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31 March 2015

RECEIVED
- 1 APR 2015
Horizons Regional Council

The Regulatory Manager
Horizons Regional Council
Private Bag 11 025
Palmerston North

Dear Sir

Resource Consent Lodgement – Eketahuna Wastewater Treatment Plant

Please find enclosed a copy of the Resource Consent Application for the Eketahuna Wastewater Treatment Plant.

The deposit fee for this application has already been paid to Horizons directly by Tararua District Council.

We are happy to provide additional hard copies and an electronic copy of the application if you require.

pp. [signature]

Regards

Tabitha Manderson
Senior Planner

Eketahuna Waste Water Treatment Plant

Discharge of Treated Wastewater

Eketahuna Waste Water Treatment Plant

Discharge of Treated Wastewater

Prepared By pp. [signature]
Tabitha Manderson
Senior Resource Management Planner

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Utilities Manager Tararua District

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Date: March 2015
Reference: 5-P0531.05
Status:

Eketahuna Waste Water Treatment Plant

Discharge of Treated Wastewater

Contents

PART A	**DISCHARGE PERMIT APPLICATION PURSUANT TO SECTION 88 OF THE RESOURCE MANAGEMENT ACT 1991**
To:	The General Manager Horizons Regional Council Private Bag 11025 Palmerston North
Applicant:	Tararua District Council
Proposal:	To discharge treated wastewater from the Eketahuna Wastewater Treatment Plant into the Makakahi River.
Location:	Bridge Street, Eketahuna
Legal Description:	Lot 1 DP 47463 and Lot 2 DP 246
Valuation	17770/133/00 and 17770/133/00
Consent Required:	Discharge Permit to discharge treated wastewater to water under Rule 14-30 of the One Plan Discharge of Treated Wastewater to Land where it may enter water under Rule 14-30 Discharge to Air (Odour) under Rule 15-17
Term Sought	20 Years
Attachments:	The Assessment of Environmental Effects is attached as Part B of this report. Other attachments include: Appendix I — Eketahuna Wastewater Treatment Plant Consent Renewal: Assessment of Environmental Effects Appendix II — Options for upgrades Report Appendix III — Annotated Aerial Image Showing the Plant, Including Existing and Proposed Upgrades
Consultation:	Please refer to Section 4 of this AEE for information on the consultation undertaken.

On behalf of
Tararua District Council

pp. [signature]
....

Dated 31. 3. 15.

Address for Service:

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Ph: (06) 350 3272
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Attention: Tabitha Manderson

PART B ASSESSMENT OF ENVIRONMENTAL EFFECTS

1 Introduction

This application has been prepared in accordance with those matters set out in section 88 of, and the Fourth Schedule to, the Resource Management Act 1991. This statement of effects accompanies and forms part of the resource consent application.

The purpose of this application is to obtain resource consent to allow for the ongoing operation of the Eketahuna Wastewater Treatment Plant (WWTP) by Tararua District Council (TDC). This application will replace Discharge Permits 103346 and 103732.

The Tararua District Council is the territorial authority for a large land area (424,000 hectares) that extends from Mount Bruce at the southern boundary to just north of Norsewood at the northern boundary, and from the Tararua and Ruahine Ranges to the Pacific Coast. The District contains four urban centres and has a total population of 16,854 (Statistics NZ, 2013).

The Manawatu River and five of its major tributaries flow through the district and are highly valued for the resources and recreational opportunities that they provide the wider community and local economy. Numerous smaller tributaries of the Manawatu River also originate within the District, several of which are used by Tararua District Council for water supply purposes and for the discharge of treated wastewater.

The provision of a reticulated sewerage system is integral to the functioning and health of any community and Tararua District Council is therefore committed to providing this service to its residents, whilst ensuring a balance between minimizing adverse effects of domestic wastewater discharges on waterways and not overly burdening the District's ratepayers. Tararua District Council has recently signed the Manawatu River Accord and this has marked a significant shift in focus to Council being committed to working collaboratively with other interested parties and landowners to jointly improve the water quality of the Manawatu River.

TDC have recently investigated a number of upgrade options to improve the performance of a number of its WWTPs. There are some commonalities of design across the sites while still allowing for specific individual site values to be addressed. Improving the treatment of wastewater discharges is a key issue identified by TDCs Vision Statement in its Long Term Plan (2012-2022). The River Accord actions that Council is a signatory to underpin the need to increase the wastewater discharge standards to the Manawatu River system.

1.1 Background

Tararua District Council (TDC) is currently working with the Manawatu Wanganui Regional Council (Horizons) and the Ministry for the Environment (MfE) to undertake upgrades to various wastewater treatment plants in the Manawatu Catchment.

The Eketahuna WWTP is currently operating under Discharge Permits 103346 and 103732. The existing discharge point is to the Makakahi River.

On 20th January 2014 a magnitude 6.2 earthquake struck Eketahuna and surrounds. This earthquake caused damage to the sewer pipes in the urban areas close to the epicentre. Following the earthquake

TDC staff undertook detailed investigations of the reticulation network in the area. No significant damage was noted for culverts and waterpipes (which are mostly new and PVC).

An investigation using CCTV was used to investigate the wastewater system for Eketahuna. This investigation showed that approximately 95% of the pipe network has suffered some damage, either misalignment, cracking or in some cases fracturing of the pipes. It is the intention of TDC to remedy the situation through a mixture of pipe replacement and pipe lining. This work is scheduled and expected to be completed by approximately January 2016.

1.2 The Existing Environment

The resident population for Eketahuna according to the 2013 Census is 450 people.

The WWTP is accessed from Bridge Street, Eketahuna on the north-western edge of town. The WWTP is at the edge of the residential zone of Eketahuna. The site that the WWTP is located on is 2.27ha in size, and is adjacent to the confluence of the Ngatahaka Stream and Makakahi River. The other side of the site is bounded by pasture land.

1.2.1 Makakahi River

The Makakahi River is described in the current discharge permit decision as follows -

The Makakahi River arises in the North-Eastern Tararua Ranges and the uppermost headwaters are within the Tararua Forest Park. Downstream of these headwater reaches, the remainder of the catchment moves rapidly from plantation forestry to hill country pastoral farming and dairy farming. The Makakahi River is home to introduced and native fish populations. Brown trout, longfin eel, koura (freshwater crayfish), upland bully and shortjaw kokopu have been found in fish surveys of the Makakahi River (Source: National Freshwater Fish Database). The 1999 biomonitoring report (Coffey, 1999) also identified common bullies as present in the Makakahi River. Both the longfin eel and the shortjaw kokopu are classified threatened species in gradual decline by the Department of Conservation. The shortjaw kokopu is also identified as a high priority species in the Wellington Conservation Management Strategy, and as a regionally rare or threatened species in Horizons Regional Council's technical report to define the Sites of Significance for aquatic biodiversity for the Proposed One Plan (McArthur et al., 2007). The Makakahi River is a significant trout fishery, which received specific protection in 1991 by way of a Local Water Conservation Notice.

Under the Horizons Regional Council One Plan the following Schedule B assessment identifies the following Values:

- Life Supporting Capacity – Hill country mixed geology;
- Aesthetics;
- Mauri;
- Contact Recreation;
- Industrial abstraction;
- Irrigation abstraction;
- Stock water;
- Existing infrastructure; and
- Capacity to assimilate pollution.

Schedule B site specific values that apply to the main stem reach of the stream are:

- Trout Fishery – Regionally Significant Trout Fishery
- Trout Spawning
- Upstream of a Water supply take - Pahiatua
- Flood Control - Drainage

1.3 Existing Treatment System

1.3.1 Domestic Loading

The population of Eketahuna township is approximately 450[1] in roughly 220 households. The population decreased slightly between the 2006 and 2013 censuses and no significant population growth is projected.

TDC has confirmed that all septic tank waste is transferred to the Dannevirke WWTP, not to Eketahuna WWTP.

No data is available on the influent characteristics of the wastewater as there has been no historical sampling of the raw wastewater entering the WWTP. Estimates of the likely loading have been made based on the census data and typical per capita loading rates. These estimates are summarised in Table 1 below.

Table 1: Estimated loading on Eketahuna WWTP

Parameter	Units	Typical Loading per Capita[2]	Estimated Loading
BOD	kg/day	0.08	36
COD	kg/day	0.205	92
TSS	kg/day	0.0785	35
NH_3-N	kg/day	0.00775	3.5
TKN	kg/day	0.01345	3.0
TP	kg/day	0.00215	6.1

1.3.2 Trade Waste

There is no significant industry discharging effluent to the WWTP.

1.3.3 Flow data

No flow data is available, for inflow or outflow. In the absence of flow data, the average dry weather flow (ADWF) into the WWTP has been estimated as 400m³/day. This figure was derived

[1] 2013 Census recorded 441 people
[2] Domestic loading data from Metcalf & Eddy Table 3.13, 5th Edition:

using a flow of 0.9m³/day per person to allow for recent earthquake damage to the wastewater network. The figure of 0.9m³/day per person was based on above average flow rates post-earthquake in Christchurch. An above average flow rate has been used because prior to the earthquake damage in Eketahuna an ADWF of 0.67m³/person/day[3] was reported as shown in Figure 1 below, which is very high in comparison with flows recorded at other plants, particularly as it is (reported as) a dry weather flow rather than an overall average daily flow. Therefore, without any current data or knowledge of the system, an ADWF of 400m³/day is an estimated figure to use. The peak wet weather flow (PWWF) reported by Good Earth Matters equates to 5.4m³/person/day so the PWWF post-earthquake is estimated as 3,200m³/day, using a peaking factor of eight.

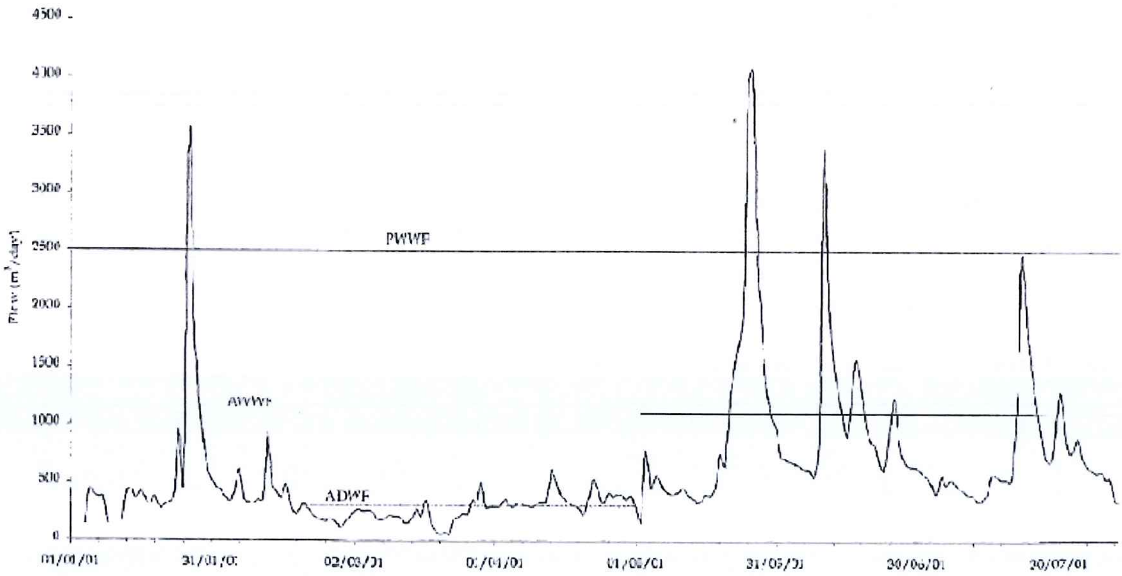

Figure 1: 2001 WWTP flows, reproduced from *Assessment of Environmental Effects* (Good Earth Matters, 2006)

It is important to note that no flow data is available for analysis other than the 2001 flow figures (pre-earthquake) shown in Figure 1. Flow monitoring, post-earthquake, at sites around Christchurch found that average per person flow rates ranged hugely from -80% to +200% of the post-earthquake mean, depending on ground and pipe conditions (groundwater table depth, soil conditions, pipe depth/material/diameter, etc). Therefore without any actual flow data, estimates of the potential flows should be treated as potentially very misleading.

It is understood that TDC are in the process of relining and replacing pipework and manholes damaged during the earthquake and have relined 1700m of pipework to date. The intention is to have completed the work by the end of 2015. It will be very important to collect flow data at the WWTP inlet as this relining and replacement programme will reduce infiltration and hence also the dilution of the effluent. The expected reduction in infiltration is unknown and could continue after 2015 as cracked house laterals are identified and fixed.

[3] *Assessment of Environmental Effects*, Good Earth Matters, 2006

1.3.4 Existing Effluent Quality

Data on the existing effluent quality has been provided in the form of 47 sample results taken between 5/10/2010 and 12/08/2014.

As a small portion of the sample data which does not appear to be reasonable from a pond based treatment plant without tertiary treatment processes, a conservative approach has been taken and the data has been 'cleaned' by removing figures below a threshold of what would be expected from an oxidation pond system like Eketahuna. This cleaning process is fairly arbitrary given that there is no information on the quality or volume of wastewater entering the WWTP. Only results which are not believed to be feasible from the existing plant have been removed from the data set in order to minimise manipulation of the data.

This approach has been taken to ensure a realistic assessment of the future effluent quality once the upgrades have occurred. The resulting mean concentrations may therefore still represent a higher level of treatment than the plant is realistically achieving but there is insufficient data to draw any conclusions. It is also possible that the extremely high flow rates per capita reported by GEM in 2006 are indicating a large amount of dilution with inflow and infiltration which reduces the effluent concentrations. The raw and edited data is summarised in Table 2 below.

Table 2: Raw and edited effluent concentration data (5/10/10-12/08/14)

Parameter	Mean Concentration (mg/L)		Value below which data removed in edited data
	Raw Data	Edited Data	
Ammoniacal Nitrogen	3	4	1
DRP	0.6	0.9	0.3
E Coli	430	460	50
Nitrate	0.5	0.5	-
Nitrite	0.04	0.04	-
Total Coliforms	48,000	48,000	200
Total Nitrogen	7	9	6
Total Oxidised Nitrogen	0.5	0.5	-
Total Phosphorus	1.0	1.2	0.5
Total Suspended Solids	34	38	10
Turbidity	12	12	-
Volatile Matter	31	32	7.5

1.4 WWTP Prior to Upgrades

1.4.1 Description of WWTP Prior to Upgrades

The WWTP prior to the upgrades, consisted of two oxidation ponds (facultative and maturation) and a river discharge. Pond 1 has a Reliant aerator and also baffle curtains to improve circulation. Overall, the WWTP was very typical of plants in similarly sized towns across NZ and it produced an effluent of significantly better quality than is typical from other oxidation pond systems surveyed in NZ[4], particularly with regard to microbiological performance.

Facultative ponds rely on biological processes for wastewater treatment. Generally coarse solids will settle on the bottom of the ponds, forming a sludge layer where anaerobic treatment occurs. Aerobic treatment occurs in the upper layers of the pond. Various organisms facilitate the treatment process function at different levels in the pond.

Facultative ponds primarily reduce BOD and bacteria. The aerobic stabilization of carbonaceous BOD is primarily dependent on heterotrophic bacterial activity. Heterotrophic bacterial activity is primarily a function of substrate availability, temperature and oxygen availability. Generally good levels of BOD reduction can be achieved in a facultative pond system.

Various forms of nitrogen are found in wastewater, most often ammonia, nitrate and organic nitrogen. Typically organic nitrogen is converted to ammonia by bacteria. Ammonia can be removed in an oxidation pond through losses to the atmosphere, being assimilated into bacteria and algal cell and bacterial nitrification (which may be followed by denitrification). Adequate levels of dissolved oxygen (generally levels of 2.0 mg/l is recommended) for nitrification to occur. As the nitrifying bacteria do not compete well with heterotropic bacteria for D.O. and nutrients, before nitrification can take place, BOD levels need to have been reduced to avoid this competition. Accordingly, in a well-functioning pond system nitrification would be expected to occur in the final stages of a pond system. In general, the longer the detention time, the more likely nitrification will occur.

1.5 Effluent Quality Prior to Upgrades

Overall, the WWTP appeared typical of oxidation pond systems in similarly sized towns across NZ and its performance was also comparable or better, even when data that did not appear credible had been filtered.

Mean effluent quality results from Eketahuna WWTP and a number of other similar plants are shown in Table 3.

Table 3: Mean effluent concentrations from other WWTPs around NZ

Site	Description	$cBOD_5$	TSS	NH_3-N	TKN	DRP	TP	FC	E.coli	Ent
Bulls	2 pond + aerator	13		6			7.3			325

[4] Table 6, Eketahuna Sewage Treatment Plant Upgrade Options, Opus 2011.

Site	Description	$cBOD_5$	TSS	NH_3-N	TKN	DRP	TP	FC	E.coli	Ent
Ratana	2 pond + aerator	15	48	8		1.9				250
Gore	2 pond + aerator	29	56	14	24	3.5	4.8		2301	
Leeston	8 pond + aerator	22	63	17	23					
Queenstown	3 pond + aerator	36	65	31	38		6	44,100		
Woodend	2 pond + aerator + UV	10	59	15	27		9	430	430	202
Rangiora	2 pond + aerator	38	78	17		3.8		4,350	4285	465
Eketahuna (Filtered data))	2 pond + aerator		38	4	9	0.9	1.2	48,000	463	

1.6 Changes Made to the WWTP in Recent Years

A number of small improvements have been made to the WWTP in recent years:

- A step screen had been installed in 2009 but it was installed above grade and the pumping costs required to use the screen were found to be disproportionate to the volume of screenings removed and its use was discontinued.
- Two baffle curtains were added to Pond 1.
- A Reliant aerator, with two 1.5kW blowers and a diffuser, was added to Pond 1.

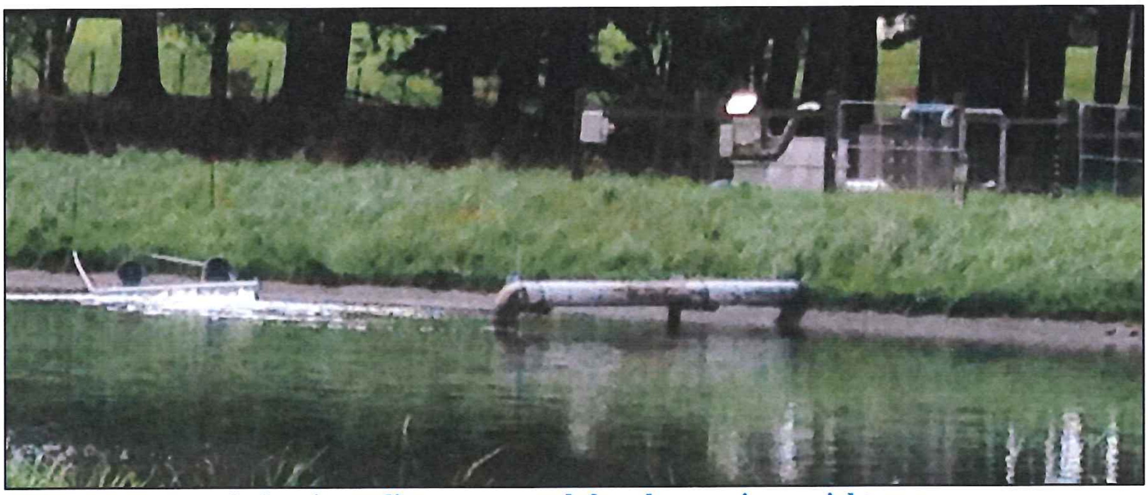

Figure 2 Photograph showing Reliant aerator at left and screen in top right.

The addition of aeration to the ponds would have reduced BOD and, normally increased ammonia oxidation. Effectively, mechanical aeration increases the oxidation capacity of the ponds beyond what it would be when naturally aspirated by the wind. Desludging and installing mixing walls would have increased the hydraulic retention time, giving a higher probability of increasing nitrification and bacterial and viral removal rates.

1.7 Proposed WWTP Upgrades

A number of upgrades are planned for the Eketahuna WWTP, these are described in more detail below.

1.7.1 WWTP Process Flow Diagram

An annotated aerial image showing the plant, including existing and proposed upgrades, is in Appendix III. The processes are also displayed in the process flow diagram (PFD) in Figure 3 below.

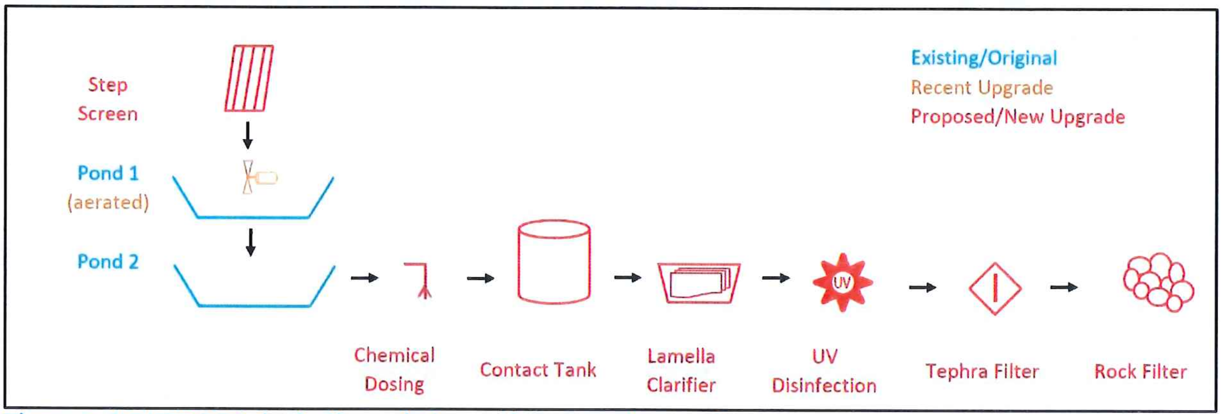

Figure 3 WWTP PFD, including existing and proposed upgrades

1.7.2 Proposed Upgrades

The following upgrades are proposed:

- Re-use the step screen by lowering it 'to grade'
- Install a lamella plate clarifier, including a contact tank for coagulation and a chemical dosing facility
- Install an additional aerator
- Install a UV disinfection system if still necessary following other upgrades
- Install a Tephra filter
- Relocate the current WWTP discharge some 100m downstream, including construction of a rock filter.

1.8 Effluent Quality Improvements

There is insufficient influent and effluent quality data available to be able to accurately quantify the improvements resulting from the upgrade work undertaken to date.

Anticipated effluent quality improvements resulting from upgrades are described by process in the following sections.

1.8.1 Step Screen

The Huber step screen will remove coarse material from the influent wastewater stream that could damage or clog downstream process equipment and the exfiltration gallery or introduce coarse contaminants to the Makakahi River. Although the screen will not dramatically improve the performance of the WWTP, it will slightly reduce the rate at which sludge accumulates in the ponds and it will help mitigate breakdowns in the new, more intensive unit processes.

1.8.2 Lamella Plate Clarifier

Lamella clarification is a counter-current settling process in which a series of inclined plates or tubes enhance the separation and removal of solids from the effluent. The addition of a flocculant in the contact tank before the clarifier promotes the aggregation of small particles into larger particles to further enhance their removal by gravity settlement in the clarifier.

A Filtec Lamella Settler will be purchased from Filtration Technology Ltd. Details are as follows:

Model	Lamella Settler
Max. hydraulic capacity	80m^3/hr (approx. 22L/s)
Proposed flocculant	Unknown

The performance of coagulation and flocculation and therefore of the clarification process, is dependent on a large number of factors, many of which are interrelated. Wastewater characteristics, chemical dose rates, mixing conditions, flocculation times, the selection of chemicals and their order of addition, can all affect performance. Control of pH and alkalinity is also essential to maintain performance. We have approached the suppliers for their comment on the likely performance of their equipment, as supplied for this installation, but have received no response.

The lamella clarifier will be expected to provide improvements in a number of areas of plant performance:

- Total suspended solids via coagulation and settlement
- Total nitrogen via removal organic n in particulate material
- Dissolved reactive phosphorous

1.8.3 UV Disinfection

Radiation from ultraviolet (UV) light can be an effective bacteriocide and virucide. Since UV light is not a chemical agent, no toxic residuals are produced.

It is understood that, should it prove necessary following the other upgrades, TDC intend to purchase TrojanUV3000 PTP UV disinfection system from Trojan Technologies Inc. Details are assumed to be as follows:

Model	**TrojanUV3100K PTP**
Peak hydraulic flow rate	6.1L/s
Validated UV dose	31,023 μWs/cm^2
Total number of lamps	4

The effectiveness of UV disinfection depends on the turbidity and solids content of the effluent as solids can both absorb the ultraviolet energy and shield microorganisms. Further, dissolved organic substances, including colour, can absorb significant proportions of the UV light and further reduce disinfection efficiency. The performance of the UV disinfection is therefore dependant on the performance of the upstream treatment processes, including the lamella clarifier.

Given a minimum effluent UV Light transmissivity (design values are currently uncertain), low effluent suspended solids and service flow rates that are within the design limitations of the selected system, the UV disinfection will inactivate bacteria, viruses and protozoa. The extent of inactivation depends upon the particular microbe (some are much tougher than others) and the dose rate provided.

Treating oxidation pond effluent, with no tertiary treatment of the effluent, a UV system, appropriately designed would be expected to deliver performance of between 1 and 1.5 $\log_{10}$ inactivation of faecal indicator bacteria. With an effective tertiary or set of tertiary unit processes in place, low suspended solids, low dissolved colour, and the dose rate indicated above, an inactivation rate of between 2 and 3 $\log_{10}$ could be expected.

1.8.4 Tephra Filter

Some andesitic tephra subsoils, as found in the Ruapehu district, have relatively high phosphorous adsorption capacities. The Fertilizer and Lime Research Centre (Massey University), in conjunction with TDC, undertook small scale pilot trials of a tephra subsoil filter to remove DRP from wastewater at Dannevirke WWTP in 2012-2013[5]. These pilot trials identified that the effectiveness of a tephra filter depends not only on the soil properties but also on the design of the filter and the characteristics of the wastewater (particularly its TSS concentration and pH).

In the pilot trials DRP removal rates were initially high (up to 97% removal) but fell over time to almost nothing as shown in Figure 4 below. As written by Hanly *et al* (2013), “Further work needs to be conducted to assess methods to improve the performance [of] pilot tephra filters.”

[5] Hanly, J., Cheuyglintase, S. and Horne, D. *An evaluation of the capacity of andesitic tephra, from the Ruapehu district, to remove dissolved phosphorus from municipal wastewater: Small-scale pilot study*, Massey University, 2013.

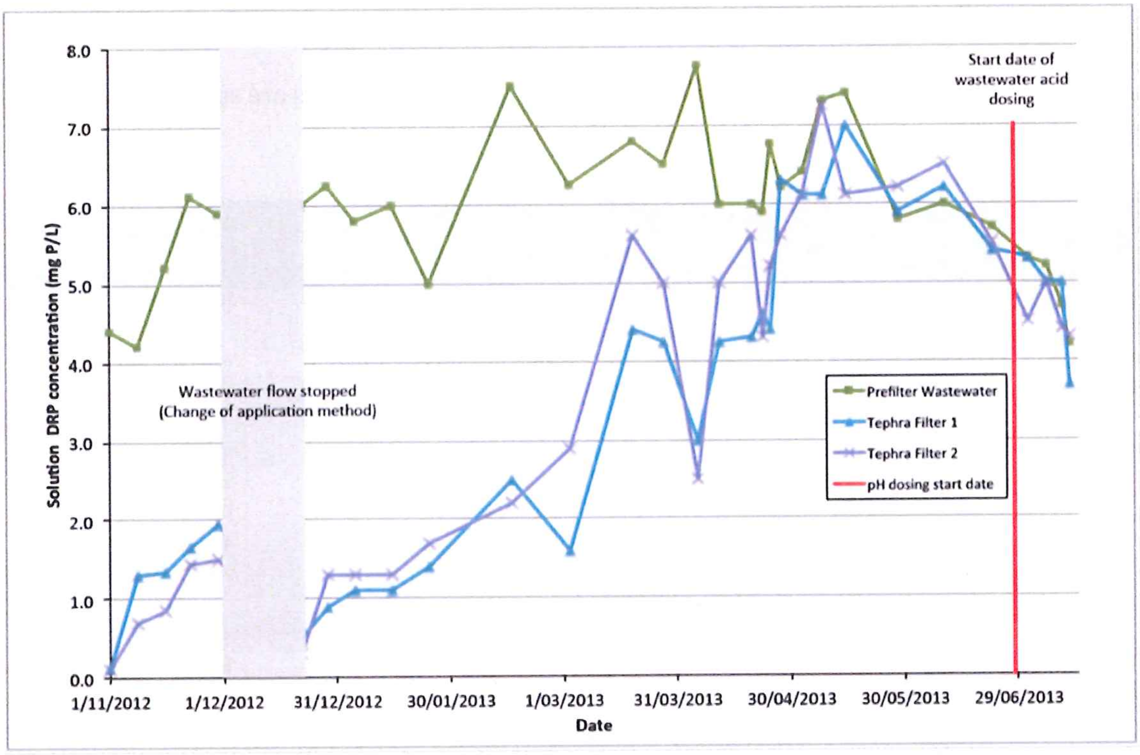

Figure 4: DRP concentrations in the Dannevirke influent wastewater and the wastewater treated by the two pilot tephra filters (copied from Figure 2, Hanly et al., 2013)

1.9 Summary of Anticipated Effluent Quality Improvements

Anticipated effluent quality improvements resulting from the upgrades are summarised in Table 4 below.

Table 4: Summary of anticipated effluent quality improvement

Process Upgrade	Affected Effluent Parameters	Anticipated Improvement*	Confidence Rating (1-10, low-high)	Reason for Confidence Rating
Inlet screen	Gross Solids	Protection of downstream mechanical equipment	10	No Numeric
Lamella Clarifier	TSS,	TSS – 60%	4	No pilot results
	TN,	TN – 60% of 3mg/l	4	Filtered data indicates 3mg/l Organic N in SS. But TSS not reliable
	DRP,	DRP to approx. 0.5mg/l**	7	Essentially tunable with coagulant
		Small reduction in faecal indicator bacteria by physical removal.	7	Experience with other solids removal processes.
UV Disinfection	Bacteria, Viruses, Protozoa	2 - 3 Log_{10} Inactivation	6	Based on a good tertiary effluent but not specified dose.
Tephra Filter	DRP	There is insufficient hard data on which to base any more than a very short-term projection.		

* Based on Table 2 numbers above

** Depending upon chemical dose rate and clarifier up flow rate.

1.10 Conclusions and Recommendations

Overall, the WWTP appears typical of oxidation pond systems in similarly sized towns across NZ and its performance is also comparable or better, even when data that did not appear credible has been filtered.

It is very difficult to accurately predict the effluent quality following completion of the upgrades, given the number of unknowns about both the influent wastewater and the details of the proposed upgrades. Estimates of the anticipated improvements in effluent quality have been made, based on data from similar plants around the country (refer to Table 4). Confidence in these estimates is low due to the number of unknowns. In order to calculate potential performance with more certainty, additional monitoring following the installation of the upgrade equipment is recommended.

Results from accelerated monitoring from other TDC sites, Pahiatua and Woodville, would be able to refine the anticipated improvement in effluent quality from Eketahuna (recognising there will still be some differences between the plants). This collected data can then be used to both predict effluent quality as well as determine appropriate consent conditions that will manage the effects resulting from this proposed discharge.

1.11 Alternatives Considered

1.11.1 Land Disposal

Land Disposal has been considered for the site. TDC commissioned a report for preliminary investigations into land irrigation. This report had not yet been finalised at the time of preparing this application, the report will be forwarded as soon as it is available.

Alternative Treatment Configurations

A number of alternatives were considered in an options report prepared in 2011. Options considered in that report are shown below.

Option 1: Direct Pond Dosing with Ferric Sulphate and T Floc

The cheapest option for introducing phosphorus removal will be to dose directly into the final pond, as is currently practised at Woodville. The Woodville system has been found to remove phosphorus reliably below 1.0 g/m3 as dissolved reactive phosphorus, by using a combination of ferric sulphate and T Floc as an organic coagulant. The primary advantage of this sort of system is that there is no alum residual, and also the chemicals are safer to handle and do not require specialist containment facilities. T Floc has another key advantage in that it is able to be made up and stored for several months, and also pumped a considerable distance (unlike polyacrilamide which tends to block lines and is typically mixed up on a daily basis). Therefore; while chemical costs are high, this type of system provides a number of advantages for smaller plants.

Internationally, clarifier systems using Ferric sulphate have been successful at removing phosphorus below 0.4 g/m3 as total phosphorus (USEPA 1987); however, apart from the Woodville system, we have not found any other examples of systems that work on pond effluent.

As the Eketahuna pond system has a relatively high loading, we have allowed to baffle off the end of the maturation pond. The final cell would be used for the phosphorus dosing, with a mixing chamber for injection of coagulant and precipitation chemicals. Note that there is some risk that the upgrade may result in an increase of biological oxygen demand and ammonia levels, and this would need to be monitored carefully.

Option 1: was discounted because of the likely hood of getting more sludge build up in the pond.

Option 2: Conventional Clarifier with Ferric Sulphate and T Floc Dosing

The Clarifier option is similar to Option 1, but with the phosphorus removal in a clarifier rather than directly into the pond. The main advantage of this is that there is no reduction in the existing pond area, and the sludge will be transferred to Dannevirke to a thickening plant that is to be built for further treatment.

This was the preferred option that has been progressed.

Option 3: Actiflo Clarifier with Alum and Poly Dosing
Actiflo clarifiers use sand and a lamella separator to provide better settling and a smaller footprint than a conventional clarifier. In New Zealand, an Actiflo clarifier has been installed for phosphorus removal at the Gore oxidation ponds, and found to be effective in removal of dissolved reactive phosphorus (down to 0.5g/m3 under low flow conditions), solids and faecal

coliforms (Ross Hazzlemore, Gore District Council, pers comm.). During trials at the site they managed to get phosphorus levels down to 0.1 g/m3, but a high doseage rate was required.

Actiflo clarifiers can provide very good treatment performance, and have lower chemical dosing costs as they are based on alum and polyacrilamide dosing. However, the capital cost is high and electricity consumption is also significant, meaning that overall annual operating costs are estimated to be similar to the direct pond dosing system.

Option 3 was discounted because TDC did not want to deal with the alum.

Option 4: Dissolved Air Flotation Clarifier with Alum and Poly Dosing

Dissolved air floatation (DAF) systems have a reputation for effective removal of algae that have been chemically conditioned. An Armatech DAF system has been installed at Waihi on the Coromandel and has been found to be effective in removal of dissolved reactive phosphorus, solids and faecal coliforms (Kevin Kotze, Armatech, backed up by Opus experience). A prethickened sludge is produced as the 'float' off the top of the DAF. Post DAF pH correctionoften required to raise the pH back up due to the effects of the acid coagulants such as Alum or ferricchloride.

The DAF system is quoted as having a lower energy consumption that the Actiflo plant, resulting in a slightly lower annual operating cost.

Option 4 was discounted because TDC did not want to deal with the alum.

1.11.2 Alternative discharge location

Consideration was given to altering the discharge location to discharge directly to upstream of the confluence of Ngatahere Stream. This was discounted due to it being impractical to install the required pipework down a cliff face. The discharge point has been altered, but not as far because of the golf course and cliff face.

2 Assessment of Environmental Effects

An assessment of water quality effects, focusing on the existing discharge, has been undertaken by Aquanet Consulting. This report is in Appendix I.

The Aquanet report analysed existing monitoring data and undertook modelling for the determination of the effects of the existing discharge. The report also discusses, where appropriate, the likely influence of the Ngatahaka Creek tributary which enters the Makakahi River within 10m (on the opposite side of the river) of the existing Eketahuna WWTP discharge point. Therefore, the monitoring data collected for the downstream site, some 40m downstream of the discharge point, incorporates both the WWTP discharge and the Ngatahaka Creek. The methodology used by Aquanet (further explained in their full report) was to model effects based on a mass concentration principles.

2.1 Effects on Water Quality

The Aquanet report summarises and presents water quality data collected at sites upstream and downstream of the Eketahuna WWTP between July 2007 and June 2014. The report also presents water quality data from paired sampling days between October 2010 and May 2014 for sites upstream and downstream of the discharge with the influence of the Ngatahaka Creek tributary removed from downstream concentrations, giving the theoretical effect of the Eketahuna WWTP discharge on the downstream site (explained further in the Aquanet report)

Daily loads calculated on data between October 2010 and May 2014 are presented in the Aquanet report, and compare the downstream site with and without the influence of the tributary. Annual loads which were calculated on data between July 2007 and June 2014 are presented in the report.

Key water quality determinants measured in the Makakahi River are summarised below. One Plan targets applicable at various flows are shown along with an indication of whether or not the One Plan target has been met.

Table 5: Summary of key water quality determinants measured in the Makakahi River upstream and downstream of the Eketahuna WWTP discharge and assessment against One Plan water quality targets. (NB: Table 4 in Aquanet Report)

	TNH_3-N (g/m³)			SIN (g/m³)			DRP (g/m³)			*E. coli* (/100mL)			
	U/S	D/S	Theoretical D/S	U/S	D/S	Theoretical D/S	U/S	D/S	Theoretical D/S	U/S	D/S	U/S	D/S
Mean	0.010	0.017	0.015	0.224	0.407	0.217	0.004	0.007	0.006	215.3	238.8	220.6	248.9
Median	0.009	0.011	0.012	0.141	0.260	0.100	0.003	0.006	0.006	135.0	212.0	146.8	165.0
20th percentile	0.001	0.001	0.000	0.019	0.053	-0.022	0.003	0.003	0.003	89.8	91.9	75.0	92.6
95th percentile	0.02	0.04	0.05	0.66	1.00	0.73	0.01	0.02	0.02	469.3	668.3	596.6	709.2
N. samples	44	44	44	40	40	40	40	40	40	19	19	40	40
OP Target	<0.4			<0.444			<0.01			<260		<550	
Applicable Flow	All flows			Below 20th FEP			Below 20th FEP			Below 50th FEP Summer months		Below 20th FEP	
OP Target met?	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	x	x	x

Table 6: Summary of key water quality determinants measured in the Makakahi River upstream and downstream of the Eketahuna WWTP discharge, and assessment against One Plan water quality targets. (NB: Table 5 in Aquanet Report)

	Clarity		Clarity change	POM		pH		Temperature		sCBOD5		DO	
	(m)		(%)	(g/m³)				(°C)		(g/m³)		(%Sat.)	
	U/S	D/S		U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S
Mean	2.1	2.2	-4.4	1.2	1.0	7.62	7.63	13.1	13.1	0.8	0.8	97.3	99.1
Median	2.0	2.1	1.3	0.5	1.0	7.61	7.61	13.1	13.1	1.0	1.0	96.9	99.9
20^{th} percentile	1.6	1.9	-16.1	0.0	0.0	7.40	7.45	9.7	9.5	0.3	0.3	89.9	94.2
95^{th} percentile	3.1	3.0	0.1	4.0	2.9	8.29	8.10	18.7	19.1	1.0	1.0	109.1	107.1
N. samples	20	18	36	23	23	44	44	44	44	39	40	43	44
OP Target	>3m		<20%	<5		>7 & <8.5		<19		<1.5		>80	
Applicable Flow	Below 50th FEP		All flows	Below 50th FEP		All flows		All flows		Below 20th FEP		All flows	
OP Target met?	x	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

2.1.1 Total Ammonical Nitrogen

The following sections are from the Aquanet report. Please note the figures referred to from the Aquanet report are not repeated below but are contained in the Aquanet report in Appendix I.

The One Plan and Consent defines two total ammoniacal nitrogen concentration targets: an average concentration of 0.4 mg/L (chronic exposure) and a maximum concentration of 2.1 mg/L (acute exposure).

Total ammoniacal nitrogen concentrations were always well below the One Plan and Consent target, both upstream and downstream of the Eketahuna WWTP discharge (Figure 2A & B), indicating a low risk of toxic effects from ammonia on aquatic life both upstream and downstream of the discharge.

Statistically significant increases were observed between upstream and downstream sites within all flow bins except flows above 20th FEP and median to 20th FEP (Figure 2A). When the influence of the tributary was removed from the downstream site the significant differences remained.

2.1.2 Nitrate Nitrogen

Mean nitrate nitrogen concentration in the Makakahi River upstream of the discharge were in the order of 0.23 g/m3 at all flows, and decreased at lower river flows, to 0.08 g/m3 at river flows below median and 0.05 g/m3 at flows below half median flows.

Significant increases in nitrate nitrogen concentrations occurred between upstream and downstream of the discharge in all flow bins except at flows above 20th FEP (Figure 5A).

Of all three sites, the Ngatahaka Creek presented the highest concentrations, approximately 2.6 times higher than at the Makakahi upstream site. Once the inputs from the Ngatahaka Creek *were removed from the downstream site, using the daily load adjustment methodology described in Section 2.3.2, no significant differences were observed other than at flows below median flow, indicating that the Ngatahaka Creek is the likely main source of the increase in nitrate-nitrogen concentrations between the Makakahi upstream and downstream sites.*

2.1.3 Soluble Inorganic Nitrogen

Concentrations of Soluble Inorganic Nitrogen (SIN) at flows below the 20th FEP both upstream and downstream of the WWTP were below the One Plan and Consent SIN target (i.e. an annual average concentration of 0.444 g/m3 at flows below the 20th FEP). The Ngatahaka Stream largely exceeded the SIN target (Figure 6A & B).

SIN concentrations were significantly higher downstream than upstream of the discharge point before the influence of the Ngatahaka Creek tributary was removed at all flows except those above 20th FEP (Figure 3A).

As was observed for nitrate nitrogen, the Ngatahaka Creek presented the highest SIN concentrations of all three sites, and no significant differences were found between upstream and downstream sites within any flow bins (Figure 6B) once the inputs from the Ngatahaka Stream were subtracted from the Makakahi downstream site. This indicates that the inputs from the Ngatahaka Stream are likely to be the key driver of the SIN concentration increases measured between the Makakahi upstream and downstream sites.

This result was reflected in daily loads of SIN presented in Appendix B.

2.1.4 DRP

The One Plan and Consent DRP target (i.e. an annual average concentration of 0.010 g/m3 at flows below the 20th FEP) at sites upstream and downstream of the discharge was met at all three sites (Figure 7A).

Concentrations of DRP were significantly different upstream to downstream of the discharge within five of the six flow bins: All flows, Below 20th FEP, Median to 20th FEP, Below median and Below half median (Figure 4A). The greatest concentration increases between upstream and downstream were measured under low river flow conditions (Below half median flow).

Once the daily DRP inputs from the Ngatahaka Creek were removed from the Makakahi downstream loads/concentrations, only two of the six significant differences remained between upstream and downstream sites within any of the flow bins. This indicates that inputs from the Ngatahaka Creek are a likely contributor to the concentration increases measured at the downstream site, but it also indicates that the discharge also contributes to the measured DRP concentration increase during periods of low flows (Figure 7B).

Average DRP concentrations in the Ngatahaka Creek were higher than at the Makakahi upstream site in all flow bins, which is another indication that inputs from the Ngatahaka Creek are likely to increase DRP concentrations in the Makakahi River. However, average concentrations in the Ngatahaka Creek at flows below half median were lower than in the Makakahi at the downstream site, indicating that inputs from the Ngatahaka Creek are unlikely to be the sole cause of the concentrations increase in the Makakahi River, at least under low river flow conditions.

The pattern (described above) of increasing concentrations at low river flows is consistent with inputs from a point source discharge, and it seems likely that the discharge also contributes to the measured DRP concentration increase, particularly during times of low river flow.

2.1.5 Nutrient ratios and nutrient limitation

The ratio of SIN to DRP can provide useful indications of when one nutrient occurs in excess of the other when considering periphyton's nutrient needs. Plants generally utilise nitrogen and phosphorus at a mass ratio of about 7:1. It is generally considered that when the ratio of SIN to DRP in river water exceeds 15, then phosphorus may become the limiting nutrient. Conversely, when the ratio is below 7, nitrogen becomes the most limiting nutrient. At ratios between 7 and 15, co-limitation occurs where both nutrients may limit plant growth.

The analysis indicates that the Makakahi upstream site is mostly nitrogen-limited at low flows, with a shift towards co-limited an then P-limited conditions as river flows increase (Figure 8). This is a common pattern observed at several other Manawatu Catchment sites. Nutrient ratios at the downstream site indicate that there is a general disappearance of strongly N-limited conditions under all but the lowest river flows, and a shift towards co- or P-limited conditions. This is likely to be primarily caused by SIN inputs, which have the net result of increasing SIN/DRP ratios.

2.1.6 E.Coli

The One Plan defines two E. coli concentration targets: 260 E. coli/100mL at flows below median flow during the main bathing season and 550 E. coli/100mL at flows below the 20th exceedance percentile year-round.

E. coli concentrations within summer months (1 November – 30 April), without taking into account the effects of the concentrations within the tributary, met the One Plan limit of 260/100mL 68% of the time upstream and 58% of the time at the downstream site within the sampling period at flows below 50th FEP (47% compliance at the tributary site). It is noted that E.coli concentrations in the Ngatahaka Creek were generally higher than in the Makakahi upstream of the discharge, and often higher than at the downstream site. It appears likely that some of the changes between upstream and downstream are at least in part attributable to inputs from the Ngatahaka Creek.

At flows below the 20th FEP, sites upstream and downstream of the WWTP discharge as well as within the Ngatahaka Creek had average concentrations under the 550 E.coli/100mL limit, and complied with the target 93%, 90% and 85% (U/S, D/S and Tributary, respectively) during the sampling period (October 2010 – May 2014) (Figure 9). There were no significant differences between upstream and downstream sites within any of the flow bins.

2.1.7 Black Disc, Total Suspended Solids and Particulate Organic Matter

The One Plan also sets a target of 3 meters for visual clarity when the Makakahi Stream is at or below median flow (50th FEP). The One Plan also sets a maximum reduction in water clarity of 20%, whilst the current consent conditons set a maximum change in water clarity of 30%, regardless of river. No consent conditions or One Plan targets refer to Total Suspended Solids (TSS).

The One Plan and Consent limit for Particulate Organic Matter (POM) is 5 g/m³ at flows at or below the 50th FEP.

Average black disc readings both upstream and downstream of the Eketahuna WWTP discharge point were below the One Plan and Consent target of 3 m minimum visual clarity within all flow bins (Figure 10). There were no statistically significant differences between upstream and downstream sites in any flow bins.

Comparisons on individual days indicate that while there were changes in excess of the One Plan target of 20% and the Consent Condition limit of 30% over the time period sampled, there were just as many increases as decreases in visual clarity between upstream and downstream of the discharge point, meaning the Eketahuna WWTP was not having a significant effect on the Makakahi river in terms of visual clarity (Figure 11).

Median concentrations of total suspended solids (TSS) were higher upstream of the discharge point than at the downstream site for all flow bins except half median to median flows (Figure 12), with no significant differences in concentrations between sites. It is also of note that TSS concentrations in the Ngatahaka Stream were higher than at either Makakahi River sites in four of the flow bins considered.

Comparisons of Particulate Organic Matter (POM) concentrations between upstream and downstream sites showed slightly higher concentrations upstream than downstream of the discharge point and were well under the target required by both Consent conditions and the One Plan of 5 g/m³ at both sites at flows at or below the 50th FEP (Figure 13). No significant differences were observed between sites. Similarly to TSS, mean POM concentrations in the Ngatahaka Creek were higher than in the Makakahi downstream site in all flow bins.

2.1.8 pH, Temperature, scBOD5 and Dissolved Oxygen

Both the One Plan and Consent states that the pH must be within the range of 7 to 8.5 and not be changed by more than 0.5.

Consent Condition 11(j) states that the temperature shall not exceed 19°C between the 1st October and the 30th April or 11°C between the 1st May and the 30th September, while the One Plan requires that the temperature of the Makakahi River not exceed 19°C at any time during the sampling period. Both require that the temperature does not change by more than 3°C.

Both the Consent and One Plan require that concentrations of sCBOD5 do not exceed 1.5 g/m³ when the Makakahi River is at or below the 20th FEP.

Consent Condition 11(m) and Horizons One Plan require that Dissolved Oxygen (DO) concentrations exceed 80 %.

Water pH levels fell within ranges required by the Consent and Horizons One Plan (Figure 14) and no significant differences were observed between upstream and downstream of the discharge.

Water temperature in the Makakahi River remained low over the monitoring period and complied with the limit set by the One Plan at sites upstream and downstream of the Eketahuna WWTP (Figure 15). No significant differences were observed between upstream and downstream sites for all flow bins.

The Consent limit of 19°C during Summer months (1st October to 30th April) was complied with 93% of the time at the upstream site and 86% at the downstream site (Figure 16A). The limit of 11°C during winter months (1st May to 30th November) was complied with 88% of the time at both the upstream and downstream sites (Figure 16B).

Soluble CBOD5 levels were below One Plan and Consent limit at all sites on all sampling occasions (Figure 13), with no significant differences between upstream and downstream sites (Figure 17).

Dissolved oxygen concentrations exceeded 80% at sites upstream and downstream of the discharge from the Eketahuna WWTP, complying with Consent and One Plan targets; 91% compliance at the upstream site & 98% compliance at the downstream site (Figure 18). Significant differences were observed between upstream and downstream sites at flows below median (higher DO downstream) and flows below half median (higher DO downstream).

It is plausible that the measured day-time increases in DO saturation may be associated with photosynthetic activity from the increased periphyton biomass present at the downstream site. It is also noted that the only DO data available are day-time 'spot' measurements, which do not provide any indication of night-time minima, and a detailed assessment of DO against provisions of the One Plan and/or the NPSFM (2014) is not possible on the basis of existing data.

2.2 Effects on River Ecology

The following sections are from the Aquanet report. Please note the figures referred to from the Aquanet report are not repeated below but are contained in the Aquanet report in Appendix I.

2.2.1 Periphyton Communities

Mean periphyton biomass, measured as Chlorophyll a, and visual estimates of periphyton cover were measured in 2013 and 2014. Results are presented in Figure 19 to Figure 22 and Table 8. Periphyton biomass increased between upstream and downstream sites on seven out of ten sampling occasions between February 2013 and May 2014 (Figure 19). Chlorophyll a concentrations were below the Consent and One Plan target (120 mg/m2) on all sampling occasions at the upstream site, and exceeded the target at the downstream site on one occasion (151 mg/m2 in May 2014) and on two occasions within the Ngatahaka Creek (131 mg/m2 in July 2013 & 130 mg/m2 in May 2014).

Overall compliance with the One Plan biomass target should generally be undertaken at 95th percentile level, meaning that up to one exceedance per 12 consecutive monthly samples is within the One Plan target (Ausseil and Clark, 2007). On that basis, all three sites meet the One Plan target for periphyton biomass.

The NPSFM (2014) defines attribute states for periphyton (Trophic State). It is our understanding that the Makakahi River is classified in the Default Class (as per the footnote to Appendix D, Table 4). The NPSFM Attribute State thresholds for periphyton are based on monthly monitoring, with a minimum record length for grading of 3 years. Records used in this analysis are for a period of ten individual monthly records taken over an 15 months period, and consequently only a partial, or preliminary, grading can be applied. Bearing in mind this limitation, the upstream site fell within Attribute State A while the downstream site fell between Attribute B and Attribute State C.

River bed cover by "nuisance" periphyton growth, i.e. long (>2cm) filamentous algae or thick (>3mm) diatom or cyanobacteria mats remained well below the One Plan targets at all three sites throughout the monitoring period (Figures 20 & Figure 22). Bed substrate cover was generally dominated by "film" growths and clean substrate (Figure 21, Table 8). However, the percentage of substrate covered by long filamentous algae and diatom mats was higher at the downstream site over most of the monitoring period.

Cyanobacteria levels visually assessed between February 2013 and September 2014 were highest at the downstream site, particularly over the 2014 summer months (reaching 20% coverage) and lowest at the Ngatahaka Creek site (Figure 21).

It is noted that the Makakahi upstream and the Ngatahaka Creek monitoring sites are within gorges, and thus are quite heavily shaded, whilst the Makakahi downstream site is more open, and receives more sunlight. This may explain some of the differences in periphyton growth between the Makakahi upstream and downstream sites.

2.2.2 Macroinvertebrate Communities

Macroinvertebrate samples were collected in 2013 and 2014 during summer months. Biotic index scores for sites sampled on the Makakahi River in 2013 and 2014 are presented in Figure 23 to Figure 25 and Table 9. Relative abundance, and a Non Metric Multidimensional Scaling (NMDS) ordination on macroinvertebrate communities are presented in Figure 26 and Figure 27 respectively.

A higher degree of similarity was seen between the upstream and tributary sites than between either site and the site downstream in terms of macroinvertebrate indices and community composition. At the downstream site, greater numbers of Chironomids were found (in particular Tanytarsini sp.) and less EPT individuals, resulting in lower MCI and QMCI scores in both 2013 and 2014. At the site upstream of the WWTP discharge and within the Ngatahaka Creek tributary, higher numbers of the relatively sensitive Mayfly Deleatidium sp. were observed, particularly in 2014. There were significant differences between sites for Number of Individuals, % EPT Individuals and QMCI (Figure 23 to Figure 25).

The One Plan target for MCI for the Mangatainoka - Makakahi Water Management Zone (120) was not met both upstream and downstream of the Eketahuna WWTP discharge nor within the Ngatahaka Creek tributary in 2013 or 2014. MCI scores indicate possible mild pollution at all sites in both years with the exception of the downstream site in 2013 which fell within the probable moderate pollution category.

No statistically significant differences in MCI scores were found between sites in either year (ANOVA) (Figure 25A & Table 9).

With regards to QMCI, the Consent and One Plan target is of no more than a 20% reduction between upstream and downstream of a point-source discharge. Reductions in QMCI of 20% or more were observed on both sampling occasions (2013: 25% decrease and 2014: 43% decrease) therefore not meeting the One Plan target (Figure 25B & Table 9). Statistically significant differences were found between upstream and downstream sites in both years sampled (ANOVA). These results suggest that the combined inputs from the Ngatahaka River and the discharge are having a significant adverse effect on macroinvertebrate communities at the downstream site. It is noted however, that the decrease in shading at the downstream site and consequential increase *in periphyton growth may account for some of the changes. Unfortunately, the relative contribution of the two sources to the level of effect measured cannot easily be estimated.*

Similarly, the extent of effects further downstream in the Makakahi River, i.e. whether a measure of recovery occurs, and at what distance, cannot be directly assessed.

2.3 Potential effects on air quality - odour

No odour complaints have been received for the Eketahuna plant. Maintaining the plant in accordance with the management plant proposed to be prepared as a consent condition will ensure this continues to be the case.

The potential effects from odour will be no more than minor.

3 STATUTORY CONSIDERATIONS

3.1 Resource Management Act 1991

The purpose of the Resource Management Act 1991 is to promote the sustainable management of natural and physical resources.

3.1.1 Part II

Part 2 of the Resource Management Act 1991 sets out the purpose and principles of the Act, to promote the sustainable management of natural and physical resources while enabling people and communities to provide for their social, economic and cultural wellbeing and for their health and safety.

The wastewater treatment plant is a physical resource and provides a vital function by contributing to the health and safety of people and the community of Eketahuna. TDC has duties under the Local Government Act (2001) and Health Act (1956) to provide wastewater treatment for the Eketahuna community. It is important that these services be provided in a cost effective way, meeting the social and economic aspirations of the community. Improvements to the existing treatment system and imposition of appropriate consent conditions will ensure the sustainable management of the receiving environment.

Section 6 of the Act sets out the Matters of National Importance that need to be recognised and provided for. Those relevant to this proposal are:

> *(a) The preservation of the natural character of the coastal environment (including the coastal marine area), wetlands, and lakes and rivers and their margins, and the protection of them from inappropriate subdivision, use, and development;*
>
> *(e) The relationship of Maori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, and other taonga*

The proposed discharge is an existing discharge, the continuation of the discharge with improved treatment of the wastewater is not considered to be an inappropriate use. The change in the discharge point, and therefore additional structure, is also not considered to be an inappropriate use, given the additional treatment and fact that the discharge will be via a rock filter. The preservation of the natural character will be maintained through the imposition of appropriate resource consent conditions in accordance with section 6(a).

The proposal has been discussed with local iwi representatives. Further consultation and involvement through the consent process, and imposition of appropriate consent conditions will assist with providing for section 6(e).

Section 7, Other Matters, lists a number of issues Council must consider when assessing applications for resource consents. Those relevant to this proposal include:

(b) the efficient use and development of natural and physical resources

(c) the maintenance and enhancement of amenity values;

(d) intrinsic values of ecosystems; and

(f) the maintenance and enhancement of the quality of the environment.

(h) the protection of the habitat of trout and salmon

As noted above the WWTP represents a significant physical resource, the proposed ongoing use of that resource is considered to be an efficient use; the upgrades to the treatment system represent a development of that physical resource.

The amenity values of the area will be maintained as the effects are no more than minor. The intrinsic values of ecosystems and the quality of the environment will be enhanced with the proposed upgrades by way of improved effluent quality.

A more refined assessment of the relevant matters in Section 7 will be able to be undertaken once the planned further assessment of effluent quality is calculated, based on trial data, this will in turn be used to refine the potential effects on the receiving environment. However, based on the existing assessments and proposed upgrades no significant effects on the relevant matters from Section 7 are anticipated.

Section 8 of the Act states that consent authorities must take into account the principles of the Treaty of Waitangi. There are no specific Treaty issues with regard to this application.

3.1.2 Section 104 Assessment

Subject to Part 2 of the Act, in making a decision on this application, Manawatu-Wanganui Regional Council is required, under section 104 (1) of the RMA, to have regard to -

(a) any actual and potential effects on the environment of allowing the activity; and

(b) any relevant provisions of—

(i) a national environmental standard:

(ii) other regulations:

(iii) a national policy statement:

(iv) a New Zealand coastal policy statement:

(v) a regional policy statement or proposed regional policy statement:

(vi) a plan or proposed plan; and

(c) any other matter the consent authority considers relevant and reasonably necessary to determine the application.

The actual and potential effects of the discharge have been considered in section 2 above.

3.1.2.1 NPSFM (2014)

The AEE prepared by Aquanet Consulting Ltd in support of this application provides a technical assessment against the National Policy Statement for Freshwater Management 2014 and is repeated below:

Total ammonical nitrogen

Assessment of data, corrected for pH and temperature, against the NPSFM 2014 for ammoniacal nitrogen assigns sites on the Makakahi River upstream and downstream of the discharge into Attribute State A (refer Appendix D, Table 1) with respect to annual median concentrations both with and without the influence of the tributary (Figure 6 & 7). Annual maximum concentrations of ammoniacal nitrogen are assigned to Attribute State A on six of the seven 12-month periods and B on the remaining one both upstream and downstream of the discharge. Attribute State A of the NPSFM 2014 corresponds to a 99% species protection level, meaning that, on most years, there should be no observed effect on any species tested.

Nitrate Nitrogen

Assessment against the NPSFM (2014) for nitrate (Toxicity) concentrations monitored between July 2009 and June 2014, assigns sites on the Makakahi River both upstream and downstream of the Eketahuna WWTP discharge according to Attribute State A for both annual median and annual 95th percentile (Table 6) while nitrate concentrations within the Ngatahaka Creek tributary are assigned to Attribute State A for the periods July 2011 to June 2012 and July 2012 to June 2013 and Attribute State B for the period July 2013 to June 2014 (refer Appendix D, Table 2).

This suggests a high conservation value system where any effects of nitrate toxicity are unlikely even on sensitive species at all sites except within the tributary in the 2013/2014 period (during which the NPSFM narrative Attribute State suggests some growth effect on up to 5 % of species).

E.coli

Assessment against the NPSFM 2014 for E.coli concentrations (refer Appendix D, Table 3) in the Makakahi River at the upstream of the Eketahuna WWTP discharge site assigns an Attribute State of A (when considering annual median) in all years. These results imply a low risk of infection (< 0.1% risk) from contact during water activities. At the downstream site, annual median E.coli levels are assigned an Attribute State of B (<1% risk) in the periods 2007/2008 and 2009/2010 and an Attribute State of A in the four subsequent years. When using all the data available to conduct an overall assessment, all three sites receive an A grading.

When considering 95th percentile however, all three sites receive an overall C grading, indicative of a moderate to high risk of infection from contact during water activities.

3.1.2.2 Relevant Other Matter - Manawatu River Accord

TDC are signatories of the Manawatu River Accord, this is considered to be a relevant other matter. The Accord sets out focus, vision and goals for the Manawatu River.

Specific goals set out in the Accord are:

- *The Manawatu River becomes a source of regional pride and mana.*
- *Waterways in the Manawatu Catchment are safe, accessible, swimmable, and provide good recreation and food resources.*
- *The Manawatu Catchment and waterways are returned to a healthy condition.*
- *Sustainable use of the land and water resources of the Manawatu Catchment continues to underpin the economic prosperity of the Region.*

The renewal of the discharge permit for Eketahuna is identified as one of the tasks for TDC under the Accord Action Plan.

Under 104 (2A) *When considering an application affected by section 124[or 165ZH(1)(c)], the consent authority must have regard to the value of the investment of the existing consent holder.*

The current asset value of the WWTP is $650k the planned upgrades are approximately $800k.

3.1.3 Matters relevant to certain applications

105 Matters relevant to certain applications

(1) If an application is for a discharge permit or coastal permit to do something that would contravene section 15 or section 15B, the consent authority must, in addition to the matters in section 104(1), have regard to—

(a) the nature of the discharge and the sensitivity of the receiving environment to adverse effects; and

(b) the applicant's reasons for the proposed choice; and

(c) any possible alternative methods of discharge, including discharge into any other receiving environment.

The likely effluent quality once upgrades have been installed have been estimated, further refinement of this assessment is planned. The assessment of existing effects and planned further refinement takes into account the sensitivity of the receiving environment.

TDC reasoning for the choice of upgrade includes the efficiency of having some commonality across the different WWTPs, allowing for learnings to be shared across the WWTPs.

Alternatives have been considered, including discharge to land, in section 1.5.

3.1.4 107 Assessment

Section 107 of the RMA describes that a consent authority shall not grant a discharge permit that, after reasonable mixing, gives rise to any of the following effects:

(c) The production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials:

(d) Any conspicuous change in the colour or visual clarity:

(e) Any emission of objectionable odour:

(f) The rendering of fresh water unsuitable for consumption by farm animals:

(g) Any significant adverse effects on aquatic life.

There have been no reports of any of the effects described in Section 107 as a result of the existing discharge. Given the proposed upgrades to the plant this would be expected to continue. However, further assessment can be given to this once the refined effluent quality data is available.

3.2 Regional Policy Statement

The Horizons Regional Council One Plan is considered to be the relevant planning document. This contains both the Regional Policy Statement (RPS) and Regional Plans.

The objectives and policies of the RPS relevant to the proposal are:

3.2.1 Chapter 3 - Infrastructure

Objective 3-1: Infrastructure^ and other physical resources of regional or national importance

Have regard to the benefits of infrastructure^ and other physical resources of regional or national importance by enabling their establishment, operation, maintenance* and upgrading*.*

Policy 3-1: Benefits of infrastructure^ and other physical resources of regional or national importance

(a) The Regional Council and Territorial Authorities^ must recognise the following infrastructure^ as being physical resources of regional or national importance:

> *(viii) public or community sewage treatment plants and associated reticulation and disposal systems*

(c) The Regional Council and Territorial Authorities^ must, in relation to the establishment, operation, maintenance*, or upgrading* of infrastructure^ and other physical resources of regional or national importance, listed in (a) and (b), have regard to the benefits derived from those activities.*

COMMENT

The WWTP at Eketahuna provides ongoing benefits to the residents of Eketahuna by providing functioning wastewater treatment infrastructure. TDC is proposing a number of upgrades to the WWTP. The reticulation system will also be undergoing upgrades, replacing pipe networks damaged as a result of the earthquake, which is predicted to have some impact on infiltration to the system. Benefits from the WWTP include providing for social and economic well-beings for the community. It is considered to be appropriate to have regard to Objective 3-1 and Policy 3-1 when making a decision regarding this application.

3.2.2 Chapter 5 - Water

Objective 5-2: Water^ quality

(a) Surface water^ quality is managed to ensure that:

(i) water^ quality is maintained in those rivers^ and lakes^ where the existing water^ quality is at a level sufficient to support the Values in Schedule B

(ii) water^ quality is enhanced in those rivers^ and lakes^ where the existing water^ quality is not at a level sufficient to support the Values in Schedule B

COMMENT

Objective 5-2 is supported by various Policies which outline how water quality targets must be used to inform the management of surface water. Policies 5-3 to 5-5 set out the policies depending on whether the specified targets are being met for each Water Management Sub-Zone.

In this case it is considered the Policy 5-4 is the most relevant as the water quality targets are not all being met for the sub-zone.

Policy 5-4: Enhancement where water quality targets* are not met

(a) Where the existing water^ quality does not meet the relevant Schedule E water quality targets within a Water Management Sub-zone*, water^ quality within that sub-zone must be managed in a manner that enhances existing water^ quality in order to meet:*

(ia) the water quality target for the Water Management Zone in Schedule E; and/or*

(ii) the relevant Schedule B Values and management objectives that the water quality target is designed to safeguard.*

(b) For the avoidance of doubt:

(i) in circumstances where the existing water^ quality of a Water Management Sub-zone does not meet all of the water quality targets* for the Sub-zone*, (a) applies to every water quality target* for the Sub-zone*

(ii) in circumstances where the existing water^ quality of a Water Management Sub-zone does not meet some of the water quality targets* for the Sub-zone*, (a) applies only to those water quality targets* not met.*

COMMENT

The proposed discharge is located within Mangatainoka (Mana_8) and Mangatainoka-Makakahi (Mana_8d) Water Management Zones and Sub-zones which has zone wide values for: Life Supporting Capacity – Hill Country Mixed geology; aesthetics; Mauri; contact recreation; stockwater; Industrial abstraction; Irrigation; Existing Infrastructure and Capacity to Assimilate Pollution. Schedule AB site specific values for the main stem reach of the River are: Trout Fishery – Regionally Significant Trout Fishery; Trout Spawning; Upstream of a Water supply take - Pahiatua; Flood Control – Drainage.

As determined by the AEE prepared by Aquanet the One Plan Schedule E water quality targets were met with the exception of Enterococci and clarity and changes to MCI. Hence it is appropriate for Horizons Regional Council to manage the Sub-zone to enhance water quality in relation to Enterococci and clarity and MCI, this is discussed further below.

The proposal is for an upgraded treatment system, the lamella clarifier treat total suspended solids. UV Disinfection is proposed, which treats bacteria, viruses and protozoa. Results from accelerated monitoring from Pahiatua would be able to refine the anticipated improvement in effluent quality from Eketahuna. This can be used to determine appropriate consent conditions, this is considered to be an appropriate way to manage the effects resulting from this proposed discharge.

Overall the proposal is consistent with Policy 5-4.

*Policy 5-9: Point source discharges^ to water^*

The management of point source discharges^ into surface water^ must have regard to the strategies for surface water^ quality management set out in Policies 5-3, 5-4 and 5-5, while having regard to:

*(a) the degree to which the activity will adversely affect the Schedule B Values for the relevant Water Management Sub-zone**

(b) whether the discharge^, in combination with other discharges^, including non-point source discharges^ will cause the Schedule E water quality targets to be breached*

(c) the extent to which the activity is consistent with contaminant^ treatment and discharge^ best management practices

*(d) the need to allow reasonable time to achieve any required improvements to the quality of the discharge^*

(e) whether the discharge^ is of a temporary nature or is associated with necessary maintenance^ or upgrade work and the discharge^ cannot practicably be avoided*

(f) whether adverse effects^ resulting from the discharge^ can be offset by way of a financial contribution set in accordance with Chapter 19

(g) whether it is appropriate to adopt the best practicable option^.

COMMENT

Table 3 compares the performance of the Eketahuna WWTP to a number of other similar plants in NZ. This shows that the current system is performing as well or better than those plants. The addition of tertiary treatment processes is consistent with best management practice.

From the AEE work done to date the discharge of WWTP is not individually responsible for causing water quality targets to be breached, particularly once the probable influence of the Ngatahaka Creek are removed. However, as concluded in the Aquanet report "*Direct comparison between upstream and downstream data indicates significant increases of total ammoniacal nitrogen, nitrate-nitrogen, Dissolved Reactive phosphorus (DRP), Soluble Inorganic Nitrogen (SIN), Dissolved Oxygen (DO) and periphyton growth (biomass and cover)*". Each of these determinands is below the One Plan Targets.

In relation to MCI and QMCI, from the Aquanet Report –

- *With regards to macroinvertebrate communities, all three sites (including the Ngatahaka Creek) were below the One Plan target for MCI (120). There was a significant decrease in QMCI between the Makakahi upstream and downstream sites, in excess of the One Plan target, of no more than 20% reduction in QMCI, in both 2013 and 2014. This is a surprising result given that all water quality and ecological determinands relevant to macroinvertebrate communities showed either no significant change (temperature, clarity, ScBOD5, POM) or did change but remained within the One Plan targets (ammoniacal nitrogen, DRP, SIN, periphtyton biomass).*

- *The causes of the measured degradation in macroinvertebrate communities between upstream and downstream of the discharge are unclear at this stage, and so are the relative contributions to this effect by the WWTP discharge vs. inputs from the Ngatahaka Creek catchment, although likely mechanisms include the increase in periphyton growth (itself potentially caused by the measured increased in dissolved available nutrients (SIN and DRP)) and the deposition of organic or inorganic sediment.*

- *As indicated above, a number of upgrades are planned for the Eketahuna WWTP, and further detailed water quality assessment will be undertaken once the nature and likely outcomes (in relation to effluent quality and quantity) are known. This additional assessment should consider known mechanisms of effects on macroinvertebrate communities.*

The further assessment recommended will assist in determining if there is any adverse effect on the identified values for the zone.

The proposed upgrades will improve long term effluent quality, once time is allowed to optimise the plant. The designed upgrades are considered to be the best practicable option for the site.

Policy 5-11: Human sewage discharges^

Notwithstanding other policies in this chapter:
(a) before entering a surface water body^ all new discharges^ of treated human sewage must:
(i) be applied onto or into land^, or
(ii) flow overland, or
(iii) pass through a rock filter, or

(iv) pass though a wetland^ treatment system, or
(v) pass through an alternative system that mitigates the adverse effects^ on the mauri of the receiving water body^, and*

(b) all existing direct discharges^ of treated human sewage into a surface water body^ must change to a treatment system described under (a) by the year 2020 or on renewal of an existing consent, whichever is the earlier date.

COMMENT

The treated wastewater will pass through a tephra and rock filter prior to final discharge in to the Makakahi River. This is consistent with Policy 5-11.

OVERALL CONCLUSION

The proposal is consistent with the relevant Objectives and Policies from the Regional Policy Statement.

3.3 The Regional Plan

3.3.1 Rules Assessment

The Summary of consent requirements as follows

- Discharge of Treated Wastewater to Water – Rule 14-30, Discretionary Activity
- Discharge of Treated Wastewater to Land where it may enter water (as it is not known if the storage facilities, ponds will meet the Permitted Activity Rule standards of Rule 14-16). – Rule 14-30
- Discharge to Air (Odour) – Rule 15-17, Discretionary Activity

3.3.2 CHAPTER 14 - DISCHARGES TO LAND AND WATER

Objective 14-1 Management of discharges^ to land^ and water^ and land^ uses affecting groundwater and surface water quality

The management of discharges^ onto or into land^ (including those that enter water^) or directly into water^ and land^ use activities affecting groundwater and surface water^ quality in a manner that:

(a) safeguards the life supporting capacity of water and recognises and provides for the Values and management objectives in Schedule B,

(b) provides for the objectives and policies of Chapter 5 as they relate to surface water^ and groundwater quality, and

(c) where a discharge^ is onto or into land^, avoids, remedies or mitigates adverse effects^ on surface water^ or groundwater.

Policy 14-1: Consent decision-making for discharges^ to water^

When making decisions on resource consent^ applications, and setting consent conditions^, for discharges^ of water^ or contaminants^ into water^, the Regional Council must specifically consider:

(a) the objectives and policies 5-1 to 5-5 and 5-9 of Chapter 5, and have regard to:

(b) avoiding discharges^ which contain any persistent contaminants^ that are likely to accumulate in a water body^ or its bed^,

(c) the appropriateness of adopting the best practicable option^ to prevent or minimise adverse effects^ in circumstances where:

> *(i) it is difficult to establish discharge^ parameters for a particular discharge^ that give effect to the management approaches for water^ quality and discharges^ set out in Chapter 6, or*
>
> *(ii) the potential adverse effects^ are likely to be minor, and the costs associated with adopting the best practicable option^ are small in comparison to the costs of investigating the likely effects^ on land^ and water^, and*

(d) the objectives and policies of Chapters 2, 3, 6, 9 and 12 to the extent that they are relevant to the discharge^.

COMMENT

As there is no significant industry contributing to the WWTP it is not considered there would be any persistent contaminants that would accumulate in the River or its bed.

The proposed discharge from an upgraded treatment system is considered to be the best practicable option taking into account effects on the environment and economics. The existing discharge has been shown to be having minimal impact on the receiving environment. While a quantitative assessment will only be possible once additional data is recorded once upgrades are installed, it is anticipated that the upgrades will further reduce effects on the Makakihi River.

Policy 13-2B: Options for discharges^ to surface water^ and land^

When applying for consents and making decisions on consent applications for discharges^ of contaminants^ into water^ or onto or into land^, the opportunity to utilise alternative discharge^ options, or a mix of discharge^ regimes, for the purpose of mitigating adverse effects^, applying the best practicable option, must be considered, including but not limited to:

(a) discharging contaminants^ onto or into land^ as an alternative to discharging contaminants^ into water^,

(b) withholding from discharging contaminants^ into surface water^ at times of low flow, and

(c) adopting different treatment and discharge^ options for different receiving environments^ or at different times (including different flow regimes or levels in surface water bodies^).

COMMENT

Land treatment is not considered to be practical due to the high annual rainfall at Eketahuna. The further report commissioned, but not yet finalised at the time of preparing this application, will allow further assessment of this policy. The proposed upgrade is considered to be the best practicable option at this stage.

Policy 13-4: Monitoring requirements for consent holders

Point source discharges^ of contaminants^ to water^ must generally be subject to the following monitoring requirements:

(a) the regular monitoring of discharge^ volumes on discharges^ smaller than 100 m3/day and making the records available to the Regional Council on request,

(b) the installation of a pulse-count capable meter in order to monitor the volume discharged^ for discharges^ of 100 m3/day or greater,

(c) the installation of a Regional Council compatible telemetry system on discharges^ of 300 m3/day or greater, and

(d) monitoring and reporting on the quality of the discharge^ at the point of discharge^ before it enters surface water^ and the quality of the receiving water^ upstream and downstream of the point of discharge^ (after reasonable mixing) may also be required. This must align with the Regional Council's environmental monitoring programme where reasonably practicable to enable cumulative impacts to be measured.*

COMMENT

Flow meters now in place which will be capable of monitoring volumes being discharged.

As most of the proposed upgrades are due to be installed from 2015, a period of more intensive monitoring of effluent quality is proposed. This more intensive period of monitoring will provide certainty with regards to effluent quality that is likely to be sustained in the longer term.

4 Mitigation

The main form of mitigation for the Eketahuna WWTP is the extensive upgrades that are planned for the site.

Additional monitoring is recommended during the commissioning stage in order to help refine the running of the processing and provide further certainty about long term effluent quality.

Below is the indicative sampling that will be done at the Pahiatua WWTP where new upgrades are shortly to be installed and connected. Testing will occur at this site during March and April which can be used to refine anticipated effluent quality for the three TDC sites (Eketahuna, Pahiatua and Woodville) where similar upgrades are planned.

- Influent
  - » Inflow rate and daily totals – continuous monitoring.
  - » Take 24 hour flow weighted composite samples every 6 or 8 days for a month or two, then monthly for the balance of a year.
  - » Sample $cBOD_5$, TKN, TP and Alkalinity.
- Effluent - Commissioning Phase and Trial period
  - » Sample daily or multiple times per day for a duration of two weeks
  - » Sample TSS, DRP and UVT at the Pond 2 outlet and after the clarifier in order to confirm the improvement across each new tertiary process
  - » Sample full list of analytes at discharge (after UV disinfection or Tephra filter)
- Effluent - Normal Operation and Consent Compliance
  - » Sample full list of analytes fortnightly at discharge (after UV disinfection or Tephra filter if installed)
  - » Sample between each unit process (ponds, clarifier, UV) quarterly
  - » Collection of effluent flow data, once the meter is installed.

The full list of effluent analytes to be sampled (except in between unit processes as detailed above) is as follows:

- Grab Samples - Effluent
  - » $cBOD_5$
  - » $scBOD_5$
  - » Ammonia
  - » TKN
  - » TN
  - » DRP
  - » TP
  - » TSS
  - » UVT%
  - » pH
  - » E.coli

In addition, once the commissioning phase is completed a management plan will be prepared by TDC. This will ensure that the optimised plant performance can be continued, even if staff changes occur.

5 Consultation

TDC have led consultation with a number of interested parties regarding upgrades at their sites this has included local iwi, NZ Fish and Game, and WEKA. Representatives from Fish and Game and Ngati Kahungunu have visited the site.

6 Summary

The resource consent application to discharge treated wastewater to water under Rule 14-30 and discharge to air (odour) under Rule 15-17 of the One Plan, addresses the actual and potential effects arising from this activity and assesses the activity against the Resource Management Act 1991, National Policy Statement, Regional Policy Statement and the relevant Regional Plans. The proposal is consistent with the objectives and policies listed in this application, and given the proposed upgrades to the treatment plant, subject to the imposition of appropriate resource consent conditions, the effects of the activity are considered to be no more than minor.

APPENDIX I – Eketahuna WWTP discharge to the Makakahi River:
Summary of Current effects on freshwater quality and ecology
Aquanet Consulting Ltd Report

Eketahuna WWTP discharge to the Makakahi River: Summary of Current effects on freshwater quality and ecology

30 March 2015

Report Prepared for Tararua District Council

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Eketahuna WWTP discharge to the Makakahi River: Summary of Current effects on freshwater quality and ecology

Final 30 March 2015

Report prepared for Tararua District Council by:

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EXECUTIVE SUMMARY

Context

The Tararua District Council (TDC) owns and operates the Eketahuna Wastewater Treatment Plant (WWTP). Resource Consent N. 103346 currently allow for the discharge of treated sewage waste, of no more than 2,600 cubic metres per day, from the Eketahuna WWTP to the Makakahi River. The consent was granted in December 2012 subject to a suite of conditions.

The aim of this report is to provide an assessment of the nature and scale of effects of the current discharge of treated effluent from the Eketahuna WWTP on the water quality of the Makakahi River.

A number of upgrades are planned for the Eketahuna WWTP, and further detailed water quality assessment will be undertaken once the nature and likely outcomes (in relation to effluent quality and quantity) are known.

Assessment undertaken

This assessment of effects of the Eketahuna WWTP discharge is based on compliance monitoring data collected by Horizons Regional Council acting on behalf of Tararua DC for the period 2007-2014.

Typically, an assessment of the effects of a point source discharge on water quality and aquatic ecology relies to a large extent on the comparison of data collected upstream vs. downstream of the discharge point. However, in the case of the Eketahuna WWTP, an added complication is brought by the inflow of a significant tributary of the Makakahi River, the Ngatahaka Creek, within 10m (on the opposite side of the river) of the discharge point. This means that water quality measured at the "Makakahi Downstream" site, located approximately 40m downstream of the discharge point, incorporates the inputs from the discharge and the Ngatahaka Creek. Any comparison between the "Makakahi Upstream" and "Makakahi Downstream" is reflective of the combined influence of inputs from the Ekatahuna WWTP discharge and the Ngatahaka Creek catchment. To overcome this difficuly, a simple modelling approach, based on mass conservation principles, was undertaken to "remove" the influence of the Ngatahaka Creek and estimate what water quality would have been dowsntream of the discharge in the absence of flow and contaminant inputs from the Ngatahaka Creek.

The analysis of water quality and ecological data presented in this report includes an assessment aginst the provisions of:

- the current resource consent conditions
- the One Plan water quality targets for the Makakahi Water Management Sub-Zone; and
- the National Policy Policy Statement for Freshwater Management (NPSFM) (2014)'s relevant numeric Attribute States.

Results – Current effects of the Eketahuna WWTP

With regards to the direct effects of the Eketahuna WWTP discharge on water quality and freshwater ecology, the following conclusions were drawn, based on monitoring data collected upstream and downstream of the discharge as well as from the Ngatahaka Creek which enters the Makakahi River approximately 10 meters upstream of the discharge point, over the period 2007 – 2014 (noting that a number of data analyses and assessments were conducted over the 2010 – 2014 period, as detailed in the report):

- Data available do not indicate significant changes between the Makakahi upstream and downstream sites for the following water quality determinands: water clarity, total suspended solids (TSS), water temperature, water pH, $ScBOD_5$, and Particulate Organic Matter (POM). This means that the discharge, even when combined with the inputs from the Ngatahaka Creek, does not cause any significant adverse effect s in relation to these determinands;
- Although no statistically significant, differences in *E.coli* concentrations were identified between upstream and downstream of the discharge, the proportion of samples compliant with the One Plan targets decreased between upstream and downstream and the discharge, It is noted that *E.coli* concentrations in the Ngatahaka Creek were generally higher than in the Makakahi upstream of the discharge, and often higher than at the downstream site. It thus appears likely that some of the changes between upstream and downstream are at least in part attributable to inputs from the Ngatahaka Creek;
- Direct comparison between upstream and downstream data indicates significant increases of total ammoniacal nitrogen, nitrate-nitrogen, Dissolved Reactive phosphorus (DRP), Soluble Inorganic Nitrogen (SIN), Dissolved Oxygen (DO) and periphyton growth (biomass and cover).
- The measured increase in DO saturation does not affect compliance with the One Plan target assessed on the basis of existing data, as the One Plan only defines a minimum saturation target. It is plausible that the measured day-time increases in DO saturation may be associated with photosynthetic activity from the increased periphyton biomass present at the downstream site. It is also noted that the only DO data available are day-time 'spot' measurements, which do not provide any indication of night-time minima, and a detailed assessment of DO against provisions of the One Plan and/or the NPSFM (2014) is not possible on the basis of existing data.
- Although increases in total ammoniacal nitrogen were statistically significant, measured concentrations at the downstream site remained well below the One Plan targets and did not result in any change in NPSFM grading for the ammoniacal nitrogen grading. Risks of toxic effects associated with ammonia are considered low and no observable effects are expected.
- The One Plan SIN target was met in the Makakahi River both upstream and downstream of the discharge, but largely exceeded in the Ngatahaka Creek. Additional modelling of contaminant loads and concentrations indicates that the measured increases in SIN (and nitrate-nitrogen) concentrations at the Makakahi downstream site compared with upstream are mostly attributable to inputs from the Ngatahaka catchment.
- The One Plan DRP target was met at all three sites, although both the Ngatahaka Creek and the downstream site presented higher concentrations than the upstream site. Additional analysis indicates that inputs from the Ngatahaka Creek are in part responsible for the increase in DRP concentration at the Makakahi downstream site compared with upstream, but that the discharge from the WWTP is also likely to be a significant contributor, particularly during periods of low river flows.
- Periphyton biomass, and cover by filamentous algae and diatom or cyanobacteria mats increased but remained below the One Plan targets at all three sites, indicating that the increase in periphyton

growth currently observed is not at levels that would cause significant adverse effects on river values as identified in the One Plan. Although insufficient data are available, a preliminary assessment indicates that the upstream site is likely to fall in the NPSFM 'B' grade for periphyton (Trophic state), whilst the downstream site may fall in either the 'B' or 'C' grades. It is noted that the Makakahi upstream and the Ngatahaka Creek monitoring sites are within gorges, and thus are quite heavily shaded, whilst the Makakahi downstream site is more open, and receives more sunlight. This may explain some of the differences in periphyton growth between the Makakahi upstream and downstream sites;

- An analysis of nutrient concentration ratios was undertaken to provide an indication of likely nutrient limiting conditions in the Makakahi River. It indicates that the Makakahi upstream site is mostly nitrogen-limited at low flows, with a shift towards co-limited an then P-limited conditions as river flows increase. This is a common pattern observed at several other Manawatu Catchment sites. Nutrient ratios at the downstream site indicate that there is a general disappearance of strongly N-limited conditions under all but the lowest river flows, and a shift towards co- or P-limited conditions. This is thought to be primarily caused by SIN inputs, which have the net result of increasing SIN/DRP ratios;
- With regards to macroinvertebrate communities, all three sites (including the Ngatahaka Creek) were below the One Plan target for MCI (120). There was a significant decrease in QMCI between the Makakahi upstream and downstream sites, in excess of the One Plan target, of no more than 20% reduction in QMCI, in both 2013 and 2014. This is a surprising result given that all water quality and ecological determinands relevant to macroinvertebrate communities showed either no significant change (temperature, clarity, $ScBOD_5$, POM) or did change but remained within the One Plan targets (ammoniacal nitrogen, DRP, SIN, periphtyton biomass).
- The causes of the measured degradation in macroinvertebrate communities between upstream and downstream of the discharge are unclear at this stage, and so are the relative contributions to this effect by the WWTP discharge vs. inputs from the Ngatahaka Creek catchment, although likely mechanisms include the increase in periphyton growth (itself potentially caused by the measured increased in dissolved available nutrients (SIN and DRP)) and the deposition of organic or inorganic sediment.
- As indicated above, a number of upgrades are planned for the Eketahuna WWTP, and further detailed water quality assessment will be undertaken once the nature and likely outcomes (in relation to effluent quality and quantity) are known. This additional assessment should consider known mechanisms of effects on macroinvertebrate communities.

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1. Introduction

1.1. Background

The Tararua District Council (TDC) owns and operates the Eketahuna Wastewater Treatment Plant (WWTP). Currently, wastewater from the township of Eketahuna is fed into a two pond system whereby treated effluent from the secondary oxidation pond flows through a 150 mm pipe down a steep embankment and into the Makakahi River.

Resource Consent N. 103346 currently allows for the discharge of treated sewage waste, of no more than 2600 cubic metres per day, from the Eketahuna WWTP to the Makakahi River. The consent was granted in December 2012 subject to a suite of conditions.

1.2. Aim and scope

The following provides an assessment of the nature and scale of the current effects of discharge of treated effluent from the Eketahuna WWTP on the water quality and in-stream ecology of the Makakahi River. This report was prepared to inform the development of an Assessment of Environmental Effects as part of consent renewal applications by Tararua District Council for the Eketahuna WWTP.

The assessment conducted here is made purely on technical grounds and is limited to water quality and aquatic ecology considerations. It is primarily based on monitoring data collected during the period July 2010 to June 2014. Where data are considered insufficient to fully inform a robust assessment, the conclusions of this report should be considered preliminary. Additional data/information may be required if specific parts of the assessment need to be refined in the future.

A number of upgrades are planned for the Eketahuna WWTP, and further detailed water quality assessment will be undertaken once the nature and likely outcomes (in relation to effluent quality and quantity) are known.

1.3. Structure of report

This report is comprised of four sections:

Section 2 outlines the data available for analysis, presents a map of sites included in the monitoring data analysed and explains approaches used in data analysis. It also explains the water quality targets included in assessments to provide some context around the scale of effects from the discharge.

Section 3 presents an assessment of the current state of water quality, periphyton cover and biomass, and macroinvertebrate health in the Makakahi River and the Ngatahaka Creek. It also presents the results of the analysis.

Section 4 presents conclusions from the main findings of sections 2 to 4.

2. Methods

2.1. Available data and data preparation

The data used for the assessment presented in this report are summarised in Table 1 below. River flow statistics used in this report are summarised in Table 2. Data were provided by Horizons Regional Council.

Table 1: Summary of data used in this assessment.

Site	Type	Parameters	Frequency	Period	Source
Makakahi River at Hamua	River flow	Daily mean flow	Daily	Jan 1980 to May 2014	Horizons
Makakahi River above confluence (Synthetic)				Dec 1979 to June 2014	OPUS
Makakahi River below confluence (Synthetic)				Dec 1979 to June 2014	
Ngatahaka Creek (Synthetic)				Dec 1979 to June 2014	
Makakahi River upstream of Eketahuna WWTP discharge	River water quality	DRP, TP, TN, NO_3-N, NO_2-N, TNH_3-N, SIN, *E. coli*, Enterococci, TSS, POM, Visual clarity (Black disc), sCBOD5, DOsat., pH, Temp	Monthly	July 2007 to June 2014	Horizons
Makakahi River downstream of Eketahuna WWTP discharge				July 2007 to June 2014	
Tributary (Ngatahaka Creek)				Oct 2010 to June 2014	
Makakahi River upstream of Eketahuna WWTP discharge	Biological indicators	Macroinvertebrate indices (MCI, QMCI, %EPT taxa, %EPT individuals, No. of taxa, No. of individuals); Periphyton biomass (Chlorophyll *a*), %Periphyton cover	Annually (Macroinvertebrates) Bi-monthly (Periphyton)	Feb 2013 and March 2014 (Macroinvertebrates); Feb 2013 to Sept 2014 (Periphyton)	Horizons
Makakahi River downstream of Eketahuna WWTP discharge					
Tributary (Ngatahaka Creek)					

Table 2: Summary of flow statistics used in this assessment. (Data for Makakahi River at Hamua provided by Horizons Regional Council, data for Makakahi River upstream, downstream and Ngatahaka Creek provided by Opus International Consultants). All flows in m^3/s.

Site	Mean flow	Median flow (50th exceedance %ile)	Half median flow	20th exceedance %ile flow
Makakahi River at Hamua	6.287	3.158	1.579	8.224
Makakahi River above confluence (Synthetic)	3.024	1.613	0.807	4.290
Makakahi River below confluence (Synthetic)	4.602	2.455	1.228	6.529
Ngatahaka Creek (Synthetic)	1.578	0.842	0.421	2.239

2.2. Sites monitored

Water quality, periphyton and macroinvertebrate data were collected from sites sampled on the Makakahi River upstream and downstream of Eketahuna WWTP discharge point, as well as from within the Ngatahaka Creek tributary which joins the Makakahi River approximately 10 meters below the discharge point. Sites are shown on Figure 1 below.

Synthetic flow data for each site was calculated from flow data collected from the Makakahi River at Hamua (not shown on the map).

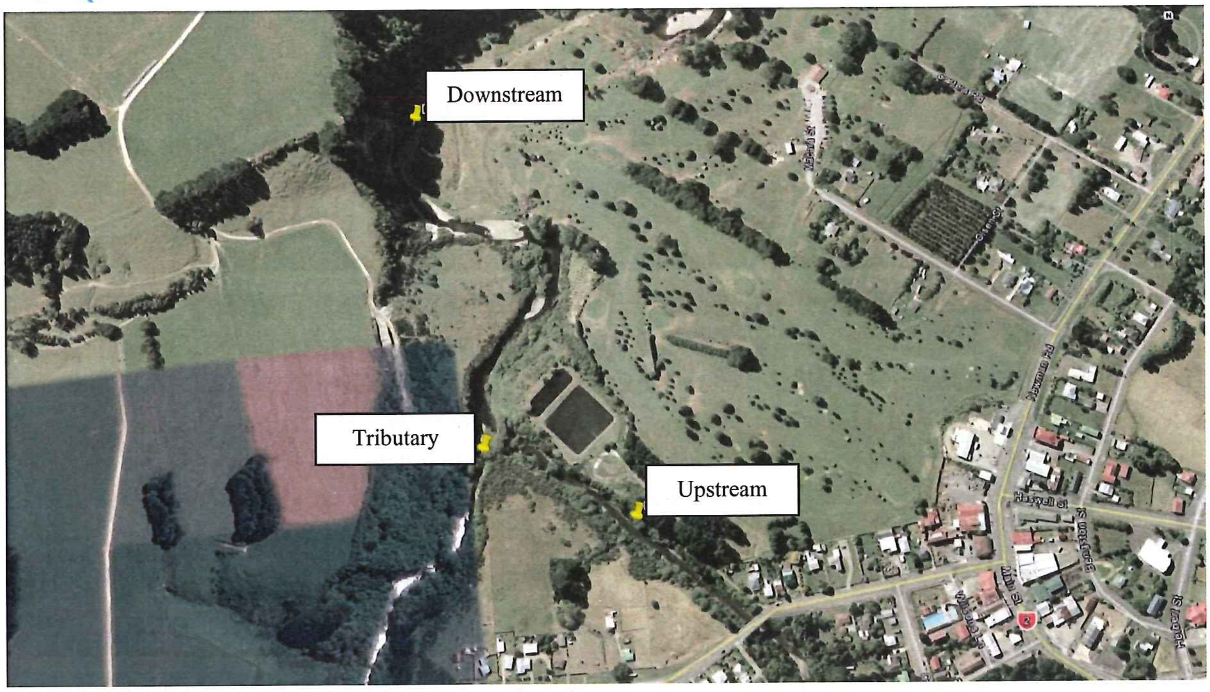


Figure 1: Locations of sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP discharge point and within the Ngatahaka Creek tributary.

2.3. Data analysis

Detailed descriptive statistics, such as mean, median, distribution percentiles, standard error and confidence intervals were calculated from water quality data. Water quality results were also classified according to river flow, and upstream/downstream comparisons were undertaken using all the results available ("all flows"), and within six distinct flow "bins" (i.e. data collected above the 20^{th} FEP, below the 20^{th} FEP, between the 20^{th} FEP and median flow, below median flow, between median and half median flow, and below half median flow). Comparisons of upstream/downstream results were carried out using a Wilcoxon Signed Rank Test in Statistix 9. Comparisons were run for each flow "bin".

Assessments against the Attribute State tables in Appendix 2 of the National Policy Statement for Freshwater Management 2014 (NPSFM 2014) were undertaken for Total ammoniacal nitrogen, Nitrate nitrogen, *E.coli* and Periphyton biomass. The NPSFM (2014) specifies that the numeric attribute states for ammoniacal nitrogen are based on pH 8 and temperature of 20°C and that compliance with the numeric attribute states should be undertaken after pH adjustment. This was achieved by firstly calculating the proportion of unionised ammonia nitrogen at pH of 8 and 20°C, then calculating the unionised ammonia-nitrogen concentrations corresponding to the NPSFM thresholds. The unionised ammonia concentration in each in-river sample was calculated on the basis of water pH and temperature measured on-site on each day of sampling, then compared with the unionised ammonia nitrogen NPSFM thresholds.

In addition, differences in biotic indices between sites were also assessed using two way analysis of variance (ANOVA) with both treatments considered fixed effects using the Statistix 9 software. Differences in abundance of the invertebrate taxa were assessed using Non Metric Multidimensional Scaling in Primer 6.1.16.

2.3.1. Influence of the Ngatahaka Creek

As explained in Section 2.2, a tributary of the Makakahi River, the Ngatahaka Creek, flows into the Makakahi River between the "Makakahi Upstream" and the "Makakahi Downstream" water quality monitoring sites. This poses a significant challenge with regards to the assesssment of the Eketahuna WWTP discharge on the Makakahi River's water quality, as water quality measured at the "Makakahi Downstream" site incorporates the inputs from the discharge and the Ngatahaka Creek. As a result, any comparison between the "Makakahi Upstream" and "Makakahi Downstream" is reflective of the combined influence of inputs from the Ekatahuna WWTP discharge and the Ngatahaka Creek catchment.

To overcome this difficulty, an analysis of contaminant loads was undertaken, with a view to quantify the contaminant loads at the different monitoring sites on each day concurrent water qaulity sampling occurred at all three sites, i.e. the Makakahi River upstream of the discharge, the Ngatahaka Creek itself, and the Makakhi River downstream of the discharge. On each sampling date, and for each contaminant, the daily load from the Ngatahaka Creek was calculated, and then substracted from the daily load at the "Makakahi downstream" site, thus providing an estimate of what the daily load at that latter site would have been without the inputs from the Ngatahaka Creek. A corrected "Makakahi downstream without Ngatahaka inputs" concentration was then back-calculated using the synthetic flow record for this site. In theory, the comparison of this "corrected" downstream concentration with the "Makakahi upstream" concentration provides an estimate of the influence of the discharge from the Eketahune WWTP on the Makakahi River's water quality.The details of the daily loads calculations are presented in Appendix B of this report.

2.3.2. Consent Conditions & OnePlan limits

Water quality, peripyton and macroinvertebrate targets have been included in assessments to provide some context around the scale of effects from the discharge. These are summarised in Table 3 and include both those from the Horizons One Plan the Mangatainoka - Makakahi management sub-zone (Mana_8d) and those included in the current resource consent conditions (Discharge Consent N. 4367). All references to the One Plan in this report refer the web-based version, accessed on 2nd December 2014.

Table 3: Summary of Water Quality targets used in this assessment.

Parameter	Target as per condition 11 in Resource Consent N.103346	Target as per Horizons One Plan (Full Wording of the Target)
pH	**pH** must be within range of **7 to 8.5** pH units and must not have a change of greater than 0.5 units (11l)	The **pH** of the *water^* must be within the range **7 to 8.5** unless natural levels are already outside this range.
		The **pH** of the *water^* must not be **changed** by more than **0.5.**
Temp (°C)	**Temperature** shall not exceed **19°C** between 1 October & 30 April or **11°C** between 1 May & 30 September (11j)	The **temperature** of the *water^* must not exceed **19** degrees Celsius.
	Temperature change shall not be greater than **3°C** between 1 October & 30 April, or greater than **2°C** between 1 May & 30 September (11i)	The **temperature** of the *water^* must not be **changed** by more than **3** degrees Celsius.
	There shall not be a **temperature** change of greater than 1 degree Celsius if the upstream temperature is greater than **19°C** between 1 October & 30 April (11k)	
DO (% SAT)	**DO** concentration shall not fall below **80% saturation** (11m)	The concentration of dissolved oxygen (**DO**) must exceed **80 %** of saturation.
sCBOD5 (g/m³)	**BOD**$_5$ concentration shall not exceed **1.5 g.m³** (4ii)	The monthly average five-days filtered / soluble carbonaceous biochemical oxygen demand (**sCBOD5**) when the *river^* flow is at or below the 20th *flow exceedance percentile** must not exceed **1.5** grams per cubic metre.
POM (g/m³)	**POM** concentration shall not exceed **5 g.m³** (12ii)	The average concentration of particulate organic matter (**POM**) when the *river^* flow is at or below the 50th *flow exceedance percentile** must not exceed **5** grams per cubic metre.
Periphyton (*rivers^*)	**Chlorophyll a** concentrations must not exceed **120** mg.m² (11r)	The algal biomass on the *river^ bed^* must not exceed **120** milligrams of chlorophyll *a* per square metre.
	Cover of filamentous algae greater than 2 cm long must not exceed **30%** or cover of mats greater than 3mm thick to exceed **60%** (11s)	The maximum cover of visible *river^ bed^* by periphyton as filamentous algae more than 2 centimetres long must not exceed **30 %.**
		The maximum cover of visible river bed by periphyton as diatoms or cyanobacteria more than 0.3 centimetres thick must not exceed **60 %.**
DRP (g/m³)	**DRP** concentrations must not exceed **0.010** g/m³ at or below the 20th FEP (11o)	The annual average concentration of dissolved reactive phosphorus (**DRP**) when the *river^* flow is at or below the 20th *flow exceedance percentile** must not exceed **0.010** grams per cubic metre, unless natural levels already exceed this target.
Deposited Sediment		The maximum cover of visible river bed by deposited sediment less than 2 millimetres in diameter must be less than **20 %,** unless natural physical conditions are beyond the scope of the application of the deposited sediment protocol of Clapcott et al. (2010)

SIN (g/m^3)	**SIN** concentrations must not exceed **0.444** g/m^3 at or below the 20th FEP (11p)	The annual average concentration of soluble inorganic nitrogen (**SIN**) when the *river^* flow is at or below the 20th *flow exceedance percentile* must not exceed **0.444** grams per cubic metre, unless natural levels already exceed this target.
MCI		The Macroinvertebrate Community Index (**MCI**) must exceed **120**, unless natural physical conditions are beyond the scope of application of the MCI. In cases where the river^ habitat is suitable for the application of the soft-bottomed variant of the MCI (sb-MCI) the Water Quality Target* (or standard where specified under conditions/standards/terms in a rule) also apply.
QMCI	There shall not be a reduction of more than **20%** in **QMCI** (11t)	There must be no more than a **20 % reduction** in Quantitative Macroinvertebrate Community Index (**QMCI**) score between appropriately matched habitats upstream and downstream of discharges to *water^*.
Ammoniacal Nitrogen	**Ammonia** concentration must not exceed **2.1** g/m^3 at any time or exceed **0.4** g.m3 on an annual average (11n)	The average concentration of **ammoniacal nitrogen** must not exceed **0.400** grams per cubic metre.
		The maximum concentration of **ammoniacal nitrogen** must not exceed **2.1** grams per cubic metre
Toxicants		For toxicants not otherwise defined in these targets, the concentration of toxicants in the *water^* must not exceed the trigger values for freshwater defined in the 2000 ANZECC guidelines Table 3.4.1 for the level of protection of 99 % of species. For metals the trigger value must be adjusted for hardness and apply to the dissolved fraction as directed in the table.
Visual Clarity	No change in **horizontal visibility** of more than **20%** (11g)	The visual **clarity** of the *water^* measured as the horizontal sighting range of a black disc must not be **reduced** by more than **20 %**.
	The minimum **horizontal visibility** to be no less than **3** metres (11h)	The visual **clarity** of the *water^* measured as the horizontal sighting range of a black disc must equal or exceed **3** metres when the *river^* is at or below the 50th *flow exceedance percentile**
E. coli / 100 ml (rivers^)		The concentration of ***Escherichia coli*** must not exceed **260** per 100 millilitres 1 November - 30 April (inclusive) when the *river^* flow is at or below the 50th *flow exceedance percentile**.
		The concentration of ***Escherichia coli*** must not exceed **550** per 100 millilitres year round when the *river^* flow is at or below the 20th *flow exceedance percentile**.

3. Effects of the Eketahuna WWTP discharge on fresh water quality and aquatic ecology

3.1. Effects on water quality

Water quality data from paired sampling days collected at sites upstream and downstream of the Eketahuna WWTP discharge to the Makakahi River and within the Ngatahaka Creek tributary between October 2010 and May 2014 have been summarised and are presented in Figures below (mean concentrations with error bars representing the 95% confidence intervals). This represents the period of time during which samples from all three sites are available.

Figures 2B, 5B, 6B and 7B present water quality data from paired sampling days between October 2010 and May 2014 for sites upstream and downstream of the discharge with the influence of the Ngatahaka Creek tributary removed from downstream concentrations, giving the theoretical effect of the Eketahuna WWTP discharge on the downstream site, as explained in Section 2.3.1.

Daily and annual loads calculated on data between October 2010 and May 2014 are presented in Appendix B and C, and compare the downstream site with and without the influence of the tributary.

NPSFM assessments presented below were carried out on Total ammoniacal nitrogen, Nitrate nitrogen and E.*coli* data collected from the three sites for each twelve month period beginning in July and ending in June between 2007 and 2014 (Figure 3 & 4, Table 6 & 7).

Key water quality determinants measured in the Makakahi River are summarised in Table 5 below. One Plan targets applicable at various flows are shown along with an indication of whether or not the One Plan target has been meet.

Table 4: Summary of key water quality determinants measured in the Makakahi River upstream and downstream of the Eketahuna WWTP discharge and assessment against One Plan water quality targets.

	TNH_3-N (g/m^3)			SIN (g/m^3)			DRP (g/m^3)			*E. coli* (/100mL)			
	U/S	D/S	Theoretical D/S	U/S	D/S	Theoretical D/S	U/S	D/S	Theoretical D/S	U/S	D/S	U/S	D/S
Mean	0.010	0.017	0.015	0.224	0.407	0.217	0.004	0.007	0.006	215.3	238.8	220.6	248.9
Median	0.009	0.011	0.012	0.141	0.260	0.100	0.003	0.006	0.006	135.0	212.0	146.8	165.0
20th percentile	0.001	0.001	0.000	0.019	0.053	-0.022	0.003	0.003	0.003	89.8	91.9	75.0	92.6
95th percentile	0.02	0.04	0.05	0.66	1.00	0.73	0.01	0.02	0.02	469.3	668.3	596.6	709.2
N. samples	44	44	44	40	40	40	40	40	40	19	19	40	40
OP Target	<0.4			<0.444			<0.01			<260		<550	
Applicable Flow	All flows			Below 20th FEP			Below 20th FEP			Below 50th FEP Summer months		Below 20th FEP	
OP Target met?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗

Table 5: Summary of key water quality determinants measured in the Makakahi River upstream and downstream of the Eketahuna WWTP discharge, and assessment against One Plan water quality targets.

	Clarity (m)		Clarity change (%)	POM (g/m^3)		pH		Temperature (°C)		sCBOD5 (g/m^3)		DO (%Sat.)	
	U/S	D/S		U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S	U/S	D/S
Mean	2.1	2.2	-4.4	1.2	1.0	7.62	7.63	13.1	13.1	0.8	0.8	97.3	99.1
Median	2.0	2.1	1.3	0.5	1.0	7.61	7.61	13.1	13.1	1.0	1.0	96.9	99.9
20th percentile	1.6	1.9	-16.1	0.0	0.0	7.40	7.45	9.7	9.5	0.3	0.3	89.9	94.2
95th percentile	3.1	3.0	0.1	4.0	2.9	8.29	8.10	18.7	19.1	1.0	1.0	109.1	107.1
N. samples	20	18	36	23	23	44	44	44	44	39	40	43	44
OP Target	>3m		<20%	<5		>7 & <8.5		<19		<1.5		>80	
Applicable Flow	Below 50th FEP		All flows	Below 50th FEP		All flows		All flows		Below 20th FEP		All flows	
OP Target met?	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

3.1.1. Total Ammoniacal Nitrogen

The One Plan and current consent conditions define two total ammoniacal nitrogen concentration targets: an average concentration of 0.4 mg/L (chronic exposure) and a maximum concentration of 2.1 mg/L (acute exposure).

Total ammoniacal nitrogen concentrations were always well below the One Plan and Consent target, both upstream and downstream of the Eketahuna WWTP discharge (Figure 2A & B), indicating a low risk of toxic effects from ammonia on aquatic life both upstream and downstream of the discharge.

Statistically significant increases were observed between upstream and downstream sites within all flow bins except flows above 20th FEP and median to 20th FEP (Figure 2A). When the influence of the tributary was removed from the downstream site, the significant differences remained (Figure 2B).

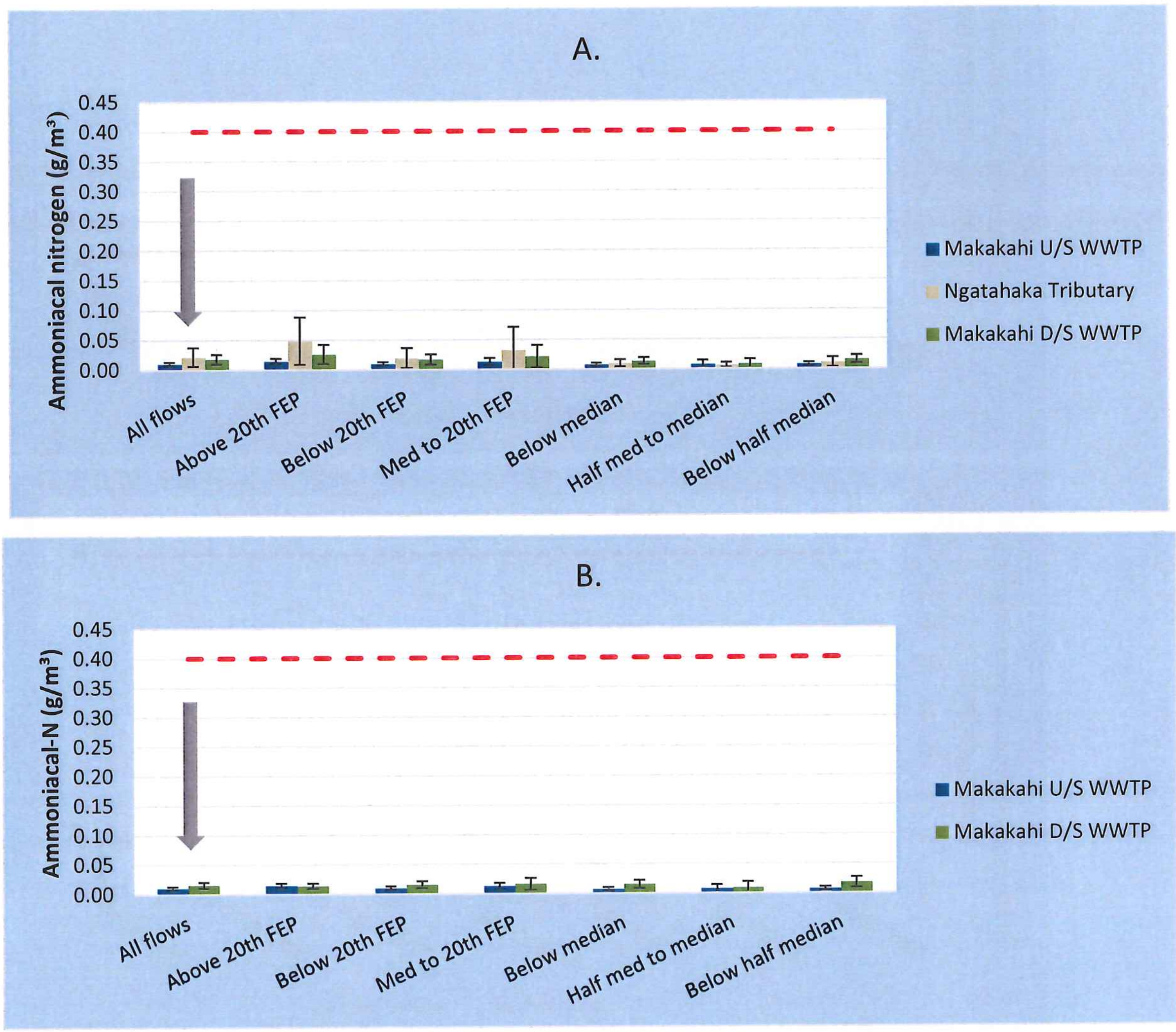


Figure 2: A. Mean Total Ammoniacal Nitrogen concentrations for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (October 2010 – May 2014) at various flows. B. Upstream and theoretical downstream mean Total Ammoniacal Nitrogen concentrations (October 2010 – May 2014). The One Plan target for Total Ammoniacal Nitrogen (chronic exposure) is represented as a dashed red line. The grey arrow points to the flow bin defined in the One Plan target.

3.1.1.1. Assessment against NPSFM 2014 Attribute State

Assessment of data, corrected for pH and temperature, against the NPSFM 2014 for ammoniacal nitrogen assigns sites on the Makakahi River upstream and downstream of the discharge into Attribute State A (refer Appendix D, Table 1) with respect to annual median concentrations both with and without the influence of the tributary (Figure 6 & 7). Annual maximum concentrations of ammoniacal nitrogen are assigned to Attribute State A on six of the seven 12-month periods and Attribute State B on the remaining one both upstream and downstream of the discharge. Attribute State A of the NPSFM 2014 corresponds to a 99% species protection level, meaning that, on most years, there should be no observed effect on any species tested.

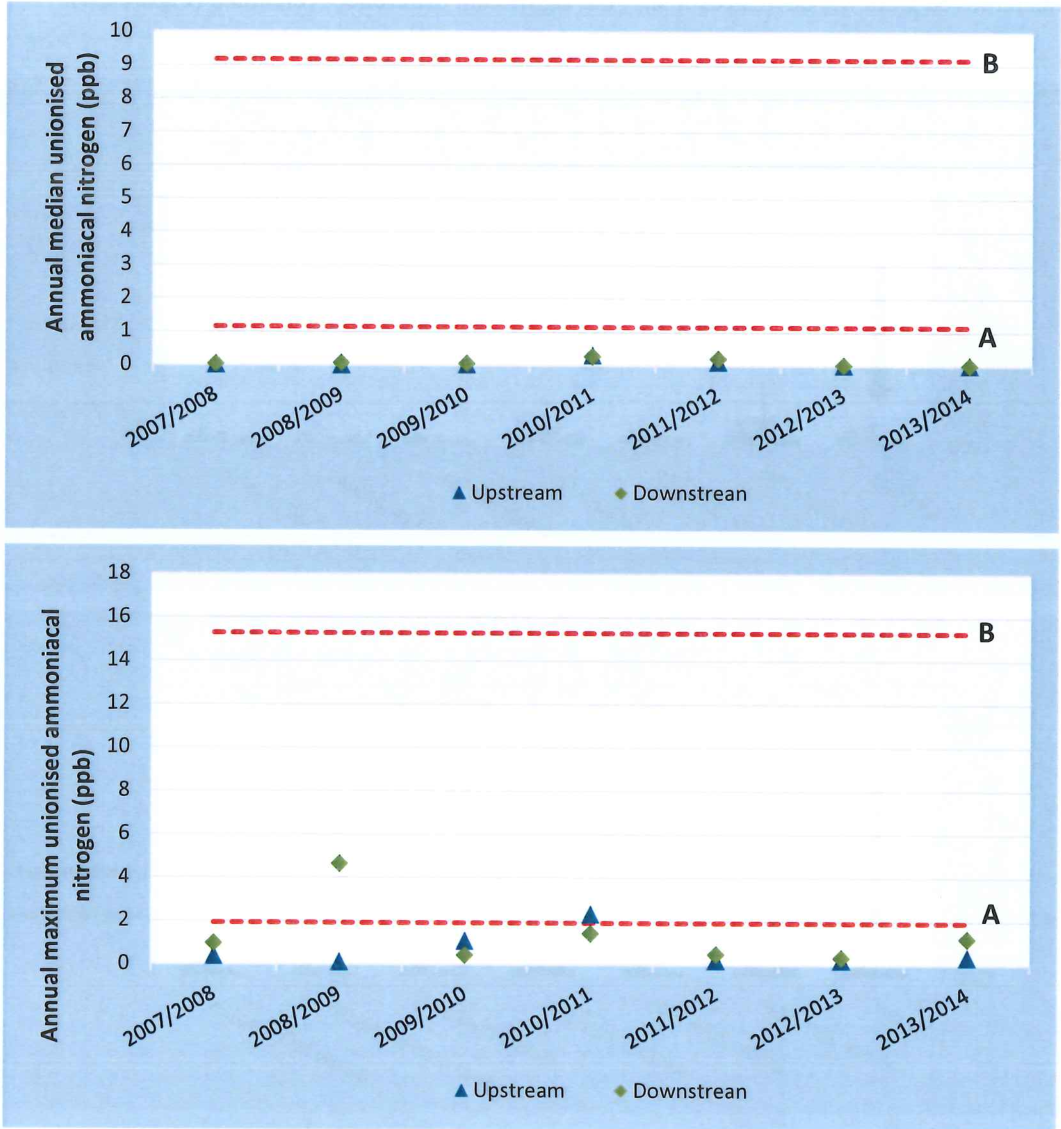


Figure 3: Annual Median (upper) and Annual Maximum (lower) unionised ammoniacal nitrogen concentrations for sites sampled on Makakahi River (July 2007 – June 2014) upstream and downstream of the Eketahuna WWTP. NPSFM 2014 Attribute States (A, B & C) are indicated by the red lines.

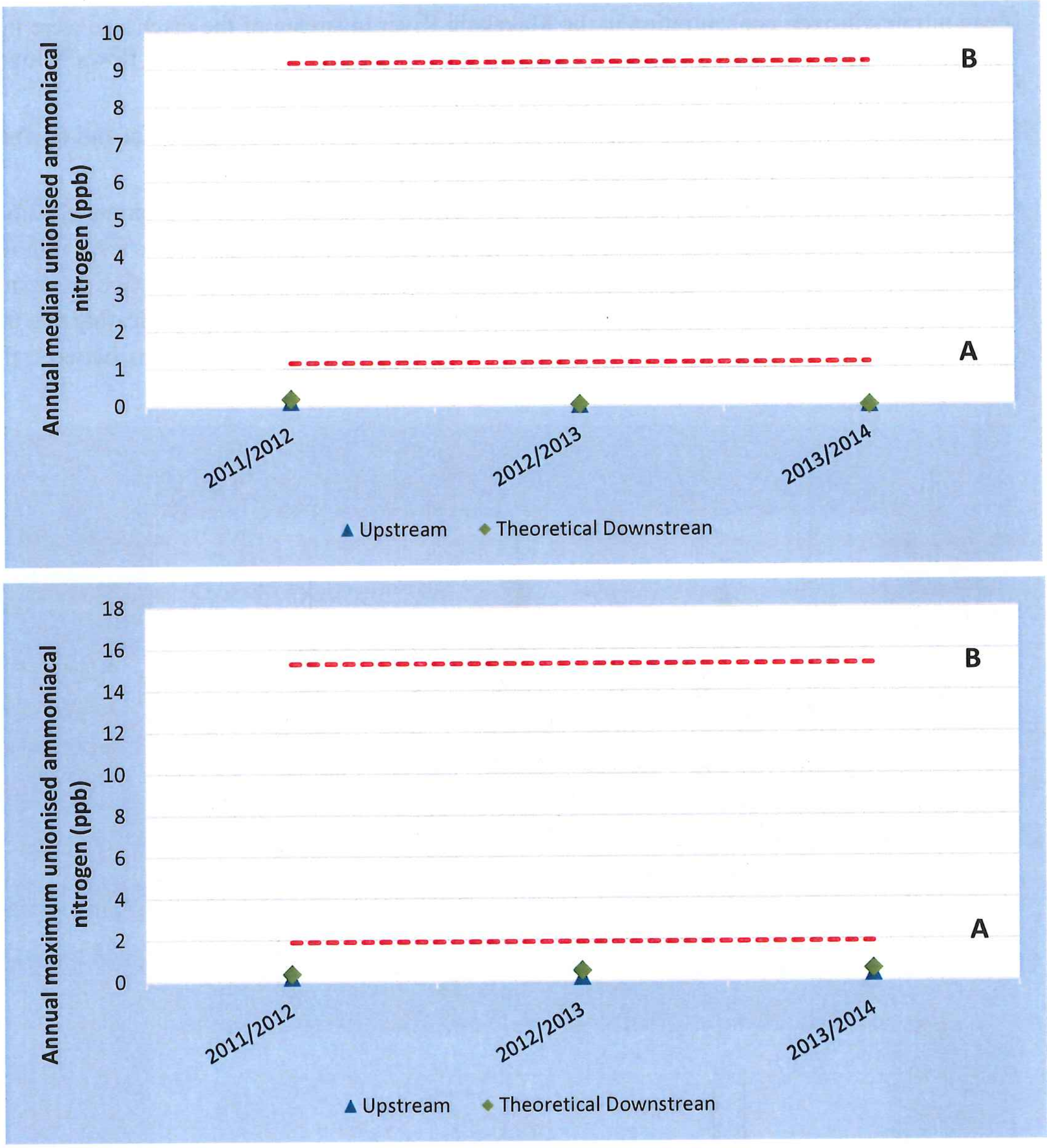


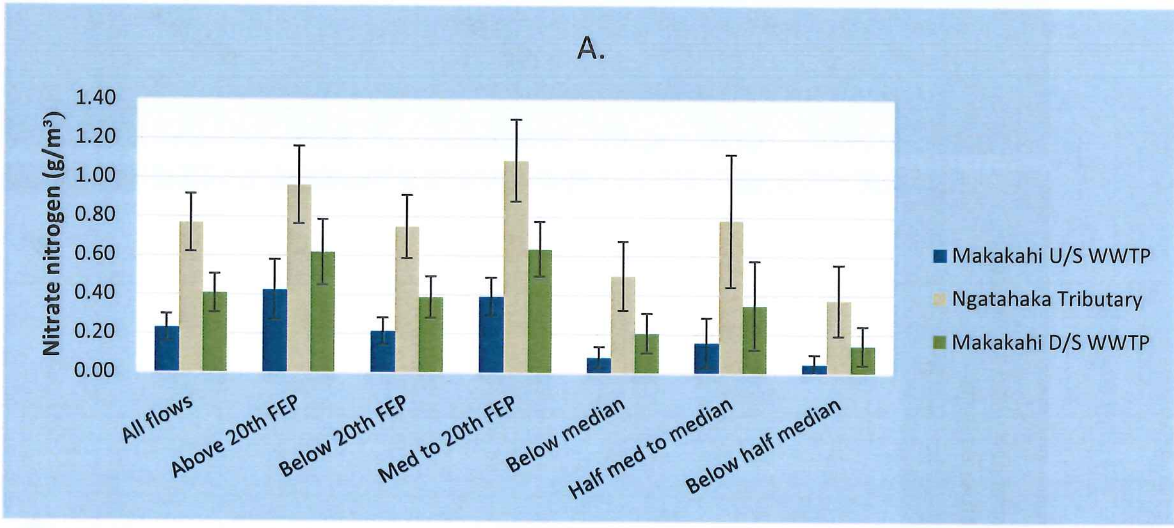
Figure 4: Median unionised total ammoniacal nitrogen (upper) and Maximum unionised total ammoniacal nitrogen (lower) concentrations for upstream of the Eketahuna WWTP and the theoretical downstream sampled on the Makakahi River (July 2011 – May 2014) upstream and downstream of the Eketahuna WWTP. NPSFM 2014 Attribute States (A, B & C) are indicated by the red lines.

3.1.2. Nitrate Nitrogen

Mean nitrate nitrogen concentration in the Makakahi River upstream of the discharge were in the order of 0.23 g/m^3 at all flows, and decreased at lower river flows, to 0.08 g/m^3 at river flows below median and 0.05 g/m^3 at flows below half median flows.

Significant increases in nitrate nitrogen concentrations occurred between upstream and downstream of the discharge in all flow bins except at flows above 20th FEP (Figure 5A).

Of all three sites, the Ngatahaka Creek presented the highest concentrations, approximately 2.6 times higher than at the Makakahi upstream site. Once the inputs from the Ngatahaka Creek were removed from the downstream site, using the daily load adjustment methodology described in Section 2.3.2, no significant differences were observed other than at flows below median flow (Figure 5B), indicating that the Ngatahaka Creek is the likely main source of the increase in nitrate-nitrogen concentrations between the Makakahi upstream and downstream sites.



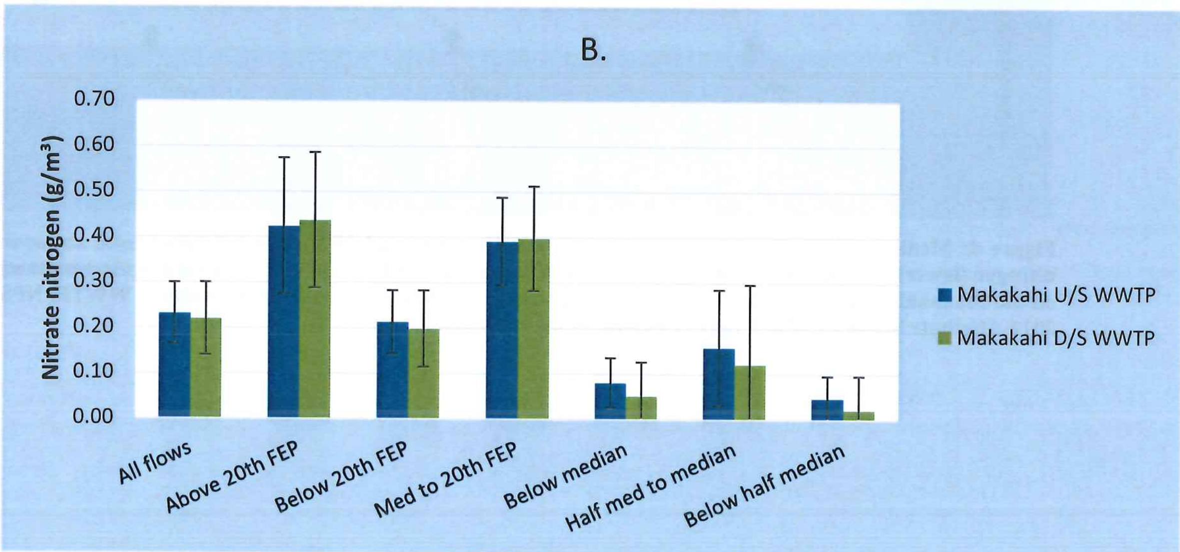


Figure 5: A. Mean Nitrate Nitrogen concentrations for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (October 2010 – May 2014) at various flows. B. Upstream and theoretical downstream mean Nitrate Nitrogen concentrations (October 2010 – May 2014).

3.1.2.1. Assessment against NPSFM 2014 Attribute State

Assessment against the NPSFM (2014) for nitrate (Toxicity) concentrations monitored between July 2009 and June 2014, assigns sites on the Makakahi River both upstream and downstream of the Eketahuna WWTP discharge according to Attribute State A for both annual median and annual 95th percentile (Table 6), while nitrate concentrations within the Ngatahaka Creek tributary are assigned to Attribute State A for the periods July 2011 to June 2012 and July 2012 to June 2013 and Attribute State B for the period July 2013 to June 2014 (refer Appendix D, Table 2).

This suggests a high conservation value system where any effects of nitrate toxicity are unlikely even on sensitive species at all sites except within the tributary in the 2013/2014 period (during which the NPSFM narrative Attribute State suggests some growth effect on up to 5 % of species).

Table 6: Annual median and 95th percentile Nitrate concentrations along with the NPSFM Attribute State for sites monitored on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (July 2009 – June 2014).

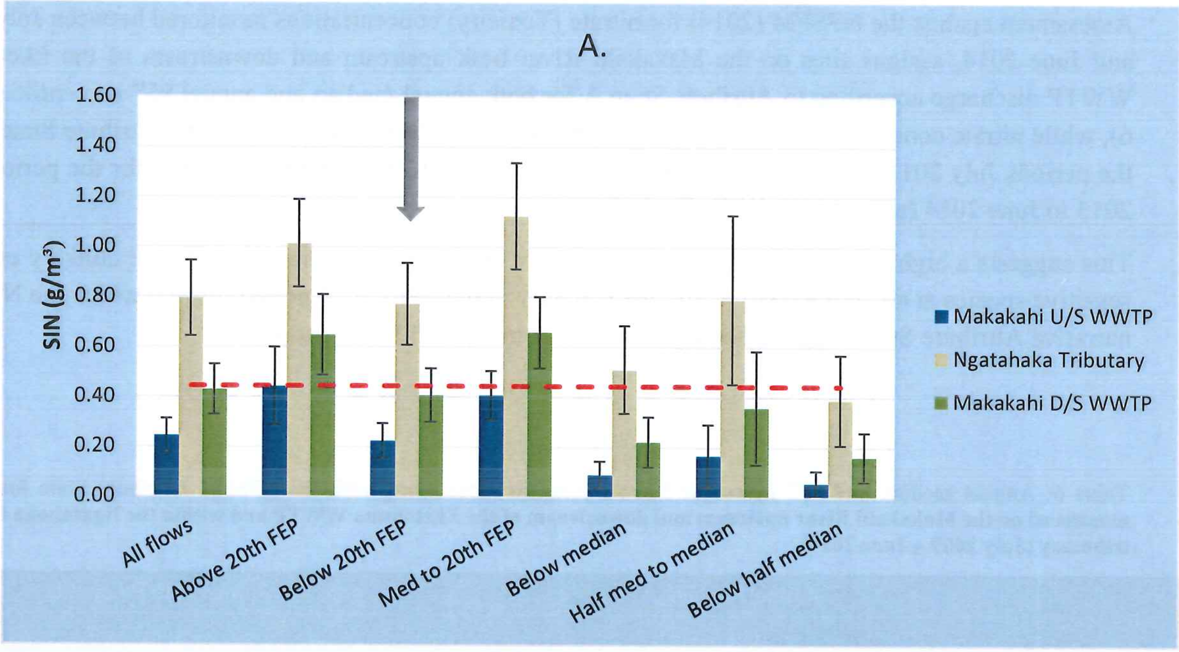
	Annual median g/m³						Annual 95th Percentile g/m³					
	Upstream		Ngatahaka		Downstream		Upstream		Ngatahaka		Downstream	
2009 / 2010	0.428	(A)	-	-	0.555	(A)	0.667	(A)	-	-	0.926	(A)
2010 / 2011	0.236	(A)	-	-	0.380	(A)	0.628	(A)	-	-	0.888	(A)
2011 / 2012	0.265	(A)	0.975	(A)	0.570	(A)	0.608	(A)	1.485	(A)	0.924	(A)
2012 / 2013	0.103	(A)	0.698	(A)	0.270	(A)	0.522	(A)	1.304	(A)	0.751	(A)
2013 / 2014	0.243	(A)	1.106	(B)	0.560	(A)	0.634	(A)	1.548	(B)	0.963	(A)
Overall	**0.236**	**(A)**	**0.887**	**(A)**	**0.481**	**(A)**	**0.644**	**(A)**	**1.445**	**(A)**	**0.940**	**(A)**

3.1.3. Soluble Inorganic Nitrogen (SIN)

Concentrations of Soluble Inorganic Nitrogen (SIN) at flows below the 20th FEP both upstream and downstream of the WWTP were below the One Plan and current consent SIN target (i.e. an annual average concentration of 0.444 g/m³ at flows below the 20th FEP). The Ngatahaka Stream largely exceeded the SIN target (Figure 6A & B).

SIN concentrations were significantly higher downstream than upstream of the discharge point before the influence of the Ngatahaka Creek tributary was removed, at all flows except those above 20th FEP (Figure 3A).

As was observed for nitrate nitrogen, the Ngatahaka Creek presented the highest SIN concentrations of all three sites, and no significant differences were found between upstream and downstream sites within any flow bins once the inputs from the Ngatahaka Stream were subtracted from the Makakahi downstream site (Figure 6B). This indicates that the inputs from the Ngatahaka Stream are likely to be the key driver of the SIN concentration increases measured between the Makakahi upstream and downstream sites. This result was reflected in daily loads of SIN presented in Appendix B.



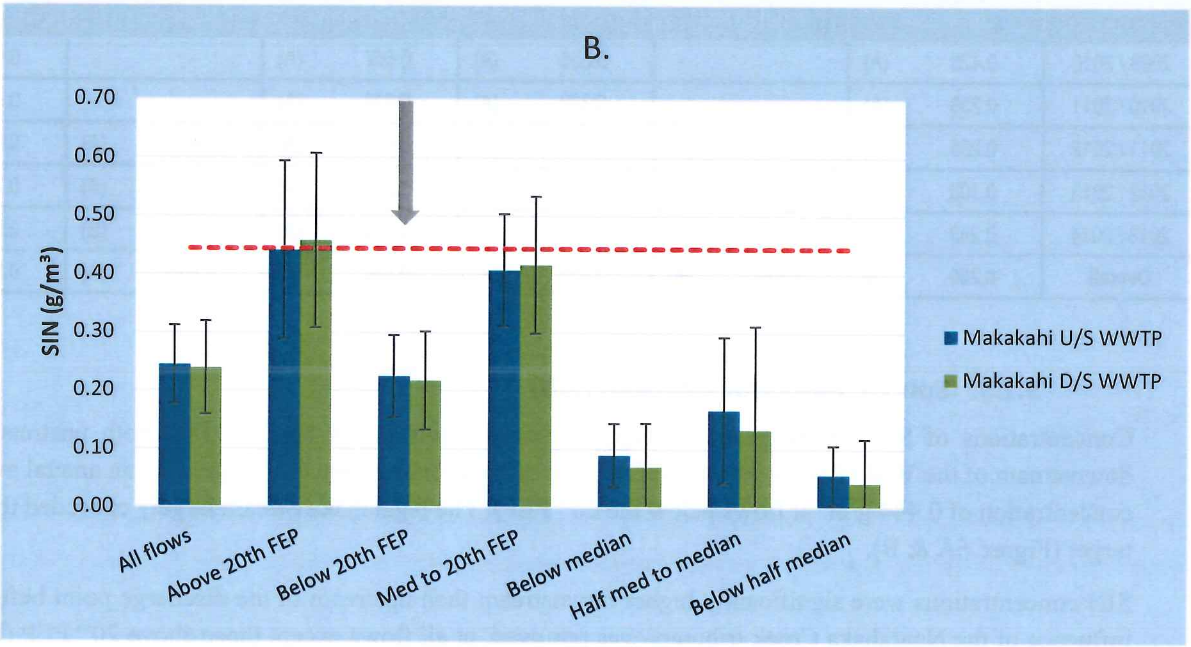


Figure 6: A. Mean Soluble Inorganic Nitrogen (SIN) for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (October 2010 – May 2014) within various river flow 'bins'. B. Upstream and theoretical downstream mean SIN concentrations (October 2010 – May 2014). The One Plan target for SIN is represented as a dashed red line. The grey arrow points to the flow bin defined in the One Plan target.

3.1.4. Dissolved Reactive Phosphorus (DRP)

The One Plan and Consent DRP target (i.e. an annual average concentration of 0.010 g/m^3 at flows below the 20^{th} FEP) at sites upstream and downstream of the discharge was met at all three sites (Figure 7A).

Concentrations of DRP were significantly different upstream to downstream of the discharge within five of the six flow bins: All flows, Below 20^{th} FEP, Median to 20^{th} FEP, Below median and Below half median (Figure 4A). The greatest concentration increases between upstream and downstream were measured under low river flow conditions (Below half median flow).

Once the daily DRP inputs from the Ngatahaka Creek were removed from the Makakahi downstream loads/concentrations, only two of the six significant differences remained between upstream and downstream sites within any of the flow bins. This indicates that inputs from the Ngatahaka Creek are a likely contributor to the concentration increases measured at the downstream site, but it also indicates that the discharge also contributes to the measured DRP concentration increase during periods of low flows (Figure 7B).

Average DRP concentrations in the Ngatahaka Creek were higher than at the Makakahi upstream site in all flow bins, which is another indication that inputs from the Ngatahaka Creek are likely to increase DRP concentrations in the Makakahi River. However, average concentrations in the Ngatahaka Creek at flows below half median were lower than in the Makakahi at the downstream site, indicating that inputs from the Ngatahaka Creek are unlikely to be the sole cause of the concentrations increase in the Makakahi River, at least under low river flow conditions.

The pattern (described above) of increasing concentrations at low river flows is consistent with inputs from a point source discharge, and it seems likely that the discharge also contributes to the measured DRP concentration increase, particularly during times of low river flow.

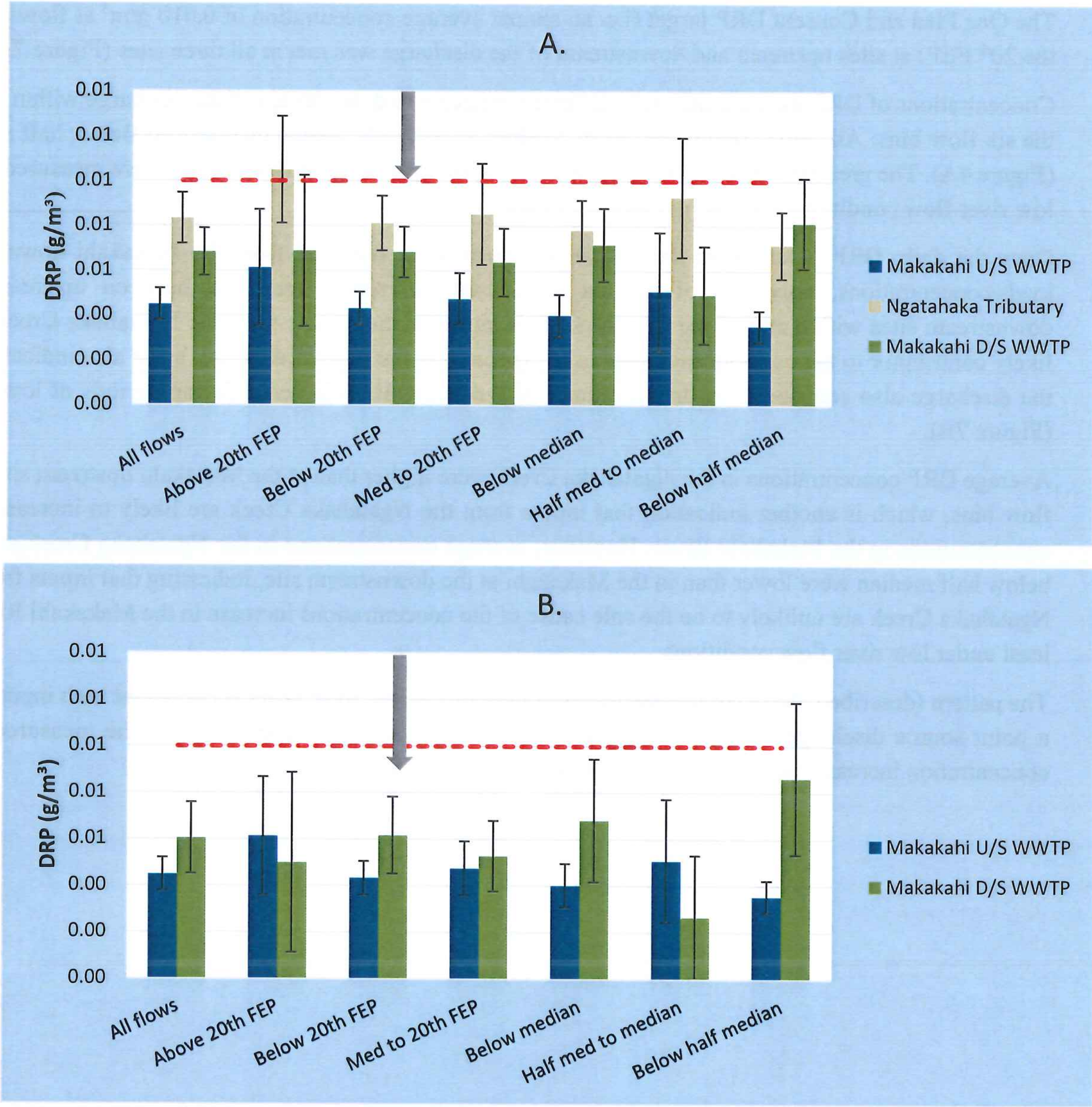


Figure 7: Mean Dissolved Reactive Phosphorus (DRP) for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (October 2010 – May 2014) at various flows. B. Upstream and theoretical downstream mean DRP concentrations (October 2010 – May 2014). The One Plan target for DRP is represented as a dashed red line. The grey arrow points to the flow bin defined in the One Plan target.

3.1.5. Nutrient ratios and nutrient limitation

The ratio of SIN to DRP can provide useful indications of when one nutrient occurs in excess of the other when considering periphyton's nutrient needs. Plants generally utilise nitrogen and phosphorus at a mass ratio of about 7:1. It is generally considered that when the ratio of SIN to DRP in river water exceeds 15, then phosphorus may become the limiting nutrient. Conversely, when the ratio is below 7, nitrogen becomes the most limiting nutrient[1]. At ratios between 7 and 15, co-limitation occurs where both nutrients may limit plant growth.

The analysis indicates that the Makakahi upstream site is mostly nitrogen-limited at low flows, with a shift towards co-limited an then P-limited conditions as river flows increase (Figure 8). This is a common pattern observed at several other Manawatu Catchment sites. Nutrient ratios at the downstream site indicate that there is a general disappearance of strongly N-limited conditions under all but the lowest river flows, and a shift towards co- or P-limited conditions. This is likely to be primarily caused by SIN inputs, which have the net result of increasing SIN/DRP ratios.

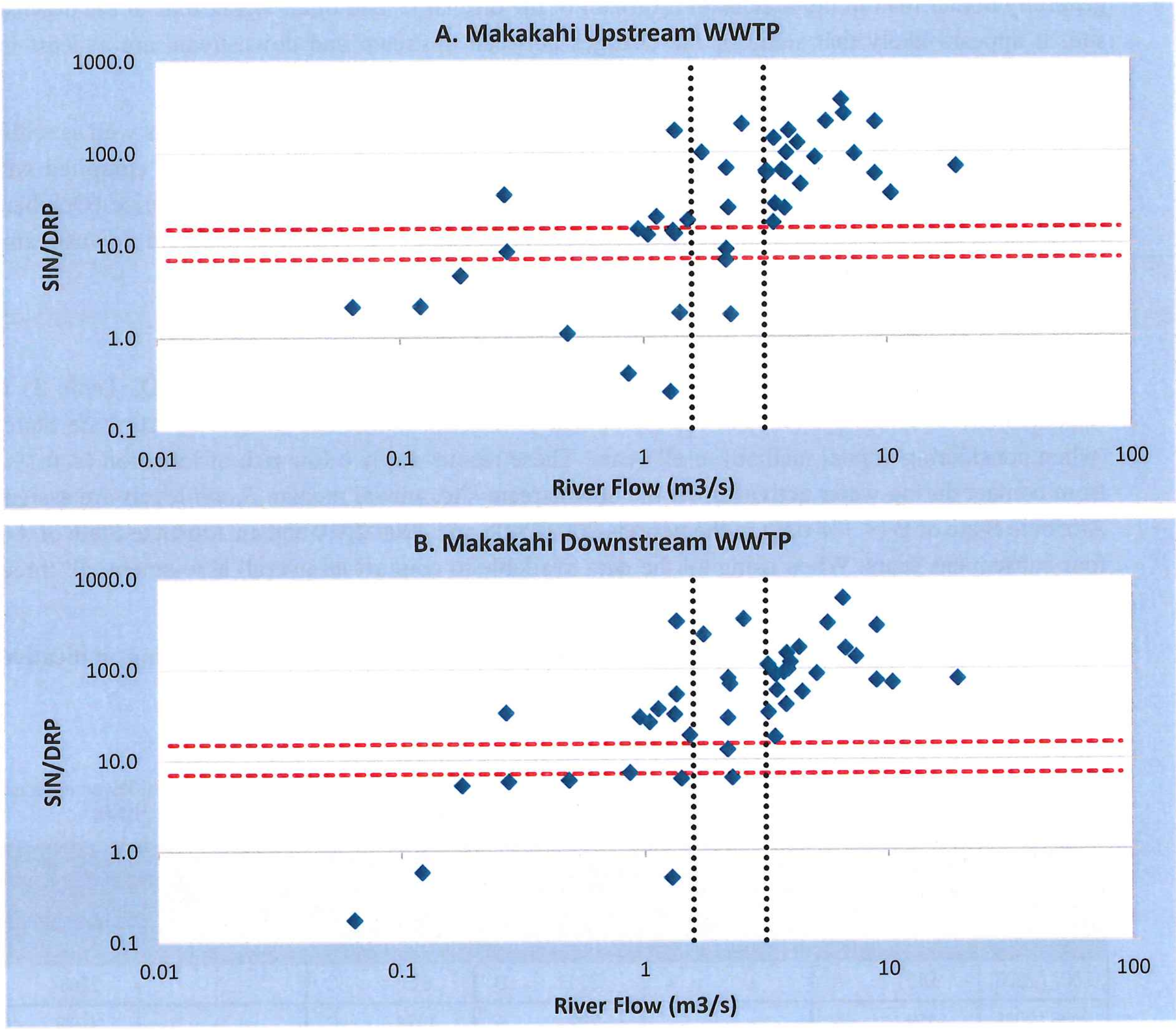


Figure 8: DIN: DRP ratios in the Makakahi upstream (A.) and downstream (B.) of the Eketahuna WWTP discharge at different river flows as measured at the Makakahi at Hamua flow recorder. Vertical dotted lines represent the half median and median flows at the Makakahi at Hamua flow recorder.

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[1] McDowell, R. W., S. T. Larned and D. J. Houlbrooke (2009). "Nitrogen and phosphorus in New Zealand streams and rivers: control and impact of eutrophication and the influence of land management." New Zealand Journal of Marine and Freshwater Research **43**(4): 985-999.

3.1.6. *E. coli*

The One Plan defines two *E. coli* concentration targets: 260 *E. coli*/100mL at flows below median flow during the main bathing season and 550 *E. coli*/100mL at flows below the 20th exceedance percentile year-round.

E. coli concentrations within summer months (1 November – 30 April), without taking into account the effects of the concentrations within the tributary, met the One Plan limit of 260/100mL 68% of the time upstream and 58% of the time at the downstream site within the sampling period at flows below 50th FEP (47% compliance at the tributary site). It is noted that *E.coli* concentrations in the Ngatahaka Creek were generally higher than in the Makakahi upstream of the discharge, and often higher than at the downstream site. It appears likely that some of the changes between upstream and downstream are at least in part attributable to inputs from the Ngatahaka Creek.

At flows below the 20th FEP, sites upstream and downstream of the WWTP discharge as well as within the Ngatahaka Creek had average concentrations under the 550 *E.coli*/100mL limit, and complied with the target 93%, 90% and 85% (U/S, D/S and Tributary, respectively) during the sampling period (October 2010 – May 2014) (Figure 9). There were no significant differences between upstream and downstream sites within any of the flow bins.

3.1.6.1. Assessment against NPSFM 2014

Assessment against the NPSFM (2014) for *E.coli* concentrations (refer Appendix D, Table 3) in the Makakahi River at the upstream of the Eketahuna WWTP discharge site assigns an Attribute State of A (when considering annual median) in all years. These results imply a low risk of infection (< 0.1% risk) from contact during water activities. At the downstream site, annual median *E.coli* levels are assigned an Attribute State of B (< 1% risk) in the periods 2007/2008 and 2009/2010 and an Attribute State of A in the four subsequent years. When using all the data available to conduct an overall assessment, all three sites receive an A grading.

When considering 95th percentile however, all three sites receive an overall C grading, indicative of a moderate to high risk of infection from contact during water activities.

Table 7: Annual median and 95th percentile *E. coli* concentrations for sites monitored on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (July 2007 – June 2014).

	Annual median g/m³						Annual 95th Percentile g/m³					
	Upstream		Tributary		Downstream		Upstream		Tributary		Downstream	
2007 / 2008	215	A	-	-	300	B	613	C	-	-	2248	C
2008 / 2009	159	A	-	-	239	A	1426	C	-	-	12278	C
2009 / 2010	235	A	-	-	288	B	691	C	-	-	709	C
2010 / 2011	179	A	-	-	198	A	942	C	-	-	1500	C
2011 / 2012	123	A	245	A	165	A	3289	C	11757	C	6952	C
2012 / 2013	124	A	166	A	126	A	663	C	1051	C	666	C
2013 / 2014	206	A	361	B	259	A	455	B	2267	C	1334	C
Overall	**165**	**A**	**244**	**A**	**231**	**A**	**862**	**C**	**1948**	**C**	**1919**	**C**

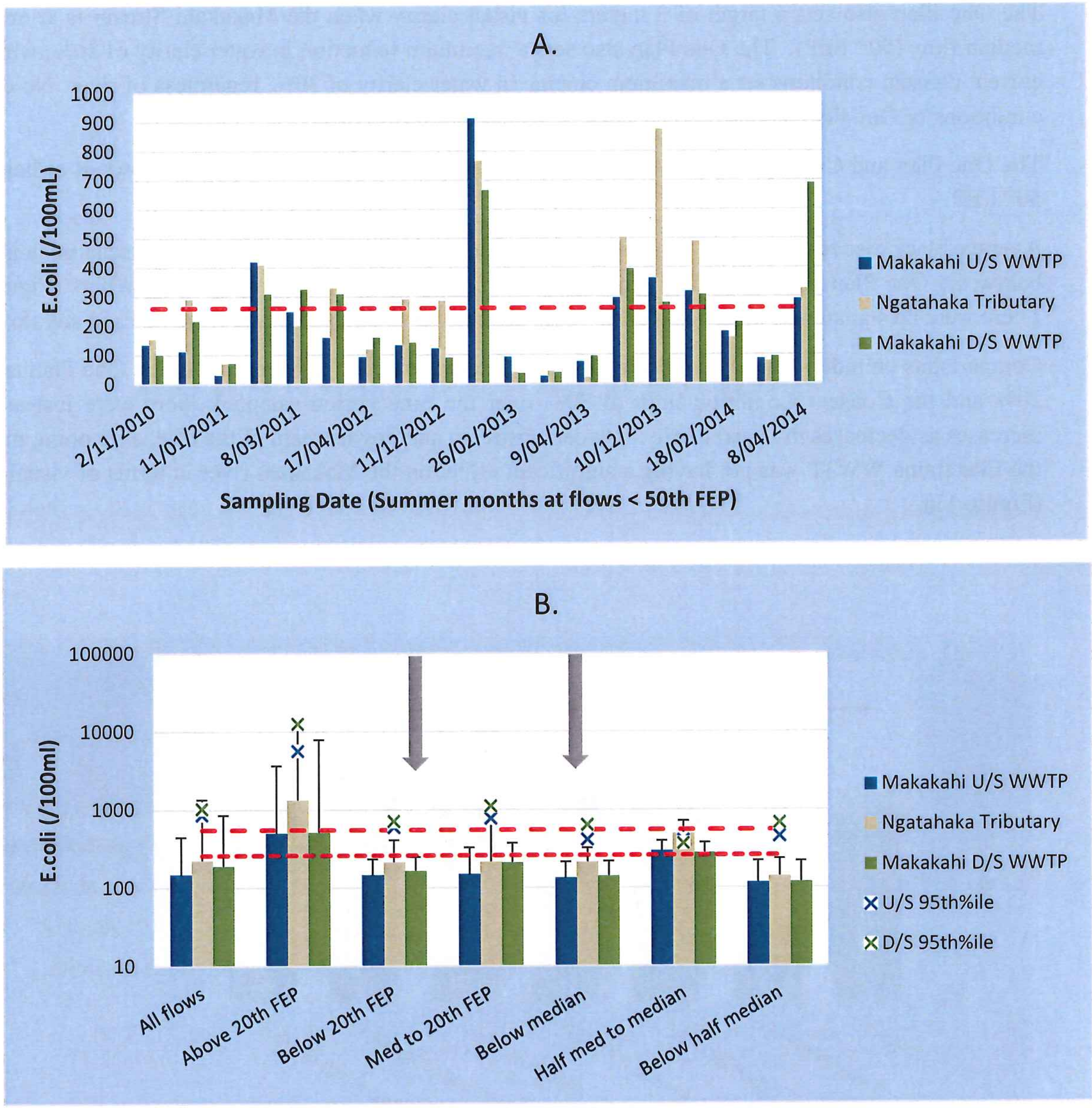


Figure 9: A. Daily E.coli concentrations at or below median flow during summer months & B. Median (bars) and 95th percentile (crosses) *E. coli* concentrations at sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (October 2010 – May 2014) at various flows. One Plan targets for E. coli are represented as dashed and dotted red lines. The grey arrows point to the flow bins defined in the One Plan targets.

3.1.7. Black Disk, Total suspended solids and Particulate organic matter:

The One Plan also sets a target of 3 meters for visual clarity when the Makakahi Stream is at or below median flow (50th FEP). The One Plan also sets a maximum reduction in water clarity of 20%, whilst the current consent conditons set a maximum change in water clarity of 30%, regardless of river. No consent conditions or One Plan targets refer to Total Suspended Solids (TSS).

The One Plan and Consent limit for Particulate Organic Matter (POM) is 5 g/m³ at flows at or below the 50th FEP.

Average black disc readings both upstream and downstream of the Eketahuna WWTP discharge point were below the One Plan and Consent target of 3 m minimum visual clarity within all flow bins (Figure 10). There were no statistically significant differences between upstream and downstream sites in any flow bins.

Comparisons on individual days indicate that while there were changes in excess of the One Plan target of 20% and the Consent Condition limit of 30% over the time period sampled, there were just as many increases as decreases in visual clarity between upstream and downstream of the discharge point, meaning the Eketahuna WWTP was not having a significant effect on the Makakahi river in terms of visual clarity (Figure 11).

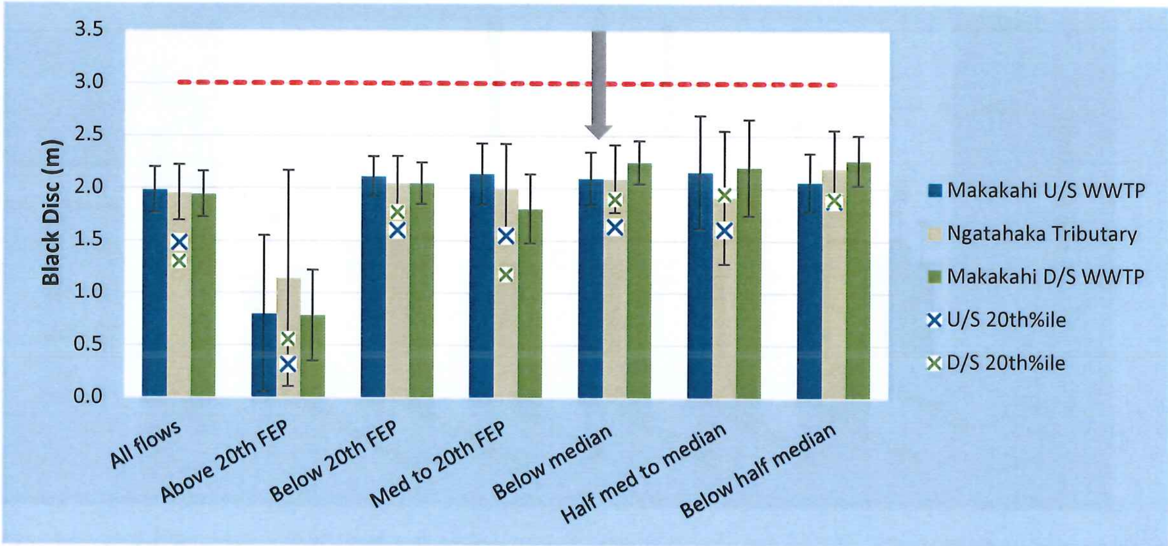


Figure 10: Mean (bars) and 95th percentile (crosses) black disk readings for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (October 2010 – May 2014) at various flows. The One Plan target for Black disk is represented as a dashed red line. The grey arrow points to the flow bin defined in the One Plan target.

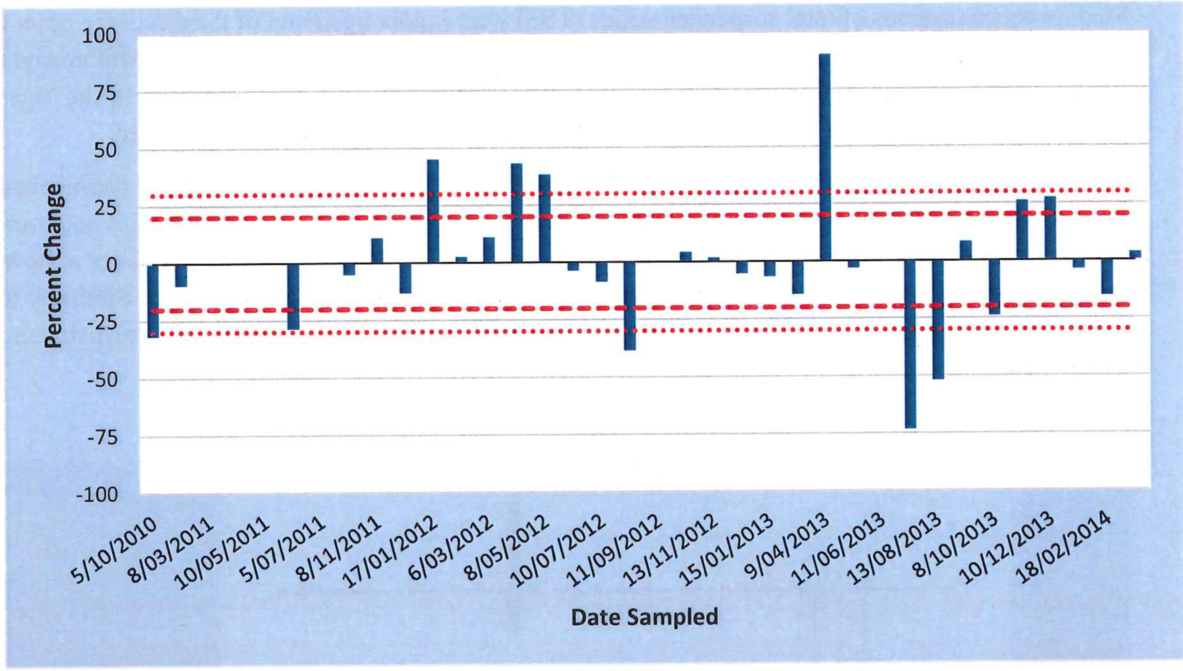


Figure 11: Percent change in visual clarity measured with a black disc between upstream and downstream of the Eketahuna WWTP discharge point into the Makakahi River sampled between October 2010 and May 2014. Dashed red lines indicate a change of 20 percent (One Plan & Consent limit).

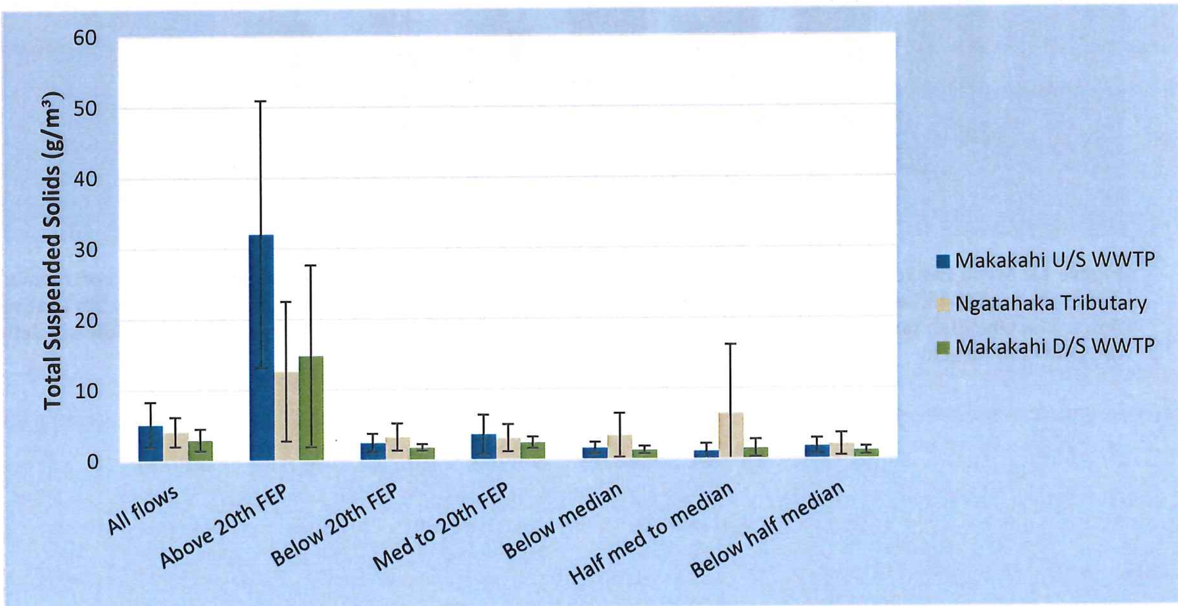


Figure 12: Mean Total Suspended Solids (TSS) concentrations for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (October 2010 – May 2014) at various flows.

Median concentrations of total suspended solids (TSS) were higher upstream of the discharge point than at the downstream site for all flow bins except half median to median flows (Figure 12), with no significant differences in concentrations between sites. It is also of note that TSS concentrations in the Ngatahaka Stream were higher than at either Makakahi River sites in four of the flow bins considered.

Comparisons of Particulate Organic Matter (POM) concentrations between upstream and downstream sites showed slightly higher concentrations upstream than downstream of the discharge point and were well under the target required by both Consent conditions and the One Plan of 5 g/m³ at both sites at flows at or below the 50th FEP (Figure 13). No significant differences were observed between sites. Similarly to TSS, mean POM concentrations in the Ngatahaka Creek were higher than in the Makakahi downstream site in all flow bins.

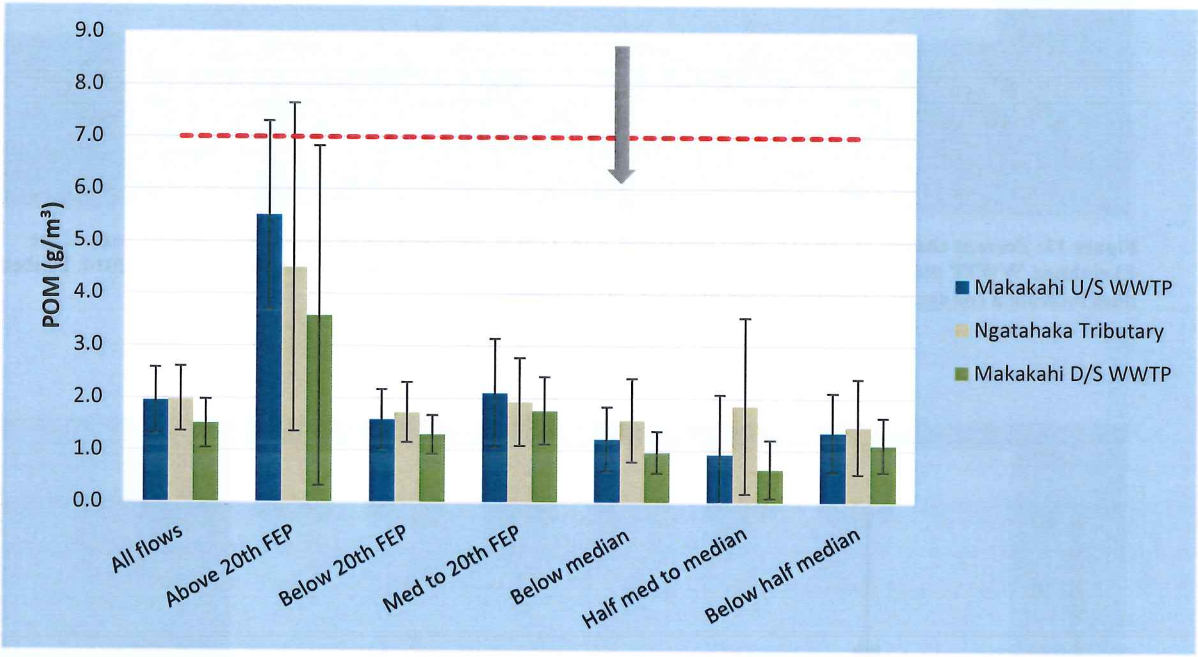


Figure 13: Mean Particulate Organic Matter (POM) concentrations at for sites on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (October 2010 – May 2014) at various flows. The One Plan target for POM is represented as a dashed red line. The grey arrow points to the flow bin defined in the One Plan target.

3.1.8. pH, Temperature, $sCBOD_5$ and Dissolved Oxygen:

Both the One Plan and Consent states that the pH must be within the range of 7 to 8.5 and not be changed by more than 0.5.

Consent Condition 11(j) states that the temperature shall not exceed 19°C between the 1st October and the 30th April or 11°C between the 1st May and the 30th September, while the One Plan requires that the temperature of the Makakahi River not exceed 19°C at any time during the sampling period. Both require that the temperature does not change by more than 3°C.

Both the Consent and One Plan require that concentrations of $sCBOD_5$ do not exceed 1.5 g/m^3 when the Makakahi River is at or below the 20th FEP.

Consent Condition 11(m) and Horizons One Plan require that Dissolved Oxygen (DO) concentrations exceed 80 %.

Water pH levels fell within ranges required by the Consent and Horizons One Plan (Figure 14) and no significant differences were observed between upstream and downstream of the discharge.

Water temperature in the Makakahi River remained low over the monitoring period and complied with the limit set by the One Plan at sites upstream and downstream of the Eketahuna WWTP (Figure 15). No significant differences were observed between upstream and downstream sites for all flow bins.

The Consent limit of 19°C during Summer months (1st October to 30th April) was complied with 93% of the time at the upstream site and 86% at the downstream site (Figure 16A). The limit of 11°C during winter months (1st May to 30th November) was complied with 88% of the time at both the upstream and downstream sites (Figure 16B).

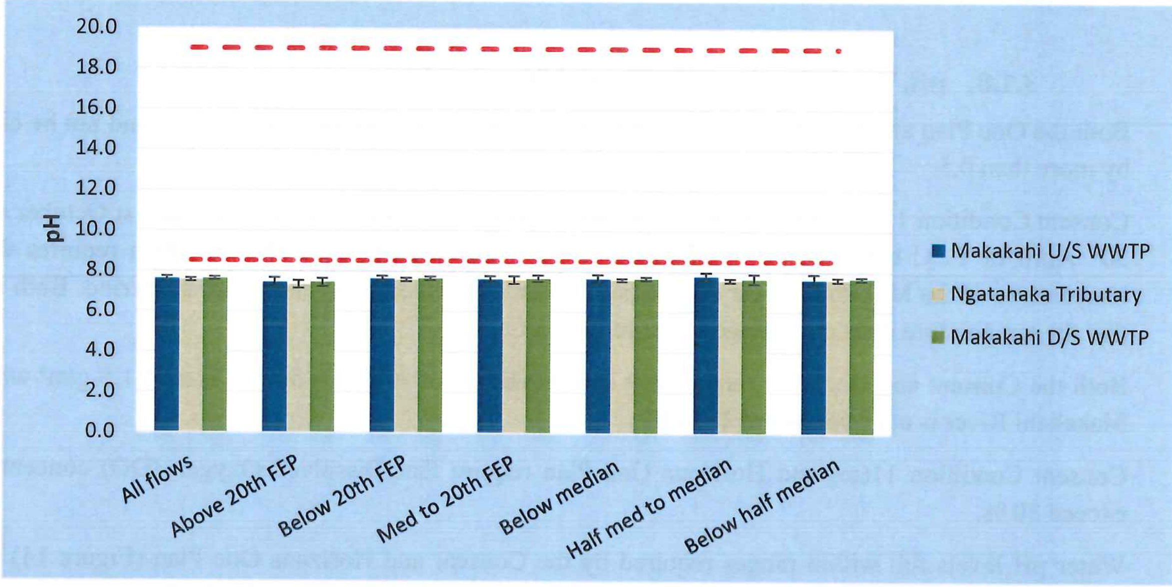


Figure 14: Mean pH for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (October 2010 – May 2014) at various flows. The One Plan recommended target range for pH is represented as a dashed red line.

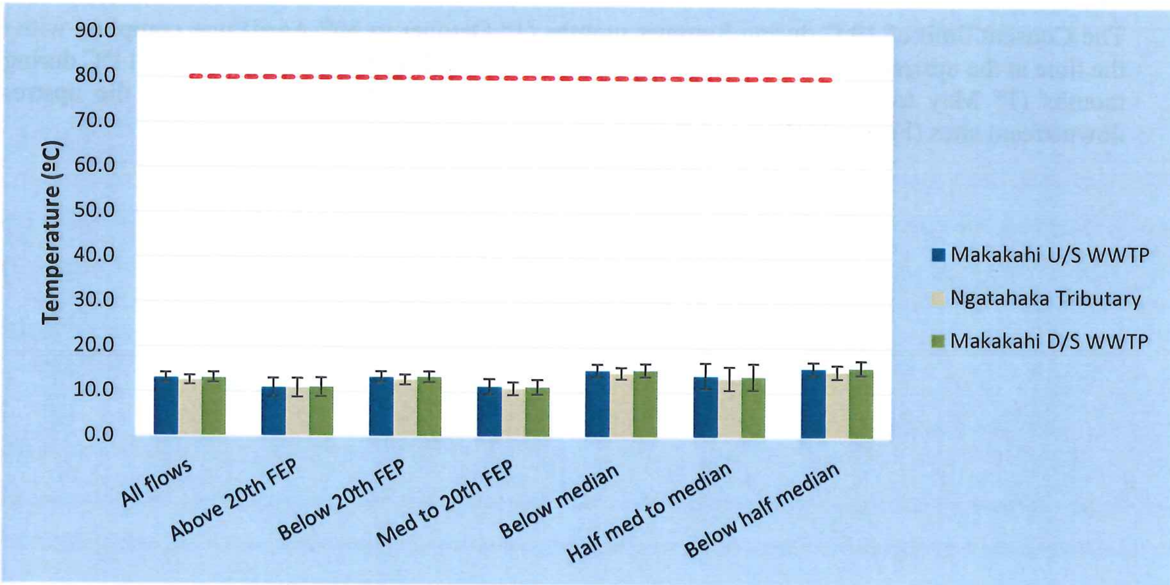


Figure 15: Mean Temperature for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (October 2010 – May 2014) at various flows. Temperature target (as per consent conditions and the One Plan) is represented as a dashed red line.

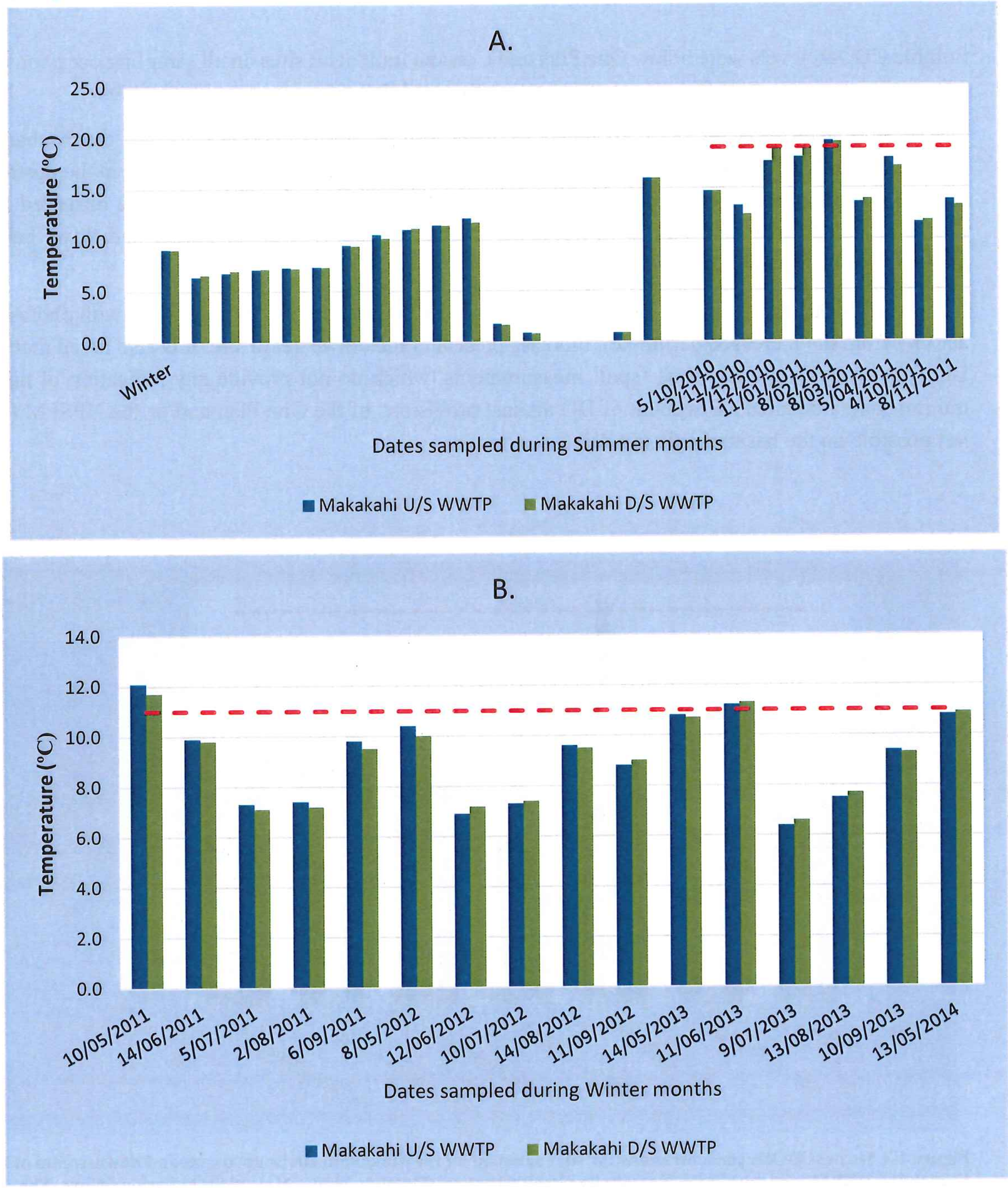


Figure 16: Daily temperature readings for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP during summer months (A) and winter months (B) (October 2010 – May 2014) at various flows. Temperature target (as per Consent Condition) is represented as a dashed red line.

Soluble $CBOD_5$ levels were below One Plan and Consent limit at all sites on all sampling occasions (Figure 13), with no significant differences between upstream and downstream sites (Figure 17).

Dissolved oxygen concentrations exceeded 80% at sites upstream and downstream of the discharge from the Eketahuna WWTP, complying with Consent and One Plan targets; 91% compliance at the upstream site & 98% compliance at the downstream site (Figure 18). Significant differences were observed between upstream and downstream sites at flows below median (higher DO downstream) and flows below half median (higher DO downstream).

It is plausible that the measured day-time increases in DO saturation may be associated with photosynthetic activity from the increased periphyton biomass present at the downstream site. It is also noted that the only DO data available are day-time 'spot' measurements, which do not provide any indication of night-time minima, and a detailed assessment of DO against provisions of the One Plan and/or the NPSFM (2014) is not possible on the basis of existing data.

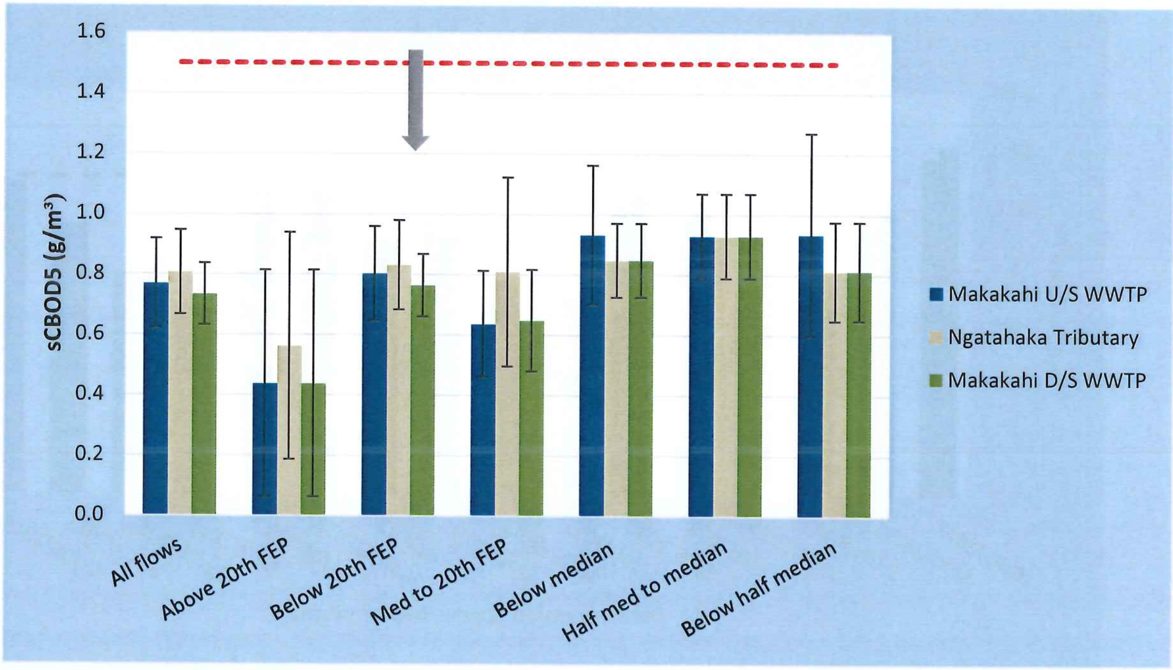


Figure 17: Mean $sCBOD_5$ concentrations for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (October 2010 – May 2014) at various flows. The recommended target for sCBOD5 (as per consent conditions and The One Plan) is represented as a dashed red line. The grey arrow points to the flow bin defined in the One Plan target.

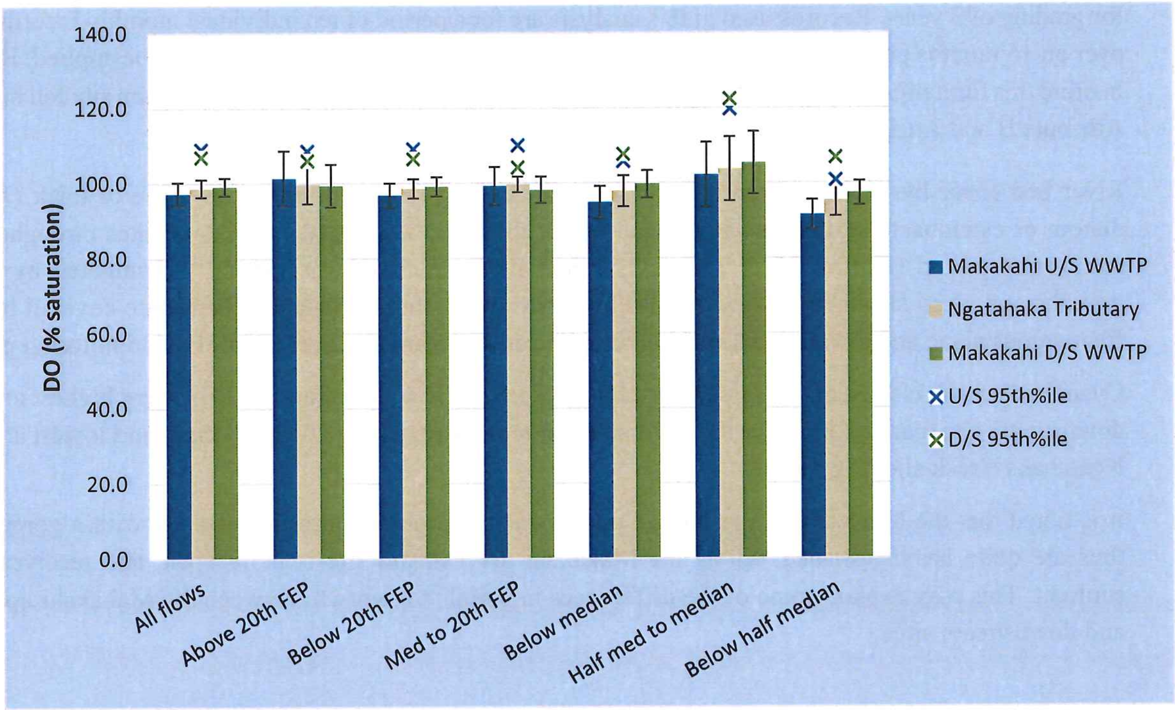


Figure 18: Mean (bars) and 95th percentile (crosses) DO (% saturation) for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek (October 2010 – May 2014) tributary at various flows. The recommended target for DO (% saturation) (as per consent conditions and One Plan) is represented as a dashed red line.

3.2. Effects on river ecology

3.2.1. Periphyton Communities

Mean periphyton biomass, measured as Chlorophyll *a*, and visual estimates of periphyton cover were measured in 2013 and 2014. Results are presented in Figure 19 to Figure 22 and Table 8.

Periphyton biomass increased between upstream and downstream sites on seven out of ten sampling occasions between February 2013 and May 2014 (Figure 19). Chlorophyll *a* concentrations were below the Consent and One Plan target (120 mg/m^2) on all sampling occasions at the upstream site, and exceeded the target at the downstream site on one occasion (151 mg/m^2 in May 2014) and on two occasions within the Ngatahaka Creek (131 mg/m^2 in July 2013 & 130 mg/m^2 in May 2014).

Overall compliance with the One Plan biomass target should generally be undertaken at 95th percentile level, meaning that up to one exceedance per 12 consecutive monthly samples is within the One Plan target (Ausseil and Clark, 2007). On that basis, all three sites meet the One Plan target for periphyton biomass.

The NPSFM (2014) defines attribute states for periphyton (Trophic State). It is our understanding that the Makakahi River is classified in the Default Class (as per the footnote to Appendix D, Table 4). The NPSFM Attribute State thresholds for periphyton are based on monthly monitoring, with a minimum record length for grading of 3 years. Records used in this analysis are for a period of ten individual monthly records taken over an 15 months period, and consequently only a partial, or preliminary, grading can be applied. Bearing in mind this limitation, the upstream site fell within Attribute State A while the downstream site fell between Attribute B and Attribute State C.

River bed cover by "nuisance" periphyton growth, i.e. long (>2cm) filamentous algae or thick (>3mm) diatom or cyanobacteria mats remained well below the One Plan targets at all three sites throughout the monitoring period (Figures 20 & Figure 22). Bed substrate cover was generally dominated by "film" growths and clean substrate (Figure 21, Table 8). However, the percentage of substrate covered by long filamentous algae and diatom mats was higher at the downstream site over most of the monitoring period.

Cyanobacteria levels visually assessed between February 2013 and September 2014 were highest at the downstream site, particularly over the 2014 summer months (reaching 20% coverage) and lowest at the Ngatahaka Creek site (Figure 21).

It is noted that the Makakahi upstream and the Ngatahaka Creek monitoring sites are within gorges, and thus are quite heavily shaded, whilst the Makakahi downstream site is more open, and receives more sunlight. This may explain some of the differences in periphyton growth between the Makakahi upstream and downstream sites.

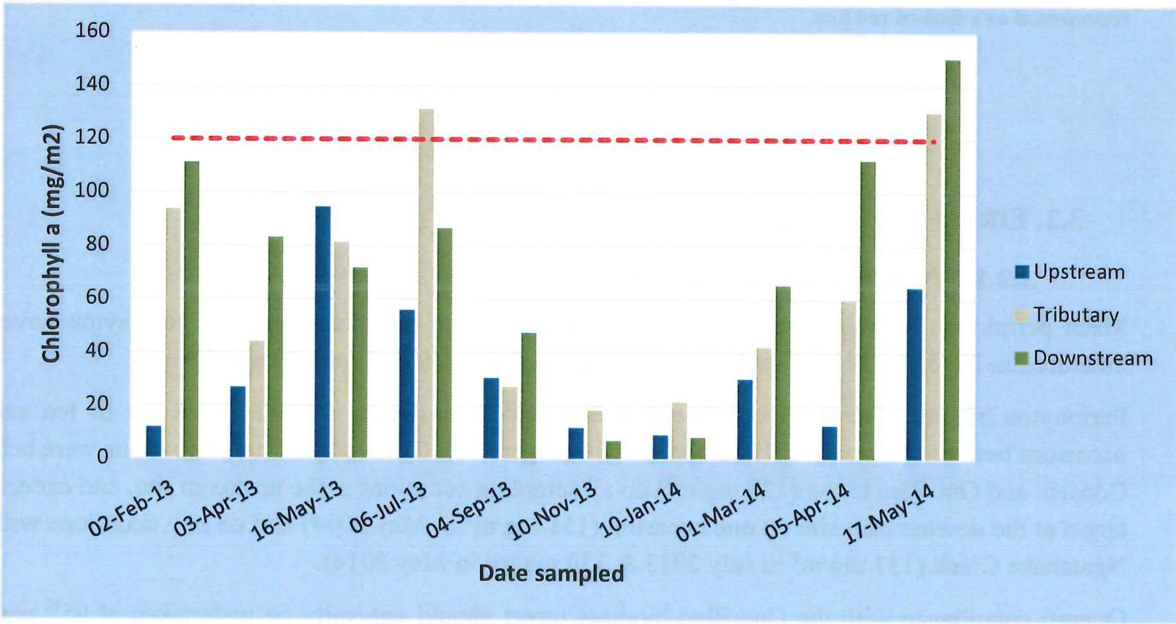
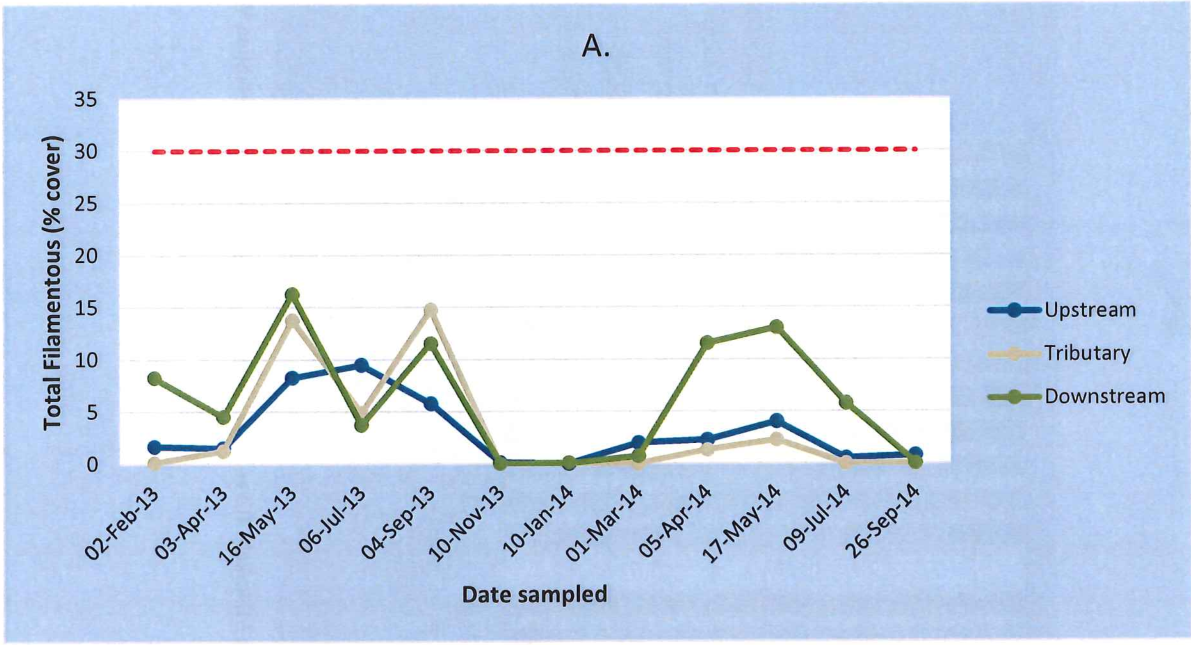


Figure 19: Mean periphyton biomass, measured as Chlorophyll a (mg/m2), for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary between 2013 and 2014. The One Plan target of 120 mg /m2 is represented as a dashed red line.



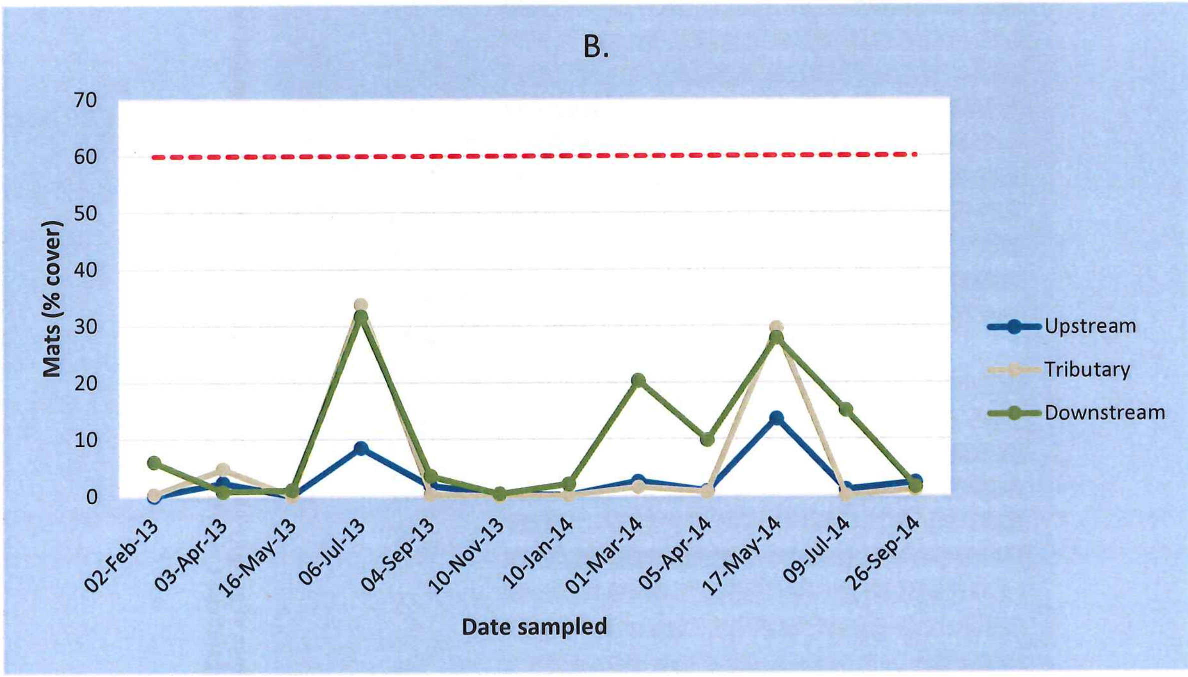


Figure 20: Percentage of substrate cover by A. Total filamentous algae cover and B. Mats, for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary between 2013 and 2014. The One Plan targets are presented as dashed red lines.

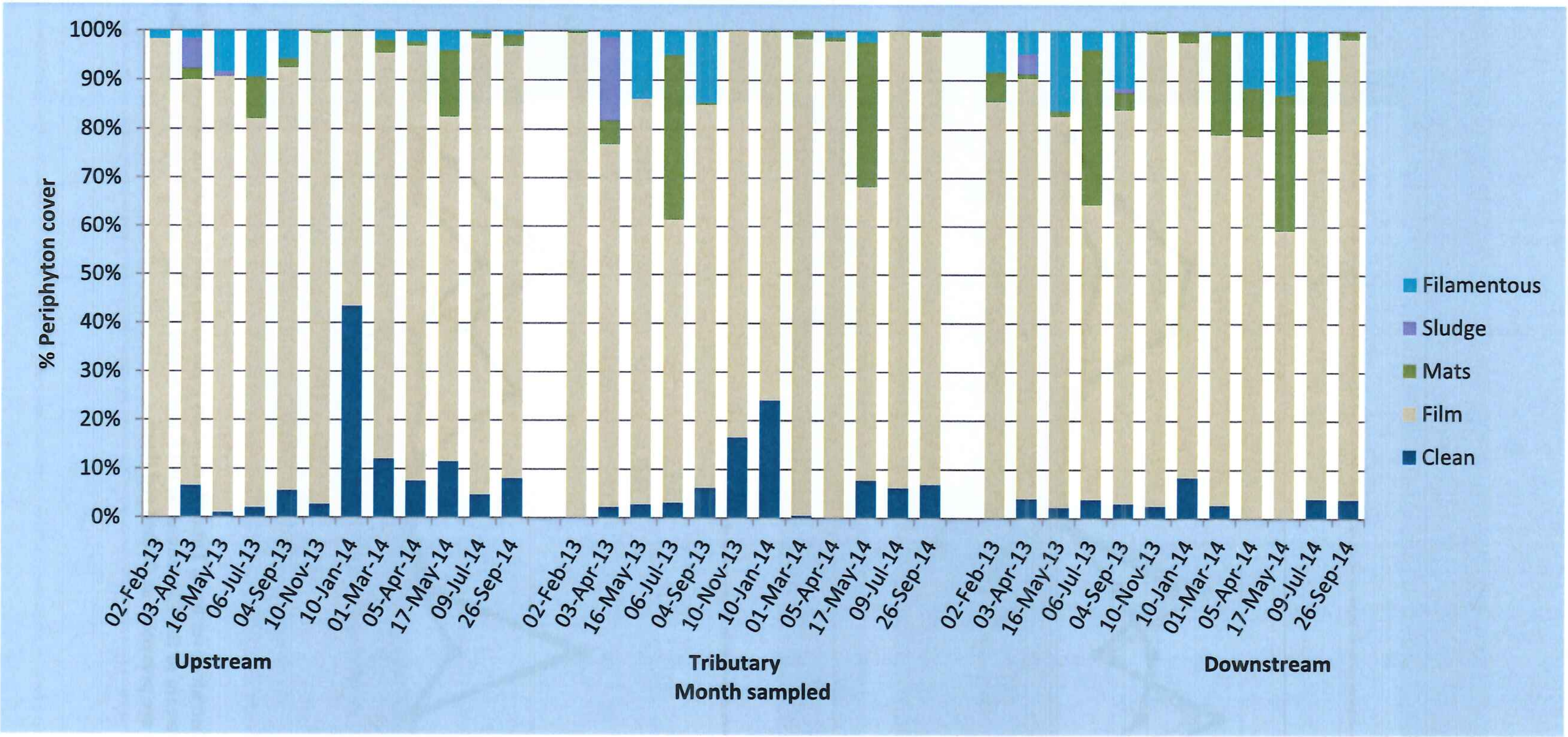


Figure 21: Relative abundance of periphyton communities visually assessed at sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP discharge and within the Ngatahaka Creek tributary between 2013 and 2014.

Table 8: Mean periphyton biomass, measured as Chlorophyll *a* (mg/m^2), and % periphyton cover visually assessed for sites sampled on the Makakahi River upstream (U/S) and downstream (D/S) of the Eketahuna WWTP and within the Ngatahaka Creek tributary (Trib) between 2013 and 2014.

Date Sampled	Chlorophyll *a* (mg/m^2)			% Clean			% Film			% Sludge			% Mats			% Filam -Slimy			% Filam - Course			% Filam - Total		
	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S
Feb-13	11.8	93.7	111.2	0	0	0	98.4	99.7	85.8	0	0	0	0	0.3	6.0	1.7	0.1	6.3	0	0	2.0	1.7	0.1	8.3
Apr-13	26.8	44.1	83.2	6.5	2.3	4.0	83.5	74.8	86.5	6.3	17.0	4.3	2.3	4.8	0.8	0.8	1.0	2.5	0.8	0.3	2.0	1.5	1.3	4.5
May-13	94.6	81.3	71.8	1.0	2.8	2.3	89.8	83.5	80.5	1.0	0	0	0	0	1.0	8.3	13.8	16.3	0	0	0	8.3	13.8	16.3
Jul-13	55.8	131.3	86.6	2.1	3.1	3.9	80.1	58.3	60.8	0	0	0.0	8.5	33.8	31.7	9.5	4.9	3.7	0	0	0	9.5	4.9	3.7
Sep-13	30.4	27.2	47.5	5.5	6.3	3.0	87.0	78.8	81.0	0	0	1.0	1.8	0.3	3.5	5.8	14.8	11.3	0	0	0.3	5.8	14.8	11.5
Nov-13	11.8	18.4	7.1	2.7	16.5	2.6	96.9	83.5	97.1	0	0	0	0.4	0	0.4	0	0	0	0.1	0	0	0.1	0	0
Jan-14	9.2	21.7	8.3	43.4	24.1	8.4	56.5	75.8	89.5	0	0	0	0.1	0.1	2.1	0	0.1	0	0	0	0.1	0	0.1	0.1
Mar-14	30.2	42.3	65.4	12.1	0.5	2.7	83.5	98.0	76.4	0	0	0	2.5	1.5	20.3	2.0	0	0.6	0	0	0.1	2.0	0.0	0.7
Apr-14	12.8	59.9	112.3	7.5	0	0	89.5	98.1	78.8	0	0	0	0.8	0.7	9.8	2.3	1.3	11.5	0	0	0	2.3	1.3	11.5
May-14	64.6	130.5	150.6	11.5	7.8	0	71.0	60.5	59.3	0	0	0	13.5	29.5	27.8	4.0	2.3	13.0	0	0	0	4.0	2.3	13.0
Jul-14	-	-	-	4.8	6.3	4.0	93.8	93.8	75.3	0	0	0	1.0	0	15.0	0	0	5.8	0.5	0	0	0.5	0	5.8
Sep-14	-	-	-	8.1	6.9	3.9	88.9	92.2	94.7	0	0	0	2.3	1.0	1.5	0.8	0	0	0	0	0	0.8	0	0

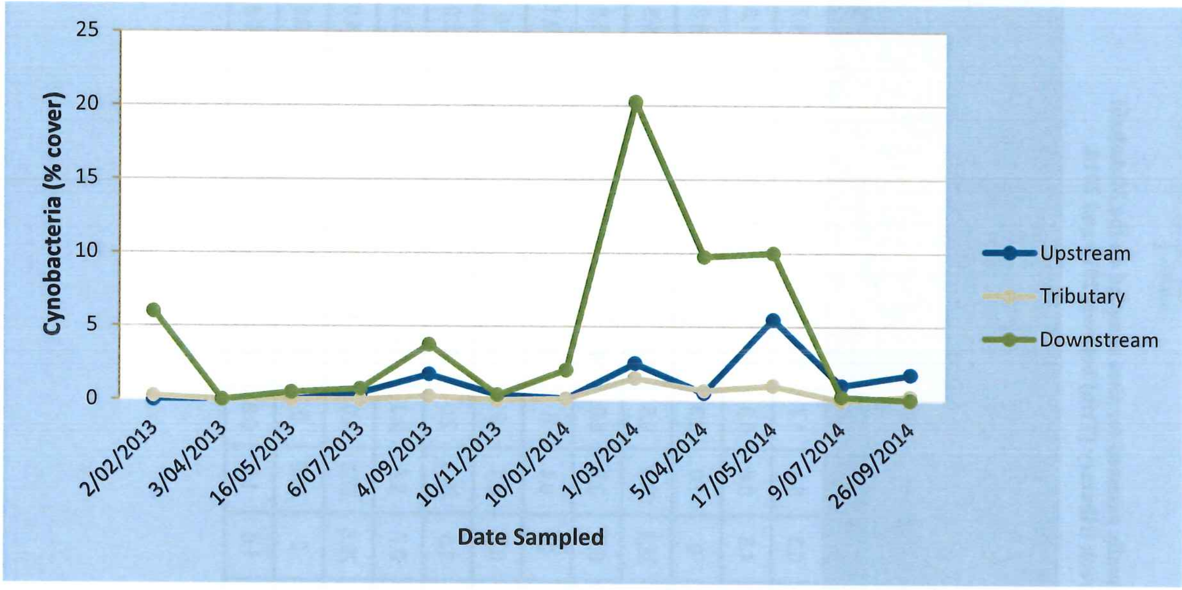


Figure 22: Percentage of substrate cover by Cyanobacteria, for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary between 2013 and 2014.

3.2.2. Macroinvertebrate Communities

Macroinvertebrate samples were collected in 2013 and 2014 during summer months. Biotic index scores for sites sampled on the Makakahi River in 2013 and 2014 are presented in Figure 23 to Figure 25 and Table 9. Relative abundance, and a Non Metric Multidimensional Scaling (NMDS) ordination on macroinvertebrate communities are presented in Figure 26 and Figure 27 respectively.

A higher degree of similarity was seen between the upstream and tributary sites than between either site and the site downstream in terms of macroinvertebrate indices and community composition. At the downstream site, greater numbers of Chironomids were found (in particular *Tanytarsini* sp.) and less EPT individuals, resulting in lower MCI and QMCI scores in both 2013 and 2014. At the site upstream of the WWTP discharge and within the Ngatahaka Creek tributary, higher numbers of the relatively sensitive Mayfly *Deleatidium* sp. were observed, particularly in 2014. There were significant differences between sites for Number of Individuals, % EPT Individuals and QMCI (Figure 23 to Figure 25).

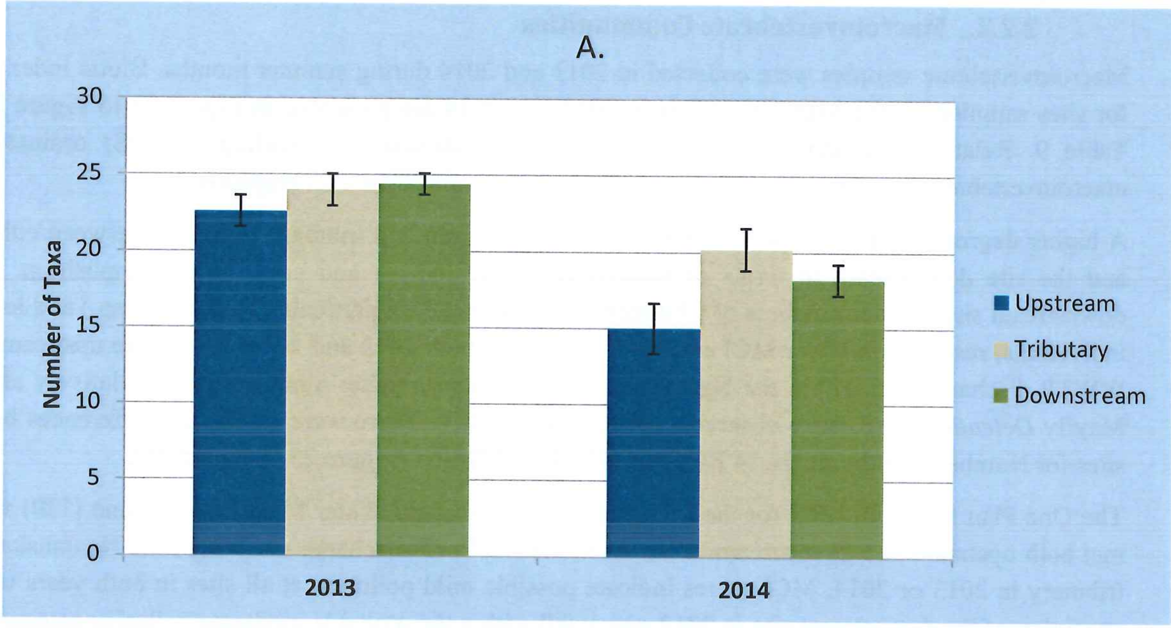
The One Plan target for MCI for the Mangatainoka - Makakahi Water Management Zone (120) was not met both upstream and downstream of the Eketahuna WWTP discharge nor within the Ngatahaka Creek tributary in 2013 or 2014. MCI scores indicate possible mild pollution at all sites in both years with the exception of the downstream site in 2013 which fell within the probable moderate pollution category.

No statistically significant differences in MCI scores were found between sites in either year (ANOVA) (Figure 25A & Table 9).

With regards to QMCI, the Consent and One Plan target is of no more than a 20% reduction between upstream and downstream of a point-source discharge. Reductions in QMCI of 20% or more were observed on both sampling occasions (2013: 25% decrease and 2014: 43% decrease) therefore not meeting the One Plan target (Figure 25B & Table 9). Statistically significant differences were found between upstream and downstream sites in both years sampled (ANOVA). These results suggest that the combined inputs from the Ngatahaka River and the discharge are having a significant adverse effect on macroinvertebrate communities at the downstream site. It is noted however, that the decrease in shading at the downstream site and consequential increase in periphyton growth may account for some of the changes. Unfortunately, the relative contribution of the two sources to the level of effect measured cannot easily be estimated.

Similarly, the extent of effects further downstream in the Makakahi River, i.e. whether a measure of recovery occurs, and at what distance, cannot be directly assessed.

A plot of axis 1 against axis 2 from a Non Metric Multidimensional Scaling (NMDS) ordination has a good fit to the data (stress = 0.07) and separates out upstream communities from those downstream (Figure 26).



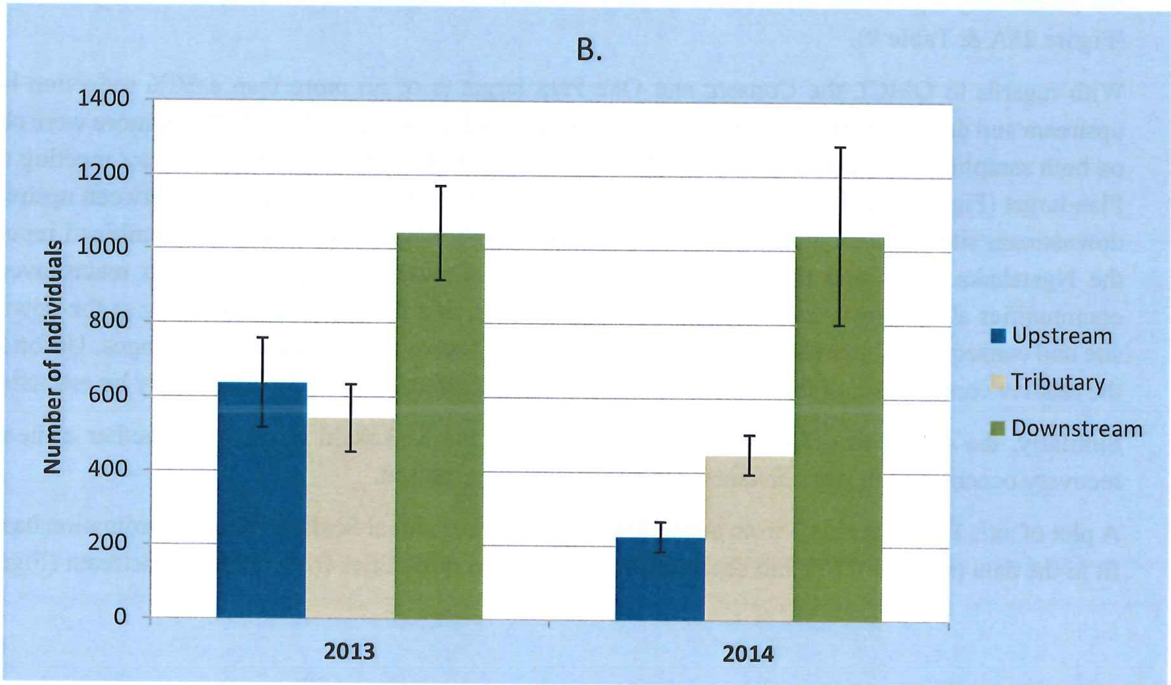
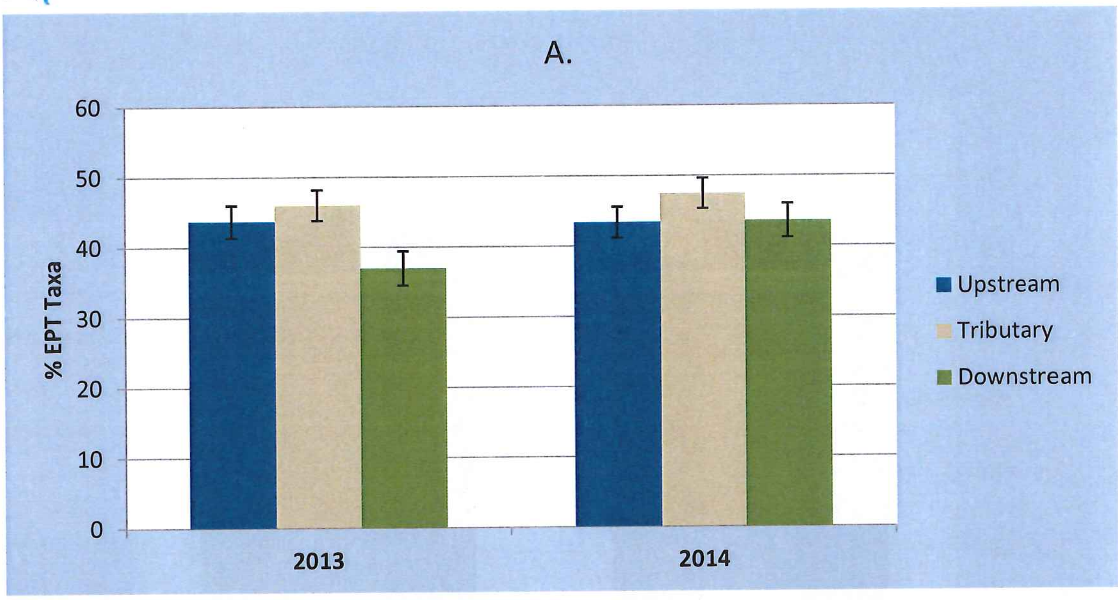


Figure 23: Mean (± 1 SE) A. Number of taxa and B. Number of individuals for the sites sampled on the Makakahi River upstream of the Eketahuna WWTP discharge, within the Ngatahaka Creek tributary, downstream of the discharge in 2013 and 2014.



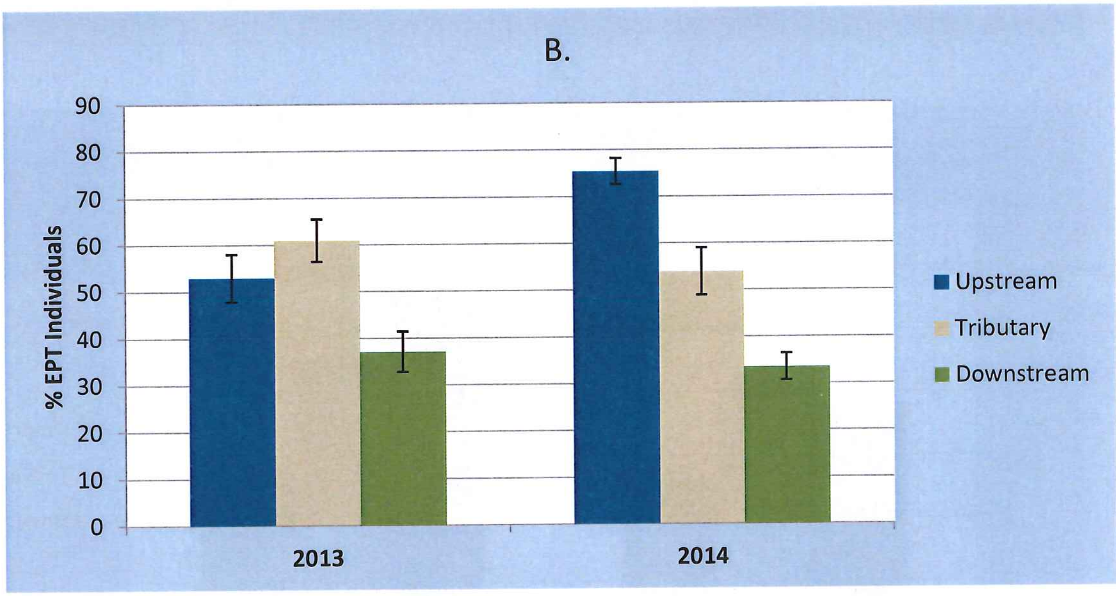


Figure 24: Mean (± 1 SE) A. % EPT taxa and B. % EPT individuals for the sites sampled on the Makakahi River upstream of the Eketahuna WWTP discharge, within the Ngatahaka Creek tributary, downstream of the discharge in 2013 and 2014.

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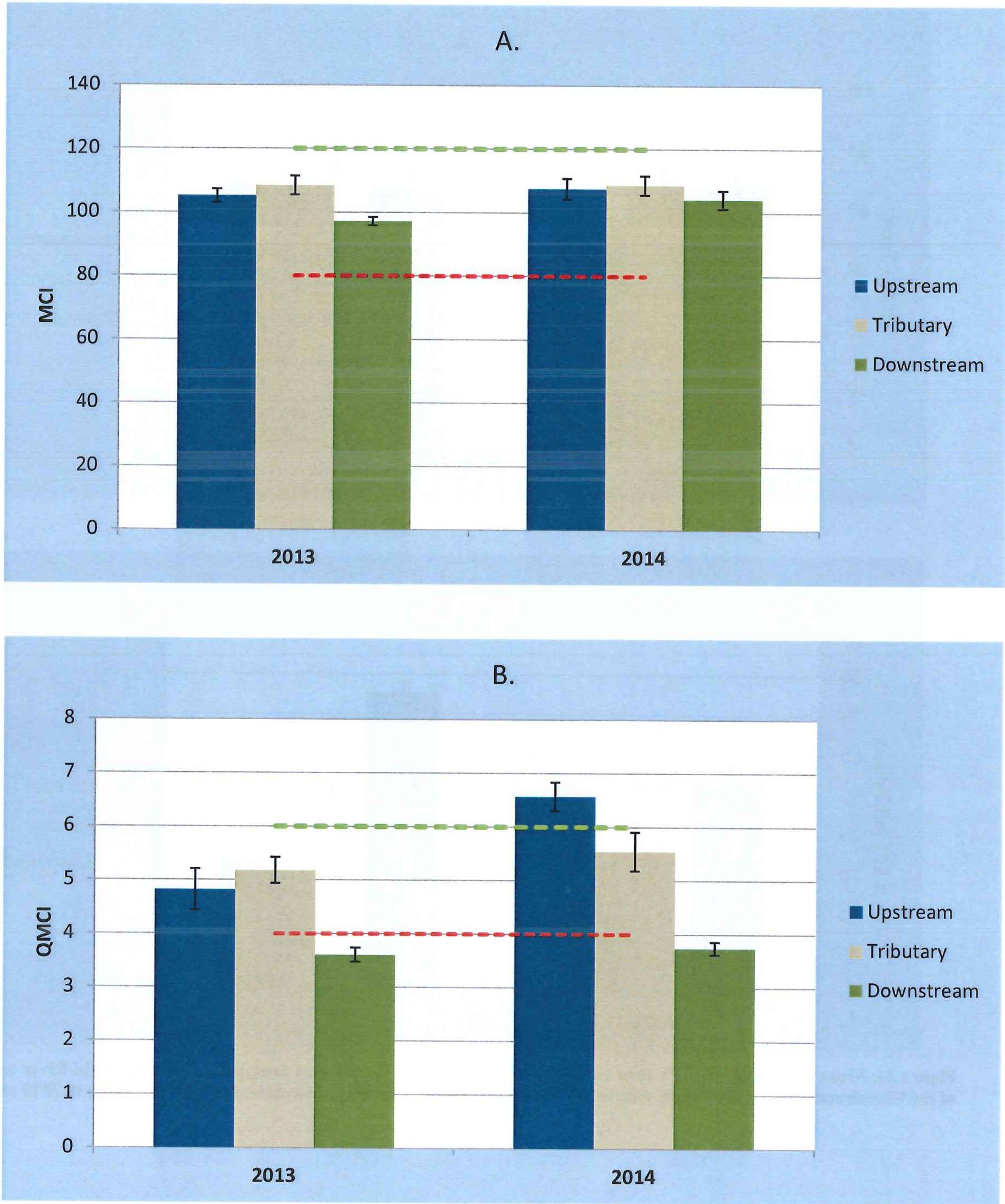

Figure 25: Mean (± 1 SE) A. MCI and B. QMCI for the sites sampled on the Makakahi River upstream of the Eketahuna WWTP discharge, within the Ngatahaka Creek tributary, downstream of the discharge in 2013 and 2014. Dashed lines represent clean water (green line) and probable polluted water (red line).

Table 9: Summary of annual biotic indices for sites sampled upstream (U/S) and downstream (D/S) of the Eketahuna WWTP discharge to the Makakahi River and within the Ngatahaka Creek tributary (Trib). Percent change in QMCI is between upstream and downstream of the WWTP.

Year	Number of taxa			Number of individuals			% EPT Taxa			% EPT Individuals			MCI			QMCI			%Δ
	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	QMCI
2013	22.6	24.0	24.4	637.2	542.4	1043.0	42.6	45.2	34.6	52.8	60.8	36.9	105.1	108.5	97.2	4.8	5.2	3.6	-25.2
2014	15.0	20.2	18.2	225.2	447.4	1040.4	43.4	46.6	42.6	75.4	53.9	33.4	107.5	108.7	104.1	6.6	5.5	3.7	-43.1

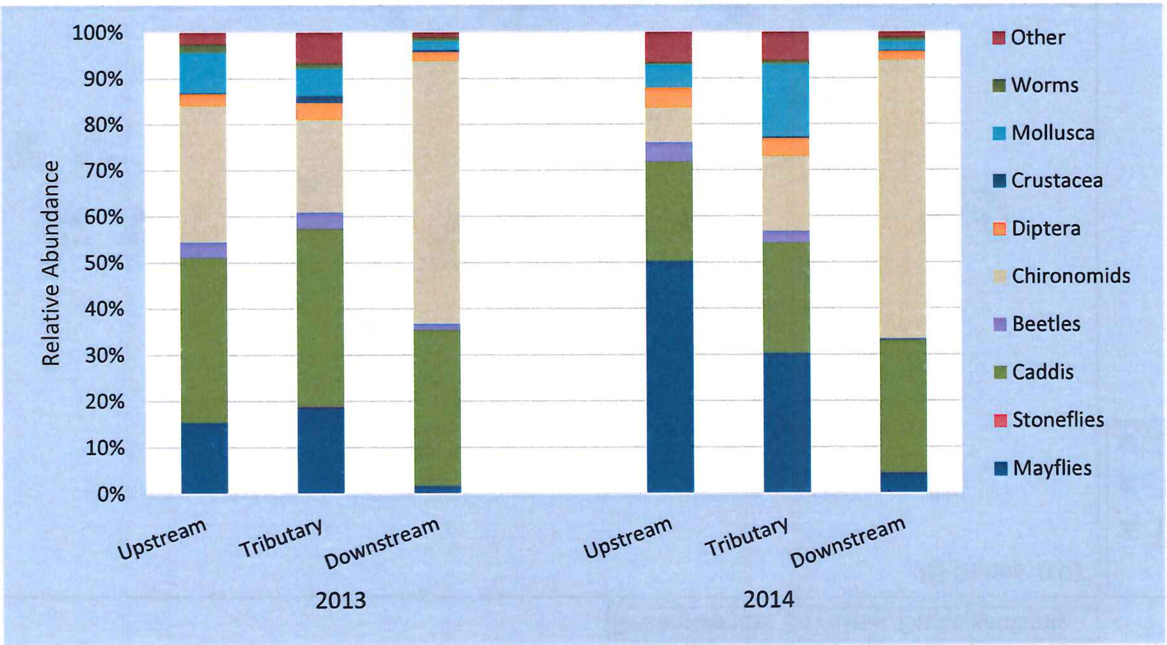

Figure 26: Relative abundance of the main taxonomic groups for the sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP discharge and within the Ngatahaka Creek tributary in 2013 (left three bars) and 2014 (right three bars).

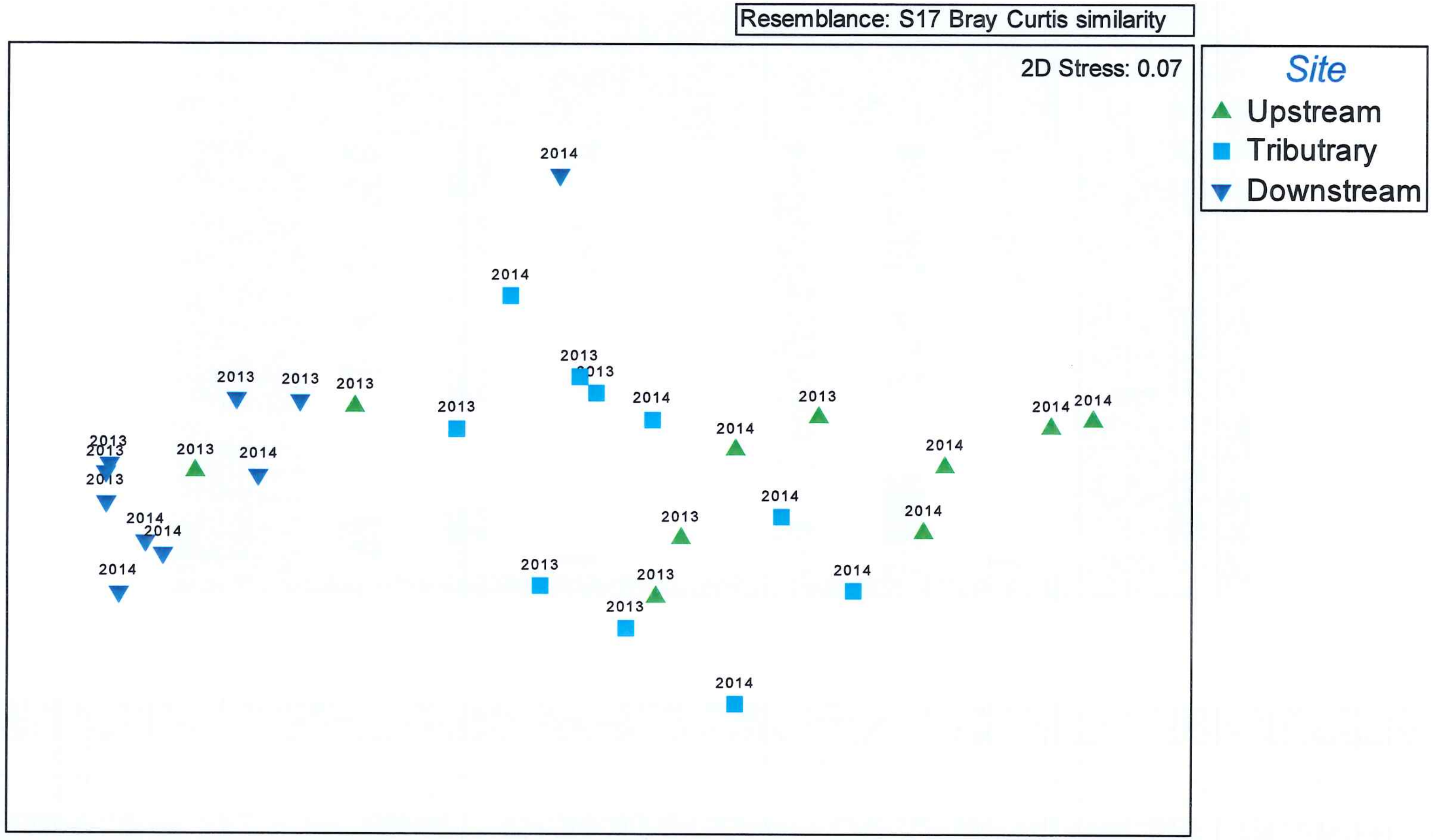

Figure 27: Plot of axis 1 against axis 2 from a NMDS (Stress = 0.07) for invertebrate communities collected at sites on the Makakahi River upstream and downstream of the Eketahuna WWTP discharge and within the Ngatahaka Creek tributary in 2013 and 2014.

4. Conclusions

With regards to the direct effects of the Eketahuna WWTP discharge on water quality and freshwater ecology, the following conclusions were drawn, based on monitoring data collected upstream and downstream of the discharge as well as from the Ngatahaka Creek which enters the Makakahi River approximately 10 meters upstream of the discharge point, over the period 2007 – 2014 (noting that a number of data analyses and assessments were conducted over the 2010 – 2014 period, as detailed in the report):

- Data available do not indicate significant changes between the Makakahi upstream and downstream sites for the following water quality determinands: water clarity, total suspended solids (TSS), water temperature, water pH, $ScBOD_5$, and Particulate Organic Matter (POM). This means that the discharge, even when combined with the inputs from the Ngatahaka Creek, does not cause any significant adverse effect s in relation to these determinands;
- Although no statistically significant, differences in *E.coli* concentrations were identified between upstream and downstream of the discharge, the proportion of samples compliant with the One Plan targets decreased between upstream and downstream and the discharge, It is noted that *E.coli* concentrations in the Ngatahaka Creek were generally higher than in the Makakahi upstream of the discharge, and often higher than at the downstream site. It thus appears likely that some of the changes between upstream and downstream are at least in part attributable to inputs from the Ngatahaka Creek;
- Direct comparison between upstream and downstream data indicates significant increases of total ammoniacal nitrogen, nitrate-nitrogen, Dissolved Reactive phosphorus (DRP), Soluble Inorganic Nitrogen (SIN), Dissolved Oxygen (DO) and periphyton growth (biomass and cover).
- The measured increase in DO saturation does not affect compliance with the One Plan target assessed on the basis of existing data, as the One Plan only defines a minimum saturation target. It is plausible that the measured day-time increases in DO saturation may be associated with photosynthetic activity from the increased periphyton biomass present at the downstream site. It is also noted that the only DO data available are day-time 'spot' measurements, which do not provide any indication of night-time minima, and a detailed assessment of DO against provisions of the One Plan and/or the NPSFM (2014) is not possible on the basis of existing data.
- Although increases in total ammoniacal nitrogen were statistically significant, measured concentrations at the downstream site remained well below the One Plan targets and did not result in any change in NPSFM grading for the ammoniacal nitrogen grading. Risks of toxic effects associated with ammonia are considered low and no observable effects are expected.
- The One Plan SIN target was met in the Makakahi River both upstream and downstream of the discharge, but largely exceeded in the Ngatahaka Creek. Additional modelling of contaminant loads and concentrations indicates that the measured increases in SIN (and nitrate-nitrogen) concentrations at the Makakahi downstream site compared with upstream are mostly attributable to inputs from the Ngatahaka catchment.
- The One Plan DRP target was met at all three sites, although both the Ngatahaka Creek and the downstream site presented higher concentrations than the upstream site. Additional analysis indicates that inputs from the Ngatahaka Creek are in part responsible for the increase in DRP concentration at the Makakahi downstream site compared with upstream, but that the discharge from the WWTP is also likely to be a significant contributor, particularly during periods of low river flows.

- Periphyton biomass, and cover by filamentous algae and diatom or cyanobacteria mats increased but remained below the One Plan targets at all three sites, indicating that the increase in periphyton growth currently observed is not at levels that would cause significant adverse effects on river values as identified in the One Plan. Although insufficient data are available, a preliminary assessment indicates that the upstream site is likely to fall in the NPSFM 'B' grade for periphyton (Trophic state), whilst the downstream site may fall in either the 'B' or 'C' grades. It is noted that the Makakahi upstream and the Ngatahaka Creek monitoring sites are within gorges, and thus are quite heavily shaded, whilst the Makakahi downstream site is more open, and receives more sunlight. This may explain some of the differences in periphyton growth between the Makakahi upstream and downstream sites;

- An analysis of nutrient concentration ratios was undertaken to provide an indication of likely nutrient limiting conditions in the Makakahi River. It indicates that the Makakahi upstream site is mostly nitrogen-limited at low flows, with a shift towards co-limited an then P-limited conditions as river flows increase. This is a common pattern observed at several other Manawatu Catchment sites. Nutrient ratios at the downstream site indicate that there is a general disappearance of strongly N-limited conditions under all but the lowest river flows, and a shift towards co- or P-limited conditions. This is thought to be primarily caused by SIN inputs, which have the net result of increasing SIN/DRP ratios;

- With regards to macroinvertebrate communities, all three sites (including the Ngatahaka Creek) were below the One Plan target for MCI (120). There was a significant decrease in QMCI between the Makakahi upstream and downstream sites, in excess of the One Plan target, of no more than 20% reduction in QMCI, in both 2013 and 2014. This is a surprising result given that all water quality and ecological determinands relevant to macroinvertebrate communities showed either no significant change (temperature, clarity, $ScBOD_5$, POM) or did change but remained within the One Plan targets (ammoniacal nitrogen, DRP, SIN, periphtyton biomass).

- The causes of the measured degradation in macroinvertebrate communities between upstream and downstream of the discharge are unclear at this stage, and so are the relative contributions to this effect by the WWTP discharge vs. inputs from the Ngatahaka Creek catchment, although likely mechanisms include the increase in periphyton growth (itself potentially caused by the measured increased in dissolved available nutrients (SIN and DRP)) and the deposition of organic or inorganic sediment.

- As indicated above, a number of upgrades are planned for the Eketahuna WWTP, and further detailed water quality assessment will be undertaken once the nature and likely outcomes (in relation to effluent quality and quantity) are known. This additional assessment should consider known mechanisms of effects on macroinvertebrate communities.

REFERENCES

McDowell, R. W., S. T. Larned and D. J. Houlbrooke (2009). "Nitrogen and phosphorus in New Zealand streams and rivers: control and impact of eutrophication and the influence of land management." *New Zealand Journal of Marine and Freshwater Research* ***43****(4): 985-999.*

APPENDICES

Appendix A: Summary of water quality data for sites sampled on the Makakahi River upstream (U/S) and downstream (D/S) of the Eketahuna WWTP and within the Ngatahaka Creek tributary (Trib), October 2010 – May 2014, at different flows. Guidelines from Horizons One Plan for the Mangatainoka - Makakahi management sub-zone (Mana_8d) as per the web-based version, accessed on 2nd December 2014.

		TSS			AMM			TN			Nitrate			Nitrite			DRP			TP			SIN		
		U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S
	Average	5.10	4.09	2.93	0.01	0.02	0.02	0.42	1.08	0.65	0.23	0.77	0.41	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.02	0.24	0.79	0.43
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.23	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00
	5%ile	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.33	0.23	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.06	0.01
	10%ile	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.37	0.30	0.00	0.16	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.18	0.04
	20%ile	0.00	0.50	0.50	0.00	0.00	0.00	0.21	0.55	0.33	0.01	0.23	0.04	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.02	0.25	0.06
	25%ile	0.38	0.50	1.00	0.00	0.00	0.00	0.23	0.61	0.35	0.02	0.25	0.05	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.02	0.01	0.03	0.26	0.08
	50%ile (median)	1.30	1.50	1.00	0.01	0.01	0.01	0.37	1.10	0.60	0.17	0.69	0.33	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.18	0.74	0.34
	75%ile	4.55	3.70	3.25	0.02	0.02	0.03	0.59	1.52	0.93	0.41	1.17	0.72	0.00	0.01	0.00	0.01	0.01	0.01	0.02	0.03	0.02	0.43	1.29	0.74
ALL FLOWS	90%ile	8.70	11.10	4.82	0.02	0.05	0.03	0.76	1.68	1.06	0.52	1.36	0.81	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.04	0.04	0.55	1.42	0.82
	95%ile	29.25	15.70	5.97	0.02	0.07	0.04	0.81	1.96	1.10	0.61	1.50	0.96	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.05	0.04	0.64	1.51	0.98
	Max	55.00	36.00	32.00	0.05	0.34	0.17	0.93	2.15	1.43	0.74	1.79	1.17	0.01	0.03	0.01	0.01	0.02	0.02	0.05	0.10	0.07	0.76	1.80	1.18
	StDev	10.71	7.07	5.30	0.01	0.05	0.03	0.23	0.54	0.33	0.23	0.50	0.34	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.23	0.51	0.34
	95% C.I.	3.17	2.09	1.57	0.00	0.02	0.01	0.07	0.16	0.10	0.07	0.15	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.07	0.15	0.10
	Guideline					<0.4																			
	%compliance				100%	100%	100%																		
	N. of Samples	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44

		E. coli			Enterococci			Black Disc			Temperature			DO Saturation			pH			POM			sCBOD5		
		U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S
	Average	375	967	591	72.65	-	104.41	1.98	1.95	1.94	13.06	12.54	13.08	97.25	98.75	99.12	7.62	7.56	7.63	1.94	1.98	1.51	0.77	0.81	0.73
	Min	21	21	36	0.50	-	1.00	0.20	0.20	0.40	6.40	6.70	6.60	76.20	75.00	72.80	5.84	7.07	7.23	0.00	0.00	0.00	0.06	0.25	0.25
	5%ile	27	40	48	0.83	-	2.00	0.70	0.59	0.80	7.30	7.20	7.20	78.17	88.36	89.79	7.25	7.14	7.29	0.00	0.00	0.00	0.25	0.25	0.25
	10%ile	35	50	61	2.00	-	3.00	1.09	0.98	1.05	7.43	7.62	7.49	85.46	90.65	90.82	7.32	7.28	7.38	0.00	0.00	0.00	0.25	0.25	0.25
	20%ile	75	112	94	3.60	-	4.60	1.48	1.10	1.30	9.72	9.18	9.50	89.88	94.20	94.20	7.40	7.37	7.45	0.00	0.00	0.00	0.25	0.25	0.25
	25%ile	92	128	100	4.00	-	5.25	1.59	1.36	1.62	10.28	10.25	9.95	92.35	94.60	94.83	7.44	7.38	7.47	0.00	0.50	0.50	0.25	0.44	0.25
	50%ile (median)	149	225	190	20.00	-	17.50	2.00	1.90	2.03	13.10	12.50	13.05	96.90	98.75	99.85	7.61	7.52	7.61	1.00	1.00	1.00	1.00	1.00	1.00
	75%ile	292	430	310	59.50	-	65.25	2.50	2.45	2.29	16.45	15.33	16.13	104.45	101.65	103.33	7.77	7.70	7.74	3.00	3.00	2.00	1.00	1.00	1.00
ALL FLOWS	90%ile	522	859	666	95.10	-	98.60	2.96	2.88	2.90	17.90	16.47	18.87	107.88	106.41	105.17	8.06	7.85	7.97	4.28	5.14	3.74	1.00	1.00	1.00
	95%ile	863	1706	1030	475.95	-	459.15	3.01	3.23	3.00	18.68	18.27	19.09	109.11	107.71	107.10	8.29	8.07	8.10	5.51	6.00	3.97	1.00	1.00	1.00
	Max	6600	25000	14900	613.00	-	1733.00	3.20	4.10	3.10	19.60	19.10	19.50	126.20	129.60	129.80	8.66	8.67	8.64	9.20	9.00	8.00	3.00	3.00	1.00
	StDev	998	3762	2222	149.87	-	307.84	0.71	0.84	0.67	3.75	3.44	3.83	10.24	7.91	7.98	0.41	0.29	0.27	2.16	2.11	1.58	0.50	0.47	0.35
	95% C.I.	295	1111	657	50.38	-	103.48	0.22	0.26	0.22	1.11	1.02	1.13	3.06	2.34	2.36	0.12	0.09	0.08	0.64	0.62	0.47	0.15	0.14	0.10
	Guideline											<19			>80			>7 & <8.5							
	%compliance										95%	95%	91%	91%	98%	98%	95%	98%	98%						
	N. of Samples	44	44	44	34	0	34	40	39	36	44	44	44	43	44	44	44	44	44	44	44	44	43	44	44

		TSS			AMM			TN			Nitrate			Nitrite			DRP			TP			SIN		
		U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S
> 20TH FEP	Average	32.00	12.60	14.75	0.01	0.05	0.03	0.68	1.45	0.97	0.42	0.96	0.62	0.00	0.00	0.00	0.01	0.01	0.01	0.03	0.05	0.04	0.44	1.01	0.65
	Min	9.00	4.40	4.20	0.01	0.01	0.01	0.60	1.20	0.77	0.20	0.67	0.37	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.02	0.02	0.21	0.77	0.42
	5%ile	12.15	4.64	4.44	0.01	0.01	0.01	0.61	1.22	0.79	0.24	0.72	0.41	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.02	0.02	0.25	0.80	0.45
	10%ile	15.30	4.88	4.68	0.01	0.01	0.01	0.62	1.23	0.82	0.28	0.77	0.45	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.02	0.02	0.29	0.84	0.49
	20%ile	21.60	5.36	5.16	0.01	0.02	0.01	0.63	1.26	0.87	0.35	0.87	0.54	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.03	0.02	0.36	0.92	0.57
	25%ile	24.75	5.60	5.40	0.01	0.02	0.01	0.64	1.28	0.89	0.39	0.92	0.58	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.03	0.02	0.40	0.96	0.60
	50%ile (median)	32.00	10.00	11.40	0.01	0.04	0.02	0.67	1.41	1.00	0.49	1.04	0.69	0.00	0.00	0.00	0.01	0.01	0.01	0.03	0.04	0.03	0.50	1.07	0.70
	75%ile	39.25	17.00	20.75	0.02	0.08	0.04	0.70	1.59	1.08	0.52	1.08	0.72	0.00	0.00	0.00	0.01	0.01	0.01	0.04	0.07	0.05	0.54	1.12	0.75
	90%ile	48.70	22.40	27.50	0.02	0.09	0.04	0.75	1.71	1.09	0.52	1.09	0.72	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.08	0.06	0.55	1.14	0.76
	95%ile	51.85	24.20	29.75	0.02	0.09	0.04	0.76	1.76	1.10	0.52	1.10	0.73	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.09	0.07	0.55	1.15	0.77
	Max	55.00	26.00	32.00	0.02	0.09	0.05	0.78	1.80	1.10	0.52	1.10	0.73	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.09	0.07	0.55	1.16	0.77
	StDev	18.85	9.87	12.83	0.00	0.04	0.02	0.07	0.27	0.15	0.15	0.20	0.17	0.00	0.01	0.01	0.00	0.00	0.00	0.02	0.03	0.03	0.16	0.18	0.16
	95% C.I.	18.89	9.89	12.86	0.00	0.04	0.02	0.07	0.27	0.15	0.15	0.20	0.17	0.00	0.01	0.01	0.00	0.00	0.00	0.02	0.03	0.03	0.16	0.18	0.16
	Guideline																								
	%compliance																								
	N. of Samples	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

		E. coli			Enterococci			Black Disc			Temperature			DO Saturation			pH			POM			sCBOD5		
		U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S
> 20TH FEP	Average	1920	6941	4012	171.75	-	458.25	0.80	1.14	0.78	10.88	10.85	10.98	101.38	99.80	99.40	7.44	7.33	7.45	5.50	4.50	3.58	0.44	0.56	0.44
	Min	73	100	120	1.00	-	3.00	0.20	0.20	0.40	8.80	9.00	9.00	94.90	93.90	94.40	7.24	7.14	7.28	4.00	2.00	0.50	0.25	0.25	0.25
	5%ile	131	208	156	3.10	-	6.15	0.23	0.24	0.44	8.92	9.05	9.08	94.98	94.37	94.64	7.25	7.16	7.29	4.06	2.12	0.73	0.25	0.25	0.25
	10%ile	189	316	192	5.20	-	9.30	0.26	0.28	0.48	9.04	9.09	9.15	95.05	94.83	94.88	7.26	7.18	7.30	4.12	2.24	0.95	0.25	0.25	0.25
	20%ile	304	532	264	9.40	-	15.60	0.32	0.35	0.56	9.28	9.18	9.30	95.20	95.76	95.36	7.28	7.22	7.32	4.24	2.48	1.40	0.25	0.25	0.25
	25%ile	362	640	300	11.50	-	18.75	0.35	0.39	0.60	9.40	9.23	9.38	95.28	96.23	95.60	7.29	7.25	7.33	4.30	2.60	1.63	0.25	0.25	0.25
	50%ile (median)	504	1332	513	36.50	-	48.50	0.56	0.95	0.80	10.60	10.50	10.65	100.70	100.25	98.00	7.37	7.30	7.40	5.00	3.50	2.90	0.25	0.50	0.25
	75%ile	2063	7633	4225	196.75	-	488.00	1.01	1.70	0.98	12.08	12.13	12.25	106.80	103.83	101.80	7.52	7.38	7.51	6.20	5.40	4.85	0.44	0.81	0.44
	90%ile	4785	18053	10630	446.50	-	1235.00	1.53	2.15	1.08	12.93	12.89	13.06	108.24	104.41	105.04	7.67	7.51	7.64	7.28	7.56	6.74	0.78	0.93	0.78
	95%ile	5693	21527	12765	529.75	-	1484.00	1.70	2.30	1.12	13.22	13.15	13.33	108.72	104.61	106.12	7.72	7.56	7.68	7.64	8.28	7.37	0.89	0.96	0.89
	Max	6600	25000	14900	613.00	-	1733.00	1.87	2.45	1.15	13.50	13.40	13.60	109.20	104.80	107.20	7.77	7.60	7.72	8.00	9.00	8.00	1.00	1.00	1.00
	StDev	3127	12061	7262	295.16	-	850.34	0.75	1.03	0.38	2.11	2.09	2.13	7.31	5.21	5.71	0.24	0.19	0.19	1.80	3.13	3.24	0.38	0.38	0.38
	95% C.I.	3134	12089	7279	295.85	-	852.32	0.75	1.03	0.43	2.11	2.09	2.14	7.33	5.22	5.72	0.24	0.19	0.19	1.80	3.14	3.25	0.38	0.38	0.38
	Guideline																								
	%compliance																								
	N. of Samples	4	4	4	4	0	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

		TSS			AMM			TN			Nitrate			Nitrite			DRP			TP			SIN		
		U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S
< 20TH FEP	Average	2.42	3.24	1.75	0.01	0.02	0.02	0.39	1.04	0.62	0.21	0.75	0.39	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.22	0.77	0.41
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.23	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00
	5%ile	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.33	0.22	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.05	0.01
	10%ile	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.34	0.29	0.00	0.15	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.16	0.04
	20%ile	0.00	0.50	0.50	0.00	0.00	0.00	0.21	0.54	0.31	0.01	0.22	0.03	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.02	0.24	0.05
	25%ile	0.00	0.50	0.88	0.00	0.00	0.00	0.22	0.59	0.35	0.02	0.24	0.05	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.03	0.25	0.07
	50%ile (median)	1.00	1.00	1.00	0.01	0.01	0.01	0.34	0.92	0.53	0.13	0.65	0.25	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.14	0.66	0.26
	75%ile	2.30	3.00	3.00	0.02	0.01	0.02	0.55	1.51	0.92	0.38	1.28	0.68	0.00	0.01	0.00	0.01	0.01	0.01	0.02	0.03	0.02	0.41	1.30	0.72
	90%ile	5.00	7.74	4.00	0.02	0.02	0.03	0.76	1.64	1.03	0.52	1.38	0.82	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.04	0.03	0.54	1.44	0.83
	95%ile	7.05	12.20	4.43	0.02	0.07	0.04	0.82	1.99	1.11	0.62	1.51	0.98	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.04	0.04	0.66	1.53	1.00
	Max	25.00	36.00	6.00	0.05	0.34	0.17	0.93	2.15	1.43	0.74	1.79	1.17	0.01	0.03	0.01	0.01	0.02	0.02	0.05	0.10	0.05	0.76	1.80	1.18
	StDev	4.20	6.28	1.59	0.01	0.05	0.03	0.22	0.55	0.33	0.23	0.52	0.34	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.23	0.53	0.35
	95% C.I.	1.30	1.95	0.49	0.00	0.02	0.01	0.07	0.17	0.10	0.07	0.16	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.16	0.11
	Guideline																	<0.01						<0.444	
	%compliance																98%	68%	85%				83%	35%	58%
	N. of Samples	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40

		E. coli			Enterococci			Black Disc			Temperature			DO Saturation			pH			POM			sCBOD5		
		U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S
< 20TH FEP	Average	220.56	369.30	248.89	59.43	-	57.23	2.11	2.05	2.05	13.28	12.71	13.29	96.83	98.64	99.09	7.63	7.58	7.65	1.59	1.73	1.30	0.80	0.83	0.76
	Min	21.00	21.00	36.00	0.50	-	1.00	1.00	0.60	0.80	6.40	6.70	6.60	76.20	75.00	72.80	5.84	7.07	7.23	0.00	0.00	0.00	0.06	0.25	0.25
	5%ile	26.90	39.20	47.55	1.18	-	2.00	1.18	0.97	1.06	7.28	7.20	7.20	77.94	88.02	89.58	7.29	7.16	7.37	0.00	0.00	0.00	0.25	0.25	0.25
	10%ile	30.90	49.30	56.20	2.00	-	2.90	1.38	1.06	1.22	7.39	7.47	7.38	84.02	90.16	90.66	7.36	7.32	7.40	0.00	0.00	0.00	0.25	0.25	0.25
	20%ile	75.00	111.92	92.56	3.80	-	4.80	1.60	1.24	1.77	9.88	9.60	9.74	88.40	94.14	93.74	7.43	7.38	7.47	0.00	0.00	0.00	0.25	0.25	0.25
	25%ile	91.75	127.50	98.75	4.00	-	5.25	1.80	1.55	1.84	10.70	10.48	10.53	92.00	94.60	94.83	7.47	7.40	7.50	0.00	0.38	0.38	0.38	0.50	0.44
	50%ile (median)	146.80	213.00	165.00	20.00	-	14.00	2.05	2.10	2.05	13.45	12.60	13.20	96.90	98.75	99.85	7.65	7.55	7.61	1.00	1.00	1.00	1.00	1.00	1.00
	75%ile	241.25	376.50	286.00	56.50	-	55.75	2.50	2.48	2.40	16.65	15.53	16.50	104.25	101.45	103.33	7.77	7.71	7.76	2.05	2.85	2.00	1.00	1.00	1.00
	90%ile	368.70	733.70	471.60	93.30	-	87.80	2.98	2.94	2.93	17.91	16.66	18.91	107.52	106.51	105.11	8.12	7.87	8.01	4.00	5.02	3.06	1.00	1.00	1.00
	95%ile	596.65	877.30	709.24	282.45	-	286.05	3.03	3.29	3.00	18.84	18.34	19.12	109.19	107.98	106.57	8.32	8.09	8.12	4.05	6.00	3.81	1.00	1.00	1.00
	Max	1580.00	3922.00	1230.00	552.00	-	504.00	3.20	4.10	3.10	19.60	19.10	19.50	126.20	129.60	129.80	8.66	8.67	8.64	9.20	6.00	4.00	3.00	3.00	1.00
	StDev	276.50	620.89	259.21	122.52	-	116.04	0.58	0.78	0.59	3.82	3.52	3.91	10.47	8.18	8.23	0.42	0.29	0.27	1.86	1.86	1.21	0.50	0.48	0.33
	95% C.I.	85.69	192.41	80.33	43.84	-	41.52	0.19	0.26	0.20	1.18	1.09	1.21	3.29	2.53	2.55	0.13	0.09	0.08	0.58	0.58	0.37	0.16	0.15	0.10
	Guideline		<550																					<1.5	
	%compliance	93%	85%	90%																			97%	98%	100%
	N. of Samples	40	40	40	30	0	30	36	35	33	40	40	40	39	40	40	40	40	40	40	40	40	39	40	40

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		TSS			AMM			TN			Nitrate			Nitrite			DRP			TP			SIN		
		U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S
MEDIAN TO 20TH FEP	Average	3.55	3.05	2.39	0.01	0.03	0.02	0.56	1.40	0.83	0.39	1.09	0.63	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.41	1.12	0.66
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.34	0.17	0.03	0.24	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.04	0.25	0.04
	5%ile	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.56	0.31	0.10	0.25	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.13	0.26	0.20
	10%ile	0.60	0.30	0.30	0.00	0.00	0.00	0.34	0.74	0.41	0.15	0.43	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.17	0.45	0.26
	20%ile	1.00	0.60	1.00	0.00	0.00	0.00	0.37	0.89	0.53	0.22	0.71	0.38	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.23	0.72	0.39
	25%ile	1.00	1.00	1.00	0.01	0.00	0.00	0.40	1.10	0.64	0.24	0.95	0.49	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.25	0.97	0.52
	50%ile (median)	2.00	2.00	2.60	0.01	0.01	0.01	0.56	1.55	0.92	0.37	1.28	0.67	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.40	1.30	0.72
	75%ile	2.60	3.00	4.00	0.02	0.02	0.02	0.76	1.63	1.03	0.52	1.32	0.78	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.54	1.35	0.81
	90%ile	6.20	6.60	4.16	0.03	0.04	0.03	0.83	2.03	1.14	0.66	1.52	0.99	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.02	0.68	1.54	1.01
	95%ile	11.40	10.40	4.72	0.03	0.12	0.06	0.86	2.11	1.25	0.73	1.59	1.03	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.05	0.03	0.74	1.60	1.05
	Max	25.00	16.00	6.00	0.05	0.34	0.17	0.93	2.15	1.43	0.74	1.79	1.17	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.10	0.04	0.76	1.80	1.18
	StDev	5.89	4.00	1.75	0.01	0.08	0.04	0.21	0.51	0.33	0.20	0.44	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.20	0.45	0.30
	95% C.I.	2.80	1.90	0.83	0.01	0.04	0.02	0.10	0.24	0.16	0.10	0.21	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.10	0.21	0.14
	Guideline																								
	%compliance																								
	N. of Samples	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17

		E. coli			Enterococci			Black Disc			Temperature			DO Saturation			pH			POM			sCBOD5		
		U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S
MEDIAN TO 20TH FEP	Average	246.80	476.94	300.54	48.69	-	53.46	2.13	1.99	1.80	11.18	10.71	11.09	99.32	99.68	98.21	7.61	7.58	7.65	2.09	1.93	1.76	0.64	0.81	0.65
	Min	21.00	50.00	57.00	0.50	-	1.00	1.10	0.60	0.80	6.40	6.70	6.60	77.40	91.70	72.80	7.12	7.07	7.24	0.00	0.00	0.00	0.06	0.25	0.25
	5%ile	25.80	106.00	91.40	0.50	-	1.60	1.18	0.90	0.94	6.80	7.02	7.08	77.88	92.18	89.04	7.26	7.14	7.35	0.00	0.00	0.00	0.21	0.25	0.25
	10%ile	37.20	126.00	108.40	0.80	-	2.80	1.30	1.05	1.04	7.14	7.16	7.20	84.06	93.68	93.58	7.32	7.24	7.39	0.60	0.00	0.00	0.25	0.25	0.25
	20%ile	77.60	135.60	120.60	2.00	-	7.20	1.55	1.10	1.18	7.42	7.26	7.46	93.52	97.24	96.16	7.36	7.33	7.42	1.00	0.50	0.60	0.25	0.25	0.25
	25%ile	96.00	150.00	131.00	2.00	-	9.00	1.78	1.40	1.25	7.50	7.50	7.70	96.40	97.40	96.40	7.38	7.36	7.45	1.00	0.50	1.00	0.25	0.25	0.25
	50%ile (median)	150.00	215.00	210.00	6.00	-	12.00	2.22	2.00	1.90	11.10	11.10	11.10	102.20	99.50	100.00	7.60	7.40	7.54	1.00	2.00	2.00	0.50	1.00	0.50
	75%ile	230.00	370.00	239.00	37.00	-	48.00	2.50	2.50	2.20	13.80	12.60	13.30	106.20	101.40	103.30	7.72	7.76	7.75	2.60	2.80	2.60	1.00	1.00	1.00
	90%ile	375.40	664.00	706.00	44.00	-	64.80	2.88	2.83	2.55	15.66	14.34	15.54	108.12	106.32	103.80	7.83	8.01	7.96	4.00	4.40	3.76	1.00	1.00	1.00
	95%ile	780.00	1368.40	1118.00	200.40	-	214.80	3.00	3.28	2.76	17.26	16.00	16.86	110.08	106.52	104.24	8.06	8.23	8.22	5.04	5.20	4.00	1.00	1.40	1.00
	Max	1580.00	3922.00	1230.00	435.00	-	435.00	3.00	4.10	3.00	17.90	16.40	17.10	117.20	106.60	104.80	8.66	8.67	8.64	9.20	6.00	4.00	1.00	3.00	1.00
	StDev	366.58	905.77	336.15	117.37	-	116.58	0.60	0.88	0.65	3.54	2.99	3.34	10.58	4.38	7.45	0.34	0.40	0.33	2.18	1.77	1.35	0.37	0.66	0.35
	95% C.I.	174.26	430.57	159.79	63.80	-	63.37	0.29	0.43	0.33	1.68	1.42	1.59	5.03	2.08	3.54	0.16	0.19	0.16	1.04	0.84	0.64	0.18	0.31	0.17
	Guideline																								
	%compliance																								
	N. of Samples	17	17	17	13	0	13	16	16	15	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17

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		TSS			AMM			TN			Nitrate			Nitrite			DRP			TP			SIN		
		U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S
BELOW MEDIAN	Average	1.57	3.38	1.28	0.01	0.01	0.01	0.27	0.77	0.46	0.08	0.50	0.20	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.09	0.51	0.22
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.23	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00
	5%ile	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.26	0.23	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.03	0.00
	10%ile	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.33	0.27	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.06	0.01
	20%ile	0.00	0.20	0.20	0.00	0.00	0.00	0.17	0.45	0.30	0.00	0.16	0.03	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.02	0.01	0.01	0.18	0.04
	25%ile	0.00	0.50	0.50	0.00	0.00	0.00	0.20	0.48	0.31	0.00	0.18	0.03	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.02	0.02	0.01	0.22	0.05
	50%ile (median)	1.00	1.00	1.00	0.01	0.00	0.01	0.24	0.70	0.36	0.02	0.34	0.17	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.04	0.35	0.19
	75%ile	2.10	2.50	1.20	0.01	0.01	0.02	0.31	1.04	0.55	0.07	0.69	0.24	0.00	0.01	0.00	0.00	0.01	0.01	0.02	0.03	0.03	0.08	0.69	0.25
	90%ile	4.88	6.80	3.00	0.02	0.02	0.03	0.43	1.44	0.79	0.22	1.12	0.55	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.04	0.03	0.23	1.12	0.57
	95%ile	5.00	11.56	3.90	0.02	0.02	0.03	0.53	1.50	0.93	0.40	1.35	0.79	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.04	0.04	0.41	1.35	0.80
	Max	7.00	36.00	5.00	0.02	0.07	0.04	0.67	1.50	1.00	0.50	1.44	0.86	0.01	0.03	0.01	0.01	0.01	0.02	0.05	0.04	0.05	0.50	1.44	0.87
	StDev	2.06	7.63	1.31	0.01	0.01	0.01	0.13	0.40	0.23	0.13	0.43	0.25	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.13	0.43	0.25
	95% C.I.	0.84	3.12	0.54	0.00	0.01	0.01	0.06	0.16	0.09	0.05	0.18	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.18	0.10
	Guideline																								
	%compliance																								
	N. of Samples	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23

		E. coli			Enterococci			Black Disc			Temperature			DO Saturation			pH			POM			sCBOD5		
		U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S
BELOW MEDIAN	Average	201.17	289.74	210.71	67.65	-	60.12	2.09	2.09	2.25	14.83	14.19	14.92	94.90	97.87	99.74	7.65	7.59	7.65	1.21	1.58	0.97	0.93	0.85	0.85
	Min	25.00	21.00	36.00	3.00	-	2.00	1.00	0.90	1.73	7.30	7.90	7.10	76.20	75.00	87.30	5.84	7.11	7.23	0.00	0.00	0.00	0.25	0.25	0.25
	5%ile	30.10	25.60	39.90	3.80	-	2.80	1.34	1.03	1.82	9.86	8.90	9.55	79.97	86.66	89.76	7.39	7.40	7.39	0.00	0.00	0.00	0.25	0.25	0.25
	10%ile	39.80	40.60	48.20	4.00	-	3.60	1.49	1.09	1.84	10.48	9.92	10.14	85.28	88.44	90.38	7.44	7.42	7.48	0.00	0.00	0.00	0.25	0.25	0.25
	20%ile	81.40	58.60	75.00	4.20	-	4.20	1.64	1.53	1.90	12.78	11.88	12.52	87.56	91.36	91.74	7.47	7.45	7.50	0.00	0.00	0.00	0.60	0.70	0.70
	25%ile	91.50	74.80	85.50	5.00	-	5.00	1.80	1.71	1.90	12.90	12.20	12.85	89.40	93.75	93.65	7.49	7.46	7.51	0.00	0.00	0.00	1.00	1.00	1.00
	50%ile (median)	133.00	211.00	142.00	32.00	-	16.00	2.00	2.20	2.08	15.19	14.90	15.30	95.00	98.00	99.70	7.68	7.60	7.63	0.50	1.00	1.00	1.00	1.00	1.00
	75%ile	292.90	370.00	308.50	68.00	-	72.00	2.26	2.45	2.52	17.40	16.20	18.35	98.20	101.70	103.60	7.88	7.70	7.73	1.90	2.50	1.00	1.00	1.00	1.00
	90%ile	354.00	714.40	381.20	94.20	-	93.20	2.97	2.92	2.97	18.64	18.26	19.08	104.46	107.08	106.24	8.13	7.77	7.97	3.80	4.88	2.00	1.00	1.00	1.00
	95%ile	414.30	864.20	638.90	187.20	-	184.00	3.11	3.23	3.02	19.43	19.02	19.37	105.83	109.34	107.76	8.30	7.81	8.03	4.00	5.92	2.90	1.00	1.00	1.00
	Max	913.00	921.00	689.20	552.00	-	504.00	3.20	3.50	3.10	19.60	19.10	19.50	126.20	129.60	129.80	8.33	8.09	8.21	5.00	6.00	3.80	3.00	1.00	1.00
	StDev	192.02	266.75	182.62	129.27	-	119.14	0.58	0.72	0.45	3.29	3.17	3.53	10.20	10.15	8.87	0.48	0.19	0.22	1.52	1.95	0.99	0.55	0.30	0.30
	95% C.I.	78.48	109.02	74.63	61.45	-	56.63	0.25	0.32	0.21	1.35	1.30	1.44	4.26	4.15	3.63	0.20	0.08	0.09	0.62	0.80	0.40	0.23	0.12	0.12
	Guideline								>3												<5				
	%compliance							10%	11%	11%										96%	87%	100%			
	N. of Samples	23	23	23	17	0	17	20	19	18	23	23	23	22	23	23	23	23	23	23	23	23	22	23	23

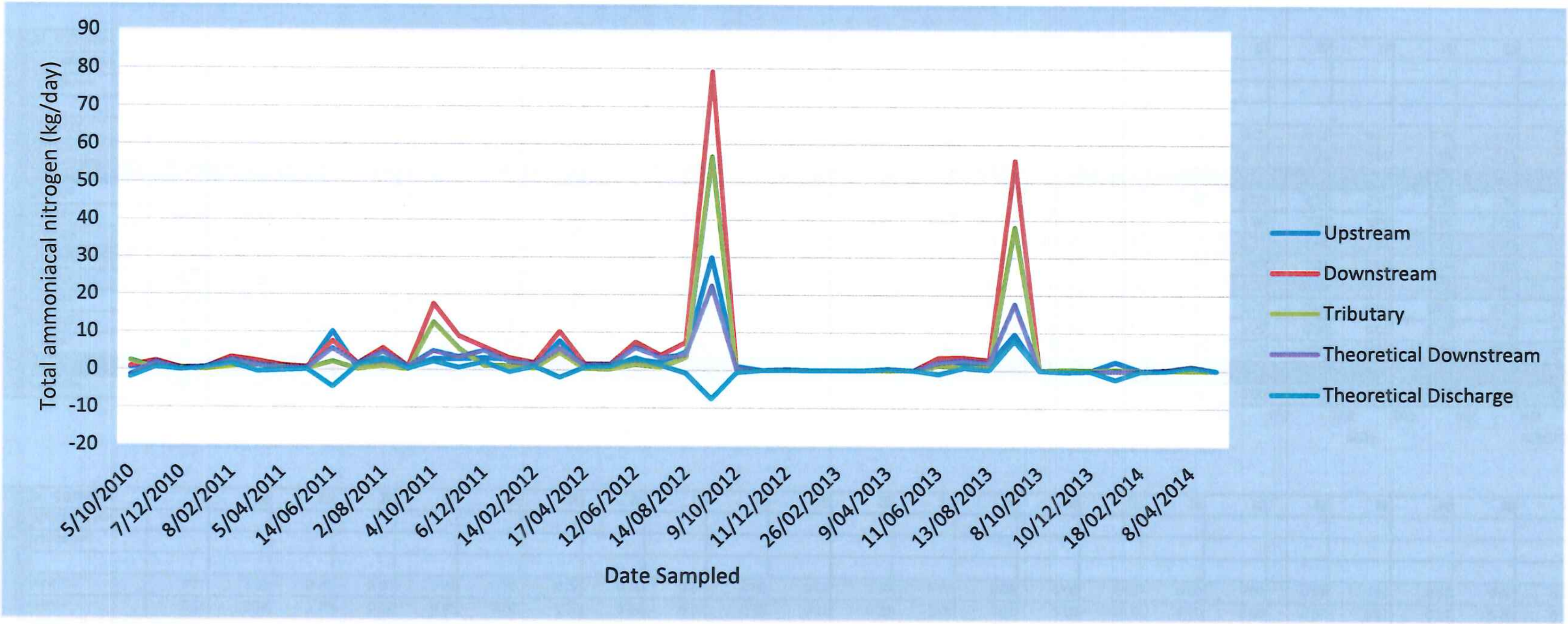
		TSS			AMM			TN			Nitrate			Nitrite			DRP			TP			SIN		
		U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S
HALF MEDIAN TO MEDIAN	Average	1.07	6.43	1.50	0.01	0.01	0.01	0.36	1.09	0.62	0.16	0.78	0.35	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.02	0.02	0.17	0.79	0.36
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.55	0.31	0.00	0.22	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.02	0.24	0.03
	5%ile	0.00	0.00	0.15	0.00	0.00	0.00	0.21	0.57	0.32	0.00	0.23	0.02	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.02	0.24	0.04
	10%ile	0.00	0.00	0.30	0.00	0.00	0.00	0.21	0.58	0.34	0.00	0.23	0.03	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.02	0.25	0.04
	20%ile	0.00	0.20	0.60	0.00	0.00	0.00	0.22	0.68	0.39	0.02	0.33	0.08	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.02	0.01	0.03	0.33	0.09
	25%ile	0.00	0.50	0.75	0.00	0.00	0.00	0.24	0.79	0.43	0.04	0.45	0.14	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.02	0.02	0.05	0.46	0.14
	50%ile (median)	0.50	2.00	1.00	0.00	0.00	0.00	0.34	1.20	0.64	0.13	0.72	0.25	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.03	0.02	0.13	0.72	0.26
	75%ile	1.50	3.00	1.50	0.01	0.01	0.02	0.42	1.40	0.76	0.20	1.10	0.52	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.03	0.02	0.21	1.11	0.53
	90%ile	2.80	16.20	3.20	0.02	0.01	0.02	0.53	1.48	0.89	0.34	1.25	0.69	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.03	0.02	0.35	1.26	0.70
	95%ile	3.40	26.10	4.10	0.02	0.01	0.02	0.60	1.49	0.95	0.42	1.35	0.77	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.04	0.02	0.43	1.35	0.79
	Max	4.00	36.00	5.00	0.02	0.02	0.03	0.67	1.50	1.00	0.50	1.44	0.86	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.04	0.02	0.50	1.44	0.87
	StDev	1.48	13.10	1.66	0.01	0.01	0.01	0.16	0.39	0.25	0.17	0.46	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.17	0.46	0.31
	95% C.I.	1.10	9.70	1.23	0.01	0.00	0.01	0.12	0.29	0.18	0.13	0.34	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.13	0.34	0.23
	Guideline																								
	%compliance																								
	N. of Samples	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7

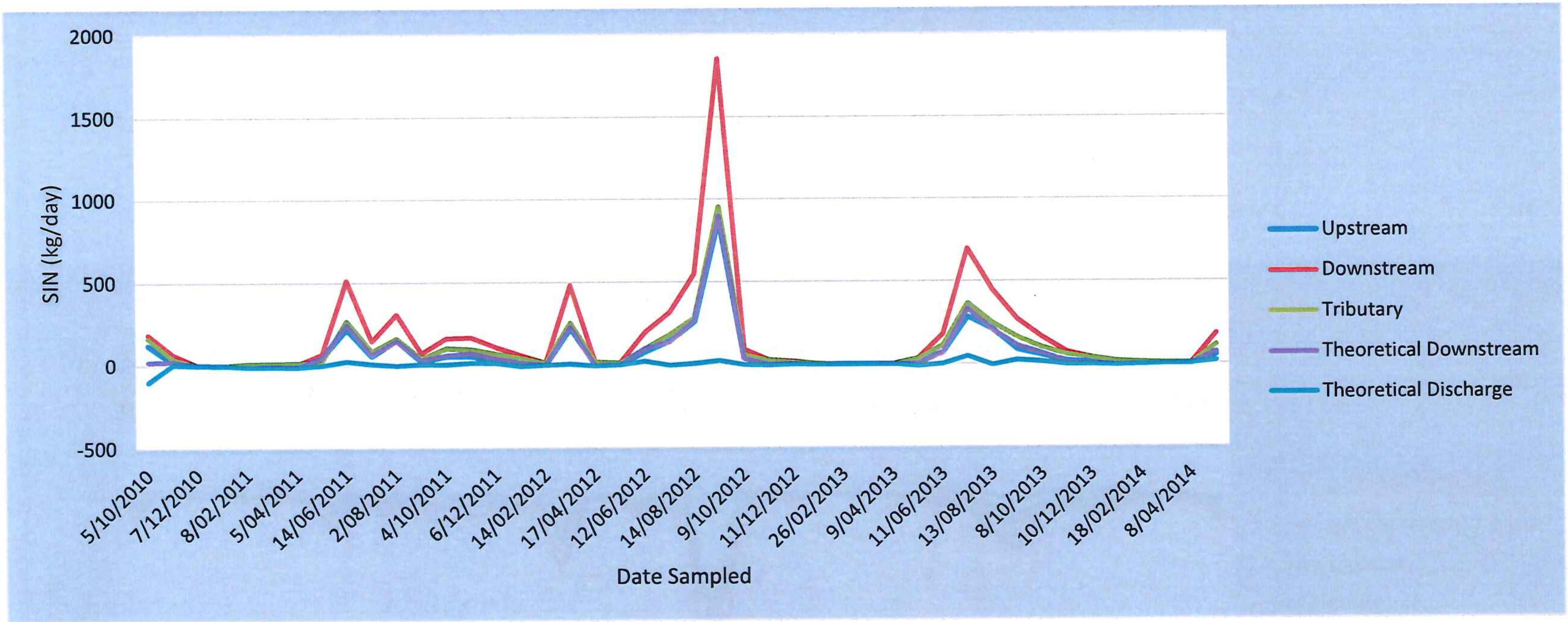
		E. coli			Enterococci			Black Disc			Temperature			DO Saturation			pH			POM			sCBOD5		
		U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S
HALF MEDIAN TO MEDIAN	Average	247.43	509.29	224.43	45.50	-	50.00	2.15	1.91	2.20	13.67	13.10	13.50	102.19	103.73	105.34	7.77	7.56	7.63	0.93	1.86	0.64	0.93	0.93	0.93
	Min	75.00	155.00	48.00	4.00	-	5.00	1.36	0.90	1.73	7.30	7.90	7.10	92.20	96.80	94.90	7.47	7.42	7.23	0.00	0.00	0.00	0.50	0.50	0.50
	5%ile	90.30	171.80	63.60	4.15	-	5.00	1.43	0.96	1.78	8.35	8.65	8.18	92.38	97.37	96.76	7.48	7.43	7.28	0.00	0.00	0.00	0.65	0.65	0.65
	10%ile	105.60	188.60	79.20	4.30	-	5.00	1.50	1.02	1.84	9.40	9.40	9.26	92.56	97.94	98.62	7.48	7.44	7.32	0.00	0.00	0.00	0.80	0.80	0.80
	20%ile	127.80	250.80	106.40	4.60	-	5.00	1.61	1.24	1.95	11.30	10.84	11.04	93.56	98.70	101.12	7.51	7.46	7.41	0.00	0.00	0.00	1.00	1.00	1.00
	25%ile	130.50	310.50	116.00	4.75	-	5.00	1.63	1.44	2.00	12.05	11.50	11.55	94.70	98.70	101.15	7.55	7.47	7.45	0.00	0.00	0.00	1.00	1.00	1.00
	50%ile (median)	295.00	489.00	279.00	42.50	-	45.50	2.00	1.89	2.08	13.90	13.20	14.10	98.90	98.80	102.20	7.69	7.51	7.61	0.00	1.00	0.50	1.00	1.00	1.00
	75%ile	340.50	689.50	308.50	83.25	-	90.50	2.63	2.12	2.08	15.40	14.25	15.35	104.30	101.75	104.10	7.99	7.62	7.74	1.25	3.00	1.00	1.00	1.00	1.00
	90%ile	385.80	893.40	344.00	89.10	-	98.60	3.14	2.80	2.69	17.80	16.64	17.70	113.18	112.98	114.98	8.12	7.71	7.98	2.80	4.20	1.40	1.00	1.00	1.00
	95%ile	402.90	907.20	369.50	91.05	-	101.30	3.17	3.15	2.90	18.70	17.87	18.60	119.69	121.29	122.39	8.13	7.76	8.10	3.40	5.10	1.70	1.00	1.00	1.00
	Max	420.00	921.00	395.00	93.00	-	104.00	3.20	3.50	3.10	19.60	19.10	19.50	126.20	129.60	129.80	8.13	7.81	8.21	4.00	6.00	2.00	1.00	1.00	1.00
	StDev	133.85	296.66	129.98	47.64	-	52.48	0.73	0.86	0.52	3.94	3.52	4.00	11.66	11.55	11.23	0.28	0.14	0.32	1.54	2.27	0.75	0.19	0.19	0.19
	95% C.I.	99.16	219.77	96.29	46.69	-	51.43	0.54	0.63	0.46	2.92	2.61	2.96	8.64	8.55	8.32	0.21	0.10	0.24	1.14	1.68	0.55	0.14	0.14	0.14
	Guideline																								
	%compliance																								
	N. of Samples	7	7	7	4	0	4	7	7	5	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7

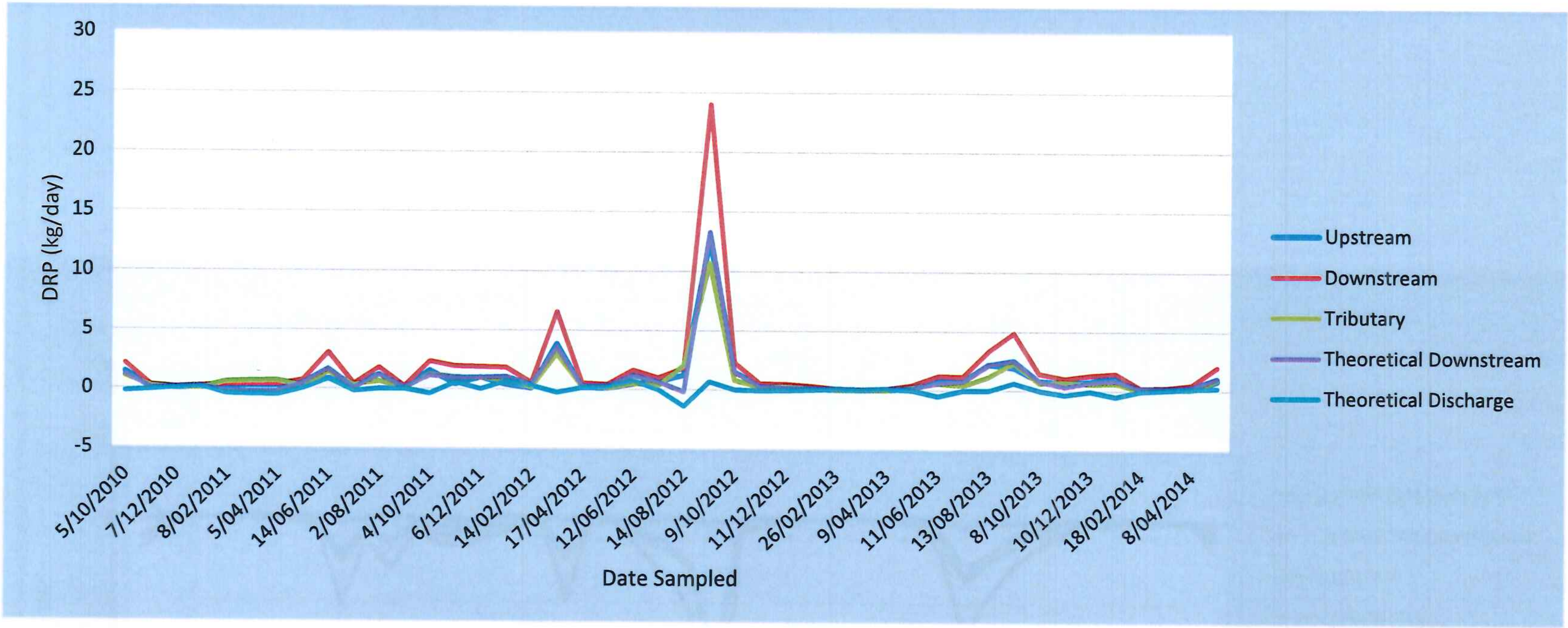
		TSS			AMM			TN			Nitrate			Nitrite			DRP			TP			SIN		
		U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S
BELOW HALF MEDIAN	Average	1.79	2.04	1.18	0.01	0.01	0.02	0.23	0.63	0.39	0.05	0.37	0.14	0.00	0.01	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.06	0.39	0.16
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.23	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00
	5%ile	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.24	0.21	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.02	0.00
	10%ile	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.29	0.24	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.04	0.01
	20%ile	0.00	0.50	0.00	0.00	0.00	0.00	0.15	0.34	0.30	0.00	0.07	0.03	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.01	0.09	0.04
	25%ile	0.00	0.50	0.38	0.00	0.00	0.00	0.16	0.42	0.30	0.00	0.14	0.03	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.01	0.15	0.04
	50%ile (median)	1.00	1.00	1.00	0.01	0.00	0.01	0.23	0.60	0.35	0.01	0.23	0.05	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.03	0.26	0.07
	75%ile	2.75	1.25	1.10	0.01	0.01	0.03	0.24	0.75	0.44	0.04	0.55	0.19	0.00	0.01	0.01	0.00	0.01	0.01	0.02	0.03	0.03	0.05	0.56	0.22
	90%ile	5.00	5.60	3.00	0.02	0.02	0.03	0.31	0.98	0.55	0.07	0.77	0.25	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.04	0.04	0.08	0.78	0.27
	95%ile	5.50	8.70	3.25	0.02	0.04	0.04	0.41	1.20	0.65	0.16	1.03	0.43	0.01	0.02	0.01	0.01	0.01	0.02	0.04	0.04	0.04	0.17	1.04	0.44
	Max	7.00	12.00	4.00	0.02	0.07	0.04	0.54	1.50	0.94	0.41	1.37	0.81	0.01	0.03	0.01	0.01	0.01	0.02	0.05	0.04	0.05	0.43	1.37	0.83
	StDev	2.27	3.25	1.18	0.01	0.02	0.01	0.10	0.33	0.18	0.10	0.37	0.20	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.10	0.37	0.20
	95% C.I.	1.11	1.59	0.58	0.00	0.01	0.01	0.05	0.16	0.09	0.05	0.18	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.05	0.18	0.10
	Guideline																								
	%compliance																								
	N. of Samples	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16

		E. coli			Enterococci			Black Disc			Temperature			DO Saturation			pH			POM			sCBOD5		
		U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S	U/S	Trib	D/S
BELOW HALF MEDIAN	Average	180.93	193.69	204.71	74.46	#DIV/0!	63.23	2.06	2.19	2.27	15.34	14.67	15.54	91.51	95.31	97.29	7.60	7.60	7.65	1.34	1.46	1.11	0.93	0.81	0.81
	Min	25.00	21.00	36.00	3.00	0.00	2.00	1.00	1.04	1.84	9.80	8.80	9.50	76.20	75.00	87.30	5.84	7.11	7.47	0.00	0.00	0.00	0.25	0.25	0.25
	5%ile	28.75	23.25	38.25	3.60	#NUM!	2.60	1.30	1.17	1.84	10.25	9.55	9.88	78.65	83.63	89.10	7.00	7.33	7.49	0.00	0.00	0.00	0.25	0.25	0.25
	10%ile	30.50	32.00	44.00	4.00	#NUM!	3.20	1.57	1.31	1.85	11.55	10.80	11.35	81.86	87.30	90.00	7.41	7.41	7.50	0.00	0.00	0.00	0.25	0.25	0.25
	20%ile	75.00	43.00	71.00	5.60	#NUM!	4.00	1.89	1.70	1.90	12.90	12.00	13.00	86.54	89.80	90.70	7.45	7.45	7.50	0.00	0.00	0.00	0.25	0.25	0.25
	25%ile	87.00	49.00	78.50	8.00	#NUM!	4.00	1.94	1.72	1.90	12.90	12.30	13.08	87.10	90.10	91.00	7.47	7.46	7.52	0.00	0.38	0.38	0.63	0.81	0.81
	50%ile (median)	117.00	140.00	118.50	32.00	#NUM!	16.00	2.00	2.37	2.10	16.10	15.35	15.75	92.50	94.75	97.90	7.65	7.64	7.63	1.00	1.00	1.00	1.00	1.00	1.00
	75%ile	196.25	291.00	239.50	64.00	#NUM!	57.00	2.10	2.51	2.56	17.68	16.35	18.83	96.40	101.43	102.90	7.80	7.71	7.71	1.90	1.25	1.10	1.00	1.00	1.00
	90%ile	295.40	328.20	496.00	90.40	#NUM!	72.00	2.75	2.84	2.93	18.40	18.20	19.05	98.02	105.85	105.85	8.12	7.75	7.89	3.50	4.40	2.50	1.00	1.00	1.00
	95%ile	453.25	439.25	671.80	278.40	#NUM!	244.80	2.86	3.01	2.97	18.98	18.50	19.18	100.72	108.30	106.85	8.32	7.86	8.02	4.25	5.40	3.20	1.60	1.00	1.00
	Max	913.00	767.00	689.20	552.00	#NUM!	504.00	2.96	3.20	3.01	19.50	19.10	19.40	105.90	109.50	107.90	8.33	8.09	8.03	5.00	6.00	3.80	3.00	1.00	1.00
	StDev	213.25	191.90	205.01	146.63	#DIV/0!	134.87	0.51	0.64	0.44	2.97	3.00	3.25	7.69	8.65	6.62	0.55	0.22	0.17	1.55	1.86	1.07	0.66	0.34	0.34
	95% C.I.	104.49	94.03	100.45	79.71	#DIV/0!	73.32	0.28	0.36	0.24	1.45	1.47	1.59	3.89	4.24	3.25	0.27	0.11	0.08	0.76	0.91	0.52	0.34	0.16	0.16
	Guideline																								
	%compliance																								
	N. of Samples	16	16	16	13	0	13	13	12	13	16	16	16	15	16	16	16	16	16	16	16	16	15	16	16

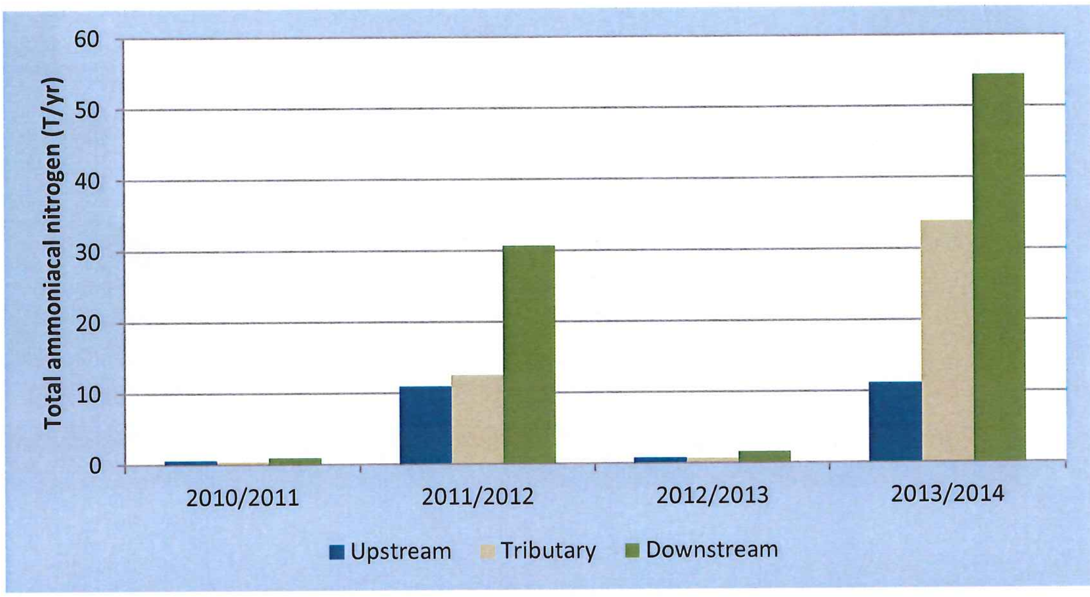
Appendix B: Total Ammoniacal Nitrogen, Soluble Inorganic Nitrogen (SIN) and Dissolved Reactive Phosphorus (DRP) daily loads in kg/day for sites upstream and downstream of the Eketahuna WWTP discharge point as well as within the Ngatahaka Creek tributary, theoretical downstream and discharge loads calculated from data collected on matched days between October 2010 and May 2014.

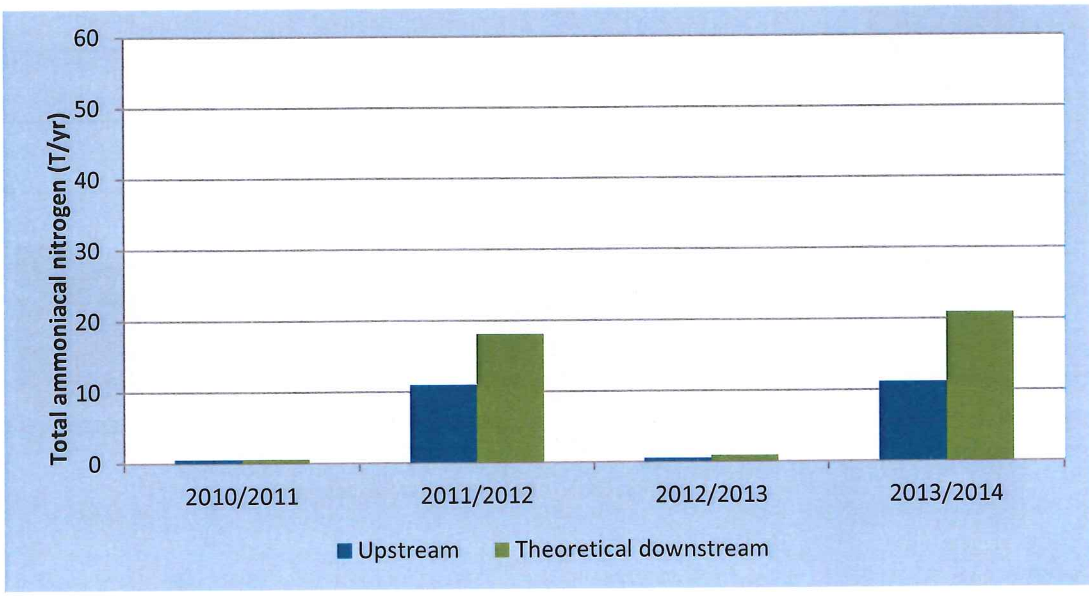


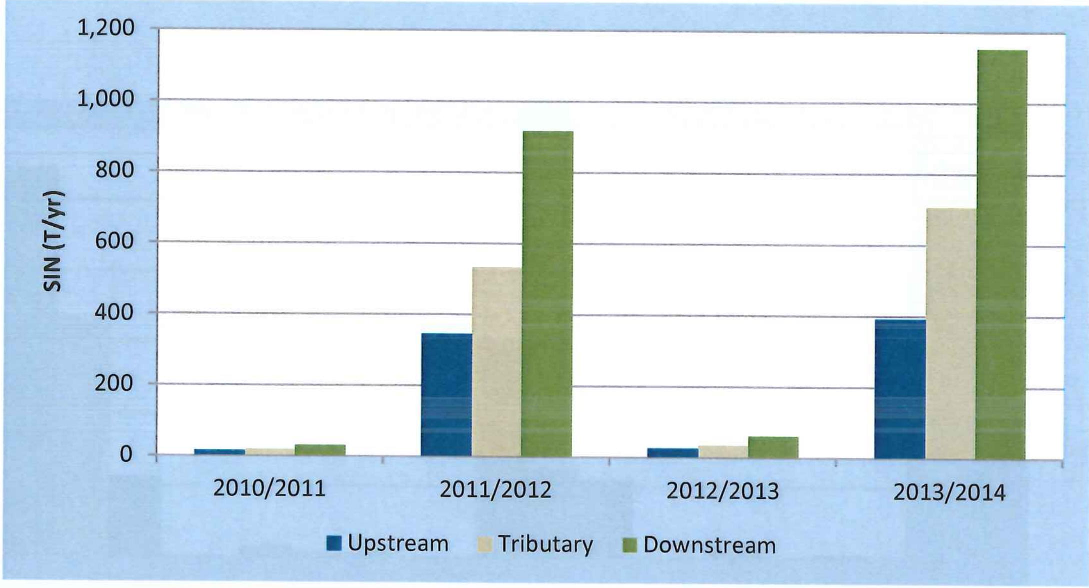

2000
1500
1000
500
0
-500
SIN (kg/day)
5/10/2010
7/12/2010
8/02/2011
5/04/2011
14/06/2011
2/08/2011
4/10/2011
6/12/2011
14/02/2012
17/04/2012
12/06/2012
14/08/2012
9/10/2012
11/12/2012
26/02/2013
9/04/2013
11/06/2013
13/08/2013
8/10/2013
10/12/2013
18/02/2014
8/04/2014
Date Sampled
Upstream
Downstream
Tributary
Theoretical Downstream
Theoretical Discharge

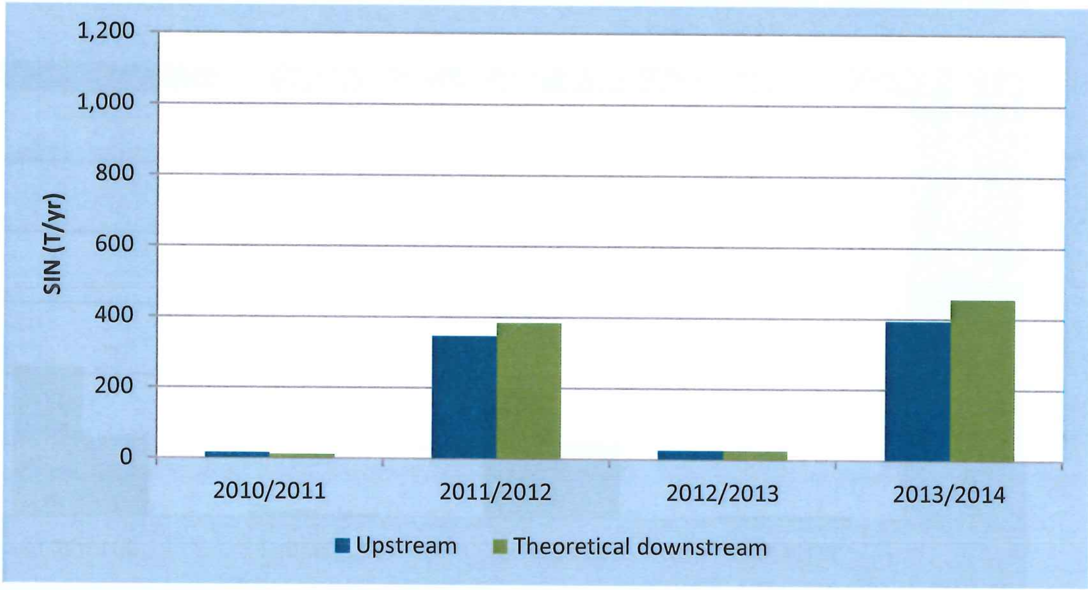

30
25
20
15
10
5
0
-5
DRP (kg/day)
5/10/2010
7/12/2010
8/02/2011
5/04/2011
14/06/2011
2/08/2011
4/10/2011
6/12/2011
14/02/2012
17/04/2012
12/06/2012
14/08/2012
9/10/2012
11/12/2012
26/02/2013
9/04/2013
11/06/2013
13/08/2013
8/10/2013
10/12/2013
18/02/2014
8/04/2014
Date Sampled
Upstream
Downstream
Tributary
Theoretical Downstream
Theoretical Discharge

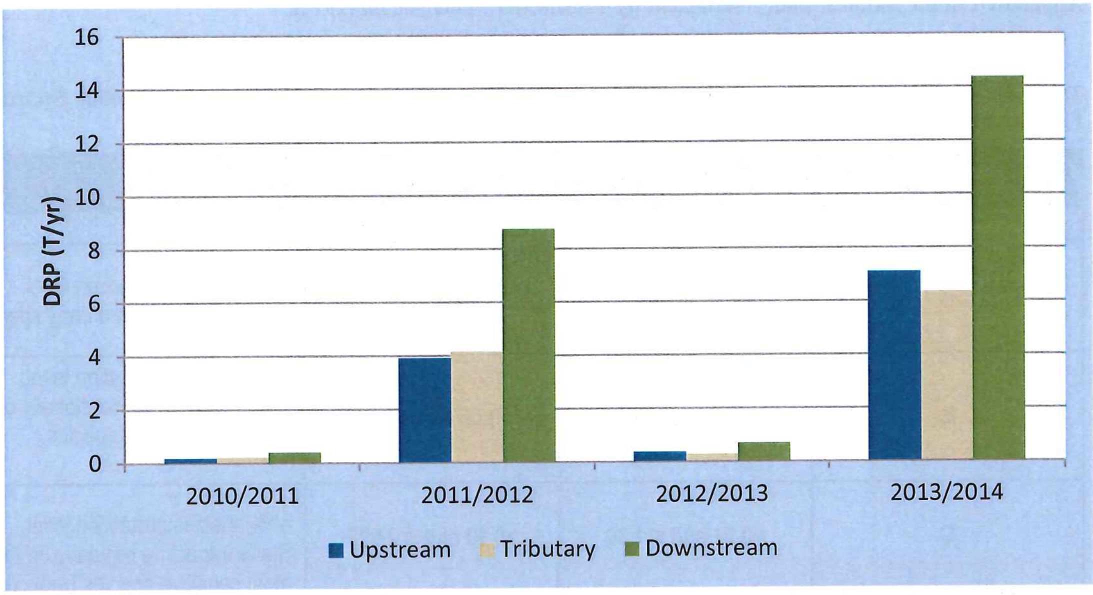
Appendix C: Total Ammoniacal Nitrogen, Soluble Inorganic Nitrogen (SIN) and Dissolved Reactive Phosphorus (DRP) annual loads in tons/year for sites upstream and downstream of the Eketahuna WWTP discharge point as well as within the Ngatahaka Creek tributary (2010 - 2014).

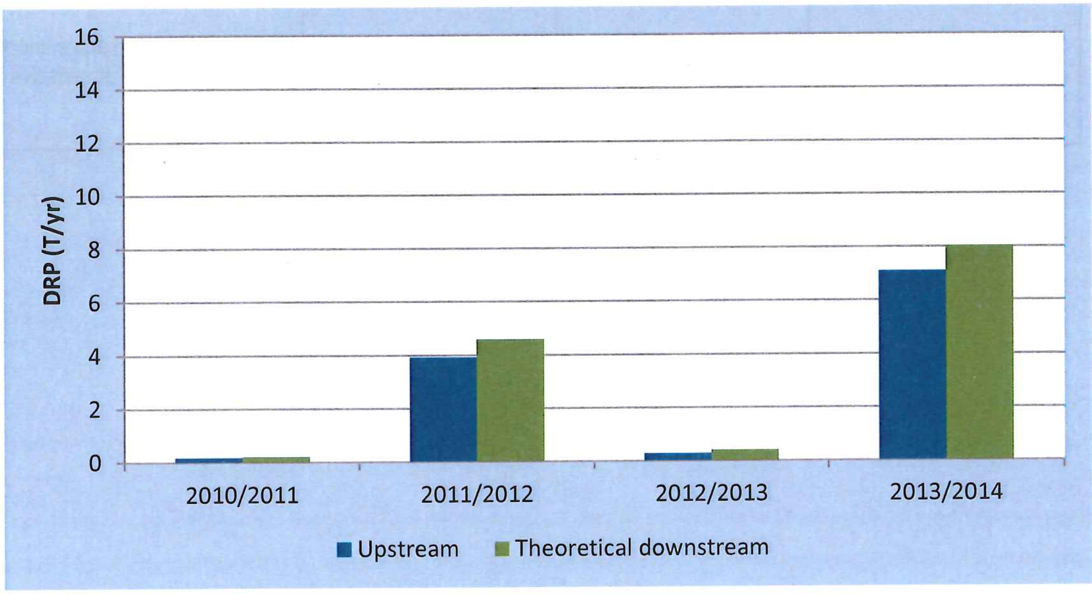





1,200
1,000
800
600
400
200
0
SIN (T/yr)
2010/2011
2011/2012
2012/2013
2013/2014
Upstream
Tributary
Downstream


1,200
1,000
800
600
400
200
0
SIN (T/yr)
2010/2011
2011/2012
2012/2013
2013/2014
Upstream
Theoretical downstream


16
14
12
10
8
6
4
2
0
DRP (T/yr)
2010/2011
2011/2012
2012/2013
2013/2014
Upstream
Tributary
Downstream


16
14
12
10
8
6
4
2
0
DRP (T/yr)
2010/2011
2011/2012
2012/2013
2013/2014
Upstream
Theoretical downstream

Appendix D: Summary of Attribute States for Total Ammoniacal Nitrogen, Nitrate, *E.coli* and Periphyton, copied from Appendix 2 of the National Policy Statement for Freshwater Management (2014).

Table 1: Attribute states for Ammonia (Toxicity) taken from Appendix 2 of the National Policy Statement for Freshwater management (2014).

Attribute State	Numeric Attribute State		Narrative Attribute State
	Annual Median*	**Annual 95th Percentile***	
A	≤ 0.03	≤ 0.05	99% species protection level. No observed effect on any species.
B	>0.03 and ≤ 0.24	>0.05 and ≤ 0.40	95% species protection level. Starts impacting occasionally on the 5% most sensitive species.
C	>0.24 and ≤ 1.30	>0.40 and ≤ 2.020	80% species protection level. Starts impacting regularly on the 20% most sensitive species (reduced survival of most sensitive species).
National Bottom Line	**1.30**	**2.20**	
D	>1.30	>2.20	Starts approaching acute impact level (i.e. risk of death) for sensitive species.

*Based on pH 8 and temperature of 20°C
Compliance with the numeric attribute states should be undertaken after pH adjustment.

Table 2: Attribute states for Nitrate (Toxicity) taken from Appendix 2 of the National Policy Statement for Freshwater management (2014).

Attribute State	Numeric Attribute State		Narrative Attribute State
	Annual Median	**Annual 95th Percentile**	
A	≤ 1.0	≤ 1.5	High conservation value system. Unlikely to be effects even on sensitive species.
B	>1.0 and ≤ 2.4	>1.5 and ≤ 3.5	Some growth effect on up to 5% of species.
C	>2.4 and ≤ 6.9	>3.5 and ≤ 9.8	Growth effects on up to 20% of species (mainly sensitive species such as fish). No acute effects.
National Bottom Line	**6.9**	**9.8**	
D	>6.9	>9.8	Impacts on growth of multiple species, and starts approaching acute impact level (i.e. risk of death) for sensitive species at higher concentrations (> 20 mg/L).

Table 3: Attribute states for *E.coli* taken from Appendix 2 of the National Policy Statement for Freshwater management (2014).

Attribute State	Numeric Attribute State	Sampling Statistic	Narrative Attribute State
A	≤ 260	Annual median	People are exposed to a very low risk of infection (less than 0.1% risk) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating).
		95th percentile	People are exposed to a low risk of infection (less than 1% risk) when undertaking activities likely to involve full immersion.
B	>260 and ≤ 540	Annual median	People are exposed to a low risk of infection (less than 1% risk) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating).
		95th percentile	People are exposed to a moderate risk of infection (less than 5% risk) when undertaking activities likely to involve full immersion. 540/100 ml is the **minimum acceptable state** for activities likely to involve full immersion.
C	>540 and ≤ 1,000	Annual median	People are exposed to a moderate risk of infection (less than 5% risk) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating). People are exposed to a high risk of infection (greater than 5% risk) from contact with water during activities likely to involve full immersion.
National Bottom Line	**1,000**	Annual median	
D	>1,000	Annual median	People are exposed to a high risk of infection (greater than 5% risk) from contact with water during activities with occasional immersion and some ingestion of water (such as wading and boating).

Table 4: Attribute states for periphyton taken from Appendix 2 of the National Policy Statement for Freshwater management (2014).

Attribute State	Numeric Attribute State (Default Class)	Numeric Attribute State (Productive Class)	Narrative Attribute State
	Exceeded no more than 8% of samples	**Exceeded no more than17% of samples**	
A	≤ 50	≤ 50	Rare blooms reflecting negligible nutrient enrichment and/or alteration of the natural flow regime or habitat
B	>50 and ≤ 120	>50 and ≤ 120	Occasional blooms reflecting low nutrient enrichment and/or alteration of the natural flow regime or habitat
C	>120 and ≤ 200	>120 and ≤ 200	Periodic short-duration nuisance blooms reflecting moderate nutrient enrichment and/or alteration of the natural flow regime or habitat
National Bottom Line	**200**	**200**	
D	>200	>200	Regular and/or extended-duration nuisance blooms reflecting high nutrient enrichment and/or significant alteration of the natural flow regime or habitat

APPENDIX II – OPTIONS FOR UPGRADES REPORT

Eketahuna Sewage Treatment Plant Upgrade Options

OPUS

Tararua District Council

Eketahuna Sewage Treatment Plant
Upgrade Options

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Date: 22/08/2011
Reference: 5P0401.00
Status: Final

Approved for Release By

Guy Dennis
Business Manager, Palmerston North

Contents

1 Introduction and Key Results

1.1 Background

Eketahuna has an oxidation pond treatment system that was constructed in the 1970s to provide wastewater treatment for this rural service town which has a current population of around 460 people (Statistics NZ, 2006). While Eketahuna is infamous in New Zealand for being a quintessential example of the 'real New Zealand', gradual urban drift has contributed to a slowly declining population. The small population base means there are limited funds available for upgrade of the treatment system.

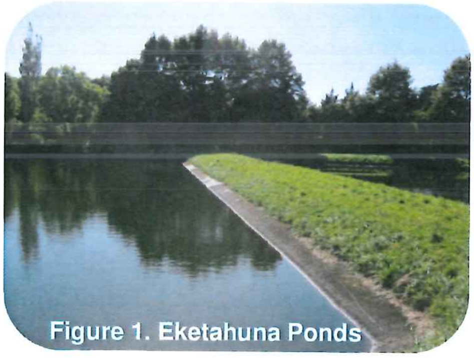


Figure 1. Eketahuna Ponds

Tararua District Council is currently in the process of obtaining a resource consent for the discharge of treated wastewater from Eketahuna's oxidation pond system. The application for resource consent was submitted in February 2005, and since that time the application has been on hold while further investigations and consultation have been completed.

An assessment of environmental effects was completed in 2006, and proposed a number of options for upgrading the treatment system. The preferred option consisted of a primary screen for removal of coarse solids, chemical dosing for reduction of phosphorus, ultraviolet disinfection for improvement of microbiological quality, and aerobic treatment for reduction of ammonia (Good Earth Matters 2006). While these systems were a substantial upgrade over the existing treatment system, no capital or operating costs were estimated to determine whether the proposal was affordable to the community.

Subsequent working group meetings appear to have had a reasonably positive response to the proposed treatment upgrades. Working on behalf of Horizons Regional Council, Olivier Ausseil provided a review of the 2006 assessment of environmental effects (Ausseil 2007), and generally concluded that the proposed upgrades would have a significant effect on helping the system achieve compliance under the Manawatu Catchment Water Quality (MCWQ) standards. Concerns that were raised by Ausseil included the effect of high flows on the discharge quality, the limited amount of monitoring data that was then available, and the effect of the discharge on the stream under low flow conditions.

Tararua District Council began the proposed upgrade by installing a primary screen in 2009. The design for the screen consisted of a deep wetwell with duty and standby pumps to raise the effluent to the level of the screen. Unfortunately the ongoing cost of the pump operation has been high, with monthly electricity costs around $1500. The high operating cost of the screen alone has led to concerns that the upgrades proposed in the 2006 assessment of environmental effects may be simply unaffordable for the Eketahuna community.


Figure 2. Discharge Point

1.2 Purpose of this Report

This report has been prepared to assist Tararua District Council in obtaining resource consent for the Eketahuna Sewage Treatment Plant system. Successfully gaining the resource consent will be achieved through managing the conflicting constraints on the treatment system. We consider that the conflicting constraints include: the MCWQ regulatory standards that are applicable now; allowing for future regulatory standards under the proposed One Plan; the effect of the discharge on the stream; the cost of the proposed upgrade, and the expectations of the community and interested parties.

The primary purpose of this report is to provide a higher degree of certainty around the capital and operating costs of the upgrade options for the sewage treatment plant. However, at an early stage in the work it became apparent that the required level of treatment had not been very well defined. Therefore, we have expanded the scope to include an assessment of the downstream water quality measurements, with the aim of determining which characteristics of the discharge are critical for achieving compliance with the MCWQ standards. This assessment carries on from the earlier work by Good Earth Matters (2006) and Ausseil (2007).

A further purpose of the report is to provide information about the capacity of the existing pond system and when de-sludging may be required. This was a direct request from Horizons Regional Council, and may be in response to concerns that the ponds have not been de-sludged to date (Ausseil 2007).

1.3 What is the Upgrade Trying to Achieve?

Based on our analysis, we consider that the upgrade of the Eketahuna sewage treatment system needs to achieve the following:

- Reduction of dissolved reactive phosphorus to a level where in-stream dissolved reactive phosphorus complies with MCWQ standards (for assumed 0.07 g/m^3 upstream concentrations of dissolved reactive phosphorus).
- Contribute to the achievement of One Plan guidelines for microbiological quality in the Makakahi River.
- Provide robust performance under high wet weather flows.
- Achieve overall environmental benefits, including consideration for the environmental footprint of the treatment plant
- Provide cost effective and affordable treatment.
- Have consideration for the proposed One Plan guidelines.

1.4 What are the main Options?

In our opinion, chemical dosing is currently the most practical and cost effective means of achieving the treatment aims. We have considered four methods of achieving phosphorus removal by chemical dosing:

- Direct pond dosing with ferric sulphate and T floc coagulant
- Conventional clarifier with ferric sulphate and T floc coagulant
- Actiflo sand-assisted clarifier system with alum and polyacrilimide dosing
- Dissolved air flotation (DAF) plant with alum and polyacrilimide dosing

1.5 How Much will it Cost?

For each upgrade option, net present value costs have been estimated based on a 30 year operating period. The cost is heavily dependent on the in-stream phosphorus levels that the discharge will need to achieve, as presented in Figure 3. Note that there are many assumptions behind this graph, and the results are intended to provide a relative indication of costs only. Assumptions have been listed in Section 2.8.

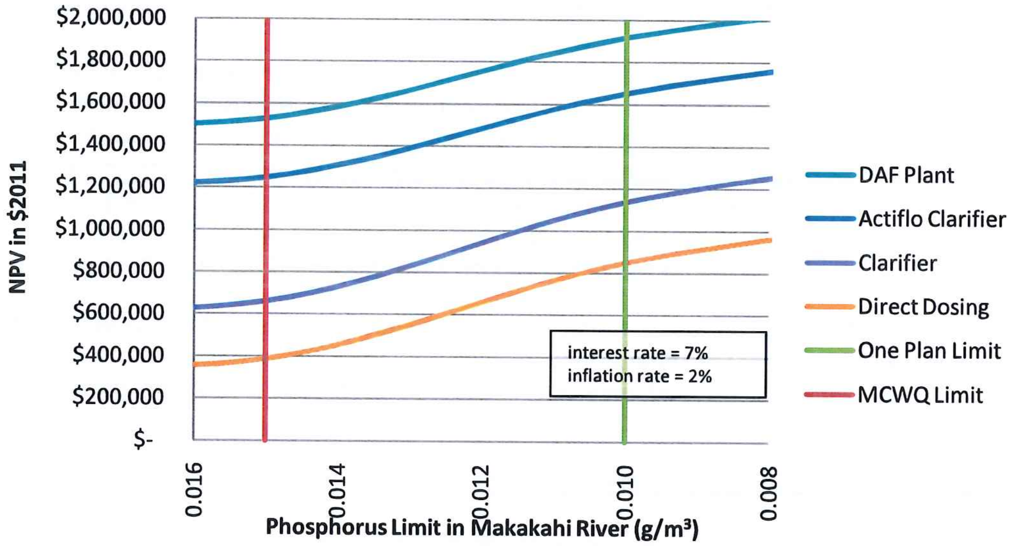


Figure 3. Effect of in-river phosphorus limit on net present value for each of the options

1.6 Where are main risks for Tararua District Council?

One of the challenges in completing this assessment has been the limited flow data available for the Eketahuna sewage treatment plant discharge. Operating costs are dependent on the total phosphorus load out of the treatment plant, which can only be accurately determined from the concentration and the flow rate. In the meantime we have estimated loads based on population loading rates, but recommend that flow monitoring equipment be installed so that cost estimates (and proposed resource consent conditions) can be refined.

The other main uncertainty in our analysis is that it may not reflect the complexity of practical phosphorus removal chemistry, particularly at low phosphorus concentrations. We have based our analysis on standard stoichiometric relationships, plus an allowance for overdosing at low phosphorus concentrations. Onsite jar testing and dosing trials are needed to confirm dose rates.

Proposed options that rely on ferric sulphate and TFloc for precipitation will need a period of onsite trials to confirm feasibility and optimum chemical combination. For the clarifier option, a pilot scale clarifier will be needed to assist with sizing and ensure the performance is acceptable. For the direct pond dosing option, trails will be needed to make sure there is no deterioration in pond performance (such as BOD breakthrough) caused by the reduction of algal cells in the final pond.

2 Inputs and Assumptions

2.1 Planning Assessment

Due to the 2005 date of application for the resource consent, the sewage treatment plant discharge is covered by the Manawatu Catchment Water Quality standards. A summary of these standards is provided in Appendix C, along with the latest One Plan guidelines. While the discharge must comply with the MCWQ standards, consideration also needs to be given to the One Plan guidelines which many need to be complied with in the future.

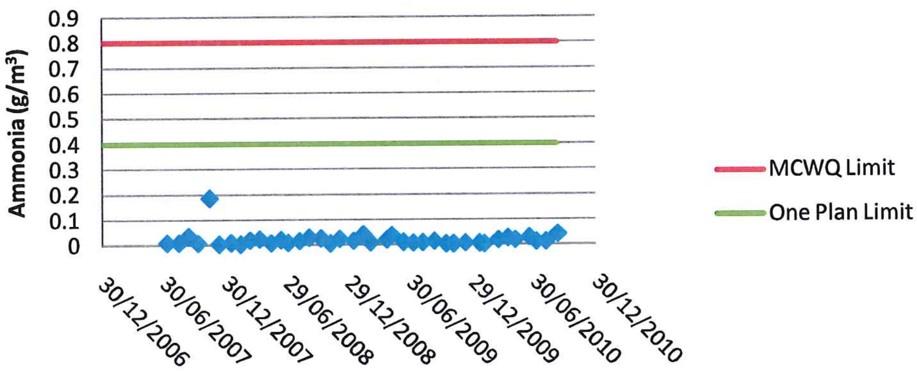
2.2 River Monitoring

2.2.1 Downstream Results

This assessment of downstream water quality is based on all monitoring data held in Horizon's database as at May 2011, and should be read in conjunction with the 2006 assessment of environmental effects (Good Earth Matters) and Horizons review (Ausseil 2007).

There is some concern (Ausseil 2007) that the downstream monitoring results have been taken from a site around 700m downstream rather than from a point close to the end of the mixing zone. While there may be some validity to this concern, the water quality database provides the best available assessment of the quality of the river water following mixing with the oxidation pond effluent.

We have completed this assessment to determine which characteristics of the discharge are critical for achieving compliance with the MCWQ standards. Results of the monitoring are presented in Figure 4, along with the relevant limits from the Manawatu Catchment Plan standards and One Plan guidelines.



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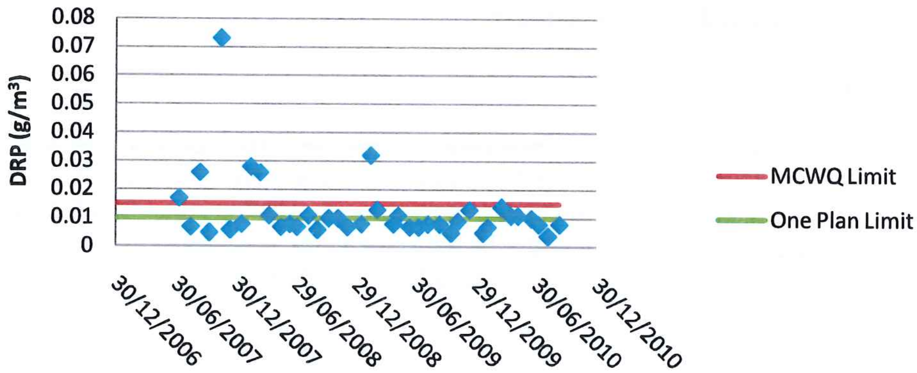
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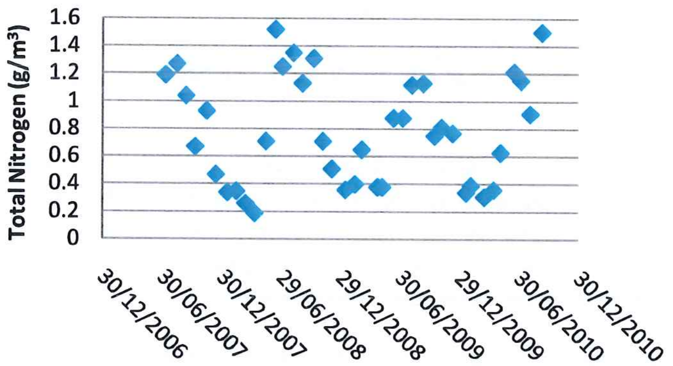
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
30/12/2006
30/06/2007
30/12/2007
29/06/2008
29/12/2008
30/06/2009
29/12/2009
30/06/2010
30/12/2010
MCWQ Limit
One Plan Limit

(b)


Total Nitrogen (g/m³)
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1.4
1.2
1
0.8
0.6
0.4
0.2
0
30/12/2006
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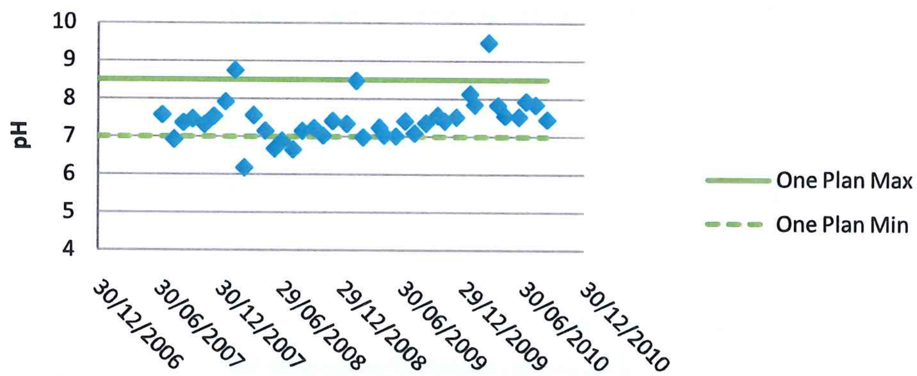
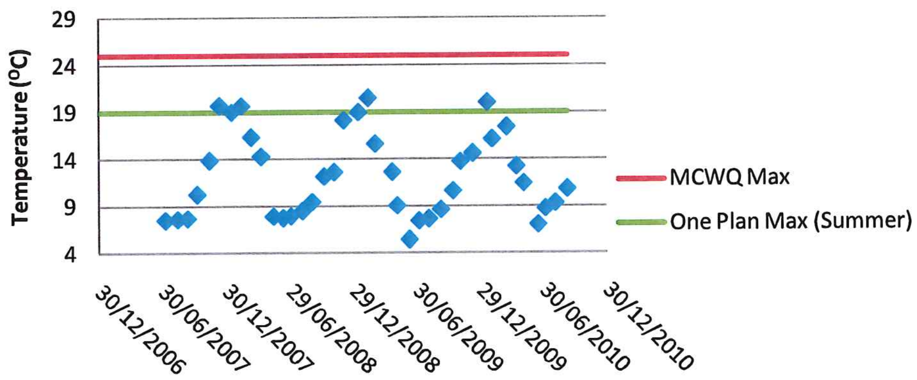
29/06/2008
29/12/2008
30/06/2009
29/12/2009
30/06/2010
30/12/2010

(c)


pH
10
9
8
7
6
5
4
30/12/2006
30/06/2007
30/12/2007
29/06/2008
29/12/2008
30/06/2009
29/12/2009
30/06/2010
30/12/2010
One Plan Max
One Plan Min

(d)


Temperature (°C)
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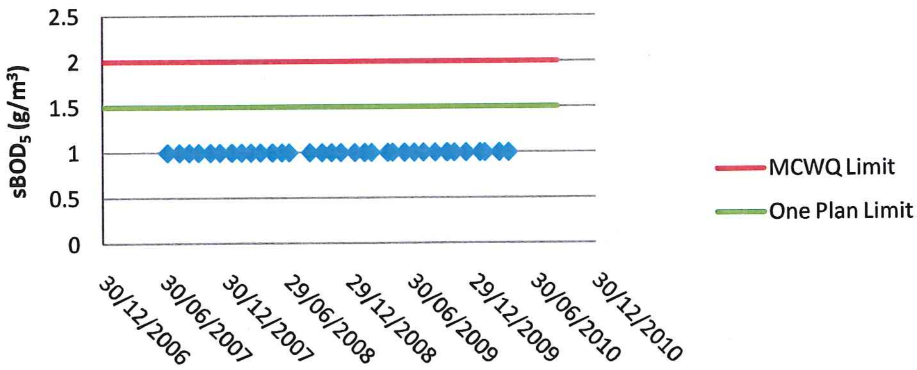
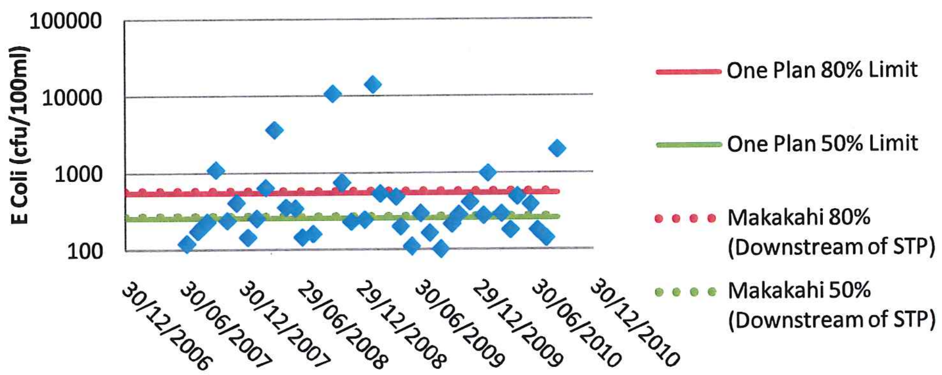
24
19
14
9
4
30/12/2006
30/06/2007
30/12/2007
29/06/2008
29/12/2008
30/06/2009
29/12/2009
30/06/2010
30/12/2010
MCWQ Max
One Plan Max (Summer)

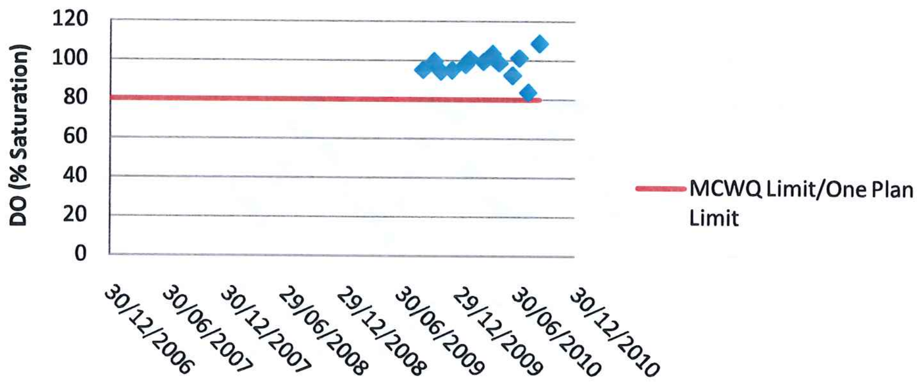
(e)


sBOD5 (g/m3)
2.5
2
1.5
1
0.5
0
30/12/2006
30/06/2007
30/12/2007
29/06/2008
29/12/2008
30/06/2009
29/12/2009
30/06/2010
30/12/2010
MCWQ Limit
One Plan Limit

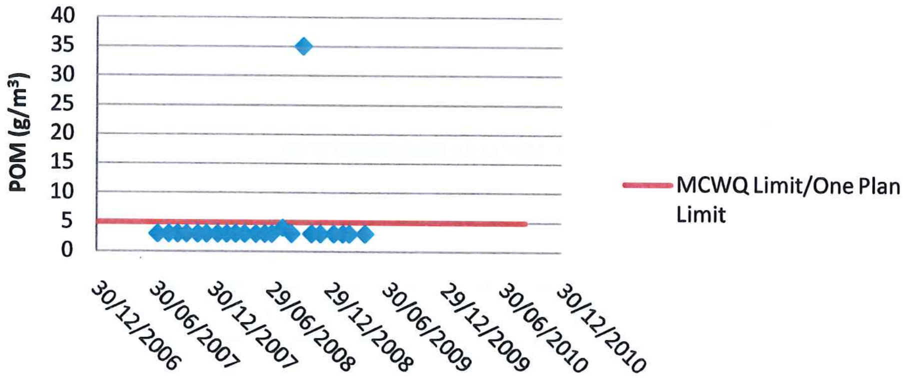
(f)


E Coli (cfu/100ml)
100000
10000
1000
100
30/12/2006
30/06/2007
30/12/2007
29/06/2008
29/12/2008
30/06/2009
29/12/2009
30/06/2010
30/12/2010
One Plan 80% Limit
One Plan 50% Limit
Makakahi 80% (Downstream of STP)
Makakahi 50% (Downstream of STP)

(g)



(h)



(i)

Figure 4. Graphs presenting monitoring results from a site roughly 700m downstream of the sewage treatment plan. Data is from the Horizons database as at May 2011.

2.2.2 Conclusions from downstream monitoring results

Without attempting to remove measurements that may be a result of high upstream concentrations, the following broad observations can be made about the quality of the water compared to MCWQ standards and the proposed One Plan guidelines:

- Ammonia levels have been consistently below the One Plan guidelines, and well below MCWQ standards.
- Only a limited number of dissolved oxygen measurements are available; however so far these have all been above the 80% saturation limit, indicating well oxygenated conditions.
- Soluble $cBOD_5$ levels have been consistently below the One Plan guidelines and below MCWQ standards.
- Maximum temperatures have remained below the MCWQ limit. The stricter proposed One Plan guideline has been exceeded on several occasions.
- Ecoli levels are above, but very close to, the proposed One Plan guidelines for 80th and 50th percentiles (MCWQ standard have not been included since these were

based on Enterococci, which are no longer regarded as the preferred indicator organism for freshwater rivers).

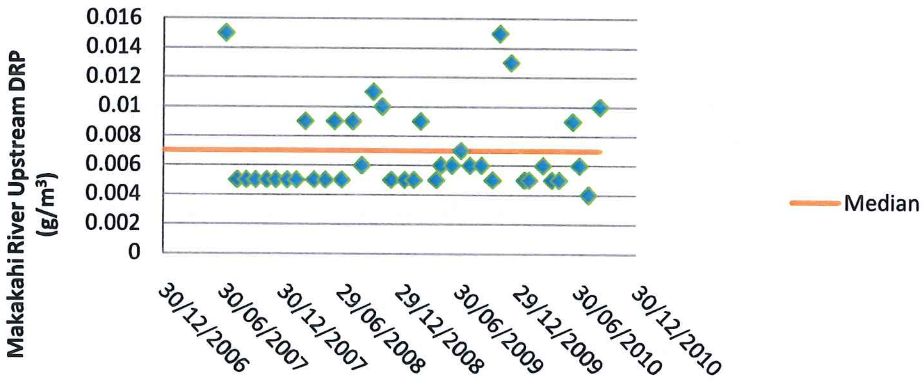
- Dissolved reactive phosphorus levels have exceeded the MCWQ standard of 0.015g/m^3 on around seven occasions, and have regularly been above the proposed One Plan guideline of 0.01 g/m^3.
- Total nitrogen levels are around one to two orders of magnitude greater than dissolved reactive phosphorus levels, which is consistent with a phosphorus-limited river.
- pH measurements have exceeded both maximum and minimum guidelines for the proposed One Plan; however, they have generally remained within the guideline.
- Particulate organic matter has remained below the guideline of 5 g/m^3, except for one occasion when a level of 35 g/m^3 was observed.

As a result of the observations above, and taking into account the natural pond based treatment system that is utilised at Eketahuna, the following conclusions are proposed:

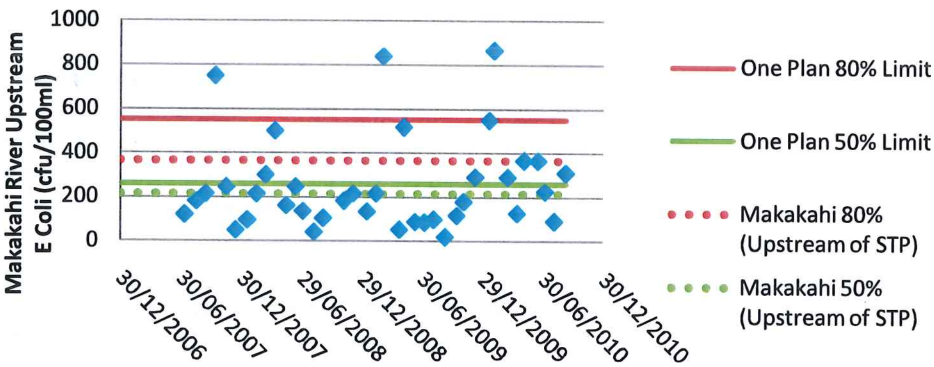
- Dissolved reactive phosphorus levels in the Makakahi River need to be lowered if they are to comply with the MCWQ standards. A further and more dramatic reduction would be needed to achieve the proposed One Plan guidelines.
- E coli levels in the river are close to complying with the proposed One Plan guidelines, and a small reduction would bring these under the proposed One Plan guidelines.
- The temperature of the water currently appears to comply with MCWQ standards. As the pond based treatment system is not expected to contribute significantly to temperature pollution, no further analysis of temperature is proposed.
- pH levels in the river water are variable, and may be partly influenced by the Eketahuna sewage treatment system. Treatment adjustments that will promote a neutral pH may have benefits for the river system.
- The treatment process does not need to focus on further reductions in ammonia, dissolved oxygen and particulate organic matter.

2.2.3 Upstream Results

Results for dissolved reactive phosphorus and E coli are presented here (for the Makakahi River). Results from the Ngatahaka Creek have not been included since these were not available from the combined database. Further analysis of upstream results, including results from the Ngatahaka Creek are presented in Good Earth Matters (2008) and Good Earth Matters (2009). The upstream Makakahi River contributes around 70% of the flow (Ausseil 2007, page 12).



(a)



(b)

Figure 5. Graphs presenting monitoring results from the Makakahi River, upstream of the discharge point

2.2.4 Conclusions from Upstream Results

The following conclusions can be made about the effect of the wastewater treatment plant on the downstream water quality:

- Dissolved reactive phosphorus levels are elevated below the wastewater treatment plant, relative to upstream levels in the Makakahi River.
- E coli levels are elevated below the wastewater treatment plant, relative to upstream levels in the Makakahi River.

2.3 Flow Monitoring

2.3.1 Sewage Treatment Plant

Previous work at the Eketahuna site has involved installing a mechanical screen system and moving the magnetic flow-meter to a gravity line between the screen and the pond system. Unfortunately this upgrade was incorrectly designed and the pipe system does not stay sufficiently full for the flowmeter to read correctly. Therefore there is very little flow data available from the pond system. A limited amount of flow data was presented as part of the 2006 Assessment of Environmental Effects, and this is reproduced below in Figure 6.

The flow assessment completed as part of the Assessment of Environmental Effects (GEM 2006) determined the following flows:

Average Dry Weather Flow	300 m3/day
Average Wet Weather Flow	1,100 m3/day
Peak Wet Weather Flow (90th Percentile)	2,500 m3/day

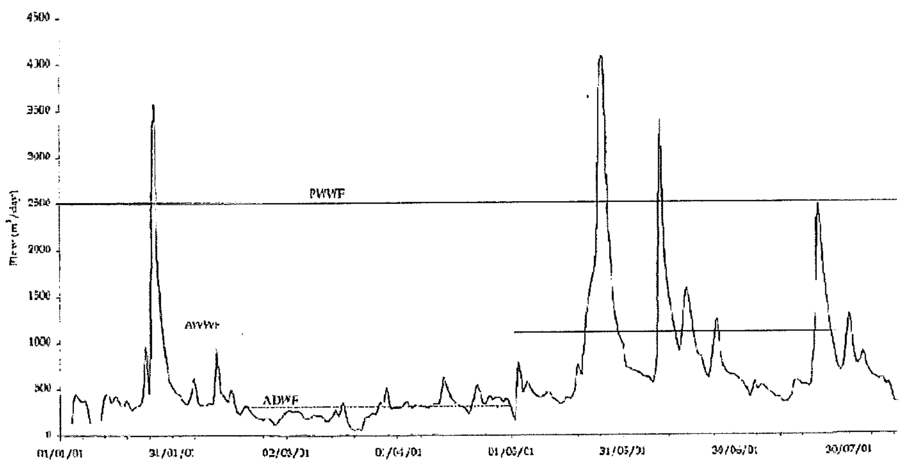


Figure 6 Sewage treatment plant flows, reproduced from Assessment of Environmental Effects (Good Earth Matters, 2006)

Flow rates through the sewage treatment plant are high, and suggest substantial groundwater and stormwater infiltration under most conditions. Unfortunately the length of the flow record is not sufficient to allow a more thorough statistical analysis of the flows.

To provide a context to other New Zealand systems, flow rates for Porangahau, Te Paerahi, Featherston and Masterton are presented in Table 1.

Table 1. Comparison of Flowrates for New Zealand Towns

	Eketahuna	Porangahau	Masterton[1]	Martinborough[2]
ADWF (m^3 per head of population)	0.64	0.25	0.35	0.4
PWWF (m^3 per head of population)	5.4	2.9	1.8	2.2

2.3.2 Makakahi River Flow Monitoring

There are no continuous flow records available for either the Makakahi River or Ngatahaka Creek in the vicinity of the discharge from the Eketahuna waste water treatment facility. The nearest flow site is on the Makakahi River at Hamua, a considerable distance downstream (Figure 7). The catchment area at Hamua is approximately 163km², which is over twice the size of the catchment upstream of the Makakahi-Ngatahaka confluence at the waste water treatment facility.

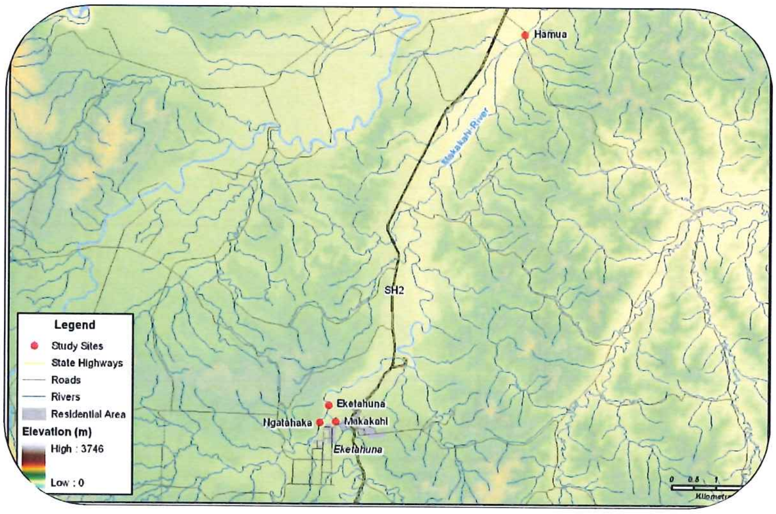


Figure 7. Location of the various flow sites.

To provide estimates of the Makakahi River flows in the vicinity of Eketahuna's waste water treatment facility, downstream flows were scaled based on a simple ratio of the catchment areas. Results and further descriptions of this analysis are included in Appendix A.

[1] Beca, Homebush Oxidation Pond Location Report
[2] NZET, Masterton Resource Consent Application

2.3.3 River Flow Monitoring and Comparison to STP Flows

The high flow rates through the sewage treatment plant have a number of implications for the treatment of the wastewater:

- The method of treatment must be stable under high flows. This suggests a pond-based treatment method is ideal, as facultative and maturation ponds are stable even under very dilute pond loadings. This is demonstrated by the fact that ponds are generally commissioned by filling with clean stormwater or river water (unlike activated sludge plants which may become unstable under dilute inflow).
- The higher flow rates through the sewage treatment plant will correspond with higher flows through the Makakahi River. This relationship between the STP flows and the Makakahi River flows needs to be understood to set the maximum flows that the sewage treatment plant will need to treat. In particular, the MCWQ phosphorus limit only applies up to half the median flow in the river. It would be advantageous to know the typical or most probable flow out of the sewage treatment plant when the river is at half median flow.

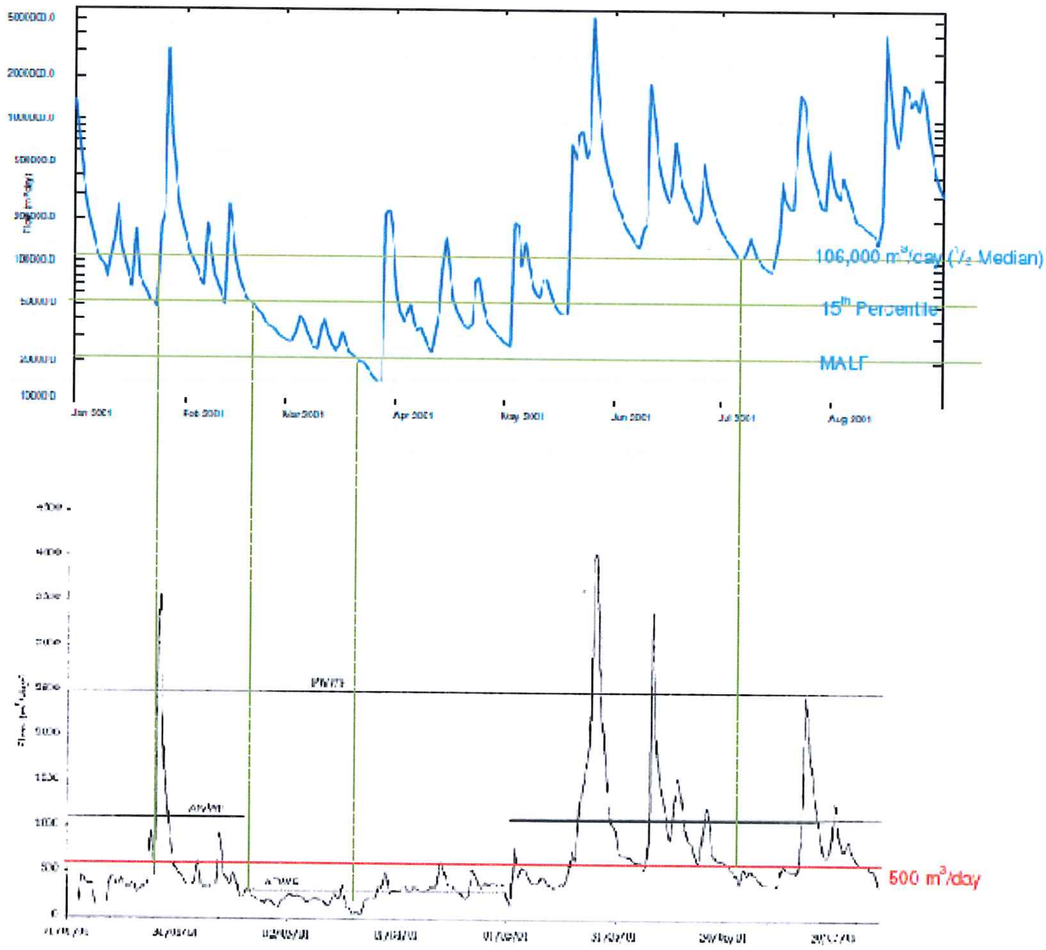


Figure 8. Rough comparison of Makakahi River Flows (log scale) to Eketahuna sewage treatment plant inflows (normal scale).

A rough comparison of river flows to the (very short) available flow record for Eketahuna sewage treatment plant flows is presented in Figure 8. Based on the short flow record, we tentatively suggest the following estimated STP flows for the following river flows, as presented in Table 2

Table 2. Preliminary Flow Analysis

Makakahi River Flow Downstream of Eketahuna STP	Estimated Flow from Eketahuna STP	Dilution
Mean annual low flow (20736 m^3/day)	125 m^3/day	166
15th Percentile flow (53914 m^3/day)	300 m^3/day	179
Half median flow (106272 m^3/day)	500 m^3/day	212

Additional flow monitoring of the STP flows is needed to allow the relationship to Makakahi river flows to be confirmed by statistical analysis. It remains, however, that it is unrealistic to expect that high sewer outflows occur concurrently with low river flows .

2.4 Phosphorus Dilution Assessment

2.4.1 Estimated Downstream Phosphorus Levels

Out of all of the contaminants presented in Figure 4, dissolved reactive phosphorus is the contaminant that exceeds the MCWQ standard by the greatest amount. Understanding the contribution of the sewage treatment plant to the in-stream phosphorus concentrations requires that the amount of phosphorus discharged is known, rather than the concentration. Due to the very limited amount of flow data available for the Eketahuna ponds, phosphorus loading has been assessed on a population based loading rate, as presented in Table 3 .

Table 3. Estimated DRP Loading for Eketahuna

Population	TP Loading	DRP//TP	Estimated DRP Loading
467people	3g/person/day	0.65	0.91 kg/day

The estimated downstream DRP levels are presented in Table 4. DRP levels are expected to exceed MCWQ guidelines when the river flow rate drops below half median flow.

Table 4. Estimated Downstream DRP Levels

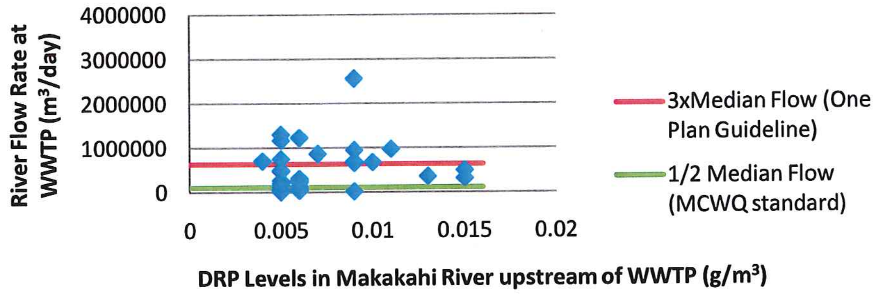
Case	River Flow (m3/day)	Upstream DRP (g/m3)	Effluent DRP (g/day)	Downstream DRP (g/m3)
Minimum Flow	6048	0.007	907	0.157
MALF	20736	0.007	907	0.051
15th Percentile	53914	0.007	907	0.024
1/2 Median	106272	0.007	907	0.016
Median	212544	0.007	907	0.011
2 x Median	425088	0.007	907	0.009
3 x Median	637632	0.007	907	0.008

We have assumed that total phosphorus levels do not decrease through the pond system, as in our experience it is relatively unusual to observe consistent total phosphorus reductions through pond systems (it may occur in some situations such as high hardness and high pH, but additional monitoring would be needed to assess whether this is a significant mechanism at Eketahuna). The following additional assumptions were made:

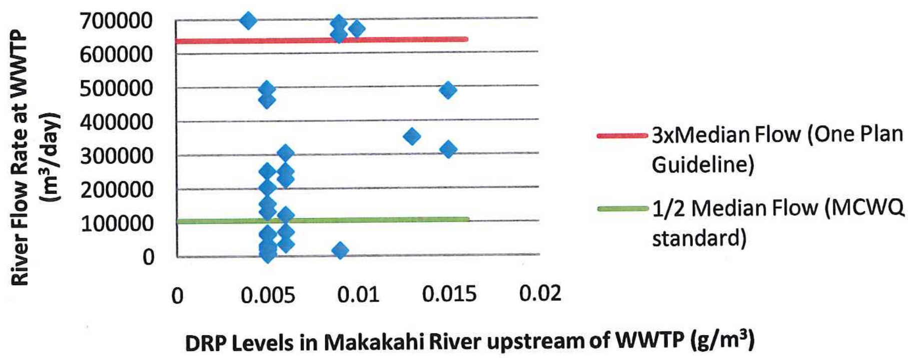
- A total phosphorus loading of 3 g/person/day was assumed, based on Ministry for the Environment guidelines for small communities (2003).
- The ratio of dissolved reactive phosphorus to total phosphorus was assumed to be 0.65 in the pond effluent. Actual pond effluent monitoring shows the ratio has varied between 0.2 and 0.9, with the median around 0.6. The value of 0.65 is therefore expected to provide a reasonable estimate of average dissolved reactive phosphorus loadings.
- Background upstream total phosphorus concentrations were assumed to be $0.007 g/m^3$, as suggested by Olivier Ausseil (2007, page 20) in his assessment of the 2007 Assessment of Environmental Effects. Further discussion on this assumption is given below.

2.4.2 Assumption for Upstream Phosphorus Levels

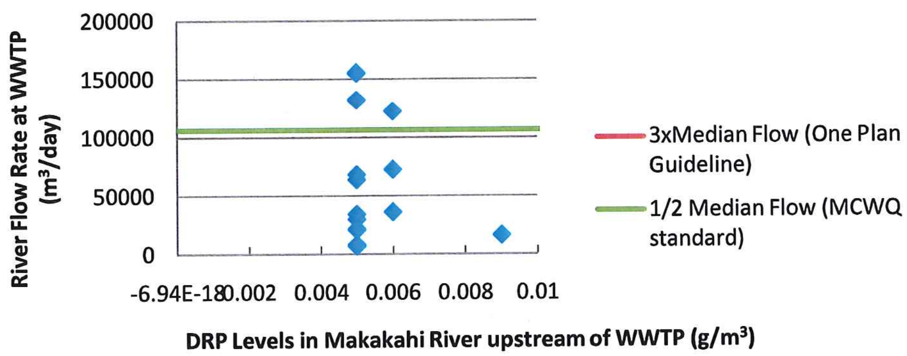
The concentration of dissolved reactive phosphorus in the river above the wastewater treatment plant discharge is critical for determining whether the Manawatu Catchment Water Quality standard for phosphorus can be achieved. The discussion in Section 2.4.1 assumed a background concentration of $0.007 g/m^3$, which can be compared to upstream levels from the combined water quality database, as presented in Figure 5. The value of $0.007 g/m^3$ is the median value for the results, meaning that it was exceeded for 50% of the results. To further understand the significance of this, graphs of dissolved reactive phosphorus levels vs river flowrate are presented in Figure 9 (a) to (c)



(a)



(b)



(c)

Figure 9. Graphs of upstream dissolved reactive phosphorus levels. The graphs are identical except for the scale of the vertical axis.

Based on the results presented in Figure 9, the following conclusions are suggested:

- The adopted value of 0.007g/m^3 appears to be appropriate for flows below half median flow as only one result exceeded this value.
- At higher flows in the river the range of phosphorus concentrations increases. The value of 0.007g/m^3 is still appropriate as a median.
- It is possible that very high upstream phosphorus levels occur at times. Therefore, the proposed upgrades to the wastewater treatment system can only contribute to

achievement of the MCWQ standard (and no guarantee of this can be given, as the upstream catchment is not controlled by Tararua District Council).

2.5 Assessment of Existing Treatment Performance

2.5.1 Existing Pond Capacity and Loading

The combined pond system at the Eketahuna Wastewater Treatment Plant has a surface area of 0.45 hectare. Using the Ministry of Works' design criteria of 1200 people/hectare/day, this gives a treatment capacity of 540 people, comfortably in excess of the existing population of 456 persons (Statistics NZ, 2006). The Eketahuna population has declined from 579 people in 2001, and growth is not expected in the foreseeable future.

Pond loading on the primary pond is estimated to be 96 kg/ha/day based on Ministry for the Environment guidelines of 70gBOD/person/day, and this is slightly above the traditional guideline of 84 kg/ha/day (MWD 1974). However, there is no history of odour issues or pond failures at the Eketahuna site, and supplementary aeration has not been required so far. Based on the combined area of the ponds, there are no concerns about the overall treatment capacity of the pond system. Other pond design guidelines such as those by Mara (1998) allow loading rates of around 100 kg/ha/day for similar climatic conditions.

2.5.2 Existing Treatment Performance

Performance data for the pond is summarised in Table 5 below. These are values taken from the pond discharge.

Table 5. Effluent Quality from Eketahuna STP

Parameter	25th Percentile	Median	90th Percentile	No Of Samples
$cBOD_5$ (g/m^3)	3	6	29	98
Suspended Solids (g/m^3)	11	26	52	98
Faecal Coliforms (CFU/100ml) [1]	375	1850	7370	29
Ecoli	364	530	6350	56
Particulate Organic Matter	16	25	46	29
pH[1]	7	7	9	61
Dissolved Oxygen (g/m^3) [1]	7	9	15	56
Nitrogen (ammoniacal-g/m^3)[2]	1	2	7	99
Phosphorus (reactive-g/m^3)[2]	0.4	1.2	2.8	99

The effluent quality is better than typical of other oxidation pond systems surveyed in New Zealand. Table 6 compares Eketahuna with typical data from other sources. Note that the high flow rates at Eketahuna will have the effect of diluting the effluent concentration, which partly explains the low concentrations that are observed.

Table 6. Comparative Performance Data for the Eketahuna STP

	Faecal coli	$cBOD_5$	Suspended Solids	Ammonia	DRP
	cfu/100ml	g/m^3	g/m^3	gN/m^3	g/m^3
Eketahuna	1850	6	26	2	1.2
Ministry of Works 1974[3]	50,000	35	50		
Davies-Colley 1995[4]		34	70	8	
Hickey et al 1989[5]	43,000	27	56	7	5.0
Martinborough	19,100	35	72	5	
Otane	2850	38	56	19	7.5
Porangahau	9750	32	71	6	3.1
Thames	4250	20	43	20	4.4 (TP)
NZWWA 2005[6]	20,000	40	50	5-15	6

Overall the Eketahuna sewage treatment plant performs very well for an oxidation pond system, particularly with regard to microbiological performance.

2.6 Sludge Survey

2.6.1 Sludge Levels

The sludge layer at the base of the facultative pond currently occupies around 33% of the pond depth, as surveyed on 31st March 2011. A bathymetric sketch of the sludge layer is presented in Figure 1, and a scaled drawing is included in Appendix B.

3 Guidelines for the Design, Construction and Operation of Oxidation Ponds, Ministry of Works, 1974.
4 Medians from 10 oxidation ponds in NZ.
5 Medians, NZ ponds.
6 Averages, NZ ponds

The current sludge levels at Eketahuna have gradually accumulated over the last 30 to 40 years, and will continue to rise at a slow rate.

Sludge levels become a concern in facultative ponds if the sludge begins to restrict the growth of algae in the pond, or if the sludge is resuspended into pond layers in windy weather. The re-suspension of solids is a particular concern in larger ponds where there is more potential for waves and turbulence. Sludge accumulation is also a concern for maturation ponds if it begins to affect hydraulic residence time and disinfection processes.

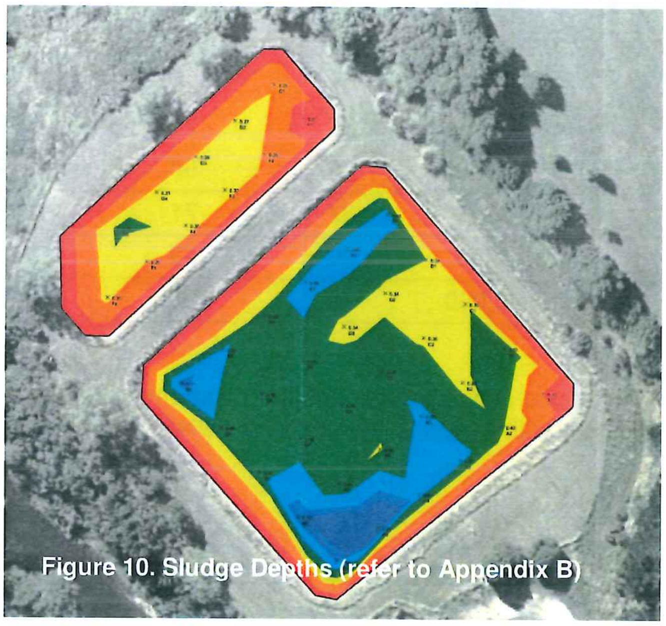


Figure 10. Sludge Depths (refer to Appendix B)

We recommend beginning to look at options for sludge disposal, as this will provide an opportunity to develop the most cost effective disposal option. We also recommend further sludge surveys at intervals of 1 to 2 years. For the facultative pond, we suggest that de-sludging is needed before the average water depth decreases to approximately 0.8m. Currently the average water depth is around 0.9m.

2.6.2 Contaminant Levels

A composite sludge sample was taken during the survey and analysed for heavy metal concentrations. Only one sample was taken because there are no current plans to de-sludge the ponds. Organic contaminants and pathogens were not measured. The results of this sampling are presented in Table 7, along with a comparison to the Grade a and Grade b Biosolids classification (Ministry for the Environment 2003).

Table 7 Comparison of Eketahuna metal levels to Grade a and Grade b biosolids

Parameter	Grade a Biosolids max. concentration (mg/kg dry weight)	Grade b Biosolids max. concentration (mg/kg dry weight)	Eketahuna concentration (mg/kg dry weight)
Arsenic	20	30	101
Cadmium	1	10	3

Chromium	600	1500	390
Copper	100	1250	1310
Lead	300	300	192
Mercury	1	7.5	1.5
Nickel	60	135	18
Zinc	300	1500	1250

The results in Table 7 indicate that the raw sludge does not meet the Grade b Biosolids level (in terms of metal concentrations) for application to land. This allows the following general conclusions to be made:

- Achieving the Grade b Biosolids standard for metals may be expensive, as large amounts of clean fill (or sand or sawdust) would be needed to bring the arsenic within the guideline level.
- Stockpiling or bagging the sludge onsite in a suitably bunded and protected area may provide the most cost effective management method in the short term. There appears to be adequate land area available.
- Adding additional treatment chemicals (such as from phosphorus removal processes) to the sludge is unlikely to have a significant impact on the options for sludge disposal. It may, however, affect the de-waterability of the sludge and make processing more difficult.
- Further work would be needed to determine the preferred option for sludge management at the Eketahuna site.

2.7 Existing Inlet Screen

The existing inlet screen was installed after the completion of the 2006AEE and subsequent hearing group meetings. The screen removes approximately 2 wheeli-bins of screenings a year. Screenings are collected in a sealed plastic rubbish bag, and no significant odour issues have been observed to date.

The volume of screenings removed is generally proportional to the connected population. Figures from Sindico (John Dickens 2011) suggest that a typical figure is around 0.01 litres of screenings per head of population on a daily basis. For Eketahuna, this would suggest that around 1700 litres of screenings should be removed each year, which is roughly seven full wheeli-bins of 'raw' screenings. The raw screenings would be expected to reduce in volume slightly while sitting; however at most this would be around 30% to 50% of the volume (our own estimates). This suggests that the volume of screenings removed is less than is typical, and it may be worth reviewing the screen set-points to ensure it is not 'stepping' more frequently than is necessary.

Figure 11. Existing Inlet Screen

The screen is fed by a pumpstation. Over winter the operating costs of the pumpstation are very high, with power costs alone exceeding $1500 per month. We have not completed a detailed analysis of the pumpstation, but suggest that the high operating costs may be due to a combination of relatively high flow rates and poor pump selection (low efficiency).

Options to reduce the operating cost of the screen include revising the pump selection, or constructing a channel for the screen to sit in so that it can operate without pumping.

The screen does not dramatically improve the performance of the sewage treatment system (due to the low volume of screenings removed); however, it does reduce the risk of floating rubbish or foreign objects passing through into the Makakahi River.

2.8 Assumptions Used for Cost Estimates and Option Evaluation

Our cost estimate and option evaluation presented in section 3 are based on the assumptions in Table 8:

Table 8. Cost Estimating Assumptions

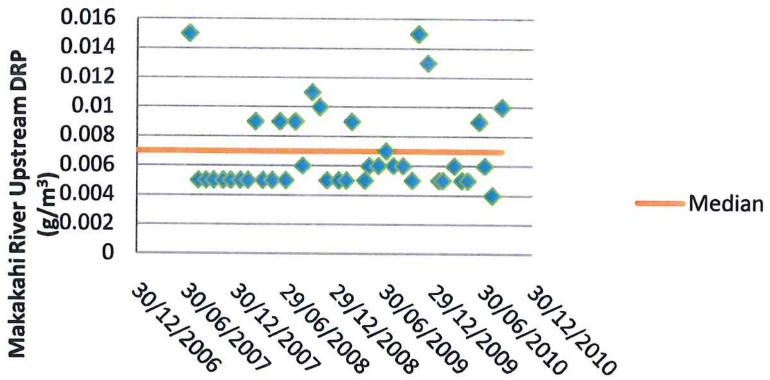
1.	Dosing Rates	Dosing rates are based on stoichiometry, plus an allowance for 200% overdosing for DRP concentrations above 1.0 g/m^3, and 400% overdosing for DRP concentrations below 1.0 g/m^3 . DAF and Actiflo systems are assumed to require 10% less chemicals than the direct dosing and clarifier dosing.
2	Chemical Supply	Chemicals assumed to be supplied in powder form (rather than in solution). Chemical prices were supplied by Fontis New Zealand (May 2011)
3	Operator Costs	All the systems will require regular operator input. Operator input was estimated at $75/1000m^3 for the DAF and Actiflo systems, $50/1000 m^3 for the clarifier and direct dosing systems.
4	Maintenance Costs	Annual maintenance costs are based on: -0.5% of capital costs for the DAF, Actiflo and Clarifier options -2.0% of capital costs for the pond dosing option
5	Engineering Fees	Engineering fees have not been included at this stage since we are unsure what level of involvement would be needed.
6	Electricity Cost	Electricity costs have been based on a $0.35/kWh rate, as this is typical of other plants we have been involved with. We understand that Tararua District Council is currently charged $0.80/kWh, and we have considered the effect of this on the cost of each option .
7	Flow Rates	We have assumed that the flow rates follow the relationship developed

<table>
<tr><td></td><td></td><td>in Section 2.3.3</td></tr>
<tr><td>8</td><td>Costs</td><td>Where possible, we have obtained costs directly from relevant suppliers. Other costs have been estimated or pro-rated from similar projects.</td></tr>
<tr><td>9</td><td>Dosing Control</td><td>We have assumed that the dosing system adjusts the amount of phosphorus-reducing chemical dosed per day, depending on the flow in the river. Under the MCWQ standards there are three flow ranges that influence the dosing, while under the One Plan guideline there are five flow ranges that influence dosing. Achieving this level of control will take manual operator input, but the adjustment could be made remotely.</td></tr>
<tr><td>10</td><td>Target Effluent DRP Level</td><td>The target DRP level in the effluent varies depending on the effluent flowrate, the river flowrate and whether the in-stream phosphorus limit is under the MCWQ guidelines or One Plan guidelines.

Under the MCWQ limit, the target DRP level varies as follows:
<table>
<tr><th>Case</th><th>River Flow, m³/day</th><th>Estimated STP Flow m³/day</th><th>Effluent DRP Concentration g/m³</th></tr>
<tr><td>MALF</td><td>20736</td><td>152</td><td>1.09</td></tr>
<tr><td>15th Percentile</td><td>53913.6</td><td>294</td><td>1.47</td></tr>
<tr><td>1/2 Median</td><td>106272</td><td>520</td><td>1.64</td></tr>
</table>

Under the One Plan limit, the target DRP level varies as follows:
<table>
<tr><th>Case</th><th>River Flow, m³/day</th><th>Estimated STP Flow m³/day</th><th>Effluent DRP Concentration g/m³</th></tr>
<tr><td>MALF</td><td>20736</td><td>152</td><td>0.41</td></tr>
<tr><td>15th Percentile</td><td>53913.6</td><td>294</td><td>0.55</td></tr>
<tr><td>1/2 Median</td><td>106272</td><td>520</td><td>0.61</td></tr>
<tr><td>Median</td><td>212544</td><td>977</td><td>0.65</td></tr>
<tr><td>Intermediate</td><td>319680</td><td>1437</td><td>0.67</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td></td><td></td><td>
<table>
<tr><td>2 x Median</td><td>425088</td><td>1890</td><td>0.67</td></tr>
<tr><td></td><td>637632</td><td>2804</td><td>0.68</td></tr>
</table>
These calculations are based on an assumed upstream DRP concentration of 0.007 g/m³, refer to following assumption.
</td></tr>
<tr><td>11</td><td>Upstream DRP Level</td><td>An background DRP concentration of 0.007 g/m³ was assumed, as suggested by Ausseil (2007) for a simplified modelling approach. This is equivalent to the median DRP concentration as measured in the Makakahi River upstream of the Eketahuna sewage treatment plant.



Further discussion on this assumption is given in Section 2.4.2.</td></tr>
<tr><td>12</td><td>Sludge Disposal</td><td>In our opinion sludge thickening equipment is unlikely to be cost effective for Eketahuna, and therefore we have assumed that solids will be disposed of to the facultative pond. We have not allowed for the cost of de-sludging the pond.</td></tr>
<tr><td>13</td><td>Screen Adjustments</td><td>We have allowed to lower the inlet screen so that pumping is no longer required. We recommend checking the levels of the reticulation system to ensure there is no risk of overflow if the screen clogs. We have allowed a nominal amount of $10K to repower the screen with hydraulic motors as a mitigation measure for flooding.</td></tr>
<tr><td>14</td><td>Flow Rates</td><td>All systems have been designed to achieve phosphorus removal up to a maximum flow around 1000 m³/day, which is approximately the maximum flow we anticipate treating under the One Plan guidelines (based on our preliminary flow assessment). To only achieve compliance with the MCWQ standards would allow a smaller device – however in practice this would only affect the clarifier option, since the DAF and Actiflo systems are already the smallest available (and the</td></tr>
</table>

		pond option would not be affected).
15	E Coli	Experience at Woodville and at Waihi suggests that chemical dosing can reduce bacterial levels even though it is not a formal disinfection process. Based on this experience we have not allowed for the additional cost of a UV disinfection unit; however the hydraulic design of the system should make provision for the possible future installation of a UV unit.

3 Treatment Options

3.1 Aims of the Treatment Upgrade

Based on our analysis, we consider that the upgrade of the Eketahuna sewage treatment system needs to achieve the following:

- Reduction of dissolved reactive phosphorus to the levels indicated on the proposed resource consent conditions (Section 6). These levels have been selected to achieve the MCWQ standard based on an upstream phosphorus concentration of 0.007 g/m^3.
- Contribute to the achievement of One Plan guidelines for microbiological quality in the Makakahi River.
- Provide robust performance under high wet weather flows.
- Achieve overall environmental benefits, including consideration for the environmental footprint of the treatment plant.
- Provide cost effective and affordable treatment.
- Have consideration for the proposed One Plan guidelines.

3.2 Overview of the Treatment Systems

A net present value cost for each of the options is presented in Figure 12. Capital and operating costs are presented in Table 9.

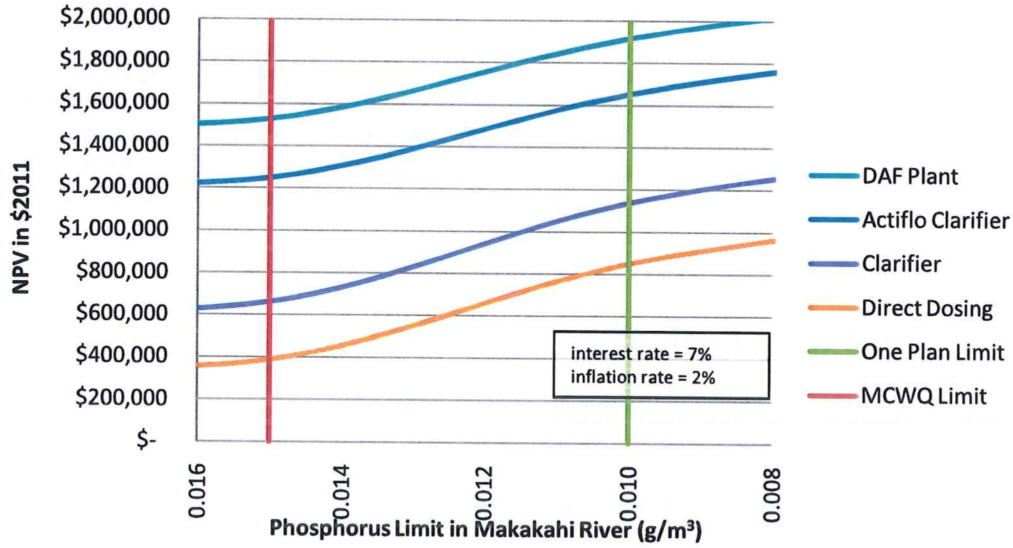


Figure 12 Capital and Operating Costs presented as Net Present Value.

Table 9. Summary of Capital and Operating Costs.

Option	Capital Cost Estimate ($2011)	Approximate Annual Operating Cost to achieve instream DRP <0.015g/m^3	Approximate Annual Operating Cost at achieve instream DRP < 0.01g/m^3
Direct Pond Dosing	$135,000 to $180,000	$14,000	$40,000
Clarifier	$370,000 to $520,000	$13,000	$40,000
Actiflo System	$900,000 to $1,000,000	$17,000	$40,000
DAF System	$1,300,000 to $1,400,000	$11,000	$35,000

The results of our analysis are somewhat surprising since they suggest that the overall cost of the direct pond dosing and clarifier options are cheaper than the package plant systems, even at the lower in-stream dissolved reactive phosphorus level of 0.01 g/m^3 (One Plan guideline level). While the chemical dosing costs for the direct pond and clarifier options are very high (they make up most of the operating cost), electricity consumption and operator input is lower – which reduces the effect of the increased chemical costs.

Note that while these options are aimed at achieving the in-stream targets for MCWQ standards, or One Plan guidelines, whether or not these values are actually achieved will depend on upstream levels of dissolved reactive phosphorus. Refer to Section 2.4.2.

3.3 Option 1: Direct Pond Dosing with Ferric Sulphate and T Floc

The cheapest option for introducing phosphorus removal will be to dose directly into the final pond, as is currently practised at Woodville. The Woodville system has been found to remove phosphorus reliably below 1.0 g/m^3 as dissolved reactive phosphorus, by using a combination of ferric sulphate and T Floc as an organic coagulant. The primary advantage of this sort of system is that there is no alum residual, and also the chemicals are safer to handle and do not require specialist containment facilities. T Floc has another key advantage in that it is able to be made up and stored for several months, and also pumped a considerable distance (unlike polyacrilamide which tends to block lines and is typically mixed up on a daily basis). Therefore; while chemical costs are high, this type of system provides a number of advantages for smaller plants.

Internationally, clarifier systems using Ferric sulphate have been successful at removing phosphorus below 0.4 g/m^3 as total phosphorus (USEPA 1987); however, apart from the Woodville system, we have not found any other examples of systems that work on pond effluent.

As the Eketahuna pond system has a relatively high loading, we have allowed to baffle off the end of the maturation pond. The final cell would be used for the phosphorus dosing, with a mixing chamber for injection of coagulant and precipitation chemicals. Note that there is some risk that the upgrade may result in an increase of biological oxygen demand and ammonia levels, and this would need to be monitored carefully.

3.4 Option 2: Conventional Clarifier with Ferric Sulphate and T Floc Dosing

The Clarifier option is similar to Option 1, but with the phosphorus removal in a clarifier rather than directly into the pond. The main advantage of this is that there is no reduction in the existing pond area, and the sludge could be transferred to a thickening plant for further treatment.

In our opinion the cost of a thickening plant is unlikely to be justified; therefore this removes one of the key advantages in having the clarifier.

3.5 Option 3: Actiflo Clarifier with Alum and Poly Dosing

Actiflo clarifiers use sand and a lamella separator to provide better settling and a smaller footprint than a conventional clarifier. In New Zealand, an Actiflo clarifier has been installed for phosphorus removal at the Gore oxidation ponds, and found to be effective in removal of dissolved reactive phosphorus (down to 0.5g/m^3 under low flow conditions), solids and faecal coliforms (Ross Hazzlemore, Gore District Council, pers comm.). During trials at the site they managed to get phosphorus levels down to 0.1 g/m^3, but a high doseage rate was required.

Actiflo clarifiers can provide very good treatment performance, and have lower chemical dosing costs as they are based on alum and polyacrilamide dosing. However, the capital cost is high and electricity consumption is also significant, meaning that overall annual operating costs are estimated to be similar to the direct pond dosing system.

3.6 Option 4: Dissolved Air Flotation Clarifier with Alum and Poly Dosing

Dissolved air floatation (DAF) systems have a reputation for effective removal of algae that have been chemically conditioned. An Armatech DAF system has been installed at Waihi on the Coromandel and has been found to be effective in removal of dissolved reactive phosphorus, solids and faecal coliforms (Kevin Kotze, Armatech, backed up by Opus experience). A pre-thickened sludge is produced as the 'float' off the top of the DAF. Post DAF pH correction is often required to raise the pH back up due to the effects of the acid coagulants such as Alum or ferricchloride.

The DAF system is quoted as having a lower energy consumption that the Actiflo plant, resulting in a slightly lower annual operating cost.

3.7 The Effect Of Electricity Cost Increases

The sensitivity of each of the options to electricity cost is shown in NPV format in Figure 13.

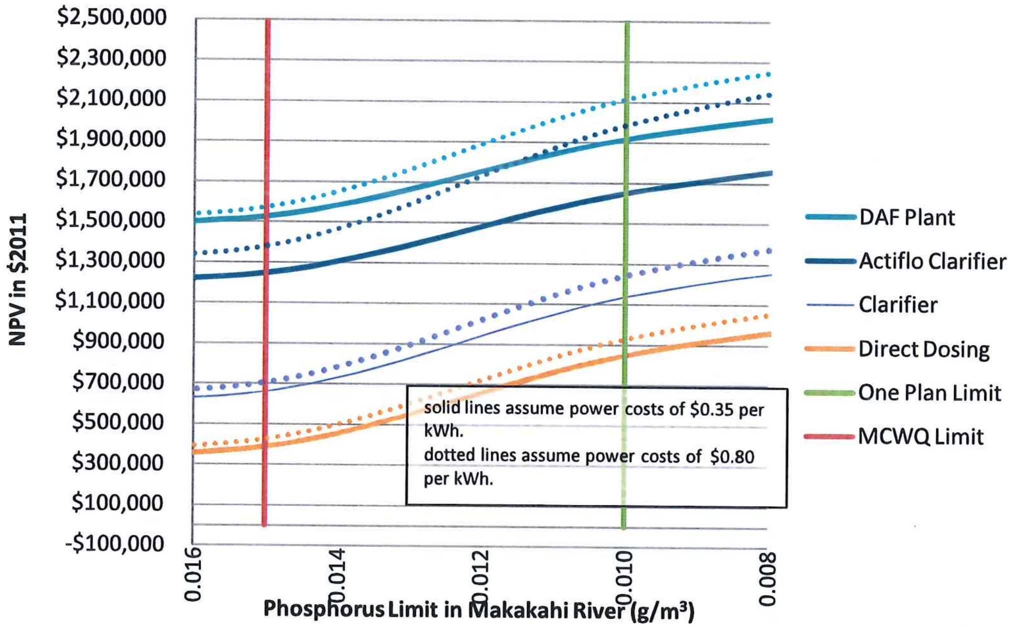


Figure 13. Sensitivity of Net Present Value to Higher Electricity Costs

As would be expected, the DAF and Actiflo options are more sensitive to increases in the cost of electricity.

3.8 Disposal of Treatment Sludge

3.8.1 Components of Sludge

The sludge produced from the chemical precipitation of phosphorus will be made up of organic solids removed from the effluent, chemical precipitates, inorganic components and residual dosing chemicals. The organic component may be quite diverse (including bacteria, fungi, worms, snails and insect larvae) but will be predominantly algae for a pond-based treatment system.

3.8.2 Sludge Produced from T Floc and Ferric Sulphate Treatment

We are not aware of any documented experience of the management of T Floc and Ferric Sulphate sludge, other than the Tararua District Council experience with the Woodville Wastewater Treatment Plant.

Sludge levels were monitored at Woodville over the first year of the chemical precipitation operation. While sludge levels did initially increase, the levels then gradually dropped so that there was no measurable net change at the end of the first year. It seems likely that the precipitation sludge has become concentrated by sedimentation and compression, and that the volume has reduced as biological components have been degraded.

3.8.3 Sludge Produced from Alum and Anionic Flocculent Treatment

Sludge produced from alum and anionic flocculent treatment will have many similarities to conventional water treatment sludge which is treated with similar chemicals, although the wastewater sludge will have a higher organic content. Disposal of water treatment sludge can be problematic for New Zealand local authorities, and the most typical method is disposal to the sewer or to landfill following storage in a lagoon. Other disposal methods such as re-processing for recovery of chemicals and disposal to land are not commonly practiced in New Zealand.

Alum sludge can be de-watered in geotextile bags, typically with additional inputs of flocculent to improve the solids capture.

4 Conclusions and Recommendations

4.1 Conclusions

The Eketahuna sewage treatment system is a good match for the flows and loads that are received from Eketahuna. The oxidation pond based system has an ability to cope with shock loading, provides affordable treatment, and has many favourable sustainable characteristics such as low inputs of energy and chemicals. With the proposed upgrade, the challenge will be achieve environmental benefits for the Makakahi River without making the system unaffordable to the community.

Tararua District Council has proactively developed and implemented a phosphorus dosing system at Woodville. This system achieves phosphorus removal at a level of capital and operating cost that is affordable to the community. If similar treatment results are achieved at Eketahuna, this would bring the Makakahi River into compliance with the MCWQ standards for dissolved reactive phosphorus and the One Plan guideline for faecal coliforms (based on median upstream concentrations in the Makakahi River).

Consideration needs to be given to achieving compliance with the One Plan guidelines for dissolved reactive phosphorus in the future. Our initial assessment suggests that it is probably not affordable for the community to comply with these guidelines, due to the high annual cost of chemical dosing. Further work is needed to investigate what other flocculants could be used to achieve the removal, as the cost of T Floc is prohibitive with extended periods of dosing. The cost of the chemical dosing is also very sensitive to the flowrates through the treatment plant, and flow monitoring is needed to provide a flow record for design and consenting purposes.

Reduction of infiltration will reduce chemical dosing costs due to the lower flow rate and higher phosphorus concentrations in the influent. The lower flow rate will allow a higher dissolved reactive phosphorus concentration in the discharge while still achieving the same in-stream phosphorus concentrations. High rates of stormwater infiltration are common in many parts of New Zealand, and unfortunately there is seldom a quick-fix solution to the problem. Central Hawkes Bay District Council (which has a shared utilities service provider with Tararua District Council) is also trying to come to terms with this issue. There may be an opportunity to develop a combined infiltration policy.

Neither of the package plants we have looked at provide a cost effective means of wastewater disposal for the Eketahuna wastewater treatment plant. This is partly because the package plants are suitable for much higher flows, and could be used to service a much larger town. If smaller plants become available in the future then it may be worth considering a package plant – but in the meantime our analysis suggests it is worth persevering with a custom-designed system such as the Woodville treatment system.

The sludge form the facultative pond does not currently comply with the Ministry for the Environment guidelines for 'grade b' Biosolids due to Arsenic and Copper concentrations. Adding additional phosphorus removal chemicals is unlikely to dramatically increase the cost of sludge disposal (per tonne of solids removed), although the overall quantity of solids will increase.

4.2 Recommendations

We recommend installing flow monitoring equipment as a first step. An accurate record of flows is needed to reduce the uncertainty in the operating costs, to allow equipment to be sized and to ensure resource consent conditions are realistic. The affordability of the upgrade option is a key issue that will need to be re-visited once more data and information becomes available.

Resource consent conditions should be based on the effluent quality that the upgraded system will need to achieve, rather than specifying the method of treatment. This will provide flexibility for Tararua District Council to adjust their treatment process to accommodate new technologies and operational experience. We have provided a draft set of conditions in Section 6 for discussion purposes. We recommend that conditions are re-considered once additional flow monitoring results are available.

We suggest Tararua District Council consider developing an infiltration policy. This would describe the relevant legislation, the aims of the policy and how it will be implemented. Once the policy is developed it will allow a programme of works to be scheduled that complies with any budget constraints. There may also be an opportunity to develop a combined policy with Central Hawkes Bay District Council.

Our survey of sludge levels suggests that the Eketahuna ponds are close to capacity. We recommend looking at options for sludge disposal to clarify the expected cost, space requirements and disposal methodology. For the facultative pond, we suggest that de-sludging is needed before the average water depth decreases to approximately 0.8m.

5 References

Ausseil, O, 2007, Report of Olivier Ausseil in the matter of the application from Tararua District Council for two resource consents to discharge treated domestic wastewater from the Eketahuna sewage treatment plant (application N.103346 and Imhoff tank (application N. 103347) to the Makakahi River, Report prepared for Horizons Regional Council.

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New Zealand Wastewater Association 2005, *Oxidation Pond Guidelines* (Unpublished final draft, at time of writing was available online from www.waternz.org.nz/)

U.S Environmental Protection Agency 1987, *Phosphorus Removal Design Manual.*

6 Proposed Consent Conditions

The following proposed consent conditions have been modelled on those for the Woodville Wastewater Treatment Plant Consent:

1. Following the upgrade of the sewage treatment plant, the treated wastewater shall meet the dissolved reactive phosphorus limits listed in Table 1:

Table 1. Proposed Dissolved Reactive Phosphorus Limits for Eketahuna Wastewater Treatment Plant.

River Flowrate, as measured at the Makakahi at Hamua recording station, is between:	Dissolved Reactive Phosphorus Limit
½ Median Flow and 15th Percentile Flow	No more than five out of ten consecutive samples shall exceed 1.4 g/m^3
15th Percentile and MALF	No more than five out of ten consecutive samples shall exceed 1.0 g/m^3
MALF and Minimum Flow	No more than five out of ten consecutive samples shall exceed 0.5 g/m^3

2. Taking into consideration the explanatory note below and following reasonable mixing (condition 4), the treated wastewater discharge shall not cause the following in the Makakahi River:

a) a change in horizontal visibility, defined as the horizontal sighting range of a 200 millimetre diameter black disc, by more than 30%; or
b) the ammonia nitrogen (NH4-N) concentration to exceed 1.1 grams per cubic meter at water temperatures equal to or less than 15 degrees Celsius, or to exceed 0.8 grams per cubic meter at water temperatures greater than 15 degrees Celsius.
c) 50th percentile E coli levels to exceed 260 Ecoli/100ml or 80th percentile E coli levels to exceed 550 Ecoli/100ml.

3. Taking into consideration the explanatory note below and following reasonable mixing (condition 4), the treated wastewater discharge shall not cause the following in the Makakahi River when the flow is below half median flow:

a) the particulate organic matter concentration to exceed 5.0 grams per cubic metre; or
b) the daily average carbonaceous BOD5 concentrations (GF/C filter) shall not exceed 2g/m^3.

4. Unless further refined by an onsite mixing study, the zone of reasonable mixing shall be assumed to be 200m from the point of discharge.

Explanatory Note: Achieving compliance with Condition 2 is based on the assumption that upstream concentrations are not more than 100% above median values, as determined by monthly monitoring.

7 Appendix A. Report on Makakahi River Flows

TO	**Tim Strang, Tabitha Manderson**
FROM	**Sheryl Paine & Jack McConchie**
DATE	**22 August 2011**
SUBJECT	***Eketahuna flow information***

Introduction

There are no continuous flow records available for either the Makakahi River or Ngatahaka Creek in the vicinity of the discharge from the Eketahuna waste water treatment facility. The nearest flow site is on the Makakahi River at Hamua, a considerable distance downstream (Figure 1). The catchment area at Hamua is approximately 163km², which is over twice the size of the catchment upstream of the Makakahi-Ngatahaka confluence at the waste water treatment facility.

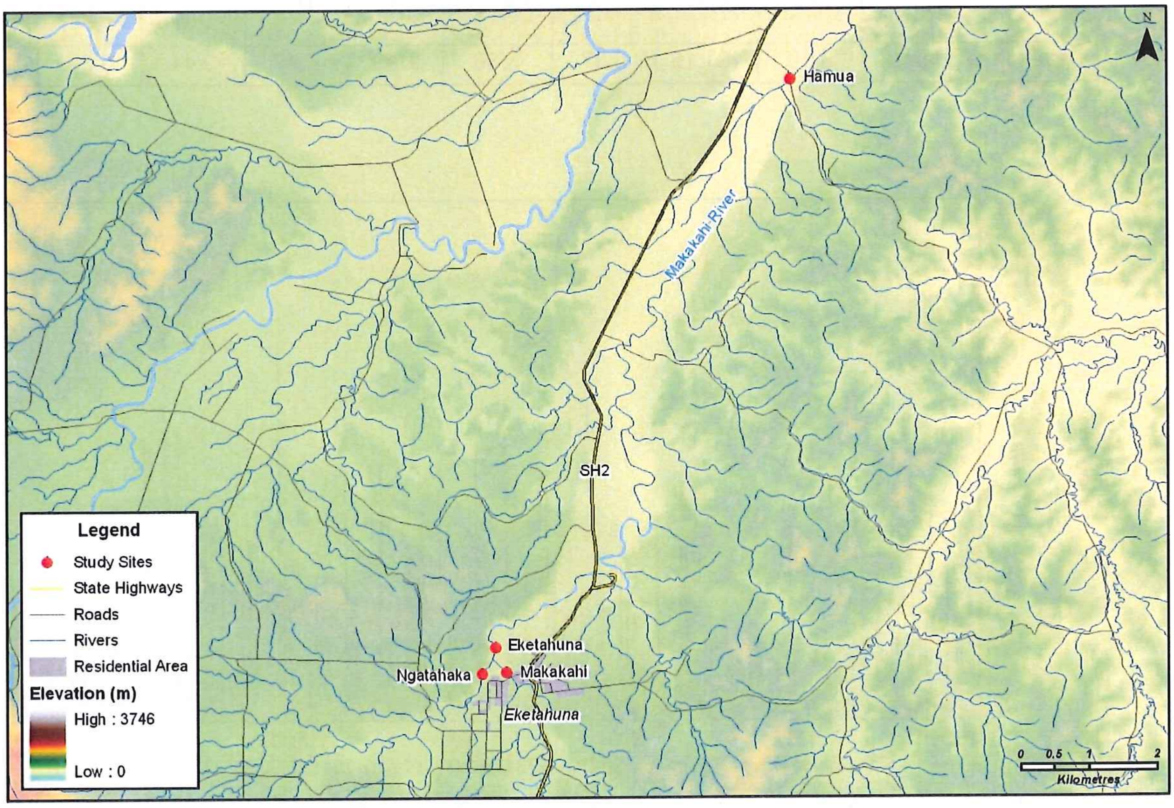


Figure 1: Location of the various flow sites.

Two previous studies have assessed the low flow regime of the Makakahi River (Watson, 1994 & 1997). This report therefore provides updated estimates of the flow regime of the Makakahi River in the vicinity of Eketahuna's waste water treatment facility.

Makakahi River at Hamua

A continuous flow monitoring site has been maintained on the Makakahi River @ Hamua since 1979. This site now provides approximately 31 years of flow information (Figure 2).

Average daily flows in the Makakahi River have varied from as low as 100l/s to a maximum flood of 181m³/s. The mean daily flow is significantly greater than the median because of the effect of short duration but large flood events. The mean annual daily low flow has been approximately 330l/s, with a mean annual seven day low flow of about 410l/s (Table 1).

The flow regime of the Makakahi River at Hamua is therefore typical of a moderate size river draining a hill country catchment in northern Wairarapa. The river has sustained periods of relatively low flows interspersed by a number of significant flood events. The variability of daily flows is summarised in Table 2.

Table 1: Summary statistics for the average daily flow in the Makakahi River at Hamua (m³/s).

	Min	Max	Mean	Median	LQ	UQ	Std Dev	MALF	7-day MALF
Makakahi at Hamua	0.10	181.16	6.37	3.36	1.39	7.47	9.44	0.33	0.41

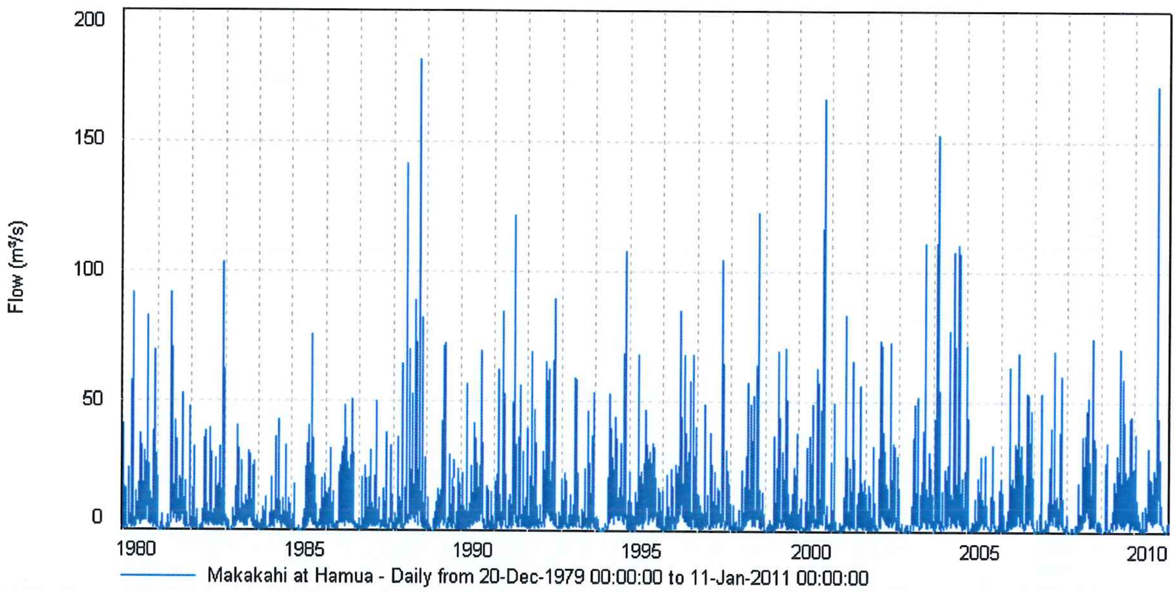


Figure 2: Record of daily flows in the Makakahi River at Hamua (1979-2011).

Table 2: Makakahi at Hamua distribution of daily flows (m³/s)

	0	1	2	3	4	5	6	7	8	9
0	181.157	46.254	33.822	28.477	24.867	22.009	19.950	18.324	16.992	15.861
10	14.852	14.016	13.234	12.514	11.889	11.325	10.827	10.350	9.893	9.460
20	9.071	8.708	8.361	8.044	7.752	7.474	7.220	6.980	6.746	6.531
30	6.324	6.113	5.910	5.718	5.539	5.366	5.199	5.036	4.880	4.733
40	4.586	4.442	4.308	4.180	4.051	3.926	3.799	3.679	3.571	3.464
50	3.361	3.257	3.157	3.060	2.963	2.872	2.784	2.696	2.610	2.521
60	2.437	2.356	2.277	2.200	2.122	2.047	1.972	1.900	1.832	1.766
70	1.700	1.633	1.573	1.512	1.450	1.390	1.331	1.272	1.219	1.172
80	1.121	1.068	1.016	0.964	0.908	0.852	0.810	0.764	0.714	0.662
90	0.612	0.565	0.518	0.467	0.424	0.381	0.341	0.298	0.252	0.179
100	0.100									

Makakahi River at Treatment Plant

At sites where there are concurrent flow gaugings it is possible to generate a synthetic flow record using the relationship between the two sets of gauging data. There are 13 concurrent flow gaugings in the vicinity of the treatment facility and Hamua. However, the three gaugings completed between 1980 and 1987 were measured at the State Highway Bridge, approximately 2km downstream of the treatment facility. The other 10 gaugings were completed at the 'Motor Camp' which is on the branch of the Makakahi River upstream of the confluence.

Use of the three downstream gaugings to create a relationship would be subject to considerable uncertainty. These gaugings also measure flow from a catchment which is significantly larger than at the waste water treatment facility. Any relationship derived from the 10 gaugings of the upstream tributary would need to be scaled to provide estimates of flows downstream of the treatment facility, and including flow from the Ngatahaka Creek. Again, this is likely to be subject to unquantifiable uncertainty.

In the absence of concurrent gauging and flow records, it is often possible to translate and transform flow records from comparable catchments as a function the ratio of the two catchment areas. Such an approach can have significant error associated with the estimates of high flows because of differences in the rainfall regimes, rain storm distributions, and rainfall-runoff relationships. The approach can, however, be very effective in producing robust estimates of the low flow regime; the flows of most interest in the current study. This is because the low flow regime is controlled largely by the drainage properties of the catchment, and these tend to be consistent over quite large areas. Flood flows are controlled largely be the characteristics of the storm i.e., magnitude, duration and intensity, which all vary with catchment size.

A synthetic flow record was therefore generated by scaling the flows recorded in the Makakahi River at Hamua as a simple ratio of the two catchment areas (Figure 3). The flow regime is summarised in Tables 3 and 4.

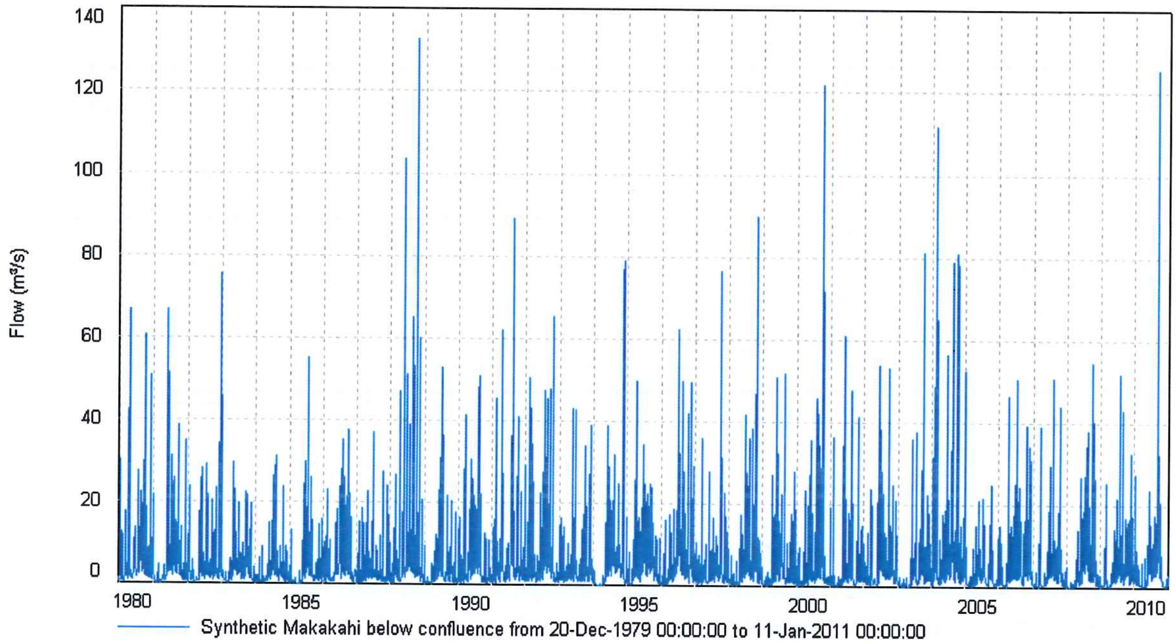


Figure 3: **Synthetic record of estimated daily flows in the Makakahi River at the Eketahuna waste water facility (1979-2011); derived by scaling flows at Hamua by catchment area.**

Table 3: **Distribution of flows for the synthetic record of estimated daily flows in the Makakahi River at the Eketahuna waste water facility (1979-2011); derived by scaling flows at Hamua by catchment area.**

	Min	Max	Mean	Median	LQ	UQ	Std Dev	MALF	7-day MALF
Synthetic Makakahi (below confluence)	0.07	132.61	4.66	2.46	1.02	5.47	6.91	0.24	0.30

Table 4: **Synthetic Makakahi below the confluence (m³/s).**

	0	1	2	3	4	5	6	7	8	9
0	132.607	33.858	24.758	20.845	18.203	16.110	14.604	13.413	12.438	11.610
10	10.871	10.260	9.687	9.161	8.703	8.290	7.925	7.576	7.241	6.925
20	6.640	6.374	6.120	5.888	5.674	5.471	5.285	5.110	4.938	4.781
30	4.630	4.475	4.326	4.185	4.055	3.928	3.806	3.687	3.572	3.465
40	3.357	3.252	3.154	3.060	2.966	2.874	2.781	2.693	2.614	2.535
50	2.460	2.384	2.311	2.240	2.169	2.103	2.038	1.973	1.910	1.845
60	1.784	1.725	1.666	1.610	1.554	1.498	1.444	1.391	1.341	1.292
70	1.244	1.196	1.152	1.107	1.061	1.017	0.974	0.931	0.893	0.858
80	0.821	0.782	0.743	0.706	0.665	0.624	0.593	0.559	0.523	0.485

90	0.448	0.414	0.379	0.342	0.311	0.279	0.250	0.218	0.184	0.131
100	0.073									

Synthetic flow regimes were also generated by scaling the daily flows at Hamua as a function of catchment area for both Ngatahaka Creek and the Makakahi River upstream of their confluence at the waste water treatment facility (Figures 4 & 5; Tables 5 & 6).

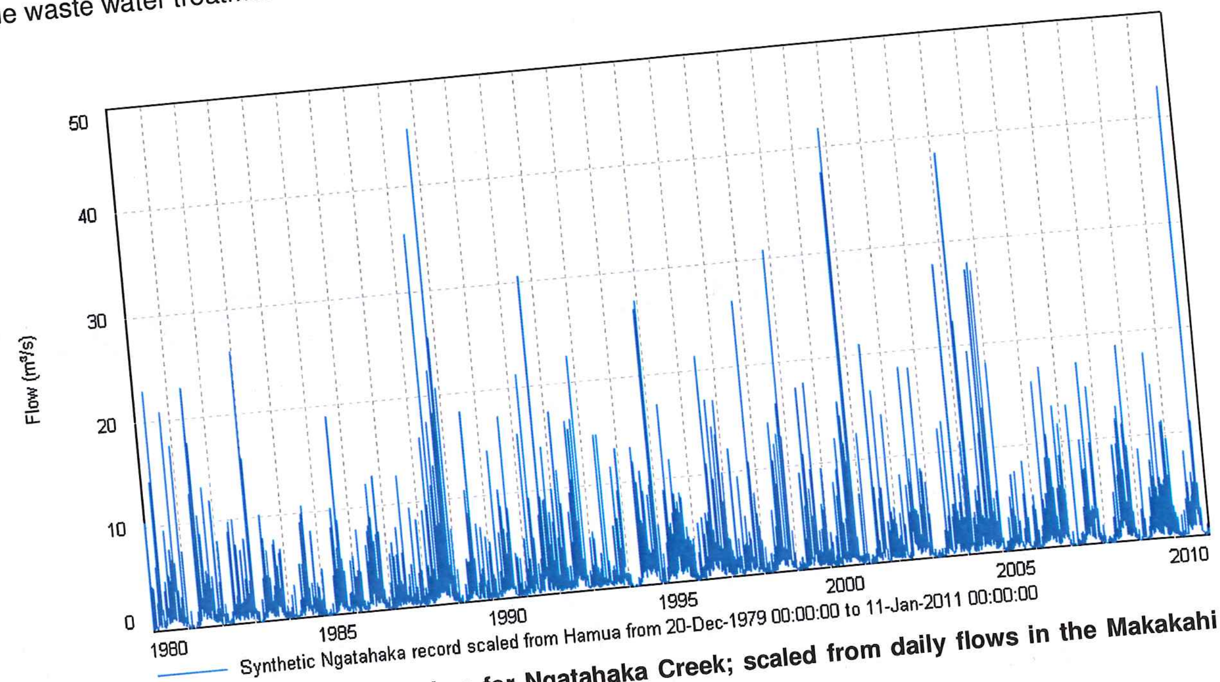


Figure 4: **Synthetic flow regime for Ngatahaka Creek; scaled from daily flows in the Makakahi River at Hamua.**

Table 5: **Distribution of synthetic flows for Ngatahaka Creek; scaled from daily flows in the Makakahi River at Hamua (m³/s).**

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0	45.470	11.610	8.489	7.148	6.242	5.524	5.007	4.599	4.265	3.981
10	3.728	3.518	3.322	3.141	2.984	2.843	2.718	2.598	2.483	2.375
20	2.277	2.186	2.099	2.019	1.946	1.876	1.812	1.752	1.693	1.639
30	1.587	1.534	1.483	1.435	1.390	1.347	1.305	1.264	1.225	1.188
40	1.151	1.115	1.081	1.049	1.017	0.985	0.953	0.924	0.896	0.869
50	0.844	0.818	0.792	0.768	0.744	0.721	0.699	0.677	0.655	0.633
60	0.612	0.591	0.571	0.552	0.533	0.514	0.495	0.477	0.460	0.443
70	0.427	0.410	0.395	0.380	0.364	0.349	0.334	0.319	0.306	0.294
80	0.281	0.268	0.255	0.242	0.228	0.214	0.203	0.192	0.179	0.166
90	0.154	0.142	0.130	0.117	0.106	0.096	0.086	0.075	0.063	0.045
100	0.025									

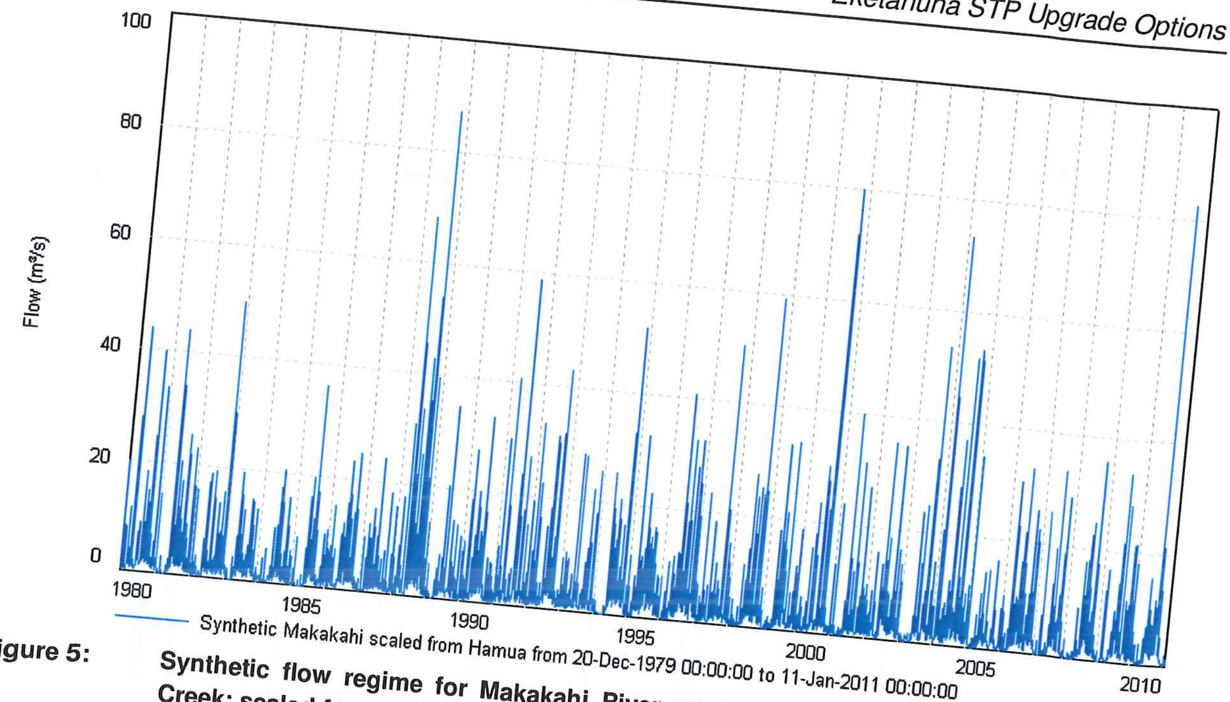


Figure 5: **Synthetic flow regime for Makakahi River upstream of confluence with Ngatahaka Creek; scaled from daily flows in the Makakahi River at Hamua.**

Table 6: **Distribution of synthetic flows for Makakahi River upstream of confluence with Ngatahaka Creek; scaled from daily flows in the Makakahi River at Hamua (m^3/s).**

	0	1	2	3	4	5	6	7	8	9
0	87.137	22.248	16.269	13.697	11.961	10.586	9.597	8.814	8.173	7.629
10	7.144	6.742	6.366	6.019	5.719	5.447	5.208	4.979	4.758	4.550
20	4.363	4.188	4.022	3.869	3.729	3.595	3.473	3.358	3.245	3.142
30	3.042	2.941	2.843	2.750	2.664	2.581	2.501	2.422	2.347	2.277
40	2.206	2.137	2.072	2.011	1.949	1.888	1.827	1.770	1.718	1.666
50	1.617	1.567	1.518	1.472	1.425	1.382	1.339	1.297	1.255	1.213
60	1.172	1.133	1.095	1.058	1.021	0.984	0.949	0.914	0.881	0.849
70	0.818	0.786	0.757	0.727	0.697	0.669	0.640	0.612	0.587	0.564
80	0.539	0.514	0.488	0.464	0.437	0.410	0.390	0.368	0.343	0.319
90	0.295	0.272	0.249	0.225	0.204	0.183	0.164	0.143	0.121	0.086
100	0.000									

Conclusion

Scaling the flow record in the Makakahi River at Hamua as a simple function of area was used to estimate the flow regime in the vicinity of Eketahuna's waste water treatment facility. The various statistical parameters relating to the synthetic flow regime are highlighted in Table 7.

If other flow parameters are required, they can be obtained from the flow distribution presented in Table 4.

Table 7: Summary statistics for the various actual and synthetic flow records (m^3/s).

	Min	Max	Mean	Median	LQ	UQ	Std Dev	MALF	7-day MALF
Makakahi at Hamua	0.10	181.16	6.37	3.36	1.39	7.47	9.44	0.33	0.41
Synthetic Ngatahaka	0.03	45.47	1.60	0.84	0.35	1.88	2.37	0.08	0.10
Synthetic Makakahi (above confluence.)	0.05	87.14	3.06	1.62	0.67	3.60	4.54	0.16	0.20
Synthetic Makakahi (below confluence at EWWTP)	***0.07***	***132.61***	***4.66***	***2.46***	***1.02***	***5.47***	***6.91***	***0.24***	***0.30***

References

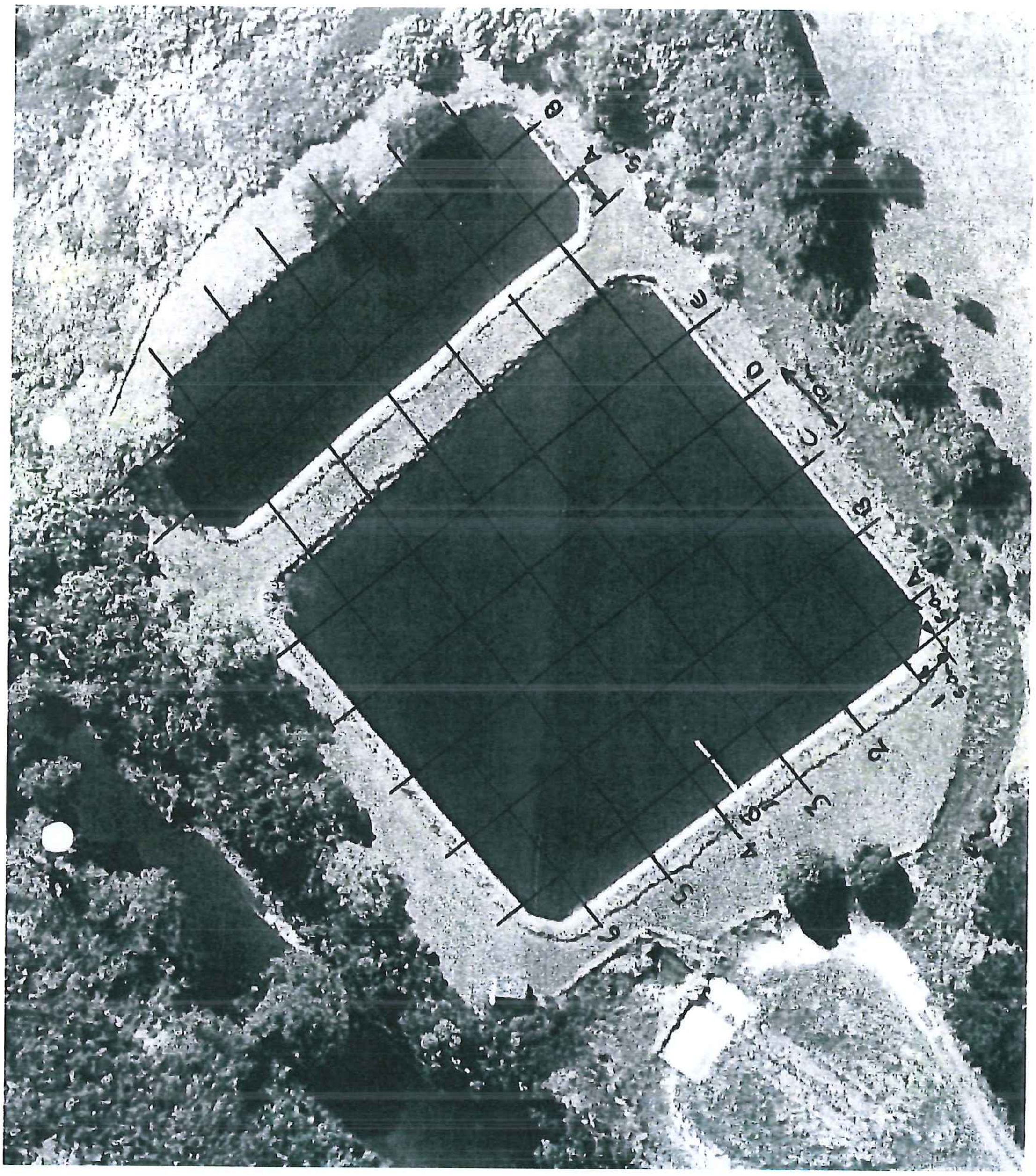
Watson, M. 1994: Estimates of average annual one day low flow for rivers and streams receiving effluent from Tararua District Council landfills and sewage systems. Manawatu Wanganui Regional Council 94/INT/61.

Watson, M. 1997: Estimates of flow in rivers and streams receiving effluent from Tararua District Council sewage facilities. Manawatu Wanganui Regional Council 97/INT/88.

8 Appendix B. Eketahuna Ponds Sludge Survey

The sludge survey was completed on 31/03/2011. The following methodology and results are presented:

- The sampling grid is presented below
- Tabulated results are shown on the following two pages
- An A3 contour plot is presented at the end.



EKETAHUNA WWTP
Sludge Levels Report

OPUS

Pond No : 1
Tested by : E J West / Tim Strang
Date : 1/04/11

Project No : **5-P0401.00**
Lab Ref No : **11/852/001**
Client Ref :

Position	Depth to Base (m)	Depth to Sludge (m)	Sludge Thickness (m)	Position	Depth to Base (m)	Depth to Sludge (m)	Sludge Thickness (m)
A1	1.08	0.98	0.10				
A2	1.45	1.05	0.40				
A3	1.33	0.76	0.57				
A4	1.31	0.71	0.60				
A5	1.52	0.59	0.93				
A6	1.26	0.60	0.66				
B1	1.40	0.90	0.50				
B2	1.45	1.10	0.35				
B3	1.47	0.92	0.55				
B4	1.33	0.96	0.37				
B5	1.36	0.96	0.40				
B6	1.33	0.60	0.73				
C1	1.35	0.99	0.36				
C2	1.42	1.06	0.36				
C3	1.45	0.98	0.47				
C4	1.47	0.95	0.52				
C5	1.38	0.95	0.43				
C6	1.42	0.95	0.47				
D1	1.32	0.94	0.38				
D2	1.38	1.04	0.34				
D3	1.48	1.14	0.34				
D4	1.50	1.06	0.44				
D5	1.39	1.01	0.38				
D6	1.40	0.92	0.48				
E1	1.33	0.75	0.58				
E2	1.57	0.95	0.62				
E3	1.75	1.16	0.59				
E4	1.39	0.95	0.44				
E5	1.40	0.86	0.54				
E6	1.35	0.64	0.71				

Date tested : 31/03/11
Date reported : 5/04/11

Approved egwest

Designation : *Senior Civil Engineering Technician*
Date : 5/04/11

Sludge Depth Report Sheet

Opus International Consultants Limited
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Hamilton 3240, New Zealand

Telephone +64 7 856 2870
Facsimile +64 7 856 2873
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EKETAHUNA WWTP
Sludge Levels Report

Pond No : 2
Tested by : E J West / Tim Strang
Date : 1/04/11

OPUS

Project No : 5-P0401.00
Lab Ref No : 11/852/001
Client Ref :

Position	Depth to Base (m)	Depth to Sludge (m)	Sludge Thickness (m)	Position	Depth to Base (m)	Depth to Sludge (m)	Sludge Thickness (m)
A1	1.19	1.18	0.01				
A2	1.25	1.00	0.25				
A3	1.39	1.02	0.37				
A4	1.38	1.03	0.35				
A5	1.26	1.00	0.26				
A6	1.17	0.87	0.30				
B1	1.28	0.87	0.41				
B2	1.22	0.91	0.31				
B3	1.22	0.96	0.26				
B4	1.26	0.99	0.27				
B5	1.20	0.95	0.25				

Date tested : 31/03/11
Date reported : 5/04/11

Approved [signature]

Designation : Senior Civil Engineering Technician
Date : 5/04/11

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Sludge Depth Report Sheet

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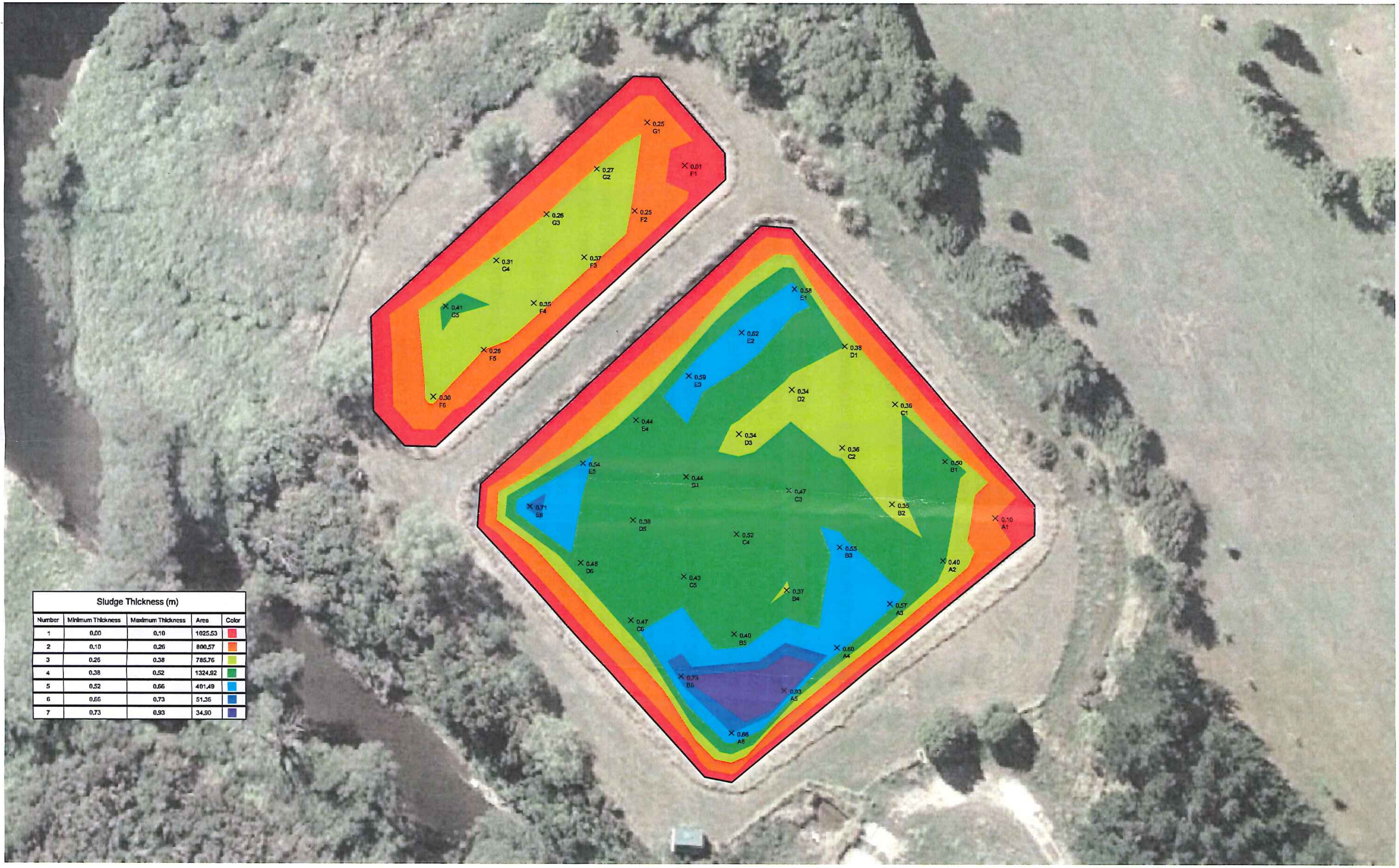
Page 1 of 2



Sludge Thickness (m)

Number	Minimum Thickness	Maximum Thickness	Area	Color
1	0.00	0.10	1025.53	
2	0.10	0.26	800.57	
3	0.26	0.38	785.76	
4	0.38	0.52	1324.82	
5	0.52	0.66	401.49	
6	0.66	0.73	51.36	
7	0.73	0.93	34.90	

1:250 @ A1 0 4 8 12 16 20 24 m

Revision	Amendment	Approved	Revision Date

TARARUA® DISTRICT COUNCIL

OPUS

Wellington Office
PO Box 12-003, Thorndon
Wellington 6144, New Zealand
+ 64 4 471 7000

Project: Tararua District Council
Eketahuna Sewage
Treatment Plant Upgrade

Sheet: Oxidation Pond Plan
Sludge Survey (March 31, 2011)

Drawn	Designed	Approved	Revision Date
H. Clarke	J. West	Tim Strang	14/04/11

Project No.	Scale	Drawing No.	Sheet No.	Revision
5-P0401.00	1:250 [A1], 1:500 [A3]	5 / 1408 / 5 / 2505	1	A

Original Sheet Size A1 [841x594] Plot Date 15/04/11 @ 09:00 c:\tenvida_north\tararua\dwgs\5p0401.00 eketahuna sewage treatment plant upgrade\5_1408_5_2505_1a.dwg - 01

9 Appendix C. Planning Assessment

9.1 Manawatu Catchment Water Quality Regional Plan

All of the following standards apply to the Eketahuna WWTP discharge

MCWQ Rule 1 – General water standards for water quality

a. The change in horizontal visibility shall not be greater than 30%
b. The change in hue shall not be greater than 10 points on the Munsell scale.
c. Euphotic depth (as measured on a standard PAR meter) shall not be changed more than 10%.
d. Average daily concentration of ammonia (NH4-N) in water shall not exceed 1.1g/m3 at water temperatures equal to or less than 15C; or 0.8g/m3 at water temperatures greater than 15C.
e. The daily average carbonaceous BOD5 concentrations (GF/C filter) shall not exceed 2g/m3.

These standards apply to any discharge of any contaminants into surface waters, after reasonable mixing and regardless of flow levels in the receiving waters, the above standards are to be met.

MCWQ Rule 2 – Contact Recreation water quality standards

a. Water not to be rendered unsuitable for bathing by the presence of contaminants.
b. Horizontal visibility (200mm black disc) to be greater than 1.6 meters, unless existing physical and/or biological factors cause the visibility to be less than 1.6 metres at the point of discharge.
c. Bacterial and/or fungal slime growth shall not be visible to the naked eye as plumose growth or mats.
d. Daily average concentration of POM shall not exceed 5g/m3.
e. Median concentration of enterococci of at least 20 samples taken throughout the bathing season shall not exceed 33 per 100ml no shall any sample exceed 107 enterococci per 100ml (1 November to 1 May inclusive).
f. Seasonal maximum cover of a stream or river bed by periphyton as filamentous growth or mats (more than 3mm thick) shall not exceed 40% and the biomass on the bed shall not exceed 100mg chlorophyll a/m2 over a representative reach.
g. The daily average concentration of DRP shall be less than 15mg/m3.

Standards apply after reasonable mixing. Policy 5 provides guidance on determining reasonable mixing

Policy 5
To require, in general, that reasonable mixing in the receiving waters of any point-source discharge should be achieved within a distance downstream from the discharge to whichever is the least of:

a. The distance which equals seven times the width of the river when the flow is at half the median flow; or
b. 200 metres from the point of discharge; or
c. The point at which mixing of the particular contaminant concerned has occurred across the full width of the body of water in the river.

MCWQ Rule 3 – Fishery water quality standards

a. The natural temperature of the water shall not be changed by more than 3^{o} Celsius and shall not exceed 25^{o} Celsius.
b. The concentration of DO shall exceed 80% of saturation concentration.
c. Fish shall not be rendered unsuitable for human consumption by the presence of contaminants.

MCWQ Rule 6 – Prohibited discharges to water
Any discharge to surface water in the Manawatu catchment

c. of any contaminant, or water, which contravenes MCWQ Rule 2,3,4 or 5, after 1 January 2009, except discharges granted according to Policy 2 of the Plan

is a Prohibited Activity.

MCWQ Rule 8 – Non-complying discharges to rivers and streams
Subject to MCWQ Rule 6 any discharge to surface water in the Manawatu catchment which causes any standards in MCWQ Rules 1, 2, 3, 4, 5 or 5A, so far as they are applicable, to be breached is a Non-Complying Activity.

Policy 2 guides decision making regarding discharges which do not comply with the standards.

Policy 2

2.1 To grant consents for discharges which breach water quality standards in this Plan only where the Council is satisfied:

a. that exceptional circumstances justify the granting of the consent; or
b. that the discharge is of a temporary nature; or
c. that the discharge is associated with necessary maintenance work –

and in any case that it is consistent with the purpose of the Act to do so, and practical alternatives that avoid such discharges to water are not available.

9.2 Proposed One Plan – as amended by Decisions

For the purpose of this assessment the policies and objectives (not the rules) have been assessed.

Objective 6-1: Water management Values
Surface water bodies and their beds are managed in a manner which has regard to the Values in Schedule AB.

Objective 6-2: Water quality
(a) Surface water quality is manage to ensure that:
  (i) Water quality is maintained in those rivers and lakes where the existing water quality is at a level sufficient to support the Values in Schedule AB
  (ii) Water quality is enhanced in those rivers and lakes where the existing water quality is not at a level sufficient to support the Values in Schedule AB

Policy 6-1: Water Management Zones and Values
In summary, rivers must be managed in a manner which has regard to the Schedule AB Values when decisions are made on avoiding, remedying or mitigating the adverse effects of activities.

Policy 6-2: Water quality targets
In summary, water quality targets are identified for each zone and are used for the management of surface water quality in the manner set out in Policies 6-3, 6-4 and 6-5.

Policy 6-3: Ongoing compliance where water quality targets are met
Policy 6-4: Enhancement where water quality targets are not met

Policy 6-8: Point source discharges to water

(a) The management of point source discharges into surface water must have regard to the strategies for surface water quality management set out in Policies 6-3, 6-4 and 6-5 while having regard to:
   (i) The degree to which the activity will adversely affect the Schedule AB Values for the relevant Water Management Sub-zone
   (ii) Whether the discharge, in combination with other discharges including non-point source discharges will cause the Schedule D water quality targets to be breached
   (iii) The extent to which the activity is consistent with contaminant treatment and discharge best management practices
   (iv) The need to allow reasonable time to achieve any required improvements to the quality of the discharge
   (iva) whether the discharge is of a temporary nature or is associated with necessary maintenance or upgrade work and the discharge cannot practicably be avoided
   (ivb) where adverse effects resulting from the discharge can be offset by way of a financial contribution set in accordance with Chapter 18
   (ivc) whether it is appropriate to adopt the best practicable option.

Policy 6-11: Human sewage discharges

Notwithstanding other policies in this chapter:

(a) Before entering a surface water body all new discharges of treated human sewage must:
   (i) Be applied onto or into land, or
   (ii) Flow overland, or
   (iii) Pass through a rock filter, or
   (iv) Pass through a wetland treatment system, or
   (v) Pass through an alternative system that mitigates the adverse effects on the mauri of the receiving water body, and
(b) All existing direct discharges of treated human sewage into a surface water body much change to a treatment system described under (a) by the year 2020.

Zone and Sub-zone
The receiving environment is identified as being the Makakahi River, and at the point of discharge is within the Mana_8b subzone (Middle Mangatainoka).

Water Quality Targets that Apply are shown in the following Table

<u>Region Wide Water Quality Targets</u>	
E.coli /100ml	260 <50th %tile 550 <20th %tile
Periphyton Filamentous Cover	30%
Diatom or Cyanobacterial Cover	60%
QMCI %Δ	20
<u>Mana 8b Subzone Water Quality Targets</u>	
pH	7 to 8.5 (range) 0.5 Δ
Temp	< 19 3 Δ
DO (%SAT)	80
scBOD5 (g/m3)	<1.5
POM (g/m3)	5
Periphyton	120 Chl a (mg/m3)
DRP (g/m3)	< 0.010
SIN (g/m3)	< 0.444
MCI	➢ 120
Ammonical N (g/m3)	< 0.400 Max 2.1
Tox %	99
Visual Clarity (m)	< 50 %tile 3 % Δ 20
<u>Additional Targets that apply 1 May – 30 September</u>	
Temp	< 11 2 Δ
DO (% SAT)	80
Sediment or POM	No measurable increase of deposited sediment or particulate organic matter (POM) on the *bed*^ of the *river*^
Toxicity %	99

Values associated with the subzone are as follows: Zone Wide Values - Aesthetics, Contact Recreation, Mauri, Industrial Abstraction, Irrigation, Stock Water, Existing Infrastructure, Capacity to Assimilate Pollution; Site Specific Values –Trout Fishery II, Trout Spawning.

Other areas in the catchment have the following values identified - Natural State, SOS-Aquatic, Water Supply, Flood Control and Drainage.

10 Appendix D. Cost Estimates

OPTION 1: DAF PLANT

	Item	Unit	Quant/Dist	Rate	Base Estimate	Average Risk Allowance	Maximum Risk Allowance	Spread (maximum - average)	Spread Square	Average	Maximum
1	Price Supplied by Armatech (includes preliminary and general)	LS	1	1,147,253	1,147,253.00	1,204,616	1,261,978	57,363	3,290,473,615	5%	10%
2	Preliminary and General for remainder of works	LS	1	11,030	11,030.00	11,582	12,133	552	304,152	5%	10%
3	New 1500 manhole (with stopgate to allow diversion)	LS	1.0	6,500	6,500.00	7,800	9,750	1,950	3,802,500	20%	50%
4	Pipework to existing pumpstation, 150mm	m	125.0	100	12,500.00	15,000	18,750	3,750	14,062,500	20%	50%
5	New pumps (12 L/s at 7m head)	each	2.0	9,500	19,000.00	22,800	28,500	5,700	32,490,000	20%	50%
6	Pipe from Treatment Unit to existing discharge pipe	m	125.0	100	12,500.00	15,000	25,000	10,000	100,000,000	20%	100%
7	Control cables to existing control shed and telemetry	m	60.0	30	1,800.00	2,160	2,700	540	291,600	20%	50%
8	Potable water supply	LS	1.0	1,000	1,000.00	1,200	1,500	300	90,000	20%	50%
9	Electrical supply Underground, 60A MAX	m	60.0	100	6,000.00	7,200	9,000	1,800	3,240,000	20%	50%
10	Adjustments to existing screen and flow meter, including carport	LS	1	37,000	37,000.00	44,400	55,500	11,100	123,210,000	20%	50%
11	Discharge flow measurement (300mm magflo in chamber, output cable)	LS	1	14,000	14,000	15,400	18,200	2,800	7,840,000	10%	30%
12	Rock Filter at tail end of pond (manhole outlet, surrounded by 1m of rip rap)	LS	1	5,500	5,500	6,600	8,800	2,200	4,840,000	20%	60%
	- SUBTOTAL					1,353,757.15	**1,451,811.30**				
	- TOTALS				$ 1,274,083	$ 1,353,757	$ 1,451,811	$ 98,054	$ 59,838		
				% Over		6%	14%				

Base Estimate	1,274,083	Average Risk Allowance	1,353,757	90%ile Risk Allowance	1,413,596

OPTION 2: ACTIFLO CLARIFIER

	Item	Unit	Quant/Dist	Rate	Base Estimate	Average Risk Allowance	Maximum Risk Allowance	Spread (maximum - average)	Spread Square	Average	Maximum
1	Prelminary and General	LS	1	82,370.00	82,370.00	86,489	90,607	4,119	16,962,042	5%	10%
2	APWW1 Actiflo APW3	LS	1	554,000.00	554,000.00	581,700	609,400	27,700	767,290,000	5%	10%
3	Off loading and positioning (by crane)	LS	1	3,500.00	3,500.00	4,200	5,250	1,050	1,102,500	20%	50%
4	Site assembly of components (3 people, 10 days)	hours	240	80.00	19,200.00	23,040	28,800	5,760	33,177,600	20%	50%
5	Sub-base and concrete foundation pad (10m x 5m, 200mm thick)	m^3	10	500.00	5,000.00	6,000	7,500	1,500	2,250,000	20%	50%
6	Screen between pond and Actiflo (600mm Huber perforated plate screen)	LS	1	75,000.00	75,000.00	78,750	82,500	3,750	14,062,500	5%	10%
7	Rock Filter at tail end of pond (manhole outlet, surrounded by 1m of rip rap)	LS	1.0	5,500.00	5,500.00	6,600	8,800	2,200	4,840,000	20%	60%
8	New 1500 manhole (with stopgate to allow diversion)	LS	1.0	6,500.00	6,500.00	7,800	9,750	1,950	3,802,500	20%	50%
9	Pipework to existing pumpstation, 150mm	m	125.0	100.00	12,500.00	15,000	18,750	3,750	14,062,500	20%	50%
10	New pumps (12 L/s at 7m head)	each	2.0	8,000.00	16,000.00	19,200	24,000	4,800	23,040,000	20%	50%
11	Pipe from Treatment Unit to existing discharge pipe	m	125.0	100.00	12,500.00	15,000	18,750	3,750	14,062,500	20%	50%
12	Bulk chemical storage	LS	1.0	50,000.00	50,000.00	60,000	75,000	15,000	225,000,000	20%	50%
13	Control cables to existing control shed and telemetry	m	60.0	100.00	6,000.00	7,200	9,000	1,800	3,240,000	20%	50%
14	Potable water supply	LS	1.0	1,000.00	1,000.00	1,200	1,500	300	90,000	20%	50%
15	Electrical supply Underground, 60A MAX	m	60.0	100.00	6,000.00	7,200	9,000	1,800	3,240,000	20%	50%
16	Adjustments to existing screen and flow meter, including carport	LS	1	37,000	37,000.00	44,400	55,500	11,100	123,210,000	20%	50%
17	Discharge flow measurement (300mm magflo in chamber, output cable)	LS	1	14,000	14,000	16,800	21,000	4,200	17,640,000	20%	50%
	- SUBTOTAL					980,578.50	**1,075,107.00**				
	- TOTALS				$ 906,070	$ 980,579	$ 1,075,107	$ 94,529	$ 35,596		
				% Over		8%	19%				
				Base Estimate	**906,070**	**Average Risk Allowance**	**980,579**	**90%ile Risk Allowance**	**1,016,174**		

OPTION 3: CONVENTIONAL CLARIFIER

	Item	Unit	Quant/Dist	Rate	Base Estimate	Average Risk Allowance	Maximum Risk Allowance	Spread (maximum - average)	Spread Square	Average	Maximum
1	Prelminary and General	LS	1	33,340	33,340	35,007	36,674	1,667	2,778,889	5%	10%
2	Clarifier 7m diameter	LS	1	175,000	175,000	218,750	297,500	78,750	6,201,562,500	25%	70%
3	Pump Station (Clarifier Sludge)	LS	1	17,000	17,000	20,400	25,500	5,100	26,010,000	20%	50%
4	Dosing Plant	LS	1	20,000	20,000	24,000	30,000	6,000	36,000,000	20%	50%
5	Mixing Tank	LS	1	15,000	15,000	18,000	22,500	4,500	20,250,000	20%	50%
6	Electrical supply, underground	m	150	50	7,500	9,000	11,250	2,250	5,062,500	20%	50%
7	Discharge Pipe, 300mm	m	120	250	30,000	36,000	45,000	9,000	81,000,000	20%	50%
8	New pond outlet with manhole and rip rap filter	LS	1	5,500	5,500	6,600	8,800	2,200	4,840,000	20%	60%
9	Manholes	each	2	2,700	5,400	6,480	8,100	1,620	2,624,400	20%	50%
10	New pipe between ponds, 300mm	LS	1	5,000	5,000	6,000	7,500	1,500	2,250,000	20%	50%
11	Install riser or plug in existing pipes	LS	1	2,000	2,000	2,400	3,000	600	360,000	20%	50%
12	Adjustments to existing screen and flow meter, including carport	LS	1	37,000	37,000	44,400	55,500	11,100	123,210,000	20%	50%
13	Discharge flow measurement (300mm magflo in chamber, output cable)	LS	1	14,000	14,000	16,800	21,000	4,200	17,640,000	20%	50%
	- SUBTOTAL					443,837.00	572,324.00				
	- TOTALS				$ 366,740	$ 443,837	$ 572,324	$ 128,487	$ 80,769		
				% Over		21%	56%				

Base Estimate	366,740	Average Risk Allowance	443,837	90%ile Risk Allowance	524,606

OPTION 4: DIRECT DOSING INTO POND

	Item	Unit	Quant/Dist	Rate	Base Estimate	Average Risk Allowance	Maximum Risk Allowance	Spread (maximum - average)	Spread Square	Average	Maximum
1	Prelminary and General	LS	1	12,250.00	12,250	12,863	13,475	613	375,156	5%	10%
2	Dosing Plant	LS	1	20,000	20,000	24,000	30,000	6,000	36,000,000	20%	50%
3	Electrical supply, underground	m	150	50	7,500	9,000	11,250	2,250	5,062,500	20%	50%
4	Mixer (approx 1.5kw)	LS	1	11,000	11,000	13,200	16,500	3,300	10,890,000	20%	50%
5	HDPE Pond Baffle and mounting	LS	1	15,000	15,000	18,000	22,500	4,500	20,250,000	20%	50%
6	1500mm manhole to act as mixing chamber, 1.5m deep, installed within baffle	LS	1	6,500	6,500	7,800	9,750	1,950	3,802,500	20%	50%
7	Bridge to mixing chamber, 3m long	LS	1	6,000	6,000	7,200	9,000	1,800	3,240,000	20%	50%
8	Adjustments to existing screen and flow meter, including carport	LS	1	37,000	37,000	44,400	55,500	11,100	123,210,000	20%	50%
9	Discharge flow measurement (300mm magflo in chamber, output cable)	LS	1	14,000	14,000	16,800	21,000	4,200	17,640,000	20%	50%
10	Rock Filter at tail end of pond (manhole outlet, surrounded by 1m of rip rap)	LS	1.0	5,500.00	5,500.00	6,600	8,800	2,200	4,840,000	20%	60%
	- SUBTOTAL					159,862.50	**197,775.00**				
	- TOTALS				$ 134,750.00	$ 159,862.50	$ 197,775.00	$ 37,912.50	$ 15,010		
				% Over		19%	47%				
				Base Estimate	**134,750**	**Average Risk Allowance**	**159,863**	**90%ile Risk Allowance**	**174,873**		

OPUS

APPENDIX III - ANNOTATED AERIAL IMAGE SHOWING THE PLANT, INCLUDING EXISTING AND PROPOSED UPGRADES

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