Otarao Catchment Water Quality Study

July 2002 – June 2006

August 2006
Northland Regional Council
Private Bag 9021
Whangarei
www.nrc.govt.nz

Contents

1 Introduction

Otarao catchment project is a joint project between the Northland Regional Council (NRC), Landcare Trust, Mangakahia Landcare Group and the landowners of the Otarao catchment. Otarao catchment is approximately 2500 ha in size and is a sub-catchment of the Mangakahia River. Located about 30 minutes west of Whangarei, the catchment has varying land uses including a dairy farm and dairy run off's, forestry, sheep and beef farms, native bush and lifestyle blocks.

The purpose of the water quality-monitoring component of the project is to characterise the existing water quality of the catchment, and to identify any issues that may exist. These first few years of monitoring are also important to establish background pre-restoration data that post restoration data can be compared to.

This report is a summary of the first four years of background water quality sampling for the Otarao catchment from July 2002 to June 2006, as well as the rainfall, fish and macroinvertebrate monitoring.

2 Sampling sites

From July 2002 to June 2004 samples were collected monthly from five sites within the catchment. The five sites were selected to represent different land uses, geology and relative location throughout the catchment (Hall 2003). These sites were:

1. Otarao Stream near the Mangakahia River Confluence
2. Unnamed tributary to Otarao Stream (end of Coxhead Road)
3. Ruahuia Stream at Viaduct (where the stream exits the native bush)
4. Tarakiekie Stream near Otarao confluence (end of Norvil Road)
5. Otarao Stream downstream of Tarakiekie Stream confluence (end of Norvil Road)

Land cover (such as indigenous forest or pasture) has a major effect on water quality, but other factors such as underlying geology and flow can also affect water quality (Hall 2003). The sites sampled are shown in table 1 and figure 1 (below).

Table 1: Five original Otarao catchment sites, with their surrounding land use, geology, stream order and stream gradient.

Site	Land cover	Underlying geology	Stream Order	Stream Gradient
1. Otarao near Mangakahia	Pastoral	Soft sedimentary	Middle	Low
2. Unnamed tributary to Otarao	Pastoral (some exotic forest)	Soft sedimentary	Middle	Low
3. Ruahuia Stream at Viaduct	Indigenous Forest	Volcanic acidic	High	High
4. Tarakiekie Stream near Otarao	Pastoral (some exotic forest)	Soft sedimentary	High	Low
5. Otarao Stream near Tarakiekie	Pastoral	Soft sedimentary	Middle	Low

After reviewing the first two years of sampling and results it was recommended that sampling could be reduced to every two months, supplementing the data with extra sites and macroinvertebrate sampling. From September 2004 seven sites (including the five original and two extra sites) were sampled bimonthly. The two extra sites were:

6. Mangakahia River upstream of Otarao confluence
7. Headwaters of unnamed tributary to Otarao stream

The Mangakahia River site was added to give people an indication of how the Otarao compares to the Mangakahia River and the headwaters of the unnamed tributary is of similar size to the Ruahuia Stream site but in pastoral farming.

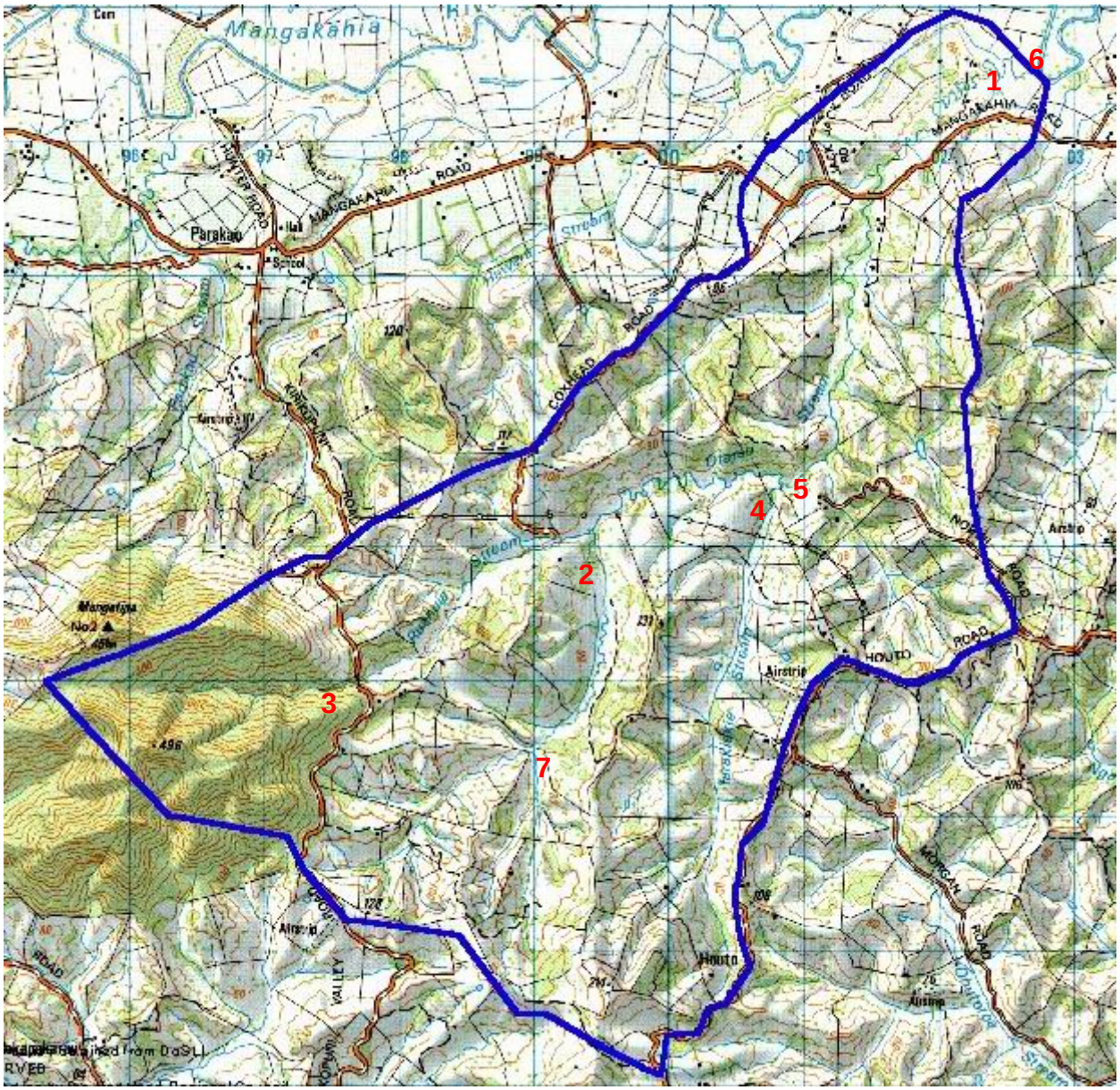

Figure 1: Map showing five original sites sampled in the Otarao catchment (sites 1 - 5) and two additional sites sampled since September 2004 (6 & 7)

3 Methods

3.1 Water quality

3.1.1 Field measurements

Field measurements of water temperature (°C), dissolved oxygen (both in mg/L and % Saturation) and conductivity (mS/m at 25°C) were taken using an YSI Dissolved oxygen meter. Water clarity was measured using the black disc method. Several samples were collected at each site, kept chilled and transported to the appropriate laboratory for analysis within 24 hours.

3.1.2 Temperature logging

Temperature logging was carried out in March 2005 at two sites; site 3 - Ruahuia Stream at the viaduct and site 1 – Otarao Stream near Mangakahia River. Temperature was recorded every 10 minutes for approximately one month, using Tinytag Plus™ temperature loggers. The data was downloaded using the Gemini Logger Manager™ software and then exported to Microsoft Excel™.

3.1.3 Laboratory analysis

The samples were tested for pH, turbidity (ntu), nitrate/nitrite nitrogen (g/m^3), total kjedahl nitrogen (g/m^3), ammoniacal nitrogen (g/m^3), dissolved reactive phosphorus (g/m^3), total phosphorus (g/m^3) and the indicator bacteria, *Escherichia coli* (n/100mL). These tests were all carried out following the procedures in '*Standard Methods for the Examination of Water and Wastewater*' (APHA, 1998).

3.1.4 Data storage and analysis

All data collected was quality checked and stored in the Northland Regional Council database following the procedures outlined in relevant Monitoring quality manuals. The monitoring department has a well established Quality System, which is ISO 9001:2000™ registered.

All water quality data for the Otarao catchment was collated and reviewed in Microsoft Excel™. The results were than compared to the guidelines for the protection of aquatic ecosystems (ANZECC 2000), and the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (MFE 2003) and the NZ drinking water standards (MOH 2000) for the protection of public health (see APPENDIX A: Relevant Guidelines).

3.2 Rainfall

Daily rainfall data was collected using rain gauges from two different areas within the catchment, Rain Gauge A was located on a property on Kirikopuni Road and Rain Gauge B on a property where Mangakahia Road intercepts with Otarao Stream.

3.3 Stream Biota

3.3.1 Macroinvertebrate monitoring

Macroinvertebrates can be used to determine the health of a stream. The advantage of macroinvertebrates compared to water quality sampling is that they show changes

or perturbation that has happened over a length of time where as water quality samples are only a snap shot of what is happening in the water at that particular point in time when the sample is collected.

Macroinvertebrate samples were collected, on three occasions; February 2004, March 2005 and March 2006 from the original five water quality sites (except the unnamed tributary at Coxhead Road and Tarakiekie Stream were only sampled on one occasion in February 2004). An additional site on the Otarao Stream at Wares Property off Mangakahia Road was also sampled on all three occasions. The samples were collected and sorted using the standard protocols (Stark et al 2001). Species richness, Macroinvertebrate Community Index (MCI), Semi Quantitative MCI (SQMCI) and percentage of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) (%EPT) were calculated for each site.

MCI and SQMCI are used as an indication of water quality or level of impact and are calculated using scores pre-assigned to each macroinvertebrate taxa based on its sensitivity to pollution. The higher the MCI or SQMCI score the higher the water quality as shown in table 2 (below). For the same reason the percentage of EPT taxa can be used as an indication of water quality, as stoneflies, mayflies and caddisflies tend to be sensitive to pollution more than other taxa such as fly and beetle larvae, worms and snails.

Table 2: Interpretation of MCI and SQMCI (Boothroyd and Stark 2000)

Interpretation	MCI score	SQMCI score
Clean water	>120	>6.0
Doubtful quality or possible mild pollution	100-119	5.0-5.99
Probable moderate pollution	80-99	4.0-4.99
Probable severe pollution	<80	<4.0

3.3.2 Fish monitoring

A Department of Conservation and Regional Council staff member carried out fish surveys on 14 December 2004 at two sites in the Otarao catchment; the lowest site (Otarao by Mangakahia River) and the highest site (Ruahuia Stream but below the viaduct). The electro-fishing method was used, where an electrical current is passed through the water to temporarily paralysis the fish but not harm them. While in temporary paralysis fish are collected either in a handheld dip net or washed downstream with the current and caught in a net across the stream.

The two operators have to be qualified to use the electro-fishing equipment. One uses the backpack electro-fishing machine and controls the electrical current in the water, while the other person holds the net across the stream. A total stream length of about 100 m was surveyed at each site but sampled in shorter lengths of about 20 m. Each stream length was passed twice, with the machine operator starting upstream and making their way downstream in a zig-zagging motion towards the net and then repeating this process. The nets are then checked and any fish caught are removed to buckets for identification. All fish are returned to the stream once identified.

4 Results

4.1 Water quality

4.1.1 Water temperature

Both water temperature and dissolved oxygen are important factors for stream biota to survive. Sudden changes or gradual but large increases in water temperature can be dangerous or lethal to stream biota particularly if there is no refugia where cooler water temperatures can be sought. Different macroinvertebrates and fish show different tolerances to changes in water temperature. Lower water temperatures are important for fish spawning and it is thought that water temperature should remain below 25°C to ensure native fish survival.

Ruahuia Stream at the viaduct tended to have lower water temperatures than the other four sites during the summer months, where as there was very little difference between temperature for the five sites in the winter months (April to September). The highest recorded water temperature was 22.8°C at the Mangakahia River site on 10 February 2005. However, the highest temperature in the actual Otarao catchment was 20.9°C recorded in the very small headwaters section of the unnamed tributary, also on 10 February 2005, as shown in table 3 (below).

Table 3: Average and range in temperature (°C) recorded at the seven Otarao catchment sites from July 2002 to June 2006.

Site	Average Temp (°C)	Range (°C)
1. Otarao Stream near Mangakahia	15.1	9.0 – 20.7
2. Unnamed tributary to Otarao	14.9	8.3 – 20.3
3. Ruahuia Stream at the viaduct	13.9	8.8 – 18.8
4. Tarakiekie Stream near Otarao	15.0	9.1 – 20.0
5. Otarao Stream near Tarakiekie	15.2	9.3 – 20.6
6. Mangakahia River near Otarao	16.2	10.9 – 22.8
7. Headwaters of unnamed tribuatry	15.1	10.2 – 20.9

In the last report it was suggested that the water may reach temperatures several degrees higher at certain times and days in the peak of summer, than the highest temperatures recorded during sampling visits (Cook 2004). However the highest temperature reached during temperature logging was 21.8°C on 24 March 2005 in the exposed Otarao Stream site near Mangakahia River, only one degree higher than the highest temperature recorded during sampling. The highest water temperature recorded in the shaded Ruahuia Stream site was 19.8°C on 25 March.

A small proportion of the logging from 10 am on 21 March to midnight on 26 March is shown in Figure 2 (below). This highlights the daily cyclic change in temperature and the difference between the shaded Ruahuia and unshaded Otarao sites.

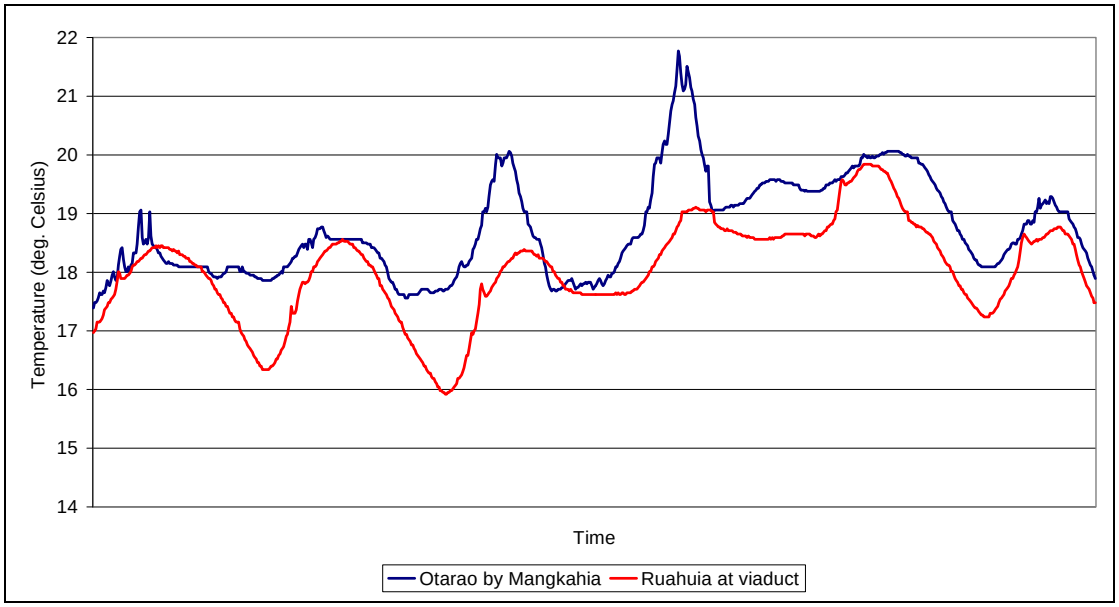

Figure 2: Temperature (°C) logging data from 21 March to 26 March 2005 at the Ruahuia Stream site (red line) and Otarao upstream of Mangakahia site (blue line)

4.1.2 Dissolved oxygen

The amount of dissolved oxygen available in the water is important for fish and macroinvertebrates to breathe. It is commonly thought that a dissolved oxygen level below 6 mg/L can be detrimental to native fish.

Dissolved oxygen reached low levels at all sites, except Ruahuia stream at the viaduct and the Mangakahia River site, as shown in table 4 (below). The site on the lower reaches of the Otarao near the Mangakahia recorded dissolved oxygen levels below 6 mg/L on 13 sampling occasions. Dissolved oxygen was less than 6 mg/L in Otarao stream near Tarakiekie, in Tarakiekie Stream itself and the unnamed Tributary on 11, seven and five sampling occasions respectively.

Table 4: Average and range of dissolved oxygen (mg/L) levels recorded for the seven Otarao catchment study sites

Site	Average DO (mg/L)	Range (mg/L)
1. Otarao Stream near Mangakahia	7.4	0.7 – 11.7
2. Unnamed tributary to Otarao	8.8	3.9 – 11.9
3. Ruahuia Stream at the viaduct	10.5	6.5 – 12.5
4. Tarakiekie Stream near Otarao	8.0	0.1 – 12.6
5. Otarao Stream near Tarakiekie	8.3	0.1 – 11.6
6. Mangakahia River near Otarao	9.3	7.6 – 10.8
7. Headwaters of unnamed tributary	8.8	0.2 – 12.3

Dissolved oxygen tends to be higher in Ruahuia stream at the Viaduct, as shown in figure 3 (below). The dissolved oxygen levels at the viaduct show much less variation throughout the year, unlike the other four sites, which experience large drops in dissolved oxygen throughout summer, when the flows are low.

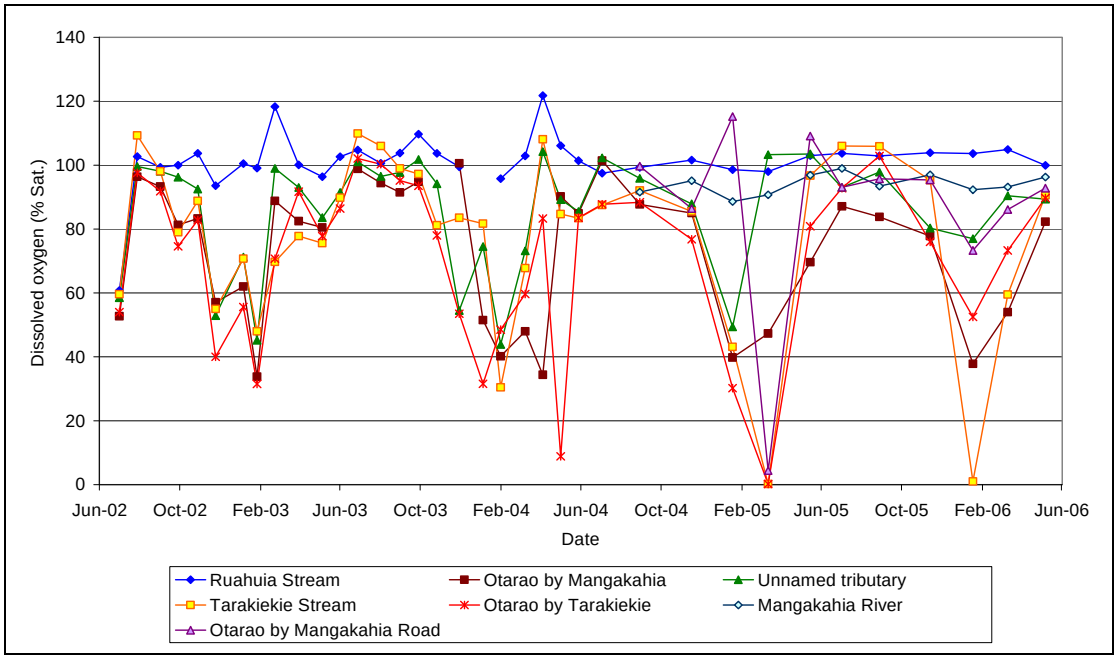

Figure 3: Dissolved oxygen (% saturation) at all seven sites sampled in the Otarao catchment

In Ruahuia Stream 75% of the recorded dissolved oxygen readings comply with the ANZECC guideline of 98 to 105% Saturation, where as 25% or less of the readings from the other six sites comply with the guidelines, as shown in table 5 (below).

Table 5: Average and range of dissolved oxygen (% saturation) levels recorded at the seven Otarao catchment sites from July 2002 to June 2006, with the percentage that comply with the ANZECC guidelines (2000)

Site	Average DO (% Sat.)	Range (% Sat.)	% comply
1. Otarao Stream near Mangakahia	71.5	6.8 – 101.4	9
2. Unnamed tributary to Otarao	85.2	43.9 – 104.2	25
3. Ruahuia Stream at the viaduct	101.3	60.8 – 121.8	75
4. Tarakiekie Stream near Otarao	78.3	0.2 – 109.9	6
5. Otarao Stream near Tarakiekie	69.3	0.2 – 102.9	8
6. Mangakahia River near Otarao	94.0	88.6 – 99.0	9
7. Headwaters of unnamed tributary	86.5	4.4 – 115.2	9

4.1.3 Conductivity

Conductivity is a measure of the amount of ions in the water and can be used as an indictor of nutrients in the water either from natural sources or contamination.

In general, conductivity tends to be highest at the Ruahuia Stream site apart from the large peaks found in Tarakiekie Stream, where conductivity reaches levels greater than 40 mS/m on two sampling occasions, as shown in table 6 (below). Conductivity tends to be consistently elevated all year round at the Ruahuia Stream site, suggesting it is likely to be of natural origin from nutrients leaching out of the volcanic acidic substrate. Where as the large peaks recorded at some of the other sites tend to occur in summer when flows are extremely low leading to greater concentrations of nutrients (i.e. less dilution).

Table 6: Average and range of conductivity (mSm@25°C) levels recorded for the seven Otarao catchment study sites

Site	Average Cond (mS/m@25°C)	Range (mS/m@25°C)
1. Otarao Stream near Mangakahia	19.2	12.3 – 28.6
2. Unnamed tributary to Otarao	19.7	14.1 - 34.4
3. Ruahuia Stream at the viaduct	24.9	13.8 – 30.7
4. Tarakiekie Stream near Otarao	25.4	14.1 – 54.7
5. Otarao Stream near Tarakiekie	21.6	15.2 – 49.3
6. Mangakahia River near Otarao	13.0	10.3 – 16.3
7. Headwaters of unnamed tributary	17.0	10.8 – 42.6

4.1.4 pH

How acidic or alkaline the water is, can be measured using the pH scale. A pH of 7 is neutral, 3 is acidic and 10 is basic. The pH guideline for the protection of aquatic ecosystems for lowland rivers is 7.2 to 7.8 (ANZECC 2000). A pH outside of this range indicates an increased risk of adverse effects on the aquatic ecosystem. Extreme pH levels outside this range can have a significant detrimental impact either by causing fish kills and/or changing the availability and solubility of chemicals, such as nutrients, within the water column. Water can become more alkaline (increased pH) if the amount of photosynthesis by plants or algae is high.

The seven sites have similar pH fluctuating around 7.1 to 7.3, except for Ruahuia Stream, which tends to have a slightly higher pH (more alkaline) with an average of 7.7, as shown in table 7 (below). Similarly to conductivity this is likely to be a natural occurrence due to the geology of this site.

All the sites, except the lowest site on the Otarao Stream by Mangakahia River and the small headwaters site on the unnamed tributary, had at least 50 percent of their samples comply with the ANZECC trigger values of 7.2 to 7.8 pH units.

Table 7: Average and range of pH at the seven Otarao catchment sites from June 2002 to July 2006, with the percentage that comply with the trigger values for the protection of aquatic ecosystems (ANZECC 2000)

Site	Average pH (pH unit)	Range (pH unit)	% comply
1. Otarao Stream near Mangakahia	7.1	6.6 – 7.9	31
2. Unnamed tributary to Otarao	7.3	6.8 – 9.2	50
3. Ruahuia Stream at the viaduct	7.7	6.9 – 8.3	61
4. Tarakiekie Stream near Otarao	7.3	6.7 – 7.7	75
5. Otarao Stream near Tarakiekie	7.3	6.9 – 7.8	78
6. Mangakahia River near Otarao	7.4	6.9 – 7.9	64
7. Headwaters of unnamed tributary	7.1	6.5 – 7.5	45

4.1.5 Water clarity and turbidity

Water clarity and turbidity are directly related and are basically a measure of the amount of solids suspended in the water or how clear the water is. Water clarity (visibility) is important for the survival of stream biota, recreational use and for aesthetic value. Some fish and macroinvertebrates need visual cues for feeding and breeding. Many macroinvertebrates are filter feeders; so high sediment loadings can affect their ability to feed. Poor water clarity limits the amount of light reaching the

streambed which aquatic plants need to grow. High sediment loadings can also be an indication of potentially high bacteria and nutrient levels, as they can attach to sediment particles and get carried into the stream from catchment runoff. Poor water clarity can also be related to high algal biomass.

4.1.5.1 Water clarity

Water clarity in streams is measured using a black disc and is the distance until the disc disappears from view on a vertical plane. Water clarity tends to be better (highest) in Ruahuia Stream at the viaduct with an average of 2.36 m and the worse in Otarao Stream near Mangakahia River with an average of 0.77 m, as shown in figure 4 (below).

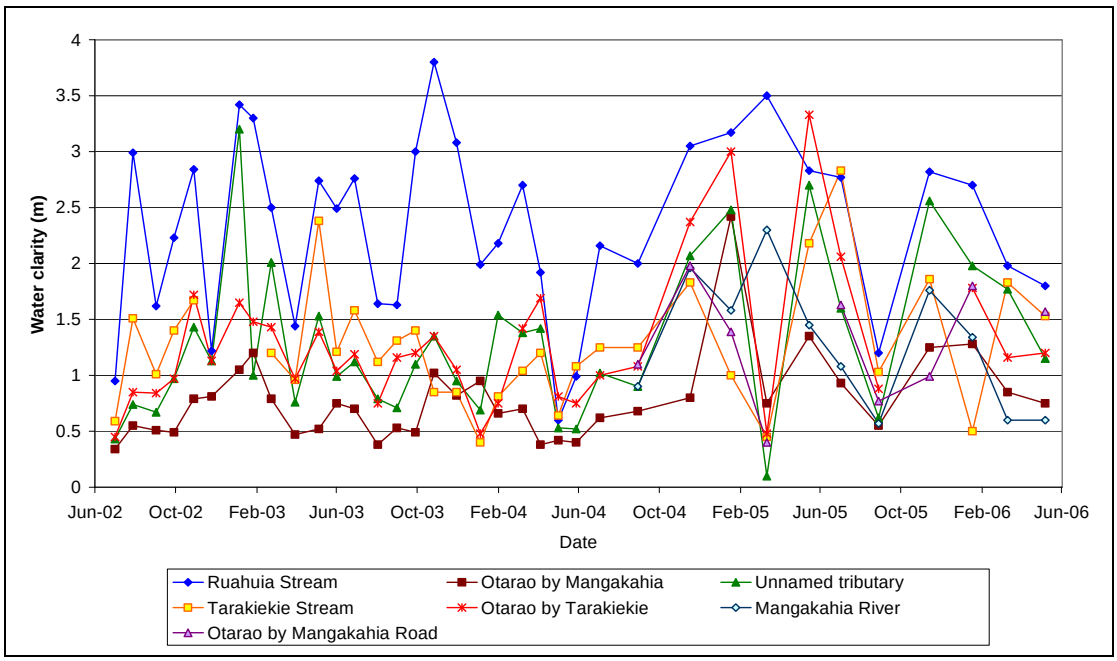

Figure 4: Water clarity (black disc readings) for all seven sites sampled in the Otarao catchment

Water clarity complies with the ANZECC (2000) trigger value for the protection of aquatic ecosystems on all but one of the sampling occasions at the Ruahuia Stream site, as shown in table 8 (below). The percentage of sampling occasions that comply with this ANZECC trigger value for the other six sites are also reasonably good, with at least 65% complying for each site.

However the ANZECC trigger value of 0.6 m for a New Zealand lowland river is conservative and it may be more appropriate to use the guideline of 1.6 m for water managed for the purpose of contact recreation taken from the Regional Water and Soil Plan for Northland (NRC 2004). If the guideline of 1.6 m is used, only three to 33% of sampling occasions comply with the guideline for each of these six sites.

Table 8: Average and range of black disc readings (m) for the seven Otarao catchment sites from June 2002 to July 2006, with the percentage that comply with the trigger values for the protection of aquatic ecosystems (ANZECC 2000)

Site	Average water clarity (m)	Range (m)	% comply
1. Otarao Stream near Mangakahia	0.77	0.34 – 2.42	65
2. Unnamed tributary to Otarao	1.29	0.10 – 3.20	89
3. Ruahuia Stream at the viaduct	2.36	0.60 – 3.80	97
4. Tarakiekie Stream near Otarao	1.33	0.45 – 2.83	88
5. Otarao Stream near Tarakiekie	1.31	0.45 – 3.33	92
6. Mangakahia River near Otarao	1.32	0.57 – 2.30	73
7. Headwaters of unnamed tributary	1.22	0.40 – 1.98	89

4.1.5.2 Turbidity

Consistent with the water clarity results the site in the headwaters of the Otarao at the viaduct tends to have the best (lowest) turbidity, with an average of 3.5 NTU and a 77% sample compliance rate with the ANZECC trigger value of 5.6 NTU, as shown in table 9 (below). While the lowest site in the catchment near the Mangakahia River tends to have the worst turbidity with an average of 11.4 NTU and only a 26% sample compliance rate with the ANZECC trigger value.

Table 9: Average and range in turbidity readings for the seven Otarao catchment sites from June 2002 to July 2006, with the percentage that comply with the trigger values for the protection of aquatic ecosystems (ANZECC 2000)

Site	Average turbidity (NTU)	Range (NTU)	% comply
1. Otarao Stream near Mangakahia	11.4	1.5 – 43.0	26
2. Unnamed tributary to Otarao	7.6	0.4 – 27.0	49
3. Ruahuia Stream at the viaduct	3.5	0.2 – 11.9	77
4. Tarakiekie Stream near Otarao	6.3	0.2 – 55.0	66
5. Otarao Stream near Tarakiekie	7.8	0.3 – 75.0	49
6. Mangakahia River near Otarao	6.9	2.1 – 21.0	64
7. Headwaters of unnamed tributary	10.1	1.5 – 68.0	82

4.1.6 Nutrients

Nutrients such as phosphorus and nitrogen are important for plant and algal growth. High nutrient loadings often cause excessive growth of nuisance plants, which choke out native plants and can restrict water flow, possibly causing flooding and/or anoxic (low oxygen) events. High nutrients levels can also lead to algal blooms. The likely source of nutrients in the Otarao catchment is agricultural and forestry surface run off, particularly in heavily stocked areas or where stock have access to the stream. There is also potential for contamination from poorly positioned, designed or maintained septic tanks in the catchment; however this risk is extremely low in the Otarao.

4.1.6.1 Nitrate/nitrite nitrogen

All the samples collected from the unnamed tributary, Ruahuia Stream, Mangakahia River and headwaters of unnamed tributary sites comply with the ANZECC trigger value for nitrate/nitrite nitrogen (NNN) of 0.444 g/m^3, while only 81% of the samples at Otarao by Mangakahia comply with the trigger value, as shown in table 10 (below).

Table 10: Average and range of NNN results for the seven Otarao catchment sites from June 2002 to July 2006, with the percentage that comply with the trigger values for the protection of aquatic ecosystems (ANZECC 2000)

Site	Average NNN (g/m^3)	Range (g/m^3)	% comply
1. Otarao Stream near Mangakahia	0.338	0.044 – 1.27	81
2. Unnamed tributary to Otarao	0.111	0.001 - 0.425	100
3. Ruahuia Stream at the viaduct	0.026	0.001 – 0.066	100
4. Tarakiekie Stream near Otarao	0.119	0.001 – 1.30	94
5. Otarao Stream near Tarakiekie	0.110	0.001 – 0.530	94
6. Mangakahia River near Otarao	0.088	0.001 – 0.284	100
7. Headwaters of unnamed tributary	0.035	0.001 – 0.115	100

Nitrogen levels (NNN) are highest at Otarao Stream by the Mangakahia River, with levels consistently high throughout the year. Nitrogen levels at the other six sites tend to peak in winter months, with lower levels recorded at the Ruahuia Stream site compared to the other five, as shown in figure 5 (below). While during summer months it is similar at these six sites.

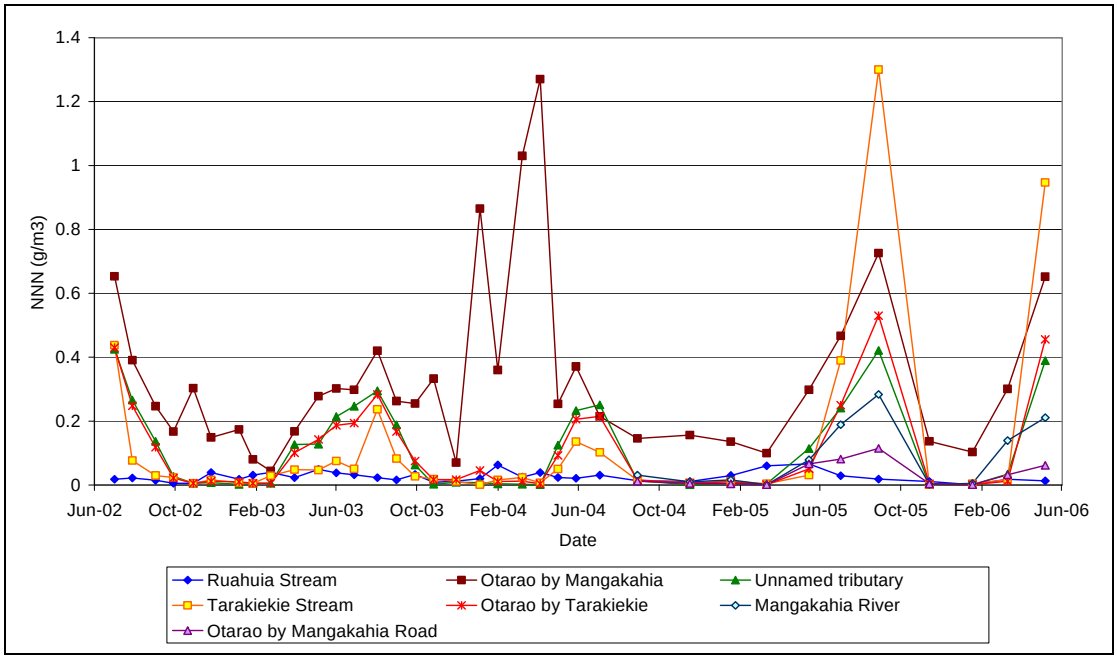

Figure 5: NNN results for all seven sites sampled in the Otarao catchment

4.1.6.2 Ammoniacal Nitrogen

Ammoniacal nitrogen (NH_4) levels tend to be higher at the lowest site in the catchment with an average of 0.14 g/m^3 and only 33% of the samples complying with the ANZECC trigger value of 0.021 g/m^3, as shown in table 11 (below) The average NH_4 at the headwaters site on the unnamed tributary is relatively high at 0.136 g/m^3, however this is skewed by the high level recorded on 5 April 2005 of 1.35 g/m^3, otherwise results are typically low for this site which is shown by the median of 0.02 g/m^3.

The rest of the sites have reasonably low levels of ammoniacal nitrogen on most occasions with at least 73 to 97% of their samples complying with the trigger value.

The only exception to this is an extreme NH_4 level in the end of April 2004 of 2.02 g/m^3, this could be from cattle defecating in and/or by the stream.

Table 11: Average and range of ammoniacal nitrogen results for the seven Otarao catchment sites from June 2002 to July 2006, with the percentage that comply with the trigger values for the protection of aquatic ecosystems (ANZECC 2000)

Site	Average NH_4 (g/m^3)	Range (g/m^3)	% comply
1. Otarao Stream near Mangakahia	0.14	0.005 – 2.02	33
2. Unnamed tributary to Otarao	0.076	0.005 – 2.02	86
3. Ruahuia Stream at the viaduct	0.012	0.005 - 0.4	97
4. Tarakiekie Stream near Otarao	0.041	0.005 – 0.74	81
5. Otarao Stream near Tarakiekie	0.023	0.005 – 0.28	92
6. Mangakahia River near Otarao	0.013	0.005 – 0.03	73
7. Headwaters of unnamed tributary	0.136	0.005 – 1.35	82

4.1.6.3 Dissolved reactive phosphorus

Dissolved reactive phosphorus (DRP) is a measure of soluble phosphorus (i.e. the amount that is readily available for algae and aquatic plant growth). DRP tends to be higher in Ruahuia Stream at the viaduct with an average of 0.036 g/m^3 and in fact only one sample collected from this site complies with the ANZECC trigger value of 0.01 g/m^3, as shown in table 12 (below). This is likely to be a natural phenomenon as a result of the geology at this site. The lowest site in the catchment by Mangakahia River also tends to have elevated DRP with an average of 0.41 g/m^3 and only 8% of the samples complying with the trigger value.

The other five sites tend to have similar levels of DRP, with 44 to 73% of their samples complying with the trigger value. Unlike NNN above, dissolved reactive phosphorus tends to peak during summer at all the sites.

Table 12: Average and range of DRP results for the seven Otarao catchment sites from June 2002 to July 2006, with the percentage that comply with the trigger values for the protection of aquatic ecosystems (ANZECC 2000)

Site	Average DRP (g/m^3)	Range (g/m^3)	% comply
1. Otarao Stream near Mangakahia	0.041	0.002 – 0.273	8
2. Unnamed tributary to Otarao	0.036	0.002 – 0.389	61
3. Ruahuia Stream at the viaduct	0.036	0.01 – 0.288	3
4. Tarakiekie Stream near Otarao	0.061	0.003 – 0.947	44
5. Otarao Stream near Tarakiekie	0.048	0.002 – 0.467	44
6. Mangakahia River near Otarao	0.026	0.002 – 0.211	73
7. Headwaters of unnamed tributary	0.013	0.004 – 0.062	64

4.1.6.4 Total phosphorus

Total phosphorus includes all the forms of phosphate including DRP, except those bound in sediment. Total phosphorus (TP) tended to be highest at the lowest site in the catchment (Otarao Stream by Mangakahia River) with an average of 0.11 g/m^3, as shown in table 13 (below). A total phosphorus value of 3.05 g/m^3 was recorded from Otarao by Mangakahia River in March 2003. This is extremely high and unusual compared to the other results from this site and the other sites on this day. This is

most likely to be contamination of the sample or bottle and therefore this value has been removed from the average.

Table 13: Average and range of TP results for the seven Otarao catchment sites from June 2002 to July 2006, with the percentage that comply with the trigger values for the protection of aquatic ecosystems (ANZECC 2000)

Site	Average TP (g/m^3)	Range (g/m^3)	% comply
1. Otarao Stream near Mangakahia	0.110	0.029 – 3.05	3
2. Unnamed tributary to Otarao	0.084	0.014 – 0.68	33
3. Ruahuia Stream at the viaduct	0.039	0.02 – 0.209	53
4. Tarakiekie Stream near Otarao	0.10	0.014 – 0.80	36
5. Otarao Stream near Tarakiekie	0.072	0.012 – 0.535	33
6. Mangakahia River near Otarao	0.024	0.011 – 0.042	82
7. Headwaters of unnamed tributary	0.07	0.018 – 0.44	36

Consistent with DRP, total phosphorus also tends to peak in the summer months for all the sites, as shown in figure 6 (below). Only one of the TP results for this lowest site in the catchment complies with the ANZECC trigger value of 0.033 g/m^3. Around 33 to 36% of the samples from the unnamed tributary, Tarakiekie Stream, Otarao near Tarakiekie and headwaters of the unnamed tributary sites comply with the trigger value, while 53% at the viaduct and 82% at the Mangakahia River comply.

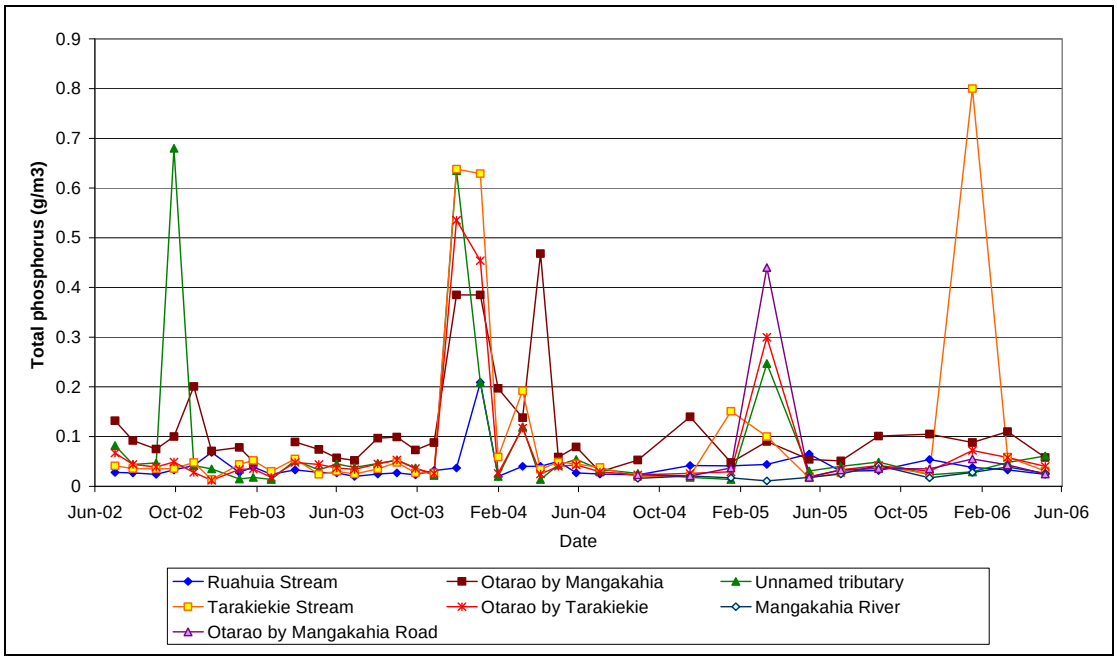

Figure 6: Total phosphorus results for the seven sites sampled in the Otarao catchment. Note: The high result of 3.05 g/m3 on 18 March 2003 has been removed

4.1.7 Bacteria

The level of bacteria in the water is important for drinking water, both human consumption and stock drinking water, and contact recreation. *Escherichia coli* (*E. coli*) is a bacteria species from a group of bacteria known as faecal coliforms, which are found in the intestines of animals. *E. coli* is generally harmless but has a strong correlation with dangerous pathogens such as *Giardia* and other waterborne

diseases. So a high *E. coli* level is a good indicator of contamination from animal waste and suggests that the water is not suitable for drinking or contact recreation.

E. coli numbers tends to be greater at the Ruahuia Stream site in the headwaters of the catchment with an average of 1664 MPN/100mL and only 11% of the samples complying with the contact recreational guideline of 260 *E. coli*/100mL (MFE 2003), as shown in table 14 (below). There is no stock or houses above this site, so the only possible source of contamination is feral animals such as pigs, goats, possums and birds or the decay of leaf litter (which is quite prevalent at this site). During site visits, goats and faecal material from feral animals has been seen by the stream. Any animal waste that reaches the stream will easily cause elevated bacterial levels at this site, as the base flow this high up in the catchment is low and therefore there is less dilution. It is also obvious that there are feral animals in the bush grazing on the understorey, as there are large areas of bare soil. Any animal waste sitting on this bare soil can get washed into the stream in heavy rain, causing elevated bacterial levels.

The other six sites have moderate bacterial water quality, complying with the contact recreational guideline of 260 E. coli/100mL for 50 to 78% of sampling occasions. However this scenario looks much worse when you compare the results to the national standards for drinking water (MOH 2000), which state that water is only fit for human consumption if it contains less than 1 *E. coli* cell per 100 ml, which basically means no bacteria in the water. This means that the water from all of the sites, without treatment, according to the NZ Drinking water standards are not safe for human consumption.

Table 14: Average and range of E. coli results for the seven Otarao catchment sites from June 2002 to July 2006, with the percentage that comply with the contact recreation guideline (MFE 2003)

Site	Average E. coli (MPN/100 mL)	Range (MPN/100 mL)	% comply
1. Otarao Stream near Mangakahia	409	10 – 1723	57
2. Unnamed Trib to Otarao	249	41 – 1539	78
3. Ruahuia Stream at the viaduct	1664	74 – 17329	11
4. Tarakiekie Stream near Otarao	659	10 – 5475	56
5. Otarao Stream near Tarakiekie	765	30 – 15531	50
6. Mangakahia River near Otarao	337	108 – 1130	64
7. Headwaters of unnamed trib	478	52 - 2481	73

4.2 Water quality summary

4.2.1 Ranking of sites for aquatic ecosystems

The sites are ranked below in terms of quality for aquatic ecosystems based on all the water quality results above. Ruahuia Stream at the viaduct is the least impacted site, providing high water quality for aquatic ecosystems. However now with another 12 sampling occasions there is very little difference between this site and the next five, which show moderate to high water quality for aquatic ecosystems. Otarao Stream near Mangakahia River (the lowest site in the catchment) continues to be ranked the lowest with poor water quality.

1. 70.4% - Ruahuia Stream at the viaduct
2. 69.0% - Headwaters of unnamed tributary
3. 67.3% - Mangakahia River upstream of Otarao
4. 61.6% - Unnamed tributary upstream of Otarao
5. 61.3% - Tarakiekie Stream upstream of Otarao
   61.3% - Otarao Stream downstream of Tarakiekie
6. 32.0% - Otarao upstream of Mangakahia

4.2.2 Ranking of sites for recreational use

The sites below are ranked in terms of their suitability for contact recreation based on the percentage of samples that comply with the freshwater bathing standard of 260 *E. coli*/100mL (MFE 2003). Although Ruahuia stream at the viaduct has high water quality in relation to aquatic ecosystems it has the lowest ranking in relation to its suitability for swimming.

1. 78% (249/100mL) – Unnamed tributary upstream of Otarao
2. 73% (478/100mL) – Headwaters of unnamed Tributary
3. 64% (337/100mL) – Mangakahia River upstream of Otarao
4. 57% (409/100mL) – Otarao Stream upstream of Mangakahia
5. 56% (659/100mL) – Tarakiekie Stream upstream of Otarao
6. 50% (765/100mL) – Otarao Stream downstream of Tarakiekie
7. 11% (1664/100 mL) - Ruahuia Stream at the viaduct

4.3 Rainfall data

The daily rainfall data for the two rain gauges in the Otarao catchment has been summarised into typical statistics in tables 15 and 16 (below). This includes monthly average, daily average, average daily maximum and average number of days a month with zero rainfall for the four years of available data.

Table 15: Average monthly, daily, daily maximum and number of days with zero rainfall from June 2002 to June 2006 collected from Rain Gauge A, located off Kirikopuni Road

Averages	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly	106	112	111	91	178	175	155	154	131	120	79	102
Daily	3.4	3.9	3.6	3.0	5.7	5.8	5.0	5.0	4.4	3.9	2.6	3.3
Daily max	46	25	30	28	41	40	37	28	32	29	25	31
Zero days	10	13	15	16	18	17	19	23	16	18	16	13

Table 16: Average monthly, daily, daily maximum and number of days with zero rainfall for June 2002 to June 2006 collected from Rain Gauge B, off Mangakahia Road

Averages	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly	103	98	109	103	169	165	165	134	114	129	69	89
Daily	3.3	3.4	3.5	3.4	5.5	5.5	5.3	4.3	3.8	4.2	2.3	2.9
Daily max	41	30	41	36	47	36	47	28	22	34	22	23
Zero days	12	12	14	17	22	19	20	21	18	17	13	15

It becomes apparent after looking at the data that rainfall is reasonably varied throughout the year and even within the catchment. However there are a few observations that can be noted:

- June 2002 was extremely wet with 317 mm rainfall recorded in one rain gauge and 291 mm in the other, as shown in figures 7 and 8 (below). However, 70 mm of this fell in one day and there were in fact still 24 days with no rain in this month.

- March 2004 was extremely dry with 14 and 17 mm recorded, as was March 2005 with 24 and 27 mm recorded, while March 2003 was quite wet with an average rainfall of 222 mm.

- On the other hand February 2004 was quite wet with an average rainfall of 237 mm, in comparison to February this year (2006) where an average rainfall of 36 mm was recorded.

- On average, May, June and July tend to be the wettest months of the year. However in some years they still can have 20 or more days in a month with zero rainfall.

- In general, November and December tend to be the driest months with typically less than 100 mm rainfall recorded in a month.

- Rainfall tends to be greater at the location of rain gauge A on Kirikopuni Road with an average annual rainfall of 1557 mm, compared to 1488 mm from rain gauge B off Mangakahia Road. This is not unexpected as rain gauge A is located higher in the catchment, and therefore we would expect it to receive slightly more rainfall a year.

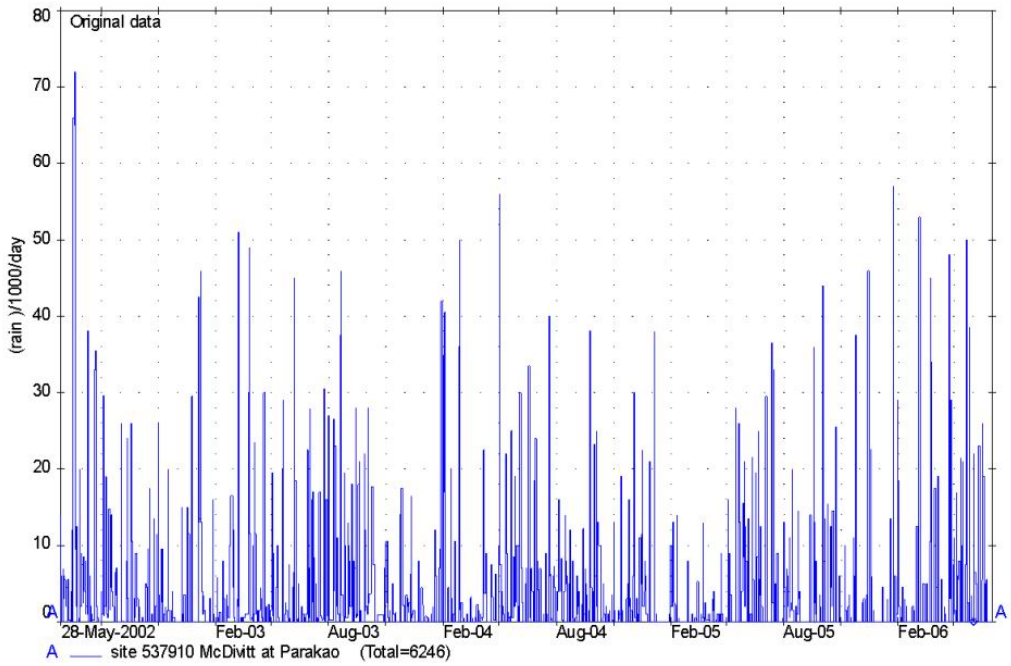

Figure 7: Daily rainfall measurements (mm) from Rain Gauge A on Kirikopuni Road

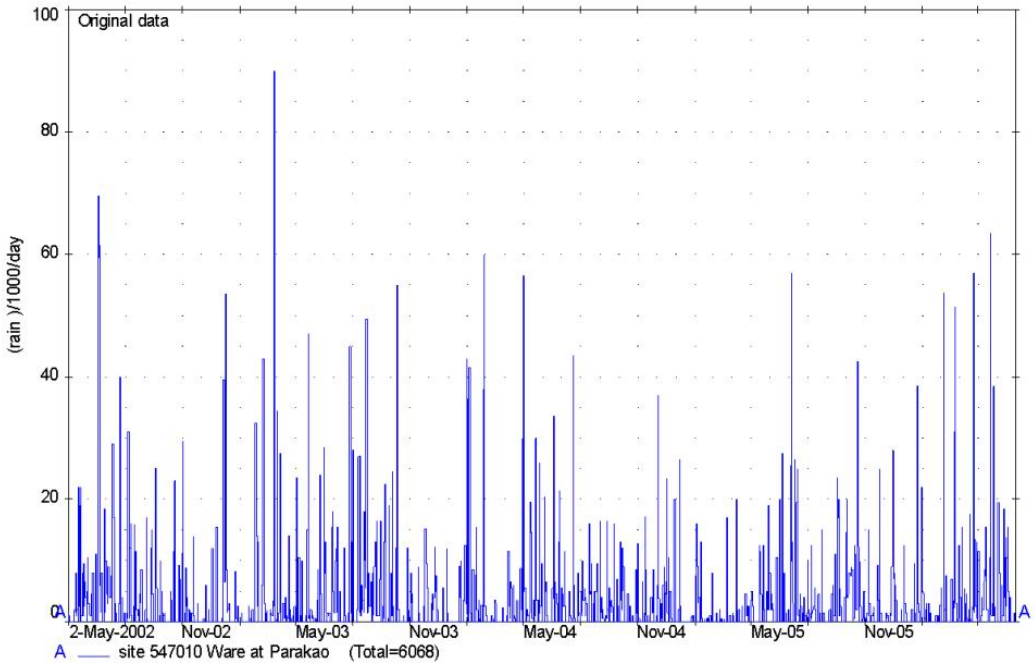

Figure 8: Daily rainfall measurements (mm) from Rain Gauge B on Mangakahia Road

4.4 Stream Biota

4.4.1 Macroinvertebrates

Macroinvertebrates samples have been collected on three occasions. The average number of taxa, Macroinvertebrate Community Index score (MCI), Semi-Quantitative MCI scores (SQMCI) and percentage of Ephemeroptera, Plecoptera and Trichoptera taxa (%EPT taxa) are shown in table 17 (below). The native forest site at the viaduct has a high average MCI score of 136, which indicates very clean and clear water with

minimal disturbance. This site has a good diversity of high scoring pollution sensitive taxa such as stoneflies, dobsonflies, mayflies and caddisflies.

Table 17: Average number of taxa, MCI, SQMCI and percentage of EPT taxa for 6 sites in the Otarao catchment. Note: The unnamed tributary and Tarakiekie Stream (results marked with asterisk) were only sampled on one occasion and therefore are not averages.

Site	Otarao by Mangakahia River	Otarao at Mangakahia Rd	Otarao by Tarakiekie	Ruahuia at Viaduct	Unnamed tributary	Tarakiekie Stream
Number of taxa	9	11	12	20	6*	11*
MCI	73	93	84	136	73*	93*
SQMCI	3.9	4.6	4.2	7.0	4.0*	4.2*
%EPT (taxa)	3	29	14	65	17*	9*

The extra site sampled for macroinvertebrates where the Otarao Stream intercepts with Mangakahia Road, chosen because of its better habitat quality, scored quite well. This site has fences to exclude stock and riparian vegetation, particularly mature trees that provide shade and leaf litter to the stream. Several EPT taxa were present at this site on all three sampling occasions, mainly mayflies and caddisflies. It also had the second highest average MCI and SQMCI scores.

Interestingly, this site is likely to have degraded water quality to some extent as it is so far down in the catchment, further downstream then the Otarao by Tarakiekie site; however this site was ranked second of the six sites sampled. If you look at figures 9, 10 and 11 in which the sites are arranged from the most downstream to upstream, it is clear that this site on the Otarao by Mangakahia Road has a higher value macroinvertebrate community then the Otarao by Tarakiekie site further upstream. This highlights the value of good canopy cover and instream habitat including deep pools, woody debris and leaf litter. So even though this site is likely to have degraded water quality in terms of nutrient and sediment levels, the lower water temperatures, better dissolved oxygen levels and greater instream variability provides better habitat for invertebrate and fish communities.

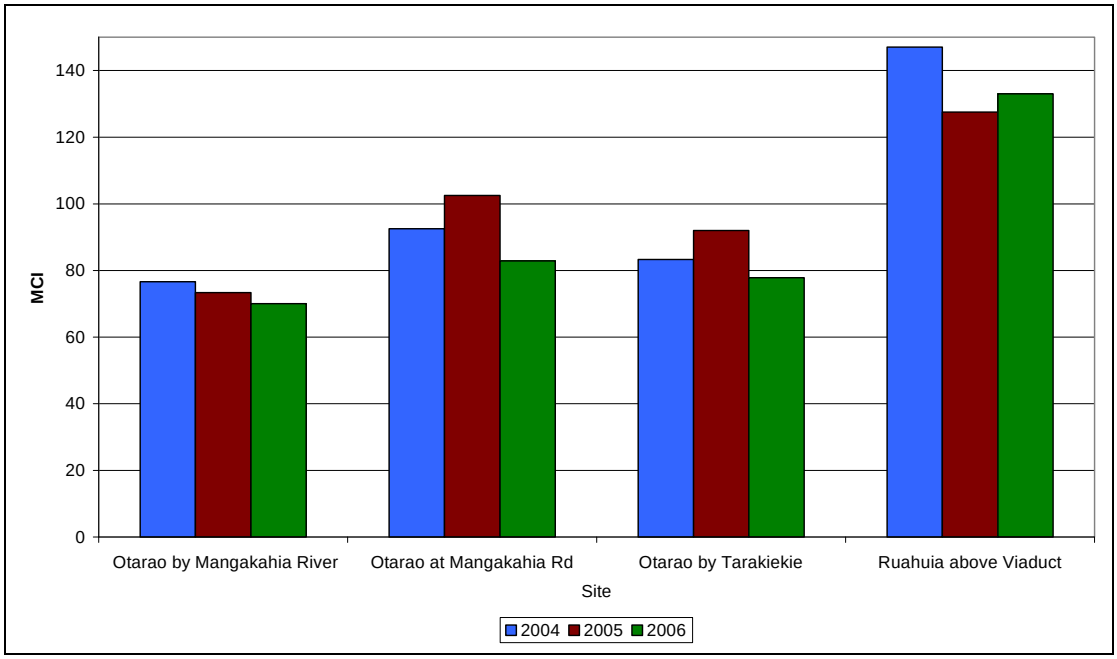

Figure 9: MCI at the four Otarao sites sampled on three occasions

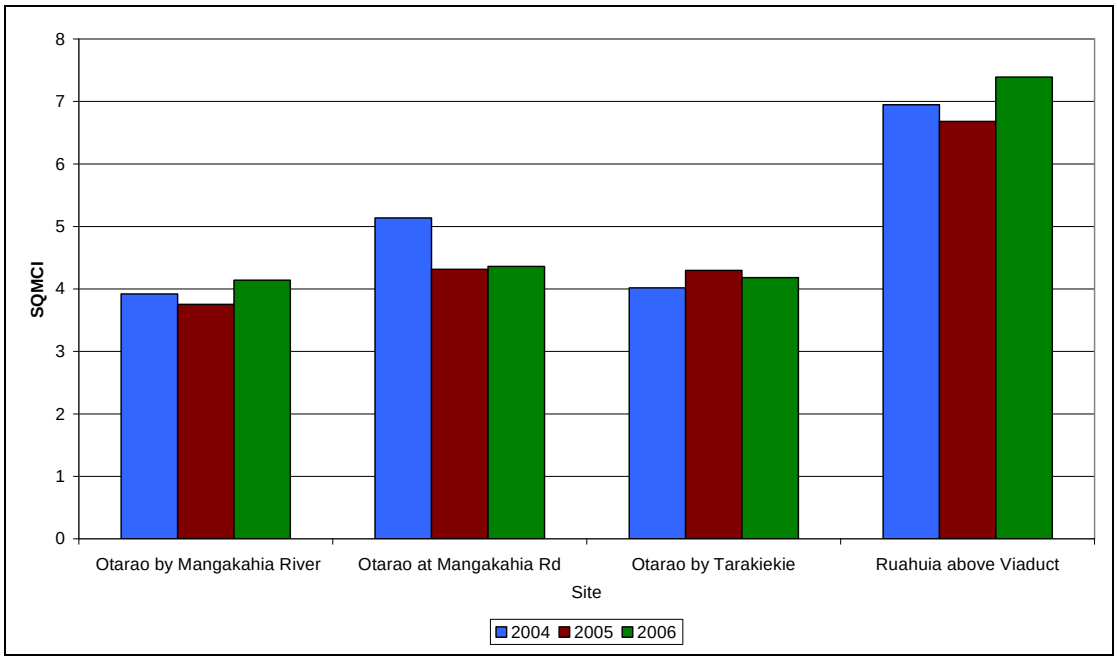

Figure 10: SQMCI at the four Otarao sites sampled on three sampling occasions

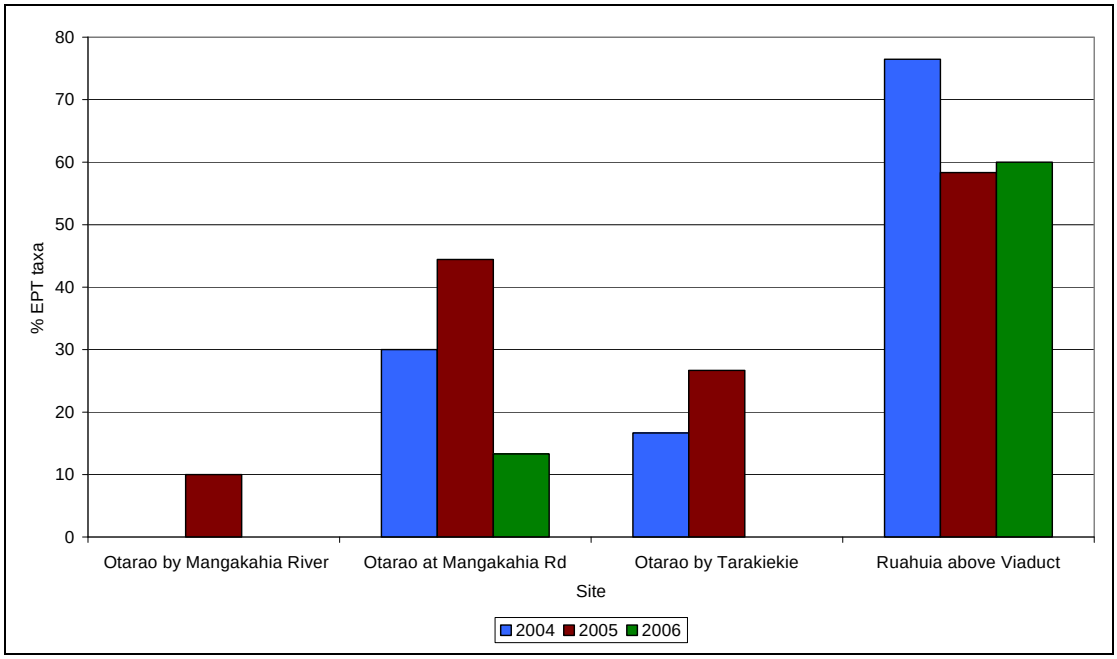

Figure 11: Percentage of EPT taxa at the four Otarao sites sampled on three occasions

The macroinvertebrate communities in Tarakiekie Stream and in Otarao Stream by Tarakiekie and at Mangakahia Road indicate probable organic pollution and/or moderate disturbance, while communities in the unnamed tributary and the lowest site in the catchment by Mangakahia River indicate severe pollution and impacted water quality.

4.4.2 Fish survey

At the lowest site in the catchment Otarao by Mangakahia River, only two fish species were caught during the survey carried out in December 2004. They were short fin eels, which were abundant, and common smelt, which were occasional. At the highest site in the catchment Ruahuia Stream (but directly below the viaduct) four fish species were found; short fin and long fin eels (both common), crans bully (abundant) and banded kokopu (rare). Although the fish diversity was found to be low, at least all fish found at these two sites were native.

It was suggested that different sampling methods such as spotlighting, would most likely identify higher numbers of fish and different species (Bruno David, pers. comm. 2004). It would also be worth surveying further sites and at different times of year.

5 Summary

- Temperature and dissolved oxygen varied between sites and through seasons. The highest temperatures and lowest dissolved oxygen levels were recorded at the lowest site in the catchment near the Mangakahia River, while the headwaters site (Ruahuia Stream) had consistently good temperature and dissolved oxygen levels showing less variation through the year.

- Although, conductivity was often highest at the headwater site, it is likely this is of natural origin, rather than an indication of pollution. Likewise the headwater site has slightly higher pH than the other six sites.

- As expected, water clarity and turbidity was best at the headwater site and worst at the lowest site in the catchment.

- The greatest concern in terms of nutrients levels in the Otarao is phosphorus. Both dissolved reactive phosphorus and total phosphorus exceed the ANZECC trigger values at all sites on several occasions. The elevated DRP at the headwater site is likely to be natural. Nitrogen and ammoniacal nitrogen levels are elevated at the bottom site in the catchment on several sampling occasions. This contamination is a result of cumulative nutrient inputs from the catchment.

- Bacterial levels were typically highest at the headwater site. This is likely to be from leave decay and faecal material from feral animals such as goats, pigs and possums. The other six sites had bacterial levels that exceeded the recreational bathing guideline of 126 E. coli/100mL on more than half there sampling occasions.

- Rainfall is reasonably varied throughout the year and the catchment.

- The macroinvertebrate communities in Tarakiekie Stream, Otarao Stream by Tarakiekie and Otarao at Mangakahia Road indicate probable organic pollution and/or moderate disturbance, while the communities in the unnamed tributary and lowest site in the catchment by Mangakahia River indicate severe pollution and impacted water quality. The macroinvertebrate community at the Ruahuia Stream headwater sites indicates good water quality/pristine conditions.

- At the lowest site in the catchment only short fin eels and common smelt were caught, while at the highest site in the catchment short fin and long fin eels, crans bully and banded kokopu were recorded.

6 Recommendations

There is now four years (36 data points) for the five original sites sampled in the Otarao Catchment. This provides sufficient background information to detect any changes in water quality as a result of improved farming practices within the catchment over the next 5 – 10 years. It is recommended that sampling be reduced to monthly at the bottom site in the catchment (Otarao Stream near Mangakahia River) for the next two to three years. This site shows the effect of the entire catchment on water quality and can be used for long term trend analysis.

After this reduced sampling period, an assessment should be made on how much change has occurred within the catchment and whether it is warranted to reinstate the initial sampling regime of monthly water quality sampling at five sites. This should be done for three to four years (on the approval of budget) to obtain an equivalent data set for comparison. Also monitoring of macroinvertebrates should be carried out three times, in February to April of each year for comparison.

7 Acknowledgements

Thank you to all those landowners that have allowed Regional Council access across their land to collect samples each month and a special thank you to the two landowners that have collected daily rainfall data for the last four years.

Appreciation needs to go out to the active members of the Mangakahia Landcare group that initiated this project and all the landowners and other interested parties that have kept the project on track, attending water quality field days, planting days and meetings. Also to the landowners within the catchment that have already taken so much on board from this project and successfully fenced of streams and wetlands, held planting days on their property and improved their farm management practices in general. Congratulations everyone for a job well done so far but keep up the hard work.

Finally, thank you to all the staff at the Department of Conservation, Northland Regional Council and New Zealand Landcare Trust that have been involved with the four years of the project thus far.

8 References

ANZECC (2000) *Australian and New Zealand guidelines for fresh and marine water quality.* Australian and New Zealand Environment and Conservation Council.

APHA (1998). *Standard methods for the Examination of Water and Wastewater*, 20th edition. American Public Health Association: 1015 15th Street NW, Washington, DC 20005-2605.

Boothroyd, I.K.G. and Stark, J.D. (2000) Use of invertebrates in monitoring. *In: New Zealand stream invertebrates: ecology and implications for management.* New Zealand Limnological Society, Christchurch. p 357.

Cook, T. (2004). *Otarao Catchment study water quality results: July 2002 to June 2004.* Report published by Northland Regional Council, Whangarei.

Hall, G. (2003) *Otarao Catchment water quality results.* Northland Regional Council, Whangarei.

Ministry for the Environment. (2003) *Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas.* Ministry for the Environment, Wellington.

Ministry of Health. (2000) *Drinking water standards for New Zealand 2000.* Ministry of Health, Wellington.

NRC (2004) *Regional Water and Soil Plan for Northland.* Northland Regional Council: Whangarei, New Zealand. Section 7.8(a), p 53.

Stark, J.D.; Boothroyd, I.K.G.; Harding, J.S.; Maxted, J.R. and Scarsbrook, M.R. (2001) *Protocols for sampling macroinvertebrates in wadeable streams.* Prepared for the Ministry for the Environment

9 Appendices

9.1 APPENDIX A: Relevant Guidelines

The results for the Otarao catchment were compared to a range of guidelines depending on the parameter and water use. The main guidelines used were the trigger values for the protection of slightly disturbed aquatic ecosystems designed for physical and chemical stressors in New Zealand lowland rivers (altitude < 150 m) (ANZECC 2000). These are displayed in Table 18. As the visual clarity guideline is rather lenient at 0.6 m, black disc readings were also compared to the guideline for contact recreation purposes in the Regional Water and Soil Plan for Northland (NRC 2004) which is 1.6 metres.

Table 18: Trigger values for the protection of aquatic ecosystems in New Zealand (ANZECC 2000)

Parameter	Guideline Value
Total Phosphorous (TP)	0.033 g/m3
Dissolved Reactive Phosphorous (DRP)	0.010 g/m3
Nitrate-Nitrite Nitrogen (NNN)	0.444 g/m3
Total Ammoniacal Nitrogen (NH4-N)	0.021 g/m3
Dissolved Oxygen (% saturation)	98 - 105%
pH	7.2 – 7.8
Visual Clarity	0.6 m
Turbidity	5.6 NTU

As children often play in the stream and water from the stream is used for stock water and human consumption, indicator bacteria levels (namely *E. coli*) were compared to the '*Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas*' (MFE 2003) and the '*New Zealand Drinking Water standards'* (MOH 2000). The guidelines for freshwater recreational areas is no single sample greater than 260 E. coli/100mL, while the drinking water standards state that water is only fit for human consumption with less than 1 E. coli per 100 mL sample.