly the result of flood irrigation run off and stock access introducing fine sediment. Stock access creates tracks along the stream banks which are more susceptible to being eroded by flood irrigation run off in the Pool Burn. The macroinvertebrate community was also dominated by snails which indicates organic pollution in the form of nutrient enrichment. Consequently, this site has little in the way of habitat and food resources for fish. Lauder Creek lower also had fair water quality, poor physical habitat, a poor macroinvertebrate community and a poor trout population. The native fish population was dominated by Upland Bullies and this excellent population is again possibly the result of the limited predatory pressure by brown trout.

Dovedale Creek and Ida Burn lower all had excellent densities of Central Otago Roundhead galaxiids which are threatened species. The high densities of these fish was most likely the result of the absense of trout at Dovedale Creek and the poor densities of trout in Ida Burn lower. In the case of the Ida Burn lower this was most likely due to the effect of irrigation restricting flow and killing trout due to high temperatures and low oxygen levels while the more hardy Central Otago Roundhead galaxiids are more tolerant of low flow conditons, thus able to persist.

In the sites that were electric fished, what was praticularly evident was the absence of Longfin eels from many of the streams. Single, large (700 mm plus) Longfin Eels were caught in the Pool Burn lower, Ida Burn lower and Lauder Creek lower, but not in the other sites surveyed. It was also concerning that no smaller individuals, indicating recruitment, were caught. This is consistent with reported effects of hydro dams (Glova and Davis, 1981, Jellyman, 1982) which suggested that the Clutha River/ Mata-Au dams would have significant effect on the Longfin eel population in the Manuherikia Catchment.

5. Conclusion

- This 12 month targeted water quality and ecological health study was implemented to provide a baseline of water quality and ecological data for the Manuherikia catchment.

- Water quality results have shown that the Manuherikia mainstem has good water quality with a change from excellent water quality at the top of the catchment to good at the bottom near Alexandra.

- There are some tributaries to the mainstem of the Manuherikia River that have degraded water quality during low flows caused by irrigation run-off. These are Thomson's lower, Ida Burn lower, Pool Burn and Lauder Creek lower.

- Nitrogen was well below effects-based guideline values especially during the high risk period during lower flow conditions. Analysis suggests this catchment is N limited.

- In streams such as Dovedale Creek and the lower Ida Burn where high densities of the threatened Central Otago Roundhead galaxiid are located, it is likely that the low river flows are protecting these populations by excluding trout invasion.

- Water quality and physical habitat could probably easily be improved in the degraded tributaries by improving flood irrigation methods to minimise or eliminate irrigation run off, and better riparian management.

- The ecological values in these streams are not just related to water quality issues. They are also possibly reflective of hydro-electric dams on the Clutha River/ Mata-Au disrupting Longfin eel migration, competition between native fish and sports fish and natural low flows exacerbated by irrigation.

6. Recommendation

That this report is noted.

John Threlfall
Director Environmental Information and Science