ASSESSMENT OF ECOLOGICAL EFFECTS ON THE RUAMAHANGA RIVER, SOUTH WAIRARAPA

FROM THE MARTINBOROUGH WASTEWATER TREATMENT PLANT

PROJECT NO.
EAM298

PREPARED FOR
SOUTH WAIRARAPA DISTRICT COUNCIL

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EXECUTIVE SUMMARY

South Wairarapa District Council (SWDC) operates and maintains a wastewater treatment plant that services the requirements of the approximately 1500 residents of Martinborough. Treated wastewater from the Martinborough Wastewater Treatment Plant (MWWTP) is ultimately discharged to the Ruamahanga River as permitted under Resource Consent WA970079 [30753] which expires on 10 July 2012.

SWDC are currently considering options for increased treatment of the effluent prior to discharge to the Ruamahanga River. As such, SWDC are applying to GWRC for a short-term Resource Consent for the 'status quo' to assess these options.

To support their application for resource consent SWDC has engaged Environmental Assessments and Monitoring (EAM) Limited to prepare a report detailing the current environmental effects to the aquatic receiving environment of the Ruamahanga River as a direct result of the current discharge.

The Regional Freshwater Plan for the Wellington Region (GWRC 1999) recognises the Ruamahanga River as having regionally important recreational and amenity values such as, fishing, swimming, canoeing, kayaking, tubing, jet boating, and picnicking. With regards to Maori customery values, the Ruamahanga River as the most significant river in the Wairarapa Valley, is of high spiritual value to Wairarapa Iwi

In general terms the Ruamahanga suffers from high nutrient enrichment from agricultural runoff, and discharges from urban stormwater, and treated municipal sewage effluents. Nutrient concentration ratios indicate that the system is generally phosphorus limited; however periods of co-limitation are likely during low river flows.

Of the total contribution of contaminants to the Ruamahanga River, WWTPs represent only a small percentage.

Macroinvertebrate monitoring data indicates that the discharge from the MWWTP is having a negative effect on pollution sensitive taxa up to 200 m downstream. However, downstream data (500m downstream) indicates that effects are no more than minor.

Although there is relatively high nutrient enrichment in the Ruamahanga River, periphyton growth is largely kept in check by the high frequency of flood events that occur in this system. Calculations indicate that periphyton biomass is likely to reach levels exceeding guideline limits during periods of stables flows in excess of 10 to 15 days.

E. coli levels from monitoring data shows that they are typically below guideline levels for recreational values at all monitoring sites downstream of the MWWTP discharge. With the commissioning of a U. V system underway this should enhance the situation even further.

As with nutrient loads, visual clarity decreases significantly with distance downstream in the Ruamahanga River with the highest clarity being at times of low flow. Calculations indicate that MWWTP is unlikely to cause significant changes in visual clarity considering the large dilution factors occurring in the river at the point of discharge.

Dissolved oxygen levels are relatively stable throughout the Ruamahanga main stem however this data may be misleading due to the time of day that these have been monitored historically. The discharge from the MWWTP is unlikely to cause significant decreases in dissolved oxygen in the Ruamahanga River.

The Ruamahanga River system supports around 36 species of fish with the three major families being the galaxiids, the bullies, and the eels. The species most frequently recorded are the longfin eel, brown trout, shortfin eel and brown mudfish. Of the native fish identified in the catchment only four are non-migratory (dwarf galaxias, crans bully, upland bully, and brown mudfish). The high ratio of diadromous species listed in the Ruamahanga catchment illustrates that the lower Ruamahanga River is an important 'fish corridor' that allows many species to travel between upstream freshwater habitats and the sea. The discharge is unlikely to cause significant barriers to fish in the Ruamahanga River as it is unlikely to be present in toxic levels across the width of the river allowing fish to avoid any high concentrations should they occur. This is supported by the fact that most fish have been identified upstream of the MWWTP discharge point and that ammoniacal nitrogen in particular is likely to be below guideline limits after reasonable mixing has occurred.

As the ultimate receiving body for the Ruamahanga River, Lake Onoke is subjected to high contaminant loadings, particularly nutrients. To date there have not been any studies quantifying the effect(s) of the discharge from the MWWTP, or in fact any WWTP, to Lake Onoke. The MWWTP discharge (and associated contaminant loads) is relatively small in comparison to other point source and diffuse sources, to the Ruamahanga River. Therefore, while the MWWTP does indeed contribute to the contaminant loading and any cumulative effects to Lake Onoke, it is suggested that once the Masterton WWTP discharge is partially removed, the effects from the MWWTP to Lake Onoke will be less.

Overall, the MWWTP discharge to the Ruamahanga does appear to cause localised effects with regards to aquatic macroinvertebrates and periphyton growth. However, a greater concern for this catchment appears to be the inputs occurring from diffuse sources due to on-going agricultural intensification.

The planned scope of works as detailed in the current application aims at improving the discharge quality of the current system so that it complies with the standards (7 year) detailed in the original 1999 consent. An increase in the discharge quality is likely to result in improved receiving environment quality.

1. INTRODUCTION

1.1 BACKGROUND

South Wairarapa District Council (SWDC) operates and maintains a wastewater treatment plant that services the requirements of the approximately 1500 residents of Martinborough. Treated wastewater from the Martinborough Wastewater Treatment Plant (MWWTP) is ultimately discharged to the Ruamahanga River as permitted under Resource Consent WA970079 [30753] which expires 10 July 2012.

SWDC are currently considering options for increased treatment of the effluent prior to discharge to the Ruamahanga River. As such, SWDC are applying to GWRC for a short-term Resource Consent for the 'status quo'. As with any such application it is required, that an Assessment of Environmental Effects (AEE) be carried out.

A significant aspect of this AEE is to quantify the current ecological impacts resulting from the MWWTP. Environmental Assessments and Monitoring (EAM) Limited has been engaged by SWDC to prepare a report detailing the current environmental effects to the aquatic receiving environment of the Ruamahanga River as a direct result of the current discharge.

1.2 SCOPE

The structure of this report has been divided into three main components: (i) effluent quality and quantity; (ii) characterisation of the receiving environment and; (iii) the environmental impact assessment of the discharge.

1.3 BACKGROUND DISCUSSION ON SURFACE WATER QUALITY PARAMETERS

1.3.1 NUTRIENTS, PERIPHYTON AND AQUATIC MACROPHYTES

Periphyton refers to the brown and green slimes and algae present on the stones, wood, weeds and any other stable substrate in streams and rivers. The growth and type of periphyton present in a waterway is controlled by a number of environmental factors including habitat (local geology, substrate type, flow regimes, climate, surrounding landuse), water quality (temperature, and concentration of bioavailable nutrients specifically phosphorus and nitrogen), and the density of biota that interact with periphyton (e.g. grazing aquatic invertebrates) (Biggs 2000).

The amount of periphyton biomass in a stream is always fluctuating and is dependent on the dynamic equilibrium between periphyton growth and biomass loss (Ausseil 2011). Biomass loss occurs through two main processes; 1) physical removal during flood events through the movement of substratum, high water velocities, and abrasion by suspended solids; and 2) the amount of invertebrate grazing (Biggs 2000). In general, flood events decrease periphyton biomass to a lower level and the period between flood events is termed the "accrual period". It is during this accrual period that periphyton biomass increases to a "peak biomass" (Ausseil 2011).

It should be noted also that extremely long accrual periods can also result in high periphyton biomass even if nutrient concentrations are low (Biggs 2000).

In conjunction with other favourable factors (e.g. periods of sustained low flow and high sunlight penetration) high bio-available nutrient concentrations in the water column can increase peak biomass (and the time in which it is reached), likely resulting in undesirable periphyton proliferation (Wilcox, Biggs et al. 2007; Ausseil 2011).

Excessive periphyton growth can impact the aesthetic/recreational values, fishery values, and negatively impact aquatic biodiversity of waterbodies (Biggs 2000) and for these reasons nutrient-based guidelines or standards are often used as a way of limiting periphyton growth to acceptable levels in a waterway (Ausseil 2011). Furthermore, the proliferation of periphyton growth can lead to a number of serious problems in aquatic systems including altered flows, large diurnal fluctuations in dissolved oxygen concentrations, eutrophication (resulting from rotting plants/algae), and in some instances can contribute to the formation of algal blooms, which can be (in some instances) toxic to humans and animals.

The oxides of nitrogen (nitrate-and nitrite-nitrogen) and ammonia nitrogen are known collectively as Dissolved Inorganic Nitrogen (DIN) and represent the species able to be assimilated (used) directly by plants (Ausseil 2011). Dissolved Reactive Phosphorus (DRP) is a measure of orthophosphate, the filterable (soluble) fraction of phosphorus that is generally considered as the measurement of phosphorus directly taken up by plant cells.

Nitrogen and phosphorus are required for periphyton growth at an average weight ratio of 7.5:1 as defined in the Redfield equations (Stumm and Morgan 1996). A ratio of approximately 7.5 is the theoretical limit between N-limited (ratio <7.5) and P-limited (ratio >7.5) conditions (Ausseil 2011).

The ratio of DIN/DRP can provide an indication of whether DIN or DRP is the limiting nutrient for periphyton growth with elevated ratios >20 and low ratios <4 indicating P-limited conditions and N-limited conditions respectively. Ratios between 4 and 20 are inconclusive or can indicate that the nutrient limitation may change between nitrogen and phosphorus at different times of the year/flows (Ausseil 2011).

DIN:DRP ratios can help in determining which nutrient requires priority management in an aquatic system, however care should be taken when interpreting these ratios. In particular, DIN:DRP ratios measured at one site should not be used in isolation but rather a consideration on the likelihood of nutrient limitation should be assessed e.g. if unfavourable physical factors such as shading are present then periphyton growth is unlikely to attain nuisance levels, regardless of the concentration of bio-available nutrients present. Equally, if both nitrogen and phosphorus are present in high concentrations, then the controls exerted by nutrient concentrations will be largely non-existent regardless of DIN:DRP ratios – conditions often termed "un-limited" (Ausseil 2011).

In contrast to periphyton, macrophytes (large multi-celled flowering aquatic plants) are not limited by nutrient supply in the water column. Instead the primary source of nutrients is via sediments through their root system, and hence macrophytes tend to dominate in soft-bottomed waterways. The principal regulators of periphyton growth include, total nutrient input (soluble and particulate bound), channel and hydrological characteristics (e.g. depth and velocity), and most importantly light (Wilcox, Biggs et al. 2007).

1.3.1.1 GUIDELINES

Both the Resource Management Act (RMA) and the relevant statutory plan for the Ruamahanga River Catchment, the Regional Freshwater Plan for the Wellington Region (RFPWR), place narrative restrictions on granting permits for discharges to water, but neither document contains any regulation or numeric standard for nutrients concentrations in receiving waters. Both documents instead rely on case-by-case, effects-based assessment of wastewater discharge permit applications (Hickey, Norton et al. 2004).

For the purpose of this assessment the default trigger values in the (ANZECC 2000) guidelines were used as target values for nutrient concentrations. Guideline DRP and DIN concentrations are shown for upland (>150m elevation) and lowland streams and rivers in Table 1.

It should be noted that these 'trigger values' are only guidance and in any situation where the values identified are exceeded the ANZECC (2000) guideline process recommends environmental/ecological investigations be undertaken to assess consequences of increased nutrient concentrations. ANZECC (2000) then recommend that site specific nutrient values be determined to account for local conditions.

With respect to periphyton assessment, the New Zealand periphyton guidelines (Biggs, 2000) were used as reference values (Table 2) for periphyton biomass and cover. These guidelines provide an objective way of managing periphyton in New Zealand stony bottomed streams by exploiting the relationships between peak periphyton biomass and the various parameters that control growth, specifically these are river accrual periods (time between flood events, calculated as 3 x median flow) and nutrient concentrations in the water. The guidelines provide monthly mean concentration of DRP and DIN for various accrual periods. As the accrual period increases, the concentration of DRP and DIN that can be tolerated in a river without nuisance growth occurring is reduced.

The New Zealand periphyton guidelines recommend two maximum thresholds for periphyton biomass in gravel/cobble bed streams managed for trout habitat, and aesthetic/recreational values:

1. 50 mg chlorophyll-*a*/ m^2 for the protection of aquatic biodiversity
2. 120 mg chlorophyll *a*/ m^2 for the protection of trout habitat and aesthetics/recreational values.

Table 1: ANZECC default 'trigger values' for dissolved nutrient concentrations for the 95% protection level of species in a slightly disturbed New Zealand lowland stream. *Note: DIN concentration is calculated as the sum of the guideline values for NH_4-N and oxides of nitrogen (NO_X-N).

	DRP (g/m^3)	DIN (g/m^3)*
Upland streams	0.009	0.177
Lowland streams	0.010	0.465

Table 2: Periphyton biomass and cover guidelines (adapted from Biggs 2000, in Ausseil 2011)

Instream value	Diatoms/cyanobacteria		Filamentous algae	
	Biomass(mg Chlorophyll-a/m^2)	Cover (%)	Biomass (mg Chlorophyll-a/m^2)	Cover (%)
Biodiversity (reference conditions)	50	-	50	-
Aesthetics and recreation	-	-	120	30
Trout habitat and angling	200	60	120	30

As mentioned above, ANZECC (2000) guidelines recommend environmental/ecological investigations be undertaken to assess consequences of increased nutrient concentrations and that site specific nutrient values be determined to account for local conditions. Greater Wellington Regional Council (GWDC) are currently going through this process for the Ruamahanga River and the current draft of proposed water quality limits for the protection of in-stream values is shown in Table 3. It is important to note that these values are only in draft form and subject to further refinement. Further, it should be noted that these draft limits DO NOT carry any regional plan or regulatory status (Olivier Ausseil, pers. comm). The significance of these draft limits are discussed in later sections of this report.

1.3.2 AMMONIA

Ammonia can be toxic to many aquatic organisms, particularly cold water salmonoids and is a common pollutant in treated domestic, agricultural and industrial discharges. In aqueous solution, ammonia exists in two chemical forms: the ammonium cation (NH_4^+) and un-ionised ammonia (NH_3). Ammoniacal Nitrogen is the sum concentration of both the ammonium cation and unionised ammonia. The respective proportion of these two forms is determined by a chemical equilibrium governed by pH, temperature, and salinity. The toxicity of ammonia nitrogen is highly dependent on pH, temperature and salinity with the concentration of ammonia increasing with increasing pH and temperature and decreasing with increasing salinity. The higher the pH, and temperature the higher the proportion of un-ionised ammonia, which is by far the most toxic form to aquatic life.

ANZECC (2000) guidelines 'trigger values' define a maximum ammoniacal nitrogen concentration of 0.021mg/L for the 95% protection level of species in a slightly disturbed New Zealand lowland stream.

Table 3: GWRC proposed water quality limits for the protection of in-stream values in the Lower Ruamahanga River

Determinand	In-stream value	Recommended limit	Flow	Season
E.coli	CR	260/100mL	<median	Bathing
		550/100mL	<3*median	All
Nitrate-N	AE, TF	1.7 mg/L (chronic toxicity)	All	All
pH change	AE, TF	0.5 pH units	All	All
Temp change	AE, TF	3°C	All	All
Total ammonia-N		0.9 mg/L at pH=8 And 20°C Adjust for pH and temperature	All	All
Other toxicants	AE, TF	95% protection	All	All
Particulate organic matter	Ae, TF	5 mg/L	<median	All
$ScBOD_5$	AE, TF	2 mg/L	<3*median	All
Periphyton	AE, TF, CR	120 mg/m^2	All	All
		30% filamentous cover		
		60% filamentous cover (thick mats)		
DRP (annual average)	Periphyton growth	0.014 mg/L	<3*median	All
DIN (annual average)	AE, TF, CR	0.180 mg/L		
Water clarity	AE, TF	3 m	<median	All
Water clarity change	CR/amenity	<30% change	All	All
DO saturation	AE, TF	>80% saturation	All	All

1.3.3 MICROBIOLOGICAL WATER QUALITY – E.COLI

Escherichia coli (E. coli), which is a bacteria commonly measured in freshwater systems as an indicator of faecal contamination. If there is faecal contamination there is a possibility of the presence of disease-causing organisms such as bacteria, viruses and protozoa. These organisms may pose a health hazard when the water is used for recreational activities such as swimming, board riding and other high-contact aquatic activities.

The contact recreation guidelines (Ministry for the Environment and Ministry of Health 2003) define a three mode management system for recreational freshwaters as follows: acceptable/Green (*E.coli* <260cfu/100mL); Alert/Amber (*E.coli* <550cfu/100mL); and Red/Action (*E.coli* >550cfu/100mL). The red mode indicates an unacceptable level of risk to the health of recreational users (e.g. swimmers). These are single-value criteria designed to trigger further investigation and additional sampling (amber mode) and positive action to identify the source(s) of contamination and warn recreational users (red mode).

It is acknowledged that these guidelines specifically restrict their use for assessing areas downstream of WWTPs. However in the absence of site specific pathogen/indicator derived assessments, it is largely agreed that this provides the only guidance for New Zealand resource managers.

1.3.4 MACROINVERTEBRATE COMMUNITIES

Benthic macroinvertebrates include the diverse assemblage of organisms that live on the surface, under or within the substrates of streams and include insect larvae (e.g., mayflies, stoneflies, caddisflies, and beetles), aquatic oligochaetes (worms), snails and crustaceans (e.g., shrimps and crayfish). Because stream macroinvertebrates are such a diverse group and are strongly influenced by aquatic habitat and water quality, they are used widely for monitoring and evaluating water quality and more broadly 'stream health' in New Zealand and overseas (Winterbourn 2004). A benefit of using macroinvertebrates is that they can be indicators of ecosystem health through the calculation and interpretation of biological indices such as MCI.

MCI and QMCI were developed to assess organic enrichment in stony streams by sampling in stony riffles, where the greatest variety of the most sensitive macroinvertebrates may be expected (Stark 1985; Stark 1998). The MCI-sb, and QMCI-sb have been developed for assessing the condition of soft-bottomed streams (Stark and Maxted 2004; Stark and Maxted 2007). These indices are designed to be used with samples collected according to the national protocols (Stark, Boothroyd et al. 2001).

The MCI and MCI-sb respond to any perturbation that alters the list of taxa (*i.e.* taxonomic composition) present at a site. The QMCI, and QMCI-sb, respond to changes in taxonomic and numerical composition or relative abundances. An advantage of the MCI (and soft bottom variant) indices is that they provide a simple pollution tolerance score for each taxon ranging from 1 (very pollution tolerant) to 10 (pollution-sensitive), and site scores can be compared to national guideline values (see Table 4).

Taxonomic Richness is a measure of the number of macroinvertebrate taxa present in a given area. In general, the greater the numbers of taxa present the higher the quality of the environment.

EPT Taxonomic Richness and %EPT provides a measure of the number and proportion of water and habitat sensitive mayfly (Ephemeroptera), stonefly (Plecoptera) and caddisfly (Trichoptera) (EPT) taxa in a sample. A high number of EPT taxa in a sample is indicative of good water and habitat quality. EPT richness and abundance is generally reduced by urbanisation (Suren 2000).

Table 4: Interpretation of MCI-type biotic indices (Stark and Maxted, 2007)

Quality class	MCI MCI-sb	QMCI QMCI-sb
Excellent	>119	>5.99
Good	100-119	5.00-5.90
Fair	80-99	4.00-4.99
Poor	<80	<4.00

Ephemeroptera, Plecotptera, and Trichptera/Chironomidae ratio uses the relative abundance of these indicator groups as a measure of community balance. Healthy biotic condition is reflected in even distribution of all four major groups and with substantial representation in the sensitive EPT groups. Skewed populations with a disproportionate number of pollution-tolerant Chironomidae relative to EPT may indicate environmental stress. Chironomids tend to be incresingly dominant in terms of community composition and abundance along a gradient of increasing nuterient enrichment.

1.3.4 DATA ANALYSIS – GWRC RSoE DATA

Assessment of water quality at sites upstream and downstream of the Greytown WWTP was based on the monthly sampling of Ruamahanga River water by Greater Wellington staff at regional State of the Environment sites; McLays, Te Ore Ore, Gladstone Bridge and Pukio between September 2003 and August 2011. As water quality characteristics tend to co-vary with flow, data were categorised into one of four broad flow categories; Low (<25th percentile), Base (25th – 50th percentile, i.e. median), High (median – 3 x median) and Very High (>3 x median). The flow data, from which these categories were based, comprised of mean daily flows at Mt. Bruce, Wardells and Waihenga flow monitoring stations and included all data between September 2003 and August 2011. The monthly water quality results at sites were then matched to the respective flow category calculated from the nearest flow monitoring station record. For these analyses McLays and Te Ore Ore data were assumed to co-vary with the Mt. Bruce flow record, Gladstone Bridge to Wardells and Pukio to Waihenga.

Differences in water quality characteristics (clarity, nutrients, DO, and E. coli) between sites (within flow categories), and between flow categories (within sites), were assessed using the non-parametric Wilcoxan matched pairs test (StatSoft, 2004). Results were described as statistically significantly different when p-values were <5% (i.e. testing at the 95% level of significance). Where chemistry results from the laboratory where reported as less than the detection limit then a result of half the detection limit was used for that particular sample so that this result could be included in statistical analyses.

2. EFFLUENT QUALITY AND DISCHARGE

2.1 EXISTING OPERATION AND TREATMENT

The MWWTP is relatively simple in design consisting of a main facultative pond followed by a series of four maturation cells. It is operated by the SWDC and serves a population of approximately 1500. Wastewater entering the MWWTP is primarily domestic in origin although there is a small waste stream from commercial activities such as cafes, restaurants, hotels, and garages. A simplified schematic of the MWWTP is presented in Figure 1.

Since 1998 there have been two mechanical aerators in operation to enhance the treatment process. The four stage maturation cells were commissioned in 2007 to help 'polish' the effluent from the facultative pond prior to discharge to the Ruamahanga River. The combined pond system has an approximate volume of 25,400m^3 and an annual theoretical mean retention time for the entire system has been calculated as 47 days(NZET 2010).

Note: At the time of writing this report SWDC were in the process of commissioning an ultra-violet treatment system. This system is currently indicating that bacterial counts in the final discharge will be in the order of <$1x10^2$ cfu's/100mL.

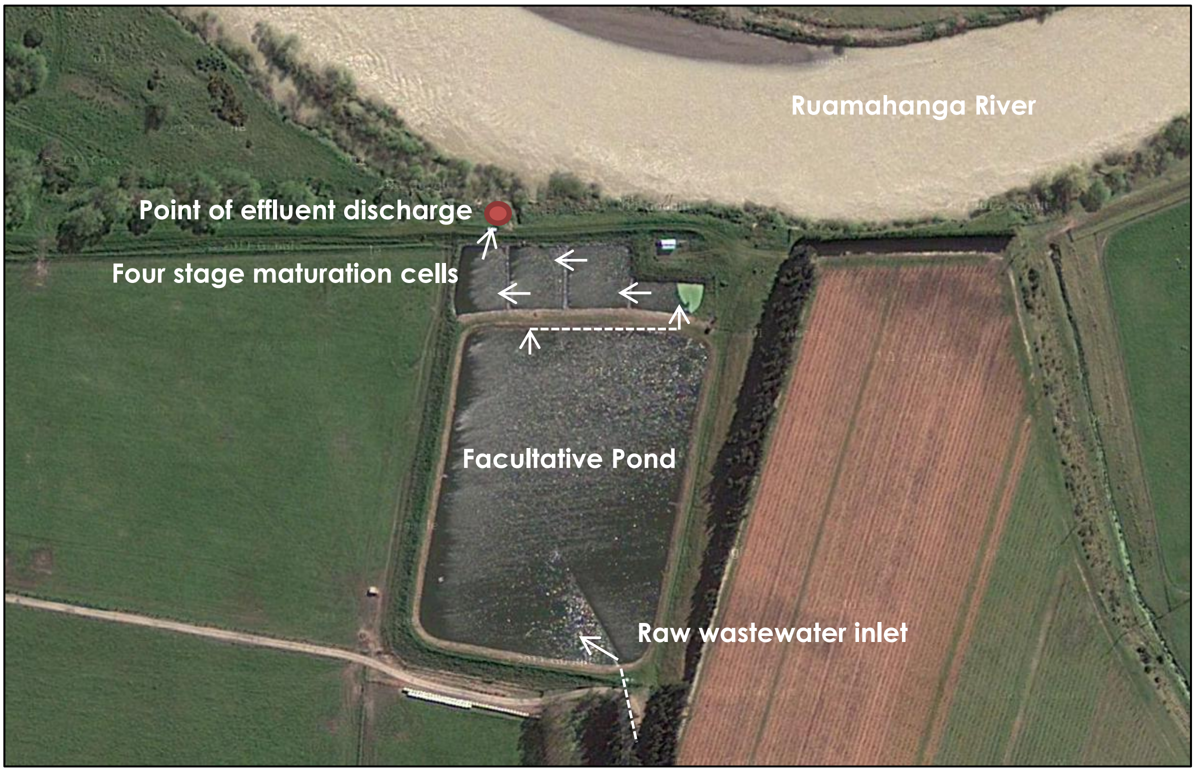

FIGURE 1: MARTINBOROUGH WASTEWATER TREATMENT PLANT

2.2 RESOURCE CONSENT REQUIREMENTS FOR DISCHARGE QUALITY

The current resource consent (WAR970079 [30753]) for the MWWTP discharge to the Ruamahanga River is a variation of the original consent (WAR970079 [2624]) that was granted 23 July 2002. A variation was sought in 2010 (granted 28 October 2011) to address re-occurring non-compliance issues relating to discharge quality as per Condition 7 of the original resource consent. Table 5 shows the original requirements of Condition 7 compared to the current requirements.

Table 5: 'Condition 7' requirements for discharge quality for original resource consent and after agreed variations.

Condition 7 WAR970079 [2624] – Original consent 2002								
Parameter	**E.coli cfu/ 100 mL**	**BOD mg/L**	**Suspended solids mg/L**	**Oil & Grease mg/L**	**Total N mg/L**	**Ammonia Nitrogen mg/L**	**Total P mg/L**	***pH***
2 ½ years from commencement of consent	2000	40	60	10	20	5 Summer 10 Winter	10	6.5-8.5
7 years from commencement of consent	200	15	20	10	15	5 Summer 10 Winter	3	6.5-8.5

Condition 7 WAR970079 [30753] – 2011 Variation															
Parameter	**E.coli cfu/ 100 mL**	**BOD mg/L**		**SS mg/L**		**Oil & Grease mg/L**		**Total N mg/L**		**Ammonia Nitrogen mg/L**		**Total P mg/L**		***pH***	
	Absolute Standard	Geomean	90th percentile	Geomean	90th percentile	Geomean	90th percentile	Geomean	90th percentile	Geomean	90th percentile	Geomean	90th percentile	Geomean	90th percentile
Pre UV treatment system (up to 1 December 2011)	10000	60	90	100	170	10	15	25	37.5	6.5 summer 24 winter	25 summer 36 winter	10	15	6.5-8.5	9
Post UV treatment system (from 1 December 2011)	200	60	90	100	170	10	15	25	37.5	6.5 summer 24 winter	25 summer 36 winter	10	15	6.5-8.5	9

Note: As detailed in Condition 8 of the current resource consent: The tabulated values in Condition 7 are standards. The geometric mean of a minimum of twenty samples must comply with the standards in Condition 7. The 90th percentile may exceed the standards by up to 50% provided the geometric mean complies with the standard.

2.3 WASTEWATER QUALITY

Prior to the original resource consent being granted in July 2002, the discharge from the MWWTP was monitored monthly by GWRC. A summary of this data (March 1994 to July 2001) is summarised in Table 6.

Since 2001 SWDC have assumed the responsibility for the monitoring of effluent quality (monthly) from the MWWTP discharge to the Ruamahanga River. This data is summarised in Table 7.

For some parameters, there is little seasonal difference in effluent concentration, whereas for others, the seasonal concentrations can vary and have therefore been divided into both summer and winter concentrations (Table 8).

Table 6: Summary of MWWTP effluent discharge monitoring data collected between 1994 and 2001 (Source GWRC)

Parameter	*n*	Min	Median	Geometric Mean	Max	90%ile
pH	64	7.1	7.7	7.6	8.2	8.0
Suspended solids (mg/L)	64	22	73	71	346	126
BOD_5 (mg/L)	64	9.3	41	40	212	70
Total P (mg/L)	64	4.2	8.4	8.4	67.4	10.7
DRP (mg/L)	64	2.6	6.6	6.2	10.2	8.8
Ammoniacal- N (mg/L)	64	12.0	10.5	4.9	28.6	21.0
Nitrate+Nitrite-N (mg/L)	64	0.008	0.40	0.44	9.1	5.9
Total N (mg/L)	64	5.8	21.9	20.9	47.0	32.4
Faecal coliforms (cfu's/100 mL)	65	3	22,400	18,200	296,000	101,400
E.coli (cfu's/100 mL)	20	1,100	11,000	10,900	67,000	29,900

Table 7: Summary of MWWTP effluent discharge monitoring data collected between 2001 and 2011 (Source SWDC)

Parameter	*n*	Min	Median	Geometric Mean	Max	90%ile
pH	210	6.9	7.7	7.8	9.2	8.3
Suspended solids (mg/L)	243	5	53	49	208	117
BOD_5 (mg/L)	243	7.6	36	36	9302	72
Total P (mg/L)	226	1.7	7.7	6.7	12.6	10.6
DRP (mg/L)	222	0.59	6.1	5.3	11.4	9.3
Ammoniacal- N (mg/L)	234	0.08	15.0	9.5	62.0	28.6
Nitrate+Nitrite-N (mg/L)	*	*	*	*	*	*
Total N (mg/L)	139	7.0	25.0	22.9	43.5	37.5
Faecal coliforms (cfu's/100 mL)	243	100	9,400	6,400	185,000	42,200
E.coli (cfu's/100 mL)	218	20	6,100	4,400	190,000	34,600

* No longer measured

Table 8: MWWTP (all data - 1994 to 2011)) seasonal treated effluent composition (summer = 6 months from November – April inclusive; winter = May to October inclusive)

Parameter		*n*	Min	Median	Goemetric Mean	Max	90%ile
pH	Summer	164	6.9	7.7	7.7	8.9	8.2
	Winter	139	6.9	7.7	7.7	8.8	8.1
Suspended solids (mg/L)	Summer	165	5	44	44	346	105
	Winter	126	5	40	37	150	81
BOD_5 (mg/L)	Summer	134	8	29	30	106	64
	Winter	157	16	31	31	83	54
Total P (mg/L)	Summer	164	1.7	7.6	6.4	13.2	10.6
	Winter	149	1.7	7.7	6.7	67.4	10.1
DRP (mg/L)	Summer	163	1.7	6.2	5.3	16.8	9.3
	Winter	145	1.3	6.3	5.4	16.8	9.1
Ammoniacal N (mg/L)	Summer	164	0.11	16.6	11.8	62	33.8
	Winter	154	0.2	20.7	16.2	42	31.8
Nitrate+Nitrite N (mg/L)	Summer	33	0.02	0.74	0.80	9.1	7.1
	Winter	32	0.01	0.31	0.26	8.4	5.5
Total N (mg/L)	Summer	121	5.8	25.6	23.5	50.1	40.3
	Winter	107	9.6	27.6	25.6	50.1	40.7
Oil and Grease (mg/L)	Summer	60	<1	4	4	60	8
	Winter	49	<3	6	5	28	19
Faecal coliforms (cfu's/100 mL)	Summer	163	3	9,300	6,400	296,000	39,200
	Winter	157	720	13,300	13,000	185,000	58,700
E.coli (cfu's/100 mL)	Summer	145	28	6,000	4,600	190,000	26,500
	Winter	121	675	10,500	8,900	190,000	40,900

2.3 WASTEWATER QUANTITY

Under the current Resource Consent the discharge of treated effluent to the Ruamahanga River should not exceed a mean flow rate of 465 m^3/d and a maximum rate of 1460 m^3/d. At present flow measurements are undertaken at both the inlet to the MWWTP primary pond and discharge to the Ruamahanga River. However, flow data for the effluent point of discharge is not regarded reliable and therefore inflow data is substituted i.e. inflow is used to estimate outflow. Flow data for the period 2008 to 2010 shows the following summary for flows into (and therefore out of) the MWWTP:

- Average dry weather flow of 521 m^3/d
- Average wet weather flows of 640 m^3/d
- Peak wet weather flows of 2800 m^3/d
- Calculated annual average daily flow of 536 m^3/day

Figure 2 has been taken from the AEE (NZET, 2010) originally submitted to gain the above-mentioned variation to the MWWTP resource consent conditions. The plot shows the measured daily inlet flow versus daily rainfall. Also shown are the designated mean and maximum flows, as specified in the resource consent, and the theoretical daily flow (331m^3/day), based on Martinborough's 2006 census population of 1326 persons, and allowing for a standard effluent discharge flow of 250 L per person per day.

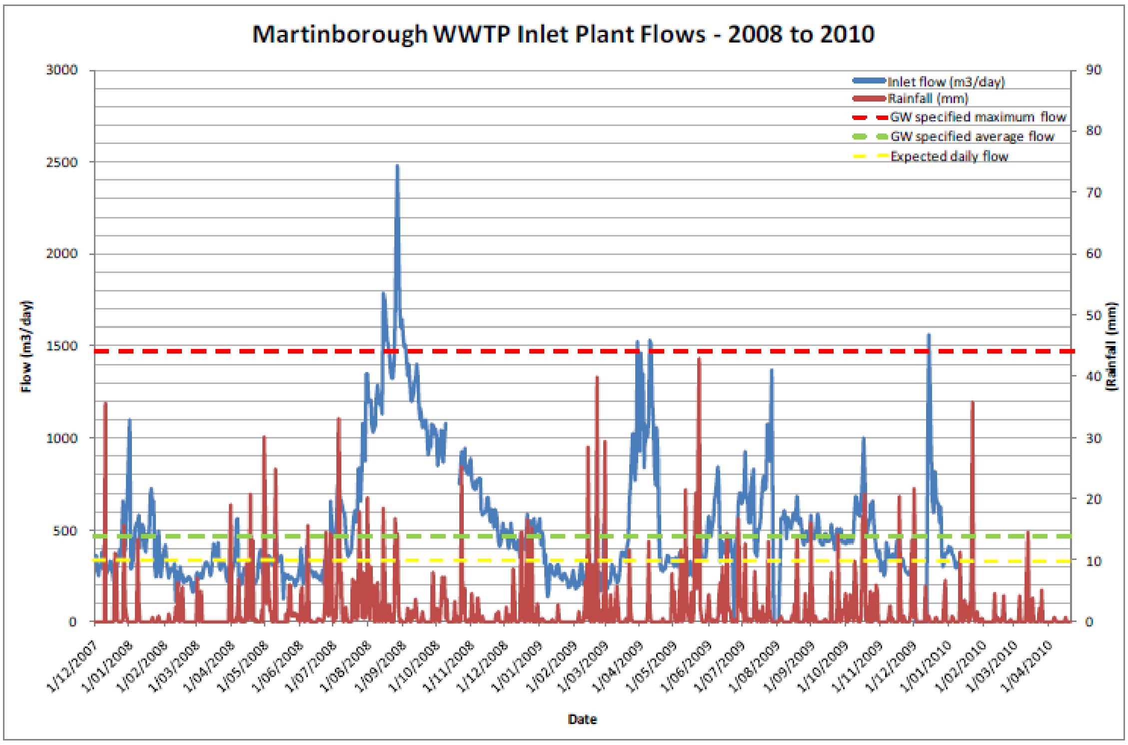

FIGURE 2: MWWTP SYSTEM INLET FLOWS AND KEY LIMITS / THEORETICAL FLOWS (NZET, 2010).

Figure 2 shows that after a period of heavy rainfall, the flow often increases dramatically and occasionally the maximum allowable flow (as identified in the consent) is exceeded. The consent maximum is however based on outflow and so is probably not exceeded once the hydraulic buffering capacity of the pond system is taken into account. It also shows that approximately 85% of the time the theoretical daily flow is exceeded. These increases in flow, when compared to relative rainfall events, are indicative of inflow and infiltration of stormwater occurring and lead to the raw influent concentration being at times of lower strength than typical domestic wastewater, and a seasonally variable pond hydraulic retention time.

2.4 MASS LOADS OF CONTAMINANTS IN DISCHARGE

Table 9 shows the mass loads of individual effluent parametres discharged to the Ruamahanga River on a daily and per annum basis. These figures are derived using the average daily flow into the MWWTP (536 m^3/day) and calculated median parameter concentrations.

Table 9: Mass loading of measured parameters in MWWTP effluent discharge to Ruamahanga River

Parameter	Mass loading kg/day	Mass loading kg/annum
Suspended solids	28.4	10,370
Biological Oxygen Demand	22.0	8,020
Total Phosphorus	4.5	1,643
Dissolved Reactive Phosphorus	3.5	1,291
Ammoniacal- Nitrogen	5.6	2,054
Nitrate+Nitrite-Nitrogen	0.21	78.3
Total Nitrogen	11.7	4,285

3. CHARACTERISING THE RECEIVING ENVIRONMENT

3.1 INTRODUCTION

Section 104 of the RMA identifies the matters that must be considered when making decisions on approvals required by the RMA. This includes an assessment of the actual and potential effects of the activity, in this case the discharge of treated effluent from the MWWTP to the Ruamahanga River. To be able to undertake such an effects assessment it is necessary to describe the nature of the receiving environment.

3.2 RUAMAHANGA RIVER CATCHMENT DESCRIPTION

The Ruamahanga River originates in the north eastern Tararua Range near Mt Dundas and flows through the Wairarapa valley to Lake Onoke, which discharges to the sea. The Ruamahanga River is about 162 kilometres long with a catchment area of approximately 3430 square kilometres. It has major tributaries rising from the Tararua Range (including the Waipoua, Waingawa and Waiohine rivers) and also from the eastern Wairarapa hills (Kopuaranga, Whangaehu, Tauweru and Huangarua rivers) (Watts and Perrie 2007).

The MWWTP is located in the reach generally referred to as the Lower Ruamahanga River. This reach is approximately 72 kilometres in length and includes the section of river between the confluence with the Waiohine River down to Lake Onoke. With the exception of the Waiohine River, other significant tributaries to the Lower Ruamahanga River are the Huangarua River and the outflow from Lake Wairarapa (Watts and Perrie, 2007).

3.3 LAND USE

The major land use in the Ruamahanga catchment (Figure 3) is arable farming including sheep, beef, and dairying. On the lower Wairarapa plains dairying has become the predominant land use in recent years, while the remainder is used for sheep and cattle grazing. Within the eastern hill country sheep and cattle grazing is the dominant land use. Although the western Ruamahanga River tributaries have a significant proportion of their catchment area under indigenous forest (in the Tararua Range), the pastoral land use of the plains is likely to have a significant impact on the water quality of these rivers (and the Lower Ruamahanga River) (Watts and Perrie, 2007).

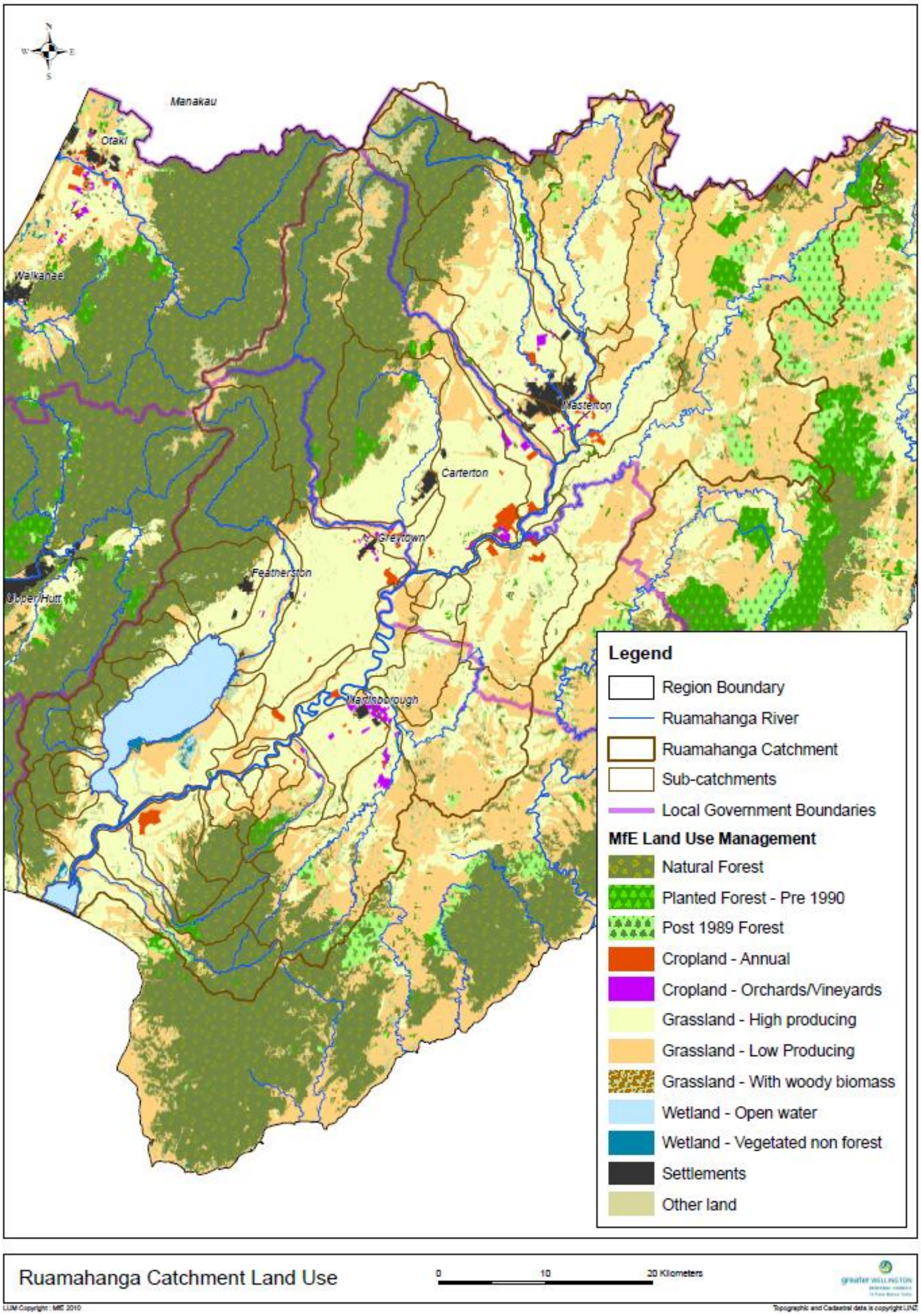

FIGURE 3: LAND USE IN THE RUAMAHANGA CATCHMENT

3.4 USES AND VALUES OF RUAMAHANGA RIVER

The Regional Freshwater Plan for the Wellington Region (GWRC, 1999) recognises the Ruamahanga River as having regionally important recreational and amenity values such as, fishing, swimming, canoeing, kayaking, tubing, and jet boating.

With regards to Maori customery values, the Ruamahanga River as the most significant river in the Wairarapa Valley, is likely to be of high spiritual value to Wairarapa Iwi particularly with respect to mauri, waahi tapu and mahinga kai. A recent report (Keenan 2009) illustrates general Maori cultural and traditional values relating to rivers as follows:

"Ko Waiohine ko Ruamahanga ënei

e wairua tipu mai

i Tararua maunga

e oranga e te iwi"

"These are Waiohine and Ruamahanga. They are like mothers milk flowing out of the Tararua Mountains for the prosperity of the people" (Hoani Te Whatahoro Jury, 1841-1923, a Ngati Kahungunu scholar).

Ki Uta ki Tai (from the mountains to the sea): Water bodies are viewed holistically and cannot be distinguished from the surrounding land and catchments. Water provides cultural and spiritual sustenance, is viewed as the source of life with life giving properties, and is regarded as a taonga. Wairarapa whänau, hapu and iwi whakapapa to the Ruamahanga River.

Mahinga kai: The waterways of the Wairarapa are used for mahinga kai (the gathering and processing of food). The gathering of food such as birds, eels, fish and plants enable tangata whenua to provide manaakitanga (hospitality), a symbol of tribal mana. In particular, it is important that the waterbody sustains a healthy tuna (eel) population.

Mauri: Iwi try to protect the mauri (life force) which flows through all waterways. In particular, water from different catchments should not be mixed.

Kaitiakitanga: Iwi are charged with the responsibility to protect both the spiritual and physical waterways (including streams and rivers) within their rohe.

Waahi Tapu: Along the rivers are many ancestral sites and other sites of special value to tangata whenua.

3.5 SURFACE WATER QUALITY OF RUAMAHANGA RIVER

GWRC monitor four sites (McLays, Te Ore Ore, Gladstone, and Pukio) on the Ruamahanga River (Figure 4) for water quality under the Rivers State of the Environment (RSoE) monitoring programme. Each of these sites have been monitored under this programme on a monthly basis for a variety of physico-chemical and microbiological parameters since September 2003. Biological (macroinvertebrates and periphyton) monitoring has also occurred on an annual basis during the late summer - early winter period (Perrie 2007).

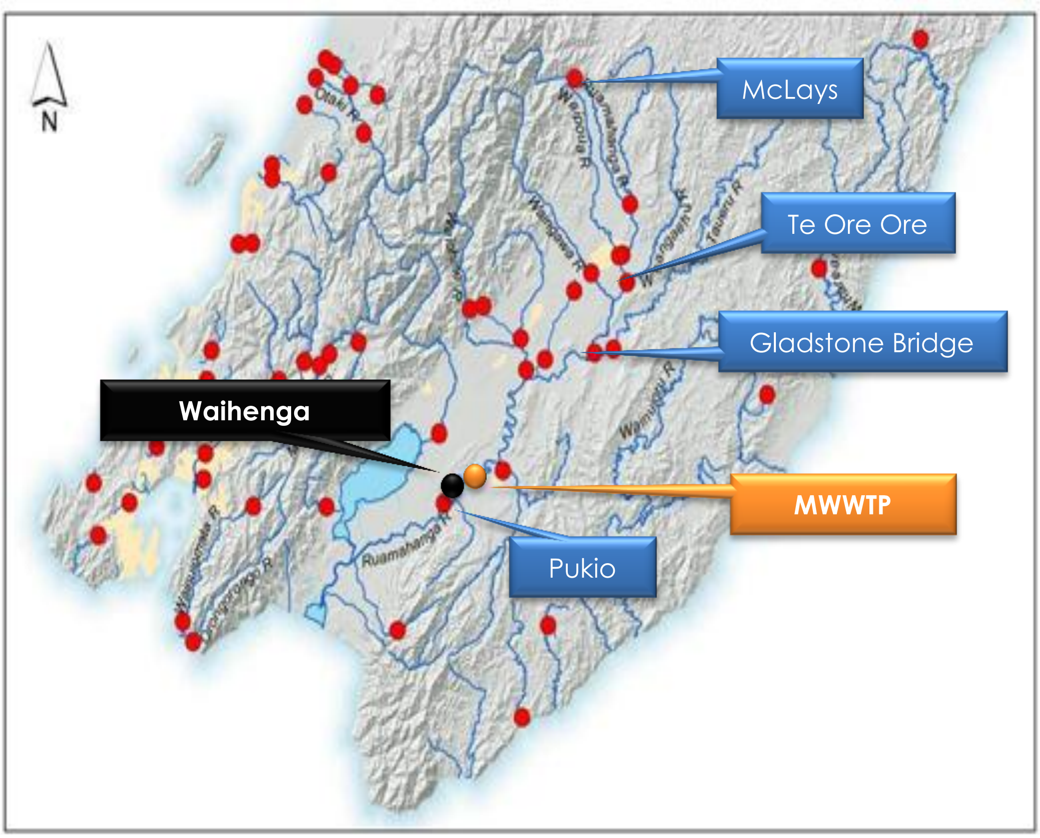

FIGURE 4: GWRC RSoE (BLUE BOXES), RECREATIONAL AND FLOW (BLACK BOX) MONITORING SITES ON THE RUAMAHANGA RIVER IN RELATION TO MWWTP (PERRIE 2007).

3.5.1 NUTRIENTS AND PERIPHYTON

This section summarises the findings of a recent report (Ausseil 2011) that analysed the nutrient and periphyton data collected under the RSoE programme for rivers and streams in the Wellington Region including the Ruamahanga River for the 5 year period July 2004 to June 2009. Tables 9 to 12 show the summary data from this report.

Table 9: Summary of nutrient RSoE data for McLays monitoring site (from Ausseil 2011)

			All flows			Flows below median flow			Flows below half median flow		
Site	**Site Name**		**DRP (mg/L)**	**DIN (mg/L)**	**DIN:DRP Ratio**	**DRP (mg/L)**	**DIN (mg/L)**	**DIN:DRP Ratio**	**DRP (mg/L)**	**DIN (mg/L)**	**DIN:DRP Ratio**
RS31	Ruamahanga River at McLays C7 (Upland/ Reference)	Average	0.004	0.036	12	0.004	0.027	10	0.003	0.027	11
		Min	0.002	0.005	1	0.002	0.005	1	0.002	0.005	1
		5%ile	0.002	0.005	2	0.002	0.005	1	0.002	0.005	1
		10%ile	0.002	0.012	3	0.002	0.005	1	0.002	0.005	1
		25%ile	0.002	0.021	5	0.002	0.016	3	0.002	0.006	3
		50%ile (median)	0.002	0.030	11	0.002	0.030	7	0.002	0.030	9
		75%ile	0.005	0.038	17	0.006	0.037	16	0.004	0.038	19
		90%ile	0.007	0.050	24	0.008	0.045	19	0.007	0.050	23
		95%ile	0.008	0.064	26	0.008	0.050	23	0.007	0.055	24
		Max	0.019	0.304	51	0.009	0.062	25	0.007	0.062	25
		StDev	0.003	0.040	10	0.003	0.016	8	0.002	0.020	9
		95% C.I.	0.001	0.010	3	0.001	0.006	3	0.001	0.011	5
		Guideline	0.009	0.177		0.009	0.177		0.009	0.177	
		%compliance	98	98		100	100		100	100	
		N. of Samples	60	59	59	25	24	24	14	13	13

Table 10: Summary of nutrient RSoE data for Te Ore Ore monitoring site (from Ausseil 2011)

RS32	Ruamahanga River at Te Ore Ore C6a (Lowland/ Impacted)	Average	0.012	0.464	77	0.008	0.466	95	0.005	0.450	127
		Min	0.002	0.016	2	0.002	0.016	6	0.002	0.016	6
		5%ile	0.002	0.099	8	0.002	0.169	15	0.002	0.113	19
		10%ile	0.002	0.128	10	0.002	0.231	26	0.002	0.200	25
		25%ile	0.005	0.288	31	0.003	0.288	33	0.002	0.268	37
		50%ile (median)	0.008	0.410	51	0.008	0.385	57	0.003	0.365	116
		75%ile	0.011	0.554	93	0.009	0.541	130	0.009	0.460	189
		90%ile	0.016	0.791	196	0.011	0.777	204	0.010	0.710	232
		95%ile	0.027	0.992	215	0.014	0.974	246	0.011	1.112	311
		Max	0.182	1.800	400	0.034	1.800	400	0.011	1.800	400
		StDev	0.023	0.316	77	0.006	0.328	89	0.003	0.395	105
		95% C.I.	0.006	0.080	20	0.002	0.114	31	0.002	0.182	49
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	70	62		78	66		89	78	
		N. of Samples	60	60	60	32	32	32	18	18	18

Table 11: Summary of nutrient RSoE data for Gladstone Bridge monitoring site (from Ausseil 2011)

RS33	Ruamahanga River at Gladstone O6a (Lowland/ Impacted)	Average	0.028	0.505	21	0.033	0.479	17	0.037	0.395	11
		Min	0.007	0.054	2	0.012	0.054	2	0.023	0.054	2
		5%ile	0.012	0.120	4	0.021	0.199	4	0.025	0.176	3
		10%ile	0.014	0.163	6	0.023	0.230	5	0.025	0.199	5
		25%ile	0.021	0.260	10	0.025	0.260	9	0.029	0.253	6
		50%ile (median)	0.025	0.470	19	0.031	0.429	14	0.035	0.320	9
		75%ile	0.034	0.608	28	0.041	0.600	19	0.045	0.476	18
		90%ile	0.045	0.870	36	0.046	0.864	28	0.052	0.663	20
		95%ile	0.051	1.104	41	0.052	0.996	32	0.054	0.854	21
		Max	0.057	1.640	102	0.055	1.220	102	0.055	1.100	24
		StDev	0.012	0.305	16	0.010	0.274	17	0.010	0.246	7
		95% C.I.	0.003	0.077	4	0.004	0.095	6	0.005	0.114	3
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	3	50		0	63		0	72	
		N. of Samples	60	60	60	32	32	32	18	18	18

Table 12: Summary of nutrient RSoE data for Pukio monitoring site (from Ausseil 2011)

			All flows			Flows below median flow			Flows below half median flow		
Site	**Site Name**		**DRP (mg/L)**	**DIN (mg/L)**	**DIN:DRP Ratio**	**DRP (mg/L)**	**DIN (mg/L)**	**DIN:DRP Ratio**	**DRP (mg/L)**	**DIN (mg/L)**	**DIN:DRP Ratio**
RS34	Ruamahanga River at Pukio O6a (Lowland/ Impacted)	Average	0.017	0.419	30	0.015	0.360	29	0.011	0.209	29
		Min	0.002	0.005	1	0.002	0.005	1	0.002	0.005	1
		5%ile	0.002	0.015	2	0.002	0.005	1	0.002	0.005	1
		10%ile	0.006	0.088	10	0.003	0.026	4	0.002	0.005	1
		25%ile	0.010	0.178	14	0.006	0.128	13	0.005	0.072	10
		50%ile (median)	0.017	0.375	23	0.015	0.330	20	0.007	0.149	18
		75%ile	0.022	0.595	38	0.022	0.478	39	0.019	0.278	37
		90%ile	0.027	0.782	47	0.026	0.778	51	0.024	0.372	57
		95%ile	0.030	0.950	88	0.028	0.910	89	0.027	0.526	97
		Max	0.061	1.550	145	0.030	1.140	140	0.030	0.970	140
		StDev	0.010	0.308	28	0.009	0.292	29	0.009	0.231	35
		95% C.I.	0.003	0.078	7	0.003	0.100	10	0.004	0.107	16
		Guideline	0.01	0.465		0.01	0.465		0.01	0.465	
		%compliance	27	62		36	73		67	94	
		N. of Samples	60	60	60	33	33	33	18	18	18

3.5.2 DISSOLVED INORGANIC NITROGEN

Median DIN concentrations (Figure 5) were shown to be low (0.030 mg/L) at the upland McLays reference site. Between McLays and the next downstream monitoring site, at Te Ore Ore, DIN concentrations significantly increase to just below ANZECC lowland guideline with a median value of 0.410 mg/L. Similarly, there is an increase (slight but statistically significant) in DIN concentration between Te Ore Ore and Gladstone Bridge (0.470 mg/L). In the lower reaches DIN concentrations reduce between Gladstone Bridge and Pukio monitoring sites to levels (0.375 mg/L) similar to those found upstream at Te Ore Ore.

Decreasing river flows do not appear to affect DIN concentrations (Figure 5) at the McLays and Te Ore Ore sites. However, at decreasing flows DIN concentrations reduce slightly at Gladstone Bridge and sharply at Pukio. At Pukio median DIN concentrations at low flows (<median flow) are significantly lower (below ANZECC lowland guideline) than at Te Ore Ore and Gladstone Bridge.

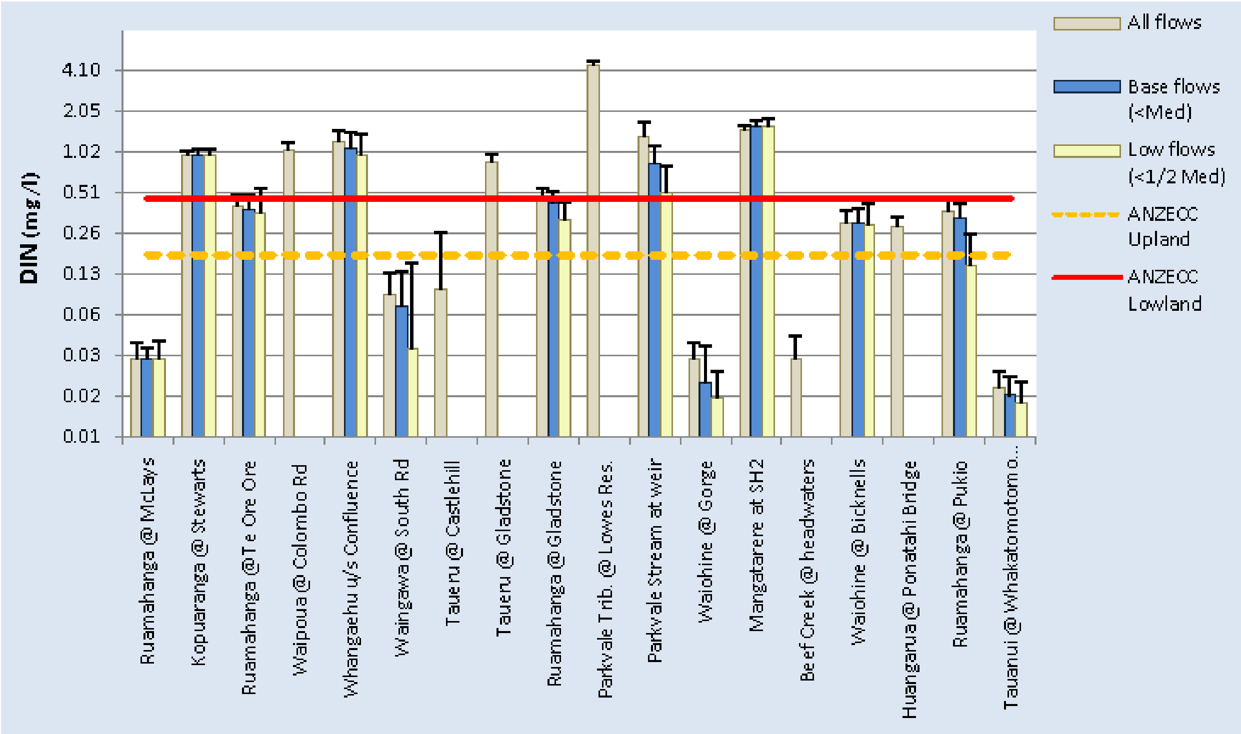

FIGURE 5: MEDIAN DIN CONCENTRATIONS (95 % CONFIDENCE INTERVAL) FOR RSOE SITES IN THE RUAMAHANGA RIVER CATCHMENT. NOTE THE LOGARITHMIC SCALE. SOURCED FROM AUSSEIL (2011)

3.5.3 DISSOLVED REACTIVE PHOSPHORUS

Median DRP concentrations measured at the McLays upland reference site are low at 0.002 mg/L. Moving downstream from the McLays site DRP concentrations show statistically significant increases between McLays and the Te Ore Ore (0.008 mg/L) monitoring sites, and again between the Te Ore Ore and Gladstone Bridge (0.025 mg/L) monitoring sites. Median DRP concentrations illustrate a significant decrease between Gladstone Bridge and the last downstream monitoring site at Pukio (0.017 mg/L).

Median DRP concentrations (Figure 6) remain stable with decreasing river flows at the McLays reference site. At the Te Ore Ore site DRP concentrations decrease at low river flows (<median) and this is thought to be associated with algal biomass uptake of DRP. DRP concentrations show a marked increase at the Gladstone Bridge site at low river flows and is a typical pattern associated with point source discharges such as from the Masterton WWTP located upstream of this monitoring site. DRP concentrations decrease at low flows between the Gladstone Bridge and Pukio monitoring sites similar to that observed at the Te Ore Ore site.

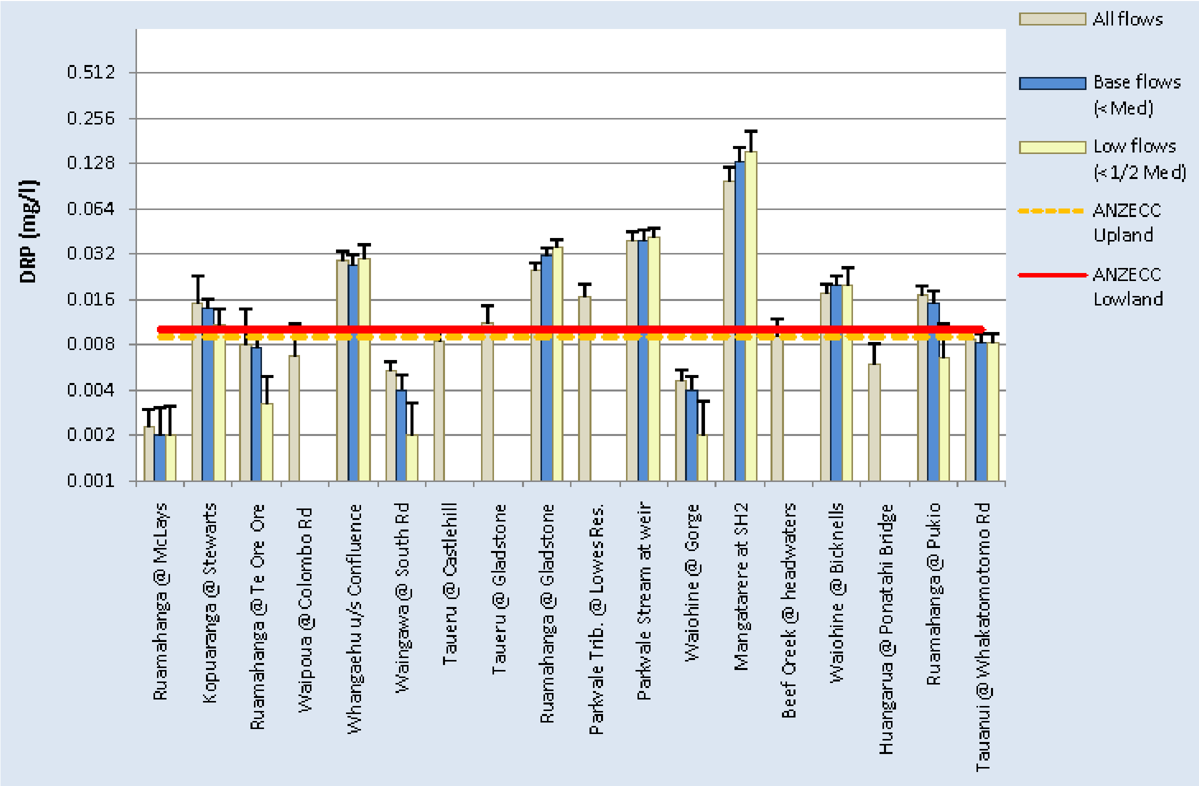

FIGURE 6: MEDIAN DRP CONCENTRATIONS (95 % CONFIDENCE INTERVAL) FOR RSOE SITES IN THE RUAMAHANGA RIVER CATCHMENT. NOTE THE LOGARITHMIC SCALE. SOURCED FROM AUSSEIL (2011)

3.5.4 PERIPHYTON

GWRC monitoring data for the Ruamahanga River shows that periphyton biomass and cover are consistently low (median biomass 1 mg/m^2) at McLays. Moving downstream periphyton biomass significantly increases at Te Ore Ore (median biomass of 27 mg/m^2) and generally remains stable down to Gladstone Bridge (30 mg/m^2). However, as shown in Table 13 there have been occasional breaches of the 50 mg/m^2 biomass guideline for the protection of high biodiversity values and no breaches at either site of the higher biomass guideline (120 mg/m^2) for the protection of aesthetic, recreational, and trout fishing values. Statistical analysis indicates no significant difference between Te Ore Ore and Gladstone Bridge with only one recorded breach of the periphyton cover occurring at Gladstone Bridge.

Although not statistically significant there appears to be a small increase in periphyton growth at Pukio when compared to the Gladstone Bridge site with more regular breaches of the 50 mg/m^2 biomass guideline and some of the filamentous algae cover guideline. As with upstream sites there has not been a recorded breach of the higher biomass guideline 120 mg/m^2 for the protection of aesthetic, recreational, and trout fishing values at the Pukio site. The noted increase in periphyton growth at Pukio is thought to be a combination of a longer accrual period in this lower section of the river and that dissolved nutrient concentrations (DRP and DIN) are consistent with nutrient use by the algal biomass.

Note: In the report by Ausseil (2011) it is noted that periphyton cover in the Ruamahanga is possibly under-estimated by the current assessment method (single transect in a run habitat) because in deep rivers such as this run habitat is not likely to be as suitable for periphyton growth as riffle habitat.

Table 13: Summary of exceedances of periphyton guidelines at RSoE sites in the Ruamahanga River catchment (adapted from Ausseil 2011)

Site Name	Site Class	Elevation	Biomass		Cover	
			50 mg/m²	120 mg/m²	Mats	Filamentous
Ruamahanga @McLays	Reference	Upland	0/6	0/6	0	0
Ruamahanga @Te Ore Ore	Impacted	Lowland	2/6	0/6	0	0
Ruamahanga @Gladstone	Impacted	Lowland	1/6	0/6	1	0
Ruamahanga @ Pukio	Impacted	Lowland	3/6	0/6	0	1

3.5.5 DIN:DRP RATIOS – NUTRIENT LIMITATION

The Ruamahanga River at McLays is predominantly under co-limited conditions (median DIN:DRP ratio of 11) and regularly changes between N-limited (25% of the time) and P-limited (22% of the time) conditions (Figure 7). As for individual nutrients these ratios are relatively stable under all flow regimes.

At Te Ore Ore DIN:DRP ratios indicate P-limited conditions especially at low flows. DRP and DIN concentrations significantly increase between McLays and Te Ore Ore however there appears to be a greater increase of DIN resulting in a change from co-limiting conditions at McLays to P-limited at Te Ore Ore.

Ratios of DIN:DRP indicate a return of co-limited conditions at Gladstone Bridge, however this is largely as a result of increased DRP concentrations rather than a decrease in DIN concentrations. At this site DIN and DRP are in relatively high concentrations under all flows and it is unlikely that nutrient limitation of periphyton growth exists. This is supported by the fact that there does not appear to be significant increases in periphyton biomass or cover between Te Ore Ore and Gladstone Bridge.

In general DIN:DRP ratios at Pukio suggest P-limited conditions with frequent co-limited conditions and N-limited conditions (approximately 20% of the time) during low flows.

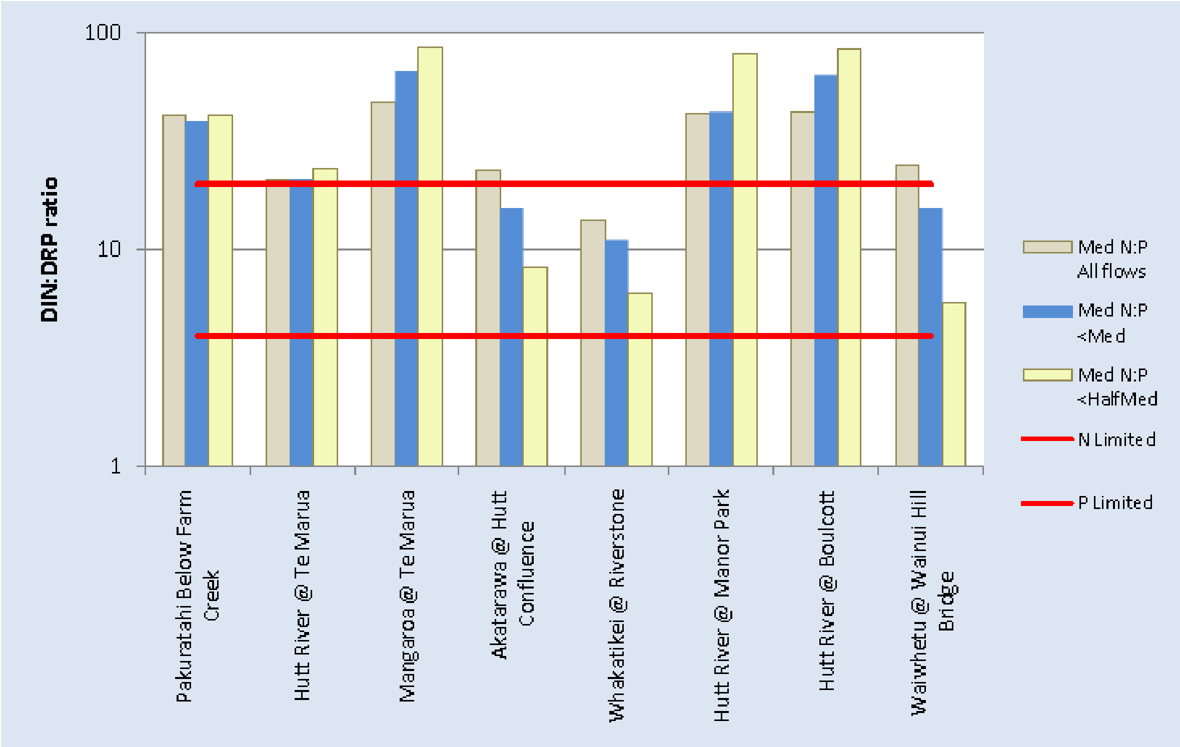

FIGURE 7: MEDIAN DIN:DRP RATIOS CONCENTRATIONS FOR RSOE SITES IN THE RUAMAHANGA RIVER CATCHMENT. THE AREA ABOVE THE TOP RED LINE (DIN: DRP=20) IS INDICATIVE OF P-LIMITED CONDITIONS; BELOW THE BOTTOM RED LINE (DIN:DRP=4) IS INDICATIVE OF N-LIMITED CONDITIONS. SOURCED FROM AUSSEIL (2011)

3.5.6 AMMONIA

Ammonia can be toxic to many aquatic organisms, particularly cold water salmonoids and is a common pollutant in treated domestic, agricultural and industrial discharges.

Figure 8 shows box and whisker plots of all RSoE data for the Ruamahanga River between September 2003 and September 2011. Table 14 and Figure 9 present median ammoniacal-N data for the Ruamahanga River at RSoE monitoring sites at differing flows.

Examining NH_4-N concentrations few differences were noted among the different flow categories. The only significant differences detected were between low and high flows at Pukio and Te Ore Ore, where during low flows NH_4-N was significantly less. Also at Pukio NH_4-N was estimated to be significantly lower during base flow conditions compared to high flows.

Comparing NH_4-N between sites within flow categories it was clear that among all flow categories Gladstone Bridge had the highest median results of all sites. With one exception, the results at Gladstone Bridge in all flow categories were significantly higher than respective results at all other sites. The exception was a non-significant difference in NH_4-N between Gladstone Bridge and Pukio during very high flow conditions. Other differences detected included significantly lower results at McLays and Te Ore Ore during high flows compared to respective results at Pukio. Additionally McLays was also lower during very high flows compared to Pukio.

These results indicate that site specific effects are relatively stronger than flow related influences on the concentration of NH_4-N.

Table 14: Median NH_4-N (mg/L) results for RSoE monitoring sites on the Ruamahanga River (September 2003 to September 2011). Figures in parenthesis represent the percentages of sampling occasions that results exceeded ANZECC guideline. Number of samples = 96.

Site Name	NH_4-N (mg/L) all flows	NH_4-N (mg/L) Flows below half median flow	NH_4-N (mg/L) Flows below median flow	NH_4-N (mg/L) Flows below FRE3 flow	NH_4-N (mg/L) Flows >FRE3 flow
Ruamahanga @McLays[1]	0.005 (8.3%)	0.005 (8.0%)	0.005 (5.9%)	0.005 (10.8%)	0.005 (0%)
Ruamahanga @Te Ore Ore[1]	0.005 (6.3%)	0.005 (0%)	0.005 (5.9%)	0.005 (8.3%)	0.008 (16.7%)
Ruamahanga @Gladstone[2]	0.02 (41.7%)	0.012 (21.7%)	0.020 (36.8%)	0.025 (52.8%)	0.029 (61.1%)
Ruamahanga @ Pukio[3]	0.01 (19.8%)	0.005 (9.1%)	0.005 (13.6%)	0.017 (25%)	0.016 (33.3%)

[1]Compared with flow data from GWRC flow monitoring site at Mt Bruce; [2]Compared with flow data from GWRC flow monitoring site at Wardells; [3]Compared with flow data from GWRC flow monitoring site at Waihenga.

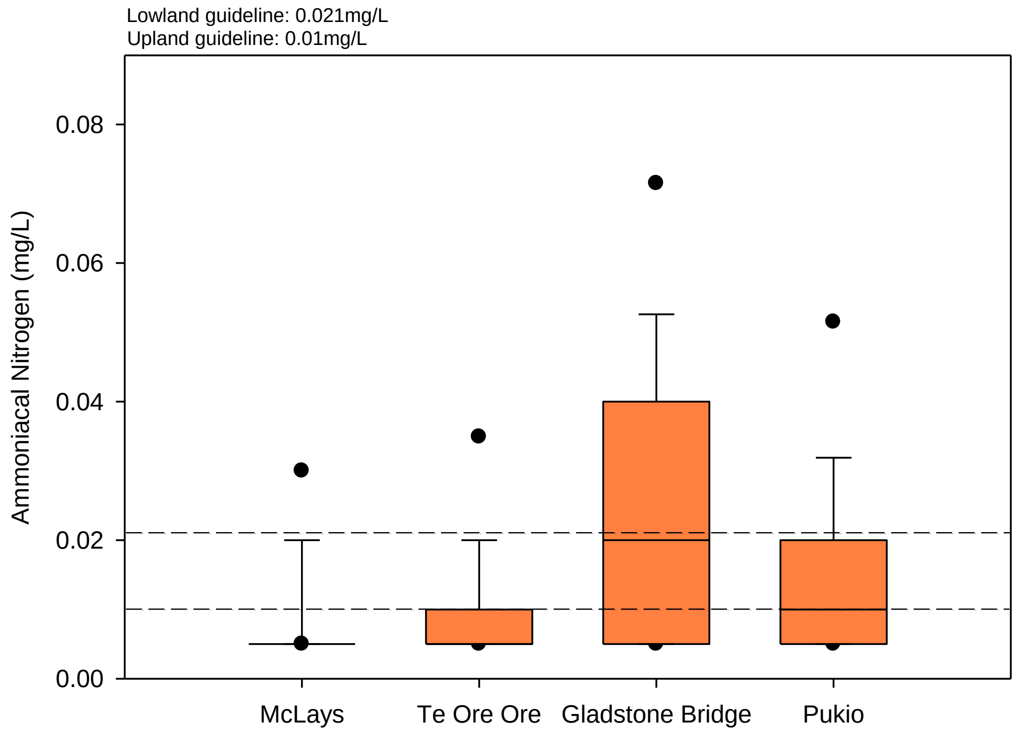

FIGURE 8: NH_4 –N (ALL DATA) FOR RSOE SITES IN THE RUAMAHANGA RIVER CATCHMENT

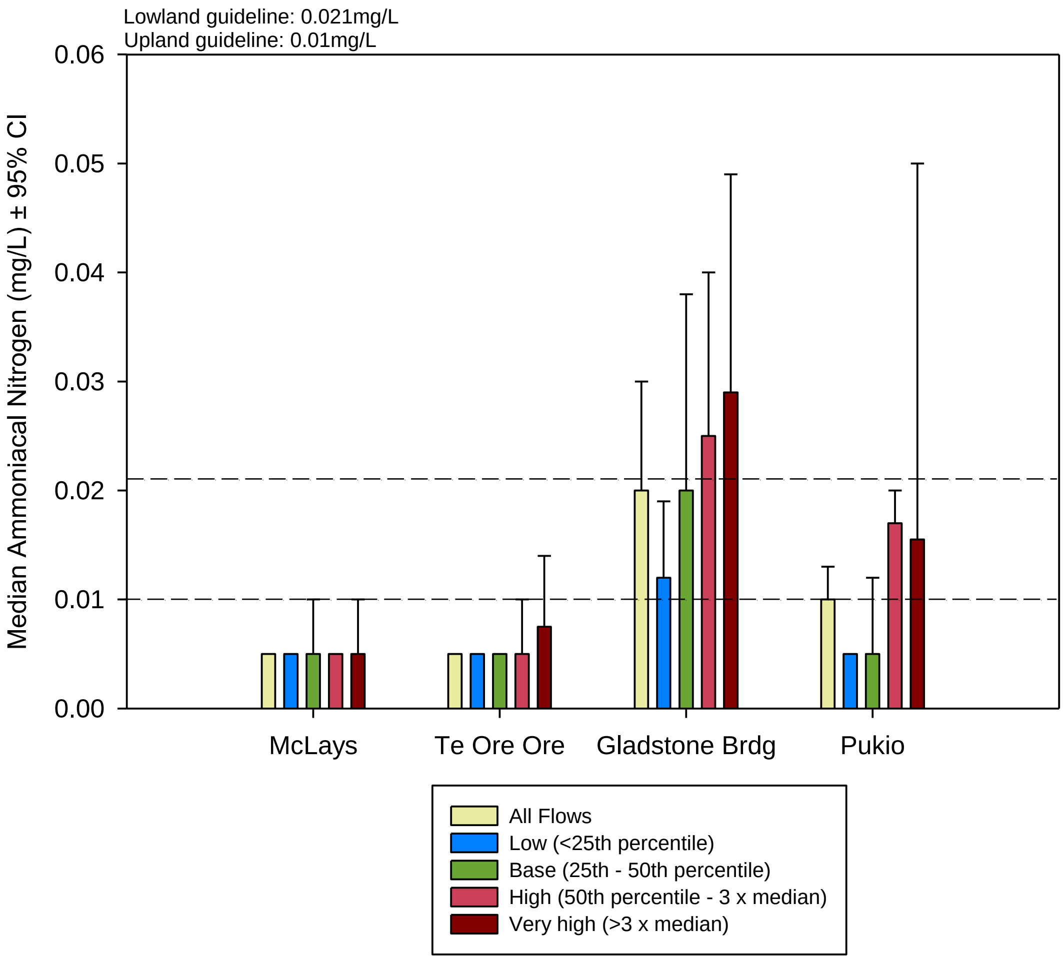

FIGURE 9: MEDIAN AMMONIACAL-N RESULTS (95% CONFIDENCE LEVEL) FOR RSoE SITES IN THE RUAMAHANGA RIVER AT VARYING FLOWS

3.5.7 BACTERIOLOGICAL QUALITY

Escherichia coli (E. *coli*), is a bacteria commonly measured in freshwater systems as an indicator of faecal contamination which could ultimately pose a health hazard when the water is used for recreational activities such as swimming, board riding and other high-contact aquatic activities. GWRC monitor E.*coli* monthly as part of its RSoE monitoring programme as well as 'recreational' sites as part of its region-wide recreational water quality monitoring programme. Recreational monitoring is limited to the official bathing season of between 1 November and 31 March.

3.5.7.1 RECREATIONAL MONITORING DATA

GWRC publish an annual report "On the Beaches" that summarises the freshwater (and marine) microbiological data for each monitoring year. With regards to the Ruamahanga River each annual report since the 2005/2006 bathing season (Milne and Wyatt 2006; Milne 2007; Ryan and Warr 2008; Warr 2009; Ryan and Warr 2010; Morar and Warr 2011) has indicated that sites monitored on the Ruamahanga River typically breach the "action" guideline of 550 cfu/100 mL at least once per season.

Almost without exception where an action level has been recorded it has been positively correlated with significant rainfall events. This illustrates that E.*coli* counts in fresh water are typically related to urban stormwater, re-suspension of sediments, and diffuse-source runoff (Milne 2007).

3.5.7.2 RSoE MONITORING DATA

Figure 10 shows box and whisker plots of all RSoE data for the Ruamahanga River between September 2003 and September 2011. Table 15 and Figure 11 present median E.*coli* data for the Ruamahanga River at RSoE monitoring sites at differing flows.

Median E.*coli* counts remain stable with all river flows at the McLays reference site and rarely (2.7% of the time) exceed the MoH/MfE alert guideline of 550 cfu/100mL even at times of higher flows (> 3 times median).

Similarly, median E.*coli* counts at the Te Ore Ore site are reletively stable at all flows and are below the guideline level for approximately 83% of the time. However, median E.coli counts are in the order of 25 times higher than the McLays reference site and reflects the change from indigenous forest to pastoral land use. Breaches of the 550 cfus/100mL MoH/MfE guideline limit are shown to occur more frequently above median flows i.e. consistent with rainfall.

Median E.coli counts (at all flows) at the Gladstone Bridge site are below the guideline value for greater than 86% of the time and are stable at all flows below 3 times median flows but increase (approximately 45 fold) at flows above 3 times median. Overall, E.coli counts show a marked decrease (approximately 2.6 times reduction) when compared to the upstream Te Ore Ore site.

The Pukio site shows that median E.coli counts are slightly higher under all flow conditions when compared to the Gladstone Bridge monitoring site and are similar to those counts observed at the Te Ore Ore site. The guideline limit of 550 cfus/100mL is rarely breached (<10%) at flows below median flow, up to 28% at flows between median and 3 times median, and around 70% of the time at flows above 3 times median flow.

Table 15: Median E.coli results for RSoE monitoring sites on the Ruamahanga River (September 2003 to September 2011). Figures in brackets represent the percentages of sampling occasions that results exceeded MfE/MoH 'Alert' guideline of 550 cfus/100mL. Number of samples = 96.

Site Name	E.coli /100mL all flows	E.coli /100mL Flows below half median flow	E.coli /100mL Flows below median flow	E.coli /100mL Flows below FRE3 flow	E.coli /100mL Flows >FRE3 flow
Ruamahanga @McLays[1]	4 (2.7%)	4 (0%)	1.5 (0%)	9 (0%)	5 (0%)
Ruamahanga @Te Ore Ore[1]	100 (16.7%)	60 (4.0%)	120 (5.9%)	120 (21.6%)	180 (35.3%)
Ruamahanga @Gladstone[2]	39 (13.5%)	20 (0%)	25 (0%)	48.5 (2.8%)	1400 (72.2%)
Ruamahanga @ Pukio[3]	105 (20.8%)	45 (9.1%)	61 (0%)	170 (28.2%)	1700 (70.0%)

[1]Compared with flow data from GWRC flow monitoring site at Mt Bruce; [2]Compared with flow data from GWRC flow monitoring site at Wardells; [3]Compared with flow data from GWRC flow monitoring site at Waihenga.

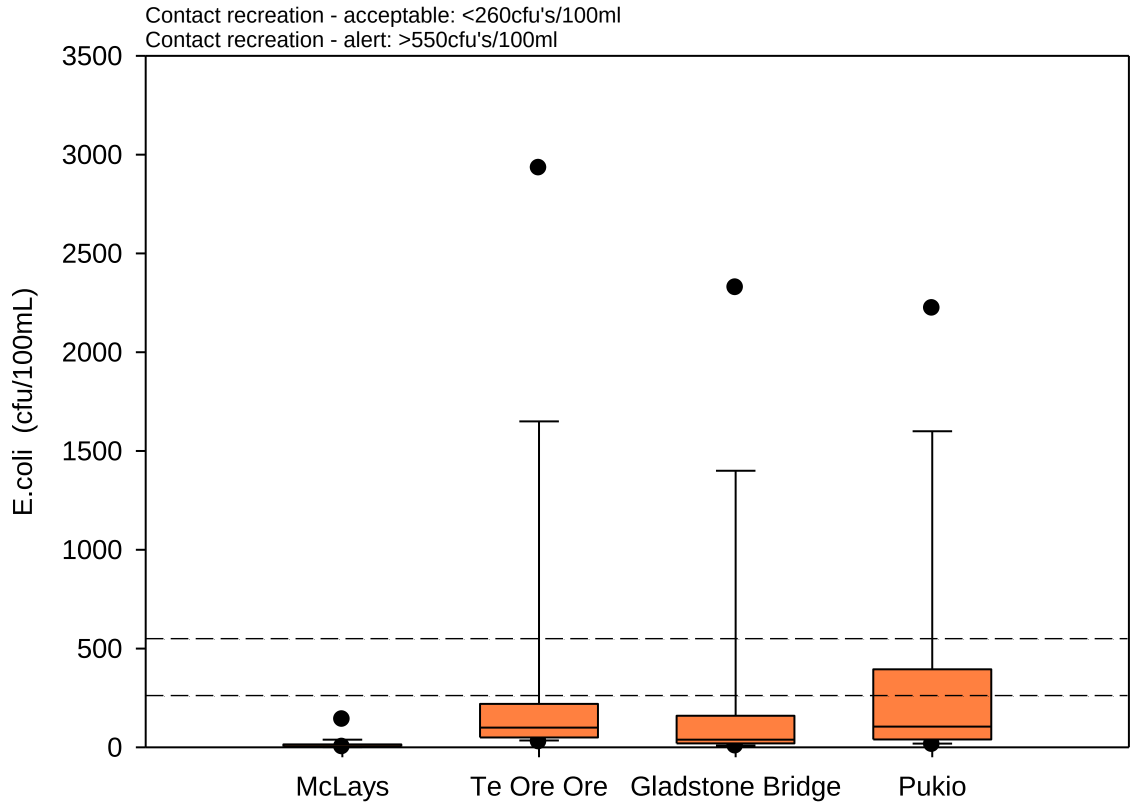

FIGURE 10: E.COLI COUNTS (ALL DATA) FOR RSoE SITES IN THE RUAMAHANGA RIVER CATCHMENT

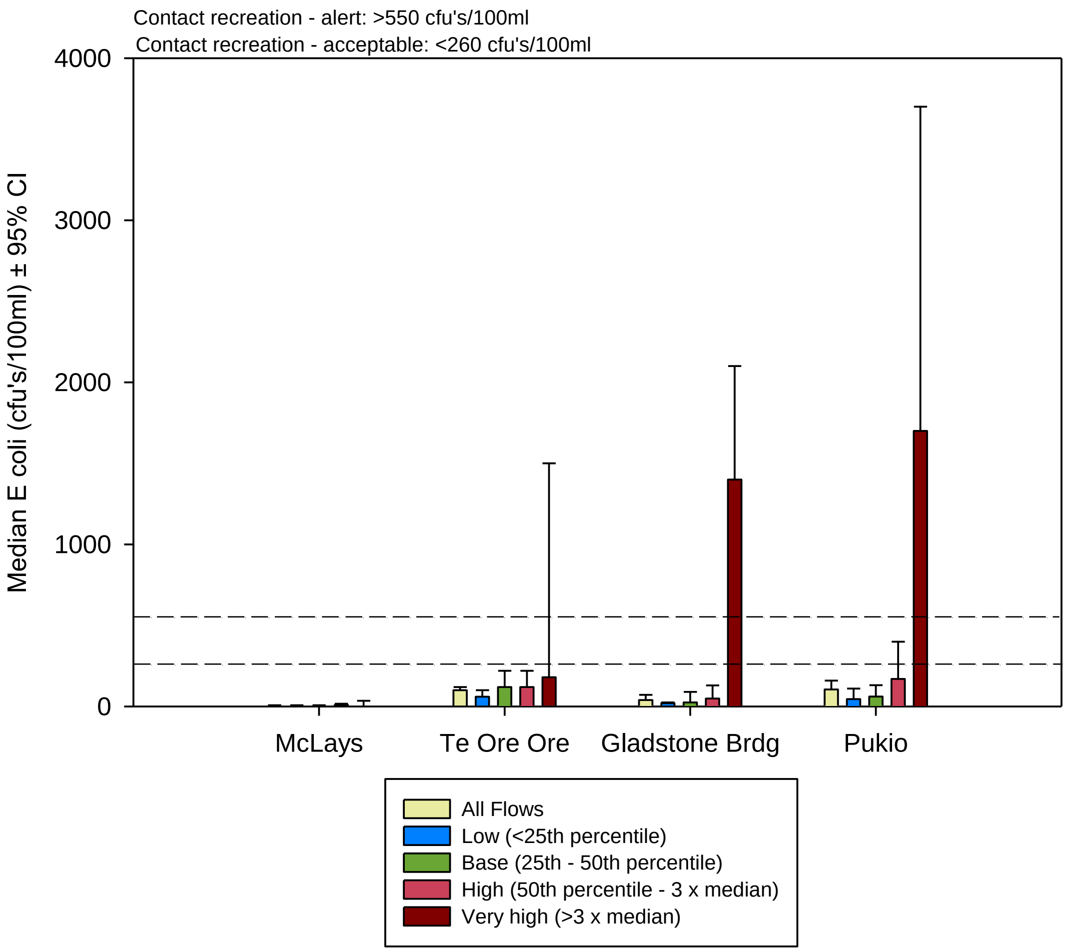

FIGURE 11: MEDIAN E.COLI COUNTS (95% CONFIDENCE LEVEL) FOR RSoE SITES IN THE RUAMAHANGA RIVER

3.5.8 VISUAL CLARITY

Clarity is a measure of the transparency of a water body, and decreases as suspended solids and associated turbidity increases. GWRC monitor clarity (black disc) as part of its RSoE water quality programme. Figure 12 shows box and whisker plots of all RSoE data for the Ruamahanga River between September 2003 and September 2011. Table 16 and Figure 13 present median clarity data for the Ruamahanga River at RSoE monitoring sites at differing flows.

The most obvious conclusions that can be made from this dataset are that, following periods of rainfall, flows in the Ruamahanga River increase, and with these increased flows come decreased visual clarity (Figure 13). Conversely, as river flows decrease so visual clarity increases.

Under all flows, but most importantly at times of low flow, monitoring data illustrates that visual clarity in the Ruamahanga River declines with distance downstream of the McLays site and in particular between the McLays and the Te Ore Ore sites (north of Masterton). This pronounced change between the McLays and the Te Ore Ore sites has been attributed largely to the change in land use between these i.e. from indigenous forest to pastoral. Further downstream point source municipal wastewater discharges in conjunction with the intensification of pastoral land use activities result in further degradation of visual clarity in the Ruamahanga River.

Comparing clarity between flows within sites it is evident that at all sites median clarity measurements during low flows were significantly higher compared to all other flow categories. During base flow conditions, clarity measurements at all sites (except Te Ore Ore) were significantly higher compared to high and very high flow conditions, and during high flow conditions, among all sites, clarity was significantly higher than very high flows. Thus, results suggest a strong relationship at all sites between increasing flow and decreasing clarity.

Comparing clarity between sites, and within flow categories, it was evident that at McLays during all flow conditions clarity was significantly higher than all other sites. Comparing between Te Ore Ore and Gladstone Bridge, no differences were evident in any of the flow categories. Comparing within the all flows category, it was evident that Te Ore Ore was significantly higher than Pukio, though the source of this variation was significantly higher results during low and high flows only. Comparing results between Gladstone Bridge and Pukio, generally, with one exception (during very high flows) clarity was significantly higher at Gladstone Bridge than Pukio.

Of most relevance to this assessment is the fact that Pukio as the site immediately downstream of the MWWTP, typically fails to meet the guideline of 1.6 m^{-1} at all flows except those below half median flows whereas Gladstone Bridge typically meets the guideline limit at all flows below median flows.

Table 16: Median clarity results for RSoE monitoring sites on the Ruamahanga River (September 2003 to September 2011). Figures in brackets represent the percentages of sampling occasions that results exceeded MfE (1994) clarity guideline of 1.6m. Number of samples = 96.

Site Name	Clarity (m^{-1}) all flows	Clarity (m^{-1}) Flows below half median flow	Clarity (m^{-1}) Flows below median flow	Clarity (m^{-1}) Flows below FRE3 flow	Clarity (m^{-1}) Flows >FRE3 flow
Ruamahanga @McLays[1]	3.24 (26%)	5.07 (0%)	4.26 (6%)	2.05 (27%)	0.82 (76.5%)
Ruamahanga @Te Ore Ore[1]	1.15 (61%)	2.63 (16%)	1.79 (47%)	0.64 (84%)	0.16 (100%)
Ruamahanga @Gladstone[2]	1.16 (60%)	2.78 (0%)	1.92 (37%)	0.75 (92%)	0.16 (100%)
Ruamahanga @ Pukio[3]	0.67 (78%)	2.10 (54%)	1.00 (82.6%)	0.23 (100%)	0.08 (100%)

[1]Compared with flow data from GWRC flow monitoring site at Mt Bruce; [2]Compared with flow data from GWRC flow monitoring site at Wardells; [3]Compared with flow data from GWRC flow monitoring site at Waihenga.

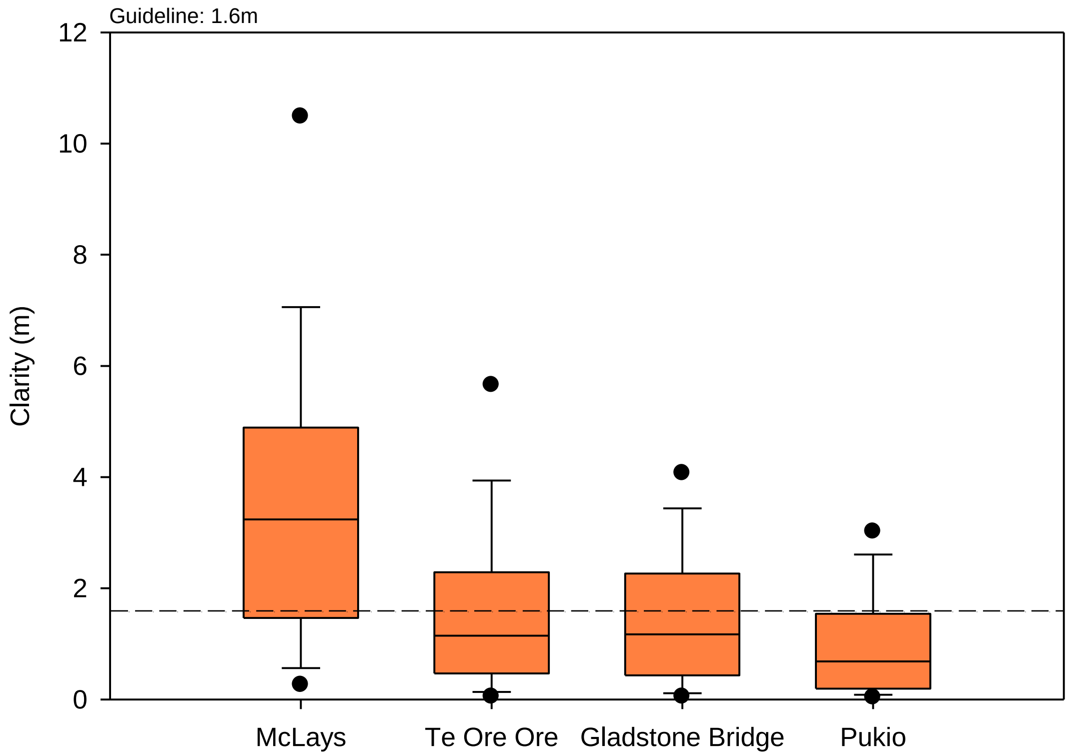

FIGURE 12: CLARITY (m^{-1}) (ALL DATA) FOR RSOE SITES IN THE RUAMAHANGA RIVER CATCHMENT

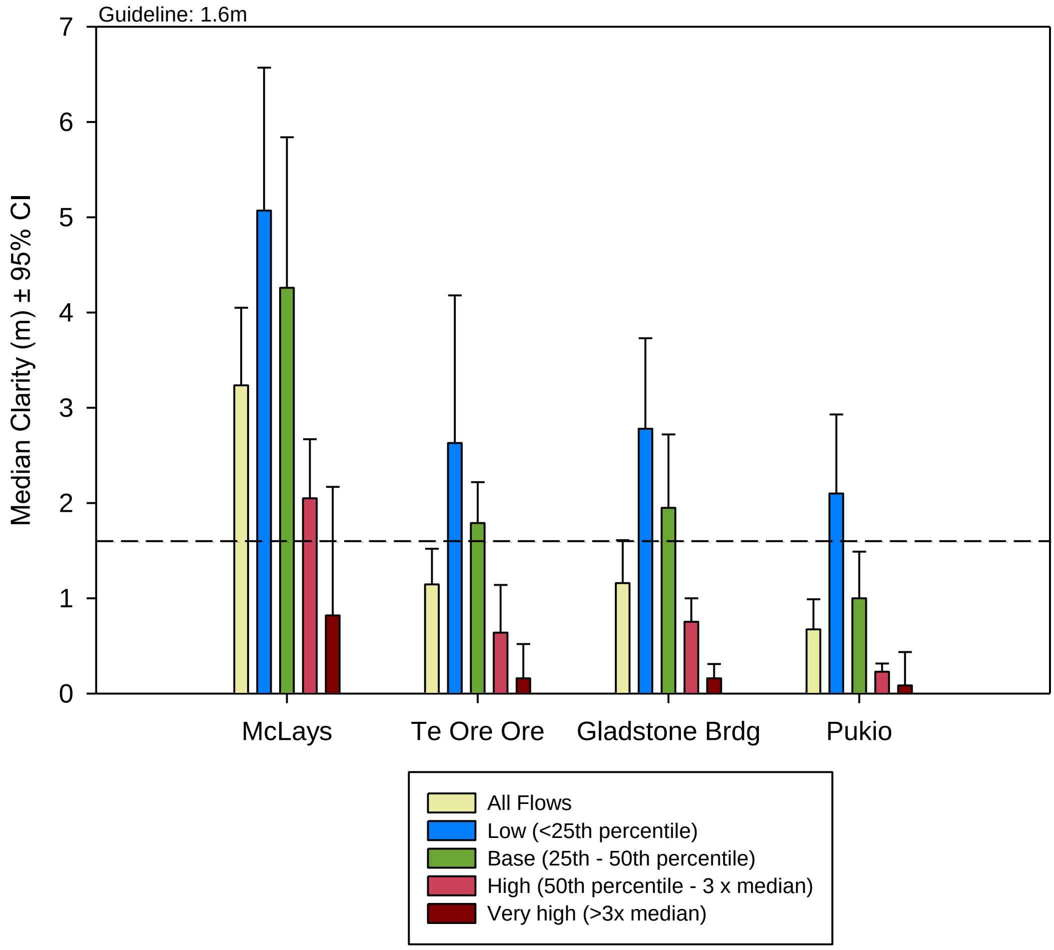

FIGURE 13: MEDIAN CLARITY READINGS (M) (95% CONFIDENCE LEVEL) FOR RSOE SITES IN THE RUAMAHANGA RIVER CATCHMENT

3.5.9 DISSOLVED OXYGEN

Figure 14 shows box and whisker plots of all RSoE data for the Ruamahanga River between September 2003 and September 2011. Table 17 and Figure 15 present median dissolved oxygen data for the Ruamahanga River at RSoE monitoring sites at differing flows.

DO (% saturation) monitoring data does not suggest any significant differences between sites or flows. Median DO (% saturation) concentrations indicate that all sites are consistently above guideline (80%) concentrations.

It should be noted that instantaneous dissolved oxygen measurements recorded as part of the RSoE monitoring programme are only a snapshot in time and thus only have limited value in assessing compliance with any guideline value. Dissolved oxygen varies diurnally, with maximum concentrations typically occurring in late afternoon and minimum concentrations at early morning (dawn). Therefore it is only readings taken in early morning or from continuous monitoring that can provide any useful measure of daily minimum dissolved oxygen concentrations occurring in the river (Ausseil 2008).

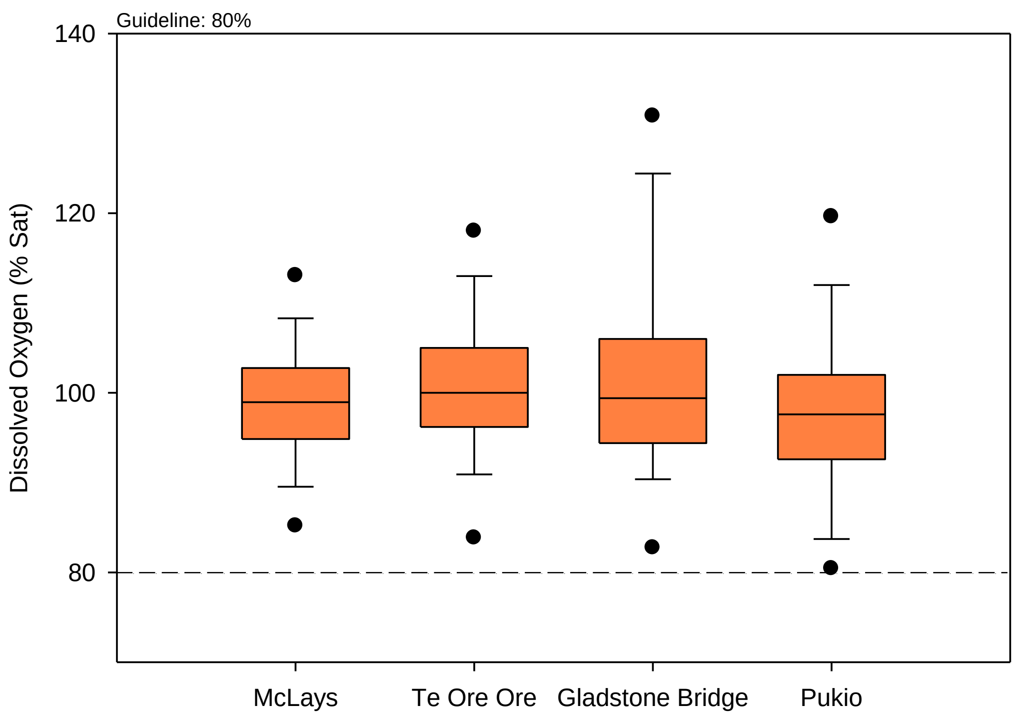

FIGURE 14: DO (% SATURATION) (ALL DATA) FOR RSOE SITES IN THE RUAMAHANGA RIVER CATCHMENT

Table 17: Median dissolved oxygen (DO) %saturation results for RSoE monitoring sites on the Ruamahanga River (September 2003 to September 2011). Figures in brackets represent the percentages of sampling occasions that results exceed (RMA, 1991) guideline of 80% saturation. Number of samples = 96.

Site Name	DO % sat all flows	DO % sat Flows below half median flow	DO % sat Flows below median flow	DO % sat Flows below FRE3 flow	DO % sat Flows >FRE3 flow
Ruamahanga @McLays[1]	99 (2.1%)	99 (0%)	100 (0%)	97 (0%)	99 (13.3%)
Ruamahanga @Te Ore Ore[1]	100 (2.1%)	102 (0%)	102 (0%)	98 (2.7%)	99 (5.9%)
Ruamahanga @Gladstone[2]	99 (2.1%)	118 (0%)	100 (0%)	97 (2.8%)	94 (5.6%)
Ruamahanga @ Pukio[3]	98 (4.2%)	102 (0%)	98 (0%)	98 (5.0%)	93 (22.2%)

[1]Compared with flow data from GWRC flow monitoring site at Mt Bruce; [2]Compared with flow data from GWRC flow monitoring site at Wardells; [3]Compared with flow data from GWRC flow monitoring site at Waihenga.

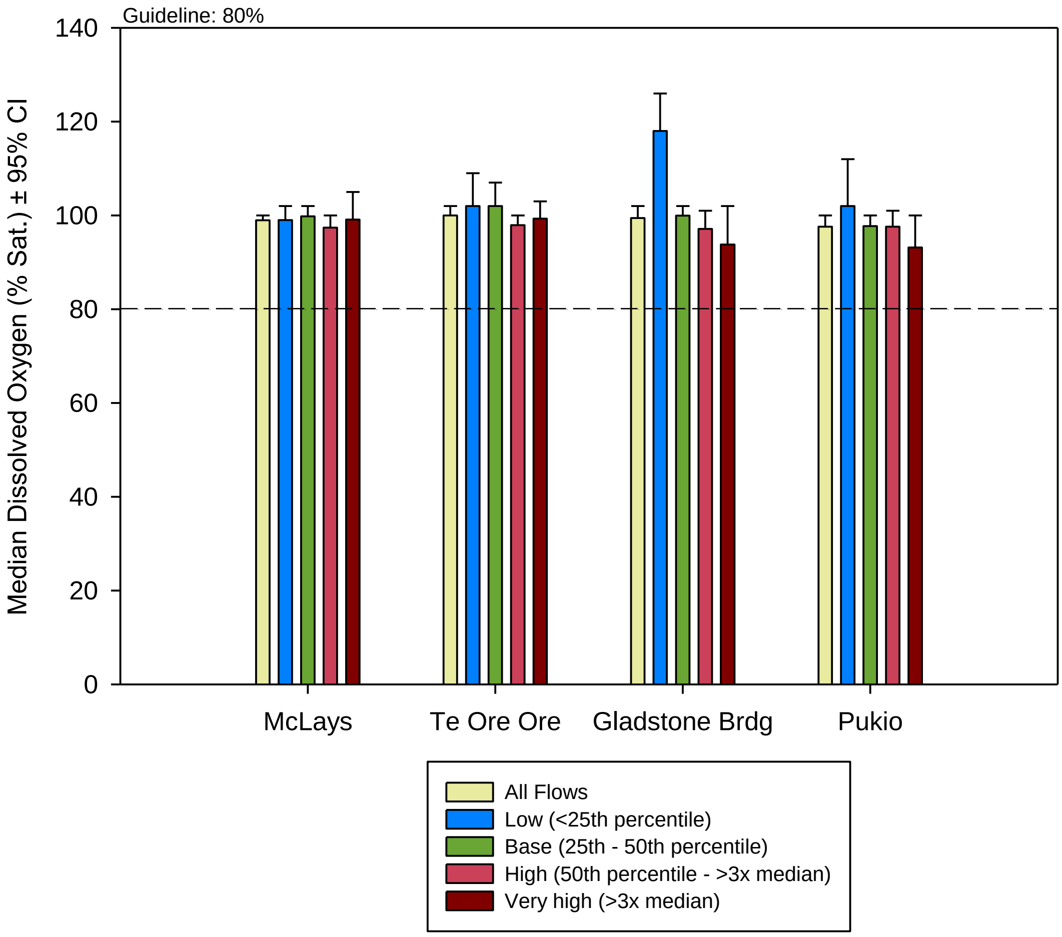

FIGURE 15: MEDIAN DO (% SATURATION) (95% CONFIDENCE LEVEL) FOR RSoE SITES IN THE RUAMAHANGA RIVER CATCHMENT

3.5.10 ASSIMILATIVE CAPACITY OF RUAMAHANGA RIVER

The assimilative capacity of a water body can be defined as 'the ability of a body of water to cleanse itself; its capacity to receive waste waters or toxic materials without deleterious effects and without damage to aquatic life or humans who consume/use the water'.

The discharge of effluent and runoff from sewage treatment plants, industries and agricultural activities often has the potential to degrade water quality in the receiving water body. Therefore an assimilative capacity assessment is an important first step to establish if the receiving water body has sufficient capacity to assimilate proposed loadings and to ensure that increases in discharges will not substantially degrade water quality. Tables 18 to 21 summarise the assimilative capacities at each RSoE monitoring site on the Ruamahanga.

Please note: These assimilative assessments have been made using data supplied by the applicant. It is acknowledged that these guidelines are not definitive points above or below which a system will show deleterious effects or not (respectively). Systems are dynamic as assimilative capacity can be altered by numerous factors (e.g. flow, other inputs, changes in biology etc.)

Table 18: Assimilative capacity of selected determinands in the Ruamahanga River at McLays RSoE monitoring site. Figures in black brackets denote the assimilative capacity available at this site while those in red brackets illustrate the level (concentration) currently exceeded at the site

Determinand	Guideline value	Flows below half median flow	Flows below median flow	Flows below FRE3 flow	Flows >FRE3 flow
DRP (mg/L)	**0.010**	0.002 (+0.008)	0.002 (+0.008)	-	-
DIN (mg/L)	**0.465**	0.030 (+0.435)	0.030 (+0.435)	-	-
NH_4-N (mg/L)	**0.021**	0.005 (+0.016)	0.005 (+0.016)	0.017 (+0.004)	0.016 (+0.005)
Clarity (m^{-1})	**1.6**	5.07 (+3.47)	4.26 (+2.66)	2.05 (+0.45)	0.82 **(-0.78)**
E.coli cfus/100mL	**550**	4 (+546)	1.5 (+448.5)	9 (+441)	5 (+445)

Table 19: Assimilative capacity of selected determinands in the Ruamahanga River at Te Ore Ore RSoE monitoring site. Figures in black brackets denote the assimilative capacity available at this site while those in red brackets illustrate the level (concentration) currently exceeded at the site.

Determinand	Guideline value	Flows below half median flow	Flows below median flow	Flows below FRE3 flow	Flows >FRE3 flow
DRP (mg/L)	**0.010**	0.008 (+0.002)	0.003 (+0.007)	-	-
DIN (mg/L)	**0.465**	0.385 (+0.080)	0.385 (+0.080)	-	-
NH_4-N (mg/L)	**0.021**	0.005 (+0.016)	0.005 (+0.016)	0.005 (+0.016)	0.008 (+0.013)
Clarity (m^{-1})	**1.6**	2.63 (+1.07)	1.79 (+0.11)	0.64 **(-0.96)**	0.16 **(-1.44)**
E.coli (cfus/100mL)	**550**	60 (+490)	120 (+430)	120 (+430)	180 (+370)

Table 20: Assimilative capacity of selected determinands in the Ruamahanga River at Gladstone RSoE monitoring site. Figures in black brackets denote the assimilative capacity available at this site while those in red brackets illustrate the level (concentration) currently exceeded at the site.

Determinand	Guideline value	Flows below half median flow	Flows below median flow	Flows below FRE3 flow	Flows >FRE3 flow
DRP (mg/L)	**0.010**	0.031(**-0.021**)	0.035 (**-0.025**)	-	-
DIN (mg/L)	**0.465**	0.429 (+0.036)	0.320 (+0.145)	-	-
NH_4-N (mg/L)	**0.021**	0.012 (+0.009)	0.020 (+0.001)	0.025 (**-0.004**)	0.029 (**-0.008**)
Clarity (m^{-1})	**1.6**	2.78 (+1.18)	1.92 (+0.32)	0.75 (**-0.85**)	0.16 (**-1.44**)
E.coli cfus/100mL	**550**	20 (+530)	25 (+525)	48.5 (+501.5)	1400 (**-850**)

Table 21: Assimilative capacity of selected determinands in the Ruamahanga River at Pukio RSoE monitoring site. Figures in black brackets denote the assimilative capacity available at this site while those in red brackets illustrate the level (concentration) currently exceeded at the site.

Determinand	Guideline value	Flows below half median flow	Flows below median flow	Flows below FRE3 flow	Flows >FRE3 flow
DRP (mg/L)	**0.010**	0.007 (+0.003)	0.015 (**-0.005**)	-	-
DIN (mg/L)	**0.465**	0.139 (+0.326)	0.330 (+0.135)	-	-
NH_4-N (mg/L)	**0.021**	0.005 (+0.016)	0.005 (+0.016)	0.017 (+0.004)	0.016 (+0.005)
Clarity (m^{-1})	**1.6**	2.1 (+0.5)	1.0 (**-0.6**)	0.23 (**-1.37**)	0.08 (**-1.52**)
E.coli cfus/100mL	**550**	45 (+505)	61 (+489)	170 (+380)	1700 (**-1150**)

Data for the reference site at McLays illustrates that at the top of the catchment there is a relatively large assimilative capacity for all determinands and that only clarity becomes an issue at flows above 3 times medium.

Similarly at Te Ore Ore only clarity values indicate no assimilative capacity at higher flows (3 times median and above). However, the capacity for DRP, DIN, Clarity, and E.coli has been reduced by approximately 4, 10, 2, and 10 fold respectively. Ammoniacal –N remained largely unchanged.

DRP concentrations at the Gladstone site increase significantly and show that there is largely no assimilative capacity for this nutrient under flows below median flow. Clarity remains unchanged at flows below median, while the assimilative capacity at flows below median for ammoniacal-N and clarity are above guideline values at flows above median and thus has no capacity at these flows. DIN has been reduced by approximately half. Ammoniacal-N and E.coli numbers have reduced to provide a larger capacity than upstream at Te Ore Ore.

The Pukio site which is the most relevant for this proposal indicates that DRP concentrations are somewhat lower than the Gladstone site however at median flows they are above guideline levels resulting in no assimilative capacity available. At half median flows there is a negligible margin available (0.003 mg/L). Ammoniacal-N appears to be reduced from Gladstone concentrations allowing a considerable buffer available. E.coli numbers are relatively unchanged and there remains good capacity. An assimilative capacity for clarity not surprisingly only exists at flows below half median flow.

3.5.11 CONTAMINANT MASS LOAD/BALANCE IN RUAMAHANGA RIVER

Contaminant loads are the amount of contaminant carried by the river through one point, or more correctly one transversal section of the river in a given length of time. Calculation methods generally assume that the contaminant concentration is homogenous across the section of river.

When both continuous river flow and contaminant concentration data are available, instantaneous contaminant flux can be calculated at any point in time, and an estimate of the contaminant load during a given period of time can be calculated by simply summing up the instantaneous flux:

$$Load(year_i) = \int_{01/01/year_i}^{31/12/year_i} [Pollut](t) \cdot Flow(t) \cdot dt$$

When contaminant concentrations are known only at regular time intervals (e.g. monthly), the above formula can be approximated using a number of approaches. The following method was used in this report.

3.5.11.1 AVERAGING APPROACH

This method uses the monthly average river flow and the monthly average contaminant concentration to estimate monthly loads. The annual load is then calculated by summing up the monthly loads. This method is particularly applicable when the contaminant concentration and river flow are independent variables (Richards, 1998).

Monthly load:

$$Load(month_i) = [Pollut](month_i) \cdot \int_{01/month_i}^{31/month_i} Flow(t) \cdot dt$$

Annual load:

$$Load(year_i) = \sum_{i=1}^{12} Load(month_i)$$

3.5.11.2 NUTRIENTS – ANNUAL LOADS

Figures 16 to 19 and Table 22 show the increasing amount (median load in tonnes per year) of nutrients (TN, DIN, TP, and DRP) carried by the Ruamahanga River as it flows downstream from the source through farmland down towards the sea. Additionally they show the median annual inputs of these nutrients from the WWTPs of Masterton, Carterton, Greytown, and Martinborough.

TP loads increase by a factor of 3.5, 3.4, and 4.2 between McLays and Te Ore Ore, Te Ore Ore and Gladstone, and Gladstone and Pukio respectively. Of the median annual total phosphorus load (t/a) (based on Pukio data) the discharge from MWWTP represents approximately 1.1% of this and 1.1% of the annual inputs occurring between Gladstone Bridge and Pukio.

Dissolved reactive phosphorus loads increase by a factor of 4.2, 4.2, and 2.9 between McLays and Te Ore Ore, Te Ore Ore and Gladstone, and Gladstone and Pukio respectively. Of the median annual DRP load (t/a) (based on Pukio data) the discharge from MWWTP represents approximately 2.6% of this and 4.0% of the inputs occurring between Gladstone Bridge and Pukio.

Total nitrogen loads increase by a factor of 7.5, 2.7, and 3.3 between McLays and Te Ore Ore, Te Ore Ore and Gladstone, and Gladstone and Pukio respectively. Of the median annual total nitrogen load (t/a) (based on Pukio data) the discharge from MWWTP represents approximately 0.2% of this and 0.3% of the annual inputs occurring between Gladstone Bridge and Pukio.

Dissolved inorganic nitrogen loads increase by a factor of 12.1, 2.7, and 3.0 between McLays and Te Ore Ore, Te Ore Ore and Gladstone, and Gladstone and Pukio respectively. Of the median annual DIN load (t/a) (based on Pukio data) the discharge from MWWTP represents approximately 0.2% of this and 0.3% of the inputs occurring between Gladstone Bridge and Pukio.

The combined WWTP discharges upstream of Pukio are responsible for approximately 22.9 t/a (13.6%), 19.2 t/a (39.4%), 78.5 t/a (4.0%), and 52.1 t/a (4.2%) of TP, DRP, TN, and DIN respectively. Of these discharges Masterton WWTP contributes approximately 76% TP, 75% DRP, 81% TN, and 83% DIN.

Table 22: Comparison of median annual nutrient loads (tonnes/annum) for the period September 2003 – August 2011, at Greater Wellington RSoEmonitoring sites (McLays, Te Ore Ore, Gladstone Bridge, Pukio) in the Ruamahanga River. These are also compared to median annual nutrient loads of the Masterton, Carterton, Greytown and Martinborough WWTP discharges into the Ruamahanga River. Numbers in brackets denote the increase (t/a) between sites moving downstream.

Site	TP	DRP	TN	NH_4-N	DIN
McLays	3.35	0.95	29.6	2.30	12.9
Te Ore Ore	11.8 (+8.45)	4.00 (+3.05)	221.5 (+191.9)	3.52 (+1.22)	155.6 (+142.7)
Gladstone Bridge	40.2 (+31.75)	16.8 (+12.8)	599.4 (+377.9)	23.3 (+19.8)	416.2 (+261.2)
Pukio	168.0 (+150.7)	48.7 (+31.9)	1959 (+1360)	38.0 (+14.7)	1229 (+813)
Masterton WWTP	17.3	14.40	63.3	37.7	43.0
Carterton WWTP	2.00	1.74	5.09	4.20	No data
Greytown WWTP	2.00	1.73	5.79	3.45	3.50
Martinborough WWTP	**1.64**	**1.29**	**4.28**	**2.05**	**2.13**

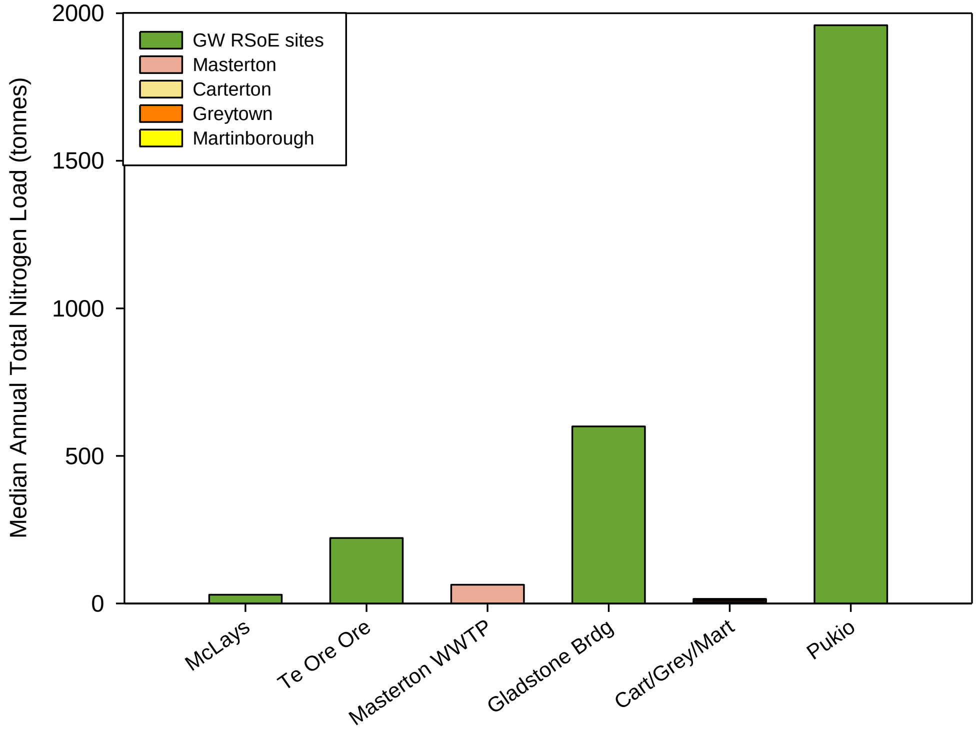

FIGURE 16: MEDIAN ANNUAL TOTAL NITROGEN LOAD (TONNES) IN THE RUAMAHANGA RIVER AT GWDC RSoE MONITORING SITES (SOURCE TO SEA) COMPARED TO MEDIAN ANNUAL INPUTS FROM WWTPS.

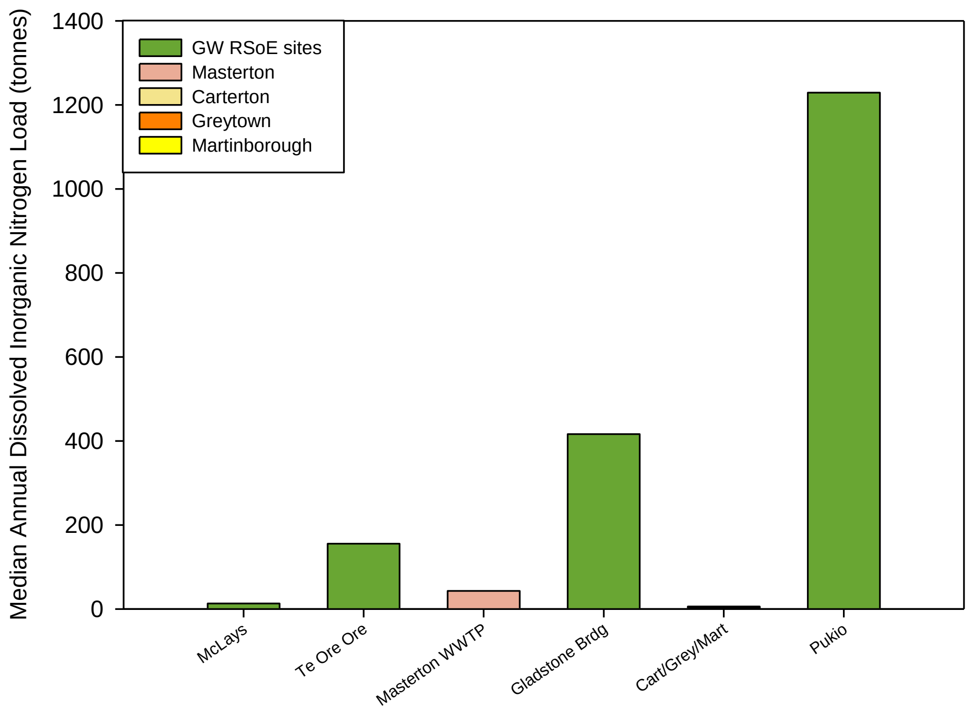

FIGURE 17: MEDIAN ANNUAL DIN LOAD (TONNES) IN THE RUAMAHANGA RIVER AT GWDC RSoE MONITORING SITES (SOURCE TO SEA) COMPARED TO MEDIAN ANNUAL INPUTS FROM WWTPS.

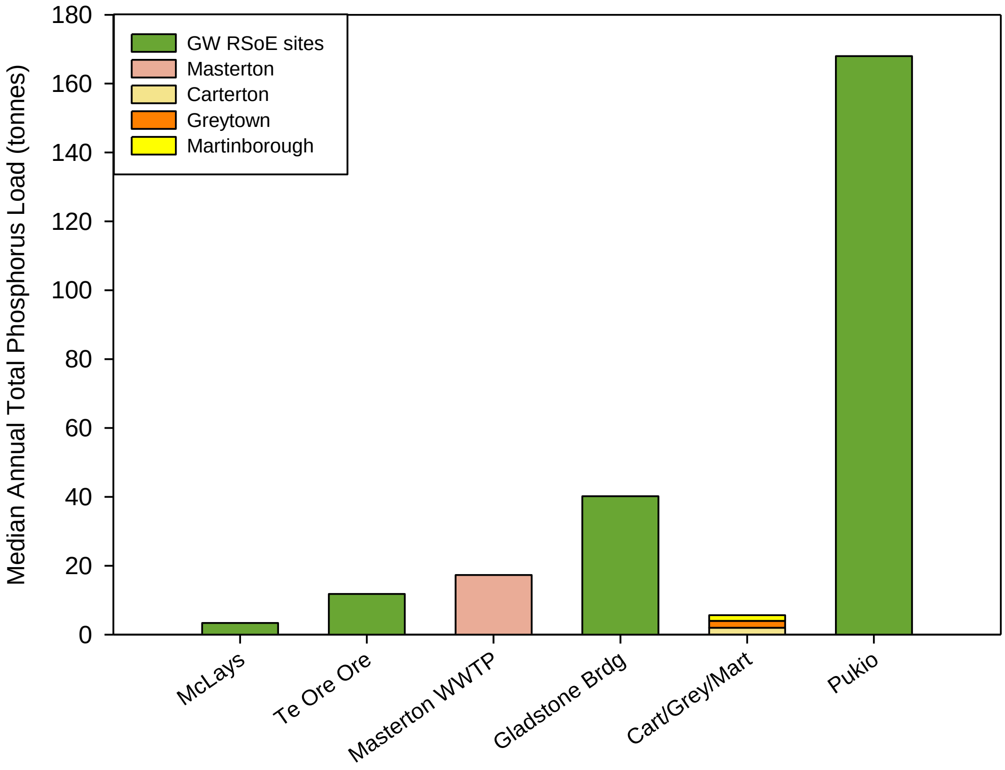

FIGURE 18: MEDIAN ANNUAL TP LOAD (TONNES) IN THE RUAMAHANGA RIVER AT GWDC RSoE MONITORING SITES (SOURCE TO SEA) COMPARED TO MEDIAN ANNUAL INPUTS FROM WWTPS.

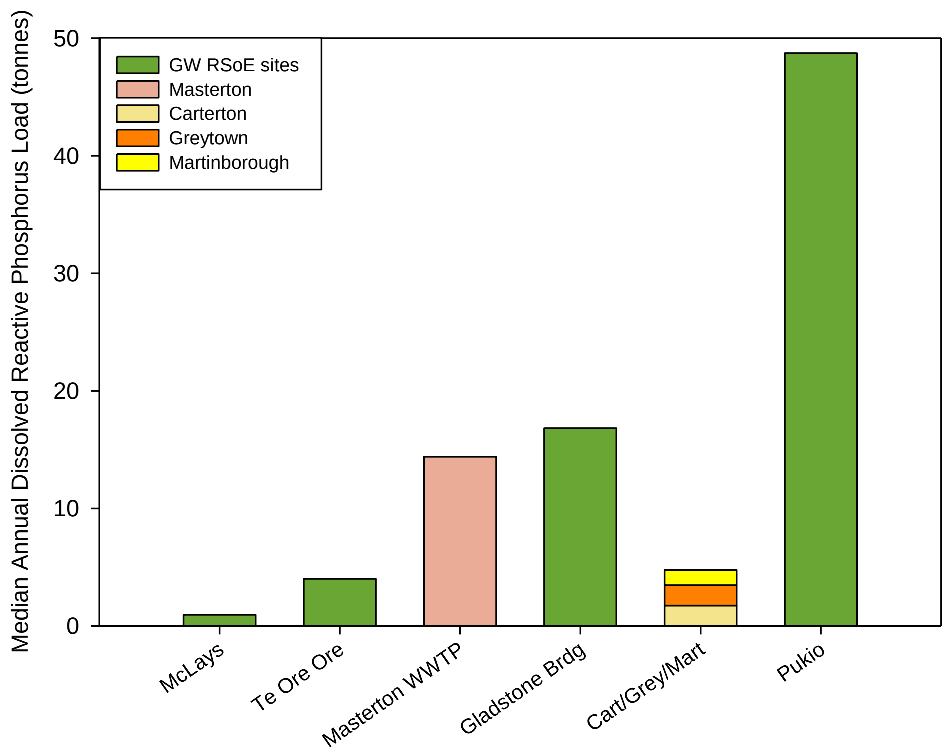

FIGURE 19: MEDIAN ANNUAL DRP LOAD (TONNES) IN THE RUAMAHANGA RIVER AT GWDC RSoE MONITORING SITES (SOURCE TO SEA) COMPARED TO MEDIAN ANNUAL INPUTS FROM WWTPS.

3.5.11.3 AMMONIA – ANNUAL LOADING

Figure 20 and Table 17 show the increasing amount (median load in tonnes per year) of ammoniacal nitrogen carried by the Ruamahanga River as it flows downstream from the source through farmland towards the sea. Additionally they show the median annual inputs of ammoniacal nitrogen from the WWTPs of Masterton, Carterton, Greytown, and Martinborough.

The ammoniacal nitrogen load increases by a factor of 1.5, 6.6, and 1.6 between McLays and Te Ore Ore, Te Ore Ore and Gladstone, and Gladstone and Pukio respectively.

Combined WWTP discharges upstream of Pukio are responsible for approximately 47.5 t/a ammoniacal nitrogen to the Ruamahanga River. Of these discharges Masterton WWTP is responsible for approximately 79%. Between Gladstone Bridge and Pukio WWTPs (Carterton, Greytown, and Martinborough) contribute approximately 66% of ammoniacal nitrogen inputs. Of the median annual ammoniacal nitrogen load (t/a) (based on Pukio data) the discharge from MWWTP represents approximately 5.4% of the inputs occurring between Gladstone Bridge and Pukio.

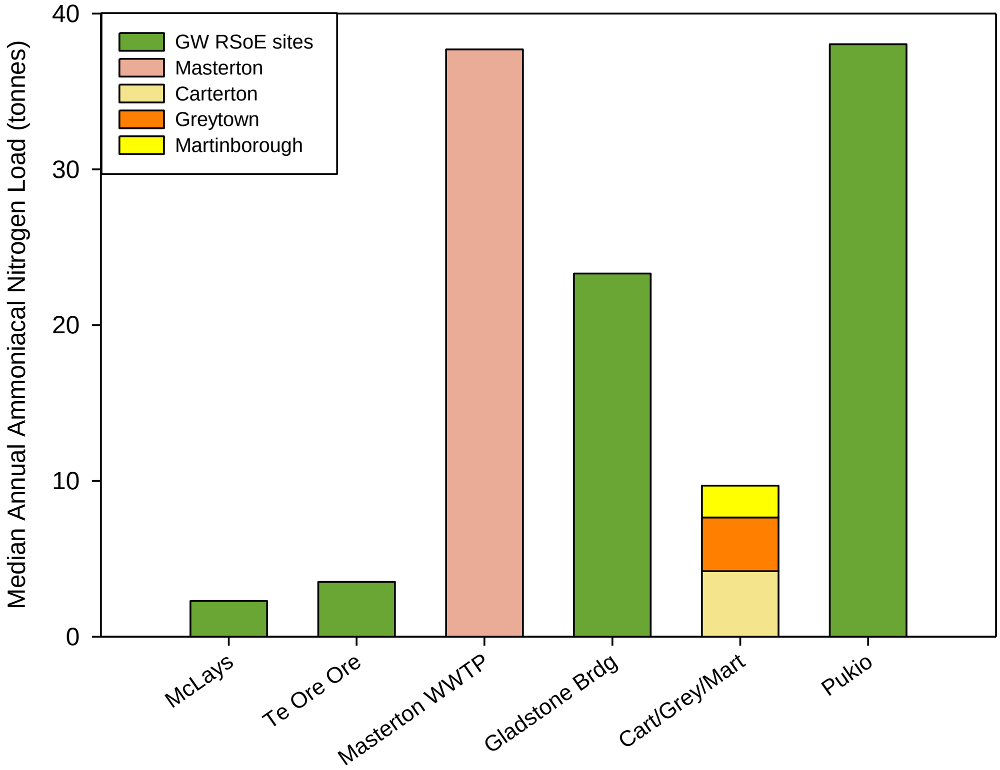

FIGURE 20: MEDIAN ANNUAL AMMONIACAL NITROGEN LOAD (TONNES) IN THE RUAMAHANGA RIVER AT GWDC RSoE MONITORING SITES (SOURCE TO SEA) COMPARED TO MEDIAN ANNUAL INPUTS FROM WWTPS.

3.5.11.4 NUTRIENTS – FLOW BASED LOADING

Monthly flow based loading data at RSoE sites were derived from monthly sampling of Ruamhanga River water and average monthly flows at respective flow monitoring stations. A summary of median monthly flow based loadings for nutrients at all sites is detailed in Table 23 and illustrated in Figures 21 to 24.

Examining total nutrient parameters (total phosphorus and total nitrogen) monthly loads of total phosphorus are greatest at very high flows among lowland sites Gladstone Bridge and Pukio (Figure 23). These peaks likely reflect both the increased amount of nutrients entering the river from these lower catchment areas (compared to upper catchment sites McLays and Te Ore Ore) and also the increased amount of deposited autochthonous solids entrained during high to very high flows. Similarly, these factors also likely influence the peak loadings of total nitrogen observed during very high flows at Gladstone Bridge and Pukio (Figure 21). Although these peak loads at very high flows are evident among the dissolved nutrient fractions the differences between the high flow loading and the very high flow load is much less.

Conversely, during low flows, there is relatively little variability in either total nutrient loads or dissolved nutrients. For example between sites and during low flows, median monthly DIN and DRP loads ranged between 0.43 – 13.05 tonnes/month and 0.03 – 0.6 tonnes/month, respectively (Figures 22 and 24) whereas during very high flows DIN and DRP loads ranged between 0.99 – 177.02 tonnes/month and 0.11 – 5.9 tonnes/month, respectively.

Table 23: Comparison of median monthly flow related surface water nutrient and ammoniacal nitrogen loads (tonnes/month) at Greater Wellington RSoE monitoring sites (McLays, Te Ore Ore, Gladstone Bridge, Pukio) in the Ruamahanga River. Flow categories derived from average daily flows at Mt. Bruce, Wardells and Waihenga flow monitoring stations September 2003 – August 2011 and are described as Low (flows < 25%ile), Base (flows 25%ile – 50%ile (i.e. median)), High (flows median – 3 x median), Very High (flows > 3 x median).

Site	Flow	TP	DRP	TN	NH_4-N	DIN
McLays	All Flows	0.14	0.07	1.73	0.15	0.71
	Low	0.05	0.03	0.65	0.07	0.43
	Base	0.08	0.07	1.33	0.14	0.68
	High	0.21	0.09	2.02	0.18	0.87
	Very High	2.48	0.11	3.30	0.24	0.99
Te Ore Ore	All Flows	0.51	0.21	14.57	0.15	10.60
	Low	0.14	0.06	6.66	0.07	5.30
	Base	0.47	0.19	14.08	0.13	11.22
	High	0.77	0.30	19.51	0.19	12.83
	Very High	1.26	0.33	21.77	0.28	13.03
Gladstone Bridge	All Flows	1.86	1.13	37.08	0.97	24.07
	Low	0.77	0.60	9.91	0.25	8.22
	Base	1.33	1.09	31.11	1.00	25.68
	High	2.48	1.42	50.28	1.45	36.23
	Very High	9.44	2.11	92.63	4.12	59.63
Pukio	All Flows	7.35	3.24	111.17	1.52	79.35
	Low	1.15	0.39	19.05	0.40	13.05
	Base	5.02	2.87	105.30	1.18	81.39
	High	13.03	4.74	177.43	3.36	123.78
	Very High	0.14	5.90	347.41	8.26	177.02

These results suggest interplay between load, flow, and site location. Thus at lower catchment sites the majority of monthly nutrient loads are carried during high – very high flow conditions, whereas at high catchment sites the monthly nutrient load carried in the river is spread relatively more consistently among the various flow conditions.

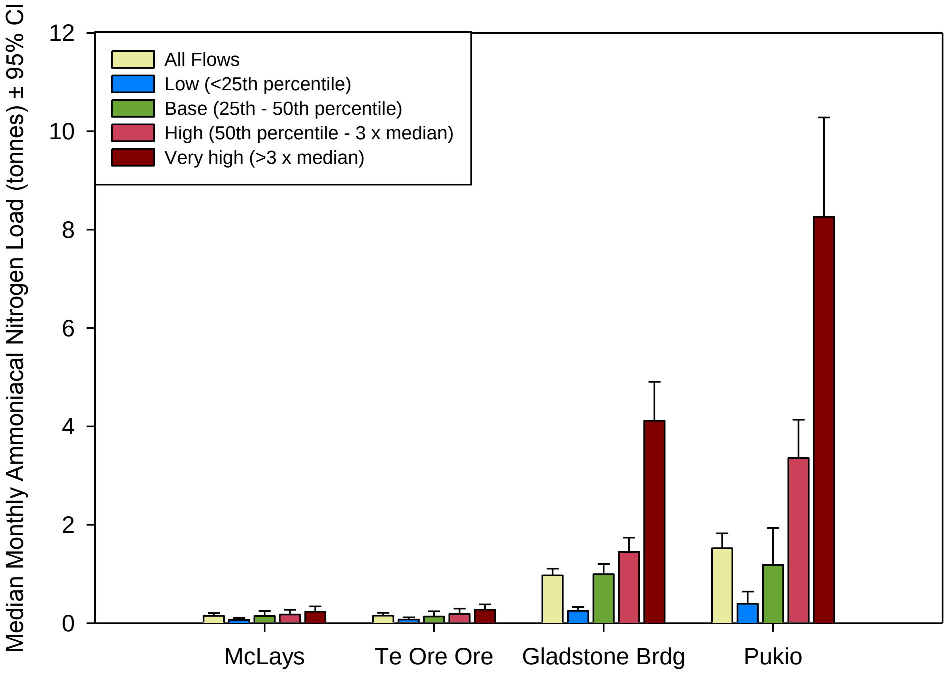

FIGURE 21: MEDIAN MONTHLY TOTAL NITROGEN LOAD (TONNES) IN THE RUAMAHANGA RIVER AT GWDC RSOE MONITORING SITES (SOURCE TO SEA) AT DIFFERENT FLOWS.

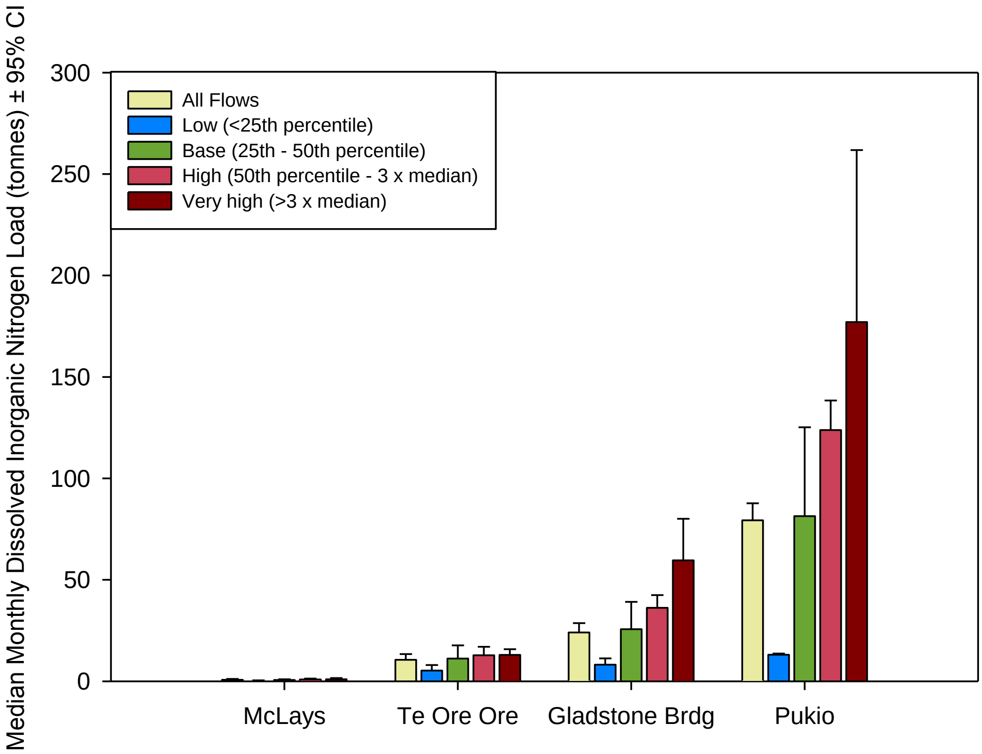

FIGURE 22: MEDIAN MONTHLY DIN LOAD (TONNES) IN THE RUAMAHANGA RIVER AT GWDC RSOE MONITORING SITES (SOURCE TO SEA) AT DIFFERENT FLOWS.

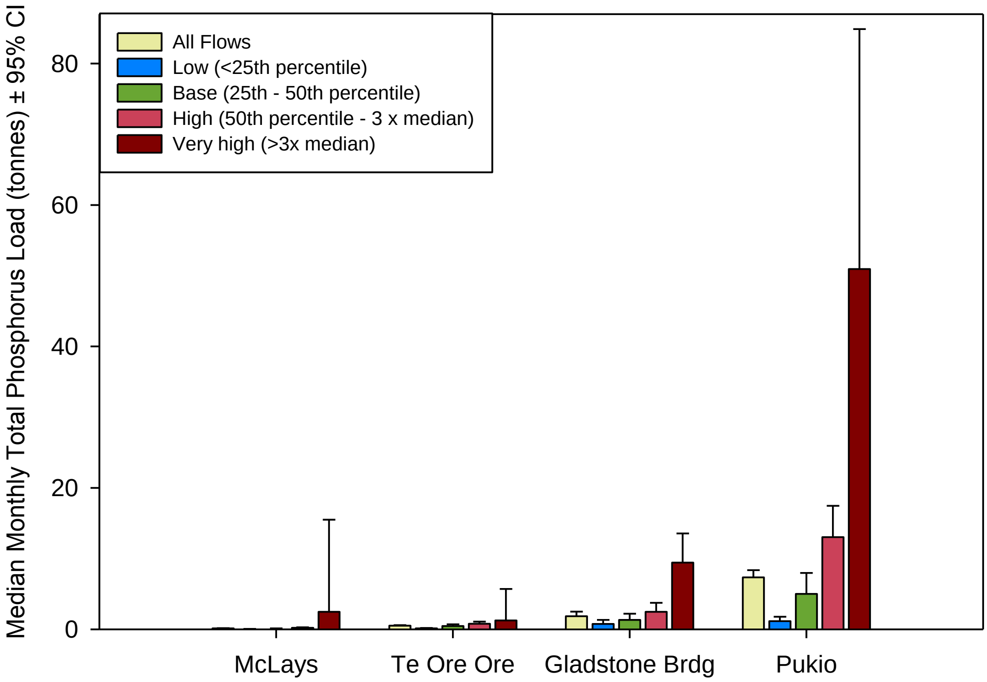

FIGURE 23: MEDIAN MONTHLY TOTAL PHOSPHORUS LOAD (TONNES) IN THE RUAMAHANGA RIVER AT GWDC RSOE MONITORING SITES (SOURCE TO SEA) AT DIFFERENT FLOWS

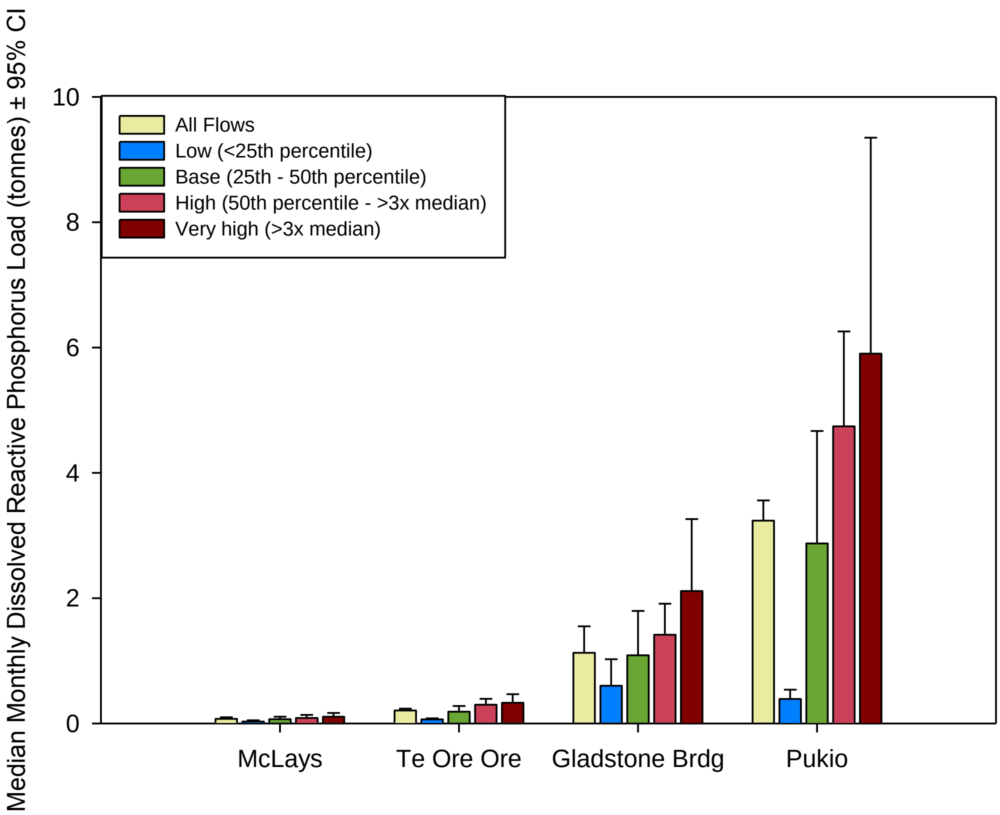

FIGURE 24: MEDIAN MONTHLY DRP LOAD (TONNES) IN THE RUAMAHANGA RIVER AT GWDC RSOE MONITORING SITES (SOURCE TO SEA) AT DIFFERENT FLOWS

3.5 AQUATIC ECOLOGY OF RUAMAHANGA RIVER

3.5.1 MACROINVERTEBRATES

The RSoE monitoring programme also includes macoinvertebrate community sampling and these data are included in the annual freshwater quality monitoring reports for the Wellington Region' published by GWRC (Perrie 2007; Perrie 2007; Perrie 2008; Perrie 2009; Perrie and Cockeram 2010). Table 24 summarises the median data collected by GWRC for biotic indices in the Ruamahanga River between the years 2003 and 2010.

Table 24: Median macroinvertebrate index scores – GWRC RSoE monitoring data for the period 2003 to 2010. 'Excellent' and 'good' refer to habitat class interpretation of MCI-type biotic indices from Stark and Maxted (2007)

Site Name	MCI	QMCI	Taxa richness	%EPT taxa
Ruamahanga @McLays	146.2 (Excellent)	7.99 (Excellent)	14	90.3
Ruamahanga @Te Ore Ore	113.0 (Good)	6.99 (Excellent)	16	58.0
Ruamahanga @Gladstone	104.6 (Good)	7.01 (Excellent)	12	63.0
Ruamahanga @ Pukio	105.0 (Good)	6.50 (Excellent)	10	60.5

These show that;

- The McClays reference site is assigned a Macroinvertebrate Community Index (MCI) grade of "excellent" with a median score for all years of 146.2. For Quantitative MCI (QMCI) an "excellent" score was also assigned, with a median of 7.99 for all years (see Table 4 for a description of MCI/QMCI scores). Comparing indices between sites using non parametric Kruskal-Wallis testing, it was evident that the McClays site was significantly higher in MCI, QMCI, and % EPT taxa than all other sites (Kruskal-Wallis tests, all $p < 0.008$). For taxa richness McClays was significantly higher than Pukio only ($p < 0.008$). Seasonal Kendal trend testing did not detect any trends for any of the indices.

- The Te Ore Ore site is assigned a MCI score of "good" with a median score for all years of 113. For QMCI, an "excellent" score was assigned, with a median of 6.99 for all years. Comparing indices between Te Ore Ore and other sites, the only significant differences were a significantly higher result at Te Ore Ore in terms of taxa richness compared to both Gladstone Bridge ($p = 0.049$) and Pukio ($p = 0.007$). Seasonal Kendal trend testing detected one significant trend in % EPT taxa richness.

- The Gladstone Bridge site is assigned MCI score of "good" with a median score for all years of 104.6. For QMCI an "excellent" grade was assigned, with a median of 7.01 for all years. Besides those significant differences mentioned above, there were no other differences found. Seasonal Kendal trend testing did not detect any trends for any of the indices.

- The Pukio site is assigned MCI score of "good" with a median score for all years of 105. For QMCI an "excellent" grade was assigned, with a median of 6.5 for all years. Besides those significant differences mentioned above, there were no other differences found. Seasonal Kendal trend testing did not detect any trends for any of the indices.

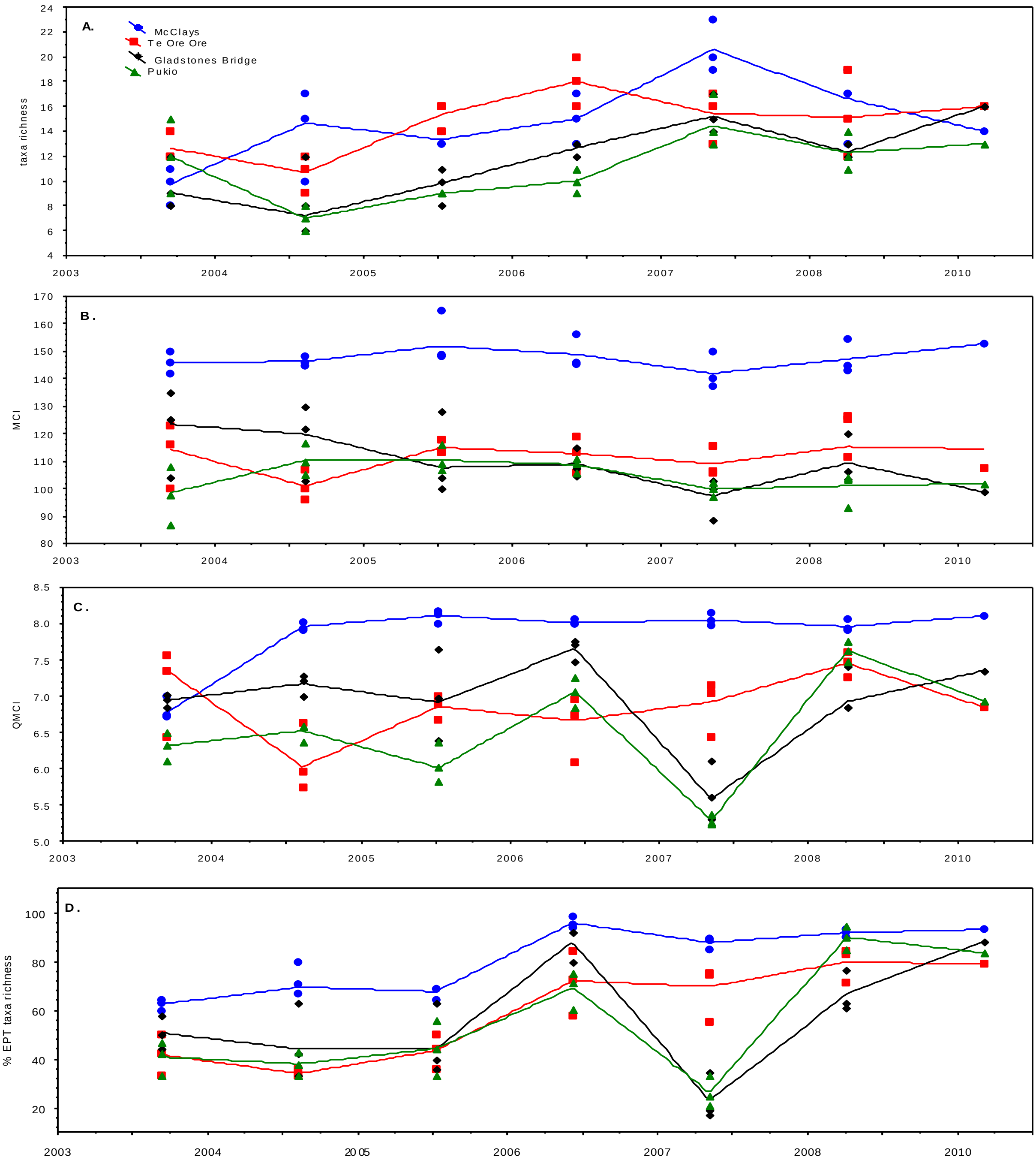

FIGURE 25: PLOTS COMPARING MEDIAN SCORES OF A) TAXA RICHNESS, B) MCI, AND C) QMCI, AND D) %EPT TAXA RICHNESS (WITH LOWESS (TENSION 0.4) FITTED LINES) AT GWRC RSOE MONITORING SITES IN THE RUAMAHANGA RIVER FROM 2003 TO 2010.

3.5.2 FISH COMMUNITIES

There are around 50 native freshwater fish species in New Zealand, with the three major families being the galaxiids, the bullies, and the eels. As at 10 January 2012, there were 36 species of fish identified in the Ruamahanga Catchment (Table 29), 23 of which are native species, and seven of which are exotic (introduced species) and one, the grayling is extinct. The species most frequently recorded are the Longfin Eel, Brown Trout, Shortfin Eel and brown mudfish. Of the native fish identified in the catchment only 4 are non-migratory (Dwarf Galaxias, Crans Bully, Upland Bully, and Brown Mudfish) (Strickland and Quarterman 2001).

The high ratio of diadromous species listed in the Ruamahanga catchment illustrates that the Lower Ruamahanga River is an important 'fish corridor' that allows many species to travel between upstream freshwater habitats and the sea (Perrie, 2007). It is well recognised as a regionally significant river in the Wellington region for native fish migration (Strickland and Quaterman, 2001). The Lower Ruamahanga River is also important as a conduit for trout and in particular for providing access to spawning reaches in tributary rivers such as the Mangatatere and Huangarua Rivers (Strickland and quaterman 2001). Figures 26 to 34 show the fish species identified from the NZFFDB at various sites in the Ruamahanga catchment. It should be noted however that many of these records relate to tributaries of the Ruamahanga rather than the main stem.

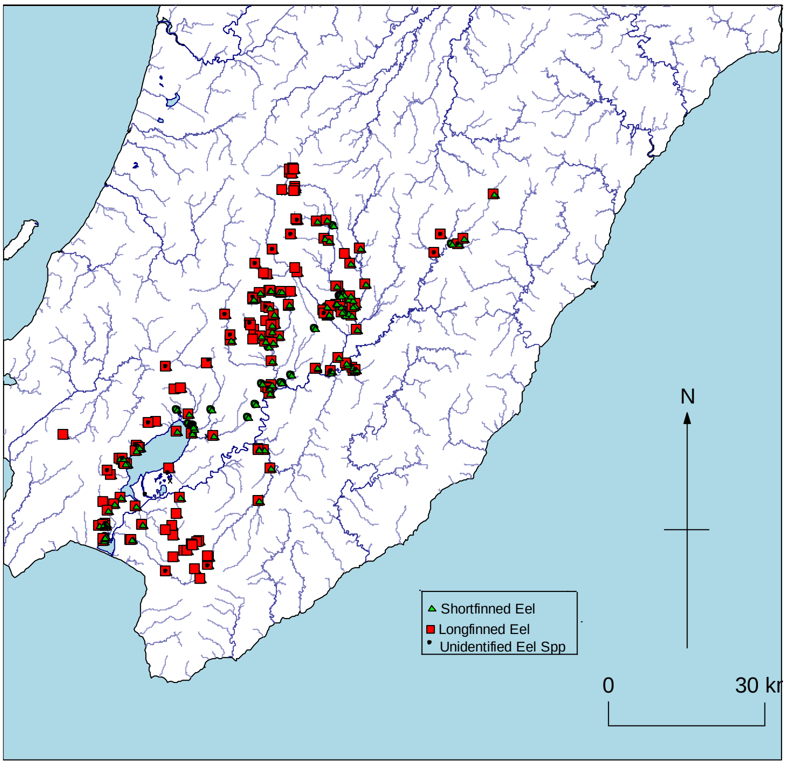

FIGURE 26: EEL DISTRIBUTION IN THE RUAMAHANGA RIVER CATCHMENT

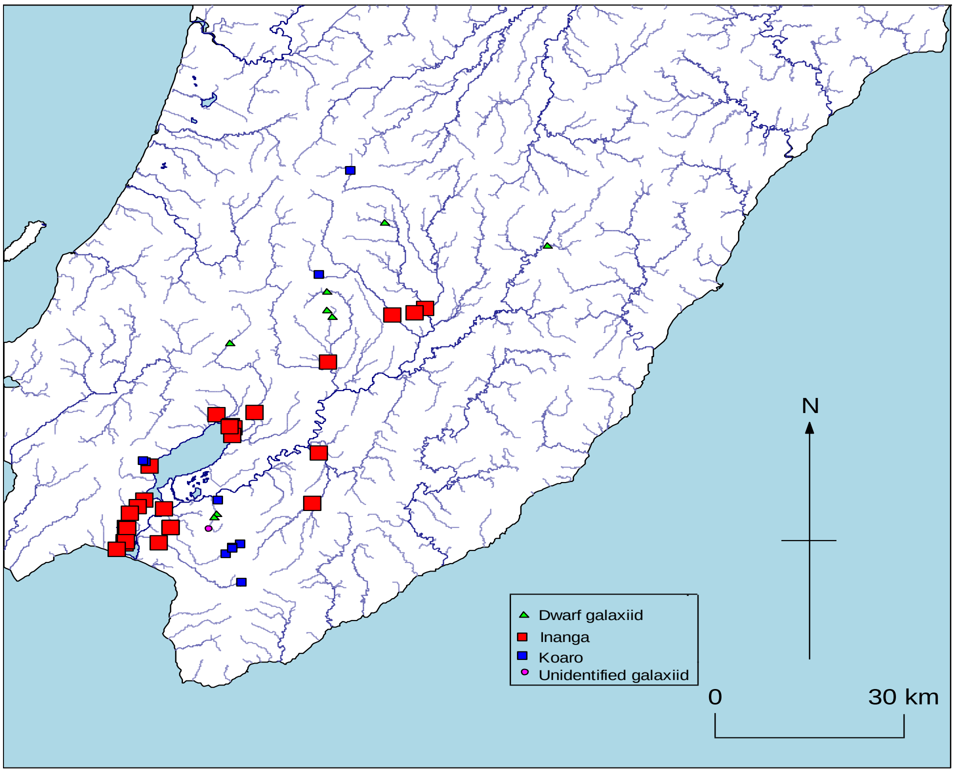

FIGURE 27: GALAXIID spp IN RUAMAHANGA RIVER CATCHMENT

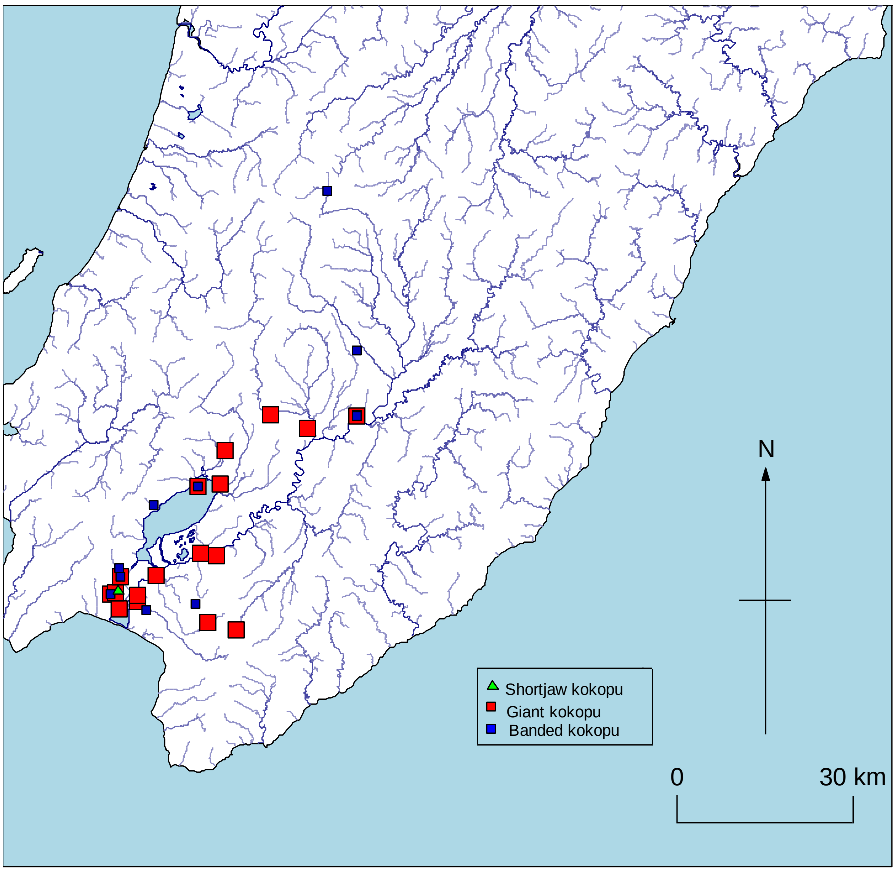

FIGURE 28: KOKOPU IN RUAMAHANGA RIVER CATCHMENT

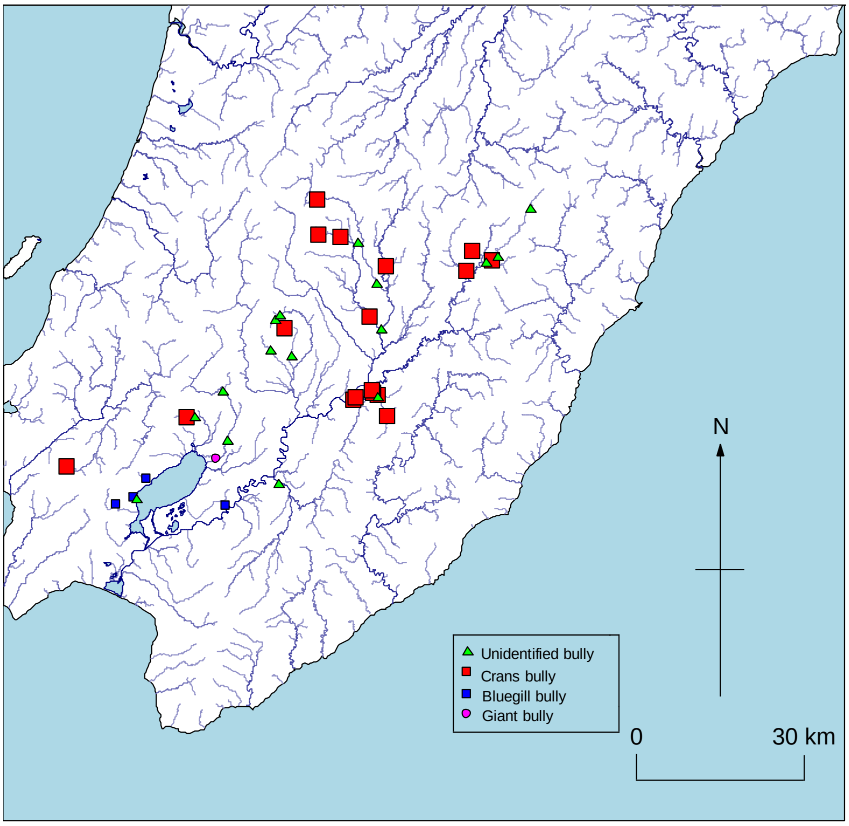

FIGURE 29: BULLIES IN RUAMAHANGA RIVER CATCHMENT

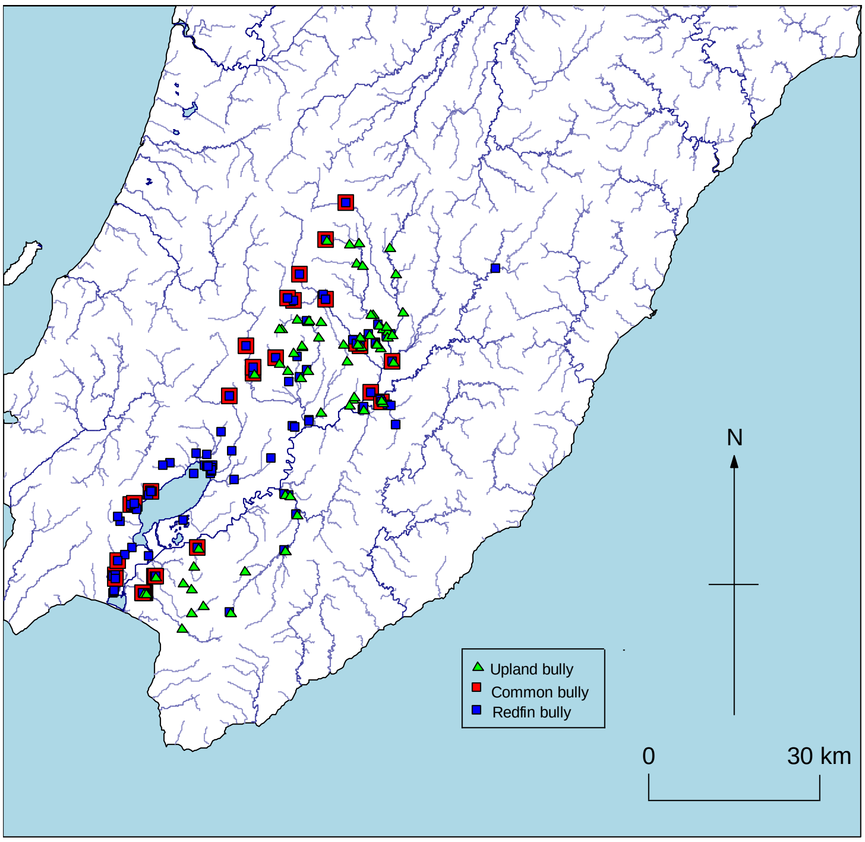

FIGURE 30: BULLIES IN RUAMAHANGA RIVER CATCHMENT

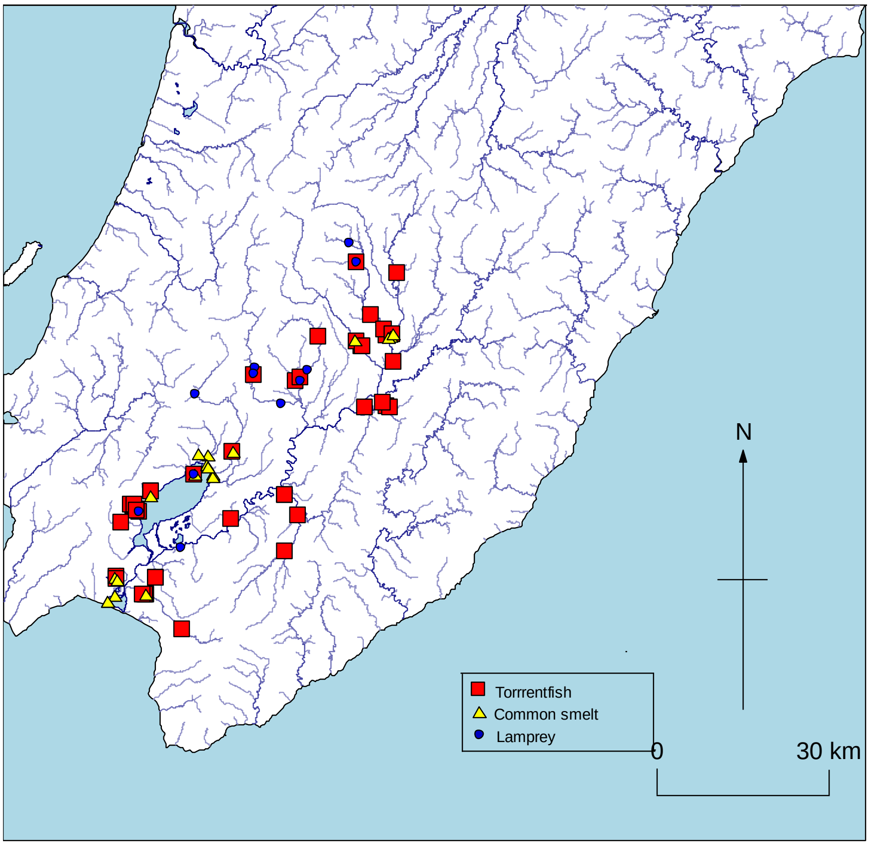

FIGURE 31: OTHER NATIVE FISH IN RUAMAHANGA RIVER CATCHMENT

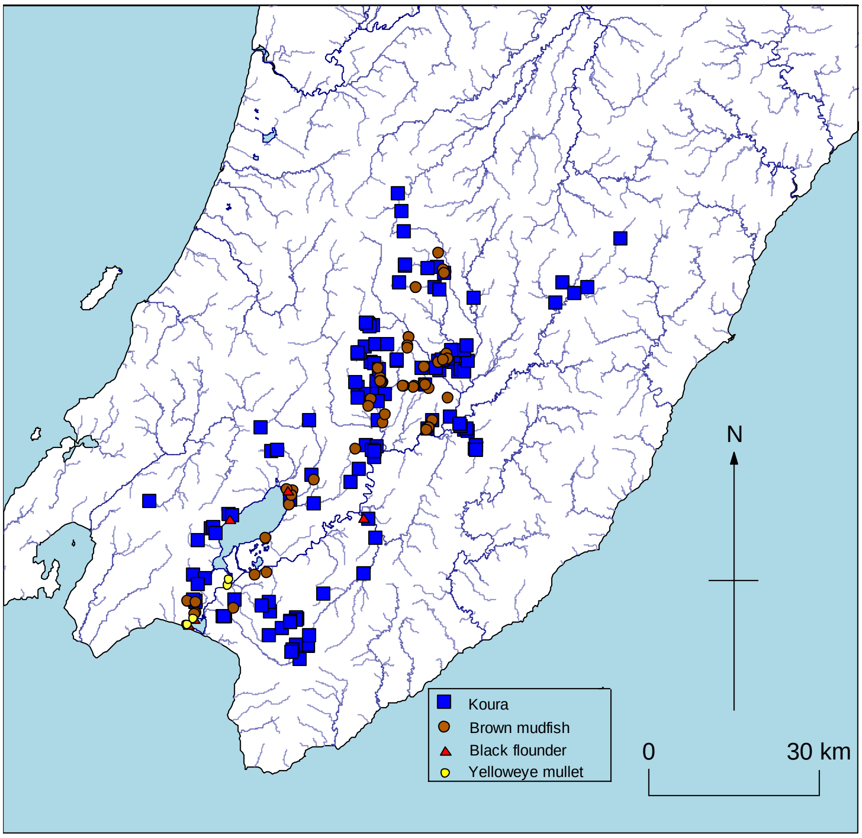

FIGURE 32: OTHER NATIVE FISH IN RUAMAHANGA RIVER CATCHMENT

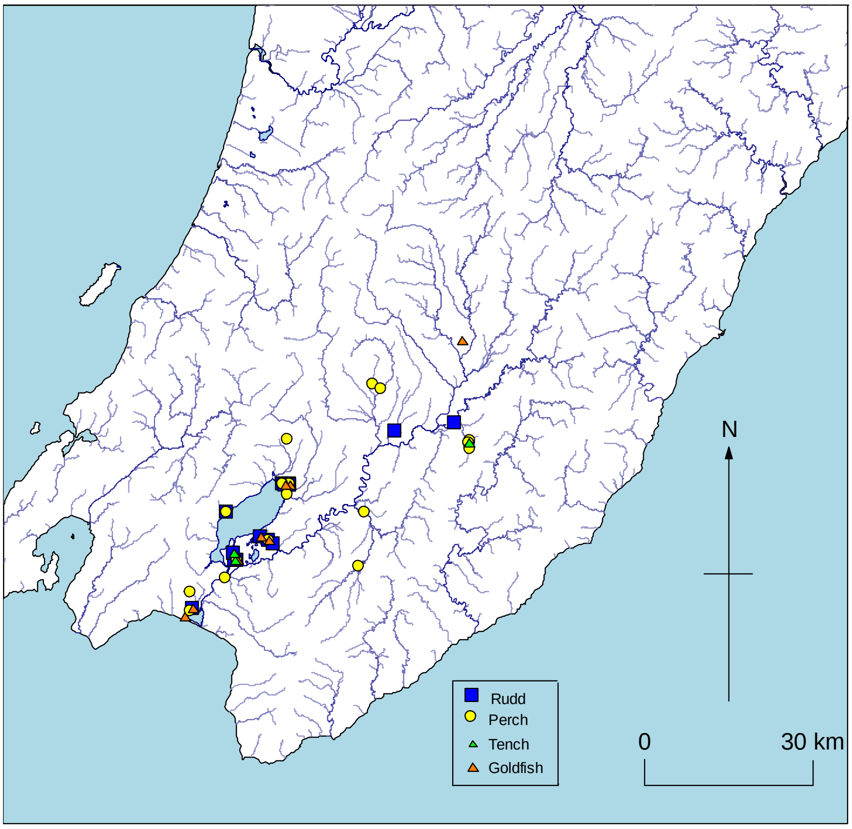

FIGURE 33: EXOTIC FISH SPECIES IN RUAMAHANGA RIVER CATCHMENT

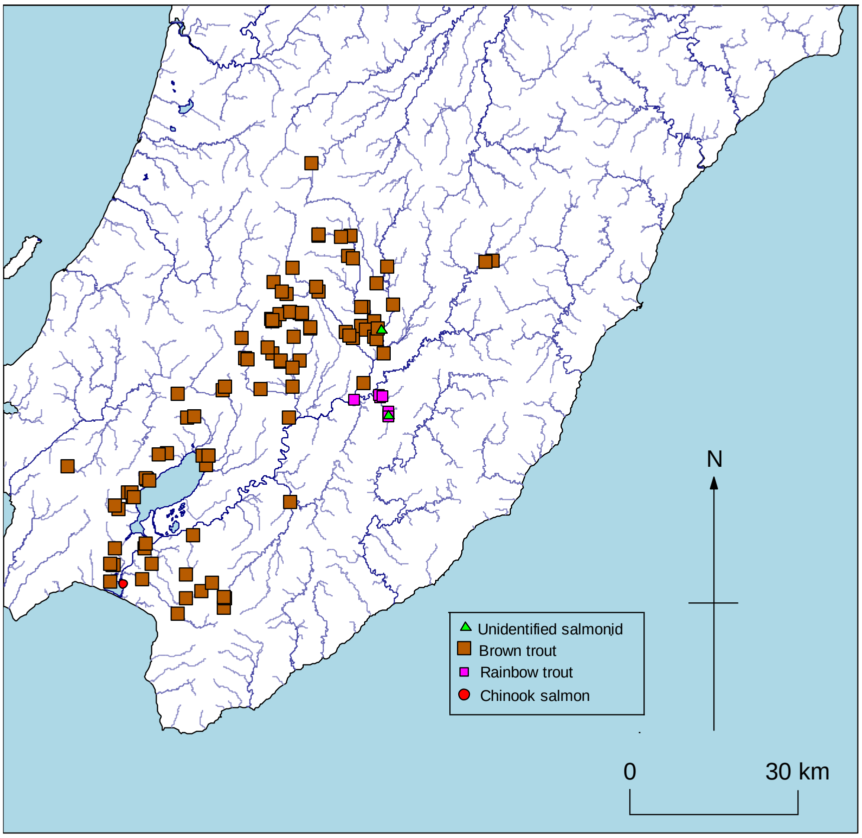

FIGURE 34: SALMONIDS IN RUAMAHANGA RIVER CATCHMENT

TABLE 25: FISH SPECIES IDENTIFIED IN THE RUAMAHANGA CATCHMENT (SOURCE NZFFDB)

Common Name	Scientific name	Native/Introduced	Diadromous*
Shortfin eel	*Anguilla australis*	Native	Yes
Longfin eel	*Anguilla dieffenbachii*	Native	Yes
Unidentified eel	*Anguilla spp.*	Native	Yes
Crans Bully	*Gobiomorphus basalis*	Native	No
Upland Bully	*Gobiomorphus breviceps*	Native	No
Common Bully	*Gobiomorphus cotidianus*	Native	Yes
Giant Bully	*Gobiomorphus gobioides*	Native	Yes
Bluegill Bully	*Gobiomorphus hubbsi*	Native	Yes
Redfin Bully	*Gobiomorphus huttoni*	Native	Yes
Unidentified bully	*Gobiomorphus spp.*	Native	-
Giant Kokopu	*Galaxias argenteus*	Native	Yes
Koaro	*Galaxias brevipinnis*	Native	Yes
Dwarf Galaxias	*Galaxias divergens*	Native	No
Banded Kokopu	*Galaxias fasciatus*	Native	Yes
Inanga	*Galaxias maculatus*	Native	Yes
Shortjaw Kokopu	*Galaxias postvectis*	Native	Yes
Unidentified galaxiid	*Galaxias spp.*	Native	-
Torrentfish	*Cheimarrichthys fosteri*	Native	Yes
Lamprey	*Geotria australis*	Native	Yes
Common Smelt	*Retropinna retropinna*	Native	Yes
Brown Mudfish	*Neochanna apoda*	Native	No
Black Flounder	*Rhombosolea retiaria*	Native	Yes
Yelloweye Mullet	*Aldrichetta forsteri*	Native	Yes
Grey Mullet	*Mugil cephalus*	Native	Yes
Unidentified Mullet	*Mugil*	Native	-
Brown Trout	*Salmo trutta*	Introduced	Yes
Rainbow Trout	*Oncorhynchus mykiss*	Introduced	Yes
Chinook Salmon	*Oncorhynchus tshawytscha*	Introduced	Yes
Perch	*Perca fluviatilis*	Introduced	No
Rudd	*Scardinius erythrophthalmus*	Introduced	No
Tench	*Tinca tinca*	Introduced	No
Goldfish	*Carassius auratus*	Introduced	No
Estuarine Triplefin	*Grahamina sp.*	Native	Marginal
Mullet	*Mugil*	Native	Yes
Koura	*Paranephrops*	Native	No
Grayling	*Prototroctes oxyrhynchus*	Native (extinct)	-

*Diadromous – fishes that migrate between fresh and saltwater, usually in relation to spawning

4. ASSESSMENT OF ENVIRONMENTAL EFFECTS

4.1 SURFACE WATER QUALITY DATA

This assessment of effects on water quality in the Ruamahanga River resulting from the discharge of treated effluent from the MWWTP is limited due to the small dataset available and limited analytes measured (16 samples have been collected over the course of 10 months in one year (2011)). Therefore, where required professional judgement and commonly used methodologies have been used to predict effects.

4.1.1 DATA ANALYSIS

Ammoniacal–N and *E. coli* results were compared between sites using the non-parametric equivalent of ANOVA, the Kruskal-Wallis test (StatSoft 2004) and Post hoc 2-tailed multiple comparison of mean ranks also conducted. Differences were reported as significant when a *p*-value of <5% was estimated (i.e. testing at the 95% level of significance).

4.1.2 MONITORING SITES IN RUAMAHANGA RIVER

Figure 35 shows the MWWTP resource consent monitoring sites in the Ruamahanga River.

FIGURE 35: RESOURCE CONSENT MONITORING SITES FOR THE MWWTP TREATED EFFLUENT DISCHARGE TO THE RUAMAHANGA RIVER.

4.2 RESULTS

4.2.1 AMMONIACAL - N

Considering the small amount of water quality data available at MWWTP discharge monitoring sites in the Ruamahanga River, it is difficult to perform a detailed assessment of the existing effects of the MWWTP discharge. ANZECC (2000) recommend the taking of 24 samples to estimate the 20th and 80th percentiles at a reference site. Because only 16 samples have been collected over the course of 10 months in one year (2011) the basis for making inferences is somewhat tenuous and conclusions should be considered with some caution.

Table 26, details summary statistics for ammoniacal–N, at consented discharge monitoring sites. Examining individual sites in terms of ANZECC (2000) water quality guidelines, where a maximum ammoniacal–N concentration of 0.021mg/L for the 95% protection level of species in a slightly disturbed New Zealand lowland stream is defined, it is apparent that on all but one occasion ammoniacal–N levels at the upstream reference site are below relevant guideline levels (Figure 36a). At the downstream monitoring sites there were only two occasions (March) when levels were below guideline values. In comparison, the maximum ammoniacal–N level recorded in the discharge was 20,000 times above the ANZECC guideline level (Figure 36b). In summary, results indicate that at the 50m, 250m and 500m downstream sites respective median levels were 4.28, 2.86 and 2.62 times above the guideline value.

Comparing results between sites, it is evident that ammoniacal–N at the upstream reference site was significantly lower than all other monitoring sites (all $p < 0.002$), while there was no difference between either the 50m, 250m or 500m downstream monitoring sites.

Table 26: NH_4 – N (mg/L) summary statistics at MWWTP discharge monitoring sites and at GWRC SoE monitoring sites on the Ruamahanga River

	n	Median	Min	Max	20th %tile	80th %tile
Reference	16	0.01	0.01	0.03	0.01	0.01
Discharge	16	24.9	1.31	42.0	16.4	40.7
50m DS	16	0.09	0.01	0.28	0.05	0.1
250m DS	16	0.06	0.01	0.15	0.04	0.07
500m DS	16	0.055	0.01	0.12	0.03	0.07
Gladstone Bridge	96	0.02	0.005	0.09	0.005	0.043
Pukio	96	0.01	0.0054	0.1	0.005	0.027

To put these results into a regional context a comparison to selected GWRC RSoE monitoring sites is appropriate. The two closest upstream and downstream SoE sites are Gladstone's Bridge, which lies approximately 40km upstream of the MWWTP discharge and the Pukio SoE site, located approximately 15km downstream. Comparing the upstream reference site to the Gladstone Bridge site no significant difference was evident, moreover there was no significant between the reference site and the downstream RSoE Pukio site either. However, comparing the downstream monitoring sites (50m, 250m, 500m) to the Pukio RSoE site it is evident that median levels at the three discharge monitoring sites are significantly higher than the Pukio site (all $p < 0.001$).

Therefore it is evident that the discharge is contributing significant levels of NH_4-N to the Ruamahanga River, causing levels of which adverse effects may be occurring up to 500m downstream of the site.

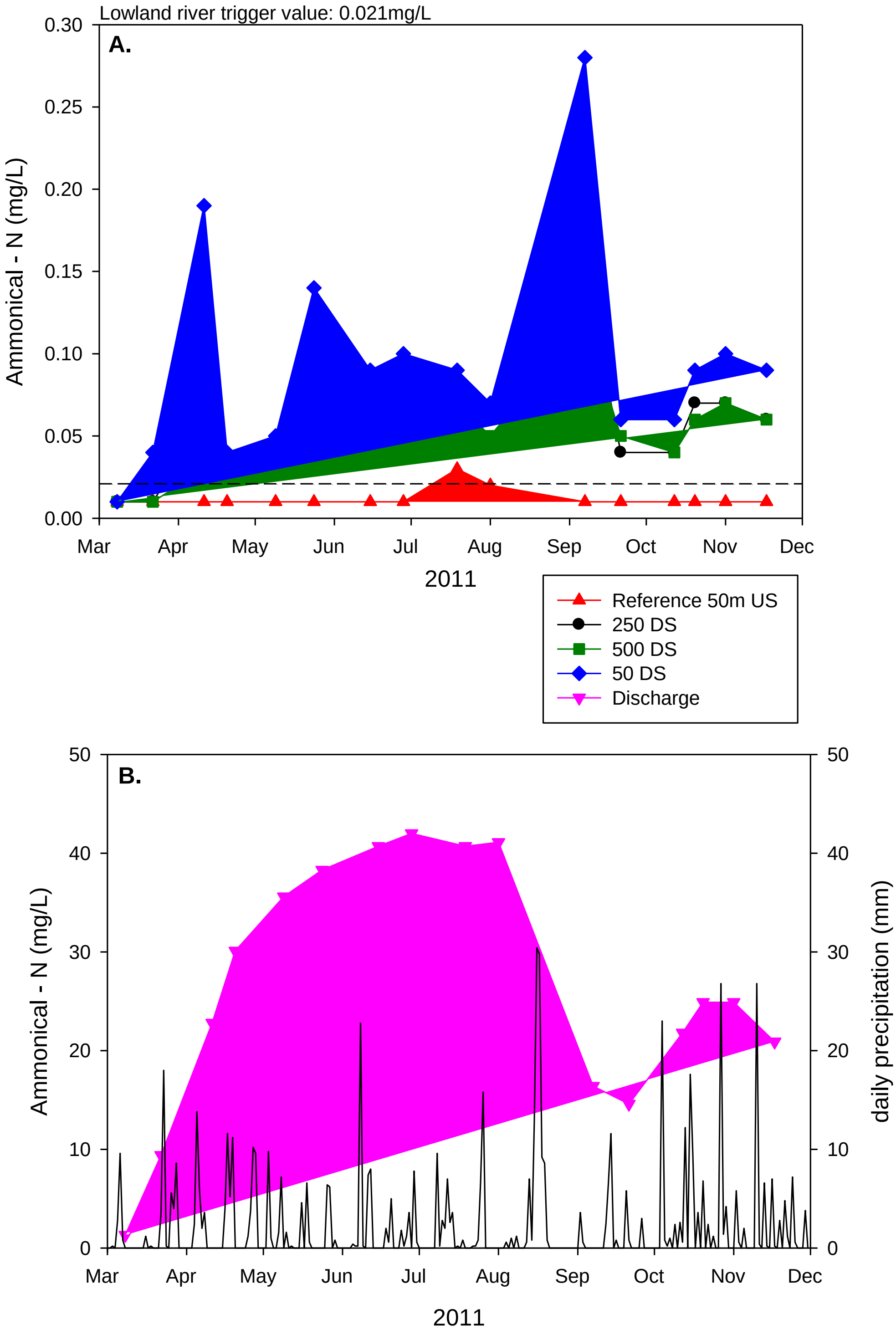

FIGURE 36: CONCENTRATION OF AMMONIACAL–N AT A) UPSTREAM AND DOWNSTREAM MONITORING SITES IN THE RECEIVING ENVIRONMENT AND B) THE DISCHARGE AND DAILY PRECIPITATION AT THE MARTINBOROUGH EWS (NIWA, CLIFLO). GUIDELINE VALUE RELATES TO THE ANZECC LOWLAND RIVER TRIGGER VALUE FOR SLIGHTLY/MODERATELY DISTURBED SYSTEMS.

As the above dataset is relatively small and sampling consisted of single grab samples it is difficult to determine whether the data reflects the concentration of ammoniacal-N after full mixing has occurred. However, it is possible to estimate what the likely concentration will be downstream of the discharge after full mixing has occurred using the following equation:

$C_{river} = C_d (F_d/F_r) + C_{up} (F_{up}/F_r)$

Where;

C = Median contaminant concentration (mg/L)

F_r = River flow downstream of discharge (L/s)

F_d = Effluent discharge flow (L/s) = (6 L/s dry weather and 7.4 L/s wet weather)

F_{up} = Upstream flow of river (L/s)[1]

[1] Upstream river flows are those recorded at Waihenga between 2003 and 2011. The figures represent the median value for each flow regime e.g. for 25%ile range, 25%ile to 50%ile range…etc.

Therefore: at river flows:

Half median (<25%ile) river flows (15,613 L/s) = **<u>0.011 mg/L</u>**

Median (25%ile to 50%ile) river flows (37,346 L/s) = **<u>0.008 mg/L</u>**

3 x median (3 x 50%ile) river flows (78,786 L/s) = **<u>0.019 mg/L</u>**

>3 x median river flows (226,088 L/s) = **<u>0.017 mg/L</u>**

Note: Guideline (ANZECC 2000) = 0.021 mg/L; proposed GWRC guideline is 0.9 9 mg/L annual average for all flows.

These calculated values suggest that the dowstream concentration once fully mixed would likely be lower than the recorded data.

4.2.3 E. COLI

Table 27 details the summary statistics for *E. coli* at discharge monitoring sites. Data from discharge monitoring sites indicates that *E.coli* counts around the MWWTP have been, with one exception, below the MfE alert range for contact recreation guidelines (Figure 37a). The one occasion where *E. coli* levels entered the amber range was in March at the 50m downstream site. Compared to the discharge itself, median levels at the reference site were 8.7 times lower. Comparing the reference site to the three downstream discharge monitoring sites, no significant differences were evident. These results suggest that *E. coli* levels reduce to within the range reported at the upstream reference site within 50m of the discharge.

Comparing *E. coli* levels at the reference and downstream discharge monitoring sites to GWRC SoE sites (Gladstone Bridge and Pukio) in order to assess cumulative effects in the wider Ruamahanga system, few significant differences were evident (in fact the sole significant difference among all sites was between Gladstone Bridge and Pukio (p = 0.003), where Pukio was higher). These results suggest a cumulative decline in bacteriological water quality occurs between Gladstone Bridge and the Pukio site, with the MWWTP a likely influencing factor.

Table 27: E. coli summary statistics at MWWTP discharge monitoring sites and at GWRC SoE monitoring sites in the Ruamahanga River

	n	Median	Min	Max	20^{th} %tile	80^{th}%tile
Reference	16	54	20	210	40	96
Discharge	16	470	28	5000	250	1700
50m DS	16	73	31	390	44	130
250m DS	16	64	12	220	46	88
500m DS	16	59	19	240	48	120
Gladstone Bridge	96	39	2	9300	18	250
Pukio	96	105	6	3800	36	600

It should be again noted that a U. V. plant is currently being commisioned and reports suggest that E. *coli* counts in the final effluent are in the order of <1x10^2 cfus/100mL. If these figures are attainable consistently this should allow downstream counts (during dry periods) to remain as they typically are i.e. mostly below recreational guideline alert level of 550 cfus/100mL during periods of no rainfall.

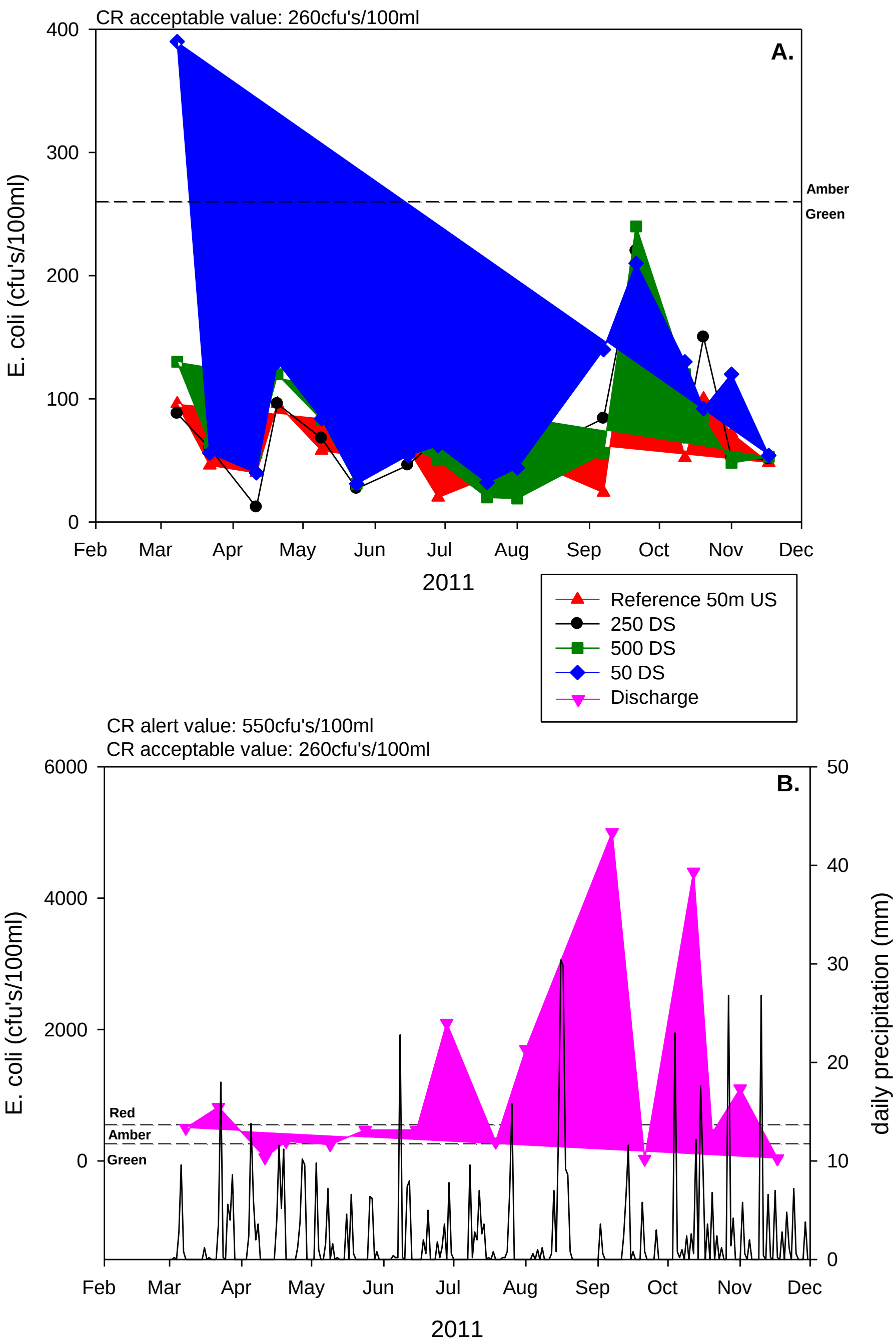

FIGURE 37: CONCENTRATION OF E. COLI AT A) UPSTREAM AND DOWNSTREAM MONITORING SITES IN THE RECEIVING ENVIRONMENT AND B) THE DISCHARGE AND DAILY PRECIPITATION AT THE MARTINBOROUGH EWS (NIWA, CLIFLO). GUIDELINE VALUES RELATE TO MfE MANAGEMENT SYSTEM FOR RECREATIONAL FRESHWATER USE.

4.2.4 NUTRIENTS AND PERIPHYTON

4.2.4.1 DRP

As previously mentioned there is limited water quality data with regards to the effects of the MWWTP discharge to the Ruamahanga River and none at all for nutrients. However, it is possible to estimate what the likely concentration of DRP (or any determinand) will be downstream of the discharge after full mixing has occurred using the following equation:

$C_{river} = C_d (F_d/F_r) + C_{up} (F_{up}/F_r)$

Where;

C = Median contaminant concentration (mg/L)

F_r = River flow downstream of discharge (L/s)

F_d = Effluent discharge flow (L/s) = (6 L/s dry weather and 7.4 L/s wet weather)

F_{up} = Upstream flow of river (L/s)[1]

[1] Upstream river flows are those recorded at Waihenga between 2003 and 2011. The figures represent the median value for each flow regime e.g. for 25%ile range, 25%ile to 50%ile range…etc.

Therefore: DRP at river flows:

Half median (<25%ile) river flows (15,613 L/s) = **<u>0.009 mg/L</u>**

Median (25%ile to 50%ile) river flows (37,346 L/s) = **<u>0.017 mg/L</u>**

3 x median (3 x 50%ile) river flows (78,786 L/s) = **<u>0.020 mg/L</u>**

>3 x median river flows (226,088 L/s) = **<u>0.015 mg/L</u>**

Note: Guideline (ANZECC 2000) = 0.010 mg/L DRP; proposed GWRC guideline is 0.014 mg/L annual average for flows <3 x median river flow.

4.2.4.2 DIN

Using the equation from above the calculated DIN concentrations for different river flows after full mixing has occurred downstream of the discharge suggest river concentrations will be approximately:

Half median (<25%ile) river flows (15,613 L/s) = **<u>0.151 mg/L</u>**

Median (25%ile to 50%ile) river flows (37,346 L/s) = **<u>0.332 mg/L</u>**

3 x median (3 x 50%ile) river flows (78,786 L/s) = **<u>0.437 mg/L</u>**

>3 x median river flows (226,088 L/s) = **<u>0.376 mg/L</u>**

Note: Guideline (ANZECC 2000) = 0.465 mg/L DIN; proposed GWRC guideline is 0.180 mg/L DIN annual average for flows <3 x median river flow.

4.2.4.3 PERIPHYTON

As discussed earlier periphyton growth is influenced by not only the nutrient supply in the water but also the frequency of flood events (determined as flows >3 x median flow), or more specifically the the accrual period (period between flood events). Figure 43 illustrates the typical relationship between peak periphyton growth (chlorophyll *a*) and accrual time in a river (from the *NZ Periphyton Guidelines* (Biggs 2000)).

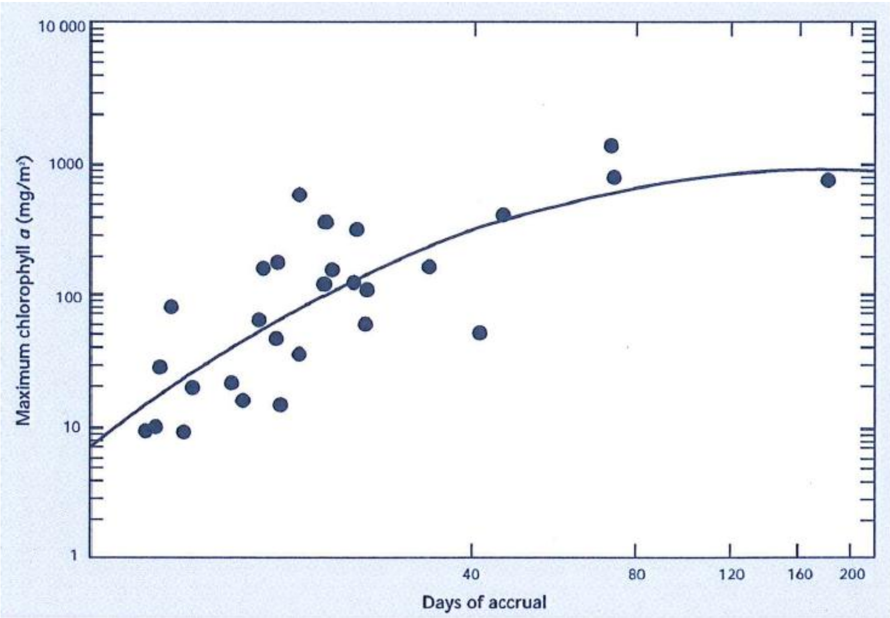

FIGURE 38: RELATIONSHIP BETWEEN MAXIMUM CHLOROPHYLL a AND ACCRUAL TIME FOR VARIOUS NEW ZEALAND RIVERS (BIGGS 2000)

The *NZ Periphyton Guidelines* (Biggs 2000) provide a multiple regression equation to predict algal biomass as a function of DRP and days of accrual (p43, equation 2). A requirement of this equation therefore is to have an understanding of the 'mean days of accrual'. A report by NIWA (Hickey, Norton et al. 2004) investigating suitable DRP guidelines for the Ruamahanga River calculated the mean accrual period in the lower Ruamahanga River to be 13 days (based on summer flow data). Using this calculated accrual period Hickey et al. (2000) went on to predict (using the *NZ Periphyton Guidelines* regression equation) algal biomass in the lower Ruamahanga River as a function of DRP concentration and days of accrual (Table 28).

Table 28: Predicted algal biomass in (as maximum chlorophyll a, mg/m²) as a function of dissolved reactive phosphorus (DRP, mg/m³) and days of accrual (duration of stable flow) (calculated from Biggs 2000, p43, equation 2). Shaded results are for a 13 day accrual period. Table taken from (Hickey, Norton et al. 2004).

DRP conc. (mg/m3)	Accrual time (d)				
	10	13	15	20	30
2	16	32	47	94	222
5	25	51	73	147	349
10	35	71	103	207	492
15	42	87	126	253	601
20	49	101	146	292	693
25	55	112	163	326	774
30	60	123	178	356	847
40	69	142	205	411	976
50	77	158	229	459	1090

The above assessment by Hickey et al. (2004) illustrates that the lower Ruamahanga River is subjected to frequent high flows (>3 times median) resulting in the relatively short mean accrual period of 13 days calculated for summer flows. These frequent high flows and short accrual periods largely explain the relatively low percentage of guideline breaches, despite high soluble nutrient loads, of the the 50 mg/m² guideline for the protection of high biodiversity values and the higher biomass guideline (120 mg/m²) for the protection of aesthetic, recreational, and trout fishing values at the Te Ore Ore, Gladstone Bridge, and Pukio RSoE monitoring sites (refer Section 1.3.1.1).

With regards to the MWWTP, it is fair to consider that under flows less than median flow in the Ruamahanga River (and after full mixing of the effluent from the MWWTP has occurred), the DRP concentration is likely to be in the range of 0.009 to 0.017 mg/L (from Section 6.2.1) and therefore (from Table 28) periphyton biomass is likely to exceed the guideline limits of 50 mg/m², and 120 mg/m² guidelines after approximately 10 to 20 days, and 15 to 20 days respectively during stable flows.

Within the zone of mixing DRP concentrations will be higher and therefore it is expected that during these same accrual periods periphyton biomass is likely to exceed both guideline values in less time.

4.2.5 VISUAL CLARITY

There is no data for visual clarity of either the MWWTP effluent discharge or in the Ruamahanga River directly upstream or downstream.

Therefore, the effect of the MWWTP effluent on the visual clarity of Ruamahanga River can be tentatively calculated using the methodology set out in the RMA Water Quality Guidelines No. 2: *Guidelines for the Management of Water Colour and Clarity* (MfE 1994). This method first involves calculating the beam attenuation coefficient, *c*, downstream, once the effluent is fully mixed using the mass balance expression:

$$c_d Q = c_u(Q - q) + c_{eff} q$$

where:

Q = river flow rate (upstream of the discharge);

q = effluent flow rate;

and the subscripts refer to the effluent and the river upstream ($_u$) and downstream ($_d$) of the discharge.

The beam attenuation coefficient can be calculated as $c \approx 4.8/y_{BD}$ (black disc clarity).

Therefore using the following characteristics:

- Ruamahanga River flow at; half median flows (<25%) = 15.613 m^3/s ; at median flow (25% to 50% flows) = 37.346 m^3/s ; at 3 times median flow = 78.786 m^3/s
- Ruamahanga River clarity (m^{-1}) at Pukio = at half median flows (<25%) = 2.10 m^{-1}; at median flows (25% to 50% flows) = 1.00 m^{-1}; at 3 times median flow = 0.23 m^{-1}
- Median dry weather effluent flow = 0.0084 m^3/s; Median wet weather effluent flow = 0.0112 m^3/s
- Effluent clarity* = 0.20 m^{-1}

Note: *As there is no historic clarity data for the MWWTP effluent discharge average secchi disc reading for oxidation ponds in New Zealand (MfE 1994)) were used instead.

The summary of predicted changes in clarity results for the different flow regimes calculated from above are presented in Table 30.

Table 30: Predicted clarity (m^{-1}) in the Ruamahanga River downstream of the proposed MWWTP discharge site after reasonable mixing.

Ruamahanga River flow (m^3/s)	Clarity(m^{-1}) @ RSoE Pukio	Effluent flow (m^3/s)	Effluent clarity (m^{-1})	Predicted clarity (m^{-1})	Predicted % change
15.613	2.10	0.0084 (dry weather)	0.20	2.09	<0.5
37.346	1.00	0.0084 (dry weather)	0.20	0.999	<0.5
78.786	0.23	0.0112 (wet weather)	0.20	0.23	<0.5

As illustrated in Table 30, it is predicted that there is unlikely to be significant changes in visual clarity (<0.5%) downstream of the discharge from the MWWTP at all flows and will meet the in-stream target of <30% change for the protection of contact recreation and amenity values of the Ruamahanga River. These predicted values are plausible as the effluent flow from the MWWTP, when compared to the flows Ruamahanga River, is small (<0.1% of the total flow downstream at half median flows) and is likely to be fully mixed relatively quickly.

4.2.6 DISSOLVED OXYGEN

RSoE monitoring data suggests that there is very little differences along the length of the Ruamahanga River with regards to DO concentrations and that they are typically well above the RMA (1991) guideline value of 80% saturation. Considering this, the dynamic nature of the river, and the likely large dilution factors that will occur on initial mixing, it is unlikely that the discharge of treated effluent from the MWWTP will have anything but negligible effects with regards to % DO saturation levels in the Ruamahanga River after reasonable mixing has occurred.

However as previously mentioned the RSoE DO data should be treated with caution due to the one off nature and timing of sampling (i.e. during the day) it is recommended that more long-term DO monitoring is carried out once the proposed discharge is operational.

4.2.7 OVERVIEW

- Limited amount of monitoring data provides for a snapshot only of water quality at sites surrounding the MWWTP in the Ruamahanga River.
- Ammoniacal–N levels at the reference site generally fall below ANZECC guidelines and are within the range of results reported at the RSoE monitoring site 40km upstream (Gladstone Bridge) and 15km downstream (Pukio).
- Ammoniacal–N levels at sites 50m, 250m and 500m downstream of the MWWTP discharge levels are elevated compared to ANZECC guidelines and are significantly higher than the reference site.
- No difference in ammoniacal–N among monitoring sites downstream of the discharge.
- Ammoniacal–N levels at the Pukio site, 15km downstream, are within those reported at the upstream reference site.
- There is a median 8.7 times higher *E. coli* concentration in the discharge effluent compared to the upstream reference.
- *E. coli* levels at all sites are generally well within MfE contact recreation guidelines (one exceedance only, at the 50m downstream site).
- No difference in *E. coli* levels among either the reference site or downstream monitoring sites or between RSoE site Gladstone Road and downstream monitoring sites.
- Some evidence of a cumulative decline in bacteriological water quality between the Gladstone Bridge and Pukio site, with the MWWTP discharge a likely influencing factor.
- Due to the dynamic nature of the river, and the likely large dilution factors that will occur on initial mixing, it is unlikely that the discharge of treated effluent from the MWWTP will have anything but negligible effects with regards to % DO saturation levels in the Ruamahanga River after reasonable mixing has occurred.
- It is predicted that there is unlikely to be significant changes in visual clarity (<0.5%) downstream of the discharge from the MWWTP at all flows and will meet the in-stream target of <30% change for the protection of contact recreation and amenity values of the Ruamahanga River.
- Under flows less than median flow (and after full mixing of the effluent from the MWWTP has occurred), DRP concentration is likely to be in the range of 0.009 to 0.017 mg/L and therefore periphyton biomass is likely to exceed the guideline limits of 50 mg/m^2, and 120 mg/m^2 guidelines after approximately 10 to 20 days, and 15 to 20 days respectively during stable flows.
- Within the zone of mixing DRP concentrations will be higher and therefore it is expected that during these same accrual periods periphyton biomass is likely to exceed both guideline values in less than 15 days.
- Further consent monitoring is suggested to ensure that effects are as predicted.

4.3 MACROINVERTEBRATES

4.3.1 METHODOLOGY

Sampling has been conducted during the month of March at reference (initially 2 but dropped back to 1) and discharge monitoring sites (Figure 40) every year between 2006 and the present, except for 2010 when samples were collected in April. Sampling at an alternative reference site ceased after the 2006 survey while a sampling site 1000m dowstream was discontinued in 2008. Full sampling methodologies and results are published elsewhere (Coffey 2006; Coffey 2007; Coffey 2008; Coffey 2009; Coffey 2010; Coffey 2011).

4.3.2 DATA ANALYSIS

Macroinvertebrate indices were compared between sites, and years. Differences in diversity indices (taxa richness, MCI, QMCI, EPT taxa richness %EPT abundance, % EPT taxa richness and the EPT/Chironomidae ratio) were explored by single or two factor ANOVA (StatSoft 2004) with post hoc analysis of individual terms by Tukeys HSD test. Results reported as significantly different when *p*-values were <5% (i.e. testing at the 95% level of significance).

4.3.3 RESULTS

4.3.3.1 COMMUNITY DIVERSITY INDICES

A complete list of all macroinvertebrate data is included in Appendix 1. An analysis of the taxonomic groups present among sites showed that in the initial 2006 survey at upstream reference sites and at sites 200m and 500m downstream mayflies (ephemeroptera) and snails (mollusca) dominated (Figure 43). The following year true flies (diptera) and caddisflies (trichoptera) were the dominant species at the reference sites and at the 500m and 1000m sites downstream of the discharge.

Since 2008 dominant species at the reference site and the 500m downstream site have been Elmid beetles (coleoptera), caddisflies and true flies. In comparison, throughout time and on average dominant species at the closest downstream site of the discharge (200m DS) have been midges of the true flies and snails. However results from the most recent 2011 survey show trichoptera and ephemeroptera taxa were a stronger component of the community compared to previous surveys at this 200m downstream site.

The most abundant species at the reference sites upstream of the discharge and at sites 500m and 1000m downstream of the discharge during the initial 2006 survey were the mayfly *Deleatidium* (22% - 25% of all individuals), Elmid beetles (8% - 17% of individuals), the snails *Physella acuta* (10% - 13% of individuals) and *Potamopyrgus antipodarum* (11% - 22% of individuals). Together these species accounted for between 56% - 65% of all individuals at these sites. The following year (2007) chironomids were the most abundant species accounting for between 29% - 31% of individuals at the reference site and 500m and 1000m downstream sites.

The next most abundant species was the caddis *Aoteapsyche colonica* (25% of individuals) followed by *P. antipodarum* (13% of individuals). Together, these species accounted for 67% - 69% of all individuals. Between 2008 and the present the most abundant species at the reference site and 500m downstream site and 1000m downstream site (2008 only) were Elmid beetles (28% - 43% of individuals), *Deleatidium* (11% - 17% of individuals), chironomids (13% – 16% of individuals), *A. colonica* (4% - 13% of individuals) and *P. antipodarum* (10% - 18% of individuals). Together, these species accounted for 82% - 84% of all individuals. The variability in species composition through time at the reference sites and at the 500m and 1000m downstream sites contrasts markedly with the relative consistency in species composition at the 200m downstream site. There, the community appears to be dominated by chironomids and *P. antipodarum* (23% of individuals each) and the mosquito midge *Austrosiumulium austrolense* (15% of individuals). In total these three species accounted for 59% of all species enumerated between 2006 and the present.

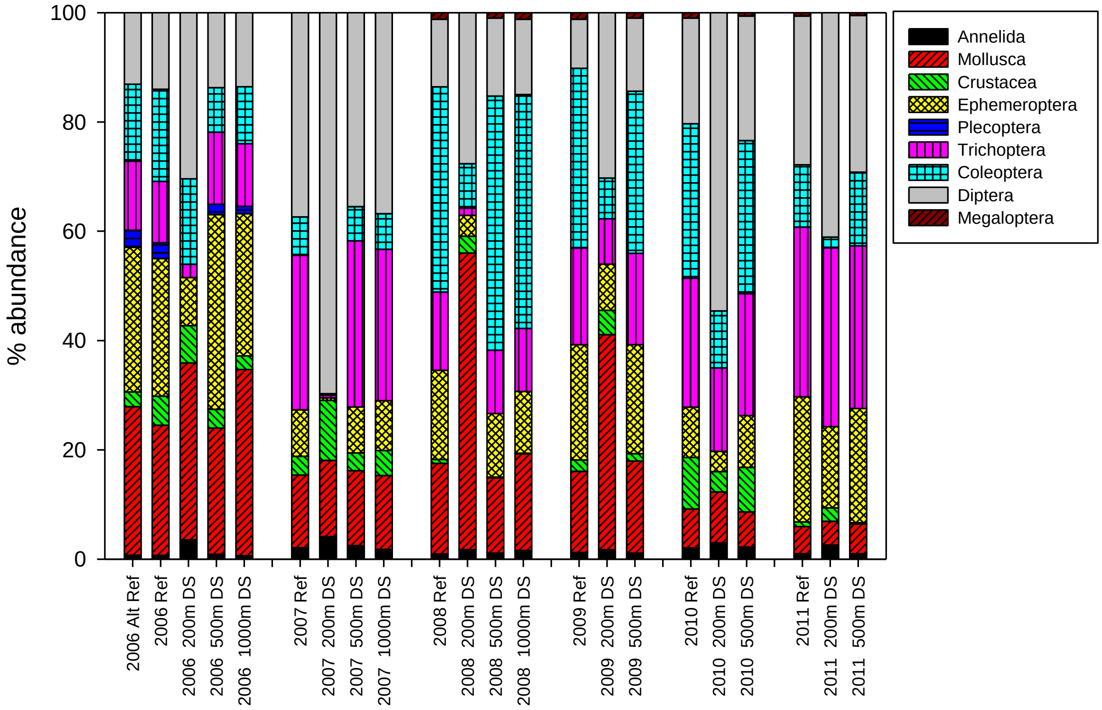

Figure 39: PLOT SHOWING MEAN PERCENT ABUNDANCE OF MAJOR MACROINVERTEBRATE TAXA GROUPS BETWEEN 2006 AND THE PRESENT AT DISCHARGE MONITORING SITES IN THE RUAMAHANGA RIVER.

As a result of there being little evidence of significant differences between the alternative reference site and the reference site or between the 1000m downstream site and the 500m downstream site these sites were removed from the required monitoring programme after one and three years respectively. As a consequence of this cessation of sampling at the alternative reference site and the 1000m downstream site statistical comparisons between sites are focussed on the reference site and the 200m and 500m downstream sites.

Number of taxa, or taxa richness, in each sample at the reference site ranged 11 - 16 across all years with an average of 13.6 (Figure 20a), while at the 200m and 500m downstream sites richness ranged between 8 to 15 and 11 to 16 respectively, averaging 11.8 and 13.8 respectively. Examining individual site differences Tukeys HSD comparisons revealed no significant differences in taxa richness between the reference site and the 500m downstream site in any year.

Comparisons between the reference site and the 200m downstream site however show that in 2007, 2009, 2010 and 2011 the 200m downstream site was significantly lower in taxa richness than the reference site (all at least $p < 0.039$). Similarly, significantly lower taxa richness at the 200m downstream site compared to the 500m downstream site was also evidenced during these same years.

Examining taxa richness within sites, over time, significant temporal variability is evident, and this variability is largely consistent among sites. At all sites taxa richness decreased significantly between 2006 and 2007 (all $p < 0.001$), then between 2007 and 2008 only the 200m downstream site recorded a significant difference ($p < 0.001$), being an increase. Between 2008 and 2009 a significant increase was estimated at all three sites (all at least $p < 0.008$) while in the next year between 2009 and 2010, no differences at any of the sites were estimated. Between 2010 and 2011 there was no difference at the 500m site but taxa richness at both the reference site and the 200m downstream site increased significantly (both at least $p < 0.04$).

Across all years MCI scores at the reference site ranged 83 – 112, averaging 92.7 (Figure 44b). At the 200m downstream site MCI scores ranged 62.5 – 85.7, averaging 75.8 while at the 500m downstream site scores ranged 78.6 – 105.7, averaging 89.1. MCI scores at both the reference site and the 500m downstream site fall within the 'fair' range indicating pollution tolerant species typically associated with wastewater discharges exist within communities at these sites at levels of some concern. MCI scores at the 200m downstream site generally fall within the 'poor' range indicating abundance of pollution tolerant species occurring at a concerning level that likely impairs the functioning of the macroinvertebrate community. Significant differences among sites related to the 200m downstream site only, which was lower than the reference site for all years except 2011 (all at least $p < 0.025$) and the 500m downstream site for all years except 2010 and 2011 (all at least $p < 0.008$). Examining within sites temporally, apart from significant decreases at all sites between the initial 2006 survey and 2007 (all at least $p < 0.0027$) there has been no further changes between years, except at the 200m downstream site where it was estimated that between 2007 and 2008 the MCI increased significantly.

QMCI scores at the reference site ranged 3.4 – 5.6, across all years, averaging 4.7 (Figure 44c). QMCI scores at the 200m downstream site ranged 2.2 – 4, averaging 3.3, while scores at the 500m downstream site ranged 3.4 – 5.4, averaging 4.6. Similar to the MCI evaluations, the QMCI scores of the reference site and the 500m downstream site largely fall within the 'fair' range, indicative of some stress while the QMCI scores at the 200m downstream site typically within the 'poor' range indicating impairment of community functioning is likely. Comparing between sites within years, similar to the MCI comparisons there were no significant differences between the reference site and the 500m downstream site. However both these sites were significantly higher than the 200m downstream site for all years (all $p < 0.001$). The temporal comparison shows a consistency in variability between sites, with all three sites decreasing significantly between 2007 and 2008 and then increasing between 2008 and 2009. The reference site and the 500m downstream site also showed a significant decrease between 2009 and 2010.

The ratio of EPT taxa to chironomidae taxa at the reference site ranged between 1.1-36, averaging 4.7 (Figure 45a). At the downstream monitoring site 200m downstream of the discharge EPT:Chironomidae ranged between 0 – 14 and averaged 1.3. At the 500m downstream site the ration ranged between 1 and 20, averaging 4.5.

The sole difference between either years or sites was a significantly higher result at the reference site in 2009 compared to the 200m downstream site.

Examining the EPT specific indices (EPT taxa richness %EPT abundance, % EPT taxa richness), with one exception (2007) there were no significant differences for any of the EPT indices between the reference site and the 500m downstream site. Comparisons between these sites and the 200m downstream site showed that during the initial three surveys (2006, 2007, 2008) the 200m downstream site was significantly lower than both the reference site and the 500m downstream site for all three EPT indices (all $p < 0.001$) (Figures 45b, c, d). However, more recent surveys in 2009, 2010 and 2011 show the gap in EPT specific indices between the 200m downstream site and the other sites has reduced such that few significant differences were estimated between sites for these years. Thus, EPT indices at the reference and 500m downstream site have remained fairly stable through time, while at the 200m downstream site there appears to have been an increase over time.

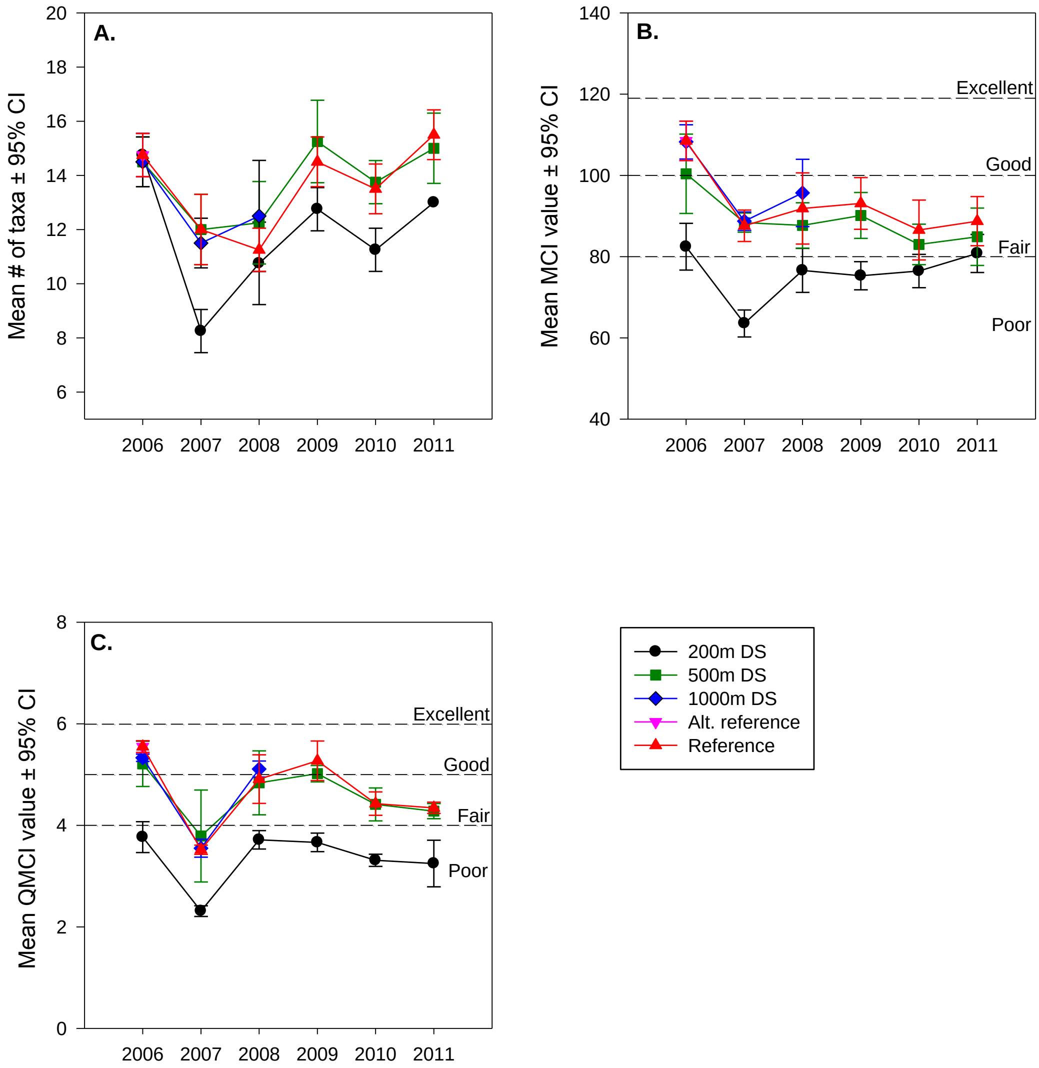

FIGURE 40: PLOTS COMPARING MEANS OF A) NUMBER OF TAXA, B) MCI VALUES AND, C) QMCI VALUES OF MACROINVERTEBRATES FROM ANNUAL MONITORING (2006 – PRESENT) AT DISCHARGE MONITORING SITES WITHIN THE RUAMAHANGA RIVER.

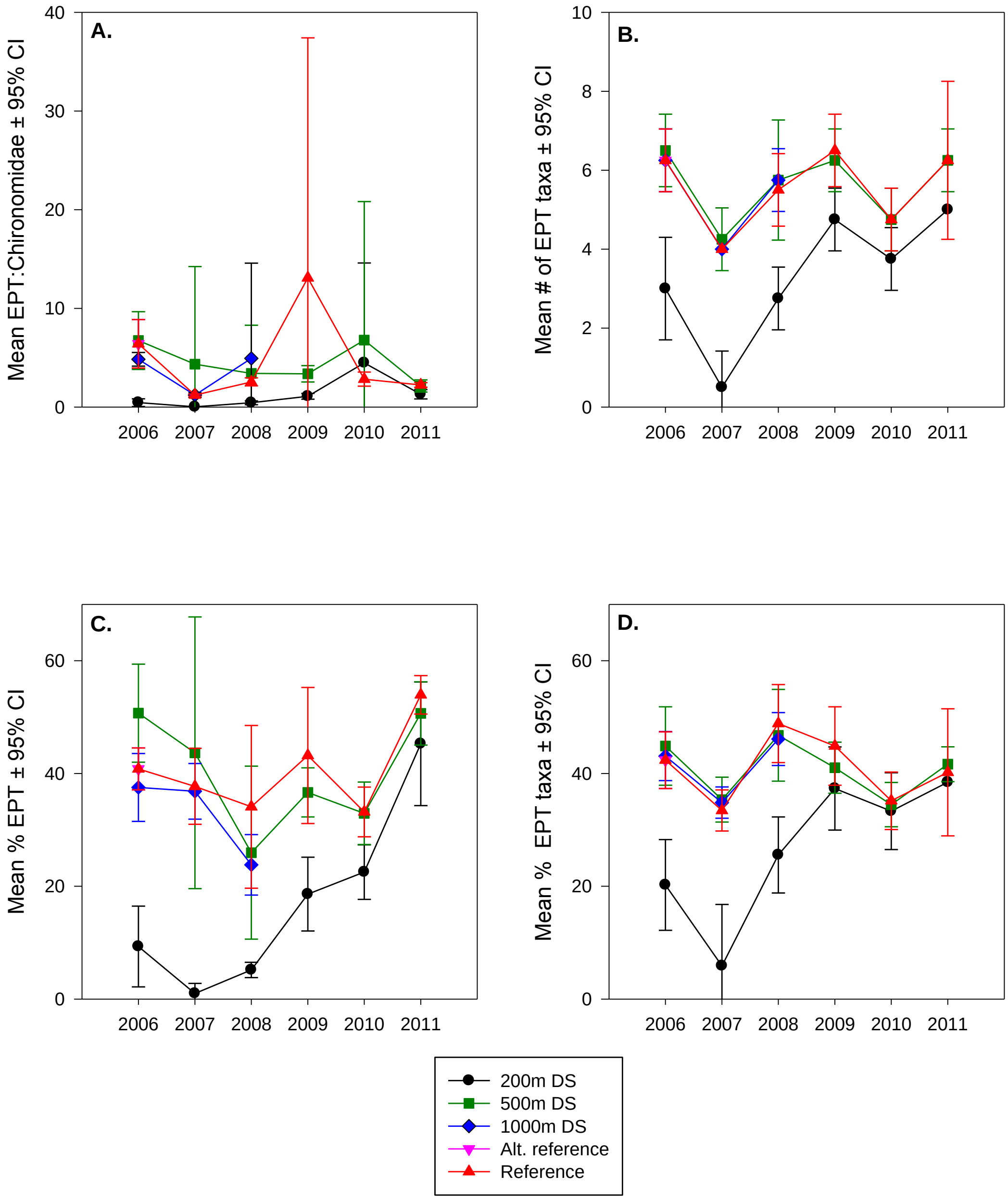

FIGURE 41: PLOTS COMPARING MEANS OF A) EPT:CHIRONOMIDAE, B) EPT TAXA, C) %EPT, AND D) %EPT TAXA VALUES OF MACROINVERTEBRATES FROM ANNUAL MONITORING (2006 – PRESENT) AT DISCHARGE MONITORING SITES WITHIN THE RUAMAHANGA RIVER.

4.4 OVERVIEW

- Dominant taxa at reference sites and at the 500m and 1000m downstream monitoring sites include; mayflies, caddisflies, snails, beetles and true flies with the relative dominance of these taxa varying between years.
- Dominant taxa at the 200m downstream site have over time consistently been pollution tolerant species; chironomids and snails.
- No differences in taxa richness at the reference site and 500m downstream site among any years.
- Taxa richness at the reference site and 500m downstream site were significantly higher than at the 200m downstream site 4 out of 6 annual surveys completed to date.
- Temporal variability in taxa richness appears to be consistent among sites, with some evidence of an increase in taxa richness at all sites since 2007.
- MCI and QMCI scores at the reference site and the 500m downstream site fall within the 'fair' range while at the 200m downstream site scores generally fall with the 'poor' range.
- Some stress evident in macroinvertebrate communities at both the reference and 500m downstream sites, while the community at the 200m downstream site is likely impaired.
- No significant differences in MCI or QMCI scores between the reference site and the 500m downstream site (within years).
- Significantly lower QMCI scores at the 200m downstream site compared to the reference site and 500m downstream site for all years.
- Significantly lower MCI scores at the 200m downstream site compared to the reference site in all years except 2011 and in all years except 2010 and 2011 at the 500m downstream site
- Some interannual variability in MCI and QMCI scores evident, however this appears consistent among sites.
- Little difference in the EPT:Chironomidae ratio between sites or years indicating a similar level of evenness in these taxa over time and between sites.
- EPT specific indices at the reference and 500m downstream site were similar and generally no significant differences between these sites were detected.
- EPT specific indices were significantly lower at the 200m downstream site compared to the other sites during initial surveys (2006-2008) while in later surveys (2009-2011) few differences were evident.
- Temporally, EPT indices at the reference and 500m downstream site have remained fairly stable, while at the 200m downstream site there appears to have been an increase over time.

4.4 FISH COMMUNITIES

To date there has been no work quantifying the effects of the MWWTP effluent discharge (or any WWTP discharge) to fish communities in the Ruamahanga River.

4.5 CUMMULATIVE EFFECTS - LAKE ONOKE

Lake Onoke is a 630 hectare highly modified shallow coastal lake/estuary and the ultimate receiving environment for the MWWTP and other discharges that enter the Ruamahanga River. Lake Onoke drains to the sea at Palliser Bay through an opening at the southeastern end of the lake. The lake outlet regularly blocks and is opened artificially.

An ecological vulnerability assessment undertaken in September 2007 (Robertson & Stevens 2007) rated Lake Onoke's existing condition as poor for sedimentation, nutrients, saltmarsh and aquatic macrophytes. This poor rating reflects significant modifications to the lake environment including the loss of a large proportion of saltmarsh habitat, likely loss of submerged aquatic macrophyte beds, and reduced water and sediment quality. Most of these modifications can be attributed to the extensive drainage, river training and realignment, reclamation and artificial lake outlet actions which were undertaken to develop pastureland and minimise flooding, and to past and present catchment landuse intensification.

Despite these modifications, Lake Onoke still has considerable human uses and values, particularly fishing, boating and natural character. Ecologically it is valued for its remaining saltmarsh habitat (particularly Pounui Lagoon which drains into the northwestern end of the lake), adjoining duneland on Onoke Spit, and its bird and fish life (Wellington Regional Council 2008).

High nutrient, sediment and pathogen inputs from terrestrial catchment intensification are considered to be one of the major threats to the existing values of Lake Onoke. This is because the lake's outlet has a tendency to block, creating a high natural susceptibility to issues such as eutrophication (excessive nutrients) and sedimentation.

To date there have not been any studies quantifying the effect(s) of the discharge from the MWWTP, or in fact any WWTP, to Lake Onoke. As illustrated in Section 3.5.12.2, the MWWTP discharge (and associated contaminant loads) is relatively small in comparison to other point source and diffuse sources, to the Ruamahanga River. Therefore, without sidestepping the fact that the MWWTP does indeed contribute to the contaminant loading and any cumulative effects to Lake Onoke, it is suggested that once the Masterton WWTP discharge is partially removed, the effects from the MWWTP to Lake Onoke will be significantly less.

5. DISCUSSION

5.1 WATER QUALITY MONITORING AND DATA

The water quality dataset for the assessment of effects that the MWWTP is having on the Ruamahanga River is small and largely limited to 16 samples (analysed for ammoniacal nitrogen and E.coli only) collected over the course of 10 months (March to December) during 2011. Therefore the following discussion should be read with a significant degree of caution.

5.2 AMMONIACAL NITROGEN

RSoE monitoring data shows that ammoniacal-N concentrations/load increases in the Ruamahanga River as it flows downstream from the source through farmland towards the sea.

Combined WWTP discharges upstream of Pukio are responsible for approximately 47.5 t/a ammoniacal nitrogen to the Ruamahanga River. Of these discharges Masterton WWTP is responsible for approximately 79%. Between Gladstone Bridge and Pukio WWTPs (Carterton, Greytown, and Martinborough) contribute approximately 66% of ammoniacal nitrogen inputs. Of the median annual ammoniacal nitrogen load (t/a) (based on Pukio data) the discharge from MWWTP represents approximately 5.4% of the inputs occurring between Gladstone Bridge and Pukio.

An assimilative capacity assessment indicates that there is available capacity for ammoniacal-N in the lower Ruamahanger River at all flows (assessed at Pukio).

Monitoring data suggests that the MWWTP discharge is significantly elevating ammoniacal–N concentrations downstream of the discharge when compared to the upstream reference site. Approximately 88% of sampling results at all downstream sites (50m, 250m, 500m) were elevated above (4.28, 2.86 and 2.62 times respectively) the ANZECC guideline of 0.021 mg/L for slightly/moderately degraded lowland streams/rivers.

Predictions of ammoniacal-N concentrations at different river flows (after full mixing) in the Ruamahanga River suggest that the discharge from the MWWTP is likely to result in downstream ammoniacal concentrations of 0.011 mg/L (at <25%ile), 0.008 mg/L (at median flows), 0.019 mg/L (at 3 x median flows), and 0.017 mg/L (at flows >3 x median). These predictions suggest that ammoniacal-N concentrations should remain below ANZECC guideline level of 0.021 mg/L at all flows.

5.3 E. COLI

GWRC recreational water quality monitoring data indicates that sites monitored on the Ruamahanga River typically breach the E. coli “action” guideline of 550 cfu/100 mL at least once per season. However, almost without exception where this action level has been recorded it has been positively correlated with significant rainfall events illustratrating that E.coli counts re typically related to urban stormwater, resuspension of sediments, and diffuse-source runoff.

RSoE data shows that E.coli counts at Pukio increase under all flow conditions when compared to the Gladstone Bridge monitoring site and are similar to those counts observed at the Te Ore Ore site. The guideline limit of 550 cfus/100mL is rarely breached (<10%) at flows below median flow, up to 28% at flows between median and 3 times median, and around 70% of the time at flows above 3 times median flow.

E. coli data collected around the MWWTP discharge, suggest there is little difference between the reference site, located 50m upstream of the discharge site and the upstream RSoE Gladstone Bridge site. Conversely, the results of *E. coli* testing around the discharge suggest pathogens have a less than minor effect on water quality as a result of the discharge. This is evidenced by the large majority of results falling within MfE guidelines for contact recreation, and the lack of significant differences between either, the reference site and any of the monitoring sites downstream of the discharge, or indeed between discharge monitoring sites and the upstream RSoE Gladstone Bridge site.

It is worth noting that there is a relatively high median level of *E. coli* at the 50 m upstream reference site when compared to the Gladstone Road RSoE site is likely associated with other discharges into the Ruamahanga River upstream of the MWWTP and downstream of the Gladstone Bridge site, e.g. the Greytown wastewater treatment plant discharge. Furthermore, it appears that other sources of *E. coli* further downstream of the MWWTP discharge may have a much greater impact on bacteriological water quality than the discharge given the significantly higher median level of *E. coli* at the Pukio RSoE site compared to the Gladstone Bridge site.

5.4 NUTRIENTS AND PERIPHYTON

DRP at river flows:

Half median (<25%ile) river flows (15,613 L/s) = **0.009 mg/L**

Median (25%ile to 50%ile) river flows (37,346 L/s) = **0.017 mg/L**

3 x median (3 x 50%ile) river flows (78,786 L/s) = **0.020 mg/L**

>3 x median river flows (226,088 L/s) = **0.015 mg/L**

Note: Guideline (ANZECC 2000) = 0.010 mg/L DRP; proposed GWRC guideline is 0.014 mg/L annual average for flows <3 x median river flow.

5.5 VISUAL CLARITY

RSoE monitoring data shows that under all flows, but most importantly at times of low flow, visual clarity in the Ruamahanga River declines with distance downstream of the McLays site with the biggest decline occurring between the McLays and the Te Ore Ore sites (north of Masterton). This pronounced change between the McLays and the Te Ore Ore sites has been attributed largely to the change in landuse between these i.e. from indigenous forest to pastoral. Further downstream point source municipal wastewater discharges in conjuction with the intensification of pastoral landuse activities result in further degradation of visuaul clarity in the Ruamahanga River.

At the Pukio monitoring site, which is the most relevant to this study, the visual clarity guideline limit of 1.6 m^{-1} is complied with only 22% of the time at all flows, 46% at <25%ile river flows, and 17.4% at median river flows.

With no monitoring data available predictions on changes in visual clarity in the Ruamahanga River were made using methodology set out in the RMA Water Quality Guidelines No. 2: *Guidelines for the Management of Water Colour and Clarity* (MfE 1994). These calculations predicted that there is unlikely to be significant changes in visual claritity (<0.5%) downstream of the discharge from the MWWTP at all flows and will meet the instream target of <30% change for the protection of contact recreation and amenity values of the Ruamahanga River.

5.6 DISSOLVED OXYGEN

RSoE monitoring data suggests that there is very little differences along the length of the Ruamahanga River with regards to DO concentrations and that they are typically well above the RMA (1991) guideline value of 80% saturation. Considering this, the dymamic nature of the river, and the likely large dilution factors that will occur on initial mixing, it is unlikely that the discharge of treated effluent from the MWWTP will have anything but negligible effects with regards to % DO saturation levels in the Ruamahanga River after reasonable mixing has occurred.

BIOLOGICAL CHARACTERISTICS

Macroinvertebrate community diversity indices at the 500m downstream monitoring site and the upstream reference site were both similar and fairly stable over time. At these sites the MCI and QMCI scores rank the health of the stream as ‘fair’, indicating some stress on the community is evident. At these sites the community was largely driven by a mix of key species, some that are negatively affected by increased pollution (e.g. *Deleatidium*, *Aoteapsyche colonica*, and beetles) and others that have some tolerance to pollution (e.g. *Physella* and *Potamopyrgus* snails and chironomid midges). Considering the surrounding catchment (i.e. farmland) it is likely these sites experience nutrient enrichment from diffuse sources that impacts the structure of the macroinvertebrate community.

In comparison, the closest downstream monitoring site to the discharge (200m downstream) scored consistently lower among the various indices in initial surveys (2006-2008) and is generally classed as being of ‘poor’ stream health. Here key drivers of community structure were the pollution tolerant snail and dipteran *Chironomus* species. These results suggest the 200m downstream site is significantly adversely impacted.

However recent (2010, 2011) survey results showing no differences in, particularly EPT specific indices, between sites, suggest either that the 200m downstream site is improving or that that the reference site and 500m downstream site are deteriorating. Given the paucity of data, trend analysis is not yet feasible, thus it is problematic to assess longterm site specific effects.

Whatever the case, evidence suggests that over time, and presently, macroinvertebrate communities, at the 200m downstream monitoring site are responding negatively to wastewater discharge. This impact from the discharge does not extend further downstream than 500m. The evidence for this includes the similarities in community composition and diversity indices between the upstream reference site and the 500m downstream monitoring site.

6. CONCLUSIONS

- Water quality monitoring data for the assessment of effects that the MWWTP is having on the Ruamahanga River is limited to 16 samples (analysed for ammoniacal nitrogen and E.coli only) collected over the course of 10 months (March to December) during 2011 and therefore this assessment should be considered with a degree of caution.

- Combined WWTP discharges upstream of Pukio are responsible for approximately 47.5 t/a ammoniacal nitrogen to the Ruamahanga River. Of these discharges Masterton WWTP is responsible for approximately 79%. Of the median annual ammoniacal nitrogen load (t/a) (based on Pukio data) the discharge from MWWTP represents approximately 5.4% of the inputs occurring between Gladstone Bridge and Pukio.

- An assimilative capacity assessment indicates that there is likely to be available capacity for ammoniacal-N in the lower Ruamahanger River at all flows (when assessed at Pukio).

- Monitoring data suggests that the MWWTP discharge is significantly elevating ammoniacal–N concentrations immediately downstream of the discharge when compared to the upstream reference site. Approximately 88% of sampling results at all downstream sites (50m, 250m, 500m) were elevated above (4.28, 2.86 and 2.62 times respectively) the ANZECC guideline of 0.021 mg/L for slightly/moderately degraded lowland streams/rivers.

- Calculated predictions of ammoniacal-N concentrations at different river flows (after full mixing) in the Ruamahanga River suggest that the discharge from the MWWTP will result in downstream ammoniacal concentrations of 0.011 mg/L (at <25%ile), 0.008 mg/L (at median flows), 0.019 mg/L (at 3 x median flows), and 0.017 mg/L (at flows >3 x median. When comparing these calculated concentrations to those data recorded

- In general terms the Ruamahanga suffers from high nutrient enrichment from agricultural runoff, and discharges from urban stormwater, and treated municipal sewage effluents. Nutrient concentration ratios indicate that the system is generally phosphorus limited; however periods of co-limitation are likely during low river flows.

- Predictions of DRP concentrations at different river flows (after full mixing) in the Ruamahanga River suggest that the discharge from the MWWTP will result in downstream DRP concentrations of 0.009 mg/L (at <25%ile), 0.017 mg/L (at median flows), 0.020 mg/L (at 3 x median flows), and 0.015 mg/L (at flows >3 x median and therefore exceeding ANZECC guideline value of 0.010 mg/L under all flow regimes except at flows below the 25%ile.

- The Pukio site which is the most relevant to this proposal indicates that DRP concentrations are somewhat lower than the Gladstone site however at median flows they are above guideline levels resulting in no assimilative capacity available. At half median flows there is a negligible margin available (0.003 mg/L).

- Although there is relatively high nutrient enrichment in the Ruamahanga River, periphyton growth is largely kept in check by the high frequency of flood events that occur in this system. Calculations indicate that periphyton biomass is likely to reach levels exceeding recreational and aesthetic guideline limits during periods of stable flows in excess of 15 days.

- GWRC recreational water quality monitoring data indicates that sites monitored on the Ruamahanga River typically breach the E. coli "action" guideline of 550 cfu/100 mL at least once per season. However, almost without exception where this action level has been recorded it has been positively correlated with significant rainfall events illustratrating that E.coli counts re typically related to urban stormwater, resuspension of sediments, and diffuse-source runoff.

- RSoE data shows that E.coli counts at Pukio increase under all flow conditions when compared to the Gladstone Bridge monitoring site and are similar to those counts observed at the Te Ore Ore site. The guideline limit of 550 cfus/100mL is rarely breached (<10%) at flows below median flow, up to 28% at flows between median and 3 times median, and around 70% of the time at flows above 3 times median flow.

- E.coli counts upstream (measured at Gladstone Bridge) of the MWWTP discharge point are similar to those recorded at the downstream RSoE site at Pukio suggesting that there are significant sources to the Ruamahanga River prior to the point of discharge from the MWWTP.

- The installation of a U. V treatment system should significantly decrease the E. coli loading downstream (after full mixing) of the MWWTP to maintain recreational guideline levels at stable flows.

- RSoE monitoring data shows that under all flows, but most importantly at times of low flow, visual clarity in the Ruamahanga River declines with distance downstream of the McLays site with the biggest decline occurring between the McLays and the Te Ore Ore sites (north of Masterton). This change has been attributed largely to the change in landuse between these sites i.e. from indigenous forest to pastoral.

- Visual clarity calculations predict that there is unlikely to be significant changes in visual claritity (<0.5%) downstream of the discharge from the MWWTP at all flows and will meet the instream target of <30% change for the protection of contact recreation and amenity values of the Ruamahanga River.

- RSoE monitoring data suggests that there is very little differences along the length of the Ruamahanga River with regards to DO concentrations and that they are typically well above the RMA (1991) guideline value of 80% saturation. Therefore, due to the likely large dilution factors that will occur on initial mixing, it is unlikely that the discharge from the MWWTP will have anything but negligible effects with regards to % DO saturation levels in the Ruamahanga River after reasonable mixing has occurred.

- To date there have not been any studies quantifying the effect(s) of the discharge from the MWWTP, or in fact any WWTP, to Lake Onoke. The MWWTP discharge (and associated contaminant loads) is relatively small in comparison to other point source and diffuse sources, to the Ruamahanga River. Therefore, without sidestepping the fact that the MWWTP does indeed contribute to the contaminant loading and any cumulative effects to Lake Onoke, it is suggested that once the Masterton WWTP discharge is partially removed, the effects from the MWWTP to Lake Onoke will be less.

- Evidence suggests that over time, and presently, macroinvertebrate communities, at the 200m downstream monitoring site are responding negatively to the MWWTP. This impact from the discharge does not extend further downstream than 500m. The evidence for this includes the similarities in community composition and diversity indices between the upstream reference site and the 500m downstream monitoring site.

- Should the planned scope of works set out in the application with respect to improving the efficiency and effectiveness of the current treatment system so that it complies with most year 7 standards (as specified in the original 1997 consent) it is envisioned that the environmental effects should in the longer term be reduced from what currently occurs.

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APPENDIX ONE

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